

March 6, 1951

W. HORBERG

2,544,318

METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT PROPPING OF WORK BY ABRADING SURFACE

Filed Sept. 11, 1946

7 Sheets-Sheet 1

Fig. 1

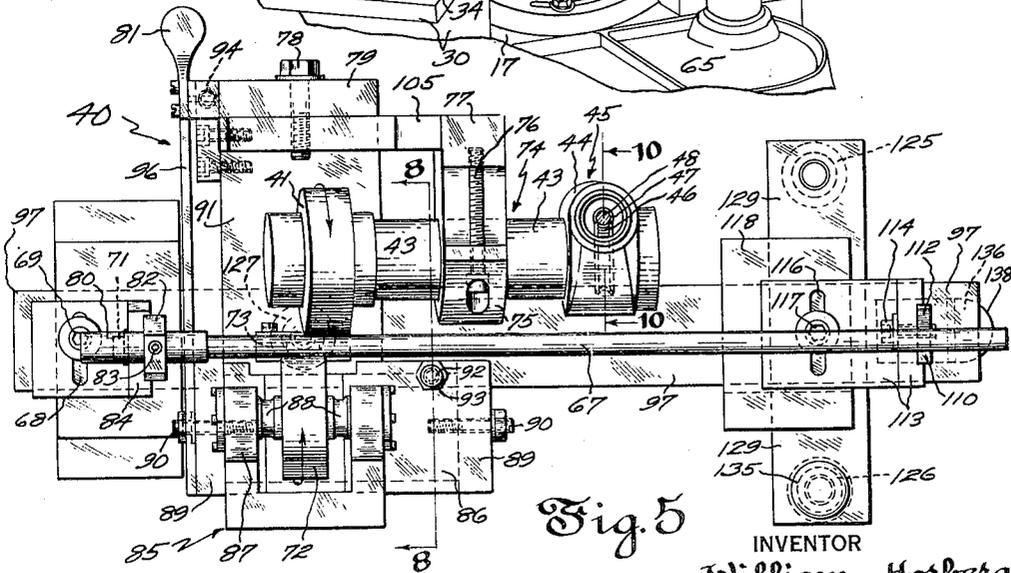
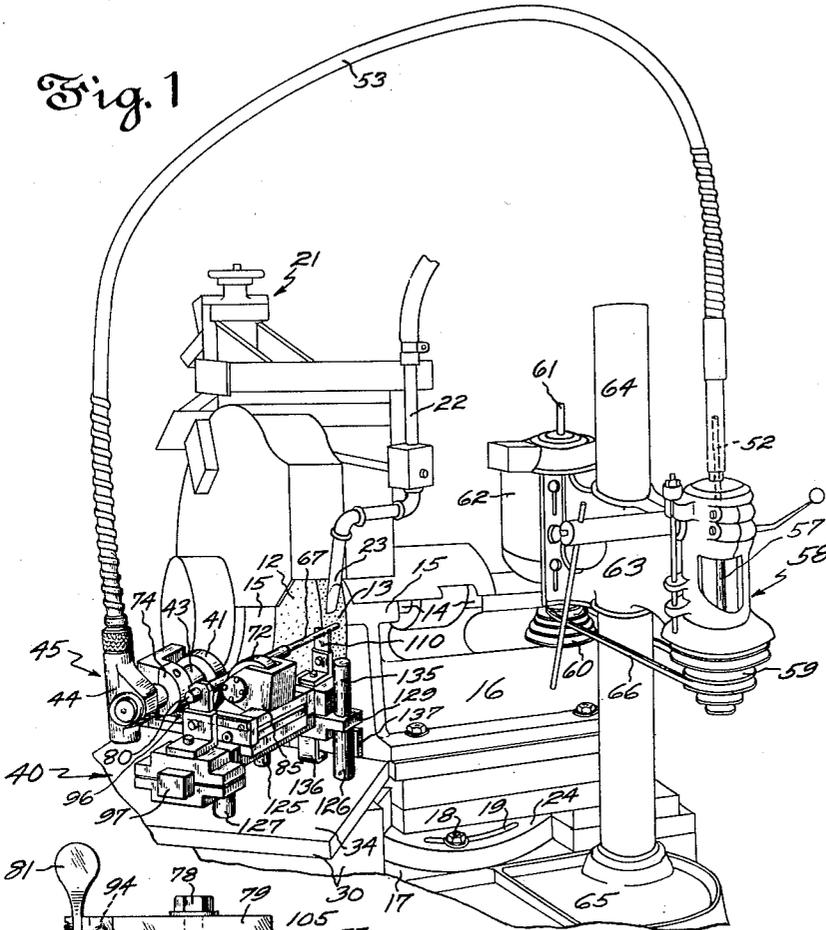


Fig. 5

INVENTOR
William Horberg
BY *W. Smith*
ATTORNEY

March 6, 1951

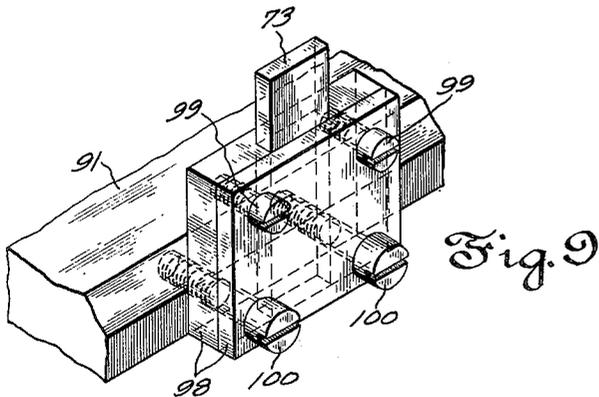
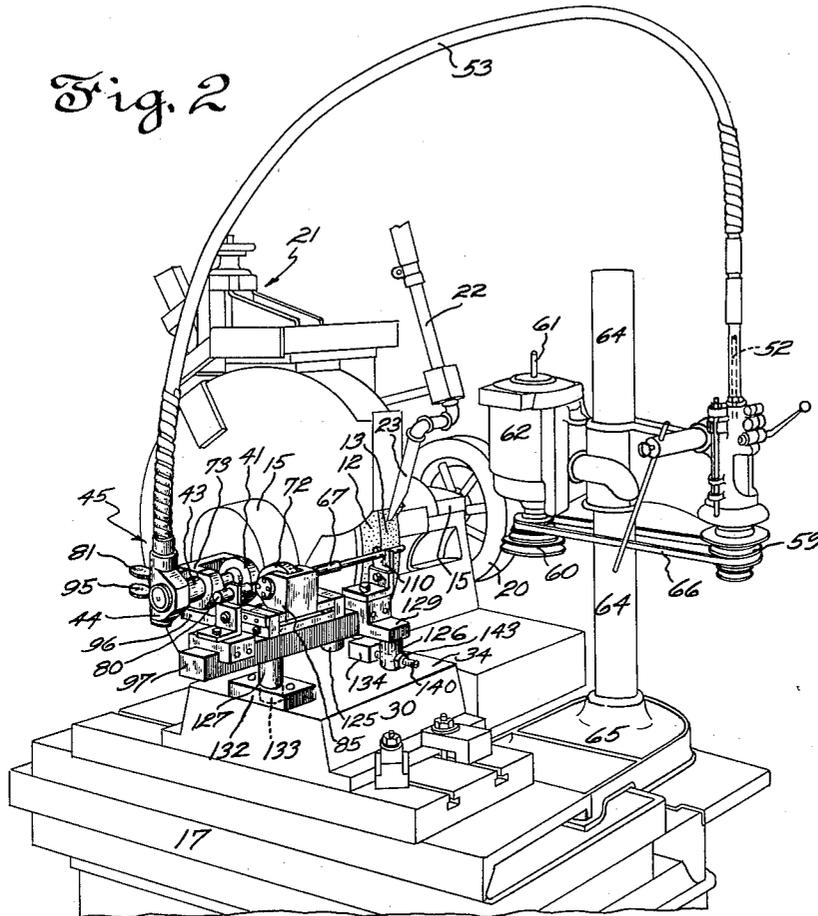
W. HORBERG

2,544,318

METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT
PROPPING OF WORK BY ABRADING SURFACE

Filed Sept. 11, 1946

7 Sheets-Sheet 2



INVENTOR
William Horberg
BY *W. Smith*
ATTORNEY

March 6, 1951

W. HORBERG

2,544,318

METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT
PROPPING OF WORK BY ABRADING SURFACE

Filed Sept. 11, 1946

7 Sheets-Sheet 3

Fig. 3

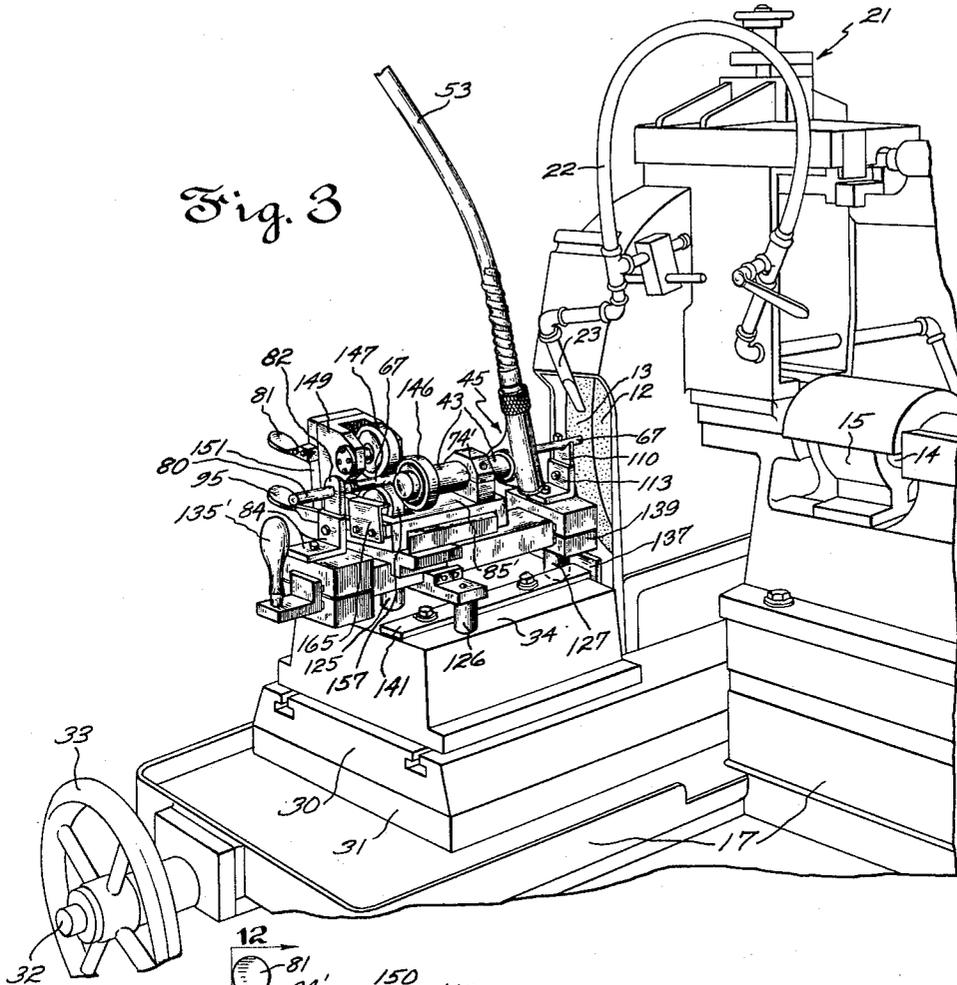
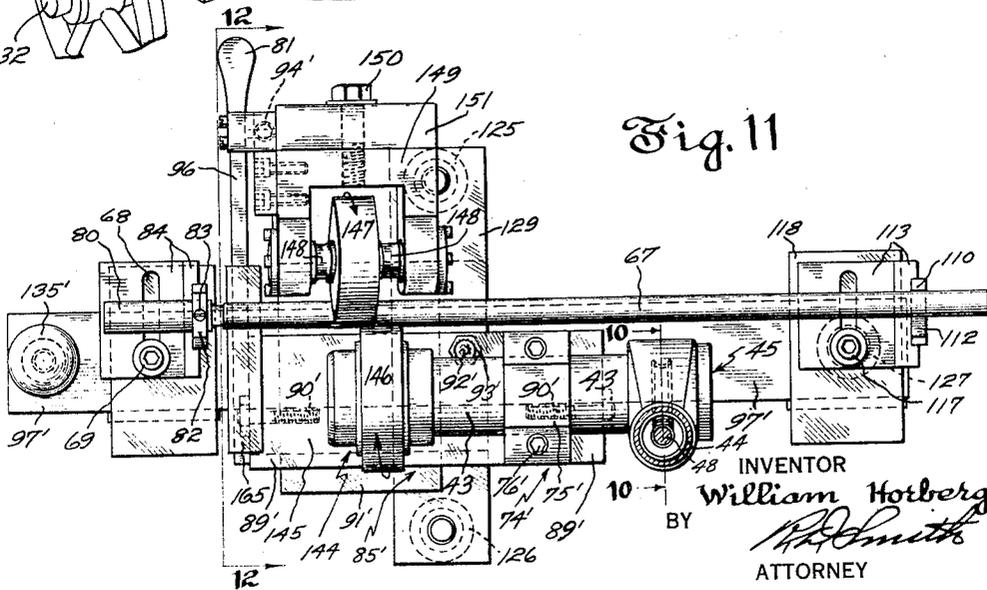


Fig. 11



March 6, 1951

W. HORBERG
METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT
PROPPING OF WORK BY ABRADING SURFACE

2,544,318

Filed Sept. 11, 1946

7 Sheets-Sheet 4

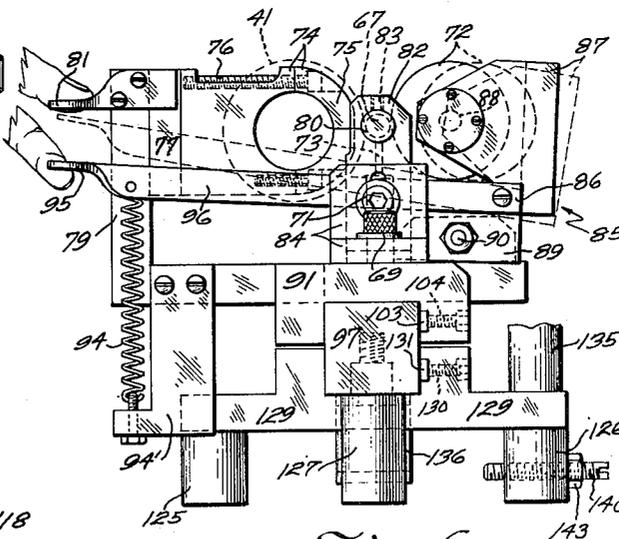
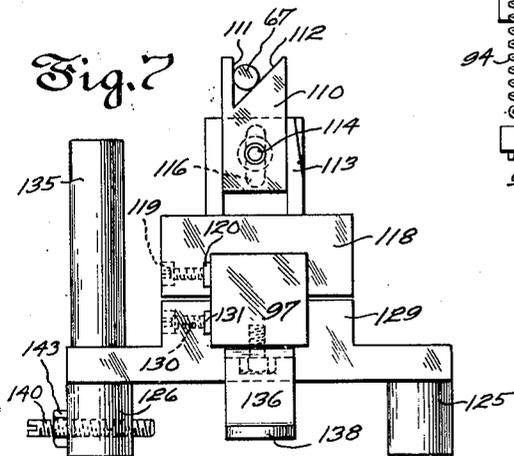
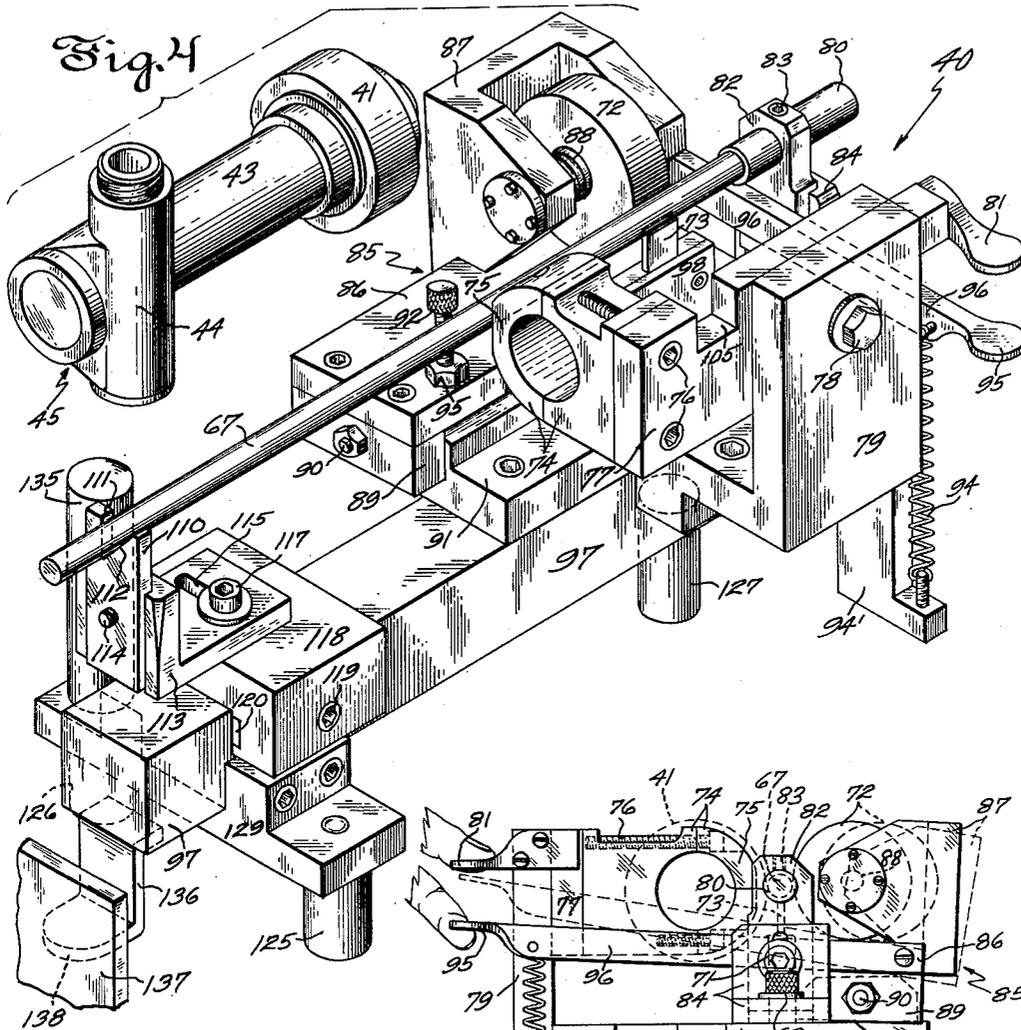


Fig. 6

INVENTOR
William Horberg
BY
R. Smith
ATTORNEY

March 6, 1951

W. HORBERG
METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT
PROPPING OF WORK BY ABRADING SURFACE

2,544,318

Filed Sept. 11, 1946

7 Sheets-Sheet 6

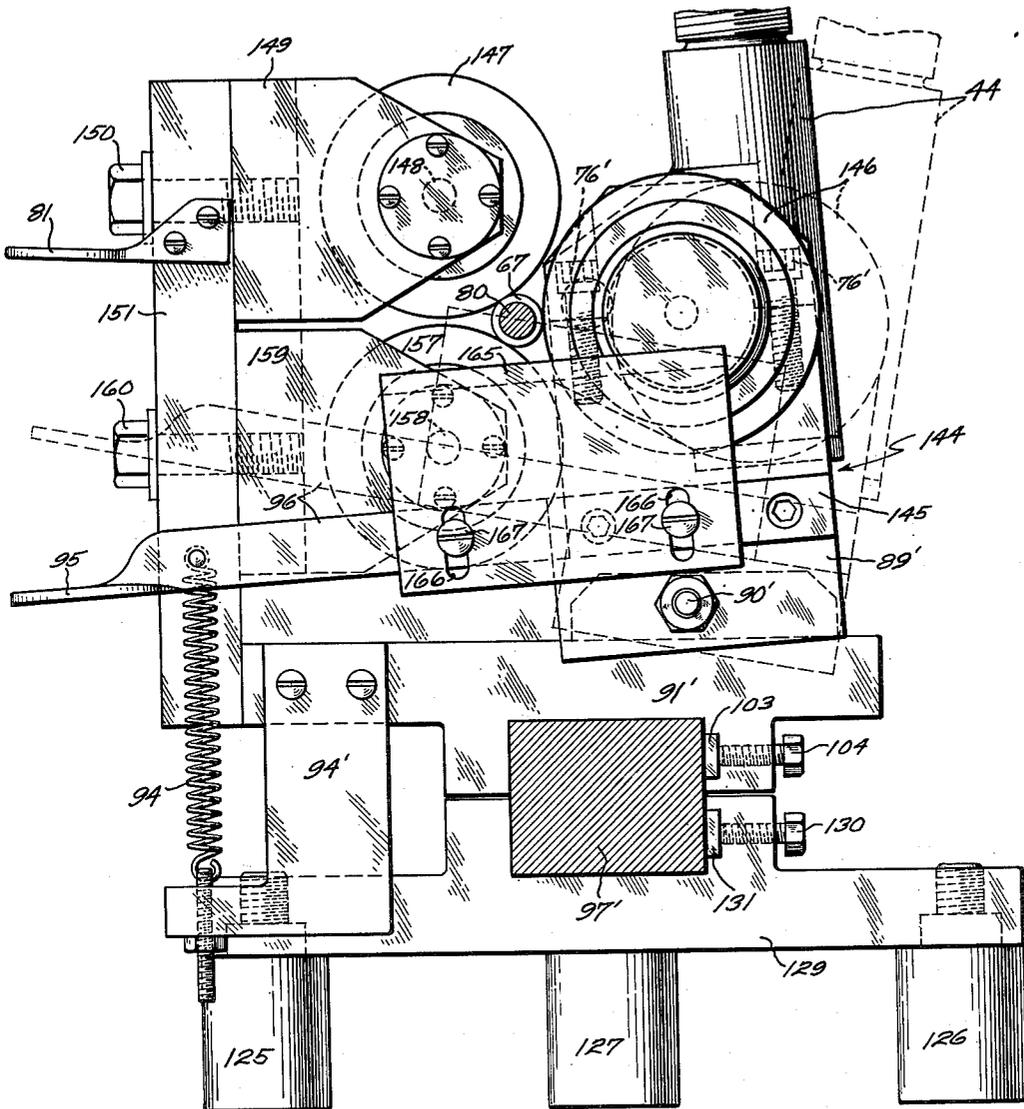


Fig. 12

INVENTOR
William Horberg
BY *R. Smith*
ATTORNEY

March 6, 1951

W. HORBERG
METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT
PROPPING OF WORK BY ABRADING SURFACE

2,544,318

Filed Sept. 11, 1946

7 Sheets-Sheet 7

Fig. 13

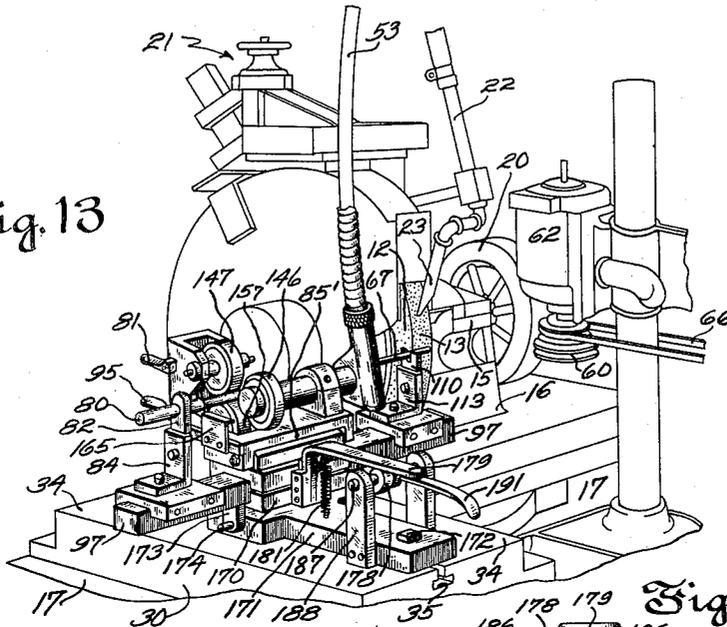


Fig. 16

Fig. 15

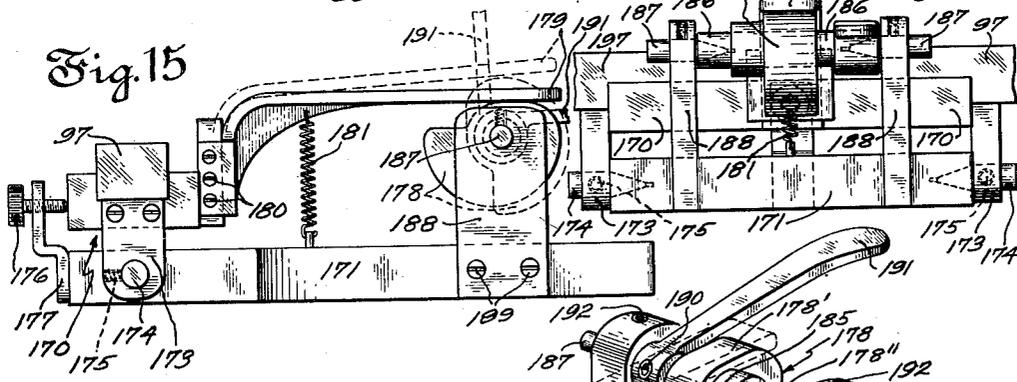
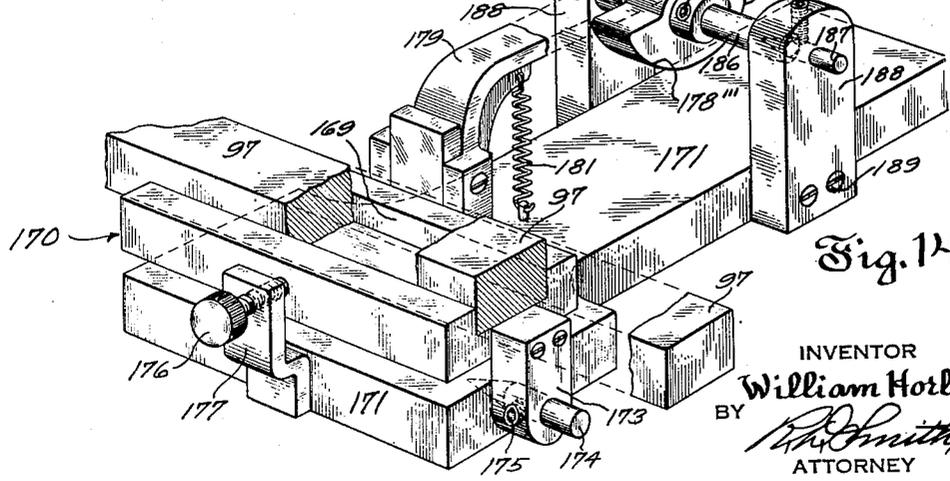


Fig. 14



INVENTOR
William Horberg
BY *W. Smith*
ATTORNEY

UNITED STATES PATENT OFFICE

2,544,318

METHOD AND MEANS FOR CENTERLESS GRINDING WITHOUT PROPPING OF WORK BY ABRADING SURFACE

William Horberg, Bridgeport, Conn.

Application September 11, 1946, Serial No. 696,308

15 Claims. (Cl. 51-103)

1

This invention relates to the art of centerless grinding and particularly to methods and machines for performing centerless grinding where-in the grinding wheel or other fast moving abrasive surface is not employed to assist in the centerless support of the work piece that is being ground.

In the conventional practice of centerless grinding a work piece is rotated usually on a horizontal axis while supported solely by means of its periphery. The means of support commonly consists of three elements—the grinding wheel which scrapes in contact with one side of the work piece, an opposed frictional or work control wheel which clingingly rolls in contact with the other side of the work piece and a stationary underlying support on which the bottom peripheral surface of the work piece bears while rotating. These three elements form a constraining channel which may be referred to as the grinding throat of a conventional centerless grinding machine in which throat the work piece is nested while being rotated by the control wheel and ultimately ground to size. The ultimate size is determined by the narrowest dimension of the space or gap between the grinding wheel and the control wheel to which the work piece is permitted to sink by the underlying stationary rest or work support. Obviously under these conventional conditions if a peripheral contour is to be imparted to the work piece other than that of an all-cylindrical or all-conical shape, such can be accomplished only by correspondingly shaping the abrading surface of the grinding wheel, whereas profiling the terminal end of the work piece to various crowned shapes can not be done at all in a conventional grinding machine.

There is a large range of work which heretofore has been ground in ordinary centerless grinding machines consisting of relatively slender and elongated rods or spindle-like work pieces, many work pieces of this character having stepped diameters and irregular profile shapes and requiring grinding to accurate shapes and sizes at or near both ends as well as in various sections of their length. Not only are conventional centerless grinding machines wholly incapable of profiling the end of such work pieces in a manner to produce desired varieties of rounded, beveled, or flat end shapes but centerless grinding machines as heretofore known are far more heavy and cumbersome in relation to the size and weight of such slender, spindle-like work pieces than is necessary for the requisite firmness of work support during centerless grind-

2

ing thereof. Consequently the rate of production and degree of accuracy of shaping and sizing which it has heretofore been possible to accomplish by centerless grinding have fallen far short of the resultant efficiency demanded by modern production standards.

My present invention successfully overcomes the above explained disadvantages of those practices which have prevailed in the centerless grinding art. It aims to retain the well understood operative benefits of centerless grinding while greatly speeding up and increasing the accuracy of output of centerless ground work, and especially of slender, spindle-like pieces.

A contributory object is to avoid dependence on the rotating grinding wheel to serve as the lateral abutment against which the work piece is urged by the rolling thrust of the work driving frictional or control wheel. Attainment of this object leaves the work piece free to be maneuvered bodily in chosen angular relationships to the grinding wheel while it is being rotated on its own longitudinal axis by the control wheel.

A related object is to provide a centerless support for a rotating work piece confined to carrier structure that is free to be maneuvered bodily for presenting selectively different surfaces of the work piece to the grinding wheel. A contributory object is to include in such centerless support a work driving or frictional control wheel driven by a flexible shaft from a source of power stationed apart from the work carrying structure.

A further object is to constrain a carrier affording centerless means of support for the work piece in a manner to restrict and in part predetermine the permissible paths in which it can manually be maneuvered.

A further object is to facilitate placement of the work piece on its means of centerless support as well as removal of the work piece therefrom.

A further object is to avoid the necessity of feeding small work pieces toward a grinding wheel by means of bodily moving a heavy, cumbersome and hard to budge bearing frame structure in which the work driving frictional or control wheel is journaled in conventional centerless grinding practice.

A further object is to make use of a furcate rest for supporting the work piece near its surface which is to be presented to the grinding wheel.

A related object is to arrange plural work control wheels so acting on one section of the length

3

of a single work piece that an outboard section of said length is biased by the control wheels in a predetermined lateral direction against the aforesaid furcate rest while the work piece is being rotated by the control wheels.

A further object is to provide stop means pre-determining positively the endwise placement of the work piece on its centerless support carrier so that the location of the carrier in relation to a grinding wheel in directions lengthwise of the work piece can accurately determine the length to which the work piece will be ground by the grinding wheel.

A related object is so to skew the work control wheels that they will constantly urge the work piece endwise against the aforesaid stop means while the control wheels are causing the work piece to rotate.

The foregoing and other objects of the invention are obtainable by practices and mechanism of which illustrative examples are explained in the following description having reference to the appended drawings wherein:

Fig. 1 is a perspective view of a complete grinding machine incorporating improved apparatus for practicing my new method of centerless grinding in the operation of profiling rod ends.

Fig. 2 shows a special set-up of the same apparatus as Fig. 1 arranged for cylindrical and taper grinding of rod-like work pieces.

Fig. 3 shows an apparatus of modified construction set up to grind flat ends on elongated work pieces in a manner to produce accurate lengths of the latter.

Fig. 4 is an isometric exploded view of a two-wheel planchette type of work carrier removed from the grinding machine of Figs. 1 and 2.

Fig. 5 is a plan view of the work carrier of Fig. 4 completely assembled with a work piece in place.

Fig. 6 is a view of the heel end of the work carrier looking from the left toward Fig. 5.

Fig. 7 is a view of the toe end of the work carrier looking from the right toward Fig. 5.

Fig. 8 is a view taken in section on the planes 8-8 in Fig. 5 looking in the direction of the arrows drawn on an enlarged scale in size suitable for actual structure.

Fig. 9 is an enlarged detached isometric view exposing the work rest blade of Fig. 4.

Fig. 10 is a view taken partially in central lengthwise section through the speed reduction angle unit of Figs. 1, 2 and 3, as on the plane 10-10 in Fig. 5 or 11.

Fig. 11 is a plan view of a modified or three-wheel planchette type of work carrier removed from the grinding machine of Fig. 3.

Fig. 12 is a view taken in section on the plane 12-12 in Fig. 11, looking in the direction of the arrows showing the parts on an enlarged scale suitable in size for actual use on work of common sizes.

Fig. 13 shows a set-up of the three wheel work carrier of Fig. 3 specially equipped with a base fixture enabling the work to be swung toward and away from the grinding wheel about a stationary horizontal axis.

Fig. 14 is an enlarged perspective view of the base fixture of Fig. 13 with most of the work carrier parts omitted.

Fig. 15 is a side elevation of the base fixture of Fig. 14.

Fig. 16 is an end view of the same base fixture looking from the right at Fig. 15.

4

The grinding machine

As the present invention is concerned more particularly with apparatus for bodily maneuvering the work in relation to a power driven abrasive surface in a grinding machine and for peripherally supporting a rotating work piece without constraining assistance by such abrasive surface, there is shown only sketchily herein a power driven abrasive surface 13 embodied as the peripheral face of a grinding wheel 12 whose horizontal power shaft 14 is journaled in suitable bearings 15. These shaft bearings are part of a turret head 16 that is mounted to be turned about a vertical axis on the bed 17 of a grinding machine of the surface grinder type. Turret head 16 can be fastened in any selective position to which it may be turned by tightening suitable clamp bolts such as 18 that extend through segmental slots such as 19 in a base flange 24 of the turret head, bolts 18 having threaded engagement with the machine bed 17.

The grinding wheel shaft 14 has fixed thereon a belted pulley 20 (see Fig. 2) driven from a line shaft, or if preferred from a direct connected power motor fast to the frame of the machine. The grinding machine may also be equipped with any conventional attachment 21 for dressing the grinding wheel. Also as is conventional in grinding machines, a liquid coolant is pumped through pipe line 22 and out of a discharge nozzle 23 against the abrasive surface 13 of grinding wheel 12.

On frame 17 of the grinding machine there is mounted a table 30 slidable on ways 31 by means of feed screw 32 turned by operating handle 33 to push and pull table 30 along ways 31 relative to grinding wheel 12. Feed screw 32 also serves to hold table 30 in selected positions in which it may be set. For fastening table 30 even more fixedly to its ways 31 conventional clamp gibs releasably tightened by set screws in the usual manner may be employed. Such are not herein illustrated because for many of the purposes of the present invention table 30 remains stationary with frame 17 of the grinding machine.

Differing types of work carriers

The top surface 34 of table 30 serves as a stationary platform on which rests, and with respect to which is maneuvered, various work piece carriers characterized by the features of this invention including the feature that the work piece carrier is bodily movable as a whole in relation to the power driven abrasive surface or grinding wheel face 13 while it supports the work piece and causes it to rotate. Constraint and rotation of the work piece is accomplished by means of a set of work control wheels rotatably mounted on the bodily movable work carrier and arranged to turn in peripheral rolling contact with opposite sides of the circular work piece simultaneously.

In all forms of my improved work carrier herein illustrated at least one of the wheels of the said set is power driven and transmits its rotary power drive by friction to the work piece, and there are work supporting means below the levels of peripheral contact of two of the aforesaid wheels with the work piece. Such work supporting means may comprise a stationary work rest or an additional wheel or roller that underlies and bears the weight of the rotating work piece in a manner that determines the height level at which the work piece will be maintained while it is being rotated on its bodily movable carrier.

Each form of my improved bodily movable work carrier also employs a furcate rest presenting a guide surface 111 axially distant from the aforesaid set of work control wheels, together with an adjustably positioned stop arranged to take the endwise thrust of the work piece in a direction away from such furcate rest.

The foregoing and associated features of my improved work rotating carrier will now be described in several particular forms of mechanism in which they may be incorporated according to the constructions herein illustrated. For brevity these different forms of carrier may be classed as of the two-wheel or three-wheel type according to their means for constraining and rotating the work, and as of planchette or swingable types according to their manner of bodily maneuvering the work. Of the swingable types there is herein illustrated one carrier (Fig. 2) which swings on a vertical axis and another carrier (Fig. 13) which swings on a horizontal axis. All types embody my present improvements in the art of centerless grinding wherein a work piece is ground to true roundness and perfect size by centerless grinding principles without depending on the surface of the grinding wheel to assist in the constraint of the work or to predetermine its finished size.

Construction of two-wheel planchette work carrier

In Fig. 1, this form of work carrier is shown set up for use in profiling the end of a circular work piece 67 of elongated, slender or spindle-like nature. Construction of its details appears more clearly in Figs. 4 to 8, inclusive. See also Fig. 2 and Fig. 11. In this carrier there are only two wheels in the set of wheels which roll simultaneously against the periphery of the work piece. One of these wheels 41 is removably fixed on a stub shaft 42 that is journaled within the tubular extension 43 of a housing 44 for a portable power transmission unit 45 of the angle type. Within housing 44, as best shown in Fig. 10, a worm wheel 46 is keyed to shaft 42 and in mesh with a driving worm 47 whose spindle 48 has roller bearings 49 and 50 in housing 44 and is flatted at 51 to be drivably coupled to a flexible power shaft 52 (see Fig. 5). Shaft 52 extends throughout the length of a flexible conduit 53 and connects to the shaft 57 of pulley 59 in the variable speed power unit 58. One end of conduit 53 is anchored to the bearing structure 63 for shaft 57 while its other end is anchored to the housing 44 of a speed reduction unit hereinafter described.

Unit 58 may take any of numerous forms. For convenience of illustration it is herein shown to comprise two reversely stepped pulleys 59 and 60 the former of which is coupled to the flexible shaft 52 and the latter of which is fast on the shaft 61 of motor 62. The bearing structure 63 for shafts 52 and 61 is adjustably supported by an upright frame post 64 whose base may stand on the floor at the side of grinding machine 17, or whose base, as appears at 65, may rest on the bed 17 of the grinding machine. The present invention is not particularly concerned with the exact construction nor the location of the variable speed unit 58. In some cases it might to advantage be located overhead like a line shaft in the near neighborhood of the grinding machine. It is highly desirable, however, that the source of motive power for driving wheel 41 shall not constitute a load burdening my improved work carrier with its weight nor imparting to

such carrier the periodic vibrations of electric motor 62, and of the pulley connecting belt 66. Such burden of weight would destroy the sensitivity with which the work carrier as a whole could be bodily moved and such vibrations would interfere with smooth true concentric rotation of work piece 67. Also the drawings show the importance to free and random roving mobility of the work carrier that the shaft 52 and its conduit 53 be long enough and so disposed as to extend downward into operatively coupled relationship to transmission unit 45. I have further discovered that in transmitting driving power to one or more of the wheels of my improved work carrying apparatus it considerably relieves any tendency to jerkiness, arising from the performance of flexible shaft 52 or looseness in its connections, if such shaft is driven at high speed rather than low speed in its conduit 53. This calls for the speed reducing function of transmission unit 45 to be performed at the work carrier end of shaft 52 rather than at its power source end. In Fig. 4, wheel 41 together with the housing 44 of power transmission 45 is shown removed from its working position in the planchette work carrier in order better to expose the other work piece supporting and constraining elements. These elements include the presser wheel 72 and the underlying stationary supporting blade whose flat top edge serves as work rest 73. (See also Fig. 9.)

In Figs. 4 to 8, inclusive, it will be clear that in normal use the tubular housing extension 43 of transmission 45 is firmly clamped in stationary working position within a split bearing 74 whose lateral cap piece 75 is removable by loosening clamp bolts 76 having threaded engagement therewith. Bolts 76 pass through clearance holes in the bearing bracket 77 which itself can swivel about the axis of a clamp bolt 78 that has threaded engagement therewith and passes through a clearance hole in the frame bracket 79 of this two-wheel, planchette type of carrier. When clamp bolt 78 is tightened the split bearing 74 and hence the work driving wheel 41 is bodily stationed with its axis of rotation disposed at any chosen angle of deviation from true horizontal disposition that will cause work drive wheel 41 to be slightly skewed in a direction serving constantly to urge work piece 67 axially endwise against a fixed adjustable stop rod 80. The work contacting end of the rod may be crowned or pointed to reduce the friction between it and the work piece.

Stop 80 also takes any endwise thrust by the grinding wheel upon the work piece in directions lengthwise of the work piece. Stop rod 80 is supported in and longitudinally adjustable in a hole in the top portion of a vertically adjustable post 82 being releasably fastened therein by a set screw 83. Post 82 is itself fastenable in chosen vertical positions in a groove in its standard 84 by means of a clamp screw 71 passing through an elongated slot 70 in standard 84 and having threaded engagement with post 82. The angle base of standard 84 contains a transversely elongated slot 68 through which passes a holding bolt 69 having threaded engagement with a saddle slide 102 so that standard 84 while adjustably mounted on slide 102 can also be shifted with the latter lengthwise of the main frame bar 97 of the work carrier. A gib 103 and screws 104 fasten slide 102.

The other or presser wheel 72 may have roller bearings in a rocker sub-frame 85 which includes

a tilting base 86 in rigid relation to an upstanding bearing bracket 87 in which the trunnion shaft 88 of idler wheel 72 is given plain or roller bearings with suitable thrust means to keep idler wheel 72 from axial movement. Figs. 4, 6, 8 and 9 show that sub-frame base 86 has downward extending flanges 89 which are swingably supported by hinge bolts 90 passing through clearance holes in the flanges 89 respectively and having threaded engagement with a frame block 91 against which the bottom end of an adjustable stop screw 92 abuts to limit the clockwise tilting of sub-frame base 86 in Fig. 8 if the work piece 67 is absent. Stop screw 92 may be locked in any set position by the lock nut 93, and threads into tilting base 86.

An arm 96 is fixed on sub-frame 86 and extends crosswise of the frame bar 97 which serves as the backbone of the carrier frame and supports the aforesaid frame block 91 and frame bracket 79 in fixed relation to each other. This arm terminates in a flattened handle 95 and is urged downward by a spring 94 stretched between said arm and a stationary spring anchorage bracket 94' fixed on frame bracket 79 as best shown in Fig. 6. A finger rest 81 is also fixedly secured on frame bracket 79 for use cooperatively with handle 95 as indicated in Fig. 6 and hereinafter further referred to.

The work rest blade 73, as best shown in Figs. 4, 8 and 9, may be fixedly clamped at chosen heights in a groove in its split holding block 98 whose separable sections are drawn together by the clamp screws 99 and which as a whole is kept rigid with the frame block 91 by holding screws 100 passing therethrough and having threaded engagement with holes in the edge of block 91. Thus the work rest blade 73 occupies a vertically adjustable position directly beneath work piece 67. The periphery of the rotating work piece rests on the top flat edge of this blade while the work piece is being rotated by its rolling contact with work control wheels 41 and 72. Presser wheel 72 can be swung retractably away from the work piece (counterclockwise in Fig. 8) by manually lifting handle 95 against the resistance of spring 94 to the position shown in broken lines in Fig. 6.

The foregoing means of support and means of rotary drive for the work piece is comparable to conventional centerless grinding practice with the exception that the presser wheel 72 in constraining the work piece, serves what has formerly been a propping function of the grinding wheel in conventional centerless grinding.

In this improved practice of centerless grinding, the remote or toe end of the work piece which is in outboard relation to the work control wheels 41 and 72 rests in a furcate upstanding guide plate 110 near a portion of the length of the work piece that is to be brought against the grinding wheel. Guide plate 110 is an abutment presenting to one side of the work piece a vertical constraining face or notch edge 111 and to the opposite side of the work piece an oblique or sloping notch edge 112. Guide plate 110 also is shiftable to chosen vertical positions in the groove of an upstanding arm of holding bracket 113 to which it is made fast by the clamp screw 114 which passes through an elongated slot 116 in bracket 113 (see Fig. 7) and threads into guide plate 110. The base branch of bracket 113 contains a transversely elongated slot 115 through which passes a holding screw 117 having threaded engagement with the saddle slide

118 that seats snugly on and is shiftable lengthwise of the frame bar 97 of the carrier, being fastenable thereto by set screw 119. A gib 120 clamped by screw 119 fastens slide 118 to frame bar 97.

Frame bar 97 is given three-point, gliding support by two front legs 125, 126 and one rear leg 127. Front legs 125, 126 are made adjustably rigid with frame bar 97 at chosen stations along its length by means of a cross bar 129 grooved to receive and fit the frame bar 97 and fastenable thereto by a gib 131 and set screw 130. Each of the legs 125, 126 is screwed tightly into bar 129 while leg 127 is tightly screwed directly into the frame bar 97. While this three-legged support of the carrier enables it to rest stably on the top surface 34 of table 30 it enables the carrier as a whole to be slidable freely along said surface in random directions to arbitrary positions. From this characteristic of mobility the carrier derives its name "planchette." More than three-point support can be provided to enable the carrier to glide freely about on table surface 34 within the novel principles of this invention.

The planchette type of two-wheel carrier of Figs. 1, 2 and 4 to 10, inclusive, is further equipped with a carrier manipulating and steering handle 135 that is rigid with and upstands from cross bar 129. For profiling the ends of rod-like or spindle-like work pieces a pilot or pattern contour toe 136 is fixed at the end of the frame bar 97 nearest the grinding wheel. This pattern toe is located as best shown in Figs. 1, 4 and 5 to meet and rock against a rigid upstanding work sizing plate 137 that is rigid with the grinding machine table 30 and hence normally fixed in relation to the bodily position of grinding wheel 12. While the convex pilot edge of pattern toe 136 is shown to have a circular curvature whose diameter parallel with the axis of the work piece 67 is offset laterally from such axis, it is more often desirable to have the diameter of circular pattern curvature in a common vertical plane with the axis of the work piece and therebelow.

Operation of pattern controlled two-wheel planchette carrier

Referring particularly to Fig. 1 the two-wheel planchette carrier of Figs. 4 to 9, inclusive, is shown resting upon and free to glide in random directions to arbitrary positions with respect to the abrasive face 13 of grinding wheel 12, while it supports and rotates the work piece 67. Whereas the speed reduction unit 45 is shown at the heel end of the carrier in Fig. 1 this speed reduction unit in Fig. 5 is shown to be located nearer the toe end of the carrier. This need not affect the operation of the work control wheels but merely illustrates that the positioning of the speed reduction may be shifted to either of these locations owing to the ability of bracket 77 to swivel through a half circle about the axis of its clamp bolt 78. When bracket 77 is positioned as in Figs. 1 and 2, the notch 105 accommodates handle lever 96.

Assuming that a crown end is to be ground on work piece 67 in three dimensional conformity with the two-dimensional convex pattern edge 138 of the pattern toe 136, the operator will grasp handles 81 and 95 as shown in Fig. 6 and retract presser wheel 72 to its broken line position in Fig. 6 by lifting on handle 95 thereby to make room for laying the work piece 67 on the work rest

73 between control wheels 41 and 72. In doing this the operator with his right hand will thrust the work piece endwise against stop 80 and will lay a truly round end section of the work piece near its surface that is to be ground within the notch of furcate guide plate 110 in outboard relation to the control throat of the carrier formed by rest 73 and control wheels 41, 42. Then the work piece is without support or interference with its desired concentricity of rotation at any point between the aforesaid control throat and the guide plate 110. Upon releasing handle 95, spring 94 causes the presser wheel 72 to thrust work piece 67 against the driving wheel 41 and slightly downward against the stationary rest 73. The latter is adjusted to a vertical height such that its center is preferably no higher than the center of rotation of at least one of the control wheels 41 and 72. Stop screw 92 will be observed in Fig. 8 not to interfere with the pressing of wheel 72 against the work piece. However, in the absence of the work piece this screw will come into play to prevent contact between wheel 72 and the edge of work rest 73.

With the work piece 67 supported jointly by the control throat of the carrier and guide plate 110, the power driven rotation of the work driving wheel 41 will impart high speed rotation to the work piece 67 and at the same time will exert a component of force on the work piece lengthwise thereof toward stop 80 because of the skewed disposition of wheel 41 clearly shown in Fig. 5. If desired, wheel 146 may be correspondingly skewed to strengthen the urge of the rotating work piece against stop 80. In Fig. 5 it is also to be observed that wheel 41 preferably bears laterally against the periphery of the work piece at points at least partially offset in an axial direction toward the toe end of the carrier with respect to presser wheel 72. This constantly biases the end of the work piece that rests in guide plate 110 against the vertical edge 111 of the notch in such guide plate while the work piece is rotating. The work piece 67 is thus urged by the cooperative action of control wheels 41 and 72 downward against both the rest 73, and sidewise against the vertical edge 111 of the notch in the guide plate 110, as well as rearward against stop 80.

With the work piece so supported and in rapid rotation, the operator may easily grasp steering handle 135 with his right hand and may grasp any convenient portion of the heel end of the carrier with his left hand and under the control of both hands shove the carrier bodily about the table surface 34 in random directions to and from, as well as across, the face 13 of the grinding wheel. However the proximity of the carrier to the grinding wheel is limited and predetermined in all angular dispositions by the abutting of pattern edge 138 of pattern toe 136 against the stationary work sizing or baffle plate 138. Hence if this toe of the carrier is thrust toward the grinding wheel as far as plate 138 permits while the heel end of the carrier is swung from left to right and vice versa in Fig. 1, the grinding wheel will impart to the end of the work piece a crowned contour or a profile shape that duplicates the two-dimensional curvature of pattern edge 138 in a three-dimensional form of work because the work piece itself is rapidly being rotated by a power source that is independent of the grinding wheel. At the same time an exact desired overall length will be produced in the finished work piece because it always re-

mains in endwise contact with stop 80 and the distance from the latter to pattern toe edge 138 is an adjustable constant.

Operation of pivot anchored two-wheel swinging carrier

In Fig. 2, the same two-wheel planchette or gliding carrier is shown as is shown in Figs. 1 and 4 to 9, inclusive. In Fig. 2, however, the single carrier leg 127 near the heel end of the carrier is rotatably journaled in a vertical bearing hole 133 in the pivot block 132 that is made fast to the table surface 34. This permits the carrier to glide about on table surface 34 as in Fig. 1 except that all parts of the carrier, together with its carried work piece, are constrained to move solely in circular paths about the vertical axis of leg 127. This more or less stations the work piece control throat of the carrier but permits those portions of the work piece that are in outboard relation to such grinding throat to be swung toward and away from the abrading surface 13 of grinding wheel 12. If it is desired to predetermine the finished cylindrical or conical size of work thus fed against the grinding wheel, a stationary work sizing block 134 may be fixed on the table surface 34 to be contacted by a stop screw 140 threading crosswise through the carrier leg 126 and locked in adjusted position by nut 143.

Construction of three-wheel planchette carrier

Figs. 3, 11, 12 and 13 show a work carrier differing from the two-wheel carrier of Figs. 1, 2 and 4 to 10, inclusive, in several respects. One point of difference is the elimination of the stationary work rest blade 73 and the substitution of a third wheel for supporting the weight of the work piece and determining the height level at which the work piece will be rotated. Another difference is in combining in a single wheel the functions of a power drive wheel and of a retractable presser wheel. Another feature is the provision of an ejector for the work piece with which the two-wheel carrier might also be equipped. Other differences reside in placement of an upstanding, carrier manipulating, steering handle at the heel end of the carrier instead of at the toe end, and in the placement of two of the three carrier supporting legs at the heel end of the carrier while the third supporting leg is located at the toe end of the carrier nearest the grinding wheel.

Referring to the specific construction of the carrier shown in Figs. 3, 11 and 12, the main frame bar of the carrier is designated 97', as in the two-wheel planchette type of carrier. The points of difference between the two-wheel and three-wheel carriers reside partly in differing arrangements of shiftable sections of the carrier superstructure which derive their support in common from frame bar 97'. There is no substantial change in the furcate guide plate 110, except that its vertical notch edge 111 is interchanged with its oblique or sloping notch edge 112. As in the two-wheel carrier its support bracket 113 is clamped by screw 114 to the saddle slide 118 fastened by a screw clamped gib like 120.

Also similar in construction to the two-wheel carrier is the horizontal stop rod 80 for the work piece adjustably supported in its post 82 and fastened therein by set screw 83. Post 82 as hereinbefore described is fastenable in chosen vertical positions on its standard 84 by clamp screw 71 while standard 84 is adjustably mounted on slide

102 which is shiftable lengthwise of frame bar 97' and can be fastened thereto by a screw clamped gib. An upstanding steering handle 135' for maneuvering the carrier is set rigidly into the frame bar 97' at the heel end of the carrier as best shown in Figs. 3 and 11. The supporting legs 125, 126 on cross bar 129 are fastened to the frame bar 97' in a location approximately beneath the work piece control wheels. The single leg 127, instead of screwing directly into frame bar 97', screws into a slide 139 that fastens to frame bar 97' at chosen points along its length by means of a conventional gib and clamp screw.

The three-wheel carrier makes use of a rocker sub-frame 144, similar to 85 in the two-wheel carrier, similarly having a tilting base 145 like 86 in the two-wheel carrier equipped with an adjustable stop screw 92 and lock nut 93 adapted to abut against saddle block 91 to limit the counter-clockwise tilting of sub-frame 144 in Fig. 12. Rocker frame 144 tilts on hinge bolts 90' passing through its flanges 89'.

However, in Figs. 3, 11 and 12, the work driving wheel 146 is carried by rocker frame 144 and thereby serves at the same time as a presser wheel since it is constantly thrust toward the left against the work piece 67 in Fig. 12 by the pull of spring 94 on the rocker arm 96 of handle 95. In this arrangement the tubular extension 43 of the housing 44 of power transmission unit 45 is clamped in a split bearing 74' fast to rocker frame 144 and whose cap piece 75' is removable by loosening clamp bolts 76'.

The upper control wheel 147 of the three-wheel set functions as an axial thrust exerting wheel, whose stub shaft 148 is given bearings, which may be of the ball or roller type, in a top bearing bracket 149 which can swivel adjustably about the axis of a clamp bolt 150 that passes through a central clearance hole in the frame bracket 157 and threads into bearing bracket 149. When clamp bolt 150 is tightened the idler wheel 147 is stationed bodily with its axis of rotation disposed at any chosen angle of deviation from true horizontal disposition that will cause idler wheel 147 to be skewed in such direction as to urge work piece 67 constantly endwise against the stop rod 80 during its rotation as shown in Fig. 11.

Referring now to the additional lower or third wheel of the three-wheel carrier, this may aptly be termed the work supporting wheel 157 whose stub shaft 158 like stub shaft 148 of idler wheel 147 is journaled in anti-frictional bearings in a lower bearing bracket 159. In the manner of bearing bracket 149, bearing bracket 159 can swivel about the axis of a clamp bolt 160 passing through a clearance hole in frame bracket 151 and threading into bearing bracket 159. When clamp bolt 160 is tightened the work supporting wheel 157 is stationed bodily with its axis of rotation disposed at any chosen angle of deviation from true horizontal disposition that will cause the work support wheel 157 to be skewed in a direction serving constantly to urge work piece 67 endwise against the aforesaid stop rod 80.

A further feature of the three-wheel carrier, which can as well be introduced into the two-wheel type of carrier, is the provision of a work ejector 165 comprising an upstanding metal plate having a shelf-like bent-over top margin underlying work piece 67. This plate is provided with two elongated slots 166 penetrated by holding screws 167 that thread into the handle arm 96. Slots 166 make the work ejector 165 vertically adjustable on handle arm 96 so that when the lat-

ter is swung upward for retracting the combined work driving and presser wheel 146 from the work piece, the work piece is lifted away from its support wheel 157 to a more accessible position for reaching it and removing it from the carrier. Also ejector 165 prevents the work piece from dropping too low, while wheel 146 is retracted to its broken line position in Fig. 12, to permit restoration of this wheel to its full line position when urged toward the left in Fig. 12 by wheel 146.

Operation of three-wheel rail guided planchette carrier

Referring particularly to Fig. 3, the three-wheel planchette carrier of Figs. 11 and 12 is shown resting upon and free to slide in a guided straight direction, that may be perpendicular to the axis of rotation of grinding wheel 12, toward and away from the abrading surface of the grinding wheel while it constrains and rotates the work piece 67. Guiding of the carrier movement is afforded by a parallel edge rail 141 against whose respectively opposite edges two of the carrier legs 126 and 127 will be held in sliding contact as the operator shoves the carrier toward and away from the grinding wheel. For so moving the carrier a steering handle 135' is provided at the heel end of the carrier to be conveniently grasped by either hand of the operator while his other hand is left free to grasp any convenient portion of the toe end of the carrier so that the work feeding movement of the carrier will be under the joint control of both hands of the operator.

This set-up of grinding machine, making use of my improved planchette carrier, is particularly suited to grinding flat ends on rod-like or slender, spindle types of work pieces. The overall length of the finished work piece can be predetermined accurately by direct contact of toe leg 127 with stationary baffle or work sizing plate 137 that is fixed on the grinding machine table 30. Stop 80 will be pre-adjusted to the proper distance from leg 127 to give the desired length to the finished work piece. If desired an adjustable stop screw like 140 may project from leg 127 into contact with baffle plate 137 to permit sizing of the work piece length by pre-adjustment of such stop screw. The fact that the work piece is being rapidly rotated simultaneously with the rotation of the grinding wheel and about an axis perpendicular to the axis of rotation of the grinding wheel will result in a perfectly flat surface being smoothly ground on the end of the work piece. The center of the work piece should be on a common height level with the center of rotation of the grinding wheel.

The manner of placing work piece 67 in the three-wheel carrier of Figs. 3, 11 and 12 does not differ in any important respect from the manner of loading the two-wheel carrier with its work piece. In both cases the handle 95 is lifted to retract the presser wheel 146, which in a three-wheel carrier is also the work driving wheel, away from idler wheel 147 and work supporting wheel 157. With the wheel 146 so retracted the work piece 67 can be deposited in the notch of guide plate 110 and temporarily rest upon the ejector 165 between the control wheels. As in the two-wheel carrier, the work piece will be thrust endwise into abutment with its stop 80 after which handle 95 will be permitted to drop under the urge of spring 94'. Thereupon, as the work ejector 165 correspondingly drops, presser wheel 146 will move in and constrain the work piece in its position shown in Fig. 12 in which position it

13

rolls in simultaneous contact with all three of the control wheels while centered therebetween in the control throat of the carrier. When the grinding process is completed the carrier is drawn bodily away from the grinding wheel and the handle 95 again lifted whereupon ejector 165 rises and lifts the work piece 67 clear of the control throat of the carrier so that it can easily be reached and removed therefrom.

Construction of hinge base for work carriers

Any one of the work carriers illustrated in Figs. 1, 2 and 3 may be mounted in a manner to be manually swingable about an adjustably stationed horizontal axis for plunging the work against the grinding wheel as shown in Fig. 13. As an example the frame bar 97 in Figs. 14, 15 and 16 is shown to be seated fixedly in the groove 169 of a rockable yoke 170 pivotally supported on a hinge base 171. Base 171 may be a simple slab-like block adjustably fastened on the table top 34 by clamp bolts such as 172 cooperative as usual with a T-slot 35 in table 30.

Yoke 170 is rigid and includes downward directed hinge legs 173 at its ends, each of which receives a pivot pin 174 longitudinally adjustable therein and fixed to the leg by set screw 175. Pins 174 are cone pointed at their inner ends to seat pivotally in conical bearing holes in the edges of base 171. Thus yoke 170 is given adjustably tight hinged connection to base 171 so as to be rockable relatively thereto about the common horizontal axis of pivot pins 174 in a manner to move work piece 67 toward or away from the abrasive face 13 of grinding wheel 12.

The rocking movement of yoke 170 toward the grinding wheel may be limited positively to an adjustable degree predetermined by stop screw 176 threading through a bracket 177 fixed on base 171. The rocking movement of yoke 170 is accomplished manually under finely modulated control by means of a rotary cam 178 acting on a stiff arm 179 that is adjustably fixed on yoke 170 by set screws 180. A spring 181 yieldingly urges arm 179 downward constantly against cam 178 whose operative peripheral contour in Fig. 15 includes a quick lifting spiral arc 178', a slow lifting spiral arc 178'' and a circular arc of dwell 178''' concentric with the axis of rotation of the cam.

The hub of cam 178 is fixed by set screw 185 on the cam shaft 186 in each of whose ends is a conical bearing hole occupied by a cone pointed bearing pin 187 similar to 174. Bearing pins 187 are fixed respectively in upstanding posts 188 made fast to base 171 by screws 190. Also fixed on cam shaft 186 by set screw 199 is a cam operating handle 191. Set screws 192 secure pins 187 in posts 188.

Work feeding operation of carrier on hinge base

The following description of the manner of manually feeding work against the grinding wheel by means of the cam handle 191 in Fig. 13 will be understood to be as fully applicable to the two-wheel carriers of Figs. 1 and 2 as to the three-wheel carrier of Fig. 3, and the frame bar 97 of all types of carriers herein disclosed may be fixedly seated interchangeably by set screws in yoke groove 169. In Fig. 13 the work piece 67 is supported by the carrier of Figs. 11 and 12 with its axis at a level preferably not higher than that of the center of grinding wheel 12 and with its peripheral face which is to be ground disposed to meet the abrasive face 13 of the grinding wheel when yoke arm 179 is swung

14

upward about pivot 174 to its broken line position in Fig. 15 and disposed to be spaced from the grinding wheel when yoke arm occupies its full line position in Figs. 14 and 15.

The operator, as herebefore described, first lifts handle 95 to open the work receiving throat of the carrier and with the work driving presser wheel 146 thus retracted to its broken line position in Fig. 12 lays work piece 67 in place with its outboard end resting in the notch of furcate guide plate 110. When handle 95 is released the work will be rotated on its own axis and biased endwise against stop 80 and biased laterally against the straight edge 111 of guide plate 110, all by the cooperative action of the power rotated work control wheels 146, 147 and 157. While the work piece is so rotating, the operator lifts the work feeding cam handle 191 which turns cam 178 counter-clockwise about pivot 187 from its full line position in Figs. 14 and 15 toward its broken line position in Fig. 15. At the beginning of this movement of the cam, its "quick rise" peripheral arc 178' plunges the work quickly toward and into initial contact with face 13 of the grinding wheel. Thereafter, continued turning of cam 178 causes its "slow-rise" peripheral arc 178'' to act on arm 179 and thereby to more slowly and with greater leverage force the work against the grinding wheel while it is being ground down to size. The ultimate size of the ground work piece is determined by contact of arm 179 with the largest radius of cam 178 in the latter's circular arc of dwell 178'''. The operator by means of handle 191 will hold the cam so positioned until final sparking has died out. Stop screw 176 insures against accidental overthrow of the carrier and the work piece toward the grinding wheel. When all sparking has died out handle 191 will be lowered and the consequent turning of cam 178 back to its full line position in Figs. 14 and 15 will be followed by rocking of yoke 170 in a clockwise direction in those figures under the urge of spring 181. This removes the work piece 67 from contact with the grinding wheel, after which the finished work piece will be released from the control throat of the carrier and in part ejected therefrom as before explained by manually lifting handle 95.

Modifications

From the foregoing examples of carriers for rotating a work piece on the centerless support principle while presenting it free of prop by the grinding wheel to the abrading surface of the latter, it will be apparent that the use of the two-wheel carrier is optional with use of the three-wheel carrier, the former tending to greater dependability in extreme accuracy of location of the work piece center while the latter is capable of imparting stronger driving torque for rotating the work piece.

While for simplicity of illustration the work piece referred to in the foregoing has been shown and described as an integral rod like spindle of relatively long and slender proportions, the present invention may be practiced and its advantages availed of in the grinding of work pieces that are very short in axial extent and of work pieces that are diametrically larger or smaller than the work piece 67 shown in the drawings.

The relative directions of rotation of the rod 67 and of the grinding wheel 12 may be selected at the choice of the operator depending on the kind of grinding operation it is desired to per-

form. The materials of which 41 and 72 or wheels 146, 147 and 157 may be made will depend upon which of these wheels are to impart rotary torque to rod 67. Hard rubber or composition materials having a surface of high frictional properties may be preferable for the driving wheels. The other or prop wheel or wheels may be of metal as hard as the rod or tube 67 and polished for perfect surface smoothness.

These are but instances of many varieties of construction that may be resorted to for seizing upon the novel principles underlying the invention wherefore the following claims are directed to and intended to cover all substitutes and equivalents for the specific constructions herein disclosed that come fairly within the definitions of the claims.

I claim:

1. A centerless grinder, comprising a base, a slide movably mounted on said base, a grinding wheel supported rearwardly of said base and projecting above said slide, a pair of spaced apart work supporting rolls mounted vertically one above the other on the slide, a frame pivoted to said slide adjacent said work supporting rolls, a work driving roll mounted in the frame for movement toward and away from said work supporting rolls in an approximately horizontal direction for gripping a work piece therebetween at three circumferentially spaced points, drive means for driving said work driving roll, and means for yieldingly urging said work driving roll toward said work supporting rolls.

2. The method of centerless grinding by means of a fast moving abrasive surface which comprises, pressing in radially opposed directions upon the circular periphery of an axially elongated round work piece at respectively different pressure points therealong that are relatively disaligned in an axial direction with a roller force of sufficient frictional cling to rotate the work piece about an axis encompassed by its own periphery thereby to urge said axis of the rotating work piece in a swinging direction, and nesting against relatively fixed supporting surfaces of a stationary constraining abutment at least two circumferential points in the periphery of a different section of the length of the rotating work piece axially spaced from said pressure points, and presenting into abrading contact with said fast moving abrasive surface the revolving periphery of a still different section of the length of said work piece axially displaced from all of said points.

3. The method of centerless grinding in pattern guided relation to a fast moving abrasive surface which comprises, pressing in radially opposed directions upon the circular periphery of an axially elongated round work piece at respectively different pressure points therealong that are relatively disaligned in an axial direction with the aid of a roller force of sufficient frictional cling to rotate the work piece about an axis encompassed by its own periphery thereby to urge said axis of the rotating work piece in a swinging direction, nesting against relatively fixed supporting surfaces of a stationary constraining abutment at least two circumferential points in the periphery of a different section of the length of the rotating work piece axially spaced from said pressure points, presenting into abrading contact with said fast moving abrasive surface the revolving periphery of a still different section of the length of said work piece axially displaced from all of said points, and conveying said rotating support-

ingly nested work piece bodily in pattern guided relation to the fast moving abrasive surface.

4. The method of centerless grinding by means of a fast moving abrasive surface which comprises, pressing in radially opposed directions upon the circular periphery of an axially elongated round work piece at pressure points sufficiently offset lengthwise thereof to urge the axis of the work piece in a swinging direction with the aid of a roller force of sufficient frictional cling to rotate the work piece about an axis encompassed by its own periphery said force being directed at sufficient obliquity to said axis to urge the work piece in a lengthwise direction, nesting against relatively fixed supporting surfaces of a stationary constraining abutment at least two circumferential points in the periphery of a different section of the length of the rotating work piece axially spaced from said pressure points, and presenting into abrading contact with said fast moving abrasive surface the revolving periphery of a still different section of the length of said work piece axially displaced from all of said points.

5. In a grinding machine having a fast moving abrasive surface, a maneuverable carrier affording centerless support and constraint for an elongated work piece of circular periphery while the work piece is conveyed and rotated by said carrier with respect to said abrasive surface, comprising the combination of, a carrier frame pivotally mounted on said machine for swinging movement about a vertical axis relative to said abrasive surface, a set of roller wheels rotatably mounted on said carrier frame arranged for simultaneous rolling contact with horizontally opposite sides of the periphery of the work piece at least one of which wheels is a driving wheel having a surface of sufficient frictional properties to rotate the work piece, a stationary support below the horizontal level of peripheral contact of said wheels with the work piece underlying and thereby adapted to bear the entire weight of the work piece in a manner to determine the level at which the work piece will be maintained while being rotated by said wheels, a source of power supported apart from said carrier frame, and mechanical means operatively coupled to said driving wheel arranged to transmit power thereto from said source during bodily movement of said carrier frame.

6. In a grinding machine having a fast moving abrasive surface, a maneuverable carrier affording centerless support and constraint for an elongated work piece of circular periphery while the work piece is conveyed and rotated by said carrier with respect to said abrasive surface, comprising the combination of, a carrier frame pivotally mounted on said machine for swinging movement about a horizontal axis relative to said abrasive surface, a set of roller wheels rotatably mounted on said carrier frame arranged for simultaneous rolling contact with horizontally opposite sides of the periphery of the work piece at least one of which wheels is a driving wheel having a surface of sufficient frictional properties to rotate the work piece, a stationary support below the horizontal level of peripheral contact of said wheels with the work piece underlying and thereby adapted to bear the entire weight of the work piece in a manner to determine the level at which the work piece will be maintained while being rotated by said wheels, a source of power supported apart from said carrier frame, and me-

chanical means operatively coupled to said driving wheel arranged to transmit power thereto from said source during bodily movement of said carrier frame.

7. Centerless grinding apparatus for bodily maneuvering an elongated circular work piece in relation to the power driven abrasive surface of a grinding machine while peripherally supporting and rotating such work piece without assistance from said abrasive surface, comprising in combination with the abrasive surface of the grinding machine, a stationary grinding machine frame, a work carrier supported by said frame in a manner to be movable bodily in relation to said abrasive surface, a set of wheels rotatably mounted on said work carrier arranged for peripheral rolling contact simultaneously with horizontally opposite sides of the circular work piece, at least one of said wheels being power driven, a stationary support below the horizontal level of peripheral contact of said wheels with the work piece constructed and arranged to underlie and bear the entire weight of the work piece in a manner to determine the level at which the work piece will be maintained while rotated by said wheels, an upright stop surface fixed on said stationary frame of the grinding machine, and a pattern toe carried by and projecting from said work carrier having a convex contour adapted to rock against said stop surface in a manner restricting the approach of said carrier toward said abrasive surface.

8. In a grinding machine including a fast moving abrasive surface, apparatus affording centerless support and constraint for an elongated work piece of circular periphery while the work piece is rotated with respect to said abrasive surface without propping thereby, comprising in combination with said abrasive surface, plural rotors arranged for simultaneous rolling contact with the periphery of the work piece at opposite sides thereof and at points relatively offset axially of the work piece thereby to impart to the rotating work piece a bias tending to cause swinging of the latter's length in a lateral direction, and a stationary abutment displaced from said rotors axially of the work piece having a constraining face arranged to oppose and limit said swinging of the rotating work piece in said direction thereby to establish fixity of the axis of the rotating work piece.

9. In a grinding machine having a fast moving abrasive surface, a maneuverable carrier affording rolling support and constraint for an elongated work piece of circular periphery while the work piece is conveyed and rotated by said carrier with respect to said abrasive surface, comprising the combination of, a carrier frame supportable on said machine for free-roving movement relative thereto in random directions at will relative to said abrasive surface, a set of rotors arranged for simultaneous rolling contact with the periphery of the work piece at least one of which rotors is a work-driving wheel, a bearing in which one of said rotors is rotatably supported, structure supporting said bearing movably on said free-roving frame in a manner to convey one of said work contacting rotors toward and away from the work piece, a source of power supported apart from said carrier frame, and a flexible shaft connected to said source of power and extending from a relatively high level downward into operatively coupled relationship to one of said wheels thereby to transmit power to the latter from said

source of power, said flexible shaft being long enough to trail and permit free bodily movement of said carrier frame into an unlimited variety of positions of said carrier relative to said abrasive surface.

10. In a grinding machine having a fast moving abrasive surface, a maneuverable carrier affording rolling support and constraint for an elongated work piece of circular periphery while the work piece is conveyed and rotated by said carrier with respect to said abrasive surface, comprising the combination of, a carrier frame supportable on said machine for bodily movement relative to said abrasive surface, a set of rotors including at least two roller wheels at least one of which is a work-driving rotor and includes a wheel surface of sufficient frictional properties to rotate the work piece said roller wheels being rotatably mounted on said carrier frame and arranged for simultaneous rolling contact with the periphery of the work piece, a bearing on said frame in which one of said wheels is rotatably supported, a source of power supported apart from said carrier frame, and a flexible shaft operatively coupled to one of said wheels and arranged to transmit power thereto from said source of power while permitting free bodily movement of said carrier frame, together with a stationary work support underlying a gap between said wheels in a position to limit the depth to which the said work piece can sink while being rotated in rolling contact with said wheels.

11. In a grinding machine having a fast moving abrasive surface, a maneuverable carrier affording rolling support and constraint for an elongated work piece of circular periphery while the work piece is conveyed and rotated by the carrier with respect to the abrasive surface, comprising the combination of, a carrier frame supportable on said machine for bodily movement relative to said abrasive surface, a set of rotors comprising at least three roller wheels arranged for simultaneous rolling contact with the periphery of the work piece at least one of which wheels has a surface of sufficient frictional properties to rotate the work piece and at least one of which wheels sufficiently underlies a gap between two others of the wheels to limit thereby the depth to which the work piece can sink while being rotated in rolling contact with all of said wheels, three bearings on said carrier frame in which said three wheels are respectively journaled, connections constructed and arranged to permit at least two of said rotors to be shifted to selected degrees of skewed disposition relative to each other and to said third wheel, a source of power supported apart from said carrier frame, and a flexible shaft operatively coupled to one of said wheels and arranged to transmit power thereto from said source of power while permitting free bodily movement of said carrier frame.

12. In a grinding machine having a fast moving abrasive surface, a maneuverable carrier affording rolling support and constraint for an elongated work piece of circular periphery while the work piece is conveyed and rotated by said carrier with respect to said abrasive surface, comprising the combination of, a carrier frame supportable on said machine for bodily movement relative to said abrasive surface, a set of rotors rotatably mounted on said carrier frame arranged for simultaneous rolling contact with the periphery of the work piece at least one of which is a work driving rotor and includes a wheel sur-

face of sufficient frictional properties to rotate the work piece, a bearing on said frame in which said work driving rotor is rotatably supported, a source of power supported apart from said carrier frame, a flexible shaft operatively coupled to said driving wheel arranged to transmit power thereto from said source of power while permitting free bodily roving movement of said carrier frame, a stationary abutment face shaped and arranged on said carrier frame to engage a portion of said rotating work piece that projects in outboard relation to its locus of rolling contact with said roller wheels in a manner to limit movement thereof in at least one lateral direction, the respective points of rolling contact of said wheels with said work piece being relatively offset lengthwise of the work piece in a manner to impart to the latter a bias tending to swing said work piece portion in said lateral direction toward said abutment face, and a rotary bearing supporting at least one of said rotors movably mounted on said carrier frame in a manner to permit shifting of the rotor in directions toward and away from another of said rotor thereby to press said shiftable roller against or retract it from a work piece lying between the wheels.

13. In a grinding machine including a fast moving abrasive surface, apparatus affording centerless support and constraint for an elongated work piece of circular periphery while the work piece is rotated with respect to said abrasive surface without propping thereby, comprising in combination with said abrasive surface, plural rotors arranged for simultaneous rolling contact with the periphery of the work piece at opposite sides thereof and at points relatively offset axially of the work piece thereby to impart to the rotating work piece a bias tending to cause swinging of the latter's length in a lateral direction, and a stationary abutment displaced from said rotors axially of the work piece having a constraining face arranged to oppose and limit said swinging of the rotating work piece in said direction thereby to establish directional alignment of the axis of the rotating work piece, said abutment comprising a furcate rest of size and shape to permit rotary nesting therein of a portion of the rotating work piece that projects in outboard relation to its said points of rolling contact with said rotors.

14. In a grinding machine including a fast moving abrasive surface, apparatus affording centerless support and constraint for an elongated work piece of circular periphery while the work piece is rotated with respect to said abrasive surface without propping thereby, comprising in combination with said abrasive surface, plural rotors arranged for simultaneous rolling contact with the periphery of the work piece at opposite sides thereof and at points relatively

offset axially of the work piece thereby to impart to the rotating work piece a bias tending to cause swinging of the latter's length in a lateral direction, a stationary abutment displaced from said rotors axially of the work piece having a constraining face arranged to oppose and limit said swinging of the rotating work piece in said direction thereby to establish directional alignment of the axis of the rotating work piece, and a stop stationed in a position to contact with an end of the work piece at the opposite side of said rotors from said abutment.

15. In a grinding machine including a fast moving abrasive surface, apparatus affording centerless support and constraint for an elongated work piece of circular periphery while the work piece is rotated with respect to said abrasive surface without propping thereby, comprising in combination with said abrasive surface, plural rotors arranged for simultaneous rolling contact with the periphery of the work piece at opposite sides thereof and at points relatively offset axially of the work piece thereby to impart to the rotating work piece a bias tending to cause swinging of the latter's length in a lateral direction, at least one of said rotors being skewed in a manner to thrust the work piece longitudinally in a direction away from said abrasive surface while rolling in contact with the work piece, a stationary abutment displaced from said rotors axially of the work piece having a constraining face arranged to oppose and limit said swinging of the rotating work piece in said direction thereby to establish directional alignment of the axis of the rotating work piece, and a stop stationed in a position to contact an end of the work piece and to oppose the longitudinally directed thrust thereupon of said skewed rotor.

WILLIAM HORBERG.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,452,508	Hervig	Apr. 24, 1923
1,590,190	Heim	June 29, 1926
1,733,098	Kern	Oct. 22, 1929
1,803,984	Van Norman	May 5, 1931
1,814,361	Booth	July 14, 1931
2,264,179	Johnson	Nov. 25, 1941
2,269,805	Arter	Jan. 13, 1942
2,331,381	Ekstedt	Oct. 12, 1943
2,411,972	Melin	Dec. 3, 1946

FOREIGN PATENTS

Number	Country	Date
394,472	Germany	Apr. 17, 1924