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1,826,070

GRINDING MACHINE

Filed May 31, 1929

2 Sheets-Sheet 1

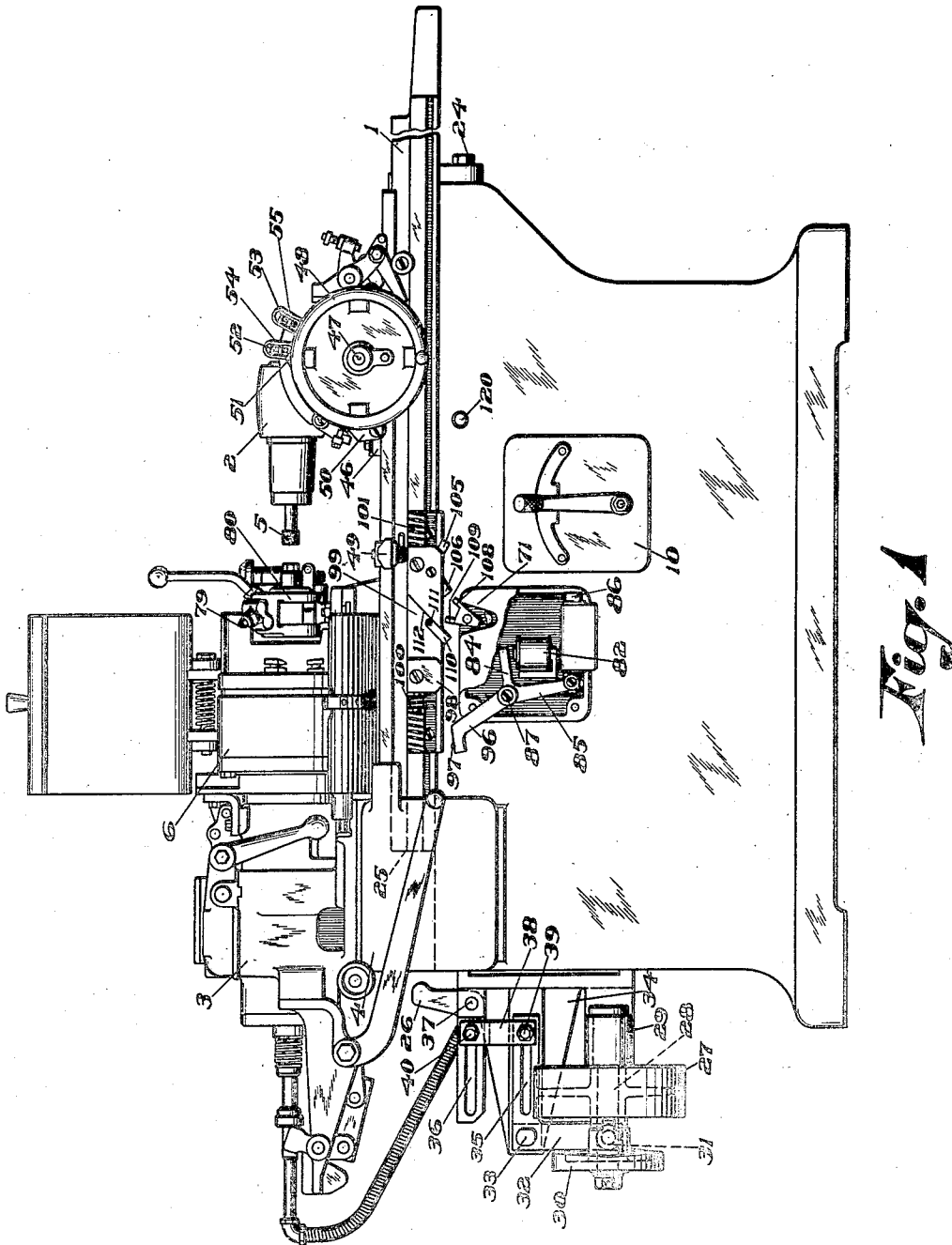


Fig. 1

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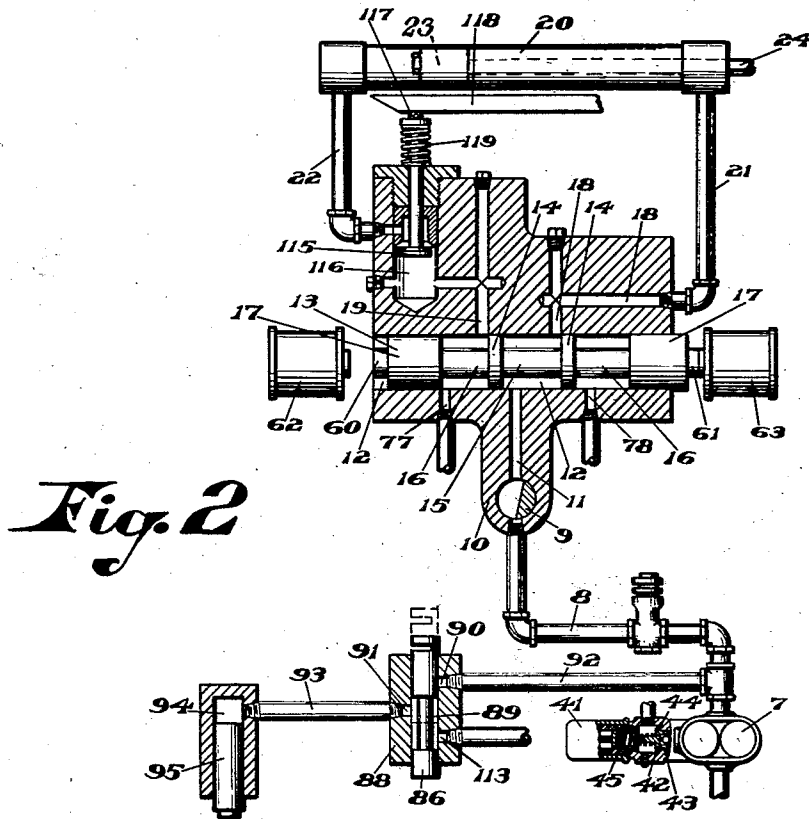


Fig. 2

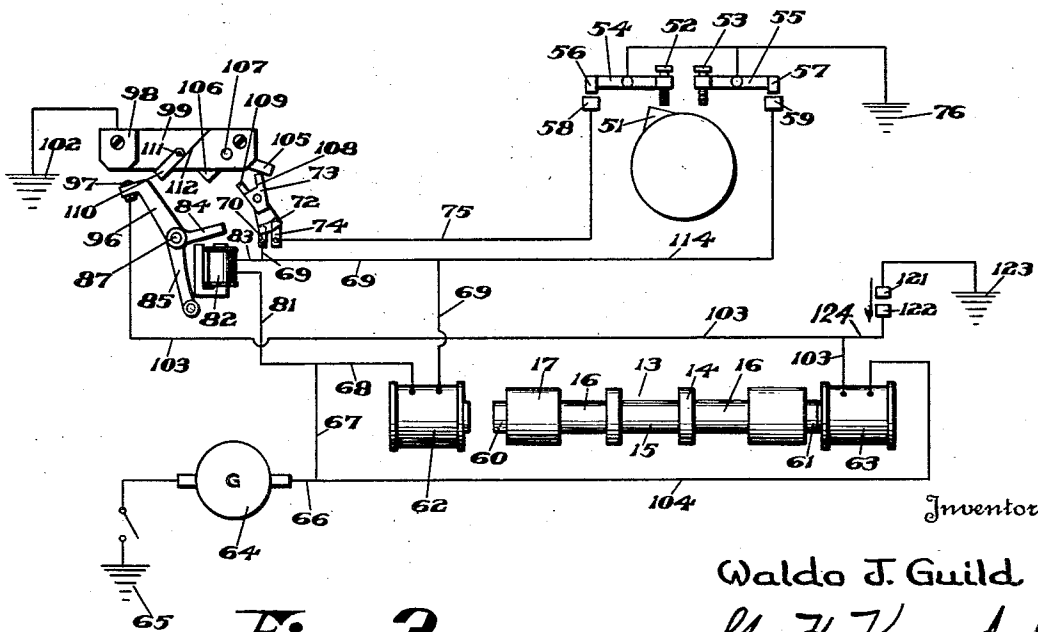


Fig. 3

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GRINDING MACHINE

Application filed May 31, 1929. Serial No. 367,399.

The invention relates to grinding machines, being particularly adapted to internal grinding machines, and involves the provision of fluid pressure mechanism, otherwise called hydraulic mechanism, to move the grinding carriage to and from its idle position, and mechanical devices for controlling the reciprocation of said carriage in its working position. The invention further involves devices to cause the carriage to be moved through a limited distance, for the dressing operation, by means of the fluid pressure mechanism.

The use of hydraulic or fluid pressure actuating means for the tables or carriages of grinding machines has greatly simplified these machines and permitted the carriage speed to be more easily and completely controlled. Certain classes of work, however, such as small annular workpieces, the interior surface of which must be ground very close to a shoulder, and also workpieces having very short surfaces to be ground, cannot be effectively handled by machines whose working reciprocations are produced hydraulically. This limitation on the operation of the usual hydraulically actuated grinding machine arises from the fact that invariably the actual points of reversal of the table are affected by the latter's momentum, which varies with the speed imparted to said table, and also from the fact that the length of table travel necessary to actuate the hydraulic reversing valve is oftentimes as great as or greater than the length of the surface to be ground. While the reversing valve can always be actuated at the same relative point in the travel of the table, still, on account of the factors above set forth, the point at which the table actually reverses cannot be definitely predetermined. According to this invention, the necessity for actuating the reversing valve of a hydraulically operated grinding machine, during the working reciprocations of the table, has been eliminated, by the incorporation into such a machine of mechanical devices, effective in the working position of the carriage, to control its reciprocations between definitely predetermined limits.

In order that the advantages of fluid pressure actuation may not be lost, and in order that the table may be caused to run out either to the dressing position or to the remote position where the grinding wheel is separated from the workpiece, I make use of fluid pressure means to move the carriage, desirably involving the usual piston and cylinder unit, and cause this to bring the carriage against a member which is oscillated between predetermined limits by mechanical devices. This member secures the working reciprocations of the table or carriage, the latter being held against said member by the pressure of the fluid. The carriage movement beyond the range of working reciprocation takes place without any disconnection of clutches or other complicated mechanical expedients. Thus a new principle in the internal grinding of workpieces has been evolved.

The invention further involves the use of electromagnetic means to shift a reversing valve, whereby the carriage is urged against the mechanical oscillating element or away therefrom by the fluid pressure actuation, and this electrical control of the machine is another feature of the invention. It should be understood that an essential part of this last named object involves the use of suitable controlling means to effect the change from fluid pressure table actuation to mechanical table actuation and that the invention is not limited to the use of electromagnetic means for this purpose.

Other objects and advantages will appear from the following detailed description taken in connection with the accompanying drawings, in which:—

Fig. 1 is a front elevation of an internal grinding machine constructed according to the invention.

Fig. 2 is a vertical sectional view of the fluid pressure controlling valve and casing therefor, together with a diagrammatic representation of the main fluid pressure connections used in the machine.

Fig. 3 is a wiring diagram disclosing also the mechanisms which make and break the circuits and the valve member shifted by the electromagnets.

Like reference characters refer to like parts throughout the drawings.

The machine of the present invention is shown applied, by way of example, to a machine incorporating the principles of my prior invention set forth in Letters Patent No. 1,682,672 granted August 28, 1928, and also the principles of an improvement thereon shown in Patent No. 1,682,673 to Taylor granted the same day, but it will be readily understood that the present invention could be equally well applied to other types of machines. Referring to Fig. 1, the machine provides the usual reciprocatory table or carriage 1 by the movement of which a grinding traverse between the wheel and the work is produced. In this embodiment of the invention the wheelhead 2 is carried by the carriage 1, while the workhead 3 is carried by a bridge 4 which spans the slideways provided by the machine frame for the back and forth movement of the table.

The reciprocatory motion of the table 1 to move the grinding wheel 5 to and fro in relation to a workpiece held in the workholding chuck 6 is produced by mechanical means, but before describing this the fluid pressure mechanism which moves the carriage from its remote inoperative position to the position of reciprocation will be described.

As shown in the diagrammatic view of Fig. 2, the machine is provided with a suitable fluid pressure pump 7 or any other source of fluid under pressure. The fluid is transmitted by a supply line 8 to a throttle valve 9 located in a casing 10 on the front of the machine. After leaving the throttle valve 9, the fluid is led by way of a passage 11 to a valve chamber 12, which is herein shown as a hollow cylinder and in which is located a slidable valve member generally designated by the numeral 13. The valve member 13 provides portions 14, 14 of full diameter, which touch the walls of the chamber 12, these portions being separated by a reduced portion 15. On the outside of the portions 14, 14 are reduced portions 16, 16, which are bounded by full diameter portions 17, 17. It will be apparent that the valve member 13 thus divides the hollow cylinder 12 into three chambers, which are movable relative to the stationary parts of the valve as the member 13 is moved.

On either side of the place where the passage 11 is located are passages 18 and 19 which lead respectively to the right and left hand sides of a cylinder 20 by way of piping 21 and 22 respectively. With the valve 13 in the position shown in Fig. 2, fluid is admitted from the supply line 8, by way of the throttle valve 9, passage 11, around the reduced portion 15, through the passage 18 and pipe 21 to the right hand end of the cylinder 20 in which is located a piston 23. This produces a force against the piston 23, and since

the piston rod 24 is attached to the table 1, it urges the table or carriage 1 to the left, Fig. 1.

Assuming the carriage 1 to be thus moved to the left, it will continue until the left hand end 25 of the carriage abuts a bell crank lever 26 which, in the operation of the machine, is subject to continuous oscillation, in the following manner:—As shown in Fig. 1, a pulley 27, fastened to a shaft 28, is mounted on the left hand end of the machine, the shaft being journaled in a bearing 29. The pulley may be rotated in any suitable manner as by a belt from an over-head shaft, and it procures continuous rotation of a face cam 30 which is fastened to the shaft 28. A roller 31, carried by one arm of a bell crank lever 32, pivoted at 33, is held in engagement with the face of cam 30 by the pressure of the carriage against the lever 26, the latter being connected, as hereinafter described, to the lever 32; all of the above described parts are carried by an overhanging bracket 34, suitably secured to the left hand end of the machine.

The horizontal portion of the bell crank lever 32 contains a long slot 35, and the bell crank lever 26 provides a parallel horizontal portion which contains a long slot 36. The bell crank lever 26 is pivotally mounted at 37, while a link 38 having bolts 39 and 40 at its opposite ends connects the bell crank levers, being adjustable along them in the slots 35 and 36 to procure any desired amplitude of the bell crank lever 26 within fairly wide limits. It is obvious that the oscillation imparted to the bell crank lever 32 by reason of the engagement of the cam 30 with the roller 31 produces oscillation of the bell crank lever 26, which will be more or less accordingly as the link 38 is moved to the right or to the left respectively.

This mechanism constitutes an adjustable vibratory stop for the carriage 1, and it is obvious that any other desired form of mechanical means for producing such a vibratory motion could be substituted therefor, for example, by using a track cam in place of the face cam 30 for vibrating the levers 32 and 26. In the illustrated mechanism, the fluid pressure acting on the piston 23 and the cylinder 20 forces the end 25 of the carriage 1 against the vibrating lever 26, and this produces definite reciprocation of the carriage for the following reason.

As shown in Fig. 2, associated with the pump 7 or other source of fluid pressure supply, is a relief valve 41, which may be of any form known to the art, being illustrated by way of example as comprising a piston 42 mounted in a chamber 43 and normally closing a port 44 because of the pressure of a spring 45. When, however, the pressure of the fluid rises beyond the normal limits, the piston 42 is urged to the left against the pressure of the spring 45 thus opening the port

44 and allowing the fluid to flow through the relief valve; this action permits the carriage 1 to be forcibly urged to the right during that part of the oscillatory motion of the member 26. It will thus be seen that by providing resilient fluid pressure means urging the carriage to the left, and mechanical means to vibrate an end stop for the carriage, that the carriage is reciprocated through a definite distance, and at all events can not move farther to the left than a known limit.

In order to make the machine automatic, that is to cause it to automatically terminate the grinding operation when the workpieces have been reduced to the desired size, and in order to obtain precision in the grinding operation, means is provided for causing the carriage to automatically run out and stop at the termination of a grinding operation, and to automatically undergo an amplified reciprocation for the purpose of dressing the wheel prior to the coming of size of the workpiece. In order to procure this cycle of operations which is the cycle set forth in the patents referred to, with the form of reciprocating mechanism provided by the present invention, the following mechanism is provided.

The wheelhead 2 is not mounted directly upon the carriage 1, but is longitudinally adjustable upon a cross slide 46, said cross slide controlling the position of the wheelhead in a direction transverse to its reciprocation and procuring the cutting feed between the grinding wheel and the workpiece. The feature of longitudinal adjustability of the wheelhead on the cross slide is not novel in grinding machines of this type, and permits, in the case of the present invention, the position as well as the amplitude of the reciprocatory motion of the wheel to be adjusted. The manner of mounting the cross slide upon the carriage 1 is fully set forth in the patents referred to, as is also the operation of the mechanism which causes intermittent rotation of the screw shaft 47 and hand wheel 48 together with the periodic compensatory additional advance given to the cross slide as set forth in the patent to Taylor referred to. Suffice it herein to state that such intermittent rotation of the hand wheel and screw shaft is procured by the engagement of an adjustable cam 49 with a member to which is connected a pawl 50 that engages a ratchet wheel, not shown.

Secured upon the hand wheel 48 or on a member carried thereby, and thus intermittently rotated with said hand wheel is a cam piece 51, which may be seen in Fig. 1 and also in the diagrammatic view of Fig. 3. In its movement of partial rotation this cam 51 successively engages adjustable screws 52 and 53 which are carried by rock levers 54 and 55 respectively; these rock levers provide contacts 56 and 57 which are adapted to engage

stationary contacts 58 and 59. The bringing together of the contacts 56 and 58 closes an electric circuit which procures the withdrawal of the carriage 1 from the position in which it is mechanically reciprocated in the following manner:—

As shown in Figs. 2 and 3, the extreme ends 60 and 61 of the reversing valve member 13, which is made of magnetic material, are spaced but a short distance from electromagnets 62 and 63 respectively. A generator 64 represents a source of electric energy, said generator being grounded at 65 and connected by a main lead 66 and branch leads 67 and 68 to the electromagnet 62. The other terminal of the magnet 62 is connected by a lead 69 to the left hand bar 70 of a switch generally designated by the numeral 71. The bar 70 is connected by a bridge 72 provided by an oscillatory member 73 to the right hand bar 74 of said switch 71. Said right hand bar is connected by a conductor 75 to the contact terminal 58.

During the grinding operation, while the carriage 1 is being reciprocated back and forth by the novel mechanism hereinbefore described, and while the valve 13 is in the position shown in Fig. 2 thus keeping the carriage in said position, the oscillatory switch member 73 is in the position shown in Fig. 3, and thus the bars 70 and 74 are connected. The moment, therefore, that the contacts 56 and 58 are brought together by movement of the cam piece 51, and consequent rocking of the rock lever 54, a circuit is completed through the electromagnet 62 by the path just described, and by reason of the fact that the rock lever is grounded as indicated at 76. Energization of the electromagnet 62 attracts the portion 60 of the valve 13 and causes said valve to shift bodily to the left. This forces the reduced portion 15 to the left of the passage 18 (Fig. 2), thus shutting off the pressure fluid from said passage, and at the same time it brings the reduced portion 15 directly into position under the passage 19. The reduced portion 16, which previously connected the passage 19 to an exhaust passage 77, is now cut off from said passage while the reduced portion 16 on the right connects the passage 18 to an exhaust 78. It will be seen without further description that the left hand end of the cylinder 20 is connected to the fluid pressure supply force, while the right hand end of said cylinder is open to the exhaust, and thus the piston 23 is urged to the right and there being nothing to prevent the carriage from moving, it moves to the right carrying the grinding wheel 5 away from the workpiece and away from the chuck 6. Simultaneously with this action, a dressing device or diamond 79 which is mounted upon an oscillatory member 80 is moved into the path of the wheel 5 so as to dress and true said wheel. Still referring to Fig. 3, a branch lead

81 is connected to the branch lead 67, and this lead 81 is connected to one terminal of an electromagnet 82 which, as best shown in Fig. 1, is mounted on the front of the machine.

The other terminal of the electromagnet 82 is connected by a conductor 83 to the conductor 69, and consequently also to the contact bar 70. At the same time, therefore, as the electromagnet 62 is energized, the electromagnet 82 is likewise energized, these magnets being in parallel with each other and the circuits for both of them passing through the movable contact bridge 72. Energization of the electromagnet 82 attracts an armature member 84 which comprises one arm of a three armed member, whose depending arm 85 is connected to a plunger valve 86, the three armed member being pivotally mounted at 87 on the front of the machine. This action results in drawing the plunger valve 86 to the left, Fig. 1. The plunger valve 86 is shown in Fig. 2 in section, although its position in this figure is not the same as it actually is on the machine; movement to the left of said valve member in its casing 88 is represented by upward movement of it in Fig. 2. At all events such movement brings a reduced portion 89 of the valve member 86 to such a position that it connects ports 90 and 91, the former being connected to a pressure supply pipe 92 that is shunted into the main supply pipe 8, and the latter being connected by way of piping 93 to a cylinder 94 in which is located a piston 95. It will thus be apparent that the pressure fluid is admitted into the cylinder 94 and thus causes movement of the piston 95, and this movement of the piston 95 procures downward movement of the diamond 79. The precise manner of mounting the diamond and producing oscillation thereof from rectilinear motion of a movable element will be found fully described in a patent to myself and Grimshaw No. 1,655,903 granted January 10, 1928, and neither this nor the precise connection between the piston 95 and the oscillatory member 80 of the diamond is any part of the present invention. At all events, the diamond 79 is lowered into the path of the grinding wheel 5 and dresses and trues the same.

The right hand motion of the table or carriage 1 thus described procures, by the means now to be described, the ultimate reversal of said carriage to bring it back again into engagement with the bell crank lever 26 for further reciprocatory motion and further grinding of the workpiece by the grinding wheel 5. At the same time the motion of the carriage likewise causes the diamond 79 to be returned to its position as shown in Fig. 1.

As shown in Fig. 3, the third arm 96 of the three armed member provides a contact button 97 which, when raised, is in the path of a contact plate 98 that is attached to an adjustable carrying block 99 mounted on the

front of the machine. The carrying block 99 may be adjusted along the front of the carriage 1 by means of a hand screw nut 100 which engages a screw rack 101 provided by the table. Since the contact block 98 is uninsulated from the machine and therefore is grounded as indicated at 102, contact of the button 97 with said plate grounds a conductor 103 which is connected to said button 97. The conductor 103 leads to one terminal of the magnet 63, while the other terminal of said magnet is connected by means of a conductor 104 with the conductor 66 connected to the generator 64. Thus, at this time, and just after the grinding wheel 5 has passed once by the dressing device 79, the electromagnet 63 is energized. This causes attraction of the armature portion 61 of the valve 13, since the electromagnet 62 has previously been deenergized in the following manner:—

The carrying block 99 on the front of the machine carries a pair of depending arms 105 and 106 which are pivotally mounted at 107 and normally hang in the position shown in Fig. 1, but are capable of being raised therefrom. The arms 105 and 106 do not lie in the same plane; in the path of the former is an upstanding arm 108 while in the path of the latter is a similar arm 109, both provided by the oscillatory member 73 of the switch 71. When the carriage 1 is in its inoperative position as shown in Fig. 1, the switch 71 is in the position shown in Fig. 1; movement of the carriage to the left to carry the grinding wheel 5 into the workpiece causes engagement of the depending arm 106 with the arm 109, and shifts the switch to the position shown in Fig. 3, this figure illustrating the parts in the position which they occupy when the carriage is advancing to carry the grinding wheel into the work for the first time. The arm 105 readily rides over the arm 108 as shown in this figure. With the oscillatory member 73 of the switch in the position shown in Fig. 3, the electric circuit through the magnets 62 and 82 can be readily completed, as already set forth; when, however, owing to the completion of the circuit through the magnet 62 the carriage starts outward, the depending arm 105 strikes the arm 108, and this causes the oscillatory member 73 to move in a clockwise direction, removing the bridge 72 from contact with the bars 70 and 74, and discontinuing the supply of current to the magnets 62 and 82.

As the movement of the oscillatory member 73 of the switch 71 occurs just prior to the making of the contact between the contact button 97 and the contact plate 98, the energization of the magnet 63 takes place after the magnet 62 has been deenergized, and consequently the valve member 13 is moved to the right. In order to eliminate the effects of residual magnetism brass caps

may be placed on the poles of both electromagnets. The shifting of the valve member 13 to the right, connects the passage 18 with the supply passage 11, and connects the passage 19 with the exhaust passage 77, and consequently causes the pressure fluid to be made active on the right hand side of the piston 23, which energizes the carriage 1 to the left again. The carriage moves to the left until it engages the vibratory bell crank lever 26 and in this position it reciprocates until the grinding operation is completed.

Return motion of the carriage 1 causes a resetting of the valve member 86 so as to relieve the pressure against the piston 95 that had moved the diamond 79 into the path of the wheel. As shown in Figs. 1 and 3, a bar 110 is pivotally mounted at 111 on the block 99 and is prevented from moving in one direction by means of a ledge 112. The end of the bar 110 readily passes over the upper end of the arm 96 on movement of the carriage to the right, but upon movement of the carriage to the left, the bar 110 engages an inclined surface of the arm 96 and forces it back to its original position. This returns the valve member 86 to the full line position shown in Fig. 2, and connects the port 91 to an exhaust port 113, and thus the fluid is allowed to exhaust from the cylinder 94. The diamond 79 is actually returned to the position shown in Fig. 1 by mechanical means which forms no part of the present invention.

The carriage 1 continues to reciprocate with the grinding wheel 5 taking the final and finishing cuts on the workpiece, until such time as the cam member 51 attached to the hand wheel 48 or some member associated therewith has moved far enough to engage the adjustable screw 53 and cause engagement of the contacts 57 and 59. When this happens, the magnet 62 is again energized in the following manner. A branch lead 114, shunted into the conductor 69, connects one terminal of the electromagnet 62 with the contact 59; since the other terminal of the magnet 62 is always connected to the generator 64 as already described, and since the contact 57 as well as said generator is grounded, the circuit through electromagnet 62 is completed as soon as the contacts 57 and 59 are brought together irrespective of the position of the switch 71. As the circuit through the magnet 63 was broken by the resetting of the three armed member 84, 85, 96 and the movement of the contact plate 98 away from the contact button 97, the magnet 63 is therefore no longer energized, and the valve 13 is again drawn to the left, causing the carriage to move to the right, where it is ultimately stopped by any suitable means. As illustrative of one means of stopping the carriage in its idle position, I have herein disclosed a valve 115, which is located in a chamber 116 between the passage 19 and the pip-

ing 22. The valve 115 is a poppet valve located on the end of a valve stem 117, and is normally kept open by the engagement of a cam bar 118 carried by the table 1 with said stem 117. When the carriage 1 has moved beyond the range of its normal reciprocation and beyond the range of the dressing stroke, the cam 118 ultimately moves off the stem 117, and thereupon a spring 119 moves the valve 115 upwardly and prevents any more fluid from entering the pipe 22 and thus stops the carriage. It will be noted that the pressure of the fluid assists in maintaining the valve 115 closed.

Briefly reviewing the operations of the machine, the operator, finding the carriage in the position shown in Fig. 1, will revolve the hand wheel 48 counterclockwise to reposition the grinding wheel 5 so that it can grind a new workpiece. After placing a new workpiece in the chuck 6, the operator presses a button 120 on the front of the machine which causes engagement of contacts 121 and 122, the former being grounded at 123. This energizes the electromagnet 63 because the left hand terminal of said magnet is connected by the lead 103 and a lead 124 to the terminal 122. The slide valve 13 is thereupon drawn to the right, and this causes the carriage to run to the left notwithstanding the fact that the valve 115 is closed, because fluid can always move outwardly from the left hand side of the cylinder 20 past said valve as will be readily seen from an inspection of Fig. 2, the spring 119 being merely strong enough to cause the valve to seat gently.

This movement of the table or carriage 1 to the left carries the grinding wheel 5 into the bore of the workpiece, where it reciprocates under the influence of the oscillatory member 26, as above described until, at the completion of the rough grinding, the carriage is given an amplified stroke in order to submit the wheel to a dressing operation. During such rough grinding, the carriage is held by the fluid under pressure against said oscillatory member 26, the latter controlling the length of the working reciprocation by limiting the left hand movement of the carriage, and by moving the carriage to the right against the pressure of the fluid,—the latter, at each right hand movement, backing up through the passage 18, pipe 21 and supply pipe 8, and relieving itself through the valve 41. The working reciprocation of the carriage thus takes place through the mechanical vibration of an end stop, combined with resilient fluid pressure means to cause the carriage to maintain itself in engagement with the stop. During such working reciprocation, the valve 115 is maintained wide open by engagement of the cam bar 118 with the stem 117 of the valve.

When the preliminary or rough grinding

operation is completed, the valve 13 is shifted to the left by energization of the electromagnet 62, through coming together of the contacts 56 and 58. This causes the carriage to move outwardly, whereupon the outward movement of said carriage actuates the switch 71 and deenergizes the electromagnet 62. Outward movement of the carriage also causes the completion of an electric circuit through the magnet 63, and thus shifts the valve 13 again, thus causing return of the carriage. During this amplified reciprocation of the carriage, the dressing device 79 is first lowered and then returned to its original position by energization of the magnet 82, and subsequent deenergization thereof, with electromagnetic movement of the valve 86 and mechanical return of said valve, and with fluid pressure actuation of the diamond 79 and subsequent return of said diamond by mechanical means.

The outward movement of the carriage 1 to the dressing position is just sufficient to cause the bar 105 to engage the arm 108 of the oscillatory member 73 to shift said oscillatory member to the clockwise position, but not sufficient to cause the bar 106 to pass over the arm 109, and consequently the switch 71 is not returned to the position in which the bridge 72 connects the bars 70 and 74. Consequently a repetition of the dressing stroke is prevented, and the magnet 61 can not be again energized until such time as the contacts 57 and 59 come together. When this event happens, the valve 13 is again shifted, and the carriage runs out to its position of rest, where it is stopped as already fully described by the freeing of the valve 115 allowing it to seat under the influence of the fluid pressure and the spring 119.

It will thus be seen that by providing fluid pressure means acting against a mechanically reciprocated element, I am enabled to give the carriage 1 a great variety of motions, and these motions may be controlled in speed by suitable valves, thus giving the machine all the advantages of a hydraulically actuated machine. At the same time, the grinding stroke, being controlled by mechanical devices, can be determined within exact limits, and therefore the machine has all the advantages of positive limited mechanical reciprocation.

I claim,

1. In a grinding machine, the combination with a grinding wheel, a workhead, and a reciprocatory table or carriage carrying one of said parts, of mechanical devices associated with said carriage to control its reciprocations in the grinding or working range of said wheel, and fluid pressure means to move said carriage to and from said range.

2. In a grinding machine, a grinding wheel, workholding means, a table or carriage carrying one of said parts, fluid pressure

means to move said carriage from a remote position to a grinding position, and a vibratory end stop, cooperating with said fluid pressure means to procure the reciprocation of said carriage in the grinding position.

3. In a grinding machine, mechanical devices to control the reciprocation of a grinding wheel in operative relation to a workpiece, a wheel dressing device, and fluid pressure means to withdraw said grinding wheel from the workpiece, and to move it relatively to said dressing device to procure a dressing operation on said wheel.

4. In a grinding machine, a grinding wheel, mechanical devices for controlling the reciprocation of said wheel in operative relation to the work, and fluid pressure means to withdraw said grinding wheel to a remote position in relation to the work.

5. In a grinding machine, a carriage, resilient means to urge said carriage in either of two directions, a mechanically reciprocated element with which said carriage contacts, when urged by said resilient means in one direction, thereby to procure reciprocation of said carriage, and control means operating on said resilient means for alternately urging said carriage against said reciprocating element and away therefrom.

6. In a grinding machine, a carriage, fluid pressure means to actuate said carriage, an end stop for said carriage, means to reciprocate said end stop, a valve to control the direction of carriage movement by said fluid pressure means, and electromagnetic means operative on said valve to procure movement of said carriage either into engagement with the said end stop or away therefrom.

7. In a grinding machine, a grinding wheel, workholding means, and means for procuring a grinding reciprocation of one of said parts in relation to the other comprising a mechanically reciprocated element, and fluid pressure means urging said part against said element.

8. In a grinding machine, a grinding wheel, workholding means, and means for procuring a grinding reciprocation of one of said parts in relation to the other comprising a mechanically reciprocated element, fluid pressure means for urging said part against said element, and valve means to relieve the pressure of the fluid when the action of the reciprocating element urges the reciprocated part against the force of the fluid.

9. In a grinding machine, a grinding wheel, workholding means, a table or carriage carrying one of said parts, fluid pressure means to move said carriage, a valve to control the direction of movement of said carriage, electromagnetic means to move said valve, and mechanical means to reverse said carriage when it is moved in one direction into engagement with said mechanical

means by energization of one of said electromagnetic means.

10. In a grinding machine, a grinding wheel, workholding means, a table or carriage carrying one of said parts, fluid pressure means to move said carriage, a valve to control the direction of movement of said carriage, a pair of electromagnetic means to move said valve, mechanical means to reverse said carriage when it is moved in one direction into engagement with said mechanical means by energization of one of said electromagnetic means, and means governed by the progress of the grinding operation to energize the other electromagnetic means to cause said carriage to withdraw from said mechanical means.

11. In a grinding machine, a table or carriage, and reciprocating means therefor comprising a cam, a pair of levers each having an arm substantially parallel to each other, one end of one arm being in engagement with said cam and the other end of the other arm being adapted to engage said carriage, and a link adjustable along the parallel arms to vary the amplitude of reciprocation.

12. In a grinding machine, a grinding wheel having a working position and an idle position with respect to the workpiece, fluid pressure means for procuring the movements of said wheel between said positions, and a mechanically-operated device, cooperating with said fluid pressure means to produce relative reciprocation between workpiece and wheel when the latter is in working position.

13. In a grinding machine, a grinding wheel, a dressing device beyond the working position of said wheel, fluid pressure means operative in the grinding of each workpiece for procuring a dressing operation on said wheel by said dressing device, and a mechanically-operated member, cooperating with said fluid pressure means to produce relative reciprocation between workpiece and wheel in the latter's working position.

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