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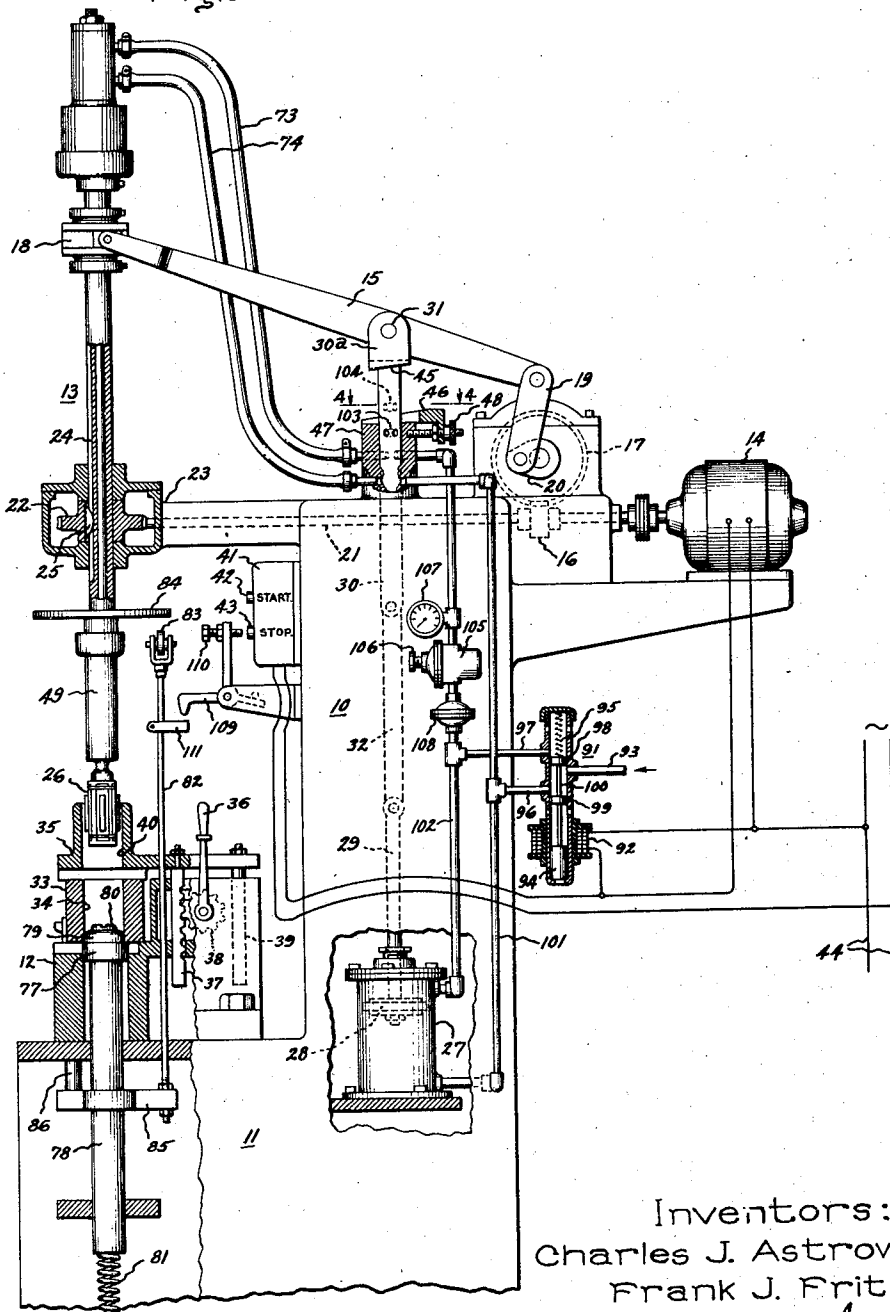
2,251,607

ABRADING MACHINE

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2 Sheets-Sheet 1

Fig. 1.



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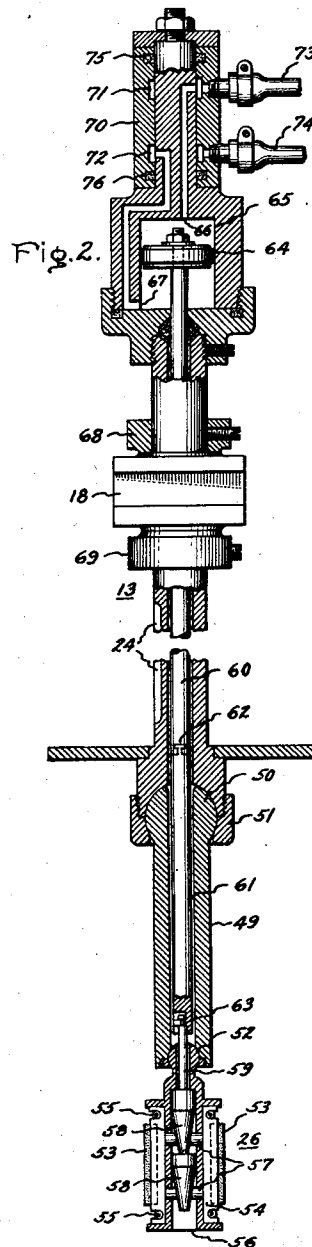
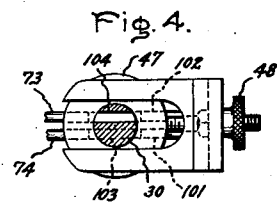
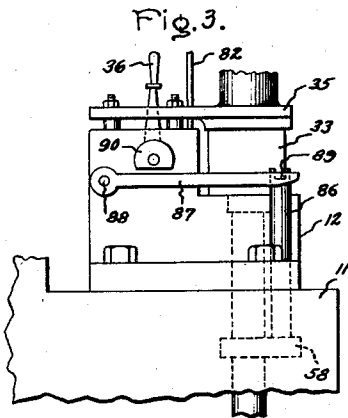
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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ABRADING MACHINE

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8 Claims. (Cl. 51-34)

Our invention relates to abrading machines, and particularly to automatic abrading machines for providing finished surfaces within extremely narrow tolerances.

It is an object of our invention to provide an improved automatically operated abrading machine which shall finish surfaces such as those of compressor cylinders, journal bearings, and the like, within extremely narrow limits of accuracy.

Another object of our invention is to provide an automatic abrading machine having an improved arrangement for controlling the operation thereof and for assuring the finishing of a surface to be ground or honed within extremely narrow limits of accuracy and for stopping the abrading operation immediately upon the finishing of the surface to the desired dimension.

Another object of our invention is to provide an abrading machine including an improved arrangement for coordinating automatically the positioning and operation of the abrading tool and for automatically gauging the surface to be finished to provide accurate and consistent finishing of the surface of the work within very narrow tolerances.

Further objects and advantages of our invention will become apparent as the following description proceeds, and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of our invention, reference may be had to the accompanying drawings in which Fig. 1 is a side elevation view partly in section of an automatic cylinder honing machine embodying our invention; Fig. 2 is an enlarged detail view, partially in section, of the spindle of the machine shown in Fig. 1; Fig. 3 is a side elevation view showing the opposite side of the work holding support of the machine shown in Fig. 1; and Fig. 4 is an enlarged view of a portion of the machine shown in Fig. 1 on the line 4-4 thereof.

In the illustrated embodiment of our invention, we have shown a honing machine of the type utilizing a hone having expansible elements or abrading sticks and provided with a spindle whereby the hone may be rotated and reciprocated with respect to the work. The rotation or reciprocation of the hone or abrading tool is effected by operation of a motor and suitable shafts and levers and the movement of the abrading tool toward and away from the work as well as the expansion and contraction of the abrading elements thereof is effected by a fluid pres-

sure operated mechanism. The operation of the mechanism to perform the several functions thereof is coordinated and the fluid pressure is controlled in such a manner that the finishing of the honed surface may be effected consistently within extremely narrow limits of accuracy, a suitable gauging mechanism being provided to terminate the honing operation when the surface of the work has been finished to the required size. The honing machine illustrated is particularly adapted for high speed production of compressor cylinders and will accurately finish large numbers of such cylinders without requiring manual gauging of the cylinders during the honing operation or any adjustment by the operator during the operation on a given piece of work, it being necessary merely to place the work in position on the machine, start the machine and remove the work after the machine has stopped automatically.

Referring now to the drawings, in Fig. 1 we have shown a honing machine for honing the bores of refrigerant compressor cylinders and comprising a support or standard 10 mounted on a base 11 and provided with a work support 12 and a spindle 13. The spindle 13 is arranged to be rotated and reciprocated by operation of an electric motor 14 which actuates a rocking crank 15 through a worm 16 and gear 17, crank 15 being slidably connected to a collar 18 mounted on the spindle 13 and being connected to be driven by the gear 17 through a link 19 and crank 20. Extension 21 of the motor shaft rotates the spindle through a worm (not shown) and a gear 22 mounted in a supporting housing 23. The spindle 13 is provided with a keyway 24 engaged by a key 25 in the hub of the gear 22. A honing tool 26 of the expansible type is secured to the lower end of the spindle and may be moved toward and away from its working position by operation of a fluid pressure motor 27 having a piston 28 and piston rod 29 arranged to raise and lower a rod 30 having a forked connector 30a at the upper end thereof, to which the lever 31 is pivoted at 31, the rods 29 and 30 being connected by a link 32. In Fig. 1 the spindle has been shown in its raised position. We have shown a compressor block 33 having a cylinder bore 34 secured in place on the work support 12, the block being held between the stationary support 12 and movable clamp 35 arranged to be raised and lowered by operation of the lever 36 through a rack and pinion 37, 38, suitable guides 39 being provided for the clamp. The clamp 35 is provided with a bore 40 arranged

to guide the abrading tool or honing element into the cylinder 34 of the work. In order to control the motor 14 we provide a switch mechanism 41 provided with start and stop buttons 42 and 43 respectively, the switch mechanism being arranged to connect the motor to suitable supply lines 44.

When the spindle is lowered into its working position a lower inclined face 45 of the forked connector 30a rests on an adjustable wedge 46 secured to the top of a boss or guide 47 at the top of the support 10. The wedge 46 is provided with an adjusting screw 48 adapted to slide the wedge horizontally along the top of the boss 47 in order that the lowermost position of the spindle may be adjusted.

The construction and working parts of the spindle 13 are clearly shown in Fig. 2. The abrading element or honing tool 26 is secured to the lower end of the spindle on an extension 49 connected to the spindle by a ball and socket joint 50 having a removable collar 51, the tool 26 being secured in the lower end of the extension 49 by a ball and socket joint 52. The hone comprises a plurality of honing sticks or working elements 53 held in suitable shoes 54 and retained by garter springs 55 in suitable slots or grooves in a cylindrical frame or quill 56. Each of the shoes 54 is provided with a pair of lugs 57 slidably mounted in holes in the quill 56 and engaging cones 58 secured on an operating rod 59 passing through the center of the tool. The spindle 13 and shaft 49 are hollow and are provided with rods 60 and 61 respectively held together by a slot and key connection 62 adjacent the ball and socket joint 50, the rod 59 being secured to the lower end of the rod 61 by a slot and key connection 63 whereby longitudinal movement of the rod 60 effects movement of the cones 58 to force the honing sticks radially outwardly. In order to effect longitudinal movement of the rod 60 within the spindle, we provide a piston 64 mounted in a cylinder 65 near the top of the spindle and provided with compressed air inlets 66 and 67 at the top and bottom thereof to effect downward and upward movement respectively of the rod. In Fig. 2 the gear 22 for rotating the spindle has not been shown, since it would be connected in the broken away portion. The collar 18 for raising and lowering the spindle is rotatably mounted between collars 68 and 69 which are secured to the spindle. In order to supply compressed air to the cylinder 65 during rotation and reciprocation of the spindle, we provide a sleeve or collar 70 having annular grooves 71 and 72 arranged to communicate with the inlets 66 and 67 respectively and connected to flexible fluid pressure conduits 73 and 74 respectively. The collar 70 is arranged to be held stationary while the spindle is rotated therein, suitable oil sealed packings 75 and 76 being provided near the upper and lower end respectively of the collar 70. It is, therefore, evident that the honing spindle may be rotated and reciprocated without interfering with the desired communication between the compressed air supply conduits 73 and 74 and the upper and lower ends respectively of the cylinder 65.

In order to determine when the work has been finished to the required dimension, we provide a gauge or gauging plug 77 arranged to test the size of the work after each stroke of the honing tool. The gauge 77 is mounted on a slide 8 extending through the work support 12 and into

the base 11 of the machine. A locating plug or preliminary gauge 79 having a diameter slightly smaller than that of the gauge plug 77 is arranged to enter the work ahead of the plug 77 and locates the plug 77 with respect to the cylinder bore. The plugs 77 and 79 are secured to the upper end of the slide 78 by a cap screw 80. The slide 78 is biased upwardly toward the work by a helical spring 81. In order to prevent the tool 26 from coming in contact with the gauge plugs we provide a pin or rod 82 extending upwardly through the work support 12 and clamp 35 and provided with a wheel 83 at the top thereof arranged to engage a disk 84 rigidly secured to the spindle 13. The rod 82 is secured to the slide 78 on a collar 85 and it is readily apparent that when the spindle moves downwardly to place the tool 26 in its working position, the disk 84 will press the rod 82 downwardly and move the slide 78 away from the work 33 against the pressure of the spring 81. The disk 84 is rotated with the spindle and the wheel 83 is provided to prevent undue friction between the rod and the disk. Also attached to the collar 85 is a guide rod 86 which extends upwardly through the base 11 and the lower portion of the work support 12 as clearly shown in Fig. 3. This rod is provided in order to move the gauge plugs out of their gauging position when the work is being adjusted on the support. An arm 87 pivoted to the support 12 at 88 is provided with a pin 89 engaging the top of the rod 86. The handle 36 for operating the clamp 35 rotates a cam 90 which engages the arm 87 and presses the rod 86 downwardly whenever the handle 36 is rotated to move the clamp 35 away from the work. This arrangement keeps the gauging plugs out of the way during the handling of the work.

In order to control the movement of the spindle and the abrading tool toward and away from their respective working positions, we provide a valve 91 actuated by a solenoid 92 which is energized whenever the motor 14 is connected across the power supply lines 44. The valve 91 is arranged to connect the fluid supply lines for the pistons 28 and 64 to a suitable source of compressed air through a supply pipe or conduit 93. As clearly shown in Fig. 1, the solenoid valve is provided with an armature 94 biased to its "drop out" position by gravity and by a spring 95. Two outlet connections 96 and 97 are provided to convey fluid under pressure from the valve casing to the fluid operated pistons. Either one of the outlet connections may be placed in communication with the supply conduit 93 depending upon the position of two valve pistons 98 and 99 rigidly secured to the armature 94 on a valve stem 100. In its "drop out" position the solenoid valve 91 connects the outlet connection 96 to the supply conduit 93 and in its "pick up" position it connects the outlet 97 to the supply conduit. When the solenoid valve is in its "drop out" position the outlet 96 conveys fluid under pressure to a conduit 101 to raise the pistons 28 and 64 and thereby retract the honing sticks and move the spindle away from its working position. When the solenoid is in its "pick up" position a supply conduit 97 conveys fluid under pressure through a supply conduit 102 to lower the spindle to its working position and to move the honing sticks radially outward into their working positions. In order to maintain the hone or abrading tool in its retracted position when the spindle is not in its working posi-

tion, we provide within the boss 47 a pair of valves comprising ducts or ports 103 and 104 in the rod 30 arranged to provide communication between the supply conduits 101 and 102 and the flexible conduits 74 and 73 respectively when the rod 30 is in its lowermost position. The arrangement of the valve ducts 103 and 104 and the passages which they connect is clearly shown in Fig. 4. The ducts 103 and 104 are arranged on opposite sides of the axis of the rod 30 so that they provide communication between the supply and delivery conduits only when the rod is in its lowered position.

The arrangement of the valve ducts 103 and 104 in the rod 30 insures actuation of the mechanism in a manner such that the honing sticks cannot be forced outwardly against the work when the honing tool is being moved toward or away from its working position upon operation of the piston 28. In the position of the spindle shown in Fig. 1, the rod 30 is held in its raised position by fluid pressure admitted to the lower side of the piston 28 through the connection 96 and the conduit 101. In this position, the valve ports 103 and 104 are raised and communication between the supply conduits 101 and 102 and the flexible conduits 73 and 74 is cut off by the rod 30. Although the air pressure to the lower side of the hone expanding piston 64 has been cut off, the hone sticks are maintained in their retracted position by the garter springs 55. If the motor is now started by pressing the starting button 42, the solenoid valve will be picked up and compressed air admitted to the connection 97 and the air will enter the top side of the cylinder 27 through the conduit 102 and force the piston 28 downwardly thereby moving the tool into its working position. When the rod 30 reaches its lowermost position the port 104 will provide communication between the conduit 102 and the flexible conduit 73 thereby admitting compressed air to the top side of the piston 64 through the inlet 66 and expanding the hone, this operation being effected while the motor is rotating and reciprocating the spindle 13. When the honing operation has been completed, switch 41 is actuated to deenergize the motor and solenoid valve and fluid pressure is thereby cut off from the conduit 102 and admitted to the conduit 101. Since the conduit 101 is in direct communication with the flexible conduit 74 through the port 103, the fluid pressure is immediately effective to force the piston 64 upward and return the honing sticks to their retracted positions. Since the weight of the spindle and its associated mechanism such as the arm 15 is great as compared with that of the parts connected to the piston 64, the piston 64 is operated immediately and moves to its upper position before the fluid pressure can raise the piston 28 sufficiently to cut off the port 103. It is, therefore, apparent that the honing elements are retracted before the spindle is raised to remove the abrading tool from its working position. This arrangement prevents "bell-mouthing" or other injuries to the work.

In order to obtain a high degree of accuracy and consistent finishing of large numbers of pieces of work, we provide a fluid pressure regulating device 105 in the conduit 102 between the inlet 97 and the inlet 66 of the cylinder 65. The pressure maintained by the device 105 may be adjusted by adjustment of a thumb screw or other suitable device 106, the selected position being determined by a pressure gauge 107. The pres-

sure regulating device insures a constant predetermined pressure between the honing sticks and the work and highly consistent work is performed by the machine without the necessity of frequent adjustments of the setting of the hone. In order to prevent the passage of foreign matter to the pressure control device 105, we provide a suitable filter or strainer 108 at the inlet side of the pressure regulator.

As soon as the compressor cylinder has been finished to the desired size, the gauge 77 will enter the cylinder. This movement of the gauge into the cylinder is utilized to stop the honing operation and thereby prevent any further honing of the cylinder bore after it has been finished to the desired size. In order to stop the honing machine illustrated in Fig. 1, we provide a bell crank 109 having an adjustable screw 110 arranged to engage the stop button 43 of the switching mechanism 41. When the gauge plug 77 enters the cylinder bore, the rod 82 follows the disk 84 and a lug 111 secured to the rod strikes the bell crank 109 and presses the screw 110 against the stop button 43 to stop the motor 14 and deenergize the solenoid valve 91 thereby operating the fluid pressure pistons to retract the abrading elements and lift the spindle away from its working position.

The operation of the honing machine described above is as follows: A piece of work such as the cylinder block 33 is placed on the work support 12 and the clamp 35 lowered in place by operation of the handle 36, the clamp and support being constructed to receive the particular type of work so that it is readily placed in position with the bore to be honed in alignment with the guide 40 and the gauging blocks 77 and 79. Clamp 35 is tightened in place and the honing operation started by pressing the button 42. The motor 14 and solenoid valve 91 are energized and air pressure admitted to the cylinder 27 through the conduit 102 to force the piston 28 downwardly. The spindle 13 is thus moved into its working position with the honing tool 26 in the cylinder bore 34 which is to be honed. As soon as the piston 28 reaches its lowermost position, the port 104 in the rod 30 provides communication between the conduit 102 and the flexible conduit 73 and thereby forces the piston 64 downwardly in the cylinder 65 and expands the hone by moving the abrading elements 53 radially outward into their working positions. Rotation and reciprocation of the honing tool 26 removes material from the cylinder walls at a rate dependent upon the pressure maintained by the regulating device 105 in accordance with the setting of the adjusting screw 106. On each stroke of the spindle 13 as it reaches its upper position, the gauge block 79 enters the cylinder bore, and, as soon as the bore has been finished to the desired size, the gauge plug 77 follows the gauge block 79 into the bore and allows the rod 82 to move upwardly until the lug 111 strikes the bell crank 109 thereby pressing the stop button 43 of the switching mechanism 41 and deenergizing the motor and solenoid valve. The valve thereupon falls to its "drop out" position admitting compressed air to the flexible conduit 74 through the conduit 101 and port 103 and contracting the hone by raising the piston 64. Compressed air is admitted also to the lower side of the piston 28 in the cylinder 27 and the piston is raised to lift the spindle 13 away from its working position. The retraction of the honing elements from their working positions is assured before the spindle can lift the

tool from its position within the finished cylinder because the spindle and the parts of the mechanism which move therewith have a high moment of inertia as compared with that of the piston 64 and its associated mechanism. The entire honing operation is effected within extremely narrow tolerances in a single operation of the automatic machine. Because of the automatic gauging it is unnecessary to stop and adjust the hone or to stop the machine in order to gauge the work.

From the foregoing, it is readily apparent that we have provided a simple and effective abrading machine and control which makes possible the finishing of large numbers of pieces within extremely narrow limits of accuracy. Oversized finishing of bores or other surfaces is prevented as well as defects such as "bell-mouthing."

While we have shown our invention as applied to a cylinder honing machine, other applications will readily be apparent to those skilled in the art. We do not, therefore, desire our invention to be limited to the particular construction shown and described and we intend in the appended claims to cover all modifications within the spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means for operating said tool in its working position, fluid operated means for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, common fluid pressure conduit means for conveying fluid under pressure to both of said fluid operated means to effect movement of said tool and said abrading element toward their respective working positions, common fluid pressure conduit means for supplying fluid under pressure to both of said fluid operated means to effect movement of said tool and said abrading element away from their respective working positions, a common source for supplying fluid under pressure to both of said conduit means, means for selectively connecting either of said conduit means to said source, and means for assuring positioning of said second-mentioned fluid operated means to hold said abrading element away from its working position before said first-mentioned fluid operated means can effect movement of said tool into or out of its working position.

2. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means for operating said tool in its working position, fluid operated means including a rod for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, a common source for supplying fluid under pressure to both of said fluid operated means, and means including valves arranged to be actuated by said rod for assuring positioning of said second-mentioned fluid operated means to hold said abrading element away from its working position before said first-mentioned fluid operated means can effect movement of said tool into or out of its working position.

3. In an abrading machine, a work support, a clamping device for holding the work in position

on said support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means for operating said tool in its working position, fluid operated means for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, a common source for supplying fluid under pressure to both of said fluid operated means, means for assuring positioning of said second-mentioned fluid operated means to hold said abrading element away from its working position before said first-mentioned fluid operated means can effect movement of said tool into or out of its working position, means including a gauge for determining when the work has been finished to the desired size and for terminating operation of said machine, and common means for moving said clamping device to and from its clamping position and for moving said gauge to and from its gauging position.

4. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means including a motor for rotating said tool and for reciprocating said tool with respect to said support, fluid operated means for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, common fluid pressure conduit means for conveying fluid under pressure to both of said fluid operated means to effect movement of said tool and said abrading element toward their respective working positions, common fluid pressure conduit means for conveying fluid under pressure to both of said fluid operated means to effect movement of said tool and said abrading element away from their respective working positions, means for supplying fluid under pressure to both of said conduit means, means including a solenoid operated valve for selectively connecting either of said conduit means to said fluid supplying means, said solenoid valve being arranged when deenergized to connect said fluid supplying means to said second-mentioned fluid pressure conduit means, means including a gauge arranged to move over the surface of the work when the work has been finished to the desired size, a common electrical circuit for energizing said solenoid and said motor, and means including a switch arranged to be actuated by movement of said gauge over the surface of the work for deenergizing said circuit to stop said motor and to withdraw said tool from its working position.

5. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means including a motor for rotating said tool and for reciprocating said tool with respect to said support, fluid operated means for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, common fluid pressure conduit means for conveying fluid under pressure to both of said fluid operated means to effect movement of said tool and said abrading element toward their respective working positions, common fluid pressure conduit means for conveying fluid under pressure to both of said fluid operated means to effect movement of said tool and said

abrading element away from their respective working positions, means for supplying fluid under pressure to both of said conduit means, and means including a solenoid operated valve for selectively connecting either of said conduit means to said fluid supplying means, said solenoid valve being arranged when deenergized to connect said fluid supplying means to said second-mentioned fluid pressure conduit means, said first-mentioned fluid operated means and the mechanism associated therewith having a greater moment of inertia than said second-mentioned fluid operated means and the mechanism associated therewith whereby fluid pressure supplied to said second-mentioned fluid pressure conduit means effects operation of said second-mentioned fluid operated means before effecting operation of said first-mentioned fluid operated means.

6. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means for operating said tool in its working position, fluid operated means including a rod and a rod guide for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, a common source for supplying fluid under pressure to both of said fluid operated means, and means including valves formed in said rod and said rod guide for assuring positioning of said second mentioned fluid operated means to hold said abrading element away from its working position before said first mentioned fluid operated means can effect movement of said tool into or out of its working position.

7. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means for operating said tool in its working position, fluid operated means including a rod and a rod guide for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, a common

source for supplying fluid under pressure to both of said fluid operated means, valve means selectively operable into either of two positions for controlling the operation of said machine, said valve means in one position connecting said source to both of said fluid operated means to effect movement of said tool and said abrading element into their working positions and in its other position connecting said source to both of said fluid operated means to effect movement of said tool and said abrading element away from their working positions, and means including valves formed in said rod and said rod guide for assuring positioning of said second mentioned fluid operated means to hold said abrading element away from its working position before said first mentioned fluid operated means can effect movement of said tool into or out of its working position.

8. In an abrading machine, a work support, an abrading tool movable toward and away from a working position and having an abrading element movable toward and away from a working position, means for operating said tool in its working position, fluid operated means for moving said tool toward and away from its working position, fluid operated means for moving said abrading element toward and away from its working position, a common source for supplying fluid under pressure to both of said fluid operated means, valve means selectively operable into either of two positions for controlling the operation of said machine, said valve means in one position connecting said source to both of said fluid operated means to effect movement of said tool and said abrading element into their working positions and in its other position connecting said source to both of said fluid operated means to effect movement of said tool and said abrading element away from their working positions, electrical means for actuating simultaneously said valve means and said means for operating said tool, and fluid pressure regulating means arranged between said source and said second mentioned fluid operated means for controlling the pressure between said abrading element and the work.

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