Sept. 22, 1953 J. L. JESSUP ET AL 2,652,665

INVOLUTE CHECKING FIXTURE AND TAILSTOCK MOUNTING THEREFOR

Filed Aug. 22, 1947 4 Sheets-Sheet 1

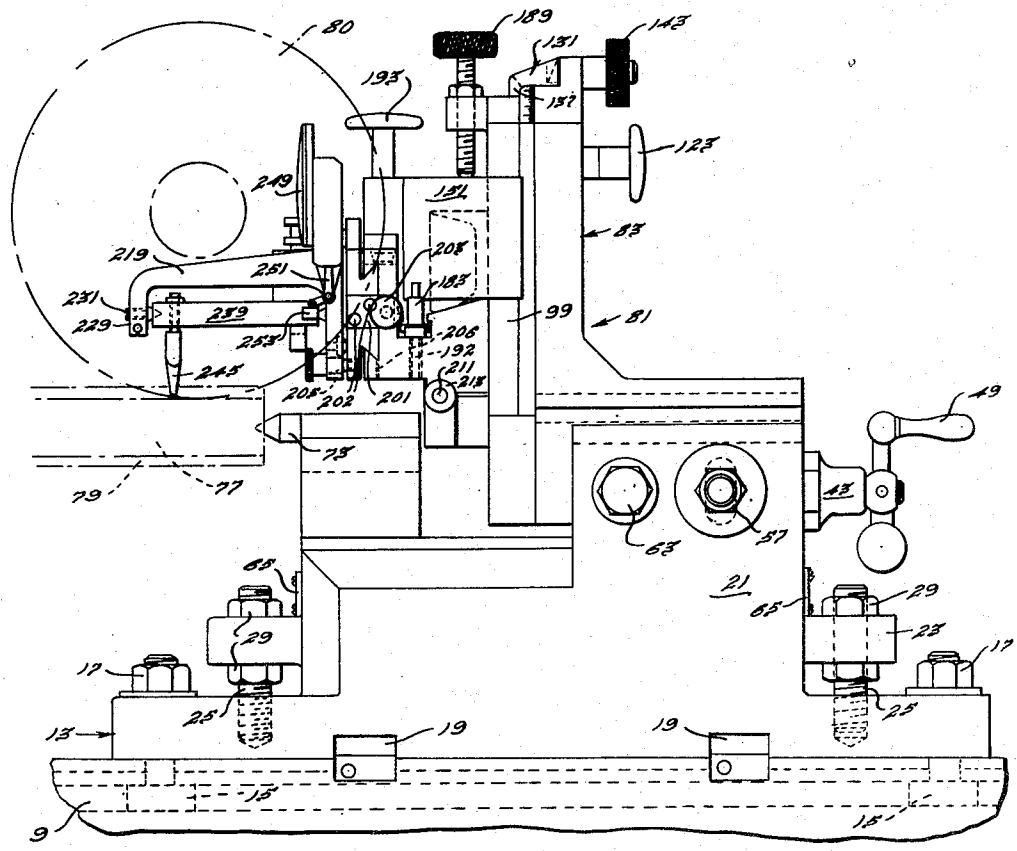

FIG. 1.

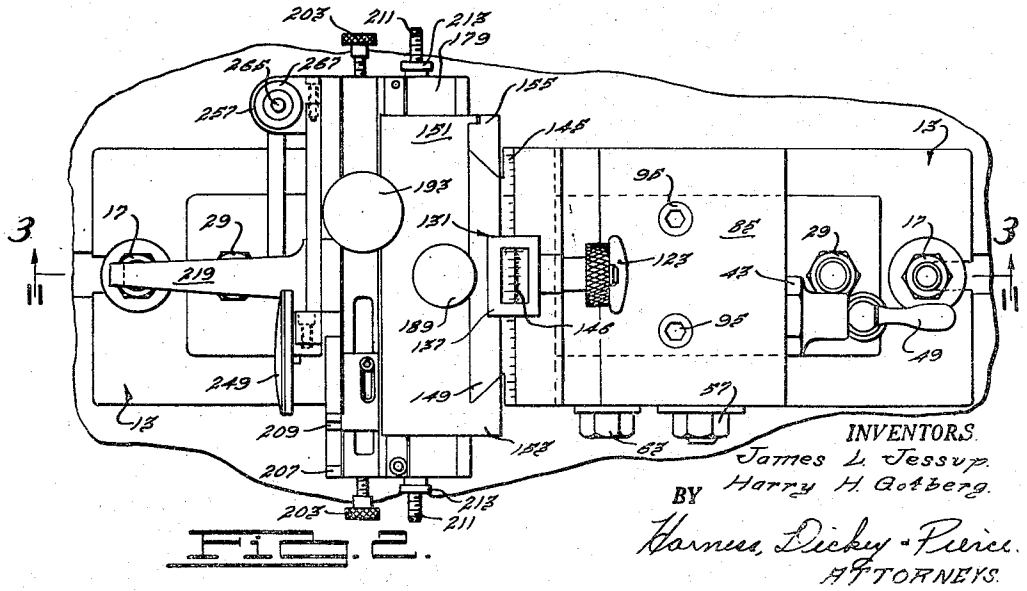

FIG. 2.

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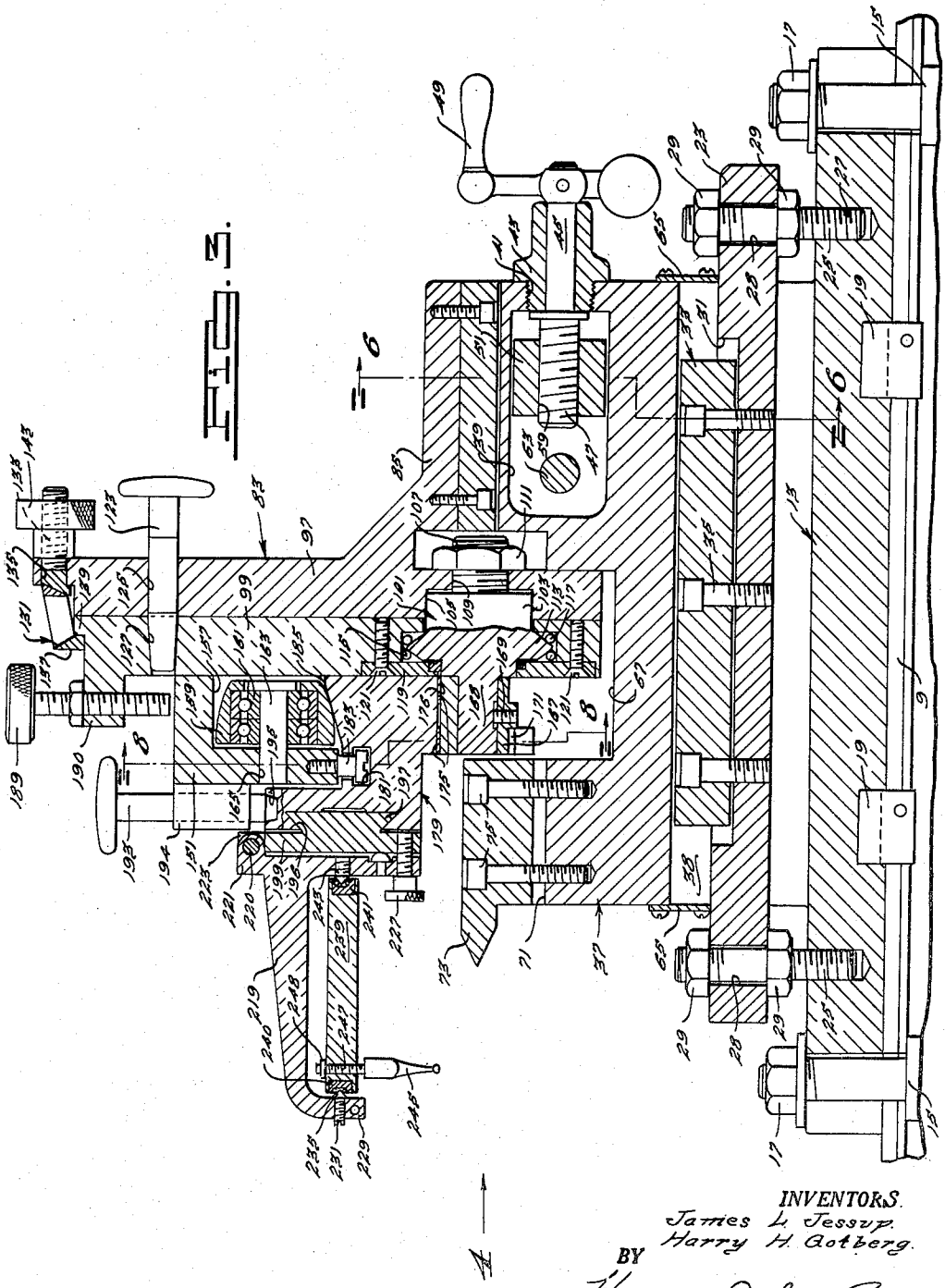
4 Sheets-Sheet 2



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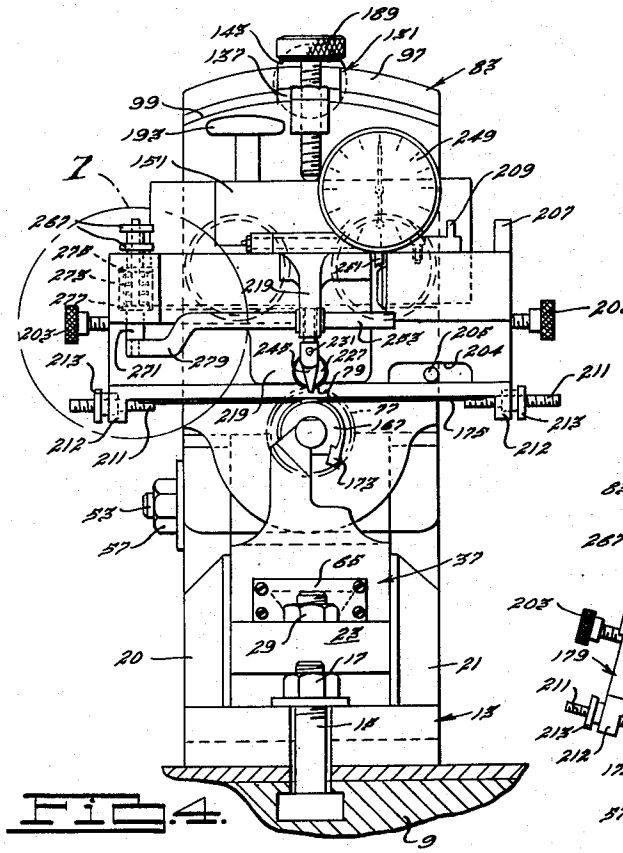

FIG. 4.

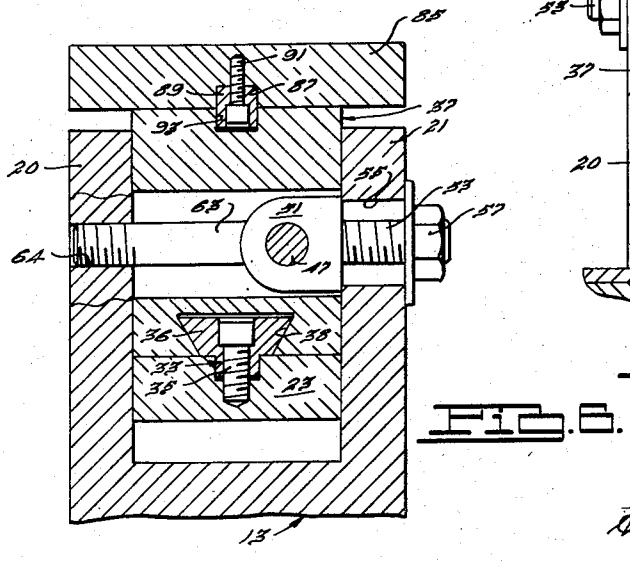

FIG. 6.

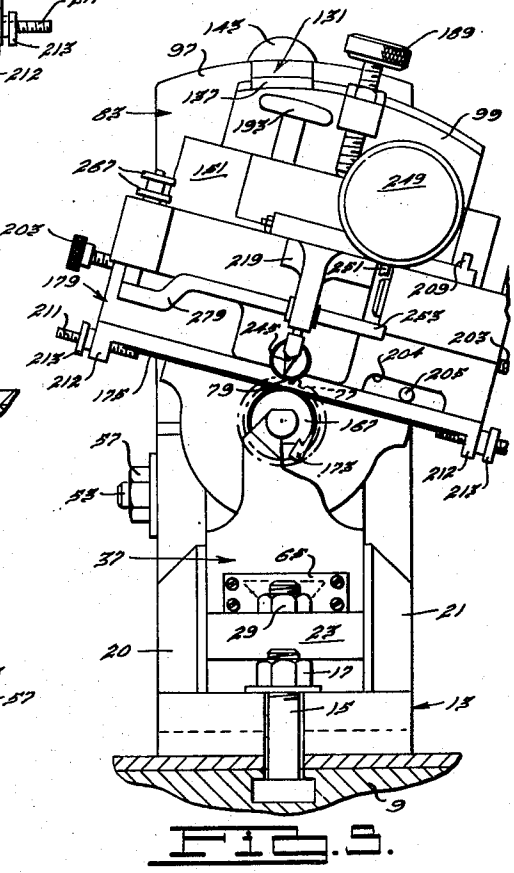

FIG. 5.

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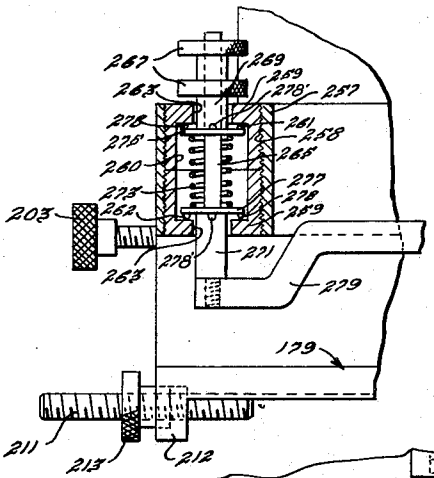

Fig. 7.

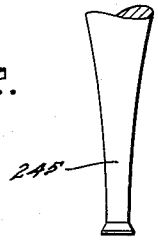

Fig. 9.

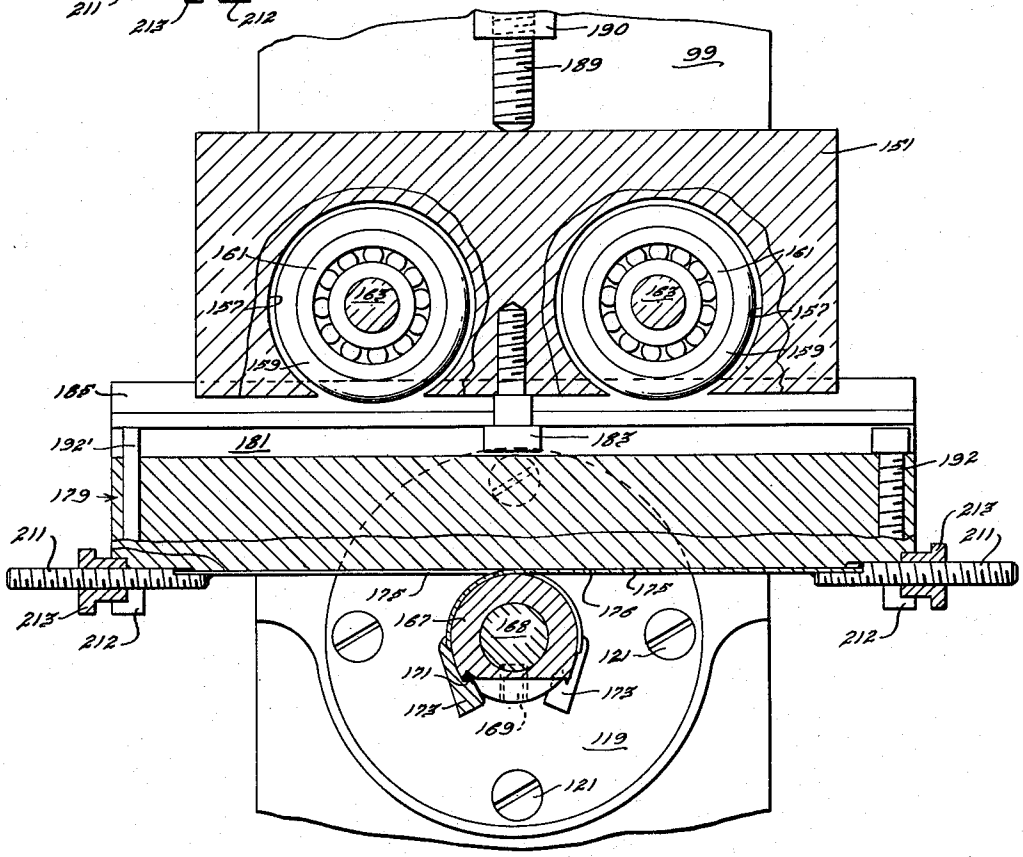

Fig. 8.

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INVOLUTE CHECKING FIXTURE AND TAILSTOCK MOUNTING THEREFOR

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Application August 22, 1947, Serial No. 770,132

6 Claims. (Cl. 51—165)

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This invention relates generally to checking fixtures and more particularly to an involute tooth checking fixture and a tailstock mounting base therefor.

It is an object of this invention to provide an involute tooth checking fixture which is adapted to be mounted on the tailstock of an involute spline or gear grinding machine so that the involute teeth of a workpiece, such as a broach or gear, may be checked without removing the workpiece from the machine in which it is ground.

It is a further object of this invention to provide an involute tooth checking fixture which can quickly and accurately check both the form and spacing of the teeth of a workpiece.

It is a further object of the present invention to provide an improved dial indicator mechanism capable of indicating deflections on either side of the neutral position of the pointer which engages the work.

These and other objects of this invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a side elevational view of the checking fixture of this invention mounted on the tailstock of a broach grinding machine;

Fig. 2 is a top plan view of the structure illustrated in Fig. 1;

Fig. 3 is an enlarged sectional view of the structure illustrated in Fig. 2, taken along the line 3—3 thereof;

Fig. 4 is a reduced front elevational view of the structure illustrated in Fig. 3, taken in the direction of the arrow 4 thereof, and illustrating the position of the fixture prior to checking the form of a tooth on a broach;

Fig. 5 is a view similar to Fig. 4 illustrating the position of the fixture at the completion of the checking operation of the tooth;

Fig. 6 is an enlarged fragmentary sectional view of the structure illustrated in Fig. 3 taken along the line 6—6 thereof;

Fig. 7 is an enlarged fragmentary view, partially in section and partially in elevation, of the portion of the structure illustrated in Fig. 4 enclosed within the circle designated 7;

Fig. 8 is an enlarged fragmentary sectional view of the structure illustrated in Fig. 3 taken along the line 8—8 thereof; and

Fig. 9 is an enlarged view of the end of the pointer which engages the work.

Referring now to the drawings, it will be seen that a tailstock base 13 is secured to the bed

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plate 9 of a grinding machine by means of T headed bolts 15 and nuts 17. Cross keys 19 are provided for preventing lateral movement of the tailstock base 13 with respect to the bed plate 9.

The tailstock base 13 is formed, intermediate its ends, with stepped side walls 20 and 21, between which is received a longitudinally extending plate 23. The plate 23 is supported on the tailstock base 13 by means of screws 25, which are threadably received in tapped apertures 27 in the base 13, adjacent each end of the side walls. The upper end of each screw projects through an aligned aperture 28 in the plate 23 and nuts 29 are threaded on each screw 25 so as to engage the upper and lower surfaces of the plate 23. By loosening and adjusting the nuts 29 the height of the plate 23 may be varied with respect to the base, for a reason which will hereinafter appear. The upper surface of the plate 23 is formed, intermediate its ends, with a longitudinally extending groove or notch 31. A gib 33 is received in the groove 31, and secured to the plate 23 by means of longitudinally spaced, countersunk screws 35. The gib 33 has an upper dovetail projection 36, formed thereon, as can be seen in Fig. 6.

A slide 37 is disposed between the side walls 20 and 21 of the base 13, which has a longitudinally extending dovetail recess 38, in the underside thereof. The dovetail projection 36 of the gib 33 is slidably received in the complemental recess 38 in the slide 37. The slide 37 is provided, adjacent its rear end, with a longitudinally elongated, transversely extending opening 39, and a tapped aperture 41 is provided in the rear end of the slide 37 which communicates with the opening 39. A bushing 43 is threaded into the tapped aperture 41 and supports a rotatable shank portion 45, of a shouldered screw 47 which projects into the opening 39. A handle 49 is rigidly secured to the outer end of the shank portion 45, in order to rotate the screw 47. A block 51 is disposed within the opening 39, and is provided with an integral threaded stem 53 extending transversely through a vertically elongated aperture 55 in the side wall 21 of the base 13. A nut 57 is secured to the outer end of the stem 53 to secure the block 51 to the base side wall 21. The block 51 has a longitudinally extending tapped aperture 59 therein, in which is received the threaded portion of the screw 47, so that when the handle 49 is turned, the slide 37 will be moved longitudinally along the gib 33. Forwardly of the block 51, a cap screw 63 is provided which ex-

tends through the side wall 21 of the base 13, the opening 39 in the slide 37, and is threadably received at 64 in the opposite side wall 20, of the base 13. By tightening the cap screw 63, the side walls 20 and 21 are compressed against the side faces of the slide 37, and prevent movement of the slide with respect to the base after it has been longitudinally adjusted. Depending dust plates 65 are secured to opposite ends of the slide 37, to prevent the ingress of dirt between the slide and the plate 23.

Forwardly of the opening 39, the slide 37 is formed with a slot or cutout portion 67, in which is received members to be hereinafter described. The extreme forward end of the slide 37 is provided with a keyway 71 in which is received a complemental key portion of a center 73. The center 73 is rigidly connected to the forward end of the slide 37 by means of countersunk cap screws 75. The pointed end of the center is adapted to engage one end of a broach 77, as illustrated in Fig. 1, and the opposite end of the broach 77 is conventionally supported in the grinding machine index head (not shown).

It will thus be seen that the center 73 may be adjusted vertically to align with the center of the index head by loosening the cap screw 63 and the nut 57 on the stem of block 51, and then threading the nuts 29 upwardly or downwardly. Horizontal adjustment is accomplished by turning handle 49, so that the center 73 will properly engage the end of the broach 77 to support the same while involute teeth or splines 79 are ground thereon by means of a form grinding wheel 80, illustrated in dot and dash lines in Fig. 1.

The fixture for checking the form and spacing of the broach teeth 79 is generally indicated at 81, and is illustrated in the drawings in its position on the tailstock. However, it is to be understood that during the machining operation, the checking fixture 81 is detached from the tailstock, and only after the grinding operation has been completed, is it secured to the tailstock in order to accurately check the form and spacing of the broach teeth. This arrangement, therefore permits the broach teeth to be checked, without removing the broach from the grinding machine.

The checking fixture 81 includes a stationary, generally T-shaped plate 83. The horizontal leg 85, of the plate 83, is provided with a longitudinal slot 87 in the underside thereof, as shown in Fig. 6, in which a key 89 is secured by means of countersunk screws 91. The key 89 is adapted to be received in a slot 93 formed in the upper surface of the slide 37, above the opening 39 therein. Screws 95 are provided for rigidly securing the plate 83 to the slide 37, as can be seen in Fig. 2. The vertical leg 97 of the plate 83 extends above and below the horizontal leg 85 and when the parts are assembled, the rear face of the lower portion of the vertical leg 97 abuts against the back face of the slot or cutout portion 67 of the slide 37, so that the plate 83 is rigidly held with respect to the slide.

A second vertical plate 99 is pivotally mounted on the plate 83 by means of a pivot pin, generally indicated at 101, and the rear face of the plate 99 engages and slides on the front face of the vertical leg 97 of the plate 83. The pivot pin 101 is formed with an annular hublike portion 103, intermediate its ends, which is received in a recess 105 in the lower portion of the vertical leg 97 and an aligned recess in the

second plate 99. A threaded stem 107 extends rearwardly from the pivot pin hub portion 103, through an aligned threaded aperture 109 in the lower portion of the plate 83 and carries a nut 111 which secures the pivot pin 101 fixedly with respect to the plate 83 and preloads bearings 117 as hereinafter explained. Forwardly of the pivot pin hublike portion 103, a circumferential flange 113 is formed, which has outwardly converging conical side walls, and which is located within a recess 115 of the second plate 99. A plurality of steel balls 117 are disposed around the outer periphery of the recess 115 and on opposite sides of the pivot pin flange 113. A centrally apertured cover plate 119 is secured in the front face of the plate 99, by means of countersunk screws 121 and thrusts against the steel balls 117. By tightening the nut 111 on the threaded stem of the pivot pin, the flange 113 is pulled rearwardly against the rear set of steel balls 117 so as to force the second plate 99 against the plate 83, and thereby prevent any play between the plates 83 and 99 respectively, but still permit the second plate 99 to be swung in a true vertical plane, with respect to the first plate 83. The plate 119 loads the two sets of balls against the conical flange 113 and the recess 115, thus providing a preloaded ball bearing pivot for the plate 99.

A tapered pin 123 is adapted to be inserted through an aperture 125, adjacent the upper end of the plate 83, into a tapered aperture 127 of the swinging plate 99, to center the swinging plate with respect to the stationary plate 83, for a reason which will hereinafter appear.

In order to hold the second plate 99 against movement with respect to the first plate, when the tapered pin 123 is removed, a clamp 131 is provided adjacent the upper end of the plate 83. The clamp 131 has a rearwardly extending threaded stem 133 which projects through an aperture 135, adjacent the upper end of the first plate 83. The clamp 131 is of a generally hollow rectangular shape, as seen in Fig. 2, and the front wall thereof has a downwardly projecting nose 137 formed thereon. The clamp nose 137 fits over, and engages the front face of an upstanding arcuate flange 139 formed on the upper arcuate surface of the plate 99. A thumb nut 143 is threaded onto the outer end of the threaded stem 133, of the clamp, so that by adjusting the thumb nut the clamp may be tightened, to hold the plate 99 against movement with respect to the first plate 83, or loosened, to allow the second plate to swing relative to the first plate.

Due to the hollow construction of the clamp 131 the top surface of the flange 139, of the swinging plate 99, and the forward portion of the upper arcuate surface of the plate 83 may be viewed by looking down through the center of the clamp. Secured to the upper surface of the flange 139 is a plate 145 having a protractor scale marked thereon. A similar plate 146, having a vernier scale marked thereon, is secured to the upper surface of the plate 83, so that when the second plate is centered with respect to the plate 83, the zero marking on the vernier scale will be aligned with the zero marking on the regular scale. Therefore when plate 99 is swung relative to plate 83 the amount of such movement may be read by means of this protractor and vernier scale.

The opposite side walls of the swinging plate 99 are cut back so as to converge rearwardly and provide in effect a male dovetail 149 (Fig. 2). A

bar like member 151 is mounted for vertical movement on the front face of the swinging plate 99 and held in sliding engagement therewith by means of a female dovetail formed on the rear face thereof, which receives the male dovetail 149 of the swinging plate 99. The female dovetail of the bar 151 is formed by means of a rearwardly projecting leg 153, on one end of the bar 151, and an adjustable gib 155 on the opposite end. The gib 155 may be loosened or tightened against the male dovetail 149 to eliminate play yet permit vertical sliding of the bar 151 on the swinging plate 99.

As best shown in Figures 3 and 8 the lower portion of the rear face of the bar 151 is provided with a pair of spaced recesses 157 in each of which is received a roller 159. Each of the rollers 159 is journaled on a shaft 163 by means of bearings 161. The free ends of the shafts 163 are fixed in apertures 165 in the bar 151, so that the rollers 159 are rotatably journaled on the bar 151.

An annular base circle roller 167 is journaled on the forward shank portion 168 of the pivot pin 101, and is adapted to be locked thereto by means of a set screw 169. The outer periphery of the roller 167, below and on opposite sides of the pivot pin shank 168 is cut to provide notches 171. As can be seen in Fig. 8, a hook like member 173 is received in each of the notches 171 and has one end of a flat flexible steel tangent band 175 secured thereto. Each of the bands extends around a portion of the outer periphery of the roller 167, on opposite sides thereof and in axially spaced relation to each other so as to cross and extend outwardly in opposite directions along a common tangent to the roller. The opposite ends of the bands are connected to the ends of a tangent bar 179 which has a flat surface 176 that, in operation, rests on the bands at the point of their common tangency to the base circle roller 167. The connection between the ends of the bands and the ends of the tangent bar is effected by means of screws 211. Each of the screws 211 is received in a notch in the underside of depending flanges 212, at each end of the tangent bar. The outer face of each flange 212 is recessed to receive the inner end of a thumb nut 213, which in turn threadably receives the outer end of one of the screws 211, so that by tightening the thumb nut 213, each band 175 will be tightened against the base roll 167.

The tangent bar 179 has its back face abutting against the lower portion of the front face of swinging plate 99, and the cover plate 119. Intermediate the front and rear faces of the tangent bar 179 an upwardly opening, longitudinally extending, T-slot 181 is provided, in which is received the head of a headed bolt 183. The threaded stem of the bolt 183 is fixed in the underside of the bar 151 near its center, so as to slidably and loosely secure the tangent bar 179 to the bar 151. The top face of the rear portion of the tangent bar 179 is pitched downward angularly at 185, as seen in Fig. 3, and the rollers 159 which are supported by the bar 151 are adapted to roll on this pitched surface. In order to prevent vertical play between the base roller 167 and the tangent bar 179, the lower end of a thumb screw 189, which is threaded into a forwardly projecting boss 190 on the upper end of the swinging plate 99, is adapted to be screwed downwardly against the top face of the bar 151 and thus load the rollers 159 against the surface 185 of the tangent bar 179. This forces the bottom face of the tangent bar against the tangent bands 175, and the roller 167, and the inclined face 185 prevents the tangent bar from moving away from the front face of swinging plate 99. In this way, therefore, the bar 151 and its transversely spaced rollers 159 effectively hold the tangent bar 179 against the base roll 167 and therefore eliminate any play which may occur therebetween.

In order to prevent the tangent bar from sliding transversely out of the bar 151 when the bands 175 are removed, a stud 192 and a pin 192' are provided in the opposite ends of the T-slot 181 of the tangent bar, to act as stops for the headed bolt 183. In order to positively hold the tangent bar in its central position during adjustment, a tapered pin 193 is adapted to be slidably received in a forwardly projecting boss 194 of the bar 151, and in a notch 195, in the top face of the tangent bar, and adjacent the front face thereof.

The forward face of the tangent bar 179 is formed with a dovetail recess 196 which receives a dovetail projection 197 formed on the back face of a plate 199, which is therefore movable transversely with respect to the tangent bar 179. End plates 201 are secured, by means of screws 202, to each end of the sliding plate 199 and the end plates overlap a portion of the tangent bar end faces. The end faces of the tangent bar 179 are notched inwardly to permit the overlapping portion of the end plates 201 to be received therein when the plate 199 is moved relative to the tangent bar. A thumb screw 203 is threadably received in each of the end plates 201 and the inner end of each thumb screw is adapted to abut against the inner end of the notch cut in its respective end of the tangent bar. By turning the thumb screws 203, the sliding plate 199 can be moved transversely with respect to the tangent bar and fixed relative thereto in any desired position.

As can be seen in Figs. 1 and 4 the bottom edge of the plate 199 is notched at 204, adjacent one end thereof. The front face of the tangent bar 179, behind the notch 204 is tapped and countersunk to receive a cap screw 205. The tangent bar is slotted along the line 206 (Fig. 1), intermediate its ends in the vicinity of the screw 205, so that when the screw is threaded into its aperture and tightened, the dovetail portion of the tangent bar will collapse against the dovetail portion of the sliding plate 199 and clamp the plate 199 against movement relative to the tangent bar.

An upstanding gauge lug 207 is formed on the top face of the sliding plate 199, adjacent one end thereof, as can be seen in Fig. 4. Adjustably secured to the tangent bar 179 is an upstanding gauge lug 209, which is spaced longitudinally of the tangent bar from the lug 207 and is in alignment therewith, so that the distance between the gauge lugs can be accurately measured by gauge blocks or either inside or outside calipers for reasons which will hereinafter appear.

An indicator arm 219 is pivotally mounted on the front face of the sliding plate 199, by means of a pin 220 which pivotally connects a pair of transversely spaced upstanding ears 221, formed on the rear, upper end of said arm, to the opposite ends of a boss 223 formed on the top face of the plate 199. The lower rear end of the arm 219 which is in the form of a flat plate is adapted to be secured to the front face of the

plate 199 by means of a thumb screw 227. By unscrewing the thumb screw 227, the arm 219 may be swung upwardly with respect to the plate 199. The extreme forward end of the arm 219 has a vertically depending end 229 formed thereon, in which is received a screw 231, having a conically pointed end 235. The pointed end 235 of the screw 231 rotatably supports the forward end of a pointer arm 239 through a bearing 240. The rear end of the pointer arm 239 has a similar bearing 241 mounted therein which receives the pointed end of a screw 243, which in turn is threaded into the rear end of the indicator arm 219.

A pointer 245 is mounted in the forward end of the pointer arm 239, by means of a threaded stem 247 and a nut 248, so that it is possible to adjust the pointer 245 vertically with respect to its arm 239. The end of the pointer 245, is adapted to contact the teeth or splines of the broach 77. In order to insure that any errors in the tooth form will be measured on a tangent to the base circle extending through the point of contact between the pointer 245 and the involute form, the end of the pointer is formed as a truncated cone which contacts the involute form at the edge of the base of the cone, as best shown in Figure 9. The diameter of the base of the cone is so correlated with the length of the pointer that on limited pivotal movements of the pointer, the point of contact between the pointer and the involute form travels in a straight line parallel with the tangent bar. A conventional dial indicator 249 is rigidly mounted on one of the ears 221, of the indicator arm, adjacent the front face of the sliding plate, and its depending pivoted actuating arm 251 abuts a horizontal arm portion 253, which is connected to and extends outwardly on one side of the pivotally mounted pointer arm 239.

A centering spring housing 257 is rigidly mounted on the left hand end of the indicator arm rear portion, adjacent the front face of the sliding plate 199, as viewed in Figs. 4 and 7. A pair of cup shaped members 259 are threaded into the threaded cylindrical bore 258 of the housing 257, and thus form a cylindrical recess 260 having end walls 261 and 262, each of which has a central aperture 263 therethrough. Extending upwardly through the apertures 263 in the members 259 with substantial radial clearance, and through the recess 260 is a plunger 265 which has its upper end threaded, to receive thumb nuts 267 thereon. The hub portion 269 of the lower thumb nut 267 extends through the aperture 263 in the end wall 261 of the upper member 259. The lower end of the pin 265 is enlarged at 271, to provide a shoulder. Disposed within the recess 260, and surrounding the pin 265, is a coil spring 273 which abuts loose washers 275 and 277 disposed above and below the spring, respectively. The washers 275 and 277 each have a pair of buttons 278 mounted on their outer faces at diametrically opposed points adjacent the outer edges of the washer, and a pair of diametrically opposed buttons 278' located adjacent the inner edges of the washer. The thumb nuts 267 are adjusted on the plunger 265 so that the buttons 279 on the upper washer 275 abut the lower end of the thumb nut hub portion 269, while its buttons 278 abut the end wall 261. The buttons 279 on the lower washer 277 then abut the upper end of the plunger shoulder portion 271, and its buttons 278 abut the lower end wall 262. Under these circumstances the spring 273 is under compression. Thus the plunger 265 may be moved upwardly or downwardly against the action of the spring, but when the plunger is released, the spring and washers will return the plunger to its central position, as illustrated in Fig. 7 and positively hold it in that position.

The lower end of the plunger 265 is fixedly connected to the outer end of an arm portion 279, which extends outwardly on the opposite side of the pointer arm 239, from the arm portion 253 which contacts the dial indicator plunger. Therefore, the centering spring arrangement will positively zero the dial indicator, and will always return the pointer 245 and the needle of the dial indicator to zero, after the same have been actuated, in either direction. If desired, the location of the pointer may be adjusted, by adjusting the cap members 259, within the housing 257, and then adjusting the thumb nuts 267, so that the spring and washers will be in a centered position, as previously described.

In operation the center 73 of the tailstock 11 is engaged in the end of the broach 77, by adjusting its height, by means of the screws 25, as previously described, and by adjusting it horizontally by means of the handle 49 and screw 47. After the broach has been ground by the grinding wheel 80, and it is desired to check the form and spacing of the involute teeth formed thereon, the grinding wheel is either removed or moved away from the tailstock. The checking fixture 81, during the grinding operation is disassembled from the tailstock.

While the checking fixture 81 is disassembled from the tailstock, the swinging plate 99 is centered on the stationary plate by means of the tapered pin 123. The gib 155 is then adjusted to take up any play between the roller bar 151 and the swinging plate 99. The tangent bar and indicator assembly is removed from the fixture by removing the stud 192 from one end of the tangent bar and sliding the same outwardly from the roller bar 151 so that the headed bolt 183 is removed from the T-slot 181. The tangent bar is then set on end on a flat surface such as a surface plate and the point of the pointer 245 is adjusted to the exact known distance from the notch 195 in the tangent bar. This distance may be, for example, one inch and the adjustment can be made by turning the thumb screws 203 so as to move the sliding plate 199 and the pointer 245 the necessary amount. Also by adjusting the cap members 259 in the centering spring housing, as previously described, the pointer may be moved a limited distance, with respect to the tangent bar without introducing errors due to the angular movement of the pointer. The sliding plate 199 is then secured against movement to the tangent bar 179 by means of the cap screw 205, and the gauge lug 209, on the tangent bar, is adjusted to exactly one inch, or the known distance, from the gauge lug 207 on the plate 199.

The proper size base roll 167 is then placed on the forward end of the pivot pin 101, so that the diameter of the base roll plus twice the thickness of the bands (which are formed of shim stock) corresponds exactly to the diameter of the base circle on which the involute teeth of the broach are generated. The tangent bar 179 is then replaced in the fixture and the stud 192 threaded into the tangent bar to prevent it from sliding off the roller bar. The tapered pin 193 is then inserted into the notch 195 in the tangent bar to positively secure the tangent bar in its

central position. The swinging plate 99 is brought to its central position and the taper pin 123 inserted. The bands 175 are then connected to the base roll 167; while the latter is free to rotate on the forward end of the pivot pin. The tangent bands are then tightened by adjusting the thumb nuts 213. Since at this time the roll 167 is free to rotate, equal tension in the two bands is assured. The set screw 169 is then tightened to secure the base roll 167 against rotation, on the forward portion of the pivot pin 101. The thumb screw 189 is threaded downwardly in the boss 190, of plate 99, against the bar 151 to load its rollers 159 against the tangent bar, to thereby take up any play between the tangent bar and the base roll 167, so that the tangent bar can roll on the base roll 167 but cannot slide with respect thereto. All of these adjustments insure that the center of the pointer will lie exactly in the vertical plane containing the axis of the broach when the fixture is assembled and the outer faces of the gauge lugs 207 and 209 are exactly one inch apart. Once these adjustments are made they need not be repeated when the unit is removed from or installed on the tailstock, or when base rolls are changed.

The checking fixture is then mounted on the tailstock by securing the stationary plate 83 on the upper surface of the tailstock by means of key 89 and screws 95, as previously described. It will be understood that the broach may be rotated and fixed by means of the usual index head in the position in which the two uppermost teeth in the transverse plane of pointer 245 are at equal distances on opposite sides of the vertical center line. Accordingly the pointer will now be disposed exactly midway between the two uppermost involute teeth 79 on the broach 77.

By calculation, the tangential distance from the vertical center line of the base circle of the teeth on the broach 79 to the point on the involute curve at which the involute tooth form begins can be determined. The pointer 245 can then be moved tangentially a calculated distance by adjusting the thumb screws 203 and measuring the calculated amount of movement between the gauge lugs 207 and 209. The amount of movement provided should, of course, be less than the calculated distance by the radius of the conical base of the pointer 245. The contacting edge of the pointer 245 will now lie at the base of the tooth form to be checked. By then removing the tapered pin 123 and the tapered pin 193, which fits into the notch of the tangent bar; the plate 99 can be swung about the pivot pin 101 so as to cause the tangent bar 179 to roll on the base roll 167. This will cause the pointer 245 to move on the path of the desired tooth form, and the dial indicator 249 will indicate any variations in the form of the tooth being checked. The amount which the plate 99 has moved angularly can be determined by reading the scales mounted on the upper end of the swinging plate 99 and stationary plate 83, and thus the location of any errors in form determined.

In most involute gear and spline teeth the base circle is of smaller diameter than the root diameter of the teeth and consequently the pointer 245 cannot engage the involute form at the base circle. It is for this reason that the indicator arm is pivoted at 220 so that it can be swung upwardly out of the way until after the pivoted plate has been swung, as above described, far enough to permit engagement of the pointer with innermost part of the tooth flank. The pointer 245 can then be moved in the opposite direction, twice the distance it was moved in the first place, so as to be at the theoretical base of the tooth form for the adjacent tooth. This movement is accomplished by adjusting the thumb screws 203 and measuring the movement between the gauge blocks 207 and 209. By swinging the plate 99 in the opposite direction, the pointer 245 will again move on the path of the desired tooth form and any variations in the form of the tooth being checked as well as its distance from the other tooth will be indicated on the dial indicator. It will be noted that in this case the opposite side of the pointer is engaging the tooth and that therefore the indicator is actuated in the opposite direction if the tooth spacing is too small. In order to insure accurate readings in opposite directions from a neutral point the indicating mechanism includes the previously described positive centering device within housing 257. This permits measurements of tooth spacing which has hitherto been impossible with involute checking devices.

It will therefore be seen that both the form and the spacing of the teeth of the broach, splined shaft or gear can be quickly and accurately checked, without removing the workpiece from the grinding machine. The entire checking fixture can be removed from the tailstock as a unit and reinstalled without difficulty and without disturbing any of the adjustments. This greatly facilitates checking of involute forms.

While the use of tension bands connecting the tangent bar and base roll is preferred, it will be apparent that the bands may be omitted, if desired, and friction between the tangent bar and base roll relied upon to prevent slippage. In that case the base roll will be the full base circle diameter of the form checked. When the bands are used the effective diameter of the base roller is its actual diameter plus twice the thickness of the bands.

I claim:

1. A fixture for checking the form and spacing of circumferentially spaced involute teeth of a member, including a roller element having an outside diameter equal to that of the base circle on which the involute teeth of the member are generated, means for supporting said roller element in axial alignment with said toothed member, a tangent bar supported on said roller element and adapted to be rolled thereon, a pointer, means pivotally mounting said pointer on said tangent bar, indicator means operatively connected to said pointer, adjustable centering means supported on said tangent bar and operatively connected to said pointer for operatively returning said indicator and said pointer to zero following displacement in either of two opposite directions, means for adjusting said pointer to a known point with respect to said involute teeth base circle, and means for shifting said pointer a known distance parallel to a tangent to said base circle.

2. A fixture for checking the form and spacing of circumferentially spaced involute teeth of a workpiece, including a roller element having an outside diameter equal to that of the base circle on which the involute teeth of the workpiece are generated; means for supporting said roller element in axial alignment with said workpiece, a tangent bar supported on said roller element and adapted to be swung in rolling engagement therewith, a member mounted on one face of said

tangent bar and movable longitudinally with respect thereto, a pair of members mounted respectively on said tangent bar and member and having surfaces which extend transversely to the tangent bar and are longitudinally aligned so that they may cooperate with a measuring device for measuring the longitudinal position of said member with respect to said tangent bar, means for fixing the tangent bar in a position of reference, a work engaging element movably mounted on said member and having a work engaging portion movable approximately parallel to the tangent bar, said portion of the element being located in a known position with respect to the theoretical location of the involute form to be checked when said tangent bar is in said position of reference and said surfaces on said members are spaced a predetermined distance, an indicator mechanism operatively connected to said element, and means for adjusting said longitudinally movable member parallel to said tangent bar, whereby the work engaging surface on said element can be located at the theoretical position of the tooth form to be checked by changing the distance between the surfaces on said members by a calculated amount.

3. A fixture for checking the form and spacing of circumferentially spaced involute teeth of a workpiece including a roller element having an outside diameter equal to that of the base circle on which the involute teeth of the workpiece are generated; means for supporting said roller element in axial alignment with said workpiece, a tangent bar supported on said roller element and adapted to be swung in rolling engagement therewith, a member mounted on one face of said tangent bar and movable longitudinally with respect thereto, a pair of members mounted respectively on said tangent bar and member and having surfaces which extend transversely to the tangent bar and are longitudinally aligned so that they may cooperate with a measuring device for measuring the longitudinal position of said member with respect to said tangent bar, means for fixing the tangent bar in a position of reference, a work engaging element movably mounted on said member and having a work engaging portion movable approximately parallel to the tangent bar, said portion of the element being located in a known position with respect to the theoretical location of the involute form to be checked when said tangent bar is in said position of reference and said surfaces on said members are spaced a predetermined distance, an indicator mechanism operatively connected to said element, means for adjusting said longitudinally movable member parallel to said tangent bar, whereby the work engaging surface on said element can be located at the theoretical position of the tooth form to be checked by changing the distance between the surfaces on said members by a calculated amount, and centering means operatively connected to said work engaging element for operatively returning said indicator to zero following displacement in either of two opposite directions.

4. A fixture for checking the form and spacing of circumferentially spaced involute teeth of a workpiece, including a detachable roller element having an outside diameter equal to that of the base circle on which the involute teeth of the workpiece are generated, means for supporting said element in axial alignment with said workpiece, a tangent bar supported on said roller element and adapted to be swung in rolling engagement therewith, a member mounted on one face of said tangent bar and movable longitudinally with respect thereto, a pair of members mounted respectively on said tangent bar and member and having surfaces which extend transversely to the tangent bar and are longitudinally aligned so that they may cooperate with a measuring device for measuring the longitudinal position of said member with respect to said tangent bar, detachable tension bands for connecting said roller element and said tangent bar to prevent slippage therebetween, means for fixing said tangent bar in a position of reference during the tensioning of said bands, a work engaging element movably mounted on said member and having a work engaging portion movable approximately parallel to the tangent bar, said portion of the element being located in a known position with respect to the theoretical location of the involute form to be checked when said tangent bar is in said position of reference and said surfaces on said members are spaced a predetermined distance, an indicator mechanism operatively connected to said element, and means for adjusting said longitudinally movable member parallel to said tangent bar, whereby the work engaging surface on said element can be located at the theoretical position of the tooth form to be checked by changing the distance between the surfaces on said members by a calculated amount.

5. A fixture for checking the form and spacing of circumferentially spaced involute teeth of a workpiece including a spindle having its axis fixed on the axis of said workpiece, a detachable roller element mounted on said spindle and having an outside diameter equal to that of the base circle on which the involute teeth of the workpiece are generated, a tangent bar supported on said roller element and adapted to be swung in rolling engagement therewith, a member mounted on one face of said tangent bar and movable longitudinally with respect thereto, a pair of members mounted respectively on said tangent bar and member and having surfaces which extend transversely to the tangent bar and are longitudinally aligned so that they may cooperate with a measuring device for measuring the longitudinal position of said member with respect to said tangent bar, detachable tension bands for connecting said roller element and said tangent bar to prevent slippage therebetween, releasable means for locking said roller element to said spindle so that said roller element is freely rotatable on said spindle during the tensioning of said bands, means for fixing said tangent bar in a position of reference during the tensioning of said bands, a work engaging element movably mounted on said member and having a work engaging portion movable approximately parallel to the tangent bar, said portion of the element being located in a known position with respect to the theoretical location of the involute form to be checked when said tangent bar is in said position of reference and said surfaces on said members are spaced a predetermined distance, an indicator mechanism operatively connected to said element, and means for adjusting said longitudinally movable member parallel to said tangent bar, whereby the work engaging surface on said element can be located at the theoretical position of the tooth form to be checked by changing the distance between the surfaces on said members by a calculated amount.

6. In combination, a tailstock for a grinding machine, a center rigidly secured to said tailstock, said tailstock having a flat surface fixed

relative to said center, a detachable involute tooth checking fixture mounted on said tailstock flat surface, said fixture including a member having a flat surface engaging said tailstock flat surface, a roller element having an outside diameter equal to that of the base circle on which the involute teeth of the member are registered, means connected with said fixture for supporting said roller element in axial alignment with said center, a tangent bar supported and adapted to roll on said roller element, a pointer, and means mounting said pointer on said tangent bar.

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