March 11, 1941. T. H. RYAN 2,234,384

AUTOMATIC POWER TRANSMISSION DEVICE

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Fig. 1.

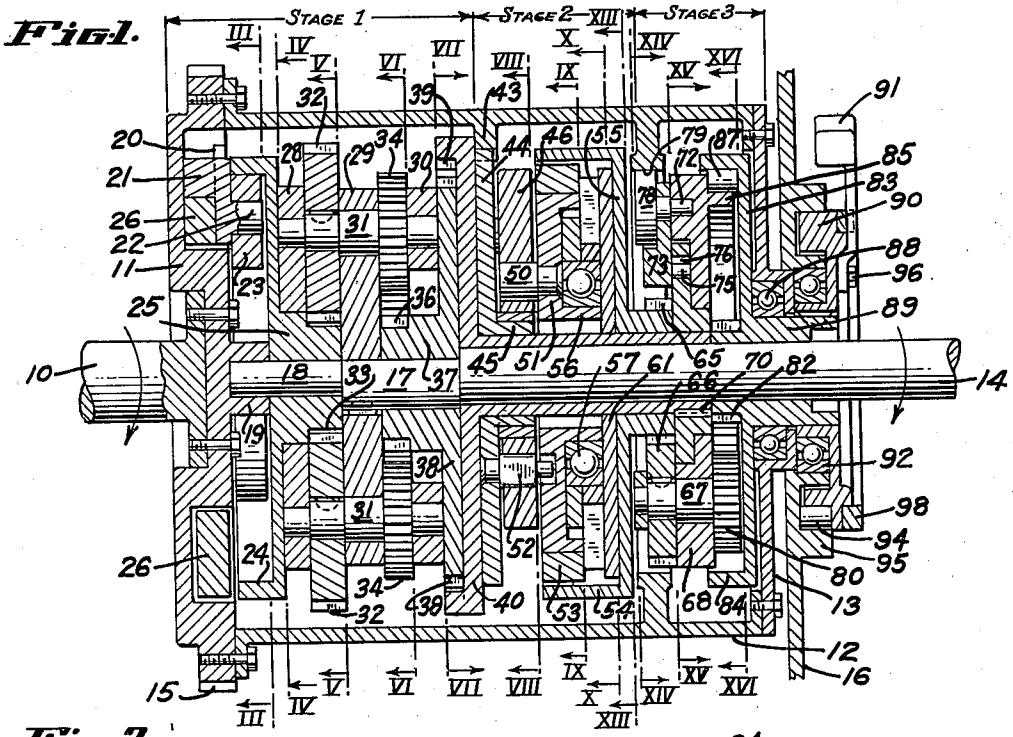
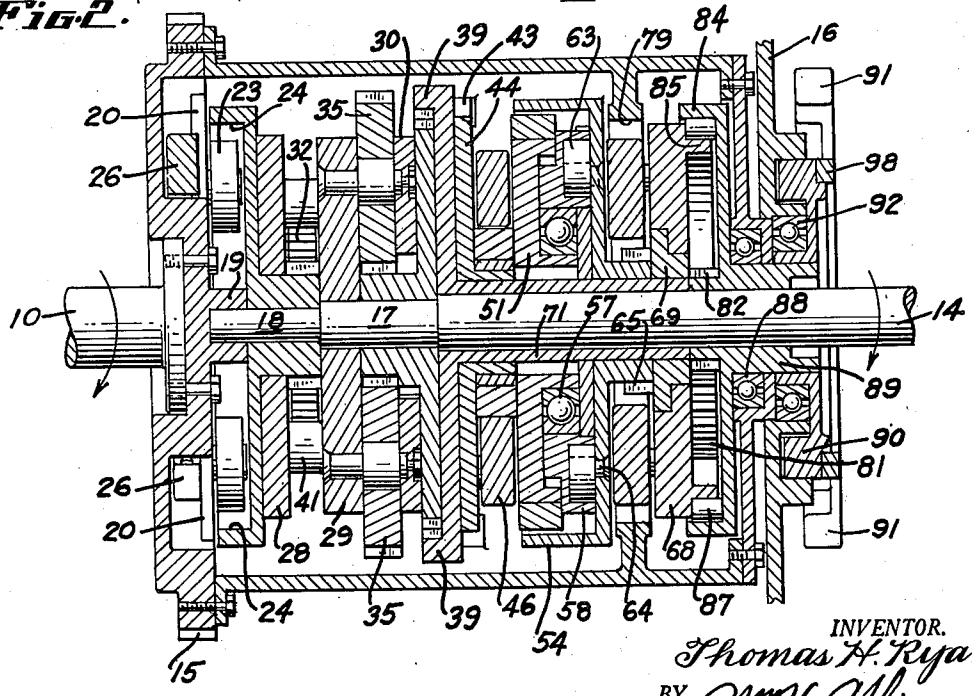


Fig. 2.



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Fig. 3.

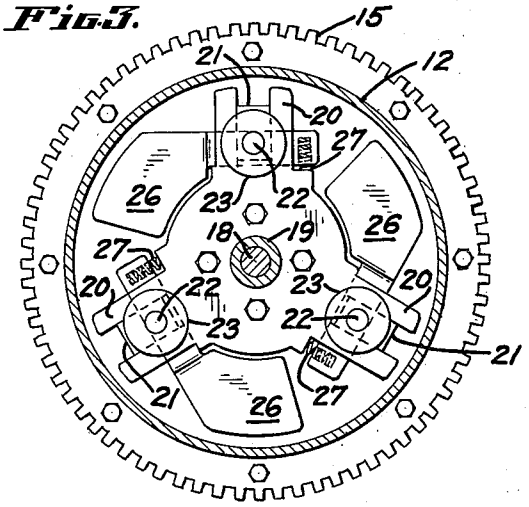


Fig. 6.

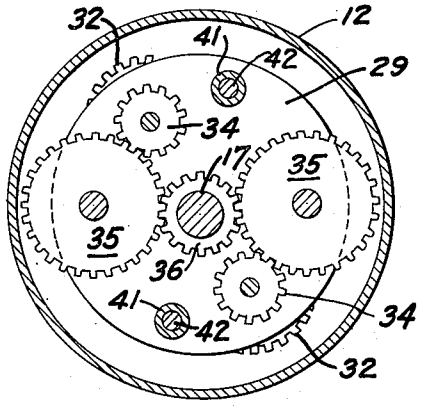


Fig. 4.

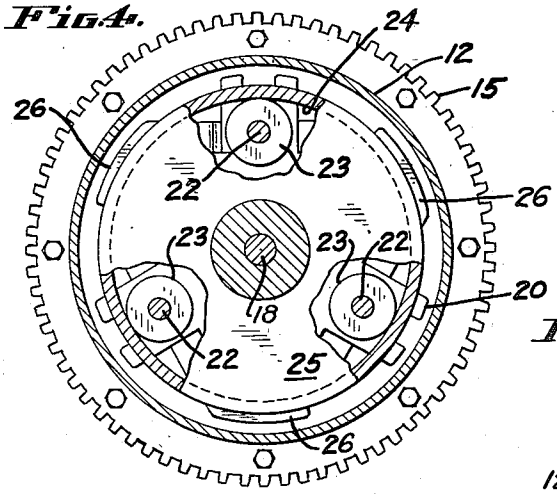


Fig. 7.

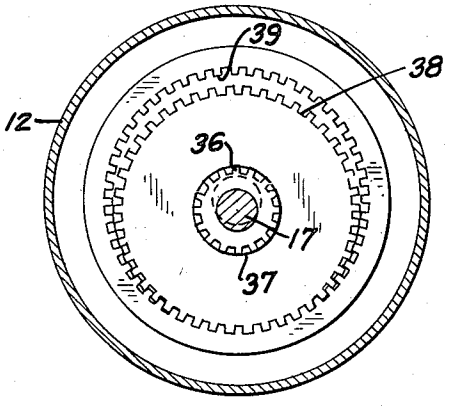
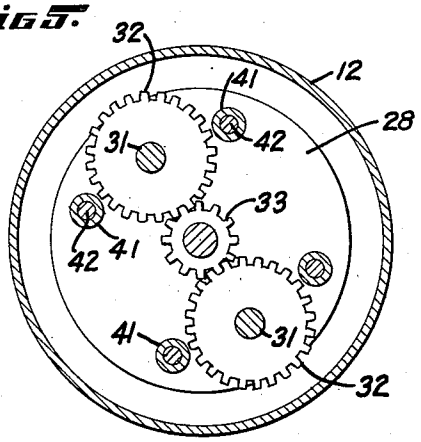


Fig. 5.



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Fig. 8.

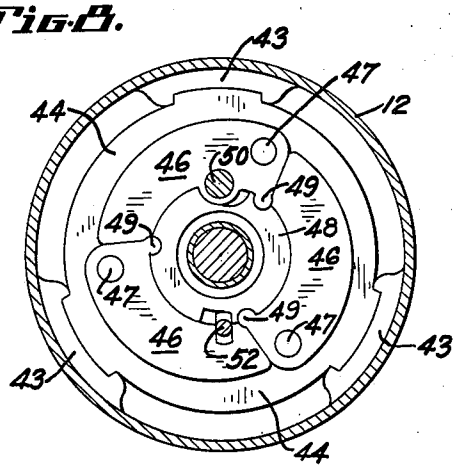


Fig. 9.

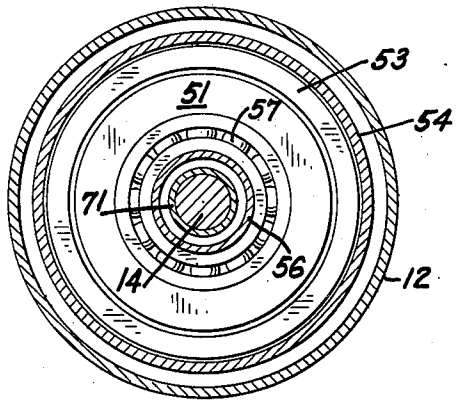


Fig. 10.

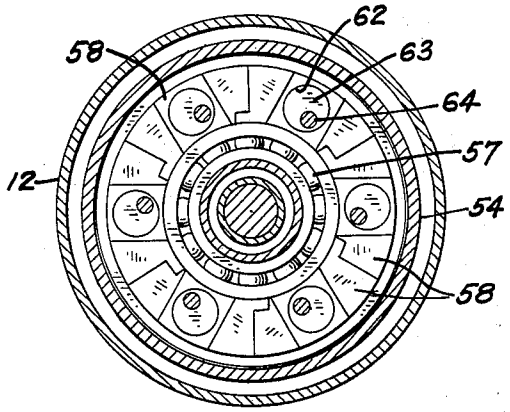


Fig. 11.

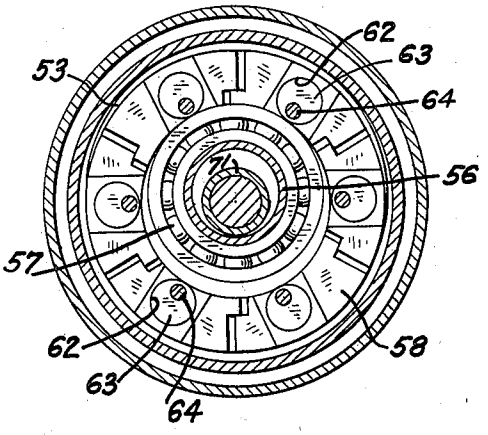
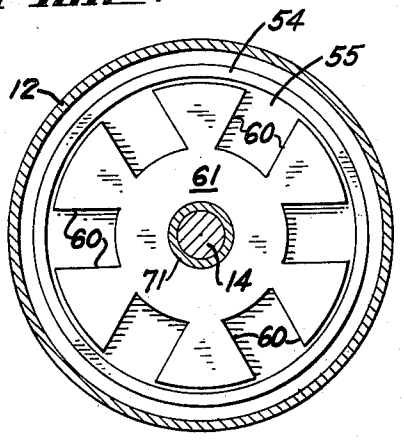


Fig. 12.



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Fig13.

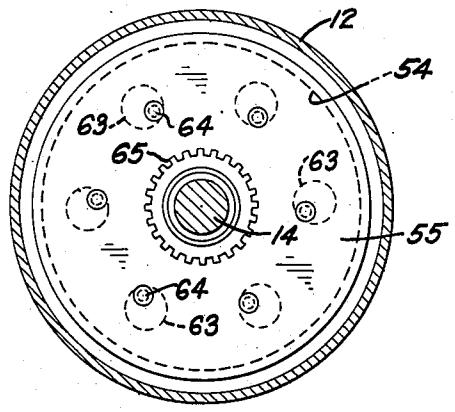


Fig14.

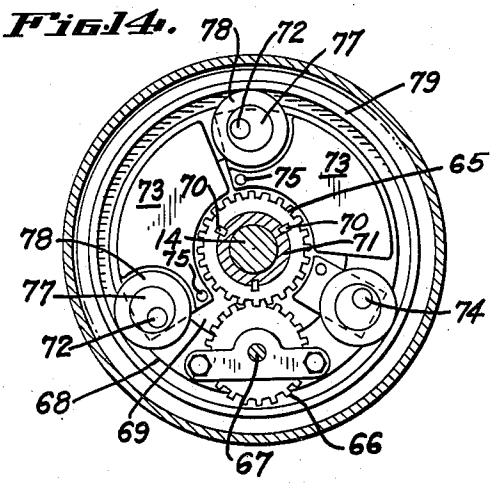


Fig15.

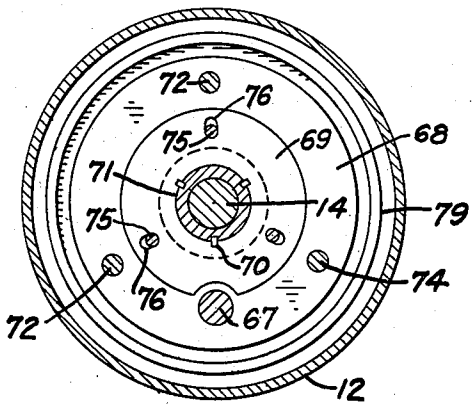


Fig16.

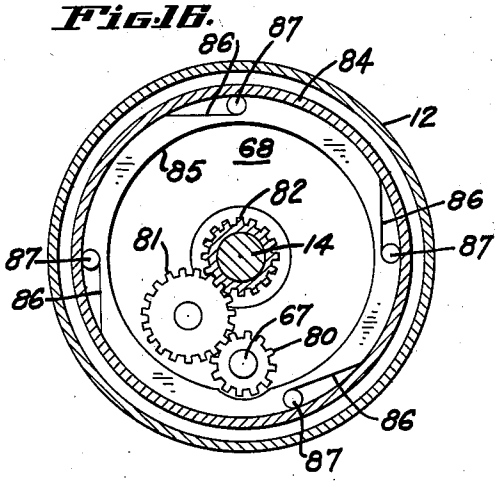
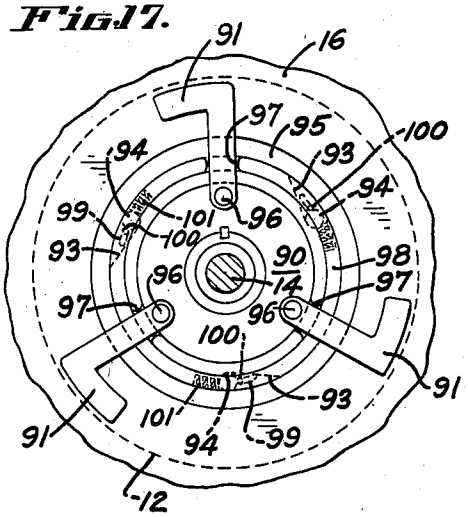


Fig17.



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Fig.18.

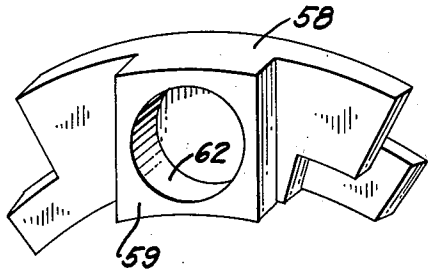


Fig.19.

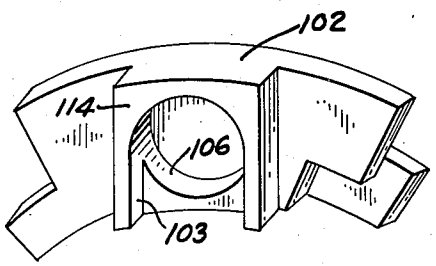


Fig.20.

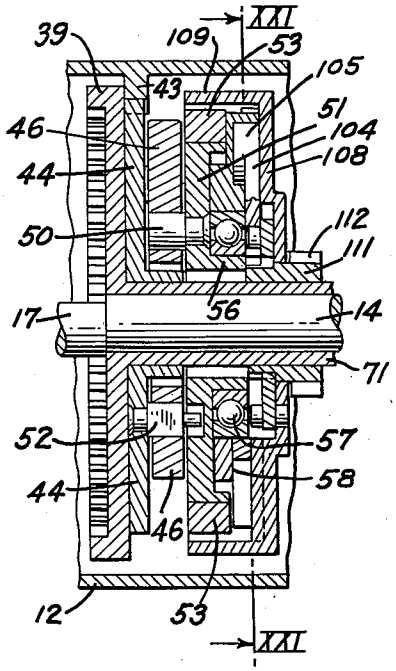
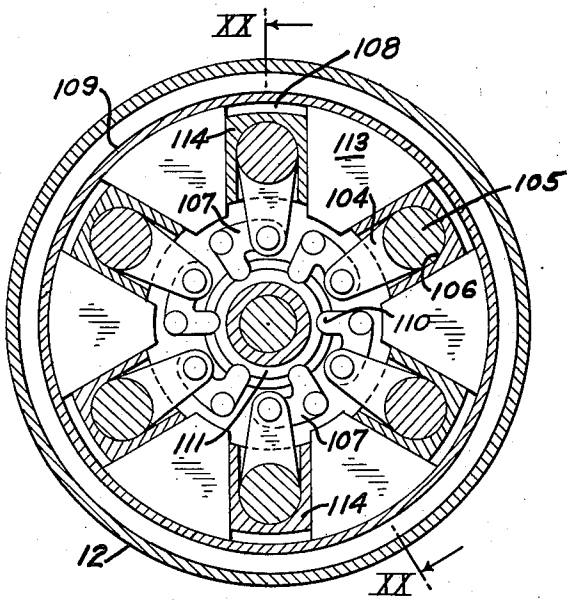


Fig.21.



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Patented Mar. 11, 1941

2,234,384

UNITED STATES PATENT OFFICE

2,234,384

AUTOMATIC POWER TRANSMISSION DEVICE

Thomas H. Ryan, San Francisco, Calif.

Application February 24, 1939, Serial No. 258,228

16 Claims. (Cl. 74—260)

The present invention relates to power transmission devices and more particularly to a variable torque transmitting mechanism which when interposed between the driving and a driven shaft will automatically provide for a speed reduction between these shafts that is dependent upon the load carried by the driven shaft and the speed of the driving shaft.

An object of the invention is to provide a transmission device for use between an internal combustion engine and the driving shaft of an automobile that will automatically provide for a smooth and efficient acceleration of the automobile without overloading the engine.

Another object of the invention is to provide an automatic transmission device for obtaining a speed reduction between a driving and a driven shaft which is dependent upon the speed of the driving shaft and/or the load on the driven shaft.

A further object of the invention is to provide an automatic power transmission device having a plurality of centrifugally responsive elements that successively come into operation to produce a variable torque transmitting means through which power is transmitted from a driving shaft to a driven shaft.

Another object of the invention is to provide an automatically operating device for the transmission of power from a driving to a driven shaft which will permit an initial free rotation of the driving shaft and subsequently come into operation automatically to transmit torque from the driving shaft to a driven shaft.

A further object of the invention is to provide in a power transmission device of the character described, means that will become effective automatically to prevent any over-running of the driven shaft when the device is used in an automobile drive.

Other objects and advantages of the invention will be in part pointed out hereinafter and in part evident to those skilled in the art as the description thereof proceeds.

For a better understanding of the invention reference should be had to the accompanying drawings, wherein there is shown by way of illustration and not of limitation, apparatus constructed in accordance with a preferred embodiment of the invention.

In the drawings, wherein like numerals refer to like parts throughout the several views—

Figure 1 is a vertical sectional view taken through the center of a preferred form of the invention,

Figure 2 is a horizontal sectional view taken along the axis of the device illustrated in Figure 1,

Figure 3 is a sectional view taken along line III—III of Figure 1 looking in direction of arrows,

Figure 4 is a sectional view taken along line IV—IV of Figure 1 looking in direction of arrows,

Figure 5 is a partial sectional view taken along line V—V of Figure 1 looking in direction of arrows,

Figure 6 is a sectional view taken along line VI—VI of Figure 1 looking in direction of arrows,

Figure 7 is a sectional view taken along line VII—VII of Figure 1 looking in direction of arrows,

Figure 8 is a sectional view taken along line VIII—VIII of Figure 1 looking in direction of arrows,

Figure 9 is a sectional view taken along line IX—IX of Figure 1 looking in direction of arrows,

Figure 10 is a sectional view taken along line X—X of Figure 1 looking in direction of arrows,

Figure 11 is a view similar to that of Figure 10 showing the parts in another position which they will assume during an operation of the device,

Figure 12 is a fragmentary sectional view corresponding to Figures 10 and 11 with parts removed,

Figure 13 is a sectional view taken along line XIII—XIII of Figure 1 looking in direction of arrows,

Figure 14 is a sectional view taken along line XIV—XIV of Figure 1 looking in direction of arrows,

Figure 15 is a sectional view taken along line XV—XV of Figure 1 looking in direction of arrows,

Figure 16 is a sectional view taken along line XVI—XVI of Figure 1 looking in direction of arrows,

Figure 17 is a fragmentary end view of the device illustrated in Figure 1 of the drawings,

Figure 18 is a detailed perspective view of an element of the device,

Figure 19 is a detailed perspective view of the element shown in Figure 18 with changes which adapt it for use in a modified form of the invention,

Figure 20 is a fragmentary vertical sectional view showing a modified arrangement for one of the stages of the device taken along line XX—XX of Figure 21 looking in direction of arrows, and

Figure 21 is a sectional view taken along line XXI—XXI of Figure 20 looking in direction of arrows.

As illustrated in Figures 1 and 2 of the drawings, the transmission device contemplated by the invention is adapted to be interposed in driving relation between and concentric with two axially aligned shafts so that it may rotate as a whole or its internal parts may move relative to one or the other of these shafts or relative to each other during the operation of the device.

The driving shaft, designated by the numeral 10, carries an end plate or flange 11 that is fixedly secured to the end thereof. Extending rearwardly from this end plate 11 there is a cylindrical housing forming member 12 that carries an end closure or plate 13 at its other end. Extending through the end plate 13 and concentric with the driving shaft 10 there is a driven shaft 14. The end plate 11, the cylindrical housing forming member 12 and the end plate 13 form what may be termed an enclosing housing within which the torque and speed responsive elements of the device are enclosed. When completely assembled the housing formed by these members is adapted to be completely filled with a light grease or oil so that the parts will be effectively and completely lubricated. While the driving shaft 10 and the driven shaft 14 are here illustrated without any visible support, it is to be understood that these shafts will each be properly supported upon adequate bearings independently of the apparatus illustrated. It will also be understood where no keying means is shown between the concentric parts that these parts may have relative movement with respect to each other at various times during the operation of the device.

Before proceeding with the description of the internal mechanism it should be pointed out that the end plate 11 together with the cylindrical housing forming member 12 and the end plate 13 constitute the equivalent of a conventional fly wheel and for this reason the end plate 11 is shown as having gear teeth 15 at its outer periphery with which the pinion of a starting motor may engage. It will also be understood that the entire device, as illustrated in these figures of the drawings, will preferably be enclosed by an extending portion of the conventional crank case of the internal combustion engine. A portion of this crank case, designated by the numeral 16, is shown at the right hand end of these figures of the drawings. In this particular embodiment of the invention, the internal parts of the device are shown as having an axial dimension which permits all of the elements to be positioned in close fitting relation with each other where they will be retained in cooperating relation by the enclosing housing and without resort to any other means for preventing axial displacement or disengagement of the parts.

As indicated in Figure 1 of the drawings, the various elements of the device are arranged so that the transmission of power in respect to the relative speed between the driving and driven shaft is controlled in three separate stages, each one of which will take care of a particular range of the differential in speeds in a successive manner so that the increase in speed of the driven shaft in coming up to the speed of the driving shaft will be uniform throughout the entire range of operation of the three stages of the device. At this point it should be pointed out that the driven shaft 14, except for a small portion thereof, is concentric with the axis of the driving shaft 10. In this respect the shaft 14 is shown as having a slightly eccentric portion 17 which in operation will function as what may be termed a crank arm within the first stage of the device. Extending beyond the eccentric portion 17, the driven shaft 14 has a concentric extension 18 that is journalled in a central boss 19 upon the end plate 11.

As is more clearly illustrated in Figure 3 of the drawings, the end plate 11 is provided, in addition to the boss 19, with three sets of radially extending guides 20 between which roller supporting members 21 slide. The members 21 have extending stub shafts 22 upon which there is rotatably mounted rollers 23 that are adapted to engage the internal surface of an overhanging flange 24 carried by a rotatable member 25, as is more clearly illustrated in Figure 4 of the drawings. Normally, the rollers 23 are held against outward movement by the overhanging flange 24 of the rotatable member 25. Cooperating with the members 21, however, there are individual centrifugally operating weights 26 that are adapted to exert an outward pressure upon the members 21 as the speed of the shaft 10 increases. These weights 26 are here illustrated as fulcrumed upon compression springs 27 arranged opposite the centers of the rollers 23 and operate as will be hereinafter pointed out to produce a driving connection between these parts of the device as the speed of the driving shaft 10 increases. This portion of the device provides what may be termed a free running connection which will permit a starting of the internal combustion engine without an initial load. Next adjacent the member 25, there is a shaft supporting disc 28 that is rotatable with respect thereto. Associated with the supporting disc 28 there are two other supporting discs or rings 29 and 30 which provide a three point bearing for two oppositely disposed stub shafts 31. Keyed upon these stub shafts 31 between the supporting discs 28 and 29 there are two oppositely disposed gears 32 that mesh with a pinion 33 shown as cut in the projecting hub of the member 25. Similarly keyed upon the shafts 31 and between the supporting discs 29 and 30 there are two additional gears 34 that mesh with oppositely disposed idling gears 35 that engage a pinion 36 which is rotatably mounted upon the eccentric portion 17 of the driven shaft 14. The pinion 36 is illustrated as formed upon a hub 37 of an internal planetating gear 38 which during the operation of the device will first roll around the interior of a ring gear 39 formed upon a disc-like member 40 and subsequently form a driving connection with this internal ring gear 39 as the relative speed between the driving and driven shafts is reduced.

Before proceeding further and into a description of those elements of the device which constitute the second stage, it should be pointed out, as shown in Figures 5 and 6 of the drawings, that the shaft supporting discs 28, 29 and 30 are held in fixed relation and against angular displacement with respect to each other by spacing collars 41 and tie rods 42 and that the shafts 31 with their gears 32 and 34 are displaced from the vertical axis of the device so that the gears 34 thereupon will mesh with the idling gears 35 which, as illustrated in Figure 6, are mounted upon the horizontal center line of the device, as positioned in the drawings. In this connection it should be explained that the shafts 31 and 32 are purposely shown in Figures 1 and 2 of the drawings as on the vertical center line, in order to simplify the illustration and understanding

thereof. However, with this explanation, it is to be understood that the shaft 31 with its gears 32 and 34 will be angularly displaced with respect to their vertical axis, as illustrated in Figures 5 and 6 of the drawings. The necessity for this angular displacement of the shafts 31 with respect to the vertical axis of the device is to permit a positioning of the idling gears 35 upon centers along a line extending at a right angle to a line extending through the centers of the driven shaft 14 and the eccentric portion 17 thereof.

Upon referring to Figure 7 of the drawings, it will be noted that the teeth of the internal planetating gear 38 are adapted to mesh with the overhanging ring gear 39 as it planetates therewithin. In the particular device illustrated, the internal planetating gear 38 is provided with four less teeth than is the overhanging ring gear 39. Therefore, the relative speed between these two parts during any one complete revolution of one with respect to the other will be determined by the ratio between the number of teeth carried by these parts.

The above described elements constitute what may be considered the first transition stage of the device.

At this point it will be noted that the cylindrical housing forming member 12, as is more clearly shown in Figure 8 of the drawings, is provided with three radially spaced bosses 43 which support a disc-like member 44 that has an axially extending hub 45. The member 44 is made removable from the bosses 43 in order to facilitate an assembly of the parts but in operation it will function as an integral part of the cylindrical housing forming member 12. The disc-like member 44 carries three spaced centrifugally responsive weights 46. These weights 46, as is more clearly shown in Figure 8 of the drawings, are pivotally mounted at one end upon stub shafts 47 which project from the disc-like member 44. These weights 46 are also tied together by means of an interlocking oscillatable ring 48 into which extensions 49 upon the weights 46 project.

With this arrangement it will be seen that each of the weights 46 will be confined by reason of their engagement with the ring 48 to an outward movement of the same magnitude. As is clearly shown in Figures 1 and 8 of the drawings, the uppermost of the three weights 46 is engaged by a stub shaft 50 that is carried by a floating ring-like support 51 so that as the centrifugal weights move outwardly the stub shaft 50 with the floating support 51 will be moved into an eccentric position with respect to the central axis of the device. In order to confine the position of the floating support 51 along a definite radial line, this floating support slidably engages an oppositely disposed guide 52 that is carried by the disc-like member 44. It will also be seen that as the individual weights 46 move outwardly the forces exerted thereby will be transmitted through the synchronizing ring 48 and thus become additive to exert their entire force upon the stub shaft 50 to thus move the floating support 51 into an eccentric position where its outer periphery, shown as provided with a wear resisting ring 53, will engage with an overhanging lip 54 of another disc-like member 55. At this point it will be noted that the floating support 51 also has a hub portion 56 upon which there is mounted a ball bearing 57 which includes an inner and outer ball race.

Reacting against the forces exerted by the weights 46 to move the floating support 51 into an eccentric position, there is disposed about the ball bearing 57 a plurality of radially arranged interlocking sectors 58 which form what might be termed an expandable ring. The form which these sectors 58 may take is clearly illustrated in Figure 18 of the drawings. As shown in this latter figure of the drawings, in addition to their interlocking features the interlocking sectors 58 each have a radially disposed boss or guide engaging portion 59 that extends between oppositely disposed parallel guide surfaces 60 formed in a free floating tie plate 61 adjacent the disc-like member 55. This tie plate 61 is more clearly shown in Figure 12 of the drawings. Formed in the bosses 59 of the sectors 58, as illustrated in Figures 2 and 18 of the drawings, there is a cylindrical recess 62 into which an eccentrically movable cylinder 63 is disposed. The cylinders 63, of which there is one for each sector 58, are also shown as journaled upon eccentrically disposed stub shafts 64 which extend inwardly from the disc-like member 55. As shown in Figure 13, the eccentricity of the stub shafts 64 with respect to the cylinders 63 is such that the reacting force created by a load upon the disc-like member 55 will cause these eccentrically rotatable cylinders 63 to exert a contracting force upon the individual sectors 58 so as to cause them to move in unison toward the center of the device and thus exert a force tending to maintain the ball race 57 and the floating support 51 concentric with respect to the axis of the driving and driven shafts, as shown in Figure 10 of the drawings, while at the same time the centrifugal forces exerted by the weights 46 will tend to oppose and cause the floating support 51 with its ring 53 to assume an eccentric position, as illustrated in Figure 11 of the drawings.

Therefore, when the centrifugal force becomes greater than the opposing forces created through the eccentrically movable cylinders 63, the ring 53 will be moved outwardly into its eccentric position where it will engage the overhanging flange 54 of the member 55 and establish a driving connection therebetween which will cause the disc-like member 55 to rotate with the disc 44 carried by the cylindrical housing forming member 12. When this occurs, a pinion 65 formed upon the disc-like member 55 will operate to drive a gear 66 which is mounted upon a shaft 67 carried by an annular ring 68 which is mounted upon a bearing forming member 69 that is keyed as at 70 upon a sleeve 71 which extends from and is an integral part of the disc-like member 40 that carries the overhanging gear 39 of the first stage of the transmission device. In addition to forming a support for the shaft 67, the annular ring 68 also carries two spaced stub shafts 72 upon which centrifugal weights 73 are pivotally mounted, as is more clearly shown in Figure 14 of the drawings. A third stub shaft 74 which cooperates with the stub shafts 72 is also provided upon the annular ring 68. At a point spaced inwardly from their axis, the weights 73 each carry a pin 75 that engages radial slots 76 formed in the bearing forming member 69, as is clearly shown in Figures 1 and 15 of the drawings. Arranged eccentric to their axis, the weights 73 also have an outwardly extending cylindrical boss 77 upon which there are rotatably mounted roller forming rings 78. These roller forming rings 78 when urged outwardly, due to centrifugal force, by the weights 73, as will hereinafter ap-

pear, are adapted to engage a traction forming ring 79 which is arranged concentrically within and carried by the cylindrical housing forming member 12.

With this arrangement the eccentricity of the roller forming rings 78 with respect to the pivotal axis of the centrifugal weights 73 and with respect to the pins 75 carried by the centrifugal weights 73 is such that the torque or driving force transmitted through the keying connection 70 upon the extension 71 of the disc-like member 40 and the pins 75 will tend to overcome the centrifugal force exerted by the weights 73 and thus permit the bearing forming member 69 and the supporting ring 68 with the gear supporting shaft 67 to be rotated. When this occurs, a second gear 80 carried by the shaft 67 will be caused to rotate and drive an idler gear 81 which meshes with a third gear 82 formed upon a third disc-like member 83 that has an overhanging lip 84 at its outer periphery. Cooperating with the overhanging lip 84 of the disc-like member 83 the annular ring 68 has an outwardly extending flange 85 into which there are formed, as is more clearly shown in Figure 16 of the drawings, four substantially tangent notches 86 which at their deepest point accommodate interlocking rollers 87 that, as will hereinafter appear, serve to permit a relative rotary movement between the annular member 68 and the disc-like member 83 in one direction, but serve to prevent any relative movement between these parts in a reverse direction.

As shown in Figures 1 and 2, the disc-like member 83 is shown as movable about the driven shaft 14 and as journaled in the end plate 13 of the housing forming member 12 by means of a bearing 88 and as having an outwardly extending hub portion 89 upon which there is keyed an annular member 90 upon which centrifugally responsive weights 91 are mounted. The member 90 is shown as journaled in the end wall 16 of the transmission housing by means of a ball bearing 92 and arranged at its outer periphery this member 90, as is more clearly illustrated in Figure 17 of the drawings, has three substantially tangent recesses 93 that are adapted to accommodate one-way clutch forming rollers 94 that cooperate with an overhanging flange 95 upon the end wall 16 of the transmission housing to prevent any overrunning of the driven shaft 14 in the event of any sudden decrease in the load upon this shaft. As illustrated, the centrifugally responsive weights 91 are designed with an off-center mass at one side of radially disposed inwardly extending arms which are pivotally secured at their inner ends upon studs 96. These radially extending arms of the weights 91 are positioned in radially extending slots 97 formed in a ring 98 which is carried by the annular member 90. The annular member 90 immediately beneath the ring 98 is provided with slots 99 through which pins 100 carried by the ring 98 extend to a point where they engage with one side of the clutch forming rollers 94. Cooperating with the pins 100 and the ring 98 and at the opposite side of the clutch forming rollers 94 there are disposed small compression springs 101 which tend to urge the rollers 94 into clutching relation with the annular flange 95 upon the end wall 16 of the transmission housing. The ring 98 is movably mounted upon the annular member 90 so that any angular movement of the centrifugally responsive weights 91 will be transmitted to the ring 98 and thus cause it to move in a direction to force the rollers 94 against the action of the springs 101 and release this connection as soon as the speed of the driven shaft 14 becomes equal to the speed then obtaining at its point of connection with the internal mechanism of the transmission device.

Before proceeding with a further description of the embodiment of the invention illustrated and described in connection with the preceding figures of the drawings and particularly with respect to the operation thereof, reference is now made to Figures 19, 20 and 21 of the drawings for a description of a modified arrangement that may be used optionally with the arrangement described above as constituting stage 2 of the transmission device. In this variation of the invention the overhanging ring gear 39 and the disc-like member 44 which carries the centrifugal weights 46 and the floating support 51 with its wear resisting ring 53 and the ball bearing 57 are identical in construction and arrangement. The departure from the previously described embodiment of the invention resides in a change in the interlocking sectors, previously designated by the numeral 58, and the means for effecting an operating connection with the remaining elements which constitute the second stage of the device as modified.

As illustrated in Figure 19, the interlocking sectors, designated by the numeral 102, are cut out as at 103 to accommodate an inwardly extending link 104. Each of the links 104 is provided at its upper end with an enlarged cylindrical boss 105 that extends into a cylindrical recess 106 of the sectors 102. As is more clearly shown in Figure 21, the inner ends of the links 104 connect with bell crank forming members 107 that are pivotally mounted upon a free floating disc 108 which carries an overhanging lip 109 with which the wear resisting ring 53 of the disc-like member is adapted to cooperate as previously described. The inwardly projecting ends of the bell cranks 107, designated by the numeral 110, engage with a rotable sleeve 111 which is provided at its outer end with a pinion 112 that corresponds to the pinion 65 of the previously described embodiment of the invention. A further difference found in this embodiment of the invention over the previously described arrangement contemplates the provision of a plurality of radial bosses or extensions 113 upon the disc-like member 108 between which a guide engaging portion 114 of the sectors 102 are adapted to slide. In other words, in this embodiment of the invention the radial bosses 113, which are formed integral with the disc-like member 108, take the place of the free floating tie plate 61 previously described in connection with Figure 12 of the drawings. With this latter arrangement it will be seen, as illustrated in Figure 21, that when the rotatable sleeve 111 with the pinion 112 moves in a counter-clockwise direction the bell cranks 107 will be rotated in a clockwise direction about their pivotal axis and thus exert an inward pulling force upon the links 104 which will act through the interlocking sectors 102 to counteract the forces exerted by the centrifugal weights 46 which tend to move the floating support 51 and the ball bearing 57 into an eccentric position.

For the purpose of describing the operation of the device chosen to illustrate the principles of the present invention, it will first be assumed

that the driven shaft 14 is stationary and that the driving shaft 10 has just begun to rotate as in starting and later the operation of the device will be described as it occurs when an increased load is imposed upon the driven shaft 14, as for example, when a steep grade is being ascended.

When the driving shaft 10, as assumed above, begins to rotate at a slow speed it will cause the end plate 11, together with the cylindrical housing 12 and the other associated parts affixed therewith to also slowly rotate. The other associated parts referred to may be specifically identified as comprising the disc-like member 44 which carries the weights 46 and also the traction forming ring 79 which cooperates with the rollers 73 carried by the weights 73. At the same time the floating support 51 which carries the ball bearing 57 will also be rotated concentric to the axis of the driven shaft 14.

Now when the driving shaft 10 and the end plate 11 have attained sufficient speed, the centrifugal weights 26 carried by the end plate 11 will move outwardly and thus bring the rollers 23 carried thereby into driving relation with the overhanging flange 24 upon the rotatable member 25 and cause this latter member to slowly accelerate and eventually attain a speed corresponding to that of the driving shaft 10. As the rotatable member 25 rotates, the pinion 33 thereupon will exert pressure upon the gears 32 carried by the oppositely disposed counter-shafts 31. This pressure will be transmitted by the shafts 31 to the gears 34 which are likewise keyed upon the counter-shafts 31 and exert a driving force through the idler gears 35, shown in Figure 6, upon the pinion 36 carried by the internal planatating gear 38 which, as illustrated in Figure 7, meshes with the overhanging ring gear 39 formed upon the disc-like member 40. Since at this stage of the operation the disc-like member 40, as will hereinafter appear, is held stationary the pinion 36 upon the internal planetating gear 38 will form a traction surface about which the idler gears 35 will gyrate. This will exert a driving force upon the gears 34 carried by the eccentrically disposed counter-shafts 31 which will cooperate with the driving force imposed upon the gears 32 by the pinion 25 and turn the supporting disc 29 with the counter-shafts 31 and operate as a lever upon the eccentric portion 17 of the driven shaft 14 and thus cause the driven shaft 14 to rotate. In other words, during this operation the eccentric portion 17 of the driven shaft 14 will turn within the hub 37 of the internal planetating gear 38 while at the same time this gear 38 will planetate within the ring gear 39. At the same time the idler gears 35 which are driven by the gears 34 upon the counter-shafts 31 will tractively move around the pinion 36 upon the internal planetating gear 38 and thus cause a driving torque to be applied upon the driven shaft 14 through the offset or concentric portion 17 thereof. As the load on the driven shaft 14 gains momentum and thus presents a reduction in the load imposed upon the driving shaft 10 the disc-like member 40 will be relieved of pressure, as will hereinafter appear, and the subsequent stages of the device will then come into operation. When the above described elements which constitute stage 1 of the devcice come into full operation, the driven shaft 14 will be rotated at a slower speed than the driving shaft 10 by an amount which will be dependent upon the gear ratio provided between the pinions 33 and 36. This is dependent upon the diameters of the gears 32 and 34 upon the counter-shafts 31 and the ratio between the internal planetating gear 38 and the overhanging ring gear 39.

At this point some explanation as to the operation of the centrifugal clutching means carried by the end plate 11 should be given. For this purpose reference is made to Figures 3 and 4 of the drawings. As here shown, the centrifugal weights 26 are fulcrumed on yielding springs 27 the resilience of which is so proportioned that the weights 26 will not become fully operative to establish a fixed driving connection between the rollers 23 and the overhanging lip 24 of the rotatable member 25 until the engine or other motive power supplying unit has attained a suitable operating speed. The purpose of this centrifugal operating clutching means is to reduce the load upon the engine during the initial starting period. In other words, this clutching means frees the elements of stage 1 from the driving shaft 10 and leaves only the end plate 11, the cylindrical housing 12, the end plate 13 and the disc-like member 44, together with its associated parts to function as an inertia mass in the same manner as does the fly wheel customarily provided with internal combustion engines.

At this point it should also be pointed out that where the driven shaft 14 is arranged to be connected to the load through a suitable clutch the rotatable member 25 which carries the overhanging lip 24 may be permanently attached to or formed as an integral part of the end plate 11. Under these conditions the centrifugally responsive weights 26 can be dispensed with as the driven shaft 14 will then be permanently connected to the driving shaft 10 through the gears provided in stage 1 of the device as described above. With this arrangement in starting the driven shaft 14 will rotate at a considerably slower speed than the driving shaft 10. This will be determined by the speed ratio established by the gears 32, 34 and 35 between the driving shaft 10 and the driven shaft 14.

Before proceeding with the description of the operation as it pertains to the elements which constitute stages 2 and 3 of the device, an explanation will here be given as to how the disc-like member 40 with its overhanging ring gear 39 is held stationary during the initial starting operation, or in other words, when the elements of stage 1 are operating in the manner above described. It will be noted that the disc-like member 40 has a long cylindrical hub or sleeve 71 which extends through the elements that constitute stage 2 of the device. This sleeve 71 connects with the bearing forming member 69 by means of the keys 70, as is more clearly shown in Figure 14 of the drawings. Since the bearing forming member 69 is connected so as to have only a slight relative movement with respect to the annular ring 68 which is controlled by the position of the weights 73, it will be understood that except for this small angular movement permitted between the parts 68 and 69 the sleeve 71 of the disc-like member 40 is firmly attached to the annular ring 68. This is in fact true during the period when the disc-like member 40 is stationary, as the forces tending to rotate the disc-like member 40 counter-clockwise will at the same time tend to rotate the annular ring 68 in a counter-clockwise direction and thus cause the rollers 87 which are carried by the annular ring 68 to roll outwardly and establish a non-rotatable

connection with the overhanging lip 84 of the disc-like member 83. At the same time the disc-like member 83 will be held stationary by the similarly operating overrunning clutch arrangement provided by the rollers 94 which engage with and provide a counter-clockwise clutching connection with the stationary crank case housing 16, as will be readily understood. At this point it will be noted that the hub 89 of the disc-like member 83 is keyed to the clockwise rotatable member 90 which cooperates through the rollers 94 with the flange 95 upon the stationary end wall 16 of the crank case. This, therefore, prevents any counter-clockwise movement of the rotatable annular member 90 and consequently also prevents a similar counter-clockwise movement to be taken by the disc-like member 83 and the disc-like member 40.

A description of the operation of the parts which comprise stage 2 of the device will now be given. During the operation of the device as described above in connection with the elements that constitute stage 1, it will be understood that the load upon the driven shaft 14; as for example the automobile has gained some momentum. As a result the load upon the driving shaft 10 will be decreased so as to permit a speeding up of the engine and consequently the driving shaft 10. At this point the weights 46 carried by the disc-like member 44 will become operative due to this increased speed of the driving shaft 10 and as a result these weights 46 will tend to move outwardly and thus carry the floating support 51 into an eccentric position which will bring the wear resisting ring 53 upon the floating support 51 into driving relation with the overhanging lip 54 upon the disc-like member 55. When the floating member 51 has thus been moved into an eccentric position it will operate through the ball bearing 57 as a variable crank to transmit a further clockwise driving torque upon the disc-like member 55 which carries the pinion 65. When this occurs the pinion 65 will exert a driving force upon the gear 66 and cause the gear 80 at the other end of the shaft 67 to operate through the idling gear 81 and impart a clockwise rotation to the disc-like member 83 which will release the overrunning clutches provided by the rollers 87 and 94.

Should the load on the driven shaft 14 remain constant at this point, the transmission device will continue to operate with stages 1 and 2 furnishing the driving connection between the driving shaft 10 and the driven shaft 14, but as soon as the load on the driven shaft 14 gains additional momentum or in other words, as soon as the speed of the driven shaft 14 more nearly approaches the speed of the driving shaft 10 the elements of stage 3 of the device will come into operation. At this time the centrifugal weights 73 will be rotating at such a speed that they will then be in a position to bring their roller forming rings 78 into driving engagement with the traction forming ring 79 carried by the enclosing housing 12. When these roller forming rings 78 have been brought into full cooperating engagement with the traction forming ring 79, the parts associated therewith will be brought up to a speed corresponding to that of the enclosing housing 12 and at the same time the disc-like member 40 will have attained a similar rotative speed and as a result the elements of stage 1 in connection with the elements of stages 2 and 3 of the device will form a direct connection between the driving and driven shafts and as a result the driven shaft 14 will be rotated at the same speed as the driving shaft 10.

At this point reference is made to Figures 8 to 12 of the drawings for a more detailed description of the manner in which the position of the floating support 51 is controlled by the centrifugal weights 46 and the eccentric disc-like members 63 which cooperate therewith. From the above description it will be readily understood that the centrifugal weights 46, as shown in Figure 8 of the drawings, will move outwardly under the influence of centrifugal force and as a result the stub shaft 50 will also be moved outwardly under the influence of the joint action of the three weights 46. As this stub shaft 50 moves outwardly the ball bearing 57 will be likewise moved outwardly into an eccentric position as this movement is permitted by the interlocking sectors 58. As shown in Figure 10, the interlocking sectors 58 are held in close contact with each other so as to retain the ball bearing 57 in a position concentric with the driving and driven shafts. This is due to the fact that the reaction of the load is transmitted back through the stub shafts 64 which are carried by the disc-like member 55. This reaction is counter to the normal rotation of the driving shaft 10 and as a result these stub shafts 64 assume a trailing position with respect to the central axis of the disc-like members 63. As the driven shaft 14 increased in speed the reaction upon the stub shafts 64 will correspondingly decrease and the weights 46 by their centrifugal action will therefore become effective to overcome this reaction and carry the ball bearing 57 into its eccentric position, as illustrated in Figure 11 of the drawings. As here shown, it will be seen that each of the interlocking sectors 58 will be held outwardly in a concentric circle-like arrangement so that the outer race of the ball bearing 57 may roll therearound and thus permit relative movement between the interlocking sectors 58 and the ball bearing 57 while the latter member maintains its eccentric position with respect to the driven shaft 14.

Reference is now made to Figures 20 and 21 of the drawings for a description of the operation of the modification of the invention that may be substituted for the arrangement described above as that constituting stage 2. In this latter arrangement as the centrifugal weights 46 move outwardly under the influence of centrifugal force, the floating support 51 will be carried outwardly so as to bring the ball bearing 57 into its eccentric position, as suggested above. At this time the interlocking sectors 102, shown in Figure 19, will be likewise carried outwardly along the guide surfaces between the extensions 113 of the disc-like member 108 so that the ball bearing 57 may roll therewithin while maintaining its eccentric position. At the same time and tending to retain the sectors 102 in their innermost positions the links 104 will be urged inwardly by the connected bell crank members 107 by the reacting counter-clockwise torque which will be established by the pinion 112 through its contact with the gear 66 which, as has been described above, serves to connect the elements of stage 3 into driving relation with the driven shaft 14. In this embodiment the pinion 112 constitutes the equivalent of the pinion 65 first above described. It will be understood that the only difference in the operation of the mechanism resides in the manner in which the reacting forces are applied to the interlocking sectors to produce the constricting action which tends to counteract the forces

exerted by the centrifugal weights 46 to bring the ball bearing 57 into a concentric position where its crank action, as described above, will be overcome.

A description will now be given of the operation of the device when subjected to an additional load after having previously established a direct driving connection between the shaft 10 and the driven shaft 14. When such a further load is imposed upon the driven shaft 14 this shaft will necessarily be slowed up and as a result this slowing up of the driven shaft 14 will react, through the eccentric portion 17 thereof, upon the internal planetating gear 38 so as to impart movement to the disc-like member 40 which carries the ring gear 39. This will exert a torque through the sleeve 71 of the disc-like member 40 and bring the rollers 78 of stage 3 out of engagement with the traction forming ring 79 of the cylindrical housing 12. This will permit the bearing forming member 69 to turn and thus the counter-shaft 67 with the gears 66 and 80 will likewise be permitted to planetate and thus release the reacting forces which are exerted upon the disc-like members 63 through the stub shafts 64 carried by the disc-like member 55. This action, however, assumes that the load is sufficient to overcome the centrifugal forces exerted by the weights 46 of stage 2 and the centrifugal weights 73 of stage 3. When this happens the drive will then be continued through the elements which constitute stage 1 or in other words at the lowest speed ratio as determined by the relative diameters of the gears 32 and 34 and the gear ratio which exists between the internal planetating gear 38 and the overhanging ring gear 39.

The above described mode of operation is based upon observations made over a long period during which time a device constructed and modified as illustrated in Figures 1 to 21 of the drawings was successfully operated in connection with an automobile drive. During this period the device has and still is operating successfully to bring an automobile when fully loaded from a standing start to the full speed of the driving motor without requiring any other operation on the part of the driver than to control the gas throttle. The device has also been subjected to extreme loads; for example, such as are encountered in ascending steep hills. Under these conditions the device has likewise responded to automatically control the ratio of drive between the driving shaft 10 and the driven shaft 14 so as to operate successfully over any grade and at the same time prevent a stalling of the internal combustion engine to which the driving shaft 10 was directly connected.

In the past a great number of devices have been proposed for automatically connecting a motive power unit with a load to produce a variable driving connection therebetween. In practically all of these devices resort has been had to centrifugal weights which are presumed to absorb energy from the source of motor power and subsequently give up this force to the driven shaft. The present invention distinguishes over these earlier attempts at a solution of this problem in that while the centrifugal weights are employed in the present device these weights do not operate in the manner of the prior art devices to store up and release energy and establish the driving connection between the driving and driven shafts. In the present invention the driving connection between the driving and driven shaft is established through the disclosed arrangement of gears which afford a definite ratio of reduction and which at the same time because of the fact that these gear trains contemplate the further novel feature of a floating or gyrating counter-shaft they provide an infinite variation from their maximum differential ratio to a direct one to one connection, these infinite variations being under the control of the centrifugally responsive weights which, as described above, function to control the positions and/or relative gyrating movements of the floating counter-shafts associated with the gear trains. The present invention may be said to be an improvement upon the arrangements illustrated in my prior Patents No. 1,906,103 dated April 25, 1933, and No. 1,983,641 dated December 11, 1934, wherein the principle of a variable crank arm is disclosed in connection with an automatic power transmission device suitable to the purpose for which the present invention is intended.

While I have, for the sake of clearness and in order to disclose the invention so that the same can be readily understood, described and illustrated specific devices and arrangements, I desire to have it understood that this invention is not limited to the specific means disclosed, but may be embodied in other ways that will suggest themselves to persons skilled in the art. It is believed that this invention is new and it is desired to claim it so that all such changes as come within the scope of the appended claims are to be considered as part of this invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and adapted to be driven thereby, a second pinion rotatably mounted upon the eccentric crank forming portion of said driven shaft, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear disposed in driving relation between said second gear upon said counter-shaft and said pinion upon the eccentric crank forming portion of the driven shaft, and centrifugally operating means responsive to the speed of said driving shaft for controlling the speed of rotation of said latter pinion about the eccentric crank forming portion of the driven shaft, whereby the driving connection between the driving shaft and the driven shaft will vary as the speed of the driving shaft varies.

2. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and adapted to be driven thereby, a second pinion rotatably mounted upon the eccentric crank forming portion of said driven shaft, a plurality of counter-shafts extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the cen-

tral axis of the driving and driven shafts, said counter-shafts being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon each of said counter-shafts and meshing with said first pinion, a second gear keyed upon each of said counter-shafts, idling gears disposed in driving relation between said second gears upon said counter-shafts and the pinion upon the eccentric crank forming portion of the driven shaft, and centrifugally operating means responsive to the speed of the driving shaft for controlling the speed of rotation of said latter pinion about the eccentric crank forming portion of the driven shaft, whereby the driving connection between the driving shaft and the driven shaft will vary as the speed of the driving shaft varies.

3. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and adapted to be driven thereby, a second pinion rotatably mounted upon the eccentric crank forming portion of said driven shaft, two oppositely disposed counter-shafts extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shafts being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon each of said counter-shafts and meshing with said first pinion, a second gear keyed upon each of said counter-shafts, an idling gear disposed in driving relation between the second gears upon said counter-shafts and the pinion upon the eccentric crank forming portion of the driven shaft, and centrifugally operating means responsive to the speed of the driving shaft for controlling the speed of rotation of said latter pinion about the eccentric crank forming portion of the driven shaft, whereby the driving connection between the driving shaft and the driven shaft will vary as the speed of the driving shaft varies.

4. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and connected directly thereto, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear, a second pinion rotatably mounted upon the eccentric crank forming portion of the driven shaft and meshing with said idling gear, a larger gear rotatably mounted upon the eccentric crank forming portion of the driven shaft and connected with said second pinion, whereby said larger gear and said second pinion will planetate as a unit about the axis of the driven shaft as the crank forming portion of the driven shaft moves about the axis thereof, an overhanging ring gear within which said last above gear is adapted to planetate, a non-rotatable abutment disposed outwardly from the axis of said driven shaft, and an overrunning clutch arrangement cooperating with said abutment to prevent a turning of said ring gear when the load upon said driven shaft exceeds a predetermined value.

5. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and connected directly thereto, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear, a second pinion rotatably mounted upon the eccentric crank forming portion of the driven shaft and meshing with said idling gear, a larger gear rotatably mounted upon the eccentric crank forming portion of the driven shaft and connected to said second pinion, whereby said larger gear and said second pinion will planetate as a unit about the axis of the driven shaft as the crank forming portion thereof turns, an overhanging ring gear within which said last above gear is adapted to planetate, a non-rotatable abutment disposed outwardly from the axis of the driving and driven shafts, an overrunning clutch arrangement cooperating with said abutment for preventing a turning of said ring gear when the load upon said driven shaft exceeds a predetermined value, and centrifugally operating means responsive to the speed of said driving shaft and the load upon said driven shaft for controlling the operation of said overrunning clutch arrangement, whereby said overhanging ring gear will be rendered rotatable as the speed of the driven shaft approaches the speed of the driving shaft.

6. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and connected directly thereto, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis fo the driving and driven shafts, said counter-shaft being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear, a second pinion rotatably mounted upon the eccentric crank forming portion of the driven shaft and meshing with said idling gear, a larger gear rotatably mounted upon the eccentric crank forming portion of the driven shaft and connected with said pinion, whereby said larger gear and said second pinion will planetate as a unit about the axis of the driven shaft as the crank forming portion

of the driven shaft moves about the axis thereof, an overhanging ring gear within which said last above gear is adapted to planetate, a stationary abutment, an overrunning clutch arrangement cooperating with said abutment for preventing a turning of said ring gear when the load upon said driven shaft exceeds a predetermined value, a differential gearing interposed between said overrunning clutch arrangement and said overhanging ring gear, and a centrifugally operating means responsive to the speed of the driving shaft for controliing the operation of said differential gearing, whereby said overhanging ring gear will be permitted to rotate at a predetermined speed with respect to the driven shaft as determined by the ratio of said differential gearing when the speed of said driven shaft reaches a predetermined speed relative to the speed of the driving shaft.

7. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and connected directly thereto, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear, a second pinion rotatably mounted upon the eccentric crank forming portion of the driven shaft and meshing with said idling gear, a larger gear rotatably mounted upon the eccentric crank forming portion of the driven shaft and connected with said pinion, whereby said larger gear and said second pinion will planetate as a unit about the axis of the driven shaft as the crank forming portion of the driven shaft moves about the axis thereof, an overhanging ring gear within which said last above gear is adapted to planetate, a stationary abutment, means cooperating with said abutment for preventing a turning of said ring gear when the load upon said driven shaft exceeds a predetermined value, a speed reducing gearing interposed between said last means and said overhanging ring gear, a centrifugally operating means responsive to the speed of the driving shaft for controling the operation of said speed reducing gearing, whereby said overhanging ring gear will be permitted to rotate at a speed with respect to the driven shaft as determined by the ratio of said speed reducing gearing when the speed of said driven shaft reaches a predetermined value relative to the speed of the driving shaft.

8. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, said driven shaft having an eccentric crank forming portion, a pinion disposed axially with respect to said driving shaft and adapted to be connected thereto, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being held in fixed relation with respect to the eccentricity of the crank forming portion of said driven shaft during its movement about the axis of said driving and driven shafts, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear, a second pinion rotatably mounted upon the eccentric crank forming portion of the driven shaft and meshing with said idling gear, a larger gear rotatably mounted upon the eccentric crank forming portion of the driven shaft and connected with said pinion, whereby said larger gear and said second pinion will gyrate as a unit about the axis of the driven shaft as the crank forming portion of the driven shaft moves about the axis thereof, an overhanging ring gear within which said last above gear is adapted to planetate, means for preventing rotation of said ring gear, and a centrifugally operating clutch means for connecting said first pinion to said driving shaft when the speed thereof reaches a predetermined value.

9. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, a pinion adapted to be driven by said driving shaft, a second pinion rotatably mounted upon said driven shaft, a rotatable counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being carried by means fixed to and rotatable with said driven shaft, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear disposed in driving relation between said second gear upon said counter-shaft and said pinion upon the driven shaft, and centrifugally operating means responsive to the speed of said driving shaft for controlling the speed of rotation of said latter pinion upon the driven shaft, whereby the driving connection between the driving shaft and the driven shaft will vary as the speed of the driving shaft varies.

10. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, a pinion adapted to be driven by said driving shaft, a second pinion rotatably mounted upon said driven shaft, a rotatable counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being mounted upon means attached to and movable with said driven shaft, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear disposed in driving relation between said second gear upon said counter-shaft and said pinion upon the driven shaft, and centrifugally operating means responsive to the speed of said driving shaft for holding said second pinion against rotation upon said driven shaft, whereby said idling gear will tractively engage and gyrate around said second pinion and cause said counter-shaft to move around the axis of the driven shaft and impart rotation to said latter shaft.

11. In a device of the character described the combination of a driving shaft, an axially aligned driven shaft, a disc-like member rotatably mounted upon said driven shaft and connected to said driving shaft, centrifugally operating means carried by said disc-like member, a normally concentric crank arm forming member adapted to

move into an eccentric crank arm forming position as said centrifugally operating means are influenced by the speed of the driving shaft, a pinion rotatably mounted upon said driven shaft, means for transmitting a driving torque from said pinion to the driven shaft when said pinion is rotated, and leverage means connected between said pinion and said crank arm forming member adapted to prevent movement of said crank arm forming member into an eccentric position with respect to the, driven shaft when the driving torque exerted upon the driven shaft by said pinion exceeds a predetermined value relative to the speed of the driving shaft, whereby the crank arm forming position of said member will be determined by the speed of the driving shaft and the reactive load imposed upon said pinion.

12. In a device of the character described the combination of a driving shaft, an axially aligned driven shaft, a disc-like member rotatably mounted upon said driven shaft and having a driving connection with said driving shaft, centrifugally operating means carried by said disc-like member, a normally concentric crank arm forming member adapted to move into an eccentric crank arm forming position as said centrifugally operating means is influenced by the speed of the driving shaft, a pinion rotatably mounted upon said driven shaft, means for transmitting a driving torque from said pinion to the driven shaft when said pinion is rotated, eccentrically operating lever means connected between said pinion and said crank arm forming member adapted to transmit the forces exerted by said crank arm forming member when in an eccentric crank arm forming position to said pinion, and an anti-friction bearing interposed between said crank arm forming member and said eccentrically operating lever means, whereby said crank arm forming member will be rendered ineffective to transmit a driving torque through said lever means to said pinion when said crank arm forming member is in a position concentric to the axis of said driven shaft.

13. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, a pinion disposed axially in line with and adapted to be driven by said driving shaft, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being supported upon and movable with said driven shaft, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear upon said counter-shaft, a pinion rotatably mounted upon said driven shaft and meshing with said idling gear, means for holding said latter pinion against rotation upon said driven shaft until the driving and the driven shafts have attained a predetermined relative difference in speed, a second pinion rotatably mounted upon said driven shaft, centrifugally operating means responsive to the speed of the driving shaft for establishing a driving connection between said second pinion and the driving shaft when the latter shaft has attained a predetermined speed of rotation, a second counter-shaft arranged radially outward from the axis of said driven shaft and adapted to move concentrically about said driven shaft, said counter-shaft being held against this latter movement by the means which holds said second pinion against rotation, a gear upon said counter-shaft meshing with said second pinion, a second gear upon said second counter-shaft, a third pinion upon said driven shaft, an idling gear between said second gear upon said second counter-shaft and said third pinion, whereby said second counter-shaft and the gears carried thereby will form a differential gearing connection between said first pinion upon the driven shaft and the means for holding said latter pinion against rotation to render said holding means ineffective and impart a predetermined intermediate speed of rotation to said first pinion upon the driven shaft.

14. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, a pinion disposed axially in line with and adapted to be driven by said driving shaft, a counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being supported upon and movable with said driven shaft, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear adapted to be driven by said second gear upon said counter-shaft, a pinion rotatably mounted upon said driven shaft and meshing with said idling gear, means for holding said latter pinion against rotation upon said driven shaft until the driving and the driven shafts have attained a predetermined relative difference in speed, a second pinion rotatably mounted upon said driven shaft, centrifugally operating means responsive to the speed of the driving shaft for establishing a driving connection between said second pinion and the driving shaft when the latter shaft has attained a predetermined speed of rotation, a second counter-shaft arranged radially outward from the axis of said driven shaft and adapted to move concentrically about said driven shaft, said counter-shaft being held against movement about said driven shaft, a gear upon said counter-shaft meshing with said second pinion, a second gear upon said second counter-shaft, a third pinion upon said driven shaft, an idling gear between said second gear upon said second counter-shaft and said third pinion, whereby said second counter-shaft and the gears carried thereby will form a differential gearing connection between the driving shaft and said first pinion upon the driven shaft and impart a predetermined intermediate speed of rotation to said first pinion upon the driven shaft, and a second centrifugally responsive means adapted to connect the differential gearing connection defined above directly to the driving shaft and render the same inoperative, whereby a direct driving connection will be established between the driving and driven shafts.

15. In a device of the character described the combination of a driving shaft, a housing connected to said driving shaft having an annular traction forming surface concentric to the axis of the driving shaft, a driven shaft extending into said housing centrally of the traction forming surface carried by said housing, a pinion rotatably mounted upon said driven shaft, means for holding said pinion against backward rotation, a rotatable support mounted upon said driven shaft adjacent said pinion, a counter-shaft carried by said support and disposed outwardly from said driven shaft, a gear upon said counter-shaft connected to said pinion through a rotation reversing idling gear, a second pinion mounted con-

centrically with respect to the axis of said driven shaft, a second gear upon said counter-shaft having a driving connection with said second pinion, means for connecting said second pinion to said driving shaft, whereby said counter-shaft will transmit a force through said idling gear tending to rotate said first pinion in a backward direction and against the action of said holding means, and a plurality of centrifugally responsive weights carried by said rotatable support having rollers adapted to tractively engage the overhanging traction forming surface of said housing and establish a direct driving connection between said rotatable support and the driving shaft, whereby said driven shaft will rotate at the same speed as the driving shaft.

16. In a power transmission device, the combination of a driving shaft, a driven shaft disposed axially in line with said driving shaft, a pinion driven by said driving shaft, a second pinion rotatably mounted upon an axis eccentric to the normal axis of the driven shaft, a rotatable counter-shaft extending parallel with the axis of the driving and driven shafts and adapted to move in a path concentric to the central axis of the driving and driven shafts, said counter-shaft being movable in its concentric path at a speed corresponding to the speed of the driven shaft, a gear keyed upon said counter-shaft and meshing with said first pinion, a second gear keyed upon said counter-shaft, an idling gear disposed in driving relation between said second gear upon said counter-shaft and the pinion upon the driven shaft, an internal ring gear rotatably mounted upon said driven shaft, an eccentrically disposed gear connected to and rotatable with the pinion upon said driven shaft and meshing with said internal ring gear, and centrifugally operating means responsive to the speed of the driving shaft for connecting said internal ring gear to the driving shaft when the speed of the driven shaft approaches the speed of the driving shaft, whereby a direct driving connection will be established between the driving and driven shafts.

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