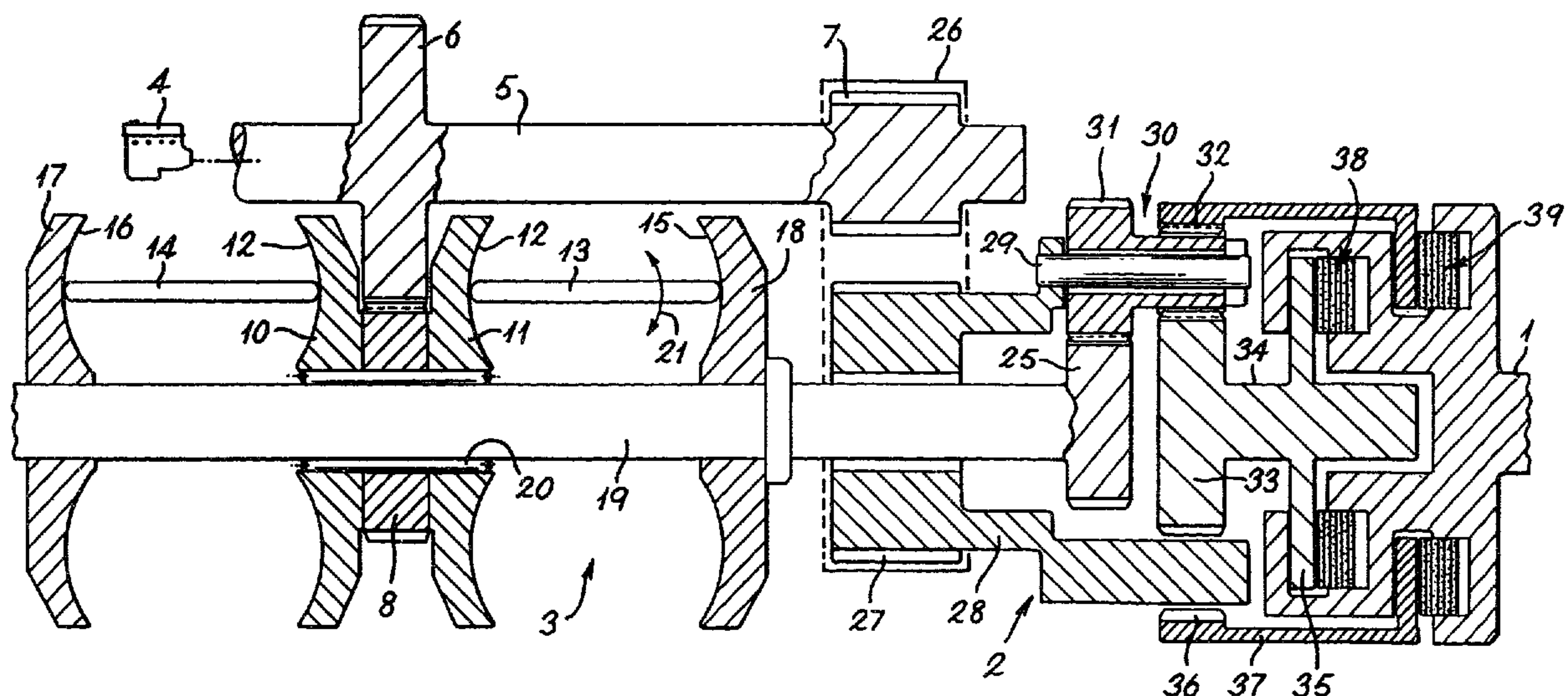




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(54) Titre : TRANSMISSIONS A CHANGEMENT DE VITESSES CONTINU AVEC CHEMIN DE ROULEMENT TOROIDAL
(54) Title: CONTINUOUSLY-VARIABLE-RATIO TRANSMISSIONS OF TOROIDAL-RACE ROLLING-TRACTION TYPE



(57) Abrégé/Abstract:

A continuously-variable-ratio transmission (CVT) of the toroidal-race rolling-traction type, capable of operating in "low" and "high" regimes with synchronous change between those regimes, and including a variator (3) - that is to say a ratio-varying component - and an associated gearing set (2) of which the components are capable of being set in different combinations for the high and low regimes, in which the output of the gearing is connectable to the output (1) of the CVT as a whole, and the gearing has first (25) and second (29) inputs connected with the variator output (19) and engine output (5) respectively, and in which in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.

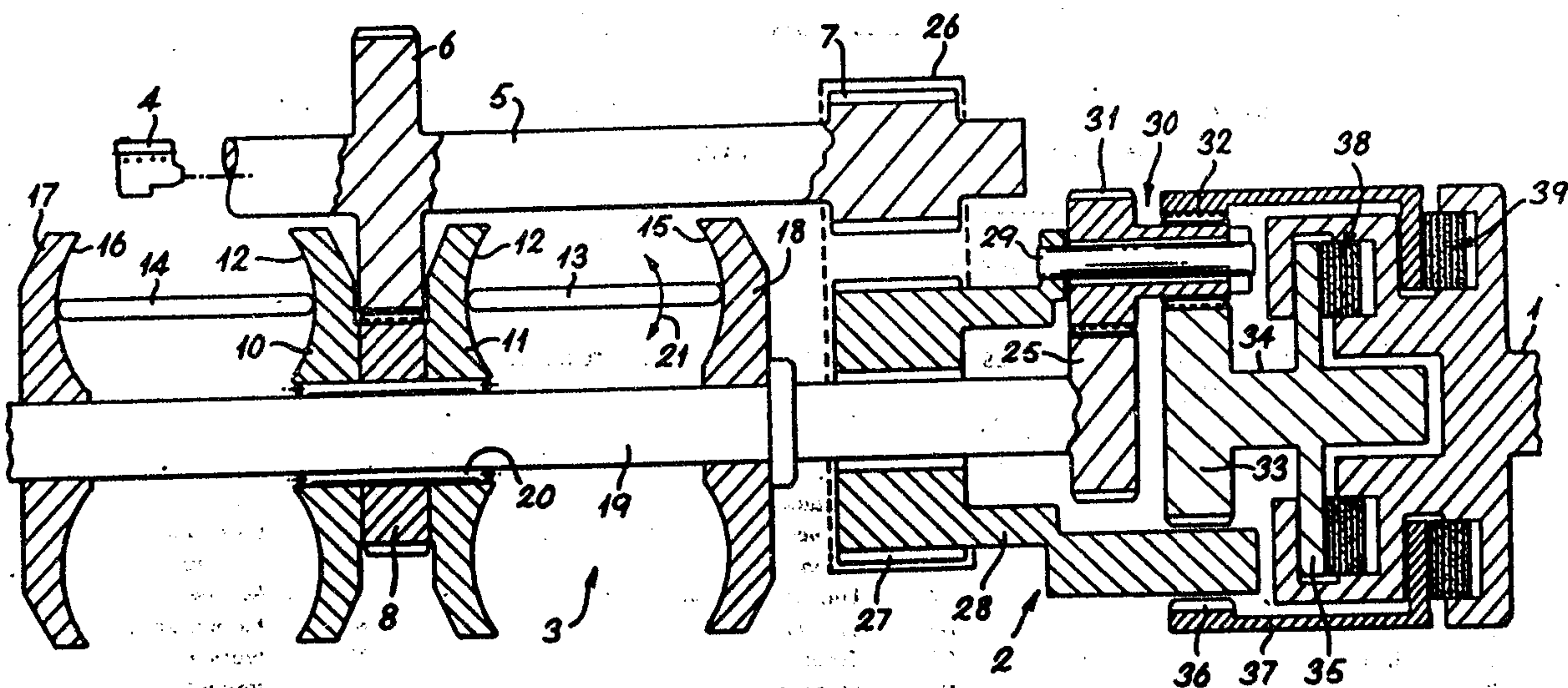




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(21) International Application Number: PCT/GB91/02184 (22) International Filing Date: 10 December 1991 (10.12.91) (30) Priority data: 9026830.1 11 December 1990 (11.12.90) GB (71) Applicant (for all designated States except US): TOROTRAK (DEVELOPMENT) LIMITED [GB/GB]; 101 Newington Causeway, London SE1 6BU (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : FELLOWS, Thomas, George [GB/GB]; 1 Greenbrook Avenue, Hadley Wood, Barnet, Hertfordshire EN4 0LS (GB). (74) Agent: STABLES, Patrick, Antony; Patents Department, National Research Development Corporation, 101 Newington Causeway, London SE1 6BU (GB).			(81) Designated States: AT (European patent), AU, BE (European patent), BR, CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB, GB (European patent), GR (European patent), HU, IT (European patent), JP, KR, LU (European patent), MC (European patent), NL (European patent), PL, SE (European patent), SU+, US. Published With international search report.

(54) Title: CONTINUOUSLY-VARIABLE-RATIO TRANSMISSION OF THE TOROIDAL-RACE ROLLING TRACTION TYPE



(57) Abstract

A continuously-variable-ratio transmission (CVT) of the toroidal-race rolling-traction type, capable of operating in "low" and "high" regimes with synchronous change between those regimes, and including a variator (3) - that is to say a ratio-varying component - and an associated gearing set (2) of which the components are capable of being set in different combinations for the high and low regimes, in which the output of the gearing is connectable to the output (1) of the CVT as a whole, and the gearing has first (25) and second (29) inputs connected with the variator output (19) and engine output (5) respectively, and in which in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.

CONTINUOUSLY-VARIABLE RATIO TRANSMISSION OF THE
TOROIDAL RACE ROLLING TRACTION TYPE,

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This invention relates to continuously-variable-ratio
5 transmissions (CVT's) of the toroidal-race rolling-traction
type. It relates in particular to CVT's of this type in which a
ratio-varying component (variator) and a gearing combination are
arranged in that sequence, between an engine and the output of
the CVT, in which the gearing combination is driven by the
10 outputs both of the engine and of the variator, and in which the
gearing combination is capable of two different settings so that
the CVT is capable of working in two different "regimes", thus
extending the effective ratio range of the CVT. Typically in one
regime and assuming constant engine speed, a full sweep of the
15 ratio range of the variator from one extreme to the other will
result in the CVT output speed beginning at a maximum reverse
value, reducing to zero speed (a condition known in the art as
"geared neutral" or "geared idle") and then rotating in the
forward sense and with increasing speed, reaching a low value of
20 forward speed when the opposite extreme of the variator range is
reached. If ratios are appropriately chosen it will then be
possible to change the setting of the gearing combination, so
that the CVT changes from one regime to the other, in a so-called
synchronous manner, that is to say without instantaneous change
25 of the speed of rotation of the CVT output. The CVT is now said
to be in high regime, and if the variator is progressed back to
the original end of its ratio range the forward speed of the CVT
output increases steadily to maximum value.

Examples of such two-regime CVT's of the toroidal-race
30 rolling-traction type are to be found described in Patent
Specification GB-A-1078791, GB-B-2150240 and many other prior
publications. It has been a common feature of most such known
CVT's that in the first or low regime, the gearing combination -
typically of epicyclic type - has been used in conjunction with
35 the variator as an output side or downstream shunt: in this
regime power has recirculated, and the variator output has

2098170

- 2 -

subtracted speed from its engine-driven input. In contrast in the second or high regime, there has in effect been a direct driving connection between the engine and the CVT output: the variator has taken full engine power, and the output range of the transmission has been the same as that of the variator.

In a variator which reverses the direction of rotation between input and output, the torque reaction (on the casing) will be the sum of the input and output torques. The tractive forces between the discs and rollers are proportional to the torque reaction. The ratio between tractive force and normal force between each disc and roller, commonly known in the art as the "design traction coefficient", is usually fixed by the layout of the variator. The normal force determines the contact stresses and therefore the size of the variator for a specified fatigue life. For any given operating condition size is approximately proportional to the cube root of the normal force, i.e. the cube root of the torque reaction. It is therefore advantageous to reduce torque reactions as far as possible.

If, for example, a variator with a ratio range from 0.5:1 to 2.0:1 is connected in high ratio to an input producing 100 Nm of torque, the torque reactions would range from 300 Nm at the low output speed end of the range to 150 Nm at the high end. The size of a variator will be influenced by its duty cycle, i.e. the time spent at full and part load and the time spent at each ratio. In most road vehicles little time is spent in low regime. Hard acceleration or hill climbing in high regime will tend to utilise low variator ratios at large engine torques.

Benefits in size and weight (size cubed) can therefore be achieved by reducing the maximum torque reaction which occurs in high regime at the low end of the variator ratio range.

The present invention arises from appreciating the possibility of reducing the maximum torque reaction in high regime within the variator of a two-regime CVT by avoiding direct drive in high regime, and instead using a form of gearing shunt in that regime as well as in low regime. More particularly, the

2098170

- 3 -

typically epicyclic gearing combination downstream of the variator is capable of a low regime setting in which it recirculates power, and an alternative high regime setting in which it "splits" the power flow from the engine to the output.

5 By limiting the fraction of full power passing directly through the variator, the invention thus offers the prospect of a variator with components of smaller size than would have been necessary if direct drive had been used, and economy of design may be achieved by maximising the number of gearing components
10 that are used in both regimes, and minimising the number that are used in only one regime.

The invention is defined by the claims, the contents of which are to be read as included within the disclosure of this specification, and includes a CVT as described with reference to
15 the accompanying diagrammatic drawing. An embodiment of the invention will now be described by way of example with reference to that drawing, which shows some components of a CVT schematically and others in axial section.

A CVT having an output 1 and an epicyclic gearing combination
20 2 and toroidal-race variator 3 is driven by an engine 4. The output shaft 5 of the engine carries a gear 6 and a chain gear 7. Gear 6 drives a gear 8, carried by the central input member of variator 3, with direction reversal and slight increase in rotary speed. The variator input member comprises two discs
25 and 11, arranged back-to-back and each formed with a part-toroidal race 12. Two coordinated sets of rollers, of which single rollers 13 and 14 are shown by way of example, transmit traction from races 12 to corresponding races 15, 16 formed on
30 the faces of output discs 17 and 18 which are carried by and rotate with an output shaft 19, from which gear 8 and discs 10, 11 are separated by a rotary bearing 20. When rollers 13, 14 change orientation in unison by pivoting as indicated by arrow
21, the rotational speed ratio transmitted from input discs 10, 11 to output discs 17 and 18, and so to output shaft 19, is
35 changed also.

2098170

- 4 -

Output shaft 19 is directly connected to a central, sun-like gear 25 of epicyclic 2, and gear 7 is connected by a chain 26 to a chain gear 27 mounted on a hollow extension 28 of a member 29 which carries planet gears 30 of stepped form, comprising a larger gear 31 and a smaller gear 32. By means of the chain connection 26, the engine output shaft 5 drives member 29 without reversal, and with some speed reduction.

The large gears 31 of planets 30 mesh with central gear 25. The small gears 32 of the same planets mesh firstly with a central gear 33, the shaft 34 of which also carries a flange 35 which is engageable, by operation of a high-regime clutch 38, with CVT output shaft 1. Secondly, the smaller gears 32 mesh exteriorly with an annular gear 36 formed on a sleeve 37 which is engageable, by operation of a low regime clutch 39, with the same output shaft 1.

In high regime clutch 38 is engaged and clutch 39 disengaged. Carrier 29 is driven by engine output shaft 5 by way of chain 26, central gear 25 is rotated in the same sense by variator output shaft 19, and the smaller planet gears 32 drive the central gear 33, and so the output 1, in a manner which represents the sum of the two inputs (at 25, 29) to epicyclic 2.

In low regime clutch 38 is disengaged and clutch 39 engaged in its place. Gear 25 and carrier 29 are respectively driven by variator output shaft 19 and engine output shaft 5 as before, but now the annular gear 36 and sleeve 37 transmit drive from the radially-outer sides of smaller planet gears 32 to the output member 1. The drawing thus shows an epicyclic 2 in which two of the components — central gear 25 and "carrier" 29 — are common to both regimes of CVT operation, but in which by changing over just the third component two different epicyclic ratios are achieved, one for high and low regime respectively.

Calculations have been made, for one possible CVT according to the invention, using the following assumptions:—

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2098170

- 6 -

Of particular note, in the above figures, are the relatively low values of torque reaction T_r at low values of V in high regime, when typically the engine is most likely to be under hard acceleration, and where in a conventional two-regime CVT, with
5 direct drive in high regime, the torque reaction could be expected to be approaching twice the value shown.

2098170

- 7 -

CLAIMS

1. A continuously-variable-ratio transmission (CVT) of the toroidal-race rolling-traction type, capable of operating in "low" and "high" regimes with synchronous change between those regimes, and including a variator (3) - that is to say a ratio-varying component - and an associated gearing set (2) of which the components are capable of being set in different combinations for the high and low regimes, in which the output of the gearing is connectable to the output (1) of the CVT as a whole, and the gearing has first (25) and second (29) inputs connected with the variator output (19) and engine output (5) respectively, characterised in that in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set to as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
2. A CVT according to Claim 1 characterised in that all components (25, 29, 33, 36) of the gearing set are coaxial.
3. A CVT according to Claim 2 characterised in that the gearing combination and variator are coaxial.
4. A CVT according to Claim 1 characterised in that first (25) and second (29) components of the gearing, to which the variator and engine outputs are respectively connected, intermesh with each other in epicyclic fashion.
5. A CVT according to Claim 4 characterised in that the second component carries planet gears (30).
6. A CVT according to Claim 5 characterised in that in high regime drive is transmitted to the CVT output by way of a third component (33) meshing internally with the planets, and in low regime by way of a fourth component (36) meshing with them externally.
7. A CVT according to Claim 6 characterised in that the planets are in the form of stepped gears presenting both a greater and a lesser radius, in which the greater radius (at 31) meshes with the first component, and in which the lesser radius (at 32) meshes with the third and fourth components.

1/1

2098170

