July 8, 1930.

C. C. STEVENS

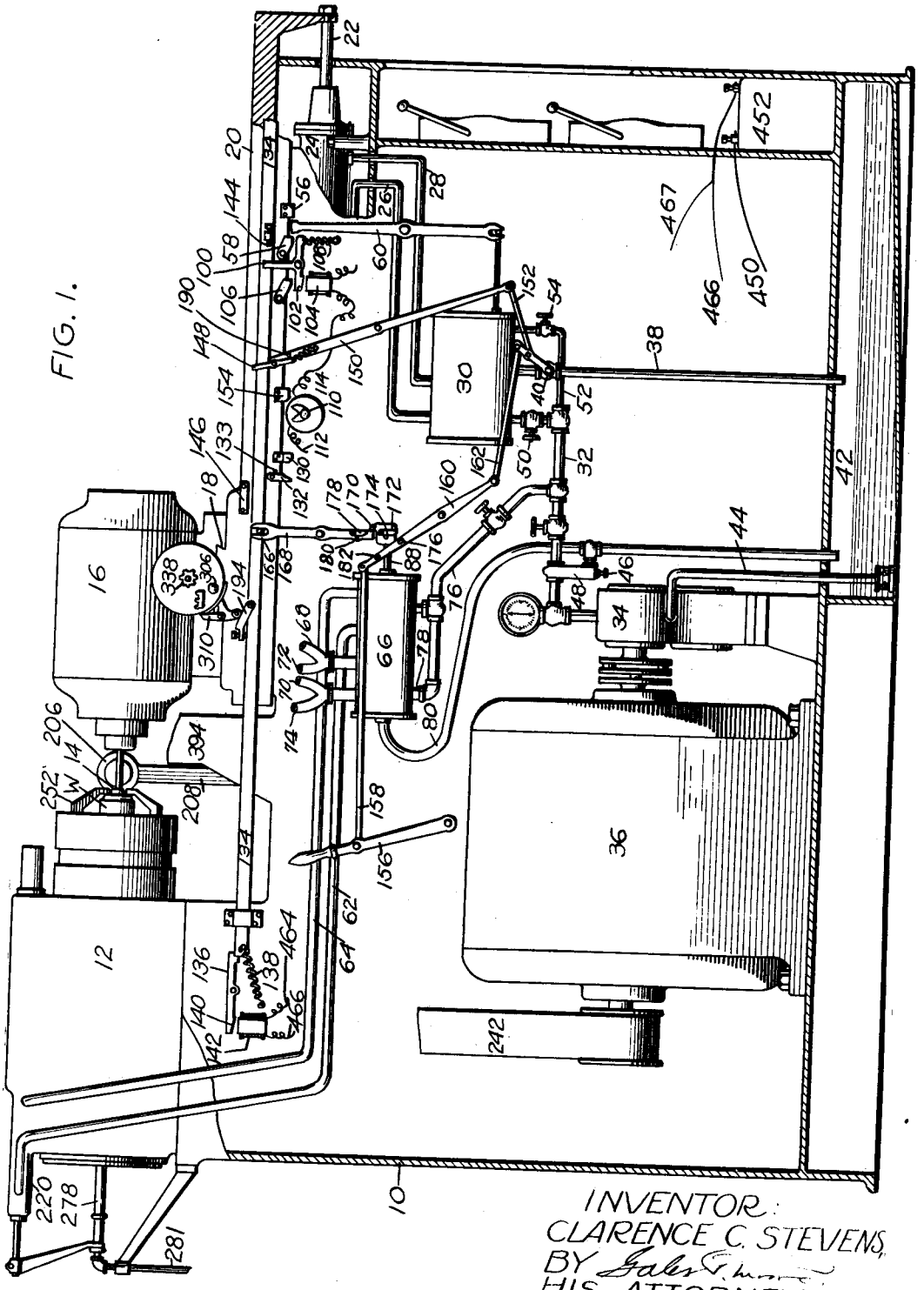
1,770,148

GRINDING MACHINE

Filed June 9, 1926

6 Sheets-Sheet 1

FIG. 1.



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July 8, 1930. C. C. STEVENS 1,770,148

GRINDING MACHINE

Filed June 9, 1926 6 Sheets-Sheet 2

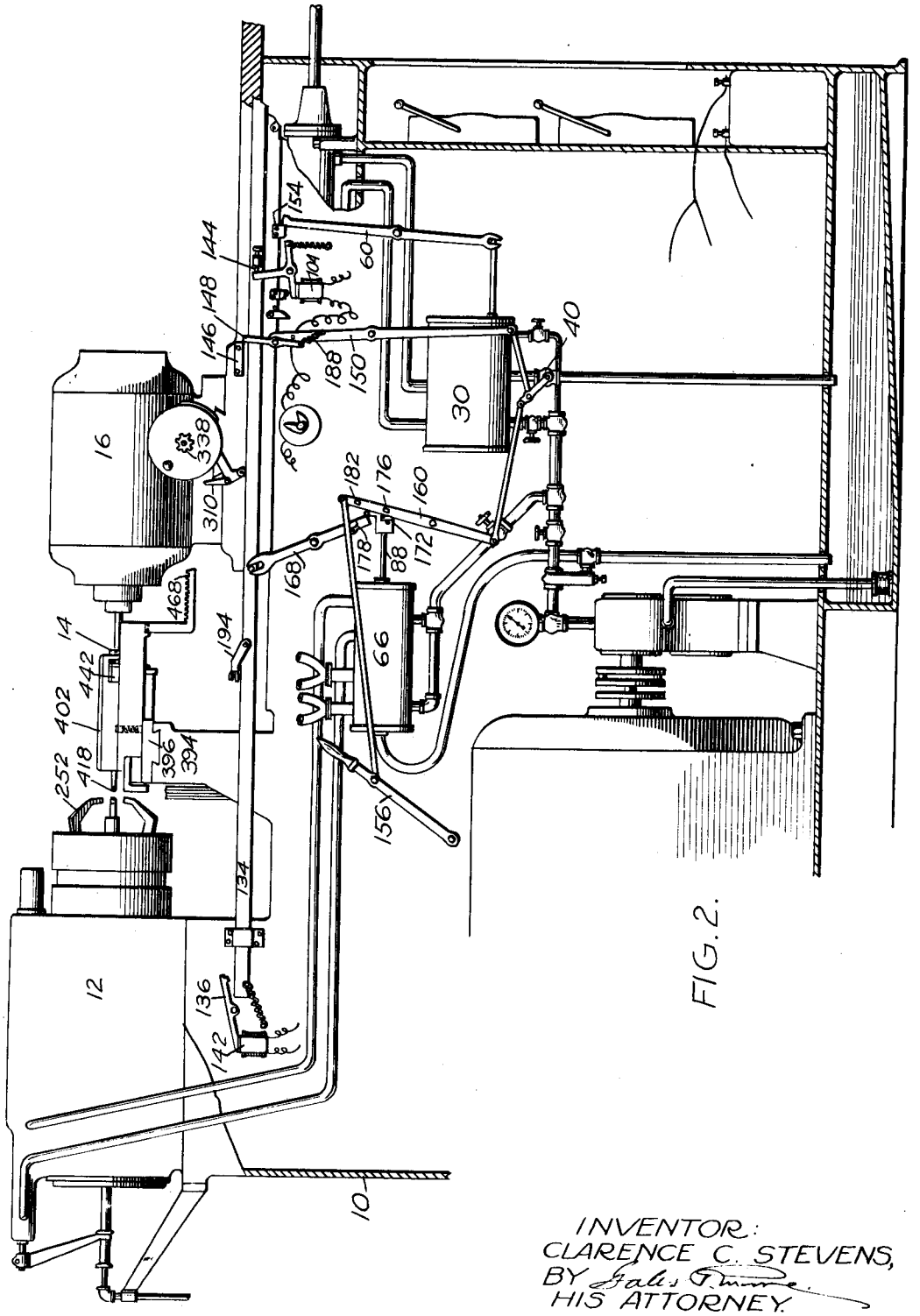

FIG. 2.

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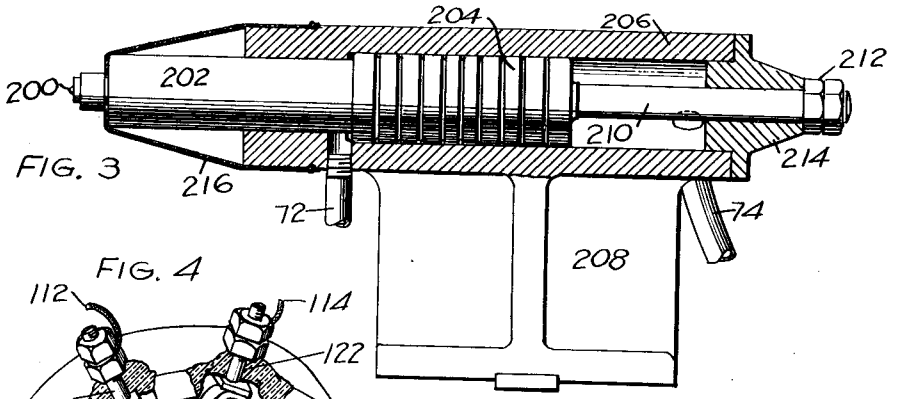


FIG. 3

FIG. 4

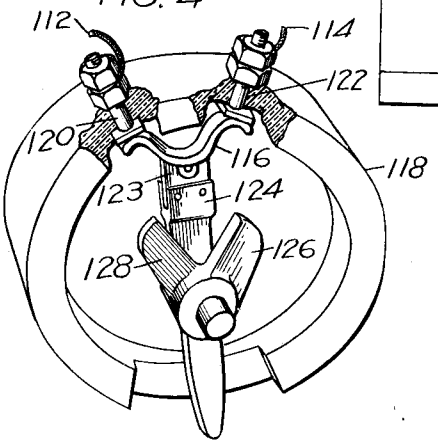


FIG. 5

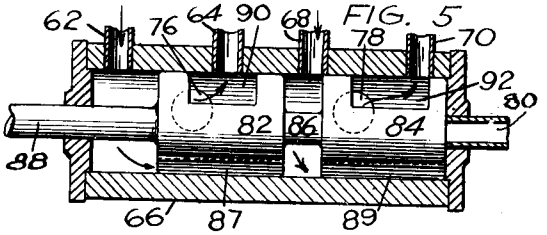


FIG. 6.

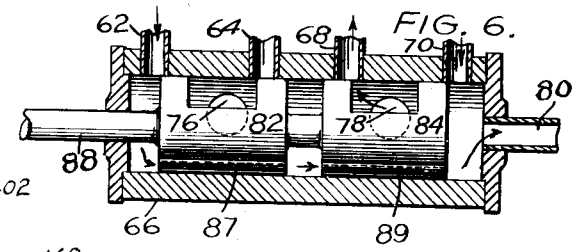
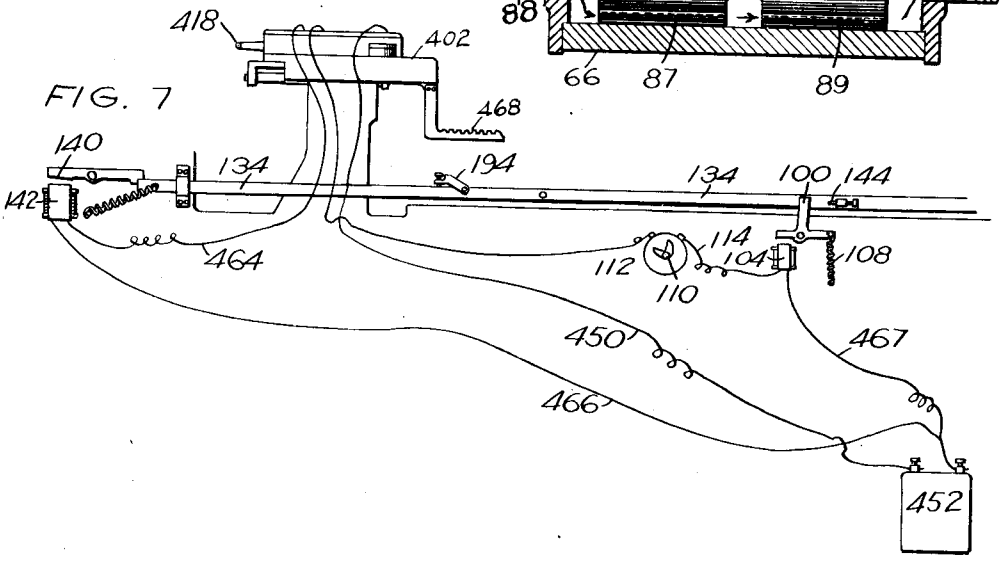


FIG. 7



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GRINDING MACHINE

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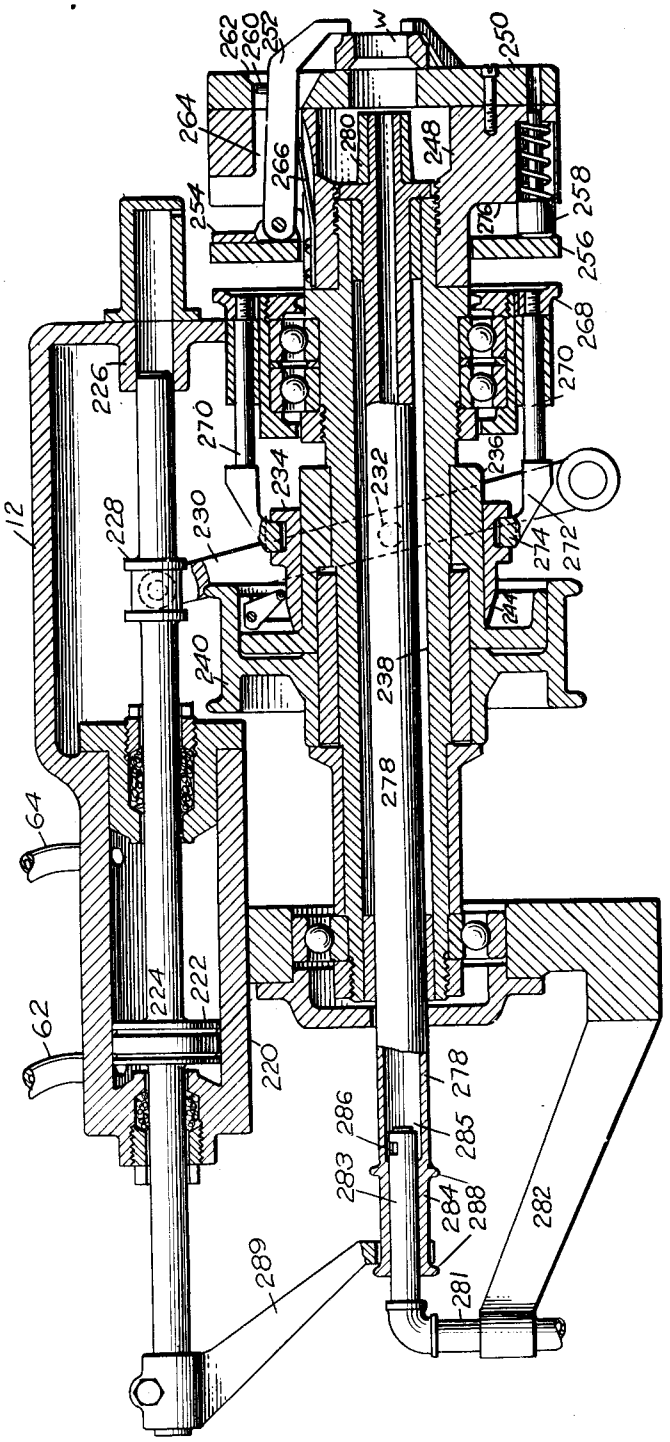

FIG. 8.

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GRINDING MACHINE

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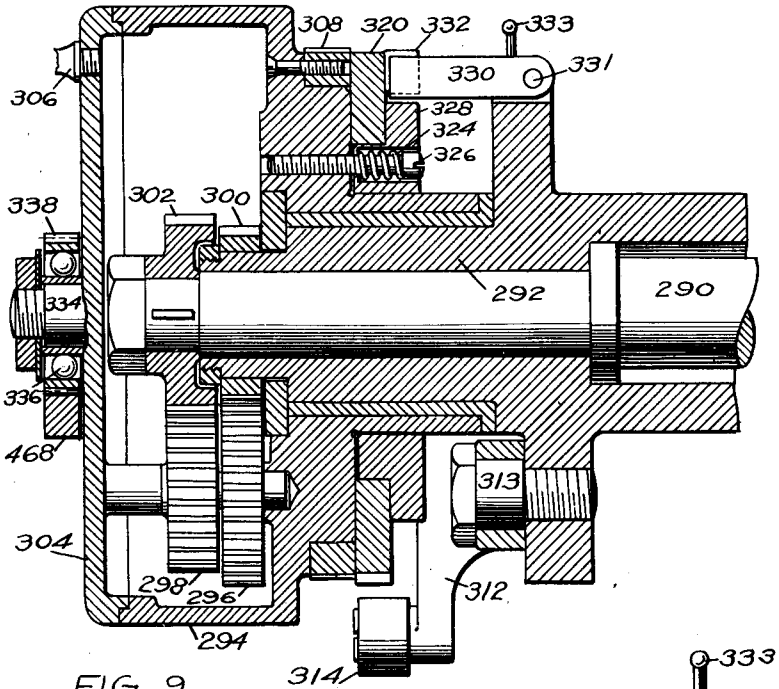

FIG. 9

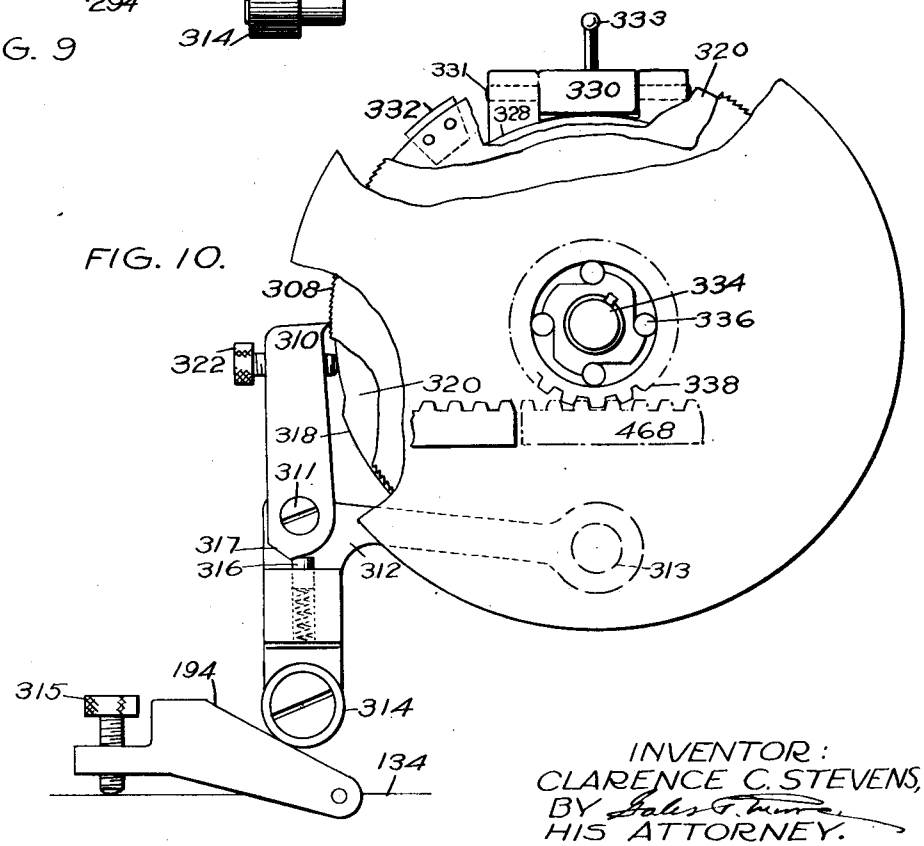

FIG. 10.

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GRINDING MACHINE

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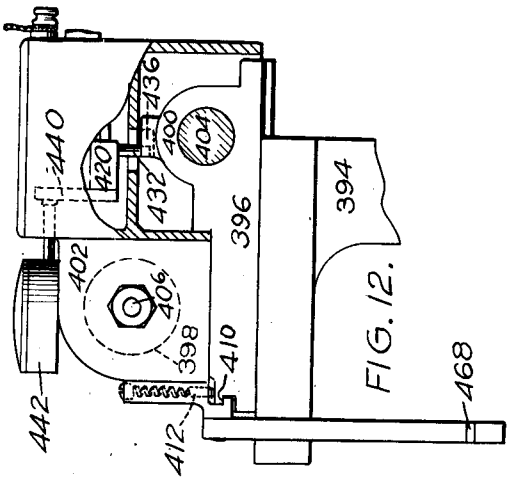

FIG. 12.

FIG. 11.

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Patented July 8, 1930

1,770,148

UNITED STATES PATENT OFFICE

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GRINDING MACHINE

Application filed June 9, 1926. Serial No. 114,855.

This invention relates to grinding machines and comprises all the features of novelty herein disclosed, by way of example, as embodied in an internal grinding machine for cutting bores in sleeves, rings and like articles.

An object of the invention is to provide an improved grinding machine for automatically producing work-pieces of fine finish and accurate size. Another object is to provide improved work centering, clamping and rotating devices and mechanism for controlling the supply of cooling fluid to the work. Yet another object is to provide improved fluid pressure operated devices for effecting the operation of a grinding machine.

To these ends and to improve generally upon machines of this character, the invention also consists in the various matters hereinafter described and claimed.

The invention, in its broader aspects, is not necessarily limited to the particular embodiment selected for mere illustrative purposes in the accompanying drawings in which

Figure 1 is a front elevation of a grinding machine with the parts in grinding position.

Figure 2 is a similar view with the parts in the position occupied at the conclusion of grinding.

Figure 3 is a side view of the dressing tool and its actuating mechanism with some parts in section.

Figure 4 is a perspective view of a switch.

Figure 5 is a sectional view looking from the rear of the machine of a controlling valve with the parts in a position to produce advance of the dressing tool and feeler and to operate the work holder and clutch.

Figure 6 is a view similar to Figure 5 with the parts in a position to retract the dressing tool and feeler prior to the release of the clutch and the work.

Figure 7 is a schematic view of the feeler and associated mechanism.

Figure 8 is a sectional view of the chuck and clutch and associated mechanism.

Figure 9 is a sectional view of the cross feeding mechanism.

Figure 10 is a front view of the cross feeding mechanism, with some parts removed or broken away.

Figure 11 is a top view of the feeler or gauge mechanism with some parts broken away or in section and

Figure 12 is an end view to smaller scale of the feeler or gauge mechanism, with some parts broken away or in section.

The functions performed by this machine when internally grinding a work-piece are as follows: A grinding wheel reciprocates in the bore and is fed first with a coarse feed. A fine feed is later established and the wheel is given one longer reciprocation to carry it past a diamond to true it for the finish grind. When the work is finished, the grinding wheel is fed backwardly and retracted to a remote position to enable a new work-piece to be inserted in the work head which centers and grips the work, turns on cooling liquid, and starts the rotation of the work spindle. A gauge or feeler successively completes two electric circuits to effect first the truing operation and next the final backward feeding and retraction of the wheel during which the work-spindle is unclutched and braked, the chuck releases the work-piece, the cooling liquid is shut off and the centering device is advanced to operative position. All movements are automatic except the mere presentation of the work to the chuck while manually shifting a starting lever.

The numeral 10 indicates a frame supporting a work-head 12 and a grinding wheel 14 which is driven by a motor in a head 16. The head 16 has cross feeding movement on ways 18 of a reciprocating carriage 20 actuated by a piston rod 22 leading into a working cylinder 24. Pipes 26 and 28 supply fluid to the ends of the cylinder alternately under control of a reversing valve 30. The valve receives pressure fluid through an intake pipe 32 from a pump 34 driven by an electric motor 36. Exhaust fluid from the valve passes through an exhaust pipe 38 having a shut-off cock 40 to a tank 42 connected by a pipe 44 to the intake side of the pump. There is a pressure relief valve 46 in a bypass pipe 48 and an intake throttle valve 50

in the pipe 32. A small branch intake pipe 52 with a throttle valve 54 leads to the reverse valve 30 which is constructed substantially as shown in my copending application Serial No. 109,403 filed May 15, 1926. The reverse valve is actuated by the reciprocation of the carriage through contact of spaced reversing dogs 56 and 58 with a pivoted reverse lever 60.

The work head has the hereinafter described chuck and auxiliary devices operated by pressure fluid conducted to a double acting cylinder through pipes 62 and 64 from a double valve 66. The valve also controls the flow of fluid through pipes 68 and 70 and branch pipes 72 and 74 which lead to a pair of double acting cylinders for operating a dressing tool or diamond and a gauge or feeler. The intake to the double valve leads through pipe 76 and its branch pipe 78 and the exhaust leads through a pipe 80 to the tank. As shown in Figures 5 and 6, the double valve 66 has two sliding members 82 and 84 connected by a bar 86 and actuated by a stem 88. In the position shown in Figure 5, intake fluid from the pipes 76 and 78 passes through cut-out portions 90 and 92 to the pipes 64 and 70 to move the chuck and the diamond and gauge to operative position. Exhaust fluid comes into the valve through pipes 62 and 68 and leaves the valve through the pipe 80. The members 82 and 84 have longitudinal openings 87 and 89 to provide communication between the space around the bar 86 and the ends of the valve casing. As the rod 88 is moved to the left to the position shown in Figure 6, this being a right hand movement in Figures 1 and 2, the gauge and diamond are first moved to inoperative position, the intake fluid from the pipe 78 going into the pipe 68 and exhaust fluid passing through pipe 70 into the pipe 80. Thereafter, continued movement of the valve members to the left beyond the position shown in Figure 6 causes the chuck to become inoperative also, intake fluid from pipe 76 then passing into pipe 62 and exhaust fluid coming back through pipe 64 to the space around the bar 86 and going through opening 89 to pipe 80.

For dressing the grinding wheel just before the finish of the grinding operation, the gauge or feeler, to be later described, is caused to complete temporarily an electric circuit which automatically results in a longer stroke of the carriage (a little longer than the normal stroke of the grinding wheel in the work) to carry the grinding wheel across the dressing tool and back to the work. This action is brought about by temporarily lifting the pivoted reversing dog 58 by means of a three armed lever 100 pivoted on the frame and having an armature 102 for attraction by a magnet 104. Swinging of the lever lifts the dog 58, and the carriage travels outwardly until a second pivoted dog 106 on the carriage engages the reverse lever 60 and returns the carriage whereupon the dog 58 is released and rides over the reverse lever to act in the usual way. The magnet must be de-energied before the dog 106 reaches the lifting portion of the lever 100. To de-energize the magnet and allow the three-armed lever 100 to return to its normal position under control of a spring 108, it is necessary to break the electric circuit through the magnet and gauge. A switch 110 is connected to a wire 112 leading to the gauge and to a wire 114 leading to the magnet. It comprises a spring 116 (Figure 4) carried in an insulating casing 118 and normally bridging a pair of binding posts 120 and 122 for the wires. The spring is supported by an insulating block 123 on a swingable lever 124 having a hub with two diverging offset arms 126 and 128 which lie in the path of plates 130 and 132, respectively, on the carriage, plate 130 being offset forwardly from the plate 132. When, therefore, the carriage moves out, the offset plate 130 engages the arm 126 and throws the spring 116 out of electric contact with the binding posts 120 and 122. The carriage moves to the right in Figure 1 far enough so that the plate 130 turns the arm 126 and breaks the circuit but does not move so far, in the short dressing stroke, as to carry the plate 132 to the right of its contacting arm 128. As the carriage moves back to grinding position, after the short dressing stroke, the plate 130 simply leaves the arm 126 in its swung down position and this first electric circuit remains broken until a subsequent very long withdrawal of the carriage and a return of the carriage to grinding position causes the one-way swinging plate 132 to engage the arm 128 and restore the spring 116 to bridging position. The plate 132 can ride idly over the arm 128 in one direction but is prevented by a pin 133 from swinging the other way.

When the finish grind is completed, the grinding wheel carriage is retracted to a remote position automatically so that the finished work-piece can be removed and another inserted. This is accomplished by a second electric circuit completed by the gauge or feeler. A long, slidable control bar 134 extends across the front of the machine and is normally retained in the position shown in Figure 1 by a pivoted gravity latch 136 engaging the end of the bar and resisting the pull of a spring 138. The latch has an armature 140 opposed to a magnet 142 which is in circuit with a second gauge contact. When the magnet is excited under control of the gauge or feeler, the latch is tripped and the spring 138 pulls the control bar 134 to the left. This again results in swinging the three-armed lever 100 through the instrumentality of an

adjustable pin 144 attached to the control bar. Thereupon, both the pivoted reverse dogs 58 and 106 will ride up the incline presented by the oppositely extending arms of the lever 100 and will be carried over the top of the reverse lever 60. The carriage retreats to a remote position at which point the shut-off cock 40 is automatically shut to stop the machine by a dog 146 on the carriage engaging a spring pressed lever 148 on a lever 150 having a link connection 152 with the shut-off cock. As the cock is closed, a lug 154 on the carriage engages the reverse lever 60 to throw it to its reversed position such that a subsequent opening of the cock will start the carriage back again to the work. In order that the machine may be stopped manually at any point in the cycle, a hand lever 156 is placed within convenient reach of the operator and is connected by a link 158 with a pivoted lever 160 which in turn is connected by link 162 with the shut-off cock 40.

There is provision for automatically removing the gauge and diamond from operative position and for releasing the finished work-piece as the carriage retreats to its remote position. This action is controlled by the previously described movement of the control bar 134. A pin 166 on the control bar engages a fork in a pivoted lever 168 and swings the lower end of the lever against a pin 170 on the valve rod 88 of the valve 66 which is thrown to its other extreme position as above described. The withdrawal of the gauge from operative position automatically reverses the feed of the grinding wheel and breaks the second gauge circuit as will later appear.

To restore the gauge and diamond and chuck to operative position with respect to a new work-piece and to restore the control bar 134 to starting position, the lever 160 cooperates with two pick-up devices. On the valve stem 88 is a one-way swinging dog 172 limited from swinging in one direction by a stop pin 174 but free to swing in the other direction to allow a pin or picker 176 on the rear of lever 160 to get behind it. On the lever 168 there is a similar one-way-swinging dog 178 limited from swinging in one direction by a stop pin 180 but free to swing in the other direction to allow a projection or picker 182 on the lever 160 to get behind it. A movement of the lever 160 from the position shown in Figure 1 to the position shown in Figure 2 (which movement is effected by the automatic stopping of the machine) will place the pin 176 and the projection 182 in a position to pick up the valve stem and the lever 168 and a manual swinging of the hand lever 156 to the left will operate the valve 66, restore the control bar 134 to latched position and open the cock 40. The final movement of the lever 160 to the left releases the pivoted dogs 172 and 178 by reason of the relative retreating movements of the pickers and the dogs. The lever 150 is also swung back to its original position, the spring pressed lever 148 being forced to swing on its pivot against the tension of its spring 188 until the dog 146 is carried out of its way by the ingoing carriage. A pin 190 holds the lever 148 normally in a position to be engaged by the dog 146 when the carriage is retracted to its remote idle position. The spring 188 can be a weak one, or just enough to overcome the friction of the cock 40 and the link and lever system. The control bar 134 carries an adjustable cam 194 which, as the carriage reciprocates, operates a pawl and ratchet feeding mechanism to be described. This feed is automatically stopped when the cam is pulled away from the feeding mechanism by the release of the control bar to the left. The restoration of the control bar to starting position carries the cam to operative position and the pin 144 is carried to a position where it will release the three-armed lever 100.

Referring to Figure 3, a dressing tool in the form of a diamond 200 is carried on a plunger 202 having a piston 204 working in a cylinder 206. The branch pipes 72 and 74 conduct the pressure fluid to and from the ends of the cylinder under control of the valve 66 above described. The diamond is arranged to slide from front to rear on a level with and at right angles to the grinding spindle, a bracket 208 supporting the cylinder on the frame. Forward movement of the diamond into the path of the grinding wheel on the dressing stroke is adjustably limited by a rod 210 attached to the piston and having adjusting nuts 212 engaging the cylinder head 214. A flexible, protecting shield 216 encloses the front end of the plunger and cylinder.

Referring to Figure 8, the work head 12 supports a cylinder 220 to which fluid is supplied through the pipes 62 and 64 under control of the valve 66. A piston 222 is attached to a piston rod 224 passing through both ends of the cylinder and having one end guided in a sleeve 226. A grooved collar 228 on the rod actuates a lever 230 which has a roller 232 engaging a grooved collar 234 slidable on a sleeve member 236 keyed to a hollow rotary work spindle 238. The spindle is mounted on ball bearings and supports a loose pulley 240 driven by a belt 242 from the motor 36. The sleeve member 236 carries any suitable expansible clutch adapted for expansion under control of a coned face 244 on the collar 234 to clutch the pulley to the spindle.

On the end of the spindle is a chuck head 248 having a face plate 250 against which a work-piece W is clamped by a plurality of bent clamping fingers 252 pivoted on brackets 254 attached to a ring 256 slidable on a

cylindrical portion of the chuck head. Spring pressed plungers 258 press the ring in a direction to cause the clamping fingers to move inwardly due to projections 260 engaging cam faces 262 on the chuck head or its face plate. The fingers pass through slots 264 in the chuck head and are pressed to open position by leaf springs 266, when permitted by an outward movement of the ring 256. Opposite the ring is a second ring 268 secured to and movable axially by pins 270 which are guided in openings in the work head. Each pin 270 is secured to a projection 272 from a yoke 274 for operation by the grooved collar 234. The chuck is shown in work clamping and rotating position. If the piston rod 224 is moved to the right, the pulley is first unclutched. Then the ring 256 is frictionally engaged by the non-rotary ring 268 to cause a braking action to stop the spindle. The ring 256 is spaced from a surface 276 on the head so it can approach the latter and retract the spring pressed plungers 258 to let the clamping fingers open to release the work-piece.

There is also provision for plugging or centering a work-piece and for turning on and off a supply of cooling fluid which passes through the spindle to the work. A hollow sleeve 278 extends slidably through the spindle and carries a tapered centering plug 280 at one end. Cooling fluid is supplied to a pipe 281 secured in a bracket 282 and communicating with a horizontal tube 283 which extends through the thickened end 284 of the sleeve 278 as far as a bore 285 of larger diameter than the tube. The end of the tube 285 is plugged but there is a lateral inlet port 286 normally admitting cooling fluid to the bore 285. Collars 288 are formed on the end of the sleeve 278 and have lost motion engagement with a forked arm 289 clamped to the end of the piston rod 224. When the piston rod moves to the right and the lost motion is taken up, during which the spindle is stopped and the work released, the thickened end 284 of the sleeve is carried over the port 286 cutting off the cooling fluid from the bore 285 and the sleeve 278 slides through the spindle to cause the centering plug 280 to project through the face plate into a position for receiving and centering a new work-piece. When the piston rod is reversed, the brake is released, the work clamped, the plug withdrawn, the cooling fluid turned on, and the clutch reengaged.

The cross feeding mechanism best shown in Figures 9 and 10 comprises a feed screw 290 connected in any suitable way to the wheel head slide and having its front end journalled in a sleeve 292 attached to the main reciprocating carriage. A casing 294 is revolubly mounted on the sleeve and carries connected planetary gears 296 and 298 of slightly different diameter, the gear 296 meshing with a gear 300 clamped to the sleeve 292 and the gear 298 meshing with a gear 302 keyed to the feed shaft. A cover piece 304 fastened to the casing has a handle 306 by which the casing may be manually rotated to turn the feed screw. A slower feed is imparted automatically by a pawl and ratchet.

A ratchet ring 308 is secured on the casing and is engaged by a pawl 310 having limited pivotal movement at 311 on an elbow lever 312 which is pivoted at 313 to a flange on the sleeve 292. The pivot 313 is below the center of the ratchet so that, when a roller 314 on the bent lever is caused to ride up the cam 194, the pawl is caused to move first against the ratchet and then pushes substantially tangentially to feed the ratchet a number of teeth depending on the inclination of the cam 194 as determined by its adjusting screw 315. A spring pressed plunger 316 holds the pawl against the ratchet but yields as the pawl is retracted. The pawl hub has a flattened portion 317 to be engaged by the plunger 316 to hold the pawl entirely away from the ratchet when desired. The cam 194, as above explained, is on the normally fixed control bar 134 and as the main carriage reciprocates, the pawl is actuated and the cross feed screw is slowly turned to feed the grinding wheel to the work.

When a piece of work has nearly reached the desired size, it is desirable to give the grinding wheel a finer feed. This is accomplished by a cam 318 on a frictionally driven cam plate or ring 320 which can be placed in any desired angular position at the rear side of the ratchet to the end that, after a predetermined feed, the cam will arrive at and engage a screw 322 adjustably fastened to one side of the pawl and keep the pawl away from the ratchet for a portion of the stroke and so reduce the number of teeth that the ratchet is fed. The cam plate or ring 320 has a slip or lost motion engagement with the ratchet produced by one or more springs 324 interposed between screw heads 326 and recesses in a flanged friction ring 328. The cam and its ring rotate with the ratchet until they are stopped by a pivoted latch 330 engaging the end of a stop plate 332 fastened to the rear of the ring 320. At this point, the cam, which has a definite angular spacing from the stop plate, shortens the stroke of the pawl but the ratchet continues to rotate at reduced speed and slips with respect to the cam and its ring 320. The fine feed is not stopped until the control bar 134 is tripped to carry the cam 194 away from the pawl roller 314. The latch 330 is preferably liftable around a pivot 331 by a finger piece 333 so that the feed screw can be turned manually in either direction as when initially setting up the machine or when setting the cam 318 at the desired angular distance from the pawl or, what is

the same thing, setting the stop plate 332 at the desired angular distance from the latch. A projecting stud 334 on the gear casing has a one-way roller clutch connection at 336 with a pinion 338 which, as will later appear, is rotated by a rack 468 under control of the gauge or feeler to reverse the feed screw. This is to prevent further grinding and to enable the grinding wheel to be set in such a position that it is ready for subsequent feeding movement towards a new unground workpiece.

The gauge or feeler control mechanism is shown in detail in Figures 11 and 12. A bracket 394 on the main frame supports a casting 396 containing a cylinder 398 and having a projecting guide sleeve 400. A gauge or feeler and its housing or carriage 402 are supported for sliding movement parallel to the axis of the work spindle by a slide rod 404 fixed to the carriage and guided in the sleeve 400. These parts are further supported by a piston rod 406 having its piston 408 slidable in the cylinder and also by guide faces at 410 held together by a spring pressed member 412. The pipes 68 and 70 from the valve 66 lead to ports 414 and 416 which communicate with the ends of the cylinder so that a feeler point 418 is carried into and out of the bore of the work when the piston is actuated. The feeler point is supported on a gauge lever 420 pivoted at 422 to the carriage and carrying a screw 424 bearing against an electric contact carrying arm 426 near the pivot 428 of the latter. A spring 430 swings the lever in a direction to press the feeler point against the work when this action is permitted by the arrival of the feeler point in the bore of the work-piece. Until then, the feeler point is kept clear of the work by a pin 432 projecting downwardly from the lever and engaging a straight face 434 terminating in an inclined cam face 436 which releases the lever. The same cam face, which is on the sleeve 400, retracts the lever and the electric contact carrying arm 426 which is connected by a spring 438 to the lever 420. The lever 420 has a projection 440 engaging the stem of an indicating gauge 442.

The arm 426 carries a pair of electric contact making screws 444 and 446 insulated from the arm but in electrical contact through a plate 448 with a wire 450 coming from a source of electric current, such as a transformer 452. The screws are set to make contact successively with binding posts 454 and 456 in insulating bushings 458 and 460 of the gauge carriage. Contact is made first by the screw 444 meeting the binding post 454 which is in circuit through the wire 112 with the switch 110 and the magnet 104. This contact occurs when the work is ready for the finish grind and controls the dressing of the grinding wheel as above explained. The binding post 454 can yield against the tension of a coil spring 462 to allow the contact screw 446 subsequently to make contact with the binding post 456 which is in circuit through a wire 464 with the magnet 142. Wires 466 and 467 connect the magnets 142 and 104 with the source of current. The second circuit is broken when the gauge is withdrawn, the pin 432 then running along the cam face 436 and pulling the spring 438 and arm 426 in a direction to retract the contact screws 444 and 446. The first contact, which causes the dressing operation on the wheel, is not necessarily made simultanously with the shifting of the ratchet mechanism from a coarse to a fine feed but will preferably occur at the same time or a little later. An offset rack bar 468 on the gauge carriage 402 projects towards the pinion 338 on the cross feed mechanism in a position to rotate the pinion and reverse the feed screw when the gauge carriage is shifted under control of the feeler. Hence, when the second electric contact is established, the pinion is rotated counterclockwise by the rack and no further grinding can occur. The cylinder 398 is smaller than the main working cylinder so that its piston slides faster than that of the main working cylinder. Hence, the pinion is caught and turned even though the main carriage be on its way out instead of in at the instant of contact. When the main carriage continues to retreat to its remote position the one-way clutch 336 permits the pinion to rotate idly and pass off the rack.

In operation, assuming a hollow workpiece is being ground internally and that the parts are set as in Figure 1, the first electric contact by the screw 444 engaging the binding post 454 energizes the magnet 104. The lever 100 is swung and the dog 58 lifted to let the grinding wheel make a longer stroke to the right to carry it across the dressing tool. The magnet is de-energized by the plate 130 throwing the switch 110 and the dog 106 returns the wheel for the finish grinding. About this time the cam 318 of the cross feed reaches the feed pawl and shortens the feed. When the work-piece reaches size, the second electric contact by the screw 446 engaging the binding post 456 energizes the second magnet 142 and trips the latch 136. The control bar 134 moves to the left and the pin 144 again swings the lever 100 so that both dogs 58 and 106 are lifted to enable the carriage to move the grinder to a remote position where it stops when the dog 146 swings the lever 150 and closes the cock 40. Several other things happen during this movement; the cam 194 is yanked away from the pawl 310 to stop the cross feed, the lug 154 throws the reverse lever 60 and its reverse valve 30 to a position ready to return the carriage when the cock 40 is opened again, the lever 168 is swung to move the valve 66 to a position where the three fluid

pressure mechanisms are actuated. These mechanisms withdraw the dressing tool and the gauge and operate the chucking devices which throw out the clutch for the work spindle, apply the brake, release the work, shut off the cooling fluid, and advance the centering plug ready to locate a new work-piece. When the gauge is withdrawn, the cross feed screw is reversed by the rack 468, the second electric circuit is broken by the cam 436 to deenergize the second magnet. The hand lever 156 is thrown to the "off" position of Figure 2. To commence a new grinding operation, a new work-piece is merely presented to the chuck and the hand lever 156 is swung to the "on" position of Figure 1. This does several things; it picks up the lever 168 and restores the control bar 134 to latched position; it picks up the valve stem 88 and throws the valve 66 to a position where it will operate the three fluid pressure mechanisms. One of these mechanisms releases the brake, grips the work, withdraws the centering plug, turns on the cooling fluid, and throws in the clutch. The other two mechanisms advance the diamond and the gauge to operative position. The final movement of the hand lever opens the shut-off cock 40 and swings the lever 150 to its original position. The carriage advances the wheel into the work and the cross feed commences when the pawl 310 reaches the cam 194. As the carriage advances, the plate 132 engages the arm 128 of the switch 110 and throws the switch to make ready the circuit through the first magnet 104.

I claim:

1. In a machine of the character described, a rotary spindle, a work holder on the spindle, a hollow sleeve slidable in the spindle, means for conducting cooling fluid to the sleeve, a driving member supported by the spindle, a clutch between the driving member and the spindle, and mechanism for successively disengaging the clutch and sliding the sleeve to cut off the supply of cooling fluid from the sleeve; substantially as described.

2. In a machine of the character described, a rotary spindle, a work holder on the spindle, a centering member slidable in the holder to receive and center a work-piece, a driving member, a clutch between the driving member and the spindle, and mechanism for successively disengaging the clutch and advancing the centering member through the holder to operative position; substantially as described.

3. In a machine of the character described, a rotary spindle, a work holder on the spindle, a plurality of clamping fingers movably supported on the holder to clamp a work-piece, a brake ring held against rotation and movable to engage the holder, and mechanism for moving the brake ring to stop the holder and actuate the clamping fingers to release the work-piece; substantially as described.

4. In a machine of the character described, a rotary spindle, a work holder on the spindle, a hollow sleeve slidable in the spindle, means for conducting cooling fluid to the sleeve, a brake member, and mechanism for successively actuating the brake member to stop the holder and for sliding the sleeve to cut off the supply of cooling fluid from the sleeve; substantially as described.

5. In a machine of the character described, a rotary spindle, a work holder on the spindle, a centering member slidable in the holder to center a work-piece, a brake ring held against rotation, and mechanism for successively moving the brake ring against the holder to stop the holder and advancing the centering member to centering position; substantially as described.

6. In a machine of the character described, a rotary spindle, a work holder on the spindle, work clamping means on the holder, a hollow sleeve slidable in the spindle, means for conducting a supply of cooling fluid to the sleeve, and reciprocating control mechanism for disengaging the clamping means from the work and sliding the sleeve in the spindle to cut off the supply of cooling fluid; substantially as described.

7. In a machine of the character described, a rotary spindle, a work holder on the spindle, a sleeve slidable in the spindle and having a hollow work centering member at one end, means for conducting a supply of cooling fluid to the sleeve and through the centering member to the work holder, and mechanism for sliding the sleeve to cut off the supply of cooling fluid and to carry the centering member to centering position; substantially as described.

8. In a machine of the character described, a rotary spindle, a work holder on the spindle, a driving member, a clutch between the driving member and the spindle, a brake member, a hollow sleeve slidable in the spindle, means for conducting cooling fluid to the sleeve, and mechanism for successively disengaging the clutch, actuating the brake member to stop the holder, and sliding the sleeve to cut off the cooling fluid; substantially as described.

9. In a machine of the character described, a rotary spindle, a work holder on the spindle, a driving member, a clutch between the driving member and the spindle, a brake member, a centering member slidable in the holder to center a work-piece, and mechanism for successively disengaging the clutch, actuating the brake member to stop the holder, and sliding the centering member to centering position; substantially as described.

10. In a machine of the character de-

scribed, a rotary spindle, a work holder on the spindle, work clamping means on the holder, a brake member, a hollow sleeve slidable in the spindle, means for conducting cooling fluid to the sleeve, and mechanism for applying the brake, disengaging the work clamping means from the work, and sliding the sleeve to cut off the supply of cooling fluid; substantially as described.

11. In a machine of the character described, a rotary spindle, a work holder on the spindle, a centering member movable in the holder to center a work-piece, work clamping means on the holder, a brake, and mechanism for operating the brake to stop the holder and disengage the clamping means from the work and for advancing the centering member to centering position; substantially as described.

12. In a machine of the character described, a rotary spindle, a work holder on the spindle, work clamping means on the holder, a hollow sleeve slidable in the holder and having a work centering member at one end, means for conducting cooling fluid to the sleeve, and mechanism for disengaging the clamping means from the work and for sliding the sleeve to cut off the cooling fluid and to advance the centering member to centering position; substantially as described.

13. In a machine of the character described, a rotary spindle, a work holder on the spindle, a driving member, a clutch between the driving member and the spindle, work clamping means on the holder, a brake member, a sleeve extending through the spindle, means for conducting cooling fluid to the sleeve, and mechanism for disengaging the clutch, actuating the brake member to stop the holder, disengaging the clamping means from the work, and shutting off the cooling fluid; substantially as described.

14. In a machine of the character described, a rotary spindle, a work holder on the spindle, a driving member, a clutch between the driving member and the spindle, a work clamping means on the holder, a brake member, a centering member slidable in the holder to center a work-piece, and mechanism for disengaging the clutch, actuating the brake member to stop the holder, disengaging the clamping means from the work, and sliding the centering member to centering position; substantially as described.

15. In a machine of the character described, a rotary spindle, a work holder on the spindle, a hollow sleeve slidable in the spindle and having a work centering member at one end, means for conducting cooling fluid to the sleeve, and mechanism for stopping rotation of the work holder, and for sliding the sleeve to cut off the supply of cooling fluid and to carry the centering member to centering position; substantially as described.

16. In a machine of the character described, a rotary spindle, a work holder on the spindle and having a face plate to engage a work-piece, a centering plug slidable in the holder to center the work-piece, a plurality of clamping fingers, springs for spreading the fingers, cam faces for contracting the fingers, a ring pivotally supporting the fingers, means for slidably supporting the ring on the holder, springs for forcing the ring in a direction to contract the fingers, and means for engaging the ring to stop rotation of the holder and to operate the clamping fingers to release the work-piece; substantially as described.

17. In a machine of the character described, a rotary spindle, a work holder on the spindle and having a face plate to engage a work-piece, a centering plug slidable in the holder to center the work-piece, a plurality of clamping fingers, springs for spreading the fingers, cam faces for contracting the fingers, a ring pivotally supporting the fingers, means for slidably supporting the ring on the head, and means for sliding the ring in two directions; substantially as described.

18. In a machine of the character described, a rotary spindle, a work holder having a face plate, a plurality of fingers for clamping a work-piece against the face plate, a ring pivotally supporting the fingers, cam faces on the holder to engage the fingers, springs for spreading said fingers, springs acting against said ring to draw said fingers to clamping position, and means for moving the ring to actuate the fingers to release the work-piece substantially as described.

19. In a machine of the character described, a rotary spindle, a work holder on said spindle and having a face plate to engage a work piece, a centering plug slidable in the holder to center the work-piece, a plurality of clamping fingers, springs for spreading the fingers, a ring pivotally supporting the fingers, means for movably supporting the ring on the holder, and means for moving the ring to effect opening or closing of the fingers; substantially as described.

20. In a machine of the character described, a rotary spindle, a work holder on the spindle and having means to engage a work piece, a centering member in the holder to center the work-piece, means extending through the spindle to reciprocate the centering member, a plurality of clamping fingers, means for opening the fingers, means for closing the fingers, a ring pivotally supporting the fingers, and means for moving the ring to effect opening or closing of the fingers; substantially as described.

21. In a machine of the character described, a rotary spindle, a work holder on the spindle, a centering plug slidable in the holder to enter the bore and center a hollow work-piece, mechanism for moving the plug in two directions, a plurality of clamping fingers, a ring pivotally supporting the fin-

gers, and means for moving the ring to effect opening or closing of the fingers; substantially as described.

22. In a machine of the character described, a rotary spindle, a work holder on the spindle and having means to engage a work-piece, a centering plug slidable in the holder to center the work-piece, means extending through the spindle for reciprocating the centering plug, a plurality of clamping fingers, and means for opening and closing the fingers; substantially as described.

23. In a machine of the character described, a rotary spindle, a work holder on the spindle and having means to engage a work-piece, a centering plug in the holder, a plurality of clamping fingers, a brake ring pivotally supporting the fingers, means for slidably supporting the ring on the holder, and means for frictionally engaging and sliding the ring to stop rotation of the head and effect opening of the fingers; substantially as described.

24. In a machine of the character described, a rotary spindle, a work holder on the spindle and having means to engage a work-piece, a centering plug slidable in the holder to center the work-piece, means extending through the spindle for reciprocating the centering plug, a plurality of clamping fingers, a ring pivotally supporting the fingers, means for slidably supporting the ring on the holder, and means for sliding the ring; substantially as described.

25. In a machine of the character described, a rotary spindle, a work holder on the spindle, a hollow sleeve slidable in the spindle, a tube for conducting cooling fluid to the sleeve during grinding, said tube extending into the end of the sleeve and having a port opening laterally into the sleeve, and means for causing a sliding movement of the sleeve on the end of the tube to admit or cut off the cooling fluid at said opening; substantially as described.

26. In a machine of the character described, a head having a hollow spindle journalled therein, a work holder on the spindle, a driving member journalled on the spindle, a clutch for connecting the driving member to the spindle, a sleeve extending through the hollow spindle for conducting cooling fluid to the work, a cylinder carried by the head, a piston in the cylinder, a piston rod, and operating connections from the piston rod for actuating the clutch and for controlling the supply of cooling fluid to the sleeve; substantially as described.

27. In a machine of the character described, a head having a hollow spindle journalled therein, a work holder mounted on the spindle and having means to grip a work-piece, a sleeve extending through the hollow spindle for conducting cooling fluid to the work, a cylinder carried by the head, a piston in the cylinder, a piston rod, and operating connections from the piston rod for actuating the work gripping means and for controlling the supply of cooling fluid to the sleeve; substantially as described.

In testimony whereof I hereunto affix my signature.

CLARENCE C. STEVENS.