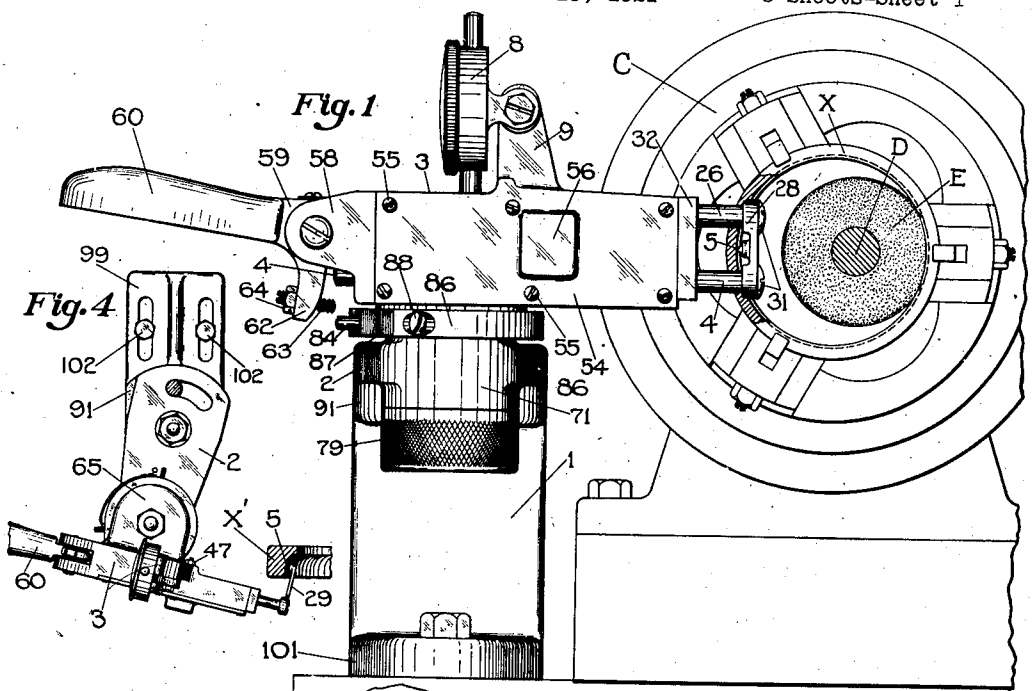
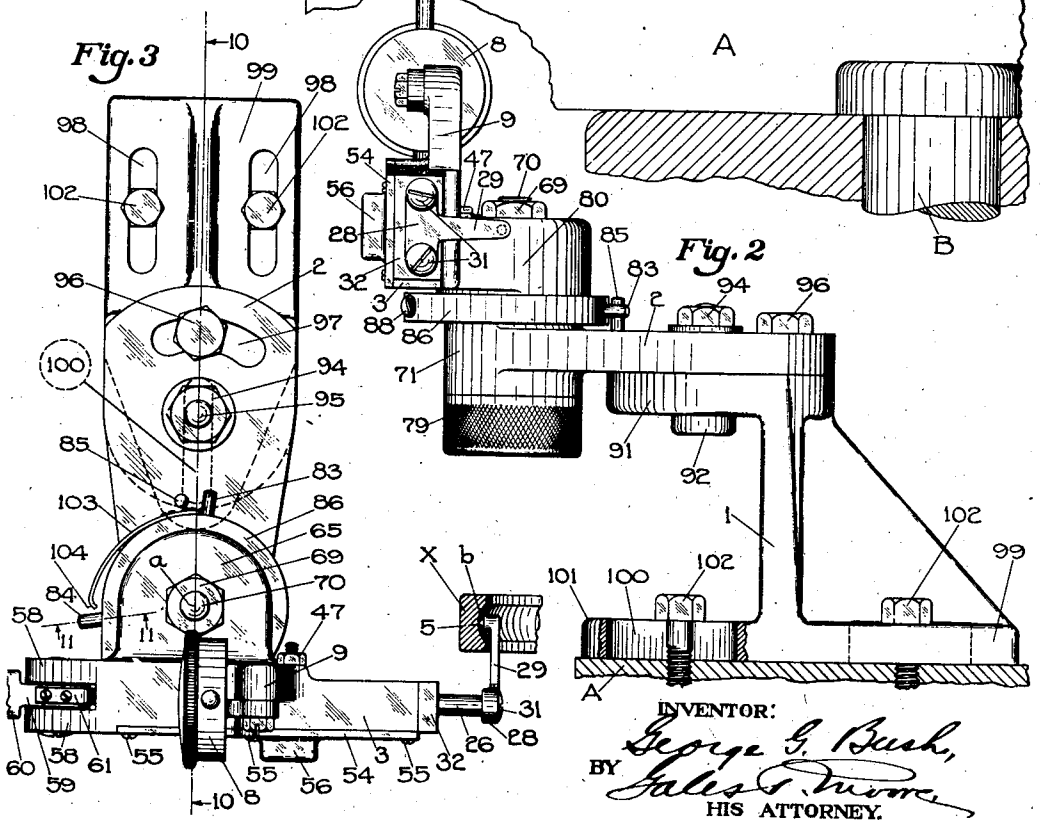
Sept. 14, 1926. 1,600,089

G. G. BUSH

GAUGE

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Sept. 14, 1926. 1,600,089

G. G. BUSH

GAUGE

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Fig. 5

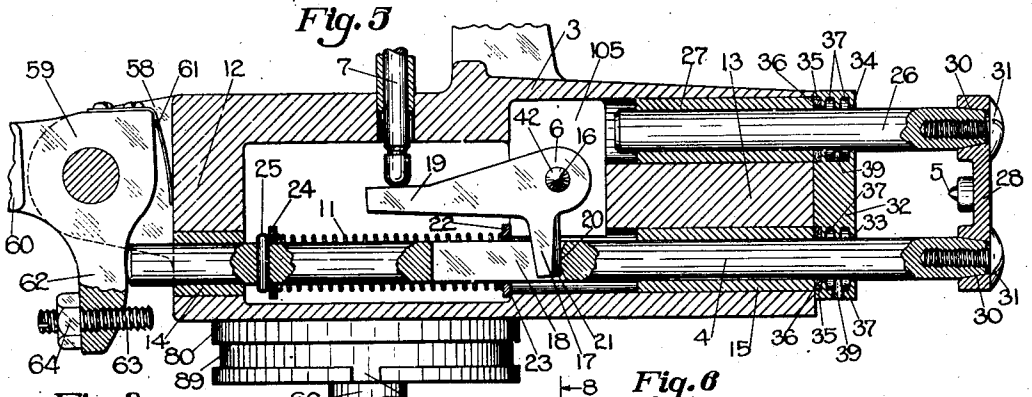


Fig. 8

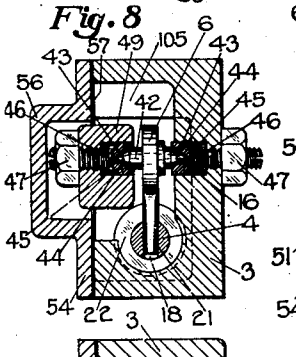


Fig. 7

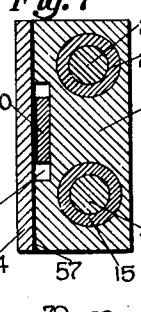


Fig. 6

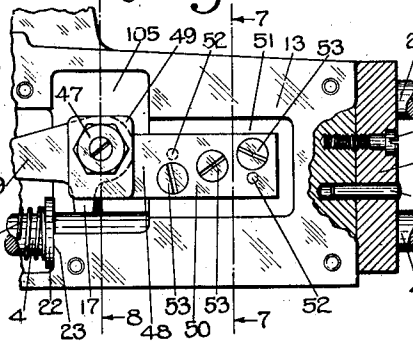


Fig. 9

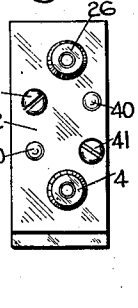


Fig. 10

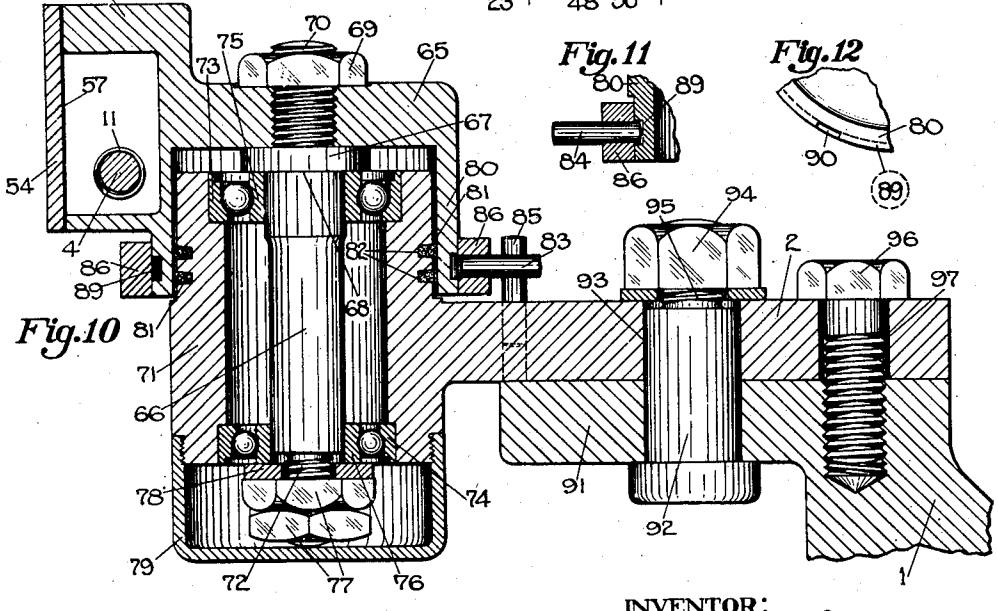


Fig. 11

Fig. 12

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Sept. 14, 1926. 1,600,089

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Fig. 13

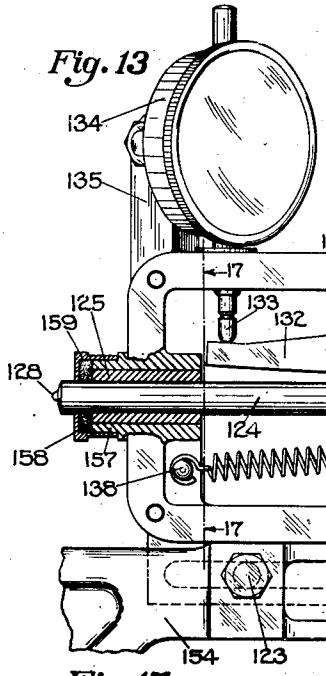


Fig. 16

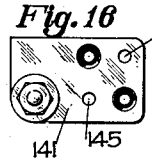


Fig. 21

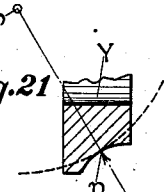


Fig. 14

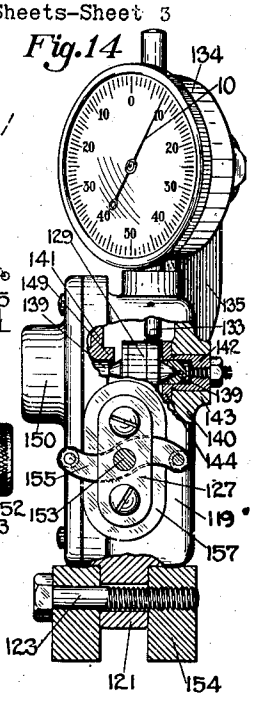


Fig. 17

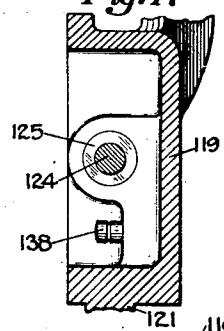


Fig. 18

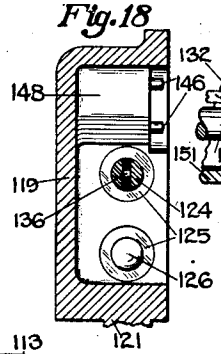
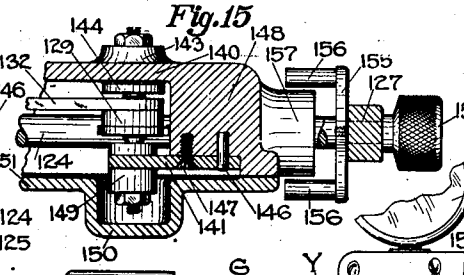


Fig. 15



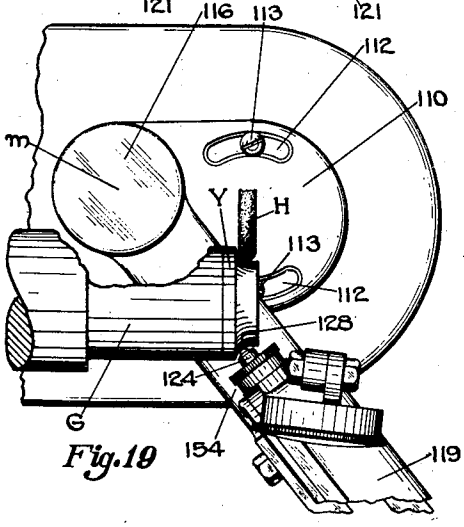


Fig. 19

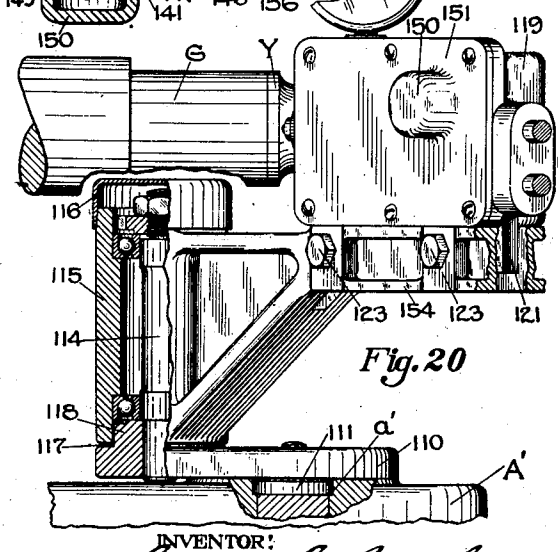


Fig. 20

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Patented Sept. 14, 1926. 1,600,089

UNITED STATES PATENT OFFICE.

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GAUGE.

Application filed December 18, 1921. Serial No. 522,077.

My invention relates to gauges, my object being to provide a structure which is extremely accurate in its operation, can be used for gauging objects of different sizes and characters, can be efficiently employed by inexpert workmen, and has its parts well protected. To this end, and also to improve generally upon devices of the character indicated, my invention consists in the various matters hereinafter described and claimed.

Although in no wise limited to such use, my present apparatus is particularly adapted to gauge race-parts of ball bearings as they are being ground, the first twelve figures of the accompanying drawings showing an embodiment of my invention especially suitable for inside gauging (such as gauging the interior diameter of the race portion of a race-cup for ball bearings), while the remaining figures show an embodiment more particularly adapted to perform outside gauging (such as gauging the exterior diameter of the race-portion of a cone for ball bearings.)

In the accompanying drawings: Figure 1 is a front elevation, the gauge being shown mounted upon a grinding machine and in operative position with respect to the work, certain of the parts being indicated in section and some of the parts being broken away; Figure 2 is an end elevation, a portion of the supporting plate being shown in section; Figure 3 is a top plan view, a fragment of the work being indicated, in section, in its operative relationship to the gauge; Figure 4 is a view similar to Figure 3 but showing a piece of work of different character from that shown in Figure 3, the gauge being shown in correspondingly adjusted position; Figure 5 is a longitudinal sectional elevation showing the casing, certain of the parts being broken away; Figure 6 is a fragmentary view of such casing chiefly in front elevation, certain of the parts being shown in section and the cover being removed; Figure 7 is a transverse sectional elevation on about the line 7—7 of Figure 6, looking in the direction of the arrows; Figure 8 is a similar view on about the line 8—8 of Figure 6; Figure 9 is a face view of the stuffing block; Figure 10 is a sectional elevation on about the line 10—10 of Figure 3, looking in the direction of the arrows; Figure 11 is a fragmentary sectional elevation on about the line 11—11 of Figure 3, looking in the direction of the arrows; Figure 12 is a fragmentary bottom plan view of the skirt of the carrier; Figure 13 is a longitudinal elevation, partly in section, showing a modified form; Figure 14 is an end elevation, partly in section, of the same; Figure 15 is a fragmentary view, partly in section, on about the line 15—15 of Figure 13, looking in the direction of the arrows; Figure 16 is a face view of the removable pivot-plate; Figure 17 is a transverse sectional elevation on about the line 17—17 of Figure 13, looking in the direction of the arrows; Figure 18 is a similar view on about the line 18—18; Figure 19 is a top plan view showing the gauge of Figure 13 in relation to its work, certain of the parts being broken away; Figure 20 is an elevation, partly in section, particularly showing the supporting elements; and Figure 21 is a diagrammatical view, a fragment of the work being shown in section.

Referring first more particularly to Figures 1–12, A indicates a portion of the customary oscillatory head of a grinding machine, this head oscillating as upon the stud B and carrying the usual rotatable chuck, or work support, C for the work X (here shown as a cup member of a ball bearing), while D indicates the usual rotary spindle carrying the customary reducing tool, such as the ordinary grinding wheel E, which, when the parts are adjusted to their usual operative positions, engages a point of the ball race of the cup X so that the ball race is ground (and the interior diameter of the race-cup is thereby increased) as the grinding wheel E rotates about the center of the spindle D while the work X is rotated about the center of the chuck and oscillates upon the center of the stud B, all of this being old and well known.

I mount my gauge upon the oscillatory head A, preferably through the instrumentality of a vertical bracket 1 fastened to the head and a horizontal supporting plate 2 fastened upon the bracket, and to that supporting plate I connect a casing or carrier 3 which carries a gauge-bar 4 longitudinally slidable in guides (Figure 5) in the carrier and itself carrying the gauge-point 5 adapt-

ed to contact with the work, as shown in Figures 1 and 3. A lever 6 (Figure 5) transmits the gauging movement of the gauge-bar 4 to the customary plunger 7 of the dial-indicator 8, conveniently mounted upon a post 9 on the casing 3 and having the usual pointer 10 (Figure 14), this plunger 7 being forced downwardly against the lever 6 by the customary spring (not shown) in the interior of the indicator, and the spring 11 (Figure 5) forces the gauge-point 5 toward the casing 3 and into gauging contact with its work. The carrier 3 is pivotally mounted upon its support, 2, (as by means of the spindle 66, Figure 10) to freely oscillate during the gauging action, so that during that action the gauge-point 5 is free to move into any position it may select across the face of the work (as in the arc *b* of Figure 3.)

This ability of the gauge-point 5 to thus freely move to select such position of contact permits gauging of the highest accuracy. For example, in grinding raceway cups, X, of ball bearings to their desired interior diameter, a master-cup (already perfectly finished) is set in place in the chuck when in proper relation to the line of contact of the grinding-wheel, the gauge is applied to the master-cup so set up, and the gauge-reading upon the indicator 8 is noted (usually by turning the indicator dial to bring its zero under the pointer 10 as that pointer stands when the gauge-point 5 is engaging the interior surface of the master-cup), and then the unground cups are successively substituted in the chuck for the master-cup and are there ground, the gauge, of course, being, by the operator, swung out of the way during the removal of a ground cup and the insertion of a new one, but being swung back into gauging position when the grinding of the new cup has started and being maintained in such position while the grinding proceeds, the grinding being stopped when the indicator pointer shows the same reading that it did when applied to the master-cup. Of course, the gauge shows the standard reading only when the gauge-point 5 stands the same distance from its center of movement (*a*, Figure 3) that it did when the gauge was calibrated in the master-cup, but should the gauge-point, during the grinding of a new cup, not happen to lie in just the same vertical line of the circle of the cup (as the parts are shown in Figure 3) as that in which it lay in the master-cup, the reading will be erroneous, that is to say, will not indicate the same interior diameter which the master-cup had; for example, if in the master-cup the gauge-point 5 had engaged the race-way *b* at the point shown in Figure 3 but (through, say, some wear of a stop-pin, or otherwise) should engage the similar race-way of the new cup at a point in Figure 3 above or below the point of engagement shown in that figure, it is quite obvious that the same gauge reading which indicated the interior diameter of the master-cup (the standard) would be shown with respect to the new cup only when its interior diameter was different from that of the standard. However, by making the carrier 3 free to oscillate about its pivot *a* and thus making the gauge-point 5 free to seek and find its point of contact with the work the above-mentioned difficulty is obviated because the gauge-point will lie in the same vertical line in each cup, as the parts are shown in Figure 3,—the gauge-point under pressure of the spring 11 will always seek that point in the cross-section of the raceway which (point) is nearest the pivot-point *a*, and that, of course, is the point at which the cross-section of the raceway-arc is intersected by the line from the pivot *a* to the center from which the arc *b* is struck, so that the arc portions upon each side of the point toward which the gauge-point 5 is being drawn are, roughly speaking, "higher" than that point of intersection and the gauge-point will, consequently, always "slide down" the arc until it reaches that "lowest" point, nearest to the pivot *a*. Thus, as the chuck, the oscillatory head A, and the grinding spindle are (as is common) so set that they produce only similar circles and arcs at each grinding, and as the gauge-point is free to find its point of rest upon the same vertical line of these similar circles and arcs in each cup, it follows that when in one of these circles the gauge can indicate a given reading for only circles of the same diameter and, therefore, when the interior diameters of the cups are the same. Of course, the point *a* in the support 2 affords the base from which the gauge measures its distances.

The rod, or gauge-point-carrying bar, 4 is protected by the casing 3 and supported in the end walls 12 and 13 thereof, the wall 13 being shown considerably thickened, longitudinally of the casing, in order to produce a block portion which gives a long, firm support for the rod, and I prefer to provide these end walls with bushings 14 and 15 which are securely driven into the end walls and whose bores are accurately ground to afford a nice sliding fit for the rod 4, which is thus confined to a single, unvarying path of longitudinal movement. The amplifying lever 6, also protected by the casing and pivoted at 16 in its chamber 105 in a manner to which I shall later more fully refer, has a depending arm 17 received in an elongated vertical slot 18 of the rod 4, while a substantially horizontal arm 19 of the lever has the plunger 7 resting upon it. Preferably, in order to reduce

friction and therefore enhance the sensitiveness of the gauge, I round the shoulder 20 of the bar 4, against which shoulder the lever arm 17 bears at what may be termed the forward end of the slot 18, and I bevel the lever arm 17 as at 21 to leave a relatively narrow surface against which the shoulder 20 engages, thus permitting the lever arm and the shoulder 20 to have relative movement with only small areas of surfaces in contact with each other but avoiding sharp edges which would wear away or dig into each other and thus destroy the accuracy of the gauge. The spring 11, coiled about the rod 4, has one end bearing against a washer 22 which contacts with a shoulder 23 of the casing, while the other end of the spring bears against a washer 24 loosely surrounding the rod 4 and abutting against a pin 25 through the rod, this pin being adapted to contact with the inner side of the end wall 12 of the casing and thus limit the movement of the rod 4 in one direction.

In order to further steady the gauge-bar 4 I prefer to provide a guide-bar 26 extending through the end wall 13 parallel with the rod 4 and preferably sliding in a bushing 27 which corresponds to the bushing 15 and with which the guide-rod 26 has a nice sliding fit. A head block 28 is rigidly connected to the outer ends of the rods 4 and 26 and has a finger 29 extending centrally from one side thereof and provided at its end with the gauge-point 5. The head block 28 is conveniently and rigidly connected to the rods 4 and 26 by tapering the outer ends of those rods and providing the head block with tapered sockets 30 in which the tapered ends of the rods are received, screws 31 entering the ends of the rods and having their heads over-lapping the head block. I prefer to make the tapered end of the rod 26 eccentric to its portion in the bearing 27, as indicated in a greatly exaggerated way in Figures 5 and 9 because in this way any slight variation in distance between either the rods or the sockets 30 can be compensated for by slightly turning the rod 26 in its socket.

Of course, in the usual operation of grinding a great amount of dust is created and considerable water or cooling fluid constantly runs over the material being acted upon. Preferably, therefore, in order to prevent ingress of extraneous matter into the casing 3, and especially to prevent its ingress into the bushings 15 and 27, I provide a stuffing block 32 which is attached to the end of the casing and has openings 33 and 34 through which the rods 4 and 26 work, and this stuffing block has, on its inner face and about the said openings, recessed seats 35 which receive washers 36 of felt or the like which closely surround the rods and form a packing about them. Also, I prefer to provide annular pockets or recesses 37 in the stuffing block and opening upon the openings 33 and 34, the pockets associated with a given opening communicating with an outlet channel, 39, leading to the exterior of the block 32. In this way any extraneous material that may flow along a rod before reaching the washer 36 becomes deposited in the pockets 37 and drains therefrom through an outlet 39. The stuffing block is conveniently held in position by pins 40 driven through the block and adapted to enter corresponding openings in the end of the casing 3, and by screws 41 also passing through the block and entering the casing end.

For conveniently and accurately mounting the lever 6, I drive through it an arbor or pivot 42, pointed at both ends 43, and seat these ends in cupped pivot blocks 44 which closely fit recesses 45 in the supports and have threaded shanks 46 the threads of which loosely engage threads tapped in openings leading from the seats 45 to the exterior of the supports in which such seats are formed, the pivot blocks being locked in place by set nuts 47 upon the threaded shanks. This provides for very accurate positioning of the pivot blocks 44 in vertical relationship, as the parts are illustrated in Figure 8, but permits proper sliding of the blocks toward and away from each other in order to engage the arbor 42 with sufficient force to prevent looseness, the loose engagement of the threaded shanks with the channel threads preventing the threads from tending to interfere with the proper relationship between the heads 45 and their seats. One of these pivot blocks is conveniently supported in the rear wall of the casing 3, and I prefer to support the other pivot block in a detachable plate 48 which has an enlarged end portion 49, in which the pivot block is received, and an extending shank 50 which is received in a recess 51 in the front of the block portion 13 of the casing and is positioned thereupon by pins 52 fastened in the shank 50 and entering corresponding recesses in the block portion 13 of the casing, said shank being secured in position by screws 53 passing through it and entering said block portion. By reason of this construction easy access can be had to the pivotal mounting of the lever 6.

A cover plate 54 fits over the front of the casing and is removably secured thereto by suitable screws 55, and this plate has a hollow protuberance 56 whose recess receives the headed portion of the supporting plate 48 with its lock nut 47. Thus the working parts of the gauge are protected by the casing but access can be readily had thereto by removing the cover plate 54. To aid in excluding dust, water and other extraneous matter from the interior of the casing I pre-

fer to place a sheet, 57, of waterproof paper between the cover plate and the body of the casing.

At what may be termed its rear the casing is provided with ears 58 between which is pivoted a central extension 59 of a handle 60. A spring 61 fastened to this extension and bearing against the adjacent end face of the wall 12 of the casing serves to normally hold the handle in the elevated position shown in Figure 1 so that the finger 62 upon the lower part of the extension 59 is held out of contact with the end of the rod 4 which projects through the rear of the casing, but by depressing the handle the finger 62 engages such projecting end of the rod 4 and serves as a retractor to move that rod and its connected gauge-point 5 in opposition to the action of the spring 11, the inward movement of the finger 62 being preferably adjustably limited as by means of an adjustable stop 63 threaded through the finger 62 and secured in place by the set nut 64. Thus, by depressing the handle so that the finger 62 engages and moves the rod 4 the operator can push that rod a sufficient distance to carry the gauge-point 5 out of the race-way of the article being ground and the gauge can then be easily moved away from the work, as for the removal of one piece of work and the insertion of another into the chuck C, and, the new work having been inserted, and the gauge swung back into gauging position, as soon as the handle is released the gauge-point 5 will resume its position in contact with the work but the relief spring 61 carries the finger 62 away from the end of the rod 4 so that the rod is free to move without having to lift the handle in such movement, thus making for sensitiveness of the gauge. The stop 63 makes it impossible to throw the gauge-point-carrying-finger against the grinding wheel.

As a convenient means of pivotally mounting the casing I provide thereon a plate 65 which extends from the rear of the casing and has centrally depending therefrom a spindle 66, the plate being firmly clamped between, on the one hand, a washer 67 which surrounds the spindle and abuts against a shoulder 68 thereon, and, on the other hand, a nut 69 which is screwed upon the threaded, extending spindle end 70. This spindle enters the opening of a cylindrical head 71 upon the supporting plate 2 and has a threaded lower end 72 extending below such head. The oscillatory bearing is between the spindle 66 and the cylindrical head 71, and I prefer to make this bearing an anti-friction one, as by driving cup members 73 and 74 of "cup-and-cone" ball bearings into the upper and lower ends of the head and driving the co-acting cone members, 75 and 76, of such bearings upon the corresponding portions of the spindle. Thus, the casing 3, carrying the gauge-point 5, is supported very sensitively and is quite free to oscillate for the purposes above indicated. The spindle is conveniently locked against accidental separation from the head 71 by providing the lower end 72 with lock nuts 77 which bear against a washer 78 loosely surrounding such end and itself bearing against the cone 76, while a cap 79, conveniently threaded upon the lower end of the head 71, covers the projecting end 72 and forms a secure closure for the open lower end of the head. To guard against entrance of extraneous matter at the upper end of the head I provide the plate 65 with a circular, depending skirt 80 which over-laps and fits about the upper end of the head, packing rings 81 of felt or the like being preferably provided between the head and the skirt, as by fitting in annular recesses 82 of the head and extending outwardly into contact with the inner face of the skirt.

I prefer to limit the amount of oscillation of the casing 3 (outside of the extent necessary for gauging action), as by providing the casing with stop pins 83 and 84 adapted to cooperate with an intermediate stop pin 85 driven into and projecting upwardly from the support 2. In order, however, that, for reasons to be hereinafter explained, the casing may, notwithstanding the stop pins, occupy various angular relationships to the support 2 and may have its given extent of oscillation over different areas, I prefer to mount the stop pins 83 and 84 on an adjustable stop-pin-carrier, here shown as a collar 86, split, as at 87, and surrounding the skirt 80, the usual locking screw 88 for such collar permitting this one to be tightened about the skirt or loosened for angular adjustment thereabout. And to hold this collar against accidental separation from the skirt and yet permit its ready application thereto and removal therefrom when so desired, I let the stop pin 84 extend through the collar and project from the inner side thereof into an annular groove 89 about the outer, lower portion of the skirt, an entrance slot 90 extending at one point from this groove to the lower edge of the skirt, as more particularly shown in Figures 11 and 12. To releasably hold the casing 3 in its outwardly swung position (away from the work), I fasten one end of a leaf spring 103 to the collar leaving its free end near the pin 84, this free end being preferably bent slightly inwardly as at 104, so that when the stop pin 84 contacts with the stop pin 85 the latter is received between the pin 84 and the inwardly bent end 104.

To enable my gauge to act upon different kinds of work I mount the pivot-member 2 adjustably. That is to say, this pivot-member, or supporting plate, 2 is preferably piv-

otally supported upon the upper horizontal arm 91 of the bracket 1, as by having a pivot stud 92, driven through the arm 91, received in a vertical opening 93 through the plate 2, a set nut 94 upon the upwardly extending threaded end 95 of the pivot stud 92 serving to hold the parts against accidental separation, while a headed set screw 96, threaded into the bracket 1 and extending loosely through a segmental slot 97 in the plate 2, serves to lock the plate in its angularly adjusted position. I prefer also to permit longitudinal adjustment of the bracket 1 upon its support, and this is conveniently provided for, and the bracket is securely held in position, by providing longitudinal slots 98 in the rearwardly extending base plate 99 of the bracket and a corresponding slot 100 in its forwardly extending base plate 101, headed set screws 102 loosely extending through these longitudinal slots and engaging threaded sockets in an appropriate portion of the oscillatory head A.

It will thus be apparent that my gauge mechanism can be adjusted longitudinally upon the oscillatory head (by reason of the slots 98 and 100) so that the gauge-point 5 can be carried toward or away from the chuck C; the support 2 can be angularly adjusted with respect to the bracket 1; and the casing 3 can be angularly adjusted with relation to the support 2. These various adjustments enable the gauge to be used upon surfaces of different character and yet permit the gauge-point to bear upon the surface being ground in the line of the radius of the curvature of such surface. For example, Figure 3 shows the parts in position to gauge the bearing surface of a cup X, the radius of whose race-way extends from a center substantially midway between the sides of the cup. Should it be desired to grind a cup wider than the one shown in Figure 3 but having the same character of race-way therein, it would only be necessary to adjust the bracket 1 longitudinally forward a sufficient distance to bring the gauge-point 5 into the new line of the center of the race-way; and if it be desired to grind a cup having a greater interior diameter than the one illustrated in Figures 1 and 3 (because of which greater diameter the inner surface of the race-way might lie a considerable distance to the left of the position occupied by the contact point 5 as the parts are shown in those two figures), this can be provided for by adjusting the support 2 angularly in order to carry its forward end the required distance to the left of the position it occupies in Figure 3 and also by swinging the casing 3 angularly around its pivotal axis together with an adjustment of the collar 86 angularly about the skirt 80 so that notwithstanding the changed position of the pivot-member 2 the gauge-point 5 can engage the work and travel in the straight line which includes the pivot a and the center from which the arc b is struck. Furthermore, should it be desired to grind a different character of race-way, such as the one upon the cup x' of Figure 4, such race-way having its radius at an angle to the radius of the race-way shown in Figure 3, this can be readily done by making any necessary adjustments of the collar 86, the casing 3, the support 2, and the bracket 1.

Should it be found desirable to prevent the oscillation of the gauge-point during gauging, as, possibly, when gauging a narrow, straight surface, I can reverse the spring 103 end for end by removing the fastenings and refastening the spring near the pin 84, and in this way the stop pin 85 will be releasably held between the free end of the spring and the stop pin 83 and the casing 3 and its supported gauge-point 5 will thereby be locked. In such use of my device the inclined, inwardly bent end of the tension spring will closely engage the pin 85 near the pin 83 and thus compensate for any wear of the latter which may have occurred.

Preferably, the bracket 1 and the other supports for the gauge-point 5 cause that gauge-point to engage the work at a point diametrically opposite that at which the grinding wheel E engages it, and, as the finger 29 and its supported gauge-point occupy but small space in that diameter, I am enabled to employ a grinding wheel of maximum diameter when using my gauge.

Thus, my present device is accurate, is compact, can be readily made and assembled, has its parts firmly held with respect to each other, has its moving parts well protected, can be manipulated by unskilled workmen, and can be used upon work of various sizes and characters.

In the adaptation of my gauge for outside work, as shown in Figures 13–21, I provide a pivot-plate 110 having near one end a downwardly extending boss 111 adapted to be received in a socket a' of the customary plate A′ of the ordinary oscillatory head of a grinding machine, this plate 110 having arcuate slots 112 concentric with the circular boss 111 and adapted to loosely receive headed set screws 113 which enter threaded sockets in the plate A′, thereby locking the plate upon the oscillatory head but permitting angular adjustment thereon. And near the other end of the supporting plate 110 I mount in it a spindle 114, substantially similar to the spindle 66 heretofore described, while upon this I mount an oscillatory cylindrical column 115 having a closure cap 116 and protected against ingress of foreign matter at its bottom by a

washer 117, of felt or the like, fitting about a circular boss 118 which is upon the plate 110 and is over-lapped by the lower end of the cylindrical column 115, this washer being between the plate 110 and the lower edge of the cylindrical column. Extending from the oscillatory column is a bracket arm 154 upon which the casing 119 is mounted to be adjusted longitudinally of the arm, this being conveniently effected by providing a central longitudinal rib 121 upon the bottom of the casing 119, which rib is received in a longitudinal slot in such arm. This rib being provided with an elongated longitudinal slot 122 and the bracket arm 154 having headed set screws 123 seated in threaded sockets therein and extending through the slot 122, it will be readily apparent that the casing can be adjusted to various longitudinal positions upon the bracket arm.

This casing has the gauge rod 124 extending through it and seated for longitudinal sliding in bushings 125 received in thickened portions of the respective end walls of the casing, and the guide-rod 126 is similarly slidably seated in one end wall of the casing and is connected to the gauge-rod 124 by the head-block 127 as heretofore explained. But the gauge-point 128 is the projecting end of the gauge-rod 124 opposite to that upon which the head-block 127 is secured, as this gauge-point can rest directly upon the work being gauged, as more particularly indicated in Figure 19, where Y indicates an ordinary cone of a ball bearing of the "cup-and-cone" type mounted in the usual way upon the spindle G of the customary grinding machine, H indicating the ordinary grinding wheel of such a machine. Of course, it is understood that in these grinding machines the spindle G is carried in supports secured to the oscillatory head plate A' to move therewith. Preferably a cap 159 removably fits upon the extending casing boss 157 through which the rod 124 passes, and a bushing 158, of felt or the like, surrounds the rod and is confined in such cap, to prevent the ingress of extraneous matter along the rod.

Within the casing 119 is a lever 129 mounted about as heretofore described and having a depending arm 130 extending into an elongated slot 131 of the gauge-rod 124 while a more or less horizontal arm 132 of the lever has the plunger 133 of the dial-indicator resting upon it, as explained in connection with the plunger 7 and the lever arm 19, the dial-indicator 134 being secured to a post 135 extending upwardly from the casing. I prefer to round the shoulder 136 of the gauge-bar 124 against which the lever arm 130 bears, for the reason previously explained in connection with the corresponding parts heretofore described, and I connect one end of the tension spring 137 to the lower end of the lever arm 130 and loop the other end of the spring over a stud 138 upon the casing. Thus, the spring tends to hold the gauge-point 128 in contact with its work, the gauge-bar 124 moving forwardly and the lever arm 132 thereby moving upwardly as the grinding progresses, so that the indicator 134 shows the extent of the grinding.

The pivot blocks 139 (substantially as heretofore described) are supported respectively in the rear wall 140 of the casing and the separable plate 141, although I prefer to directly support one of these pivot blocks in a bushing 142 extending through a thickened portion 143 of the rear wall of the casing and having at its inner end a peripheral flange 144 which engages the inner face of such rear wall. The removable plate 141, provided with the openings 145 adapted to receive the positioning pins 146, is fastened by screws 147 to the solid corner block 148, from which corner block the said positioning pins project. The enlarged head 149 of this removable plate receives the other pivot-block (corresponding to the one 139) and such enlarged head is received in the hollow protuberance 150 upon the cover plate 151.

As a convenient means of withdrawing the gauge-rod 124 and holding it in withdrawn position, I provide a milled finger-piece 152 which has a stem 153 rotatably extending through the head-block 127 and screwed into a cross-piece 155 upon the inner side of the head-block 127, this cross-piece having fingers 156 extending inwardly from its ends and such a distance from each other that the boss 157 of the adjacent end of the casing 119 can be received between these fingers when the parts are in the position indicated in Figures 14 and 15 and the gauge-point 128 is thus in extended position for engagement with the work. By grasping the finger piece 152 and pulling outwardly, the gauge-rod 124 is withdrawn from its operative position and the fingers 156 are carried to a point clear of the end face of the boss 157, and by then slightly turning the finger piece 152 (and its connected cross-plate 155) the fingers 156 are brought opposite to the end face of the boss 157 so that when the finger piece 152 is released by the operator these fingers 156 will engage the end face of the boss and will thus support the gauge-rod 124 in inoperative position.

From the description heretofore given of the operation of the form of my invention first herein described, the operation of this embodiment adapted to outside work will be readily apparent. I note, however, that the various adjustments heretofore described in connection with this second embodiment

of my invention permit the gauge-point to move in the line of the radius of the ball race, as indicated in Figure 21, where Y indicates the work, *m* indicates the center of oscillation of the column 115, the arrow head *n* indicates the gauge-point 128, and the line *m—o* indicates the line of the radius of the race-way and also indicates the line in which the bearing-rod 124 lies. Furthermore, it will be noted that as the center (*m*) of oscillation of the casing 119 is upon the side of the work opposite to that upon which the bearing point 128 (or *n*) bears, while the curved race-way of the bearing-cone Y defines an arc having its center upon the side of the work opposite to that upon which the center of oscillation (*m*), is located there is no danger of the bearing point 128 slipping out of the race-way (and, therefore, off the work) during the oscillation occurring while the work is being ground.

I claim:

1. In apparatus for automatically gauging a concave curve, a movable carrier, a gauge point mounted to move freely with the carrier substantially in the direction of the length of the curve, and a guide on the carrier to allow the gauge point to move also in a line normal to said curve and intersecting the line of the first mentioned movement; substantially as described.

2. In an apparatus for automatically gauging a concave curve, a gauge point mounted to move freely substantially in the direction of the length of the curve, and means for urging said gauge point in a line normal to said curve to hold the gauge point against said curve.

3. In apparatus for gauging a concave surface, a pivoted gauge carrier having its pivotal axis lying on a line substantially normal to said surface, and a gauge member slidably mounted on said gauge carrier to move towards said pivotal axis to contact with said surface.

4. In apparatus for gauging a concave curve, a gauge member mounted to move freely in a direction to cross the radius from which said curve is struck, and means constantly urging the gauge member in the line of said radius to press the gauge member against said curve.

5. In apparatus for gauging the deepest point in a concave surface, a gauge member mounted to swing freely about an axis lying on a line which is substantially normal to said surface and constructed and arranged to move also toward said axis, means constantly urging said gauge towards said axis to engage said deepest point, and means for confining said last mentioned movement to an unvarying path.

6. In a gauge, a base-affording member, a carrier in operative connection therewith, and a gauge-point carried by said carrier and movable thereon to vary its distance from said base-affording member, said carrier being freely movable relatively to the base-affording member in a line intersecting and normal to the path of said movement of said gauge-point; substantially as described.

7. In a gauge, a base affording member, an elongated carrier having a lateral extension pivoted to said member, a bar slidable in said carrier, and a gauge finger extending laterally from said bar.

8. In a gauge, a pivot-member, a carrier pivoted thereto to freely oscillate, guides on said carrier, a bar slidable in said guides upon said carrier, a gauge-point carried by said bar, said bar being slidable in a line intersecting the path of the above-mentioned oscillation the axis of oscillation and the gauge point both being at one side of the carrier; substantially as described.

9. In a gauge, a base affording member, a hollow carrier pivoted to said member and having guides, a bar slidable in the guides, a gauge finger extending laterally from said bar, indicating mechanism mounted in the carrier, and a connection between said indicating mechanism and said bar controlled by said gauge finger.

10. In a gauge, a pivot-member, a carrier pivoted thereto to freely oscillate, the axis of the pivot being substantially perpendicular to the plane in which the said carrier oscillates, guides on the carrier, a bar slidable in said guides upon said carrier to vary its distance from such pivot, a gauge-point carried by said bar, and means upon said carrier constantly urging said bar in its line of movement to press the gauge point against the work; substantially as described.

11. In a gauge, a pivot-member, a horizontally elongated carrier vertically pivoted to said pivot-member to freely oscillate, a bar freely slidable upon said carrier in the direction of its length, and a gauge-point carried by said bar; substantially as described.

12. In a gauge, a base-affording member, a carrier pivotally connected therewith, a gauge-point-carrying member movably supported upon said carrier, and means for adjustably securing said base-affording member in position to vary the position of such pivot; substantially as described.

13. In a gauge, a support, a pivot-member pivotally supported thereon to swing in a substantially horizontal plane, an elongated carrier pivotally supported upon said pivot-member to swing in a substantially horizontal plane, and a gauge-point-carrying member movably supported by said carrier to permit said gauge-point to move in the direction of the length of said carrier; substantially as described.

14. In a gauge, a support, means for adjustably securing the same in different posi-

tions in the direction of its length, a pivot-member pivotally supported upon said support to swing in a substantially horizontal plane, a carrier pivotally supported upon said pivot-member to swing in a substantially horizontal plane, and a gauge-point-carrying member movably supported by said carrier to permit said gauge-point to move in the direction of the length of said carrier; substantially as described.

15. In a gauge, a carrier having a pivotal axis at one side, a gauge-point-carrying member movably supported upon said carrier to move to vary its distance from the pivot point of said carrier, and a gauge-point at one side of said gauge-point-carrying member and separated from said pivot point to permit the work to lie between them; substantially as described.

16. In a gauge, a base-affording member, a carrier pivotally supported thereon to freely oscillate, a gauge-point-carrying member movably supported upon said carrier to move to vary its distance from the pivot point of said carrier, a gauge-point upon said gauge-point-carrying member and separated from said pivot point to permit the work to lie between them, and means constantly urging said gauge-point toward said pivot-point to press against the work; substantially as described.

17. In a gauge, a support, a gauge-bar slidable thereon, a guide-bar also slidable upon said support, a connection between said bars and a gauge finger at the middle of the connection; substantially as described.

18. In a gauge, a support, a gauge-bar slidable thereon, a guide-bar also slidable thereon, a head-block connecting said bars, a finger extending from said block and a gauge-point carried by said finger; substantially as described.

19. In a gauge, a support having bearings, a gauge-bar slidable in one of said bearings and having a gauge-point in connection with said bar, a guide-bar also slidable in another of said bearings, and a head-block having sockets receiving said bars, the portion of one of said bars received in its said socket being eccentric to the portion of said bar in its said bearing; substantially as described.

20. In a gauge, a casing, a gauge-bar slidably supported in opposite walls thereof and projecting therefrom and having a gauge-point in connection with such projecting portion, a lever for moving said bar and a co-operative movable element within said casing and in operative connection with said bar; substantially as described.

21. In a gauge, a casing, a gauge-bar slidably supported in opposite walls thereof and projecting therefrom and having a gauge-point in connection with such projecting portion, a spring for moving said bar in one direction, a lever for moving the gauge bar against the tension of the spring, an indicator supported by said casing, and operative connecting mechanism, in said casing, between said bar and said indicator; substantially as described.

22. In a gauge, a casing, a gauge-bar slidably supported in a wall thereof and projecting therefrom, an indicator supported upon said casing and having a longitudinally slidable stem entering the same, and a lever in said casing having one arm engaging said bar and its other arm abutting against the end of said stem; substantially as described.

23. In a gauge, a casing having a bearing opening, a bar slidably mounted in the opening and projecting therefrom, a packing about said bar, and a stuffing-block about said bar and engaging said packing and having a drain channel leading from its opening which receives said bar; substantially as described.

24. In a gauge, a support, a gauge-point-carrying member movably supported thereon, means urging said point toward gauging position, a movable retractor adapted to engage said gauge-point-carrying member and move it in opposition to said urging means, and means for normally holding said retractor out of such engagement; substantially as described.

25. In a gauge, a support, a gauge-point-carrying member movably supported thereon, means urging said point toward gauging position, a movable retractor adapted to engage said gauge-point-carrying member and move it in opposition to said urging means, and yieldable means urging said retractor out of such engagement; substantially as described.

26. In a gauge, a swinging carrier, a gauge-point-carrying member carried thereby and movable with respect thereto, means urging said point toward gauging position, and a lever pivotally supported upon said carrier and having an arm adapted to engage said gauge-point-carrying member and move it in opposition to said urging means.

27. In a gauge, a swinging carrier, a gauge-point-carrying member carried thereby and movable with respect thereto, means urging said point toward gauging position, a handle movably supported upon said carrier and having a portion adapted to engage said gauge-point-carrying member and move it in opposition to said urging means, and means for yieldingly holding said handle out of such engagement; substantially as described.

28. In a gauge, a casing having bearings in opposite walls, a gauge-bar slidable in said bearings and projecting from each end of said casing and provided with a gauge-point upon one such projecting portion, and a retractor movably supported

upon said casing and having a portion adapted to engage the other projecting portion of said bar to move the same; substantially as described.

29. In a gauge, a supporting-member having an opening therein, a carrier movably supported upon said supporting-member and having a part extending across said opening, a skirt extending from said carrier-part and about said supporting-member, members in said opening connecting said carrier and said supporting-member, and gauging means carried by said carrier; substantially as described.

30. In a gauge, a casing having a chamber therein and also having a block portion provided with a recess in its front face, a gauge-bar extending through said block portion, a pivoted operating part in said recess and provided with a pivot having one end seated on said casing, a plate on which the other end of said pivot is seated and having a portion in said recess and secured to said block portion, and a cover for said casing; substantially as described.

31. In a gauge, a supporting-member having an opening therethrough, a pivot-block fitted in said opening and movable longitudinally thereof, a threaded shank upon said block and extending loosely through said opening, and a nut upon said shank; substantially as described.

32. In a gauge, two parts having relative movement therebetween, a collar adjustably surrounding one of said parts, a stop upon the other part, and a cooperating stop upon said collar; substantially as described.

33. In a gauge, two parts having relative movement therebetween, one of said parts being provided with a groove, a stop-carrier movable upon said grooved part, a stop pin through said carrier and projecting upon both sides thereof, one of such projecting portions entering said groove, and a cooperating stop for said pin; substantially as described.

34. In a gauge, a support provided with a stop, a carrier pivotally mounted upon said support, a collar adjustably secured to said carrier, and stops upon said collar and cooperating with said first mentioned stop; substantially as described.

35. In a gauge, a supporting-member having an opening therein and provided with a stop, a carrier pivotally supported upon said supporting-member and having a part extending across said opening, a skirt extending from said carrier-part and about said supporting-member, members in said opening connecting said carrier and said supporting member, a collar adjustably secured about said skirt, and stops upon said collar cooperating with said first-mentioned stop; substantially as described.

36. In a gauge for measuring inside diameters, in combination, a reducing tool arranged to contact with the inside surface of the work, a slidable gauge member arranged to contact with the work at a point diametrically opposite the point at which the tool contacts with the work, a swinging guide for the gauge member, and means for constantly urging the gauge member to slide in a direction normal to the surface of the work during the reducing operation.

37. In apparatus of the class described, in combination, a reducing tool arranged to contact with the inside surface of a piece of work, a work holder mounted to traverse the work across the tool, and a gauge member carried by the work holder and engaging the inside surface of the work during the reducing operation.

38. In apparatus of the class described, in combination, a reducing tool arranged to contact with the inside surface of a piece of work, a work holder mounted to oscillate around an axis to carry the work past the tool in a path to produce a concave surface, and a gauge member carried by the work holder and continually engaging the inside surface of the work during the reducing operation.

39. In apparatus of the class described, in combination, a rotary reducing tool arranged to contact with the surface of a ring, a work holder mounted to swing around an axis to traverse the ring past the tool in a path to produce a concave raceway, and a gauge member carried by the work holder and being free to swing thereon to find the deepest point in said raceway.

40. In apparatus of the class described, in combination, a rotary reducing tool arranged to contact with the surface of a ring, a work holder mounted to swing around an axis to traverse the ring past the tool in a path to produce a concave raceway, a gauge member carried by the work holder and being free to swing thereon to find the deepest point in said raceway, and means for constantly moving the gauge member in a path normal to said raceway to said deepest point.

In testimony whereof I hereunto affix my signature.

GEORGE G. BUSH.