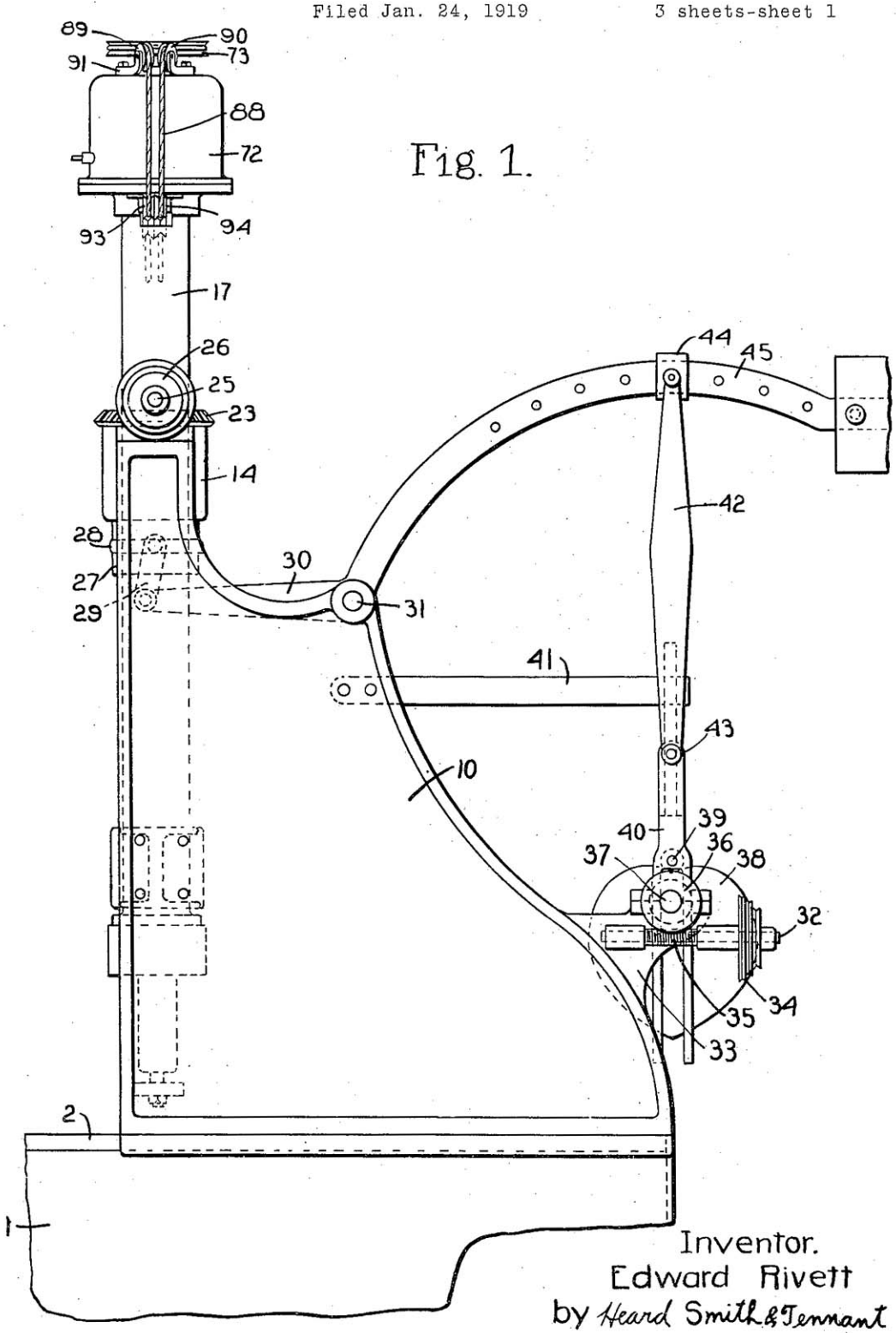
Feb. 27, 1923. 1,447,152

E. RIVETT

VERTICAL CYLINDER GRINDER

Filed Jan. 24, 1919 3 sheets-sheet 1

Fig. 1.

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Filed Jan. 24, 1919 3 sheets-sheet 2

Fig. 2.

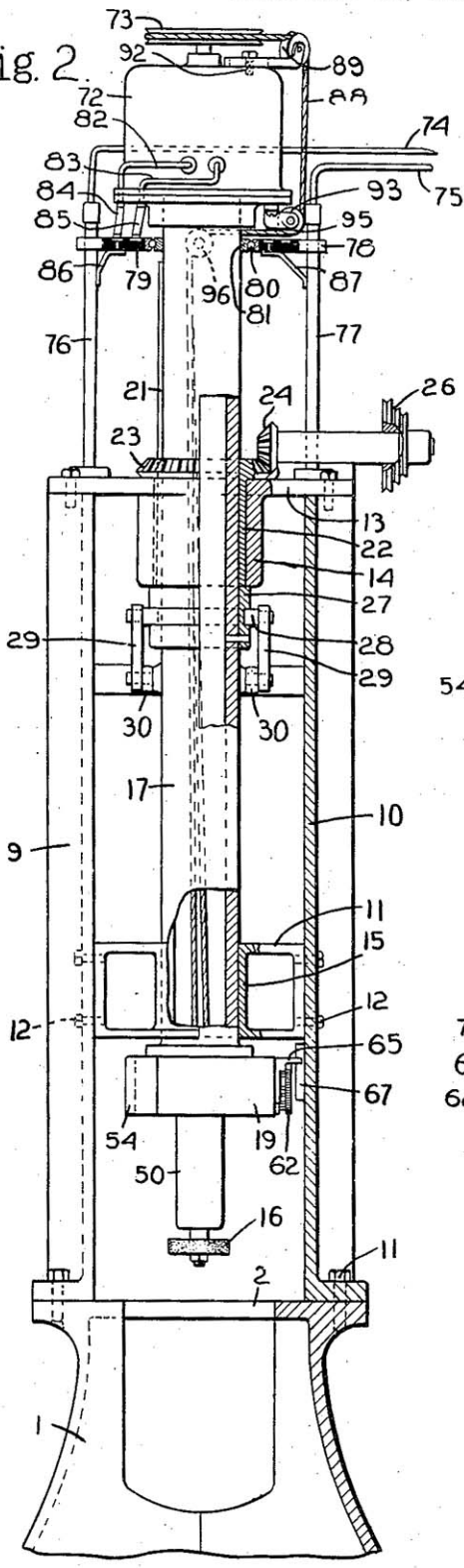


Fig. 3.

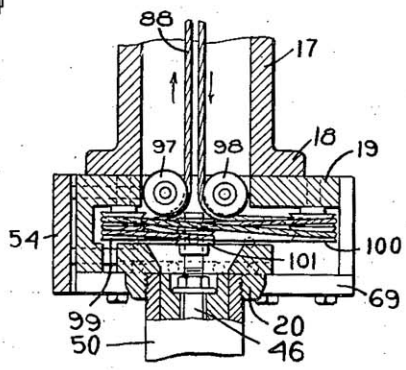


Fig. 4.

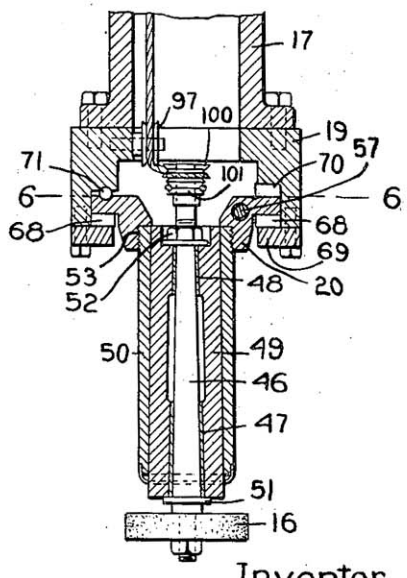


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Fig. 5.

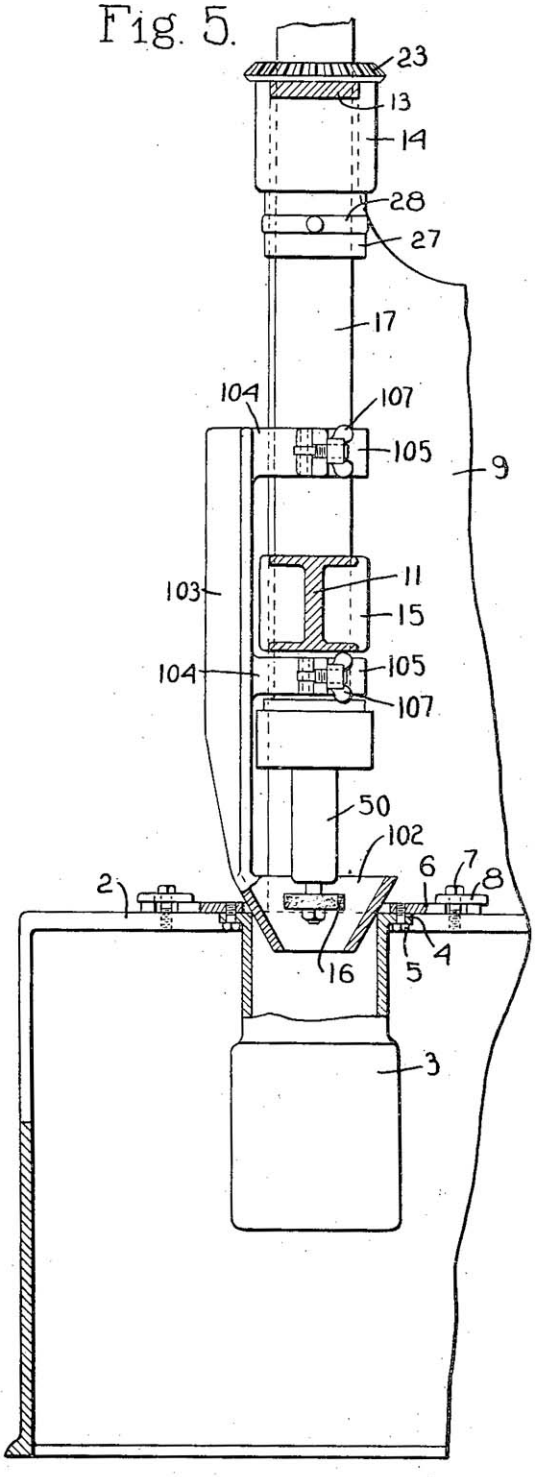



Fig. 6.

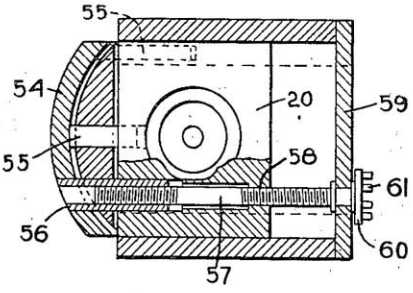



Fig. 7.

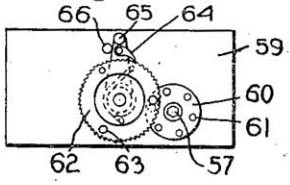
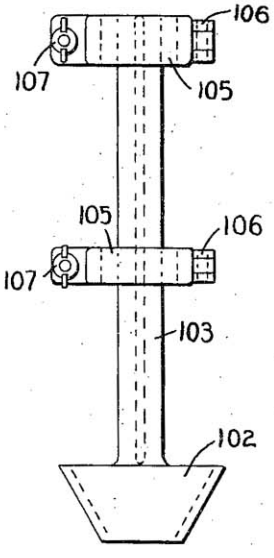



Fig. 8

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Patented Feb. 27, 1923. 1,447,152

# UNITED STATES PATENT OFFICE.

EDWARD RIVETT, OF HULL, MASSACHUSETTS.

## VERTICAL-CYLINDER GRINDER.

Application filed January 24, 1919. Serial No. 272,837.

*To all whom it may concern:*

Be it known that I, EDWARD RIVETT, a citizen of the United States, residing at Hull, county of Plymouth, State of Massachusetts, have invented an Improvement in Vertical-Cylinder Grinders, of which the following description, in connection with the accompanying drawing, is a specification, like characters on the drawing representing like parts.

This invention relates to grinding machines or to any other machines for doing similar work such as abrading, polishing or buffing, and the object of the invention is to provide a vertical cylinder machine of this class, that is, a machine employing a tool on a vertical spindle mounted eccentrically in, or out of alinement with the axis of, a carrier having a vertical and rotary movement to carry the tool over a cylindrical surface such as the interior of an engine cylinder.

The invention has for its object to provide a machine of this character in which the carrier for the tool shall have the parts carried thereby so located and arranged that they shall be balanced with respect to the axis of rotation thus insuring ease of movement and accuracy of the work.

The invention has for its further object to provide for mounting the actuating motor for rotating the tool directly upon the vertically movable and rotary carrier and preferably for transmitting rotary movement to the tool spindle from this motor through an endless belt so arranged as to give a balanced pull upon the tool spindle.

The invention has for its further object to provide means preferably governed by the number of rotations of the carrier for progressively feeding the tool radially against the work and preferably also for simultaneously feeding a counterbalance in the opposite direction.

The invention has for its further object to provide a machine of this character in which the tool may be run at very high speed while carried over the surface of the work and fed thereto at such a rate as will secure the most effective action on the work.

The invention presents a machine in which the parts are compactly arranged, one in which the construction is of simple and efficient design, one in which the wear of the parts is reduced to the minimum, and one in which accuracy of the operation is assured.

These and other features of the invention will appear more fully from the accompanying description and drawings and will be particularly pointed out in the claims.

The invention is more particularly adapted for grinding the interior of cylinders where extreme accuracy is essential and a machine designed for that purpose is therefore illustrated and described as the preferred form of the invention, but it is to be understood that the invention in its broader aspect is not to be restricted other than as defined by the claims.

In the drawings,

Figure 1 is a view in side elevation partially broken away and with some of the parts removed of a construction of vertical grinder embodying the invention;

Fig. 2 is a view in front elevation partially in vertical cross section of the main portion of the vertical grinder shown in Fig. 1;

Fig. 3 is a detail on a larger scale in vertical cross section of a portion of the carrier showing the drive for the grinder spindle;

Fig. 4 is a detail on the same scale as Fig. 3 in vertical section taken at right angles to Fig. 3;

Fig. 5 is a view in side elevation and partially in vertical cross section of a portion of the vertical grinder showing the means for centering the work with respect to the grinder;

Fig. 6 is a view in horizontal cross section taken on the line 6—6, Fig. 4;

Fig. 7 is a side elevation of the carrier base showing the means for feeding the grinder spindle radially of the carrier;

Fig. 8 is a view in rear elevation of the means adapted to be detachably secured to the carrier for centering the work with respect to the grinder.

The machine of this invention is primarily designed for grinding the interior periphery of cylindrical articles such as engine cylinders when supported with the axis of the cylinder arranged vertically.

The machine in which the invention is shown embodied in a preferred form comprises essentially a bed 1 which may be mounted on a bench or other suitable support. This bed is preferably hollow and presents a horizontal bed plate 2 recessed

to permit the work supported on the bed plate to project into or hang in the hollow interior of the bed. In the drawings a piece of work is illustrated as a gasolene engine cylinder 3. Such a piece of work may be conveniently supported in the bed by having its flange 4 secured by the bolts or screws 5 to a recessed plate 6 which plate is in turn secured by the clamping screws 7 to the bed plate 2 so that the work hangs in the hollow interior of the bed. The bolts or screws 7 pass through washers 8 and through holes in the plate 6 much larger than the shanks of the bolts or screws so that the work may be shifted about on the bed plate 2 before being clamped in place to center it beneath the grinder.

A head extends over or is mounted above the bed and may conveniently be formed as illustrated of a pair of vertical flanged side plates 9, 10 secured by screws 11 directly to the bed. These side plates are secured together at various points as required to provide a suitable support for the various portions of the mechanism. At or near the front a skeleton guide 11 extends horizontally between the plates and is secured thereby by screws 12.

At the top the plates are again shown as secured together by a top plate 13 provided with a depending cylindrical socket 14 which is vertically alined with a cylindrical socket 15 formed in the guide 11.

The grinder 16 is carried by a carrier which is mounted for vertical and rotary movement in the head so that the grinder may move up and down over the surface of the work to be ground and may be carried in a circular direction around the surface of the work to be ground. In the construction illustrated this carrier comprises a vertically arranged hollow shaft 17 flanged at 18 and having secured thereto a hollow rectangular carrier base 19 and a spindle support 20 radially movable on the carrier base and in which the grinder spindle is mounted. The carrier shaft 17 has a bearing fit in the cylindrical socket 15 of the guide 11 and is splined at 21 in the hub 22 of a bevel gear 23 which hub has a bearing fit in the cylindrical socket 14 of the top plate 15. The bevel gear 23 is driven by a bevel pinion 24 on a horizontal shaft 25 carried on the side plate 10 and driven by pulley 26 from a suitable source of power. The carrier shaft 17 has secured thereto a collar 27 provided with an annular groove in which is mounted a ring 28. This ring at opposite sides is pivotally connected to links 29 and these links are in turn pivotally connected to the forked arms 30 of a bell crank lever fulcrumed on a shaft 31 connecting the side plates 9 and 10 of the head.

It will thus be seen that when the bell crank lever is rocked upon its fulcrum the carrier will be given a vertical movement in the head and that when the pulley 26 is driven the carrier will be given a rotary movement in the head.

Suitable means are provided for rocking the bell crank lever to give the required vertical movement of the carrier. For that purpose a horizontal worm shaft 32 is shown journaled in a bracket 33 extending rearwardly from the side plate 10 of the head. This shaft is driven by a pulley 34 from any suitable source of power. The worm 35 of the shaft engages a worm wheel 36 on a shaft 37 extending horizontally between the side plates 9 and 10 of the head. This shaft 37 in turn carries a heart-shaped cam 38. A follower 39 rests upon the cam 38 and is pivoted on a vertical slide 40. This slide is bifurcated and forked at its lower end to straddle the shaft 37 and at its upper end presents a rod sliding in a bracket 41 projecting rearwardly from the head. A pair of links 42 are pivoted at their lower ends on the pivot 43 and at the upper ends to a collar 44. This collar is adjustably secured at points along the arcuate arm 45 of the bell crank lever whose shorter arm has already been described. The end of this lever is weighted to more than counterbalance the grinder, its carrier and parts supported thereby. It will thus be seen that as the pulley 34 is driven the cam 38 is revolved and acting against the follower 39 rocks the bell crank lever on its fulcrum 31 thus vertically reciprocating the carrier.

The grinder 16 is mounted upon the lower end of a tapered grinder spindle 46 which has bearings at its upper and lower ends in bushings 47 and 48 set into a two-part vertical spindle casing 49, 50. The spindle at its lower end above the grinder is provided with an annular shoulder 51 and near its upper end is screw-threaded and provided with a nut 52. Hence as wear takes place the shoulder 51 may be ground off and the nut 52 tightened to maintain the spindle with an accurate running fit in the bushings. The two-part spindle casing at its upper end is screw-threaded at 53 into the spindle support 20 which is mounted for a lateral or radial movement in the carrier base 19. This threaded connection between the spindle casing and the spindle support enables the entire spindle casing with its spindle and grinder to be removed and another of different size or length and carrying a grinder of a different size or character to be substituted therefor.

The lateral or radial movement of the spindle support in the carrier base is for the purpose of adjusting the eccentricity of the spindle in the carrier and for feeding the grinder up against the work and automatic means are provided for securing this

feeding movement. It is very important to accurate work that the mass of the revolving carrier and the parts supported by it shall be balanced with respect to the axis of rotation. Consequently, a counterbalance is provided for the spindle support and the parts carried thereby and this counterbalance is so arranged that as the spindle support is fed in one direction the counterbalance is fed in the opposite direction. Such a counterbalance which may be of such size and weight as necessary is indicated as a mass of metal 54 provided with guide pins 55 extending into guideways in the carrier base and with a hollow internally screw-threaded guide pin 56 extending into the spindle support 20. A reversely screw-threaded shaft 57 has one set of its screw-threads fitting the guide pin 56 and the other set a screw-threaded portion 58 of the spindle support while at one end it is journaled against longitudinal movement in the side plate 59 of the carrier base. It will thus be seen that as this shaft 57 is rotated the spindle support will be fed in one direction and the counterbalance in the opposite direction.

The radial feeding movement of the spindle support and consequently of the grinder is preferably governed by the number of rotations of the carrier so that for each pedetermined number of rotations of the carrier the spindle support is progressively fed a predetermined distance radially. As a simple and efficient means for securing this progressively radial feeding movement of the spindle support the shaft 57 is shown as provided at its end with a disk 60 having a plurality of removable and replaceable pins 61. Adjacent on the plate 59 of the carrier base is pivotally mounted a ratchet wheel 62 also provided with a plurality of removable and replaceable pins 63. The pins on the ratchet wheel 62 and the pins on the disk 60 contact after the manner of gear teeth and by varying the number of pins the number of rotations given to the shaft 57 by rotation of the ratchet wheel may be varied. The ratchet wheel is preferably rotated by a pawl 64 and a pawl carrier 65 pivoted on the axis of the ratchet wheel 62, limited as to its movement in one direction by the stud 66 and moved in the opposite direction by striking against a fin 67 on the side plate 10 of the head. Thus during each rotation of the carrier when at or near its upper limit of vertical movement the pawl carrier striking the fin moves the ratchet wheel 62 a predetermined distance and consequently depending upon the number and position of the pins rotates the shaft 57 to move the spindle support a predetermined amount.

The spindle support is flanged at each side and these flanges rest upon roller bearings 68 in turn resting upon the bottom plate 69 of the carrier base. A roller bearing 70 is arranged above the flange of the spindle support at one side and a ball bearing 71 is arranged in a groove in the opposite flange of the spindle support and a groove in the carrier base. This employment of roller bearings and a single ball bearing insures the accurate movement of the spindle support rectilinearly and prevents any sidewise shifting which is essential to secure accurate work.

The rotation of the grinder spindle and grinder with respect to the carrier is preferably secured in this invention by an endless belt drive extending down through the hollow carrier and actuated by an actuating pulley at the top of the carrier which actuating pulley in turn is preferably driven by a motor mounted directly upon the carrier. An electric motor may preferably be employed for this purpose and the endless belt drive may preferably be of the character disclosed in my Patent 1,302,222 granted April 29, 1919.

As a preferred form of construction for thus rotating the grinder spindle and grinder an electric motor 72 of suitable type is rigidly secured to the upper end of the hollow carrier 17 and preferably has its pulley 73 mounted on a vertical axis in line with the axis of the carrier. Since this motor has a vertical and rotary movement with the carrier means are provided for transmitting the current to the motor under these conditions. As a simple means for this purpose the current supplying wires 74 and 75 of the circuit are shown as connected to uprights 76 and 77 mounted on the side plates 9 and 10 of the head. A carriage 78 formed of or containing insulating material 79 is mounted to slide vertically on these uprights and receives its sliding movement through a ball bearing connection 80 with a collar 81 secured to the carrier. The wires 82 and 83 from the motor terminate in brushes 84 and 85 respectively, and these brushes slide upon annular contacts in the insulated carriage 78. The contact for the brush 84 is connected in turn to a contact 86 sliding on the upright 76 and the contact for the brush 85 is connected in turn to a contact 87 sliding on the upright 77. Hence the current will be properly transmitted to the motor notwithstanding the bodily vertical and rotary movement of the motor with the carrier.

The endless cord or belt 88 extends about the actuating pulley 73 down over a pair of idlers 89 and 90. These idlers are pivoted in slotted brackets 91 secured by screws 92 to the motor casing so that they may be adjusted in and out in a general radial direction to take up slack in the belt. From these idlers the endless belt extends down

to another pair of idlers 93 and 94 mounted on brackets 95 secured to the bottom of the motor casing. From these idlers the belt extends radially into the center of the carrier and about idlers 96 mounted in the upper end of the carrier which serve to divert the belt down the bore of the carrier. A pair of idlers 97 and 98 mounted in the carrier base serve to direct the two vertical runs of the belt horizontally into the carrier base and about double grooved idlers 99 and 100 mounted on vertical axes at opposite ends of the carrier base. The grinder spindle 46 at its upper end is provided with a double grooved pulley 101 about which the endless belt extends and the arrangement is such that the strain of the belt on the spindle is balanced so that there is no tendency by reason of the drive to bind the spindle in its bearing. This result is secured by leading one run of the endless belt 88, as for example the right hand run in Fig. 3, down around the idler 98, thence around the upper groove in the idler 100, thence around the upper groove in the pulley 101 on the spindle, thence back around the lower groove of the idler 100, thence across to the upper groove of the idler 99, thence around the lower groove of the pulley 101 on the spindle, thence back around the lower groove of the idler 99, thence under the idler 97, and thence back up the hollow carrier shaft. Thus, not only is the strain of the belt on the spindle balanced but the drive provides for the lateral or radial shifting of the spindle to secure the proper eccentric adjustment and as it is fed up to and from the work because it is immaterial to this arrangement of drive just what position the spindle pulley 101 occupies between the idlers 99 and 100.

With the electric motor mounted on the carrier and with the endless belt drive it is possible to run the grinder at a very high speed which is highly desirable in this class of work. The mechanism described for rotating and vertically reciprocating the carrier are easily timed to give the required movements to carry the grinder over the surface of the work and the mechanism described for feeding the grinder up against the work is readily adjusted to secure the removal of the requisite amount of metal. The whole machine is so arranged that the parts carried by the rotating carrier are symmetrically balanced with respect to the axis of rotation. The counterbalance 54 balances the spindle support and the parts carried by it, the idlers 89, 90, 93 and 94 are counterbalanced by the brushes 84, 85 and their connected parts and if necessary further weight is added in the structure of the motor casing or otherwise to insure this counterbalancing effect. This insures a steady and even rotary and vertical movement and reduces the wear of the carrier in its bearings to the minimum thus in turn insuring extreme accuracy in the grinding operation.

In order properly to center the work beneath the grinder simple and efficient means detachably secured to the carrier are provided and a preferred form of such means is illustrated in Figs. 5 and 8. The centering device comprises a conical foot 102 and an offset shank 103 extending up from the foot at one side thereof. This shank is provided with clamping means shown as made up of the semi-circular arms 104 rigid with the shank 103 and the semi-circular arms 105 hinged to the arms 104 at 106 and clamped thereto by the set screws 107. The construction is such that when the device is clamped upon the carrier 17 the vertical axis of the conical foot 102 will be in alinement with the axis of the grinder spindle when the grinder is in its central position with respect to the carrier. The work is now placed on the bed plate 2 beneath the grinder and the carrier brought down to bring the conical foot 102 into the cylindrical opening to be ground. The work is then adjusted until it fits snugly against the conical surface and then locked in place on the bed plate. The centering device is then removed and the spindle support adjusted radially in the carrier to bring the tool into contact with the work and the machine is then ready for operation.

Having fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier out of alinement with the axis of the carrier and bodily movable radially upon and with respect to the carrier, means for rotating said carrier and for moving said carrier vertically to carry the tool over the surface of the work, means for giving radial movement to the spindle and tool to feed the tool progressively against the work and means for rotating said tool spindle with respect to said carrier.

2. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on said carrier, and driving connections from said motor to said spindle for rotating the spindle with respect to the carrier.

3. A machine of the character described comprising a bed, a head above the bed, a

hollow carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier, out of alinement with the axis of the carrier, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on said carrier, an actuating pulley driven by said motor, a pulley on the tool spindle, and an endless belt leading from said actuating pulley through said hollow carrier to said spindle pulley to rotate the tool with respect to the carrier.

4. A machine of the character described comprising the construction defined in claim 3 together with means for effecting the balancing of the strain of said belt on said spindle pulley.

5. A machine of the character described comprising a bed, a head above the bed, a hollow carrier rotatably and vertically movable in said head and terminating in a base, a spindle support radially movable in said base, a tool and a vertical tool spindle rotatably mounted in said spindle support, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on the carrier and provided with an actuating pulley driven thereby, a pulley on the tool spindle, an endless belt leading from said actuating pulley through said hollow carrier to said spindle pulley to rotate the spindle with respect to the carrier, and means for progressively feeding said spindle support radially of the carrier.

6. A machine of the character described comprising a bed, a head above the bed, a hollow carrier rotatably and vertically movable in said head and terminating in a base, a spindle support radially movable in said base, a tool and a vertical tool spindle rotatably mounted in said spindle support, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on the carrier and provided with an actuating pulley driven thereby, a pulley on the tool spindle, an endless belt leading from said actuating pulley through said hollow carrier to said spindle pulley to rotate the spindle with respect to the carrier, and means governed by the number of rotations of the carrier for progressively feeding the spindle support radially of the carrier.

7. A machine of the character described comprising a bed, a head above the bed, a hollow carrier rotatably and vertically movable in said head and terminating in a base, a spindle support radially movable in said base, a tool and a vertical tool spindle rotatably mounted in said spindle support, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on the carrier and provided with an actuating pulley driven thereby, a pulley on the tool spindle, an endless belt leading from said actuating pulley through said hollow carrier to said spindle pulley to rotate the spindle with respect to the carrier, a counterbalance for the tool spindle support radially movable on said carrier base, and means for simultaneously feeding the spindle support and the counterbalance in opposite radial directions on the carrier.

8. A machine of the character described comprising a bed, a head above the bed, a hollow carrier rotatably and vertically movable in said head and terminating in a base, a tool spindle support radially movable in said base, a tool and a vertical tool spindle rotatably mounted in said spindle support, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on the carrier and provided with an actuating pulley driven thereby, a pulley on the tool spindle, an endless belt leading from said actuating pulley through said hollow carrier to said spindle pulley to rotate the spindle with respect to the carrier, a counterbalance for the spindle support radially movable on said carrier base, and means governed by the number of rotations of the carrier for progressively feeding the spindle support radially and for simultaneously feeding the counterbalance radially in the opposite direction.

9. A machine of the character described comprising a bed, a head above the bed, a hollow carrier rotatably and vertically movable in said head and terminating in a base, a tool spindle support radially movable in said base, a tool and a vertical tool spindle rotatably mounted in said spindle support, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, a motor mounted on the carrier and provided with an actuating pulley driven thereby, a pulley on the tool spindle, a pair of idler pulleys mounted in the carrier base at opposite sides of the spindle, and an endless belt leading from the actuating pulley through the hollow carrier around one idler, thence around the spindle pulley, thence back around said idler, thence around the second idler, thence around the spindle pulley, thence back around the second idler, thence through the hollow carrier to the actuating pulley, whereby the strain of the belt on the spindle pulley is balanced and whereby a radial bodily feeding movement of the tool spindle is permitted while maintaining the drive.

10. A machine of the character described comprising the construction defined in claim 9 together with means for progressively feeding the tool spindle support radially with respect to the carrier.

11. A machine of the character described, comprising the construction defined in claim 9 together with means governed by the number of rotations of the carrier for progressively feeding the tool spindle support radially with respect to the carrier.

12. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted on the carrier, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, an electric motor mounted on said carrier, electric contacts vertically movable with said carrier and held against rotary movement therewith, and brushes on said motor in rotary sliding engagement with said contacts, and driving connections from said motor to said spindle for rotating the tool with respect to the carrier.

13. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted on the carrier, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, an electric motor mounted on said carrier, uprights extending vertically from said head alongside the carrier and adapted to be electrically connected to the terminals of an electric circuit, electric contacts vertically movable with said carrier, said contacts being insulated from but slidable along and held by said uprights against rotary movement with the carrier, sliding contacts connecting said contacts respectively with said uprights, lead wire brushes on said motor in rotary slidable engagement with said contacts, and driving connections from said motor to said spindle for rotating the spindle with respect to the carrier.

14. In a machine of the character described a rotarily and vertically movable carrier provided with a carrier base, a spindle support radially movable in said base, a tool and a vertical tool spindle carried by said support, anti-friction bearings between said support and said base including a single row of balls fitting in opposed grooves in said base and support whereby accurate rectilinear movement of the support on the base is secured.

15. In a machine of the character described a rotarily and vertically movable carrier provided with a carrier base, a spindle support radially movable in said base, a tool and a vertical tool spindle carried by said support, a counterbalance for the support and parts carried thereby mounted for radial movement on said base, a reversely threaded screw extending through said support and through said counterbalance whereby when the screw is rotated the support and the counterbalance will be fed in opposite radial directions.

16. In a machine of the character described the construction defined in claim 15 together with pawl and ratchet mechanism mounted on said base and adjustable driving connections between said pawl and ratchet mechanism and said screw whereby as the pawl is actuated the screw will be turned to produce the required feeding movement.

17. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier and bodily movable radially upon and with respect to the carrier, means for rotating said carrier, means for moving said carrier vertically, means for giving the bodily radial movement to the spindle and tool to feed the tool progressively toward the work during the grinding operation and means for rotating said spindle with respect to said carrier.

18. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier, means for rotating said carrier, means for moving said carrier vertically, a motor mounted on said carrier, and driving connections from said motor to said spindle for rotating the tool with respect to the carrier.

19. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier, means for rotating said carrier and for moving said carrier vertically to carry the tool over the surface of the work, means for rotating said spindle with respect to said carrier, and adjustable means for progressively feeding the spindle bodily and radially of the carrier.

20. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in said carrier, means for rotating said carrier and for moving said carrier vertically to carry the tool over the surface of the work, means for rotating said spindle with respect to said carrier, and means governed by the number of rotations of the carrier for progressively feeding the spindle bodily and radially of the carrier.

21. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted in the carrier, means for rotating said carrier and for moving said carrier vertically to carry the tool over the surface of the work, means for rotating said

spindle with respect to said carrier, means for progressively feeding the spindle bodily and radially of the carrier, a counterbalance, and means for simultaneously feeding the counterbalance in a direction opposite to that in which the spindle is fed whereby the tool is fed progressively toward the work and the balance of the carrier is maintained.

22. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in said head, a tool and a vertical tool spindle rotatably mounted on the carrier, means for rotating said carrier and moving said carrier vertically to carry the tool over the surface of the work, an electric motor mounted on said carrier, driving connections from said motor to said spindle for rotating the tool with respect to the carrier, and means for transmitting the electric current to said motor during its bodily vertical and rotary movements.

23. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in the head, a tool and a vertical tool spindle rotatably mounted in the carrier, means for rotating said carrier, means for rotating said spindle with respect to said carrier, a lever mounted in said head and at one end engaging the carrier, and means engaging the lever at the opposite end and acting to rock the said lever and thus transmit vertical movement to the carrier.

24. A machine of the character described comprising a bed, a head above the bed, a carrier rotarily and vertically movable in the head, a vertical tool spindle rotatably mounted in the carrier, means for rotating said carrier, means for rotating said tool spindle with respect to said carrier, a lever mounted on said head and at one end engaging the carrier, a counterbalance at the other end of the lever, and means engaging the lever and acting to oscillate the same.

25. A machine of the character described having a rotatable tool spindle, a rotatable carrier for said tool spindle, means for rotating said carrier, means for rotating the tool spindle carried by and reciprocating with the carrier, means for adjusting the said tool spindle out of axial alinement with the axis of rotation of the said carrier, and means for reciprocating the said rotatable carrier and the rotatable spindle carried thereby.

In testimony whereof, I have signed my name to this specification.

EDWARD RIVETT.