

**June 29 , 1926.**

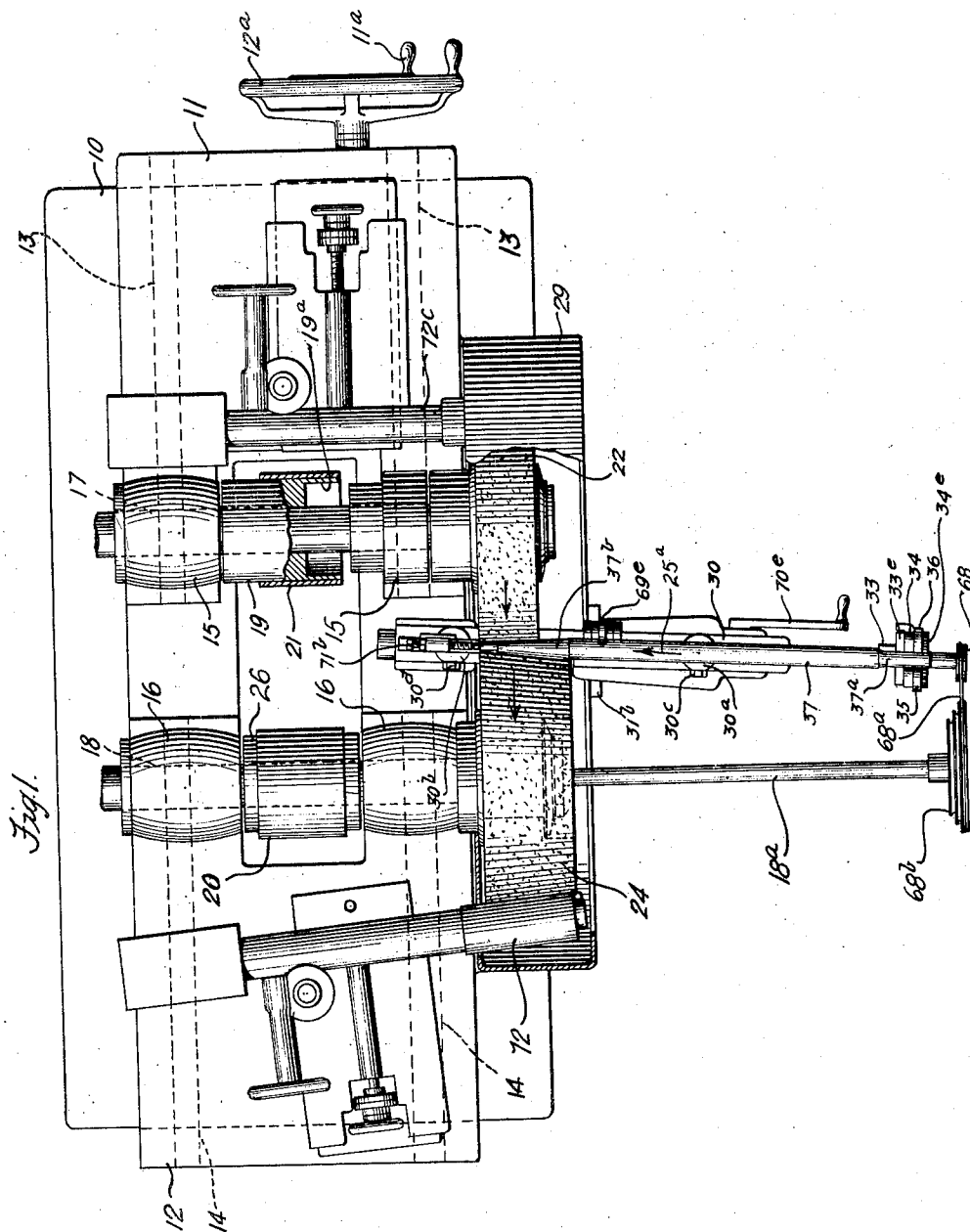
**1,590,190**

**L. R. HEIM.**

## GRINDING

Filed Oct. 20, 1923

3 Sheets-Sheet 1



Lewis R. Heine INVENTOR

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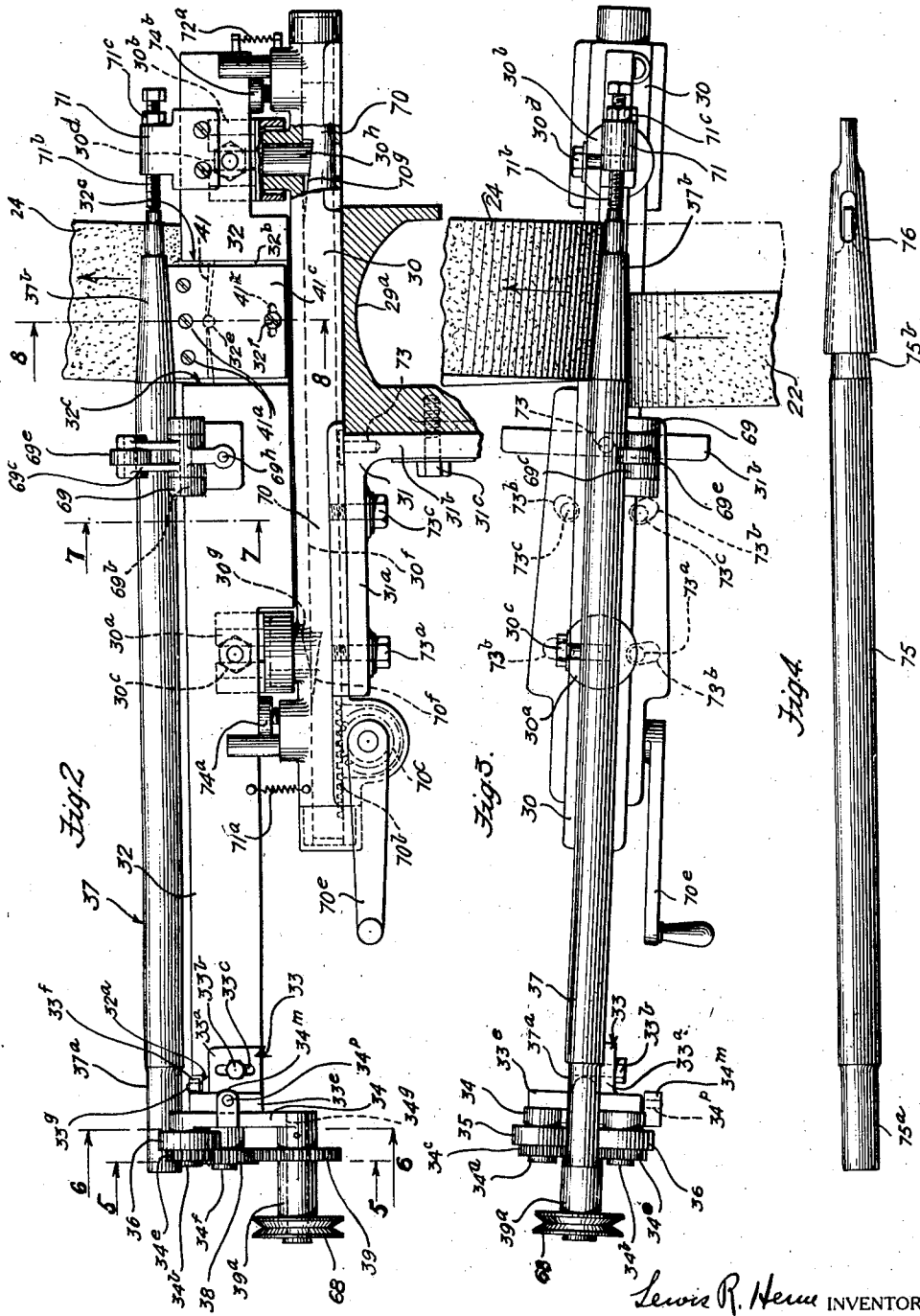
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## GRINDING

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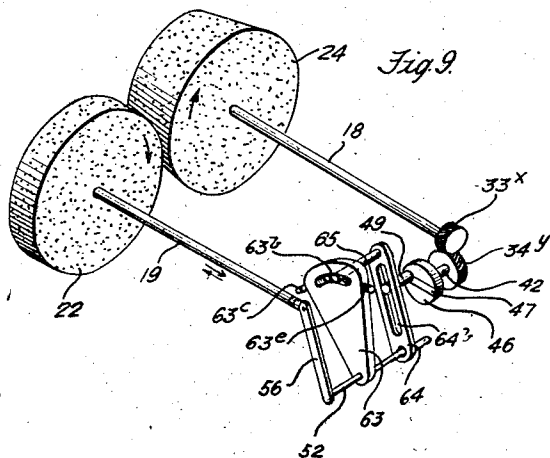
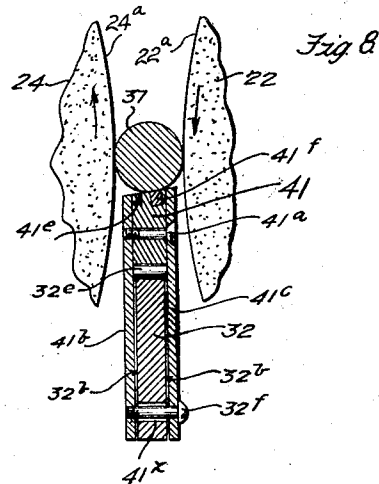
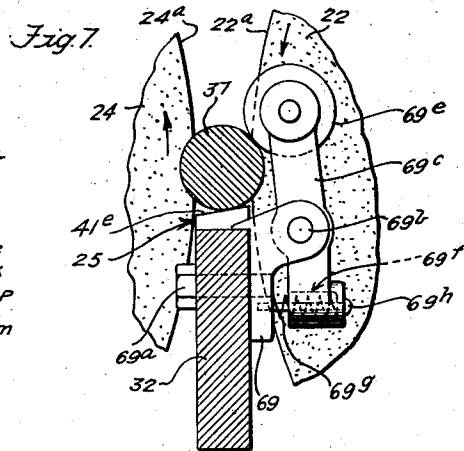
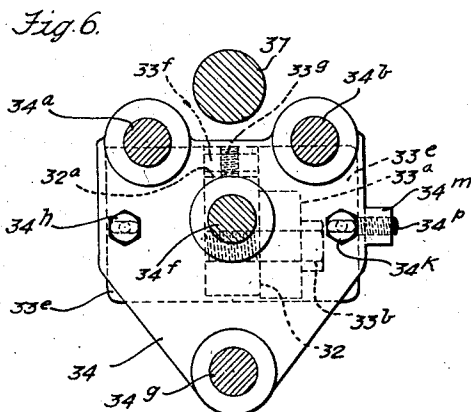
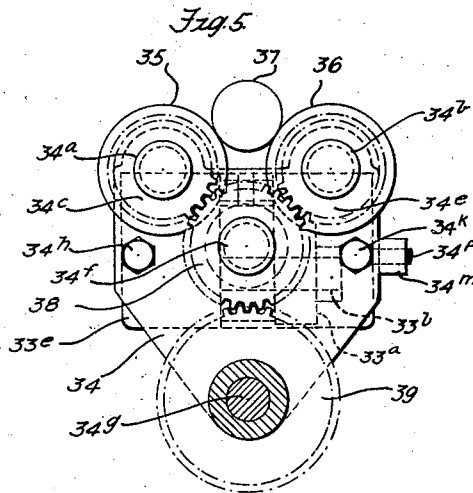
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GRINDING

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3 Sheets-Sheet 3



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Patented June 29, 1926.

1,590,190

# UNITED STATES PATENT OFFICE.

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## GRINDING.

Application filed October 20, 1923. Serial No. 669,651.

This invention relates to grinding and more particularly to apparatus for grinding articles or bodies having a round or circular cross-section.

One of the objects of this invention is to provide a grinding apparatus of practical construction and of thoroughly dependable and reliable action. Another object of this invention is to provide a grinding apparatus for reliably and dependably grinding work pieces of cumbersome shape or form and without impairment of either accuracy or efficiency of action. Another object of this invention is to provide practical grinding apparatus for grinding concentrically various portions of work having correspondingly non-uniform diameters or different diameters. Another object is to provide apparatus of the above nature that may be readily adapted to meet the varying conditions inherent in bodies or work of this character. Another object is to provide apparatus of the above character that will be capable of high speed of operation and highly accurate in its action and results. 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 drawings in which is shown one of the various possible embodiments of this invention,

Figure 1 is a plan view of the apparatus in assembled relation, certain parts being broken away to show certain features of construction more clearly,

Figure 2 is a side elevation on an enlarged scale of the work supporting means, and more particularly is a side elevation as viewed along substantially the line 2—2 of Figure 1.

Figure 3 is a plan view of the apparatus shown in Figure 2, and

Figure 4 is a plan view on an enlarged scale of an auxiliary device shown in relation to another character of work, adapted for use in connection with grinding the latter.

Figure 5 is a view on an enlarged scale taken along the line 5—5 of Figure 2, and

Figure 6 is a similarly enlarged view taken along the line 6—6 of Figure 2.

Figure 7 is an enlarged sectional view taken along the line 7—7 of Figure 2, and

Figure 8 is an enlarged sectional view taken substantially along the line 8—8 of Figure 2.

Figure 9 is a diagrammatic perspective view of part of the apparatus shown in Figure 1 together with a diagrammatic representation of certain of the operative mechanisms omitted and broken away in Figure 1.

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

Referring now to the drawings, and more particularly to Figure 1, there is shown at 10 a main supporting frame of any suitable construction and height, and provided in its upper part with suitable pairs of ways 13 and 14 extending longitudinally thereof for guiding the carriages 11 and 12 respectively lengthwise of the frame 10. The adjacent ends of the carriages 11 and 12 support pairs of transversely spaced bearings 15 and 16 respectively adapted to rotatably support the shafts 17 and 18. The shaft 17 overhangs the carriage 11 and the frame 10 at the front parts thereof and upon this overhanging end thereof is supported, to rotate with the shaft 17, a grinding wheel 22. The shaft 17 has mounted upon it, and intermediate of the bearing 15 an elongated pulley 19 adapted to be driven by means of the belt 21 from any suitable source of power. The grinding wheel 22 may thus be driven at a suitable grinding speed and is rotated in the direction of the arrow indicated in Figure 1.

The shaft 18, supported in the bearings 16 of the carriage 12, supports at its overhanging end at the front part of the machine what will hereinafter be termed a regulating wheel 24 which wheel conveniently and preferably is made of a suitable abrasive material. A pulley 26 mounted upon shaft 18 and intermediate of the spaced bearings 16 is connected to any suitable source of power by means of a belt 20 running over the pulley 26.

The regulating wheel 24 is driven at a speed which is relatively low with respect to the speed at which the grinding wheel 22 is driven, and moreover, the regulating

wheel 24 is rotated in such a direction that its operative surface, adjacent the operative surface of the grinding wheel 22, travels in a direction opposite from the direction of travel of the surface of the grinding wheel 22. In Figure 1 these directions of travel of the adjacent operative surfaces of the two wheels are clearly indicated by arrows, and from Figures 7 and 8 it will be noted that the grinding wheel surface is thus made to travel downwardly with respect to a work carrier 25 interposed between the two wheels and to be more clearly hereinafter described, and that the regulating wheel 24 is thus made to present an operative surface which travels upwardly with respect to the carrier 25.

The operative surfaces of the two wheels 22 and 24, indicated respectively at 22<sup>a</sup> and 24<sup>a</sup>, are arranged in approaching relation with respect to one another, and this relation is preferably and most conveniently attained by making both wheels of a type having peripherally operative surfaces. At this point it may be noted that the regulating wheel 24 is preferably and advantageously arranged with respect to the work supporting means so that there exists a relative inclination between the path of travel of the operative surface of the regulating wheel 24 and the tangent line of contact of the work with the surface of the grinding wheel. By providing such a relative inclination, the regulating wheel 24 is effective to urge the work along the carrier and in a direction toward the rear of the apparatus as viewed in Figure 1, and as indicated by the arrow 25<sup>a</sup>. This relative inclination is preferably obtained by inclining the axis of rotation of the regulating wheel 24 in the vertical plane where the regulating wheel takes the form of a peripherally active wheel as here illustrated. Thus the forward bearing 16 adjacent the regulating wheel 24 may be made of higher elevation than the rear bearing 16 remote from the regulating wheel 24. In Figure 2 of the drawings, as well as in Figure 3, this relation of the regulating wheel 24 is more clearly shown.

As shown in Figure 1, the wheels 22 and 24 are substantially enclosed in a protective casing 29, inasmuch as they are operated with an application thereto of some suitable cooling fluid such as water. The casing 29 is secured to the front part of the main frame 10 in any suitable manner and is of sufficient lateral and longitudinal expanse to permit of the adjustment and movement of the wheels as will be more clearly hereinafter described. At a point substantially intermediate of the two wheels 22 and 24 and below their adjacent operative surfaces, this casing 29 is formed to provide a substantially horizontally extending bridge

portion 29<sup>a</sup> (see Figure 2) upon which bridge portion 29<sup>a</sup> is supported a frame member 30 detachably held in place as by an angle plate 31 having a horizontally extending portion 31<sup>a</sup> to which the frame member 30 may be secured, and having also a downwardly extending portion 31<sup>b</sup> adapted to be detachably secured, as by the clamping screw 31<sup>c</sup> passing therethrough and into the bridge portion 29<sup>a</sup> of the casing 29. The frame member 30, as is shown in Figure 3, and as will be clear from Figure 2, extends between the two wheels and supports two vertically extending posts 30<sup>a</sup> and 30<sup>b</sup>, one on each side of the two wheels. These posts 30<sup>a</sup> and 30<sup>b</sup> support an elongated auxiliary frame member 32, taking the form preferably of a bar which is conveniently of rectangular cross-section. The posts 30<sup>a</sup> and 30<sup>b</sup> are slotted vertically as is clearly shown in Figure 2 and through these slots and through the auxiliary frame member 32 pass the clamping bolts 30<sup>c</sup> and 30<sup>d</sup> respectively. By this construction, the frame member 32 may be vertically adjusted with respect to the operative surfaces of the two wheels, and it will be noted that the vertical adjustment of each end of the frame member 32 may be made independently of the corresponding adjustment at the other end thereof. Thus, the frame member 32 may be given any desired degree of inclination with respect to the horizontal as viewed in Figure 2 and which adjustment may be demanded by the particular conditions of use.

At the forward end of the frame member 32 and as shown in Figures 2 and 3 at the left hand end thereof, there is mounted a bracket, generally indicated at 33, having a lug 33<sup>a</sup> extending in the general direction of the frame member 32 and adapted to be secured thereto as by means of the clamping screw 33<sup>b</sup>. The clamping screw 33<sup>b</sup> is preferably threaded into the frame member 32 and passes through a vertically extending slot 33<sup>c</sup> in the lug 33<sup>a</sup>. Thus the bracket 33 may be not only vertically adjusted with respect to the frame member 32, but also pivotally adjusted about the screw 33<sup>b</sup> as an axis. The bracket 33 is formed to provide a transversely extending plate member 33<sup>e</sup> (see also Figures 5 and 6) in general of a rectangular shape, and projecting rearwardly therefrom and at the upper portion thereof is a lug 33<sup>f</sup> into which is threaded an adjusting screw 33<sup>g</sup> adapted to contact with the upper surface of the frame member 32, the latter being conveniently recessed as at 32<sup>a</sup> to accommodate the lug 33<sup>f</sup> and its associated adjusting screw 33<sup>g</sup>. The adjusting screw 33<sup>g</sup> through the lug 33<sup>f</sup> acts not only to assist in rigidly supporting the bracket 33 with respect to the frame member 32, but also to permit a micrometer

adjustment of the bracket 33 to be made with respect to the frame member 32.

The front plate 33<sup>a</sup> of the bracket 33 has adjustably mounted thereon a plate member 34, more clearly shown in Figures 6 and 5. This plate member 34 supports at its opposite upper ends a pair of studs 34<sup>a</sup> and 34<sup>b</sup> upon which are rotatably mounted the rollers 35 and 36 respectively, adapted to support one end of the work piece generally indicated at 37. The rollers 35 and 36 have rigidly connected at their left hand faces as viewed in Figure 2 the gears 34<sup>c</sup> and 34<sup>d</sup> respectively, so that the rollers may be rotated or driven through their respective gears. The gears 34<sup>c</sup> and 34<sup>d</sup> mesh with gear 38 supported upon a stud 34<sup>e</sup> substantially centrally positioned with respect to the plate member 34. The gear 38 in turn is driven from a gear 39 rotatably supported upon a stud 34<sup>f</sup> rigidly mounted in the lower end of the plate 34 (see Figures 5 and 6). The gear 39 is adapted to be driven through a sleeve 39<sup>a</sup> at the outer end of which (see Figures 2 and 3) is mounted a pulley 68. The pulley 68 (see Figure 1) is adapted to be driven by means of the belt 68<sup>a</sup> selectively connected to any one of the steps of a cone pulley 68<sup>b</sup> mounted upon a shaft 18<sup>a</sup> forming a forwardly directed extension of the regulating wheel shaft 18.

The work supporting rollers 35 and 36 (see Figure 5) thus in effect may of themselves determine the axis about which the one end of the work 37 rotates, and moreover may take part, through the driving mechanism above described, in rotating the work 37. As illustrative of the character of the work adapted to be operated upon, the work may, for example, comprise a shaft member as shown in Figures 2 and 3 in which the respective end portions 37<sup>a</sup> and 37<sup>b</sup> are to be ground concentrically with respect to one another. The member 37 is shown illustratively in these figures in the form of an axle member in which the end portion 37<sup>a</sup> is to be reduced or ground to a shape of uniform diameter throughout, whereas the other end portion 37<sup>b</sup> is to be ground to tapered form.

As hereinbefore described, the rollers 35 and 36 (Figure 5) support one end of the work and in effect determine the axis about which this end rotates. As illustratively shown, the rollers 35 and 36 and their associated mounting mechanisms are arranged to support the cylindrical end 37<sup>a</sup> as distinguished from the tapered end portion 37<sup>b</sup>. Considering now the manner in which the other end portion (37<sup>b</sup>) is presented to the wheels and supported therebetween for operation thereon, it will be noted that the auxiliary frame member 32 is under cut on both sides thereof or reduced in section, as at 32<sup>b</sup>, intermediate of the wheels 22 and 24. More-

over, also, an upper portion of the frame member 32 intermediate of the wheels is cut away to form a recess 32<sup>c</sup> extending lengthwise of the frame member 32. The bottom wall of the recess 32<sup>c</sup> is downwardly inclined to both the left and right as viewed in Figure 2 to form what may be termed an apex at a substantially central point lengthwise of the recess 32<sup>c</sup>, and at this apex is formed a transversely extending seat in which rests a roller 32<sup>d</sup> upon which is pivoted a carrier member 41. The carrier member 41 extends lengthwise of the recess 32<sup>c</sup> and as clearly shown in Figure 2 extends upwardly beyond the upper surface of the frame member 32. Referring now to Figure 8, it will be seen that secured to either side of the carrier member 41, as by the screws 41<sup>a</sup>, are the downwardly extending plate members 41<sup>b</sup> and 41<sup>c</sup>, one on each side of the carrier member 41. These plate members 41<sup>b</sup> and 41<sup>c</sup> extend downwardly into the lateral recesses 32<sup>b</sup> of the auxiliary frame member 32 and, in effect, act to guide the carrier member 41 as it swings about the pivoting roller 32<sup>d</sup>, the latter being interposed between the apex at the bottom of the recess 32<sup>c</sup> and a substantially central portion of the carrier 41. The side plates 41<sup>b</sup> and 41<sup>c</sup> are each provided with an arcuate slot 41<sup>d</sup> adjacent their lower ends, a screw 32<sup>e</sup> passing through these slots and into the frame member 32 in order to effectively hold the carrier 41 in assembled relation with respect to the auxiliary frame member 32, at the same time permitting free movement of the carrier member 41 about its pivotal support 32<sup>d</sup>.

Thus referring briefly to Figure 2, it will be seen that as the work 37 is positioned so that its one end 37<sup>a</sup> is supported upon the rollers 35 and 36 to determine the axis about which that end rotates, the other end 37<sup>b</sup> of the work 37 rests upon the upper supporting surface of the carrier 41, the latter, by reason of its rocking support, automatically accommodating itself to the tapered end 37<sup>b</sup> positioned thereon. At this point it may be noted that the same self-accommodating action takes place if the work piece 37 were reversed and the straight or cylindrical end 37<sup>a</sup> thereof positioned upon the carrier member 41. The upper supporting surface 41<sup>e</sup> of the carrier member 41 (see Figure 8) is preferably inclined downwardly toward the regulating wheel 24 in order to tend to urge the portion of the work 37 supported thereon toward the regulating wheel 24. A wear strip 41<sup>f</sup> is preferably removably inserted in a suitable lengthwise extending recess in the upper portion of the carrier 41 in order that the wear on the carrier member 41 may be concentrated in this wear strip 41<sup>f</sup> which is preferably of a suitably hardened material, it being noted

that as one surface of the member 41<sup>f</sup> becomes worn, the member 41<sup>f</sup> may either be rotated to present one of its other surfaces for wear or may even be replaced.

5 In order, however, to insure positive control of the rotation of the work 37 by the regulating wheel 24, as well as to prevent  
10 unintended contact of the work with the grinding wheel 24, as will be more clearly hereinafter explained, the auxiliary frame member 32 has mounted thereon and adjacent the two wheels a bracket 69, as by  
15 the clamping screw 69<sup>a</sup>. This bracket 69, preferably positioned on the grinding wheel side of the auxiliary frame member 32, pivotally supports at 69<sup>b</sup> an arm 69<sup>c</sup> in the  
20 upper end of which is rotatably mounted a roller 69<sup>e</sup>. At the lower end of the arm 69<sup>c</sup>, the latter is recessed as at 69<sup>f</sup> to provide a housing for a spring 69<sup>g</sup> which is interposed  
25 between the bracket 69 and the lower end of the arm 69<sup>c</sup>. Preferably a pin 69<sup>h</sup> is rigidly mounted at the lower end of the bracket 69 to extend into the recess 69<sup>f</sup> to assist in holding  
30 the spring 69<sup>g</sup> in place. The spring 69<sup>g</sup>, in tending to expand, urges the roller 69<sup>e</sup> to the left as viewed in Figure 7, and the roller, in substantially non-frictionally engaging the work 37 urges the work 37 toward the regulating wheel 24, thus insuring  
35 the maintenance of the contact of the work 37 with the regulating wheel 24.

Turning now to Figure 2 of the drawings, it will be noted that the frame member 30  
35 is bored out as at 30<sup>f</sup> preferably throughout its longitudinal extent in order to house therein an operating bar 70 preferably of circular cross-section, and provided  
40 at its forward and underside with a rack 70<sup>b</sup> adapted to mesh with a gear 70<sup>c</sup> suitably mounted at the forward and underside of the frame member 30. The gear 70<sup>c</sup> is adapted to be manually rotated by means of a handle 70<sup>d</sup>, so that upon  
45 operation of the handle or lever 70<sup>d</sup>, a sufficient rotation of the gear 70<sup>c</sup> may be brought about to move the operating bar 70 lengthwise with respect to the housing or frame 30. In the position shown in Figure 2, the bar  
50 70 occupies a position substantially at the end of its possible movement to the left.

The operating bar 70 is cut away at two spaced points in its upper portion in order  
55 to provide two inclined surfaces 70<sup>f</sup> and 70<sup>g</sup>, adapted to coact with the lower end portions 30<sup>a</sup> and 30<sup>b</sup> of the supporting posts 30<sup>a</sup> and 30<sup>b</sup> respectively. The portions 30<sup>a</sup> and 30<sup>b</sup> are extended through the upper portions of the housing or frame member 30, the latter  
60 being formed at these parts to provide suitable guiding portions, so that upon a movement to the right, as viewed in Figure 2, of the operating bar 70, the inclined surfaces 70<sup>f</sup> and 70<sup>g</sup> move the supporting posts,  
65 30<sup>a</sup> and 30<sup>b</sup>, respectively and hence the auxil-

iary frame member 32 with the work upwardly as viewed in Figure 2. As will be seen from Figure 8, such a movement carries the work 37 to a position between more distant portions of the operative surfaces 24<sup>a</sup> 70 and 22<sup>a</sup> of the regulating wheel 24 and 22 respectively, it being noted that during such movement, the portion 37<sup>b</sup> of the work 37 is effectively maintained out of contact with the grinding wheel 22. Such movement, in  
75 response to, for example, the manual operation of the operating bar 70 may thus be effective to carry the work out of operative relation to the opposed operative portions of the two wheels, in order, at the completion of the desired grinding action, to permit  
80 the removal of the work from the apparatus. A new work piece may then be positioned as hereinbefore described, whereupon a reverse movement of the operating bar 70 is effective  
85 to carry the work downwardly and into operative relation to the two wheels. A pair of springs 71<sup>a</sup> and 72<sup>a</sup>, connecting the movable frame member 32 with the fixed frame member 30, insure the maintenance of  
90 the desired coacting relation between the supporting posts and the inclined surfaces of the operating bar 70.

As hereinbefore noted, the regulating wheel 24 is effective to urge the work  
95 lengthwise of itself and to the rear of the apparatus as shown in Figure 1, in addition to bringing about a control of the rotation of the work about its axis during the grinding operation thereon by the  
100 grinding wheel 22. It will be noted that the work 37, being of cumbersome form, has only a relatively small portion thereof in operative relation to the wheels as compared with the entire length of the work piece 37. The  
105 control of the rotation of the work 37 by the regulating wheel 24, however, is unimpaired and in fact is insured in that the exteriorly positioned rollers 35 and 36 for supporting the one end 37<sup>a</sup> of the work 37  
110 relieve the burden on the regulating wheel of rotating the heavy work piece 37 and materially aid or assist the regulating wheel. In this connection it might be noted that the supporting rollers 35 and 36 may be driven  
115 at a suitable speed through the belt 68<sup>a</sup> and the cone pulley 68<sup>b</sup> commensurate with the speed at which the regulating wheel 24 rotates the work.

At the rear end of the auxiliary frame member 32 and as clearly shown at the right  
120 hand end in both Figures 2 and 3, a bracket 71 on the frame member 32 has threaded into it so as to extend lengthwise of the frame member 32, a stop member 71<sup>b</sup> taking the  
125 form preferably of an elongated screw, the position of its left hand end being adjustable at will lengthwise of the frame member 32. A lock nut 71<sup>c</sup> may be employed to lock the stop member 71<sup>b</sup> in adjusted position.  
130

The stop member 71<sup>b</sup> limits the movement of the work 37 rearwardly of the frame member 32 or in a direction to the right as seen in Figures 2 and 3, the stop member 71<sup>b</sup> being positioned in substantial alignment with the right hand end of the work piece 37. The feeding action of the regulating wheel 24, which, as above noted, urges the work to the right (in Figures 2 and 3) is thus effective to securely hold the work against the stop member 71<sup>b</sup> during the rotation thereof by one wheel and the grinding action thereon by the other.

As is clearly shown in Figure 3 and also in Figure 1, it will be seen that the opposed operative portions of the two wheels, that is, substantially the tangent lines in which the two wheels contact with the work, make an angle with one another as viewed in the horizontal plane. This relation may be obtained by suitably shaping the regulating wheel 24 (see Figure 1) as by means of a suitable truing device 72, carrying a suitable truing tool such as a diamond, and adapted to be guided along a predetermined path of travel to give the regulating wheel 24 the desired shape. This angular relation between the opposed operative portions of the two wheels is desirable when work of tapered form is to be operated upon, it being noted that preferably the grinding wheel 22 is maintained, by means of a suitable truing apparatus 72<sup>c</sup> in substantially true cylindrical shape for a purpose more particularly to be hereinafter described.

As viewed in both Figures 1 and 3, it will be seen that the regulating wheel 24 is substantially broad-faced in order that it may well back up the end portion of the work desired to be operated upon. The grinding wheel 22 presents an operative surface which is of less extent lengthwise of the auxiliary frame 32. In order to insure a high degree of accuracy, the normal accuracy of the two wheels 22 and 24, due to their trued shape, is effectively combined with the high degree of accuracy resulting from a movement of the grinding wheel 22 lengthwise of the work operated upon and in a direction substantially co-incident with the line of contact of the grinding wheel with the portion of the work operated upon. As hereinbefore noted, the grinding wheel shaft 17 is driven by the belt 21 riding over the broad-faced pulley 19. With this construction it will be noted that a substantial movement of the grinding wheel 22 in the direction of its axis may readily take place without disturbing the driving connection, and it may be here pointed out that the desired movement of the grinding wheel 22 lengthwise of the work is preferably brought about in this manner because of its relatively greater simplicity and convenience of construction.

As seen in Figure 1, the rear portion of the apparatus is broken away and for the sake of simplicity, this rear portion, together with the two wheels and their driving shafts, is shown in schematic perspective in Figure 9, it being noted, in so far as the actual details of construction are concerned that reference may be had to my co-pending application, Serial No. 669,693, filed October 20, 1923.

Turning now to Figure 9, it will be seen that at the rear end of the regulating wheel shaft 18 the latter carries a helical gear 33<sup>a</sup> which meshes with and drives a helical gear 34<sup>a</sup> driving the shaft 42 suitably supported in convenient bearings. At the left hand end of the shaft 42, the latter carries a crank disk 46 which bears a diametrically extending T-slot 47 in which is adjustably mounted a crank pin 49. The crank pin 49 engages in the slot 64<sup>b</sup> of an oscillating member 64 preferably supported for oscillating movement upon and about a shaft 52 extending lengthwise of the main frame and at the rear thereof. Thus as the crank disk 46 rotates, it being noted that the slowly driven regulating wheel 24 forms a convenient low speed source of power, the arm 64 is oscillated back and forth about the axis of the shaft 52, the extent of its oscillating movement being determined by the throw of the crank pin 49.

The shaft 52 has rigidly secured thereto and adjacent the arm 64, a crank arm 63 carrying at its upper end an arcuate slot 63<sup>b</sup> through which extends a pin 65 rigidly mounted in the upper end of the oscillating arm 64. Thus as the latter is oscillated by the crank pin 49, the connecting pin 65 transmits the oscillating movement of the arm 64 to the arm 63, the latter in turn swinging with it the upwardly extended arm 56 to which the rear end of the grinding wheel shaft 19 is connected. Thus, assuming that the pin 65 is locked with respect to the crank arm 63, as by means of the two oppositely mounted adjusting screws 63<sup>c</sup> and 63<sup>d</sup> threaded into the opposite ends of the arm 63 and having their end portions extending into the respective ends of the slot 63<sup>b</sup>, the crank arm 63 will be oscillated in exact unison with the oscillating arm 64. Such action, turning now to Figures 1 and 3, is effective to reciprocate the grinding wheel lengthwise of the work operated upon, it being noted that the length of the stroke of the wheel may be adjusted by adjusting the throw of the crank pin 49.

The conditions of operation may also find it advantageous to permit a pause to take place at the end of a stroke in the movements of the grinding wheel 22 lengthwise of the work. This may be achieved by backing off the screws 63<sup>c</sup> and 63<sup>d</sup> away from

one another, thus making a lost-motion connection between the pin 65 and the crank arm 63. The length of the pause at the end of a stroke may be readily predetermined by adjusting the effective length of the slot 63<sup>b</sup> by means of the screws 63<sup>c</sup> and 63<sup>d</sup>. Any shortening in the length of the stroke of movement of the grinding wheel 22, resulting from the inter-positioning in the mechanism of the lost-motion connection, may be compensated for by increasing the stroke of the crank pin 49.

From the foregoing it will be clear that the effective length of the slot 63<sup>b</sup> may be readily and conveniently predetermined. It will also be noted, however, that the position of the effective slot may be likewise predetermined by the relative adjustment of the screws 63<sup>c</sup> and 63<sup>d</sup> with respect to the crank arm 63. The effective slot, the ends of which are predetermined by the ends of the screws 63<sup>c</sup> and 63<sup>d</sup>, may in effect be moved transversely of the crank arm 63, thus predetermining also the locus of operation or of movement of the grinding wheel 22 relative to the work.

Where the wheels are so related one to another, as herein illustratively set forth, that the opposed operative portions of the two wheels make an angle so as to permit the grinding of work to tapered form (as the end portion 37<sup>b</sup> of the work 37, for example) and in order that the path of movement of the grinding wheel 22 may be properly related to the work operated upon, the axis of the work should occupy a position such that, as viewed in Figure 3 for example, it lies in a vertical plane bisecting the angle between the operative portions of the two wheels. When so related with respect to the two wheels, the tapered portion of the work will be effectively backed up by the regulating wheel on the one side thereof, and the opposite side of the work will be substantially aligned with the path of movement of the grinding wheel 22 relative to the work. In order that this relation may be readily brought about, the frame member 30 is pivoted to the angle plate 31 as at 73 (see Figures 2 and 3) whereby the frame member 30 together with the auxiliary frame member 32 and associated devices may be swung in a substantially horizontal plane and about the pivot 73 so as to bring the axis of the work 73 into substantially the bi-secting vertical plane of the angle between the operative contacting portion of the wheel 24 and the path of travel lengthwise of the work of the operative contacting portion of the grinding wheel 22. Suitable clamping screws 73<sup>a</sup> threaded into the frame member 30 and passing through suitable slots 73<sup>b</sup> in the plate portion 31<sup>a</sup> of the angle member 31 may be employed to lock the frame

member 30 and associated parts into adjusted position. At this point it may be noted that, where the end portion of the work 37 is to be ground to true cylindrical form, (as for example the portion 37<sup>a</sup> of the work piece 37) the above mentioned adjustment may be utilized to properly align the end portion of the work with the operative portions of the two wheels, which, in this case, will be substantially parallel one to another.

In order that the above described adjustment of the position of the portion 37<sup>b</sup> of the work 37 with respect to the wheels may be accurately made, provision is made for bringing about a micrometer adjustment of the exterior end portion of the work 37 laterally with respect to the inner portion of the work presented for operation thereon by the wheels. Thus, referring more particularly to Figures 5 and 6 and also to Figure 2, it will be noted that the plate like bracket 34 is secured to the plate member 33<sup>c</sup> of the bracket 33 by means of the two clamping screws 34<sup>a</sup> and 34<sup>b</sup> threaded into the plate member 33<sup>c</sup> and passing through transversely extending slots in the plate member 34. The plate member 34 (see also Figure 3) is provided with a rearwardly extending lug 34<sup>m</sup> adapted to overlap laterally the plate member 33<sup>c</sup> of the bracket 33. An adjusting screw 34<sup>p</sup> passes through the lug 34<sup>m</sup> and abuts against the plate member 33<sup>c</sup>. By means of the adjusting screw 34<sup>p</sup>, the relative displacement laterally of the bracket 34 with its supporting rollers 35 and 36 may be accurately predetermined relative to the bracket 33. The clamping screws 34<sup>a</sup> and 34<sup>b</sup> may, after the adjustment, then lock the parts in adjusted position. Thus it will be seen that the outer end of the work may be accurately displaced laterally with respect to the inner end of the work, in order that the axis of the inner end (37<sup>b</sup> for example) may be accurately aligned with respect to the operative portions of the two wheels.

As hereinbefore described, the auxiliary frame member 32 may be vertically adjusted by means of the slot and bolt connection thereof with the movable supporting posts 30<sup>a</sup> and 30<sup>b</sup>. The auxiliary frame member 32 may be adjusted with respect to these posts so as to bring the axis of the work operated upon in substantially the same horizontal plane with the locus of operation of the grinding wheel 22, when the operating lever 70<sup>c</sup> is swung into the position shown in Figure 2 to carry the work portion 37<sup>b</sup> downwardly between the two wheels for operation thereon. A pair of stops 74<sup>a</sup> and 74<sup>b</sup> (see Figure 2) preferably taking a form of screws threaded into suitable abutments in the upper portion of the frame member 30 and one adjacent each of the movable

supporting posts 30<sup>a</sup> and 30<sup>b</sup> may be employed not only to make the above described adjustment, but also to limit the downward movement of the work when carried into operative relation to the two wheels.

In this connection it may be noted that the adjusting screw 33<sup>s</sup> (see Figure 2) may be employed to raise or lower the supporting rollers 35 and 36, thus permitting a micrometer displacement vertically of the exterior end of the work with respect to the inner end of the work, to insure the desired relation for positioning of the end portion of the work operated upon with respect to the two wheels and the movement of the grinding wheel. It will be noted that as this latter adjustment is made, the carrier member 41 hereinbefore described and upon which the inner end 37<sup>b</sup> of the work is supported automatically aligns itself with respect to this inner end and thus insures the proper supporting of the portion of the work between the wheels that is to be operated upon.

From the foregoing, it is believed that the operation of the apparatus will be readily understood, but by way of brief résumé it may be noted that with the wheels driven at the respective speeds hereinbefore described and with the supporting rollers 35 and 36 driven through the belt 68<sup>a</sup> at a speed commensurate with that of the regulating wheel surface in order thus to insure effective control of the rotation of the work during the action thereon by the grinding wheel 22, the auxiliary frame 32 is carried upwardly by swinging the operating lever 70<sup>e</sup> in clockwise direction (see Figure 2), the inclined surface 70<sup>f</sup> and 70<sup>g</sup> of the operating bar 70 being effective to bring about this upward movement of the work supporting apparatus. The work piece is then placed upon the supporting mechanisms so that its one, or inner end, rests upon the rocking carrier member 41 and so that its exterior or other end rests upon the driven supporting rollers 35 and 36. The latter at once act to coax with the regulating wheel surface 24<sup>a</sup> to rotate the work piece 37, it being noted that the yieldably positioned roller 69<sup>e</sup> (see Figure 7) co-acting with the inclined surface 41<sup>e</sup> of the carrier member 41 (see Figure 8) acts to hold the inner end 37<sup>b</sup> of the work out of contact with the grinding wheel surface 22<sup>a</sup> and in contact with the regulating wheel surface 24<sup>a</sup>. Thus the desired rotation of the work is initiated.

The operating lever 70<sup>e</sup> is thereupon swung in counter clockwise direction (see Figure 2) whereupon the work supporting apparatus carries the inner end of the work 37<sup>b</sup> downwardly as viewed in Figure 2 to present this inner end to the opposed operative portions of the two wheels, it being understood that the feeding action of the

regulating wheel 24 holds the work against the stop member 71<sup>b</sup> (see Figures 2 and 3) and that the grinding wheel 22 is being reciprocated as hereinbefore described and through the mechanism diagrammatically shown in Figure 9. The stop members 74<sup>a</sup> and 74<sup>b</sup> (see Figure 2) limit the downward movement of the work supporting apparatus with the work thereon, whereupon the work may be allowed to remain in its lowermost position during as many strokes of the grinding wheel 22 lengthwise thereof as the particular character or condition of the work piece may demand. As the end portion 37<sup>b</sup> is thus being gradually reduced and ground to desired tapered form, the rocking carrier member 41 automatically accommodates itself to the changes in the conformation of the portion 37<sup>b</sup> of the work, as the two wheels gradually bring this portion of the work to the desired accurate tapered shape. The grinding wheel in addition to contributing to the accuracy of the grinding operating by reason of its trued shape insures a very high degree of accuracy by reason of its movement lengthwise of the work, this movement being preferably a reciprocatory movement in which the pauses at the end of the stroke may or may not be utilized according to the requirements of the particular character of work operated upon. Moreover, the wear on the grinding wheel 22 is maintained more uniform as a result of this movement and thus highly uniform as well as accurate results are attained.

After the desired grinding action upon the portion 37<sup>b</sup> of the work has been allowed to take place, the operating lever 70<sup>e</sup> may be swung in clockwise direction (see Figure 2) to carry the work upwardly and between more distant portions of the operative surfaces of the two wheels, it being noted that during this movement the work is effectively maintained in contact with the regulating wheel surface and out of contact with the grinding wheel surface. The work piece may thereupon be removed from the supporting apparatus and replaced by another work piece to be ground, when the operations hereinabove described may be repeated.

In order to accommodate the apparatus to work of different diameters, the carriages 11 and 12 (see Figure 1) may be adjustably positioned toward or away from one another as by means of the hand wheels 11<sup>a</sup> and 12<sup>a</sup> respectively, these wheels being preferably concentrically arranged and operatively connected with their respective carriages to permit a movement thereof and hence of the two wheels toward or away from one another, according to the character or diameter of the work operated upon.

It will be noted that, as already herein-

before described, the bracket 33 may be pivotally adjusted about the clamping screw 33<sup>b</sup> with respect to the auxiliary frame member 32. Thus, for example, should the end portion 37<sup>a</sup> (see Figure 2) of the work be of tapered form, the bracket 33 with the bracket 34 and supporting rollers 35 and 36 thereon may be swung in clockwise direction, for example, about the clamping screw 33<sup>b</sup> to align the supporting surfaces of the rollers 35 and 36 with the tapered end of the work. This adjustment may be made for example where the wheels are related to one another to grind the straight or cylindrical portion 37<sup>a</sup> of the work 37 in which case the tapered end 37<sup>b</sup> is supported upon the rollers 35 and 36.

Turning now to Figure 4 of the drawings, there is shown an arbor 75 having at its one end a cylindrical portion 75<sup>a</sup> adapted to be supported upon the supporting rollers 35 and 36 and having at its other end a tapered shank 75<sup>b</sup> upon which is adapted to be positioned a work piece 76 illustratively shown in the form of a tapered drill shank, the exterior of which it is desired to reduce to true tapered form. By thus assembling the shank 76 with respect to the arbor 75, the former may be ground in substantially the same manner as the tapered end portion 37<sup>b</sup> of the work 37 (see Figure 2) hereinabove illustratively set forth. With such an arrangement, the advantages achieved in grinding work of elongated form may be effectively attained with work of short lengths, and the parts shown in Figure 4 are merely illustrative of an arrangement for supporting work of short lengths in a manner to achieve the advantages above mentioned. It is therefore to be understood that the term "work piece" or "work" as hereinbefore or as hereinafter used, is to be interpreted as inclusive of such an arrangement as is illustratively shown in Figure 4 as hereinabove described.

The rocking carrier member 41 will thus be seen to insure the rigid supporting throughout substantially its entire length of that end portion of the work presented to the wheels for action thereon, the other end of the work being reliably supported upon the rollers 35 and 36. Chattering is thus effectively avoided since the carrier member 41, in automatically accommodating itself to the end portion of the work, insures the support of this end portion uniformly throughout substantially its entire extent. Moreover, it may be pointed out that, as the grinding proceeds, the right hand end of the work as viewed in Figure 2 tends to be lowered because of the removal of material therefrom by the grinding wheel. As the work 37 thus in effect swings downwardly at its right hand end to an extent pro-

portional to the amount of material removed from the end portion, the rocking carrier member 41 again and continuously accommodates itself to the changing conditions, and thus maintains consistently an effective support of the one end of the work throughout the range of action of the wheels in the direction of the length of the work. Moreover, it will also be noted that, the outer or left hand end as seen in Figure 2 having been ground to true form, is supported at that end to rotate about its true axis, and this insures, together with the supporting action of the rocking carrier 41, the concentric grinding of one end of the work with respect to the other.

It will thus be seen that there has been provided in this invention an apparatus in which the several objects hereinbefore noted, as well as many others, are achieved and that many thoroughly practical advantages are attained. It will be seen that the apparatus is of a thoroughly practical nature and hence well adapted to meet the conditions of hard practical use, and that the apparatus is capable of the achievement of highly uniform and accurate results. It will moreover also be seen that the apparatus is characterized by a high degree of flexibility of adjustment and arrangement and that it may be readily adapted to meet the requirements of the specific character of work operated upon.

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 is to be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned between said wheels for supporting one portion of the work and a member positioned exteriorly of said wheels for supporting another portion of the work, and means for limiting movement of the work in the direction of its length.

2. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned adjacent said wheels for supporting one portion of the work and a member positioned remote from

said wheels for supporting another portion of the work, and means for giving one of said wheels a movement lengthwise of said carrier member during its action upon the work.

3. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned adjacent said wheels for supporting one portion of the work and a member positioned remote from said wheels for supporting another portion of the work, and means for reciprocating one of said wheels with respect to the other and in the general direction of the line of contact of said one wheel with the work.

4. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned adjacent said wheels for supporting one portion of the work and a rotatable member positioned remote from said wheels for supporting another portion of the work, means for rotating said rotatable member, and means for limiting movement of the work in the direction of its length.

5. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween; means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned adjacent said wheels for supporting one portion of the work and a rotatable member positioned exteriorly of said wheels for supporting another portion of the work, means for giving one of said wheels a movement lengthwise of said carrier member during its action on the work, and means for rotating said rotatable member.

6. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned between said wheels for supporting one portion of the work and means positioned exteriorly of said wheels for supporting another portion of the work and adapted to substantially determine the axis of rotation of said last mentioned portion of the work, and means for

adjusting laterally said exteriorly positioned means with respect to said carrier member.

7. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned between said wheels for supporting one portion of the work and means positioned exteriorly of said wheels for supporting another portion of the work and adapted to substantially determine the axis of rotation of said last mentioned portion of the work, and means for adjusting vertically said exteriorly positioned means with respect to said carrier member.

8. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, a work carrier extending between said wheels for supporting work of round section in operative relation to said operative portions of said wheels, and means for adjusting said carrier about an axis substantially transverse to the plane of the angle between the operative portions of said wheels.

9. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, a work carrier extending between said wheels for supporting work of round section in operative relation to said operative portions of said wheels, means for adjusting said carrier vertically, and means for adjusting said carrier in a substantially horizontal plane about a substantially vertically extending axis.

10. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, a work carrier extending between said wheels for supporting work of round section in operative relation to said operative portions of said wheels, means mounting said carrier

to permit said carrier to be adjustably swung about a substantially vertically extending axis, and means for locking said carrier in adjusted position with respect to said axis.

- 5 11. In apparatus of the character described, in combination, a pair of abrasive wheels having approaching operative surfaces and adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned adjacent said wheels for supporting one portion of the work and means positioned remote from said wheels for supporting another portion of the work, means for limiting movement of the work in the direction of its length, and means for moving said carrier member relative to said approaching operative surfaces to carry the portion of the work supported thereon to a position between more distant portions of the operative surfaces of said two wheels.
- 25 12. In apparatus of the character described, in combination, a pair of abrasive wheels having approaching operative surfaces and adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned between said wheels for supporting one portion of the work and means positioned exteriorly of said wheels for supporting another portion of the work, and means for moving said work supporting means in a direction to carry the portion of the work supported upon said carrier member to a position between more distant portions of the approaching operative surfaces of said two wheels.
- 40 13. In apparatus of the character described, in combination, a pair of abrasive wheels having approaching operative surfaces and adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels comprising a carrier member positioned adjacent said wheels for supporting one portion of the work and means positioned remote from said wheels for supporting another portion of the work, means for adjustably positioning said work supporting means about a substantially vertically extending axis, and means for moving said carrier member in a direction to carry the portion of the work supported thereon to a position between more distant parts of the approaching operative surfaces of said two wheels.
- 65 14. In apparatus of the character described, in combination, a pair of abrasive

wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, and means for supporting work of round section in operative relation to said wheels comprising means positioned exteriorly of said wheels for supporting one portion of the work and a self-adjusting carrier member positioned between said wheels for supporting another portion of the work in operative relation to said wheels.

15. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means positioned remote from said wheels for supporting one portion of the work, and a floating carrier member positioned adjacent the wheels for supporting another portion of the work in operative relation thereto and adapted to align itself with respect to the portion of the work supported thereby.

16. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneously rotating and grinding action upon work of round section supported therebetween, means positioned remote from said wheels for supporting one portion of the work, and a carrier member positioned adjacent said wheels for supporting another portion of the work in operative relation thereto and mounted to swing about a substantially horizontal axis.

17. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, means for supporting work of round section in operative relation to said wheels having a carrier member extending between said wheels for supporting one portion of the work and means positioned exteriorly of said wheels for supporting another portion of the work, means mounting said supporting means to permit adjustment thereof toward or away from one of said wheels, and means adapted to permit relative adjustment between said carrier member and said exteriorly positioned means laterally with respect to one another.

18. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, means for supporting work of round section in operative relation to said wheels comprising spaced supporting members, one of which is positioned between said wheels for

supporting one portion of the work in operative relation thereto and the other of which is positioned exteriorly of said wheels for supporting another portion of the work, and means for adjusting said supporting means about an axis substantially transverse to the plane of the angle between the operative portions of said wheels.

19. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, means for supporting work of round section in operative relation to said wheels comprising spaced supporting members, one of which is positioned adjacent said wheels for supporting one portion of the work in operative relation thereto and the other of which is positioned remote from said wheels for supporting another portion of the work, means for adjusting said supporting means about an axis substantially transverse to the plane of the angle between the operative portions of said wheels, and means for adjusting one of said spaced carrier members laterally with respect to the other.

20. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, means for supporting work of round section in operative relation to said wheels comprising spaced supporting members, one of which is positioned adjacent said wheels for supporting one portion of the work in operative relation thereto and the other of which is positioned remote from said wheels for supporting another portion of the work, means for adjusting said supporting means about an axis substantially transverse to the plane of the angle between the operative portions of said wheels, and means for adjusting one of said spaced carrier members vertically with respect to the other.

21. In apparatus of the character described, in combination, a carrier for supporting thereon work of round section, a regulating wheel positioned on one side of said carrier and adapted to be rotated at a relatively low speed, thereby to control the rotation of said work on said carrier, a grinding wheel positioned on the other side of said carrier and adapted to be rotated at a relatively high speed, and additional means for rotating the work on said carrier.

22. In apparatus of the character described, in combination, a carrier for supporting thereon work of round section, a regulating wheel positioned on one side of said carrier and adapted to be rotated at a relatively low speed, thereby to control the rotation of said work on said carrier, a grinding wheel positioned on the other side of said carrier and adapted to be rotated at a relatively high speed, and means acting independently of said carrier for holding the work in contact with said regulating wheel.

23. In apparatus of the character described, in combination, a carrier for supporting thereon work of round section, a regulating wheel positioned on one side of said carrier and adapted to be rotated at a relatively low speed, thereby to control the rotation of said work on said carrier, a grinding wheel positioned on the other side of said carrier and adapted to be rotated at a relatively high speed, additional means for rotating said work on said carrier, and means for giving said grinding wheel a movement lengthwise of said carrier.

24. In apparatus of the character described, in combination, a grinding wheel adapted to be rotated at a relatively high speed, a regulating wheel adapted to be rotated at a relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a pair of spaced carrier members, one of which is positioned adjacent said wheels for supporting one portion of the work in operative relation to said wheels and the other of which is positioned remote from said wheels for supporting another portion of the work, and means positioned intermediate of said two spaced carrier members for holding the work supported thereon in contact with said regulating wheel.

25. In apparatus of the character described, in combination, a grinding wheel adapted to be rotated at a relatively high speed, a regulating wheel adapted to be rotated at a relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a pair of spaced carrier members, one of which is positioned adjacent said wheels for supporting one portion of the work in operative relation to said wheels and the other of which is positioned remote from said wheels for supporting another portion of the work, and a roller member yieldingly urged against the work on the side thereof remote from said regulating wheel.

26. In apparatus of the character described, in combination, a grinding wheel adapted to be rotated at a relatively high speed, a regulating wheel adapted to be rotated at a relatively low speed, said wheels being adapted to present adjacent approach-

ing operative surfaces traveling in opposite directions, means for supporting work of round section in operative relation to said wheels, means for moving said supporting means in a direction to carry the work into or out of operative relation to said wheels, and a roller member contacting with the work and adapted to urge the latter away from the grinding wheel surface during movement of said supporting means.

27. In apparatus of the character described, in combination, a grinding wheel adapted to be rotated at a relatively high speed, a regulating wheel adapted to be rotated at a relatively low speed, said wheels being adapted to present adjacent approaching operative surfaces traveling in opposite directions, means for supporting work of round section in operative relation to said wheels, means for moving said supporting means in a direction to carry the work into or out of operative relation to said wheels, and a roller member mounted upon said supporting means to be movable therewith and yieldingly urging the work thereon toward said regulating wheel.

28. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round sections supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, an elongated frame member extended between the operative surfaces of said two wheels, means mounted adjacent the end of said frame member remote from said wheels for rotatably supporting one end of the work, a carrier member adjacent said wheels for supporting another portion of the work, and means mounting said carrier member upon said frame member adapted to permit said carrier member to align itself with respect to the portion of the work supported thereon.

29. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, an elongated frame member extended between the operative surfaces of said two wheels, carrier means mounted upon said frame member for supporting one end of the work, a carrier member rockingly mounted upon said frame member and adjacent said two wheels for supporting another portion of the work and means for angularly adjusting said frame member in a plane substan-

tially parallel to the plane of the angle between said opposed operative portions of said two wheels.

30. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, an elongated frame member extended between the operative surfaces of said two wheels, carrier means mounted upon said frame member for supporting one end of the work, a carrier member rockingly mounted upon said frame member and adjacent said two wheels for supporting another portion of the work, means for angularly adjusting said frame member in a plane substantially parallel to the angle between the opposed operated portions of said two wheels, and means for adjusting laterally one of said carrier members with respect to said frame member.

31. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, an elongated frame member extended between the operative surfaces of said two wheels, carrier means mounted upon said frame member for supporting one end of the work, a carrier member rockingly mounted upon said frame member and adjacent said two wheels for supporting another portion of the work, means for angularly adjusting said frame member in a plane substantially parallel to the angle between the opposed operated portions of said two wheels, and means for adjusting one of said carrier parts vertically with respect to the other.

32. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for a simultaneous rotating and grinding action upon work of round section supported therebetween and having operative portions of their adjacent operative surfaces more distant from one another at one end thereof than at the other end, thereby to grind work to tapered form, a work carrier extending adjacent said wheels for supporting work of round section in operative relation to said operative portions of said wheels, means for adjusting said carrier about an axis substantially transverse to the plane of the angle between the operative portions of said wheels, and means for giving one of said wheels a movement lengthwise of said carrier.

33. In apparatus of the character described, in combination, a pair of abrasive wheels adapted for simultaneous rotating and grinding action upon work of round section supported therebetween, and an arrangement for holding work of round section in operative relation to said wheels, said arrangement including means positioned adjacent said wheels for holding one portion of the work in operative relation to said wheels and means positioned remote from said wheels for holding another portion of the work, one of said means being arranged to be substantially self-aligning relative to the portion of the work engaged thereby.

In testimony whereof, I have signed my name to this specification this first day of October, 1923.

LEWIS R. HEIM.