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GRINDING WHEEL TRUING APPARATUS

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Fig. 2

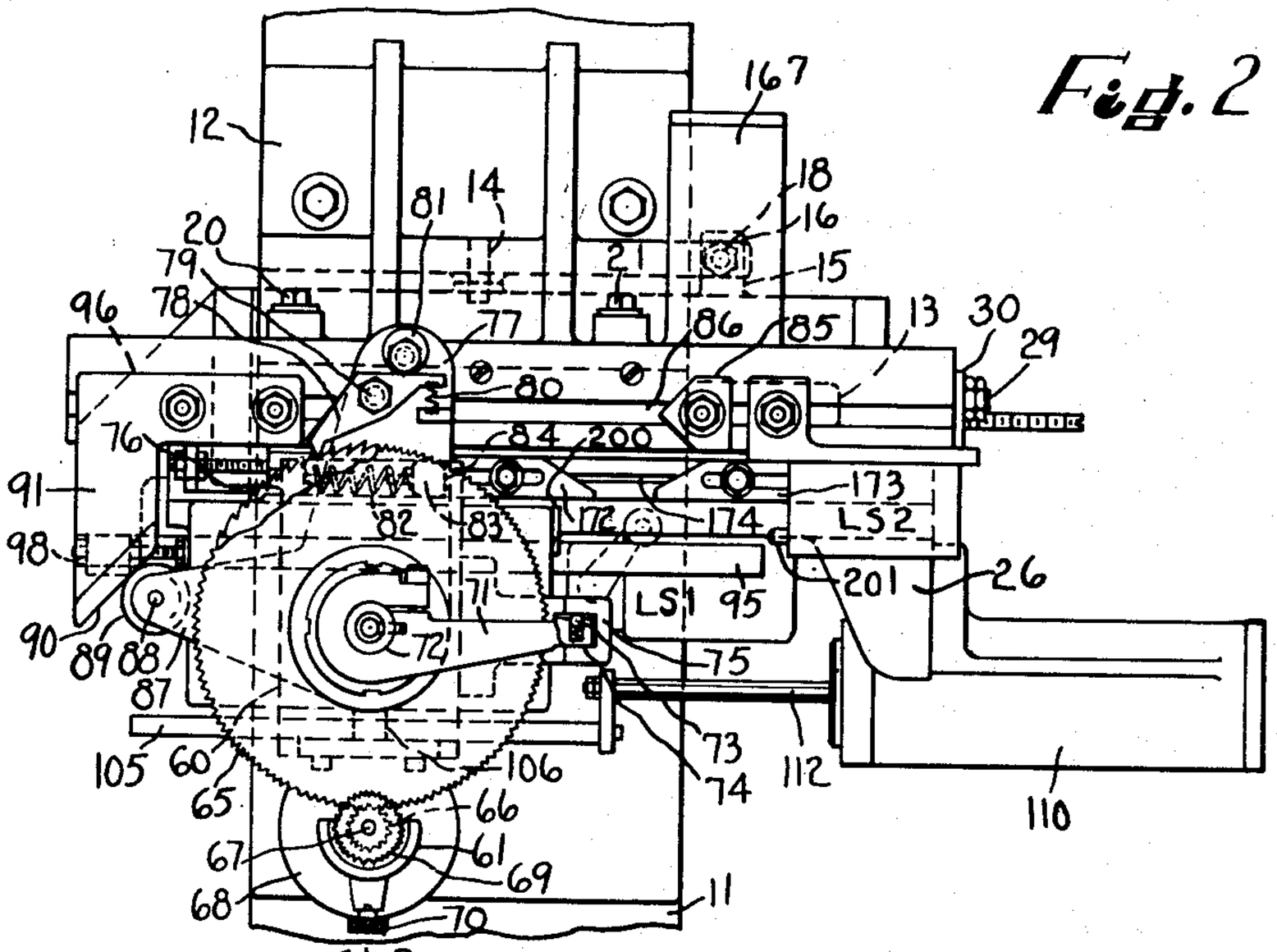
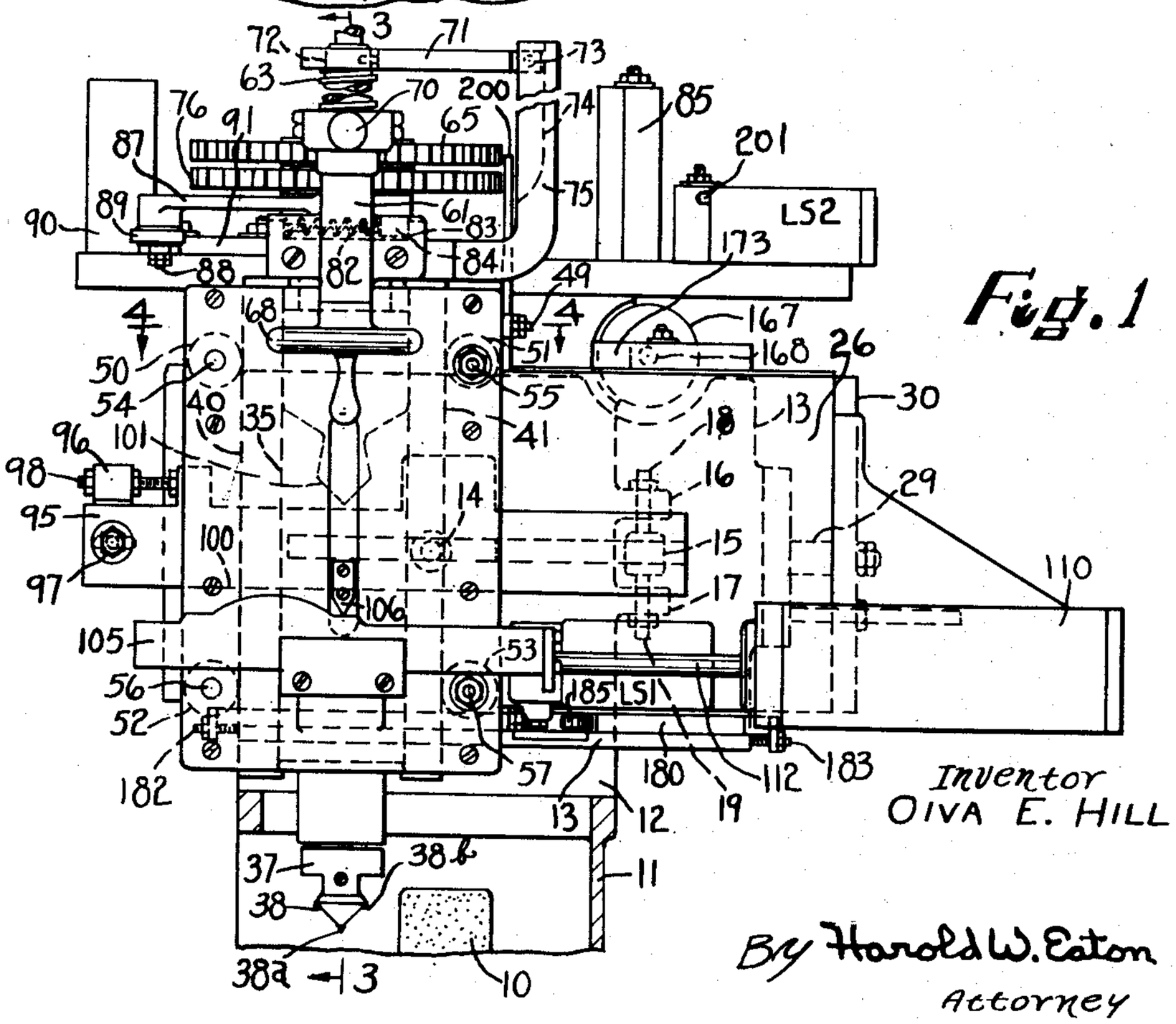



Fig. 1




Inventor
OIVA E. HILL

By Harold W. Eaton
Attorney

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GRINDING WHEEL TRUING APPARATUS

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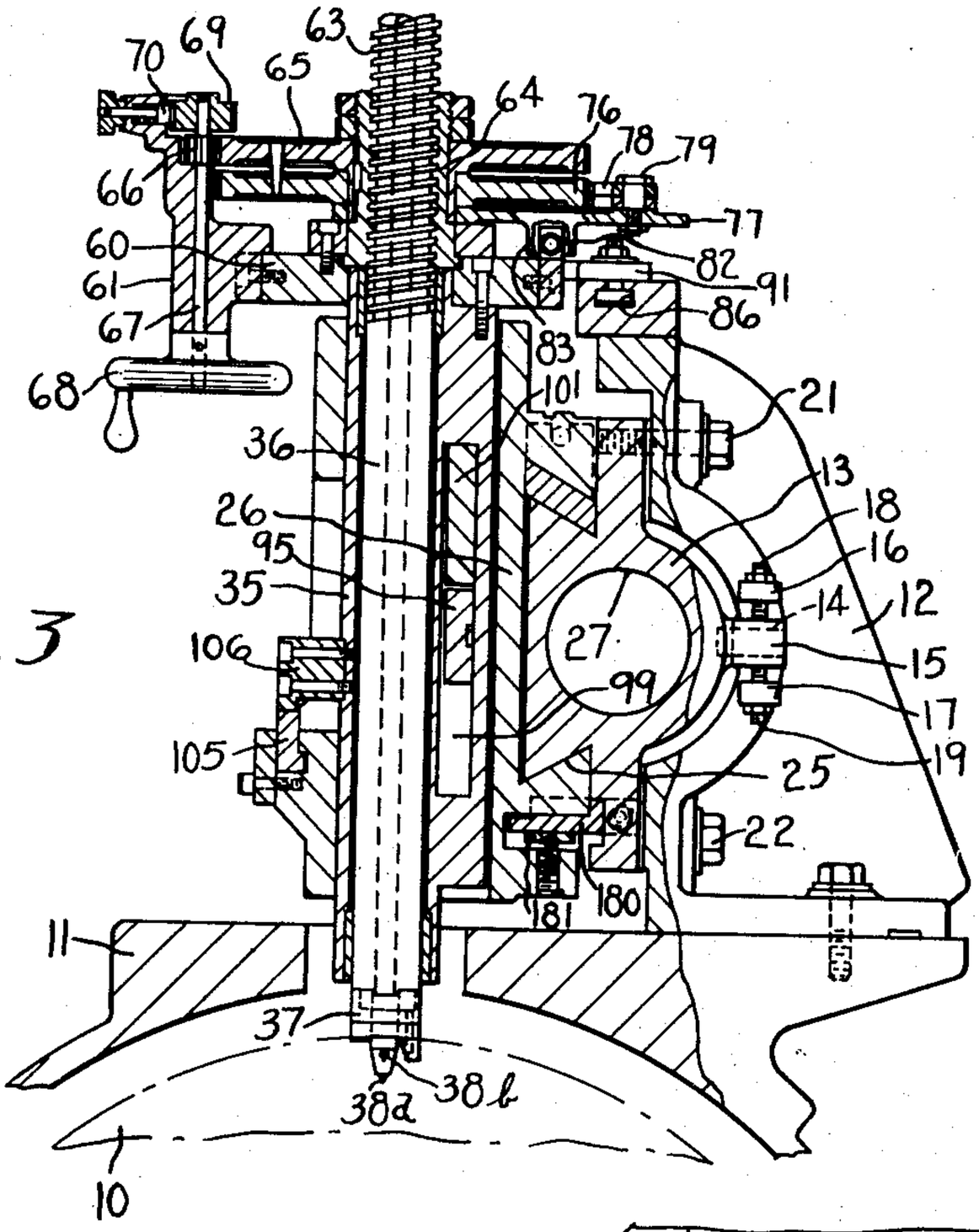


Fig. 3

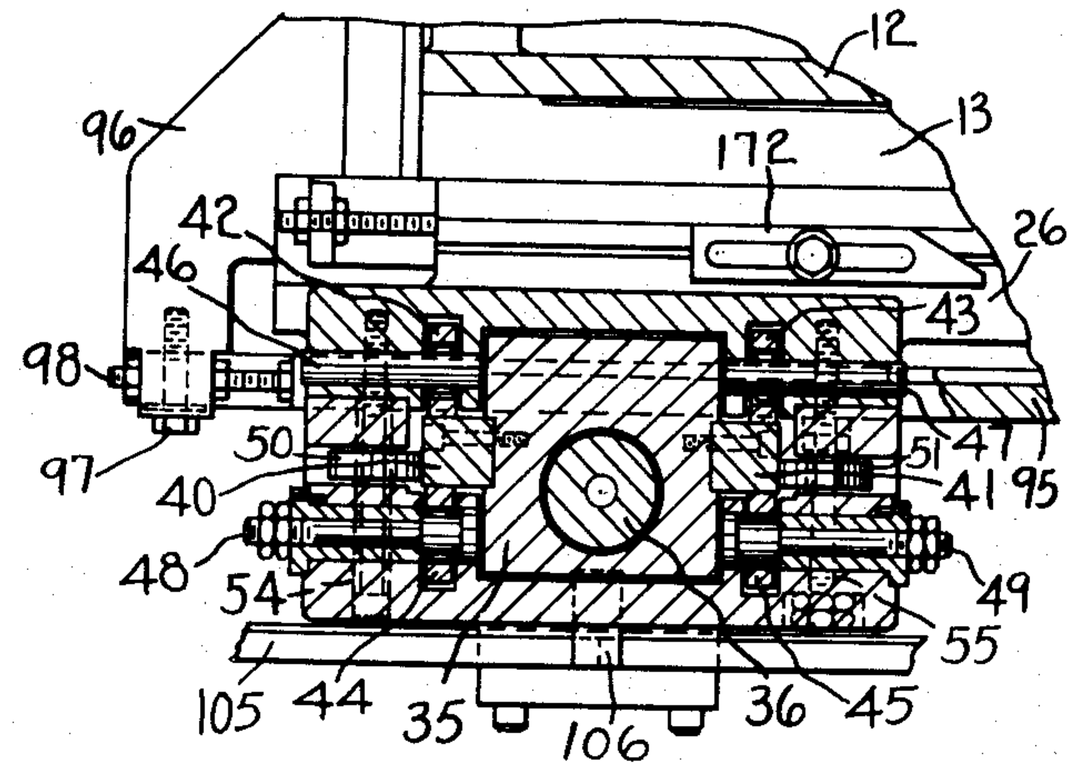


Fig. 4

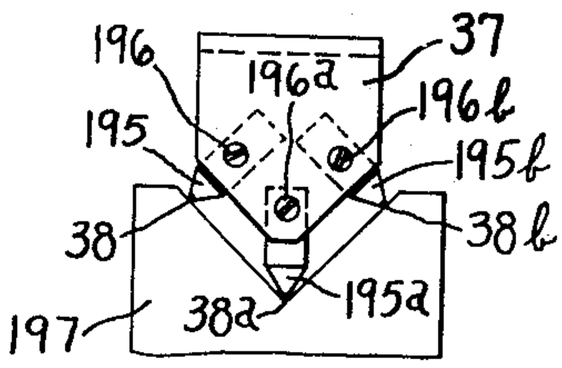


Fig. 8

Inventor
OIVA E. HILL

By Harold W. Eaton
Attorney

Nov. 17, 1953 O. E. HILL 2,659,359

GRINDING WHEEL TRUING APPARATUS

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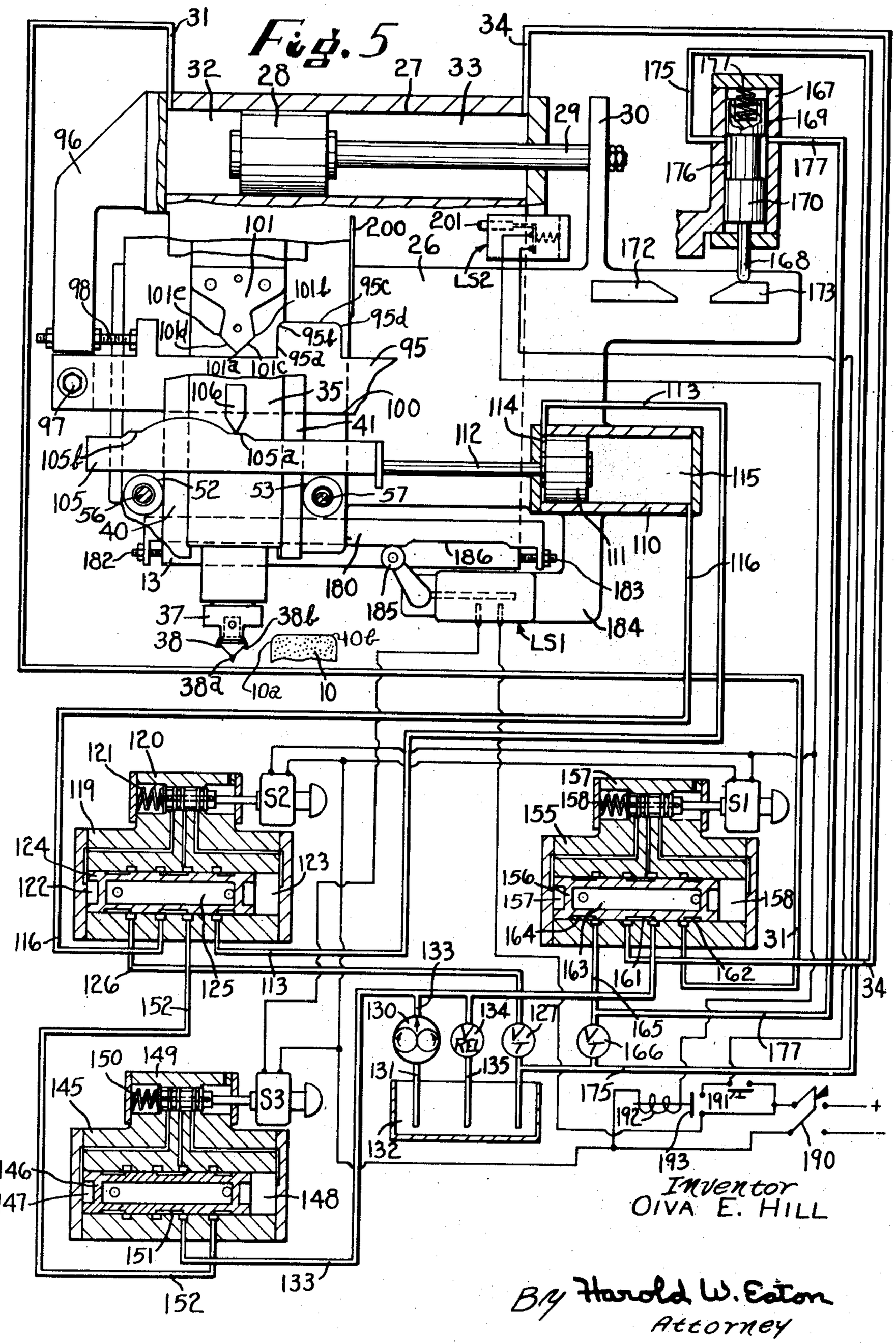
Fig. 5




Inventor
OIVA E. HILL

By Harold W. Eaton
Attorney

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GRINDING WHEEL TRUING APPARATUS

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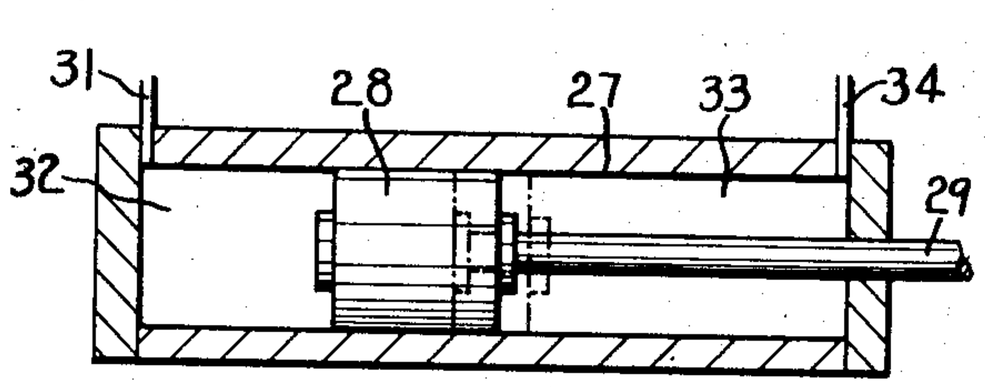
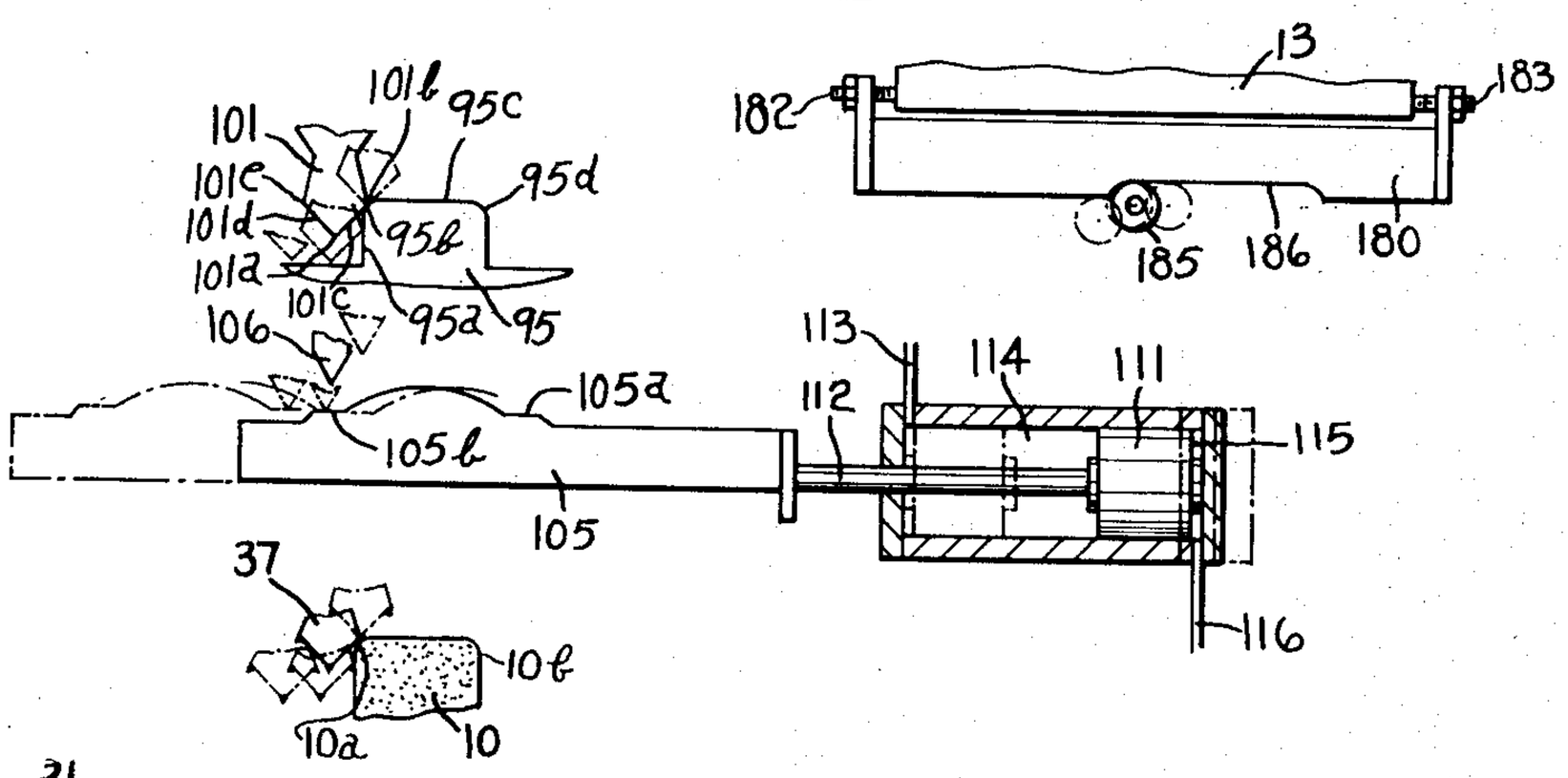



Fig. 6



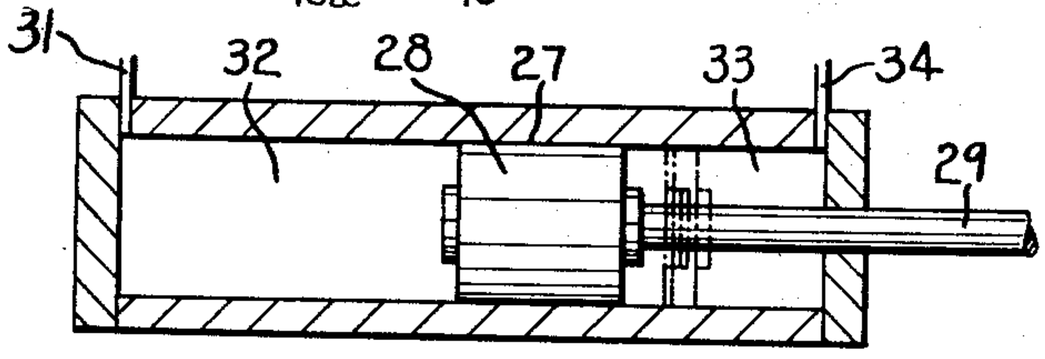
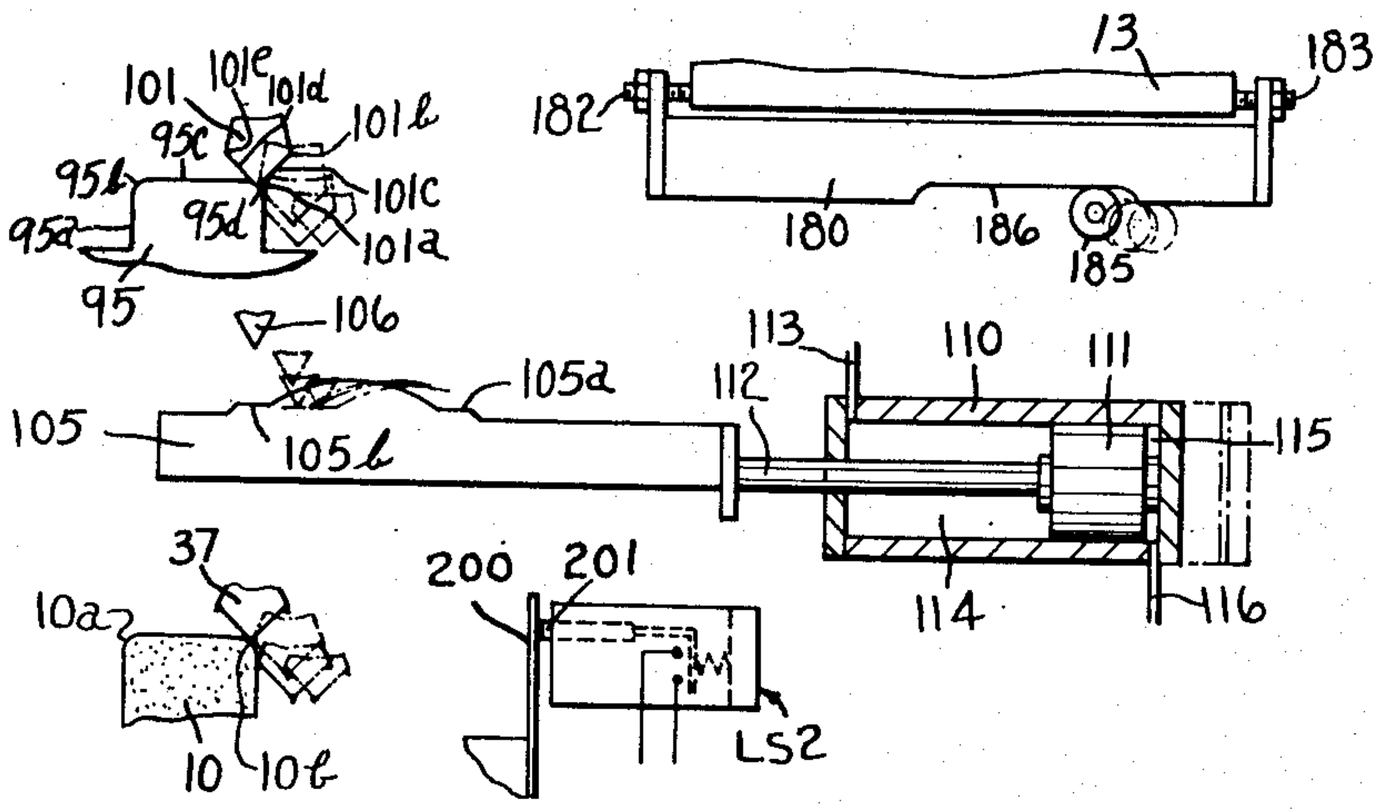




Fig. 7




Inventor
OIVA E. HILL

By Harold W. Eaton
Attorney

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# UNITED STATES PATENT OFFICE

2,659,359

## GRINDING WHEEL TRUING APPARATUS

Oiva E. Hill, West Boylston, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application May 15, 1951, Serial No. 226,453

4 Claims. (Cl. 125—11)

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The invention relates to a grinding wheel truing apparatus and more particularly to a truing apparatus for truing a predetermined shape on the periphery of a grinding wheel. The present invention relates to a modified form of the truing apparatus disclosed in my copending application, Serial No. 183,775, filed September 8, 1950.

One object of the invention is to provide a simple and thoroughly practical truing apparatus for truing an irregular surface on the periphery of a grinding wheel. Another object is to provide a truing apparatus for truing not only the peripheral surface of a grinding wheel but also the adjacent side faces thereof. Another object of the invention is to true the peripheral and side faces of a grinding wheel together with a fillet on one or both corners of the grinding wheel. Another object is to provide an hydraulically-actuated electrically-controlled truing apparatus successively to true the side faces and peripheral surface of a grinding wheel. Another object of the invention is to provide a truing apparatus with a hydraulically-actuated cam mechanism automatically to true a side face of the grinding wheel, generate a radius and then true the peripheral surface thereof after which a second radius is trued on the opposite corner of the grinding wheel and the side face adjacent thereto is trued in a single pass of the truing tool holder. Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 1 is a front elevation of the improved grinding wheel truing apparatus;

Fig. 2 is a plan view of the truing apparatus;

Fig. 3 is a vertical sectional view, taken approximately on the line 3—3 of Fig. 1, through the truing apparatus;

Fig. 4 is a horizontal sectional view taken approximately on the line 4—4 of Fig. 1;

Fig. 5 is a combined hydraulic and electrical diagram of the control and actuating mechanism for the truing apparatus;

Fig. 6 is a fragmentary diagrammatic view showing the positions of the parts as the truing tool traverses toward the right;

Fig. 7 is a similar fragmentary diagrammatic view showing the positions of the parts after a further traversing movement of the truing tool toward the right; and

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Fig. 8 is a fragmentary detail view of a modified truing tool holder and a gauge to facilitate precise adjustment of the truing tools.

A truing apparatus has been illustrated in the drawings as applied to a grinding machine having a rotatable grinding wheel 10 which is partially surrounded by a wheel guard 11. The grinding wheel 10, as illustrated, is a single grinding wheel having opposed side faces and a peripheral surface together with two adjoining radii to be trued. The wheel guard serves as a support for an upwardly extending bracket 12. The bracket 12 supports a slide base 13. The slide base 13 is preferably supported on the bracket 12 by means of a stud 14 in order to facilitate a swivelling movement thereof. The slide base 13 is provided with a rearwardly projecting lug 15 which is arranged between a pair of lugs 16 and 17 formed integrally with the bracket 12. A pair of opposed adjusting screws 18 and 19 are provided in the lugs 16 and 17 respectively. The adjusting screws 18 and 19 are arranged on opposite sides of the lug 15. It will be readily apparent from the foregoing disclosure that by manipulation of the screws 18 and 19, the slide base 13 may be angularly adjusted on the pivot stud 14 relative to the slide 12 to facilitate lining up the slide supported thereby. A plurality of clamping screws 20, 21 and 22 are provided to facilitate clamping the slide base 13 in adjusted position to the bracket 12. There are four clamping screws (only three of which appear in the drawings). The screws 20, 21 and 22 pass through elongated arcuate slots (not shown) formed in the bracket 12 and are screw threaded into the slide base 13.

The slide base 13 is provided with a dovetailed slideway 25 which mates with a correspondingly shaped dovetailed slideway fromed on a longitudinally movable slide 26. The slide 26 is arranged to traverse longitudinally in a direction substantially parallel to the axis of rotation of the grinding wheel 10.

A hydraulically operated mechanism is provided for traversing the slide 26 longitudinally comprising a hydraulic cylinder 27 which is formed integral with the slide base 13. The cylinder 27 contains a slidably mounted piston 28 mounted on one end of a piston rod 29. The other end of the piston rod 29 is fastened to a bracket 30 which is formed integral with the longitudinally movable slide 26. When fluid under pressure is passed through a pipe 31 into a cylin-

der chamber **32** (Fig. 5), the piston **28** together with the slide **26** will be moved longitudinally toward the right. During this movement of the piston **28**, fluid within a cylinder chamber **33** may exhaust through a pipe **34**. A suitable fluid pressure system and a control mechanism therefor for supplying fluid under pressure to the cylinder **27** will be hereinafter described.

The longitudinally movable slide **26** serves as a support for a transversely movable vertically arranged sleeve **35**. The sleeve **35** is square in cross-section as indicated in Fig. 4. The sleeve **35** is provided with a central aperture for supporting a vertically movable truing tool spindle **36**. The spindle **36** supports a truing tool holder **37** at its lower end. The truing tool holder **37** supports a plurality of adjustably mounted diamonds or truing tools **38**, **38***a* and **38***b*, which will be more fully described hereinafter.

The sleeve **35** is provided with a pair of vertically extending ribs or guides **40** and **41** (Fig. 4) for controlling the vertical movement of the sleeve. A plurality of rollers **42**, **43**, **44** and **45** (Fig. 4) are mounted on studs **46**, **47**, **48** and **49** respectively carried by the longitudinally movable slide **26**. The rollers **42**, **43**, **44** and **45** are arranged to engage opposite faces of the guides **40** and **41** to support the sleeve **35** for a free vertical sliding movement relative to the longitudinally movable slide **26**. The studs **48** and **49** are preferably provided with eccentric portions for supporting the rollers **44** and **45** respectively to facilitate a transverse adjustment of the rollers so as to take up lost motion between the sliding parts. A similar set of rollers (not shown) are provided for supporting and guiding the lower ends of the guides **40** and **41**.

Similarly a plurality of rollers **50**, **51**, **52** and **53** are provided for engaging the opposed faces of the guides **40** and **41**. These rollers are rotatably supported on studs **54**, **55**, **56** and **57** respectively. The studs **55** and **57** are preferably provided with eccentric portions for supporting the rollers **51** and **53** respectively to facilitate a transverse adjustment of the rollers to take up backlash between the sliding parts. It will thus be seen that an anti-friction sliding support has been provided for the sleeve **35** so that it may be freely moved in a vertical direction transverse to the longitudinally movable slide **26** to carry the truing tools **38**, **38***a* and **38***b* in the desired and predetermined path to true a predetermined shape on the periphery of the grinding wheel **10**.

A suitable adjusting mechanism is provided for adjusting the spindle **36** relative to the sleeve **35** to facilitate either a manual adjustment of the truing tools or diamonds **38** or an automatic feeding movement thereof at the ends of each reciprocably stroke of the longitudinally movable slide **26**. The upper end of the sleeve **35** is provided with a fixedly mounted flange **60** which serves as a support for a bracket **61**. The upper end of the spindle **36** is provided with a screw thread **63** which surrounds with and meshes with a rotatable nut **64**. The rotatable nut **64** is rotatably supported on the flanged portion **60** of the sleeve **35**. A gear **65** is keyed to the nut **64** and meshes with a pinion **66**. The pinion **66** is mounted on the upper end of a vertically arranged rotatable shaft **67**. The shaft **67** is rotatably mounted within the bracket **61** and is provided at its lower end with a manually operable hand wheel **68**. It will be readily apparent from the foregoing disclosure that rotation of the hand wheel **68** will be transmitted through the shaft **67**, the pinion **66**, the gear **65** to rotate the nut **64** and thereby impart a vertical axial adjustment to the truing tool spindle **36** relative to the sleeve **35**.



In order to hold the nut **64** in adjusted position, a serrated wheel **69** is fixedly mounted on the upper end of the shaft **67**. A spring pressed pawl **70** mounted on the bracket **61** is arranged to engage the periphery of the serrated wheel **69** and thereby to hold the feed nut **64** in adjusted position.

In order to steady the upwardly extending portion of the feed screw **63** and to hold it against rotation, an arm **71** is clamped around a cylindrical portion **72** formed on the upper end of the screw **63** (Figs. 1 and 2). The right-hand end of the arm **71** (Fig. 1) is provided with a spring pressed ball **73** which rides in a vertically arranged groove **74** formed in a vertically extending bracket **75**. The bracket **75** is fixedly mounted on the flanged portion **60** of the sleeve **35**. It will be readily apparent from the foregoing disclosure that the arm **71** serves to hold the screw **63** and the spindle **36** against rotary motion but allows free axial movement thereof.

It is desirable to provide an automatically actuated mechanism for imparting a feeding movement to the truing tools **38** at the ends of the longitudinal traversing movement thereof. This is preferably accomplished by means of a pawl and ratchet mechanism comprising a ratchet wheel **76** which is keyed to the nut **64**. A pawl carrier **77** is rotatably mounted on the nut **64** and is provided with a pivotally mounted feed pawl **78**. The feed pawl **78** is supported by a stud **79** fastened to the pawl carrier **77**. A compression spring **80** serves normally to maintain the pawl **78** in operative engagement with the ratchet wheel **76**. A manually operable rotatable eccentric **81** is provided to facilitate rocking the pawl **78** to an inoperative position if desired so as to facilitate a manual adjustment of the truing tool spindle **36**. A compression spring **82** (Figs. 1 and 2) normally urges the pawl carrier **77** in a clockwise direction (Fig. 2) with a stud **83** in operative engagement with a stop surface **84** which is fixedly mounted on the flange **60** of the sleeve **35**.

An automatically operated mechanism is provided for actuating the pawl carrier **77** at the ends of the longitudinal traversing movement of the truing tool to facilitate automatically feeding the truing tools **38**, **38***a* and **38***b* downwardly before each longitudinal pass of the truing tool across the peripheral face of the grinding wheel **10**. When the slide **26** approaches the right-hand end of its stroke, the pawl carrier **77** engages an adjustable dog **85** which serves to rock the pawl carrier **77** in a counter-clockwise direction during continued movement of the slide **26** toward the right so as to impart a predetermined down feeding movement to the truing tools **38**. The adjustable dog **85** is adjustably supported by a T-slot **86** formed in the upper surface of the bracket **12**. The dog **85** extends vertically a sufficient distance to allow maximum vertical movement of the spindle **36** and the sleeve **35**.

The pawl carrier **77** is provided with a laterally extending arm **87** which supports a stud **88**. A roller **89** is mounted on the stud **88**. The roller **89** is arranged in the path of a cam face **90** formed on an adjustable dog **91** so that when the longitudinally movable slide approaches the left-hand end of its stroke, the pawl carrier **77** is rocked in a counter-clockwise direction so as to

impart a predetermined down feeding movement to the truing tools 38, 38*a* and 38*b*. The cam face 90 extends vertically a sufficient distance to allow maximum vertical movement of the spindle 36 and the sleeve 35. The dog 91 is adjustably supported by the T-slot 86 so that the position of the dog 91 may be readily varied to time the feeding motion imparted to the truing tools. It will be readily apparent from the foregoing disclosure that when the slide 26 traverses toward the right, the pawl carrier 77 will move into engagement with the dog 85 as the slide 26 approaches the right-hand end of its stroke thereby imparting a down feeding movement to the truing tools 38 before the return stroke of the slide 26. Similarly when the slide 26 travels toward the left, the roller 89 will engage the cam face 90 on the dog 91 as the slide 26 approaches the left-hand end of its stroke to impart a down feeding movement to the truing tool 38.

A suitable forming mechanism is provided for generating a predetermined shape on the periphery of the grinding wheel 10. This shape may for example comprise truing the two side faces of the grinding wheel, the periphery thereof and fillets between the side faces and the periphery. This mechanism may comprise a forming bar 95 which is anchored to a bracket 96 by means of a clamping bolt 97. An adjusting screw 98 serves to precisely adjust the forming bar 95 in a longitudinal direction relative to the bracket 96 to facilitate setting up the mechanism. The bracket 96 is fixedly supported on the fixed bracket 12. The forming bar 95 extends through an elongated slot 99 formed in the slide 26 and the sleeve 35 and is arranged to slide upon a slide surface 100 formed on the longitudinally movable slide 26. An arrow-pointed follower 101 is fixedly mounted on the sleeve 35 and is arranged to follow a portion of the form on the form bar 95 during the longitudinal movement of the slide 26 in a manner to be hereinafter described. The follower 101 is shaped with a plurality of apexes 101*a*, 101*b*, and 101*e*.

The diamonds or truing tools 38, 38*a* and 38*b* may be precisely positioned and generated to correspond with the shape of the apexes 101*a*, 101*b* and 101*e* of the follower 101 or if desired the truing tools 38, 38*a* and 38*b* may be adjustably mounted on the holder 37 and precisely adjusted relative thereto to a master gauge corresponding to the shape of the follower 101.

A hydraulically operated lifting mechanism is provided for causing a vertical movement of the sleeve 35 relative to the longitudinally movable slide 26 to true a side face on the grinding wheel 10. This mechanism may comprise a slide bar 105 which is slidably supported on the longitudinally movable slide 26. A follower 106 is fixedly mounted on the sleeve 35 and is arranged to be actuated by the slide bar 105 to cause a vertical movement of the sleeve 35, the spindle 36 and the truing tools 38 when the slide bar 105 is moved longitudinally relative to the slide 26.

The bar 105 is arranged to be traversed longitudinally relative to the slide 26 by a hydraulically operated mechanism comprising a cylinder 110 which is fixedly mounted on the longitudinally movable slide 26. The cylinder 110 contains a slidably mounted piston 111 which is connected to one end of a piston rod 112. The other end of the piston rod 112 is connected to the slide bar 105. When fluid under pressure is admitted through a pipe 113 into a cylinder chamber 114, the piston 111 together with the piston rod 112 and the slide bar 105 is moved toward the right. During this movement of the piston 111, fluid within a cylinder chamber 115 exhausts through a pipe 116.



A fluid operated control valve 119 is provided for controlling the admission to and exhaust of fluid from the cylinder 110. This control valve 119 comprises a pilot valve 120 which is normally held in a right-hand end position by means of a compression spring 121. A solenoid S2 is provided which when energized serves to shift the pilot valve 120 toward the left against the compression of the spring 121 to reverse the flow of fluid to shift the control valve 119 into the reverse position. The pilot valve 120 serves to control the admission to and exhaust of fluid from a pair of end chambers 122 and 123 formed in the opposite ends of the valve 119 to control the longitudinal shifting movement of a slidably mounted valve member 124. In the position of the valve 119 (Fig. 5) fluid under pressure passes from the valve 119 through the pipe 116 into the cylinder chamber 115. Similarly fluid within the cylinder chamber 114 may exhaust through the pipe 113 through a central passage 125 in the valve member 124 and pass outwardly through an exhaust pipe 126 and through a throttle valve 127 into a reservoir 132. The throttle valve 127 serves to determine the rate of movement of the piston 111 and the slide bar 105 in either direction.

A hydraulic system is provided for supplying fluid under pressure for actuating the valve parts of the truing apparatus comprising a motor driven fluid pump 130 which draws fluid through a pipe 131 from the reservoir 132 and forces fluid under pressure through a pipe 133. A pressure relief valve 134 is connected in the pipe line 133 by means of which excess fluid under pressure may be exhausted through a pipe 135 directly into the reservoir 132.

A fluid operated control valve 145 is provided for controlling the admission of fluid to the control valve 119. This valve is a piston type valve comprising a slidably mounted valve member 146 which is moved endwise by the admission to and exhaust of fluid from a pair of end chambers 147 and 148 formed at the opposite ends of the valve 145. The valve 145 includes a pilot valve 149 which is normally held in a right-hand end position by means of a compression spring 150. A solenoid S3 is provided for shifting the pilot valve toward the left to facilitate reversing the position of the slidably mounted valve member 146. In the position of the valve 145 (Fig. 5) fluid under pressure passing through the pipe 133 may pass into a valve chamber 151. When the solenoid S3 is energized, the slidably mounted valve member is toward the right-hand end position which serves to shift the valve chamber 151 toward the right so that fluid under pressure passing through the pipe 133 passes through the valve chamber 151 and through a pipe 152 into the control valve 119.

A hydraulically operated control valve 155 is provided for controlling the admission to and exhaust of fluid from the cylinder 27. This valve comprises a slidably mounted valve member 156 which is moved endwise by means of fluid under pressure admitted to and exhausted from a pair of end chambers 157 and 158 formed at opposite ends of the valve 155. A pilot valve 157 is provided for controlling the shifting movement of the slidably mounted valve member 156. The pilot valve 157 is normally held in a right-hand end position by means of a compression spring

158. A solenoid S1 is provided which when energized shifts the pilot valve 157 toward the left thereby shifting the slidably mounted valve member toward the right. In the position of the valve 155 (Fig. 5), fluid under pressure in the pipe 133 passes through a valve chamber 161 and through the pipe 34 into the cylinder chamber 33 to cause the piston 28 to move toward the left. During movement of the piston 28 toward the left, fluid within the cylinder chamber 32 may exhaust through the pipe 31 into a valve chamber 162, through a central passage 163 within the valve member 156, through a valve chamber 164 and exhaust through a pipe 165 into the reservoir 132. In order to facilitate controlling the rate of movement of the piston 28, a throttle valve 166 is provided in the exhaust pipe 165 so that the rate of exhaust of fluid from the cylinder 32 may be readily varied as desired to control the rate of traversing movement of the slide 26 and the truing tools 38.

It is desirable to provide means for by-passing fluid around the throttle valve 166 so that the slide 26 may be moved rapidly in a longitudinal direction during idle portions of its stroke. This mechanism may comprise a bypass valve 167 which is preferably a piston type valve comprising a valve stem 168 having a pair of spaced valve pistons 169 and 170 formed integrally therewith. A compression spring 171 serves normally to urge the valve stem 168 downwardly into the path of a pair of spaced adjustable dogs 172 and 173 which are carried by a T-slot 174 formed on the upper surface of the longitudinally movable slide 26. A pair of fluid pipes 175 and 177 are connected to opposite sides of the valve 167 and in the position illustrated in Fig. 5 allow fluid to bypass through a valve chamber 176 formed between the valve pistons 169 and 170 so that unrestricted flow of fluid may bypass the throttle valve 166 thereby facilitating a rapid movement of the slide 26. It will be readily apparent from the foregoing disclosure that when the valve stem 168 rides down the slope of the dog 173, the compression spring 171 will cause a downward movement thereof so that the valve piston 169 cuts off the passage of fluid between the pipes 175 and 177 thus rendering the bypass valve inoperative so that the throttle valve 166 thereafter controls the rate of longitudinal movement of the slide 26.

A suitable eelctrical control apparatus is provided for controlling the energization of the solenoids S1, S2 and S3 so as to control the admission to and exhaust of fluid from the cylinders 27 and 110. As illustrated in Fig. 5, a slide bar 180 is slidably supported on the longitudinally movable slide 26. The slide bar 180 is held in frictional engagement with the slide 26 by means of a pressure plate 181 (Fig. 3). A pair of opposed adjusting screws 182 and 183 are carried by the slide bar 180 and serve to limit the endwise movement of the slide bar 180 relative to the slide base 13. As illustrated in Fig. 5 the adjusting screws 182 and 183 are adjusted so that the bar 180 is held against longitudinal movement on the slide base 13. The slide 26 is provided with a downwardly projecting bracket 184 (Fig. 5) which serves as a support for a limit switch LS1. The limit switch LS1 is provided with an actuating roller 185 which rides upon the under surface of the slide bar 180 (Fig. 5). The slide bar 180 is provided with a notched portion which is arranged so that when the roller 185 moves longitudinally the roller 185 may drop into the notched portion 186 thereby closing the limit switch LS1 to energize the solenoid S3.



A main control switch 190 is provided for connecting a source of electrical energy to the circuit. A manually operable push-button starter switch 191 is provided for starting the truing cycle. The closing of the starter switch 191 serves to energize a magnetic starter switch 192 and thereby close a normally open contactor 193.

As shown in Fig. 8, if desired the truing tool holder 37 may be provided with adjustably mounted diamonds 38, 38*a* and 38*b*. The diamonds are mounted in adjustably mounted nibs 195, 195*a* and 195*b* respectively. The nibs are held in adjusted position on the holder 37 by set screws 196, 196*a* and 196*b* respectively. In order to facilitate adjustment of the diamonds, the truing tool holder 37 is remived from the spindle 36 and is mounted in a fixture, not shown, having a gauge 197 which is provided with a shaped surface corresponding with the shape of the follower 101. The nibs 195, 195*a* and 195*b* may then be adjusted relative to the holder 37 after which the set screws 196, 196*a* and 196*b* are tightened to clamp the nibs 195, 195*a* and 195*b* in adjusted posiiton after which the truing tool holder 37 may again be mounted in position on the spindle 36.

The operation of the improved truing mechanism will be readily apparent from the foregoing disclosure. The main switch 190 is closed to render the electrical circuits operative. When it is desired to start a truing cycle, the push-button starter switch 191 is closed to energize the magnetic starter switch 192 and to thereby close the contactor 193. Closing of the starter switch 191 serves to energize the solenoids S1 and S2 which remain energized during the traversing movement of the truing tools 38 toward the right. Energizing the solenoid S1 shifts the valve member 156 into a right-hand end position so that fluid under pressure from the pump 130 passing through the pipe 133 passes through the valve chamber 161, through the pipe 31 into the cylinder chamber 32 to cause the piston 28 to move toward the right. During this movement, fluid within the cylinder chamber 33 may exhaust through the pipe 34, through the valve chamber 164 and out through the exhaust pipe 165 and throttle valve 166 into the reservoir 132. The throttle valve 166 is set to control the normal rate of exhaust so as to control the speed of movement of the truing relative to the grinding wheel 10. In the starting position, the bypass valve 167 is open so that fluid may freely bypass the throttle valve 166 so that the initial movement of the piston 28 and the longitudinally movable slide 26 is rapid. The rapid movement thereof continues until the valve stem 168 rides down the inclined surface of the dog 173 so that the piston 169 cuts off the passage of fluid between the pipes 175 and 177 thereby slowing down the traversing movement of the piston 28 and slide 26 to a rate controlled by the throttle valve 166. The apex or corner 101*b* of the follower 101 moves into operative engagement with the side face 95*a* of the forming bar 95. Engagement of the follower 101 with the surface 95*a* stops the longitudinal movement of the slide 26. The pressure however remains within the cylinder 32 so that the follower 101 is held against the surface 95*a* with a predetermined pressure.

During this movement of the slide 26 toward the right, the actuating roller 185 of the limit switch LS1 drops into the notched portion 186 of the bar 180 to close the limit switch LS1 when the apex 101*b* of the follower 101 moves into

engagement with the surface 95*a*. In this position of the follower the truing tool or diamond 38*b* has moved into operative engagement with the left-hand side face of the grinding wheel 10. The closing of the limit switch LS1 serves to energize the solenoid S3 which shifts the slidably mounted valve member 146 toward the right (Fig. 5) in which position fluid under pressure may pass from the pipe 133 through the valve chamber 151 through the pipe 152 into the valve 119. The solenoid S2 being energized, the slidably mounted valve member 124 is in a right-hand end position so that fluid passes through the pipe 113 into the cylinder chamber 114 to move the piston 111 and the slide bar 105 toward the right. Movement of the slide bar 105 toward the right serves to raise the follower 106 thereby traversing the truing tool 38*b* upwardly across a portion of the side face of the grinding wheel 10. The piston 111 completes its movement toward the right so that the follower 106 rides down the left-hand slope on the bar 105. When the piston 111 reaches the right-hand end of its stroke, the follower 106 rests on surface 105*b* of the slide bar 105 so that the parts are in position for the return stroke of the slide 26. The vertical movement of the diamond 38*b* continues until the apex or right-hand corner 101*b* of the follower 101 rides around a portion of the radius 95*b* of the forming bar 95 and the truing tool 38*b* moves to a corresponding position around the fillet 10*a* of the grinding wheel 10. During this movement the fillet 95*b* on the forming bar serves to generate a portion of the fillet 10*a* on the left-hand corner of the grinding wheel 10. As soon as the right-hand corner 101*b* of the follower 101 reaches the point of tangency after generating approximately one-half of the fillet 10*a* on the corner of the wheel 10, the pressure within the cylinder chamber 32 causes a movement of the piston 28 toward the right so that the sloping surface 101*c* of the follower 101 rides upwardly until the apex or the point 101*a* of the follower 101 moves into engagement with the fillet at which position the diamond or truing tool 38*a* moves into position to complete truing the radius or fillet 10*a* on the left-hand corner of the wheel where the diamond 38*b* left off. The continued movement of the piston 28 causes the apex or point 101*a* of the follower 101 to ride across the horizontal face 95*c* on the forming bar 95 to control the truing movement of the truing tool 38*a* to generate a true cylindrical peripheral surface on the grinding wheel 10.

When the apex or point 101*a* of the follower 101 reaches the fillet 95*d* at the right-hand corner of the formed portion on the bar 95, the diamond 38*a* due to the action of the follower 101 starts generation of a portion of a fillet or radius 10*b* on the right-hand corner of the grinding wheel 10. The piston 28 continues to move toward the right and the surface 101*d* of the follower 101 slides down the fillet 95*d* on the forming bar 95 in a tangential path until the apex or corner 101*e* of the follower 101 moves into engagement with the fillet 95*d*. In this position of the parts, the diamond 38 moves into engagement with the right-hand corner of the grinding wheel 10 to take over where the diamond 38*a* left off. During continued movement of the piston 28 toward the right at a slow rate of speed, the follower rides around the fillet 95*d* and down the right-hand side face of the forming bar 95 so that the diamond 38 completes the generation of the fillet or radius 10*b* at the right-hand corner of the grinding wheel 10 and trues the right-hand side face thereof.



When the diamond 38 reaches this position, the valve stem 168 rides up the inclined surface of the dog 172 which serves to raise the valve piston 169 to allow free bypassing of fluid between the pipes 175 and 177 thereby speeding up the longitudinal movement of the slide 26 toward the right for the remainder of its stroke. During the movement of the slide 26 to the extreme right-hand end of its travel, the roller 185 rides out of engagement with the notch 186 on the bar 180 thereby opening the limit switch LS1 to deenergize the solenoid S3 thereby cutting off fluid under pressure from the pipe 152. In this position, the roller 185 is in position for the return traversing stroke of the slide 26 toward the left.

When the slide 26 reaches the right-hand end of its stroke a projection 200 on the slide 26 engages the actuating plunger 201 of a limit switch LS2 to open the same. Opening of the limit switch LS2 serves to break the holding circuit thereby deenergizing the coil of the magnetic switch 192 thereby deenergizing the solenoids S1 and S2. The deenergizing of solenoids S1 and S2 continues during the entire traversing movement of the slide 26 toward the left. As soon as the solenoid S1 has been deenergized, fluid from the pipe 133 passes through the valve chamber 161, through the pipe 34 into the cylinder chamber 33 to start movement of the piston 28 toward the left. The sequence of operation on the return stroke is identical with that just described in connection with the movement of the piston toward the right. The truing tool 38 moves into operative engagement with the right-hand side face of the wheel 10 after which a vertical motion of the spindle 36 causes the truing tool 38 to true the side face thereof and to true a portion of the fillet 10*b* at the right-hand corner thereof. After this takes place, the diamond or truing tool 38*a* moves into position to continue the truing operation around the remainder of the fillet 10*b* at the right-hand corner and across the peripheral face of the grinding wheel 10. The truing tool 38*a* trues a portion of the fillet 10*a* at the left-hand corner of the grinding wheel 10 after which the diamond 38*b* takes over and completes the truing of the fillet 10*a* at the left-hand corner of the wheel 10 and trues the left-hand side face thereof.

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

I claim:

1. In a grinding wheel truing apparatus for truing the peripheral surface of a rotatable grinding wheel having a base, a longitudinally movable slide thereon, traversing means operatively connected between the base and slide to traverse said slide longitudinally, a transversely movable truing tool carrier on said slide, a truing tool holder thereon having a plurality of spaced truing tools, a forming bar fixedly mounted relative to the base, a follower on said carrier having a plurality of apexes for engagement with the

forming bar, said truing tools being shaped and positioned to correspond with said apexes, actuating mechanism on said slide operatively connected between the slide and carrier to move the carrier transversely relative to the slide, said longitudinal movement of the slide serving to position one of the apexes of the follower in engagement with the forming bar, and means actuated by and in timed relation with the longitudinal movement of the slide to initiate a transverse movement of the carrier to traverse one of the truing tools across a portion of the operative face of the grinding wheel, said longitudinal traversing means serving to move the slide longitudinally thereafter so that the follower moves along the forming bar to move another apex of the follower into engagement with the forming bar thereby moving another truing tool into operative engagement with the grinding wheel to true another portion of the operative face thereof.

2. In a grinding wheel truing apparatus for a grinding machine having a rotatable grinding wheel including a base, a longitudinally reciprocable slide thereon, means including a cylinder containing a slidable piston one of which is connected to the base and the other to the slide to traverse said slide longitudinally, a transversely movable truing tool carrier on said slide, a truing tool holder thereon having a plurality of spaced truing tools, one of said truing tools being arranged for truing a peripheral face and a pair of spaced truing tools arranged for truing opposite side faces, a forming bar fixedly mounted relative to said base, an arrow-pointed follower on said carrier, said truing tools being shaped to correspond with the apexes of said follower, a longitudinally movable cam on said slide, means including a cylinder containing a slidable piston one of which is connected to the slide and the other to the cam to move said cam longitudinally relative to said slide to cause a transverse movement of the carrier and truing tools, control means including a control valve operatively connected with said first cylinder for controlling the longitudinal movement of said slide to position one of the apexes of the follower in engagement with the forming bar, and means actuated by and in timed relation with the longitudinal movement of the slide to initiate a transverse movement of the carrier to traverse one of the side truing tools in a transverse path and through a partial radius, said longitudinally traverse means serving to move the slide longitudinally thereafter so that the follower moves along the forming bar to move the second apex of the follower into an operative position to cause the peripheral truing tool to complete the radius and move in a longitudinal direction for a peripheral truing operation and through a partial radius, said forming bar being shaped so that the follower sliding along the surface thereof moves the third apex into operative engagement therewith to shift the third truing tool into position to complete the latter radius and to move transversely to true an opposite side face.

3. In a grinding wheel truing apparatus for a grinding machine having a rotatable grinding wheel including a base, a longitudinally reciprocable slide thereon, a cylinder containing a slidable piston operatively connected between the base and slide to traverse said slide longitudinally, a transversely movable truing tool carrier on said slide, a truing tool holder thereon having a plurality of spaced truing tools, one of said truing tools being arranged for a peripheral truing operation and two spaced truing tools being arranged for opposed side truing operations, a forming bar fixedly mounted relative to the base, an arrow-pointed follower on said carrier, said truing tools being shaped and positioned to correspond with the shape of the apexes of said follower, a longitudinally movable cam on said slide, a second follower on said carrier arranged to engage said cam, a cylinder containing a slidable piston operatively connected between the slide and cam to move said cam longitudinally relative to said slide to cause a transverse movement of the carrier and truing tools, a control valve operatively connected with said first cylinder to control the admission to and exhaust of fluid from the slide cylinder to cause the first apex on said follower to move into operative engagement with the follower, a second control valve operatively connected with said second cylinder to control the admission to and exhaust of fluid from the cam cylinder, means actuated by and in timed relation with the longitudinal movement of the slide to actuate said second control valve so as to cause a transverse movement of the carrier so that the first apex and the first truing tool move in a transverse direction for a side truing operation and to true a partial radius thereafter, said slide piston serving thereafter to cause a longitudinal movement of the first follower relative to the forming bar to move the second apex into operative engagement therewith so that the peripheral truing tool completes the radius and trues a peripheral surface and a partial radius at the end thereof, said first follower thereafter moving relative to the forming bar to position the third apex in operative engagement therewith to move the second side truing tool into operative position to complete the latter radius and to move transversely for a side truing operation.

4. In a grinding wheel truing apparatus as claimed in claim 1, in combination with the parts and features therein specified of a cycle start switch operatively connected to said first and second control valves to actuate said first and second control valves so as to cause a longitudinal movement of the slide to move the first apex of the arrow-pointed follower into operative engagement with the forming bar to position the first truing tool in an operative position, and means including a limit switch actuated by longitudinal movement of the slide operative connections between said limit switch and the second control valve to actuate the second control valve so as to move said cam longitudinally to impart a transverse movement to said carrier and the first truing tool to true a side face and a portion of a radius, said first piston thereafter causing a further longitudinal movement of the slide so that the follower sliding on the forming bar moves the second apex and the second truing tool into an operative position to complete the radius and to true a peripheral face and a portion of a second radius at the end thereof, said longitudinal movement of the slide thereafter causing a transverse movement of the carrier under the influence of gravity so that the follower moves the third apex and the third truing tool to an operative position to complete the second radius and to true an opposite side face.

OIVA E. HILL.

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