Feb. 15, 1966 H. F. VON THUENGEN 3,234,816

ADJUSTMENT MECHANISM

Filed Nov. 13, 1962 5 Sheets-Sheet 1

Fig. 1a

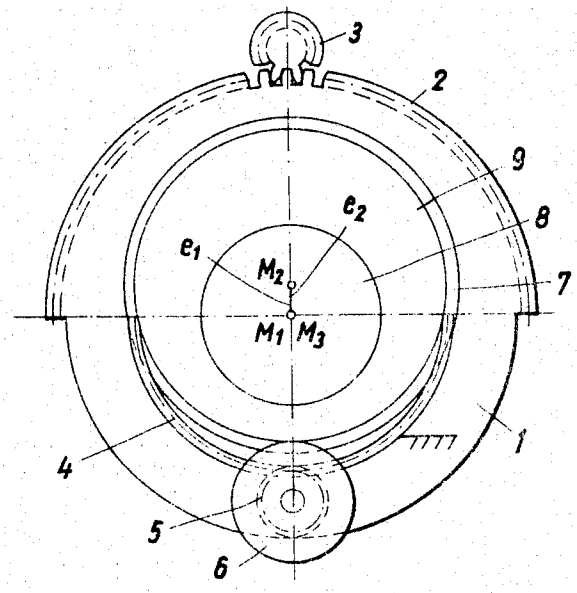
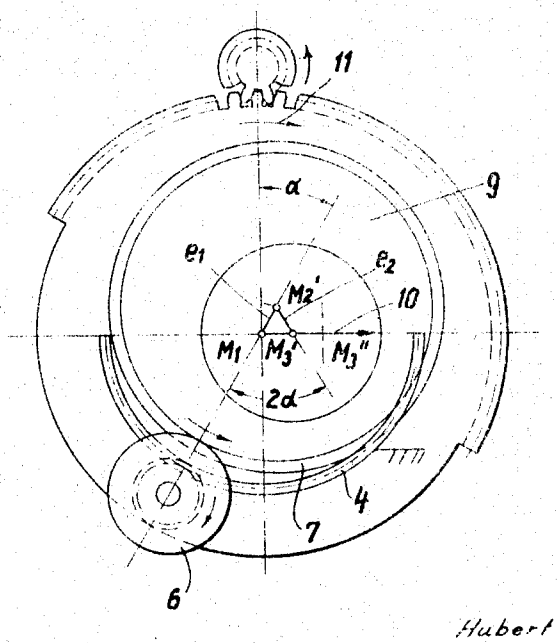


Fig. 1b



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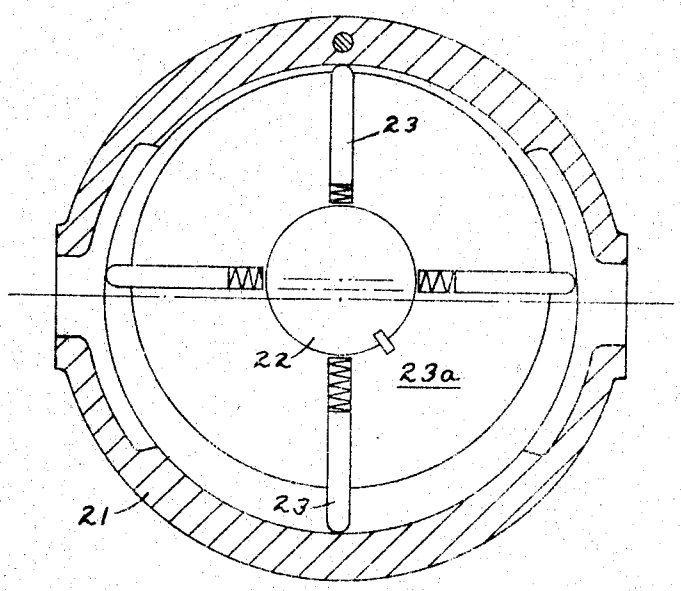


Fig. 3a

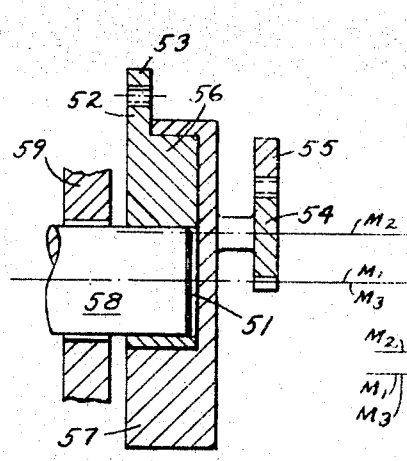


Fig. 5d

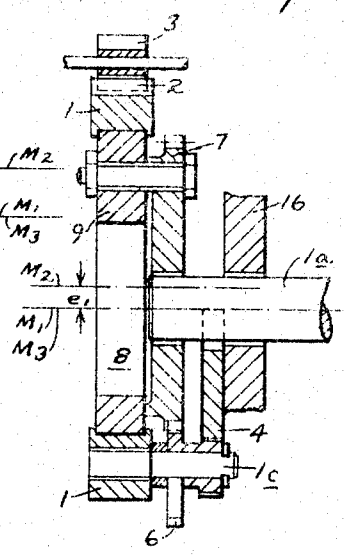


Fig. 1c

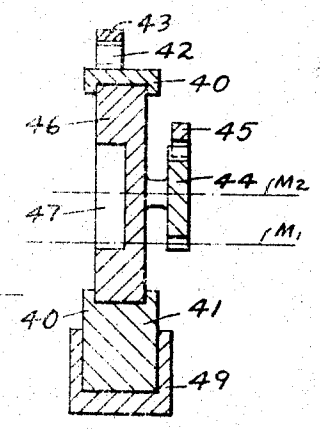


Fig. 4d

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Fig. 2

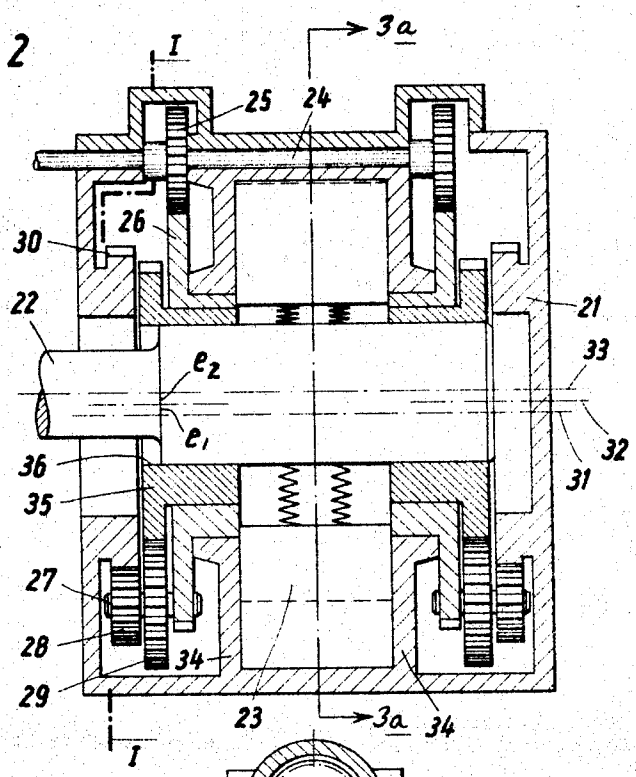
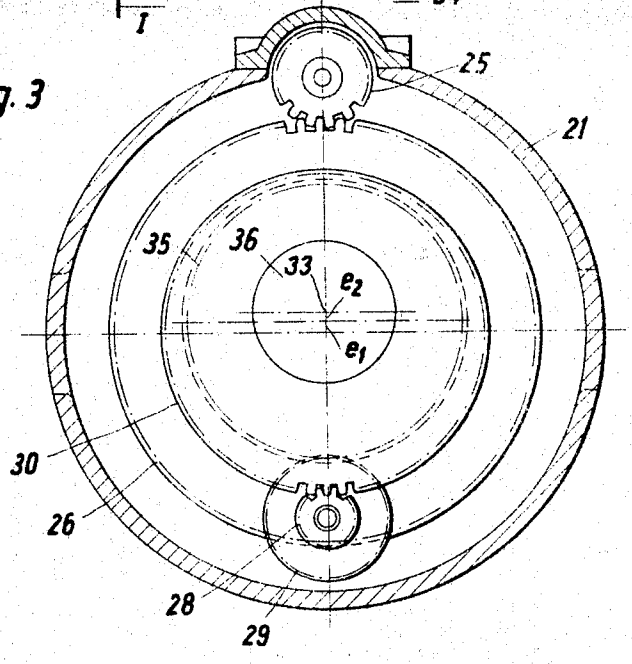


Fig. 3



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Fig. 4a

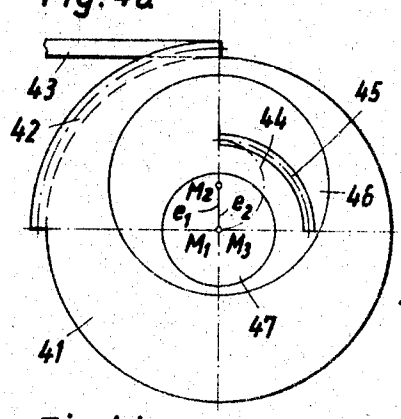


Fig. 5a

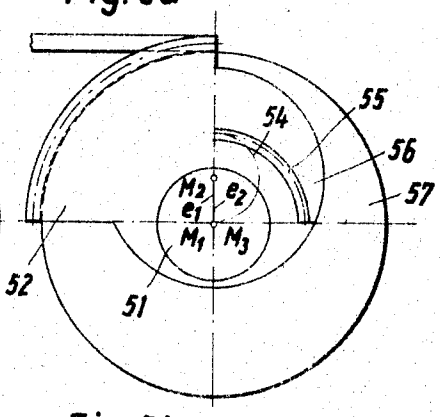


Fig. 4b

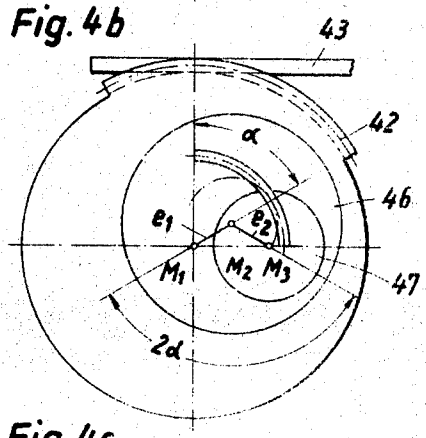


Fig. 5b

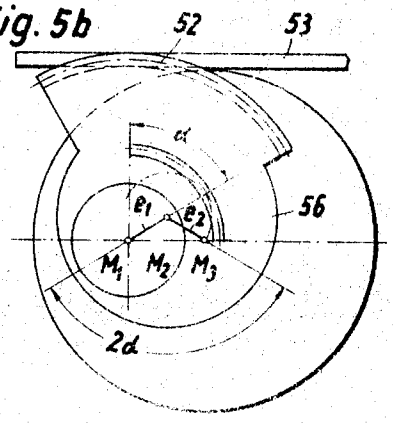


Fig. 4c

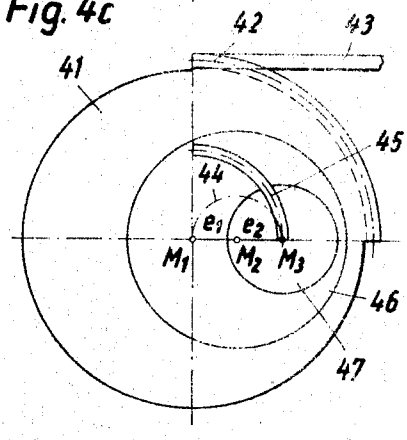
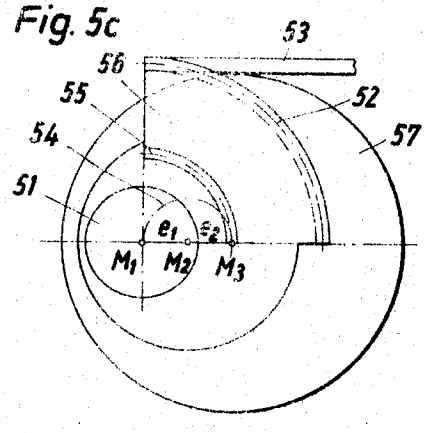
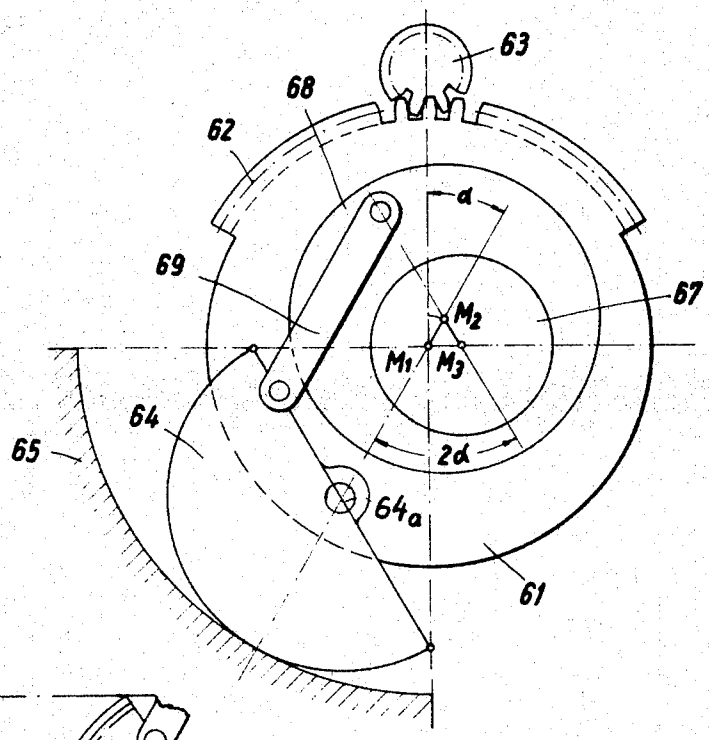


Fig. 5c



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Fig. 6



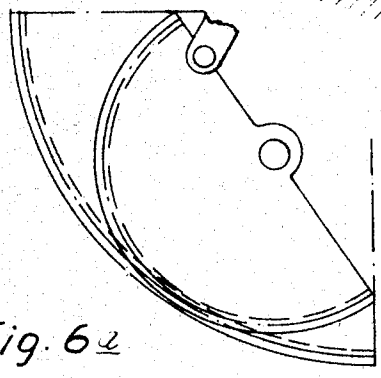


Fig. 6a

United States Patent Office 3,234,816 Patented Feb. 15, 1966

3,234,816

ADJUSTMENT MECHANISM

Hubert Freiherr von Thuengen, Friedrichshafen, Germany, assignor to Zahnradfabrik Friedrichshafen, Aktiengesellschaft, Friedrichshafen, Germany

Filed Nov. 13, 1962, Ser. No. 236,794
Claims priority, application Germany, Nov. 25, 1961, Z 9,097
17 Claims. (Cl. 74—571)

This invention relates to adjustment devices, and more particularly, to an adjustment device wherein it is desired to translate a shaft radially in a straight line from a central position. The invention also pertains to moving an element having a bore therethrough so that the axis of the bore may be adjusted along a radial line from a central position.

Prior art devices utilizing eccentrics have heretofore been used for adjustment of a part of a mechanism, for example the axis of a pump for effecting a change in pumping capacity. However, in prior art devices the adjusted part moves on an arc rather than a straight line, and accordingly, variable capacity pumps generally require a change of ports or port position. The present invention, although of general application wherever it is desired to adjust a component, is particularly directed to variable capacity pumps and eliminates the need for changing the port position, by moving the axis of the impeller shaft on a radial line to effect capacity changes.

The objects of the invention are, therefore, to provide translational adjustment control means effecting straight line motion in a simple, compact and certain manner and applicable to any device or machine where adjustment is required of a shaft or a bore.

Another object of the invention is to provide an adjustment mechanism wherein a large degree of adjustment is afforded in a compact arrangement. Other objects and features of the invention will be apparent from the description that follows.

Briefly, the invention comprises a combination of two eccentrics mounted one within the other, or mounted one on the other, wherein such eccentrics are geared or linked to each other for simultaneous motion. The two eccentric elements have the same degree of eccentricity and are mounted for rotary movement and by virtue of the geared interdependence, or otherwise linked interdependence, manually effected rotation of one eccentric produces twice the angular degree of rotation of the other eccentric.

The invention is based on the properties of Cardan circles as utilized in straight-line motion mechanisms, e.g., in an epicyclic gear and crank combination.

A Cardan circle combination consists geometrically of a circle of certain diameter and a circle of half that diameter inside and contiguous with the first circle. If the inner circle being rotated so that its periphery remains contiguous with the outer circle, any given point on the inner circle will move in a straight-line which is a diameter of the outer circle. Also, the center of the inner circle will move on a circle of diameter equal to the diameter of that inner circle. The relative movement of Cardan circles produces the effect of a 2:1 gear ratio, and such circles can be in the form of inner and outer, i.e., internally toothed, or annular gear for use in various mechanisms.

However, a Cardan circle arrangement can also be achieved with externally toothed gears, as in the present invention.

A detailed description of the invention now follows, in conjunction with the appended drawing, in which:

FIG. 1*a* shows geometrically a plan view of the components of the invention in centralized non-adjusted position;

FIG. 1*b* illustrates an adjusted position of the device of FIG. 1*a*;

FIG. 1*c* shows a physical arrangement of the elements in cross sectional elevation;

FIG. 2 is a longitudinal cross section of a pump embodying the invention;

FIG. 3 is a section through I—I of FIG. 2;

FIG. 3*a* is a section through 3*a*—3*a* of FIG. 2;

FIG. 4*a* through 4*d* shows a modification;

FIG. 5*a* through 5*d* illustrates another modification;

FIG. 6 illustrates a still further modification, and

FIG. 6*a* shows a modification of FIG. 6.

Referring now to FIG. 1*a* there is shown an eccentric element **1** in which is carried another eccentric element **9**. The center of eccentric **1** is the point M_1 about which such eccentric is rotative. The center of the eccentric **9** is the point M_2. Both of these centers are within an eccentric bore **8** having the point M_3 at its center. The eccentricities e_1 and e_2 are equal to each other wherein eccentricity e_1 is the distance from M_1 to M_2 and eccentricity e_2 is the distance from M_2 to M_3. In the central, or non-adjusted position, shown in FIG. 1, M_1 coincides with M_3. The eccentric **1** is provided with arcuately arranged gear teeth **2** meshing with an adjusting pinion **3**, which pinion will be understood to be rotative in either direction to a predetermined extent and on a fixed axis. The eccentric **1** carries a pair of double pinions **5** and **6** which are integral, the smaller pinion **5** engaging fixed arcuate gear **4**, which may be attached to housing (not shown). The larger pinion **6** engages an arcuate gearing **7** on the rim of eccentric **9**.

In operation, if pinion **3** be rotated in order to effect adjustment, the eccentric **1** will be rotated in the direction of the arrow **11** which will cause the pinion combination **5–6** to roll around the gear **4** via engagement with pinion **5**, causing rotation of pinion **6** in the direction of the arrow shown. Thus, via engagement of pinion **5** with gear segment **4**, a rotation of eccentric **9** in the direction of the arrow shown is effected. Such rotation is in the same direction as the initial manual rotation of pinion **3**. Assuming that rotation of eccentric **1** takes place to the extent of the angle α the center M_2 of eccentric **9** will move on a circular arc having radius e_1 around the point M_1, the center point of eccentric **1**, until it reaches the adjusted position M_2'. Further, due to rotation of eccentric **9** as effected by pinion **6** acting on gear segment **7**, which rotation is opposite to that of the direction of arrow **11**, such rotation will take place to an extent of the angle 2α. Accordingly, the center M_3 of the bore **8** will move to the position M_3''. Such movement of the point M_3 occurs on a radial straight line **10** which is normal to the initial line joining the directions of eccentricities e_1 and e_2 and the adjusted position of the center point at M_3'' as determined by the sum of the equal eccentricities e_1 and e_2.

The gear ratio between gears **5** and **6** may be varied as may the eccentricities e_1 and e_2, if desired, for effecting different paths of the point M_3, but in the present disclosure this is not desired, since to achieve straight line movement of M_3, which is the center of a bore or shaft to be adjusted, it is necessary that $e_1=e_2$ and also that the total ratio of gears be 1:2, in order to achieve a Cardan circles effect.

Referring to FIG. 1*c* the elements are shown in physical relationship wherein the disc **1**, the eccentric **9** and the gear segment **7** will be seen as supported for rotative bearing on a shaft **1***a* which in turn may be fixedly supported in a wall **1***b*. Disc **1** may carry a shaft **1***c* on which is rotatively supported the integral pinions **5** and **6** that may be connected by an integral collar or sleeve **5***a*. The gear segment **4** may be fixed to ground in any suitable manner. The disc **9** is supported by an integral

collar 9*a* rotative within a relatively fixed integral collar 9*c*.

A practical application of the invention is shown in FIGS. 2, 3 and 3*a* wherein a pump housing **21** is illustrated, into which extends a drive shaft **22**, which drives pump vanes **23** via rotor 23*a* and is mounted in spaced eccentric discs such as **35**, in turn mounted in eccentric discs such as **26**, wherein the discs **26** have bearing support within respective walls **34** of the housing. An adjusting shaft **24** is carried on the housing, to which shaft are keyed pinions such as **25** meshing with gear segments of respective eccentric discs **26**. The eccentric discs **26** carry double pinion arrangements **28** and **29** wherein pinion **29** meshes with the teeth on the rim of eccentric **35** and the pinion **28** meshes with a circle of fixed teeth **30** which are integral with the housing. The pinions are integral with each other and each pair is carried on a pin such as **27**.

The axial line **31** is the rotative center of the eccentric **26**; the axial line **32** is the rotative center of the eccentric **35**, and the axial line **33** is the center of bore **36** in which shaft **22** has bearing support and is therefore the center of shaft **22**. Referring to FIG. 3, the equal eccentricities e_1 and e_2 are shown wherein eccentricity e_1 is the eccentricity between the eccentric **26** and **35**, and e_2 is the eccentricity between shaft **22** and eccentric **35**.

The total overall ratio of the gears **30**, **28**, **29**, **35** at each of shaft **22** is 1:2.

In order to change pump capacity, shaft **22** is moved radially upward or downward by rotation of shaft **24**, the functioning of the components occurring as explained in connection with FIG. 1*a* and FIG. 1*b*. Thus, shaft **22**, as shown in FIGS. 2, 3 and 3*a*, is in maximum adjusted position.

Reference is now made to FIGS. 4*a* through 4*d* wherein FIGS. 4*a–c* represent a geometric relationship and wherein FIG. 4*d* illustrates a cross section of the physical arrangement. The adjusting mechanism is shown in central non-adjusted position in FIG. 4*a*. In the arrangement illustrated, an eccentric or crank disc **41** is rotative about axis M_1 in arcuate slot or channel bearing **49** and is provided with a gear segment **42** with which a reciprocal gear rack **43** meshes which is pushed or pulled to effect the degree of adjustment required for radial movement of bore **47** in a second eccentric **46** having eccentricity e_1 between axis M_1 and axis M_2 and being rotative on axis M_2. Eccentric **46** is rotatively supported in an aperture in eccentric **46** and may receive lateral restraint by guide blocks **40**.

Gear **44** also having M_2 as its axis and having a radius equal to the eccentricity e_1 carried on an arm **43** integral with eccentric **46**. Gear **44** meshes with a fixed internal gear segment **45** which is concentric with point M_1 and the radius of gear **45** is twice that of gear **44**. The axis M_3 of bore **47** which axis is to be radially and linearly has eccentricity e_2 with respect to axis M_2 which coincides in the non-adjusted position of FIG. 4*a* with axis M_1 and passes through the pitch circle of gear **44**.

If now rack **43** be pushed to the right, as seen in FIG. 4*b*, eccentric **41** is rotated through angle α and gear **44** rolls within gear segment **45** to effect rotation of eccentric **46** about axis M_2. The axis M_2 is thus rotated on a circular arc around axis M_1 into the position shown in FIG. 4*b*, while the axis M_3 rotates around axis M_2 to the extent of the angle 2α. The eccentricities e_1 and e_2 are equal and the gearing arrangement effects motion of eccentric **46** in an opposite rotative sense with respect to the rotational direction of eccentric **41**. In accordance with the principles of a pair of Cardan-circles, the gears **44** and **45** having the ratio 1:2, the axis M_3 of the shaft **47** carried by eccentric **46** moves in a straight line on a diameter of gear **45**. The final position of point M_3 is shown in FIG. 4*c*, such maximum adjusted travel of the point being equal to the sum of the eccentricities e_1 and e_2.

FIGS. 5*a* through 5*d* represent a further embodiment for an adjusting mechanism comprising a Cardan circle combination. In opposition to the modification shown in FIGS. 4*a* through 4*d* the eccentrics are arranged one upon the other instead of one within the other. The eccentric **56** being rotatable about axis M_1, comprises a gear segment **52** which meshes with a tooth rack **53**. As represented in FIG. 5*d* the eccentric **56** is supported on a pin **58** extending into the bore **51** and being secured to a fixed wall **59**. A further eccentric **57** is rotatably mounted on eccentric **56**. The eccentric **57** carries a pinion **54** which is rotative about axis M_2 of eccentric **56**.

When the eccentric **56** is rotated through rack **53**, pinion **54** rotates within the internal gear **55** concentric with M_1. As the radii of the gears **54** and **55** have the ratio 1:2 and the eccentricities e_1 and e_2 are equal, the axis M_3 of the adjustable eccentric **57** is translated radially in a straight line from its central position M_1.

Referring now to FIG. 6, the Cardan-circles arrangement therein shows how certain applications where the radii of a pair of Cardan-circles is so small that the actual use of Cardan-circle gearing is impractical, a relatively large gearing can be utilized by being positioned outside the eccentric portion of the device. Thus, the eccentric discs **61** and **68** are provided wherein disc **61** may be rotated on axis M_1 via the gear rim **62** in conjunction with the manually rotative adjusting gear **63**. The eccentric disc **68** is rotative on axis M_2 and mounted rotatively within a bore in disc **61** being connected by a link **69** to the rollable element **64**, which will be understood to have a frictional gripping surface engaging the arcuate coacting component **65**. Link **69** may be pivoted by pins **64***a* and *b* to eccentric **68** and element **64**.

The elements **64** and **65** can be gear-toothed, as indicated in FIG. 6*a* for positive engagement, and element **64** will be noted as being pivotaly carried at **64***c* on eccentric disc **61**.

A bore **67** in the eccentric disc **68** is provided and it will be understood that the axis of the bore M_3 is to be radially adjusted in a straight line. Thus, eccentric disc **61** being rotative around the axis M_1 and eccentric disc **68** being rotative around axis M_2, in keeping with previously described modifications, the rotation of axis M_2 to the extent of angle α about axis M_1 produces double rotation of the axis M_3 to the extent of angle 2α about axis M_2. The Cardan-circles relationship is retained by making the radius of the rolling component **64** half of the radius of the fixed arcuate element **65**, or as in FIG. 6*a*, the pitch circles of the gearing are in the ratio of 1:2.

The link **69** and gear **64** can be duplicated on the other side of the eccentrics, using the same pins **64***a*, *b* and *c* and thus such links effect a guide to maintain eccentric **68** within eccentric **61**.

In retrospective, it will be apparent that all forms of the invention carry out the principle of Cardan-circles in that, in effect, although the structure may be quite dissimilar from the basic Cardan-circle structure, the mechanical action remains the same in that in essence a wheel is revolved inside another wheel of twice the diameter so that for each degree of rotation of the smaller wheel with respect to the inner periphery of the bigger wheel, the smaller wheel rotates two degrees about its own axis. In effect, the eccentricities e_1 and e_2 as described herein, are the length of crank throws which correspond to the radius of the smaller wheel, where such crank throws are actual physical parts in such structures wherein one eccentric disc is not actually carried within an aperture of the other eccentric disc. In instances where the eccentric disc is actually carried within an aperture of the other eccentric disc, then the eccentricities correspond additively to the radius of the larger wheel, while each eccentricity remains equal to the radius of the smaller wheel. Since the eccentricities are the measure of the spacing between the various axes, it will be apparent that the axis of the element to be adjusted must pass through the pitch circle of the smaller wheel, if the smaller wheel be a gear, and thus

such axis can be considered a point on the periphery of such smaller wheel which travels on a diameter of the larger wheel.

Having thus described this invention, I am aware that various changes may be made without departing from the spirit thereof, and therefore am not limited to the precise illustrations herein given, except as set forth in the appended claims.

I claim:

1. An adjusting mechanism for a member comprising one rotative element, and manually adjustable means whereby said element is manually rotatively adjustable to selected positions; and another rotative element to be radially adjusted with respect to its axis of rotation in response to rotative adjustment of said one element, said elements being mounted in eccentric contiguity with each other, control means whereby the rotative movement of said adjustable one element effects rotative and radial movement of the other element, said control means comprising a fixed element, and further comprising actuating means connecting said elements with said fixed element wherein rotative adjustment of said one element effects rotation of the other element by virtue of said actuating means and said radial movement then occurring by reason of the eccentric contiguity of said elements, and said member being operatively connected to said other element for radial adjustment.

2. A straight line adjustment mechanism for a rotary pump comprising a pair of rotative elements mounted for rotation on parallel spaced axes, means connecting said elements wherein manual rotating of one element effects rotation of the other element with respect to the axis of said one element and simultaneous additional rotation of said other element about its own axis whereby said other element is adjusted radially, and means whereby the total degree of rotation of said other element is twice that of said one element, and means whereby said other element effects support of a rotary pump shaft to adjust the capacity of said pump, said means comprising a bore in said other element and the rotary pump shaft extending into said bore, said shaft and bore having a common axis.

3. A straight line adjustment mechanism comprising a housing having at opposite ends thereof an axially aligned duplication of a first gear rotative about an axis and having a circular aperture having an axis spaced from said first axis, a second gear carried rotatively in said aperture and being rotative about the axis of said aperture, said second gear having an axis coinciding with the axis of said first gear when said gears are in an initial position with respect to each other, means for effecting an adjusting rotation to a selected angular degree of said first gear, a fixed gear, a pair of integrally connected pinions rotatively carried by said first gear, one of said pinions meshing with said fixed gear and the other of said pinions meshing with said second gear, the overall gearing ratio being 2:1 whereby angular adjustment of said first gear effects double the angular rotation of said second gear, and whereby the axis of the aperture therein is translated radially with respect to the axis of said first gear upon angular adjustment thereof.

4. A straight line adjustment mechanism as set forth in claim 3, each of said second gears having a bore and a rotary shaft extending between said bores wherein said shaft is radially adjusted by adjustment of said first gears.

5. A straight line adjustment mechanism as set forth in claim 3, including a means extending between said first gears for effecting manual rotative adjustment thereof in unison.

6. A straight line adjustment mechanism as set forth in claim 3, each of said second gears having a bore and a rotary shaft extending between said bores wherein said shaft is radially adjusted by adjustment of said first gears, including a means extending between said first gears for effecting manual rotative adjustment thereof in unison.

7. In a device as set forth in claim 1, said actuating means comprising a gear device carried by said one element and being rotative upon adjustment of said one element, to effect rotation of said other element.

8. In an adjusting mechanism as set forth tin claim 1, said actuating means comprising a gear device carried by said one element and being rotative upon adjustment of said one element to effect rotation of said other element, said gear device comprising a pair of coaxial gears, said other element having gear teeth meshing with one of said coaxial gears and said fixed element being a gear coacting with the other of said coaxial gears.

9. In an adjusting mechanism as set forth in claim 1, said actuating means comprising a gear device carried by one of said movable elements and being rotative upon adjustment of said one element to effect adjustment of said other movable element, said movable elements having spaced axes and being rotative thereabout, and said fixed element comprising a gear segment.

10. A straight line adjustment mechanism for a rotary pump comprising a pair of rotative elements mounted for rotation on parallel spaced axes, means connecting said elements wherein manual rotation of one element effects rotation of the other element with respect to the axis of said one element and simultaneous additional rotation of said other element about its own axis and means whereby said other element is adjusted radially and the total degree of rotation of said other element is twice that of said one element, and means whereby said other element effects supports of a rotary uump shaft to adjust the capacity of said pump.

11. A mechanism as set forth in claim 10, wherein the means connecting said elements comprises the support of one element by the other element to effect the first mentioned rotation, and means connected to the other element for effecting said simultaneous additional rotation responsive to rotation of said one element.

12. A straight line adjustment mechanism comprising a first disc having an aperture eccentrically disposed therein, a second disc carried within said aperture and having rotative movement therein, means for effecting angular adjusting rotation of said first disc, and gear means comprising a fixed gear connected to said discs and having a 2:1 ratio whereby said second disc is afforded twice the angular degree of rotation as said first disc.

13. A mechanism as set forth in claim 12, including a shaft passing eccentrically into said second disc, and pump rotor means carried by said shaft for effecting straight line radial displacement thereof upon adjustment of said first disc.

14. A straight line adjustment mechanism comprising a manually rotative first element and means for effecting angular adjusting rotation thereof about an axis, a second rotative element carried by said first element and having its axis of rotation eccentrically displaced with respect to the axis of said first element, and means whereby said first element can be rotated about its axis during an adjusting rotation while said second element rotates about its axis during said adjusting rotation to twice the degree of rotation of said first element, said second element containing an axis to be adjusted which moves during adjustment of said first element in a straight radial line with respect to the axis of said first element and remaining parallel thereto, and said axis to be adjusted coinciding with the axis of said second element when said elements are in an initial position.

15. A straight line adjusting mechanism comprising a first element manually rotative about an axis, and means for effecting rotational adjustment of said first element about said axis, a second element carried by said first element and rotative about an axis parallel to and spaced from said first mentioned axis, and rotative about said first mentioned axis when said first element is rotated, a fixed gear element and a gear carried by said second element engaging said fixed gear element with a 2:1 ratio

effective to produce twice the angular rotation of said second element by drive between said gear and said fixed gear element when said first element is afforded an adjusting rotation, said second element containing an axis to be adjusted parallel to the above mentioned axes and spaced initially from said axis of said second element by an amount equal to the initial spacing of the axes between said first element and said second element when said elements are in an initial position and coinciding with the axis of said first element in said initial position and moving in a straight radial line with respect to and parallel to said other axes during the course of adjustment.

16. A straight line adjustment mechanism comprising a pair of rotative elements mounted for rotation on parallel spaced axes, means connecting said elements wherein rotation of one element effects rotation of the other element with respect to the axis of said one element and simultaneous additional rotation of said other element about its own axis whereby the total degree of rotation of said other element is twice that of said one element wherein the means connecting said elements comprises a link pivoted to one of said elements and a gear pivoted to the other of said elements, said link being pivotally connected to said gear and a fixed gear component engageable by said gear wherein the ratio of said gear to said fixed gear component is 2:1.

17. A straight line adjustment mechanism comprising a first gear rotative about an axis and having a circular

aperture having an axis spaced from said first axis, a second gear carried rotatively in said aperture and being rotative about the axis of said aperture, said second gear having an axis coinciding with the axis of said first gear when said gears are in an initial position with respect to each other, means for effecting an adjusting rotation to a selected angular degree of said first gear, a fixed gear, a pair of integrally connected pinions rotatively carried by said first gear, one of said pinions meshing with said fixed gear and the other of said pinions meshing with said second gear, the overall gearing ratio being 2:1 whereby angular adjustment of said first gear effects double the angular rotation of said second gear, and whereby the axis of the aperture therein is translated radially with respect to the axis of said first gear upon angular adjustment thereof.

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