Feb. 26, 1952 G. F. JOHNSON 2,586,953

MACHINE FOR END GRINDING ELONGATED WORKPIECES

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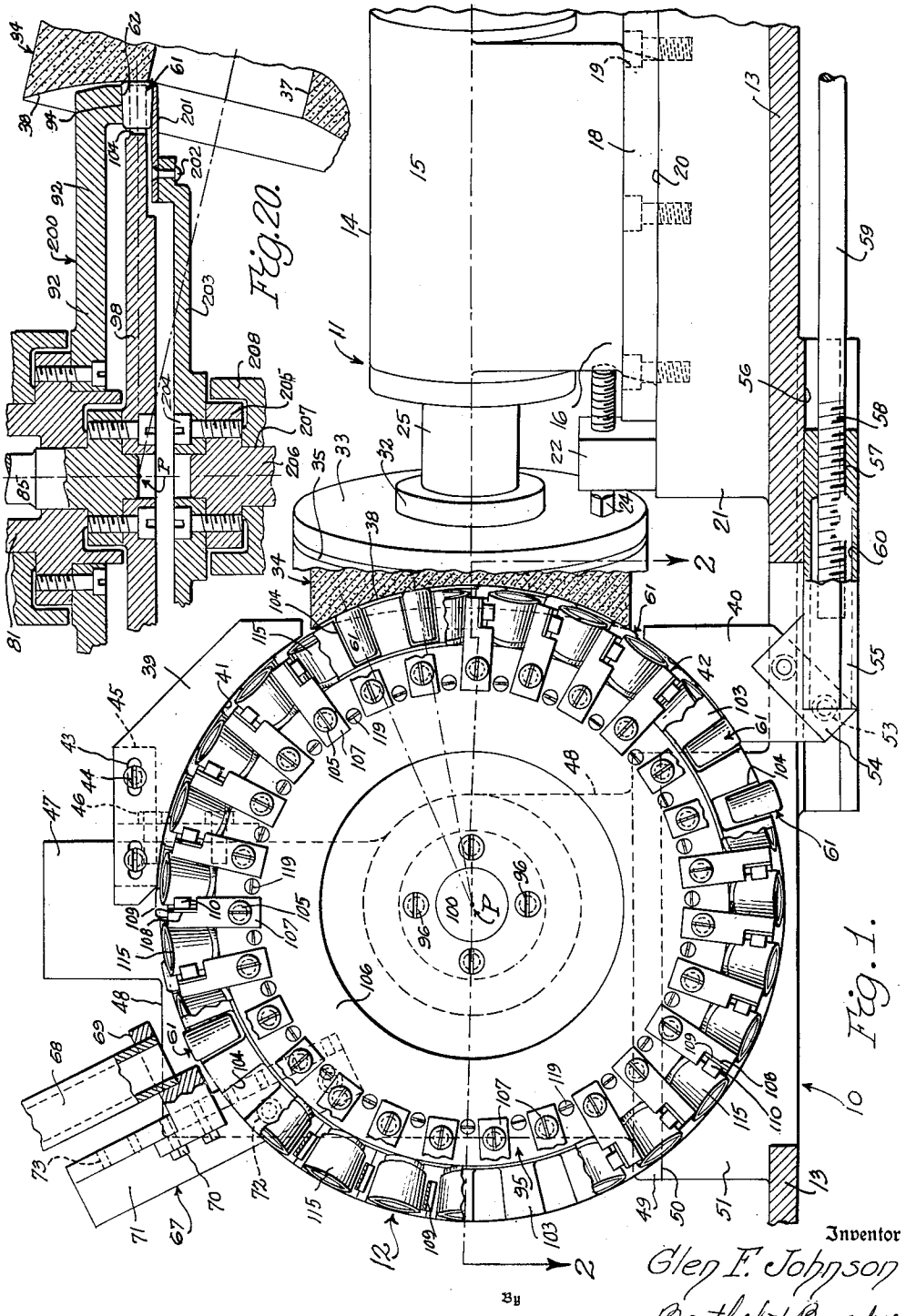


Fig. 1.

Fig. 2.

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5 Sheets-Sheet 2

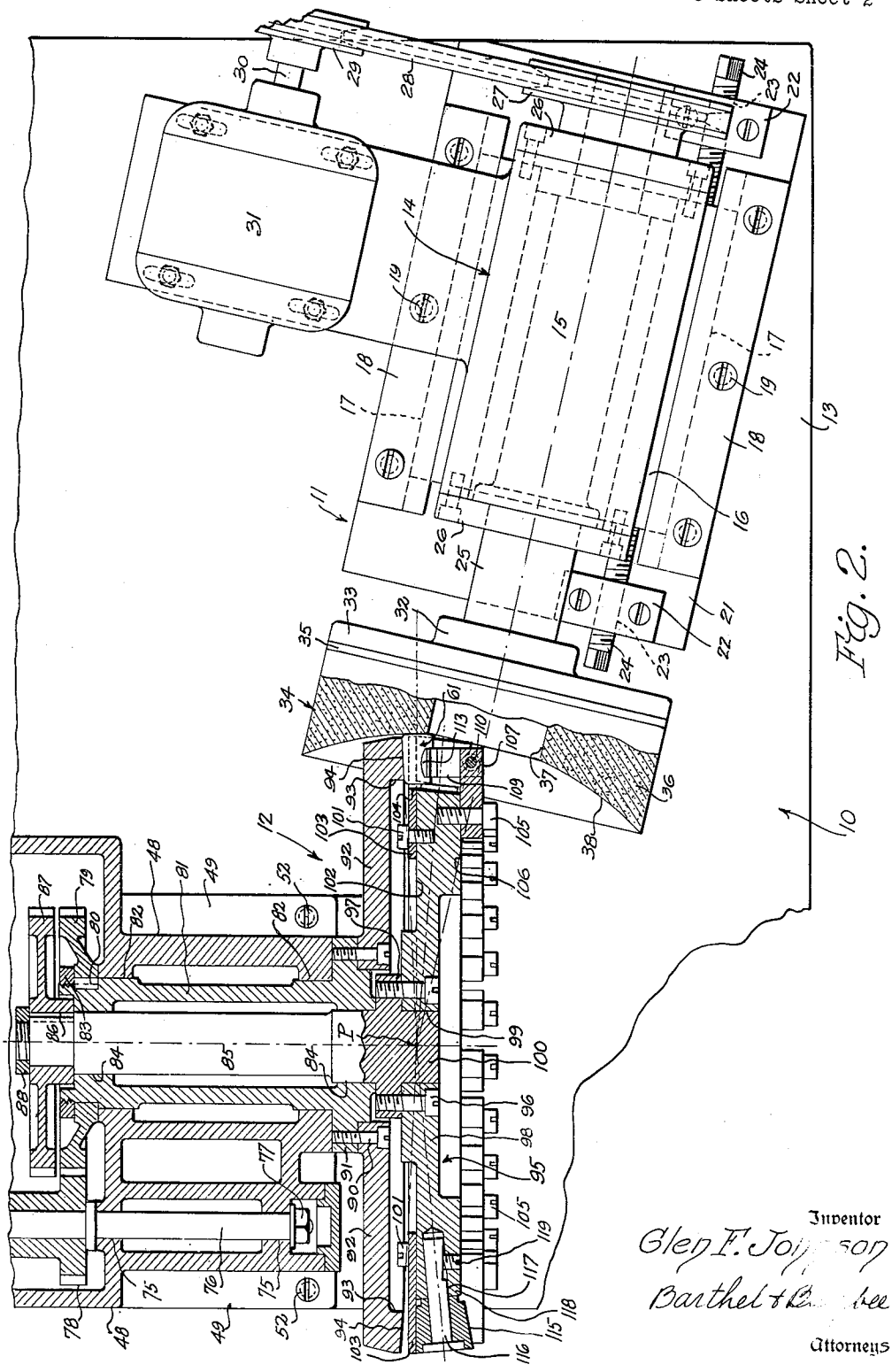


Fig. 2.

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MACHINE FOR END GRINDING ELONGATED WORKPIECES

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5 Sheets-Sheet 3

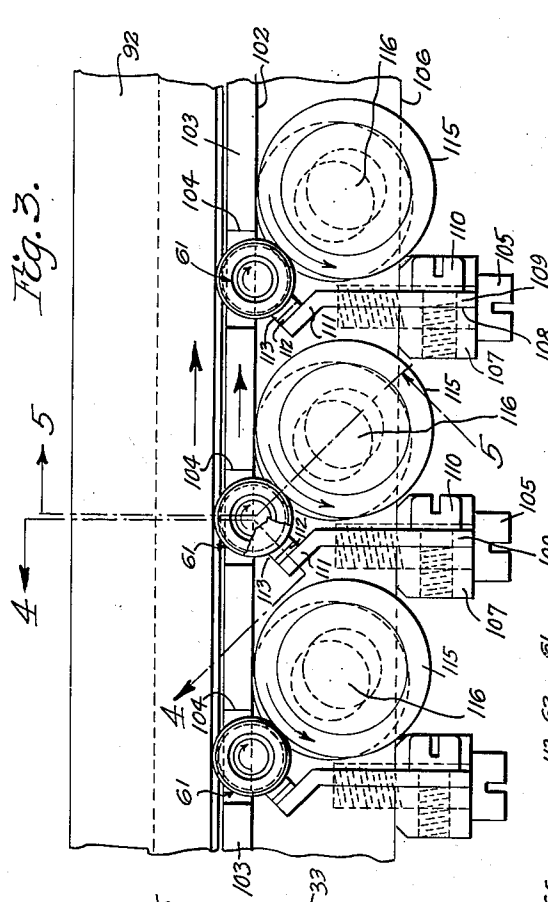


Fig. 3.

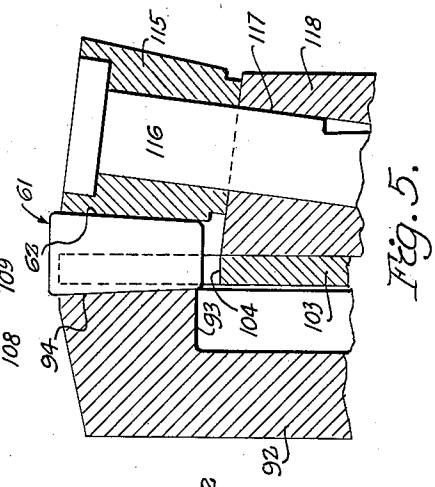


Fig. 5.

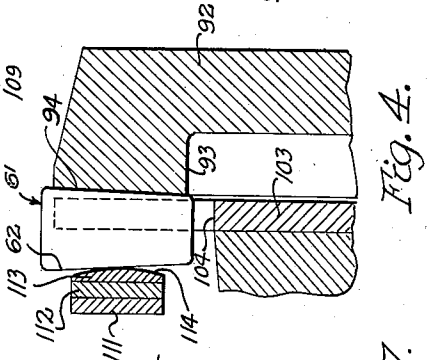


Fig. 4.

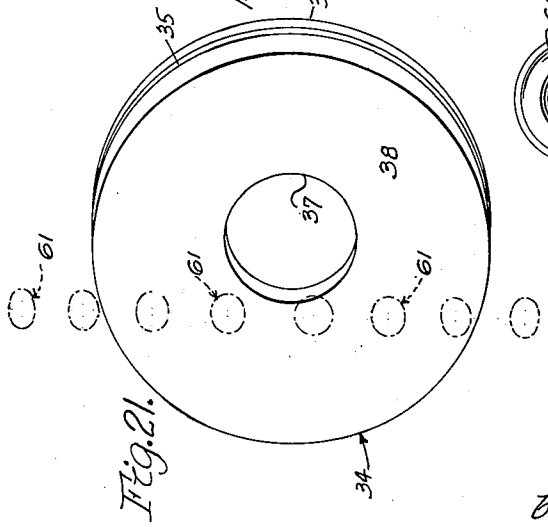


Fig. 2.

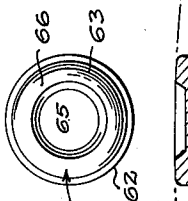


Fig. 6.

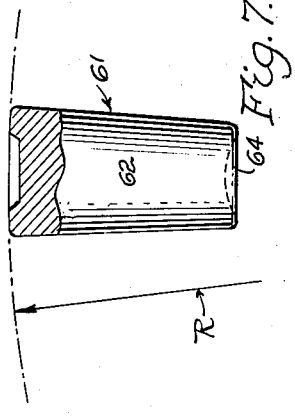


Fig. 7.

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MACHINE FOR END GRINDING ELONGATED WORKPIECES

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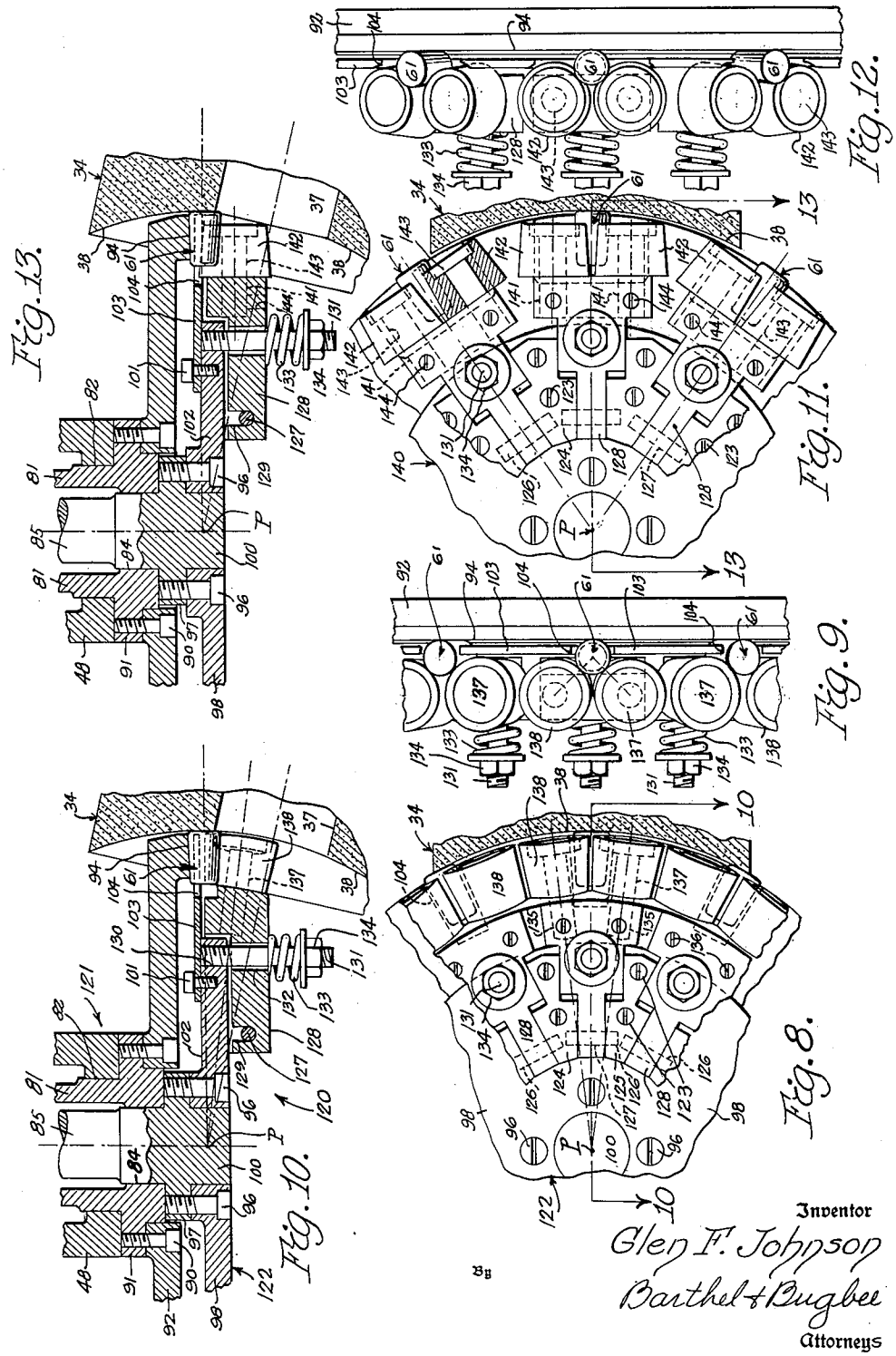


Fig. 12.

Fig. 11.

Fig. 9.

Fig. 8.

Fig. 13.

Fig. 10.

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MACHINE FOR END GRINDING ELONGATED WORKPIECES

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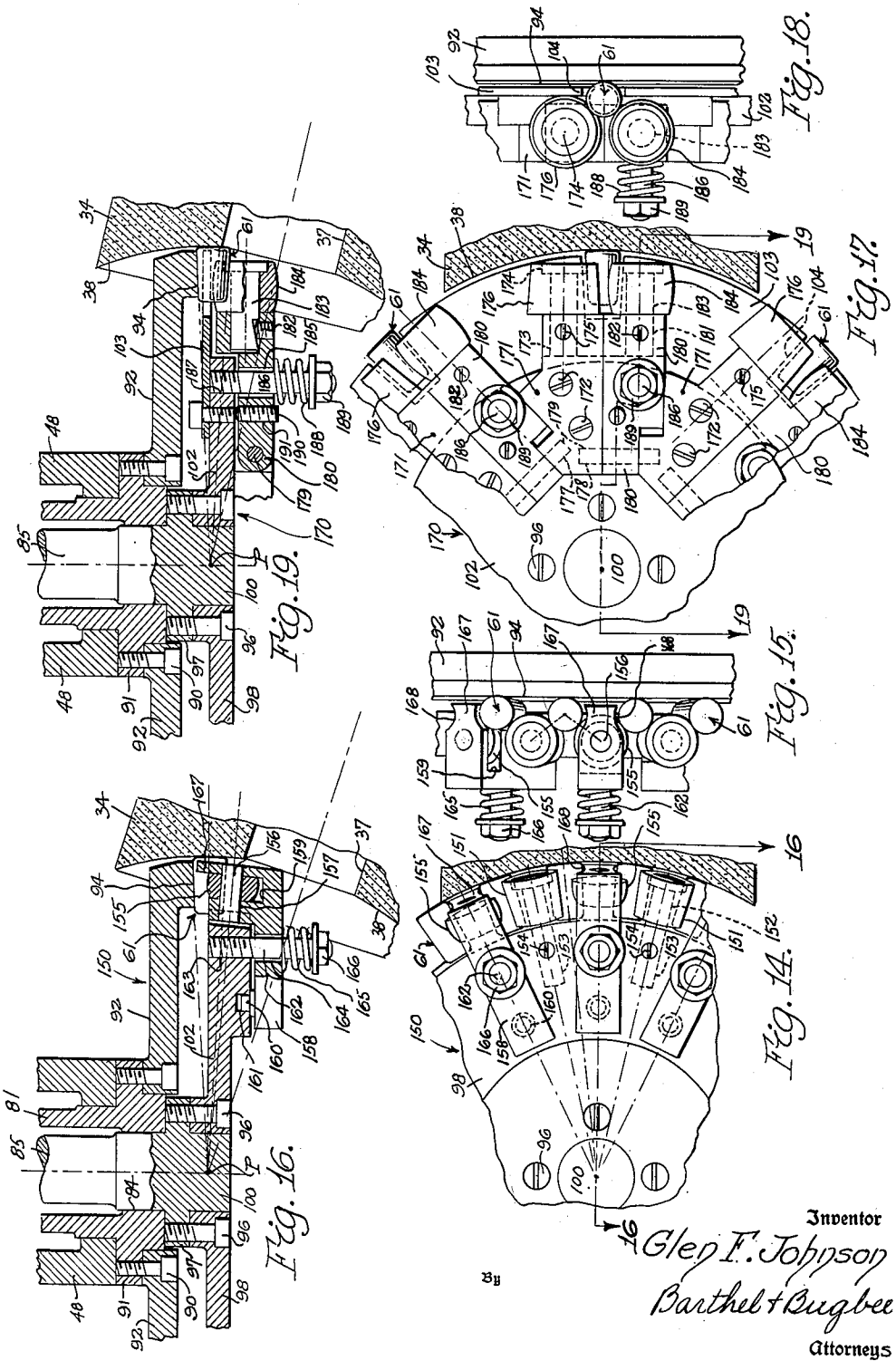


Fig. 18.

Fig. 17.

Fig. 19.

Fig. 15.

Fig. 16.

Fig. 14.

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Patented Feb. 26, 1952

2,586,953

UNITED STATES PATENT OFFICE

2,586,953

MACHINE FOR END GRINDING ELONGATED WORKPIECES

Glen F. Johnson, Detroit, Mich., assignor to Bower Roller Bearing Company, Detroit, Mich., a corporation of Michigan

Application February 2, 1949, Serial No. 74,197

17 Claims. (Cl. 51—134)

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This invention relates to grinding machines and, in particular to machines and methods for grinding curved surfaces upon the ends of rotatable workpieces such as tapered bearing rolls and other elongated articles.

One object of this invention is to provide an improved automatic machine for grinding curved surfaces upon the ends of elongated rotatable workpieces such as bearing rollers or other elongated articles in a rapid and efficient manner.

Another object is to provide an improved automatic machine for grinding curved surfaces upon the ends of elongated rotatable workpieces wherein the end of the workpiece is ground by surface contact with the grinding wheel or tool rather than by line contact, thereby producing a more accurate surface curvature in a shorter period of time.

Another object is to provide an improved automatic machine for grinding curved surfaces upon the ends of elongated rotatable workpieces wherein the workpiece holder and the grinding wheel are so constructed and arranged as to move the end of the workpiece and grinding wheel relatively to one another in a path lying between the axis of the grinding wheel and its periphery, thereby avoiding passing through the dead center of the wheel.

Another object is to provide an automatic machine for grinding curved surfaces on the ends of elongated rotatable workpieces wherein each workpiece is urged against the lateral periphery of a driving wheel or disc by one or more pressure rollers or by a pressure roller cooperating with a contact finger, with the result that the workpiece is rapidly rotated as its end is drawn across the curved face of the grinding wheel to be ground.

Another object is to provide an automatic machine for grinding curved surfaces on the ends of elongated rotatable workpieces, of the foregoing character, wherein the pressure rollers are resiliently mounted either in whole or in part so as to yieldingly urge the workpieces against the driving wheel.

Another object is to provide an automatic machine of the foregoing character for grinding curved surfaces on the ends of elongated rotatable workpieces wherein the axes of the pressure rollers converge toward and are concentric with the axis of the rotary workholder and preferably also the axis of the workpiece being ground, the surfaces of the pressure rollers being cylindrical, conical or barrel-shaped depending upon the arrangement and grinding conditions.

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In the drawings:

Figure 1 is a side elevation, partly in vertical section, of a roller grinding machine according to one form of the invention, with the grinding wheel and portions of the work holder broken away to disclose the internal construction;

Figure 2 is a top plan view, partly in approximately horizontal section along the line 2—2 in Figure 1, of the roller grinding machine shown in Figure 1;

Figure 3 is an enlarged top plan view of a peripheral portion of the workpiece holder of the roller grinding machine shown in Figures 1 and 2;

Figure 4 is an enlarged vertical section along the line 4—4 in Figure 3;

Figure 5 is a vertical section along the line 5—5 in Figure 3;

Figure 6 is a top plan view of a bearing roller after being end ground by the roller grinding machine of this invention;

Figure 7 is an enlarged side elevation, partly in central vertical section, of a workpiece such as a bearing roller after end grinding by the machine shown in Figures 1 and 2;

Figure 8 is a fragmentary side elevation of a grinding machine having a modified work holder from that shown in Figure 1;

Figure 9 is a fragmentary end elevation of the portion of the grinding machine work holder shown in Figure 8;

Figure 10 is an approximately horizontal section along the line 10—10 in Figure 8;

Figure 11 is a fragmentary side elevation, partly in vertical section, of a grinding machine with a further modified work holder;

Figure 12 is a fragmentary end elevation of the portion of the work holder shown in Figure 11;

Figure 13 is an approximately horizontal section along the line 13—13 in Figure 11;

Figure 14 is a fragmentary side elevation of a grinding machine with a still further modified work holder;

Figure 15 is a fragmentary end elevation of the work holder shown in Figure 14;

Figure 16 is an approximately horizontal section along the line 16—16 in Figure 14;

Figure 17 is a fragmentary side elevation of a grinding machine with a still further modified work holder;

Figure 18 is a fragmentary end elevation of the work holder shown in Figure 17;

Figure 19 is an approximately horizontal section along the line 19—19 in Figure 17;

Figure 20 is an approximately horizontal sec-

tion thru a still further modified work holder from that shown in the foregoing figures; and

Figure 21 is a diagrammatic elevational perspective view of the grinding wheel of the roller grinding machines of Figures 1 to 5 and 8 to 19 inclusive showing diagrammatically the path in which a workpiece is carried across the face of the grinding wheel by the work holder of the machine.

General construction

In general, the grinding machine of this invention consists of a saucer-shaped grinding wheel which is rotated upon an axis passing approximately through its center and against which the bearing rollers or other workpieces to be ground are brought by means of a rotary work-holder of special construction and of which several modifications are described herein. In general, however, the rotary work holder consists of a wheel-like or disc-like device having peripheral recesses into which the workpieces to be end ground are deposited one by one from a conventional feeding device forming no part of the present invention. The work holder is rotatably driven so as to carry the ends of the workpieces in an arcuate path across the curved surface of a grinding wheel which is being rotated on an axis passing approximately through the center of the grinding surface of the wheel. The workpieces are forcibly rotated by the annular lateral peripheral surface of a driving wheel which is likewise power driven so as to be forcibly rotated.

The workpieces to be end ground are forcibly urged against the driving wheel by one of several different forms of pressure-applying mechanism. The first form of the invention (Figures 1 to 5 inclusive) provides a tapered pressure roller cooperating with a contact finger having a tip of extremely hard wear-resisting material, such as tungsten carbide or its equivalent, to crowd the workpiece against the driving wheel. A second form (Figures 8 to 10 inclusive) provides a pair of tapered pressure rollers for each workpiece wherein each pair of rollers is resiliently mounted with the axes of the rollers converging toward and coincident with the axis of rotation of the carrier wheel. A third form of the invention (Figures 11 to 13 inclusive) provides paired pressure rollers resiliently mounted on parallel axes, the rollers being tapered reversely, that is, outwardly instead of inwardly. A fourth form of the invention (Figures 14 to 16 inclusive) provides single fixed pressure rollers alternating with single resiliently mounted pressure rollers with radial concentric axes, the resilient rollers being convexed or of bulging shape. A fifth form of the invention (Figures 17 to 19 inclusive) provides paired pressure rollers mounted on parallel axes, one roller of each pair being fixed and the other being resiliently mounted, one of the rollers having a barrel-shaped form. A sixth form of the invention (Figure 20) provides a rotary work holder wherein the workpieces are held against the lateral periphery of a rotary driving wheel by a resiliently rimmed pressure wheel or disc, thereby causing the end of the workpiece to move across the concave face of a grinding wheel.

Grinding unit and workpiece guides

Referring to the drawings in detail, Figures 1 to 5 inclusive show a grinding machine, generally designated **10**, consisting generally of a grinding unit, generally designated **11**, and a workpiece holding and driving unit, generally designated **12**, both units being mounted upon a base or bed **13**. The grinding unit **11** is common to all six forms of the invention, the different machines varying in the workpiece holding and driving unit **12**. The grinding unit **11** consists of a journal bearing structure **14** having a bearing housing **15** provided with a dovetail slide **16** slidable to and fro in dovetail grooves **17** formed by spaced parallel guide bars **18** secured as at **19** to the machined upper surface **20** of a boss **21** rising from the bed **13**. Also mounted upon and secured to the upper surface **20** of the boss **21** are blocks **22** internally threaded as at **23** to receive adjusting screws **24**. The inner ends of the adjusting screws **24** engage the opposite ends of the slide **16** so that by tightening one screw and loosening the other, the slide **16** and consequently the bearing housing **15** may be moved to and fro relatively to the guide bars **18** and locked in its adjusted position.

Rotatably mounted in suitable bearings (not shown) within the bearing housing **15** such as by tapered roller bearings (not shown) is a shaft **25**. End plates **26** are secured to the opposite ends of the bearing housing **15** and hold the journal bearing structure **14** in assembly.

Mounted on the rearward end of the shaft **25** (Figure 2) is a pulley **27** driven by a belt **28** from a pulley **29** mounted upon the armature shaft **30** of a motor **31**. The latter is bolted to the base **13**. Mounted on the forward end of the shaft **25** is the hub **32** of a rotary disc or face plate **33** which has a grinding wheel **34** secured to it, a disc **35** being interposed between the grinding wheel **34** and the face plate **33**. The grinding wheel **34** itself consists of an approximately cylindrical body **36** of abrasive material, such as silicon carbide or any other suitable abrasive. The body **36** is provided with a central recess **37** and an annular concave grinding surface **38** upon which the ends of the workpieces are ground as they pass across its face.

In order to guide the ends of the workpieces toward and away from the grinding surface **38** of the grinding wheel **34**, upper and lower workpiece guides **39** and **40** respectively are provided, these having arcuate guide edges **41** and **42** of substantially the same radius of curvature as the grinding surface **38**. The upper workpiece guide **39** is slotted as at **43** to receive fasteners **44** by which it is secured to the cross-bar of a T-bracket **45** which, in turn, is bolted as at **46** to a workpiece holder housing extension **47** (Figure 1). The housing extension **47** projects upward from the workpiece holder housing **48** which, in turn, is flanged as at **49** to rest upon and be secured to the machined upper surface **50** of an upwardly-extending boss **51**, as by the fasteners **52** (Figure 2). The boss **51** forms a part of the bed **13** and rises therefrom, approximately in the same level as the boss **21** supporting the grinding unit **11**.

The lower workpiece guide **40** is secured as at **53** to a projection **54** extending obliquely upward from a slide **55**. The slide **55** is reciprocable in guideways **56** and has a longitudinal threaded bore **57** adapted to receive the correspondingly threaded end portion **58** of an adjusting shaft **59**, the outer end of which is squared (not shown) or otherwise provided with means for its rotation in order to move the slide **55** to and fro and thereby adjust the position of the workpiece guide **40**. The interior of the slide **55** is hollowed out as at **60** beyond the threaded bore **57** in order to facilitate the free rotation of the shaft **55**.

The workpieces 61 (Figures 6 and 7) are shown, for purposes of illustration, as consisting of tapered anti-friction bearing rollers, the sides 62 of which are accurately conical and the upper end 63 is larger in diameter than the lower end 64. The upper end 63 is relieved by providing therein a recess 65 and this is surrounded by the annular ground area 66 produced by the action of the grinding wheel 34 and having a like radius of curvature R. The machine of the present invention, as previously stated, produces the annular curved surfaces 66 quickly and accurately by mass production methods.

Workpiece feeding unit

The workpieces, such as the tapered bearing rollers 61, are fed to the workpiece holding and driving unit 12 by a workpiece feeding unit generally designated 67 shown at the upper left-hand corner of Figure 1. The workpiece feeding unit 67 forms no part of the present invention and any suitable feeding unit may be used, such as that shown in the co-pending application of Charles L. Hommel, Serial No. 597,389, filed June 4, 1945, which issued as Patent No. 2,490,872 for Article Handling Apparatus. In this feeding unit 67, the workpieces 61 are fed haphazardly from a hopper through selecting mechanism which insures that the workpieces drop with their small ends downward into a delivery tube 68, the lower end of which is mounted upon a bracket 69 bolted as at 70 to an arm 71 which, in turn, is bolted as at 72 to the housing 48. The arm 71 is preferably of angle cross-section with one of its flanges having spaced holes 73 for adjustably receiving the bolts 70 in the location desired for the bracket 69 and delivery tube 68.

Workpiece holding and driving unit—first form

The first form of the workpiece holding and driving unit 12 (Figures 1 to 5 inclusive) includes a driving assembly, generally designated 74, mounted in the housing 48 bolted as at 52 (Figure 2) to the boss 51 on the bed 13, as previously described. Mounted in the coaxial bores 75 in the housing 48 is a stationary shaft 76 held in position by a nut 77 threaded on the forward end thereof and rotatably supporting a gear 78. The gear 78 meshes with a gear 79 mounted upon and keyed as at 80 to a hollow shaft 81 rotatably mounted in coaxial bores 82 in the housing 48. A retaining ring or collar 83 threaded upon the rearward end of the hollow shaft 81 holds the gear 79 in assembly. The hollow shaft 81 is, in turn, provided with coaxial bores 84 which rotatably support a shaft 85 to the rearward end of which is keyed, as at 86, a gear 87 held thereon by a retaining collar 88 threaded upon the extreme rearward end of the shaft 85. The gear 87 is driven through reduction gearing (not shown) at a greatly reduced speed relatively to the hollow shaft 81, such gearing being shown, for example, in the Johnson Patent 2,434,245, dated January 13, 1948, for Grinding Machine.

Bolted as at 90 to the head 91 on the forward end of the hollow shaft 81 (Figure 2) is a driving wheel 92 having an axially-projecting lateral annular portion 93 with a lateral tapered or inclined surface 94 corresponding to the taper of the sides 62 of the workpiece 61 (Figure 7). The surface 94 drivingly engages the workpieces 61 to rotate them while they are being held and moved downward across the grinding face 38 of the grinding wheel 34 by a workpiece holder generally designated 95.

The workpiece holder 95 is bolted as at 96 to a head 97 near the forward end of the shaft 85 and has a supporting wheel or disc 98 provided with a bore 99 by which it is mounted on the extreme forward end portion 100 of the shaft 85 (Figure 2). Bolted as at 101 to the rearward face 102 of the supporting wheel 98 is a workpiece holder or holding ring 103, the periphery of which is provided with spaced radial slots or notches 104 (Figures 1 and 3). The slots or notches 104 have circumferential widths slightly exceeding the widths of the workpieces 61, the latter fitting loosely as they drop therein from the feeding tube 68 (Figure 1).

Bolted as at 105 to the forward face 106 of the supporting wheel 98 at circumferentially-spaced intervals around the periphery thereof are radially-extending brackets 107. The outer ends of the brackets 107 are provided with lateral recesses 108 (Figures 1 and 3) in which axial arms 109 are bolted, as at 110. The inner ends of the arms 109 are bent obliquely, as at 111 (Figure 3) and to the bent portions 111 are secured the supporting discs 112 of contact buttons 113. The contact buttons 113 are provided with convex contact surfaces 114 (Figure 4) and are formed from extremely hard, wear-resisting material, such as tungsten carbide or the like. The button faces 114 engage the sides 62 of the work-pieces 61 rearwardly of the centers of the notches 104 (Figure 3). The forward portions of their sides 62 are engaged by downwardly-tapered pressure rollers 115 (Figure 3) rotatably mounted on headed notched pivot pins 116 (Figure 2). The pins 116 are inserted in slightly angled approximately radial bores 117 in the peripheral edge or rim 118 of the supporting wheel 98, and are held in position by set screws 119 engaging the notched portions of the pins 116.

It will be seen from the dotted or chain lines indicating the various axes of rotation and alignment in Figures 1 and 2 that when the machine is properly designed and adjusted, the axis of rotation of the grinding wheel shaft 25 intersects the common axis of rotation of the shafts 81 and 85 at a common point P. It will also be seen that the axes of the pivot pins 116 and therefore the axes of rotation of the pressure rollers 115 also intersect at this same common point P. Moreover, the tapered surface of each pressure roller 115 coincides with the surface of a cone, the apex of which lies at the point P. Furthermore, the center of curvature of the grinding surface 38 of the grinding wheel 34 also coincides with the point P when the machine is properly adjusted. Finally, the axes of rotation of the workpieces 61 intersect the point P and the shallow cone which forms a continuation of the annular driving surface 94 of the driving wheel 92 (Figure 2) likewise passes through the point P. The dimensions of the machine are also preferably chosen so that the sides 62 of the workpieces 61 (Figure 2) coincide with the surface of a cone, the apex of which is located at the point P.

Operation of first form of machine

In the operation of the first form 10 of the grinding machine of this invention, semi-finished workpieces 61 are placed in the receiving hopper (not shown) of the feeding unit 67 at the upper left-hand corner of Figure 1, these workpieces having comparatively flat larger ends. The selector mechanism of the feeding unit 67, as previously stated, tilts the workpieces one way

or the other so that they all descend through the feeding tube 69 with their smaller ends downward, regardless of the haphazard manner in which they were placed in the hopper. The workpieces 61 with their smaller ends downward, drop into the notches 104 of the workpiece holder 103 which meanwhile is rotating slowly in a clockwise direction toward the grinding wheel 34 while the driving wheel 92 is more rapidly rotating in the same direction. At the same time, the workpieces 61 are engaged by the contact buttons 113 (Figure 3) and pressure rollers 115 at locations spaced approximately 90 degrees from one another, these elements cooperating to crowd the workpieces 61 against the driving surface 94 of the driving wheel 92. As a consequence, the workpieces 61 are rotated rapidly around their axes while they are conveyed in a circular path, a portion of which crosses the grinding surface 38 of the grinding wheel 34 as shown by the successive dotted ovals and circles in Figure 21.

As the workpieces 61 move downward toward the grinding wheel 34 (Figure 1) they are retained in the notches 104 by the arcuate guiding edge 41 of the upper workpiece guide 39. They are also urged radially outward by the contact of their tapered surfaces 62 with the oppositely tapered conical surfaces of the driving wheel surface 94 and pressure rollers 115. In this manner the ends 63 of the workpieces 61 are brought into engagement with the grinding wheel surface 38 so that their portions 66 are ground to the desired curvatures with the radius R.

In the meantime, the motor 31 (Figure 2) has been driving the shaft 25 to rotate the grinding wheel 34, the grinding surface 38 of which has previously been provided with the curvature desired for the curved end surface 66 upon the workpieces 61, this curvature having the radius R shown in Figure 7. The surface 38 is maintained at this curvature by a conventional grinding wheel truing or dressing device (not shown) of any one of several types well known in the grinding art. As the larger ends of the rotating workpieces 61 are carried downward over the grinding surface 38 of the grinding wheel 34, they are ground to the curvature thereof.

Immediately after the workpieces 61 emerge below the grinding wheel 34 (Figure 1), they are engaged by the arcuate guiding edge of the lower workpiece guide 40, which has previously been adjusted to the correct position by rotating the screw shaft 59. When the workpieces 61 pass beyond the guide 40 they drop out of the notches 104, as shown at the bottom of Figure 1, and pass into a suitable receiver. Thus, the contact buttons 113 on the ends of the arms 109 (Figure 3) cooperate with the pressure rollers 115 to automatically urge or crowd the workpieces 61 against the driving wheel 92 regardless of minor variations in the diameters of the workpieces 61 arising during manufacture.

Workpiece holding and driving unit—second form

The second form of workpiece holding and driving unit generally designated 120 (Figures 8 to 10 inclusive) includes a driving assembly generally designated 121 similar in construction and operation to the driving assembly 74 of Figures 1 to 5 inclusive and having corresponding parts similarly designated. The workpiece holder, generally designated 122, is similarly bolted as at 96 to the head 97 or annular flange on the inner shaft 85, but is itself of modified design. The workpiece holder or holding ring 103 is also similarly bolted as at 101 to the rearward face 102 of the supporting wheel 98 and is similarly provided with spaced workpiece receiving slots or notches 104. In the modification shown in Figures 8 to 10 inclusive, however, constituting the second form of the invention, the workpiece 61 is held against the driving wheel 92 by a pair of resiliently mounted rollers rather than by the cooperating roller and finger of Figures 1 to 5 inclusive.

In particular, the supporting wheel or disc 98 has bolted thereto as at 123 (Figure 8) a series of paired right-hand and left-hand brackets 124 and 125 respectively of trowel-shaped form having sockets 126 for receiving pivot pins 127. Pivotally mounted between each pair of brackets 124, 125 is an arm 128 having a recess 129 near the inner end thereof (Figure 10) adapted to receive the pivot pin 127. The periphery of the supporting wheel 98 is provided with threaded bores 130 in which are mounted studs 131 passing through enlarged holes 132 in the arms 128 and carrying compression springs 133 compressed against the arms 128 by nuts 134.

The arms 128 are of roughly T-shaped form with spaced pairs of radially-directed sockets 135 in the cross portion thereof. Secured as at 136 in the sockets 135 are headed pivot pins 137 rotatably supporting inwardly-tapered pressure rollers 138. As was the case with the first form of the invention, the point P on the axis of rotation of the shafts 85 and 81 is the common point of coincidence of the axis of rotation of the grinding wheel 34, the center of curvature of its grinding surface 38, the point of intersection of the conical surface 94 on the driving wheel 92, the axes of rotation of the workpieces 61 and pressure rollers 138, and the location of the apex of the cone which coincides with the tapered surface of the workpieces 61 and also of the pressure rollers 138.

The operation of the second form of the invention shown in Figures 8, 9 and 10 is similar to that of the first form, except that the workpieces 61 are urged against the driving surface 94 of the driving wheel 92 by the resiliently mounted pressure rollers 138, as governed by the pressure of the springs 133. The pressure of the springs 133, in turn, can be varied by screwing the nuts 134 inward or outward along the threaded portions of the studs 131. As the pressure rollers 138 rotate in response to the rotation of the workpieces 61, they cooperate with the conical driving surface 94 on the driving wheel 92 to urge the workpieces 61 radially outward against the grinding surface 38 of the grinding wheel 24, by which their end portions 66 acquire the desired curvature of radius R. The remainder of the operation of the second form of the invention is otherwise substantially the same as that of the first form previously described.

Workpiece holding and driving unit—third form

The workpiece holding and driving unit, generally designated 140 of Figures 11, 12 and 13 has a close similarity with the second form of Figures 8, 9 and 10 and similar parts are similarly designated. In Figure 11, however, the pivot pin holes 141 in the cross bar of the T-shaped arms 128 are parallel in each pair rather than converging toward the point P as in the case of the bores or sockets 135 in Figure 8. The pressure rollers 142 are also held in place

by headed pivot pins 143 seated in the bores 141 and secured by grooves 144, but the pressure rollers 142 are tapered outward rather than inward.

The operation of the third form of the invention is substantially the same as that of the second form shown in Figures 8, 9 and 10, except that the work pieces 61 are urged outward against the grinding wheel 34 by the cooperation of the outwardly-tapered conical rollers 142 on parallel axes of rotation and the conical driving surface 94 on the driving wheel 92. The operation is otherwise similar to that of the second form of the invention in Figures 8 to 10 inclusive.

Workpiece holding and driving unit—fourth form

The fourth form of workpiece holding and driving unit, generally designated 150 shown in Figures 14, 15 and 16 is in many respects similar to that of the first form shown in Figures 1 to 5 inclusive, and similar parts are similarly designated. The fixed pressure rollers 151 are mounted on headed pins 152 secured in radially directed sockets 153 by screws 154. Instead of the contact fingers 109, the fourth form 150 makes use of convex or bowl-shaped resiliently-mounted pressure rollers 155 rotatably mounted upon pivot pins 156 secured in a bore 157 in an L-shaped arm 158 having a slot 159 for receiving the pressure roller. The inner end of the L-shaped arm 158 carries a pivot member 160 seated in a socket 161 (Figure 16) by which the arm 158 is given some freedom of motion and adjustment. The arm 158 is held against the supporting wheel 98 by a stud 162 threaded into a bore 163 therein. The stud 162 passes loosely through an enlarged bore 164 and carries a compression spring 165 which is compressed by a nut 166 threaded on the outer end of the stud 162. The upper or outer end of the arm 158 is provided with a projecting portion 167 which extends between adjacent workpieces 61 and is suitably concave as at 168 on its opposite edges to provide clearance for the workpieces 61 (Figure 15). The fixed rollers 151 and the resiliently mounted rollers 155 alternate in succession around the periphery of the supporting wheel 98, the pressure rollers 155 being urged toward the driving surface 94 of the driving wheel 92 by the coil springs 165.

The geometrical relationships of the various surfaces and axes of rotation in the fourth form of the invention shown in Figures 14, 15 and 16 are similar to those previously described in connection with the second form of the invention shown in Figures 8, 9 and 10, except that, of course, the pressure rollers 155 do not have conical tapered surfaces. In other respects, however, the point P on the axis of rotation of the shafts 81 and 85 is not only the center of curvature of the grinding surface 38 of the grinding wheel 34, but is also the point of intersection of the axis of rotation of the grinding wheel 34 and of the rollers 151 and 155 as well as being the apex of cones coinciding with the driving surface 94 and the fixed rollers 151.

The operation of the fourth form of the invention is similar to that of the other forms of the invention previously described except that the bulging or convexed surfaces of the resiliently-mounted rollers 155 do not, of course, engage the workpieces 61 except in a point contact at any one time, whereas the tapered contact rollers 158 of Figure 8 and 115 of Figure 1 engage

the workpieces 61 in a line contact. In this respect, the rollers 155 are somewhat analogous to the pressure or contact buttons 113 of Figure 3. The operation of the fourth form 150 is otherwise substantially the same as the operation of the previously-described forms of the invention, and hence requires no repetition.

Workpiece holding and driving unit—fifth form

The workpiece holding and driving unit, generally designated 170 of Figures 17, 18 and 19 is similar in many respects to the third form of Figures 11, 12 and 13. In the fifth form 170, however, brackets 171 are secured as at 172 at intervals around the periphery of the supporting wheel 102 and are bored as at 173 to receive headed pivot pins 174 secured therein as at 175 and carrying outwardly tapered pressure rollers 176. Each bracket 171 is provided with oppositely-facing sockets 177 and 178 in which pivot pins 179 are mounted. Pivotally mounted on each pivot pin 179 is a swinging arm 180 which, on its outer end, is provided with a bore 180 parallel to the bore 173 when the two are adjusted to lie side by side. Secured as at 182 in the bore 181 is a headed pivot pin 183 on which is mounted a convex approximately barrel-shaped pressure roller 184 (Figure 17). Intermediate its opposite ends the arm 180 is provided with a bore 185 through which passes a stud 186, the inner end of the latter being threaded into a bore 187 in the supporting wheel 98 (Figure 19). The bore 185 is considerably larger in diameter than the stud 186 so as to permit free tilting movement therebetween without interference. A coil spring 188 surrounding the stud 186 and held in position by an adjusting nut 189 threaded on the outer end of the stud 186 urges the arm 180 and hence the pressure roller 184 into engagement with the workpiece 61 and urges the latter into driving engagement with the driving surface 94 of the driving wheel 92. A set screw 190 threaded into the threaded bore 191 limits the extent of swing of the arm 180 (Figure 19) by engaging the forward face 106 of the supporting wheel 98.

The geometrical relationships of the various axes and centers of curvature of the fifth form 170 of Figures 17, 18 and 19 are generally the same as in the third form of Figures 11, 12 and 13. The center of curvature of the grinding surface 38 lies on the axis of rotation of the shafts 81 and 85 at the point P which is also the point of intersection with the axis of rotation of the grinding wheel 34 with that of the shaft 85. The conical surfaces coinciding with the driving surface 94 of the driving wheel 92 and the side surfaces 62 of the workpieces 61 have their apices located at the point P. The axes of rotation of the pressure rollers 176 and 184, however, being parallel to one another, do not intersect at the point P.

The operation of the fifth form of workpiece holding and driving unit 170 is generally similar to that of the third form shown in Figures 11 to 13 inclusive except that one of the pressure rollers of each pair is fixed and one is resiliently mounted. Consequently, the rollers 176 and 184 urge the tapered workpieces 61 into contact with the driving surface 94 and also urge them radially outward into contact with the grinding surface 38 of the grinding wheel 34. The roller 176 has line contact with the workpiece whereas the roller 184 has point contact at any given instant,

The remainder of the operation is substantially as that described in connection with the foregoing forms of the invention and hence requires no repetition.

Workpiece holding and driving unit—sixth form

The sixth form of workpiece holding and driving unit, generally designated **200** shown in Figure 20 differs considerably from the forms previously described although it is similar as regards the construction of the driving wheel **92** and work holder supporting wheel **98**. Similar parts are similarly designated. The wheel **98** has the notches **104** directly in its periphery rather than in a separate annular plate, as in the preceding forms of the invention. Pressure is applied to the workpieces **61** to urge them into engagement with the driving surface **94** of the driving wheel **92** by a flexible spring plate **201** of annular form secured as at **202** to a pressure wheel **203**. The latter is secured as at **204** to a head or flange **205** on a shaft **206**. The shaft **206** is mounted in suitable bearings **207** in a housing **208** which in turn is mounted on the bed **13** (not shown). The shaft **206** and consequently the pressure wheel **203** and pressure plate **201** rotate freely and are not power-driven like the shafts **81** and **85** which drive the driving wheel **92** and workholder and supporting wheel **98**. The grinding wheel **34** with its grinding surface **38** is substantially the same as that described in Figure 1, and is similarly mounted and driven. The housing **208** is mounted so that its axis of rotation may be tilted slightly so as to crowd the pressure plate **201** against the workpieces **61** in order to urge them against the driving surface **94** of the driving wheel **92** and likewise urge the ends **63** of the workpieces **61** outward against the grinding surface **38**.

The geometrical relationships existing in the sixth form of the invention shown in Figure 20 are similar in a few respects to those existing in the previously described forms of the invention in that the axis of rotation of the grinding wheel **34** intersects the axis of rotation at a common point P which is also the center of curvature of the grinding surface **38** and likewise the apex of the cone formed by the side surface **62** of the workpiece **61**.

In the operation of the sixth form of the invention, the shafts **81** and **85** are rotated, as before, at different speeds, the driving wheel **92** rotating more rapidly than the supporting wheel. This action, as before, rotates the workpieces **61** and at the same time, carries them in an arcuate path downward across the grinding face **33** of the grinding wheel **34**. At the same time, the pressure wheel **203** rotates as an idler with its resilient rim **201** urging the workpieces **61** against the driving surface **94**. At the same time, due to the fact that the space between the inner surface of the pressure plate **201** and the driving surface **94** is flared or divergent in the direction of the grinding wheel **34**, the workpieces **61** are likewise urged radially outward in their notches **104** against the grinding surface **38** and also against the arcuate edges **41** and **42** (Figure 1) of the workpiece guides **39** and **40**. In the sixth form of the invention (Figure 20), the end of the workpiece **61** has surface contact with the grinding wheel surface **38** as it moves across the latter, rather than line contact as in the applicant's prior Patent No. 2,434,245 of January 13, 1948 previously referred to. This surface grinding action gives a surface of improved quality on the end portions **66** of the workpieces **61** as compared with the line contact grinding given by the machine of the applicant's aforesaid patent.

What I claim is:

1. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element.

2. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, certain of said rollers being resiliently mounted on said device.

3. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers and pressure fingers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element.

4. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, certain of said rollers being fixedly mounted and others of said rollers being resiliently mounted on said device.

5. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding re-

cesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, the axes of rotation of said pressure rollers being directed through a substantially common point of intersection on the axis of rotation of said driving element.

6. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, said rollers being mounted in pairs on said device with the rollers of each pair having substantially parallel axes of rotation.

7. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having tapered pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element.

8. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having inwardly-tapered pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element.

9. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having outwardly-tapered pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element.

10. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, certain of said rollers having convexly bulging contact surfaces.

11. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, the axes of rotation of said pressure rollers being directed through a substantially common point of intersection on the axis of rotation of said driving element, certain of said rollers having convexly bulging contact surfaces.

12. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, said rollers being mounted in pairs on said device with the rollers of each pair having substantially parallel axes of rotation, certain of said rollers having convexly bulging contact surfaces.

13. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, the axes of rotation of said pressure rollers being directed through a substantially common point of intersection on the axis of rotation of said driving element, certain of said rollers being resiliently mounted and having convexly bulging contact surfaces.

14. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, said rollers being mounted in pairs on said device with the rollers or each pair having substantially parallel axes of rotation, certain of said rollers being resiliently mounted and having convexly bulging contact surfaces.

15. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, certain of said rollers being tapered and others of said rollers being resiliently mounted and having convexly bulging contact surfaces.

16. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, certain of said rollers being tapered inwardly and others of said rollers being resiliently mounted and having convexly bulging contact surfaces.

17. A machine for end grinding elongated workpieces comprising a rotary grinder having a grinding surface thereon, a rotary workpiece holder having a periphery thinner than said workpieces mounted for motion of said periphery in close proximity to said grinding surface, said periphery having therein workpiece-holding recesses open laterally to expose the sides of said workpieces, a rotary driving element engageable with said workpieces on one side of said workpiece holder, and a rotary pressure device having pressure rollers engageable with said workpieces on the opposite side of said workpiece holder to urge said workpieces into driving engagement with said driving element, certain of said rollers being tapered outwardly and others of said rollers being resiliently mounted and having convexly bulging contact surfaces.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,892,363	Raule	Dec. 27, 1932
1,926,974	Einstein	Sept. 12, 1933
2,024,118	Vanderbeek	Dec. 10, 1935
2,109,600	Vanderbeek	Mar. 1, 1938
2,434,245	Johnson	Jan. 13, 1948