

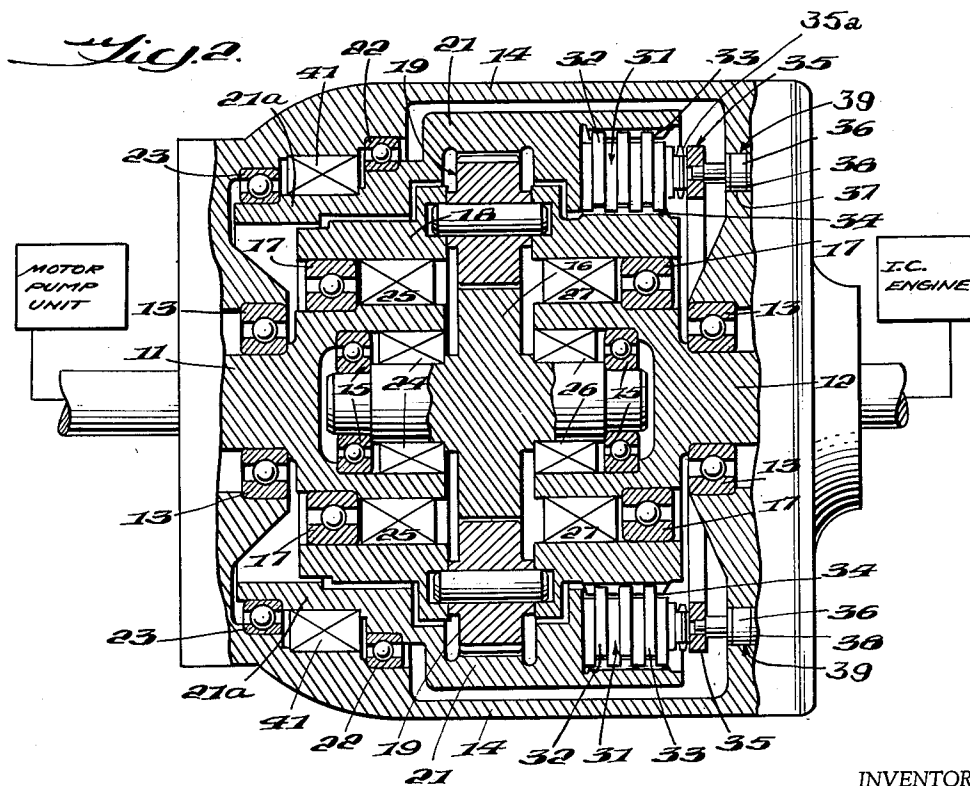
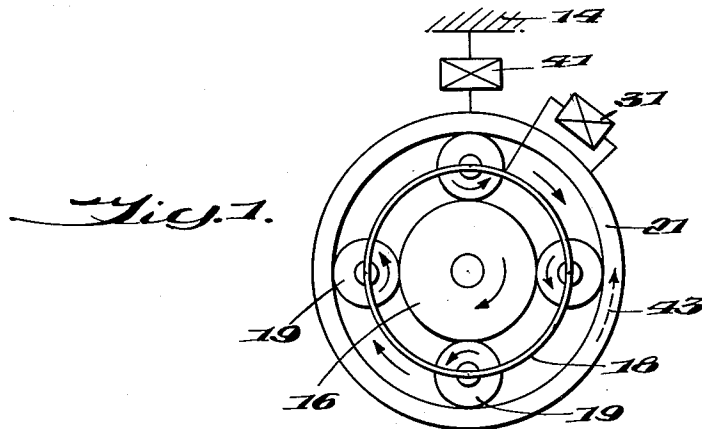
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R. D. JOHNSON ETAL

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GEARING MEANS

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INVENTORS

ROBERT D. JOHNSON
MELVIN L. KENT

BY

Dodge and Sons

ATTORNEYS

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GEARING MEANS

Robert D. Johnson, Watertown, N.Y., and Melvin L. Kent, East Cleveland, Ohio, assignors to The New York Air Brake Company, a corporation of New Jersey
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The present invention relates to an improved variable-speed planetary gearing arrangement for transmitting torque in either direction between two rotary shafts each of which rotates always in the same direction.

In starting systems for internal combustion vehicle propulsion engines, the use of a hydraulic motor-pump unit has been proposed which is operable as a motor to drive the shaft of the internal combustion engine during the starting cycle and which is operable, after the engine is started and achieves independent operation, as a pump driven by the engine for supplying fluid to auxiliary hydraulic loads of the vehicle. Such starting systems have the inherent advantage that by causing a single hydraulic unit to serve both as a motor and as a pump, the weight, size, cost, and complexity of the starting system are materially reduced.

During the starting cycle of certain internal combustion engines, an "ignition" point is reached (for example, "light-off" in the case of a jet engine) at which the engine itself is capable of delivering a relatively small amount of torque before it is actually started and obtains independent operation. In the known starting systems using a single hydraulic motor-pump unit, a pair of fixed high-ratio speed reducing gear trains is provided, one of which is operable during starting to transmit to the engine the rather large torque required during this operation, and the other of which is operable during pumping to transmit torque to the motor-pump unit and to prevent the pump from being driven at abnormally high speeds. Assuming that the engine has a high starter cut-out speed, a motor provided with a fixed high-ratio gear train has a tendency to overspeed during the latter period of the starting cycle after the engine is ignited and begins to generate some power.

The object of the present invention is to provide an improved variable-speed gearing arrangement adapted to transmit torque in either direction between two shafts each of which always rotates in the same direction, said gearing arrangement providing two selective gear ratios between the shafts when torque is transmitted from a given one of the shafts to the other. The gearing arrangement is particularly suitable for use in an internal combustion engine starting system using a single hydraulic motor-pump unit as described above. For example, when the gearing arrangement of the present invention is connected between the shafts of the motor-pump unit and the internal combustion engine, during motoring operation of the unit the gearing arrangement establishes a relatively high gear ratio between the driving and driven shafts during the initial stage of the starting cycle, and, after "ignition" of the engine, establishes a lower gear ratio between the shafts. Consequently, when the gearing arrangement is changed from the higher to the lower ratio, the motor operates at a lower speed than would normally be required to accelerate the engine to starter cut-out speed. Since the present invention affords a re-

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duction in gear ratio during the starting operation, the ratio employed at the commencement of this operation can be higher than that permissible in prior starting systems. As a result, the torque requirements of a given installation can be satisfied by a smaller motor-pump unit. Furthermore, after the internal combustion engine is fully started and transmits torque in the opposite direction through the gearing arrangement to drive the pump, the gearing arrangement again affords a reduction in speed and thus ensures that pump speed is kept within tolerable limits.

Other objects and advantages of the invention will become apparent from a study of the following specification when considered in conjunction with the accompanying drawing, in which:

FIG. 1 is a schematic illustration of the manner in which the clutch means control the operation of the planetary gearing arrangement;

FIG. 2 is a partially sectioned elevational view of the preferred variable-ratio reversible-torque gearing device.

Referring first to FIG. 2, the gearing device comprises a housing 14 whose opposite ends are provided with bearings 13 for journalling a pair of coaxial shafts 11 and 12. The adjacent ends of these shafts are bored to receive bearings 15 in which are journalled the stub shafts projecting from the opposite faces of sun gear 16. Coaxial bearings 17 mounted on the shafts 11 and 12 rotatably support planet carrier 18 in which are journalled four rotatable planet gears 19 that mesh with the sun gear 16 and with the ring gear 21. Ring gear 21 has a shaft portion 21a supported for rotation in bearings 22 and 23 mounted in housing 14.

Interposed between the stub shafts of sun gear 16 and shafts 11 and 12 are two reversely set one-way overrunning clutches 24 and 26, respectively. Another pair of reversely set one-way overrunning clutches 25 and 27 is interposed between the planet carrier 18 and the shafts 11 and 12, respectively. As will be described in greater detail below, the clutches 24 and 27 are engaged when torque is transmitted in one direction, and clutches 25 and 26 are engaged when torque is transmitted in the opposite direction. The one-way overrunning clutches are of conventional design and the specific details thereof form no part of the present invention.

A conventional friction-disc clutch 31 is provided for selectively connecting the planet carrier 18 with the ring gear 21. This clutch comprises a plurality of normally disengaged annular clutch discs 32 splined alternately to the ring gear 21 at 33 and to the planet carrier at 34. The clutch 31 is operated by a plurality of pistons 36 mounted for reciprocation in housing cylinders 37 and operatively connected with the discs through an annular thrust member 35 and a needle bearing 35a. When motors 39 are energized by the introduction of fluid into working chambers 38, pistons 36 apply a force on thrust bearing 35, needle bearing 35a and clutch discs 32 to effect engagement of clutch 31, whereupon the planet carrier is rigidly connected with the ring gear.

A one-way overrunning brake 41 is interposed between ring gear portion 21a and the housing 14. This brake is set to lock the ring gear 21 with the housing 14 when the friction-disc clutch 31 is disengaged (i.e., when the motors 39 are de-energized).

OPERATION

1. Starting

For the purpose of the following discussion it will be assumed that the shaft 11 is the output shaft of a hydraulic motor-pump unit and that the shaft 12 is connected with the power shaft of an internal combustion engine.

During the starting of the internal combustion engine, motors 39 are initially vented and, therefore, clutch 31 is disengaged. Assuming now that shaft 11 is driven in the clockwise direction (looking into the housing from the left end thereof), sun gear 16 is driven in the clockwise direction through the one-way clutch 24, and since the clutch 25 is oppositely set, it overruns. As shown in FIG. 1, rotation of sun gear 16 in the clockwise direction effects rotation of planet gears 19 in the counterclockwise direction. One-way overrunning brake 41 is set to prevent movement of ring gear 21 in the counterclockwise direction (i.e., the brake serves to lock the ring gear with the housing 14 when torque is applied in the direction shown by the dashed arrow 43 in FIG. 1) with the result that the planet gears 19 react with the stationary ring gear to rotate the planet carrier 18 in the clockwise direction. Motion of planet carrier 18 in the clockwise direction is transmitted to the shaft 12 through the one-way overrunning clutch 27 with the result that shaft 12 is also driven in the clockwise direction. Since clutch 26 is oppositely set from clutch 27, it is disengaged. Thus when clutch 31 is disengaged, a relatively high gear ratio (for example, 3:1) is established between the shafts 11 and 12 and torque is transmitted along a path including clutch 24, sun gear 16, planet gear 19, planet carrier 18, and clutch 27.

After the engine reaches ignition speed and is ignited, it commences to supply some torque of its own and, therefore, the torque demand imposed on the starter motor decreases. In order to prevent overspeeding of the starter motor during this low torque final portion of the starting cycle (i.e., as the engine is accelerated from ignition speed to "starter cut-out speed"), the gear ratio between shafts 11 and 12 is lowered to a 1:1 ratio direct drive by pressurizing motors 39 (manually or automatically as will be described below) to engage clutch 31 and thereby rigidly lock the planet carrier with ring gear 21. Referring again to FIG. 1, it is apparent that when clutch 31 is engaged, the planet gears 19, the planet carrier 18, and the ring gear 21 are all locked with the sun gear 16 and rotate as a unit therewith (it being remembered that the set of one-way overrunning brake 41 permits free rotation of the ring gear in the clockwise direction). Shaft 12 is now driven at the same speed and in the same direction as shaft 11, and the hydraulic motor accelerates to starter cut-out speed during the final stage of the starting cycle.

2. Pumping

When the internal combustion engine has been started and attains independent operation, it is able to drive the hydraulic unit as a pump for supplying pressure fluid to auxiliary hydraulic loads. Therefore, at this time, motor 39 is again vented to disengage clutch 31.

Shaft 12 is now the driving shaft and while the direction of torque transmission is reversed, the direction of rotation remains unchanged. Torque is now transmitted to sun gear 16 via clutch 26, the oppositely set clutch 27 being disengaged owing to the reversal in the direction of torque transmission, and this gear rotates in the clockwise direction. Owing to the disengagement of clutch 31 and the set of brake 41 which prevents rotation of ring gear 21 in the counterclockwise direction, planet gears 19 rotate in the counterclockwise direction and react with the stationary ring gear to rotate the planet carrier 18 in the clockwise direction. Torque is transmitted from the planet carrier to the shaft 11 via clutch 25 with the result that shaft 11 is also rotated in the clockwise direction.

At this time, clutch 24 is overrunning. Since the input torque to the gearing device is applied to the sun gear regardless of the direction of torque transmission, the gear ratio between shaft 12 and shaft 11 during pumping is the same as the ratio between shaft 11 and shaft 12 during the initial stages of starting. Therefore, the motor-pump unit runs at one-third the speed of the internal combustion engine and overspeeding is prevented.

As mentioned above, the state of engagement of clutch 31 is controlled by the state of energization of motors 39. Although the energization of these motors may be effected by manual control means during the final stage of acceleration of the hydraulic motor (i.e., for the period of time between "ignition speed" and "starter cut-out speed"), it is also contemplated that the motors 39 be energized automatically by conventional speed-responsive means operable in accordance with the speed of rotation of shaft 12. The means for pressurizing and venting the working chambers 38 is conventional and, therefore, need not be illustrated.

While the presently known best form and embodiment of the invention has been described and illustrated in the specification and drawings, it will be apparent to those skilled in the art that changes and modifications may be made in the apparatus described without deviating from the invention set forth in the following claims.

1. A variable-speed gearing system comprising a support; first and second rotary shafts carried by said support; a planetary gearing arrangement including sun, planet and ring gears, and a planet carrier carrying said planet gear; first and second oppositely-set one-way overrunning clutches engageable to connect said first shaft with said sun gear and with said planet carrier, respectively; third and fourth oppositely-set one-way overrunning clutches engageable to connect said second shaft with said sun gear and with said planet carrier, respectively, said first and fourth clutches having the same set; a fifth clutch engageable to connect said ring gear with said planet carrier; and means locking said ring gear with said support when said fifth clutch is disengaged.

2. A variable-speed gearing system comprising a support; first and second rotary shafts; a planetary gearing arrangement including sun, planet, and ring gears, and a planet carrier carrying said planet gear; first and second oppositely-set one-way overrunning clutches engageable to connect said first shaft with said sun gear and with said planet carrier, respectively; third and fourth oppositely-set one-way overrunning clutches engageable to connect said second shaft with said sun gear and with said planet carrier, respectively, said first and fourth clutches having the same set; a fifth clutch engageable to connect said ring gear with said planet carrier; a one-way brake engageable with the ring gear and the support and having a set to lock said ring gear against rotation when said fifth clutch is in a disengaged condition, whereby a first gear ratio is established between said first and second shafts; and means for engaging said fifth clutch to establish a second gear ratio between said shafts.

3. A variable speed gearing arrangement comprising a housing; first and second coaxially arranged rotary shafts journaled within opposite ends of the housing, the adjacent ends of said shafts being spaced and containing axial bores therein; a planetary gearing arrangement in said housing comprising a sun gear provided at each end with axial shafts journaled in the bores of said shafts, a planet carrier provided with tubular axial extensions at each end journaled on said shafts, a ring gear journaled in said housing concentrically with respect to said sun gear, and planet gears rotatably carried by said planet carrier, said planet gears being in meshing engagement with said sun and ring gears; a first annular one-way overrunning clutch coaxially arranged in the bore of said first shaft for connecting said first shaft with said sun gear; a second annular one-way overrunning clutch coaxially arranged on said first shaft for connecting said

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first shaft with said planet carrier; a third annular one-way overrunning clutch coaxially arranged in the bore of said second shaft for connecting said second shaft with said sun gear; a fourth annular one-way overrunning clutch coaxially arranged on said second shaft for connecting said second shaft with said planet carrier, said first and fourth clutches being set for engagement solely when torque is transmitted from said first shaft to said second shaft, and said second and third clutches being set for engagement solely when torque is transmitted from said second shaft to said first shaft; friction-disc clutch means engageable to connect the planet carrier with said ring gear; means controlling the operation of said friction-disc clutch means; and an annular one-way brake coaxially arranged on said ring gear adjacent the housing, said

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brake having a set to lock said ring gear with the housing when said friction-disc clutch is disengaged.

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