June 26, 1934. W. J. GUILD ET AL 1,964,433

GRINDING MACHINE

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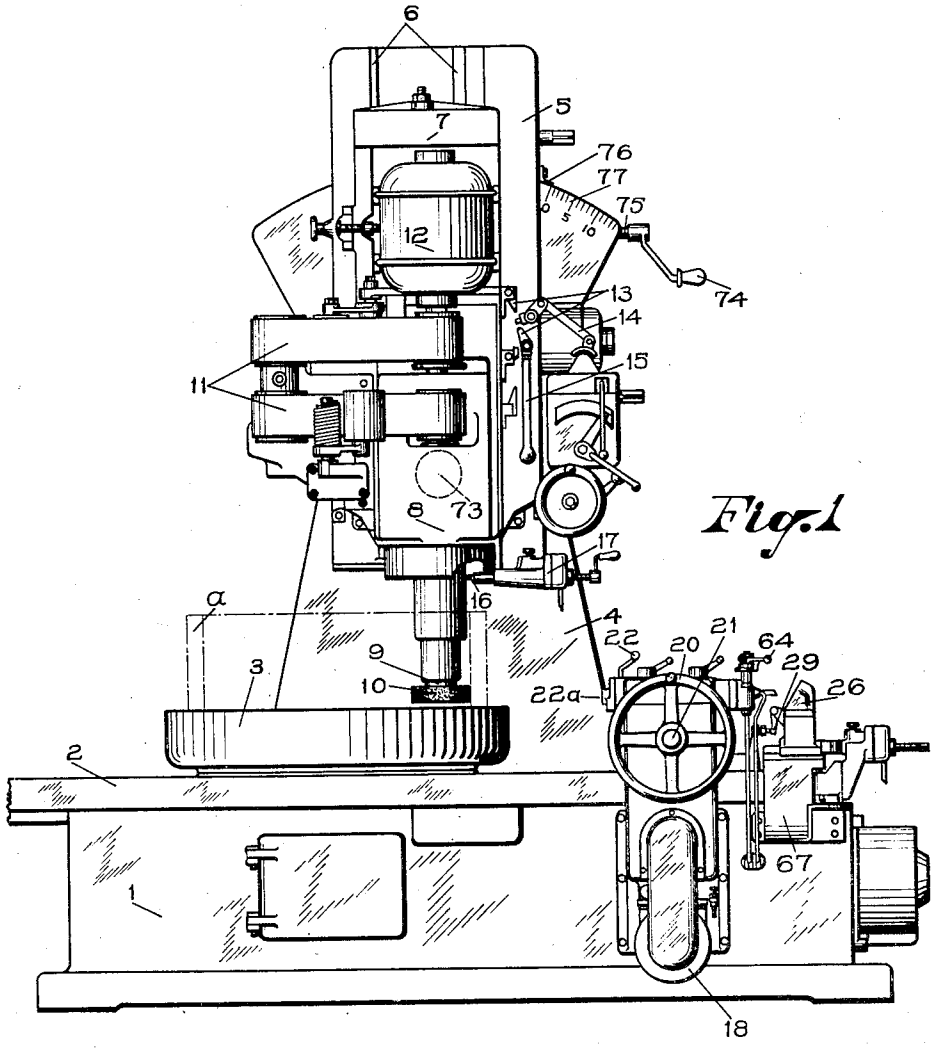


Fig. 1

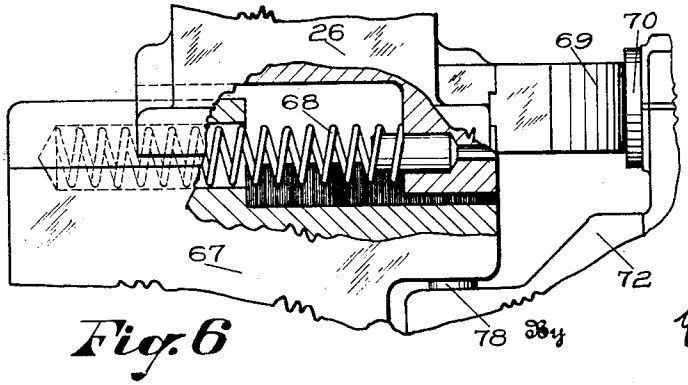


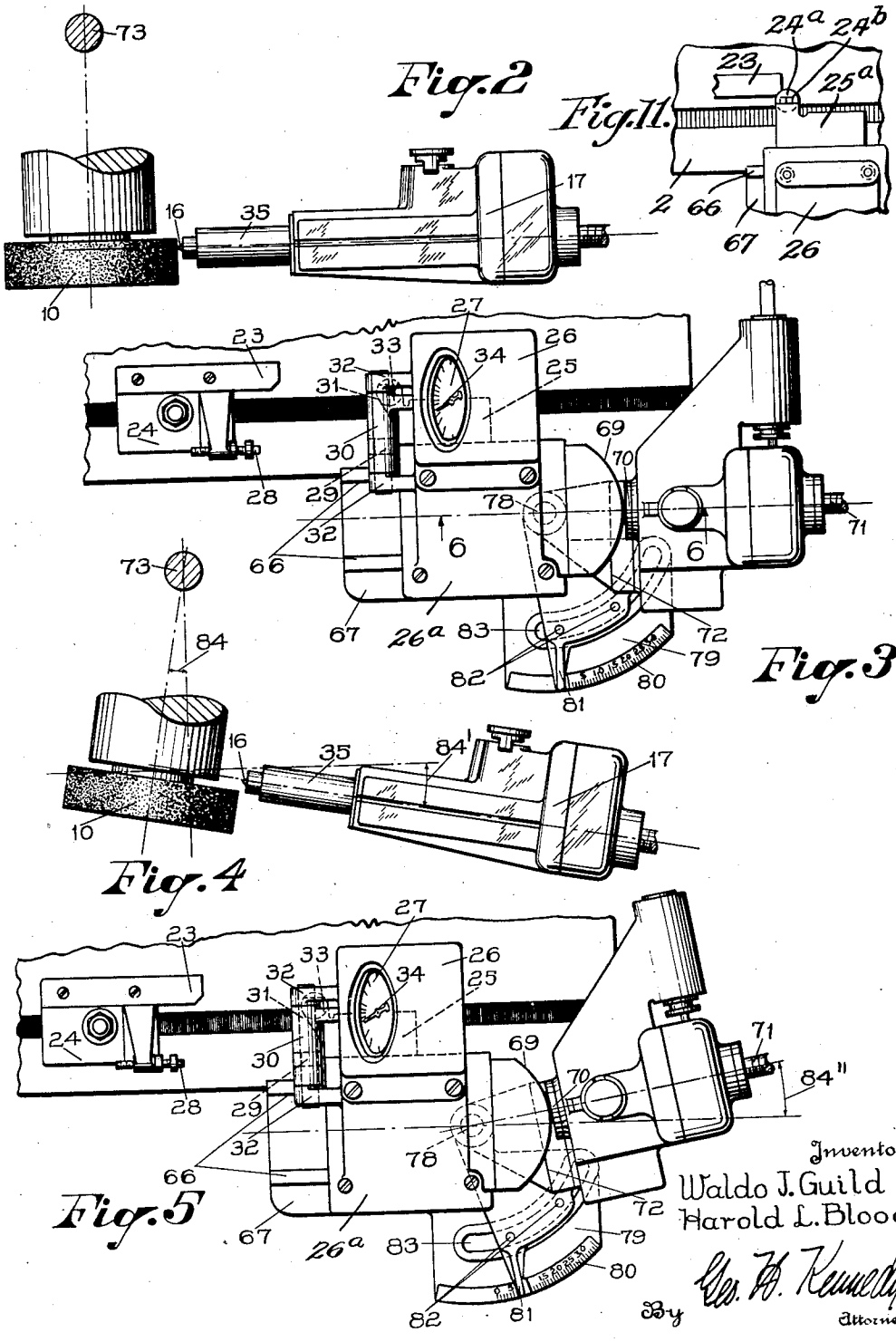
Fig. 6

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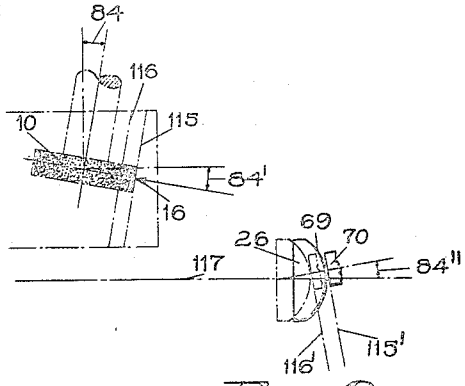


Fig. 9

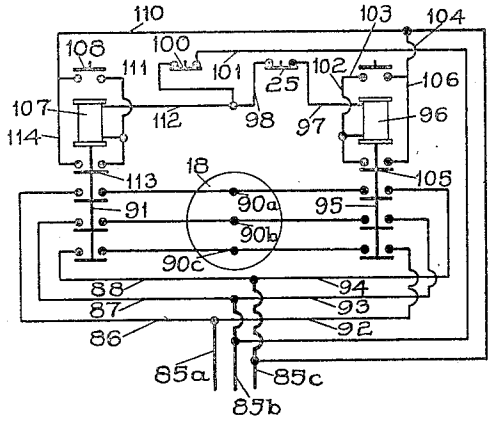


Fig. 10

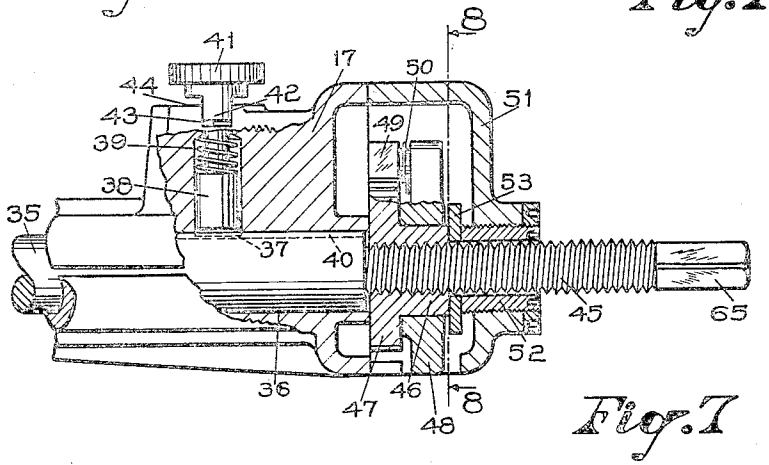


Fig. 7

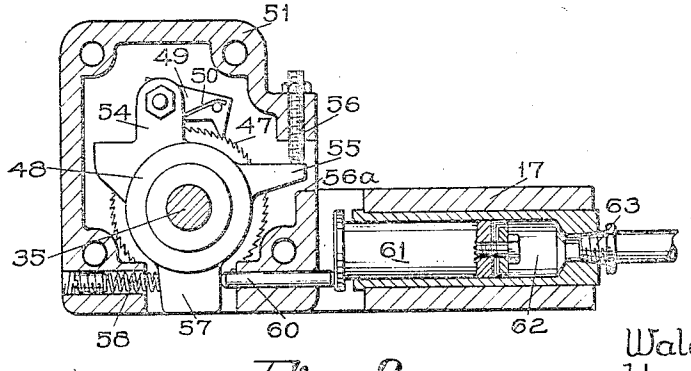


Fig. 8

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GRINDING MACHINE

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Application November 21, 1932, Serial No. 643,610

18 Claims. (Cl. 51—165)

The present invention relates to grinding machines and particularly to a mechanism for compensating for the reduction in diameter of a grinding wheel as a result of dressing operations thereon.

In some types of grinding machines, it is frequently inconvenient to mount the gauge, which indicates the size of the workpiece, in contact with the surface being ground, and in these cases, the gauge is actuated either directly or indirectly by the movement of the slide which procures the radial feeding movement between the grinding wheel and the work to indicate the relative movement therebetween. With a gauge of this type, a reduction in size of the grinding wheel, either from wear or from dressing operations thereon, results in successive workpieces whose finished size varies more and more from the desired finish size as the grinding wheel becomes smaller and smaller in diameter. It is accordingly one of the principal objects of the present invention to provide a device by which the gauge is always maintained in a predetermined relation to the cutting surface of the grinding wheel regardless of the reduction in size thereof.

When, in the grinding of tapered or conical surfaces on workpieces, the relative crossfeed or radial movement is not directly perpendicular to the axis of the grinding wheel, a movement of the gauge relative to the cross-slide a distance equal to the reduction in size of the wheel, to compensate for the wear on the wheel, would not provide for accurate compensation of said gauge by reason of the relative angularity of the movement of the cross-slide and the axis of the grinding wheel. It is accordingly a further object of the present invention to compensate for the reduction in diameter of the grinding wheel when the latter is grinding tapered or conical workpieces in a machine in which the gauge is responsive to the crossfeed movement.

According to the present invention, the slide or carriage by which the feeding movement of the workpiece relative to the grinding wheel is procured, actuates a gauge, when the workpiece approaches the desired finished size, so that the extent of the grinding operation may be observed, and so that the operation may be discontinued when the workpiece reaches the desired size. Between successive grinding operations, or when necessary, the grinding wheel is trued by a dressing tool which is advanced at a predetermined angle toward the grinding wheel, thereby positioning said dressing tool for operation upon the periphery of the wheel. At the same time, the gauge mechanism which is actuated by the cross-slide is advanced relative to said slide a distance corresponding to the resultant movement of the dressing tool in a plane parallel to the plane of movement of the slide, so that the gauge indicates at all times the relation of the workpiece to the cutting surface of the grinding wheel, rather than to the axis of the grinding wheel.

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

Fig. 1 is a front elevation of a machine embodying the invention.

Fig. 2 is a detail in elevation of the grinding wheel and the dressing tool.

Fig. 3 is a fragmentary plan view showing the gauge and its associated mechanism.

Fig. 4 is similar to Fig. 2 with the grinding wheel and dressing tool positioned at an angle relative to the plane of movement of the cross-slide for grinding of tapered or conical workpieces.

Fig. 5 is a view of the structure of Fig. 3 with the gauge advancing mechanism positioned for compensating for the reduction in diameter of the wheel when the latter is in the position of Fig. 4.

Fig. 6 is a section along the line 6—6 of Fig. 3.

Fig. 7 is a fragmentary elevation partly in section of the mechanism for advancing the dressing tool toward the grinding wheel.

Fig. 8 is a section along the line 8—8 of Fig. 7.

Fig. 9 is a diagrammatic view showing the relative movements of the dressing tool and the gauge mechanism.

Fig. 10 is a wiring diagram.

Fig. 11 is a fragmentary plan view corresponding to Fig. 3 with the gauge removed from the slide.

Like reference characters refer to like parts in the different figures.

The invention is shown as applied to a machine of the type disclosed in the copending application of Guild, one of the present inventors, and Ostlund, Serial No. 593,326, filed February 16, 1932. Referring to Fig. 1, the machine comprises a base 1 providing ways, not shown, on which a carriage 2 is mounted for longitudinal movement, the latter supporting a rotary workholder 3, said workholder being mounted for rotation about a vertical axis and being mechanically actuated in any desired manner. The base 1 is provided with an upstanding portion 4 at the back thereof to the upper end of which is secured

a member 5 having vertical ways 6 on which a slide 7 is mounted for vertical reciprocation. A wheelhead 8 is carried by the slide 7, and supports a shaft 9 to the lower end of which a grinding wheel 10 is secured and the upper end of which is connected through a series of belts 11 to a driving motor 12 also secured to the slide, the latter providing for continuous rotation of the grinding wheel.

As disclosed in the above noted Guild and Ostlund application, the slide 7 is actuated vertically by fluid under pressure which is alternately directed by a reversing valve to opposite ends of a cylinder carried by the member 5. The reciprocation is controlled in general by mechanism of the type shown in the Heald and Guild Patent No. 1,582,468 to maintain the grinding wheel 10 in a position to engage the internal bore of the workpiece *a* and to procure a vertical traversing movement of the grinding wheel over said workpiece. For the purpose of the present invention, it will be sufficient to note that the movements of the slide 7 are controlled by spaced reversing dogs 13 which alternately engage and actuate a reversing member 14 suitably connected to the reversing valve. The lower of the reversing dogs 13 is moved out of operative position manually by a lever 15 to procure an extended vertical movement of the slide 7, to withdraw the grinding wheel from horizontal alinement with the work to allow the workholder 3 to be moved to workloading position by movement of the carriage 2. During this extended movement, the wheel 10 may be carried vertically past a dressing tool 16 supported by a bracket 17 secured to the member 5.

The radial or crossfeed movement of the grinding wheel relative to the workpiece is procured by a movement of the carriage 2 longitudinally of the base, the latter being suitably actuated by a lead screw, not shown, which is journaled in the base and is in threaded engagement with a nut secured to the carriage 2 in the well-known and usual manner. Said lead screw is mechanically actuated by a motor 18 connected to said screw and the latter may be manually actuated by a hand wheel 20 on a shaft 21 which is connected through suitable gearing to said lead screw. Said hand wheel provides for a slow crossfeed movement of the carriage 2 during the grinding operation and the motor 18 provides for a rapid movement of the carriage from the grinding position shown, into a position at the extreme left of the machine for loading or unloading of the work-supporting member, and for a return movement of said carriage into grinding position. The lever 22 in one position connects the hand wheel 20 through a suitable clutch mechanism, not shown, to the lead screw and at the same time cuts off the power supply to the motor 18. In the other position of the lever 22, the hand wheel is disconnected from the lead screw by the above clutch mechanism and connections to the motor are provided so that the latter may be set in operation by the usual push button 22*a* of a starting mechanism, not shown.

After a workpiece *a* has been loaded upon the workholder, while the carriage is in workloading position, the push button 22*a* is pressed to procure advance of the carriage 2 to the right to bring the workpiece into grinding position, the wheel 10 at this time being positioned at its upper limit of travel to allow the workpiece to pass therebeneath. The workpiece is advanced to the right to a position which will allow the wheel to enter the bore of the workpiece adjacent the inner wall at the right hand side thereof, as shown, in which position the carriage 2 is automatically brought to rest. To this end, a horizontal bar 23, carried by a block 24 adjustably mounted on the carriage 2, engages a roller 24*a* on the end of a plunger 24*b* slidable in a switch box 25*a* and engaging the switch 25, Fig. 10. The switch box 25*a* is carried on a slide 26*a* beneath the gauge housing 26 which supports the gauge 27, the housing 26 being secured to the slide. The switch 25 which is normally closed is positioned in the circuit to the motor 18, as will hereinafter appear. The bar 23, during the movement of the carriage to the right, opens the switch 25 to cut off the power supply to the motor 18.

After the carriage is brought to rest, the grinding wheel is advanced downwardly within the bore of the workpiece, and closely adjacent to the wall of said workpiece adjacent the right hand portion thereof. The lever 22 is then actuated to connect the hand wheel 20 to the lead screw for procuring, by rotation of the hand wheel, a slow radial feeding movement of the workpiece into engagement with the grinding wheel, the feeding movement involving, as will be apparent, movement of the carriage 2 to the left.

During the movement of the carriage 2 to the right for moving the workpiece from inoperative position to the operative position shown, a stop 28 carried on the same block 24 which supports the bar 23 engages a depending arm 29 secured to the sleeve 30, the latter being journaled on a pin 31 extending between lugs 32 on the gauge housing 26. A second arm 33 secured to the sleeve 30 engages with a projecting member of the gauge mechanism by means of which the indicating hand 34 of the gauge 27 is actuated against the reaction of a spring, not shown, within the gauge itself. Thus, as the carriage 2 is moved to the right, just before it is brought to rest by the action of the bar 23 to open the switch 25, as above stated, the indicating needle 34 of the gauge is rocked against the tension of the above noted spring, in readiness to indicate the extent of the subsequent feeding movement of the workpiece to the left for the grinding operation. During this feeding movement, the spring maintains the arm 29 against the stop 28 so that the needle of the gauge indicates the extent of movement of the carriage.

The grinding wheel 10 is dressed either during the grinding operation or between successive grinding operations as desired by movement of said wheel past the dressing tool 16 and it will be apparent that said wheel is gradually reduced in size as a result of the wear on the grinding wheel and also the dressing operations thereon. The dressing tool 16 is advanced between successive dressing operations toward the axis of the grinding wheel in order to maintain said tool in proper cutting relation to said wheel. Referring now to Figs. 2 and 7, the dressing tool 16 is carried on the end of a rod 35 slidably mounted in a bore 36 in the bracket 17. Said rod is normally held against rotation by a key 37 carried by a plunger 38, said key being urged by a spring 39 into the key-way 40 in the rod 35. The plunger carries a knob 41 on the outer end thereof, the under side of which has a tongue 42 which normally engages in a rectangular slot 43 in the bracket 17, and the

key 37 is withdrawn from engagement within the key-way 40 by raising and turning of the knob 41 so that the tongue 42 engages the surface 44 of the bracket 17 and supports the key in spaced relation to the key-way.

In order to advance the rod 35 for positioning the dressing tool, the end of said rod 35 is screw threaded as at 45 for engagement with the threaded hub 46 of a ratchet wheel 47. The hub 46 extends beyond the ratchet wheel and provides a cylindrical bearing for a pawl carrying member 48, the latter providing a pivotal support for a pawl 49 normally held by a spring 50 in engagement with the ratchet wheel. A cap 51, which is secured to the bracket 17, extends over the pawl and ratchet and receives a sleeve 52 through which the end of the rod 35 extends, said sleeve being in threaded engagement with the cap for pressing a washer 53 against the right hand end of the hub 46, thereby urging the ratchet against the face of said bracket, and supporting said ratchet and the pawl carrying member 48 against endwise movement. The member 48, in addition to the arm 54 which supports the pawl, has an arm 55 which engages a threaded adjustable stop 56 in the cap 51 to limit the counterclockwise movement of the member 48 and which engages a fixed abutment 56a on the cap 51 to limit clockwise movement thereof. The arm 55 is normally held against the stop 56 by a spring 58 which engages a third arm 57 on said member 48.

The cap 51 carries a plunger 60, one end of which engages the arm 57 and the other end of which engages the projecting end of a piston 61 slidable in a cylinder 62 forming a part of the bracket 17. The piston 61, which is normally in the position shown, is urged to the left by fluid under pressure from the pipe 63, thereby urging the plunger 60 to the left and rocking the member 48 clockwise through a predetermined angle, the extent of which is varied by adjustment of the stop 56. The admission of fluid to the cylinder 62 is controlled by a suitable valve, not shown, connected to the manually actuated lever 64, Fig. 1, and the valve is arranged to provide a connection from the pipe 63 selectively to a source of supply of fluid under pressure or to an exhaust pipe so that a single actuation of the lever 64 between successive dressing operations will procure a clockwise movement of the member 48 and then a counterclockwise return movement of said member to the original position shown. Each clockwise movement of the member 48 procures a clockwise rotation therewith of the ratchet wheel 47, the extent of which is determined by the position of the stop 56 and, since the wheel 47 is held against axial movement, the successive clockwise actuations of said wheel procure successive advances, step by step, of the dressing tool carried by the rod 35 toward the axis of the grinding wheel.

The position of the dressing tool is manually adjusted by rotation of the rod 35, the end of said rod being squared as at 65 for the reception of a suitable wrench. The key 37 is withdrawn from the key-way to permit rotation of the rod and, as the ratchet wheel is held against rotation, turning of the rod within the hub of the ratchet wheel will procure an axial advance or retraction of the dressing tool.

Unless the reduction in size of the grinding wheel were compensated for by a relative adjustment of the gauge mechanism and the stop 28, the gauge mechanism would indicate the position of the axis of the grinding wheel relative to the workpiece, or the position of the original grinding surface relative to the workpiece, and accordingly would not indicate the position of the operative surface of the wheel relative to the workpiece. Each successive workpiece would thus be smaller than the preceding by an amount equal to the reduction in size of the wheel. To avoid this, the position of the arm 29 relative to the operative cutting surface of the grinding wheel is maintained, regardless of the reduction of the wheel by advancing the gauge structure to the left a distance corresponding to the radial advance of the dressing tool, the movements of the gauge structure and dressing tool being preferably simultaneously procured.

With the machine in the position shown with the axis of the grinding wheel parallel to the axis of rotation of the workpiece, the gauge structure, to compensate for the reduction in diameter of the wheel, is advanced a distance equal to the advance of the dressing tool, which latter determines the reduction in size of the wheel for each dressing operation. Referring now to Figs. 3 and 6, the gauge housing 26 is slidable on ways 66 provided by a bracket 67 secured to the base of the machine and a coil spring 68 mounted in the bracket 67 normally urges the housing 26 to the right. The right hand end of the housing 26 is provided with an arcuate surface 69 which engages the head 70 of an adjusting screw or rod 71 corresponding to the rod 35 of the construction of Fig. 7. As the rod 71 is advanced to the left, thereby carrying the head 70 of said rod to the left, the housing 26 is advanced to the left on the ways 66 against the pressure of the spring 68. The gauge advancing structure by which the rod 71 and the gauge housing are advanced is a duplicate of the structure of Figs. 7 and 8 used in advancing the dressing tool and accordingly will not be further described. The gauge advancing structure is mounted in a bracket 72 corresponding to the bracket 17, and the rod 71 is carried in said bracket in the same manner as the rod 35 is supported in bracket 17.

It will be noted, from the foregoing, that, by the corresponding advances of the dressing tool and the gauge structure, the gauge is advanced relative to the carriage a distance equal to the advance of the dressing tool radially of the grinding wheel so that the gauge indicates accurately the size of the workpiece, and, accordingly, the gauge will indicate the same for each successive workpiece when the latter reaches the desired finish size. Thus, the gauge actuated by the crossfeed or radial movement of the workpiece provides for a determination of the finish size of said workpiece independently of the size of the grinding wheel, the reduction in size of said wheel being compensated for. Since the switch 25 is carried by the gauge housing and is advanced therewith, it will be apparent that the rapid movement of the carriage 2 which moves the workpiece from loading position into grinding position is discontinued in each successive grinding operation when the axis of the workpiece is in a predetermined relation to the cutting surface of the grinding wheel independently of the reduction in size of said wheel.

The member 5, which carries the slideways 6 for the vertical slide 7, is mounted for adjustment about a horizontal axis to permit grinding of tapered or conical workpieces. As best shown in Fig. 1, the forward surface of the upstanding portion 4 of the base provides a plane surface over which the member 5 is movable, and the

latter is mounted for angular movement about a pivot pin 73. The angular adjustment of the member 5 is obtained by rotation of a handle 74 which rotates a screw threaded shaft 75, the latter engaging a swivelled nut, not shown, on the back of the member 5. The extent of the angular adjustment of the member 5 is indicated by a pointer 76 on the member 5 which cooperates with graduations 77 on the face of the upstanding portion 4.

The dressing tool 16 is mounted on the member 5 and thus maintains its proper relation to the grinding wheel without the necessity of adjustment independently of the angular movement of the member 5, and the advance of the dressing tool for successive dressing operations is procured in the manner above set out. However, since the axis of the rod 35 carrying the dressing tool is no longer parallel to the movement of the carriage 2, it will be apparent that an advance movement of the gauge structure equal in extent to the advance movement of the dressing tool will not procure the desired movement of the gauge since the proper advance of the gauge is a distance equal to the resultant movement of the dressing tool in the plane of movement of the carriage 2 of which the actual dressing tool movement is a component. The advance of the gauge will be increasingly greater than the advance of the dressing tool as the angularity of the grinding wheel increases.

In order that the gauge may be advanced the desired extent, the bracket 72, which carries the gauge advancing mechanism, is mounted for rotation on a pivot pin 78, the location of which corresponds substantially to the center of curvature of the arcuate surface 69. An extension 79 of the bracket 67 carries graduations 80 for indicating, in cooperation with an indicating finger 81 secured to the bracket 72, the angular adjustment of said bracket 72. The bracket 72 is locked in adjusted position by bolts 82 which extend through an arcuate slot 83 in the extension 79 of the bracket 67. In compensating for the angularity of the grinding wheel axis, the bracket 72 is adjusted to an angle equal to the angular adjustment of the member 5 which supports the grinding wheel.

With the grinding wheel 10 adjusted by swinging of the member 5, so that the axis of said wheel extends at an angle 84 to the normal vertical of the machine, as shown in Fig. 4, the effective movement of the dressing tool, or the resultant of the movement in a plane parallel to the plane of movement of the carriage 2, is proportional to a function of the angle 84 since the dressing tool is adjusted through an angle 84' equal to the angle 84 through which the member 5 is adjusted. Since the gauge structure, as above stated, should be advanced a distance equal to this resultant, the bracket 72 is adjusted so that the advancing rod 71 extends at an angle 84'' to the direction of movement of the table 2, said angle 84'' being equal to the angle 84. The dressing tool and the head 70 of the rod 71 may accordingly still be advanced to equal extents between each dressing operation, and the resultant of the movement of the dressing tool in the plane of movement of the carriage will accordingly be equal to the movement of the gauge housing in the same plane, which latter movement will obviously be the resultant of the movement of the rod 71 in the direction of movement of the table.

The wiring diagram of Fig. 10 indicates one arrangement of the electrical connections by which the carriage 2 is actuated. The power is supplied from power leads 85*a*, 85*b* and 85*c* which are connected through leads 86, 87 and 88 respectively to the terminals 90*a*, 90*b* and 90*c* of the motor 18 through a switch 91; and said power leads 85*a*, 85*b* and 85*c* are also connected in the reverse order by leads 92, 93 and 94 to the terminals 90*c*, 90*b* and 90*a*, respectively, of the motor 18 through a switch 95.

The switch 95 is connected to the armature of a solenoid 96 and is closed when the solenoid is energized. Said solenoid has one terminal thereof connected by a lead 97 to one terminal of the switch 25 which, as above stated, is normally closed and the other terminal of said switch is connected by a lead 98 to a normally closed stop switch 100. The opposite terminal of the stop switch 100 is connected to the power line 85*b* by a lead 101. The second terminal of the solenoid 96 is connected by a lead 102 to one terminal of a manually controlled switch 103, the other terminal of which is connected through a lead 104 to the power line 85*c*. The lead 102 is also connected to one terminal of a switch 105 forming part of the switch 95 and the other terminal of the switch 105 is connected by a lead 106 to the lead 104 to the power line, so that the two switches 103 and 105 are in parallel relation in the solenoid circuit. The switch 105, the same as the switch 95 is normally open so that the motor 18 is entirely disconnected from the power supply.

In order to procure movement of the carriage 2 for moving the workpiece into operative position relative to the grinding wheel, the switch 103 is manually closed, through the push button 22*a* above, thereby energizing the solenoid 96 causing attraction of its armature and closing the switch 95. The switch 105 is also closed by said solenoid and completes a circuit through said solenoid to maintain the switch 95 in closed position regardless of the subsequent release of the switch 103. The circuit through the solenoid 96 is broken for disconnecting the power supply from the motor 18 by either switch 100 or 25 which, as will be apparent, are arranged in series with the solenoid in the supply circuit.

For reversal of the carriage to retract the workpiece from operative engagement with the grinding wheel and to position the workholder in workloading position, the switch 91 is closed by energization of a solenoid 107 to the armature of which the switch 91 is connected. The solenoid is energized by closing a manually actuated switch 108, one terminal of which is connected by a lead 110 to the lead 104 from the power line 85*c*, and the other terminal of said switch is connected by a lead 111 to one terminal of the solenoid 107, the other terminal of which is connected by a lead 112 to the lead 98 between the switches 25 and 100. The terminal of the solenoid to which the switch 108 is connected is also connected through a switch 113 and a lead 114 to the lead 110 so that the switches 108 and 113 are connected in parallel with each other in the solenoid circuit.

Manual closing of the switch 108, the switch 100 being closed, energizes the solenoid, causing attraction of its armature and accordingly closing of the switch 91, thereby connecting the motor 18 to the power supply for rotation of said motor in the opposite direction to its rotation when connected to the power through the switch 95. Closing of the switch 91 also closes the switch 113 integral therewith which establishes a second circuit to the solenoid 107 so that the latter continues to be energized regardless of the position of the switch 108 until the circuit through said

solenoid is broken by opening of the stop switch 100 which latter breaks the circuit through the solenoid and accordingly brings the carriage 2 to rest.

The diagram of Fig. 9 indicates the relative movements of the gauge mechanism and the dressing tool when the grinding wheel and gauge shifting mechanism are in the angularly adjusted positions of Figs. 4 and 5. Referring to Fig. 9, the grinding wheel 10, as above stated, is dressed by the dressing tool 16 and is reduced radially a distance represented by the spacing of the two lines 115 and 116, the former indicating the original surface of the grinding wheel and the latter indicating the surface of said wheel after a dressing operation has been performed. The relative spacing of the lines 115 and 116 is greatly exaggerated in order to show clearly the relative movements. The plane of movement of the carriage is indicated by the horizontal line 117, and it will be apparent that the resultant reduction in size of the grinding wheel along the line 117 is slightly greater than the reduction in radius of said wheel, and the radial reduction of the wheel is a component of this resultant. To compensate for this reduction in size, the gauge mechanism 26 is advanced a distance along the line 117 equal to the resultant reduction of the wheel along the same line. To this end, the head 70 and the adjusting screw 71 are adjusted to extend at the angle 84'' to the line 117 equal to the angle 84' between the line of movement of the dressing tool 16 and the line 117. Thus, by advance of the head 70 from the original position represented by the line 115' into the advanced position represented by the line 116', this distance being equal to the spacing of the lines 115 and 116, the gauge mechanism or housing 26 is advanced from the full line position shown to the dot-dash line position which distance is equal to the resultant of the movement of the dressing tool.

In the operation of the machine, the operator closes the switch 103 manually by the push button 22*a* to procure movement of the carriage 2 to the right to bring the grinding wheel and workpiece into grinding position, the carriage 2 being mechanically actuated to the right until the bar 23 on the block 24 engages and opens the switch 25, thereby releasing and opening the switch 95 to disconnect the power supply to the motor 18 which actuates the carriage, thus procuring a change in the grinding operation. The grinding wheel is then advanced downwardly into the plane of the workpiece. In this position of the carriage, the cutting surface of the grinding wheel is in predetermined relation to the axis of the workpiece and also in predetermined relation to the gauge structure. The feeding movement of the carriage for the grinding operation is thereafter procured either by manual rotation of the hand wheel 20 or by a suitable mechanism, not shown, for providing a slow crossfeed movement. This slow feeding movement to the left continues until the gauge indicates that the workpiece has reached the desired size, when the grinding operation is discontinued, and the grinding wheel is withdrawn to its upper limit of travel. The carriage 2 is then moved to workloading position by manual closing of the switch 108 for actuation of the motor 18.

At any desired time during a grinding operation, or between successive grinding operations, the grinding wheel may be dressed by vertical movement of said grinding wheel past the dressing tool 16. Said dressing tool is advanced into a position for engagement with the wheel between successive dressing operations, said advancing movement being procured manually by rocking of the valve lever 64 to move the tool a predetermined distance. The gauge housing is simultaneously advanced by fluid pressure under control of the same valve lever 64 a distance corresponding to the advance of the dressing tool to compensate for the wear on the wheel.

When the grinding wheel is used in grinding tapered workpieces, the gauge is advanced simultaneously with the advance of the dressing tool but through a distance equal to the resultant movement of the dressing tool in the direction of crossfeed movement.

From the foregoing, it will be apparent that the present machine provides a gauge which is responsive to movement of the crossfeed carriage for determining the size of the workpiece with said gauge movable relative to the grinding wheel to compensate for the reduction in size thereof so that the gauge will operate to determine the size of successive workpieces independently of the size of the grinding wheel. The gauge member is also adjustable to compensate for the reduction in size of the grinding wheel when the latter is mounted for the grinding of tapered workpieces. It will be noted that the advancing movement of the gauge structure relative to the machine or to the grinding wheel maintains said gauge structure in predetermined relation to the cutting surface or locus of the wheel regardless of the reduction in size thereof. The gauge is thus at any point in the grinding operation in predetermined spaced relation not only to the axis of the workpiece but also to the cutting locus of the grinding wheel. The invention also involves a mechanism whose position relative to the grinding wheel is controlled in the same manner as the gauge, said mechanism operating to discontinue the rapid lateral or radial movement of the grinding wheel relative to the workpiece.

We claim,

1. In a grinding machine, a grinding member and a work supporting member, a dressing tool for said grinding member, a carriage on which one of said members is mounted, means to procure movement of said carriage for a substantially radial feeding movement between said grinding member and a workpiece in said work supporting member, gauge means responsive to movement of said carriage, and means to compensate said gauge means for the reduction in size of the grinding member as a result of dressing operations thereon.

2. In a grinding machine, a grinding member and a work supporting member, a dressing tool for said grinding member, a carriage on which one of said members is mounted, means to procure movement of said carriage for a substantially radial feeding movement between said grinding member and a workpiece in said work supporting member, gauge means responsive to movement of said carriage, and means to advance said gauge relative to the carriage a distance proportional to the reduction in size of the grinding member as a result of the dressing operation.

3. In a grinding machine, a grinding member and a work supporting member, a dressing tool for said grinding member, a carriage on which one of said members is mounted, means to procure movement of said carriage for a substantially radial feeding movement between said grinding member and a workpiece in said work supporting member, gauge means responsive to movement of said carriage, and means to position the gauge

between successive dressing operations to maintain said gauge in predetermined relation to the cutting locus of the grinding member.

4. In a grinding machine, a grinding member and a work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a gauge member responsive to the crossfeed movement for determining the size of the workpiece, and means to advance said gauge relative to the grinding member to maintain the gauge in predetermined relation to the cutting locus of said grinding member.

5. In a grinding machine, a grinding member and a work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, a gauge member responsive to the crossfeed movement for determining the size of the workpiece, and means to advance said gauge relative to the grinding member between successive dressing operations a distance corresponding to the reduction in size of the grinding member as a result of the dressing operation.

6. In a grinding machine, a grinding member and a work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, means to advance said dressing tool relative to said grinding member to maintain said tool in operative relation to said member, a gauge mechanism responsive to the crossfeed movement for determining the size of the workpiece, and means to advance said gauge relative to said grinding member a distance corresponding to the advance of the dressing tool.

7. In a grinding machine, a grinding member and a work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, means to advance said dressing tool relative to the grinding member to maintain said tool in operative relation to said member, a gauge mechanism responsive to the crossfeed movement for determining the size of the workpiece, and means to advance said gauge a distance equal to the advancing movement of the dressing tool to maintain said gauge in predetermined relation to the cutting locus of the grinding member.

8. In a grinding machine, a grinding member and a work supporting member, an angularly adjustable support on which one of said members is mounted to move the axis of the grinding member out of parallel relation to the axis of the work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, a gauge member responsive to the crossfeed movement for determining the size of the workpiece, means to advance said dressing tool relative to the grinding member, and means to advance the gauge in the plane of the carriage movement a distance corresponding to the reduction in size of the grinding member in the same plane.

9. In a grinding machine, a grinding member and a work supporting member, an angularly adjustable support on which one of said members is mounted to move the axis of the grinding member out of parallel relation to the axis of the work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, a gauge member responsive to the cross feed movement for determining the size of the workpiece, and means to advance said gauge relative to the carriage to compensate for the reduction in diameter of the grinding member regardless of the angular disposition of said member relative to the workpiece.

10. In a grinding machine, a grinding member and a work supporting member, an angularly adjustable support on which one of said members is mounted to move the axis of the grinding member out of parallel relation to the axis of the work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, a gauge member responsive to the crossfeed movement for determining the size of the workpiece, and a single manually controlled means to procure advance of the gauge mechanism and the dressing tool to maintain said mechanism and said tool in predetermined relation to the cutting locus of the grinding member.

11. In a grinding machine, a grinding member and a work supporting member, an angularly adjustable support on which one of said members is mounted to move the axis of the grinding member out of parallel relation to the axis of the work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, a gauge member responsive to the crossfeed movement for determining the size of the workpiece, mechanism to advance the dressing tool relative to the grinding member and similar mechanism to advance the gauge mechanism a distance corresponding to the advance of the dressing tool.

12. In a grinding machine, a grinding member and a work supporting member, an angularly adjustable support on which one of said members is mounted to move the axis of the grinding member out of parallel relation to the axis of the work supporting member, a carriage on which one of said members is mounted, means to procure a movement of said carriage for a relative crossfeed movement between said grinding member and a workpiece in said work supporting member, a dressing tool for said grinding member, a gauge member responsive to the crossfeed movement for determining the size of the workpiece, mechanism to advance the dressing tool relative to the grinding member and similar mechanism to advance the gauge mechanism a

distance corresponding to the advance of the dressing tool, and means to adjust one of said mechanisms to procure, when the axis of said grinding member is angularly related to the axis of the workpiece, an advance of said gauge mechanism proportional to the reduction in size of the grinding member in the direction of advance of said gauge.

13. In a grinding machine, a grinding wheel and a workpiece, means to procure a crossfeed movement between said wheel and workpiece, mechanism actuated in response to said crossfeed movement for determining the size of the workpiece, means to procure a dressing operation on said grinding wheel, and means to maintain said mechanism in predetermined relation to the cutting locus of the grinding wheel independently of the reduction in size of said wheel as a result of the dressing operation.

14. In a grinding machine, a grinding wheel and a workpiece, means to procure a crossfeed movement between said wheel and workpiece, mechanism responsive to said crossfeed movement to procure a change in the grinding operation, means to procure a dressing operation on said grinding wheel, and means to maintain said mechanism in predetermined relation to the cutting locus of the grinding wheel independently of the reduction in size of said wheel as a result of the dressing operation.

15. In a grinding machine, a grinding wheel and a workpiece, mechanically actuated means to procure a crossfeed movement between said wheel and workpiece, mechanism operable to discontinue the operation of said mechanically actuated means in response to the crossfeed movement, means to procure a dressing operation on said grinding wheel, and means to maintain said mechanism in predetermined relation to the cutting locus of the grinding wheel independently of the reduction in size of the grinding wheel as a result of the dressing operation.

16. In a grinding machine, a grinding member and a work supporting member, means for procuring a relative substantially radial movement between said members, mechanism actuated in response to said relative movement for determining the size of a workpiece in said work supporting member, means for procuring a dressing operation on said grinding member, and means for maintaining said mechanism in predetermined relation to the cutting locus of the grinding member independently of the reduction in size of said member as a result of the dressing operation.

17. In a grinding machine, a grinding member and a work supporting member, means for procuring a relative substantially radial movement between said members, mechanism responsive to said relative movement for procuring a change in the grinding operation, means for procuring a dressing operation on said grinding member, and means for maintaining said mechanism in predetermined relation to the cutting locus of the grinding member independently of the reduction in size of said member as a result of the dressing operation.

18. In a grinding machine, a grinding member and a work supporting member, mechanically actuated means for procuring a relative substantially radial movement between said members, mechanism operable in response to said relative movement to discontinue the operation of said mechanically actuated means, means for procuring a dressing operation on said grinding member, and means for maintaining said mechanism in predetermined relation to the cutting locus of the grinding member independently of the reduction in size of said grinding member as a result of the dressing operation.

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