

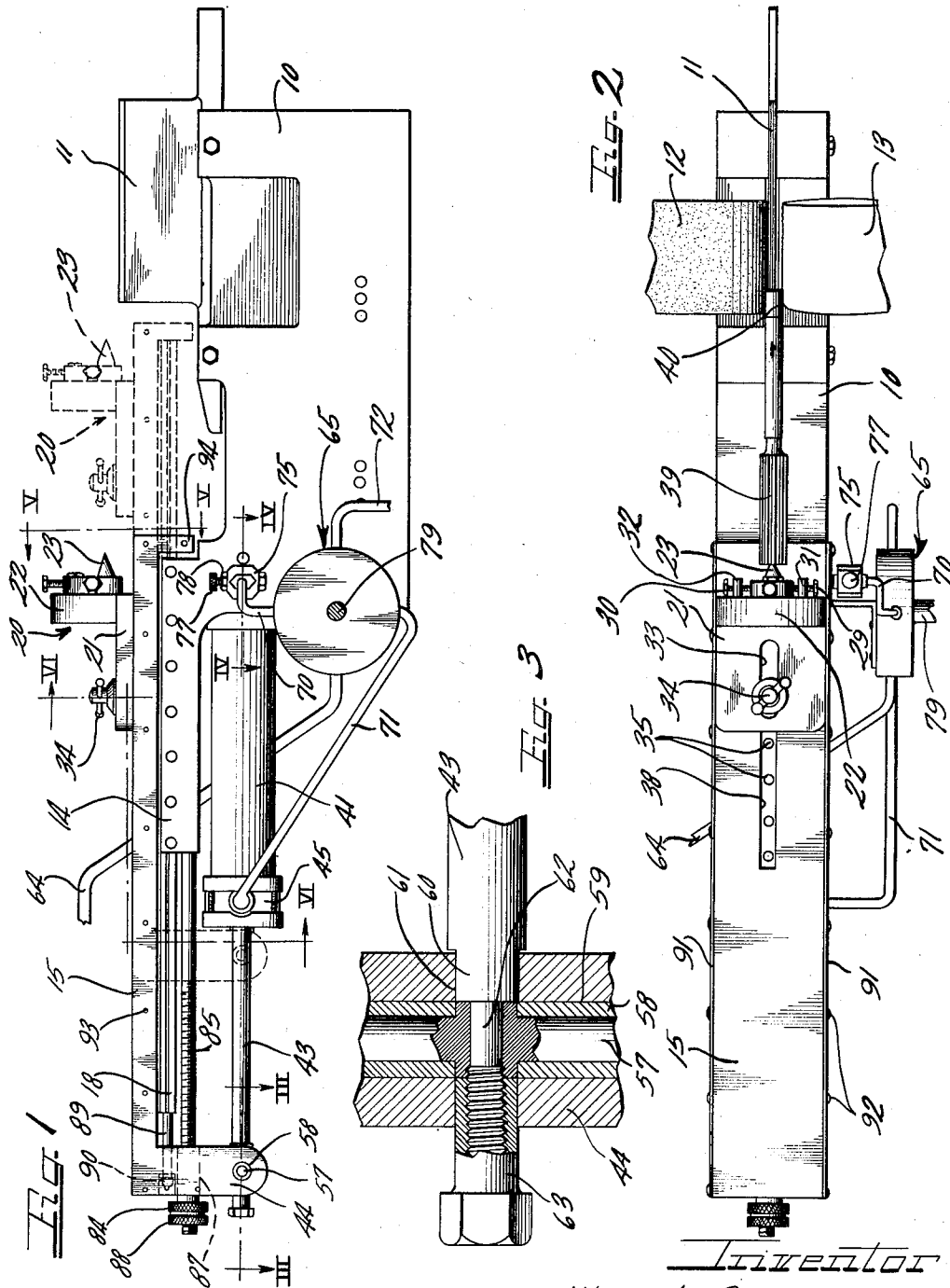
July 18, 1950

W. L. GARBERDING
METHOD AND MEANS FOR GRINDING CONCENTRICALLY
TO A PREDETERMINED CENTER IN A
CENTERLESS GRINDING MACHINE

2,515,210

Filed June 1, 1946

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 4

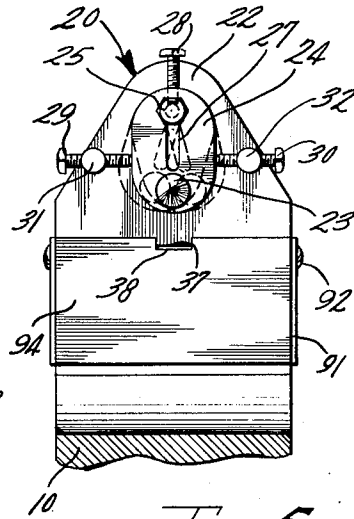
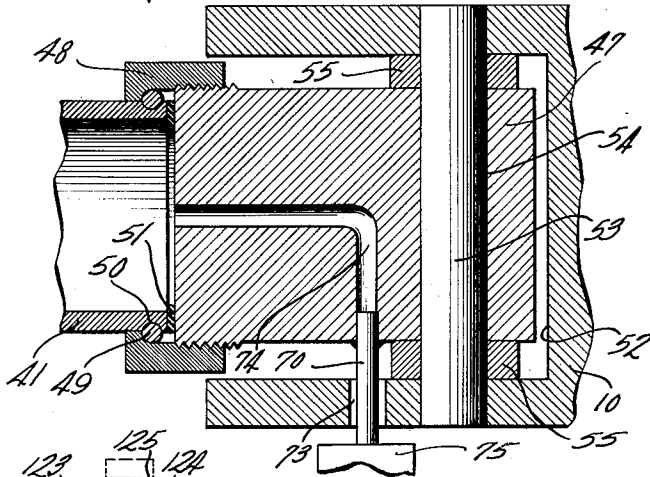


Fig. 5

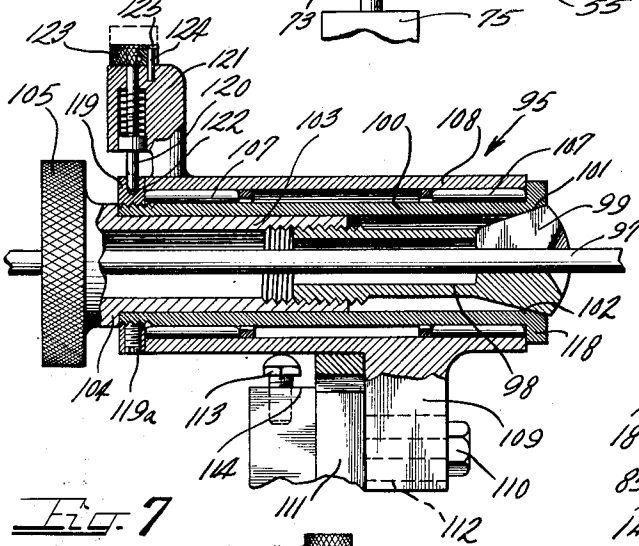


Fig. 7

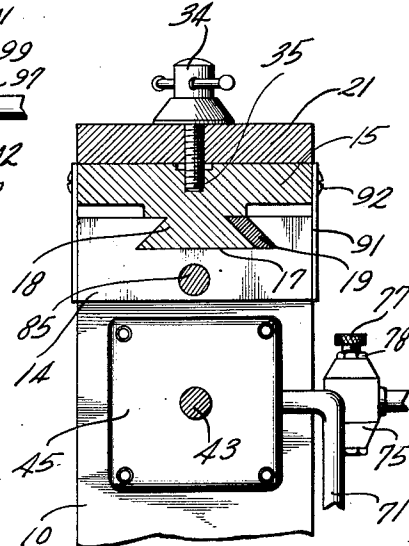


Fig. 6

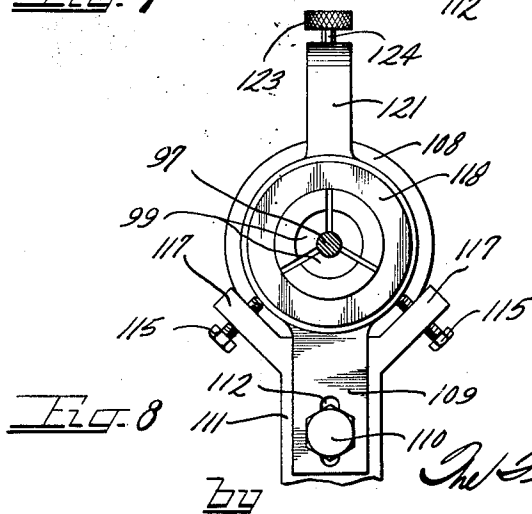


Fig. 8

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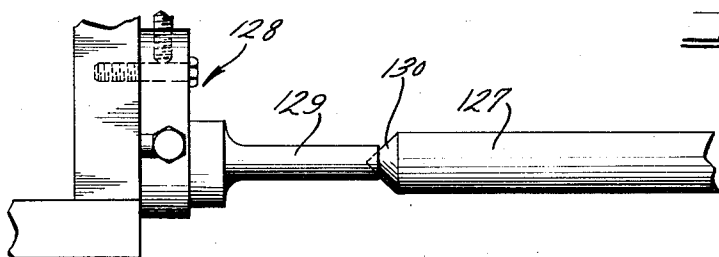


Fig. 9

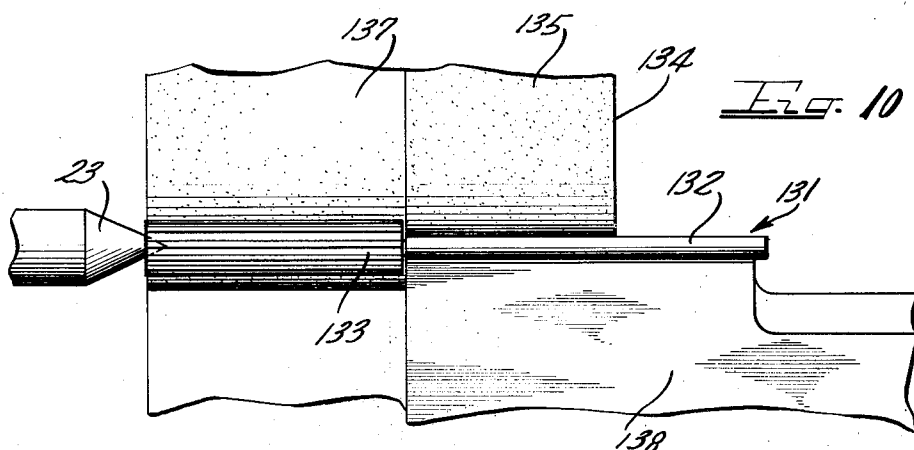


Fig. 10

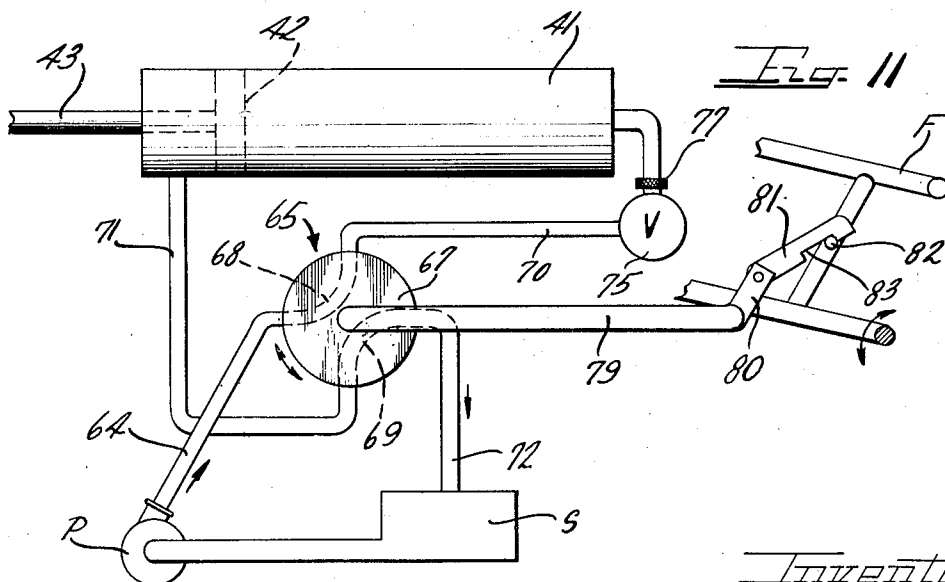


Fig. 11

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2,515,210

METHOD AND MEANS FOR GRINDING CON-
CENTRICALLY TO A PREDETERMINED
CENTER IN A CENTERLESS GRINDING
MACHINE

Waldo L. Garberding, Chicago, Ill.

Application June 1, 1946, Serial No. 673,789

18 Claims. (Cl. 51-103)

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This invention relates to a new and improved grinding means and method especially adapted for use with centerless grinding apparatus.

In centerless grinding, as the name implies, the work is not guided between centers, but rests freely on a work blade between the grinding and regulating wheels of the grinder. For grinding straight shafting or bearings or other cylindrical work, centerless grinding greatly speeds production. However, with centerless grinding it has been practically impossible heretofore to obtain the requisite concentricity in work involving portions of different diameters or character such as shafted tools on the order of reamers and the like or having centers which must be used for subsequent operations or in the ultimate functioning of the workpiece, and very close concentricity of coaxially aligned portions of the work is therefore highly essential. In consequence, these types of work have of necessity been ground on cylindrical grinders. There the work is held between centers and the grinding wheels and the work are relatively moved axially to effect the grinding. Since cylindrical grinding, even at the fastest, is restricted in performance to a much slower rate than centerless grinding the production rate is relatively low and costs comparatively high.

I have discovered that all of the high speed grinding benefits of centerless grinding can be had in grinding work of the types mentioned above, including reamers and like shafted tools, and even relatively long shafts, if the trailing end or portion of the work is held on a center for concentricity. In other words, I find that I can secure the accuracy of expertly executed cylindrical grinding, but at substantially the speed of centerless grinding.

It is accordingly an object of the present invention to provide a successful combination of centerless and centered grinding techniques, attaining the desirable attributes of both types of grinding without the faults of either.

Another object of the invention is to provide a means and method for grinding the shafts of tools such as reamers or the like to virtually perfect concentricity in a centerless grinder.

A further object of the invention is to increase materially the speed of grinding concentrically the cylindrical surfaces of work having other parts or portions aligned with and which must remain concentric with such surfaces, or having subsequently useful centers.

Still another object of the invention is to effect complete finish grinding of cutting tools in a centerless grinder.

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Yet another object of the invention is to provide an attachment for centerless grinders which will adapt such grinders for grinding the cylindrical surfaces of workpieces wherein concentricity with other portions of the work is a prerequisite such as in the shafts of cutting tools like reamers, etc.

Still another object of the invention is to provide a new and improved method of grinding.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain exemplary embodiments of the invention, taken together with the accompanying three sheets of drawings in which:

Figure 1 is a side elevational view of a centering and feeding attachment for a centerless grinder and embodying the features of the invention, and having the adjacent side skirt plate removed.

Figure 2 is a top plan view of the grinding attachment showing, more or less schematically, how the device appears in relation to the grinding and regulating wheels of a centerless grinder while in operation;

Figure 3 is a sectional detail view, on an enlarged scale, taken in substantially the plane of line III—III of Fig. 1;

Figure 4 is an enlarged sectional detail view taken on substantially the line IV—IV of Fig. 1;

Figure 5 is an enlarged elevational and sectional view taken substantially on the line V—V of Fig. 1;

Figure 6 is a sectional view taken substantially on the line VI—VI of Figure 1;

Figure 7 is a fragmentary sectional side elevational view of a modified form of center for use with the device shown in Fig. 1;

Figure 8 is a front elevational view of the modified center shown in Fig. 7;

Figure 9 is a fragmentary side elevational view of another modified form of center;

Figure 10 is a more or less schematic view showing a modified arrangement for at the same time finish grinding the shank and the cutting head of a cutting tool such as a reamer; and

Figure 11 is a schematic operating diagram showing the hydraulic circuit and the mechanical operating and control means.

According to the present invention, a centerless grinder of any known or preferred construction is utilized to effect finish grinding while the trailing end portion of the workpiece is supported on a center. Thereby extremely accurate concentricity is attained in such work as has centers that must remain concentric with a cylindrical surface to be ground, or is of stepped diameter, or can be only

partially accommodated in a centerless grinder or can only be run partially through the grinder, like headed cutting tools on the order of reamers and the like. Although at first thought the use of a center may seem to be inimical to the operation of a centerless grinder, I have found that by the practice to be hereinafter set forth in detail quite amazing results have been attained not only in the improved quality of the work but also in the tremendous increase in output with respect to at least certain types of work. By practicing my invention, it is now possible to utilize a centerless grinder for work that was previously considered outside of the scope of this kind of a grinder. Production records give ample support to the proposition that a very valuable and important step forward has been effected in this art by the present invention. For example, where approximately four reamer shanks per hour can be ground in a cylindrical grinder, from eighty to a hundred of the same shanks have been ground on a production basis by my method with, if anything, improved concentricity. This means an approximately twenty to one speedup, together with improved quality.

Since the details of structure and operation of centerless grinders, as such, form no part of the present invention and are well known in the art, only those details of such a grinder have been shown or will be referred to herein as are deemed desirable for a full understanding of the invention. A centerless grinder, of course, operates on the principle that the cylindrical work to be ground is supported by a work rest 10 including a replaceable work blade 11 operatively located between a grinding wheel 12 and a regulating wheel 13 (Figs. 1 and 2). The pressure with which the regulating wheel forces the work against the grinding wheel and the relative speeds of rotation of the wheel, as well as the hardness of the workpiece, determine the depth and speed of grind.

Since the work literally "floats" between the grinding and regulating wheels, it is always necessary in true centerless grinding to have the work supported by the slanting supporting surface of the work blade upon an axis of rotation above the plane of the axes of rotation of the grinding and regulating wheels, otherwise high spots on the surface to be ground will cause the grinding of a non-cylindrical surface rather than the desired cylinder. On the other hand, the most direct pressure and therefore the highest grinding efficiency is obtained where the axis of rotation of the work and the axes of rotation of the grinding and regulating wheels are in a common plane. There is thus obviously a corresponding loss in efficiency as the elevation of the axis of rotation of the work is raised above the wheel axes.

I have found that by holding the end portion of the workpiece to which concentricity is to be maintained, in substantially rigidly centered relation in opposition to a back feed action of the regulating wheel while grinding takes place in the centerless grinder full advantage can be taken of the maximum grinding efficiency attainable by having the axis of rotation of the work disposed not higher than a plane through the narrowest dimension of the grinding throat between the grinding and regulating wheels, while at the same time securing improved concentricity and cylinder generation. In addition, harder and more rapidly cutting grinding wheels may be used than would ordinarily be recommended for

grinding similar work in a regular centerless grind. Excellent results have been found to obtain by providing the trailing end of the work with a male or female center and spotting the leading end portion of the work concentrically to approximately the final diameter desired but with preferably a slight grinding margin of say on the average of .0005. The work piece is then fed between the wheels of the grinder starting with the spotted end and supported at its trailing end by the fixed center through the medium of which it is fed progressively between the wheels at a rate dependent upon the character of the stock and the preferred speed of grind. As a result, the maximum grinding effect of the grinding wheels is obtained and the work turns out as nearly perfectly cylindrical and concentric from end to end as is practicable of attainment.

In the manufacture of cutting tools such as reamers and the like for which the use of a centerless grinder has not been at all practical heretofore, the present method renders it not only entirely practicable to use a centerless grinder for grinding the shafts of such tools, but also to effect, in the same pass through the grinder, finish grinding the cutting heads of the tools. No special skill is required to accomplish these new and improved results aside from that ordinarily needed for running a centerless grinder. Thus, the present invention attains all of the advantage of high production rate of centerless grinding and also secures all of the accuracy and possibly improves upon the accuracy attainable with a cylindrical grinder.

Centered feeding of the workpieces in the practice of the novel grinding method of the present invention, is accomplished by the novel fixture shown in Figures 1 and 2, which for purposes of economy, compactness and convenience is preferably constructed as a unitary assembly with the work rest 10 so that the fixture can be mounted in a centerless grinding machine in substantially the same manner as any of the various standard work supporting fixtures provided for use therewith. Accordingly, the base 10 is provided with a rearwardly extending bed extension 14 which may be integrally cast therewith and is adapted to support a carriage 15 in longitudinally slidable relation. A dovetail track 17 (Fig. 6) disposed longitudinally in the upper face of the bed 14 slidably receives an integral longitudinal dovetail 18 on the carriage 15 and locked in the dovetail track by a gib 19.

Adjacent to its forward end, the carriage 15 supports a center assembly 20 which in the present instance comprises a base plate 21 having at its front end a fixed upright support 22 on which is adjustably mounted a fixed center 23. As best seen in Figs. 1, 2 and 5, the center 23 projects fixedly forwardly from a vertically elongated carrying plate 24 which is secured to the front face of the support 22 by means of a screw 25. In order to enable vertical adjustment of the center, the securing screw 25 extends through a vertical adjustment slot 27 in the carrying plate 24 so that by sliding the carrying plate 24 vertically relative to the screw 25, any adjusted vertical position of the center can be effected within certain limits and then maintained by tightening the screw 25. Slippage of the carrying plate 24 from the adjusted position is avoided by a set screw 28 threaded longitudinally through the upper end of the carrying plate 24 and into the upper end of the slot 27 to engage the shank of the securing screw 25. Lateral adjustment of the center 23

by swinging the center-carrying plate 24 about the axis of the securing screw 25, substantially as indicated in broken outlines in Fig. 5, is provided for, any preferred condition of lateral adjustment being maintained by lateral adjustment-retaining screws 29 and 30 threaded through respective supporting bosses or posts 31 and 32 projecting forwardly from the support 22 in spaced relation at respective opposite sides of the center carrier 24 and with the ends of the retaining screws adapted to engage the respective opposite side edges of the center carrier. In this way, work pieces of various diameters can be accommodated by the center.

In order to accommodate work pieces of various lengths, within certain limits, the center base 21 is longitudinally adjustably mounted on the carriage 15 and is accordingly formed with a longitudinal slot 33 (Fig. 2) through which a collared securing stud 34 extends into threaded engagement within a tapped bore 35 in the carriage 15. By loosening the stud 34, the center unit 20 can be adjusted longitudinally within the limits allowed by the adjustment slot 33 by sliding the base 21 along the top of the carriage 15. Lateral displacement of the center base 21 is avoided by an integral depending longitudinal key 37 thereon which engages in a longitudinal keyway 39 in the top of the carriage 15. By preference the keyway groove 39 is of substantial length and has a plurality of the stud receiving bores 35 therein so that, where necessary, primary adjustments of the centering unit 20 can be effected longitudinally of the carriage 15 beyond the limit afforded by the longitudinal adjusting slot 33 in the base 21.

In setting up the fixture for grinding a work piece such as a reamer 39, the center unit 20 is adjusted as to its longitudinal position on the carriage 15 to afford centered engagement by the center point 23 with the head end of the reamer in the fully retracted position of the carriage 15 and with the shank end of the reamer just engaging the adjacent end portion of the working edge of the work blade 11, substantially as seen in Fig. 2. This places the shank extremity of the reamer between the grinding wheel and the regulating wheel 13. The lateral and vertical adjustment of the center 23 is determined to maintain the reamer 39 accurately concentric with its axis of rotation during grinding. By preference, a short outer extremity portion of the reamer shank is spotted as at 40 to approximately, say one to five ten thousandths inch of final diameter, as a starter for the grinding. The regulating wheel 13 is brought into grinding engagement with the spotted section 40 of the reamer shank and the carriage 15 is actuated toward the grinding zone provided by the grinding wheel 12 and the regulating wheel 13 to feed the cylindrical reamer shank progressively between the wheels to effect the finish grinding of the shank. Since the reamer is held perfectly centered by the center 23 as it is being held or fed between the wheels the grinding will progress accurately concentric with the reamer head.

Ample resistance to feeding movement of the work piece so that it is held firmly on the center 23 and solidly in peripheral engagement with the workrest blade is afforded by having the regulating wheel 13 set for back feed action upon the work piece tending to repel the work piece and driving it against the center. Therefore, the regulating wheel 12 is tilted slightly toward the position from which the work piece is placed or

fed into the grinding throat between the wheels, as indicated in substantially exaggerated fashion in Figure 2, which is the reverse of the tilting of the regulating wheel which prevails for a through feed operation. The degree of tilt in the regulating wheel will vary with the diameter of the work, a tilt of one degree being ample for pieces from .100 to .300 diameter, but greater tilt being desirable for larger diameter pieces. The action of the grinding and regulating wheels holds the workpiece down on the workrest without requiring any additional mechanism for this purpose and therefore the space above the workrest and above the grinding throat remains entirely unobstructed so that successive workpieces can be freely placed into the grinding throat from above in the production operation of the machine.

Means is provided for driving the carriage 15 reciprocally, preferably comprising a hydraulic mechanism which can be tapped into the hydraulic motivating system of the associated grinding machine. To this end, a hydraulic cylinder 41 is mounted under the bed 14 (Fig. 1) and has reciprocable therein a piston 42 (Fig. 11) carrying a piston rod 43 which is connected to a downwardly projecting arm 44 integral at the rear end of the bed 15. The construction and assembly is such that as the piston 42 is driven reciprocally in the cylinder 41, the piston rod 43 acting through the depending arm 44 of the carriage drives the carriage reciprocally to and fro. An ample bearing head 45 is provided at the rear end of the cylinder 41 for guiding the piston rod 43 and to enable this end of the cylinder 41 for guiding the piston rod 43 and to enable this end of the cylinder to be supported by the piston rod without the need for any other support than at the forward end of the cylinder.

Since it is desirable to have the piston rod act upon the carriage 15 as close as practicable to the mean bearing plane of the carriage in order to avoid distortions by the driving forces applied in operation, it is desirable to have the connected end of the piston rod 43 as close to such bearing plane as practicable and this may under certain circumstances require a certain degree of uptilt of the operating axis of the cylinder and piston structure toward the point of engagement with the arm 44. Such an arrangement necessarily presumes a change in angle of the cylinder and piston axis as the carriage is reciprocated. In addition, provision is desirably made for accommodating manufacturing inaccuracies in the parts so as to avoid any strain or binding in operation. Accordingly, both the cylinder 41 and the piston rod 43 are pivotally mounted at their respective attached ends. For example, the piston 42 has its forward end secured to a head plug 47 (Fig. 4) which may be a solid cylindrical member threaded at its closure end to receive a connecting flange 48 by which it is secured to the cylinder, the flange being interconnected rotatably with the cylinder through the medium of a retaining ring 49 seated in a shallow annular groove 50 adjacent to the forward end of the cylinder. A gasket 51 interposed between the end of the cylinder and the head plug 47 affords a fluid tight seal.

The piston head 47 is received within a recess 52 provided therefor in the adjacent rear end of the base casting 10 and a connecting pin 53 extending in press fitted relation through the walls defining the recess 52 extends slidably through a transverse bore 54 adjacent to the forward end of the plug 47 so that the plug can swing ro-

tatably on the pin. Spacers 55 may be interposed between the plug 47 and the walls of the recess about the pin 53.

A pivotal, readily detachable connection for the piston rod 43 with the carriage arm 44 may be provided by a trunnion 57 (Fig. 3) which is rotatable supported by having its arms bearing in a bushing 58 secured as by press fitting into a transverse bore 59 in the arm 44. The outer end of the piston rod 43 has a flattened portion 60 which is slidably received in a vertical slot 61 cut up from the lower end of the carrying arm 44 to intersect the bore 59. A reduced diameter portion 62 projects axially from the flattened portion 60 and extends through the trunnion 57 and rearwardly therebeyond for threaded engagement by a cap nut 63 by which the end of the piston rod is drawn up tight against the trunnion. It will thus be seen that assembly of the piston rod 43 with the trunnion 57 is adapted to be quickly and effectively accomplished and by unscrewing the cap nut 63, the piston rod 43 can be quickly and conveniently withdrawn from engagement with the trunnion 57.

A hydraulic motivating system for the piston 42 preferably utilizes the hydraulic system of the associated grinding machine as the source for hydraulic fluid under pressure. Accordingly, a hydraulic duct 64 is suitably tapped into the hydraulic pressure fluid system of the grinder so as to receive a continuous supply of hydraulic fluid under pressure while the pump P (Fig. 11) of the grinder is in operation. The pressure duct 64 delivers through a control valve assembly 65 having therein a rotor structure 67 providing alternate delivery passageways 68 and 69 which are selectively disposable by rotation of the rotor structure to afford communication for delivery of pressure fluid from the pressure duct 64 to a return supply duct 70 and a feed supply duct 71, respectively. Alternately, the delivery passageways 68 and 69 are adapted to provide exhaust communication between the delivery ducts 71 and 70, respectively, and an exhaust duct 72 communicating with the sump S of the grinding machine. Thus, when the valve rotor 67 is in position, as shown in Figure 11, to afford communication between the high pressure duct 64 and the delivery duct 70, pressure fluid is delivered to the forward end of the cylinder 64 to drive the piston 42 into relatively protracted position in the cylinder and thus effect return of the carriage 15 to starting position. As best seen in Fig. 4, the return delivery duct 70 may extend through a clearance aperture 73 in the wall defining the mounting recess 52 and communicates fixedly with a delivery passageway 74 formed in the head plug 47 and opening into the forward end of the cylinder 41. The feed delivery duct 71 communicates in suitable fashion with the rear end of the cylinder 41 through the head 45 (Fig. 1). In order to afford flexibility both for installation purposes and to accommodate slight relative movement of parts during operation, the various ducts are preferably formed of appropriate flexible tubing adapted for this purpose.

Since it is desirable to control the feed speed of the carriage 15, means such as a metering valve 75 (Figs. 1, 3 and 11) is provided. This metering valve 75 is preferably interposed in the return fluid duct 70 and operates on the principle of controlling the exhaust flow of hydraulic fluid from the cylinder 41, thereby determining the speed with which the piston 42 will travel under the influence of hydraulic pressure fluid delivered

to the feed side thereof. By preference, the feed control valve 75 has manual adjusting means such as a knurled headed adjusting screw 77 which may be locked in any preferred adjusted position by a lock nut 78. While the feed control valve 75 affords positive control upon the exhausting hydraulic fluid passing through the duct 70, it may be of such a character that pressure fluid delivered by the return duct 70 will pass therethrough freely so as to afford rapid return of the carriage 15. In other words, the feed control valve 75 may be a one-way valve, although by this it is not meant to say that control over the return feed may not be effected if desired.

Actuation of the control valve rotor 67 is preferably coordinated with operation of the in-feed lever F (Fig. 11) of the grinding machine. For this purpose, the rotor 67 is provided with an axial operating stem 79 which has at its outer extremity a radially extending arm 80 pivotally connected to an actuating link 81 so that reciprocations of the link 81 will be translated through the arm 80 into oscillation of the operating stem 79. Connection between the actuating link 81 and the in-feed lever F is conveniently effected by a lost motion pin and slot connection comprising a pin 82 extending laterally from the arm of the lever F and received in a lost motion connecting slot 83 in the actuating link. The length of the lost motion connecting slot 83 is so calculated that in changing over from grinding position to non-grinding position, or reversely, movement of the regulating wheel 13 of the grinder is actuated in advance of the control valve rotor 67. This is of advantage at the beginning of the grinding operation in that it assures that the work piece will be thoroughly engaged between the grinding and regulating wheel when the feed is started. In the return phase of the cycle of operation opening of the wheel in advance of return of the center-carriage 15 is desirable so as to free the work piece for rapid ejection or removal. Any desirable form of work ejector can be used for pushing the ground work out from between the wheels.

A limit upon the feeding movement of the carriage 15 is determined by the extreme retracted position of the piston 42 in the cylinder 41, the length of the carriage and piston and cylinder structure being properly proportioned for this purpose. Limit upon return movement of the carriage 15 is preferably controlled by an adjustable stop 84 which may comprise a nut threaded upon a stop rod 85 which extends rearwardly from the end of the bed 14 and projects through a bore 87 in the depending connector arm 44 of the carriage. A lock nut 88 retains the stop nut 84 in any preferred adjusted position. By this arrangement practically micrometer adjustment can be effected in the return limit of the carriage 15 to accommodate various lengths of work pieces, and in particular work pieces which are too short to be accommodated by forward adjustment of the centering unit 20.

To assure free travel of the carriage 15, means may be provided for lubricating the track therefor, such as a greasing system including a duct 89 having a greasing nipple 90 recessed within the rear face of the connector arm 44 of the carriage and extending forwardly to the dovetail 18.

Since the grinding operation customarily involves use of a coolant fluid means is provided for protecting the slideway for the carriage from the fluid. In the present instance such means

comprises respective closure plates 91 (Figs. 2 and 6) removably secured as by means of screws 92 threaded into appropriate bores 93 (Fig. 1) therefor in the opposite sides of the carriage 15. At the front end of the carriage a depending lip 94 cooperates with the closure plates 91, while at the rear end of the carriage the connector arm 44 cooperates with the plates whereby to provide a protective skirt completely around the carriage.

Where the work pieces are too long to be handled by a fixed center such as provided by the centering device 20, the latter may be supplanted by a bearing collet device 95 (Figs. 7 and 8). Thereby a long work piece such as a shaft 97 is adapted to be gripped at an intermediate point close enough to the portion to be fed into the grinder to hold the work piece substantially perfectly centered. In a desirable form, the bearing collet device 95 comprises a tubular collet member 98 having integral spring jaws 99 adapted to grip the work piece 97 when they are driven uniformly radially inwardly to grip the work piece. This is accomplished by effecting relative axial movement between the collet 98 and a rotary supporting sleeve 100 which at its forward end has an annular cam surface 101 adapted to engage complementary cam surfaces 102 on the collet jaws 99. Such relative axial movement is effected by a draw sleeve 103 which is in threaded engagement with the inner end of the collet tube 98 and has an integral collar 104 bearing against the rear end of the rotary sleeve 103 and formed with a knurled head 105 by which it can be manipulated to rotate the draw sleeve 103 for drawing the collet 98 into work-gripping relationship or for releasing the collet. A free rotary support for the sleeve 100 is provided by front and rear roller bearings 107 running in a supporting sleeve 108 which is integral with a depending arm 109 secured as by a screw 110 to the front face of a supporting standard 111 adapted to be mounted on the fixture carriage 15 in much the same manner as the fixed center device 20.

Vertical adjustment of the bearing collet 95 is afforded by a vertical slot 112 for passage of the screw shank in the attachment leg 109. Any position of vertical adjustment is adapted to be maintained positively by a vertically adjustable stop screw 113 threaded into a ledge 114 provided therefor at the rear of the supporting standard 111. In addition to vertical adjustment, lateral adjustment is permitted by swinging the bearing collet device about the axis of the securing screw 110. Any such lateral adjustment is adapted to be defined by respective left and right adjusting screws 115 threadedly carried to project radially into engagement with the supporting sleeve 108 by yoke arms 117. Longitudinal displacement of the rotary sleeve 100 is avoided by the provision of an integral retaining collar 118 at its front end, while at its rear end the sleeve has a retaining collar 119 screwed thereon and held by a set screw 119a.

Means for holding the rotary sleeve 100 stationary while the work piece is being clamped in the collet 98 or being released therefrom comprises a spring-biased plunger 120 which is mounted in a bracket 121 which may be integral with the supporting sleeve 108 to overhang the retaining collar 119. A plurality of radial interlocking pits 122 in the retaining collar 119 are adapted to receive the end of the plunger 120 interlockingly and thereby to hold the rotary sleeve

100 stationary. To release the plunger 120 from the interlock relationship, it is adapted to be withdrawn by lifting it against its spring bias through the medium of a knurled head 123 which is adapted to be held in the retracted position by engagement with the top of a fixed pin 124. In the protracted position of the plunger this pin 124 is adapted to be received in a clearance notch 125 in the head. Thus, when the collet is to be released for free rotation, the plunger 120 is retracted to the broken line position shown in Fig. 7 and the full line position of Fig. 8 and by slight turn of the head 123 the clearance notch 125 is moved out of registration with the pin 124 so that the underside of the head 123 engages the top of the restraining pin 124. Then, when it is desired, to interlock the collet against rotation, turning of the head 123 until registration is effected between the pin 124 and the clearance notch 125 permits the interlock pin 120 to snap into protracted position for engagement within one of the interlock pits 122, whereupon the draw sleeve head 105 can be turned to loosen or tighten the collet while the rotary supporting sleeve 100 is held stationary.

The bearing collet 95 has been found especially useful for grinding line reamers since it permits the reamer to be held quite firmly on center while the pilot and shank portions thereof are alternately ground.

For thin work pieces which are not long enough to warrant use of the bearing collet such as a work piece 127 (Fig. 9), a fixed center device 128 may be used having an adjustable fixed female center 129 to receive a male center 130 on the work piece. Aside from the female center 129, the center device 128 may be of substantially the same construction and similarly adjustable as the center device 20.

By having the centering devices universally adjustable transversely of the center in each instance, set-up for various size work pieces is greatly facilitated.

Work pieces having axially aligned cylindrical portions of different diameters both of which must be finish ground to as nearly as practicable perfect concentricity can be ground in one pass through the grinder according to my invention. Having particular reference to Figure 10, a work piece such as a straight fluted reamer 131 having a shank 132 which is of smaller diameter than a straight fluted head 133 is shown as being ground by a grinding wheel 134 which is dressed to provide a grinding surface 135 of greater diameter than a grinding surface 137, such surfaces being adapted for grinding respectively the shank 132 and the larger diameter head 133. For this type of grinding, a work blade 136 is provided which affords support only for the smaller diameter shank 132, while the larger diameter portion or head 133 is held on center by the fixed center 23. It will be understood, of course, that the regulating wheel will be fashioned to conform to this particular arrangement either by dress-off to provide free clearance for the head portion 133 of the work or by being initially of a width to engage merely the reduced diameter or shank portion 132 of the tool and opposing the grinding surface of larger diameter 135 of the grinding wheel. The work piece 131 is set into the grinder shank first, and the support provided by the engagement of the shank piece between the grinding wheel and the regulating wheel and the head on the center 23 is sufficient to hold the larger diameter or head portion 133

of the work piece to the grinding face 137 of the grinding wheel to effect accurate finish grinding. By this method, straight flute reamers having carbon steel shanks and high speed steel flutes have been successfully ground using a grinding wheel seven times harder than ordinarily used in a centerless grinder for high speed steel. It is readily apparent from this how fast grinding can be accomplished by the present method.

From the foregoing it will be apparent that by the present invention many grinding operations can be performed in a centerless grinding machine that were not heretofore possible or practicable.

To set up for a quantity run, the center is initially adjusted for the particular work and no further adjustment is required as long as the same kind of work piece is being run. Where one kind of work piece is to be ground at different times, such as for reorders, a master piece can be kept and the set-up quickly accomplished with such master each time a run is to be made.

A very important advantage effecting a large saving in time as compared with cylindrical grinding and avoiding a serious cause of scrap is the entire elimination of the use of dogs in grinding according to the present invention. Thus, in cylindrical grinding of reamer shanks, for example, much time is consumed in placing the dogs, and much scrap results due to damage to the flutes from overtightening or slipping of the dogs.

Certain other advantages that may not have been discussed hereinbefore, may also be mentioned. All the preliminary machinery work may be completed on a work piece before finish grinding according to this invention, and since that is the last operation, the oil coolant will amply coat the article so that no further protective oiling is needed.

The invention lends itself very well to greatly accelerated through-feeding grinding. In this the successive pieces are driven through between the grinding wheels by use of a center 129 of Figure 9. It has been found in practice that unheard of heavy cuts up to .040 inch in one pass can be taken to a finished diameter by this method.

It will, of course, be understood that various details of construction and steps in the practice of my method may be varied through a wide range without departing from the principles of this invention, and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim:

1. In combination in a centering fixture for use with a centerless grinder, a bed, a carriage supported reciprocally by said bed, a centering device supported by said carriage, a cylinder supported pivotally under said bed, a piston operable within said cylinder and having a rod pivotally connected to said carriage, and means for supplying hydraulic fluid to said cylinder for driving the piston reciprocally therein for actuating said carriage.

2. In combination in a fixture for supporting work in centered relation to the work blade of a centerless grinding machine while the work is fed between the grinding and regulating wheels of the grinding machine, a reciprocable centering mechanism including a hydraulic cylinder and piston operator, and means for supporting the hydraulic operator relatively pivotally at its

opposite ends to accommodate angular displacements thereof in the reciprocation of the carriage.

3. In combination in a fixture for use in a centerless grinding machine to support the trailing portion of a work piece and feed the same between the grinding and regulating wheels of the grinder in cooperation with the work blade of the machine supporting the leading end portion of the work piece, said fixture comprising a centering device, a reciprocable carriage supporting said centering device, means for adjusting the centering device on the carriage for accommodating various lengths of work pieces, means for driving the carriage reciprocally, and means for adjustably stopping the carriage in retracted position conformable with the adjustment of the centering device and adapted to adjust the return movement of the carriage for work pieces shorter than can be accommodated by adjustment of the centering device on the carriage.

4. In combination in apparatus of the character described, a base member for supporting a work blade for a centerless grinding machine, a bed extension on said support, a carriage having a work supporting center thereon, a dove-tail slide and track structure connecting the carriage and bed extension for guided reciprocal movement of the carriage toward and away from the work blade, and a hydraulic operator for actuating said carriage comprising a cylinder pivotally connected to the supporting member and a piston operable in the cylinder and having a piston rod pivotally secured to the rear extremity of the carriage beyond the end of the bed extension.

5. In combination in apparatus of the character described, a reciprocable carriage, a standard on said carriage, an elongated member pendantly pivotally and longitudinally adjustably supported by the forward side of said standard and having a work supporting center projecting forwardly from the lower portion thereof, and means for vertically and pivotally adjusting said member for adjusting the position of said center.

6. In combination in a centering fixture of the character described, a reciprocable carriage, an upright member having an angular flat base portion, a work supporting center carried by said member above said base portion, and means for securing said base portion to said carriage in a plurality of adjusted positions.

7. In combination in apparatus of the character described including a centering device for holding a workpiece centered in a centerless type of grinder, said apparatus including a carriage having a centering device thereon, a support for said carriage, a track on said support for guiding the carriage for reciprocal movement, a rod extending rearwardly from the support, a depending portion on said carriage and having said rod extending therethrough freely, and an adjustable stop nut on said rod and engageable with said depending portion for controlling the extent of rearward movement of the carriage.

8. In a centering fixture of the character described, a support, a carriage reciprocable on said support, a center support carried by the carriage, a horizontal flange on said center support, an aperture in said flange, the carriage having a plurality of longitudinally spaced tapped holes therein, and bolt means extending through said flange aperture and selectively engageable in said tapped holes for adjusting the centering device longitudinally of the carriage to accommodate workpieces of different length.

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9. In apparatus as defined in claim 8, the aperture in the flange being elongated lengthwise of the carriage whereby to effect primary adjustment of the centering device by loosening said bolt means and adjusting the centering device longitudinally without shifting the bolt means to a different hole in the carriage.

10. In combination in a centerless grinding machine including a grinding wheel and a cooperating opposed regulating wheel and a work blade for supporting a work piece in operative relation between the wheels, means for actuating one of said wheels toward and away from the other wheel and including an in-feed control lever, a carriage supported by the machine at the side thereof from which the work is fed between the wheels onto said work blade and aligned with the work blade to hold an article centered while being operated on between the wheels, a hydraulic operator for actuating said centering device, a hydraulic fluid pressure system connected with said operator, a valve for controlling the distribution of hydraulic fluid from the hydraulic system to said operator, and an actuating connection between said valve and said lever for actuation of the valve in coordination with operation of said lever.

11. In combination in a centerless grinding machine including grinding and regulating wheels and a work support between said wheels, the regulating wheel being mounted for movement toward and away from the grinding wheel, means for controlling said relative movements of the regulating wheel and including an operating lever, a centering device including a carriage and being adapted for movement toward and away from the working area between the wheels at the top of said work support, means for actuating said carriage, and means for controlling said actuating means including a link connected to and operable by the lever.

12. In combination in a centerless grinding machine including a grinding wheel, a regulating wheel mounted for movement toward and away from the grinding wheel, a work support between the wheels, means for actuating the regulating wheel toward and away from the grinding wheel, an operating lever for controlling said actuating means, a centering device at the work feeding side of the machine considered with respect to said wheels, hydraulic means for actuating said centering means toward and away from the wheels, a control valve having an operating stem projecting therefrom and adapted to control said hydraulic means, and means operably connecting said operating stem and said lever.

13. In combination in a centering device of the character described, a supporting member, a member carrying a center, means connecting the center carrying member to said supporting member for universal adjustment relative to said supporting member transversely of the axis of the center, and means for maintaining the center carrying member in any selected adjusted position.

14. In combination in a centering fixture for use with a grinding machine or the like, a standard, a member having a center projecting forwardly therefrom, means connecting said member to said standard for substantially universal adjustment transversely relative to the axis of said center, and means for maintaining said member in any adjusted position.

15. In combination in a centering fixture of

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the character described, a standard having a substantially Y-shaped upper portion, means for supporting a work piece on center and including a member having a depending portion thereof pivotally and longitudinally adjustably connected to said standard, said member being substantially cradled in the upper Y-shaped portion of the standard, and adjustment screws operative on the divergent legs of the Y-shaped portion for maintaining said member in adjusted position.

16. In combination in a centering device of the character described, a supporting member, a plate, a center element projecting from one face of the plate, and means disposed eccentrically relative to said center element and connecting the plate to said supporting member for substantially universal relative adjustment transversely to the axis of the center element.

17. In combination in a centering device of the character described, a supporting member, a plate, a center element projecting from one face of the plate, means disposed eccentrically relative to said center element and connecting the plate to said supporting member for substantially universal relative adjustment transversely to the axis of the center element, and a plurality of retaining screws supported about the periphery of said plate and operative for retaining the plate in any selected adjusted position of the center element.

18. The method of grinding in a centerless grinder a workpiece to accurate concentricity with one end portion of the workpiece and wherein the centerless grinder is of the type including cooperating grinding and regulating wheels defining a grinding throat therebetween and having a vertical workrest blade mounted below the grinding throat but with the area above the workrest blade entirely free of obstruction, which comprises placing a workpiece to be ground on the workrest blade in the grinding throat between the wheels and with the axis of rotation of the workpiece disposed not higher than a plane through the narrowest dimension of the grinding throat, operating the wheels in grinding relation to the workpiece with the regulating wheel tilted to have a back-feed action tending to repel the workpiece, and holding the end of the workpiece to which concentricity is to be maintained in substantially rigidly centered relation in opposition to the back-feed of the regulating wheel.

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