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- (21) Application No. 32035/76 (22) Filed 31 Jul. 1976
 (23) Complete Specification Filed 21 Jul. 1977
 (44) Complete Specification Published 21 Oct. 1981
 (51) INT. CL.³ F16H 15/38
 (52) Index at Acceptance
 F2D 7B1
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(19)



(54) VARIABLE SPEED TRANSMISSION SYSTEMS

(71) We, LUCAS INDUSTRIES LIMITED, a British Company of Great King Street, Birmingham B19 2XF, England, do hereby declare the invention for which we pray that a Patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:-

5 This invention relates to variable ratio frictional drive transmission systems including drive units or gears of the kind comprising basically two axially spaced torus discs or rotors, one serving as an input and the other an output, between which there is a set of circumferentially spaced drive rollers in frictional rolling contact with part toroidal surfaces on the discs, each roller being rotatably mounted in a bearing structure which can tilt about
 10 an axis at right angles to the axis of rotation of each roller so as to vary the distances from the gear axis at which the roller engages the two discs respectively, thus varying the drive ratio of the gear. The angle of tilt of the roller bearing structure as it controls the drive ratio of the gear, is called the ratio angle.

15 One way of changing the ratio angle is to tilt the roller bearing structure by bodily moving it tangentially with respect to the gear axis, and by allowing the rollers then to steer themselves towards a different ratio angle. This adjustment is achieved by arranging the rollers at an angle to a plane perpendicular to the gear axis so as to induce the required steering. This angle is called the caster angle. Such a drive gear will for convenience herein be described as being of the kind specified.

20 This invention is particularly concerned with gears in which the plane of each roller, normal to the axis of rotation of the roller and passing through the points of contact of the roller with the two opposed torus discs, contains the axis about which the roller tilts, being tangential to the torus centre circle (i.e. the locus of the centre of the circle revolved to generate the torus) as distinct from gears in which the same plane for each roller is closer to
 25 the main axis of rotation of the gear.

The apparatus may run at very high rotational speeds, perhaps up to 20,000 revolutions per minute, and thus operating conditions may be extremely arduous and power transmission requirements may be very high.

30 There are, moreover, certain practical limitations on the size of the transmission system. If the components are of large size the wear characteristics tend to be poor and power transmissions therefore limited by the strength of the components.

It is the object of this invention to provide a variable speed transmission system in which power of relatively high order can be transmitted.

35 According to the present invention, there is provided a variable speed transmission system comprising at least two variable ratio gears, each such gear comprising two pairs of axially spaced rotors, one of each pair serving as an input and the other of each pair serving as an output, between which are disposed sets of circumferentially spaced drive rollers in frictional rolling contact with part toroidal surfaces on the rotors, the rollers being mounted
 40 in bearing structures tiltable through hydraulic control means so as to vary the distances from the central axis of the gear at which the rollers engage the rotor toroidal surfaces respectively, thus varying the drive ratio of the gear between its input and its output, and means interconnecting the gears together to operate in parallel and common hydraulic fluid supply to the hydraulic control means of the gears for controlling the ratios of the respective variable ratio gears.

45 The invention will now be described by way of example with reference to the

accompanying drawings, in which:

Figure 1 is a cross-sectional view of one variable speed ratio gear forming part of a transmission system constructed according to the invention, and

Figure 2 is a variable speed transmission system constructed according to the invention and having two gears of the general kind shown in *Figure 1*.

The transmission system is principally designed for use in driving aircraft accessories and in particular an alternator. The alternator is driven from an aircraft main engine but is required to be rotated at constant speed. The transmission is therefore designed for variable input speed, but constant output speed. It is, however, to be understood that transmissions incorporating the invention as herein defined can be used in transmission of this sort with other operating characteristics including constant input and variable output speed and variable input as well as output speeds.

Referring first to *Figure 1*, the general layout of a variable speed ratio gear used in the transmission system shown in *Figure 2*. The variable speed ratio gear has three rotors 10, 11, 12 which have respective part toroidal surfaces 10a, 11a, and 12a and 12b respectively. The rotor 12, is situated mid-way between the rotors 10 and 11, and is provided with its part toroidal surfaces 12a, 12b on opposite axially presented sides thereof. The rotor 10 has its part toroidal surface 10a presented towards the surface 12a, and similarly the surface 11a of the rotor 11 is presented towards the surface 12b of the central rotor 12. The rotors 10, 11 are input rotors and the rotor 12 is an output rotor. However, the system will operate perfectly satisfactorily with the rotors 10, 11 as output and the input is the rotor 12. Situated between the rotors 10, 12 and 11, 12 are respective sets of flat rollers 13, 14. These are rotatable in a manner which will be described and are for this purpose carried in bearing structures including respective bearings 15, 16. The rollers are shown in *Figure 1* in positions in which they engage the respective surfaces 10a, 12a and 11a, 12b at different distances from the axis of rotation of the rotors 10, 11, 12 or gear axis. Such axis is identified at 17. The rotors 10, 11 are carried non-rotatably upon a hollow shaft 18. This is supported on suitable fixed structure 22 by means of bearings 19, 20 situated near its opposite ends respectively.

The input rotor 10 has on its external periphery, gear teeth 23, engaging with a gear ring 24, on a hollow stepped shaft 25. This hollow stepped shaft is mounted for rotation about an axis 26, parallel with the axis 17. Connecting the hollow stepped shaft 25, with a surrounding sleeve 27, is a clutch 28. The sleeve 27, has gear teeth 29, meshing with a gear (not shown) which drives auxiliary equipment which forms no part of this invention.

The output rotor 12 has external gear teeth 30 and this represents the output of the drive unit.

Driving the shaft 18, through gear teeth 34, thereon is a gear wheel 35, which is carried on a further hollow sleeve 36. Between the sleeve 36, and an input shaft 37, with, at one end, dogs 38, is a coupling incorporating an intermediate slidable sleeve 39, and an element 40, which is arranged to melt and allow the sleeve 39 and hence the shaft 37 to move under the influence of springs 31 in the event of this part of the system reaching a temperature in excess of a predetermined value, to disconnect the input drive from the system. This forms the subject for co-pending British patent application No. 33909/76. (Serial No. 1600976).

To load the rotors 10, 11, 12 and the rollers 13, 14 so as to maintain frictional contact between them, there is an end load device within a housing 41, secured by screws 42, to the rotor 11, at the side thereof remote from its part toroidal surface 11a. Defined within the space between the rotor 11, and the housing 41, are cavities 43, 44 for hydraulic fluid. Within the cavities are respective pistons 45, 46 mounted on the shaft 18. In the end of the shaft 18 is a rotary fluid joint 21 engaged in the fixed structure 22. Furthermore in this end of the shaft 18 are drillings 47, 48 for supply and exhaust of fluid to the cavities 43, 44. The passage 48 communicates with the joint 21 for supplying high pressure fluid fed at one side of each of the pistons 45 and 46. At the other side of the pistons 45 and 46 lower fluid pressure is fed from one of the two drillings 47 which are symmetrical for balance of the shaft. This end load device is the subject of co-pending British patent application No 33906/76. (Serial No 1600974).

In operation of this transmission system, with variable speed input and constant output to the drive, there is automatic compensation for input speed change and this is achieved through the alteration in the ratio angle of the rollers. The inclination of the rollers as seen in *Figure 1*, regulates the ratio of the speed of the input rotors 10, 11 to the speed of the output rotor 12. As illustrated in full lines, rotation of the input rotors 10, 11 at a given speed will cause rotation of the input rotor 12, at a slower speed than said given speed. As indicated in dotted lines the opposite ratio characteristic can be achieved if the point of contact between the rollers on the input rotors 10, 11 is outside that on the surfaces 12a, 12b of the output rotor 12. If however, the rollers engage the surfaces 10a, 11a, 12a and 12b at the same radial distance on each such surface from the axis 17 of the shaft 18, the input and

output rollers 10, 11, 12 will all rotate at the same speed. This represents a drive ratio of 1:1 between the input and the output of the system. To induce the rollers to change their ratio angles, they are mounted in their bearing structures at an angle to a plane perpendicular to the gear axis 17. This angle is called the caster angle. Preferably, the higher the rotational speed induced in the output rotor 12, the greater the caster angle should be. This improves stability in the system at high rotational speeds which may be of the order of 10,000 revolutions per minute.

The transmission system which is illustrated in Figure 2 has two of the gears or drive units described in relation to Figure 1. Although there are certain constructional differences between the gears shown in Figures 1 and 2, they are basically the same and the same numerals are used for corresponding parts.

The components of the input are, in particular, different between the two Figures. In Figure 2 the inputs of the two drive units, identified generally as 8 and 9, are formed by the respective rotors 12. The two drive units are side by side and their shafts 18 are parallel. On their external peripheries, the rotors 12 have splines 71, 72 engaged with splines on hollow housings 73, 74 which enshroud the respective end loading devices, as well as the rotors 11 of each of the drives. The housing 73, 74 are connected through one-way clutches 75, 76 on hollow shafts 77, 78 which are co-axial with the respective shafts 18 of the drive units. The clutches 75, 76 are provided to prevent overrun between the two gears. The hollow shafts 77, 78 have further gear teeth 79, 80 meshing with a single input gear 81. This is on a system input shaft 82 with provision, in the form of an internal spline 82a in its outer end, for connection to the apparatus which drives the transmission system. By means of this input apparatus the two drive units are driven in parallel and at the same speed.

Within the ends of the shafts 18 remote from the input apparatus, they have respective splines 83, 84 engaging co-axial shafts 85, 86. These project into respective gears 87, 88 being connected by further splines 89, 90 thereto. The gears 87, 88 furthermore mesh with a single output gear 91 mounted on an output shaft 92 co-axial with the input shaft 82, but at the opposite end of the transmission system.

Within the shafts 18 are hydraulic fluid passages, similar to those shown in the construction shown in Figure 1, these passages communicate with common sources of high and low pressure for controlling the respective end load devices and the respective ratio control means of the two drive units. The performances of the two drive units are therefore the same during all operating conditions.

WHAT WE CLAIM IS:-

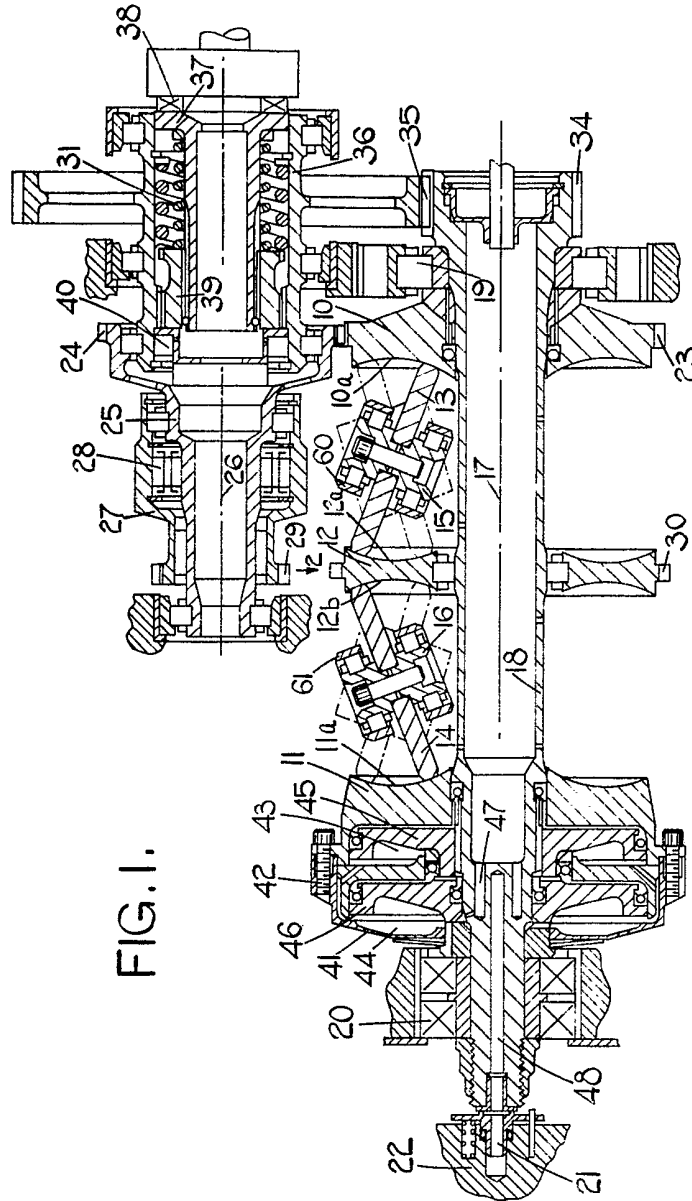
1. A variable speed transmission system comprising at least two variable ratio gears, each such gear comprising two pairs of axially spaced rotors, one of each pair serving as an input and the other of each pair serving as an output, between which are disposed sets of circumferentially spaced drive rollers in frictional rolling contact with part toroidal surfaces on the rotors, the rollers being mounted in bearing structures tiltable through hydraulic control means so as to vary the distances from the control axis of the gear at which the rollers engage the rotor toroidal surfaces respectively, thus varying the drive ratio of the gear between its input and its output, and means interconnecting the gears together to operate in parallel and common hydraulic fluid supply to the hydraulic control means of the gears for controlling the ratios of the respective variable ratio gears.

2. A variable speed transmission system as claimed in claim 1 in which one-way clutches interconnect the inputs of the variable ratio gears.

3. A variable speed transmission system substantially as hereinbefore described with reference to and as shown in Figure 1 of the accompanying drawings.

4. A variable speed transmission system substantially as hereinbefore described with reference to and as shown in Figure 2 of the accompanying drawings.

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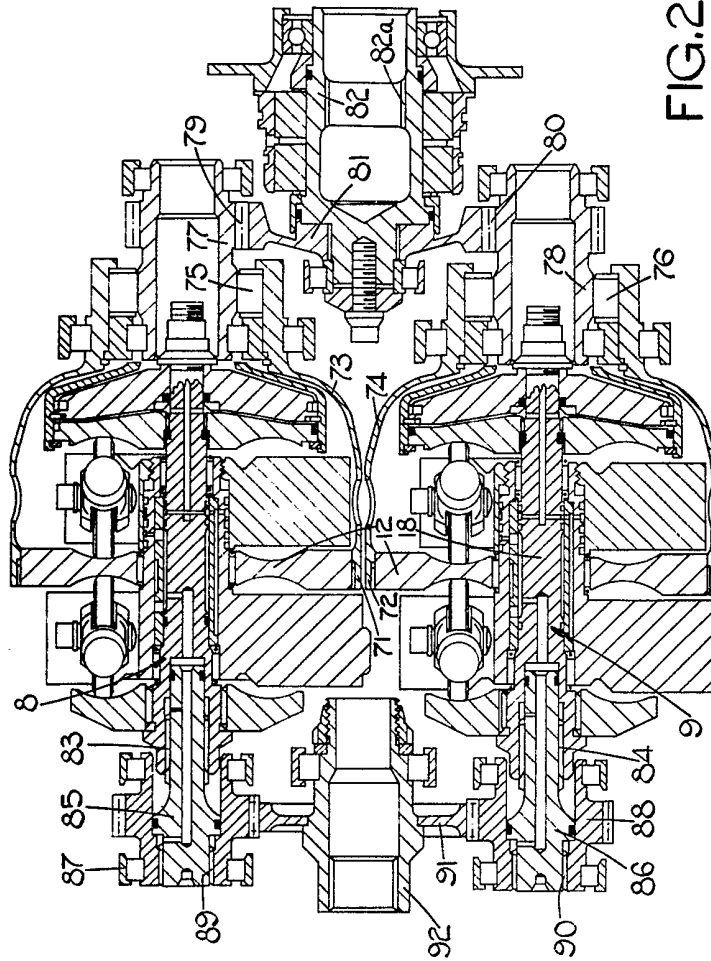


FIG. 2.