Oct. 6, 1959 O. E. HILL 2,907,315

TRUING APPARATUS

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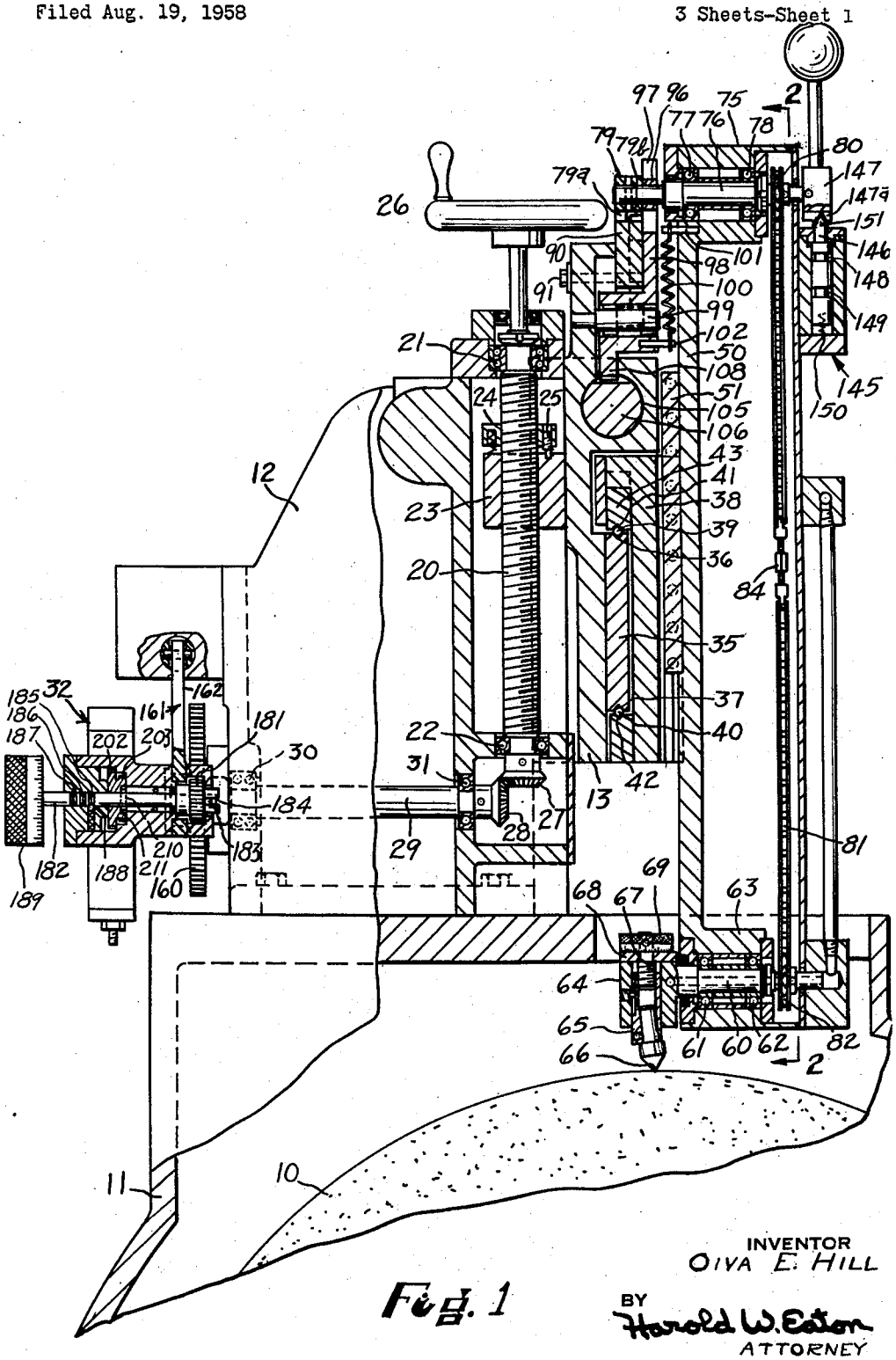


Fig. 1

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Fig. 4

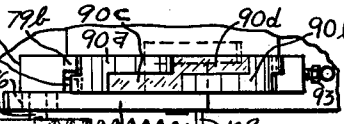


Fig. 5

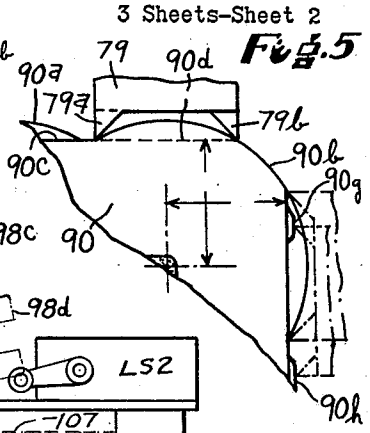


Fig. 2

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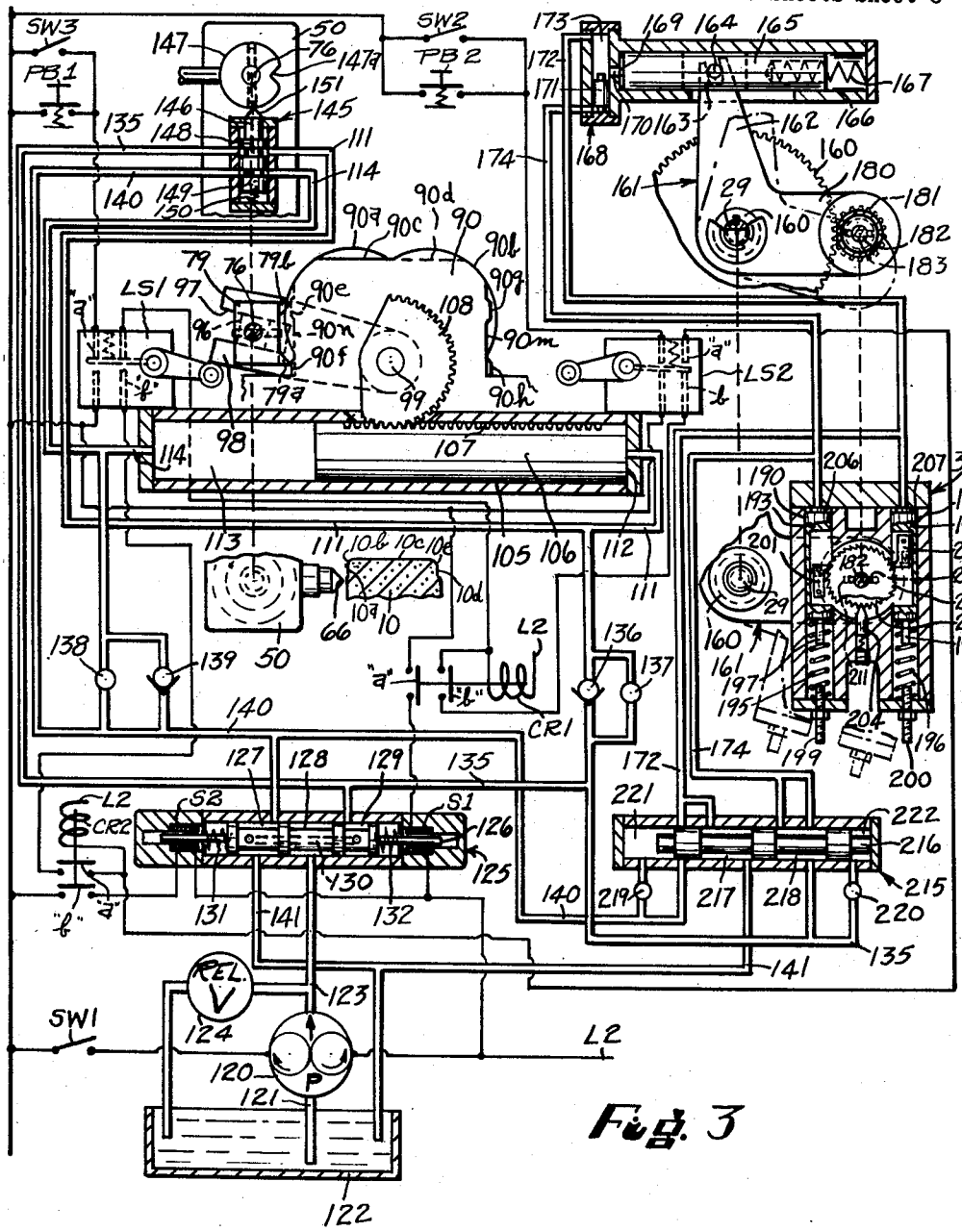


Fig. 3

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TRUING APPARATUS

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Application August 19, 1958, Serial No. 756,003

14 Claims. (Cl. 125—11)

The invention relates to grinding machines and more particularly to a grinding wheel truing apparatus.

One object of the invention is to provide a simple and thoroughly practical grinding wheel truing apparatus for truing a grinding wheel for a crank pin grinding machine. Another object of the invention is to provide a truing apparatus for truing a grinding wheel having a straight peripheral cylindrical surface with radii at opposite ends thereof. Another object is to provide a truing apparatus having a forming bar and a follower and synchronous driving connections between the follower and the truing tool for moving the truing tool in a predetermined path to true a radius, then a peripheral face and finally a second radius on a periphery of the wheel. A further object of the invention is to provide a truing apparatus in which the truing tool is moved continuously to true a plane side face, then a radius, then a peripheral cylindrical face, then a radius, and finally the opposite side face of a grinding wheel. Another object is to provide a truing apparatus in which the truing tool moves in a path to true the periphery of a crank pin grinding wheel in which the truing tool is stopped at either end of its stroke out of engagement with the grinding wheel. Other objects will be in part obvious or in part pointed out hereinafter.

One embodiment of the invention has been illustrated in the drawings in which:

Fig. 1 is a vertical sectional view through the improved grinding wheel truing apparatus;

Fig. 2 is a vertical sectional view, taken approximately on the line 2—2 of Fig. 1;

Fig. 3 is a combined hydraulic and electric diagram of the actuating mechanisms and the controls therefor;

Fig. 4 is a fragmentary plan view of the forming bar and associated parts as shown in Fig. 2; and

Fig. 5 is a diagrammatic view of the forming bar and the follower.

A grinding wheel truing apparatus has been illustrated in the drawings for truing the side faces, the peripheral face, and a radius on each corner of the grinding wheel. As illustrated in the drawings a grinding wheel **10** mounted on the conventional wheel spindle (not shown) is partially surrounded with a wheel guard **11**. The wheel guard **11** serves as a support for the truing apparatus which includes a base **12** fixedly mounted on the upper surface of the wheel guard **11**. The base **12** supports a vertically adjustable slide **13** on a pair of spaced slide ways **14** and **15**.

A feeding mechanism is provided for adjusting the slide **13** vertically relative to the base **12** comprising a rotatable feed screw **20** which is journalled in spaced anti-friction bearings **21** and **22** carried by the base **12**. The vertically adjustable slide **13** is provided with a nut **23** (Fig. 1) which meshes with or engages the feed screw **20**. The screw **20** is provided wtih a threaded collar **24** having a set screw **25** to prevent turning, and a plurality of spaced springs by means of which backlash between the screw **20** and the nut **23** may be eliminated.

A hand wheel **26** is mounted on the upper end of the feed screw **20** to facilitate manual rotation of the feed screw **20** to facilitate a vertical adjustment of the slide **13**. The lower end of the feed screw **20** is provided with a bevel gear **27** which meshes with a bevel gear **28** mounted on the right hand end of a rotatable shaft **29**. The shaft **29** is rotatably journalled in a pair of spaced anti-friction bearings **30** and **31** (Fig. 1). A feed unit **32**, to be hereinafter described is operatively connected to the left hand end of the shaft **29**. This feeding mechanism is arranged to impart a feeding adjustment to the feed screw **20** and also to simultaneously impart an unwind and a wind motion thereto each time a feeding movement is imparted to the feed screw **20**.

The vertically adjustable slide **13** supports a horizontally extending slide member **35** having horizontal parallel V-grooves **36** and **37** formed in the upper and lower surfaces thereof. The slide member **35** is arranged to support a horizontal movable slide **38** on an anti-friction bearing support comprising a pair of spaced rows of balls **39** and **40** which roll in spaced horizontally arranged V-grooves **41** and **42** on the slide **38**.

In order to facilitate taking up lost motion between the slide parts, the V-groove **41** is preferably formed in a tapered gib **43** which is adjustably mounted on the slide **38**. By manipulation of a screw **44** and a pair of opposed nuts **45** and **46** (Fig. 2) the gib **43** may be adjusted longitudinally, as desired.

The slide **38** serves as a support for a vertically movable slide **50**. The slide **50** is provided with a slide member **51** having spaced parallel V-grooves to guide a pair of spaced rows of balls **52** and **53** to form an anti-friction support for the vertically movable slide **50**. A tapered gib **54** is carried by the horizontally movable slide **38**. By manipulation of an adjusting screw **55** and a pair of spaced nuts **56** and **57**, the gib **54** may be adjusted in a vertical direction to take-up any lost motion between the vertical slide **50** and the horizontal slide **38**.

The lower end of the slide **50** supports a truing tool mechanism comprising a shaft **60** which is rotatably journalled in a pair of spaced anti-friction bearings **61** and **62**. The bearings **61** and **62** are supported within a boss **63** formed integral with the slide **50**. A truing tool head **64** is fixedly mounted on the left hand end of the shaft **60** (Fig. 1). The head **64** supports a slidably mounted sleeve **65** having a truing tool or diamond **66** mounted on its lower end. A feeding or adjusting mechanism is provided for the diamond **66** comprising a feed screw **67** which is rotatably supported by an end cap **68** fixedly mounted on the housing or boss **63**. A manually operable adjusting knob **69** is mounted on the upper end of the feed screw **67**. This knob is preferably provided with a graduated scale to facilitate adjusting a cutting point of the truing tool relative to the axis of rotation of the shaft **60**. This adjustment serves to facilitate adjusting the radius generated on the corners of the grinding wheel.

The upper end of the slide **50** is provided with an integral boss or housing **75** which supports a rotatable shaft **76** in a pair of spaced anti-friction bearings **77** and **78**. A follower **79** is pinned onto the shaft **76** so that it rotates therewith. The follower **79** is provided with a pair of spaced staggered projections **79***a* and **79***b*.

A driving mechanism is provided to synchronize the rotary motion of the shaft **76** with the shaft **60**. This driving mechanism comprises a sprocket **80** fixedly mounted on the shaft **76**. The sprocket **80** is connected by a link chain **81** with a sprocket **82** fixedly mounted on the shaft **60**. In order to facilitate setting up the machine and timing the shaft **60** with the shaft **76**, a pair of turnbuckles **83** and **84** are provided in the link chain **81**.

The staggered projections **79***a* and **79***b* of the follower **69** are arranged to engage and slide upon the operative

surface of the template or forming bar **90**. The forming bar **90** is fastened to the vertical slide **13** by a pair of screws **91** and **92**. The screws **91** and **92** pass through elongated slots (not shown) formed in the slide **13** and are screw threaded into the forming bar **90** to facilitate a longitudinal adjustment thereof. The forming bar **90** is provided with a pair of opposed adjusting screws **93** and **94** (Fig. 2) by means of which the forming bar **90** may be adjustable in a horizontal longitudinal direction to facilitate positioning the forming bar in a predetermined relationship with the grinding wheel **10**.

To facilitate truing opposite side faces of the grinding wheel adjacent to the periphery, truing the periphery, and truing a predetermined radius at each corner of the wheel, it is desirable to provide a continuous movement of the truing tool first in a direction normal to the grinding wheel axis to true the side face **10***a* of the grinding wheel **10**, then to swing the truing tool **60** through an arc to true a radius **10***b* (Fig. 2). The truing tool is then traversed across the peripheral face **10***c* of the grinding wheel **10** after which the truing tool is swung through an arc to true a radius **10***d*, and then in a plane normal to the wheel axis to true a side face **10***e* adjacent to the periphery of the wheel **10**. The shape of the forming bar or template **90** is arranged so that at the ends of the stroke of the truing tool, the truing tool is moved out of operative engagement with the grinding wheel **10**.

The operative face of the forming bar **90** is provided with two offset spaced partial cylindrical surfaces **90***a* and **90***b* (Fig. 4) which are arranged so that the centers of curvature coincide with the axes of the radii to be generated on the opposite corners of the grinding wheel. The operative face of the template or forming bar **90** is also provided with staggered plane surfaces **90***c* and **90***d*. The forming bar **90** is also provided with side faces **90***n* and **90***m* which are arranged in planes normal to the axis of the grinding wheel **10** and serve to control the movement of the truing tool **66** while truing the plane side faces **10***a* and **10***e* of the grinding wheel (Fig. 2). The side faces **90***n* and **90***m* are located at a distance Y from the axes of the radii **10***b* and **10***d*, respectively which is equal to the distance X from the plane faces **90***c* and **90***d* from the axes of the radii **10***b* and **10***c* (Figs. 2 and 5) so as to facilitate truing the radius and a tangent side face on the grinding wheel **10**. The left hand end face of the forming bar **90** is provided with spaced bosses **90***e*, **90***f* and the right hand end face thereof provided with spaced bosses **90***g* and **90***h*. The bosses **90***e*—**90***f* and **90***g*—**90***h* serve to move the truing tool **66** out of operative engagement with the side face **10***a* and **10***e*, respectively, of the grinding wheel **10** at the ends of its traversing stroke, and serve to maintain the truing tool out of operative engagement therewith during the grinding operation.

An actuating mechanism is provided for traversing the follower **79** so that its projections **79***a* and **79***b* follow the operative face of the forming bar **90** to generate a predetermined shape on the periphery of the grinding wheel. This mechanism comprises a slide block **96** which is rotatably supported on the shaft **76** and is arranged to slide within a slot **97** formed in a rock arm **98**. The rock arm **98** is rotatably supported on a stud **99**. A tension spring **100** is connected between a stud **101** fixedly mounted on slide **50** and a stud **102** fixedly mounted on the rock arm **98** (Fig. 1).

An actuating mechanism is provided for swinging the arm **98** comprising a cylinder **105** which contains a slidably mounted piston **106**. The piston **106** is provided with rack teeth **107** on its upper surface which mesh with a gear segment **108** which is formed integral with the rock arm **98**. A pair of adjustable stop screws **109** and **110** are provided to limit the movement of the piston **106** in either direction.

When fluid under pressure is passed through a pipe **111** (Fig. 3) into a cylinder chamber **112**, the piston **106** will move toward the left thereby causing the rack teeth **107** to impart a clockwise rotary motion to the gear segment **108** and also to the rock arm **98** so as to swing the rock arm **98** successively through positions **98***a*, **98***b*, **98***c*, and **98***d*. During this movement, the slide block **96** causes a combined vertical and horizontal motion to be imparted to the slide **50** so as to true a predetermined shape on the operative face of the grinding wheel **10**. During this movement fluid within a cylinder chamber **113** exhausts through a pipe **114**.

A fluid pressure system is provided for supplying fluid under pressure comprising a motor driven fluid pump **120** which draws fluid through a pipe **121** from a reservoir **122** and forces fluid under pressure through a pipe **123**. A relief valve **124** is connected to the pipe **123** to facilitate exhausting excess fluid under pressure from the pipe **123** so as to maintain a substantially uniform operating pressure within the system.

A solenoid-actuated control valve **125** is provided for controlling the admission to and exhaust of fluid from the cylinder chambers **112** and **113**. The valve **125** is a piston type valve comprising slidably mounted valve member **126** having a plurality of spaced valve pistons formed integrally therewith to form a plurality of spaced valve chambers **127**, **128**, and **129**. The valve member **126** is provided with a central pasage **130** which connects the valve chamber **127** with the valve chamber **129**. A pair of balanced compression springs **131** and **132** serve normally to maintain the valve member **126** in a central or neutral position. A pair of pull-type solenoids S1 and S2 are provided which when energized serve to shift the valve member **126** either toward the right or toward the left so as to control the flow of fluid.

A pipe **135** leading from the valve **125** is connected with a throttle valve **137** and a ball check valve **136** which are in turn connected with the pipe **111**. Similarly a pipe **140** connected with the valve **125** is connected through a throttle valve **138** and a ball check valve **139** with the pipe **114**.

A speed control valve **145** is provided to facilitate traversing the truing tool at one speed while truing the side faces and the radii on the corners of the wheel and automatically reducing the speed to a slower truing speed as the truing tool **66** passes across the peripheral face of the grinding wheel **10**. The valve **145** is a piston type valve comprising a slidably mounted valve member **146** the upper end of which rides upon a cam **147** which is fixedly mounted on the shaft **76**. The valve member **146** is provided with a plurality of integral valve pistons which form a pair of spaced valve chambers **148** and **149**. A compression spring **150** serves normally to hold the valve so as the upper end **151** is maintained in operative engagement with the cam **147**.

The pipe **111**, as shown in Fig. 3 is connected with the valve chamber **148** which is in turn connected with the pipe **135**. Similarly the pipe **114** is connected with the valve chamber **149** which connects with pipe **140**.

When the solenoid S1 is energized, the valve member **126** moves toward the right (Fig. 3) so that fluid under pressure within the valve chamber **128** passes through the pipe **135**. Fluid under pressure within the pipe **135** may pass through the ball check valve **136**, through the throttle valve **137** and also through the chamber **148** in the valve **145** so that substantially an unrestricted flow of fluid is passed to the cylinder chamber **112** to start the piston **106** moving toward the left. During this movement fluid within the cylinder chamber **113** may exhaust through the pipe **114**, through the throttle valve **138** and also through the valve chamber **149** in the valve **145**, through the pipe **140** into the valve chamber **127** and exhausts through the pipe **141** into the reservoir **122**.

During movement of the piston **106** toward the left, the rock arm **98** is moved in a clockwise direction from the full line position (Fig. 2) toward the position **98***a*. During this movement the projections **79***a* and **79***b* of the follower **79** ride off the bosses **90***e* and **90***f* so that the truing tool **66** is moved toward the right (Fig. 2) into

operative engagement with the side face of a grinding wheel **10**. Continued movement of the arm **98** causes the truing tool **66** to move upwardly to true a portion of the side face **10***a* after-which the projections **79***a* and **79***b* of the follower **79** ride on the cylindrical face **90***a* of the form **90** to true a radius **10***b* on the grinding wheel **10**. During truing of the radius **10***b* the cam **147** is rotated so that when the follower rides on the horizontal plane faces **90***c* and **90***d*, the V **147***a* allows the release compression of the spring **150** to raise the valve member **146** upwardly so as to slow down the rate of movement of the piston **106** to slow down the traversing movement of the truing tool **66** while truing the peripheral face **10***c* of the grinding wheel **10**. As the truing tool **66** completes the radius, the projections **79***a* and **79***b* ride onto the horizontal plane faces **90***c* and **90***d* so that a continued movement of the arm **98** imparts a longitudinal traversing movement to the slide **50** and the truing tool **66** to true the peripheral face **10***c* of the grinding wheel **10**. As the truing tool **66** approaches the right hand end of the longitudinal traversing movement, the projections **79***a* and **79***b* of the follower **79** engage and slide along the partial cylindrical face **90***b* of the forming bar **90** so as to generate a radius **10***d* on the right hand corner of the grinding wheel. During this movement, the valve member **146** is depressed so as to speed up movement of the truing tool **66** while truing the radius **10** and the side face **10***e*. As the radius **10***d* is completed, the projections **79***a* and **79***b* of the follower **79** ride upon a vertical face **90***m* on the forming bar **90** so that the slide **50** together with the truing tool **66** moves in a vertical direction to true the side face **10***e* on the grinding wheel **10**. After a predetermined truing on the side face **10***e* the projections **79***a* and **79***b* of the follower **79** ride upon the bosses or projections **90***g* and **90***h* which impart a longitudinal movement to the slide **50** to move the truing tool **66** into position **66***d* so that it is out of engagement with the grinding wheel **10**.

During the swinging movement of the rock arm **98** as produced by a longitudinal movement of the piston **106**, a combined vertical movement of the slide **50** and a longitudinal movement of the slide **35** serves to cause the truing tool **66** to move through the several positions **66***a*, **66***b*, **66***c*, into position **66***d* as indicated in Fig. 2. As the rock arm **98** approaches position **98***d*, a limit switch LS2 is actuated to deenergize the solenoid S1 thereby releasing the compression of the spring **131** so that the valve member **126** returns to a central position.

When the solenoid S2 is energized, the valve member **126** is moved toward the left so that fluid under pressure entering the valve chamber **128** passes through the pipe **140** through the valve chamber **149** and also through the throttle valve **138** and the ball check valve **139** into the pipe **114** and the cylinder chamber **113** to start movement of the piston **106** toward the right. During movement of the piston **106** toward the right, the slides **50** and **35** are moved similar to that previously described so that the truing tool **66** moves first vertically and toward the left from position **66***d* into engagement with the side face **10***e* of the grinding wheel **10** after which a continued vertical movement of the truing tool trues the side face **10***e*. The truing tool **66** then swings at a relatively fast speed in a counter-clockwise direction around the right hand corner of the grinding wheel to true the radius **10***d* afterwhich the truing tool **66** traverse at a slower speed in a horizontal direction across the operative face **10***c*, said speeds being such that the tool **66** moves at a substantially uniform surface speed relative to the grinding wheel. At the end of the face **10***c*, the truing tool **66** then swings in a counter-clockwise direction at a relatively fast speed to true the radius **10***b* after which the truing tool moves in a vertical downward direction to true a portion of the side face **10***a* of the grinding wheel **10** as the follower projections **79***a* and **79***b* ride down the face **90***n*. When the projections **79***a* and **79***b* of the follower **79** ride upon the bosses **90***e* and **90***f*, the truing tool **66** is moved in a longitudinal direction toward the left so that it is out of operative engagement with the grinding wheel **10**.

When the truing tool is swung to a position for truing the cylindrical operative face of the grinding wheel **10**, the cam **147** swings so that the V-shaped notch **147***a* is opposite the end **151** of the valve stem **146** at which time the released compression of the spring **150** causes an upward movement of the valve stem **146** thereby cutting off the passage of fluid through the valve **145**. When the valve **145** is in this position, the rate of traversing movement of the truing tool **66** while traversing across the cylindrical face **10***c* is controlled by the setting of the throttle valves **137** and **138**.

During the swinging movement of the rock arm **98** in either direction, the follower **79** being pinned to the shaft **76** imparts a rotary motion to the sprocket **80** which in turn transmits a corresponding motion through the ling chain **81** and the sprocket **82** so as to impart a corresponding movement to the truing tool **66**.

A feeding mechanism is provided for automatically feeding the truing tool **66** toward the axis of the grinding wheel **10** before each traversing movement of the truing tool in either direction. This mechanism also includes means for imparting an unwind and a wind movement to the feed screw **20** at the time of each feeding movement. The shaft **29** is provided with a large gear **160** which is keyed thereon. The hub of the gear **160** supports a bell crank lever **161** which is supported by the shaft **29**.

A vertically extending arm **162** of the bell crank lever **161** (Fig. 3) is provided with a yoked portion **163** which engages a stud **164** carried by a piston **165**. The piston **165** is slidably mounted within a cylinder **166**. The piston **165** is normally held in a left hand end position by means of a compression spring **167**. A shuttle type valve **168** is provided for controlling the admission to an exhaust of fluid from a cylinder chamber **169** through a port **170**. The shuttle valve **168** is provided with a slidably mounted valve piston **171**. In the position, as shown in Fig. 3, when fluid under pressure is passed through a pipe **172** into a valve chamber **173**, the piston **171** is moved downwardly (Fig. 3) to open the port **170** so that fluid may pass into the cylinder chamber **169** to move the piston **165** toward the right thereby imparting a clockwise motion to the bell crank lever **161** so as to impart an unwind movement to the feed screw **20**. When fluid is permitted to exhaust through the pipe **172**, the released compression of the spring **167** serves to move the piston **165** toward the left thereby exhausting fluid from the cylinder chamber **169**, through valve chamber **173** and out through the pipe **172** thereby moving the bell crank lever **161** in a counter-clockwise direction so as to impart a wind movement to the feed screw **20**.

Similarly when fluid under pressure is passed through the pipe **174** into the valve chamber **175**, the valve member **171** is moved upward (Fig. 3) to open the port **170** so that fluid may pass into the cylinder chamber **169** to move the piston **165** toward the right thereby imparting a clockwise unwind movement to the feed screw **20**. This takes place at the other end of the transversing stroke of the truing tool **66**. When fluid may exhaust through the pipe **174**, the released compression of the spring **167** serves to move the piston **165** toward the left thereby imparting a counterclockwise movement to the bell crank lever **161** so as to impart a wind movement to the feed screw **20**.

A horizontally extending arm **180** of the bell crank lever **161** serves as a support for the feeding unit **32**. The feed unit **32** includes a small gear **181** which is rotatably supported on a slidably mounted shaft **182**. The small gear **181** meshes with the gear **160** and is arranged so that is free to rotate on the shaft **182** or may be clutched thereto by means of a clutch pin **183** which is

fixedly mounted on the shaft 182. As illustrated in Fig. 1 the clutch pin 183 is shown in operative engagement with a notch 184 formed in a hub portion of the gear 181.

The shaft 182 is provided with a plurality of V-grooves or notches 185, 186 and 187 which are arranged to be engaged by a spring-pressed ball 188 so as to hold the shaft in the desired axial position. If it is desired to declutch the gear 181 from the shaft 182, a knob 189 mounted on the end of the shaft 182 is moved toward the right (Fig. 1) until the spring pressed ball engages the groove 187 in which position the clutch pin 183 is moved out of engagement with the slot 184.

The feed unit 32 is provided with a pair of feed cylinders 190 and 192 which contain slidably mounted pistons 193 and 194 for imparting a feeding movement to the feed screw 20 before each traversing movement of the truing tool 66. The pistons 193 and 194 are normally held in upper-most positions by a pair of compression springs 195 and 196. The pistons 193 and 194 are each provided with downwardly extending studs 197 and 198 which are arranged to engage adjustable stop screws 199 and 200 to limit the stroke of the pistons so as to control the extent of the feed movement.

The piston 193 is provided with a pawl 201 which is arranged to engage the teeth of a ratchet wheel 202 so that when the piston 193 is moved downwardly, the pawl 201 will ride idly over the teeth crank feed wheel 202. A serrated wheel 203 formed integral with the ratchet wheel 202 is engaged by a spring pressed plunger 204 to hold the ratchet wheel 202 against rotary motion of the ratchet wheel 202 during the idle stroke of the piston 193.

Similarly the piston 194 is provided with a pawl 205 which engages the teeth of the ratchet wheel 202 so that when the piston 194 is moved downwardly, the pawl 205 imparts a rotary motion to the ratchet wheel 202 which in turn serves to impart a feeding increment to the feed screw 20, through the gear 181 and the gear 160.

When fluid under pressure is passed through the pipe 174 it enters a cylinder chamber 206 formed in the upper end of the cylinder 190 to cause an idle downward stroke of the piston 193. When the pipe 174 is opened to the exhaust, as will be hereinafter described, the released compression of the spring 195 causes an upward movement of the piston 193 to impart a feeding movement to the ratchet wheel 202. This happens when the truing tool is about to start its traversing movement in one direction. Similarly when fluid under pressure is passed through the pipe 172, when the truing tool is at the other end of its stroke, it enters a cylinder chamber 207 formed in the upper end of the cylinder 192 thereby causing a downward movement to the piston 194 to impart a feeding movement to the ratchet wheel 202 which in turn transmits the feeding increment through the gear 181, the gear 160 so as to actuate the feed screw 20. When fluid in the pipe 172 is opened to exhaust, the released compression of the spring 196 causes an upward movement of the piston 194 during which movement the pawl 205 rides idly over the teeth of the ratchet wheel 202.

In order to facilitate a manual actuation of the feed screw 20, it is desirable to provide means for declutching the ratchet wheel 202 and the serrated wheel 203 from the shaft 182, thereby rendering the feed unit 32 inoperative. This is accomplished by providing the shaft 182 with a clutch pin 210 which is arranged to engage a slot 211 formed in the ratchet wheel 202. If it is desired to declutch the ratchet wheel 202 from the shaft 182, the knob 189 is moved so that the ball detent 188 engages the groove 186 formed in the shaft 182. In this position the ratchet wheel 202 and the serrated wheel 203 are free to rotate relative to the shaft 182. In this position of the parts a downward feeding adjustment of the slide 13 may be accomplished by manual manipulation of the hand wheel 26.

A shuttle-type valve 215 is provided for controlling the admission to an exhaust of fluid from the unwind-wind cylinder 166 and also to the feed cylinders 190 and 192 so that when the piston 106 starts moving in either direction a feeding increment will be imparted to the feed screw 20 and at the same time an unwind and a wind movement will be imparted thereto so as to take up the feed increment. This valve comprises a slidably mounted valve member 216 having a plurality of spaced valve pistons which form a pair of spaced valve chambers 217 and 218. A pair of throttle valves 219 and 220 are provided to control the admission to an exhaust of fluid from a pair of end chambers 221 and 222 so as to control the rate of shifting movement of the valve member 216.

The operation of the improved truing apparatus will be readily apparent from the foregoing disclosure. A switch SW1 is closed to start the motor driven fluid pump 120 to supply fluid under pressure to the system. When it is desired to start a truing cycle, a push button start switch PB1 is actuated to close a circuit through the now closed contacts *a* of a limit switch LS1 to energize a relay switch CR1. Energizing relay switch CR1 closes the normally open contacts *a* and *b* of CR1. The closing of contacts *b* of relay switch CR1 sets up a holding circuit through the now closed contacts *b* of the limit switch LS2 to maintain the switch CR1 energized after the push-button switch PB1 is released. The closing of contacts *a* of CR1 serves to energize the solenoid S1 thereby shifting the valve member 126 toward the right (Fig. 3). With the valve in this position fluid under pressure entering the valve chamber 128 passes through the valve 145 and also through the ball check valve 136 and the throttle valve 137 into the cylinder chamber 112 to start the piston 106 moving toward the left. This movement of the piston 106 serves to start a swinging movement of the arm 98 in a clockwise direction to start movement of the truing tool 66. At the same time fluid under pressure in the pipe 135 passes through the throttle valve 220 into the end chamber 222 to start the valve member 216 moving toward left at a rate controlled by the throttle valve 219 and 220. Fluid under pressure in the pipe 135 also passes into the valve chamber 218 and through the pipe 174 into the cylinder chamber 206 to cause a downward movement of the piston 193. During the downward movement of the piston 193, the pawl 201 rides idly over the teeth of the ratchet wheel 202. Fluid under pressure passing through the pipe 174 enters the end chamber 175 in the valve 168 and causes an upward movement (Fig. 3) of the valve piston 171. When the port 170 opens as the piston 171 reaches its uppermost position fluid under pressure passes into the cylinder chamber 169 to move the piston 165 toward the right (Fig. 3) thereby imparting a clockwise rotary motion to the bell crank lever 161. This movement of the bell crank lever serves to impart an unwind movement to the feed screw 20. The above takes place during the initial movement of the valve member 216 toward the left.

As soon as the valve member 216 of the shuttle valve 215 uncovers a port at the end of the pipe 141, the released compression of the spring 195 causes an upward movement of the piston 190 during which movement the pawl 201 imparts a clockwise feeding movement to the ratchet wheel 202 thereby imparting a feeding increment to the feed screw 20. At the same time the released compression of the spring 167 shifts the piston 165 toward the left thereby imparting a counter-clockwise motion to the bell crank lever 162 so as to impart a wind movement to the feed screw 20. The above described feeding movement and the unwind-wind movement takes place instantaneously as soon as the piston 106 starts its traverse movement toward the left before the truing tool 66 starts truing the operative face of the grinding wheel 10.

As soon as the arm 98 starts a swinging movement in

a clockwise direction to traverse the truing tool **66** across the operative face of the grinding wheel, the limit switch LS1 is released so that the normally open contacts *a* thereof open and the normally closed contacts *b* close. The relay switch CR1 remains energized since the holding circuit established at the start of the truing cycle through contacts *b* of CR1 and the normally closed contacts *b* of the limit switch LS2 maintains the solenoid S1 energized until the piston **106** reaches the left hand end of its stroke. As the arm **98** reaches the end of its clockwise swinging movement it actuates the limit switch LS2 opening the normally closed contacts *b* and closing the normally open contacts *a*, so as to break the holding circuit to deenergize CR1 and solenoid S1 thereby allowing the released compression of the spring **132** to return valve member **126** to a central or neutral position. The limit switch LS2 remains in this position until the start of the next truing cycle.

When it is desired to start a truing cycle in the opposite direction to move the truing tool from position **66***d* through the several positions into position **66**, the push-button switch PB2 is actuated which closes a circuit through the now closed contacts *a* of limit switch LS2 to energize a relay switch CR2 thereby closing the contacts *a* and *b* thereof. The closing of contacts *a* of relay switch CR2 sets up a holding circuit through the now closed contacts *b* of limit switch LS1 to maintain the relay switch CR2 energized during the entire truing stroke of the truing tool **66** from right to left. The closing of contacts *b* of relay switch CR2 serves to energize the solenoid S2 thereby shifting the valve member **126** toward the left so that fluid under pressure entering the valve chamber **128** passes through the pipe **140**, through the valve **145** and also through the ball check valve **139** and the throttle valve **138** into the cylinder chamber **113** to start the piston **106** moving toward the right. Movement of the piston **106** toward the right serves to impart a counter-clockwise swinging movement to the arm **98**. When fluid under pressure is passed through the pipe **140**, it also passes through the throttle valve **219** into the end chamber **221** to shift the valve member **216** toward the right. Fluid under pressure in the pipe **140** also passes through the valve chamber **217**, through the pipe **172** into the cylinder chamber **207** to cause a downward movement of the piston **192** thereby imparting a clockwise feeding movement to the ratchet wheel **202** to turn the feed screw **20** thereby advancing the truing tool **66**. At the same time fluid under pressure passing through the pipe **172** enters the valve chamber **173** to cause a downward movement (Fig. 3) of the piston **171**. When the piston **171** reaches its lowermost position fluid under pressure passes through the port **170** into the cylinder chamber **169** to move the piston **165** toward the right thereby imparting a clockwise unwind movement to the bell crank lever **161** to impart an unwind movement to the feed screw **20**.

During movement of the valve member **216** toward the right, as soon as the valve chamber **127** uncovers the port at the end of the pipe **141**, the released compression of the spring **196** causes an upward movement of the piston **194** during which movement the pawl **205** rides idly over the teeth of the ratchet wheel **202**. At the same time the released compression of the spring **167** exhausts fluid from the cylinder chamber **169**, through the pipe **172** into the valve chamber **217** and exhausts through the pipe **141** into the reservoir **122**. During this movement of the piston **165** toward the left, a counter-clockwise movement is imparted to the bell crank lever **161** thereby imparting a wind motion to the feed screw **20** so as to take-up the feed increment.

The above description of operation enables manual control of the truing tool in either direction, when it is desired to make a single pass of the truing tool either toward the right or toward the left, by actuation of either the push-button switch PB1 or PB2. If however, it is desired to make two complete passes of the truing tool, that is, toward the right and return toward the left, the switch SW2 may be closed after which the push-button switch PB1 may be actuated to initiate a truing cycle. The controls operate in the same manner as above described to traverse the truing tool **66** from the full line position into the broken line **66***d*. The switch SW2 being closed, a return stroke of the truing tool will be automatically initiated to impart a return stroke of the truing tool toward the left so that the truing tool moves from broken line position **66***d* into full line position **66** (Fig. 2).

If a continuous truing operation is desired, that is, a continuous traverse toward the right, then toward the left and so forth, the switch SW2 is closed after which a continuous truing cycle may be initiated by closing the switch SW3. With the switches SW2 and SW3 closed, the truing tool will traverse continuously, first toward the right, then toward the left and this movement will continue until the switch SW3 is manually opened to stop the continuous truing cycle. The continuous truing operation is particularly useful in the initial truing of a new grinding wheel.

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

I claim:

1. In a grinding machine having a rotatable grinding wheel, a wheel guard partially surrounding said wheel, and a truing apparatus therefor including a base fixedly mounted on said guard, a vertically movable slide on said base, a feeding mechanism to feed said slide vertically relative to said base, a longitudinally movable slide on said vertical slide, a vertically movable carrier on said longitudinally movable slide, a truing tool holder rotatably mounted adjacent to the lower end of said carrier, a truing tool adjustably supported on said holder, a forming bar on said vertical slide, a follower rotatably supported adjacent to the upper end of said carrier, means to move said follower across the operative face of the forming bar, and synchronous driving connections between said follower and said truing tool holder to impart a controlled movement to said truing tool.

2. In a grinding machine, as claimed in claim 1, having means including a motor to traverse said follower across the operative face of the forming bar, said forming bar being so shaped as to first impart a transverse movement to said carrier to true a plane side face on the grinding wheel, then a combined movement to the longitudinal slide and transverse movement to the carrier to true a radius on one corner of the grinding wheel, then a longitudinal movement to the longitudinal slide to true a peripheral face on the grinding wheel, then a combined movement to the longitudinal slide and transverse movement to the carrier to true a radius on the other corner of the grinding wheel, and finally to impart a transverse movement to said carrier to true a plane side face on the other side of the grinding wheel.

3. A grinding machine having a rotatable grinding wheel, a wheel guard partially surrounding said wheel, and a truing apparatus therefor including a base mounted on said guard, a transversely movable slide on said base, a longitudinally movable slide thereon, a transversely movable carrier on said latter slide, a rotatable shaft adjacent to the one end of said carrier, a truing tool holder on said shaft, a truing tool adjustably supported on said holder, a rotatable shaft adjacent to the other end of said carrier, synchronous driving connections between said shafts, a follower fixedly mounted on said

latter shaft, a forming bar on the transversely movable slide, yieldable means to maintain said follower in operative engagement with said forming bar, and means to move said follower relative to said forming bar so as to impart a corresponding movement to the truing tool.

4. A grinding machine, as claimed in claim 3, in which the synchronous driving connections include a sprocket on each of said shafts, a link chain connecting said sprockets, and adjustable connections in said link chain to facilitate synchronizing the truing tool holder and the truing tool with said follower.

5. A grinding machine, as claimed in claim 3, in which a nut and screw feeding mechanism is provided between the truing tool and the holder, and a graduated adjusting means therefor to facilitate imparting a precise adjustment to the truing tool relative to the supporting shaft to vary the radius trued on the grinding wheel.

6. In a grinding machine, as claimed in claim 3, in combination with the parts and features therein specified, of a pivotally mounted yoked lever on said vertical slide which is operatively connected to move said follower, a motor included in said means to move said follower, and operative connections between said motor and said yoked lever to swing said lever thereby moving the follower across the operative face of the forming bar so as to true a predetermined shape on the grinding wheel.

7. In a grinding machine, as claimed in claim 3, in combination with the parts and features therein specified, in which the forming bar is provided with a pair of spaced off-set cylindrical portions, the axes of said portions being spaced to determine the axes of the radii to be trued on a grinding wheel, said bar having off-set horizontal plane surfaces to control the truing tool during a peripheral truing operation, and a pair of spaced vertical plane side faces which are spaced apart to control truing of the plane side faces on opposite sides of the grinding wheel, said follower having off-set projections which ride upon the operative face of the forming bar successively to true a side face, a radius, a peripheral face, a radius, and a side face of the grinding wheel.

8. A grinding machine, as claimed in claim 3, in combination with the parts and features therein specified in which the the forming bar is shaped so as to cause first a vertical upward movement of the truing tool, then a swinging movement, then a horizontal movement, then a further swinging movement and finally a vertical downward movement of the truing tool to true the predetermined shape on the periphery of the grinding wheel.

9. A grinding machine, as claimed in claim 3, in combination with the parts and features therein specified in which the forming bar is shaped so as to cause first a vertical upward movement of the carrier and truing tool to true a vertical plane side face of the grinding wheel, then a combined movement of the carrier and the longitudinal slide so as to swing said truing tool to true a radius, then a longitudinal movement of the longitudinal slide to traverse the truing tool longitudinally to true a peripheral face on the grinding wheel, then a combined movement of the carrier and the longitudinal slide so as to swing said truing tool to true a second radius, and finally a vertical downward movement of the transverse carrier and truing tool to true a vertical plane side face on the opposite side of the grinding wheel.

10. A grinding machine, as claimed in claim 3, in combination with parts and features therein specified, of a pivotally mounted yoked lever to move said follower relative to said template, a fluid motor operatively connected to actuate said lever so as to traverse the follower over the template thereby imparting a corresponding movement to the truing tool, a control valve to start and stop said motor, a normally closed speed control valve for said motor to facilitate moving the truing tool at one speed for truing portions of the operative face of the grinding wheel, and means including a cam actuated in timed relation with the follower to actuate the speed control valve so as to slow down the control during movement of the truing tool while truing other portions of the operative face of the grinding wheel.

11. In a grinding machine, as claimed in claim 3, in which the forming bar is provided with a pair of spaced off-set cylindrical portions, the axes of said portions being spaced to determine the axes of the radii to be trued on a grinding wheel, said bar having off-set horizontal plane surfaces to control the truing tool during a peripheral truing operation, a pair of spaced vertical plane side faces which are spaced apart to control truing of the plane side faces on opposite sides of the grinding wheel, and a pair of spaced projections on each of the plane side faces of the forming bar to move the truing tool out of engagement with the grinding wheel after the side faces of the grinding wheel have been trued to a predetermined extent.

12. A grinding machine having a rotatable grinding wheel, a wheel guard partially surrounding said wheel, and a truing apparatus therefor including a base mounted on said guard, a vertically movable slide on said base, a horizontally movable slide thereon, a vertically movable carrier on the longitudinally movable slide, a rotatable shaft adjacent to the lower end of said carrier, a truing tool holder on said shaft, a truing tool adjustably supported on said holder, a rotatable shaft adjacent to the upper end of said carrier, synchronous driving connections between said shafts, a follower having spaced off-set projections which are fixedly mounted on the latter shaft, a forming bar on said vertically movable slide, yieldable means to maintain said follower projections in operative engagement with said forming bar, and means including a motor to move said follower relative to said forming bar so as to impart a corresponding movement to the truing tool.

13. A grinding machine having a rotatable grinding wheel, supporting means fixedly secured to said grinding machine, and a truing apparatus therefor attached to said supporting means including an articulated assembly for supporting and positioning a tool holder, a truing tool adjustably supported in said holder, an elongated forming bar mounted adjacent said assembly, a follower mounted upon said assembly and positioned in coordinated relation to said tool holder, yieldable means to maintain said follower in operative engagement with said forming bar, and means to move said follower relative to said forming bar so as to impart a corresponding movement to said truing tool, said forming bar having a pair of spaced off-set cylindrical portions, the axes of said portions being spaced to determine the axes of the radii to be trued on a grinding wheel, off-set horizontal plane surfaces to control the truing tool during a peripheral truing operation, and a pair of spaced vertical plane side faces which are spaced apart to control truing of the plane side faces on opposite sides of the grinding wheel, said follower having off-set projections which ride upon the operative face of the forming bar successively to true a side face, a radius, a peripheral face, a radius, and a side face of the grinding wheel.

14. A grinding machine having a rotatable grinding wheel, supporting means fixedly secured to said grinding machine, and a truing apparatus therefor attached to said supporting means including an articulated assembly for supporting and positioning a tool holder, a truing tool adjustably supported in said holder, an elongated forming bar mounted adjacent said assembly, a follower mounted upon said assembly and positioned in coordinated relation to said tool holder, yieldable means to maintain said follower in operative engagement with said forming bar, and means to move said follower relative to said forming bar so as to impart a corresponding movement to said truing tool, said forming bar having a pair of spaced off-set cylindrical portions, the axes of said portions being spaced to determine the axes of the radii to be trued on a grinding wheel, off-set horizontal plane

surfaces to control the truing tool during a peripheral truing operation, a pair of spaced vertical plane side faces which are spaced apart to control truing of the plane side faces on opposite sides of the grinding wheel, and a pair of spaced off-set projections on each of the plane side faces of the forming bar to move the truing tool out of engagement with the grinding wheel after the

side faces of the grinding wheel have been trued to a predetermined extent, said follower having off-set projections which ride upon the operative face of the forming bar successively to true a side face, a radius, a peripheral face, a radius, and a side face of the grinding wheel.

No references cited.