Dec. 8, 1959 E. A. THOMPSON 2,915,855

CENTERLESS GRINDER ATTACHMENT

Filed Dec. 30, 1957 3 Sheets-Sheet 1

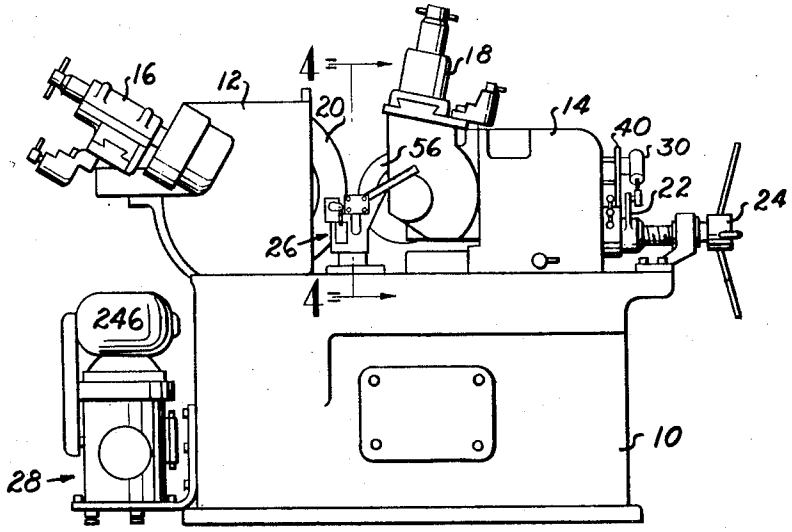


FIG. 1.

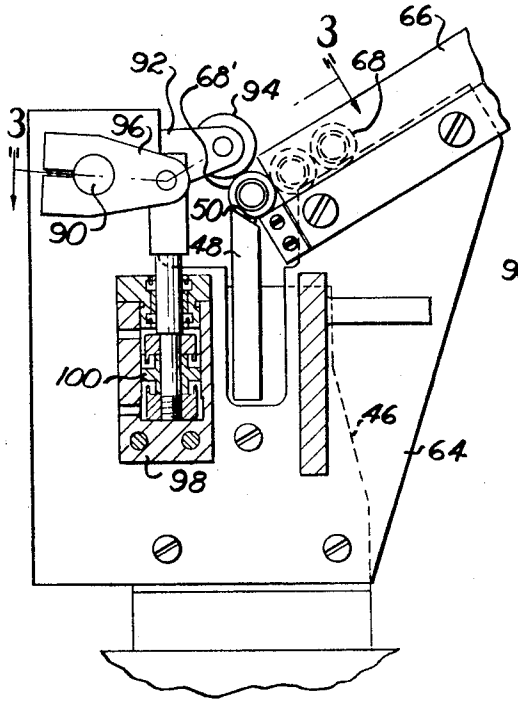


FIG. 2.

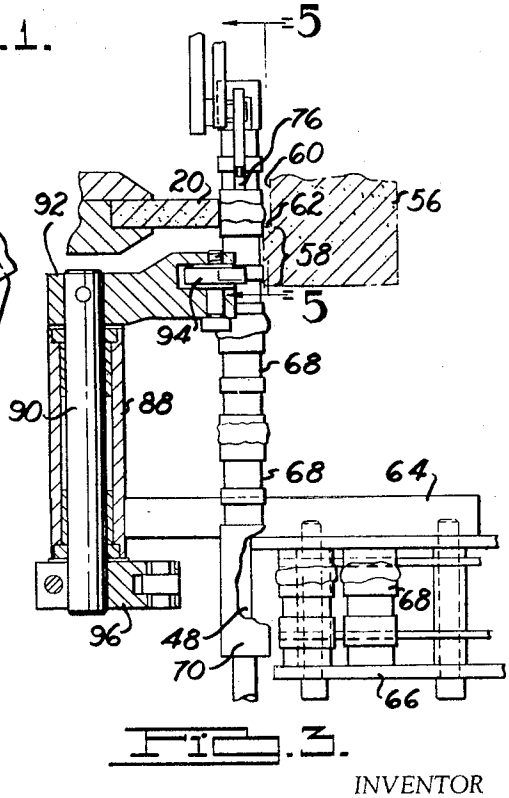


FIG. 3.

INVENTOR
EARL A. THOMPSON
BY
Ralph R Tweedale
ATTORNEY

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CENTERLESS GRINDER ATTACHMENT

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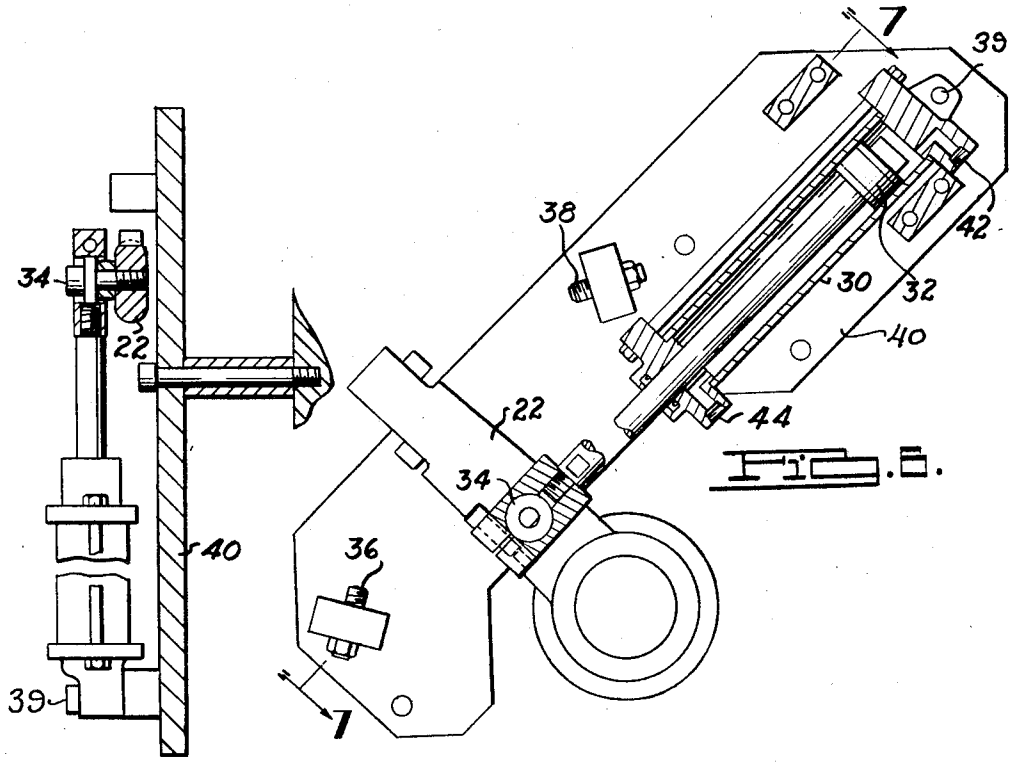


FIG. 6.

FIG. 7.

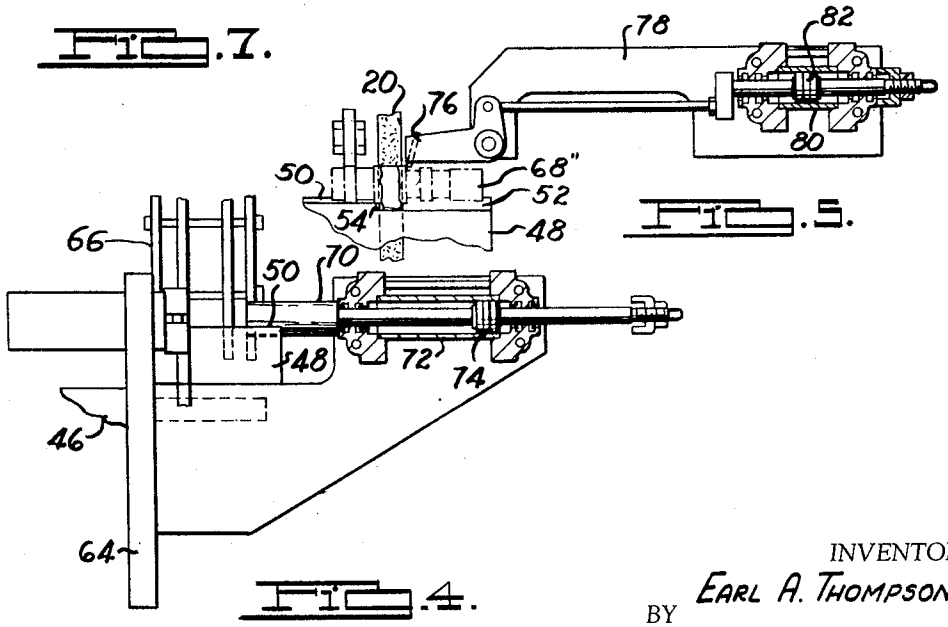


FIG. 5.

FIG. 4.

INVENTOR
EARL A. THOMPSON
BY
Ralph R. Twardoke
ATTORNEY

Dec. 8, 1959 E. A. THOMPSON 2,915,855

CENTERLESS GRINDER ATTACHMENT

Filed Dec. 30, 1957 3 Sheets-Sheet 3

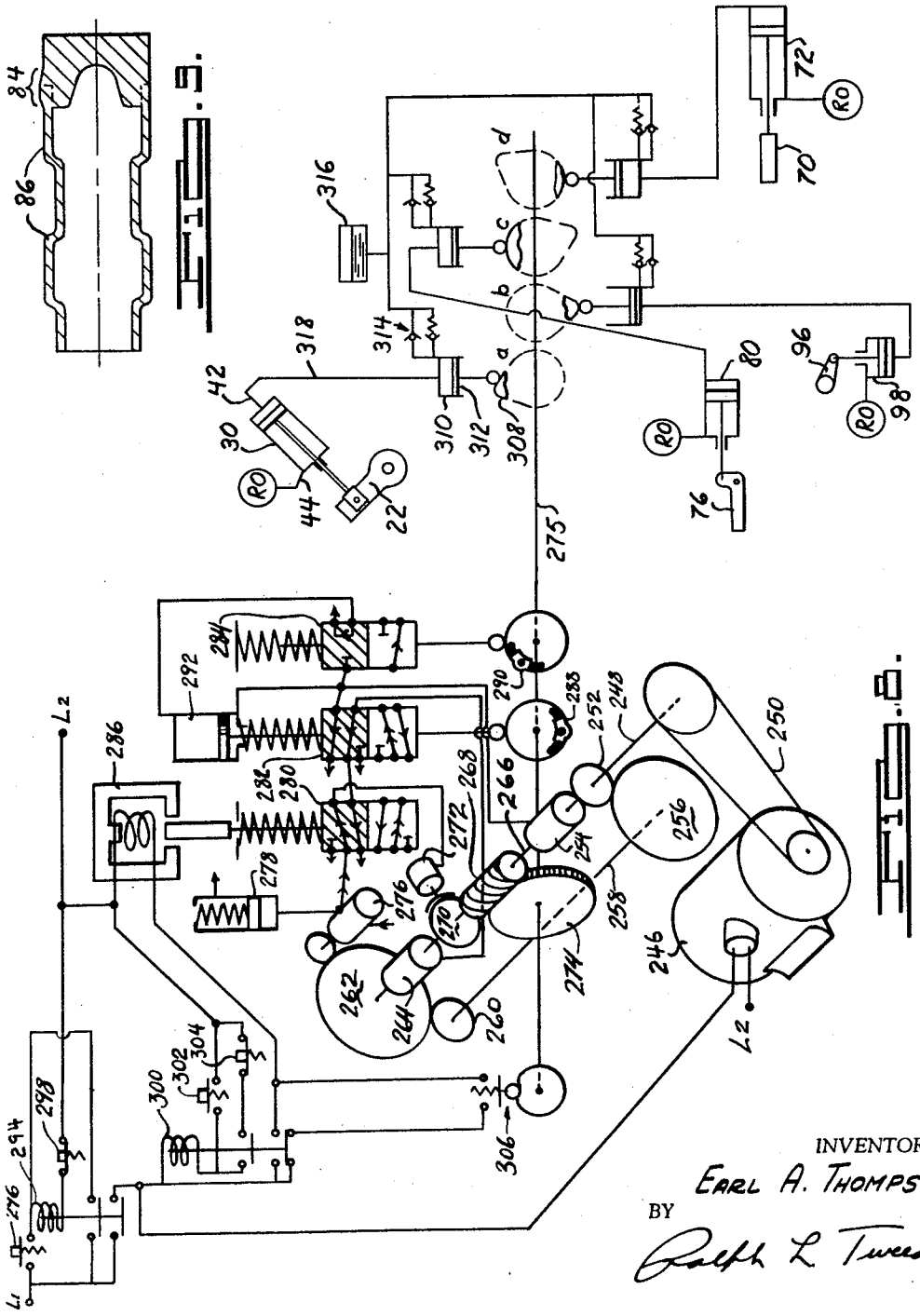


FIG. 9.

INVENTOR.
EARL A. THOMPSON
BY
Ralph L Tweedale

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CENTERLESS GRINDER ATTACHMENT

Earl A. Thompson, Ferndale, Mich.

Application December 30, 1957, Serial No. 706,095

10 Claims. (Cl. 51—103)

This invention relates to machine tools and particularly to machine tools for performing centerless grinding operations. Centerless grinders may be operated either as through-feeding machines or as plunge-cut, in-feeding machines. Where the work pieces have their greatest diameters at the surface or surfaces to be finish ground, the through-feed operation is well suited for economical and accurate production. However, with work pieces which are to be ground on more than one diameter, or with work pieces where it is desired to grind the largest diameter concentric to an already established different diameter on the work piece, the economical through-feed method is not possible to use and the parts must be ground by the plunge-cut method which has heretofore been performed only by a slow hand feeding operation or by complex mechanical work handling devices. With work pieces, moreover, which have their largest diameter upon the surface to be ground, together with a requirement for concentricity with an already established smaller diameter surface on the piece, it has heretofore been impossible to successfully perform centerless grinding operations automatically upon such pieces.

It is an object of the present invention to provide an improved centerless grinding machine which may be operated automatically to feed parts endwise through the machine as received from a supply chute or conveyor.

Another object of the present invention is to provide a centerless grinding machine wherein work pieces having multiple diameters may be centerless ground by a plunge grinding operation, and in which work pieces are fed through the machine and the machine is operated automatically.

A further object of the present invention is to provide an improved attachment which may be applied to existing centerless grinding machines in order to adapt them readily to perform the types of grinding operations mentioned.

It is another object of the present invention to provide a centerless grinding machine and an attachment having an improved coordinated drive system embodying a mechanico-hydraulic programming unit of improved form.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of the present invention is illustrated.

In the drawings:

Figure 1 is an end view of a centerless grinding machine incorporating a preferred form of the present invention.

Figure 2 is a fragmentary view on a larger scale of a portion of the mechanism in Figure 1.

Figure 3 is a fragmentary view, partly in section, taken on line 3—3 of Figure 2.

Figure 4 is an enlarged fragmentary view taken on line 4—4 of Figure 1.

Figure 5 is a fragmentary view taken along the line 5—5 of Figure 3.

Figure 6 is a fragmentary side view of a portion of the right side of the machine shown in Figure 1.

Figure 7 is a view, partly in section, along the line 7—7 of Figure 6.

Figure 8 is a diagrammatic view of a mechanico-hydraulic control system forming part of the machine of Figure 1.

Figure 9 is a sectional view of a work piece showing its condition before and after a grinding operation.

In Figure 1 there is shown a centerless grinding machine comprising a base **10** having a grinding wheel head **12** and a regulating wheel head **14** provided, respectively, with wheel dressing mechanisms **16** and **18**. The head **12** is adjustably mounted in a stationary position on base **10** and carries a main spindle, not shown, on which a grinding wheel **20** may be mounted. A suitable axial oscillating mechanism may be provided. The head **14** is mounted on the base **10** by means of ways to allow in- and out-feeding movements and for this purpose is provided with an oscillatable plunge lever **22** operating in the same manner as the usual manual plunge or in-feed lever of a conventional centerless grinder. A manually operated stop screw **24** determines the limits of in-feed motion. The parts thus far described may be of conventional form.

The grinder of Figure 1 includes a work feeding attachment, generally designated **26**, which is connected for operation by hydraulic conduits, not shown, with a mechanico-hydraulic programming and driving unit, generally designated **28**, driven by an electric motor **246**. The program unit **28** also is hydraulically connected to operate a reciprocating hydraulic motor **30** for the in-feed lever **22**. Motor **30** contains a piston **32**, the rod of which is connected to the lever **22** at the pivot **34**. Lever **22** is limited in its oscillatory stroke by adjustable stops **36** and **38**. The motor **30** is pivotally mounted at **39** on a suitable sub-base plate **40** which is attached to the regulating wheel head **14**. Motor **30** also incorporates suitable hydraulic connection passages **42** and **44**.

The base of the machine **10** carries the usual clamp structure **46**, within which a work piece rest **48** is adjustably clamped. The work rest **48** is provided with a work engaging top surface **50** which may be inclined and positioned in accordance with conventional practice. At its inner end, as shown particularly in Figure 5, the rest **48** has a top surface portion **52** positioned at a lower level and joining the surface **50** by means of a step **54**.

The regulating head **14** contains the usual regulating wheel **56** but it is dressed so as to have only a limited work engaging portion, as shown at **58**, while the remainder of the wheel is dressed down to a considerably smaller diameter, as shown at **60**. The grinding wheel **20**, at least so far as its effective surface is concerned, is positioned axially beyond the portion **58** of the regulating wheel and opposite the relieved portion **60**. The shoulder **62**, which joins portions **58** and **60**, may correspond in location to the shoulder **54** on the work rest **48**.

The work feeding mechanism **26** includes a sub-frame **64** which may be attached to the end of the work rest clamp **46**. The sub-frame **64** carries an inclined work piece supply chute **66** which may be fed from any suitable conveyer device, not illustrated, and down which work pieces **68** may roll by gravity in side-by-side relation. At the bottom of the chute **66**, there is provided a cylindrical pusher **70** which may be operated by a hydraulic motor **72** having a piston **74** to the rod of which the pusher **70** is directly connected. The pusher **70**, when retracted as shown in Figure 4, allows a work piece to roll down upon the work rest **48** to the position shown at **68'** in Figure 2. When the pusher **70** is projected to the left in Figure 4, a work piece is pushed endwise into the working throat formed between the grinding wheels **20** and **56** and the

other pieces in the chute 66 are held against advance until pusher 70 is again retracted.

With pusher 70 advanced in the position shown in Figure 3, a train of three work pieces 68 is positioned ahead of it with the third piece in grinding position in the working throat and held against advance by a retractable stop 76. The stop 76 is pivotally mounted on a stationary sub-plate 78, as shown in Figure 5, and is operated by a hydraulic motor 80. When the piston 82 shifts a short distance to the right in Figure 5, the stop 76 will be lifted to allow the pusher 70 to push the train of work pieces ahead one step. Because of space considerations in some conventional centerless grinding machines, it may be desirable to extend the lower top face of the work piece rest 48, as shown in Figure 5, so as to support a finished work piece in the position 68'' until it has progressed farther to the right in Figure 5 where it may fall clear of entanglement with portions of the machine.

Where it is desired to machine work pieces 68 of the class such as shown in the upper half of Figure 9 which have a maximum diameter zone at 84 (such as formed by welding flash), which it is desired to grind concentrically with previously finished smaller diameter portions at 86, it is desirable to provide a hold-down roller for the work piece and which is effective upon one or both the diameters 86. Thus, as shown in Figures 2 and 3, the subframe 64 may be provided with a journal bearing 88 for a shaft 90. Shaft 90 carries at one end a roller arm 92 carrying a hold-down roller 94. At its other end the shaft 90 carries an operating lever 96 which is operated by a hydraulic motor 98 having a piston 100.

For the purpose of motivating the various moving parts which are operated by the hydraulic motors, previously described, the mechanico-hydraulic programming unit 28 is provided. The mechanico-hydraulic drive and control unit 28 includes a drive motor 246 which, as shown in Figure 8, is arranged to drive a self-controlled two-speed transmission, which is shown in the left-hand half of Figure 8. The motor drives the input shaft 248 of the transmission through a belt drive 250. The input shaft 248 drives a pinion 252 and also the input member of a hydraulically engaged, spring released clutch 254. Pinion 252 drives a gear 256 secured to countershaft 258 which carries pinion 260 at its opposite end. Pinion 260 drives a gear 262 and therewith constitutes a set of speed change gears. Gear 262 drives the input member of a second hydraulically engaged, spring released clutch 264. The driven members of clutches 254 and 264 are secured to the opposite ends of a shaft 266 having a worm 268 thereon and a brake drum 270. The latter has a spring biased hydraulic motor 272 for engaging the brake. The worm 268 drives a worm wheel 274 secured to the camshaft 275.

For the purpose of automatically controlling the starting, stopping and speed of the transmission, there is provided a hydraulic control pump 276 driven from gear 262, which may circulate a body of oil contained in the transmission housing for control and lubricating purposes. The pump 276 may deliver to a combined accumulator and relief valve comprising a spring loaded piston 278 and also supplies oil to a bank of control valves 280, 282, and 284. In the diagrams, each valve is shown as a two-position valve, spring biased to the position illustrated in which the connections shown in the cross-hatched rectangles are established. Single-headed arrows are used to indicate flow at reservoir pressure and double-headed arrows to indicate flow at pump delivery pressure. Each of the valves, when shifted, establishes the connections shown in the unhatched rectangles immediately below the hatched rectangles.

Valve 280 is arranged to be shifted by solenoid 286. Valves 282 and 284 are arranged to be shifted by the adjustable cams 288 and 290, respectively, which are positioned on camshaft 275. In addition, valve 282 has a hydraulic holding cylinder 292 which holds the valve 282 in its shifted position until it is released by the shifting of valve 284. Valve 280, in the position shown, delivers pressure fluid to engage the brake 272 and also exhausts fluid from low speed clutch 264. When shifted valve exhausts fluid to release brake 272 and supplies pressure fluid to engage the low speed clutch 264, subject, however, to a conjoint control by the valve 282.

The latter valve, in the position illustrated, exhausts fluid to release the high speed clutch 254 and places the low speed clutch 264 under the control of valve 280. In its shifted position, valve 282, provided valve 280 has been shifted, delivers pressure fluid to engage high speed clutch 254 and exhausts fluid to release low speed clutch 264. As previously explained, the valve 284 is merely a reset valve for bypassing the holding cylinder 292 to permit valve 282 to return to its spring biased position, shown on the drawings.

Thus, energization of solenoid 286 will start the camshaft rotating at slow speed. Thereafter, the cam 288 will shift the transmission to drive the camshaft at high speed, and still later the cam 290 will again shift the transmission to low speed. So long as the solenoid 286 remains energized, camshaft 275 will continue to rotate, first at a slow speed and then at a high speed during each revolution, controlling its own speed changes by operation of the cams 288 and 290.

For the purpose of controlling the drive motor 246 and the solenoid 286, there is provided an electric control circuit connected between a pair of electric supply lines, designated L–1 and L–2. The circuit may include a master relay 294 of the holding type having a manual master start switch 296 and a manual master stop switch 298. Relay 294 controls the motor 246 and also a cycle control relay 300 of the holding type having a manual cycle start switch 302 and a manual cycle stop switch 304. The normally open contacts of relay 300, which are of the make-before-break type, control energization of cycle solenoid 286 directly. The normally closed contacts of relay 300 also control solenoid 286 but are in series with a cam switch 306 mounted on the left end of the master camshaft 275 and arranged to be opened once during each revolution thereof. The arrangement is such that when the cycle stop switch 304 is operated at any point in the rotation of camshaft 275, relay 300 will be deenergized but solenoid 286 will remain energized until the cam switch 306 opens at the predetermined stopping point. Operation of the master stop switch 298, however, will deenergize solenoid 286 immediately regardless of the point in the cycle and will also deenergize motor 246.

The camshaft 275 drives a number of cam operated hydraulic pulsator sections designated *a* through *d*, inclusive. Each section may comprise a cam 308 secured to the camshaft 275 and having a contour composed of predetermined rise and fall ramps designed to produce the motion sequences desired for one of the movable parts of the machine. Each section may comprise a single-acting pulsating cylinder 310 having a piston 312 operated by the follower for the cam 308. The head of each cylinder 310 may contain a balancing valve assembly 314 comprising an outwardly opening pressure relief valve and an inwardly opening check or replenishing valve, each of which is connected to a reservoir 316 which is preferably pressurized at a low super-atmospheric pressure. Each pulsator cylinder 310 communicates by a closed liquid column conduit 318 with one of the hydraulic motors of the machine and thus they together constitute a liquid column type motion transmitting device for transferring the motion of the cam follower to the machine element which is connected to the piston of the fluid motor. Thus, the liquid column 318 of the section *a* is connected to the head end of fluid motor 30 for operating the in-feed lever 22. Section *b* is connected to the fluid motor 98 for operating the hold-down roller. Section *c* is connected to the fluid motor 80

for operating the retractable stop and section *d* is connected to the fluid motor **72** for operating the work piece pusher.

Each of the fluid motors operates between limit stops which are so arranged that the total displacement of each fluid motor is slightly less than the displacement of the piston **312** in cylinder **310**. Thus, at the end of each advancing stroke, a small quantity of fluid is blown over the relief valve to the reservoir **316**. During the latter part of each return stroke, the replenishing valve permits the fluid to be returned as well as any small amount which may have leaked out of the liquid column.

For the purpose of returning each of the fluid motors and their respective transmitter piston **312**, the opposite end of each fluid motor is connected with a plenary volume source of fluid under high pressure which is indicated diagrammatically by the circles marked "RO." It will be understood that it is preferred to connect the return end of all cylinders together so as to allow for transferring motion from an advancing cam to another cam which is receding whenever possible. It is preferred to utilize a gas loaded liquid accumulator as the plenary volume high pressure source, although it will be understood that other sources such as spring or weight loaded accumulators, variable displacement pumps with pressure compensation, or fixed displacement pumps with relief valve means may be utilized.

In operation with the supply chute **66** filled with a stack of work pieces, as shown in the upper part of Figure 9, and with a train of work pieces in the position shown in Figure 3, a grinding operation is being performed and the in-feed arm **222** will be shifted, first at a rapid rate and then at a feed rate as determined by the contour of cam **308***a* and the speed of the camshaft **275**. This pushes the regulating wheel **56** toward the grinding wheel **20**. The work piece **28** is supported upon the upper section **50** of work rest **48** by means of its preformed cylindrical surfaces **86** and is held in position by means of the hold-down roller **94**. Thus, the work piece rotates about the center of the cylindrical surfaces which are in contact with the work rest, the hold-down roller, and the regulating wheel. Grinding, however, is performed upon the larger diameter represented by the welding flash which is in contact with the grinding wheel **20** only. During the in-feed movements, the work piece rides up the inclined surface **50** and roller **94** yields upwardly to permit this action, since it is subjected to the constant pressure in the return oil system which acts as a yielding bias.

When the infeeding motion is completed, as determined by the internal feed stop or by the lever **22** contacting stop **36**, the two-speed transmission will again shift to rapid speed and cam **308** will retract, allowing return oil pressure to withdraw the regulating wheel. Concurrently, the hold-down roller **94** will be raised by the cam-pulsator section *b* and, simultaneously, stop **76** will be lifted by cam-pulsator section *c* and the pusher **70** will be retracted by cam-pulsator section *d*. A new work piece will fall in front of the pusher **70** and the latter will again be advanced, pushing the train of work pieces ahead of it and dropping the foremost piece off the end of the work rest **48** to move out of the machine on a suitable exit chute or conveyer, not shown.

During the final motion of the pusher **70**, the stop **76** is returned so as to hold a new train of work pieces by the pusher **70** and stop **76**, as shown in Figure 3. The roller **94** will also be returned at this time and the in-feed level **22** will be started on its rapid advance stroke. Thereupon the transmission will shift to a slow speed drive of the camshaft **275** and the grinding in-feed motion will be completed, as previously described.

It will be seen that the present invention provides an improved centerless grinding apparatus which may take the form of a readily applied attachment that may be fitted to existing conventional centerless grinders.

The invention, furthermore, provides a centerless grinding machine and attachment which enables work pieces having multiple external diameters to be ground by the centerless method in a fully automatic manner so as to provide concentricity between finished surfaces of different diameters, even though the grinding is performed on a larger diameter than that which locates the work piece. It will be understood that grinding may be performed on more than one diameter at the same time by the use of contour grinding wheels and that the diameter, or diameters, being ground need not be larger than the locating diameter but may be smaller also, depending upon the type of work piece to be ground.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A centerless grinding machine comprising a frame, a grinding wheel journaled on the frame, a regulating wheel journaled on the frame, a work rest positioned to form with the wheels a work piece receiving throat, a work holding wheel above the rest and opposite the regulating wheel, and means for lifting the work holding wheel to permit a work piece to pass into the throat longitudinally, the work-engaging surfaces of the grinding wheel and the regulating wheel being staggered axially of the throat whereby work pieces having a stepped cylindrical contour may be positioned by the rest, the regulating wheel, and the holding wheel on one external diameter and be ground by the grinding wheel on a different external diameter.

2. A centerless grinding machine comprising a frame, a grinding wheel journaled on the frame, a regulating wheel journaled on the frame, a work rest positioned to form with the wheels a work piece receiving throat, a work holding wheel above the rest and opposite the regulating wheel, and means for lifting the work holding wheel to permit a work piece to pass into the throat longitudinally, the work-engaging surfaces of the grinding wheel and the regulating wheel being staggered axially of the throat whereby work pieces having a stepped cylindrical contour may be positioned by the rest, the regulating wheel, and the holding wheel on one external diameter and be ground by the grinding wheel on a different external diameter, said work rest having portions of different height underlying the work throat, only one of which portions is in contact with a work piece.

3. A centerless grinding machine for multi-diameter work pieces comprising a frame having a stationary blade forming a work rest, a rotary means on one side of the work rest including a grinding wheel, said rotary means being provided with a plurality of work piece engaging surfaces in stepped relation whereby to simultaneously engage a work piece along a plurality of cylindrical surfaces of different diameters, a regulating head on the opposite side of the work rest having rotary means provided with a lesser number of work piece engaging surfaces to engage a work piece along at least one diameter and to remain clear of the work piece along at least one other diameter, infeed mechanism for producing relative motion of the head toward and away from the work rest, work feeding mechanism at one end of the throat for pushing successive work pieces into the throat, a retractable end stop at the opposite end of the throat forming an abutment against which work pieces may be pushed by the work feeding mechanism, and coordinated driving means for the infeed mechanism, the work feed mechanism, and the end stop whereby a work piece may be located by contact with the blade, the rotary means and the regulating head at spaced points on one diameter and be ground concentrically on another diameter while passing through the throat from one end to the other.

4. A centerless grinding machine for multi-diameter

work pieces comprising a frame having a stationary blade forming a work rest, a rotary means on one side of the work rest including a grinding wheel, said rotary means being provided with a plurality of work piece engaging surfaces in stepped relation whereby to simultaneously engage a work piece along a plurality of cylindrical surfaces of different diameters, a regulating head on the opposite side of the work rest having rotary means provided with a lesser number of work piece engaging surfaces to engage a work piece along at least one diameter and to remain clear of the work piece along at least one other diameter, infeed mechanism for producing relative motion of the head toward and away from the work rest, work feeding mechanism at one end of the throat for pushing successive work pieces into the throat, a retractable end stop at the opposite end of the throat forming an abutment against which work pieces may be pushed by the work feeding mechanism, hydraulic motors for operating the infeed mechanism, the work feed mechanism, and the end stop, and a mechanico-hydraulic program device comprising a camshaft, means for driving the camshaft, and a plurality of liquid column type motion transfer devices operated by the camshaft and connected one to each hydraulic motor.

5. A centerless grinding machine for multi-diameter work pieces comprising a frame having a stationary blade forming a work rest, a rotary means on one side of the work rest including a grinding wheel, said rotary means being provided with a plurality of work piece engaging surfaces in stepped relation whereby to simultaneously engage a work piece along a plurality of cylindrical surfaces of different diameters, one of said surfaces being provided by a hold-down roller shiftable toward and away from the work, a regulating head on the opposite side of the work rest having rotary means provided with a lesser number of work piece engaging surfaces to engage a work piece along at least one diameter and to remain clear of the work piece along at least one other diameter, infeed mechanism for producing relative motion of the head toward and away from the work rest, work feeding mechanism at one end of the throat for pushing successive work pieces into the throat, and coordinated driving means for the infeed mechanism, the work feed mechanism, and the hold-down roller whereby a work piece may be located by contact with the blade, the rotary means and the regulating head at spaced points on one diameter and be ground concentrically on another diameter while passing through the throat from one end to the other.

6. A centerless grinding machine for multi-diameter work pieces comprising a frame having a stationary blade forming a work rest, a rotary means on one side of the work rest including a grinding wheel, said rotary means being provided with a plurality of work piece engaging surfaces in stepped relation whereby to simultaneously engage a work piece along a plurality of cylindrical surfaces of different diameters, one of said surfaces being provided by a hold-down roller shiftable toward and away from the work, a regulating head on the opposite side of the work rest having rotary means provided with a lesser number of work piece engaging surfaces to engage a work piece along at least one diameter and to remain clear of the work piece along at least one other diameter, infeed mechanism for producing relative motion of the head toward and away from the work rest, work feeding mechanism at one end of the throat for pushing successive work pieces into the throat, hydraulic motors for operating the infeed mechanism, the work-feed mechanism, and the hold-down roller, and a mechanico-hydraulic program device comprising a camshaft, means for driving the camshaft, and a plurality of liquid column type motion transfer devices operated by the camshaft and connected one to each hydraulic motor.

7. An automatic feeding attachment for a plunge-cutting centerless grinder having a stationary work rest and a pair of parallel grinding wheels forming a working throat, said attachment comprising an entry chute for feeding work pieces into alignment with the throat at one end thereof, a pusher shiftable axially of the throat to dispense work pieces one at a time from the chute and push them into the throat, a retractable stop at the opposite end of the throat located to position work pieces endwise between the pusher and the stop for grinding, a wheel feeding device operable to advance and retract one of the wheels transversely of the throat, and a coordinated driving means connected to operate the pusher, the stop, and the wheel feed in a timed program of motions.

8. An automatic feeding attachment for a plunge-cutting centerless grinder having a stationary work rest and a pair of parallel grinding wheels forming a working throat, said attachment comprising an entry chute for feeding work pieces into alignment with the throat at one end thereof, a pusher shiftable axially of the throat to dispense work pieces one at a time from the chute and push them into the throat, a retractable stop at the opposite end of the throat located to position work pieces endwise between the pusher and the stop for grinding, a wheel feeding device operable to advance and retract one of the wheels transversely of the throat, a mechanico-hydraulic programming and driving system including a camshaft, means for driving the camshaft, and a plurality of liquid column type motion transfer devices each operated by the camshaft and connected respectively to operate the pusher, the stop, and the wheel feed in timed relation.

9. An automatic feeding attachment for a plunge-cutting centerless grinder having a stationary work rest and a pair of parallel grinding wheels forming a working throat, said attachment comprising an entry chute for feeding work pieces into alignment with the throat at one end thereof, a pusher shiftable axially of the throat to dispense work pieces one at a time from the chute and push them into the throat, a retractable stop at the opposite end of the throat located to position work pieces endwise between the pusher and the stop for grinding, a hold-down roller shiftable toward and away from the work, a wheel feeding device operable to advance and retract one of the wheels transversely of the throat, and a coordinated driving means connected to operate the pusher, the roller, and the wheel feed in a timed program of motions.

10. An automatic feeding attachment for a plunge-cutting centerless grinder having a stationary work rest and a pair of parallel grinding wheels forming a working throat, said attachment comprising an entry chute for feeding work pieces into alignment with the throat at one end thereof, a pusher shiftable axially of the throat to dispense work pieces one at a time from the chute and push them into the throat, a retractable stop at the opposite end of the throat located to position work pieces endwise between the pusher and the stop for grinding, a hold-down roller shiftable toward and away from the work, a wheel feeding device operable to advance and retract one of the wheels transversely of the throat, a mechanico-hydraulic programming and driving system including a camshaft, means for driving the camshaft, and a plurality of liquid column type motion transfer devices each operated by the camshaft and connected respectively to operate the pusher, the roller, and the wheel feed in timed relation.

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