

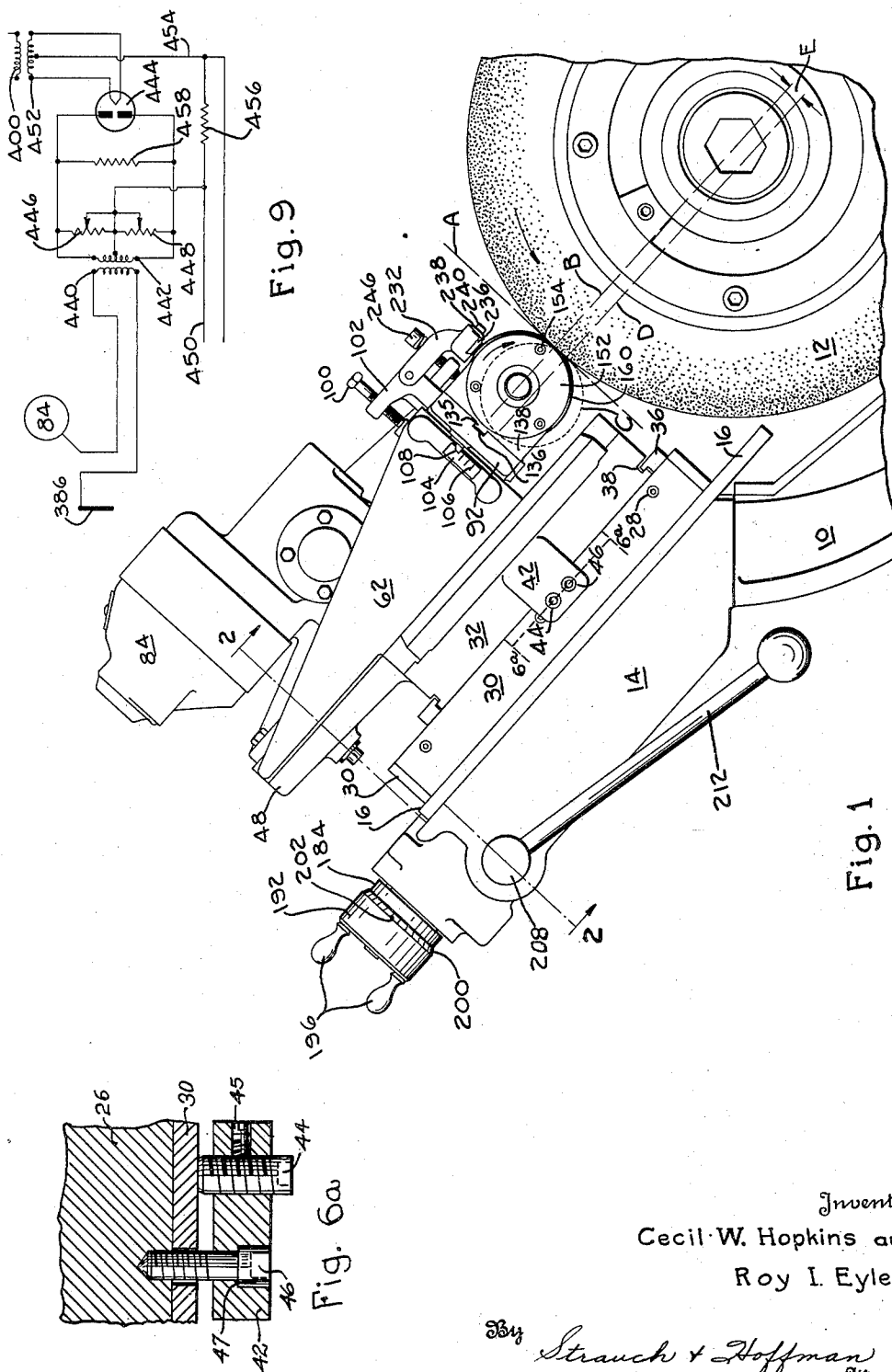
June 24, 1952

C. W. HOPKINS ET AL
WHEEL DRESSING MECHANISM

2,601,290

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4 Sheets-Sheet 1



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4 Sheets-Sheet 2

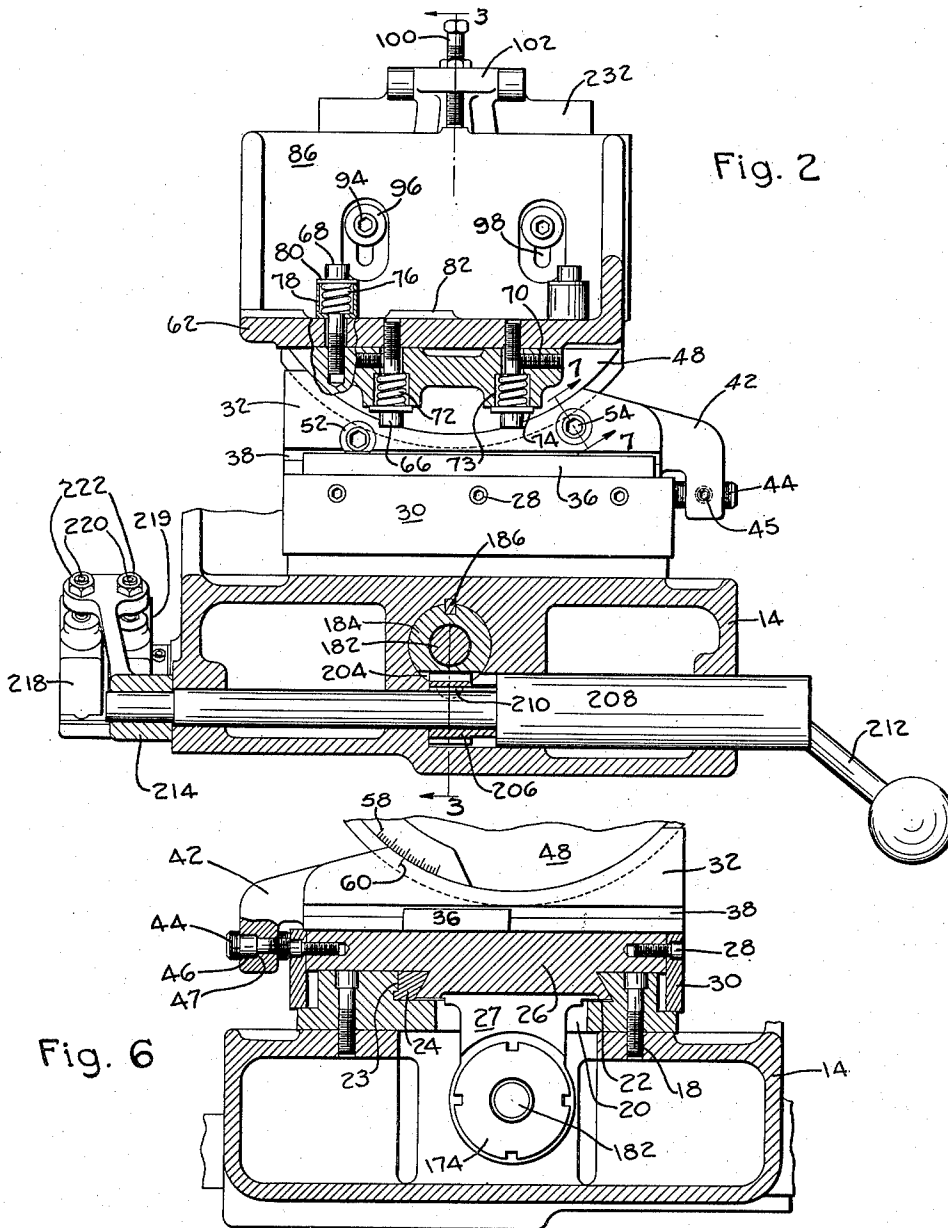


Fig. 2

Fig. 6

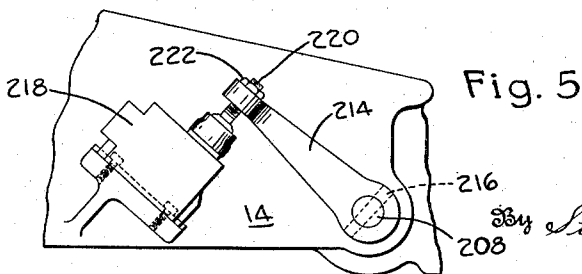


Fig. 5

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4 Sheets-Sheet 3

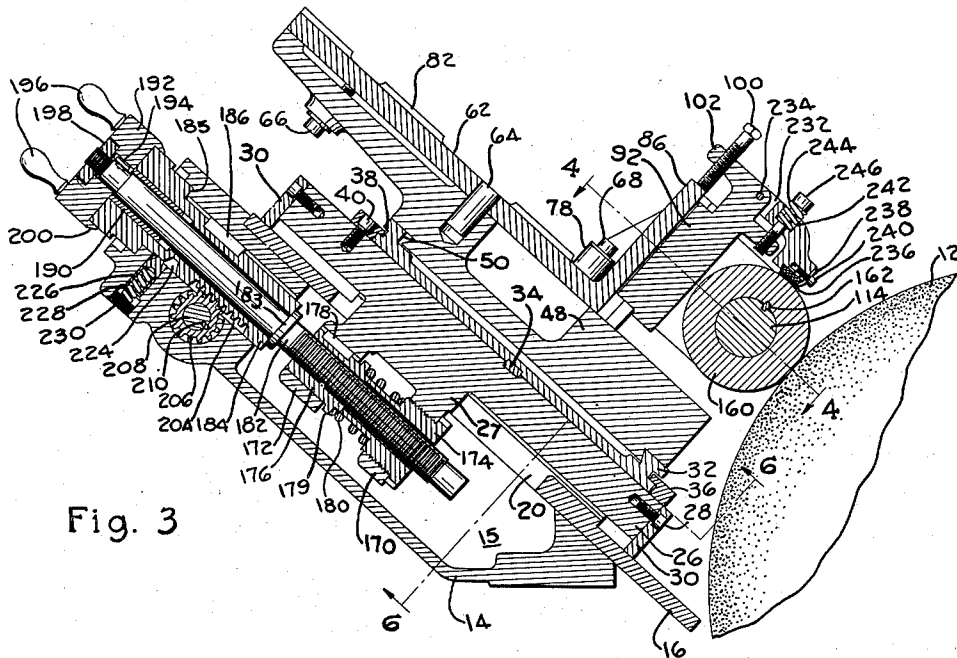


Fig. 3

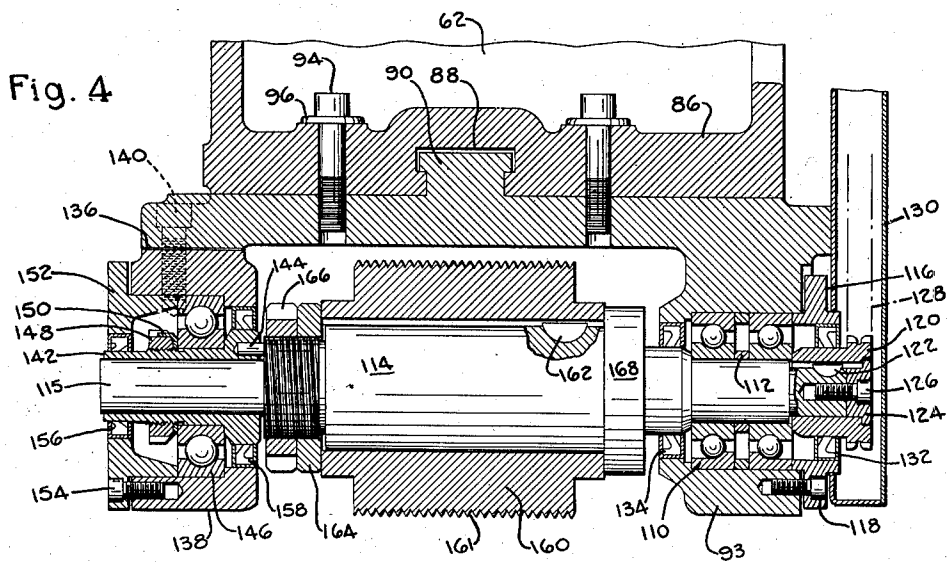


Fig. 4

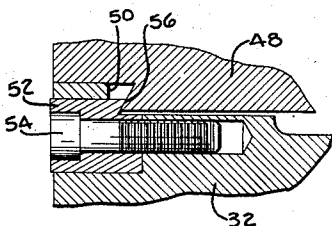


Fig. 7

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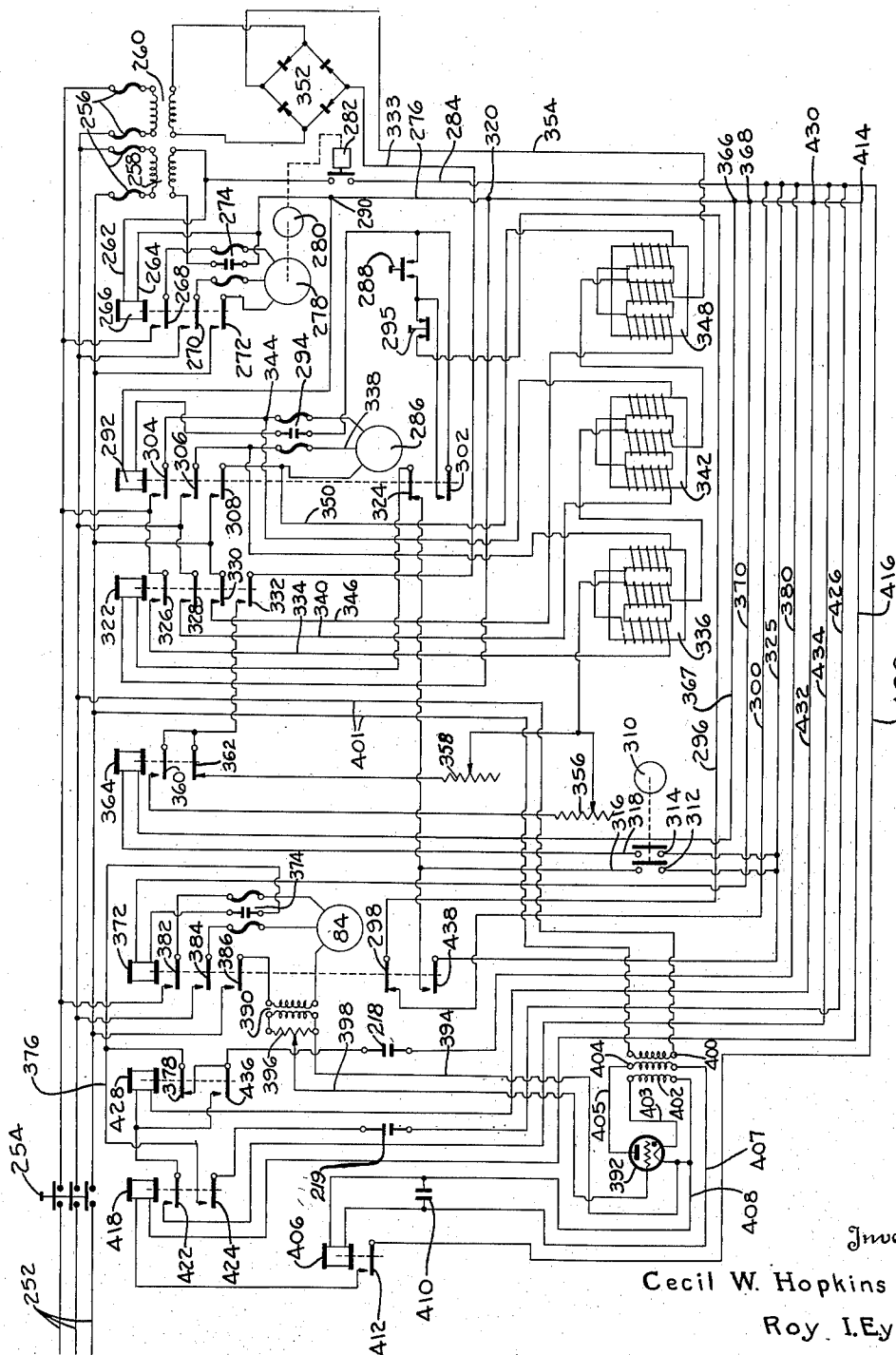


Fig. 8

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UNITED STATES PATENT OFFICE

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WHEEL DRESSING MECHANISM

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17 Claims. (Cl. 125-11)

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This invention relates to wheel dressing mechanism, and is primarily concerned with the provision of a mechanism for accurately contouring the peripheral face of a grinding wheel in counterpart of a predetermined contour to be produced on a work-piece in the operation of said wheel.

In wheel dressing or truing mechanisms heretofore employed for this purpose, diamonds have been used having a cutting or tritulating action upon the abrasive material of the grinding wheel. This results in an appreciable change in wheel diameter, as well as evolving clouds of fine abrasive dust. Despite precautionary measures, these minute abrasive particles find their way into the actuating mechanism for the wheel dressing diamond so that the accurate functional operation of the latter is more or less seriously impaired. While such dressing mechanisms may be employed in cases where, in the grinding of certain kinds of work, a high degree of accuracy is not required, they are not suitable for precision grinding, such as the grinding of a screw thread on work-pieces of various diameters, where the factors of pitch, helix angle and concentricity of the screw threads are of major importance.

It is, therefore, the general object and purpose of our present invention to provide a wheel dressing mechanism, in which instead of the usual diamond or other cutting tool we employ a hardened steel roller having a surface profile identical with that which is to be produced upon the work, together with means for urging said roller under pressure against the peripheral face of the grinding wheel, while said wheel and roller are relatively rotated, thereby contouring the relatively soft face of the abrasive wheel, so that in the operation of the latter, the desired profile is accurately reproduced upon the work-piece.

It is another object of the invention to provide a mechanism of this kind, particularly designed for use in connection with a centerless grinding machine, and in which we provide a novel mounting of the wheel dressing or contouring roller, whereby the roller axis may be adjustably inclined relative to the axis of the grinding wheel and substantially in correspondence with the inclination of the work-piece in the grinding throat of the machine.

It is a further object of the invention to provide means for adjusting the pressure roller to accurately compensate for the position of the work-piece in the grinding throat relative to the centers of the grinding and control wheels, which will vary according to the diameter of the work-piece and other operating conditions.

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It is also an additional object of the invention to provide a wheel dressing mechanism of the above character, in which the application and duration of the pressure force of said roller against the face of the abrasive wheel is independent of the manual force or dexterity of the operator so that the reduction of grinding wheel diameter is held to a minimum and uniformly accurate results are produced.

Our invention further contemplates a dressing mechanism provided with simple and effective means controlling the depth of penetration of the pressure contouring roller into the face of the abrasive wheel so that when a wheel profile having the predetermined depth is reached, further penetration of the wheel face by said roller is automatically discontinued.

Yet another object of our invention is to provide certain effectively operating electrical controls for the wheel dressing roller which are interrelated with the electrical driving system of the grinding wheel and which have for their purpose to reduce the load on the roller operating motor to a minimum and to also quickly stop the rotation of the grinding wheel so that the wheel dressing operation may be started without excessive loss of time.

Other subordinate objects of the invention include the provision of a wheel dressing unit having a minimum number of structurally durable parts cooperatively assembled in a compact organization, in which the several adjusting means for the wheel dressing roller are easily accessible for rapid operation.

With the above and other objects in view, the present invention comprises the improved wheel dressing mechanism and operational control system therefor, together with the construction and relative arrangement of the several parts, as will hereinafter be more fully described, illustrated in the accompanying drawings and subsequently incorporated in the subjoined claims.

In the drawings wherein we have disclosed an illustrative practical embodiment of our invention and in which similar reference characters designate corresponding parts throughout the several views:

Figure 1 is a side elevation of the wheel dressing mechanism showing the same mounted in operative position upon a grinding machine;

Figure 2 is a transverse sectional view taken substantially on the line 2-2 of Figure 1, the driving motor for the wheel dressing roller being removed;

Figure 3 is a longitudinal sectional view taken substantially on the line 3-3 of Figure 2;

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Figure 4 is a fragmentary horizontal sectional view on an enlarged scale, taken substantially on the line 4—4 of Figure 3;

Figure 5 is a fragmentary elevation looking at the opposite side of the machine from that shown in Figure 1;

Figure 6 is a transverse sectional view taken substantially on the line 6—6 of Figure 3;

Figure 6a is a detail horizontal section taken substantially on the line 6a—6a of Figure 1.

Figure 7 is a fragmentary sectional view taken substantially on the line 7—7 of Figure 2;

Figure 8 is a wiring diagram of the electrical control system for the machine, and

Figure 9 is a similar diagram of an alternative method of control.

Referring for the present more particularly to Figures 1, 3 and 6 of the drawings, the wheel dressing unit is rigidly fixed upon a part 10 of the grinding machine bed above the axis of the grinding wheel 12 and at an angle from the horizontal in close proximity to the grinding wheel for proper operation upon the peripheral face thereof in a manner to be presently described. This angle will vary with the diameter of the grinding wheel and in some cases the unit may be mounted to operate in a horizontal position.

In the embodiment of the invention which we have selected for purposes of illustration, the dressing unit includes a base 14 extending upwardly and laterally from its fixed end mounted on the bed 10. On the upper inclined surface of this base the plate 16 is rigidly secured by means of the screws 18 and is provided intermediate of its ends with a longitudinally elongated opening 20. The plate 16 is further provided in its upper surface with a longitudinally extending dove-tailed slideway 22, one side of which has an undercut vertical wall 23 with which a longitudinally slidable tapered key 24 cooperates for the purpose of compensating for wear between the slideway 22 and the mating dove-tail portion on the bottom surface of a slide 26. To each edge of this slide a plate 30 is secured by means of screws 28 and extends downwardly in overlapping relation to the plate 16. These plates exclude abrasive dust and other foreign matter, in all positions of the slide 26, from entrance through the opening 20 and collection upon the parts of the slide operating mechanism to be presently described.

Upon the upper surface of the slide 26, a saddle 32 is transversely adjustable and is keyed against longitudinal movement relative to said slide as shown at 34. This saddle 32 is adapted to be securely held in its adjusted position on the slide by means of the clamping members 36 each of which has a flanged portion for engagement in grooves 38 in the front and rear ends of saddle 32, as clearly seen in Figure 1. These clamping members are secured to the slide 26 by means of the screws 40. When said screws are loosened, the saddle may be transversely adjusted on the slide by means of the adjusting device shown in Figures 2 and 6 of the drawings. With reference thereto, it will be seen that saddle 32 is provided at one side thereof with a laterally and downwardly extending bracket arm 42. This arm has a tapped hole receiving the adjusting screw 44, the inner end of which has bearing contact with the side plate 30 on slide 26. The bracket arm 42, in spaced relation to the screw 44, is further provided with a counterbored opening in registering relation with an opening in the plate

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30 and a tapped hole in the slide 26 which receives the cap screw 46. Thus it will be apparent that transverse movement of the saddle on the slide in one direction is limited by the adjustable screw 44 while movement of said saddle in the opposite direction is limited by contact of the head of the screw 46 with the internal shoulder 47 of the bracket arm 42. Preferably the screw 44 is securely fixed in adjusted position by means of the set screw 45. Thus it is possible to easily and quickly make an exact transverse adjustment of the saddle 32 on the slide 26 for the purpose of accurately registering the peripheral surface configuration of the dressing or contouring roller with the pre-formed peripheral surface of the grinding wheel 12, axially thereof.

The roller cradle 48 is mounted upon the saddle 32 for transverse rocking movement relative thereto, said saddle having an arcuately dove-tailed connection with the cradle 48. The axis of rocking movement of cradle 48 is exactly parallel to the path of movement of the slide 26 which is substantially perpendicular to the axis of grinding wheel 12. The concave slideway in the top surface of the saddle 32 is formed with a rectangular rear side face, as indicated at 50 in Figure 3 of the drawings. Sufficient clearance is provided to permit the cradle 48 to be shifted rearwardly and then vertically lifted to remove the same from connection with the saddle 32. The cradle 48 is retained in any desired angularly adjusted position relative to the saddle 32 by means of the dove-tail clamps 52, shown more particularly in Figures 2 and 7 of the drawings. These clamping members are of cylindrical shape and are retained in suitable recesses formed in the rear side of the saddle 32 by means of the screws 54, each clamp being provided with an undercut inclined shoulder 56 having a curvature substantially identical with the slideway in the saddle 32. The cradle 48 may thus be rigidly held in adjusted position on the saddle by adjusting the screws 54 to force the members 52 inwardly so that shoulders 56 will urge the cradle 48 forwardly and securely clamp its dove-tail portion against the forward side wall of the slideway in the saddle 32. The required amount of angular adjustment of the cradle with respect to the saddle is easily measurable by means of suitable indicia 58 engraved upon the forward surface of the cradle 48 in conjunction with the index line 60 on the adjacent surface of saddle 32 (see Figure 6).

In the operation of centerless grinding machines, it is common practice to incline the blade of the work support from the horizontal so that the work-piece will have an endwise movement as it is being ground. In the grinding of roughly pre-formed screw threads on work-pieces this angular inclination of the work-piece should be made equal to the helix angle of the thread. On the other hand, the thread forming operation is accomplished by means of a grinding wheel which is formed with a series of alternating, circumferentially parallel ribs and grooves, and not a continuous thread. In either case, the angle of inclination of the work is variable and the grinding wheel will reproduce its exact peripheral contour on the work, only when that angle with respect to the grinding wheel axis is zero. Consequently it is necessary to axially rock the dressing or contouring roller of our invention relative to the axis of the grinding wheel so that the inclination of

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the roller axis will be equal to that of the work-piece from the horizontal in the grinding throat, to produce a slightly skewed or distorted profile upon the periphery of the grinding wheel. Thus, although the grinding wheel rotates in a perpendicular plane normal to its axis, the correct profile will be accurately produced upon the inclined work-piece.

Upon the upper flat surface of the cradle 48, a bracket 62 is mounted, said bracket having a base portion pivotally connected intermediate of its ends by means of the pin 64 with the cradle 48 for pivotal adjustment relative to the latter. Screws 65 are disposed through counterbored openings in the rear end of the cradle 48 and having threaded engagement with the bracket 62. The openings are of sufficiently greater diameter than the screws 65 to permit lateral movement of said screws in the pivotal adjustment of the bracket 62 which is effected by means of the adjusting screws 70 threaded in the cradle 48 in perpendicular relation to the screws 65 and respectively coacting therewith. By such pivotal adjustment of the bracket, the dressing or contouring roller mounted thereon may be easily positioned with its axis in accurate coinciding relation with a transverse plane normal to the path of movement of the slide 26. Springs 72 surrounding the screws 66 are seated in the enlarged outer ends 73 of the openings in the cradle 48 and retained therein by the washers 74. Similar screws 68 are also disposed through enlarged openings in the bracket 62 and are engaged in tapped openings in the cradle 48. Springs 76 surrounding the screws 68 are seated in the spring cups 78 and retained therein by washers 80. Thus the bracket 62 is resiliently retained in proper position on the cradle 48 when the screws 66 and 68 are temporarily loosened for the pivotal adjustment of said bracket by means of the screws 70.

At appropriate locations, pads 82 are formed upon the upper surface of the bracket 62 for the installation of an electric driving motor 84 for the wheel dressing roller.

As seen in Figure 3, the bracket 62 at its forward end is formed with an upwardly projecting part 86 perpendicular to the surface of the cradle 48, and, as shown in Figure 4, is provided in its front face with a T-slot 88 in which the mating rib 90 formed on the roller support 92 is slidably engaged. Screws 94 and washers 96 are provided for the purpose of rigidly securing said support in correct vertical position upon the part 86 of the bracket 62. These screws are disposed through vertically elongated slots 98 in the bracket part 86, and the vertical adjustment of the support 92 is effected by means of the screw 100 which is threaded through a rearwardly projecting part 102 on the upper end of the support 92 and has bearing engagement at its lower end upon the upper edge of the part 86 of bracket 62.

The vertical adjustment of support 92 is measured by the position of an index finger or pointer 108 on said support with respect to the indicia 106 inscribed upon the plate 104 attached to bracket 62 (see Figure 1).

As shown in Figure 4 of the drawings, the support 92 extends across the front face of bracket part 86 and is provided at one of its ends with a housing 93 for the ball thrust bearings 110 between which similar annular spacers 112 are positioned. The reduced end of the dressing roller shaft 114 is journaled in these bearings which are retained in position within the bearing

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housing 93 by means of the cap member 116 which is fixed to said housing by means of suitable screws indicated at 118. The extremity of the shaft 114 beyond the outer bearing 110 is further reduced in diameter to receive the sprocket sleeve 120 which is restrained against rotation relation to the shaft by means of the key 122. A recess in the end of the sprocket sleeve 120 receives a flanged clamping member 124 which is removably attached to the extremity of the shaft by means of the screw 126. In this manner, the inner end of the sprocket sleeve 120 is firmly held against the outer thrust bearing 110. The sprocket formed on the outer end of said sleeve is operatively connected with a similar sprocket on the drive shaft of motor 84 by means of the chain 128. The sprockets and drive chain are preferably enclosed within a suitable guard housing indicated at 130. Between the annular cap member 116 and the outer surface of the sprocket sleeve 120 a conventional type of grease seal 132 is inserted to effectively retain the lubricating grease in the bearings 110 while excluding undesirable foreign matter. A similar seal 134 is employed at the opposite side of the bearings between shaft 114 and the wall of the housing 93.

The support 92 at its other end has a slot 136 formed in the front face thereof to receive a rib or key 135 formed upon one side of a bearing housing 138 which is rigidly secured to the support 92 by means of screws indicated at 140. This end of the roller shaft 114 has a threaded section and a terminal portion 145 of reduced diameter extending therefrom upon which the bushing 142 is engaged and keyed against relative rotation by means of the pin 144 projecting from the threaded portion of the shaft 114 into a bore formed in the enlarged inner end of the bushing 142. This bushing is journaled in a bearing 146 mounted in the housing 138. A nut 148 threaded upon the bushing and the locking washer 150 retains the bearing in proper axial position. A cap member 152, removably secured by means of the screws 154 to the housing 138, retains the outer race of the bearing 146 in its proper axial position. A grease seal 156 is interposed between the cap member 152 and the bushing 142 and a similar seal 158 is provided between the inner end of the bushing and the housing 138.

Upon the central portion of the shaft 114 the hardened steel dressing or contouring roller 160 is fixed against rotation by means of a suitable key 162. The washer 164 and nut 166 engaged upon the threaded portion of the shaft 114 securely clamps the roller in a fixed axial position relative to the shaft against the shoulder 168 formed upon said shaft. The peripheral surface of the roller 160 is accurately contoured in accordance with the predetermined contour to be produced on the work. In the present instance, in Figure 4 we have shown this roller provided with alternating V-shaped ridges and grooves, as at 161, for the purpose of providing the grinding wheel with a profile contour which will accurately grind screw threads upon a roughly pre-formed work-piece.

On further reference to Figure 3 of the drawing, it will be seen that the slide 26 is formed with a part 27 depending through the opening 29 in the plate 16, said part having two longitudinally spaced apertured lugs 170 and 172 respectively, which are positioned in a cavity 15 formed in the base 14. The lug 170 is internally threaded to receive an externally threaded bushing 174 while the aligned aperture of the lug 172

receives a slidable bushing 176 which is internally threaded. The lug 172 is formed with a keyway for the reception of the key 173 carried by the bushing 176 so that while said bushing may axially slide relative to the lug 172 it is restrained against rotation with respect thereto. A powerful coil spring 180 is interposed between the bushings 174 and 176 and is supported at its opposite ends upon reduced diameter portions of the respective bushings. A shaft 182 extends through the bushing 174 in clearance relation thereto and has threaded engagement in the bushing 176 so that the latter bushing acts as a traveling nut to compress the spring 180, as well as to move said bushings, the slide 26 and the various parts supported thereon as a unit relative to the plate 16 and the base 14.

Extending rearwardly from the cavity 15, the base 14 is formed with a longitudinal bore in which the sleeve 184 is non-rotatably mounted for sliding movement by means of a suitable key 186. Through this sleeve an unthreaded section of the shaft 182 extends, the rear end of the sleeve being counterbored to receive the bearing bushing 190 for said shaft. Rearwardly of this bushing, the end of the shaft 182 is of reduced diameter and has a cylindrical member 192 fixed thereto by means of a key 194. This member is provided with suitably spaced handles 196 projecting rearwardly therefrom by means of which it may be conveniently rotated. A collar 198 is threaded upon the rear extremity of shaft 182 to prevent axial displacement of the member 192 and retain the annular flange 200 thereof in overlapping relation upon the periphery of the diametrically enlarged rear end of the sleeve 184. This flange has a beveled surface with indicia 202 inscribed thereon to cooperate with an index line on the adjacent peripheral surface of the sleeve 184 whereby the rotation of the shaft 182 may be accurately measured.

The sleeve receiving bore through the base 14 is provided at its rear end with the annular shoulder 185 against which the rear end of sleeve 184 is adapted to abut and thereby limit axial forward movement of said sleeve. Axial movement of the sleeve in the forward direction relative to shaft 182 is prevented by contact of the sleeve with the collar 183 formed upon said shaft.

The forward end portion of sleeve 184 is formed with a longitudinal series of external rack teeth 204 which are engaged by the teeth of a pinion 206 secured against rotation relative to the manually operable shaft 208 by the key 210. This shaft is transversely mounted in the base 14 and is provided at one end with the handle 212 for convenient operation. A lever 214 is fixed at one of its ends to the other end of the shaft 208 by the pin indicated at 216, and upon rotation of said shaft is adapted to actuate two limit switches 218 and 219. The properly timed simultaneous operation of these switches is obtained by means of the screws 220 adjustably threaded in the end of the lever 214 and locked in adjusted position by means of the nuts 222.

From the above, it will be evident that the mechanism, including shaft 182 and sleeve 184, is rearwardly movable on the base 14 to the extent permitted by the length of the rack teeth 204. In order to retain the mechanism in this retracted position against the force of gravity, the sleeve 184 is provided with a notch or recess 224 adapted to receive a detent 226 mounted in an opening in the base 14 and constantly urged into contact with the sleeve by the spring 228.

The spring is retained in position and its tension properly adjusted by means of the plug 230 threaded into the outer end of the opening in the base. This spring and the detent, however, offer but negligible resistance to a positive force manually applied to the handle 212.

To the top of the roller support 92 one end of a forwardly and downwardly curved bracket member 232 is pivotally connected as at 234. The lower end face of this bracket is recessed to receive a wire brush 236 which is detachably held in proper position by means of the clamping plate 238 and the screws 240. The upper side of the bracket 232 is provided with a recess 242 which contains a compression spring 244 retained therein by means of a cap screw 246 disposed loosely through an opening in the bracket and having threaded engagement in a lug or extension projecting from the front face of the support 92. By adjustment of this screw, the pressure of the spring 242 on the bracket 232 may be regulated to yieldingly hold the brush 236 in proper contact with the contoured peripheral surface of the roller 160 so that said brush will operate to continuously remove such particles of abrasive material as may adhere to the contoured surface of the roller 160.

In the operation of centerless grinding machines, it is well understood that due to variation in diameter, metallurgical characteristics and other details, different kinds of work-pieces will occupy a position in the grinding throat at a higher or lower elevation with respect to a common plane intersecting the axes of the grinding and work control wheels. Therefore, it is usual to provide means for vertically adjusting the work rest blade in the grinding throat. It is apparent that the grinding wheel will not reproduce its contoured profile on the work with equal fidelity or accuracy in all possible positions of the work-piece in the grinding throat. Consequently the peripheral profile of the grinding wheel must be altered to compensate for such difference in position of various work-pieces in the grinding throat.

Referring more particularly to Figure 1 of the drawings we accomplish this alteration in the profile of the grinding wheel by adjusting the point of tangential contact between the roller 160 and the grinding wheel to the same relationship with the radius line of the grinding wheel which is parallel to the slide 26, as that which exists between the point of tangential contact of the grinding wheel with the work and a plane intersecting the centers of the grinding wheel and work control wheel. Thus, as seen in Figure 1, the line of tangency between the roller 160 and the grinding wheel is indicated at A, and, in the position of the roller shown in full lines, the point of tangential contact is substantially coincident with the radius line B intersecting the axes of the grinding wheel and dressing roller 160 and approximately parallel to the slide 26. If the adjusting screw 100 is now operated to adjust the support 92 for a distance measured on the scale 104 to dispose the roller 160 in the dotted line position C, the point of tangential contact of said roller with the periphery of the grinding wheel will then be coincident with the line D, also parallel to slide 26, thus producing a line of thrust of the roller 160 against the grinding wheel spaced from the wheel axis for the distance E. It is evident that in the latter position of the roller 160 the contoured profile of the grinding wheel will be somewhat altered from

that which would be produced with the roller 160 operating in the position shown in full lines in Figure 1.

In preparing the mechanism for operation, the several adjustments above described are first made to position the roller 160 in accordance with the helix angle of the threaded work and the vertical position of the work in the grinding throat. It is also necessary to adjust the position of the roller 160 longitudinally of the base 14 by operation of shaft 182 to move the slide 26 forwardly until exact contact is made between the roller 160 and the periphery of the grinding wheel 12, without removing any abrasive material from the grinding wheel. Thus it is apparent that, when shaft 182 is rotated the threaded section thereof cooperates with nut 176 to move said nut, spring 180, bushing 174 and slide 26 as a unit axially of said shaft. Spring 180 prevents axial movement of nut 176 relative to the slide 26. This adjustment is made with the sleeve 184 at the extreme forward end of its stroke and in contact with stop shoulder 185.

The mechanism is now withdrawn from the grinding wheel to the extreme rearward position as limited by the rack teeth 204. Shaft 182 is then rotated by adjustment of the member 192 to move the slide 26 forwardly for an amount measured on scale 202 which is equal to the desired penetration of the peripheral face of the grinding wheel by the roller 160. The handle 212 is then rotated in a clockwise direction, forcing the sleeve 184, shaft 182, nut 176, slide 26 and the mechanism supported thereby toward the grinding wheel. Upon contact between the roller 160 and the face of the grinding wheel, further forward movement of said roller is resisted and the continued movement of handle 212 then compresses the spring 180 between the bushing 174 and nut 176, as the latter moves axially with shaft 182. Thus spring 180 is compressed for a distance equal to the pre-set depth of penetration of the grinding wheel. In this final movement of the handle 212 to the extreme clockwise position, limit switches 218 and 219 are closed and the roller driving motor 84 energized. Thereafter the spring 180 continues to force the slide 26 forwardly and feed the roller 160 into the face of the grinding wheel. When lug 172 on the slide again contacts the shoulder 179 on nut 176, further forward movement of the slide and roller 160 ceases and the load on the operating motor 84 for the dressing roller 160 sharply drops. The dressing operation is then completed, and the circuit of motor 84 is automatically opened as will presently be more fully described. The handle 212 is then moved in the counter-clockwise direction, returning the roller 160 to its original position relative to the grinding wheel and the latter is then prepared for further operation upon the work-pieces.

If desired different rollers 160 may be employed for grinding screw threads of different helix angles, said rollers having thread profiles which are distorted sufficiently with respect to the thread profile to be produced on the work to compensate for axial angularity of the work-piece. In this case the adjustable cradle 48 and saddle 32 can be dispensed with and roller supporting bracket 62 mounted directly upon the slide 26.

In Figure 8 of the drawings we have diagrammatically illustrated an electrical control system for the various operating motors during the wheel dressing operation. The three phase alternating current line 252 is adapted to be opened or closed

by the main line switch 254. After passing through the fuses 256, the main line is connected with the terminals of the primary coils of transformers 258 and 260. A relay 266 is connected across the secondary coil of transformer 258 by the lines 262 and 264. The separate wires of main line 252 are connected to the contacts 268, 270 and 272 which are normally open and are operated by the relay 266. Thus, when switch 254 is closed, the current through transformer 258 energizes relay 266, thereby closing the contacts 268, 270 and 272. Contacts 268 and 270 are connected to the heating coil of a thermal overload relay indicated at 274. The contacts of the relay 274 are connected in the line 276 through the secondary coil of transformer 258. Contacts 272 are connected directly to the motor 278 which is also connected to contacts 268 and 270 through the overload relay. Thus, the closing of contacts 268, 270 and 272 will start the motor 278, which is utilized for driving the oil pump 280 in the lubricating system of the grinding machine. Pump 280 is connected hydraulically to the pressure switch 282, so that the starting of motor 278 results in the closing of switch 282 connected in line 284 which in turn is connected to the other terminal of the secondary coil of transformer 258.

The grinding wheel motor 286 is started by depressing the start button 288. This momentarily completes the circuit from point 290 on line 276 through relay 292, contact of thermal overload relay 294, switch 288, stop switch 295, line 296, normally closed contact 298, line 300 to line 284, completing the circuit to transformer 258. Relay 292 is energized, closing contact 302 which creates a holding circuit exclusive of the start button 288, so that current is maintained to relay 292 when said start button is released. Relay 292 when thus energized also closes the contacts 304, 306 and 308, establishing a direct circuit from main line 252 through contacts 304, 306 and 308 and the heating coils of thermal overload relay 294 to the grinding wheel motor 286 and starting the motor.

It will be understood that the wheel dressing operation cannot be started until after the grinding wheel has been brought to a complete stop, since otherwise, the abrasive grinding wheel would destroy the peripheral contour of the dressing roller. Therefore when the grinding operation has continued, until it becomes apparent that a dressing or truing operation is necessary, it is desirable that the rotation of the grinding wheel be instantly stopped so that the dressing operation can be initiated without loss of time. Momentum of the heavy grinding wheel and its motor armature tends to continue the rotation of the wheel for a protracted time period, and we have solved this problem by the following control system:

A plugging switch 310 is mechanically connected to the grinding wheel spindle and, during operation of the wheel, maintains the contacts 312 and 314 in lines 316 and 318, respectively, in closed position. Therefore, these contacts remain closed after the stop switch 295 is operated to open the circuit through the grinding wheel motor operating relay 292. The de-energization of the relay 292 allows the normally closed switch contacts 324 to close, establishing a circuit from point 320 on line 276 through relay 322, contacts 324, line 316, switch contact 312 and line 325 to line 284. The energization of relay 322 closes contacts 326, 328, 330 and 332. Thus current is conducted from the main line 252 to contact 326, line 334

and the alternating current coils of the saturable reactor 336 to line 338 which leads to the grinding wheel motor 286. Current also passes through contacts 328, line 340 and the alternating current coils of saturable reactor 342 to line 344 which leads to the grinding wheel motor 286. The grinding wheel motor 286 is also connected to main line 252 through contacts 330, lines 346, the alternating current coils of saturable reactor 348 and line 350. It will be noted that this connection through contacts 328, 328 and 330 reverses the direction of the current through motor 286 and thus applies an electrical braking force to the armature and wheel spindle which results in a rapid stopping of rotation of the spindle and grinding wheel. Further, the saturable reactors 336, 342 and 348 provide a means for closely regulating the current input to motor 286.

The secondary coil of transformer 260 is connected directly to the alternating current terminals of a bridge rectifier 352. The direct current leaving the rectifier 352 passes through line 354, the direct current coils of saturable reactors 336, 342 and 348, variable resistance 356, contact 360, contact 332 and returns to the rectifier 352 through line 333. It will be noted that the operation of plugging switch 310 also energizes relay 364 by means of a circuit from point 366 on line 276 through line 367, relay 364, line 318, switch contacts 314 and line 325 to line 284, thus closing the normally open contacts 360. By adjusting the resistance 356, therefore, the amount of current supplied to motor 286 may be regulated.

The limit switches 218 and 219, above described are contacted by the screws 220 just before the dressing roller 160 touches the grinding wheel and, before contact of roller 160 with the periphery of the wheel, said switches are simultaneously closed while spring 180 is being compressed. Since handle 212 is held in this position until the dressing operation is completed it will be seen that switches 218 and 219 remain closed during the dressing operation.

When the switches 218 and 219 are thus closed, the operating motor 84 for the wheel dressing roller is energized by establishing a circuit from the point 368 on line 276 through line 370, relay 372, the contacts of thermal overload relay 374, line 376, normally closed contacts 378, limit switch 218 and line 380 to line 284. The energization of relay 372 closes contacts 362, 384, 396, which establishes a direct circuit from line 252 through contacts 382, 384 and 386 and the heating coils of thermal overload relay 374 to the wheel dressing motor 84. It will be observed that the circuit energizing relay 292 for the operation of the grinding wheel motor 286 is held open during the operation of the dresser operating motor 84 since the energization of relay 372 for the latter motor opens the normally closed contacts 298 in the grinding wheel motor circuit. The primary coil of a transformer 390 is installed in the line from contacts 386 to motor 84. Thus, a voltage is induced in the secondary coil of transformer 390, one terminal of which is connected to the filament of a gas filled tube 392 by means of line 394. The other terminal of the secondary coil of transformer 390 is connected through variable resistance 396 and line 398 to the grid of the tube 392.

A transformer primary coil 400 is connected by lines 401 across two wires of the main line 252 and induces a voltage in a secondary winding 402 connected across the filament of tube 392 by wire 403, and in another secondary winding 404 one terminal of which is connected by wire 405 to the

plate of tube 392. The other terminal of winding 404 is connected by line 407 to the relay 406 and through line 408 to the secondary winding 402. A condenser 410 is installed across the terminals of relay 406.

When the motor 84 is started, the voltage induced in the secondary winding of transformer 390 causes tube 392 to function and conduct current from the grid on line 398 to the plate and through winding 404, energizing relay 406. Contact 412 then closes and a circuit is established from the point 414 on line 276 through line 416, relay 418, contact 412 and line 420 to line 284. This energizes the relay 418 and closes contacts 422 and 424. Thus a holding circuit for relay 372 is established from point 368 on line 276 through 370, 372, 374, 376, 424, 219 and line 426 to line 284.

At the same time, relay 428 is energized by the following circuit: From point 430 on line 276, through line 432, 428, 422 and line 434 to line 284. Energizing the relay 428 causes the normally closed contact 378 to break the circuit 368, 370, 372, 374, 376, 378, 218, 380, 284, but the relay 372 is retained in energized condition by the aforementioned holding circuit. Relay 428 also closes contact 436 providing the following holding circuit for relay 428 after relay 406 is no longer energized; from point 430, 432, 428, 436, 218, 380 to 284.

As above described, the de-energization of the grinding wheel motor relay 292 allows the normally closed contacts 324 to close and establish a braking circuit through the plugging switch 310. This circuit is broken when the grinding wheel finally stops and plugging switch 310 opens contacts 312 and 314. However, when the dresser motor 84 is started, a new circuit is established from point 320 through 322, 324, contacts 438, and line 325 to line 284, thus reapplying the reversing current to the motor of the grinding wheel 12. It is to be noted that, since relay 364 is not energized, the direct current through the saturable reactors now passes through normally closed contacts 362 and variable resistance 356, which is used to control the current to motor 286 while motor 84 is operating.

By operating the grinding wheel motor 286 while the dressing roller motor 84 is operated the load imposed on the latter motor is appreciably reduced. When the current to motor 286 is adjusted to a value sufficient to overcome the inertia of the motor armature and of the relatively heavy grinding wheel, the load on the roller 160 and motor 84 is much smaller than would be the case, if it were necessary for the roller 160 to turn the dead weight of the grinding wheel. If desired, this current value supplied to the motor 286 may be such that the grinding wheel is rotated at approximately the same peripheral speed as the dressing roller 160. Thus, as the wheel and roller are rotated in the directions indicated by the arrows in Figure 1 of the drawings, peripheral friction at the point of tangential contact between said wheel and roller will be absolutely nil so that the formation of the usual cloud of abrasive dust in the immediate vicinity of the machine is substantially absent. However, the pressure force applied by spring 180 to the roller 160 in the manner above explained results in the penetration of said dressing roller into the relatively soft peripheral face of the grinding wheel to the required predetermined depth with the highly accurate truing or contouring of the wheel profile as may be required to exactly reproduce such profile

upon the work-piece, under predetermined conditions of operation, as heretofore described.

When the roller 160 has penetrated the grinding wheel 12 to the desired depth, further penetration is mechanically prevented as above described. When this point is reached, the motor 84 merely rotates the roller 160 idly and its load current decreases sharply in value to a point insufficient to operate the tube 392, with the result that relay 406 is de-energized. This causes the contacts 412 to open and de-energize relay 418. Contacts 424 therefore open and de-energize relay 372, opening the line to motor 84 and stopping said motor. Relay 428 remains energized through the circuit 430, 432, 428, 436, 218, 380 and 284 and thus prevents the re-establishment of the original circuit to relay 372 by holding contact 378 open. Relay 428 is de-energized when the limit switch 219 is opened and the dressing mechanism is withdrawn from the wheel 12 to complete the cycle.

An alternative method of automatically stopping the operation of motor 84 is illustrated in Figure 9. This provides for the installation of the primary winding 440 of a current transformer in the motor circuit. A secondary winding 442 of said transformer is connected to both plates of a full wave rectifier tube 444. Adjustable resistances 446 and 448 are connected from each terminal of the secondary winding 442 to a center tap provided on that winding. The center tap is also connected through line 450 to relay 406. Another secondary winding 452 corresponding to the secondary winding 402 of Figure 8, is connected to the filament of tube 444 and line 454 connects this circuit to the other terminal of relay 406. A protective resistance 456 is installed across lines 450 and 454. There is also connected, in parallel with the secondary winding 442, a resistance 458 with the characteristic of offering high resistance at low voltage but having a very much reduced resistance value at high voltages. This is merely a protective device for preventing abnormally high voltages from destroying the secondary winding 442.

It will be evident from the above that the starting current for motor 84 will induce a high voltage across the secondary 442 of the current transformer. This is rectified by the tube 444 and conducted through relay 406, closing contacts 412 and causing the same sequence of events as in the method first described. The variable resistances 446 and 448 permit pre-setting of the voltage value at which relay 406 is de-energized to stop motor 84 when the wheel dressing operation is completed.

From the foregoing description and the accompanying drawings, it is believed that the several novel features of our invention and the operation thereof may be clearly understood. It will be seen that we have provided a profile dressing or contouring unit for abrasive grinding wheels which is particularly desirable for use in connection with high precision grinding machines of the centerless type. In a very compact organization, provision is made for maximum flexibility in the adjustment of the wheel dressing roller to accurately locate or position its contoured surface with relation to the peripheral surface of the grinding wheel so that in the dressing or contouring operation the particular conditions required in the grinding of various different kinds of work-pieces are compensated for and the contoured surface of the dressing roller will be reproduced upon the

work-piece with a high degree of accuracy. At the same time, it will be obvious that since our invention is characterized by the pressure contouring of the grinding wheel profile as distinguished from a process of attrition, there will be a minimum reduction in grinding wheel diameter in each wheel dressing operation. Also the automatic limitation of the depth of penetration of the dressing roller into the face of the grinding wheel obviates possible inaccuracy due to human failure, and assures that only the exact amount of stock is removed from the work-piece in the grinding operation which is necessary to produce the required contoured surface thereon. It will, therefore, be appreciated that the invention herein disclosed is particularly desirable for use in connection with the grinding of roughly preformed threads on rods, bolts or other work-pieces of various diameters, where the pitch, helix angle and concentricity of the screw threads are factors of prime importance.

By the provision of the co-related control circuits for the operating motors of the grinding wheel and the wheel dressing roller, the rotation of the grinding wheel may be reversed and the dressing operation quickly inaugurated. It will further be evident that the several adjustments of the dressing roller above described to position the same relative to the axial center of the grinding wheel as well as the advancing and retracting movements of the roller carrying slide 26 can be easily and quickly made. Since the accumulation of abrasive dust upon the several relatively movable parts of the mechanism is unlikely minimum wear of said parts and highly efficient operation is obtained. It will also be noted that the several cooperating mechanical parts are of rugged and durable structural form and may be readily assembled so that production cost of our improved wheel dressing unit will be reasonably low.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. Dressing mechanism for abrasive grinding wheels, comprising a base adapted to be mounted on a machine frame in proximity to the grinding wheel, a slide movable on said base toward and from the periphery of the wheel, a contoured wheel dressing roller, means mounting said roller on the slide including means rotatably supporting the roller with its axis in a transverse plane normal to the path of movement of the slide, means operatively associated with the roller supporting means for angularly adjusting the roller supporting means to dispose the roller axis in said plane at a predetermined inclination relative to the axis of the abrasive wheel, and means mounted in the base and operatively connected with said slide to actuate the latter and including spring means rendered effective upon contact of the roller with the wheel to resiliently urge the contoured surface of said roller under pressure into the peripheral face of the abrasive wheel.

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2. The combination defined in claim 1, wherein said roller mounting means includes means adjustably positioning said roller to locate the point of tangential contact of its contoured surface and the line of thrust pressure against the periphery of the wheel circumferentially thereof in predetermined spaced relation from a plane parallel to the slide and intersecting the axial center of said wheel.

3. The combination defined in claim 1, in which said means for angularly adjusting the roller supporting means includes a bracket carried by the slide, together with means adjustably mounting the roller supporting means on said bracket for movement relative to the slide to locate the point of tangential contact of the contoured surface of the roller and the line of thrust pressure against the periphery of the wheel circumferentially thereof in predetermined spaced relation from a plane parallel to the slide and intersecting the axial center of said wheel.

4. The combination defined in claim 1, in which said means for angularly adjusting the roller supporting means comprises a saddle on said slide, a supporting cradle for the roller rockable in said saddle transversely of the slide, and means for releasably clamping said cradle in adjusted position in the saddle.

5. The combination defined in claim 1, in which said means for angularly adjusting the roller supporting means comprises a saddle on said slide, means for transversely adjusting said saddle on the slide, a supporting cradle for the roller rockable in said saddle transversely of the slide, and means for releasably clamping said cradle in adjusted position in the saddle.

6. In wheel dressing mechanism for a grinding machine having a rotatable grinding wheel, a base adapted to be mounted on the machine in proximity to the grinding wheel, a slide movable on said base toward and from the periphery of the wheel, a wheel dressing tool mounted on said slide, a shaft, means in the base mounting said shaft for axial and rotative movement, a nut threaded on said shaft and means connecting said nut with the slide, restraining the nut against rotation while permitting relative movement between the slide and nut axially of the shaft, an energy storing device coacting with said nut and a part on the slide, means for rotating said shaft in the retracted position of the slide, to move the nut, slide and energy storing device as a unit axially thereof and initially position the dressing tool in predetermined spaced relation to the wheel, and additional means operatively connected to said shaft mounting means for axially moving said shaft to advance the slide and energize said storing device, after pressure contact between the tool and wheel, to continue the advancing movement of the slide independently of said shaft and cause the tool to penetrate the peripheral face of the wheel to a depth corresponding to said initial adjustment of the tool.

7. The combination defined in claim 6, wherein said mounting means comprises a bearing supporting said shaft and slidably keyed in the base, and said additional means comprises manually operable means on the base connected with said bearing to impart unitary axial movement to said bearing and shaft.

8. The combination defined in claim 6, wherein said means for mounting the shaft comprises a rack on which the shaft is rotatably mounted, and said additional means comprises a manually operable pinion coacting with said rack.

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9. The combination defined in claim 6, wherein said means for mounting the shaft comprises a rack on which the shaft is rotatably mounted, and said additional means comprises a manually operable pinion coacting with said rack, together with means mounted in the base and coacting with the rack to yieldably retain the shaft and slide in retracted position.

10. In combination with a grinding machine having a motor driven abrasive wheel, a contouring roller mounted in opposed relation to the periphery of said wheel, means for applying a pressure force to said roller to cause its contoured surface to penetrate the peripheral face of the abrasive wheel to a predetermined depth, an operating motor for said roller, a circuit for said motor, and means in said circuit automatically operable when said predetermined depth of penetration of the abrasive wheel is reached to open the circuit and de-energize said motor.

11. The combination defined in claim 10, wherein said force applying means includes manually operable means for moving said roller into and out of contact with said wheel, and switch means in the roller motor circuit actuated to closed position by a part of said manually operable means to maintain said motor in energized condition during pressure engagement of the contouring roller with the abrasive wheel.

12. The combination defined in claim 10, together with an operating motor for the abrasive wheel and a circuit energizing said motor to rotate the wheel in grinding direction, a reversing circuit for said wheel motor, means for closing the circuit for the roller motor upon pressure engagement of the roller with the abrasive wheel, and means interconnected with said last named means for simultaneously closing the reversing circuit of the abrasive wheel motor to drive said wheel in a reverse direction during the pressure contouring operation of said roller.

13. In combination with a grinding machine having an abrasive wheel, an operating motor therefor, a contouring roller mounted in opposed relation to the periphery of said wheel, means for applying a pressure force to said roller to cause its contoured surface to penetrate the peripheral face of the abrasive wheel to a predetermined depth, an operating motor for said roller, energizing circuits for the respective motors, start and stop switches in the wheel motor circuit, additional switch means in said circuit controlled by the abrasive wheel and maintained in closed position during rotation of said wheel in grinding direction, means responsive to operation of said stop switch for closing a motor reversing circuit through said additional switch means, and apply braking torque to said wheel, means for closing the energizing circuit for the roller motor upon pressure engagement of said roller with the abrasive wheel, and means interconnected with said last-named means for simultaneously closing the reversing circuit of said abrasive wheel motor independently of said additional switch means, to drive said wheel in the reverse direction during the pressure contouring operation of said roller.

14. The combination defined in claim 13, together with means in the roller motor circuit automatically operable to open said circuit and de-energize the motor when the contouring roller has penetrated the face of the abrasive wheel to a predetermined depth.

15. The combination defined in claim 13, together with means in the reversing circuit for the abrasive wheel motor to regulate the cur-

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rent value supplied to said motor and rotate said wheel at a predetermined speed relative to the speed of rotation of the contouring roller.

16. The combination defined in claim 10, together with an additional operating motor and control circuit therefor for rotating the abrasive wheel at substantially the same peripheral speed as said contouring roller.

17. Wheel dressing mechanism, comprising a base adapted to be mounted on a machine frame in proximity to an abrasive grinding wheel, a slide movable on said base toward and away from the periphery of said wheel, a wheel dressing roller rotatably mounted on said slide, and actuating means for said slide comprising an energy storing device, fixed means on said slide supporting one end of said device, a member slidably mounted on said slide supporting the opposite end of said device, a manually operable element having a threaded connection with said member, a sleeve slidably mounted in said base rotatably supporting said element, means preventing relative axial movement between the said sleeve and said element, and means in said base operatively connected with said sleeve and operable to impart unitary axial movement to said sleeve, said element and said member, to advance the slide and contact the roller with wheel and thereafter move said member relative to the slide to render said energy storing device effective to continue advancing movement of the

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slide and urge said roller into the peripheral face of the grinding wheel.

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