April 25, 1967 T. MALSCHNER 3,315,549

DEVICE AND METHOD FOR GENERATING INTERNAL SPHERICAL SURFACES

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FIG. 1

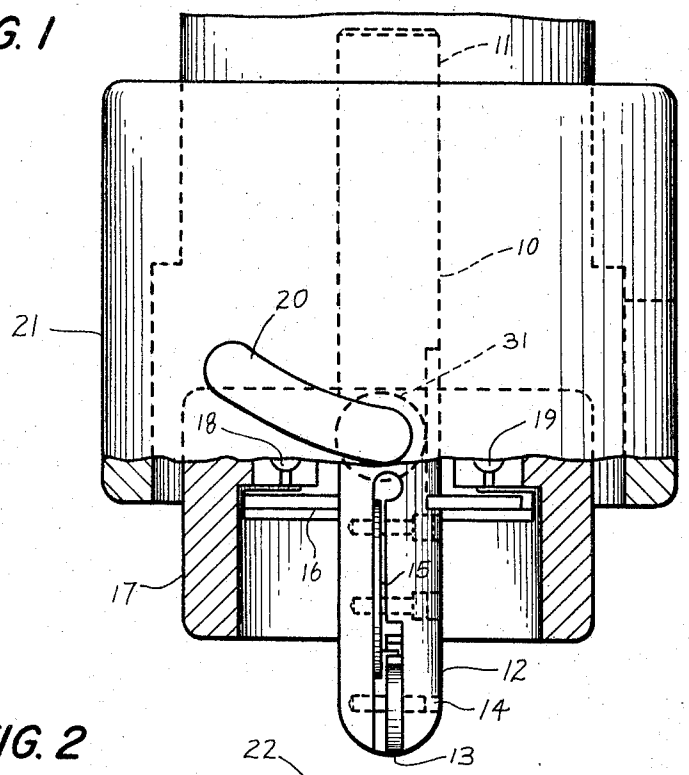

FIG. 2

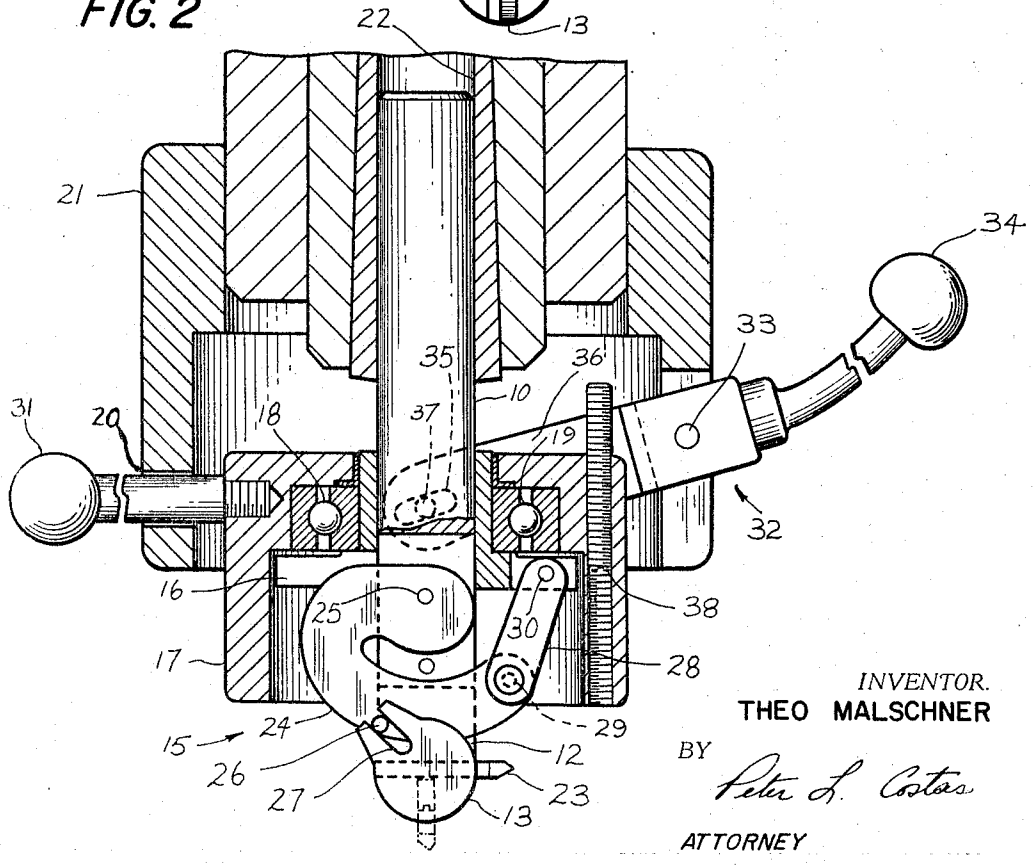

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FIG. 6

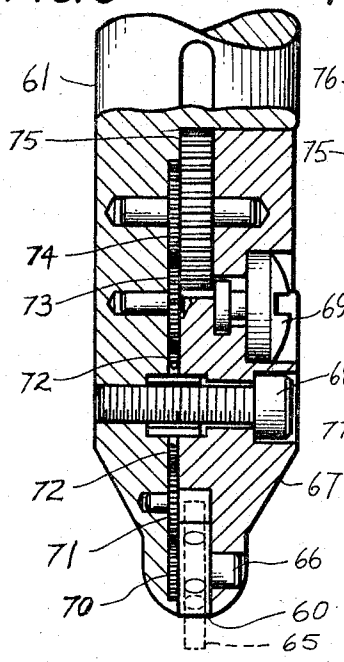

FIG. 7

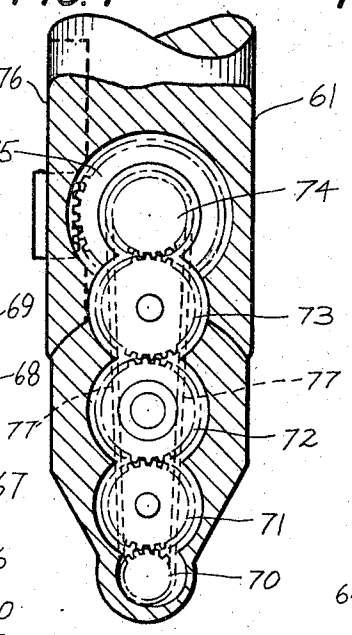

FIG. 5

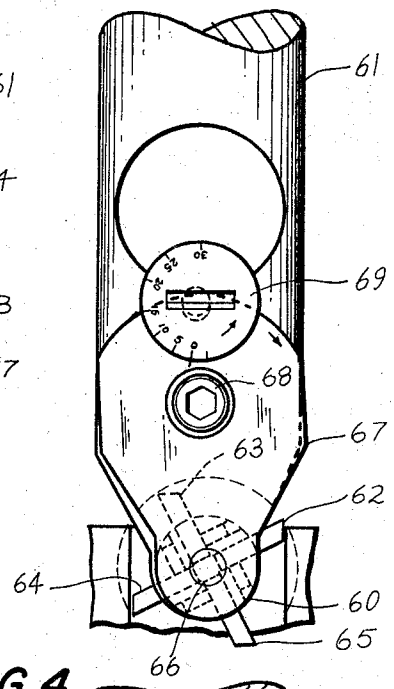

FIG. 3

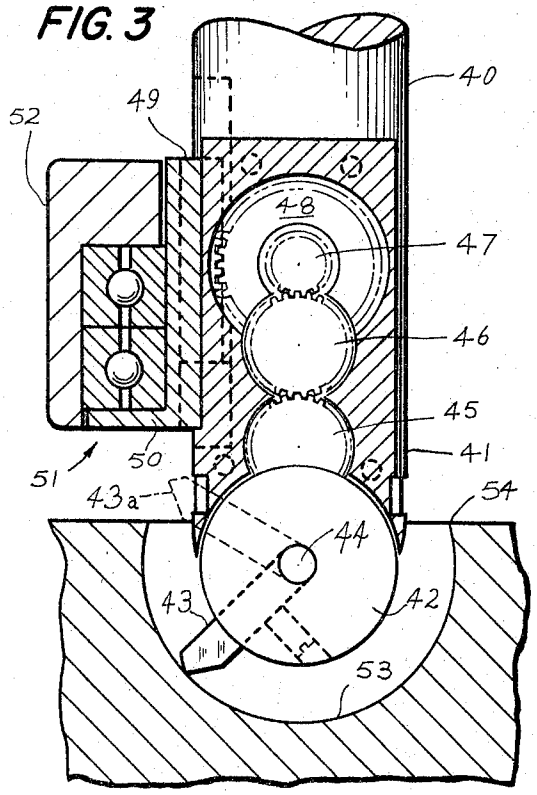

FIG. 4

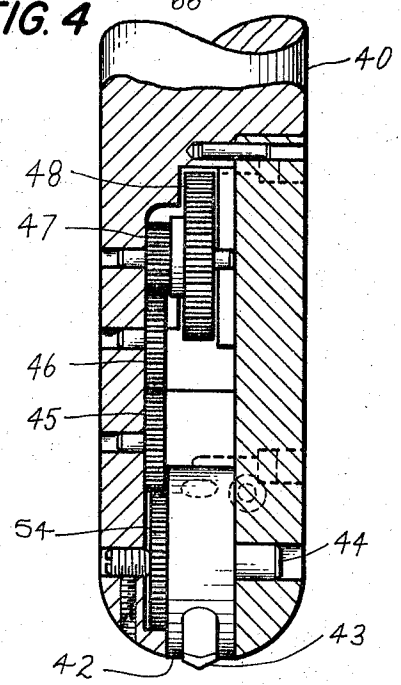

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FIG. 8

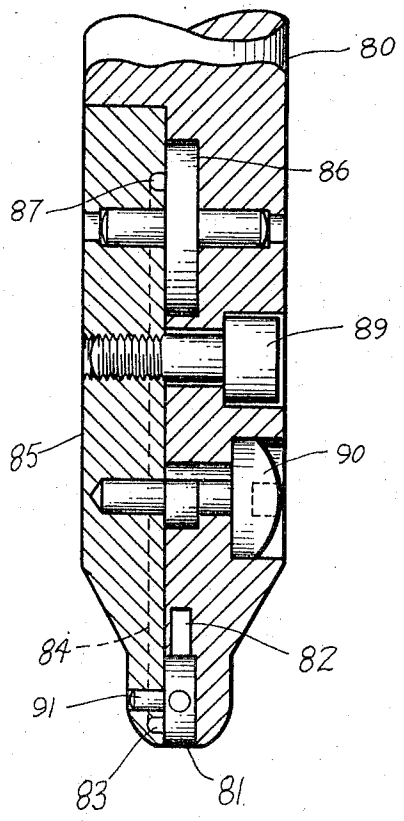


FIG. 9

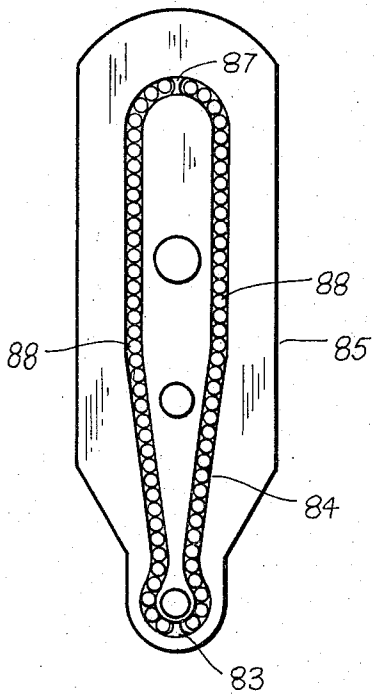


FIG. 10

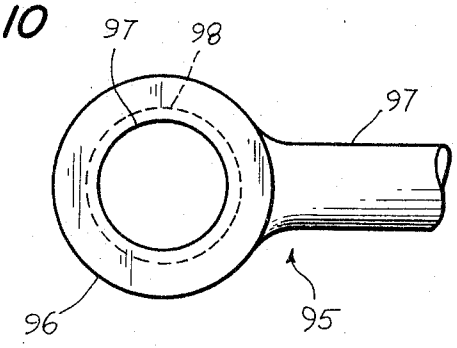
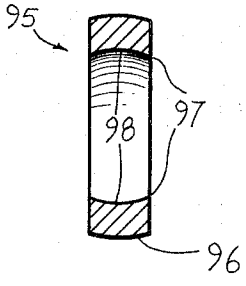


FIG. 11



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United States Patent Office

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3,315,549

DEVICE AND METHOD FOR GENERATING INTERNAL SPHERICAL SURFACES

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Filed Jan. 5, 1965, Ser. No. 423,485
21 Claims. (Cl. 77—58)

This invention relates to a device and method for generating an internal spherical surface in a workpiece which may be in the form of one of many different kinds of metal. More particularly, the present invention is concerned with a device which is adapted to be received and held by machine means so that the device and the workpiece may be rotated relative to each other either by rotation of the device with the workpiece held stationary or by rotation of the workpiece with the device of the present invention held stationary. An appropriate cutting tool is supported by the device so as to be controllably pivotable during rotation of the device and the workpiece relative to each other and thereby an internal spherical surface is cut in the workpiece.

In the prior art it was common practice to employ means such as a so-called "cherry" reamer for generating internal spherical surfaces in a workpiece. Such reamers had the disadvantage of being relatively slow-speed tools and inherently incapable of producing fine finishes such as might be desirable on high precision work. Additionally, reamers of this kind require relatively frequent, time-consuming resharpening and are not adjustable to generate internal spherical surfaces of different sizes. Another inherent limitation of reamers and similar tools is that they are necessarily incapable of generating internal spherical surfaces which are greater than a hemispherical surface, i.e., an internal spherical surface which at the surface of a flat workpiece has a diameter smaller than the extreme diameter of the spherical surface generated within the workpiece. This is so because a "cherry" reamer or similar tool has cutting edges which are fixed and accordingly will cut the maximum diameter of such cutting edges with respect to the rotational axis of the cutting tool and is incapable of undercutting within the workpiece so as to generate an internal spherical surface having a greater diameter than that which it cuts in the plane surface of a workpiece. The fact that "cherry" reamers and tools of the like are not adjustable for generating different sizes of internal spherical surfaces means in effect that one or a series of such reamers or similar tools must be purchased for each cutting job which involves a different size of internal spherical surface.

Accordingly, it is a principal object of the present invention to provide a device and method for generating an internal spherical surface in a workpiece by means of an adjustable and controllably pivotable cutting tool.

Another object of the present invention is to provide a device for generating such an internal spherical surface in a workpiece which is conceived for and adapted to high-speed cutting techniques and machines for generating internal spherical surfaces of high precision and extremely fine finishes.

Another most important object of the present invention is to provide a device for generating an internal spherical surface in a workpiece which internal spherical surface may be undercut in the workpiece so as to provide a greater than hemispherical surface as desired.

Another object of the present invention is to provide a device for generating an internal spherical surface which has a diameter greater than the diameter of the opening through which the device is inserted to cut the spherical surface.

Yet a further object of the present invention is to provide a device for generating an internal spherical surface in a workpiece through the use of a plurality of cutting tools which are disposed so as to be controllably movable to take successive cuts in the spherical surface it is desired to generate.

The device of the present invention which generates an internal spherical surface in a workpiece comprises in its simplest form a body member which has a shank portion adapted to be received and held by machine means such as the collet, for instance, of a stationary machine means or a rotatably driven machine means. The other end of the body member is configured to receive a pivotable cutting tool holder. A cutting tool holder which is adapted to adjustably support at least one cutting tool in extension therefrom is pivotably supported at the end of the body member of the device which is configured to receive it. The supporting means for the cutting tool holder, which may take the form of a suitable pin fitted to an aperture in the cutting tool holder, is positioned on the body member so as to have a pivot axis normal to the major axis of the body member of the device and affords continuous pivotal movement of the cutting tool holder through at least 90° from the rotational axis of the device and the workpiece with respect to each other. Suitable means, such as a gear train or chain, operatively connects the cutting tool holder to a means for controllably pivoting the cutting tool holder during rotation of the device and the workpiece relative to each other. Several types of such means will be described more fully hereinafter in a description of the several embodiments illustrated in the drawings. These and other features and objects of the present invention will be more fully understood from the following detailed description and the accompanying drawings and its scope will be pointed out in the appended claims.

In the drawings:

FIGURE 1 is a partially cut-away side elevational view of one embodiment of the present invention,

FIGURE 2 is a side elevational, cross-sectional view of the embodiment of FIGURE 1 taken through a section at right angles to the view of FIGURE 1,

FIGURE 3 is a side elevational, partially cross-sectional view of another embodiment of the present invention,

FIGURE 4 is a partially cut-away, side elevational view of the internal mechanism of the embodiment of FIGURE 3,

FIGURE 5 is a side elevational view of yet another embodiment of the present invention,

FIGURE 6 is a cross-sectional view of the internal mechanism of the embodiment of FIGURE 5,

FIGURE 7 is a side elevational view taken at a section at right angles to the view of FIGURE 6,

FIGURE 8 is a cross-sectional view of another embodiment of the present invention,

FIGURE 9 is a cross-sectional view of the embodiment of FIGURE 8 taken through a section at right angles to that of FIGURE 8,

FIGURE 10 is a top elevational view of a particular type of workpiece which has an internal spherical surface generated therein, and,

FIGURE 11 is an end cross-sectional view of the workpiece of FIGURE 10 illustrating the internal spherical surface generated therein.

Referring now to FIGURE 1, there is shown the device of the present invention including a body member illustrated generally at **10** having a shank portion **11** adapted to be received and held by suitable machine means. The other end of the body portion **10** is configured to receive a pivotable cutting tool holder **13**, which in the embodiment of FIGURE 1 is supported between parallel aligned

walls of the body member of the device by means of a pin **14**. A lever system indicated generally at **15** is employed in the embodiment of FIGURE 1 to actuate pivotal movement of the cutting tool holder **13** and such pivotal movement may be effected through a bearing system while the device of the present invention is rotated by suitable machine means. The bearing system as shown in FIGURE 1 comprises an inner portion **16** which is engaged with the body portion of the device so as to rotate with it but permit sliding upward and downward movement along the major axis of the body member **10**. An outer portion **17** is supported by ball bearing means as indicated at **18** and **19** so that the outer portion of the ball bearing **17** is permitted to remain stationary. A slot **20** is cut at an angle in the outside collar **21** of the machine means so as to be adapted to receive therethrough a handle means (not shown) attached to the outer portion **17** of the bearing means so that it may be gradually moved downwardly by the motion of the handle along the slot which performs in the manner of a cam. FIGURE 2 shows an alternative means of controlling the upward and downward movement of the device so as to generate the internal spherical surface.

Referring now to FIGURE 2, there is shown the arrangement of the embodiment of FIGURE 1 and like members bear the same numerical designation as in FIGURE 1. The shank portion **11** of the body member **10** of the device is shown as being received and held in a collet **22**. At the opposite end of the body member **10**, a cutting tool holder **13** is supported in a suitably configured recess in the end of the body member **10** so as to pivotally position a cutting tool **23** received and supported within the cutting tool holder **13**. A lever means shown at **24** is pivoted about a pin support **25** and has an extending pin **26** which engages a slot **27** in the cutting tool holder **13**. Suitable linkage as shown at **28** is connected by a pin means **29** to the lever **24** so as to articulate it. Suitable link means **28** is connected through a pin **30** to the inner race **16** of the ball bearing which is slidingly engaged with the body member **10** so as to be rotatable therewith. The ball bearing means **18** and **19** afford relative motion between the rotatable inner race **16** of the bearing assembly and the stationary outside race **17** of the bearing assembly. Thus, when the device of the present invention is rotated in a high speed machine means, for instance, the pivotal disposition of the cutting tool **23** may be controlled by positioning the stationary outside portion **17** of the bearing assembly through suitable means such as the handle **31** shown as being affixed to the stationary outside portion **17** of the bearing means through the slot **20** previously described as the downwardly sloping cam-like opening in connection with FIGURE 1.

Alternatively, another type of handle means such as that shown generally at **32** may be employed to position the bearing means and thereby articulate the lever connecting linkage to the cutting tool holder and pivotably move the cutting tool **23** so as to generate an internal spherical surface while the device **10** is being rotatably driven by suitable machine means. The handle **32** is pivotably supported by a pin **33** which is fixed to the outside collar **21**. The outside portion of the handle **32** has a manual grip at **34** while the portion of the control handle **32** on the other side of the pivotal axis **33** is formed generally in the shape of a semi-circle surrounding the outside portion **17** of the bearing assembly and having a suitable slot such as shown at **35** on oppositely positioned ends of the semi-circular arm **36**. A pin means **37** carried by the stationary outside portion **17** of the bearing means is engaged in the slot **35** so as to move the bearing means in an upward and downward position as desired in response to the disposition of the manual grip **34** which provides the requisite leverage about the pivotal point **33**. As the bearing means is moved upwardly from the position illustrated in FIGURE 2 by positioning the outside

portion **17** of the bearing assembly upwardly, the lever **24** is pivoted about its pivot point **25** so as to position the pin **26** which it carries to the right of its position as shown in FIGURE 2. Accordingly, the cutting tool **23** is moved to a downward disposition and is movable in accordance with the concept of the present invention so that it may be pivotably disposed through at least 90° from the rotational axis of the device as desired to generate the internal spherical surface in a workpiece by the combination of the cutting tool **23** being rotatably driven and pivotably moved through such an arc. The stationary portion **17** of the bearing assembly of the embodiment shown in FIGURE 2 carries an appropriate stop means **38** threadably received in the outer stationary bearing portion **17** so as to be adjustable and provide a stop means controlling the extreme disposition of such bearing means.

Referring now to FIGURE 3, there is shown a variant embodiment of the present invention. A body member **40** has its lower end **41** configured so as to receive a cutting tool holder **42**. The cutting tool holder **42** supports an appropriate cutting tool **43** and is arranged to be articulated about its pivotal axis **44** by an appropriate gear train means including gears **45**, **46** and **47**. The gear **47** is concentrically affixed to a secondary gear **48** engaged with a rack gear **49** which in turn is engaged with the inner portion **50** of a bearing assembly **51** having a stationary outside portion **52** in the manner previously described in connection with the bearing assembly of FIGURES 1 and 2. As shown in FIGURE 3, the tool **43** may be moved from a straight downward position in continuous pivotal movement to an extreme disposition as indicated by the dash line outline at **43***a*. Accordingly, the embodiment of FIGURE 3 is capable of generating an internal spherical surface such as illustrated at **53**, which it should be noted, has a greater diameter than the diameter of the opening at the plane surface **54** of the workpiece. In other words, the spherical surface **53** is in effect undercut, illustrating one of the features of the present invention which is not afforded by reamers or similar cutting tools known in the prior art and previously employed in generating internal spherical surfaces.

Referring now to FIGURE 4, there is shown a cross-sectional view of the embodiment of FIGURE 3 at a section which is at right angles to that shown in FIGURE 3. In FIGURE 4 like members bear the same numerical designation as in FIGURE 3. As can be readily seen from the illustration in FIGURE 4, the cutting tool holder **42** is supported by appropriate pin means such as that shown at **44** in one end of the body member **40** of the device of the present invention which is configured to receive such cutting tool holder. The cutting tool holder **42** supports therein an appropriate cutting tool **43** for pivotal movement about the pin axis **44** as well as rotational movement in response to the rotationally driven body member **40**. The gear **54** is affixed concentrically to the cutting tool holder **42** and engaged with the gear train comprising gears **45**, **46** and **47**. Gear **47** is concentrically affixed in turn to a gear **48** which is engaged with a rack gear **49** in the general manner described in connection with FIGURE 3. Accordingly, when the rack gear **49** as shown in FIGURE 3 is moved upwardly or downwardly by the bearing means **51**, the gear train comprising the described gears will rotate the bottom gear **54** and therefore pivotably move the cutting tool holder **32** as desired to generate the internal spherical surface.

FIGURE 5 illustrates a further embodiment of the present invention which includes certain additional features as conceived by the present invention. As shown in FIGURE 5, a tool holder means **60** is positioned in the lower end portion of a body member **61** which is configured to receive and support such a cutting tool holder. The cutting tool holder **60** in turn receives and secures a plurality of cutting tools as shown at **62**, **63**, **64** and **65**. The cutting tool holder **60** is pivotable about

the point **66** through suitable pin support means which extends into and is borne by a section **67** of the body member **61**, which in turn is pivotable about a pin member **68** supporting it. An appropriate eccentric means **69** is engaged with the pivotable portion **67** which supports the cutting tool holder **60** and therefore affords limited selective movement of the cutting tool holder **60** to facilitate minor adjustment as may be necessary because of minor misalignment occasioned by slightly off-center collets or other machine means holding and securing the body member **61** at its shank end as was previously described in connection with FIGURES 1 and 2.

The arrangement of FIGURE 5 will be more fully understood from the cross-sectional view of the FIGURE 6 which illustrates its gear train means as well as the eccentrically disposed means affording limited movement of the lower pivotable portion of the device which supports the cutting tool holder **60**. In FIGURE 6 like members bear the same numerical designation as in FIGURE 5. As is shown in FIGURE 6 the cutting tool holder **60** supporting a plurality of cutting tools such as that shown at **65** has affixed thereto a gear **70**. The gear **70** is connected through a gear train comprising gears **71, 72, 73** to an upper gear **74** which in turn is fixedly secured to a concentric gear of larger size **75**. The lower portion **67** of the body member of the present invention is seen to be pivotable about the support **68** and in accordance with the disposition of the eccentric **69**, may be disposed so as to compensate for slight misalignments due to the machine means by which the device is driven. The upper larger gear **75** is arranged to be engaged with a rack gear **76** as illustrated in FIGURE 7.

FIGURE 7 is an internal view of the gear train of the embodiment of FIGURES 5 and 6 and like members bear the same numerical designations as in FIGURES 5 and 6. As may be seen most clearly from FIGURE 7, the rack gear **76** which extends through and communicates externally of the body member **61**, affords a means (such as the bearing assemblies previously described) of actuating the gear train comprising the gears **70, 71, 72, 73, 74** and **75** so as to move the cutting tool holder **60** through a continuous arc of pivotable movement as may be desired. It will be noted that the cutting tool holder **60** illustrated in FIGURES 5 and 6 secures and supports a plurality of cutting tools **62, 63, 64** and **65** which in this instance are disposed at intervals of 90° from each other. It also should be noted that the embodiment illustrated in FIGURES 5 and 6 is so configured as to afford complete 360° movement of the cutting tools about the pivotal axis as defined by the support for the cutting tool holder. Thus the embodiment of the present invention as illustrated in FIGURES 5 and 6 affords the highly desirable advantage of having successive tools disposed in a cutting tool holder so as to be positionable for taking successive cuts in a workpiece thereby generating an internal spherical surface in such workpiece. For instance, the cutting tool **62** may be adjusted in the cutting tool holder **60** so as to take a relatively deep cut, with the cutting tool **65** taking a fine finishing cut to insure an extremely smooth finish and highly precisely dimensioned internal spherical surface.

Further as may be seen in FIGURE 7, the gear train comprising the gears **71, 72,** and **73** may be replaced by equivalent articulation means operatively engaging both gears **70** and **74** so that the cutting tool holder **60** is responsive to movement of the gear **74**. Such equivalent means may take the form of a chain as indicated by the dash line outline **77** shown in FIGURE 7. The chain **77** is disposed to engage both the gears **74** and **70** and is particularly adaptable to embodiments of the present invention which are used to generate internal spherical surfaces of larger diameter such as, for instance, one and one-half inches diameter and more. Those knowledgeable in the art will appreciate, of course, that with smaller tools the limitations imposed by commercially available high-grade chains of small size may make another form of the present invention more desirable for generating the smaller internal spherical surfaces.

The illustrations of FIGURES 8 and 9 similarly illustrate a device which offers the same advantages as the embodiment of FIGURES 5 and 6 in that multiple tools may be secured and held in its tool holder for successive cuts by the device in generating an internal spherical surface. Referring now to FIGURE 8, there is shown a body portion of the device generally indicated at **80** and supporting a tool holder **81** at its lower end. The lower portion of the body member **80** is configured as shown at **82** to afford clearance within the lower portion of the body member **80** for the pivotal movement of a plurality of tools which may be secured in the tool holder **81** as previously described. The tool holder **81** has a pin means **83** secured thereto and extending therefrom into a groove shown by the dotted lines in outline in FIGURE 8. Groove **84** may be more clearly seen from FIGURE 9 wherein like members bear the same numerical designation as in FIGURE 8. As is indicated in FIGURE 8 by the cross-sectional view, a portion **85** of the body member **80** is separate from the remainder of the body portion **80** and fitted thereto. This cap-like, separate portion **85** is illustrated in FIGURE 9 and the groove **84** is seen to define a continuous path from the cutting tool holder **81** and its extending pin **83** at the lower end of the body member **80**, to an upper portion of the body member which supports a gear **86** having a pin **87** extending therefrom into the groove **84**. The groove **84** is configured and dimensioned to receive a plurality of balls **88** which form a ball train from the pin member **87** to complete an operative engagement with the pin member **84**, therefore acting in the manner of a chain to articulate the pin **83** in response to movement of the pin **87** and selectively position the cutting tool holder **81** as may be desired. The gear **86** is positioned by suitable means such as the rack gear and bearing assemblies previously described. The cap-like portion **85** is secured to the lower part of the body member **80** by appropriate cap screw means **89** as shown in FIGURE 8 and the gear **86** is disposed to be engageable with a rack gear or comparable means such as was described previously in connection with the several other embodiments of the invention disclosed and illustrated herein. An eccentric means **90** is supported in the assembly so as to afford limited selective movement of the cap-like member **85** thereby positioning the cutting tool holder **81** which in turn is supported by the pin **91** in the cap-like member **85**. This latter feature is similar to that described previously in connection with the embodiments of FIGURES 5, 6 and 7 and affords a corrective adjustment to compensate for slight misalignment which may be due to minor inaccuracies of machine means in which the device of the present invention is secured to generate an internal spherical surface.

The illustrations of FIGURES 10 and 11 show a type of internal spherical surface which may be advantageously generated by a device embodying the teachings of the present invention. FIGURE 10 illustrates a workpiece which may be known as a rod end of the type which is adapted to receive a ball-like means for articulation between the two in several degrees of movement. Such means are frequently used in mechanical linkage for control instrumentation, for instance. The work piece **95** is shown to have an end **96** which is circular and connected with a rod like portion **97** (partly shown). The circular rod end has an aperture therein **97** and as indicated by the dotted lines **98** the internal spherical surface has a larger diameter internally than at the planar surface as shown at **97**. This may perhaps be more clearly seen in FIGURE 11 wherein like members bear the same numerical designation as in FIGURE 10.

As may be clearly seen from FIGURE 11, the cross-sectional view shows that the spherical surface generated internally in the circular end **96** of the member **95** has a smaller diameter **97** at the outer planar surfaces of the circular rod end **96** than at or near the center portion of the internal spherical surface as indicated generally at **98**. It will be evident to those skilled in the art that a cherry reamer or similar tool could not, because of its inherent limitations, generate a surface such as that illustrated in FIGURE 11. Thus the device of the present invention affords the generation of an internal spherical surface which is undercut in the sense that it has an internal diameter larger than the diameter of the aperture through which the device must operate to generate the internal spherical surface.

Since many changes could be made in the above-described construction and many apparently different embodiments could be made without departing from the scope or spirit thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, I claim:

1. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support at least one cutting tool exending therefrom; means pivotably supporting said cutting tool holder at said second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device; a cutting tool adjustably supported on said cutting tool holder and having its cutting portion on the outer radial edge thereof; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder about said pivotal axis fixed with respect to said major axis of said body member during and independently of rotation of the device and the workpiece relative to each other.

2. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support at least one cutting tool extending therefrom; means pivotably supporting said cutting tool holder at said second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device; lever means carried by said body member, said lever means being movable through an arc of movement having at least a portion common with the pivotal arc of movement of said cutting tool holder and being operatively connected for translating motion to each other through said common arcs of movement; and bearing means linked with said lever for coaxial sliding movement along the major axis of said body member, and having a non-rotational external portion for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

3. A rotatable device for generating an internal spherical surface in a workpiece comprising; a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support at least one cutting tool extending therefrom; means pivotably supporting said cutting tool holder at said second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device; gear train means carried by said device and having one end operatively connected with said cutting tool holder; a rack gear connected to rotationally position the other end of said gear train; and bearing means connected with said rack gear for coaxial sliding movement along the major axis of said body member and having a non-rotational external portion for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

4. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a pivoted portion at its second end supported on said body member for independent movement about an axis normal to the major axis of said body member; eccentric means supported on said body member and engaged with said pivoted portion for selectively positioning said pivoted portion about its pivot axis; a cutting tool holder adapted to adjustably support at least one cutting tool extending therefrom; means pivotally supporting said cutting tool holder on said pivoted portion, said supporting means having a pivot axis parallel to the pivot axis of said pivoted member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

5. A device as claimed in claim **4** wherein said last-named means comprises a ball train movably supported within said device and engaged with means rotationally fixed to said cutting tool holder and operatively responsive to means for movably displacing said ball train.

6. A rotatable device for generating an internal spherical surface in a workpiece comprising a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a pivoted portion at its second end supported on said body member for independent movement about an axis normal to the major axis of said body member; eccentric means supported on said body member and engaged with said pivoted portion for selectively positioning said pivoted portion about its pivot axis; a cutting tool holder adapted to adjustably support at least one cutting tool extending therefrom; means pivotally supporting said cutting tool holder on said pivoted portion, said supporting means having a pivot axis parallel to the pivot axis of said pivoted member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device; a first gear connected with said cutting tool holder and supported for pivotal movement therewith, a second gear supported for rotational movement relative to said body member; means movably supported relative to said body member and extending externally thereof, said means being engaged with said second gear for rotatably positioning said second gear; and means operatively transmitting the rotation of said second gear to said first gear, whereby said externally extending means controllably pivots said cutting tool holder.

7. A rotatable device for generating an internal spherical surface in a workpiece comprising a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a pivoted portion at its second end supported on said

body member for independent movement about an axis normal to the major axis of said body member; eccentric means supported on said body member and engaged with said pivoted portion for selectively positioning said pivoted portion about its pivot axis; a cutting tool holder adapted to adjustably support at least one cutting tool extending therefrom; means pivotally supporting said cutting tool holder on said pivoted portion; said supporting means having a pivot axis parallel to the pivot axis of said pivoted member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device; a first gear connected with said cutting tool holder and supported for pivotal movement therewith; a second gear supported for rotational movement relative to said body member; means movably supported relative to said body member and extending externally thereof, said means being engaged with said second gear for rotatably positioning said second gear; a third gear connected with said second gear for concentric rotation therewith; and means connecting said second gear with said first gear, whereby said externally extending means controllably pivots said cutting tool holder.

8. A device as claimed in claim 7 wherein said means connecting said second gear with said first gear comprises a gear train supported and engaged therebetween.

9. A device as claimed in claim 7 wherein said means connecting said second gear with said first gear comprises a chain means engaged therebetween.

10. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means, and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support a plurality of cutting tools; a plurality of cutting tools extending from said cutting tool holder in graduated increments; means pivotally supporting said cutting tool holder at said second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said cutting tool holder through at least 90° from the rotational axis of said device for each of said plurality of cutting tools; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

11. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means, and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support a plurality of cutting tools; two cutting tools supported in said cutting tool holder and extending therefrom at substantially right angles to each other; means pivotally supporting said cutting tool holder at the second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said tool holder through at least 180° from the rotational axis of said device; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

12. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means, and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support a plurality of cutting tools; three cutting tools supported in said cutting tool holder and extending therefrom substantially at right angular radial displacement; means pivotally supporting said cutting tool holder at the second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said tool holder through at least 270° from the rotational axis of said device; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

13. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means, and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support a plurality of cutting tools; four cutting tools supported in said cutting tool holder and extending therefrom substantially at right angular radial displacement; means pivotally supporting said cutting tool holder at the second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said tool holder through at least 360°; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder during rotation of the device and the workpiece relative to each other.

14. A process for generating an internal spherical cavity in a workpiece comprising: rotating a body member about an axis relative to a workpiece, said body member having a cutting tool pivotable relative thereto and is in contact with said workpiece; simultaneously pivoting said cutting tool about an axis normal to said axis of rotation of said body member independently of and during said rotation of said body member; and continuing said simultaneous rotation and pivoting of said body member and cutting tool to produce an internal cavity of generally spherical configuration in said workpiece, said cutting tool during said simultaneous pivoting passing through said major axis of rotation of said body member.

15. The process of claim 14 wherein said pivoting of said cutting tool is about an axis below the surface of said workpiece.

16. The process of claim 14 wherein said body member is rotated through at least 360°, and said cutting tool is pivoted through at least 90°.

17. The process of claim 14 wherein said cutting tool is pivoted through at least 180° to produce an internal spherical cavity in the workpiece having a greater internal diameter than the diameter at the surface of the workpiece.

18. A process for generating an internal spherical cavity in a workpiece having a void therein comprising: inserting a portion of a body member in a void in a workpiece; rotating said body member about an axis relative to said workpiece, said body member having a cutting tool pivotable relative thereto and in contact with said workpiece; simultaneously pivoting said cutting tool about an axis normal to said axis of rotation of said body member independently of and during said rotation of said body member and within said void below the surface of said workpiece; and continuing said simultaneous rotation and pivoting of said body member and cutting tool to produce an internal cavity of generally spherical configuration in said workpiece having a greater internal diameter than the diameter at the surface of said workpiece, said cutting tool during said simultaneous pivoting passing through said major axis of rotation of said body member.

19. A process for generating an internal spherical cavity in a workpiece having a void therein comprising: inserting a portion of a body member in a void in a workpiece; rotating said body member about an axis relative to said workpiece, said body member having a first and second spaced apart cutting tool pivotable rela-

tive thereto with one of said cutting tools in contact with said workpiece; simultaneously pivoting said cutting tools about an axis normal to said axis of rotation of said body member with said first cutting tool in contact with said workpiece and taking a relatively deep cut therefrom; continuing said simultaneous rotation and pivoting of said body member and said cutting tools with said first cutting tool in contact with said workpiece to produce an internal cavity of generally spherical configuration in said workpiece; and then continuing said simultaneous rotation and pivoting of said body member and said cutting tools with said second cutting tool in contact with said workpiece to produce a second cut.

20. A process for generating an internal spherical cavity in a workpiece comprising: rotating a body member about an axis relative to a workpiece, said body member having two spaced apart cutting tools pivotable relative thereto and in contact with said workpiece; simultaneously pivoting said cutting tools in the same direction about an axis normal to said axis of rotation of said body member independently of and during said rotation of said body member; and continuing said simultaneous rotation and pivoting of said body member and cutting tool to produce an internal cavity of generally spherical configuration in said workpiece, at least one of said cutting tools during said simultaneous pivoting passing through said major axis of rotation of said body member.

21. A rotatable device for generating an internal spherical surface in a workpiece comprising: a body member, said body member having a shank portion at a first end adapted to be received and held by machine means and a second end configured to receive a pivotable cutting tool holder; a cutting tool holder adapted to adjustably support at least one cutting tool extending therefrom;

means pivotably supporting said cutting tool holder at said second end of said body member, said supporting means having a pivot axis normal to the major axis of said body member for continuous pivotal movement of said cutting tool holder through at least 90 degrees from the rotational axis of said device; a cutting tool adjustably supported on said cutting tool holder and having its cutting portion on the outer radial edge thereof; and means carried by said device and operatively connected with said cutting tool holder for controllably pivoting said cutting tool holder about said pivotal axis fixed with respect to said major axis of said body member during and independently of rotation of the device and the workpiece relative to each other, said means including a ball train movably supported within said device and operatively connected with said cutting tool holder for controllably pivoting said tool holder during rotation of the device and the workpiece relative to each other.

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