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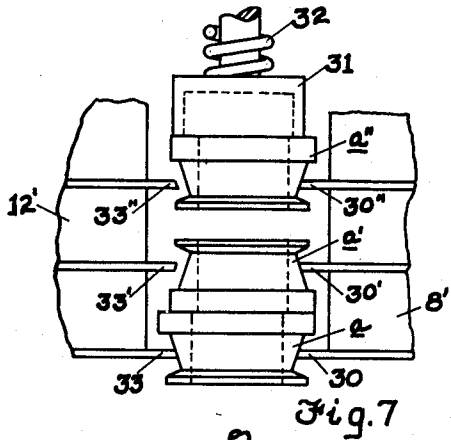
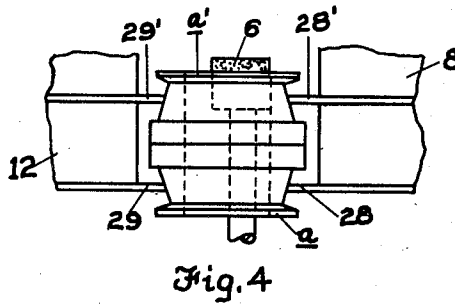
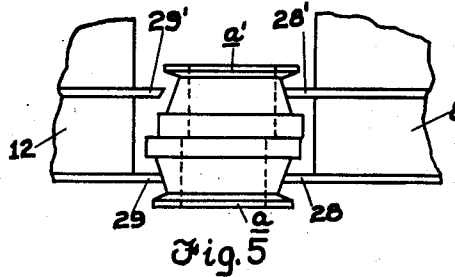
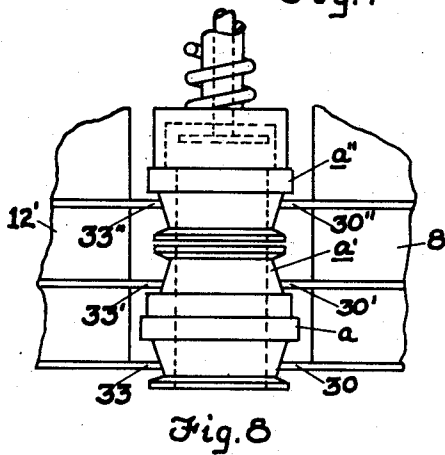
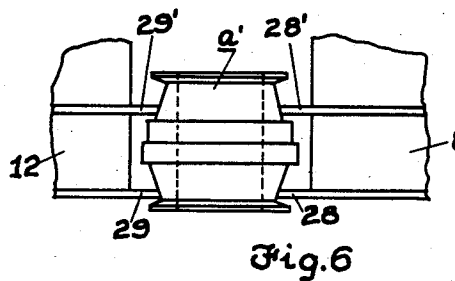
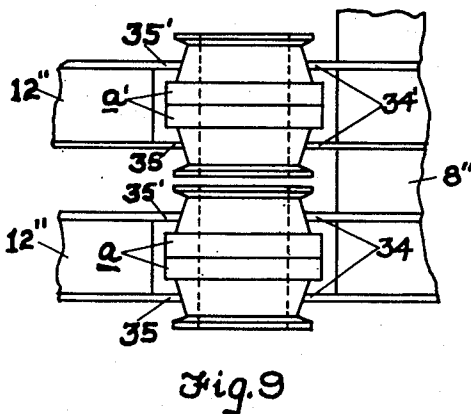
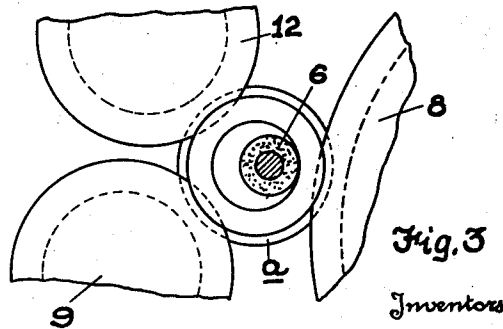
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2,329,301

INTERNAL GRINDING MACHINE AND METHOD

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INTERNAL GRINDING MACHINE AND METHOD

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The present invention relates to internal or bore grinding by the so-called chuckless or centerless method, involving the support and rotation of hollow workpieces by rolling contact with their outer peripheral surfaces, so that the internal grinding operation generates a bore or bores in truly concentric relation to said outer surfaces. More particularly, our invention is concerned with the simultaneous internal grinding in a machine organization of this centerless type of a multiplicity of aligned similarly-dimensioned workpieces having tapered or contoured (non-cylindric) outer peripheral surfaces.

Heretofore, in such simultaneous or multiple centerless internal grinding of aligned hollow workpieces having non-cylindric external surfaces, as disclosed, for example, in the copending patent application of Harold L. Blood and Richard A. Heald, Serial No. 266,164, filed April 5, 1939 (now Patent No. 2,290,269, dated July 21, 1942), it has been possible to get an approximate uniformity of results (bores all ground to the same size) only by resort to a special grinding arrangement and method which minimizes the effects of any diversities of external dimension between the workpieces being ground; such a special grinding arrangement and method being the subject matter of Blood Patent No. 2,047,055, dated July 7, 1936.

According to our invention, as hereinafter described, the need for such resort to approximate corrective measures is eliminated, by providing a machine and method for multiple internal grinding which utilizes the external taper or contour of the aligned workpieces to procure automatically their concentricity with one another, despite any variations between them in external diameter—thus to obtain absolute uniformity of result for the internal grinding operation performed simultaneously on all of said workpieces.

Other and further objects and advantages of the invention will more fully appear from the following detailed description taken in connection with the accompanying drawings, in which—

Fig. 1 is a front elevation of a machine embodying the invention.

Fig. 2 is a sectional view substantially along the line 2—2 of Fig. 1.

Fig. 3 is a fragmentary diagrammatic view showing on a larger scale one arrangement of the work-contacting elements of Fig. 2.

Fig. 4 is a partly-diagrammatic view illustrating two aligned workpieces of the same external diameter in their operative relation to certain of

the work-contacting elements, as viewed substantially from the line 4—4 of Fig. 2.

Fig. 5 is a view similar to Fig. 4 but indicating two workpieces of different external diameters.

Fig. 6 is a view similar to Figs. 4 and 5, and showing how the workpieces of Fig. 5 are brought into concentric relation.

Fig. 7 is a view similar to Fig. 5, but showing three workpieces of different diameters as initially presented to the work-contacting elements.

Fig. 8 is a view corresponding to Fig. 7 and showing how the three workpieces are brought into concentricity.

Fig. 9 is a view similar to Fig. 4, showing the arrangement for two pairs of workpieces.

Fig. 10 is a view similar to Fig. 3, but showing a slightly different arrangement of the work-contacting elements.

Referring first to Fig. 1, the machine provides a reciprocatory table 1 as is usual in an internal grinding machine; either the grinding wheel or the work to be ground is carried on said table, the reciprocations of the latter serving in either case to produce a relative translatory movement between said grinding wheel and the workpiece. In the construction shown the table supports and carries a workhead 2 while the wheelhead 3 is mounted on a bridge 4 which spans the guideways 5', Fig. 2, provided by the machine base 5 for the movements of the table. The grinding wheel 6 is carried on a spindle 7 journaled in the wheelhead 3 and is suitably rotated at a high rate of speed by any well known mechanism, not shown. The tapered or contoured workpieces as will hereinafter appear are delivered in multiple to a centerless or chuckless work-holding arrangement provided by the workhead 2 and are rotated therein at a relatively slow rate of speed.

The reciprocations of the table 1 which cause the rotating grinding wheel to make the desired traverse longitudinally, through the bores of the aligned workpieces are imparted by any suitable mechanism, as for example, the arrangement disclosed in the Blood et al. Patent No. 2,027,627, dated January 14, 1936. This patent discloses, among other things, a mechanism by which the grinding operation is interrupted for a dressing operation on the grinding wheel and other mechanism by which the grinding operation is terminated when the workpiece or workpieces in the workhead are finished to the desired dimension. These mechanisms though partly indicated at Fig. 1 are not a part of the present invention and need not be here described in detail.

With reference now to Fig. 2, the work-sup-

porting means includes a regulating roller 8 mounted on the end of a spindle, not shown, journaled in the workhead, and this wheel provides a backing for the workpieces during the grinding operation in which the grinding wheel is given the usual crossfeed movement relative to the axis of the work. Another element of the work-supporting means is a supporting roll 9 preferably mounted on a slide 10 adjustable on a bracket 11 secured to the table. The workpieces are held against the regulating and supporting rolls by a pressure roll 12 on a shaft 13 in the end of an arm 14 which is secured to a shaft 15 journaled in the workhead. The pressure wheel is resiliently held against the workpieces by a spring 16, Fig. 1, which acts upon an arm 17 secured to the shaft 15.

The backing or regulating roll 8 is positively rotated from a suitable driving means, not shown, and the rotation of this wheel procures a corresponding rotation of the workpieces by engagement with the peripheries thereof, this rotation being preferably clockwise, as shown in Fig. 2. The workpieces are thus supported and rotated on their outer surfaces during the grinding operation.

In the machine shown, the workpieces are fed from a chute 18 adjustably supported on an upright 19 on the workhead. An arm 20 prevents the workpieces from dropping onto the regulating and this arm is rocked about its axis 21 to drop a set of two or more aligned workpieces onto an ejector plate 22 when the latter has been swung upwardly into the dot-dash line position of Fig. 2. The ejector plate 22 is carried by an arm 23 mounted on a rod 24 extending through the spindle, not shown, on which the regulating roll 8 is mounted. The ejector arm is swung clockwise, Fig. 2, from the full line position to discharge finishing workpieces toward the back of the machine. The arm 20 is actuated by a cam 25 turnable with the rod 24. This mechanism is well known and is fully described in the Blood and Burns Patent No. 2,027,627, above referred to.

The crossfeed movement between the workpieces and the grinding wheel may be obtained by a transverse movement of the wheelhead on the bridge 4. This crossfeed movement may be procured by any well known mechanism, as, for example, the fluid pressure actuated crossfeed mechanism of the Blood et al. Patent No. 2,027,627, above referred to. It is sufficient to note that a cross slide, not shown carrying the wheelhead, is horizontally movable on the bridge and is shifted by a crossfeed screw 26, Fig. 1, rotated by a rod 27 connected to and reciprocated by a suitable fluid pressure actuated means. The movement of the wheelhead by the cross slide is horizontal, in the arrangement shown, and thus the path of the axis of the wheel is horizontal.

The general arrangement above described is all old and well known and represents by way of example, one type of machine to which our invention is particularly applicable. As above stated, the present invention contemplates a centerless or chuckless means for concentrically supporting and rotating a plurality of workpieces whose outer surfaces are tapered or contoured (non-cylindric) in such manner that a uniform internal grinding operation may be performed on all such workpieces simultaneously.

In Fig. 4 which shows our invention somewhat diagrammatically in relation to a pair of similar

workpieces a and a' having their outer surfaces frusto-conical, the regulating roll 8 has a pair of peripheral flanges 28 and 28', one for each workpiece. The outer edges of these flanges are preferably beveled to correspond to the taper of the workpieces and the flanges are preferably relatively narrow so that they have a small area of contact with the pieces of work.

The supporting roll 9 has similar flanges, not shown, and the pressure roll 12 has flanges 29 and 29' corresponding in spacing to the flanges 28 and 28' and also preferably having their outer edges beveled to correspond to the taper of the workpiece surfaces. The workpieces are delivered to the centerless or chuckless workholding means with their larger end surfaces opposed, so that the flanges of the rolls 8, 9 and 12 tend to urge the workpieces endwise toward each other with the workpieces thus providing a mutual backing for each other and preventing endwise movement of the workpieces after both workpieces have been fully engaged by the flanges on the several rolls.

When the two workpieces positioned in the workhead are exactly the same outside dimension, they will, of necessity, be supported and rotated about a common axis, as will be apparent from an inspection of Fig. 4. This same work-supporting arrangement, without need for any adjustment, will support and rotate workpieces whose outer surfaces are not finished precisely to the same dimension and these slightly dissimilar workpieces will both be rotated on a common axis. As shown in Fig. 5, a workpiece a' is slightly smaller in outside dimension than the normal sized workpiece a ; nevertheless, in the handling of such a pair of workpieces, when the pressure roll 12 is urged by spring 16 toward the supporting and regulating rolls, the flanges 28 and 29 which engage with the workpiece a procure an endwise movement in unison of both workpieces until the periphery of the smaller workpiece a' is brought into engagement with the flanges 28' and 29' for this workpiece, as shown in Fig. 6. Since the points of contact between the workpiece a' and the supporting flanges 28' and 29' are spaced from each other exactly the same amount as the points of contact between the workpiece a and the flanges 28 and 29, the undersized workpiece a' will be supported and rotated on exactly the same axis as the normal sized workpiece a .

In this situation, the same as in Fig. 4, the two workpieces provide mutual backing for each other and prevent any further endwise movement after the automatic shift to a concentric relationship has occurred. Fig. 5 shows the different-sized workpieces in misalignment, as initially introduced between the flanged rolls 8, 9 and 12, while Fig. 6 shows how this misalignment is automatically corrected when the workpieces have moved endwise and are supported on a common axis in readiness for a grinding operation. It will be obvious that two oversized workpieces or two undersized workpieces or a normal sized workpiece and any off-size workpiece will be centered for rotation on a common axis in the same manner as the two workpieces of Figs. 5 and 6 are brought into concentricity.

With reference now to Figs. 7 and 8, which show a modification, the work-supporting means is arranged to support three workpieces a , a' and a'' , all for rotation on a common axis, during a grinding operation on the bores of these three workpieces simultaneously. In this arrangement

the regulating roll 8' has spaced flanges 30, 30' and 30'', the peripheries of which are preferably beveled to correspond to the taper of the workpieces engaged thereby. The flanges 30 and 30' are arranged to engage with the workpieces *a* and *a'* having the back-to-back arrangement shown by Fig. 4, and the edge of the third flange tends to urge the workpiece *a''* against a backing plate 31 which is pressed by a spring 32 toward the workpiece, thereby urging the workpiece *a''* toward the pair of workpieces *a* and *a'* in the workhead.

The supporting roll (not shown) in the workhead of this arrangement has flanges corresponding to the flanges 30, 30' and 30'' and the pressure roll 12' has flanges 33, 33' and 33'' corresponding to the flanges 30, 30' and 30'' and being correspondingly spaced apart. The pairs of opposed flanges 30, 30' and 33, 33' which engage the opposed workpieces *a* and *a'* serve to locate this pair of workpieces for rotation on a common axis in the same manner as the flanges 28, 28' and 29, 29' of Figs. 4 and 5.

The workpiece *a''* which is engaged by the resilient backing plate 31 is urged into engagement with the corresponding flanges 30'' and 33''. As the peripheries of these flanges where they engage the surface of the workpiece *a''* are spaced apart a distance corresponding exactly to the spacing of the flanges engaging the pair of workpieces *a* and *a'*, it will be apparent that the axis of the workpiece engaged by the backing plate coincides exactly with the common axis on which the pair of workpieces is rotated.

By this arrangement it is possible to grind to a uniform diameter the bores of three workpieces all at one time whether the workpieces are externally finished to precisely the same diameter, represented by the workpiece *a*, or whether they are undersized, as represented by the workpieces *a'* and *a''*, or oversized. In either case, since the diameters of the flanges 30, 30' and 30'' are all equal and since the diameters of the flanges 33, 33' and 33'' are similarly all equal, and since the several workpieces are all supported on their peripheries at three spaced points, the corresponding spaced points on the individual workpieces being in line with each other, it follows that all three workpieces, when urged endwise into engagement with all three of their respective supporting flanges, must rotate on a common axis. The resilient support of the backing plate makes possible an endwise adjustment of the position of the workpiece *a''* engaged thereby so that the latter will be moved into engagement with all three of its supporting flanges, as shown in Fig. 8.

A similar arrangement to that above described may be utilized for supporting two or more pairs of workpieces *a* and *a'* for a uniform grinding operation on all of the bores simultaneously. As shown in Fig. 9, the backing roll 8'' has a plurality of circumferential flanges 34 and 34', the number of flanges corresponding to the number of workpieces to be ground at one time. These flanges are arranged in pairs (each pair indicated by the same numerals 34 and 34') and the outer edges of each pair are preferably beveled in opposed relation to each other corresponding to the back-to-back arrangement of the two workpieces *a* and *a'* engaged by the flanges; the latter by their rotation tend to urge the workpieces toward each other, as previously described. In this arrangement the supporting roll, not shown, has flanges corresponding in spacing and arrangement to the flanges 34.

The pressure element (corresponding to the roll 12 above) which holds the workpieces against the supporting and backing rolls is here shown as made up of several separate rolls 12'' which are separately mounted and individually urged resiliently toward the other rolls. Each of the pressure rolls 12'' has a pair of spaced flanges 35 and 35' corresponding in spacing to each pair of flanges 34 and 34' on the backing roll and the peripheries of the flanges 35 and 35' are preferably beveled in opposed relationship to each other the better to thrust the workpieces of each pair against each other. By this arrangement the workpieces of each pair regardless of external size variations, are supported and rotated on a common axis, although each of the several pairs of workpieces are rotated on precisely the same axis as the other pairs only when the outside diameters of all the workpieces are the same.

The several pressure rolls 12'' are separately and resiliently urged toward the workpieces by any suitable mechanism, as shown, for example, in the Blood Patent No. 2,047,055, dated July 7, 1936, in which each of a plurality of pressure rolls is urged by a coil spring toward the workpieces, each roll being supported with its axis in substantially parallel relation to the axes of the backing and supporting rolls. A similar arrangement of the pressure rolls is shown in the aforesaid Blood and Heald Patent No. 2,290,269.

In the arrangement shown by Fig. 9 the work-supporting elements are preferably in the relative positions shown by Fig. 3 which provides for the "above-center" grinding described by the Blood Patent No. 2,047,055, dated July 7, 1936, in which the axis of the regulating roll is out of the horizontal plane defined by the axis of the grinding wheel in its crossfeed movement relative to the workpieces in the work-supporting means. This "above-center" grinding, as fully described in said Blood patent, makes possible the support and rotation of a plurality of workpieces simultaneously, where the outside diameters are not precisely the same, in such a manner that the several workpieces will be finished to the same internal dimension independently of any slight variations in outside dimension. With an "above-center" supporting means of this type, the failure of all of the several pairs of workpieces of Fig. 9 to all rotate on precisely the same axis may be disregarded, as the slight difference in location of the axis of each pair of workpieces is compensated for by the "above-center" mounting.

So far as the arrangements of Figs. 4 to 6, or of Figs. 7 and 8 are concerned, since all of the workpieces simultaneously positioned and rotated in the work-supporting means are rotatable on a common axis regardless of variations in external size, they will all be finished to the same internal dimension whether the support be of the "above-center" type of Figs. 2 and 3, or the more conventional support of Fig. 10, where the backing wheel 8''' has its axis X located, as shown, in the same horizontal plane (represented by the dot-dash line 36) as the axis of the grinding wheel. In this arrangement of parts the supporting roll 9''' and the pressure roll 12''' are in approximately the same relative location as in the arrangement of Figs. 2 and 3.

Accordingly, where the grinding operation is under the control of a size measuring mechanism, as for example, the gage mechanism fully described in the Blood et al. Patent No. 2,027,627, the successively ground sets of workpieces will

all be finished to the same predetermined dimension even though the size measuring device only tests the dimension of one workpiece of each set. The accuracy of internal dimension of the other workpieces of each set is assured by the rotation of all of the simultaneously ground workpieces on a common axis.

In some instances the grinding machine is not controlled by size measuring devices, but is controlled by the crossfeed mechanism as described in the Guild Patent No. 1,682,672, dated August 28, 1928. In this type of machine control the grinding operation is terminated when the leading face of the grinding wheel is tangent to a vertical plane which is spaced a predetermined distance from the axis of the regulating roll. With this type of machine control, it may be desirable, in order that successively ground sets of workpieces may all correspond in finished dimension, to utilize the "above-center" type of work-supporting means shown by Figs. 2 and 3, with the several rolls adapted for supporting either two or three workpieces at one time, as desired. The advantages of the "above-center" grinding are fully described in the above cited Blood Patent No. 2,047,055, from which it is apparent that workpieces varying slightly in outside dimension may be simultaneously finished to the same internal dimension when the axis of the backing or regulating wheel is located somewhat out of the plane of the crossfeed movement of the grinding wheel.

In the aforesaid Blood and Heald Patent No. 2,290,269, the work-supporting means is adapted to provide for the simultaneous internal grinding of a pair of workpieces, the outer surfaces of which are non-cylindrical. In this arrangement the pressure-imparting means which holds the individual workpieces against the regulating and supporting rolls comprises a separate pressure roll for each workpiece so that each workpiece is separately and resiliently held against the other work-supporting and work-rotating elements. Although the arrangement described in this Blood and Heald application provides a centerless or chuckless support for a plurality of aligned non-cylindrical workpieces, it does not assure a rotation of all of the workpieces on a common axis. On the other hand, the present invention assures a rotation of the several aligned non-cylindrical workpieces on a common axis by having a single pressure roll which has annular work-engaging portions, the outer peripheries of which are equal in diameter and by urging the entire pressure roll as a unit resiliently against the workpieces.

We claim:

1. In an internal grinding machine, a centerless or chuckless means for the support and rotation of three hollow externally-tapered workpieces, arranged in alignment for simultaneous internal grinding, said means comprising a regulating roll, a supporting member and a pressure roll, each of said rolls having a set of three flanges thereon, each adapted to engage with one of the workpieces at a point where the elements of the periphery thereof are convergent, two adjacent flanges of each set, having their peripheries oppositely bevelled, whereby a pair of the workpieces are urged toward each other into endwise engagement and a resilient backing member engageable with the third workpiece for holding the latter in engagement with the other flanges on the regulating and pressure rolls.

2. In an internal grinding machine, a center-

less or chuckless means for support and rotation of a plurality of pairs of hollow externally-tapered workpieces, arranged in alignment for simultaneous internal grinding, with the larger-diameter ends of each pair in opposed relation, said means comprising a backing or regulating roll, a supporting member and a pressure member, said backing roll having a plurality of relatively narrow flanges corresponding in number to the number of workpieces to be supported, adjacent flanges having their outer edges oppositely beveled for engagement with each of a pair of the workpieces, said pressure member comprising a plurality of rolls, each individually urged toward the backing roll and corresponding in number to the number of pairs of workpieces, each pressure roll having a pair of relatively narrow flanges engageable with the workpieces of a pair.

3. In a machine of the class described, a chuckless or centerless means for the support and rotation in alignment of two externally-tapered hollow workpieces, to allow simultaneous tooling of their bores, said means comprising a plurality of circumferentially-spaced rotary members, the latter surrounding a workpiece-receiving space and having two sets of relatively narrow flanges spaced apart to obtain peripheral rolling contact with the respective tapered surfaces of said two workpieces when said workpieces are arranged in said spaced with their larger-diameter ends in opposed relation between said sets of flanges, said space extending appreciably beyond said sets of flanges in both directions, and means for yieldingly urging one of said rotary members and its flanges against the tapered surfaces of the so-arranged workpieces, whereby the latter, if differing in external dimension, are caused to have within said space such joint endwise movement relative to said flanges as to carry said workpieces into concentric relation for the simultaneous tooling of their bores.

4. In a machine of the class described, a chuckless or centerless means for the support and rotation in alignment of three externally-tapered hollow workpieces, to allow simultaneous tooling of their bores, said means as to two of said workpieces comprising a plurality of circumferentially-spaced rotary members, the latter having substantially identical sets of relatively-narrow flanges for rolling contact with the tapered surface of each workpiece, with corresponding flanges of each set of the same diameters, said sets of flanges being so spaced apart as to operatively accommodate said workpieces only when the latter are in end-to-end relation with their respective tapered surfaces converging away from each other, and said members for the third workpiece having a set of flanges of the same dimensions as the other two sets for contact with said third workpiece's tapered surface, and so spaced from the other sets of flanges as to support said third workpiece out of contact with the other two workpieces, and means for yieldably opposing endwise movement of said third workpiece by its associated flanges.

5. For internally tooling simultaneously or in multiple the bores of a pair of hollow workpieces having tapered external surfaces, where the support and rotation of said workpieces in alignment is by a centerless or chuckless means comprising a plurality of circumferentially spaced members adapted for rolling contact with the external surfaces of said workpieces, the improve-

ment which consists in obtaining such rolling contact by the peripheries of sets of spaced relatively narrow flanges on said members, and in presenting said workpieces thereto with their larger-diameter ends in opposed relation between said sets of flanges, whereby any diversity in external size between the so-arranged workpieces produces such joint endwise movement thereof under the influence of said members as to shift said workpieces into concentric relation for the simultaneous tooling of their bores.

6. In a machine of the class described, a chuckless or centerless means for the support and rotation in alignment of two externally-tapered hollow workpieces to allow simultaneous grinding of their bores, said means comprising a plurality of circumferentially spaced rotary members providing for each workpiece a set of flanges to obtain peripheral rolling contact with the tapered external surface thereof, said flanges being of such diameter and spacing as to afford centerless support for the two workpieces by peripheral rolling contact with their tapered surfaces only when the workpieces are arranged with their larger-diameter ends in opposed relation between said flanges and with their respective tapered surfaces converging away from each other, said flanges being of appreciably less width than the lengths of said tapered surfaces, and affording support to both workpieces in the absence of obstruction to the latter's endwise movement in either direction relative to said flanges, and means for yieldingly urging one of said rotary members and its flanges against the tapered surfaces of the so-arranged workpieces, whereby the latter, if differing in external dimension, are caused, in reaching equilibrium of support by said flanges to move endwise into concentric relation to each other.

7. In an internal grinding machine, a centerless or chuckless means for the support and rotation of a pair of hollow externally-tapered workpieces arranged in alinement for simultaneous internal grinding with their larger-diameter ends in opposed relation, said means comprising a plurality of circumferentially-spaced rotary members, each of said members having a pair of relatively narrow flanges, one for each workpiece, which are spaced to engage peripherally with the tapered surfaces of the so-arranged workpieces, the peripheries of said flanges being oppositely bevelled, to conform substantially to the tapered surfaces of said workpieces.

8. In an internal grinding machine, a centerless or chuckless work-holding structure for the support and rotation in alinement of a pair of similar hollow workpieces having tapered external surfaces, said structure comprising a backing or regulating roll, a supporting member and a pressure roll, arranged about a workpiece-receiving space, each of said rolls having a pair of annular flanges, one for each workpiece, and spaced apart in two sets to obtain peripheral rolling contact with said tapered external surfaces when said aligned workpieces have their larger-diameter ends in opposed relation between said sets of flanges, said flanges being appreciably narrower than the tapered workpiece surfaces engaged thereby and being spaced inwardly from both ends of said space by approximately the length of the associated tapered workpiece surface, whereby the so-arranged workpieces, if differing in external dimension, are free to move endwise in unison within said space relative to said flanges, until supported in concentric relation by said flanges.

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