June 22, 1948. C. G. FLYGARE 2,443,789

GRINDING WHEEL TRUING APPARATUS

Filed March 29, 1947 3 Sheets-Sheet 1

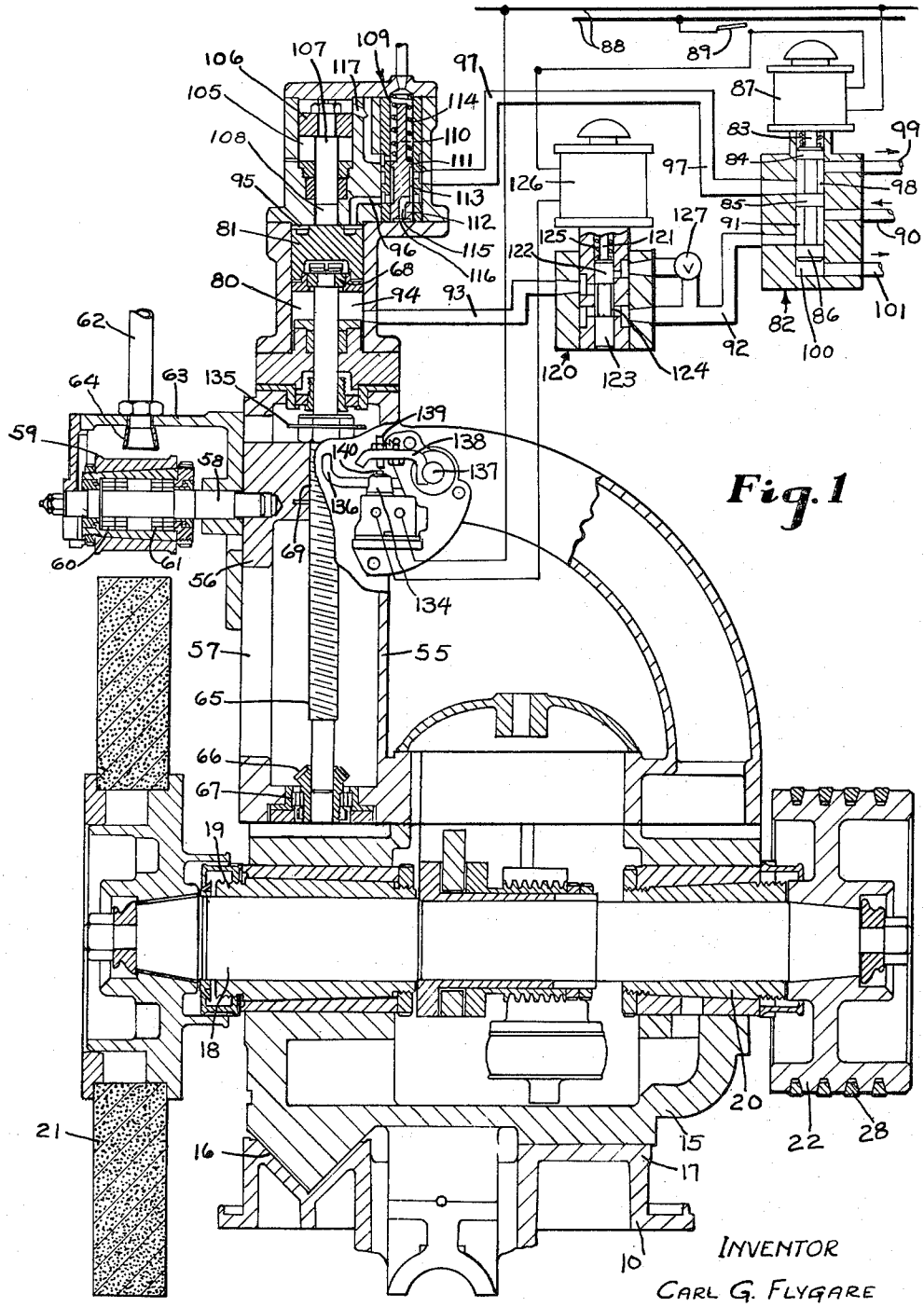


Fig. 1

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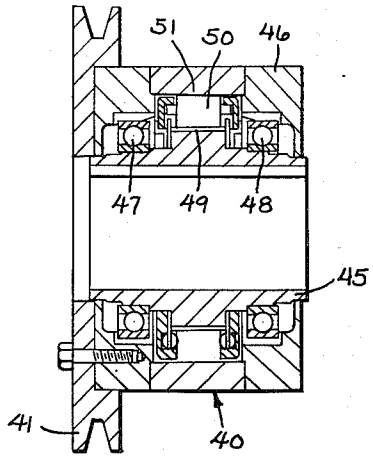


Fig. 4

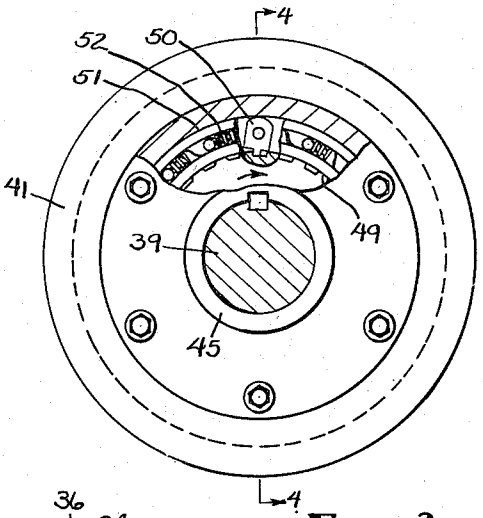


Fig. 3

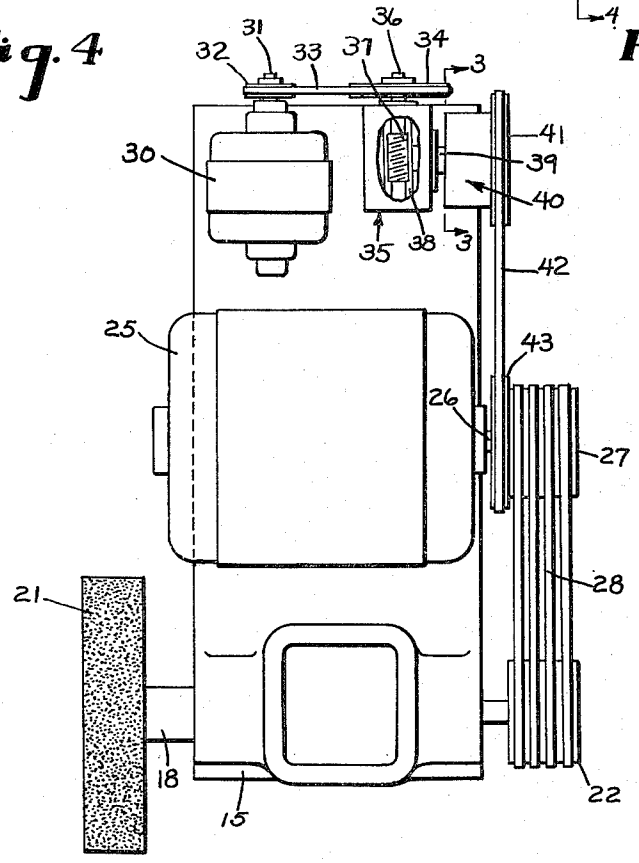


Fig. 2

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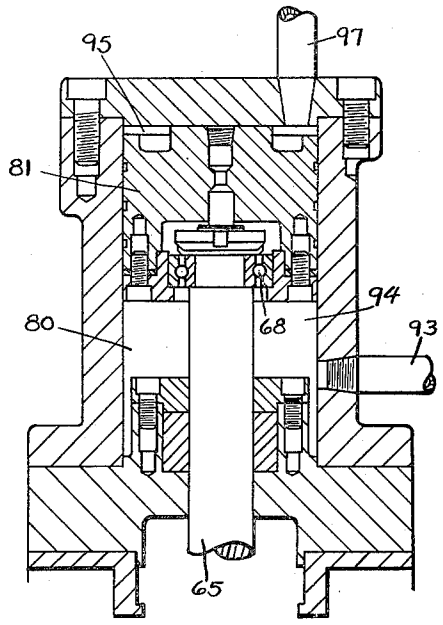


Fig. 6

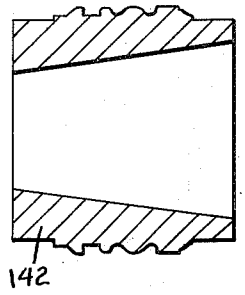


Fig. 7

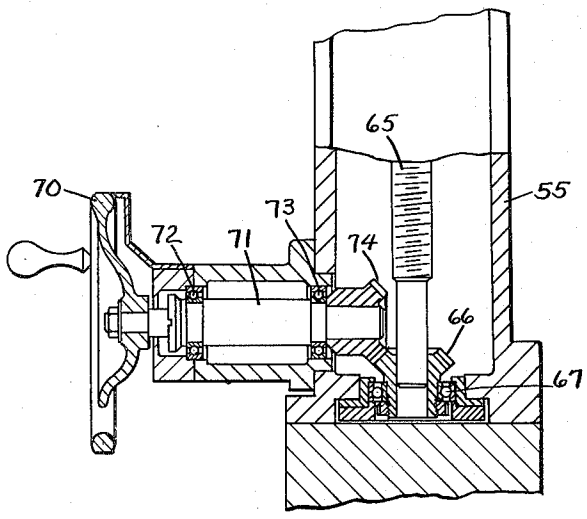


Fig. 5

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Patented June 22, 1948 2,443,789

UNITED STATES PATENT OFFICE

2,443,789

GRINDING WHEEL TRUING APPARATUS

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Application March 29, 1947, Serial No. 738,093

6 Claims. (Cl. 125—2)

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The invention relates to grinding machines and more particularly to a crush truing apparatus for truing a predetermined form on the peripheral or operative face of a grinding wheel.

One object of this invention is to provide a simple and thoroughly practical crush truing apparatus for truing a predetermined form on the operative face of a grinding wheel. Another object of the invention is to provide a crush truing apparatus in which the form crusher roll is moved hydraulically toward and away from the face of the wheel to be dressed. Another object of the invention is to provide a hydraulic control mechanism for a crush truing roll which is arranged to cause a rapid approaching movement of the crushing roll and automatically reducing the rapid approaching to a slow controlled feed as the crushing roll moves into operative engagement with the grinding wheel.

Another object of the invention is to provide a hydraulic mechanism for moving a crushing roll to and from an operative position in which a solenoid valve controls the direction of movement of the crusher roll and a second solenoid valve actuated automatically in timed relation with the movement of the crusher roll to reduce the rapid approaching to a controlled feeding movement. Another object of the invention is to provide a hydraulic piston and cylinder mechanism to control the movement of a crusher roll toward and from the operative face of a grinding wheel and to provide a booster piston and cylinder to increase the pressure of the crusher roll on the wheel during the crushing operation.

Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 1 is a vertical sectional view through a wheel slide and the crush truing apparatus supported thereby, together with a hydraulic piping and electric wiring diagram;

Fig. 2 is a fragmentary plan view of the wheel slide, showing the grinding wheel driving mechanism;

Fig. 3 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 3—3 of Fig. 2, having parts broken away and

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shown in section to illustrate the free-wheeling driving clutch;

Fig. 4 is a cross sectional view taken approximately on the line 4—4 of Fig. 3, through the free-wheeling clutch;

Fig. 5 is a fragmentary vertical sectional view through the manually operable feed mechanism for the crusher roll slide;

Fig. 6 is a modified form of the hydraulic actuating mechanism for the crusher roll and its supporting slide; and

Fig. 7 is a cross sectional view through a crusher roll.

A grinding machine has been illustrated in the drawings comprising a base 10 which supports a transversely movable wheel slide 15 on a transversely extending V-way 16 and a flat way 17. The wheel slide 15 supports a rotatable wheel spindle 18 in a pair of spaced bearings 19 and 20. A grinding wheel 21 is mounted on the left hand end of the wheel spindle and a multi V-groove pulley 22 mounted on the right hand end thereof.

A suitable driving mechanism is provided for rotating the wheel spindle 18 and grinding wheel 21 at either a relatively fast speed for a grinding operation or at a relatively low speed for a crush truing operation. An electric motor 25 is mounted on the wheel slide 15. The motor 25 is provided with a motor shaft 26 which supports a multi V-groove pulley 27 which is connected by multiple V-belts 28 with the pulley 22 on the wheel spindle 18. The motor 25 and the belt drive above described serve to rotate the grinding wheel 21 at a normal grinding speed such as for example 5,000 surface feet per minute or more depending upon the nature of the work being ground and the type of grinding wheel being used.

A slow speed driving mechanism is provided to supplement the driving mechanism above described for rotating the grinding wheel at a suitable speed for crush truing. This mechanism may comprise a relatively small electric motor 30 which is mounted adjacent to the rear portion of the wheel slide 15. The motor 30 is provided with a motor shaft 31 which supports a V-pulley 32. A V-belt 33 connects the pulley 32 with a V-pulley 34 on a speed reduction unit 35. The speed reduction unit 35 may be any of the standard well known speed reducing units which are available on the open market. This speed reduction unit may comprise a rotatable shaft 36 which supports the pulley 34. A worm 37 is either formed integral with or is fixedly mounted on the shaft 36. The worm 37 meshes with a worm gear

38 which is drivingly connected to rotate a shaft 39. A free-wheeling clutch 40 is keyed to the shaft 39 and is provided with a V-groove pulley 41 which is connected by means of a single V-belt 42 with a pulley 43. The pulley 43 is mounted on the motor shaft 26.

The free-wheeling clutch 40 (Figs. 3 and 4) comprises a sleeve 45 which is keyed to the shaft 39. The sleeve 45 supports a casing 46 on a pair of spaced ball bearings 47 and 48 (Fig. 4). Gear teeth 49 are formed on a flanged portion of the sleeve 45. A plurality of rocker cams 50, only one of which is shown in Fig. 3, are provided with gear teeth which mesh with the gear teeth 49 on the sleeve 45. When the motor 30 is set in motion, the sleeve 45 will be rotated in a clockwise direction as shown by the arrow in Fig. 3. This motion serves to rock the rocker cams 50 in a counter-clockwise direction so that the cam surface drivingly engages an internal cylindrical surface 51 formed within the casing 46 so that the driving motion of the shaft 39 will be transmitted through the gear teeth 49, through the rocker cams 50 to frictionally engage the internal cylindrical surface 51 and thereby to rotate the casing 46 and the pulley 41 to transmit a rotary motion through the pulley 27, the belt 28, the pulley 22 to rotate the wheel spindle 18 and the grinding wheel 21 at a relatively slow speed for a crush truing operation. This speed may be for example a peripheral speed of 150 to 300 surface feet per minute to produce the desired and predetermined truing operation. A plurality of springs 52 (Fig. 3) are provided normally to urge the rocker cams 50 in a clockwise direction so that when the motor 30 is idle and the motor 25 is in operation, the pulley 41 and the casing 46 is free to rotate during the normal grinding operation.

A vertically arranged truing apparatus frame is mounted on the upper portion of the wheel slide 15. The frame 55 serves as a support for a vertically movable slide 56 which is arranged to slide in slideways 57. The slide 56 serves as a support for a shaft 58. The shaft 58 supports a crusher type truing roll 59 on a pair of spaced anti-friction bearings 60 and 61.

A coolant supply system is provided comprising a pipe 62 which is connected to a suitable source of supply of coolant fluid. The pipe 62 is connected to a housing 63 formed integral with or fixedly mounted on the slide 56. The housing 63 surrounds a portion of the crusher roll 59. A coolant nozzle 64 is mounted within the casing 63 to convey coolant fluid from the pipe 62 to the crusher roll 59 and the grinding wheel 21.

A suitable feeding mechanism is provided for moving the crusher roll slide 56 either toward or from the grinding wheel 21. This mechanism may comprise a vertically arranged feed screw 65 which is supported in a pair of spaced bearings 67 and 68. The bearings 67 and 68 are fixedly mounted relative to the truing apparatus frame 55. The slide 56 is provided with a threaded aperture or nut 69 which engages or meshes with the feed screw 65.

The feed screw 65 may be rotated manually to cause a relative approaching or receding movement of the slide 56 and the crusher roll 59 relative to the grinding wheel 21. This mechanism may comprise a manually operable hand wheel 70 (Fig. 5). The hand wheel 70 is mounted on one end of a rotatable shaft 71. The shaft 71 is supported in anti-friction bearings 72 and 73 which are fixedly mounted relative to the frame 55. The shaft 71 supports a bevel gear 74 on its inner end which meshes with a bevel gear 66 slidably keyed to the lower end of the feed screw shaft 65. It will be readily apparent from the foregoing disclosure that a rotary motion of the hand wheel 70 will be transmitted through the mechanism above described to cause a vertical movement of the slide 56 and the crusher roll 59.

It is desirable to provide a suitable power operated mechanism for rapidly moving the crusher roll to and from an operative position with the crusher roll 59 in truing engagement with the periphery of the grinding wheel 21 and to maintain the crusher roll in engagement therewith at a predetermined relatively high pressure to produce the desired crushing action upon the periphery of the grinding wheel 21. This mechanism is preferably a hydraulically operated mechanism comprising a cylinder 80 which contains a slidably mounted piston 81. The piston 81 is operatively connected to the upper end of the feed shaft 65. A solenoid control valve is provided for controlling the admission to and exhaust of fluid from the cylinder 80. This valve is preferably a piston type valve comprising a valve stem 83 having a plurality of valve pistons 84, 85 and 86 formed integral therewith. An electric solenoid 87 is provided which when energized serves to move the valve stem 83 upwardly so as to reverse the flow of fluid to the cylinder 80.

Electric power is supplied as represented by the power lines 88. These power lines 88 are connected so that when a switch 89 is closed, the solenoid 87 will be energized.

Fluid under pressure from any suitable source is supplied through a pipe 90 to a valve chamber 91 which is located between the valve pistons 85 and 86. In the position of the valve 82 as shown in Fig. 1, fluid under pressure entering the valve chamber 91 passes out through a pipe 92 and through a pipe 93 into a cylinder chamber 94 formed at the lower end of the cylinder 80. The admission of fluid under pressure to the cylinder chamber 80 causes the piston 81 to move upwardly into the position illustrated in Fig. 1. During the upward movement of the piston 81, fluid within a cylinder chamber 95 exhausts through a passage 96, through a pipe 97 into a valve chamber 98 located between the valve pistons 84 and 85 and passes out through an exhaust pipe 99.

When the solenoid 87 is energized, fluid entering the valve chamber 91 from the pipe 90 passes through the pipe 97, through the passage 96 into the cylinder chamber 95 to cause a downward movement of the piston 81. During the downward movement of the piston 81, fluid within the cylinder chamber 94 is exhausted through the pipe 93, the pipe 92, into a valve chamber 100 and out through an exhaust pipe 101.

In the preferred form of this invention, it is desirable to use a comparatively low pressure for example 100 pounds per square inch in the fluid pressure system so that during the approaching movement of the crushing roll relative to the wheel, a manual adjustment of the feed screw may be obtained without difficulty. In order to obtain sufficient pressure for the crushing operation, it is therefore desirable to provide a booster cylinder 105 which is mounted on top of the cylinder 80. The booster cylinder 105 contains a slidably mounted piston 106 which is connected to the upper end of a piston rod 107. The piston rod 107 is slidably mounted in a cylindrical aperture formed in the lower portion of the cylinder

105 and forms a booster cylinder chamber 108 below the end of the piston rod 107. Due to the relatively large diameter of the piston 106 as compared to the diameter of the piston rod 107, if 100 pounds per square inch pressure is applied above the piston 106, this pressure will be increased due to the difference in area of the piston 106 and the effective area of the piston rod 107. By this arrangement it is possible to maintain a relatively low line pressure and at the same time to boost this pressure from, for example 100 pounds pressure per square inch in the supply line 90 so that an increase to 200 pounds per square inch or more is obtained within the booster cylinder 80.

A suitable control valve 109 is provided for controlling the admission of fluid to the booster cylinder 105. This control valve 109 is a piston type valve comprising a valve stem 110 having valve pistons 111 and 112 formed integrally therewith. In the position of the valve 109 (Fig. 1) fluid under pressure from the pipe 97 enters a valve chamber 113 formed between the valve pistons 111 and 112 and passes out through the passage 96 into the cylinder chamber 95 to cause a downward movement of the piston 81. A compression spring 114 surrounding the valve stem 110 serves normally to maintain the valve 109 in the position illustrated in Fig. 1.

It is desirable to provide a suitable control mechanism so that the crusher roll 59 may be moved rapidly until it is about to engage the peripheral surface of the wheel 21 to be trued and then moved at a slower controlled rate during the crush truing of the grinding wheel 21. This is preferably accomplished by means of a solenoid valve 120. The solenoid valve 120 is a piston type valve comprising a valve stem 121 having formed integral therewith valve pistons 122 and 123. The valve 120 is interposed between the pipe lines 92 and 93. In the position of the valve as shown in Fig. 1, fluid under pressure passing through the pipe 92 enters a valve chamber 124 located between the valve pistons 122 and 123 and passes outwardly through the pipe 93 into the cylinder chamber 94 to cause an upward movement of the piston 81, the slide 56 and the crusher roll 59.

When the solenoid 87 is energized to shift valve 82 upwardly to allow fluid to pass through the pipe 97 so as to cause a downward movement of the piston 81, fluid within the cylinder chamber 94 exhausts through the pipe 93, the valve chamber 124, the pipe 92, the valve chamber 100 and out through the pipe 101. This arrangement allows a substantial unrestricted exhaust of fluid from the cylinder chamber 94 so that the crusher roll moves at a comparatively rapid rate.

A compression spring 125 is provided normally to hold the valve stem 121 in a downward position as shown in Fig. 1. A solenoid 126 is provided which when energized serves to shift the valve stem 121 upwardly so that the valve piston 123 cuts off exhaust of fluid to the pipe 92. As the valve stem 121 moves upwardly, fluid exhausting through the pipe 93 into the valve chamber 124 may pass outwardly through a pipe and a throttle valve 127 into the pipe 92. By regulating the throttle valve 127, the rate of exhaust of fluid from the cylinder chamber 94 may be readily controlled so as to obtain the desired feeding movement of the crusher roll 59 into the surface of the wheel being dressed.

It is desirable to provide a suitable automatic electrical control so that the solenoid 126 may be energized in timed relation with the downward movement of the crusher roll 59 so as to change

from a rapid approaching movement to a slow controlled feed when the crusher roll 59 reaches a predetermined position. This is preferably accomplished by means of a normally open limit switch 134 which is mounted on the truing apparatus frame 55. A collar 135 is arranged in the path of an arm 136 which is supported by a rock shaft 137. The rock shaft 137 is supported in a suitable bearing formed in the frame 55. The rock shaft 137 also supports an arm 138 which carries an adjustably mounted screw 139. The screw 139 is arranged to move in the path of an actuating plunger 140 of the limit switch 134. It will be readily apparent from the foregoing disclosure that when the slide 56 moves downwardly, the collar 135 will engage the arm 136 and rock the shaft 137, the arm 138 and the adjustably mounted screw 139 in a counter clockwise direction to close the limit switch 134. When the limit switch 134 is closed, a circuit is closed thereby to energize the solenoid 126 so as to shift the valve stem 121 upwardly and thereby reduce the rapid approaching movement of the crusher roll 59 to a relatively slow controlled feeding movement. It will be readily apparent that by adjustment of the screw 139, the actuation of the plunger 140 and the closing of the limit switch 134 may be adjusted so that the rate of approaching movement of the crusher roll 59 relative to the periphery of the grinding wheel 21 may be reduced at the desired and predetermined interval.

A modified form of the hydraulic actuating mechanism for the crusher roll is shown in Fig. 6 in which the booster cylinder 105 and its controlling valve 109 is eliminated. With this arrangement a relatively high line pressure must be obtained in the hydraulic control system, for example 200 pounds per square inch or more in order to obtain the desired pressure of the crusher roll 59 against the periphery of the grinding wheel 21 during the crushing operation. In case this modified construction is utilized, the pipe 97 is connected to pass fluid directly into the cylinder chamber 95 to cause a downward movement thereof and the pipe 93 is connected directly with the lower cylinder chamber 94. With this modified arrangement, the control valves 82 and 120 are connected in the same manner as shown in Fig. 1.

After a truing operation has been completed, it is desirable to move the crusher roll rapidly in an upward direction to an inoperative position. In order to obtain this result, it is desirable that both the solenoid 87 and the solenoid 126 be deenergized at the same time. The electrical connections as illustrated in Fig. 1 are such that when the crushing operation has been completed, the switch 89 is opened thereby deenergizing both the solenoid 87 and the solenoid 126 so that fluid under pressure from the pipe 90 passing into the valve chamber 91 passes through the pipe 92, through the cylinder chamber 124 and the pipe 93 into the cylinder chamber 94 to cause a rapid upward movement of the piston 81 so as to impart a corresponding movement to the slide 56 and the crusher roll 59.

The crusher roll 59 as shown in Fig. 1 comprises a cylindrical surface having two fillets arranged at opposite ends thereof for truing a cylindrical face on the grinding wheel 21 having the corners thereof rounded to a predetermined radius. As shown in Fig. 7 a modified form of crusher roll 142 is illustrated whereby an irregular formed face may be produced on the periphery

of the grinding wheel being dressed. The shape of the crusher roll may be varied to produce practically any desirable shape or form on the periphery of the grinding wheel. It will be readily apparent from the disclosure contained herein that forms may be crush trued into the operative face of a grinding wheel by the crushing method which would be difficult or impractical to form by use of a conventional type truing apparatus.

The operation of this improved crush truing apparatus will be readily apparent from the foregoing disclosure. A crusher roll 59 is mounted in position on the spindle 58. The crusher roll 59 having a peripheral surface formed or shaped to produce the desired form or shape on the periphery of the grinding wheel 21. When it is desired to true the grinding wheel 21, the switch 89 is closed to allow fluid under pressure from the pipe 90 to pass through the system above described to cause a downward movement of the piston 81, the slide 56, and the crusher roll 59 at a rapid approaching rate. Assuming the booster cylinder arrangement of Fig. 1 is utilized and a relatively low pressure supplied in the pipe line 90, fluid under pressure passing through the pipe 97 enters the valve chamber 113, passes through the passage 96 into the cylinder chamber 95 to cause a downward movement of the piston 81. This movement continues at a rapid rate until the solenoid 126 is energized, thus throttling the exhaust of fluid through the pipe 93. As soon as the solenoid 126 shifts the valve stem 121, pressure within the cylinder chamber 95 builds up so that there is sufficient pressure in the valve chamber 113 passing through a passage 115 into a valve chamber 116 at the lower end of the control valve 107 to raise the valve stem 110 against the compression of the spring 114 so that fluid under pressure within the valve chamber 113 may pass through a passage 117 in the booster cylinder 105 thereby causing a downward movement of the booster piston 106 so that the piston rod 107 as above described will increase or boost the pressure within the chamber 108 and the cylinder chamber 95 during the crushing operation. The rapid approach of the crusher roll 59 continues until the collar 135 engages the arm 136 so as to rock the screw 139 to close the limit switch 134 thereby energizing the solenoid 126 to shift valve stem 121 and thereby throttle the exhaust of fluid from the pipe 93 to a predetermined crushing rate as the crushing roll 59 moves into operative engagement with the peripheral surface of the grinding wheel 21. The crushing operation continues until the surface of the wheel has been dressed to the desired extent after which the switch 89 is opened to simultaneously deenergize both the solenoid 87 and the solenoid 126 thus allowing an unrestricted flow of fluid to the cylinder chamber 94 to cause a rapid upward movement of the piston 81, the slide 56 and the crusher roll 59 to an inoperative position.

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

I claim:

1. In a grinding machine having a rotatable grinding wheel, independent electric motors to rotate said grinding wheel either at a relatively fast speed for a grinding operation or at a relatively slow speed for a truing operation, and a truing apparatus including a rotatably mounted crusher roller, a movable slide to support said roller, a hydraulic piston and cylinder rapidly to move said slide and crusher roller toward and from the face of the grinding wheel to be trued, a control valve to control the admission to and exhaust of fluid from said cylinder, a second normally open control valve connected between the lower end of said cylinder and the first valve, a throttle valve to control the exhaust of fluid from the lower end of said cylinder after the second valve is closed, and means including a limit switch actuated by and in timed relation with the approaching movement of the piston to actuate the second valve so as to change the rapid approaching movement of the crusher roller to a relatively slow controlled feeding movement when the crusher roller moves into operative engagement with the grinding wheel.

2. In a grinding machine having a rotatable grinding wheel, independent electric motors to rotate said grinding wheel either at a relatively fast speed for a grinding operation or at a relatively slow speed for a truing operation, and a truing apparatus including a rotatably mounted formed crusher roller, a vertically movable slide to support said roller, a hydraulic piston and cylinder axially aligned with said screw rapidly to move said screw-slide and crusher roller toward and from the face of the grinding wheel to be trued, a solenoid valve to control the admission to and exhaust of fluid from said cylinder, a second normally open solenoid valve connected between the lower end of said cylinder and the first valve normally to facilitate a rapid approaching movement of the crusher roller, a throttle valve to control the exhaust of fluid from the lower end of said cylinder after the second valve is closed, and a limit switch actuated by and in timed relation with the downward movement of the piston to energize said second solenoid valve to change the rapid approaching movement of the crusher roller to a relatively slow controlled feeding movement when the crusher roller moves into operative engagement with the grinding wheel.

3. In a grinding machine having a rotatable grinding wheel, independent electric motors to rotate said grinding wheel either at a relatively fast speed for a grinding operation or at a relatively slow speed for a truing operation, and a truing apparatus including a rotatably mounted formed crusher roller, a vertically movable slide to support said roller, a manually operable nut and screw to facilitate adjustment of said slide, a hydraulic piston and cylinder axially aligned with said screw rapidly to move said screw-slide and crusher roller toward and from the face of the grinding wheel to be trued, a solenoid valve to control the admission to and exhaust of fluid from said cylinder, a second normally open solenoid valve connected between the lower end of said cylinder and the first valve normally to facilitate a rapid approaching movement of the crusher roller, a throttle valve to control the exhaust of fluid from the lower end of said cylinder after the second valve is closed, and a limit switch actuated by and in timed relation with the downward movement of the piston to energize said second solenoid valve to change the rapid approaching movement of the crusher roller to a relatively slow controlled feeding movement when the crusher

roller moves into operative engagement with the grinding wheel.

4. In a grinding machine having a rotatable grinding wheel, driving means to rotate said grinding wheel either at a relatively fast speed for a grinding operation or at a relatively slow speed for a truing operation, and a truing apparatus including a rotatably mounted formed crusher roller, a movable slide to support said roller, a hydraulic piston and cylinder rapidly to move said slide and roller toward and from the periphery of the grinding wheel, a second piston and cylinder to increase the pressure on the first piston and slide, a normally open solenoid valve in the exhaust side of the first cylinder, a limit switch actuated by and in timed relation with the approaching movement of the slide and crusher roller to shift said solenoid valve so as to cut-off unrestricted exhaust of fluid from said cylinder, and a throttle valve to regulate the exhaust of fluid from the first cylinder after the solenoid valve is shifted to control the rate of movement of the crusher roller during a crushing operation.

5. In a grinding machine having a rotatable grinding wheel, driving means to rotate said grinding wheel either at a relatively fast speed for a grinding operation or at relatively slow speed for a truing operation, and a truing apparatus including a rotatably mounted formed crusher roller, a vertically movable slide to support said roller, a manually operable nut and screw to facilitate adjustment of said slide, a hydraulic piston and cylinder axially aligned with said screw rapidly to move said screw-slide and roller toward and from the periphery of said grinding wheel, a second piston and cylinder to increase the downward pressure on the first piston and screw, a normally open solenoid valve in the exhaust side of the first cylinder, a limit switch actuated by and in timed relation with the downward movement of said screw automatically to shift said solenoid valve to cut-off unrestricted exhaust of fluid from said cylinder, a

throttle valve to regulate the exhaust of fluid from the cylinder after the solenoid valve is shifted to control the rate of movement of the crusher roller toward the peripheral face of the grinding wheel, and a control valve automatically actuated by back pressure in the first cylinder so as to admit fluid under pressure to the second cylinder and thereby to increase the pressure of the crusher roller against the grinding wheel during a crushing operation.

6. In a grinding machine having a rotatable grinding wheel, driving means to rotate said grinding wheel either at a relatively fast speed for a grinding operation or at a relatively slow speed for a truing operation, and a truing apparatus therefor including a rotatably mounted formed crusher roller for truing a predetermined shape on said wheel, a vertically movable slide to support said crusher roller, a hydraulic piston and cylinder to move said slide toward and from said wheel periphery, a manually operable nut and screw interposed between said slide and said piston to facilitate adjustment of the slide relative to the piston, a solenoid control valve to control the admission to and exhaust of fluid from said cylinder, normally open solenoid valve in the pipe line between said control valve and the lower end of said cylinder, means including a limit switch actuated by and in time relation with the downward movement of said slide to close said second solenoid valve, a throttle valve to control the rate of the exhaust when the second solenoid valve is closed, a booster piston and cylinder which is arranged to increase the pressure in the upper cylinder chamber, and a normally closed control valve which is open by back pressure in the pipe line between the control valve and the upper end of said cylinder when the solenoid valve is closed to open said latter valve and admit fluid under pressure to the booster cylinder thereby to increase the pressure of crusher roller against grinding wheel during a truing operation.

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