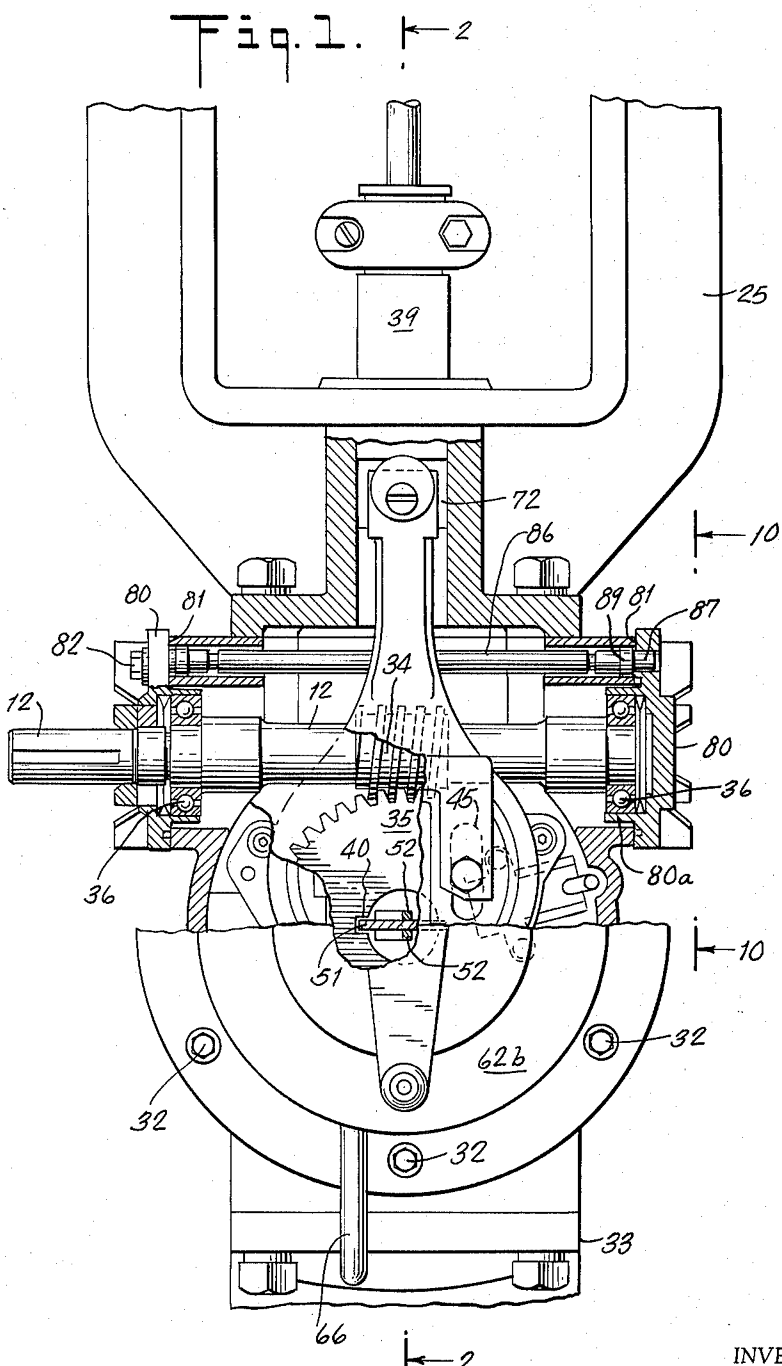
March 22, 1966 G. M. BOOTH 3,241,386

ARRANGEMENT FOR POSITIONING A ROTATABLE DRIVING ELEMENT RELATIVE TO A DRIVEN GEAR

Original Filed July 8, 1960

4 Sheets-Sheet 1

Fig. 1.

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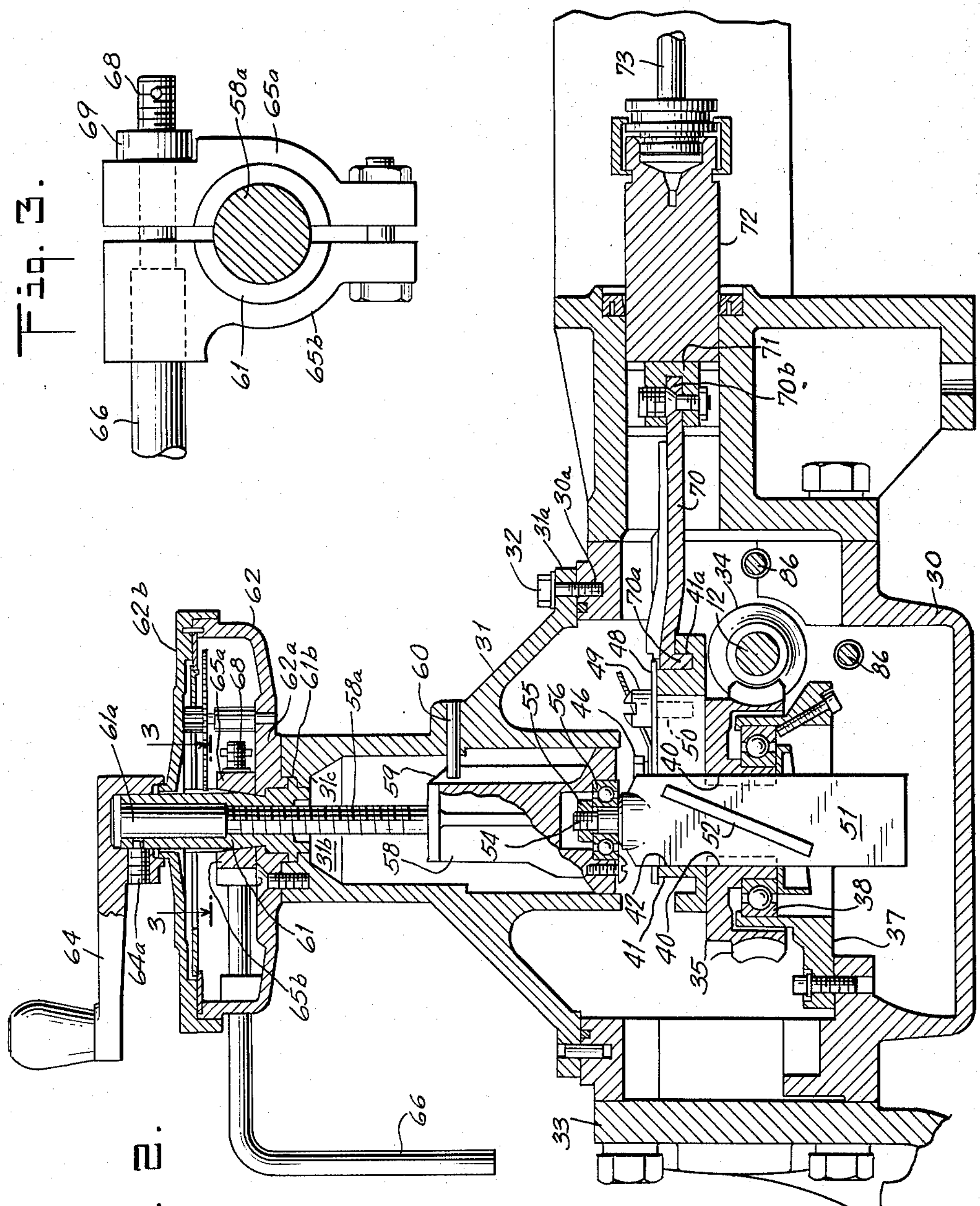

Fig. 3.

Fig. 2.

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Fig. 4.

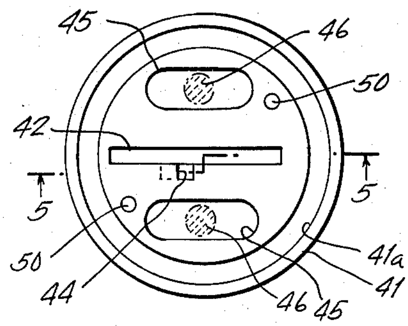


Fig. 5.

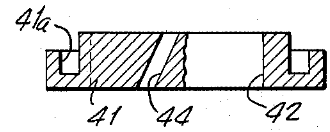


Fig. 6.

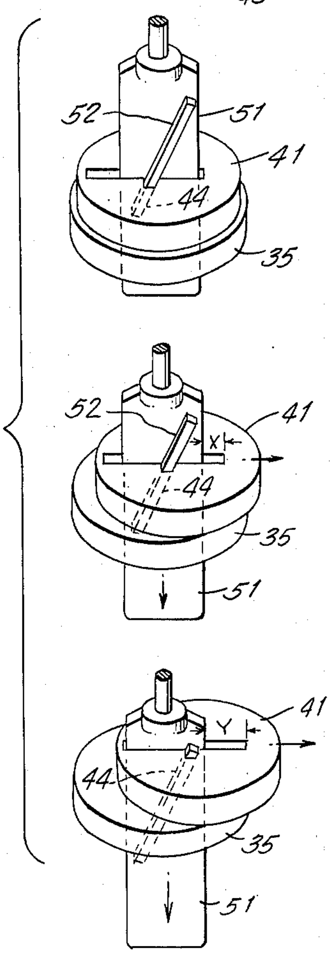


Fig. 7.

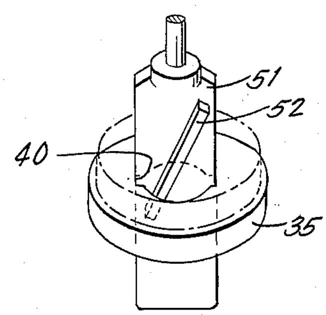


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Fig. 8.

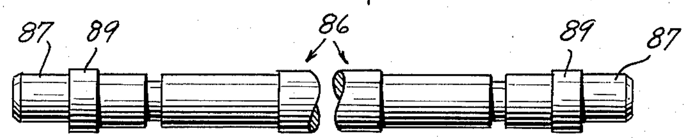



Fig. 9.

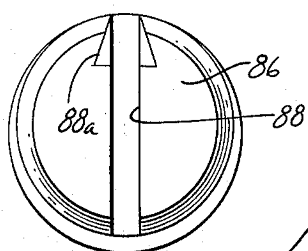
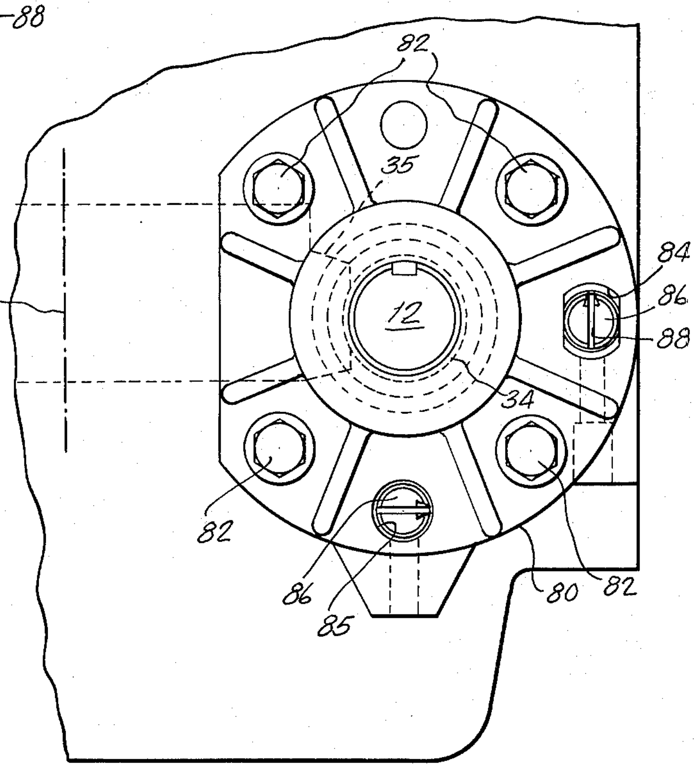



Fig. 10.

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3,241,386

# ARRANGEMENT FOR POSITIONING A ROTATABLE DRIVING ELEMENT RELATIVE TO A DRIVEN GEAR

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Original application July 8, 1960, Ser. No. 41,525, now Patent No. 3,106,105, dated Oct. 8, 1963. Divided and this application Oct. 7, 1963, Ser. No. 314,280
4 Claims. (Cl. 74—396)

This application is a division of my copending application Serial No. 41,525 filed July 8, 1960, now U.S. Patent 3,106,105, granted October 8, 1963.

This invention relates to an adjustable reciprocating stroke device. More particularly, this invention relates to an adjustable eccentric or an adjustable reciprocating stroke device capable of substantially infinite adjustment, such as from zero to a given maximum eccentricity. In accordance with one particular embodiment, this invention relates to a positive displacement plunger-type pump employing an adjustable eccentric or adjustable reciprocating stroke device of this invention.

Adjustable eccentrics or adjustable reciprocating stroke devices are well known and have been employed for many purposes. Frequently, however, such devices are not structurally rugged but are mechanically complex and require constant maintenance and attention for satisfactory operation.

It is an object of this invention to provide a simple, rugged, substantially trouble-free adjustable eccentric or adjustable reciprocating stroke device.

It is another object of this invention to provide an adjustable eccentric affording substantially infinite adjustment between zero and a given maximum eccentricity.

It is another object of this invention to provide a positive displacement plunger-type pump employing an adjustable eccentric in accordance with this invention.

Still another object of this invention is to provide an improved positive displacement plunger-type piston pump capable of substantially infinite adjustment in output from zero to a given maximum.

Still another object of this invention is to provide a positive displacement, reciprocating, plunger-type pump, the output of which is capable of variation during operation from zero to a given maximum.

How these and other objects of this invention are achieved will become apparent in the light of the accompanying disclosure made with reference to the accompanying drawings wherein:

FIG. 1 is a plan view in partial cross-section of the adjustable eccentric or adjustable reciprocating stroke device of this invention as disposed in simplex pump arrangement to operate a positive displacement plunger-type pump;

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a partial cross-sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a plan view of an eccentric bearing, an element of the adjustable eccentric of this invention;

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 2;

FIG. 6 shows perspective views of elements of the adjustable eccentric of this invention and illustrating the principle and operation of this invention;

FIG. 7 is a perspective view of an assembly of elements, adjusting blade and worm gear, and eccentric bearing in dashed outline, further illustrative of this invention;

FIG. 8 is a plan view of a worm-worm gear adjusting element employed in accordance with one feature of this invention;



FIG. 9 is an end view of the adjusting element of FIG. 8; and

FIG. 10 is a partial side elevation view of the adjustable eccentric device of this invention.

In accordance with this invention an adjustable eccentric or adjustable reciprocating stroke device is provided in an apparatus comprising a shaft mounted for rotation, a worm fixed to and carried on said shaft, a worm gear meshed with said worm and adapted to be rotated by said worm as said shaft is rotated, an eccentric bearing or plate in contact with and slidably positioned on said worm gear, a blade positioned axially within said worm gear keyed within an opening extending therethrough for axial movement therethrough, said blade extending through an opening provided in said plate for movement therethrough, a key integral with said blade and diagonally positioned on one side or face thereof, said key being positioned within a keyway provided in the opening of said bearing or plate and adapted to slidably move said bearing or plate relative to said worm gear as said blade is moved through said worm gear and said bearing or plate, and means for moving said blade through said worm gear and said bearing or plate. Means are provided in accordance with this invention for adjusting the center distance between a driving means, such as the aforesaid worm, and a driven gear, such as the aforesaid worm gear, and for adjusting the center of the driving means, such as the center of the worm, in relation to the center of the face of the driven gear, such as the worm gear.

Referring now to FIGS. 1, 2 and 3 of the drawings which illustrate an embodiment of this invention wherein the adjustable eccentric is employed in simplex pump arrangement, the adjustable eccentric or adjustable reciprocating stroke device of this invention is positioned within housing **30** which is provided with a side cover plate 33 and fitted with upper housing cover **31** fastened to housing **30** by screws **32** passing through flange ***31a*** of cover **31** into tapped holes ***30a*** provided in the upper side of housing **30** as illustrated.

Shaft **12**, driven by an electric motor, not shown, extends through housing **30** and has fixed thereto and carries for rotation therewith worm **34**. Worm **34** is positioned within housing **30** with respect to and meshed with worm gear **35** so that as shaft **12** rotates and carries with it worm **34**, worm gear **35** is rotated about its own center axis. Shaft **12** is fixed and mounted for rotation within ball bearings **36** which are supported by and mounted within bearing caps **80** fastened to housing **30** and worm gear **35** is journaled in ball bearing **38** fixed and supported by holding ring **37** fastened to the inside of and within the lower portion of housing **30**. Worm gear **35** is provided with an opening extending therethrough providing keyways **40** within worm gear **35**.

Eccentric bearing or plate **41**, shown in greater detail in FIGS. 4 and 5, is slidably positioned on top of worm gear **35** and in contact with the upper surface thereof. As indicated in FIGS. 4 and 5 eccentric bearing **41** is provided with an opening **42** extending therethrough, opening **42** being substantially rectangular in cross-section and carrying on one face or side thereof sloping keyway **44**. Eccentric bearing **41** is also provided with two elongated slots **45** extending therethrough within which are positioned a pair of screws **46** which also pass through plate **48** and engage cooperating tapped holes in worm gear **35**, screws **46** passing through slots **45** in eccentric bearing **41**. Plate **48** is mounted in contact with and adjacent the upper surface of eccentric bearing **41** and is fastened and fixed to eccentric bearing **41** by means of screws **49** which engage tapped holes **50** provided within eccentric bearing **41**. The diameter of plate **48** is such that it overlays annular groove or flange portion **41**_a_ of eccentric bearing **41**.

Referring now in detail to FIG. 2 of the drawings, adjusting blade **51** is positioned within the keyway **40** and opening **42** of worm gear **35** and eccentric bearing **41**, respectively, and an opening through plate **48**. Adjusting blade **51** is substantially rectangular in cross-section and is provided on one side or surface thereof with sloping key **52**. The sides or edges of adjusting blade **51** are fitted snugly within keyways **40** of worm gear **35** and within opening **42** of eccentric bearing **41**. Also, sloping keys **52** of adjusting blade **51**, fits snuggly within sloping keyway **44** of eccentric bearing **41**. Accordingly, the arrangement of adjusting blade **51** within keyways **40** of worm gear **35** and opening **42** and keyway **44** of eccentric bearing **41** can be looked upon as the equivalent of a spline connection inasmuch as adjusting blade **51**, although adapted and positioned to be rotated by worm gear **35** in a manner described hereinbelow, is at the same time axially adjustable through worm gear **35** and through eccentric bearing **41** and retaining plate **48** which is fixed to and moves with eccentric bearing **41**.

The upper end of adjusting blade **51** is tapered to form threaded shaft portion **54** and is affixed by cooperating nut **55** to be journaled within ball bearing **56** fastened to the lower end of adjusting member **58**. Adjusting member **58** extends downwardly through a substantially cylindrical opening **31**_b_ provided within the central portion of housing cover **31** and is provided at its lower portion with keyway **59**. Adjusting member **58** is prevented from turning by pin **60** which extends through an opening provided within the upper portion of housing cover **31** into keyway **59**.

Adjusting member **58** at the upper portion thereof is formed into threaded shaft **58**_a_, the upper end of which is threadedly engaged in nut **61** which contains a hollow portion **61**_a_ to receive the upper threaded portion **58**_a_ of adjusting member **58** as nut **61** is turned to move adjusting member **58** upwardly thereinto. Nut **61** is restrained from axial movement by flange **61**_b_ which lies between shoulder **31**_c_ at the upper end of housing cover **31** and projecting flange **62**_a_ of lower dial housing **62** which is fitted to and closed with upper dial housing cover **62**_b_. Handle **64** is fixed by a set screw **64**_a_ to the upper end of nut **61** so that upon turning handle **64**, nut **61** is rotated thereby effecting axial movement of adjusting member **58** and axially positioning adjusting blade **51** as desired. Also associated with nut **61** are split clamping parts **65**_a_ and **65**_b_. Clamping parts **65**_a_ and **65**_b_ are forced together by turning handle **66**, the other end of handle **66** being threaded engaged to screw **68** which, in cooperation with nut **69**, serves to force clamping pieces **65**_a_ and **65**_b_ against nut **61** to prevent its rotation and thereby fix the position of adjusting member **58** and associated adjusting blade **51** once a setting has been made by turning handle **64**.

As illustrated in the drawings, particularly FIG. 2, eccentric bearing **41** is provided with a peripheral, annular slot or groove **41**_a_ into which the downwardly flanged arcuate ends **70**_a_ of connecting rod **70** is fitted and positioned. The arcuate end of connecting rod **70** is maintained within annular groove **41**_a_ of eccentric bearing **41** by overhanging plate **48**. The other end **70**_b_ of connecting rod **70** is fastened to wrist pin **71** which engages cross head **72** which, in turn, is fastened to operating plunger **73**. Thus, reciprocating motion is brought out of the adjustable eccentric or adjustable reciprocating stroke device of this invention and, as disclosed herein, various sizes and types of plungers **73** can be employed for reciprocation within cylinders of the various types of liquid ends of pumps, feeders or similar apparatus.

Referring now to FIG. 6 of the drawings wherein perspective views of elements of the adjustable eccentric of this invention schematically illustrate the principle and operation of the adjustable eccentric described herein, the upper view shows the arrangement of worm gear **35**, eccentric bearing **41** and adjusting blade **51** and its key **52** all positioned and arranged (blade **51**, worm gear **35** and eccentric bearing **41** being coaxial) for zero eccentricity. As adjusting blade **51** is moved downwardly, such as to the position illustrated in the middle view of FIG. 6 the sloping key **52** forces eccentric bearing **41** to the right, a distance X, as indicated on the drawing, thereby providing a stroke length of 2X. As blade **51** is moved further downwardly within worm gear **35**, such as to the position illustrated in the bottom view of FIG. 10, eccentric bearing **41** is moved to the right a maximum distance or eccentricity Y, there by providing a stroke length of 2Y.



FIG. 7 of the drawings is further explanatory of the invention and shows the disposition of adjusting blade **51** within worm gear **35** and keyways **40**.

In actual practice only one or two thousandths of an inch clearance is provided between the side edges of adjusting blade **51** and the keyways, particularly the bottoms of keyways **40** in worm gear **35**. Adjusting blade **51** is restrained from radial motion within worm gear **35** and eccentric bearing **41** in any and every direction regardless of radial load. It is also pointed out that the width of opening or slot **42** extending through eccentric bearing **41** is held very closely to the thickness of blade **51** with the result that eccentric bearing **41** is rotated exactly in accordance with worm gear **35** and supports the eccentric bearing **41** against radial loads at right angles to the length of the slot. Sloping key **52** on adjusting blade **51** is likewise a good fit in keyway **44** of eccentric bearing **41**.

In the operation of the adjustable eccentric or adjustable reciprocating stroke device of this invention an infinite number of eccentricities from zero eccentricity to a given maximum eccentricity is available upon turning handle **64**. In the operation of the device of this invention a desired eccentricity or reciprocating stroke length from zero to a given maximum is obtainable by turning handle **64** so as to move adjusting blade **51** downwardly or upwardly within worm gear **35** and eccentric bearing **41**. Handle **64** can be turned and blade **51** moved while shaft **12** is rotating and carrying with it worm **34** which, in turn, meshes with and drives worm gear **35** which, in turn, causes adjusting blade **51** and eccentric bearing **41** and plate **48** also to be driven or rotated. As handle **64** is turned adjusting blade **51** is moved downwardly or upwardly to the desired position for the desired degree of eccentricity. As adjusting blade **51** is moved downwardly or upwardly within worm gear **35** eccentric bearing **41** is caused to move across the upper face of worm gear **35** responsive to the movement of key **52** within keyway **44** of eccentric bearing **41**.

It is pointed out that one of the advantages of the adjustable eccentric of this invention is that relatively high strength is provided with relatively light parts and therefore a minimum of distortion occurs. This advantage is derivable from the fact that the stresses in the several parts or elements of the adjustable eccentric are shear forces rather than bending forces. More particularly, a radial load at right angles to opening or slot **42** of eccentric bearing **41** is carried in shear in adjusting blade **51** at the plane defined by the junction of the upper surface of worm gear **35** with the lower surface of eccentric bearing **41**. In all other directions the radial loads are carried partially by adjusting blade **51** in this plane and partially by shear force on key **52** and the edges of adjusting blade **51** in keyways **40** of the worm gear.

As a special feature of this invention means are provided for readily adjusting the center distance between worm **34** and worm gear **35** as well as for adjusting the center of worm **34** in relation to the center of the concave worm face or the center of curvature of the concave worm face of worm gear **35**. Many apparatus, such as the positive displacement plunger-type pumps connected to and operated by the adjustable eccentric device of this invention, require some sort of speed reducer between the prime mover, such as an electric motor, and the driven output element, in the instance of this invention, connecting rod **70**. If the speed reducer, in the instance of this invention the combination of elements shaft **12**, worm **34** and worm gear **35**, has much play in its gearing a more or less violent knock occurs at the time of load reversal. Normal manufacturing tolerances on parts can result in a variation in backlash from a minimum which is required for an oil film to a maximum which results in an objectionable knock.

With respect to this feature of the invention particular reference is made to FIGS. 1, 2 and 8–10 of the drawings. As illustrated therein shaft **12** is carried for rotation within ball bearings **36** which are mounted in bearing caps **80**. Bearing caps **80** are fastened to housing **30** on machined faces **81** and have their skirts **80***a* projecting into clearance holes in housing **30**, the clearance being sufficient to be able to slide the bearing caps around for the maximum desired adjustment. The bearing caps **80** are fastened to housing **30** by four screws **82** through clearance holes in the cap itself. Each of the two caps has a vertical slot **84** and a round hole **85**.

Two shafts **86** are disposed within housing **30** extending between corresponding slots **84** and holes **85** of bearing caps **80**. Shafts **86** have off-center cylindrical ends **87** and screw driver grooves **88** with punched arrow markings **88***a* at each end. Cylindrical portions **89** of each shaft **86** within housing **30** engage cylindrical holes adjacent to faces **81** and the off-center cylindrical ends **87** engage the round holes **85** or the slots **84** of bearing caps **80**. With screws **82** slightly loose adjustment of the center distance between the worm **34** and worm gear **35** is accomplished by rotation of shaft **86** in slots **84**, such as by means turning a screw driver inserted in groove **88**. As the off-center portion **87** of shaft **86** in slots **84** is rotated the bearing cap **80** rotates about the center of hole **85** thus moving bearing cap **80** either to the right or to the left as seen in FIG. 10. Similarly, rotation of the other eccentric shaft **86** within round holes **85** serves to raise or lower bearing cap **80** in order to adjust the elevation of worm **34** to mesh properly in the concave gear face of worm gear **35**. Inasmuch as eccentric rods **86** engage bearing caps **80** on both sides of housing **30** both bearing caps **80** are simultaneously adjusted in like direction and to like extent. Hence, by one adjustment the worm is moved toward or away from the worm gear, i.e., the centerline distance between the worm and worm gear adjusted, and by the other adjustment the worm is moved essentially vertically, i.e., the center of the concave worm face of the worm gear or center of curvature of worm gear face is adjusted relative to the center or centerline of the worm, so that a desired closeness and accuracy of mating of the worm and worm gear are readily achieved and objectionable backlash can be obviated.

Although the invention has been illustrated by embodiments utilizing a worm and worm gear in a reciproaction mechanism, the invention is not limited to such arrangements but may include gear mechanisms for other purposes and utilizing other gear types than worms and worm gears, wherein it is desired to eliminate meshing backlash in spite of manufacturing variations and tooth wear.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many modifications, substitutions and alterations are possible in the practice of this invention without departing from the spirit or scope thereof.

I claim:

**1**. Apparatus comprising a shaft mounted for rotation, means for rotating said shaft, a worm fixed on said shaft and adapted to be rotated therewith, a circular worm gear meshed with said worm and adapted to be rotated by said worm as said shaft is rotated, a circular bearing plate in contact with and slidably positioned on top of said worm gear, said bearing plate being provided with a peripheral annular slot in the upper face thereof, a retaining plate fixed to the top of said bearing plate, the periphery of said retaining plate extending beyond the inner edge of said slot of said bearing plate, a blade positioned axially with said worm gear keyed within an opening extending therethrough, adapted for vertical movement therein and extending through an opening provided within said bearing plate and said retaining plate, a key integral with said blade and diagonally positioned across one face thereof, said key being positioned within a keyway provided in the opening within said bearing plate and adapted to slidably move said bearing plate together with said retaining plate, relative to the top of said worm gear as said blade is moved vertically through said worm gear and said bearing and retaining plates, a connecting rod having one end slidably fitted within the annular slot of said bearing plate, said retaining plate being positioned above the end of said connecting rod in said slot, said end of said connecting rod being disposed within said slot for sliding movement therein whereby any eccentricity between said worm gear and said bearing plate upon rotation of said worm gear and said bearing plate imparts a translational to-and-fro movement to said connecting rod, means for moving said blade vertically through said worm gear and said bearing and eccentric plate and means for adjusting the centerline distance between said worm and said worm gear and between the centerline of said worm and the center of the worm face of said worm gear.

**2**. Apparatus in accordance with claim **1** wherein said means for adjusting the centerline distance between said worm and said worm gear and between the centerline of said worm and the center of the worm face of said worm gear comprises means for independently, vertically and laterally positioning said shaft carrying said worm relative to said worm gear.

**3**. Power-transmitting gear apparatus, comprising: a housing frame; a first gear rotatably supported by said frame and rotatable about an axis fixed with reference to said frame; second gear means in meshing relationship with said first gear; a shaft carrying said second gear means; two bearings spaced along said shaft for rotatably supporting the shaft; and means for adjustably supporting said bearings on said frame to permit adjustment of the meshing relationship between said second gear means and said first gear, including means pivotally attaching each of said bearings to said frame about a common pivotal axis parallel to said shaft, said pivotal axis lying in a plane which passes through the rotational axis of said shaft and which is approximately perpendicular to a reference plane defined by said rotational axis and by the shortest line between said rotational axis and the center of rotation of said first gear, a rod member journaled in said frame also parallel to said shaft and having two similarly off-center cylindrical portions individually engaging the side walls of slots oriented similarly in each of said bearings, means for effecting rotational adjustments of said rod member to cause identical pivotal displacements of both of said bearings with corresponding displacements of said shaft in directions approximately within said reference plane, and means for locking said bearings with respect to said frame to preserve the adjusted positions of said bearings and shaft.

**4**. Power-transmitting gear apparatus, comprising: a housing frame; a worm gear rotatably supported by said frame and rotatable about an axis fixed with reference to said frame; a worm in meshing relationship with said worm gear; a shaft carrying said worm; two bearings spaced along said shaft for rotatably supporting the shaft; and means for adjustably supporting said bearings on said frame to permit adjustment of the meshing relationship between said worm and said worm gear, including two rod members each journaled in said frame parallel to said shaft, one of said rod members lying approximately in a reference plane defined by the rotational axis of said shaft and by the shortest line between said rotational axis and the center of rotation of said worm gear, said one rod member having two similarly off-center cylindrical portions individually engaging the side walls of slots similarly oriented vertically in each of said bearings, the other of said rod members lying in a plane passing through said rotational axis of said shaft approximately perpendicular to said reference plane, said other rod member having two similarly off-center cylindrical portions individually engaging the walls of cylindrical holes oriented similarly in each of said bearings, means for effecting rotational adjustments of said one and said other rod members to cause identical displacements of both of said bearings with corresponding displacements of said shaft to effect adjustments respectively of the center distance between said worm and said worm gear and of the center of said worm relative to the face of said worm gear, and means for locking said bearings with respect to said frame to preserve the adjusted positions of said bearings and shaft.

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DON A. WAITE, *Primary Examiner.*