July 25, 1933. A. A. KOTTMAN 1,919,790

FEED MECHANISM FOR GRINDING MACHINES

Filed Nov. 25, 1930 6 Sheets-Sheet 1

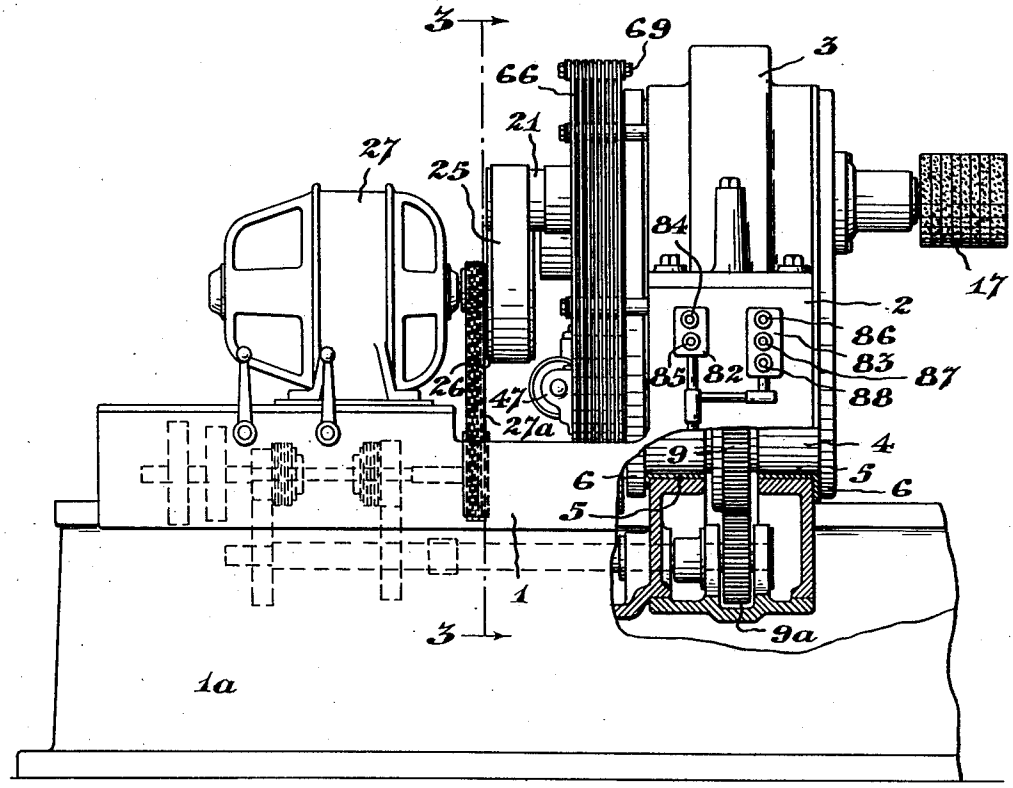


Fig. 1.

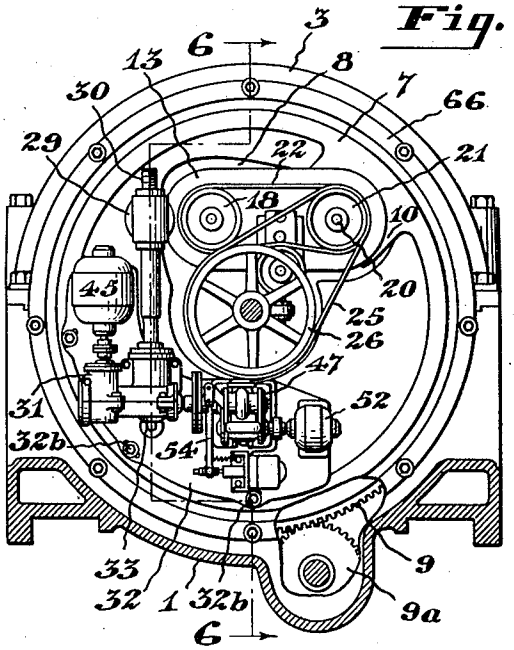


Fig. 3.

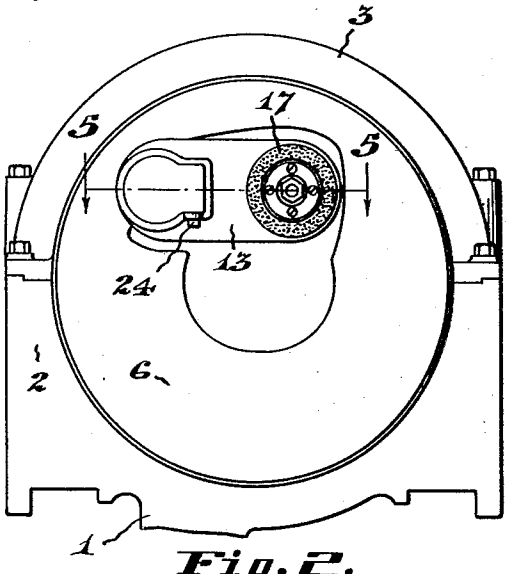


Fig. 2.

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FEED MECHANISM FOR GRINDING MACHINES

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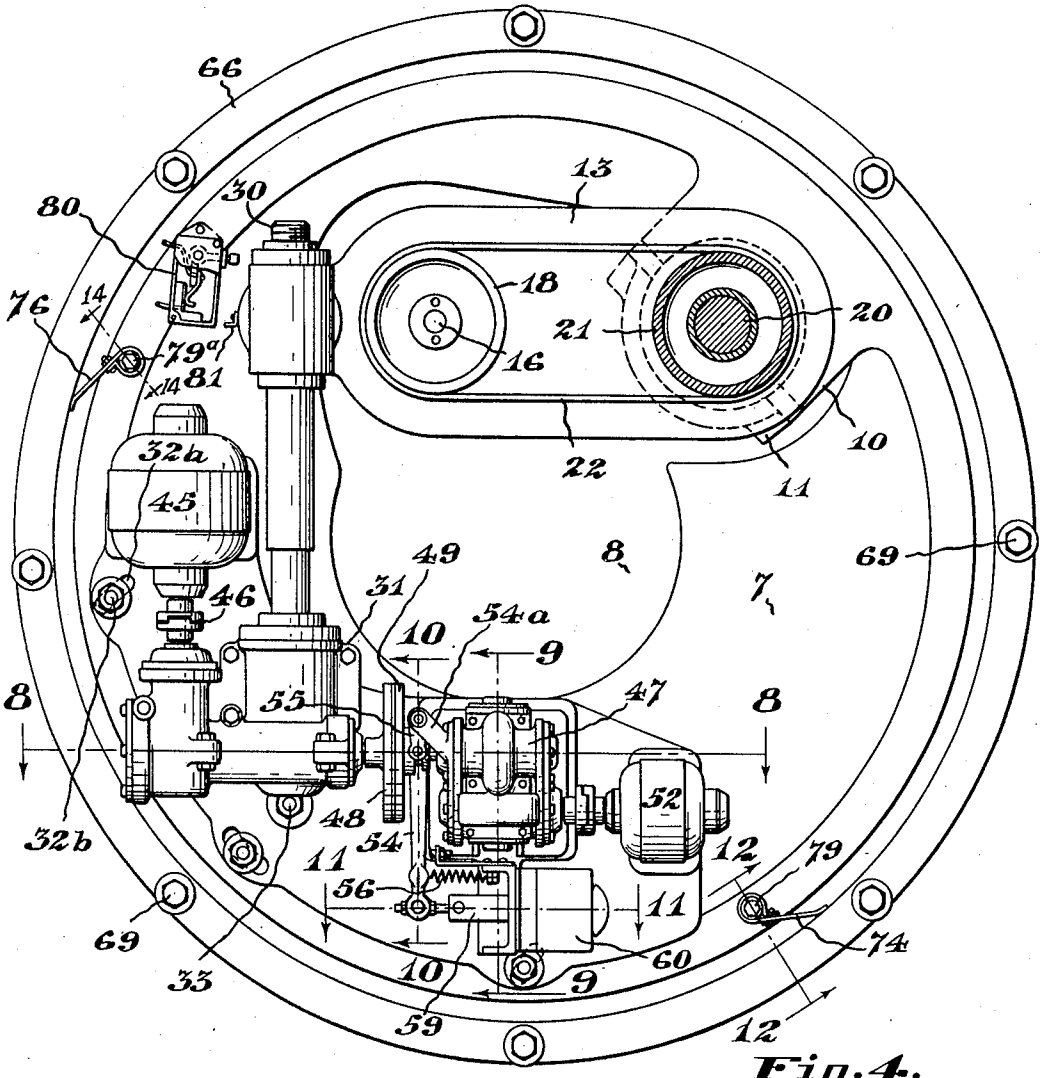


Fig. 4.

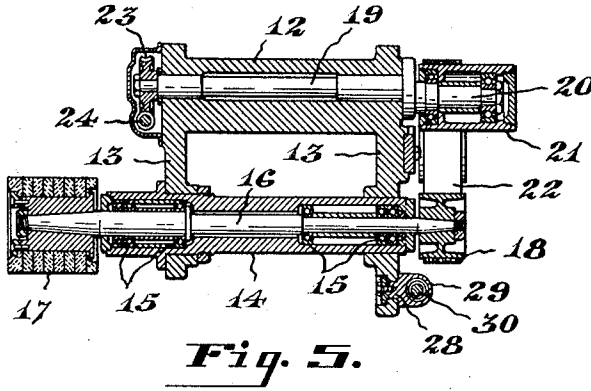


Fig. 5.

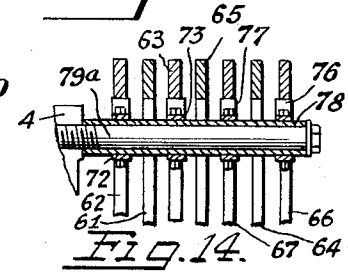


Fig. 14.

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FEED MECHANISM FOR GRINDING MACHINES

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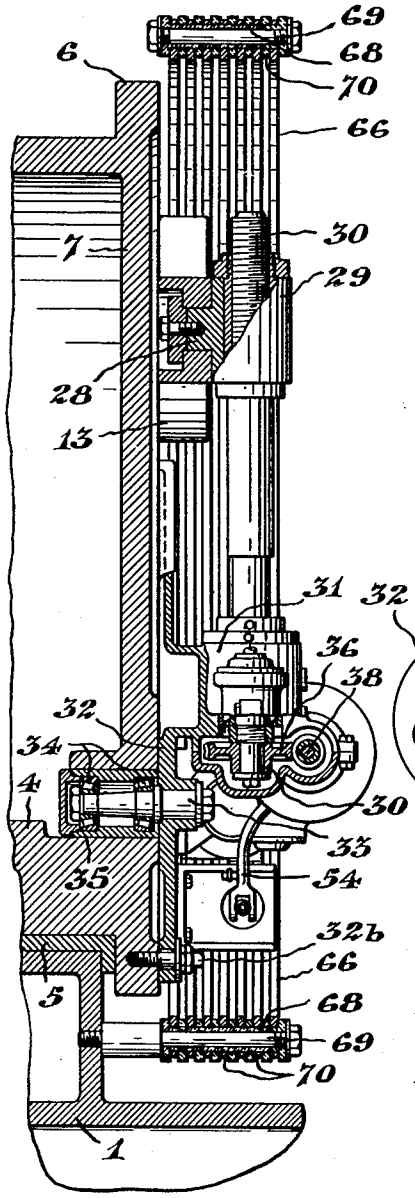


Fig. 6.

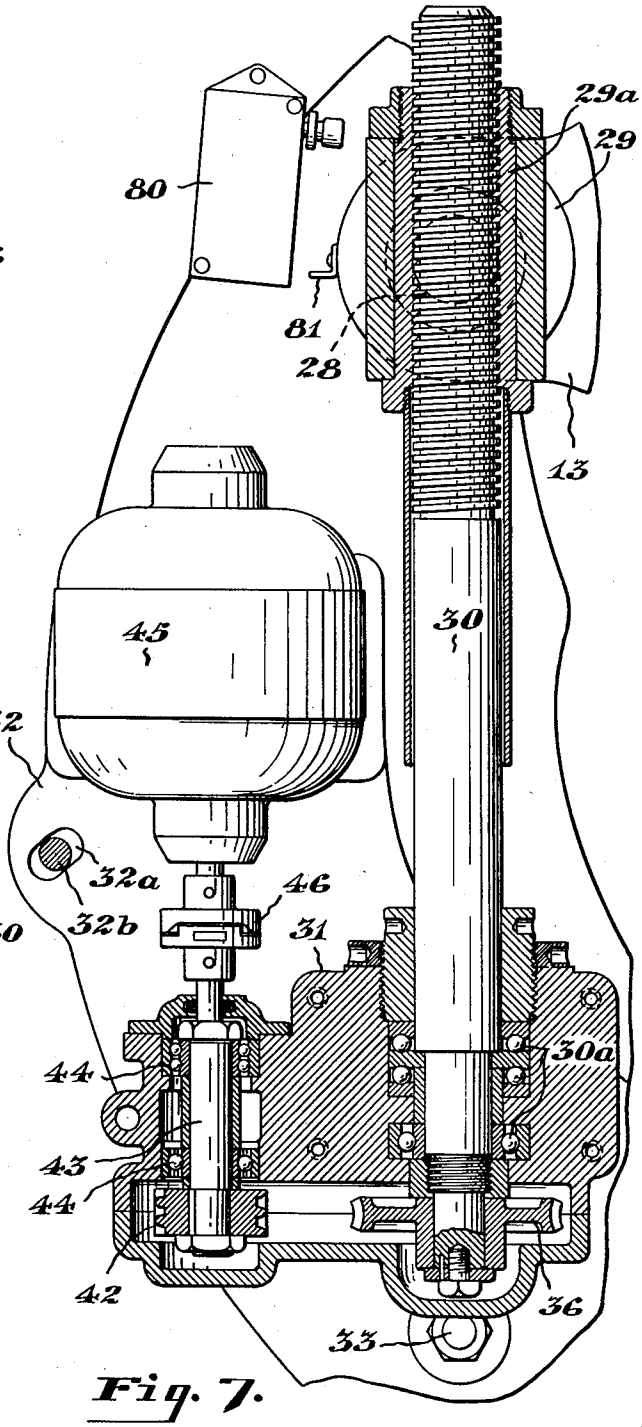


Fig. 7.

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FEED MECHANISM FOR GRINDING MACHINES

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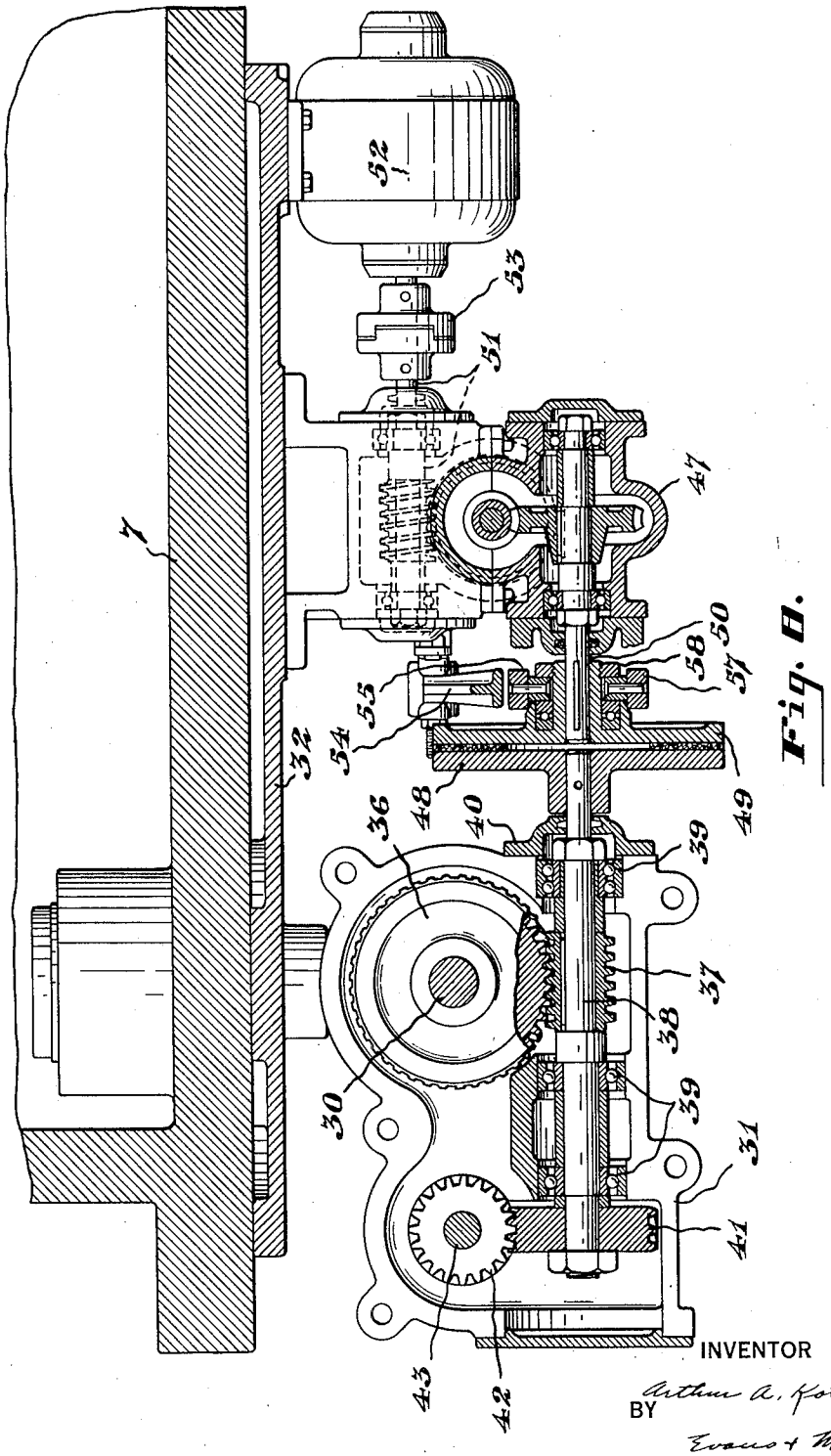


Fig. 8.

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FEED MECHANISM FOR GRINDING MACHINES

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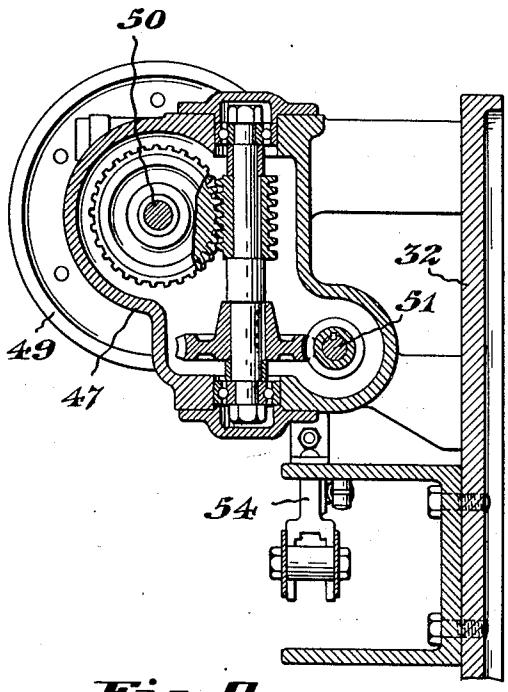


Fig. 9.

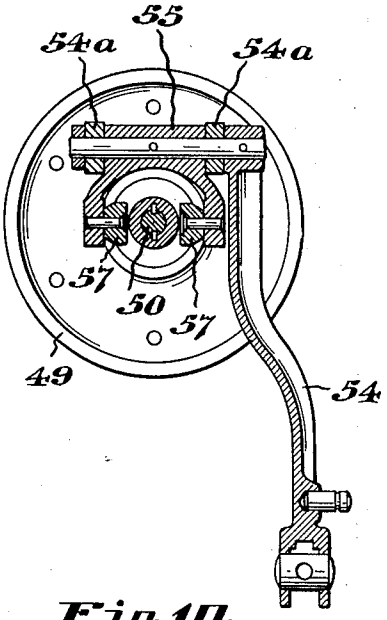


Fig. 10.

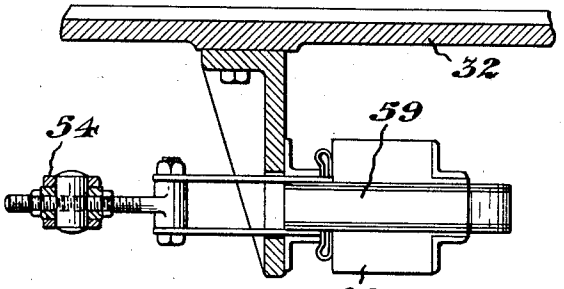


Fig. 11.

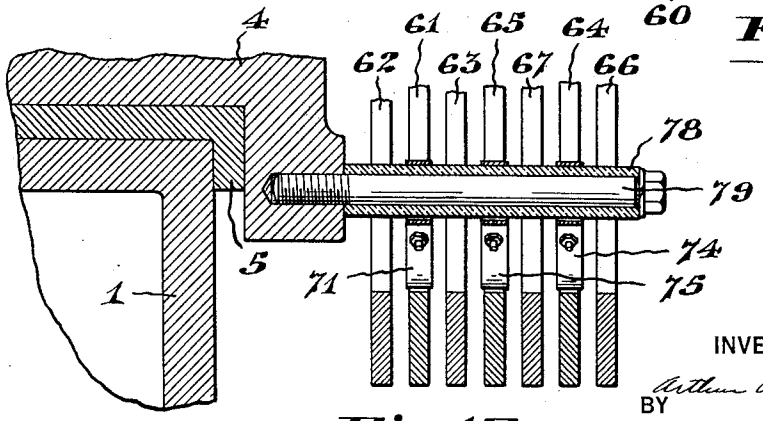


Fig. 12.

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FEED MECHANISM FOR GRINDING MACHINES

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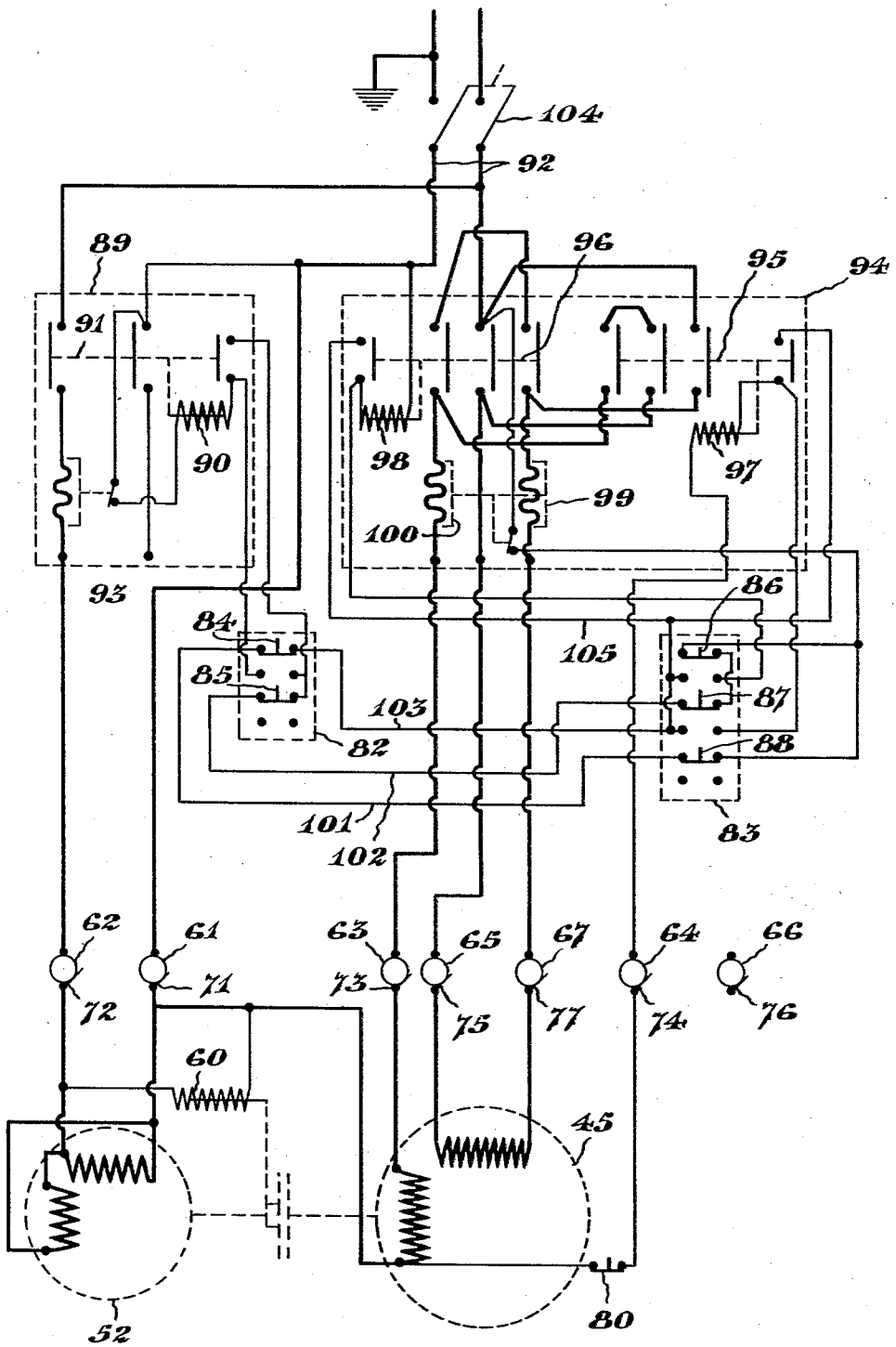


Fig. 13.

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UNITED STATES PATENT OFFICE

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FEED MECHANISM FOR GRINDING MACHINES

Application filed November 25, 1930. Serial No. 498,059.

This invention relates to apparatus for grinding and finishing cylindrical surfaces and particularly to the feed mechanism for such apparatus.

In the grinding of relatively large-diametered external and internal cylindrical surfaces, such as, for example, railway car axles, locomotive axles, crank pins and crank pin openings, and the cylindrical surfaces of other relatively large articles, the article being ground is held stationary and the grinding wheel is moved in an orbital path about the surface. The grinding wheel consequently must be movable through a relatively wide arc in order to be arranged to accommodate both external and internal surfaces of varying diameters and to permit a number of grinding cuts to be made during the grinding operation. It is also essential that the grinding wheel be capable of having a very fine degree of gradual and continuous slow feed movement into the work during the grinding operation. Furthermore, in grinding large cylindrical surfaces, it is desirable that the grinding wheel have a rapid traverse movement before and after the grinding operation, so that no time will be lost in bringing the grinding wheel up to and away from the surface.

One of the objects of the present invention, therefore, is to provide apparatus for grinding cylindrical surfaces embodying a new and improved feed mechanism.

Another object is to provide grinding apparatus having an orbitally movable grinding wheel with improved means for automatically moving the grinding wheel gradually and continuously into the surface being ground during the grinding operation.

Another object is to provide grinding apparatus having an orbitally movable grinding wheel with electrically controlled means for automatically feeding the grinding wheel toward the surface being ground.

Another object is to provide apparatus for grinding relatively large-diametered cylindrical surfaces with an orbitally movable grinding wheel having a relatively large arc of movement and which is arranged for rapid as well as relatively slow traverse through such movement.

A further object is to provide apparatus for grinding relatively large-diametered internal and external cylindrical surfaces with an orbitally movable grinding wheel and with electrically controlled means for providing a rapid or relatively slow arcuate traverse of the grinding wheel toward and away from the surface being ground, the grinding wheel during each grinding cut being arranged to be automatically and continuously moved toward the surface being ground in relatively small gradual amounts.

With the above and other objects in view, which will be readily understood from the detailed following description, the present invention consists in certain features of construction and combinations of parts which will be readily understood by those skilled in the art to which the invention appertains.

In the drawings, which illustrate a suitable embodiment of the invention,

Figure 1 is a longitudinal section of a grinding machine head stock carriage showing the support for the grinding wheel spindle and means for operating the spindle;

Fig. 2 is a front elevation of the head stock;

Fig. 3 is a rear elevation of the head stock showing the means for rotating the grinding wheel spindle, taken in the region of the line 3—3 of Fig. 1;

Fig. 4 is an enlarged rear elevation of the head stock showing means for feeding the grinding wheel spindle, a portion of the rapid traverse mechanism being shown in section;

Fig. 5 is a section taken on the line 5—5 of Fig. 2 showing the means for supporting the grinding wheel spindle;

Fig. 6 is an enlarged section taken substantially on the line 6—6 of Fig. 3 showing the means on the cylinder for supporting the feed mechanism;

Fig. 7 is an enlarged view similar to Fig. 4, portions being broken away to show the rapid traverse feed mechanism;

Fig. 8 is an enlarged section taken on the line 8—8 of Fig. 4;

Fig. 9 is an enlarged section taken substantially on the line 9—9 of Fig. 4, portions of the same being broken away to show the speed reducer for the slow feed mechanism;

Fig. 10 is a section taken on the line 10—10 of Fig. 4;

Fig. 11 is a longitudinal section taken through the solenoid which actuates the clutch mechanism;

Fig. 12 is an enlarged section taken on the line 12—12 of Fig. 4 showing the current collectors;

Fig. 13 is a wiring diagram showing the electric circuit for the feed mechanism;

Fig. 14 is a section taken substantially on the line 14—14 of Fig. 4.

Referring to the accompanying drawings, in which like numerals refer to like parts throughout the several views, the head stock for the grinding machine is mounted upon a carriage bed 1 which may be reciprocably, as shown, or rigidly mounted on a bed 1—*a*, as desired, and comprises a semi-cylindrical housing portion 2 formed on the carriage bed 1, a removable semi-cylindrical housing portion 3 securely bolted to the portion 2, and a main cylinder 4. The housing portions 2 and 3 are provided with laterally spaced bushings 5 which rotatably support the main cylinder 4.

The main cylinder 4 is of annular shape, having spaced circumferential flanges 6 at its ends which bear against the ends of the housing bushings 5. The end of the cylinder 4 opposite the end adjacent the grinding wheel is substantially closed by means of an integral plate 7 having an opening 8 therein which embraces a substantial space including the axial centerline of the main cylinder.

The main cylinder 4 is preferably rotated within the surrounding housing by means of a circumferential bull gear 9 formed intermediate the ends of the cylinder 4 and extending between the spaced bushings 5 as shown in Fig. 1. The bull gear 9 is preferably driven by a meshing pinion 9*a*, which is driven by suitable mechanism.

Spaced journal boxes 10 are formed within the cylinder 4 and by means of journal caps 11 pivotally carry a tubular bracket support 12 having bracket arms 13 thereon lying outwardly of the ends of the main cylinder 4. These bracket arms 13, as shown in Fig. 5 receive and support at their outer ends a shaft housing 14 having suitable bearings 15 therein, which carry the rotatable grinding wheel spindle 16. The housing 14 lies within the opening 8 in the cylinder head plate 7, and is spaced such a distance from the axis of the bracket support 12 that its axis lies on an arc struck through the axis of the cylinder 4 from the bracket support 10 as a center. One end of the spindle 16 is provided with a suitable grinding wheel 17 and the other end, at the closed end of the cylinder 4, is provided with a suitable belt pulley 18.

The bracket support 12 carries a shaft 19 having an offset stub shaft 20 thereon which rotatably carries a pulley 21 that drives the pulley 18 through the medium of a belt 22. The shaft 19 may be provided with a worm wheel 23 at its end opposite the pulley 21, which meshes with a worm pinion 24, in order that the shaft 19 may be rotated to change the position of the eccentric stub shaft 20 and thereby compensate for slack in the belt 22.

The pulley 21 may be rotated to drive the grinding wheel spindle 16 by means of a belt 25 which is run by a pulley 26 carried by a motor 27. This motor 27 may be mounted at one end of the carriage and may, through a chain belt 27*a*, drive the gearing, shown in broken outline in Fig. 1, which drives the pinion 9*a*, that in turn rotates the bull gear 9 on the main cylinder 4. If desired, the belts 22 and 25 and the corresponding pulleys may be replaced by link chains and sprockets, such as the type used for the gear drive just referred to.

It is obvious, therefore, that while the grinding wheel spindle 16 is rotating it is moved at the same time in an orbital path by means of the main cylinder 4 about the axis of the cylinder, so that the grinding wheel can move in a circular path to grind an internal or external cylindrical surface. In order to grind cylindrical surfaces of relatively large diameter, the grinding wheel spindle must be movable through a relatively large arc to accommodate surfaces of different diameters. The spindle must also be movable in very small increments to permit cuts of different depths to be made, and also gradually and continuously into the work during the grinding operation.

The present invention provides means for obtaining the desired slow feed movement of the grinding wheel toward the surface being ground and also provides a rapid traverse of the wheel before and after the grinding operation is completed, so that no time will be lost in bringing the grinding wheel into and away from the operative position.

Referring to Figs. 4 and 7, the end of the bracket arm 13 adjacent the closed end of the main cylinder 4 carries a transversely mounted rotatable pin 28 therein having a head 29 thereon provided with an internally threaded sleeve 29*a* which receives a feed screw 30 threaded at one end. This feed screw 30 is rotatably supported in a non-axially movable position at its opposite end within suitable radial and thrust bearings 30*a* carried by a housing 31. The housing

31 is formed integral with a supporting plate 32 which is pivotally mounted about an axis perpendicular to and intersecting the axis of the feed screw 30. The plate 32 carries a pivot pin 33 which is rotatably supported by spaced anti-friction bearings 34 carried by a tubular housing 35 securely mounted on the head plate 7 of the main cylinder 4. The plate 32 is guided by means of guide pins 32*b* extending through slots 32*a* formed in the plate 32 and threaded into the circumferential flange of the main cylinder.

As the feed screw 30 is rotated, the threaded end thereof threads through the threaded sleeve 29*a* which is mounted against axial movement and thus moves the grinding wheel spindle 16 through an arc about the center line of the bracket support 10 as an axis. It is thus seen that, in order to permit the arcuate movement of the grinding wheel spindle 16 to change the eccentric position thereof, the supporting plate 32 for the fixed end of the feed screw 30 must and does move about the center-line of the pivot pin 33 as an axis, which axis is perpendicular to and intersects the axis of the feed screw 30.

The feed screw is rotatable at two different speeds, one speed for rapid traverse in order to rapidly bring the grinding wheel to and away from grinding position, and the other speed for relatively slow movement to slowly feed the grinding wheel in relatively small increments into the work during the grinding operation.

The feed screw 30 is rotated during both movements by a worm wheel 36 secured thereto in meshing engagement with a worm pinion 37, which is mounted as shown in Fig. 8 on a shaft 38 extending through the housing 31 perpendicular to the axis of the main cylinder 4. The shaft 38 is rotatably mounted within spaced radial and thrust bearings 39 carried by the housing 31 and a cover plate 40 secured thereto.

For the rapid traverse movement of the grinding wheel spindle 16, the shaft 38 is rotated by means of a gear 41 which meshes with a pinion 42 mounted on a shaft 43 parallel to the feed screw 30. The shaft 43 is carried by suitable bearings 44 mounted in the housing 31 and is driven by a reversible electric motor 45 connected thereto through the medium of a flexible coupling 46, as shown in Fig. 7. The motor 45 is arranged to be operated in either direction at a relatively high rate of speed in order to obtain a rapid traverse movement of the grinding wheel spindle for bringing the grinding wheel up to and away from the surface to be ground or which has been ground. The gears 41 and 42 are so arranged within the housing that they may be easily removed and replaced by gears of different ratios, so that the speed of the arm during rapid traverse may be changed as desired in order to meet different conditions.

For the slow, fine feed movement of the grinding wheel spindle 16, the shaft 38 is rotated from a speed reducing unit 47 by means of a disc clutch, the one plate portion 48 being attached to the shaft 38 and the other plate portion 49 being slidably attached to the slowly driven shaft 50 of the speed reducing unit 47. The drive shaft 51 of the speed reducing unit 47 is driven from an electric motor 52 through the medium of a flexible coupling 53.

Under certain conditions, it is desirable that during the fine feed movement the grinding wheel be moved at a rate of approximately six thousandths (.006) of an inch per minute, in order to obtain cuts in thousandths of an inch. In order to accomplish this slow, fine feed movement, the unit 47 should have a speed reduction ratio of approximately 900 to 1. This, of course, is merely illustrative of one condition and it is to be understood that the feeding movement is dependent upon the size of the machine and other controlling factors.

It is clearly obvious that, for bringing the grinding wheel up to or away from the work before or after the grinding operation, considerable time would be lost if the grinding wheel were moved at the fine feed rate. Consequently, it is very advantageous to provide the grinding apparatus with a rapid traverse. The device of the present invention provides means whereby the traverse of the wheel, when not in grinding operation, may be at a relatively high rate of speed and it has been found that a speed of approximately six inches per minute is satisfactory under ordinary conditions.

The clutch plate 49 is slidably mounted on the driven shaft 50 of the speed reducing unit, and is actuated into and out of engagement with the other clutch plate 48 by a lever 54 pivoted at one end to lugs 54*a* formed on the speed reducing unit and having a yoke portion 55 which carries a collar 56 provided with portions 57 extending into a space provided by a collar 58 mounted on the clutch plate 49. The other end of the lever 54 is connected to the armature 59 of a suitable solenoid 60, a suitable tension spring 56 being employed to normally hold the lever 54 in retracted position with the clutch plates 48 and 49 disengaged.

It is to be understood that the present invention is not limited to the particular type of clutch mechanism and that any suitable type may be used. As an example, a magnetic clutch may be directly incorporated into the clutch plates.

The source of power for the motors 45 and 52 and the solenoid 60 is provided through collector rings 61 to 67, inclusive,

mounted on suitable insulators 68 secured in spaced relation to the housing members for the main cylinder 4 by bolts 69 threaded into the housing members, insulating washers 70 being provided between the collector rings 61 to 67 inclusive, to hold them in spaced relation. The power is supplied to the stationary collector rings and is picked up by suitable brushes 71 to 77, which respectively slide over the collector rings 61 to 67 and which are mounted on insulating tubes 78 that are carried by suitable bolts 79 and 79a secured to the main cylinder. These brushes may be of spring metal, as shown in the drawings, or, if desired, they may be of the conventional carbon type. In order to prevent arcing, the brushes are staggered, the brushes 71, 74 and 75 being mounted on the pin 79a and the remaining brushes 72, 73, 76 and 77 being mounted on the pin 79.

In some instances it may be desirable to employ a different type of current pick-up mechanism. In one particular type the pick-up or slip rings may be mounted within the main cylinder to rotate therewith, and the brushes may be stationary and extend axially within the cylinder to contact with the slip rings.

It is to be particularly noted that the entire mechanism for moving the grinding wheel and spindle, with the exception of the collector rings 61 to 67, is mounted on the face of the main cylinder to rotate therewith, the collector rings being fixed to the housing for the main cylinder.

The motor 45 is of the reversible type and is arranged to be intermittently operated during forward movement, that is, movement of the grinding wheel toward the work, in order to permit the grinding wheel to be "inched" toward the work. The reverse movement however, that is, the movement of the grinding wheel away from the work, is constant and a limit switch 80 is provided on the cylinder 4, which is engaged by a trip finger 81 on the spindle supporting bracket which, when the spindle approximately reaches its outermost position, opens the switch 80 to shut off the supply of current to the motor 45. This limit switch prevents accidental jamming of the spindle supports into the main cylinder. If desired, a suitable limit switch may also be provided to limit the inward travel of the grinding wheel when the work has been removed in external grinding and the path is free to prevent jamming, or in internal grinding to prevent jamming of the wheel against the work.

The motors are controlled from push button switch devices 82 and 83, the device 82 having a start button 83 and a stop button 85 for the motor 52, and the device 83 having forward and reverse buttons 86 and 87, and a stop button 88 for the motor 45.

The switch devices 82 and 83 are so connected to each other as to provide an interlock in the circuit which prevents current from being supplied to one motor while the other is in operation.

Fig. 13 clearly shows the complete electric circuit for the feeding device, but for the purpose of clearness of illustration the connections have not been shown in the other views. The wiring connections for the electric circuit are briefly as follows:

The push button device 82 is connected to a magnetic switch device 89 embodying a solenoid 90 for actuating the switch 91 thereon which closes the circuit from the power supply lines 92 to the fine feed motor 52, and an overload relay 93 which opens the circuit in the case of an overload. The push button device 83 is connected to a magnetic reversing switch device 94 having forward and reverse switches 95 and 96 connected with the forward and reverse circuits leading to the motor 45, which are operated by solenoids 97 and 98 respectively. The two circuits leading to the motor are provided with overload relays 99 and 100 as shown, and are connected through the switches 95 and 96 to the power supply lines 92. The two switch devices, as shown in Fig. 13, are connected together through the lines 101, 102 and 103 to provide means as previously described to permit the operation of only one motor at a time. A suitable throwout switch 104 is provided in the power lines 92 to completely, if desired, shut off the supply of current to the switch devices 89 and 94.

When it is desired to provide an inching movement of the grinding wheel, the line 105 connecting push button device 83 with the magnetic switch 96 should be disconnected, and similarly, when it is desired to have a constant inward traverse of the grinding wheel the line 105 should be connected.

In describing the operation of the apparatus of the present invention, it will be assumed that the work is in position to be ground or turned to size, and that the grinding wheel is rotating as well as moving in an orbital path. The switch 104 is thrown to close the circuit, and in the case where the line 105 is disconnected, the button 86 is depressed, which causes the solenoid 98 to throw the switch 96, thus closing the circuit to the motor 45. As long as the button 86 is held in depressed position the grinding wheel is constantly moved toward the work. When the grinding wheel nears the work the operator intermittently depresses the button 86 to cause an inching of the grinding wheel without letting the motor gain full speed. The operator does this at fairly

rapid intervals, until the grinding wheel first touches the work and sparking is obtained. In case, however, that straight constant feed is desired and the line 105 is connected, the button 86 is depressed and left in this position to continuously close the circuit, which is not broken until the stop button 88 is actuated.

When the grinding wheel is in grinding position, the supply of current to the motor 45 is shut off in either of the manners just described, and the motor 52 is set in operation by actuating the start button 84 in the switch device 82. The actuation of this button 84 sets the motor 52 in operation and at the same time actuates the solenoid 60, which brings the two clutch discs 48 and 49 into engagement with the other, with the result that the motor 52, through the speed reducing mechanism 47 and the clutch plates 48 and 49, drives the feed screw 30 at a very slow rate of speed and also causes the motor 45 to be freely driven in the reverse direction, there being no current supplied to the motor 45 as long as the switch button 84 is depressed.

As the surface is being ground, the grinding wheel is gradually and continuously fed into the work with the orbital movement of the wheel, and the operator does not stop the motor 52 until the work is ground to the desired size.

When the work is completely ground to its finished size the operator stops the motor 52, which incidentally breaks the circuit leading to the solenoid 60, and the spring 56 then causes the lever 54 to throw the clutch plates out of engagement with each other. The operator then depresses the reverse button 87 of the switch device 83, which causes the solenoid 97 to throw the reversing switch 95 into operation, thus causing the motor to rotate in the reverse direction and move the grinding wheel away from the work at a relatively high rate of speed. As soon as the grinding wheel has reached its outermost position the finger 81 on the spindle supporting arm engages the limit switch 80 and shuts off the motor, in order to prevent jamming of the spindle supports against the main cylinder. The motor 45, however, may be stopped at any time during the reverse movement by actuating the stop button 88. It is to be particularly noted in Fig. 13 that, when either one or the other of the motors is in operation, and if any of the buttons in either of the switch devices 82 or 83 are actuated, the circuit will be broken, thus causing the motors to stop, and thus preventing any case where one may be operated while the other is in operation.

The collector rings 66 and the collecting brush 76 as shown in the drawings have no operating connection with the wiring diagram and are used for a sizing device which does not form a part of the present invention.

Under certain conditions it may be desirable to have a variable fine feed movement, and in this case the reduction gearing shown may be replaced by a suitable change speed reduction gearing of conventional type, or the motor 52 may be replaced by a variable feed motor, so that the proper speed for any given job may be easily obtainable. In the case where the apparatus is to be used for grinding external and internal cylindrical surfaces, the motor 52 should be of the reversible type, so that the motor would drive the spindle supporting arm outwardly away from the axis of the cylinder as well as inwardly toward the same. This, of course, would necessitate a change in the wiring diagram.

From the foregoing description of the drawings it can thus be seen that the present invention provides a very satisfactory and very efficient feed mechanism control for grinding machines and particularly for grinding machines used in connection with the grinding of relatively large external and internal cylindrical surfaces. The motor 45, it can be seen, will drive the feed screw 30 at a relatively high rate of speed, so that no time will be lost in moving the grinding wheel toward and away from the cylindrical surface on which the work is being performed.

The motor 52, when thrown in operation, will also drive the feed screw 30 through the feed reducing mechanism at a very low rate of speed in very small increments, so that the grinding wheel spindle will be moved through an arc of a very few thousandths of an inch, with the result that the grinding wheel is fed into the work gradually and continuously.

This gradual and continuous fine feed automatically compensates for wear of the grinding wheel.

The construction of the present invention can be very easily adapted to be used in conjunction with any type of grinding machine for finishing cylindrical surfaces and it can be seen that by proper designing of the different parts the grinding wheel spindle can be moved through a relatively wide arc from the axis of the support as a center, so that the grinding wheel can be adapted to grind external and internal surfaces of varying diameters.

It will thus be seen that I have provided apparatus for grinding relatively large-diametered cylindrical surfaces with an orbitally movable grinding wheel which has a relatively large arc of movement and which is provided with electric means for imparting a rapid traverse of the grinding wheel toward and away from the work, as well as providing a very low fine feed traverse through the same arc, so that the proper

feed can be easily obtained by merely actuating a push button connected with the electric circuit, thus eliminating the necessity of providing complicated gearing, etc., which has heretofore been operated manually.

Furthermore, it is to be understood that the particular forms of apparatus shown and described, and the particular procedure set forth, are presented for purposes of explanation and illustration, and that various modifications of said apparatus and procedure can be made without departing from my invention as defined in the appended claims.

What I claim is:

1. In a machine for grinding cylindrical surfaces, a rotatable headstock cylinder, a spindle supporting member mounted on said cylinder for movement relative thereto, a spindle rotatably carried by said member, a grinding wheel carried by said member, and means for moving said member to cause bodily movement of said spindle and grinding wheel relative to a piece of work, said means comprising a feed screw threadably carried by said member, reversible means for rotating said screw at a relatively high speed in either direction to provide rapid traverse of said wheel relative to the work, an electric motor carried by said cylinder for driving said reversible means, and an electrically operated second means for rotating said screw at a relatively slow speed to provide fine feed movement of said wheel relative to the work.

2. In a machine for grinding cylindrical surfaces, a rotatable headstock cylinder, a spindle supporting member mounted on said cylinder for movement relative thereto, a spindle rotatably carried by said member, a grinding wheel carried by said member, and means for moving said member to cause bodily movement of said spindle and grinding wheel relative to a piece of work, said means comprising a feed screw threadably carried by said member, means connected directly with said screw for rotating said screw at a relatively high speed, a second means for rotating said screw at a relatively slow speed, and clutch means between said second means and said screw for operatively connecting said second means with said screw.

3. In a machine for grinding cylindrical surfaces, a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadably carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, means for rotating said screw at a relatively high speed to provide rapid traverse of said wheel toward and away from the work during non-grinding operation and independent means for rotating said screw at a relatively slow speed to provide a fine gradual feeding movement of said wheel into the work during the grinding operation.

4. In a machine for grinding cylindrical surfaces a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadably carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, means for rotating said screw at a relatively high speed to provide rapid traverse of said wheel toward and away from the work during non-grinding operation, independent means for rotating said screw at a relatively slow speed to provide a fine gradual feeding movement of said wheel into the work during the grinding operation, and clutch means for disconnecting said independent means from said screw during operation of said first mentioned means.

5. In a machine for grinding cylindrical surfaces, a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadably carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, a pair of gears for rotating said screw, one of said gears being carried by said screw, a rotatable shaft for supporting the other of said gears, means for rotating said shaft at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, and a second means for rotating said shaft at a relatively slow speed to provide fine feed movement of said grinding wheel during the grinding operation.

6. In a machine for grinding cylindrical surfaces, a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadedly carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, a pair of gears for rotating said screw, one of said gears being carried by said screw, a rotatable shaft for supporting the other of said gears, means for rotating said shaft at a relatively high speed to provide rapid tra

verse of said wheel during non-grinding operation, a second means for rotating said shaft at a relatively slow speed to provide fine feed movement of said grinding wheel during the grinding operation, and means for disconnecting said second driving means from said shaft during rapid traverse operation of said grinding wheel.

7. In a machine for grinding cylindrical surfaces, a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadably carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, a pair of gears for rotating said screw, one of said gears being carried by said screw, a rotatable shaft for supporting the other of said gears, means for rotating said shaft at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, and a second means for rotating said shaft at a relatively slow speed to provide fine feed movement of said grinding wheel during the grinding operation, said second means including a speed reducing mechanism and an electric motor for driving the same.

8. In a machine for grinding cylindrical surfaces, a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadably carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, a pair of gears for rotating said screw, one of said gears being carried by said screw, a rotatable shaft for supporting the other of said gears, means for rotating said shaft at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, and a second means for rotating said shaft at a relatively slow speed to provide fine feed movement of said grinding wheel during the grinding operation, said second means including a speed reducing mechanism and an electric motor for driving the same, and said first driving means including an electric motor having driving connection with said shaft.

9. In a machine for grinding cylindrical surfaces, a rotatable cylinder, a spindle supporting arm pivoted to said cylinder, a rotatable grinding wheel carried by said arm, a screw head pivoted to said arm, a supporting plate pivoted to said cylinder, a rotatable feed screw threadably carried by said head and mounted against axial movement on said supporting plate for moving said arm through an arc to provide movement of said wheel relative to a piece of work, a pair of gears for rotating said screw, one of said gears being carried by said screw, a rotatable shaft for supporting the other of said gears, means for rotating said shaft at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, and a second means for rotating said shaft at a relatively slow speed to provide fine feed movement of said grinding wheel during the grinding operation, said second means including a speed reducing mechanism, an electric motor for driving the same, and clutch means between said speed reducing mechanism and said shaft for disconnecting said second means during operation of said first driving means.

10. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said support, means for providing bodily movement of said wheel relative to said rotary member, said means comprising an electric motor carried by said rotary member for moving said support at a relatively high speed during non-grinding operation and a second electric motor carried by said rotary member for moving said support at a relatively slow speed to provide feeding movement of said grinding wheel during the grinding operation.

11. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said support, means for providing bodily movement of said wheel relative to said rotary member, said means comprising an electric motor carried by said rotary member for moving said support at a relatively high speed during non-grinding operation, a second electric motor carried by said rotary member for moving said support at a relatively slow speed to provide feeding movement of said grinding wheel during the grinding operation, and means for disconnecting said second motor during operation of said first motor.

12. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said support, means for providing bodily movement of said wheel relative to said rotary member, said means comprising an electric motor carried by said rotary member for moving said support at a relatively high speed during non-grinding operation, a second electric motor carried by said rotary member for moving said support at a relatively slow speed to provide feeding movement of said

grinding wheel during the grinding operation, and a current collector ring and collector brush for each said motor, said ring or brush being rotatable with said rotary member.

13. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and having driving connection with said screw.

14. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and a speed reducing mechanism connected with said motor and with said screw for driving said screw at a relatively slow speed to provide feeding movement of said grinding wheel during the grinding operation.

15. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member, a speed reducing mechanism connected with said motor and with said screw for driving said screw at a relatively slow speed to provide feeding movement of said grinding wheel during the grinding operation, and a clutch device interposed between said speed reducing mechanism and screw to break the driving connection therebetween.

16. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member, a speed reducing mechanism connected with said motor and with said screw for driving said screw at a relatively slow speed to provide feeding movement of said grinding wheel during the grinding operation, and a clutch device interposed between said speed reducing mechanism and screw to break the driving connection therebetween, said clutch device being arranged to automatically break said driving connection when said motor is rendered inoperative.

17. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and having driving connection with said screw, said motor being arranged to rotate said screw at a relatively slow speed to provide feeding movement of said grinding wheel into the work during the grinding operation.

18. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and having driving connection with said screw for rotating said screw at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, and a second electric motor also mounted for rotation with said rotary member and having driving connection with said screw for rotating said screw at a relatively slow speed to provide feeding movement of said grinding wheel into the work during the grinding operation when said first motor is inoperative.

19. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and having driving connection with said screw for rotating said screw at a

relatively high speed to provide rapid traverse of said wheel during nongrinding operation, and a second electric motor also mounted for rotation with said rotary member and having driving connection with said screw for rotating said screw at a relatively slow speed to provide feeding movement of said grinding wheel into the work during the grinding operation when said first motor is inoperative, the driving connection between said second motor and said screw being releasable during driving operation of said first electric motor.

20. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and having driving connection with said screw for rotating said screw at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, a second electric motor also mounted for rotation with said rotary member, and a speed reducing mechanism interposed between and having driving connection with said screw and with said motor for rotating said screw at a relatively slow speed to provide feeding movement of said grinding wheel into the work during the grinding operation.

21. In a machine for grinding cylindrical surfaces having an orbitally movable grinding wheel, a movable support for said wheel and a rotary member supporting said movable support, a screw carried by said rotary member for moving said support to provide bodily movement of said grinding wheel relative to said rotary member and relative to a piece of work, and means for rotating said screw, said means comprising an electric motor mounted for rotation with said rotary member and having driving connection with said screw for rotating said screw at a relatively high speed to provide rapid traverse of said wheel during non-grinding operation, a second electric motor also mounted for rotation with said rotary member, and a speed reducing mechanism interposed between and having driving connection with said screw and with said motor for rotating said screw at a relatively slow speed to provide feeding movement of said grinding wheel into the work during the grinding operation, the driving connection between said screw and speed reducing mechanism being releasable during driving operation of said first electric motor.

22. In a machine for grinding cylindrical surfaces, a rotatable headstock cylinder, a spindle supporting member mounted on said cylinder for movement relative thereto, a spindle rotatably carried by said member, a grinding wheel mounted on said cylinder, and means for moving said member during rotation of said cylinder to cause bodily movement of said spindle and grinding wheel toward and away from a piece of work, said means comprising a feed screw threadably connected with said member, electrically driven rapid traverse means mounted on said member to rotate therewith during rotation of said cylinder for rotating said screw at a relatively high rate of speed, and a second electrically driven slow traverse means also mounted on said member and being releasably connectible with said screw for rotating said screw at a relatively slow rate of speed, both of said electrically driven means being operatable to rotate said screw during rotation of said headstock cylinder.

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