May 28, 1957 M. H. ARMS ET AL 2,793,479

INTERNAL GRINDING MACHINE

Filed Dec. 7, 1954 2 Sheets-Sheet 1

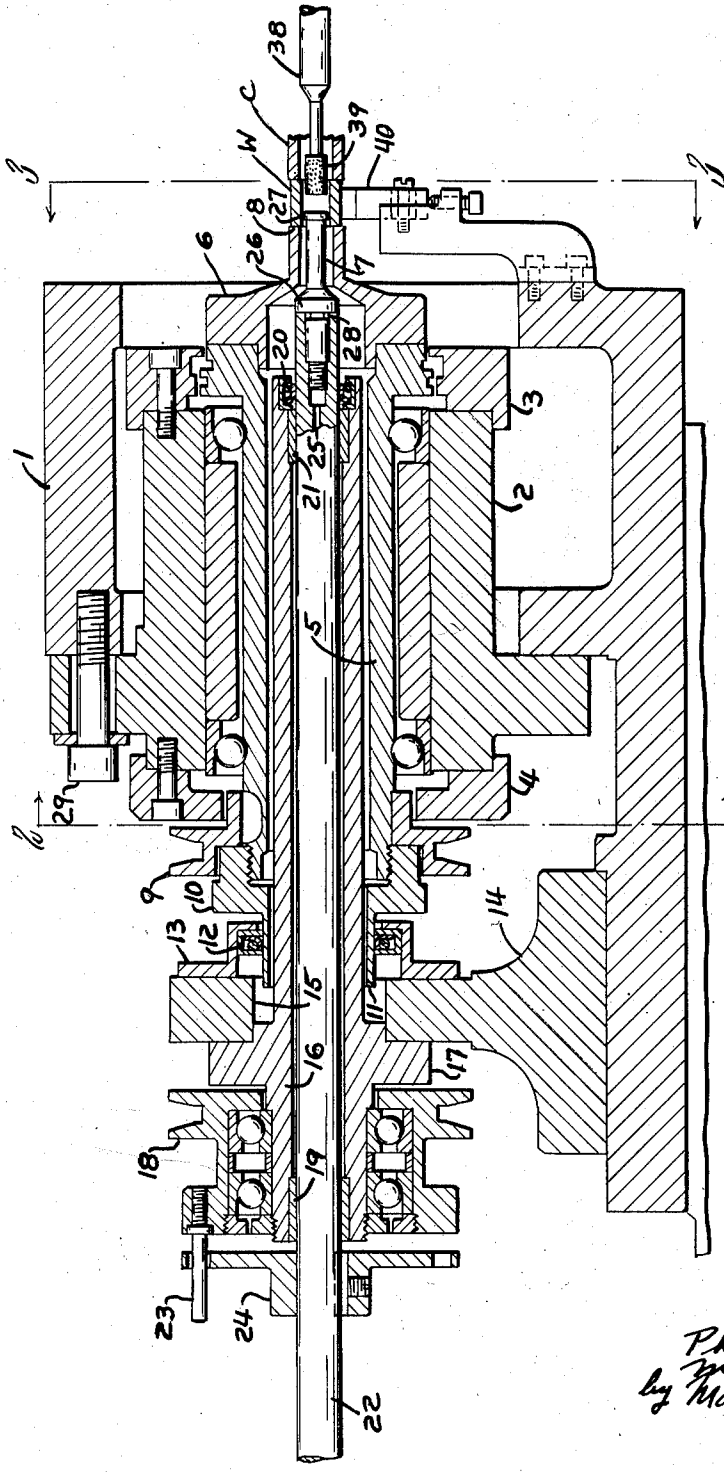

Fig. 1.

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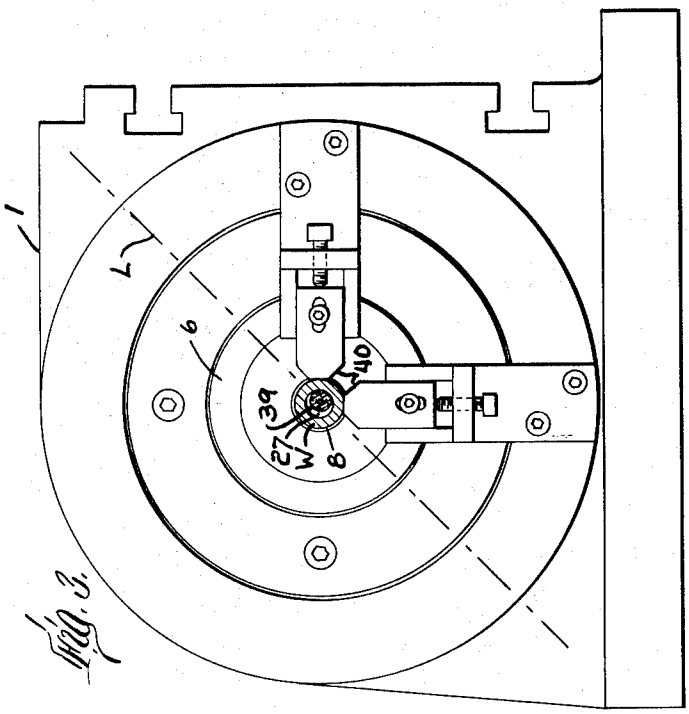

Fig. 3.

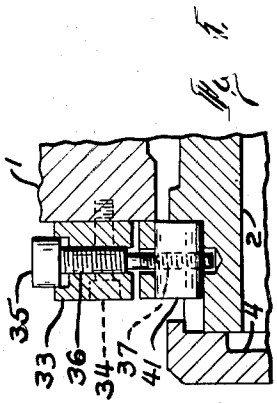

Fig. 4.

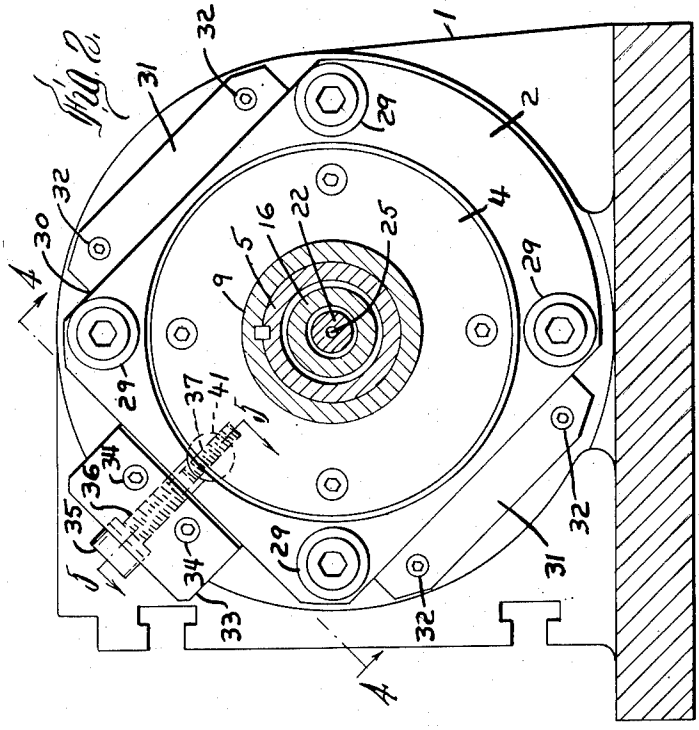

Fig. 2.

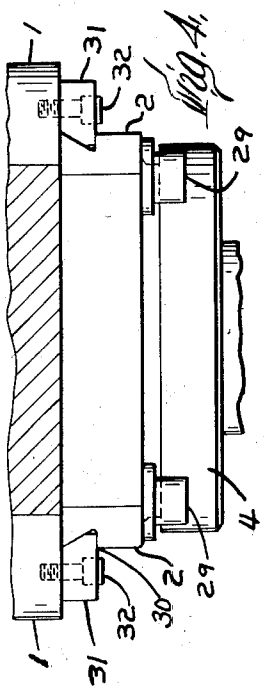

Fig. 4.

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2,793,479

INTERNAL GRINDING MACHINE

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Application December 7, 1954, Serial No. 473,649

8 Claims. (Cl. 51—236)

This invention relates to internal grinding machines of the centerless type, and more particularly to sizing mechanisms for such machines wherein the size of a workpiece may be automatically determined.

In internal grinders of the centerless type wherein the rotative axis of the workpiece is normally slightly offset from the rotative axis of the headstock spindle, such as disclosed in Arms et al., Patent No. 2,635,395, for example, it has been known to be desirable to use an automatic sizing and control means such as, for example, that disclosed in Bryant et al. Patent No. 2,585,533. In the latter patent, however, the grinding machine is of the type commonly referred to as a "chucking" grinder in which the working parts, that is the headstock spindle, workholder, workpiece and supporting and sensing element of the sizing device are on a common rotative axis. Hence it has heretofore not been possible in a centerless grinder to use a structure such as that of said Bryant patent to provide an automatic sizing and control mechanism.

Accordingly, the present invention is intended to solve the problem by providing a sizing element which is presented to the internal bore of a workpiece in concentric relationship thereto while it is simultaneously rotated in synchronism or nearly so with said workpiece to prevent wear thereto.

It is a feature of the invention that certain of the elements thereof are supported for adjustable movement independently of that of the grinder headstock mechanism so that the sizing element may be adjusted to a concentric relationship with the workpiece. Furthermore the rotative axis of the headstock spindle and the workpiece may be adjusted to a desired eccentric relationship for positioning the workpiece against its supports.

For a more complete understanding of this invention, reference is now made to the following description of a preferred embodiment thereof together with the accompanying drawings wherein:

Figure 1 is a sectional view through the work driving spindle of an internal grinder of the centerless type according to this invention;

Figure 2 is a sectional end view taken on the line 2—2 of Figure 1;

Figure 3 is another sectional end view taken on the line 3—3 of Figure 1;

Figure 4 is a sectional plan view taken on the line 4—4 of Figure 2; and

Figure 5 is a sectional side view taken on the line 5—5 of Figure 2.

In the drawings is shown the headstock bracket or base 1 which supports, in a manner hereinafter more fully explained, a bearing subframe or housing 2, such housing having end caps 3 and 4 which comprise closures for conventional ball bearing means journaling the headstock spindle 5 for rotation within said housing. At the forward end of the headstock spindle 5 is mounted a hollow workpiece driving plate 6 which plate has a central opening 7 and an annular face 8 against which

the end surface of the workpiece W, here shown as an annular ring, is held in frictional driving relationship by suitable pressure means C such as are disclosed in, for example, said Arms et al. patent. The workpiece W is directly supported on the headstock bracket in the usual manner by engagement of its external annular finished surface by shoes 40 mounted at an angle to one another to support workpiece W at its bottom and at one side concentrically with its hole to be ground. A tool spindle 38 driven by any suitable means (not shown) and having a grinding wheel 39 attached thereto is provided for grinding the inside periphery of the hole in workpiece W in the usual manner.

At the other end of spindle 5 is mounted a V-belt pulley 9 providing driving means therefor, said pulley being held in place by a nut 10 mounted on said spindle and having a neck portion 11. The outside periphery of the pulley neck portion is arranged to coact with a flexible seal 12 mounted in a cap 13, the purpose of said seal being to prevent fluid communication between the hollow of spindle 5 and the outside thereof but at the same time permit a limited amount of lateral displacement of spindle 5 as will later be described. The cap 13 is fixedly attached to one face of a bracket 14 mounted on headstock bracket 1, which bracket 14 has therein a bore 15, the center of which coincides with the center of the workpiece W. In this bore 15, is mounted the tubular support member 16, such support member having a flange 17 butting against the rear vertical face of bracket 14 and fixedly attached thereto by any suitable means. On the outer periphery of support 16 is journaled by conventional ball bearing means a V-belt pulley 18, suitable power means (not shown) being provided for driving both pulleys 9 and 18 at substantially the same speed. Inside of the tubular support member 16 at the end under said pulley 18 is mounted a bearing bushing 19 and at the opposite end is located a seal 20. Immediately inside said seal is another bearing bushing 21.

The gage stem 22 is journaled in said bearing bushings for rotative movement and reciprocative movement axially of the workpiece. The rotative movement of said gage stem is imparted thereto by a driver pin 23 attached to and depending from pulley 18, said pin being loosely fitted in a hole in the flange of driver member 24 keyed to gage stem 22. It is to be observed that driver pin 23 has an extended length to allow it to remain coupled to the flange of driver 24 as the driver reciprocates axially together with gage stem 22, the purpose and means of such reciprocatory movement being fully disclosed in said Bryant patent. The gage stem 22 has therein a central hole 25 extending for its entire length and forming a passage for the signal-transmitting fluid from the gage body 26 with its plug element 27 at the front end thereof to the other end which is in communication with suitable indicating and controlling apparatus as shown in said Bryant patent. The gage body 26 is attached to the gage stem to form a seal herein indicated as O-ring 28. As a modification, the mechanical gaging means as disclosed in Ljunggren Patent No. 2,502,674 may be substituted for the fluid gaging means herein shown. In such case the central hole 25 can be utilized to convey cooling fluid to the work zone of the machine.

According to this invention, a flanged portion of bearing sub-frame or housing 2 is adjustably secured to a machined face of the main headstock bracket 1 by means of four machine screws 29. It is to be observed that the holes in said flanged portion where screws 29 pass through are oversized in relation to the screw shanks permitting a certain latitude or relative movement between parts 1 and 2. Turning now particularly to Figures 2 through 5, the flanged portion of bearing housing 2 has a pair of parallel machined edge surfaces 30 guided

by the gibs **31**, said gibs being secured to the machined face of bracket **1** by screws **32**. To the same face is fixedly secured a block **33** by means of screws **34**. This block has therein a threaded hole **36** and in line therewith is another threaded hole **37** located in a pivot pin **41** rotatably mounted on the flanged portion of bearing housing **2**. In engaging relationship with both these threaded holes is an adjusting screw **35** for moving the housing **2** along the guide way formed by gibs **31** and thereby moving the axis of rotation of the headstock spindle **5** along a slanted line L passing through the axis of rotation of the workpiece and generally perpendicular to the bisector of the angle of supporting shoes **40** to adjust driving plate **6** to the desired eccentric position relative to the center of workpiece W to provide the force necessary to maintain the workpiece in contact with shoes **40**. Preferably, with the shoes at the 3 and 6 o'clock position as shown, the line L is at about a 45° angle to shoes **40**.

Since the required eccentric adjustment of the axes of rotation of spindle **5** and workpiece W toward and away from one another is relatively minute, that is, of the order of a few thousandths of an inch, adjusting screw **35** is preferably of the differential type wherein threads in the respective locations have different pitch. Thus, for example, the threaded portion **36** can have a lead of **13** threads to the inch, and the threaded portion **37** a lead of **24** threads to the inch. Thus, a comparatively large angular turning of screw **35** results in a comparatively small translative rectilinear movement of housing **2**. The adjustment of the position of housing **2** is done with the screws **29** slightly loosened and, after effecting the adjustment, said screws are drawn up tightly, thereby fixedly securing housing **2** to bracket **1**.

In operation, the supporting shoes **40** are adjusted to a position so that the workpiece W will be supported concentrically of gage plug **27**. Then by adjusting differential screw **35**, the desired degree of eccentricity for driving said workpiece and maintaining it in position against said shoes may readily be established. Since the gage plug **27** is rotated at the same speed as to the workpiece W and is concentric therewith, and is presented to the grinding zone within the hole in the workpiece W during a reciprocatory movement synchronized with the reciprocatory movement of the grinding wheel in such a way that the plug and the winding wheel never physically contact each other, said plug will operate to gage the inner diameter of the hole in the workpiece while rotating in synchronism therewith and essentially without contacting its surface. The output signal from the gage may be used in the usual manner to control the grinding machine if desired or to provide an indication of said diameter.

Although the invention in general is intended to allow the gage element and workpiece to rotate at synchronous speeds, it can under certain condition be adapted to allow a slight difference in speed between said elements. This can simply be done by making the pulleys **9** and **18** of slightly different diameter, to provide a slight difference in speed of about 30 to 60 R. P. M. Such an arrangement is useful in that it makes possible the exploration of the all-over roundness of the ground hole in the workpiece. Such exploration can preferably be done when the grinding cycle is terminated by letting the work rotate a few revolutions while the gage is presented inside the workpiece and the reciprocatory movement of the gage is arrested. From the above description it is clear that here is provided gaging means of the kind described in for example Patents No. 2,503,674 and 2,585,533 in shoe type centerless internal grinders of the general type of Patent No. 2,635,395. This has heretofore been impossible or at least difficult and has enforced compromises in design and method in utilizing grinders of said type. One such compromise has been to organize the elements, driver spindle, gage and workpiece in concentric relationship as on a chucking machine.

However, thereby is lost one of the important features of the concerned grinder type namely, the everpresent stable seating force from the eccentric relationship between driver and workpiece. A second solution has been to mount the gage eccentrically offset in relationship to the driver spindle and with the gage stationary. This can only be justified in comparatively slow machine cycles because of the chance of contact between the gaging element and workpiece and the adjunct risk of destroying the gage.

The present invention permits utilization of all inherently favorable features of a shoe type centerless internal grinder in combination with a gage and gaging system of the described kind and by rotating the work and the gage elements at synchronous speed the present day high speed grinder operation is no obstacle. The described organization of the parts in general and the independent adjustability of the eccentricity between the driver and gage to the work system in particular introduces another feature of great and important utility, that is it may be desirable to adjust or change the said eccentricity after the machine is set up for a certain run and this is clearly feasible with the described arrangement.

From the foregoing description of this invention, it will be evident to those skilled in the art that various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

We claim:

1. A centerless internal grinding machine sizing mechanism including workpiece supporting means comprising normally stationary spaced work supporting shoes supporting for rotation about its axis of rotation a workpiece having a hole to be ground by engagement with an external annular finished surface of said workpiece concentric with said axis, workpiece driving means for rotating said workpiece about its axis of rotation by engagement with an end surface thereof, the axis of rotation of said workpiece driving means being normally displaced from the axis of rotation of said workpiece to provide a workpiece seating force against said supporting shoes, adjusting means for positioning the axis of rotation of said workpiece driving means relatively to the axis of rotation of a workpiece concentrically supported by said shoes, plug gage means adapted to enter the hole in said workpiece concentrically with the axis of rotation of said workpiece concentrically supported by said shoes, and means for driving said plug gage means to rotate said plug gage means within the hole in said workpiece.

2. A centerless internal grinding machine sizing mechanism as claimed in claim 1 wherein said plug gage and workpiece are rotated at synchronous speeds.

3. A centerless internal grinding machine sizing mechanism as claimed in claim 1 wherein said plug gage and workpiece are rotated at slight difference in speed for exploring the eccentricity of said hole.

4. A centerless internal grinding machine sizing mechanism including a base, workpiece supporting means comprising normally stationary spaced work supporting shoes mounted on said base, said shoes supporting for rotation about its axis of rotation a workpiece having a hole to be ground by engagement with an external annular finished surface of said workpiece concentric with said axis, workpiece driving means comprising a work driving spindle for rotating said workpiece about its axis of rotation by engagement with an end surface thereof, the axis of rotation of said spindle being normally displaced from the axis of rotation of said workpiece to provide a workpiece seating force against said supporting shoes, a subframe supporting said spindle for rotary movement therein, said subframe being adjustably mounted on said base for positioning the axis of rotation of said spindle relatively to the axis of rotation of a workpiece concentrically supported by said shoes, spindle driving means, plug gage means rotatably mounted on said base concentrically with

the axis of rotation of a workpiece concentrically supported by said shoes for reciprocatory movement axially thereof, and means for driving said plug gage means to rotate said plug gage means within the hole in said workpiece.

5. A sizing mechanism as claimed in claim 4 wherein said spindle is hollow and said plug gage is mounted within said hollow spindle.

6. A sizing mechanism as claimed in claim 4 further including means for adjustably moving said subframe relatively to said base.

7. A sizing mechanism as claimed in claim 6 wherein said spindle axis may be moved along a slanted line passing through the axis of rotation of a workpiece concentrically supported by said shoes.

8. A centerless internal grinding machine sizing mechanism including a base, workpiece supporting means comprising a pair of normally stationary spaced work supporting shoes mounted on said base and positioned at an angle to one another, said shoes supporting at its bottom and one side for rotation about its axis of rotation a workpiece having a hole to be ground by engagement with an external annular finished surface of said workpiece concentric with said axis, workpiece driving means comprising a hollow work driving spindle for rotating said workpiece about its axis of rotation by engagement with an end surface thereof, the axis of rotation of said spindle being normally displaced from the axis of rotation of said workpiece to provide a workpiece seating force against said supporting shoes, a subframe supporting said spindle for rotary movement therein, said subframe being adjustably mounted on said base for adjustable movement along a slanted line passing through the axis of rotation of a workpiece concentrically supported by said shoes and generally perpendicular to the bisector of the angle of said shoes for positioning the axis of rotation of said spindle relatively to the axis of rotation of said workpiece, spindle driving means, plug gage means rotatably mounted on said base within said spindle concentrically with the axis of rotation of a workpiece concentrically supported by said shoes for reciprocatory movement axially thereof, and means for driving said plug gage means to rotate said plug gage means within the hole in said workpiece at a speed substantially equal to the speed of said workpiece.

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