Nov. 19, 1929. F. M. KERN 1,735,867

GRINDING MACHINE

Filed April 8, 1925

Fig.2

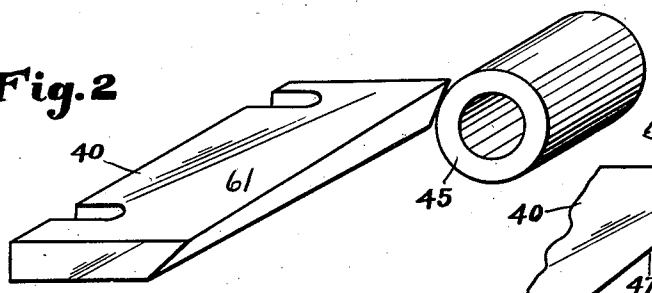


Fig.3

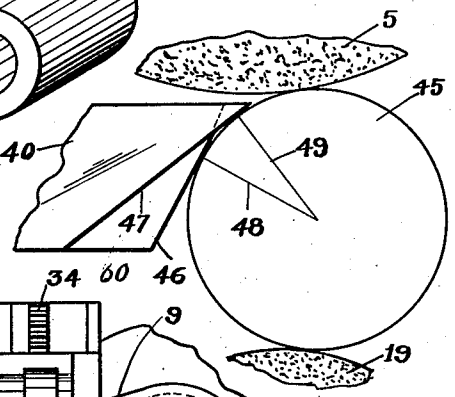


Fig.4

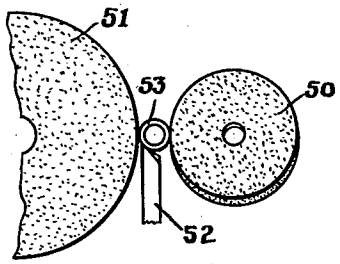


Fig.1

WITNESSES

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GRINDING MACHINE

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This invention relates to grinding apparatus and more particularly to grinding machines known as "centerless grinding machines" in which work pieces are reduced to round cross-section between a grinding wheel and a controlling or regulating wheel, the former of which acts to perform the grinding operation and the latter acts to control the rotation of the round work piece and also, if the work piece is substantially cylindrical, to cause the work piece to move in an axial direction along or past the operating surface of the grinding wheel, suitable means such as a work support being provided for holding the work in operative relation to the adjacent operative surfaces of the two wheels.

One of the objects of this invention is to provide a grinding apparatus of the above-mentioned character which will be of thoroughly practical construction and highly efficient action in practical use. Another object is to provide a grinding apparatus of the above-mentioned nature capable of rapidly reducing work pieces of generally round form to a cross-section which will be round to a high degree of accuracy and precision. Another object is to provide a grinding apparatus of the above-mentioned character in which a high degree of accuracy and satisfactory surface finish of the work pieces may be achieved with a minimum of manual effort and a minimum time consumption, and to provide such a grinding apparatus adapted to avoid the necessity, as has heretofore occurred at times in practice, of subjecting a given work piece to several successive grinding operations or passes through the apparatus. Another object is to provide a grinding apparatus in which the initial grinding or rough grinding action upon the work piece may be achieved rapidly and efficiently and in a manner tending effectively to "round-up" initially out-of-round work pieces and supplemented, in the same apparatus and without necessitating a second passage of the work piece therethrough, by a finish grinding action capable of further "rounding-up" of the work and of producing thereon a high degree of accuracy and finish of surface. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts as will be exemplified in the structure to be hereinafter described and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing, in which is shown one of various possible embodiments of this invention,

Figure 1 is a side elevation of a complete grinding apparatus;

Fig. 2 is a detached isometric view on an enlarged scale showing one of the parts of the apparatus and a work piece related thereto and substantially similarly as it is related just prior to or at the commencement of the grinding operation thereon;

Fig. 3 is a diagrammatic end view on an enlarged scale of a portion of the apparatus of Fig. 1; and

Fig. 4 is a diagrammatic side elevation of a possible modified form of grinding apparatus embodying my invention.

Similar reference characters refer to similar parts throughout the several views of the drawing.

As conducive to a clearer understanding of certain features of this invention it may at this point be noted that it has heretofore been proposed to hold a round work piece between a grinding wheel and a work rotating or work controlling wheel by means of a work support or work holding member which is shaped to present to the work piece a work supporting surface making an obtuse angle with a plane tangent to the peripheral operative surface of the grinding wheel at the line of contact of the work piece with the grinding wheel; such apparatus has been found in practice to achieve a number of thoroughly practical and important advantages. Among these advantages may be noted first the fact that the coaction of the work controlling wheel with the work thus supported or held in operative relation between the two wheels and with the grinding wheel results in much more rapidly rounding-up initially out-of-

round work pieces than had theretofore been possible and that a very high degree of accuracy may thus be effectively achieved. Also, it has been found that the above described angularity of the work supporting surface of the work support or work holding member brings about a highly desirable reaction of the thrust of the grinding wheel upon the work in that the inclined supporting surface acts to resolve this thrust into a substantial component acting to hold the work piece in more secure contact with the work controlling wheel. I have discovered that the angle which the work supporting surface of the work support or work holding member makes relative, for example, to a plane passing through the lines of contact of the work with the grinding wheel and the controlling wheel is of material importance. For example, I have found that the rapidity of the rounding-up action may vary with this angle and also with the depth of cut being taken on the work piece, and I have also found that it is desirable to support or hold the work piece nearer the grinding wheel when a finishing operation is carried on than is the case when a roughing operation is to be performed. To achieve the advantages of the change in the above-mentioned angle and in the change of the point or line of support of the work piece as noted above, it has been necessary, in apparatus heretofore used, to either replace the work support or work holding member by one having a work supporting surface of different angularity or to change the position bodily of the work support or work holding member, or both, and in any case it has necessitated passing the work through the apparatus at least one additional time. It is a dominant aim of this invention to avoid such disadvantages as those above pointed out.

Referring now to the drawing and more particularly to Fig. 1, there is shown a main frame 7 in the upper right hand portion of which is rotatably supported a shaft 6 which carries a grinding wheel of any appropriate abrasive material, the arrangement being such that the grinding wheel 5 is supported in a substantially overhanging relation. A pulley 9 mounted upon the grinding wheel shaft 6 is driven by a belt 8 which passes over a pulley 10 mounted upon a counter-shaft 11 supported in suitable bearings at the lower left hand portion of the main frame 7. The belt 8 passes over idler pulleys 15 which are supported on an arm 16 pivotally mounted on the side portion of the main frame 7 and constructed to be adjustably positioned about its pivot and locked in adjusted position by means of a bolt 17 passing through an arcuate slot 18 in the arm 16; thus the belt 8 may be appropriately tensioned. The grinding wheel 5 is rotated in a clockwise direction as viewed in Fig. 1, it being noted that its lower peripheral operative surface is thus made to travel in a direction toward the main frame 7 of the apparatus.

A regulating wheel 19 of any suitable material such as bonded abrasive grains, is mounted on a shaft 20 suitably supported in bearings carried on a vertically extending column 22 which is supported in a lower extension of the main frame 7 so as to be vertically and rotatably adustable.

The regulating wheel 19 is driven relatively slowly, preferably from the same source of power which actuates the grinding wheel 5, and in a direction relative to that of the adjacent operative surface of the grinding wheel to control the rotation of work of round section interposed between the two wheels. The shaft 20 of the regulating wheel 19 is driven slowly from the countershaft 11 by means of an appropriate train of driving gears and shafts; the latter may include the train of gears 23, 24 and 25, gear 23 being driven from the shaft 11, while gear 25 meshes with and drives gear 26 mounted upon the horizontal shaft 27 adjacent the base portion of the main frame 7. The right hand end of the shaft 27 carries a bevel gear 28 with which meshes a bevel gear 29 on the lower end of a universal jointed shaft 30 at the upper end of which is mounted a spiral gear 31. This spiral gear 31 meshes with and drives a spiral gear 32 which is secured to the shaft 20 of the regulating wheel 19.

At the upper and rear side portion of the frame 7 as viewed in Fig. 1 there is slidably mounted a slide 33 provided with a rack 34; by means of the rack 34 and appropriate coacting mechanism operated by the hand wheel 35 the slide 33 may be adjustably moved up or down. The slide 33 is provided with a forwardly projecting yoked arm 36 near the outer (or right hand, as viewed in Fig. 1) ends of which is mounted a slidable holder 37, while adjacent the inner (or left hand, as viewed in Fig. 1) ends of the yoked arm 36 is mounted a movable holder 39. The slidable holder 37 supports a front work holding member 38 and the rear holder 39 supports a rear work holding member 40. The members 38 and 40 will be seen in Fig. 1 to extend between the adjacent operative surfaces of the two wheels and to be spaced apart in a horizontal direction as seen in this figure. The spacing between and the positions of the members 38 and 40 may be adjusted or controlled. By means of a hand wheel 41 which operates a screw shaft 42 engaging the holder 37 and passing through a depending portion of the right hand end of the arm 36 the position of the front holder 37 along the yoked arm 36 may be adjusted at will. A hand wheel 43 operating a screw shaft 44 permits the rear holder 39 to be adjustably positioned along the yoked arm 36.

The work holding members 38 and 40 may

thus be spaced apart suitably to accommodate therebetween the work pieces to be operated upon while the spacing between the grinding wheel 5 and the regulating wheel 19 may similarly be predetermined or adjusted by adjusting the regulating wheel 19 with its supporting column 22 in a vertical direction and hence toward or away from the grinding wheel 5. The members 38 and 40, moreover, may be adjustably moved toward or away from either of the wheels by operating the hand wheel 35 which controls the vertically movable slide 33. The column 22 which supports the regulating wheel 19 is rotatably adjustable in the base portion of the main frame 7; by means of this construction the axis of the regulating wheel 19 (as viewed from above), may be tilted with respect to the axis of a work piece generally indicated at 45 held between the members 38 and 40 so as to cause the regulating wheel 19 to exert a thrust on the work in a direction lengthwise of the axis of the work and thus cause a work piece to be fed or moved in an axial direction along the members 38 and 40 and thus past the operative surface of the grinding wheel 5.

With the grinding wheel 5 rotating in clockwise direction as viewed in Fig. 1 and as hereinabove pointed out, the thrust exerted thereby on the work piece 45 will be taken up by the work holding member 40 which thus serves to prevent displacement of the work piece by the thrust of the grinding wheel; the front work holding member 38 serves in part to keep the work piece between the grinding wheel 5 and the regulating wheel 11 and particularly counteracts any tendency on the part of the regulating wheel 19 to displace the work piece 45 in a direction toward the right as viewed in Fig. 1. In Fig. 2 of the drawing I have shown on an enlarged scale the rear work holding member 40; the member 40 is provided with a work supporting surface 60 the angularity of which progressively changes from one end of the member 40 to the other and preferably in such a way that the series of points with which this work supporting surface contacts with a round work piece 45 as the latter moves lengthwise of the member 40 progressively change relative to a given plane, for example, the plane of the upper face 61 of the member 40 as seen in Fig. 2. In Fig. 3 in which the member 40 is shown in end view on an enlarged scale, and its relation to the work piece 45 and the two wheels is more clearly illustrated, the line 46 indicates the angle which the surface 60 makes at one end of the work holding member 40 (see also Fig. 2) and the line 47 indicates the angle which this supporting surface 60 makes at the other end of the member 40, it being understood that the surface 60 gradually and progressively changes its angularity from that indicated by the line 46 to that indicated by the line 47 as the distance from one end to the other of the member 40 is traversed.

The member 40 and the grinding wheel 5 and regulating wheel 19 are so related to each other that the end edge 46 of the supporting surface 60 of the work holding member 40 is at the entrance end of the grinding throat through which the work piece is passed and hence it is the portions of the supporting surface 60 adjacent the edge 46 which the work piece 45 first engages as it enters into operative relation to the two wheels; as the work piece 45 passes along the grinding throat and hence along the surface 60, either through the feeding action of the regulating wheel 19 or otherwise, it is brought into contact with successive portions of the inclined surface 60 but which portions are of successively different inclination. When the work piece 45, moving in an axial direction, finally reaches the exit end of the work holding member 40, it finds itself in contact with portions of the supporting surface 60 having inclinations on the order of that indicated by the line 47.

During this progress of the work piece 45 along the successively varying inclined portions of the supporting surface 60, the regulating wheel 19 controls the rotation of the work piece 45 while the grinding wheel 5 performs the grinding operations thereon; these actions, it will be understood, are accompanied by an axial feed or movement of the work piece 45 along the supporting surface 60. The shape of the inclined supporting surface 60, however, brings about certain advantageous features of action. As the work piece 45 enters the grinding throat and hence comes into contact first with those portions of the supporting surface 60 adjacent the edge 46 (see Fig. 2), the work piece 45 will contact with the supporting surface 60 at the point of tangency therebetween. This point of tangency is indicated by the upper end of the radius 48 of the work piece 45 (see Fig. 3). As the work piece 45 progresses along the surface 60 and toward the edge 47 thereof, the point or points of tangency between the work piece 45 and the supporting surface 60 progressively change and the final point of tangency at the exit end 47 of the surface 60 is indicated by the upper end of the radius 49 of the work piece 45 (Fig. 3). Thus it will be seen that not only is the angularity of the work supporting surface 60 changed as the work piece 45 moves therealong, but also the effective point of support of the work piece against the thrust of the grinding wheel 5 is progressively altered in its position relative to the grinding wheel itself. Thus, viewing Fig. 3, the angularity will be seen to have changed from one on the order indicated by the line 46 to one on the order indicated by the line 47, while at the same

time the effective point of support of the work piece 45 (by the work holding member 40) against the thrust of the grinding wheel 5 has been brought progressively nearer to the grinding wheel 5 and, in fact, has been progressively changed from that indicated by the left hand end of the radius 48 to that indicated by the left hand end of the radius 49.

It is near the entry end of the grinding throat that the grinding wheel 5 performs the greater portion of the grinding operation or takes the deeper cut, and it is near the exit end of the grinding throat that the grinding wheel may be said to be taking the finishing grinding cut. I have discovered that the heavier or initial grinding by the grinding wheel, accompanied by effective rounding-up action, may be effectively achieved by utilizing during this stage of the grinding a work supporting surface inclined on the order of the inclination of the line 46 whereby also the work piece 45 is supported against the thrust of the grinding wheel 5 at a point indicated by the left hand end of the radius 48; while the later or finishing grinding action I have found can be best achieved by supporting the work piece 45 much nearer the grinding wheel 5 and utilizing a supporting surface having an inclination on the order of that of the line 47, all as indicated in Fig. 3. Intermediate stages of grinding will be seen in view of the above to be accomplished at angularities of the work supporting surface 60 intermediate of those just above pointed out and at successive points of support of the work piece progressively nearer the grinding wheel. In actual practice I have obtained satisfactory results by employing a work holding member of suitable width and length in which the entrance end of the work supporting surface makes an angle of about 58½ degrees and the exit end makes an angle of about 39½ degrees with the central plane of the work holding member or with a horizontal plane with the parts as viewed in Fig. 3.

The above mentioned successive points of contact of the work with the inclined work supporting surface 60 as the work piece moves along the latter form substantially a helical line which, as viewed in Fig. 3, from the entrance end 46 to the exit end 47 gradually approaches the grinding wheel through substantially the arc subtended by the angle between the radii 48 and 49.

From the foregoing it is believed that the construction and action of the apparatus will be clear; it might be pointed out, however, that in practicing my invention I prefer to position the rear work holding member 40 (see Fig. 1), by means of the hand wheel 43 and the screw shaft 44, so that the axis of the work piece 45, the axis of the grinding wheel 5 and the axis of the regulating wheel 19 do not fall in a straight line when viewed as seen in Fig. 1. In the latter figure it will be noted that the work holding member 40 is so adjusted that the axis of the work piece 45 is to the right of a line drawn between the axis of the grinding wheel 5 and the axis of the regulating wheel 19. Moreover, the work holding member 40 is preferably so adjusted that the axis of the work piece is maintained substantially parallel to the axis of the grinding wheel; when, therefore, the regulating wheel 19 is slightly tilted about the axis of the column 22, there will exist an inclination between the path of travel of the operative surface of the regulating wheel 19 and the axis of the work piece 45 so that the latter is moved along and into contact with the varyingly inclined surface 60 of the work holding member 40. The front work rest 38 is so adjusted as to permit the work piece 45 to pass between the feed wheel 19 and the grinding wheel 5 and in contact with the rear work holding member 40. The grinding wheel 5 and the control wheel 19 are rotated at suitable speeds, the grinding wheel rapidly to grind the work and the regulating wheel slowly to control the work piece. As the work piece thus is rotated and propelled along the surface 60 of the member 40 by the control wheel 19, the grinding wheel performs the grinding operation thereon while the points of contact of the work piece with the member 40 continually change relative to the grinding surface of the grinding wheel.

In Fig. 4 I have illustrated diagrammatically a grinding apparatus embodying my invention but in which, instead of having the grinding wheel positioned above the regulating wheel as in the apparatus shown in Fig. 1, the grinding wheel 51 and the regulating wheel 50 have their axes in substantially a horizontal plane, and the work support 52 identical in all substantial respects to the member 40 hereinabove described is positioned therebetween and holds the work against the downward thrust of the grinding wheel 51. The tilting of the regulating wheel 50 to effect an axial movement of the work piece 53 along the work support 52 is clearly indicated in Fig. 4. The action of the apparatus shown in Fig. 4 will be clear in view of what has hereinbefore been set forth.

It will thus be seen that there has been provided in this invention a grinding apparatus in which the several objects hereinbefore noted, as well as many thoroughly practical advantages, are successfully achieved. It will be seen that the apparatus is of simple yet thoroughly practical construction, is of thoroughly dependable action and is well adapted to meet the peculiar conditions of thoroughly practical use. It will be seen that it is possible in a single apparatus to subject the work piece to a succession of different conditions, actions and treatments each best adapted to

the successive stages of completion of the work piece, and that repeated readjustments of apparatus or repeated passages of the same work piece through different apparatuses with attendant inefficiency and loss of time are all effectively avoided.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

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

1. A grinding machine comprising a rotatable grinding wheel, a rotatable feed wheel opposed thereto, and means for maintaining a round work piece between and in operative grinding contact with the wheels, said means including a member having a guiding surface in contact with the work piece and so shaped that the points of contact form a substantially unbroken line at a constantly varying angle with a given plane.

2. A grinding machine comprising a grinding wheel, a feed wheel peripherally opposed thereto and axially skewed relative to the work axis for feeding and regulating the rotation of a work piece, and a work positioning member so arranged relative to said wheels that the work is held in grinding contact therebetween and is moved axially relative thereto, said member being so shaped that as the work piece moves axially it contacts with the member at points successively nearer the grinding wheel.

3. In grinding apparatus, in combination, a grinding wheel and a regulating wheel, said wheels being rotated at respective speeds and in directions to effect grinding action by the grinding wheel and control of rotation by the regulating wheel on work of round section interposed therebetween, and a member for holding work in operative relation between said wheels, said member providing a work-engaging surface making an obtuse angle with a plane tangent to the grinding wheel at the line of contact of the grinding wheel with the work, said surface being shaped so that said obtuse angle progressively changes in a direction lengthwise of the axis of a work piece between said wheels.

4. In grinding apparatus, in combination, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed for grinding action, a work-rotating wheel rotatable at a speed and in a direction to control the rotation of the work, and a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, said member being constructed and arranged so that a round work piece in traversing said grinding throat is held against the thrust of the grinding wheel at points progressively nearer the grinding wheel.

5. In grinding apparatus, in combination, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed for grinding action, a work-rotating wheel rotatable at a speed and in a direction to control the rotation of the work, and a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, said member presenting a work-engaging surface inclined relative to the surface of the grinding wheel but the inclination of which changes progressively from one end of the grinding throat to the other.

6. In grinding apparatus, in combination, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed for grinding action, a work-rotating wheel rotatable at a speed and in a direction to control the rotation of the work, and a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, said member presenting a work-engaging surface inclined relative to the surface of the grinding wheel but the inclination of which changes progressively from one end of the grinding throat to the other, said apparatus being constructed and arranged to effect movement of work of round section axially along said grinding throat.

7. In grinding apparatus, in combination, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed for grinding action, a work-rotating wheel rotatable at a speed and in a direction to control the rotation of the work, and a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, said member providing a path of travel for work of round section lengthwise of said grinding throat but relatively inclined with respect to the path of travel of the operative surface of said work-rotating wheel, whereby the latter causes a feeding movement of the work lengthwise of the grinding throat, and said member being provided with a work-engaging surface inclined relative to the grinding wheel surface but the inclination of which changes progressively from one end of the grinding throat to the other, whereby as said work is fed along by

said work-rotating wheel the work is brought into engagement with progressively differently inclined portions of said work-engaging surface.

8. In grinding apparatus, in combination, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed for grinding action, a work-rotating wheel rotatable at a speed and in a direction to control the rotation of the work, and a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, said member providing a path of travel for work of round section lengthwise of said grinding throat but relatively inclined with respect to the path of travel of the operative surface of said work-rotating wheel, whereby the latter causes a feeding movement of the work lengthwise of the grinding throat, and said member being shaped so that, as said work-rotating wheel feeds the work lengthwise of the grinding throat, the work is held against the thrust of the grinding wheel at points the distance of which from the grinding wheel surface progressively changes.

9. In grinding apparatus, in combination, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed for grinding action, a work-rotating wheel rotatable at a speed and in a direction to control the rotation of the work, and a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, said member being provided with a work-engaging surface the inclination of which relative to a substantially central plane between the grinding wheel and the regulating wheel varies from an order of magnitude of about 39° at one end to an order of magnitude of about 58° at the other end.

10. In a machine for grinding work of round section, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at a suitable speed, a member for rotatably supporting the work, for taking up the thrust of the grinding wheel on the work and for guiding the work past the operative surface of the grinding wheel, said member being provided with a work-engaging surface inclined relative to the grinding wheel surface but the inclination of which changes progressively from one end of the operative surface of said grinding wheel to the other, and means adapted to prevent lateral displacement of the work while in operative relation to said grinding wheel.

11. In a machine for grinding work of round section, a grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at a suitable speed, a member for rotatably supporting the work, for taking up the thrust of the grinding wheel on the work and for guiding the work past the operative surface of the grinding wheel, said member being shaped so that the work is held against the thrust of the grinding wheel at points the distance of which from the grinding wheel surface progressively changes as the work is moved past the grinding wheel surface, and means adapted to prevent lateral displacement of the work while in operative relation to said grinding wheel.

Signed at Detroit, Michigan, this 2nd day of April, 1925.

FRED M. KERN.