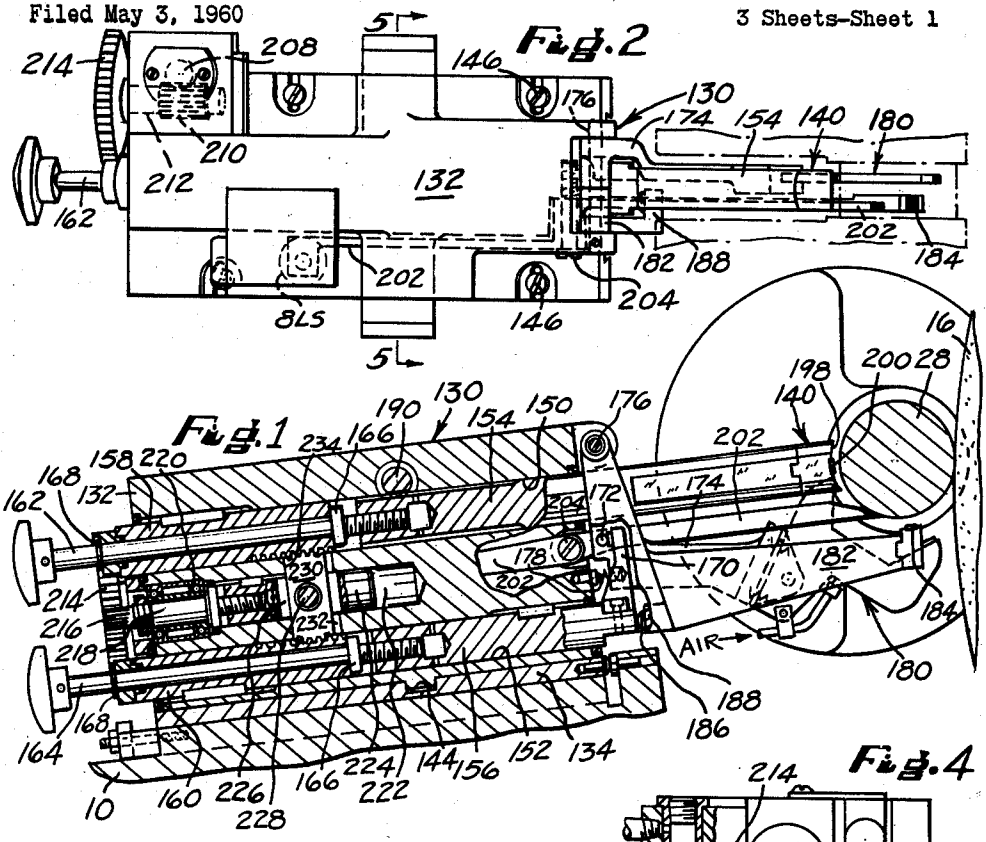
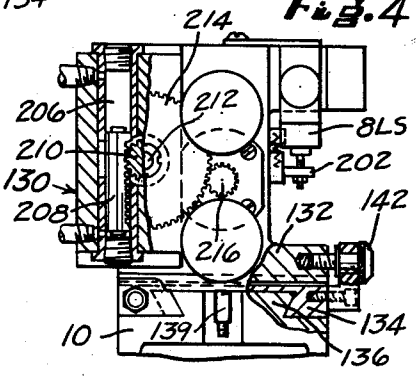
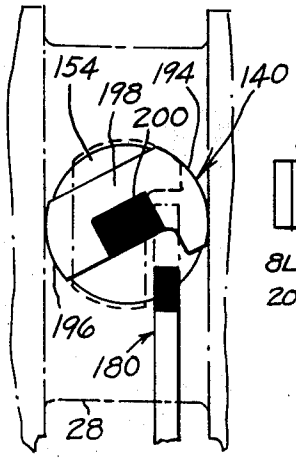
Feb. 5, 1963 G. C. JOYCE 3,076,296

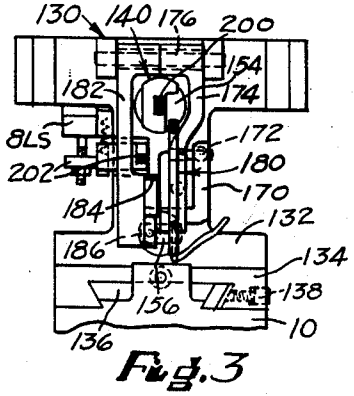
GRINDING MACHINE

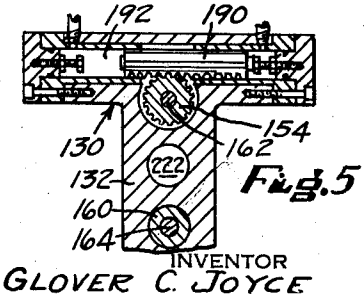
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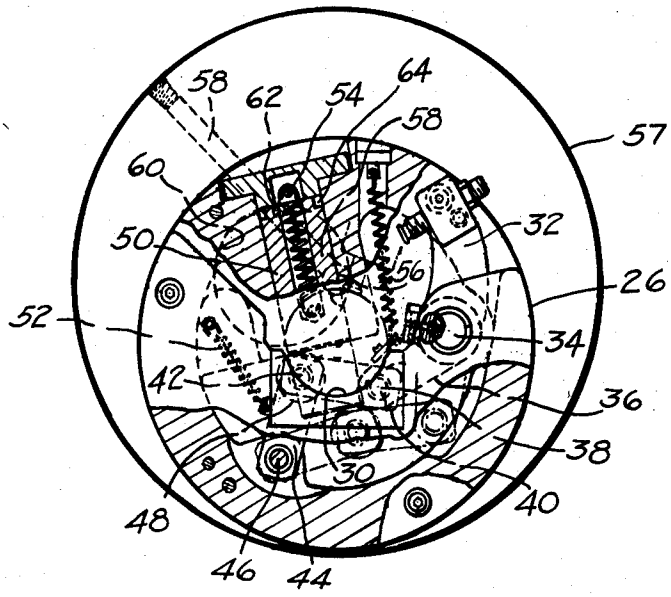
INVENTOR
GLOVER C. JOYCE
BY
ATTORNEY

Feb. 5, 1963 G. C. JOYCE 3,076,296

GRINDING MACHINE

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Fig. 7



INVENTOR
GLOVER C. JOYCE
BY
L. M. Smith Jr.
ATTORNEY

Feb. 5, 1963 G. C. JOYCE 3,076,296

GRINDING MACHINE

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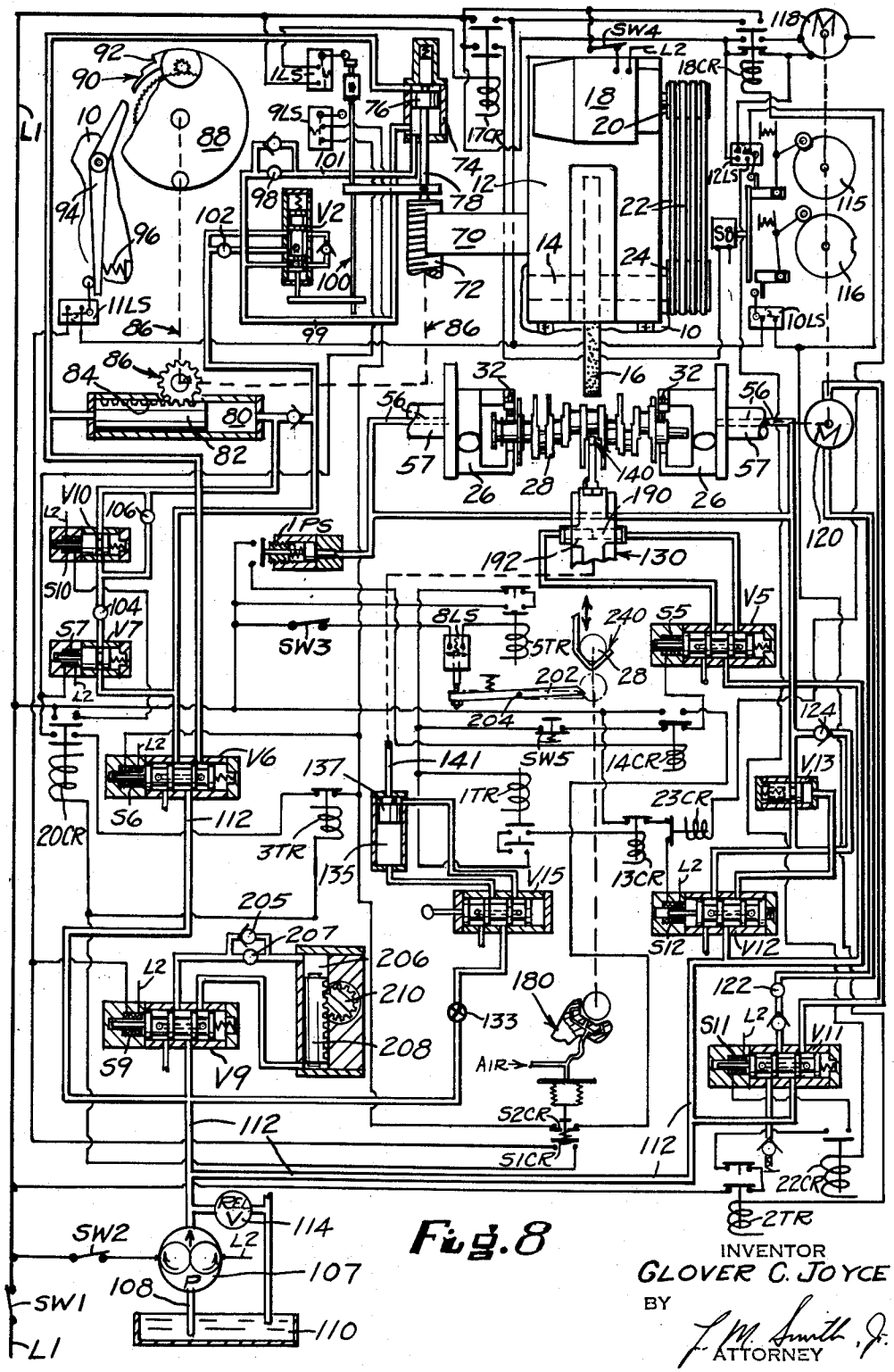


Fig. 8

INVENTOR
GLOVER C. JOYCE
BY
J. M. Smith, Jr.
ATTORNEY

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3,076,296
GRINDING MACHINE

Glover C. Joyce, Worcester, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Filed May 3, 1960, Ser. No. 26,644
15 Claims. (Cl. 51—165)

The invention relates to grinding machines and more particularly to a combined workpiece positioning, supporting and gaging mechanism.

Grinding machines representative of the prior art have incorporated workpiece supporting, gaging, and positioning mechanisms typically installed as individual units or separate units individually attached to one body but not integral therewith so that a relatively large amount of space is required in which to mount them. Such factors inherently limited the best design and increased the cost of the machine. Moreover, these units typically were mounted so that they interfered with the area through which the workpiece could be loaded into the machine most conveniently either manually or automatically, and thus, they caused a hardship in loading and unloading of the workpieces. In addition, the multiple mounting of these units individually also seriously obstructed the view of the operator. Finally, the prior art pertinent to such machines does not include teachings of in-process gages automatically positioned in engagement with a workpiece and thereafter retracted from engagement with a workpiece in coordinated relation to corresponding movements of the workpiece supporting elements during the grinding cycle by means of which the workpiece is finished.

The instant invention contemplates a more convenient simplified arrangement in which one of the steadyrests or work supporting elements incorporates an axial positioning device combined into one manually adjustable and hydraulically operated unit serving also as the actuating mechanism for one steadyrest, and the actuating mechanism for the other steadyrest or work supporting element incorporates a feature whereby both the work gaging mechanism and the other steadyrest element are engaged and disengaged with the workpiece at the same time. The mechanism is also designed so as to be a compact unit, combining the steadyrest or work supporting elements, work positioning and gaging elements in a minimum amount of space, such as between two shoulders and around a partial cylindrical portion of a workpiece, such as a crankpin of a crankshaft.

It is therefore one object of the invention to provide a combined compact work sensing, supporting, positioning and gaging mechanism for machine tools. Another object is to provide a combined work sensing, steadyrest, axial work positioner and work gaging mechanism which is simple and practical, containing fewer parts and therefore less costly to manufacture. Another object is to provide a combined steadyrest, axial positioner and gage mechanism which occupies less space for mounting and thereby allows for better design of the machine tool, making it easier to load and unload a workpiece. Another object is to enable the operator to view the workpiece more clearly and thereby avoid spoiled work. Another object is to provide a combined mechanism which is automatic and hydraulically operated. A further object is to provide a combined mechanism operable in coordinated relation to the wheel feed mechanism to initiate, interrupt, resume and terminate the grinding cycle of the machine. A further object of the invention is to provide a mechanism which applies a self-aligning gaging mechanism with as little pressure as possible thereby preventing unnecessary wear or abrasions to the gaging head and the surface being worked upon. A still further object of the invention is to provide a combined mechanism that is automatic in

operation, eliminating additional coordinated time and effort that otherwise would be required for applying individual units to a workpiece being machined to perform various functions in the requisite sequence.

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

FIGURE 1 is a side elevation, partially in cross section of the combined steadyrest, axial work positioner and gage mechanism in the retracted position;

FIGURE 2 is a plan view of the combined mechanism;

FIGURE 3 is an end elevation of the mechanism looking from the right hand side of FIGURE 1;

FIGURE 4 is an end elevation of the mechanism looking from the left hand side of FIGURE 1, partly in section showing the hydraulic portion of the steadyrest feeding mechanism;

FIGURE 5 is a sectional view taken approximately on line 5—5 of FIGURE 2, showing the means for rotating the axial positioning portion of the combined mechanism;

FIGURE 6 is a fragmentary end view of the axial positioning member looking from the right hand side of FIGURE 1 showing the positioning member rotated into engagement with the shoulder of a workpiece;

FIGURE 7 is an end elevation partly in section of one of the work supporting pot chucks; and

FIGURE 8 is a combined diagrammatically illustrated electrical and hydraulic diagram of the operating mechanisms of the machine.

This invention is particularly applicable to crankpin grinding machines such as those disclosed in the prior U.S. Patents to Stewart S. Mader, #2,723,503 dated November 15, 1955, and to Herbert A. Silven et al. #2,780,895 dated February 12, 1957, to either of which reference may be had for details not disclosed herein.

As shown in FIG. 8 fluid under pressure is supplied from any suitable source such as, for example, by an electrically driven fluid pump **107** drawing fluid through a pipe **108** from a reservoir **110**. The fluid pump passes fluid under pressure to a pipe **112** leading to the various hydraulic components of the machine. A relief valve **114** is provided for maintaining the desired operating pressure within the system independent of variations in the demand for hydraulic fluid.

As illustrated in FIG. 8 of the drawings, a base **10** serves as a support for a transversely movable wheel slide **12** and a rotatable wheel spindle **14**, journalled in suitable bearings not shown. The wheel spindle **14** supports a grinding wheel **16** rotatably driven by a motor **18**, through multiple V-groove pulleys **20** and **24** connected by belts **22**.

The base **10** also serves as a support for a pair of synchronously rotatable and axially aligned pot chucks **26** for supporting and rotating the opposite ends of a crankshaft or workpiece **28**. Each of the pot chucks are identical in construction and therefore only one of them has been illustrated in FIG. 7 of the drawings. The pot chucks **26** are each provided with a half bearing **30** for supporting one of the ends of the crankshaft **28**. A rotatable clamping member **32** is fixed on one end of a shaft **34**, rotatable within bearings in each of the pot chucks **26**. The other end of the shaft **34** is fixed to a lever arm **36**, that is pivotally connected by a pin **38** to one end of a link **40** connected at its other end by a pin **42** to a link **44** pivotally supported on a pin **46** fixed to the pot chuck **26** to form a toggle clamping arrangement.

A roller **48** is rotatably mounted on the pin **42** and is held in engagement with the end surface of a slidably mounted piston **50**, by a tension spring **52**, one end of which is attached to the link **44** and the other to the pot chuck **26**. The piston **50** is biased to an inoperative

position by a tension spring 54, one end being fixed to the inside of the piston 50 and the other end to the pot chuck 26.

When it is desired to clamp a crankshaft or workpiece 28 in the pot chucks 26, fluid under pressure is passed simultaneously through a central passage 56 in each of a pair of synchronously rotatable spindles 57 having flanges for supporting the pot chucks 26. Fluid under pressure then passes through a hole disposed within the periphery of an enlarged recess 60 in the pot chuck 26 and thence through a hole 62, which happens to be in alignment with the first mentioned hole as viewed in FIG. 7, into the cylinder chamber 64, moving the piston 50 contacting the roller 48 and thereby expanding the toggle links 40 and 44 causing the shaft 34 and the clamping member 32 to rotate counter-clockwise as viewed in FIG. 7. Thus, concurrent actuation of the clamping members 32 simultaneously clamps a workpiece in the respective pot chucks 25 against the half bearings 30 thereon.

The base 10 also is a support for a combined mechanism 130 including an axial work positioner, a work supporting steadyrest, and work gaging means, comprising a housing 132 mounted on a sub-base 134 fastened to the base 10. As illustrated in the drawings, the sub-base 134 is mounted on a slideway 136 on the base 10 and maintained in an adjusted position by screws 138. It is desirable, when applying the combined mechanism 130 to machines that grind a crankshaft complete in which different portions or bearings must be traversed longitudinally so as to position the portions or bearings to be ground opposite the grinding wheel, to provide means for retracting the combined mechanism 130 away from the workpiece so that a new portion of the workpiece can be traversed into the position opposite the grinding wheel. Any suitable retracting means such as an hydraulic cylinder may be employed for retracting the combined mechanism 130 on the slideway 136, the locking screws 138 shown in FIG. 3 being eliminated in this case. The retracting means employed may be connected into the hydraulic system for the machine so as to move the combined mechanism 130 away from and toward the work by either semi-automatic or fully automatic control means between the grinding cycles for finishing successive crankpins. One such arrangement is illustrated schematically in FIG. 8 and its operation is described further below.

The combined mechanism 130 must be precisely positioned opposite the grinding wheel 16 so that the axis of rotation of a symmetrical workpiece axial positioner 140 passes precisely through the mid plane of the grinding wheel 16. For this purpose, adjustable positioning means are provided comprising a micrometer adjusting screw 142 rotatably mounted in a bracket fixed to the sub-base 134. A slideway 144 is also provided in the sub-base 134 for guiding the housing 132 while it is being adjusted relative to the mid plane of the grinding wheel 16. There are screws 146 passing through elongated slots in the housing 132 and threaded into the sub-base 134 for clamping the housing 132 in the adjusted position.

The housing 132 supports a normally open limit switch 8LS actuated by a spring biased lever 202 pivoted on a pin 204 fixed to the housing 132. The lever 202 serves as a feeler for sensing the presence of a workpiece loaded into the pot chucks 26 and for automatically starting a grinding cycle by closing the contacts of limit switch 8LS.

The housing 132 is provided with a pair of centrally spaced bores 150 and 152 housing a pair of shafts 154 and 156 at one end of the housing 132, and a pair of shafts 158 and 160 slidably keyed within the bores 150 and 152 at the other end of the housing 132. A pair of rotatable adjusting shafts 162 and 164 pass through central bores within the shafts 158 and 160 and have threaded end portions screwed into threaded holes at one end of each of the shafts 154 and 156. The adjusting shafts 162 and 164 have flanged portions 166 engaging

one end of the shafts 158 and 160 and a retainer ring 168 at the other end for preventing the axial displacement of the adjusting shafts relative to the shafts 158 and 160. The adjusting shafts 162 and 164 when rotated cause the shafts 154 and 156 to move axially within the bores to move them either closer to or farther away from the workpiece 28.

The slidable shaft 156 is keyed to prevent its rotation within the housing 132 and has a flat portion at one end supporting a fixedly mounted upright bracket 170 having a surface engaging a pin 172, fixed to a gage support arm 174 pivotally supported on a pin 176 fixed to the housing 132. A spring 178 interposed between the housing 132 and the gage arm 174 normally acts to move the gage support arm 174 in a counter-clockwise direction as seen in FIG. 1 so as to allow a spring balanced air gaging head 180, resiliently pivotally supported on arm 174, to engage the portion or bearing being ground when the shaft 156 moves toward the workpiece such as a crankshaft. The pin 172 is held in engagement with the bracket 170 during the movement toward the work by the spring 178 interposed between the housing 132 and the gage support arm 174. When the shaft 156 is caused to be moved away from the workpiece 28, the bracket 170 engaging the pin 172 moves the gage support arm 174 clockwise to disengage the air gaging head 180 from the workpiece being ground.

The air gaging head 180 may be any of the conventional units on the market such as Airlectric gaging units manufactured by the Sheffield Corporation of Dayton, Ohio.

A lever arm 182, also rotatably supported by the pin 176 fixed to the housing 132, has a steadyrest shoe or element 184 fixedly mounted at one end thereof for engaging the adjacent underside portion of the workpiece or bearing being ground. The steadyrest shoe 184 is moved into engagement with the work by the axial displacement of the shaft 156 toward the workpiece by the engagement of one end of shaft 156 with a ground head of a pin 186 fastened into an offset portion 188 integral with the lever arm 182. On retraction of the shaft 156 away from the workpiece, the weight of the lever arm 182 causes disengagement of the steadyrest shoe or element 184 from the workpiece and continued engagement of the pin 186 with the end of the shaft 156.

The shaft 154 is mounted to be rotatable as well as slidable within the bore 150. When grinding shouldered pieces such as a crankshaft 28, it is desirable to remove equal amounts of stock from each side of the shoulders of the bearing, a process known in the art as "spark splitting." The spark splitter or axial positioner 140 operable with shaft 154 retracted is mounted on the end of the shaft 154 adjacent the workpiece 28. The shaft 154 is provided with gear teeth around its periphery at its left hand end which are engaged by the teeth of a rack type piston 190 within a cylinder 192 shown best in FIG. 5, integral with or attached to the housing 132 and operable in the manner described further below. The teeth of the rack piston 190 meshing with the teeth of the shaft 154 not only serve to rotate shaft 154 when piston 190 is displaced with shaft 154 retracted but also act as a key to prevent the shaft from rotation during axial movement of the shaft 154 with piston 190 at rest. The work positioner 140 has a concave end face 198 into which is fixedly mounted a steadyrest shoe or element 200 for engagement with the adjacent portion of a workpiece substantially opposite the grinding wheel 16. The positioner 140 is flatted off on its sides adjacent the camming surfaces 194 and 196 to provide ample clearance when a workpiece is loaded into and rotated by the machine. A recess is also machined in the positioner 140 to provide clearance for the air gaging head 180.

Considering next rotary movement of shaft 154, when fluid under pressure is passed into the cylinder 192, the piston causes the shaft 154 and the axial work positioner 140 attached thereto to rotate therewith. The work posi-

tioner or spark splitter 140 has symmetrical camming portions 194 and 196 (FIG. 6) either of which when rotated less than 90° will engage one or the other of the spaced shoulders of a workpiece 28 such as a crankshaft, so as to cause an axial displacement of the workpiece in one direction until the two camming surfaces contact both shouldered surfaces to precisely position the workpiece relative to the grinding wheel 16 so that equal amounts of stock will be removed from both shouldered surfaces. When it is desired to axially position a workpiece for a grinding operation, a solenoid S5 is energized to shift a four-way valve V5 to the right against a spring, allowing fluid under pressure to pass from the pipe 112 into the cylinder 192 causing the piston 190 to rotate the shaft 154 and the axial work positioner 140. The axial positioning of a workpiece is performed immediately after a workpiece has been lowered into the pot chucks 26 and before the clamping of the workpiece thereto.

The fluid pressure operated mechanism described above for clamping and unclamping the workpiece such as crankshaft 28 in the pot chucks 26 is controlled by a four-way valve V12 shifted to the right against a spring by a solenoid S12, shown energized in FIG. 8, allowing fluid under pressure from the pipe 112 to pass to and move and hold a valve V13 to the left, allowing fluid from the cylinders 64 of the pot chucks 26 to exhaust so that the clamps 32 are withdrawn into a position for unolading of a workpiece such as a crankshaft 28. Fluid under pressure also exhausts from a pressure switch 1PS whose function is to be hereinafter disclosed. When the solenoid S12 is deenergized allowing the spring to move the valve V12 to the left, fluid under pressure is directed so as to by-pass the valve V13, allowing the spring to bias valve V13 to the right, and to the pressure switch 1PS, closing its contacts, and through pipes 56 into the cylinders 64 to clamp the workpiece such as crankshaft 28. A check valve 124 allows pressure fluid to bypass the valve V13 when a workpiece is clamped and also prevents fluid exhausted from the cylinders 64 from bypassing the valve V13 when the valve V13 is in a right hand position, thus preventing unclamping of the workpiece in the event of loss of pressure during rotation of the pot chucks 26 and the workpiece 28.

A grinding wheel feeding mechanism is provided for imparting a transverse feeding movement to the wheel slide 12 comprising a feed nut 70 depending from the underside of the wheel slide 12, meshing or engaging with a rotatable feed screw 72. An hydraulically operated mechanism is provided for rapidly moving the wheel slide 12 to and from an operative position, comprising a cylinder 74 which contains a slidable piston 76 connected to one end of a piston rod 78 connected at the other end to the feed screw 72. The grinding wheel feeding mechanism also comprises a cylinder 80 having a piston 82 upon which are cut rack teeth 84 meshing with a gear train 86 which is substantially the same as disclosed in the U.S. patents to Stewart S. Mader #2,723,503 or Silven et al. #2,780,895 to which reference may be made for details not disclosed herein.

The gear train 86 is connected to the feed screw 72 so as to rotate the screw 72 and thereby impart a continued feeding movement to the wheel slide 12 after the initial feeding movement has been stopped by the bottoming of the piston 76 in the cylinder 74. The gear train 86 is also connected to impart a rotary movement to a hand wheel 88 which has a cam 90 including a stop surface 92 mounted thereon. A pivotally mounted stop lever 94 is mounted on the base 10 and is provided with a bevelled surface for engagement with the cam portion 90 which causes the lever 94 to rotate counter-clockwise. When the hand wheel 88 is rotated counter-clockwise the cam portion 90 engages and rotates the lever 94 so as to allow a normally closed limit switch 11LS to close and its function will be hereinafter disclosed. The rotation of the hand wheel 88 is terminated when the stop surface 92 engages the surface on the upper arm of the stop lever 94 or before it reaches the stop by operation of the work size gaging means to be hereinafter described. The grinding wheel feeding mechanism also provides a mechanism for controlling the feeding rate during various predetermined portions of the feeding cycle, which will be hereinafter disclosed.

The mechanism for controlling the wheel feeding rate includes a 4-way control valve V6 actuated by a solenoid S6 for controlling the direction of flow of fluid under pressure to and from the cylinders 74 and 80, as well as control valves V2, V7, and V10 arranged so that control valve V2 regulates the initial wheel feeding movement by controlling the rate of displacement of the piston 76 within the cylinder 74 and so that control valve V7 and control valve V10 are actuated sequentially to control the subsequent wheel feeding movement by regulating the rate of displacement of the piston 82 within the cylinder 80.

During the initial portion of the feeding cycle, the mechanically actuated control valve V2 permits a relatively rapid approach feed. Then, since it is desirable when grinding the side shoulders of a bearing of a crankshaft 28 to slow down the wheel slide 12 relative to the rapid approach feeding rate, the control valve V2 operates to initiate a relatively slower shoulder feeding rate until the wheel 16 closely approaches the bearing surface between the respective shoulders. Finally, as the piston 76 closely approaches the end of the cylinder 74, the feeding rate is further reduced to cushion the bottoming of the piston 76.

The spring biased spool contained within the control valve V2 is engaged and displaced by an element of an actuating dog bar assembly 100 adjustably fixed to and movable with the wheel slide 12 as illustrated in FIG. 8 so that the spool of the control valve V2 is displaced upwardly against a biasing spring when the wheel slide 12 is in its fully retracted position. Thus, the fluid discharged from the cylinder 74 is initially directed through the pipe 99 in the side of the cylinder 74 to and through the valve V2 and thence through the unobstructed pipe discharging from the valve V2 to the return side of the hydraulic system. This arrangement produces the initial rapid approach feed. As the actuating dog bar assembly 100 is displaced with the wheel slide 12 relative to the valve V2, the unobstructed discharge pipe from valve V2 is closed off so that the fluid discharged from cylinder 74 is then directed through an adjustable throttle valve 102 set to produce a relatively slower shoulder feed at the desired rate. Finally, as the piston 76 approaches the end of the cylinder 74 it closes off the pipe discharging from the side of the cylinder and thereafter fluid is discharged from the cylinder solely through the pipe 101 connected at the end of cylinder 74 and thence through a different throttle valve 98 set to produce a relatively slower feed which may conveniently correspond to the body feed subsequently used for grinding the bearing surface of the workpiece.

Notwithstanding the fact that fluid under pressure is admitted simultaneously to the upper end of cylinder 74 and to the left hand end of cylinder 80 as illustrated in FIG. 8 when solenoid S6 of the 4-way valve V6 is energized, the initial wheel feeding movement is produced solely by displacement of the piston 76 because the solenoid S7 of control valve V7 is initially energized to displace the spool of valve V7 to the right and thereby preclude the discharge of fluid from the right hand end of cylinder 80 until limit switch 9LS is opened at the end of the stroke of piston 76 to deenergize solenoid S7.

It is desirable when starting to grind the crankpin or bearing portion to further vary the rate of wheel feed during the final finishing portion of the grinding cycle. With the spool of control valve V7 shifted toward the left by a biasing spring when solenoid S7 is deenergized, the fluid is allowed to exhaust from the right hand end of the cylinder 80 through control valve V10 in which the spool

is biased to the left by a spring and thence through an adjustable throttle valve 104 set to produce wheel feed at a predetermined body feeding rate. When solenoid S10 is subsequently energized, the spool of the control valve V10 is shifted to the right against the biasing spring to further reduce the rate of feed of the grinding wheel 16 toward the workpiece by directing the flow of exhaust fluid through an adjustable throttle valve 105 connected in series with throttle valve 104 and control valve V7. The wheel feed produced by the displacement of piston 82 in cylinder 80 is terminated by energizing solenoid S7 again to close valve V7.

An hydraulic actuating mechanism is provided for moving the steady rest elements 184 and 200 and the air gaging head 180 into and out of engagement with a workpiece. The mechanism comprises a cylinder 206 housing a piston 208 having rack teeth engaging a gear 210 integral with a shaft 212. The shaft 212 has another gear 214 fixedly mounted on it at the other end meshing with a gear 216 integral with a feed screw shaft 218, rotatably supported in bearings 220 within the housing 132. The housing 132 has a central bore 222 into which is slidably keyed a shaft 224, having a threaded hole at its left hand end engaging the threaded portion of the feed screw 218. The slidably keyed shaft 224 has an elongated slot 226 substantially mid-way its ends and a pin 228 fixed to it for rotatably supporting a narrow gear segment 230. The gear segment 230 meshes with the rack teeth of both of the slidably keyed shafts 158 and 160 to function as a pressure equalizing element. The housing also is provided with an elongated opening 232 having an end surface 234 which engages the left hand surface of the gear segment 230 and serves as a stop for the actuating mechanism in the retracted position as shown in FIG. 1. The right hand end of the elongated opening 232 serves as a positive stop calibrated by adjusting shafts 162 and 164 with the finish diameter of a ground workpiece.

The four-way control valve V9 when energized by solenoid S9 is moved to the right against a spring, allowing fluid under pressure from the pipe 112 to pass into the cylinder 206 to move the piston 208 and thereby rotate the gears 210, 214, 216 and the feed screw shaft 218, thereby causing an axial movement of the shafts operable to move the steadyrest shoes or elements toward the workpiece 28 at a rate controlled by an adjustable throttle valve 207. When the solenoid S9 is deenergized, the valve V9 is spring biased to the left so as to pass fluid under pressure to the cylinder 206, through a check valve 205 moving the piston in the opposite direction into the position shown in FIG. 8 so as to rotate the gears 210, 214, 216 and the feed screw 218 and retract the steadyrest shoes and air gaging head 180 until the left hand surface of the gear segment 230 rests against the surface 234 of the housing 132, the mechanism being adjusted so that the piston 208 does not first bottom in the cylinder 206.

An angular work positioning mechanism for stopping the pot chucks 26 in a precise angular position is provided for easy loading and unloading of a workpiece either manually or by any well known automatic work handling mechanisms. The angular work positioning mechanism briefly comprises a pair of rotatable notched discs 115 and 116 coupled into the work drive mechanism, a pair of levers having rollers rotatably fixed to them engaging the periphery of the discs 115 and 116 for actuating the limit switches 10LS and 12LS, and a braking circuit of a short duration applied to the windings of the work drive motor 118. The braking circuit is of the type well known in the art. The braking circuit is momentarily applied to the work drive mechanism when work drive motor 118 is deenergized so that the auxiliary drive motor 120 may operate shortly thereafter to precisely position the pot chucks 26 angularly. The auxiliary drive motor 120 is an hydraulic motor coupled into the work drive so as to rotate the pot chucks at a reduced rate so that one of the above said rollers will drop into the notch in the discs 115 to function in the manner which will be hereinafter described. The angular positioning mechanism above described is substantially the same as that disclosed in a prior U.S. patent to H. A. Silven et al. #2,780,895 to which reference may be had for details not disclosed herein.

A control valve V11 moved to the right against a spring by a solenoid S11 is provided for directing the flow of fluid to the hydraulic motor 120, operable at a relatively slow rate controlled by an adjustable throttle valve 122, to rotate the pot chucks 26 and discs 115 and 116 until the roller contacting the disc 115 drops into the notch for a precise positioning of the pot chucks 26.

The operation of the machine will now be described. With the machine in the condition shown in FIG. 8, that is with the switch SW1 closed supplying power to the different electrical components, a relay 23CR is immediately energized through the normally closed contacts of a relay 18CR and through the normally open contacts, now closed, of a limit switch 12LS. The closing of the normally open contacts of the relay 23CR energizes a solenoid S12 through the normally closed contacts of a relay 13CR, shifting the valve V12 to the right. The switch SW2 is closed also and the electrically driven hydraulic pump 107 supplies fluid under pressure into the pipe 112 and thence to the various hydraulic elements of the machine. A switch SW3 is closed also so that the grinding cycle will automatically start when a workpiece such as a crankshaft is deposited into the pot chucks 26. Alternatively, if it is desired to manually operate the machine, the switch SW3 is left open until after a workpiece has been deposited into the pot chucks 26 closing the limit switch 8LS and then the grinding cycle may be started by closing the switch SW3. Finally, with switch SW4 closed, the grinding wheel drive motor 18 is energized.

A crankshaft 28 is lowered into the machine either manually or by an automatic loading and unloading mechanism, as diagrammatically represented in FIG. 8 by a crank shaft 28 shown supported by hooks 240 which represent the work engaging portion of any one of such mechanisms known to the art, such as that disclosed in a U.S. Patent No. 2,813,380 to Joseph W. Narel et al. issued November 19, 1957, to which reference may be had for details not disclosed herein. When the crankshaft is lowered into the pot chucks 26 the portion to be ground contacts the end of the sensing lever 202, rotating it clockwise so as to close the normally open contacts of the limit switch 8LS. Closing of the contacts of the limit switch 8LS energizes a time delay relay 5TR, closing one set of its contacts instantly on energization, the other set being timed on energization to open after a predetermined time interval has elapsed. Closing of the normally open contacts of the relay 5TR energizes a solenoid S5 through a normally closed manually operable switch SW5 and also energizes a relay 1TR. The solenoid S5 moves the valve V5 to the right allowing fluid pressure from the pipe 112 into the cylinder 192 to rotate the axial positioner mechanism 140 and thereby axially position the workpiece 28. The energization of the time delay relay 1TR closes one set of its contacts instantly which is connected in series with another set of its own contacts that is timed to close after a short interval at which time the relay 13CR is energized, opening its normally closed contacts breaking a circuit to deenergize the solenoid S12.

Deenergization of the solenoid S12 allows spring pressure to move the valve V12 to the left, allowing oil under pressure to pass through the passages 56 into the cylinders 64 of the pot chucks 26 clamping the workpiece 28 in the pot chucks 26. At the same time fluid under pressure closes a pressure switch 1PS closing its contacts and thereby energizing a relay 14CR. Energization of the relay 14CR opens a set of normally closed contacts and closes a normally open set of contacts. The opening of the normally closed set of contacts deenergizes the solenoid S5 allowing the valve V5 to move to the left

under spring pressure, thus permitting fluid under pressure to pass to the opposite end of the cylinder 192 to return piston 190 and thereby rotate the axial work positioner 140 to an inoperative position, shown best in dashed lines in FIG. 6, out of engagement with the shouldered portions of the workpiece 28. Closing of the normally open contacts of the relay 14CR energizes the solenoid S6 through the normally closed contacts S2CR of the gaging mechanism including the gage head 180 and the solenoid S7 through the normally closed limit switch 9LS, shifting the valves V6 and V7 to the right allowing oil under pressure to enter the cylinder 74 moving the piston 76 and the wheel slide 12 forward, and also applying fluid under pressure to the feed cylinder 80 arranged to rotate the feed screw 72 and the hand wheel 88. However, the piston 82 is not immediately displaced relative to cylinder 80 for reasons which will become apparent below.

When the wheel slide moves forward, a normally closed limit switch 1LS closes its contacts energizing a relay 17CR. Closing of the two sets of normally open contacts of the relay 17CR energizes a relay 18CR and a time delay relay 2TR through a normally closed limit switch 10LS and also energizes the solenoid S8. The normally closed contacts of the relay 18CR open to break the braking circuit to the work drive motor 118 and also deenergizes the relay 23CR, opening its contacts to prevent the solenoid S12 from becoming energized. The two sets of normally open contacts of the relay 18CR close, one set starting the work drive motor 118 and the other set by-passing a set of contacts of the relay 17CR, thereby holding the relay 18CR and the time delay relay 2TR energized independent of 17CR.

Shortly thereafter the time delay relay 5TR times out opening its timed contacts to deenergize the time delay relay 1TR opening its contacts and thereby deenergizing the relay 13CR so that its normally closed contacts close. Since the relay 23CR is now deenergized and its normally open contacts are open, the solenoid S12 cannot now become energized.

The energization of the solenoid S8 moves the angular positioning rollers out of engagement with the notched rotatable discs 115 and 116 by moving the lever actuators to the right. A limit switch 12LS is released as the rollers move out of engagement with the discs, opening a normally open set of contacts and closing a normally closed set of contacts of the limit switch 12LS.

When the relay 18CR and the time delay relay 2TR are energized, they are held energized through one set of the now closed contacts of the relay 17CR and through the normally closed contacts of the limit switch 10LS. Energizing of the time delay relay 2TR opens its contacts immediately, the contacts being in series with one another and also in series with a set of normally open contacts of a relay 22CR that now becomes energized when the above said normally closed contacts of the limit switch 12LS close in response to energization of the solenoid S8, thus preventing solenoid S11 from becoming energized, and thereby preventing premature operation of the hydraulic auxiliary drive motor 120.

With work drive motor 118 energized, the workpiece or crankshaft 28 is now rotating and the wheel slide is moving toward the workpiece. When the grinding wheel reaches the shoulders of the crankpin, a valve V2 has been gradually shifted by spring pressure so that the exhaust oil from wheel slide cylinder 74 has been throttled so as to provide a slower shoulder feeding rate. When the grinding wheel reaches the body portion between the shoulders of the crankpin shortly before the wheel slide piston 76 bottoms, a limit switch 9LS is actuated by the dog bar 100 opening its normally closed contacts, deenergizing the solenoid S7 allowing the valve V7 to shift to the left and oil under pressure to exhaust from the hand wheel feed cylinder 80 at a body feed rate controlled by a throttle valve 104, so that wheel feed cylinder 80 now becomes operative. The grinding wheel reduces the diameter of the crankpin at a body feed rate determined by throttle valve 104 until the cam 90 on the hand wheel 88 rotates the lever 94 counterclockwise allowing the normally closed contacts of the limit switch 11LS to close energizing the solenoid S9 which shifts a valve V9 to the right allowing oil under pressure to move into the cylinder 206 to move the piston 208 and thereby move the steadyrest shoes and the air gaging means into engagement with the crankpin or work portion being ground.

Grinding of the workpiece continues until the crankpin has been reduced in size so that the contacts S1CR of the air gaging means close energizing a time delay relay 3TR and a relay 20CR. Energizing the relay 20CR closes its normally open contacts energizing solenoid S10 and solenoid S7. Since the normally closed contacts of limit switch 9LS are now held open, solenoid S7 is energized through the closed contacts of the relay 3TR timed to open a predetermined interval after the coil of relay 3TR is energized. The energization of the solenoids S10 and S7 shifts the valves V10 and V7 to the right preventing the exhaust of fluid from the hand wheel feed cylinder 80 causing a period of dwell by stopping the infeed of the grinding wheel, thereby allowing the rounding up of the crankpin or bearing due to spring or stress induced by the grinding pressure against the crankshaft 28. After a short delay the normally closed timed to open contacts of the time delay relay 3TR, open deenergizing the solenoid S7 only, leaving the solenoid S10 energized and the valve V10 in the right hand position so that oil is now exhausted through a fine feed throttle valve 106. The grinding of the workpiece continues at a fine feeding rate until the normally closed contacts S2CR of the air gaging means open deenergizing the solenoid S6 allowing the valve V6 to shift to the left to pass fluid under pressure to the opposite sides of the hand wheel feed cylinder 80 and the wheel slide cylinder 74 to move the grinding wheel slide 12, the grinding wheel 16 and the hand wheel 88 in the opposite direction to an inoperative position.

When the wheel slide moves rearwardly, limit switch 9LS is released and the limit switches 1LS and 11LS are actuated. The normally closed contacts of the limit switch 9LS close, energizing the solenoid S7 to move the valve V7 toward the right. The opening of the normally closed contacts of the limit switch 1LS deenergizes the relay 17CR opening its contacts, deenergizing the solenoid S8. Opening of the normally closed contacts of the limit switch 11LS deenergizes the relay 20CR, the solenoid S9 and the time delay relay 3TR closing its normally closed contacts. Deenergization of th erelay 20CR opens the contacts of the relay 20CR, deenergizing the solenoid S10 allowing the valve V10 to shift toward the left. The deenergized solenoid S9 allows the valve V9 to move to the left under spring pressure, allowing fluid under pressure to pass to the opposite end of the cylinder 206 and retract the steadyrest shoes or elements 184 and 200 and the air gaging means including gage head 180. When the gage head 180 is retracted, its normally closed contacts S2CR close and its normally open contacts S1CR open.

When the solenoid S8 is deenergized, the angular positioning rollers are allowed to roll upon the angular work head locating discs 115 and 116 and when one of the spring biased rollers momentarily drops into the notch of the disc 116, the contacts of the limit switch 10LS are opened momentarily, deenergizing the relay 18CR. Opening of one set of the normally open contacts of the relay 18CR breaks the holding circuit through the limit switch 10LS deenergizing the time delay relay 2TR so that the continued rotation of the disc actuating the limit switch 10LS will not effect a reenergization of the time delay relay 2TR and the opening of the other set of normally open contacts of 18CR breaks the circuit of the work drive motor. The closing of the normally closed contacts

of 13CR also stops the coasting work drive motor almost instantaneously by applying a momentary braking circuit diagrammatically shown to stop the rotation of the work drive heads. The deenergization of the time delay relay 2TR closes one set of contacts immediately, but the other set is timed to close after a short period of time has elapsed, allowing time for braking of the work drive motor 118. The subsequent closing of the timed contacts of the time delay relay 2TR energizes the solenoid S11 shifting the valve V11 to the right allowing oil under pressure to rotate the hydraulic motor 120 and thereby rotate the work heads and the notched discs 115 and 116 slowly until the second spring biased roller drops into the precise angular locating notch of the disc 115 thereby opening the normally closed contacts of the limit switch 12LS, deenergizing the relay 22CR, opening its contacts which deenergizes the solenoid S11, allowing the valve V11 to shift toward the left to stop the rotation of the hydraulic motor 120.

At the same time, the normally open contacts of the limit switch 12LS are held closed energizing the relay 23CR to close its contacts, energizing the solenoid S12, shifting the valve V12 to the right, allowing fluid under pressure to move the sequence valve V13 to the left which allows oil to exhaust from the pot chuck cylinders 64 and from the pressure switch 1PS which opens to deenergize the relay 14CR. The exhaust of pressure fluid from the pot chucks unclamps the workpiece of crankshaft 28, so that the workpiece may be removed therefrom. The opening of the normally open contacts of the relay 14CR breaks a circuit to the contacts S2CR of the air gaging means so that they will have no effect in the event they are opened while the air gage is adjusted. The crankshaft or workpiece is then removed and the spring biased lever 202 rotates counter-clockwise allowing the normally open contacts of the limit switch 8LS to open, thereby deenergizing the time delay relay 5TR and resetting the same. When a new crankshaft is deposited in the pot chucks 26, the cycle is again repeated as above described.

The embodiment of the instant invention described above may include a configuration in which the sub-base 134 is mounted for reciprocation on the slideway 136 by means of a suitably controlled hydraulic cylinder, when such an arrangement is desirable. The showing in FIG. 8 includes a schematic representation of one arrangement for this purpose including a manually operated four-way valve V15 connected to the pipe 112 through a shut-off valve 133 so that valve V15 may be selectively supplied with pressure fluid by appropriate manipulation of valve 133. The four-way valve V15 in turn supplies pressure fluid to one end or the other of an actuating cylinder 135 enclosing a piston 137 provided with a piston rod 141 projecting through one end of the cylinder 135. The piston rod 141 may conveniently be provided with a suitable aperture in its outer end for engagement with a pin 139 depending from the sub-base 134 as shown in FIG. 4. Thus, suitable manipulation of the valve V15 will result in displacing the piston 137 within the cylinder 135 to move the combined mechanism 130 toward and away from the workpiece 28 as desired in order to permit traversal of the supporting means for the workpiece without interference with any portion of the combined mechanism 130. In a fully automated system, the valve V15 illustrated as manually operated could of course be automatically actuated in proper coordinated relation to operation of automatic means for traversing the workpiece supporting means.

Thus the instant invention provides a compact integrated mechanism incorporating in a single housing means for performing various necessary functions with respect to the portion of a workpiece being ground and control means to assure that these various functions are performed in the proper sequence and at the proper point in a grinding operation. In addition, the instant invention provides means for coordinating the respective phases of a feeding cycle with the performance of various necessary functions with respect to the portion of a workpiece being ground.

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 within the scope of the appended claims, 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.

What is claimed is:

1. In a grinding machine having a base, a transversely movable rotatable grinding wheel thereon; means including a traversable member on the base for presenting different portions of a workpiece to be ground opposite the grinding wheel; and a rotatable work support on the traversable member including a pair of spaced aligned rotatable pot chucks supporting a workpiece to be ground; an adjustable housing slidably mounted on the base; and means to traverse said housing toward and away from a workpiece; said housing supporting means to sense the presence of a workpiece in the grinding machine, means to axially position a workpiece relative to the grinding wheel combined with means to support the portion of a workpiece being ground on a common support movable relative to said housing in a first sense to actuate said means to axially position a workpiece and in a second sense to actuate an element of said means to support the portion of a workpiece being ground, and means for gaging a workpiece arranged to be actuated with said means to support the portion of a workpiece being ground.

2. An integrated mechanism for a machine tool comprising means to sense the presence of a workpiece therein, means initiated by said sensing means to automatically begin the machining cycle of the machine tool, means to axially position a workpiece relative to a cutting tool, means to support the portion of a workpiece being machined, and means to gage a workpiece operatively connected to control means including an adjustable timing mechanism actuated by said gaging means when a workpiece has been reduced to a predetermined size temporarily to interrupt the infeed of a cutting tool into a workpiece, means actuated by said timing mechanism at the end of the timing period to continue the infeed of a cutting tool, and control means actuated by said gaging means when a workpiece has been machined to the desired size to move a cutting tool to an inoperative position.

3. A combined compact unit for use with a grinding machine having a base, a transversely movable rotatable grinding wheel thereon, grinding wheel feeding means and a rotatable work support on the base including a pair of spaced aligned rotatable pot chucks supporting a workpiece to be ground, said unit comprising means to sense the presence of a workpiece loaded into the said grinding machine and to initiate the grinding cycle of the grinding machine, means to axially position a workpiece having shouldered portions relative to the grinding wheel, means to support the portion of a workpiece being ground, means to gage a workpiece, means actuated by said means to gage a workpiece when a predetermined workpiece size is reached to interrupt and thereafter initiate resumption of infeeding movement of the grinding wheel at a reduced feeding rate, and means actuated by said means to gage a workpiece when a workpiece reaches the desired size positively to terminate the infeeding movement of the grinding wheel.

4. In a grinding machine having a base, a transversely movable rotatable grinding wheel thereon, means including a traversable member on the base for presenting different portions of a workpiece to be ground opposite said grinding wheel, and a rotatable work support on the traversable member; an adjustable housing slidably mount-

ed on said base; means to traverse said housing to an inoperative position away from a workpiece when the traversable member is to be moved and to an operative position after the traversable member has been moved; said housing supporting means to sense the presence of a workpiece in the grinding machine, means to axially position a workpiece relative to the grinding wheel, steadyrest means to support a workpiece being ground, a supporting element for said means to axially position a workpiece and a work engaging element of said steadyrest means movably mounted upon said housing for movement in a first sense to actuate said means to axially position a workpiece and in a second sense to advance the workpiece engaging element of said steadyrest means supported thereby when said steadyrest means is moved into engagement with a workpiece, and means for gaging a workpiece being ground to a predetermined dimension moved into engagement with a workpiece concurrently with said steadyrest means.

5. In a machine tool having a base, a transversely movable rotatable cutting tool thereon, and a rotatable work supporting means on the base including a pair of spaced aligned rotatable work supports supporting a workpiece having spaced shouldered portions thereon, an integrated assembly mounted on the base comprising a housing, means to sense the presence of a workpiece in the machine tool, means to axially position the portion to be machined of a workpiece relative to the cutting tool, means to support the portion of a workpiece being machined including a pair of steadyrest members, one of said steadyrest members being combined with said axial positioning means, and the other one of said steadyrest members being pivotally mounted upon said housing, means to gage and size a portion between the shouldered portions of a workpiece during the machining thereof, first actuating means for actuating said axial positioning means, second actuating means to actuate said steadyrest means and said gaging and sizing means, a rotatable and axially movable first elongated member supporting said combined axial positioning means and one of said steadyrest members fixedly upon one end thereof, and an axially movable second elongated member acting on the other of said steadyrest members and said gaging and sizing means, said rotatable and axially movable first elongated member being selectively rotated by said first actuating means and held against rotation by said first actuating means during sequential axial displacement of said first elongated member by said second actuating means.

6. In a machine tool having a base, a transversely movable rotatable cutting tool thereon, and a rotatable work supporting assembly on the base including a pair of spaced aligned rotatable work supports supporting a workpiece having spaced shouldered portions and a cylindrical portion therebetween all to be machined, a combined unit mounted on the base comprising a housing, means actuated by the presence of a workpiece in the machine tool for initiating a machining cycle, means to axially position the portion to be machined of a workpiece relative to the cutting tool, means to support the portion of a workpiece to be machined including a pair of steadyrest members, one of said steadyrest members combined with said axial positioning means, and the other one of the said steadyrest members pivotally mounted upon said housing, means to gage and size the portion to be ground of a workpiece during the machining thereof, first actuating means including a fluid motor for operating said axial positioning means, second actuating means including a fluid motor for operating said steadyrest members and said gaging and sizing means, a rotatable and axially movable first elongated member supporting said combined steadyrest member and axial positioning means fixedly secured to one end thereof, and an axially movable second elongated member acting on the other of said steadyrest members and said gaging and sizing means, said first elongated member being rotated by said first actuating means and held against rotation by said first actuating means during sequential axial displacement of said first elongated member along with said second elongated member by said second actuating means.

7. Apparatus as described in claim 6, wherein said combined axial positioning means and steadyrest member comprises an axial positioning means having a concave face shaped and disposed to be positioned substantially concentric of and spaced from the cylindrical portion to be machined of a workpiece when the axial positioning means is disposed in its inoperative position, and a steadyrest member mounted centrally on the concave face of said axial positioning means and projecting therefrom toward the portion to be ground of a workpiece.

8. An integrated mechanism for a machine tool comprising a housing mounted upon a machine tool, means supported by said housing operable to axially position a workpiece relative to a cutting tool on a machine tool, and means supported by said housing operable to support the portion of a workpiece being machined on a machine tool, said integrated mechanism including an elongated supporting element mounted for both rotating and sliding movement relative to said housing and having fixedly secured thereto at one end thereof said means to axially position a workpiece and an element of said means to support the portion of a workpiece being machined.

9. A mechanism for use on a machine tool comprising a housing mounted upon a machine tool, an elongated supporting element mounted within said housing for rotation and for sliding movement relative to said housing, means to axially position a workpiece relative to the cutting element of a machine tool including said elongated supporting element and positioning means fixedly secured to one end of said supporting element, work support means to support the portion of a workpiece being machined on a machine tool including said elongated supporting element and a work support element fixedly secured to the same end of said supporting element, actuating means operable to rotate said supporting element to actuate said positioning means, and actuating means operable to move said supporting element slidably to actuate said work support element.

10. A mechanism for use on a machine tool comprising a housing mounted upon a machine tool, an elongated supporting element mounted within said houisng for rotation about its longitudinal axis and for sliding movement along its longitudinal axis, means to axially position a workpiece relative to the cutting element of a machine tool including said elongated supporting element and positioning means fixedly secured to one end of said supporting element concentric to the longitudinal axis of said supporting element and having opposed workpiece camming surfaces, steadyrest means to support the portion of a workpiece being machined on a machine tool including said elongated supporting element and a steadyrest element fixedly secured to the same end of said supporting element concentrically of said positioning means, and differential actuating means sequentially operable first to rotate said supporting element to actuate and then retract said positioning means and then to move said supporting element slidably to actuate and then retract said steadyrest element.

11. An integrated mechanism for a machine tool comprising a housing mounted upon a machine tool, means mounted upon said housing to sense the presence of a workpiece in a machine tool, work positioning means supported by said housing operable to axially position a workpiece relative to a cutting tool on a machine tool, work support means supported by said housing operable to support the portion of a workpiece being machined on a machine tool, and means supported by said housing and actuated with said work support means to gage the portion of a workpiece being machined, said integrated mechanism including an elongated supporting element with one end projecting from said housing selectively

alternatively movable rotatably about its longitudinal axis and lengthwise of its longitudinal axis and having said work positioning means and an element of said work support means fixedly secured thereto at the end projecting from said housing with said element of said work support means disposed centrally of and projecting from said work positioning means.

12. Apparatus for a grinding machine arranged to grind a workpiece having spaced shouldered portions thereon to be positioned symmetrically relative to a rotatable grinding wheel for grinding away equal amounts from the respective shouldered portions during a grinding operation, said apparatus including an elongated supporting element sequentially movable rotatably about its longitudinal axis and movable lengthwise of its longitudinal axis, axial positioning means mounting on one end of said supporting element for rotation therewith about its longitudinal axis for precisely locating a workpiece axially of a grinding wheel, retractable steadyrest means for supporting the portion of a workpiece to be ground including a steadyrest element mounted upon said supporting element centrally of said axial positioning means for axial movement with said supporting element, workpiece gaging means, first actuating means operable with a second actuating means at rest to actuate said axial positioning means by rotating said supporting element, and second actuating means operable with said first actuating means at rest to actuate said steadyrest means and said gaging means concurrently including means to move said supporting element lengthwise of its longitudinal axis.

13. An integrated mechanism for a machine tool comprising a housing mounted upon a machine tool, an elongated supporting element mounted within said housing for rotation about its longitudinal axis and for sliding movement along its axis, means mounted upon said housing to sense the presence of a workpiece in a machine tool, positioning means to axially position a workpiece relative to a cutting element of a machine tool including said elongated supporting element and positioning means having opposed workpiece camming surfaces fixedly secured to one end of said supporting element, steadyrest means to support the portion of a workpiece being machined on a machine tool including said elongated supporting element and a steadyrest element fixedly secured to the same end of said supporting element centrally of said positioning means, workpiece gaging means mounted upon said housing, and actuating means for said positioning means and for said steadyrest means and said gaging means including differential actuating means sequentially operable first to rotate said supporting element to actuate and then retract said positioning means and then to move said supporting element slidably to advance and then retract said steadyrest element as said steadyrest means and said gaging means are displaced concurrently by said actuating means.

14. A mechanism for use with a grinding machine having a base, a transversely movable rotatable grinding wheel thereon, grinding wheel feeding means, and a rotatable work support on the base for supporting a workpiece to be ground, said mechanism comprising a housing, means mounted on said housing actuated by the presence of a workpiece loaded into a grinding machine to initiate the grinding cycle of a grinding machine, supporting means to support the portion of a workpiece being ground mounted upon said housing for movement relative thereto toward and away from a workpiece, gage means for gaging a workpiece mounted upon said housing for movement relative thereto toward and away from a workpiece, actuating means mounted upon said housing operable to advance and retract said supporting means and said gage means in unison, and wheel feed control means actuated by said gage means during the grinding cycle operable in response to successive signals from said gage means as predetermined workpiece sizes are reached to modify and then to terminate the feeding movement of a grinding wheel toward a workpiece.

15. A combined compact unit for use with a grinding machine having a base, a transversely movable rotatable grinding wheel thereon, grinding wheel feeding means and a rotatable work support on the base including a pair of spaced aligned rotatable pot chucks supporting a workpiece to be ground, said unit comprising means actuated by the presence of a workpiece loaded into the grinding machine to initiate the grinding cycle of a grinding machine, means to axially position a workpiece having shouldered portions spaced transversely relative to the grinding wheel, means to support the portion of a workpiece being ground, and means to gage a workpiece connected to wheel feed control means operable in response to signals from said means to gage a workpiece when predetermined workpiece sizes are reached to regulate and then terminate the feeding movement of a grinding wheel toward a workpiece.

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