May 23, 1939. W. H. JOHNSON 2,159,739

OVERLAPPING CAM ACTION

Filed June 18, 1936 4 Sheets-Sheet 1

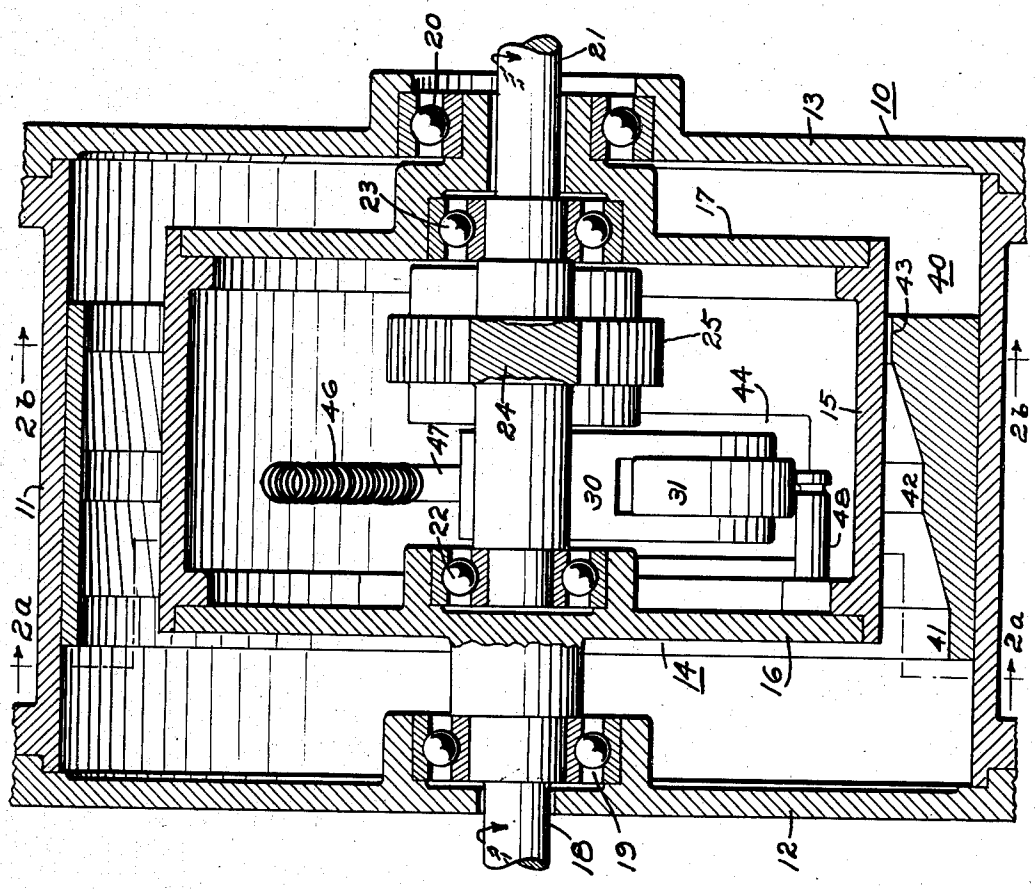


FIG 1

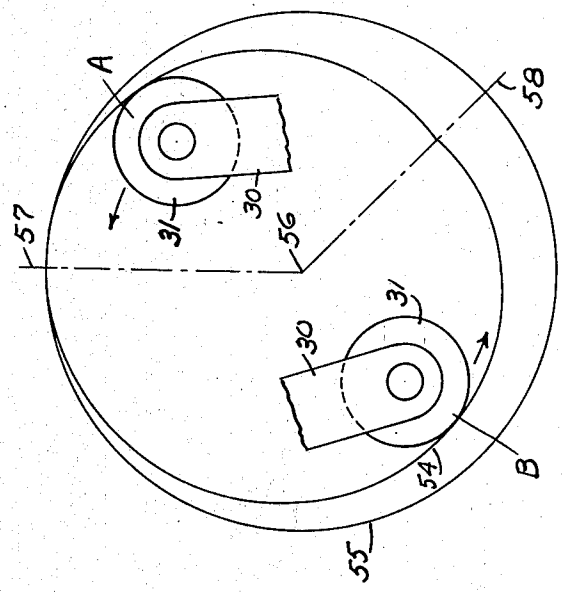


FIG 4

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OVERLAPPING CAM ACTION

Filed June 18, 1936 4 Sheets-Sheet 2

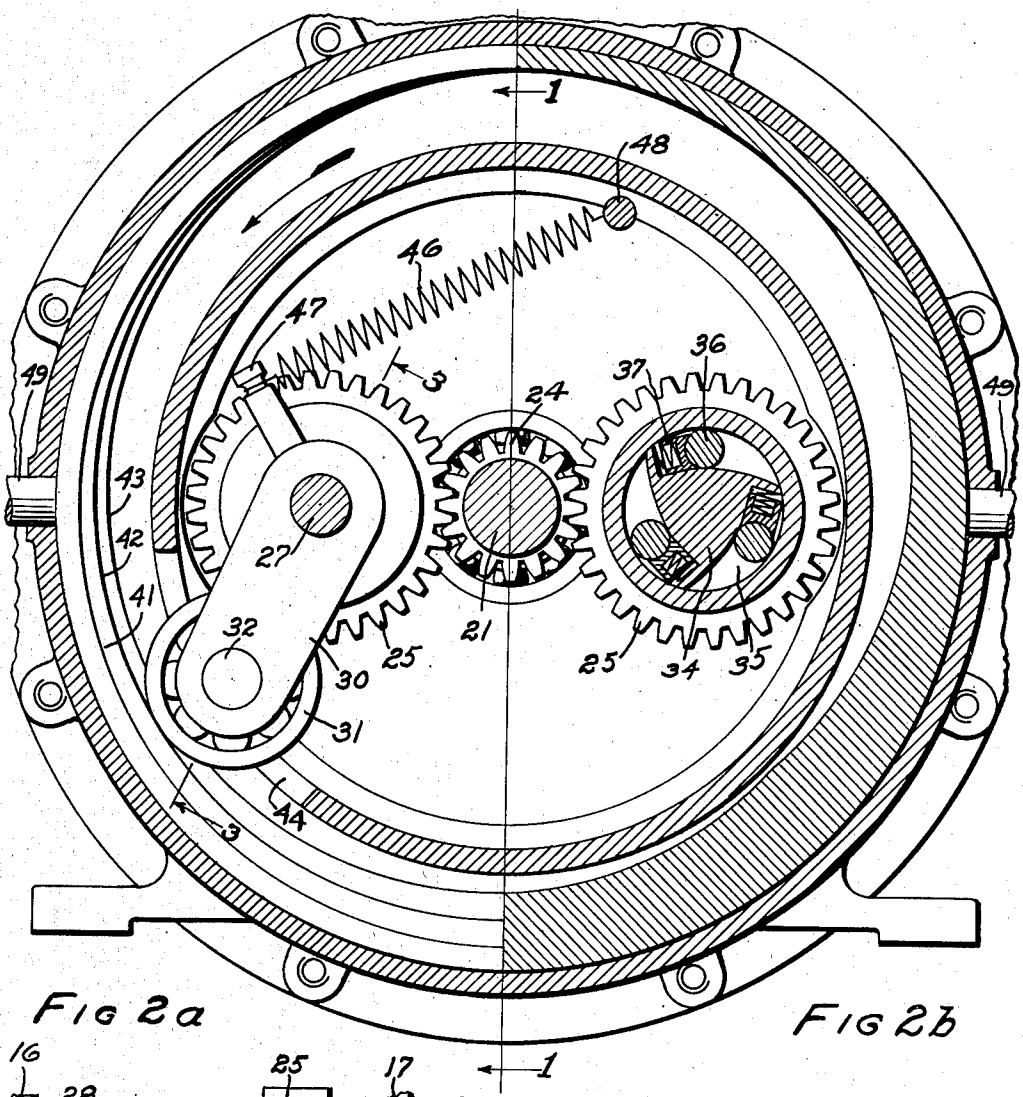


FIG 2a

FIG 2b

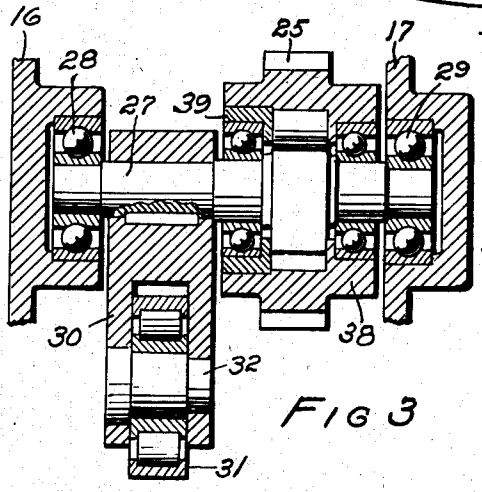


FIG 3

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OVERLAPPING CAM ACTION

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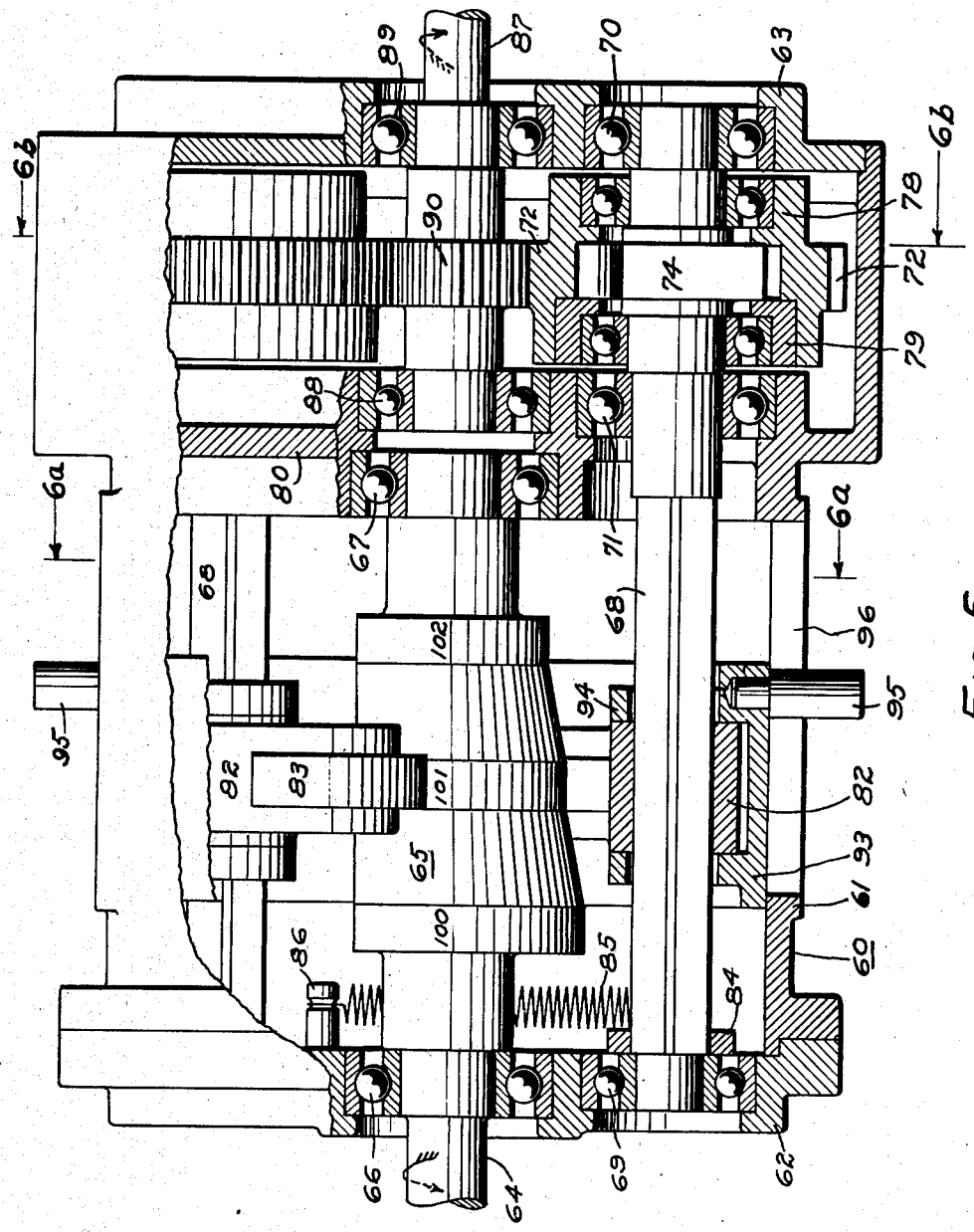


FIG 5

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OVERLAPPING CAM ACTION

Filed June 18, 1936 4 Sheets-Sheet 4

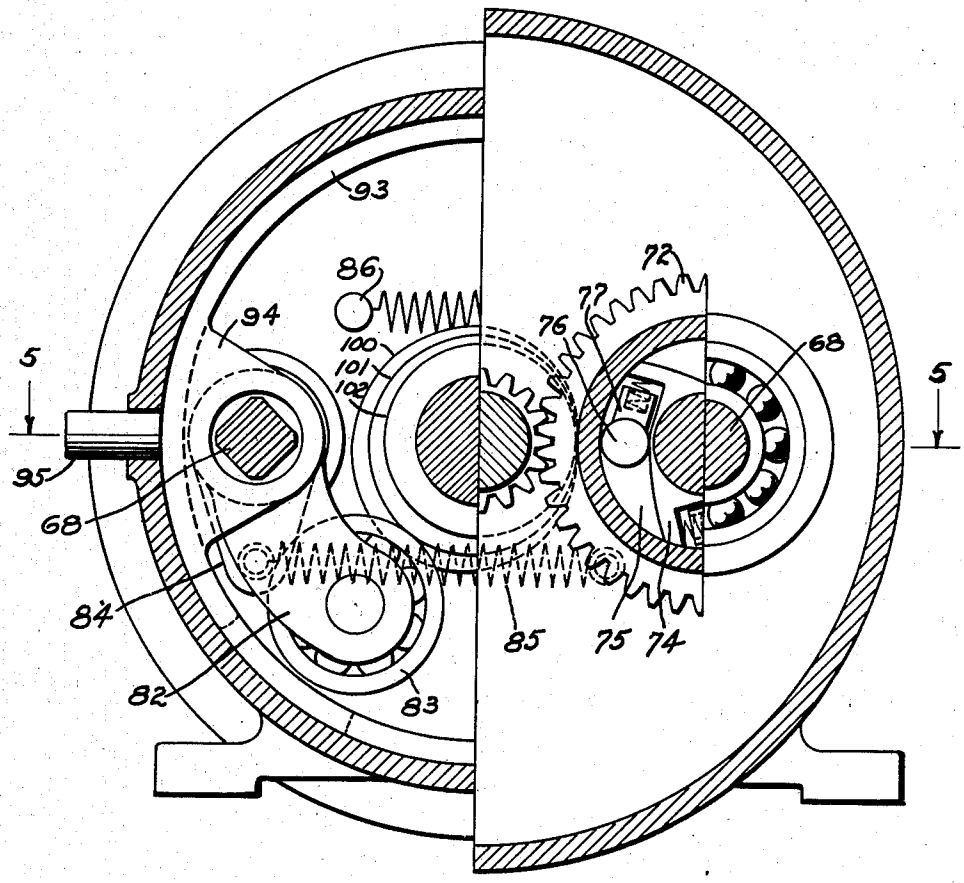


FIG 6a FIG 6b

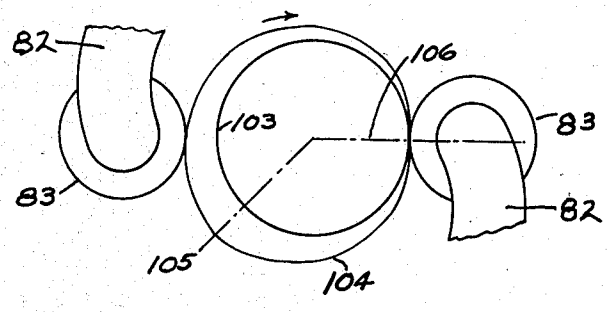


FIG 7

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Patented May 23, 1939

2,159,739

UNITED STATES PATENT OFFICE

2,159,739

OVERLAPPING CAM ACTION

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Application June 18, 1936, Serial No. 85,841

1 Claim. (Cl. 74—115)

The invention relates to mechanical transmission and, more particularly, to cam and follower mechanism.

According to the invention, a cam surface is provided having a plurality of followers preferably mounted for relative rotation. The high and low points of the cam surface may be so arranged with respect to the position of the followers that each follower in riding from its lowermost position to its uppermost position assumes its load before the preceding follower has released its load. Thus, an overlapping or continuous cam action is obtained which eliminates any undesirable effects due to lost motion.

The cam surface may have any desired circumferential configuration, but it has preferably a configuration of such shape as to impart substantially uniform velocity to the shaft driven by the followers. The cam surface may have a flaring or conical form so that, by axially shifting the cam drum and followers relatively, the throw of the followers, and consequently the speed of the driven shaft, may be changed by infinitesimally small steps with constant speed of the drive shaft and consequently constant angular velocity of the followers relative to the cam. If desired, suitable annular steps may be provided in the cam surface corresponding to predetermined most desirable speed ratios. The circumferential configuration of the cam is preferably similar at each point with the low points in line and the high points in line, the throw of the cam surface decreasing toward one end to a true circle having zero throw.

According to one embodiment of the invention, the special cam surface may be placed on the inside of a cam ring. Within this ring may be mounted a rotary casing to which the drive shaft is connected. The casing carries the plurality of followers which roll on the cam surface. These followers may be pivoted on the drum and the drum may carry a plurality of planetary gears each having incorporated therein an overriding clutch operated by one of said followers. Also within the casing may be a driven gear meshing said planetary gears, to which the driven shaft is connected. Speed variation may be obtained by axially shifting the cam ring.

If desired, the overlapping cam action and infinitely variable speed operation may be obtained by other types of cams, as for example, flat cams and drum cams. In the case of a drum cam, the cam surface may be the outside of a drum attached to a driven shaft. The followers may be pivoted to the stationary housing. The oscillating motions of the followers may be applied through overriding clutches to transfer gears which in turn mesh with a driven gear attached to the driven shaft. The transfer gear and driven gear are mounted on the stationary housing. Speed variation may be obtained by axially shifting the followers on their shafts.

This application is a continuation in part of application Serial No. 11,913, filed March 20, 1935.

The invention also consists in certain new and original features of construction and combination of parts hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Fig. 1 is a vertical section through a transmission embodying the cam action according to the invention taken on the line 1—1 of Fig. 2;

Figs. 2*a* and 2*b* are sections taken on the lines 2*a*—2*a* and 2*b*—2*b* of Fig. 1;

Fig. 3 is a detail of the follower and overriding clutch mechanism taken on the line 3—3 of Fig. 2*a*;

Fig. 4 is a diagrammatic view illustrating the cam action;

Fig. 5 is a longitudinal section of a modified form of transmission;

Figs. 6*a* and 6*b* are sections taken on the lines 6*a*—6*a* and 6*b*—6*b*, respectively, of Fig. 5; and

Fig. 7 is a diagrammatic view illustrating the cam action.

In the following description and in the claims, various details will be identified by specific names for convenience, but they are intended to be as generic in their application as the art will permit.

Like reference characters denote like parts in the several figures of the drawings.

In the drawings accompanying and forming part of this specification, certain specific disclosure of the invention is made for purposes of explanation, but it will be understood that the details may be modified in various respects without departure from the broad aspect of the invention.

Referring now to the drawings, and more particularly to Figs. 1–4, the transmission comprises a stationary housing 10 having an annular body 11 with detachable ends or heads 12 and 13. The heads 12 and 13 may be secured to the body in any desired manner, as by suitable bolts. If desired, the housing may be filled to a suitable level with lubricant for lubricating the mechanism.

Mounted within the housing 10 is a casing 14 having a drum portion 15 and detachable heads 16 and 17 secured thereto by bolts or in any other desired manner. Head 16 is suitably secured to drive shaft 18 and is journalled in a ball bearing 19 supported in a hub on the end plate 12 of the housing. The head 17 is provided with a

hub which is journalled in a ball bearing 20 supported by a hub on the end plate 13 of the housing.

The driven shaft 21 is journalled by ball bearing 22 in a hub on head 16 and by a ball bearing 23 in a hub on head 17. The driven shaft 21 carries a gear 24 which meshes a plurality of planetary gears 25 (see Figs. 2a and 2b).

Journalled in the rotatable casing 14 are a plurality of oscillating shafts 27. Each shaft 27 (Fig. 3) is journalled by ball bearings 28 and 29 in suitable hubs on heads 16 and 17. Each shaft 27 carries a follower arm 30 which in turn carries a roller or wheel 31 which may be the outer race of a roller bearing whose inner race is mounted upon shaft 32. The outer end of arm 30 is suitably forked and the shaft 32 secured thereto.

Each gear 25 is made hollow and has a hub portion 38 journalled upon shaft 27 by a suitable ball bearing. Within the hollow gear 25 is a core or holder 34 secured to the shaft 27. The core 34 has a series of tapered recesses 35 in which roll a series of rollers 36. Each roller 36 has a spring assembly 37 behind it which normally tends to wedge its roller in between the outer casing formed by gear 25 and the core 34. The gear 25 is provided with a bushing 39 suitably journalled on shaft 27 by a suitable ball bearing for closing the overriding clutch space and holding the clutch parts in position.

Mounted within the body 11 of the housing 10 is a cam ring 40. This cam ring is slidable longitudinally of the housing and is provided with diametrically disposed pins 49 (Figs. 2a and 2b) slidable in longitudinal slots in the body 11. It will be understood that suitable external devices (not shown) will be provided for longitudinally moving the pins 49 axially of the housing 10 to change the speed ratio as hereinafter explained more in detail.

The circumferential configuration of the cam surface of the cam 40 is similar at each transverse section, but the eccentricity or throw of the surface varies from the right hand end in Fig. 1 to the left hand end. The line 54 in Fig. 4 represents the curvature of the cam surface at the right hand end in Fig. 1, while the line 55 in Fig. 4 represents its curvature at the left hand end of Fig. 1. The throw of the cam surface at the left hand end of Fig. 1 is zero, the line 55 being a true circle. The cam surface 40 is provided with a series of annular steps, indicated by 41, 42 and 43, with inclined portions therebetween. These steps have similar annular characteristics throughout the longitudinal extent of each step and are for the purpose of providing stable positions on which the rollers 31 may roll. It will be understood that these steps are not absolutely necessary, but are only provided when special speed ratios are used more than any other.

Referring again to Fig. 4, the circumferential configuration of the cam surface of cam 40 is of a special form to obtain constant angular velocity of the followers. The high points of the cam surface throughout the entire longitudinal extent of the cam fall along the line 58, and the low points along the line 57. The configuration of the cam surface from the line 57 to the line 58, going in the direction of the arrow, is such as to impart a uniform rotary motion to the gear 25 as the follower wheel 31 moves from the line 57 to the line 58.

As the follower 31 moves from its low point on the line 57 to its high point on the line 58, it does work and drives its respective gear 25 through its overriding clutch. As the cam follower 31 returns from its high point on line 58 to its low point on line 57, it retracts its overriding clutch, the follower being held against the cam surface by its spring 46.

The configuration of the cam surface and the mounting of the cam followers are so arranged as to obtain an overlapping driving action. It will thus be seen from an examination of Fig. 4 that the follower, indicated by A, will pass the line 57 before the follower, indicated by B, reaches the line 58. Thus the follower A will take up its load before B releases its share of the load. This provides a continuous driving action, eliminating driving shock and greatly improving the smoothness of the drive even after the parts have become worn.

For yieldably holding the followers 31 against the cam surface in all positions of rotation of the followers and of axial movement of the cam 40, each is provided with a spring 46 secured to a pin 47 affixed to the follower arm 30. The other end of spring 46 is secured to a peg 48 affixed in the casing 14. The casing 14 is provided with recesses 44 through which the follower arms 30 and follower wheels 31 may project. If desired, to improve the engagement between the rollers 31 and the inclined parts of the cam surface, the edges of the rollers 31 may be rounded.

In operation, as the drive shaft 18 rotates in the direction of the arrow, the casing 14 revolves, causing the driven shaft 21 to rotate at the same speed and in the same direction as the drive shaft, when the rollers 31 are on the step 41 where the cam surface is truly concentric as represented by the line 55 in Fig. 4. No reciprocating motion takes place in the followers or in the three-roll overriding clutches at this time.

As the cam 40 is moved longitudinally so that an inclined part of the cam surface engages the rollers 31, the contour of the cam surface imparts a reciprocating motion to the followers which causes the driven shaft to rotate in the same direction as the drive shaft 18 and the casing 14, but at an increased speed. Thus, this speed may be increased by infinitely small amounts, depending upon the axial position of the cam 40 until the followers 31 engage the step 43 where maximum speed for the driven shaft 21 is reached. An overdriving action is thereby obtained between the drive shaft 18 and the driven shaft 21.

It will be noted, particularly from Fig. 4, that, as the casing 14 rotates, the follower arms 30, rotating in the direction of the arrows, push the rollers 31 along the cam surface. If desired, the mechanism may be so arranged that the follower arms 30 pull the rollers 31 along the cam surface.

Obviously, any number of steps may be provided on the cam 40, or, if desired, no steps may be provided, the cam being continuously inclined from one end to the other. Or, if desired, the cam may have but a single step with no provision for variation of speed ratio.

Referring now to Figs. 5, 6 and 7, the stationary housing 60 comprises a generally cylindrical body 61 with detachable heads or ends 62 and 63. Here the drive shaft 64 carries a drum type cam 65. The drive shaft 64 is journalled in a roller bearing 66 carried by the head 62 and in a roller bearing 67 carried by an intermediate support 80.

The cam 65 has the same general shape of cam surface as the cam 40 in Fig. 1 and its rotation serves to oscillate the follower arms 82 carrying the follower wheels 83. Each follower is mounted

upon a longitudinal shaft 68 mounted in the stationary casing. Each shaft 68 is journalled by bearing 69 in head 62 and by roller bearing 71 in support 80 and by roller bearing 70 in head 63. Each follower 82 has a square bore in its hub by which it is slidably mounted on its respective square shaft 68.

Oscillation of each shaft 68 drives a gear 72 through an overriding three-roll clutch similar to that forming part of gear 25 in Fig. 3. Here the core 74 is secured to shaft 68 and carries the tapered recesses 75 within which are held the rolls 76. These rolls are wedged into the tapered recesses 75 between the core 74 and outer casing of gear 72 by spring assemblies 77. The gear 72 has a hub portion 78 mounted upon shaft 68 by a suitable ball bearing. It also has a bushing 79 mounted on shaft 68 by a suitable ball bearing for holding the overriding clutch assembly together.

Each gear 72 meshes with a single gear 90 mounted upon the driven shaft 87. Driven shaft 87 is journalled in stationary support 80 by roller bearing 88 and in the head 63 by roller bearing 89. Oscillation of the followers 82 causes the overriding clutches to drive gears 72 which in turn drive gear 90 continuously in a single direction.

For yieldably holding the followers 83 against the cam surface of cam 65, each shaft 68 is provided with an arm 84 axially fixed in position. The arm 84 is connected to a coil spring 85 which is connected to a peg 86 secured to the head 62.

For changing speed, provision is made for simultaneously shifting the followers 83 axially to engage different parts of the cam 65. The shifting mechanism comprises an annular drum 93 slidably mounted within the body 61 of the housing and having a pair of pins 95 projecting out through longitudinal recesses 96. The ring 93 carries two sets of ears 94 engaging opposite sides of the follower arms 82 and encircling shaft 61, but with a clearance hole to permit free rotation of the shaft.

The ring 93 is shifted by suitable external mechanism (not shown). This mechanism will be connected to the pins 95 and will move the ring 93 and followers axially, causing the followers to engage the different steps and inclined parts of the cam surface to obtain different speed ratios.

As stated above, the surface of cam 65 is constructed on the same principle as the surface of cam 40. Here, however, the cam is provided with steps 100, 101 and 102. The step 102 corresponds to zero throw of the cam followers. This point is represented by the line 103 in Fig. 7. The line 104 represents the position of maximum throw which would be obtained by the step 100. The high points of the cam lie along the line 105, while its low points lie along the line 106.

When the followers 83 contact the concentric part of the cam 65, i. e. the step 102, there is no motion imparted to the overriding clutches and consequently the driven shaft 87 is at rest. When the followers 83 are moved toward the eccentric section of the cam, the followers 83 and arms 82 rock back and forth, depending upon the amount of throw of that particular section of the cam. The oscillation of the cam and followers oscillates the square shaft 68, which in turn drive the gears 72 through the overriding clutches. As the followers 83 move from a low position along the line 106 to a high position along the line 105, the overriding clutches engage to drive the gear 90 and driven shaft 87. The driven shaft 87 will rotate in a direction opposite to that of the drive shaft 64.

By adjusting the ring 93 axially of the housing, an infinitely variable speed ratio is obtained between zero speed of the driven shaft 87 and maximum speed. The followers are held against the cam surface during their return stroke from the high point 105 to the low point 106 by the springs 85, during which time the overriding clutch of the particular follower is retracted.

The relation between the cam surface and cam followers in this case is such as to obtain the overriding cam action obtained in the first modification, as explained above. Each follower takes up its share of the load before the preceding follower releases its share of the load.

In Fig. 5, it will be noted that the driven shaft 87 rotates oppositely from the drive shaft 64. By reversing the cam 65 end for end, the drive shaft may be revolved in the same direction as the driven shaft. In other words, the drive shaft, by changing the cam, can operate in either direction, but the driven shaft always operates in the same direction due to the frictional characteristics of the overriding clutches.

It will be noted, particularly from Fig. 7, that, as the cam 65 rotates in the direction of the arrow, it exerts a pushing action on follower arms 82 as the rollers 83 roll along the cam surface. If desired, the mechanism may be so arranged that the follower arms trail the cam surface with the rotation of the cam exerting a pulling action on the follower arms 82.

Thus, a type of transmission has been described which is rugged in construction and simple in operation. The overlapping cam action in either form above described provides smooth operation. Furthermore, by axially displacing the cam surface with respect to its followers, the speed ratio may be infinitely varied. In addition, due to the shape of the cam surface, uniform rotary motion may be given to the driven shaft when the drive shaft is rotated.

It will, of course, be understood that in each of the above described modifications, suitable counterweights (not shown) will be used to place all rotary parts in both static and dynamic balance so as to reduce vibration to a minimum.

While certain novel features of the invention have been disclosed and are pointed out in the annexed claim, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

In a cam and follower mechanism, an operatively stationary, sleeve cam member having an internal cam surface, said surface comprising a follower-raising portion and a follower-releasing portion constituting together the entire operating surface of the cam, an internal rotary member within said sleeve member, a pair of cam followers pivoted to said rotary member and engaging said cam surface at points spaced substantially 180° apart, said follower-raising portion extending through an angle greater than 180° from its low point to its high point, whereby each follower picks up its load before the other follower gives up its load.

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