

Aug. 10, 1965

C. F. PRINS

3,199,361

MOTION CHANGING MECHANISMS

Filed March 12, 1962

6 Sheets-Sheet 1

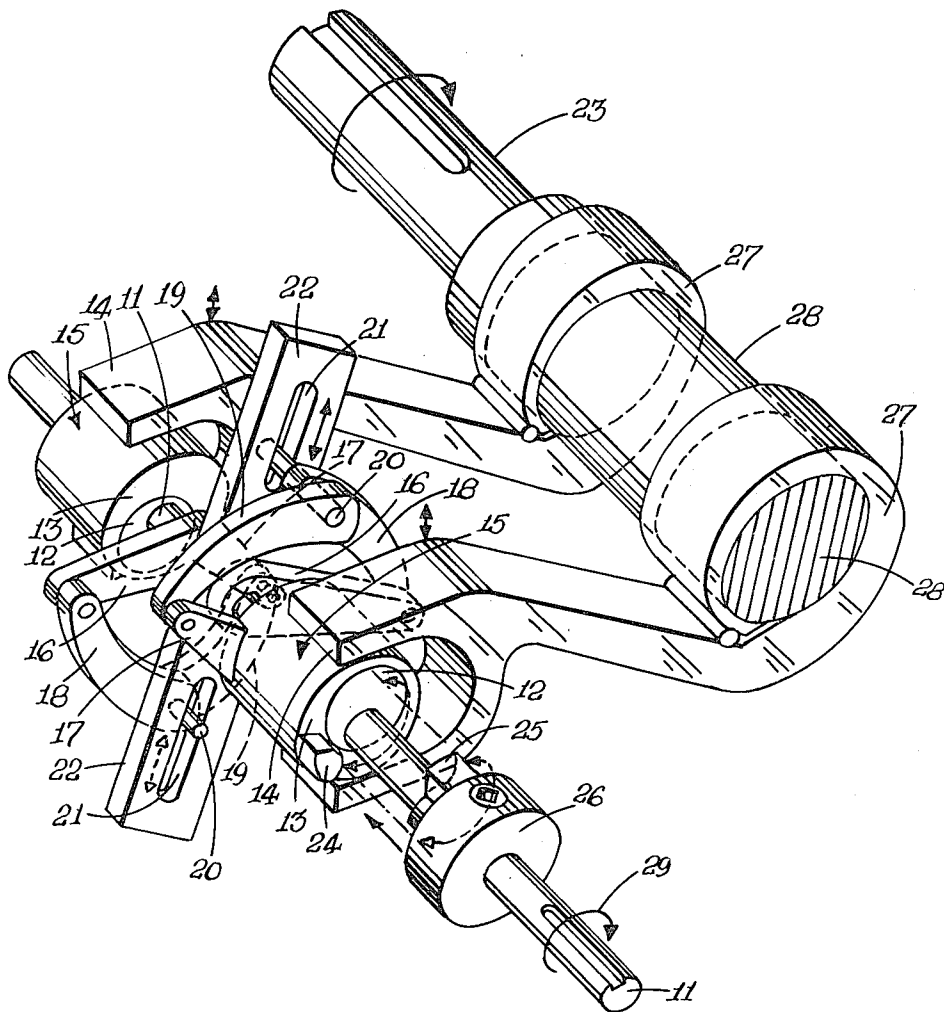


*Fig 1.*

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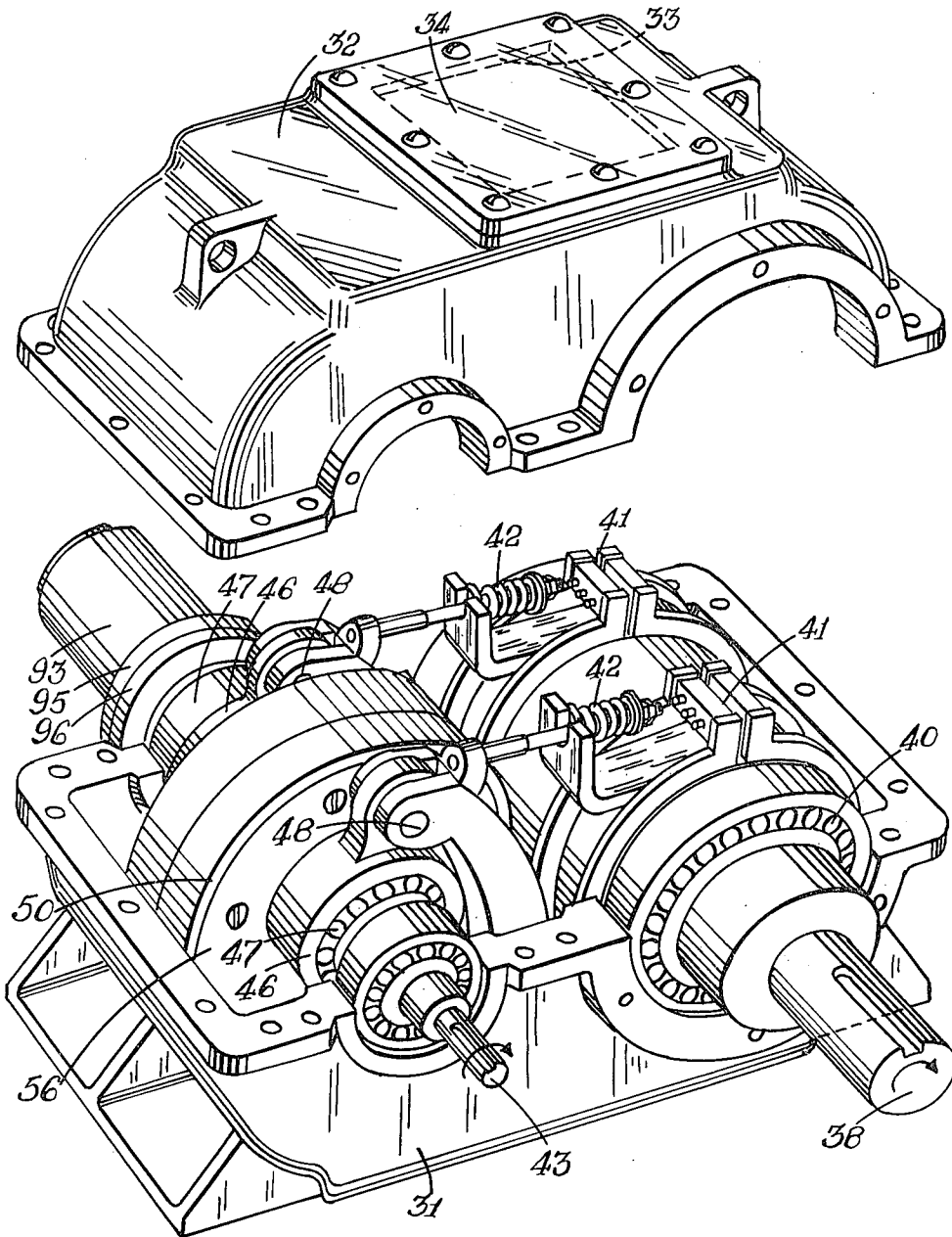


*Fig 2.*

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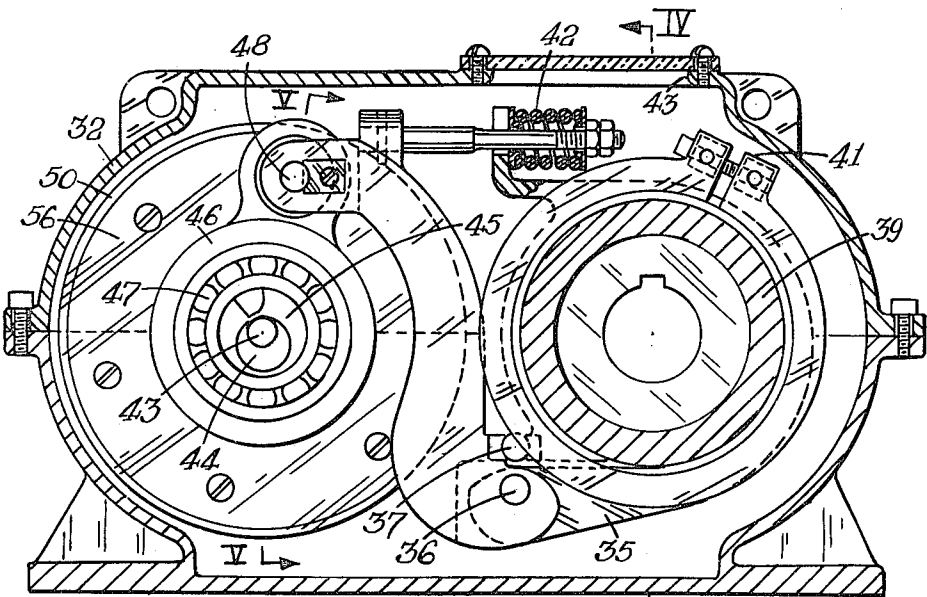


Fig 3. ← IV

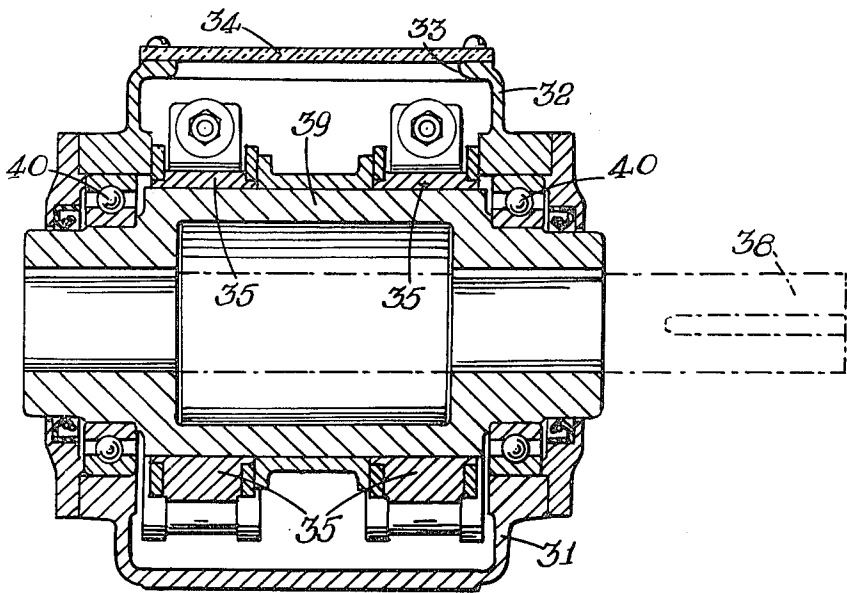


Fig 4.

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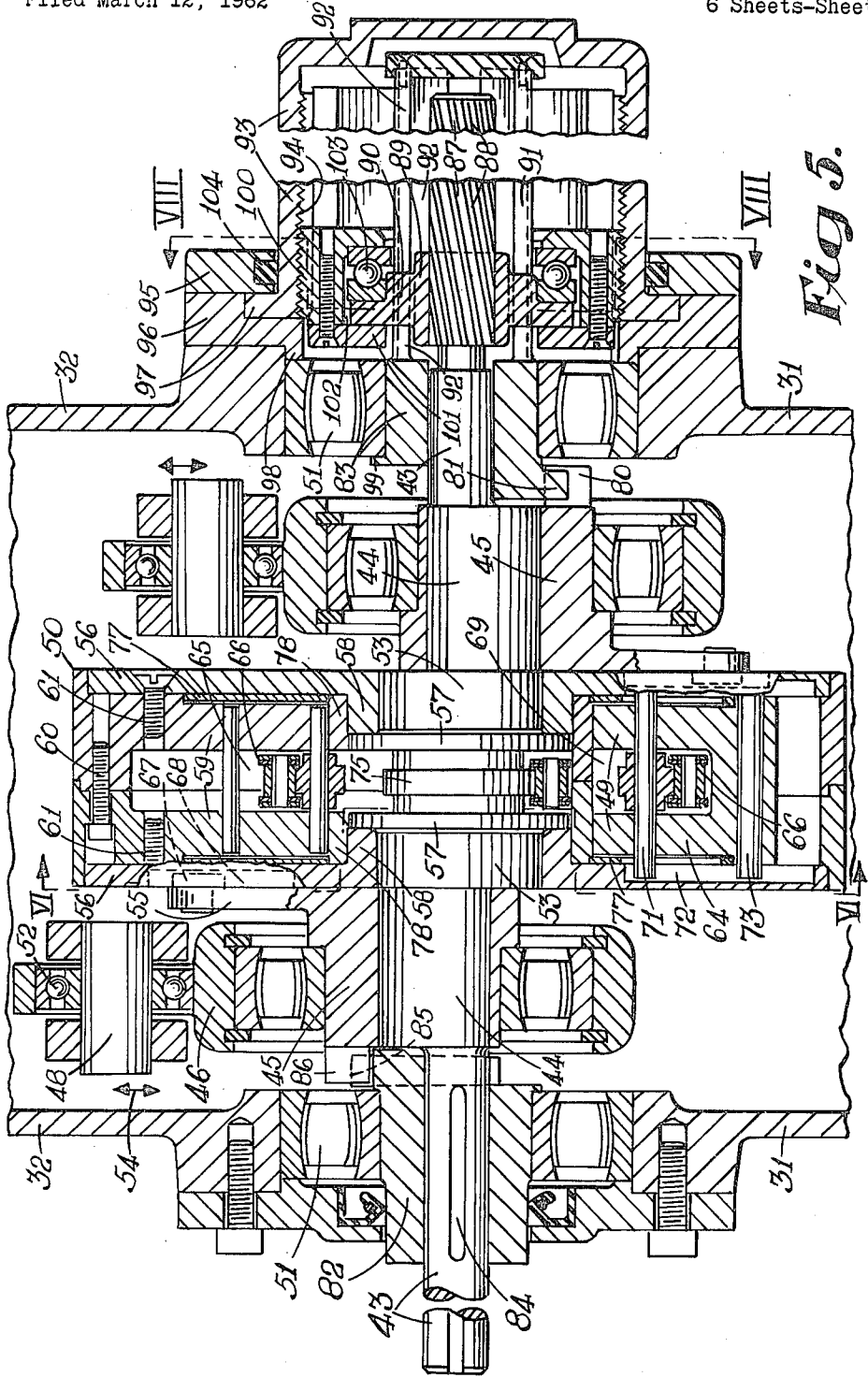


Fig. 5.

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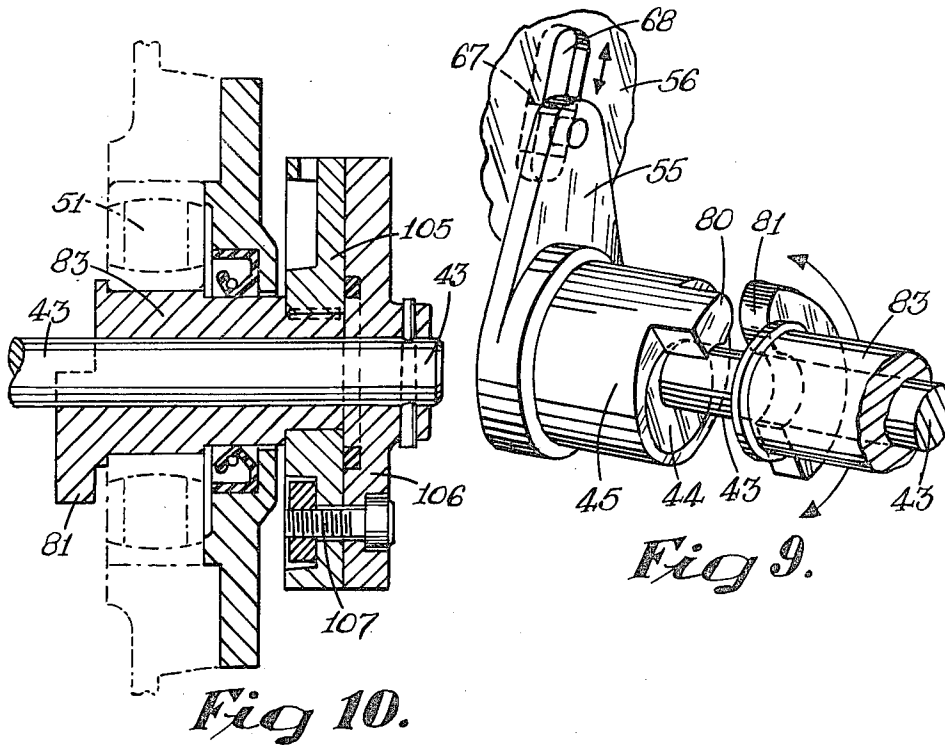
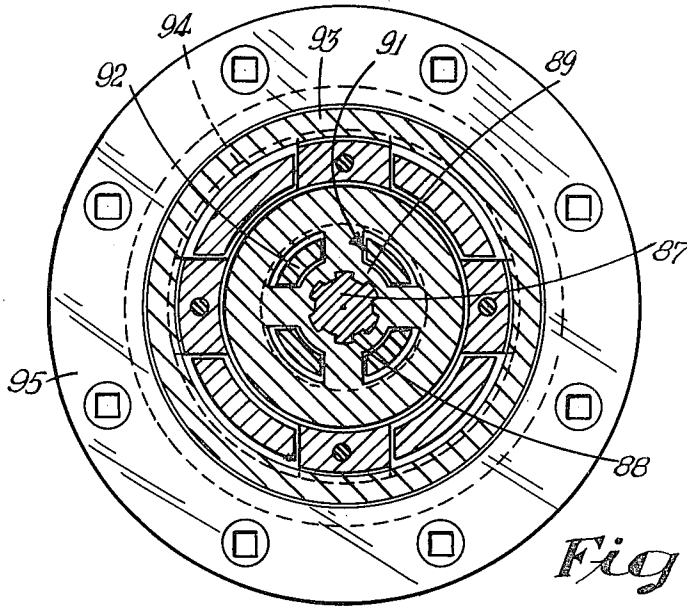
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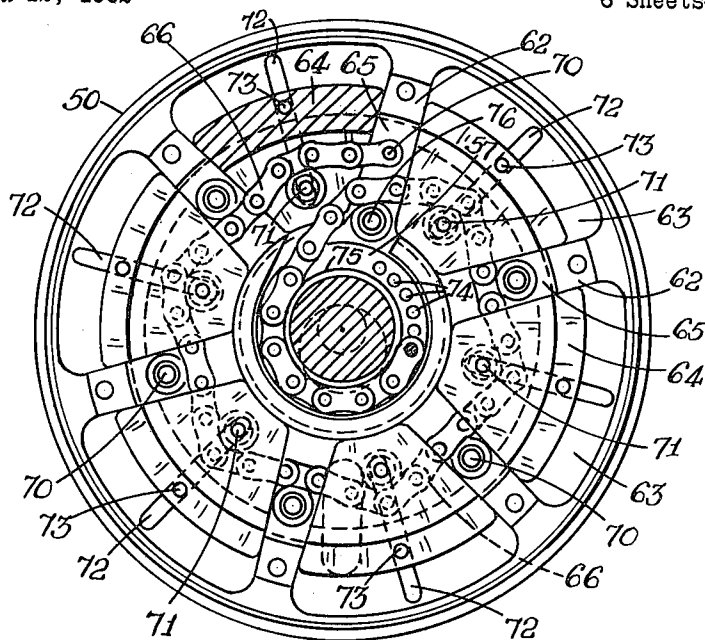


*Fig 6.*

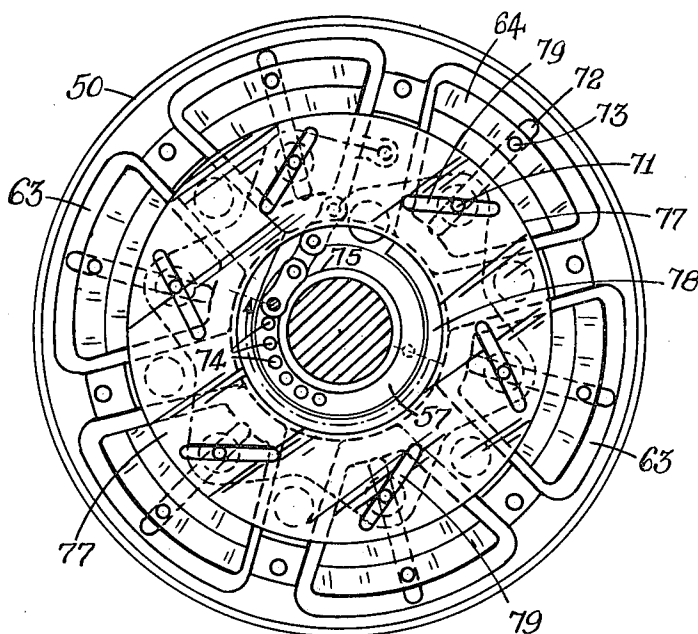


*Fig 7.*

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## MOTION CHANGING MECHANISMS

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Mar. 14, 1961, 1,026/61

7 Claims. (Cl. 74-124)

This invention relates to motion changing mechanisms of the kind in which a rotary motion is transformed into an oscillating or reciprocating movement. In particular the invention is intended for use in speed reducing devices as described below.

Speed reducing devices to which the invention relates include a drive shaft providing one or more cylindrical cams eccentrically located relative to the shaft and which act to oscillate straps, the points where the straps engage the bearing surfaces of the cams being in the nature of followers. The straps embrace an output shaft in such a manner that the oscillation of the followers at the driver causes rotation of the output shaft. The cycle of operation is such that on the rise of a follower the associated strap grips the output shaft and turns it a predetermined amount, and on the fall of the follower the strap releases its grip and returns or is returned to a neutral position. Speed reducers of this character have been the subject of study for many years.

The amplitude of oscillation of the follower, the number of straps employed and the speed of rotation of the drive shaft determine the speed of the output shaft.

Various attempts have been made to provide an effective control means for a speed reducer of the kind in question, one which would enable a substantial range of output speeds to be obtained for a fixed speed of the drive shaft, but to the knowledge of the applicant no satisfactory speed varying device has been provided. An object of the present invention is to provide a speed control mechanism which will enable variations of the output speed to be obtained for a constant drive shaft speed. Other objects of the invention will appear as the specification proceeds.

The invention is also directed to the provision of means merely for the purpose of changing rotary motion of a drive shaft into oscillatory motion of a follower, the means having special characterizing features as will appear hereunder.

According to the invention, there is provided apparatus for the conversion of rotary motion into reciprocating motion which includes a drive shaft, a first cylindrical eccentric mounted on and fixed to the shaft, a second cylindrical eccentric having a cylindrical recess for the snug accommodation of the first eccentric. The two eccentrics are rotatable relatively to one another to vary the eccentricity of the second eccentric relative to the axis of rotation of the shaft. Follower means is provided for the second eccentric which is adapted for undergoing oscillation upon eccentric rotation of the second eccentric for having the oscillation converted to rotary movement. The apparatus further comprises a flyweight system adapted to orbit the shaft under the influence of centrifugal force, and a linkage system coupling the flyweight system to both eccentrics, the linkage system including elements rigid with respective eccentrics, which elements are relatively movable upon radially outward movement of the flyweight system to increase the eccentricity of the second eccentric, the element rigid with the second eccentric being effective to convert drag which is imparted to the second eccentric by the follower means into reverse relative movement of the elements.

Also according to the invention the elements of the

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linkage system are arms rigidly coupled to the eccentrics, the arms diverging radially, the flyweight system including links pivotally connected together and to the free ends of the arms.

Preferably the apparatus provides two identical first and second eccentric sets mounted in anti-phase on the shaft, and a flywheel bar mounted on the shaft having opposed radially disposed guides for constraining pivotal movement of the links of the flywheel system.

Control means may also be provided for varying the orbital radius of the system in order to control the throw of the follower means, the control means including a stop rigid with the shaft and a mating stop rigid with a second eccentric, which stops on engagement, lock the shaft and second eccentrics against relative movement and limit the flywheel system to rotate in a predetermined orbit, and a regulator for adjusting the angular setting of the stops when the shaft is stationary. For situations in which the device is to be used as a speed changing mechanism the followers of the follower means are preferably rigid with straps embracing an output shaft and which act to rotate the shaft according to the oscillatory rise and fall of the followers.

Further according to the invention the elements of the linkage system may be arms rigid with the first and second eccentrics, the arms being coupled to the flywheel system through a flexible link slidably engaging at least one weight such that relative movement of the eccentrics acting to increase or decrease the effective length of the link alters the orbital radius of the weight about the axis of the shaft.

The flexible link arrangement is preferably one in which a plurality of weights is symmetrically disposed about the shaft and all the weights are engaged by the link.

According further to the invention a first and second eccentric set is mounted on the shaft to each side of a common flyweight system, the eccentric sets being mounted in anti-phase.

In a further arrangement of the invention the controller includes a helically threaded portion on the shaft, a sleeve covering the threaded portion of the shaft, fast with the shaft stop and having at least one axial slot, and a traveller nut on the shaft with a projection engaging in the slot, movement of the nut along the shaft acting to turn the sleeve to alter the angular relationship of the stops.

Preferably the sleeve is enclosed in a rotatable housing adapted on rotation to cause the desired movement of the traveller nut.

The invention also provides for a plurality of first and second cams mounted in sets on the shaft with the followers to operate in balanced phase relationship.

In order to illustrate the invention two examples are described hereunder with reference to the accompanying drawings in which

FIGURE 1 is a perspective view of a device for reducing speed,

FIGURE 2 is a perspective view of a second form of speed reducer in accordance with the invention with its cover plate removed,

FIGURE 3 is a sectional side view of the device of FIGURE 2,

FIGURE 4 is a sectional end elevation on the line IV—IV of FIGURE 3,

FIGURE 5 is a sectional side elevation on the line V—V of FIGURE 3,

FIGURE 6 is a section on the line VI—VI of FIGURE 5 with the left hand cover plate and locating washer removed,

FIGURE 7 is a similar view to that of FIGURE 6 with the washer in position,

FIGURE 8 is a section on the line VIII—VIII of FIGURE 5,

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FIGURE 9 is a perspective with parts broken away showing the stop means through which the output speed may be adjusted, and

FIGURE 10 is a section with parts broken away showing an alternative arrangement for controlling the output speed.

Referring to FIGURE 1, the device includes an input shaft 11 on which is mounted in anti-phase two spaced cylindrical first eccentrics 12 and on these elements ride second cylindrical eccentrics 13 which are again disposed in anti-phase on their respective first eccentrics. By movement of the first and second eccentric sets relative to one another so the eccentricity of the second eccentric relative to the axis of rotation of the shaft may be varied through a range depending upon design requirements. In the embodiment the variation is allowed to take place in a range which at one end involves no eccentricity, a position which corresponds to a state where the follower 14, riding on the eccentric surface 15, remains stationary, i.e. the follower has no throw.

In order to adjust the eccentricity of the second eccentric through the range in order to control the throw of the followers 14, the eccentrics are associated with flyweight systems which orbit the drive shaft 11. Thus, in the example under consideration, the first eccentric 12 is fast with the shaft 11 and from the shaft, and fast therewith, an arm 16 projects; in other words the arm 16 is directly or indirectly rigidly coupled to the first eccentric. A similar arm 17 projects outwardly from the second eccentric 13 and the ends of arms 16 and 17 are pivotally connected, respectively, to links 18 and 19 which in turn are joined pivotally at 20. The combination of links 18 and 19 constitute the flyweight system for the two eccentrics 12 and 13. Exactly the same arrangement is provided for the second pair of elements 12 and 13 and the two flyweight systems are constrained for movement in guides 21 provided by the flywheel bar 22 mounted on the shaft 11.

On rotation of the shaft 11 centrifugal force commences to act on the flyweight systems as they orbit the shaft axis; and the effect of the radially outward movement of the systems is to turn the eccentrics 12 and 13 relative to one another through arms 16 and 17, thereby to increase the eccentricity of the second eccentric 13 relative to the axis of the shaft 11. In some arrangements the outward travel of the flyweight systems is purely a function of the speed of rotation of the shaft 11; i.e. the faster the shaft turns the greater the radially outward movement of the system and this movement is ultimately checked by the mechanical design of the device or by load conditions imposed on the eccentric surface 15 by the follower 14.

In the embodiment, however, the throw of the follower is specially controlled to suit output requirements at shaft 23, for in this case the oscillatory motion of the followers is transformed back again into a rotary motion to make the device into a speed reducer.

For controlling the radially outward movement of the flyweight system and thereby the throw of the follower, the eccentric 13 is equipped with a stop 24 which is adapted to engage with a mating stop 25 fast with the shaft 11 through adjustable boss 26. The throw of the eccentric depends upon the angular relationship of the two stops when the device is stationary. The operation of the device will be more fully explained below when the actual functioning of the various elements will be described as the device is started up.

Each follower 14 is fast with a metal strap member 27 which embraces the shaft 23 and is adapted to impart a rotary movement to this shaft as its follower oscillates on the eccentric track 15. The strap is adapted to move through a cycle during oscillation of the follower which includes gripping the shaft boss 28 and rotating it a predetermined amount as the follower rises on the eccentric track, and releasing the grip and return-

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ing to a neutral position as the follower falls on the track. It will be noted in the example that the follower 14 is double headed in the sense that it is of a forked character. The reason for this is that on the fall of the follower the lower section of the fork is engaged by the eccentric to ensure that the strap is returned to the neutral position.

Strap type speed reducers are per se known and it is not proposed to describe in detail the method by which they change the reciprocatory motion of the followers into rotation of shaft 23. Suffice to say that their action is analogous to the gripping of a shaft with clenched hands wherein the shaft is gripped and turned, whereafter the hands return to a neutral position preliminary to a further gripping step. If the hands work in anti-phase the shaft is kept rotating. This is what happens where a plurality of straps is employed.

Assuming now that the shaft 11 is about to be started up. Stop 25 is set to give the desired oscillation of the follower 14; i.e. by fixing the stop at the correct angular relationship relative to the stop 24. On starting in the direction of arrow 29 the immediate reaction is to draw the flyweight system inwardly because of the movement of arm 16. Speed builds up and centrifugal force commences to act on the flyweight system causing it to move radially outward. This outward movement is finally checked since the effect of the movement is to rotate the arms 16 and 17 in anti-phase until the stops 24 and 25 abut. Up to this stage the throw of the follower has gradually increased and when the stops engage no further increase of the throw is possible since it is not possible for the stop 24 to over-ride the stop 25.

The unison of action of the two sets of eccentrics is maintained through the flywheel bar 22 which operatively couples the systems together.

The driven shaft 23 is now kept in motion and should any overload occur the device tends of its own accord to reduce the eccentricity until ultimately a stage can be reached when the follower has no oscillatory movement at all. The manner in which this occurs is as follows:

The effect of an overload is to turn the follower 14 into a brake pad which endeavours to check the movement of the underlying eccentric 13. Arm 17 now has a dragging effect on the flyweight system tending to overcome the effects of centrifugal force and the extent of the drag will depend upon the braking load imposed on the eccentric 13 by the follower. If the load is great enough the stage will be reached in which the drag effect will completely overcome the effects of centrifugal force and the arms 16 and 17 will be moved into a position in which the central axis of the eccentric 13 and the corresponding axis of the shaft 11 are co-incident. At this point the follower 14 is stationary.

Clearly the bore in the second eccentric 13 which accommodates the first eccentric 12 must be eccentrically disposed relative to the central axis of the second eccentric for otherwise no adjustment of the eccentricity of the two relevant axes becomes possible. The greater the eccentricity of the bore the greater the variation of follower throw which becomes possible.

In the preferred forms of the invention the device is accommodated in a casing which constitutes an oil bath as will appear from the discussion hereunder of the second embodiment illustrated in the remaining figures.

FIGURE 2 is a perspective which illustrates the appearance of a speed reducer according to the invention with its casing 31 having its top 32 removed. Top 32 enables repairs to be effected on the working parts of the device although some repairs are possible through inspection port 33. Port 33 is closed by a transparent viewing panel 34. In FIGURE 3, a sectional side elevation is illustrated which shows a strap 35 articulated at 36 and suitably held at 37, the strap embracing the output shaft 38 and strap boss arrangement 39. The

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operation of the strap is substantially as described in the previous example. With the rise of the follower the strap grips the shaft through the boss arrangement 39 and turns the shaft 38 a predetermined amount, and on the fall of the follower the grip on the boss is released and the strap returns to a neutral position. By using two straps operating in anti-phase the shaft is kept rotating. Clearly a greater number of straps may be employed if desired. FIGURE 4 is a sectional end view on the line IV—IV of FIGURE 3 from which it will be seen that the shaft 38 is supported in ball bearings 40 in the casing 31.

Adjustment of the strap in relation to shaft 38 is accomplished by the arrangement shown at 41 which illustrates diagrammatically an adjusting means. Hinge arrangements may be used if desired. Spring means 42 serves to bias the strap to a neutral position.

FIGURE 3 also shows aspects of the drive section of the device. Reference 43 indicates the drive shaft, 44 the first eccentric fast with the shaft, 45 the second eccentric mounted on the first eccentric as described with reference to the first example and the follower is shown by reference 46. In this example the follower is of a different character from the forked arrangement described previously. Here the follower is a member which is bored out to accommodate a ball or roller race 47 which in turn is mounted over the second eccentric 45. The follower is linked to the strap 35 pivotally at point 48. As in the previous example two straps are employed which work in antiphase.

Reference 50 refers to a flyweight system which is illustrated in greater detail in FIGURE 5 and which is used in the control of the throw of the followers. In FIGURE 5, the drive shaft 43 is shown located in roller bearings 51 in the side walls of the casing 31 and the shaft is seen to have first eccentric 44 and concentric boss 53 fast therewith. On each eccentric 44 there is mounted the second eccentric 45 which in turn has the follower 46 mounted on it. Pivot point 48 for the strap and follower oscillates in the direction of arrows 54. A roller bearing 52 is used at the pivot point.

In the second form of the invention the second eccentric 45 is associated with an arm 55 which is the equivalent of arm 17 shown in the example of FIGURE 1, while the arm 16 of FIGURE 1 finds its equivalent in the concentric boss 53. In the arrangement of FIGURE 1 each eccentric set had a flyweight system of its own with both systems linked together through the flywheel bar 22; in the arrangement under consideration the eccentric sets share a common flyweight arrangement 50.

The flyweight arrangement 50 includes spaced side plates 56 which are mounted on the boss 53 and which are held in spaced relationship by the peripheral ridges 57 on the boss 53. Each side plate will be seen to provide a hub section 58 and each hub section accommodates half of a flywheel 59, the two halves being keyed together by screw means 60 and screw 61 acting to lock the flywheel to the side plates. The flywheel 59 is formed with spaced radial legs 62 (see particularly FIGURE 6) between which are defined spaces 63 for accommodating planet weights 64, and a further space 65 exists between the leg sections provided by each half of the flywheel for the location of chain 66. The flywheel is fast with the boss 53 and is locked to the arms 55 of the eccentric elements 45 by the engagement of pivot shoes 67 on the arms sliding in slot arrangement 68 in the side plates 56.

Chain 66, as mentioned in the previous paragraph, is located in the spaces 65 defined between mating sections of the flywheel legs 62 and is also accommodated in similar spaces 69 defined between the limbs 49 of weights 64 which in section are of substantially U-shaped character as will be seen in FIGURE 5. In passing through the spaces 65 the chain is threaded under pins 70 in the flywheel legs and in the spaces 69 in the weights it is

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threaded over similar pins 71. Pins 71 have their ends projecting beyond the sides of the weights to be accommodated in radially disposed grooves 72 found in the inside faces of the side plates 56. Each weight has an additional pin arrangement 73 which is also accommodated in the groove or guide track 72 for stabilising purposes.

The chain is linked at one end to the boss 53 in the space between the ridges 57 and, as FIGURE 6 will show, the series of holes 74 in the ridges 57 enable the chain to be secured on the boss in any one of several positions. It will be seen that a central upstanding ridge 75 is provided in the space between ridges 57 and the purpose of this ridge is to provide a bearing surface for the chain which in this example is of the bi-cycle type. From the boss the chain is lead over the first pin 76 fast with the flywheel, then over the first weight pin 71, then under the first flywheel leg pin 70 and so on until the other end of the chain is reached. The free end of the chain is then anchored to the adjacent flywheel leg pin 70. By this means it may be said that one end of the chain is securely anchored to the first eccentrics 44, albeit through the boss 53 which will be seen to be fast with the eccentrics 44, and to the second cam elements 45 through the flywheel legs which are fast with the side walls 56 and which are in turn coupled to the eccentrics 45 through arm 55 and shoes 67. The position is thus basically identical to that described in the first example in as much as each of the eccentrics is coupled into a flyweight system which on rotation acts to move the elements relatively to one another to increase the eccentricity of the longitudinal axis of the second eccentric relative to the central axis of the shaft 43.

To ensure that on outward movement of the weights 64 they all move in unison to maintain balance in the flyweight system, special washer members 77 are located between the flywheel and the side plates, the washers being free to rotate on the boss sections 78 of the flywheel quite independently of the flywheel. As will be seen in FIGURE 7, the washers are provided with slanted guide channels 79 through which pass the ends of pins 71. As the weights move outwardly the pins tend to turn the washers so that they may ride in the grooves or guide tracks 72 in the side plates. Thus all the weights are maintained at the same radial spacing from the boss 53.

As in the previous example, the eccentricity of the central longitudinal axis of the second eccentric 45 relative to the long axis of the shaft is controlled by the setting of stops 80 and 81 on the eccentric 45 and shaft respectively. Before proceeding to describe the stop control mechanism in detail it is proposed to describe the operation of the speed reducer, for up to this stage the major description is over, there remaining simply details of the modes of controlling the eccentricity.

By fixing the relative positions the two stops 80 and 81 would assume when the shaft 43 is stationary so more or less of the chain 66 is wound on to the boss 53. The smaller the amount of chain held wound on the shaft the greater the ultimate outward movement of the flyweights and hence the greater the eccentricity. This will be apparent from a consideration of FIGURES 5 and 6. If stop 81 is turned clockwise a certain amount of slack occurs in the chain which is subsequently taken up as the weights move out. Likewise, if the stop is turned anti-clockwise more chain is wound on to the boss 53 and the orbital radius of the weights is reduced.

On rotation the weights move out according to the available slack in the chain and the outward movement of the weights acts to turn the eccentrics relatively to one another until the stops 80 and 81 engage. This engagement prevents stop 80 overriding stop 81 and fixes the throw of the follower.

On the occurrence of overloads the action of follower 46 is to exert a braking force on the eccentric 45 and this force tends to retard arm 55. In the event the stops

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80 and 81 part with the shaft acting now to wind in some of the chain thereby reducing the orbital radius of the weights, and simultaneously reducing the eccentricity of the eccentric axis relative to the axis of the shaft. If the load is of a drastic character the eccentricity may be reduced until it is eliminated altogether at which stage the follower has no throw.

As mentioned several times in the previous portion of the description, the throw of the follower determines the speed of rotation of the output shaft and control of the output speed is obtained by adjusting the eccentricity of the axis of the second eccentric 45 relative to the axis of the shaft 43. Two types of control mechanism are illustrated in connection with the embodiment of the invention shown in FIGURES 2 to 10, one enabling speed changes at the output shaft to be effected during rotation of the drive shaft 43, and the other which merely enables adjustments to be made with shaft 43 stationary.

Dealing firstly with the control mechanism which permits adjustments during rotation of the shaft 43. The control mechanism is best illustrated in FIGURES 5 and 8. The drive shaft 43 is mounted in roller bearings 51 between which and the shaft are bored bosses 82 and 83. Boss 82 is keyed to shaft 43 by key 84 and provides a stop 85 adapted to engage stop 86 on eccentric 45 of the left hand cam set. The stops 85 and 86 correspond to the stops 81 and 80 except that they are 180 degrees apart when abutment takes place. Stop 81 is fast with boss 83 and this boss is not directly keyed to shaft 43.

The shaft 43 projects through the casing 31 on the right hand side of FIGURE 5 and the projecting portion 87 has a helical thread 88 cut into it. On the thread there is mounted a threaded spider 89 having arms 90 which project through axial slots 91 in a cage arrangement 92 fast with the boss 83. The cage is in turn located in a housing 93 which is internally threaded at 94 and which is rotatably anchored between plates 95 and 96 by the engagement of flange 97 in a complementary space defined between the two plates. Roller bearing 51 on the right hand side is constrained against axial movement by means of flange 98 on plate 96 and flange 99 on boss 83. In the space between the housing and the cage there is a nut 100 which may be moved axially on rotation of the housing. The nut is releasably secured to a ring 101 so as to define a U-shaped space 102 in which is located the extremities of the spider arms 90 and a ball race 103. The provision of race 103 permits the spider to rotate while the nut moves axially on rotation of housing 93. To adjust the eccentricity of the central axis of the eccentrics 45 relative to the axis of the drive shaft 43, the nut 100 must be moved to the desired position on the cage 92. This is achieved by turning housing 93. As the nut is moved axially so the spider is pulled axially along with it and as the spider is threaded on the helical section 88 the spider is forced to turn on the shaft thereby rotating the cage 92, and moving the stops apart when the eccentricity is to be increased. If the eccentricity is to be decreased the stop 81 forces the stop 80 to retard eccentric 45 thereby to bring about slack in the chain 66 which is wound on to the boss 53 to reduce the orbital radius of the flyweight weights. A reduced throw of the follower is thus accomplished with consequent reduction in the speed of rotation of the output shaft 38. The adjustments effected by the control system referred to above may be achieved while the shaft 43 is kept rotating. The purpose of the stops 85 and 86 is to prevent an overrun, whereby when overloads occur the decrease of eccentricity to zero is accompanied by the danger of the eccentricity increasing in the reverse direction. In other words, when zero eccentricity is reached corresponding to maximum overload conditions the stops 85 and 86 engage. When the overload is removed stops 80 and 81 are urged towards one another again and stops 85 and 86 part an equivalent amount. Thus it may be said that while the members of one set of stops are being urged

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operatively towards one another the members of the other set are opening up. In the normal operating condition, stops 80 and 81 are urged together and in the neutral or inoperative, or maximum overload, conditions stops 85 and 86 abut. Reference 104 indicates a sealing ring to prevent the escape of oil from the casing.

In FIGURE 10 an alternative control mechanism is shown, a mechanism which does not permit adjustments of the follower throw to be effected while the shaft 43 is rotating. In this case stop 81 and its associated boss 83 are fast with an adjusting disc 105 which may be locked to a corresponding disc 106 fast with the shaft 43 through screw means 107 to adjust the spaced relationship of the stops 80 and 81 when the shaft is stationary.

Many more examples of the invention exist each differing from the other in matters of detail but in no way departing from the principles set out in the appended claims. The essence of the invention is the arrangement by means of which the throw of the follower may be adjusted so that devices employing the equipment have a control over the end function. In both embodiments the motion changing mechanism has been used for speed reducing purposes and in these cases speed control depends upon the duration that the straps grip the shaft during each cycle of the strap follower. Clearly the frequency of oscillation of the followers remains the same for the same speed of rotation of the drive shaft without regard to the follower throw. The effect of the throw is merely to alter the period in each cycle in which the strap is doing effective work in turning the output shaft. With small throws the effective working period in each cycle is small so that the linear movement of the output shaft is correspondingly small. At the other extreme of the permissible range of throws, i.e. with large follower oscillations the movement is much greater. In other words for a constant frequency of oscillation but with differing follower throw the speed of rotation of the output may be varied.

I claim:

1. Apparatus for the conversion of rotary motion into reciprocating motion, said apparatus comprising a drive shaft, a first cylindrical eccentric mounted on and fixed to the shaft, a second cylindrical eccentric mounted snugly on the first eccentric, the first and second eccentrics being rotatable relative to one another to vary the eccentricity of the second eccentric relative to the axis of rotation of the shaft, follower means adapted for undergoing oscillation upon eccentric rotation of the second eccentric, a flyweight system adapted to orbit the shaft under the influence of centrifugal force, said flyweight system including a linkage system coupled to at least one of said eccentrics, the linkage system including elements respectively secured for rotation to at least said one eccentric, which elements are relatively movable upon radially outward movement of the flyweight system to increase the eccentricity of the second eccentric with respect to the shaft, the reaction of said follower means on said second eccentric tending to move said second eccentric into concentric relation with said shaft.

2. The apparatus as claimed in claim 1 in which the elements of the linkage systems are arms respectively secured for rotation with the first and second eccentrics, the arms being coupled to the flyweight system through a flexible link slidably engaging at least one weight such that relative movement of the eccentrics acting to vary the effective length of the link alters the orbital radius of the weight about the axis of the shaft.

3. The apparatus as claimed in claim 2 comprising a plurality of weights including the first said weight symmetrically disposed about the shaft, all of the weights being engaged by the flexible link.

4. Apparatus for the conversion of rotary motion into reciprocating motion, said apparatus comprising a drive shaft, a first cylindrical eccentric mounted on and fixed to the shaft, a second cylindrical eccentric snugly mounted

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on the first eccentric, the two eccentrics being rotatable relatively to one another to vary the eccentricity of the second eccentric relative to the axis of rotation of the shaft, follower means for the second eccentric adapted for undergoing oscillation upon eccentric rotation of the second eccentric, a flyweight system adapted to orbit the shaft under the influence of centrifugal force, said flyweight system including a linkage system coupled to both eccentrics, the linkage system including an element rigid with at least one eccentric, which elements are relatively movable upon radially outward movement of the flyweight system to increase the eccentricity of the second eccentric with respect to the shaft, the reaction of said follower means on said second eccentric tending to move said second eccentric into concentric relation with said shaft, said control means for varying the orbital radius of the flyweight system in order to control the throw of the follower means, the control means including a stop rigid with the shaft and a mating stop rigid with the second eccentric such that upon engagement of the stops the shaft and second eccentric are locked against relative movement and hold the flyweight system to rotation in a predetermined orbit, and regulator means for adjusting the angular setting of the stops when the shaft is stationary.

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5. The apparatus as claimed in claim 4 in which the regulator means includes a boss arrangement with which the stop on the shaft is rigid and means for detachably securing the boss in any desired position on the shaft.

6. The apparatus as claimed in claim 5 in which the regulator means includes a helically threaded portion on the shaft, a sleeve covering the threaded portion on the shaft and rigid with the boss and having at least one axial slot, and a traveller nut on the shaft with a projection engaging in the slot such that movement of the nut along the shaft causes the sleeve to turn and thereby alter the angular relationship of the stops.

7. The apparatus as claimed in claim 6 comprising a rotatable housing enclosing the sleeve and adapted upon rotation to move the nut.

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