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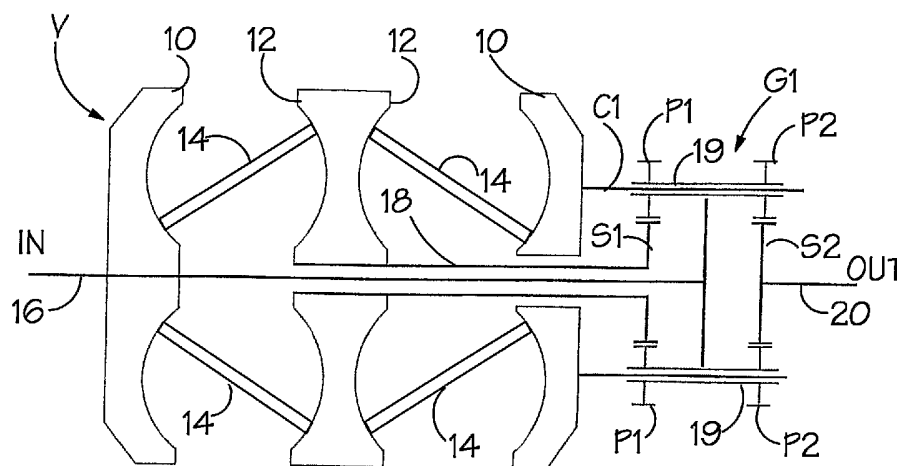
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(54) Title: CONTINUOUSLY VARIABLE RATIO TRANSMISSION SYSTEM



(57) Abstract: A continuously variable transmission comprises coaxial system input and output shafts (16, 20), a continuously variable ratio transmission unit (variator) (V) connected coaxially to the system input shaft (16) and having a coaxial variator output shaft (18) and a mixing planetary gear train (G1). The mixing planetary gear train has an input sun gear (S1) drivably connected to the variator output shaft (18), a planet carrier (C1) drivably connected to the system input shaft (16), a first planet gear (P1) mounted on the planet carrier (C1) and drivingly engaged with the input sun gear (S1), a second planet gear (P2) mounted on the planet carrier (C1) and arranged to rotate with the first planet gear (P1) and drivingly engaged with an output sun gear (S2) connected to an output shaft (20). The ratio R1 (the number of teeth on the input sun gear ÷ by the number of teeth on the first planet gear) is set to be greater than R2 (the number of teeth on the output sun gear ÷ by the number of teeth on the second planet gear). This ensures that the variator always transmits less than 100% of the engine power, which allows the variator to be made more compact.

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DESCRIPTIONCONTINUOUSLY VARIABLE RATIO TRANSMISSION SYSTEM

It is known to provide a continuously variable ratio transmission system (CVT) having coaxial system input and output shafts and a continuously variable ratio transmission unit (known as a variator) connected coaxially to the system input shaft and having a coaxial variator output shaft.

In a typical arrangement, shown in Fig. 4, the carrier C of a mixing planetary gear train G is driven by a system input shaft I and carries a plurality of double-spur planetary gears P, one of the spurs X meshing with an input sun gear Z connected to the variator output shaft and the other of the spurs Y, identical in size to the first spur gear, meshing with an output sun gear W, identical to the input sun gear Z, which is connected to a system output shaft O. The rotational speed of the system output shaft varies as the ratio of the variator changes, and since the spurs X, Y of the planetary gears P are identical, to each other and the input and output sun gears Z, W are identical to each other, the variator always transmits 100% of the input power from the engine and can operate over its entire designed ratio spread.

Such transmission systems normally form part of a multi-regime transmission, comprising a low regime which provides a system output ranging from reverse, through a geared neutral to low forward speed and a high regime operating in the forward direction from low forward speed through to deep overdrive. Changing between the two regimes is achieved by means of clutches to engage or disengage the appropriate gearing.

Changing from one regime to the other is obtained at or very near so-called "synchronous" ratio of the variator, i.e. a ratio which overlaps the high end of the low regime and the low end of the high regime and at which the transmission output in either regime is the same (or very nearly so).

However, the variator is subjected to the highest stress at and around synchronous ratio and is therefore designed always with this in mind. If, as is usual, the variator is designed to transmit 100% of the engine power, it must be built to withstand the maximum available engine power, which therefore effectively limits the minimum size of the variator, having adverse effects on the size of the transmission as a whole.

It would therefore be desirable if the transmission could be arranged to reduce the proportion of power transmitted through the variator, particularly at and near synchronous ratio where the demands on the variator are highest, as this would allow more compact variators to be used.

In accordance with the present invention, a continuously variable ratio transmission system comprises:

- coaxial system input and output shafts;

- a continuously variable ratio transmission unit (variator) connected coaxially to the system input shaft and having a coaxial variator output shaft; and

- a mixing planetary gear train having an input sun gear drivably connected to the variator output shaft, a planet carrier drivably connected to the system input shaft, a first planet gear mounted on the planet carrier and drivingly engaged with the input sun gear,

a second planet gear mounted on the planet carrier and arranged to rotate with the first planet gear and drivingly engaged with an output sun gear connected to an output shaft;

wherein ratio $R1$ (the number of teeth on the input sun gear $\div$ by the number of teeth on the first planet gear) is greater than $R2$ (the number of teeth on the output sun gear $\div$ by the number of teeth on the second planet gear).

If $R1 = R2$, the variator always transmits 100% of the engine power. By having $R1 > R2$, a "power split" is created, whereby the variator always transmits less than 100% of the engine power. The power split is greatest at the variator ratio corresponding to synchronous ratio, where the demands on the variator are greatest.

Although such an arrangement effectively reduces the ratio spread of the transmission, the advantage is that the variator can be made more compact, as it never transmits 100% of the engine power.

By way of example, specific embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:-

Fig. 1 is a diagrammatic representation of a first embodiment of continuously variable transmission in accordance with the present invention showing the principle of the invention;

Fig. 2 is a series of graphs showing the proportion of engine power transmitted by the variator with the arrangement of Fig. 1 for different values of $R2/R1$ (to be explained hereafter);

Fig. 3 is a diagrammatic illustration of a second embodiment of continuously

variable transmission in accordance with the present invention; and

Fig. 4 is a digrammatic illustration of a known arrangement of continuously variable transmission.

Referring firstly to Fig. 1, a continuously variable ratio transmission system comprises a variator V of the known toroidal race rolling traction type having two toroidally-recessed discs 10 arranged one at each end of the unit and a pair of similar output discs 12, each facing a respective one of the input discs 10 and rotating with each other. Sets of rollers 14 are mounted between the opposing faces of the input and output discs 10, 12 to transmit drive from the input discs 10 to the output discs 12 with a ratio which is variable by tilting the rollers 14. The mechanism for, and control of, the tilt of the roller is well known and will not be described further hereinafter.

The input discs 10 are connected to and driven by a system input shaft 16. One end of the input shaft 16 is connected to the output of an engine and the opposite end of the input shaft 16 is formed into the carrier C1 of a planetary gear set which will be described in more detail hereafter.

The variator provides an output via a tubular variator output shaft 18 which rotates with the output discs 12 and is arranged coaxially with the input shaft 16. The end of the shaft 18 remote from the variator V drives an input sun gear S1 of a planetary gear set G1. The sun gear S1 in turn drives a plurality of identical planetary gears P1 mounted on the carrier C1. The planet gears P1 are each mounted on the carrier C1 by means of an associated shaft 19 which additionally carries an output planet gear P2 each

of which meshes with, and drives, an output sun gear S2 which is connected to an output shaft 20.

If $R1$ is defined as [number of teeth on sun S1 ÷ by number of teeth on planet P1] and $R2$ as [number of teeth on sun S2 ÷ by number of teeth on planet P2], the planetary gearing P is arranged so that $R2 < R1$. For example, the sun gears S1 and S2 may both have 33 teeth, planetary gear P1 may have 23 teeth and planetary gear P2 may have 24 teeth.

By ensuring that $R2 < R1$ the power transmitted by the variator is always less than the power input from the engine. The effect of this can be seen from Fig. 2, which is a graph showing the proportion of engine power transmitted by the variator against the variator ratio, for different values of $R1/R2$ for a typical transmission.

Thus, it will be seen that as the engine approaches synchronous ratio, where the load on the variator is highest, a relatively large proportion of the engine power bypasses the variator. As the variator moves away from synchronous ratio, more of the engine power passes through the variator. Thus, the variator can be made more compact as it never transmits 100% of the engine power.

The arrangement of Fig. 1 is a single-regime transmission to show the principle of the invention. In practice, the arrangement of Fig. 1 would form the high-regime part of a multi-regime transmission. An example of such a transmission is illustrated in Fig. 3, which shows the arrangement of the first embodiment as part of an embodiment of two-regime transmission in accordance with the invention. The portion of the

transmission illustrated and described for the first embodiment is used in high regime or overdrive mode, in which the output shaft 20 is selectively connected to a reversing gear set comprising gear input R1 (typically of 25 teeth) and output gear R2 (typically of 27 teeth) to a final output shaft 24 by applying a high regime clutch H between the output shaft 22 and the gear R1.

In addition to the arrangement of the first embodiment, a gearing for low regime comprises a second planetary gear set G2 and carrier C1, on which are mounted a plurality of planetary gears P3 meshing with, and identical to, planet gear P2 and with an annulus or ring gear A1 (typically having 87 teeth). The annulus forms the carrier C2 for identical intermeshing radially inner and outer identical planetary gears P4 and P5 (typically having 16 teeth), the outer gear P4 of which meshes with a fixed annulus A2 (typically of 71 teeth) and the inner of which meshes with a further sun gear S3 (typically of 35 teeth) which is mounted on one end of a tubular output shaft 26 arranged coaxially with output shaft 22. The number of teeth for the components of the gear set G2 are given by way of example only. In particular, planetary gears P2, P3 and planetary gears P4, P5 need not be identical.

Low regime operation is obtained by disengaging the high regime clutch H and connecting the tubular output shaft 26 to the reversing gear set by engagement of a low regime clutch L. Regime change takes place at or near synchronous ratio of the variator V, i.e. in a condition where the transmission output speed would be the same in both high and low regime.

The invention is not restricted to the details of the foregoing embodiments.

CLAIMS

1. A continuously variable transmission comprising:
coaxial system input and output shafts (16, 20);
a continuously variable ratio transmission unit (variator) (V) connected coaxially to the system input shaft (16) and having a coaxial variator output shaft (18); and
a mixing planetary gear train (G1) having an input sun gear (S1) drivably connected to the variator output shaft (18), a planet carrier (C1) drivably connected to the system input shaft (16), a first planet gear (P1) mounted on the planet carrier (C1) and drivingly engaged with the input sun gear (S1), a second planet gear (P2) mounted on the planet carrier (C1) and arranged to rotate with the first planet gear and drivingly engaged with an output sun gear (S2) connected to an output shaft (20);
wherein ratio $R1$ (the number of teeth on the input sun gear $\div$ by the number of teeth on the first planet gear) is greater than $R2$ (the number of teeth on the output sun gear $\div$ by the number of teeth on the second planet gear).
2. A continuously variable transmission as claimed in claim 1, comprising further gearing (G2) engaged with the second planet gear.
3. A continuously variable transmission as claimed in claim 2, further comprising clutch means (H, L) for selectively engaging either the output shaft (20) or the output (26) of the further gearing (G2) as the transmission output.

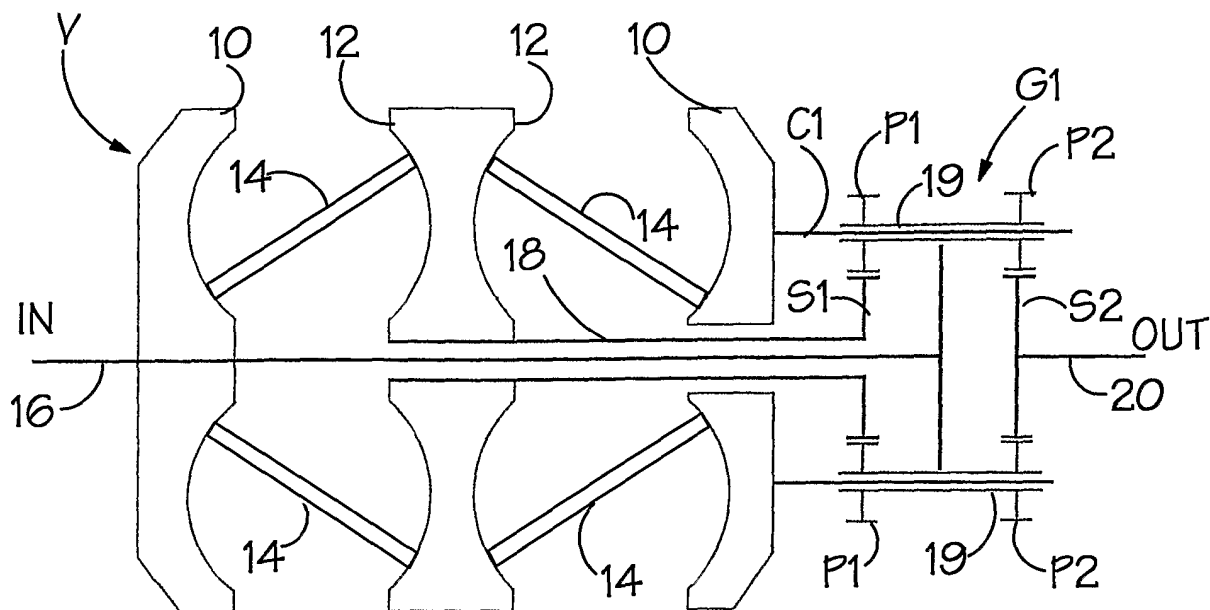


FIG.1.

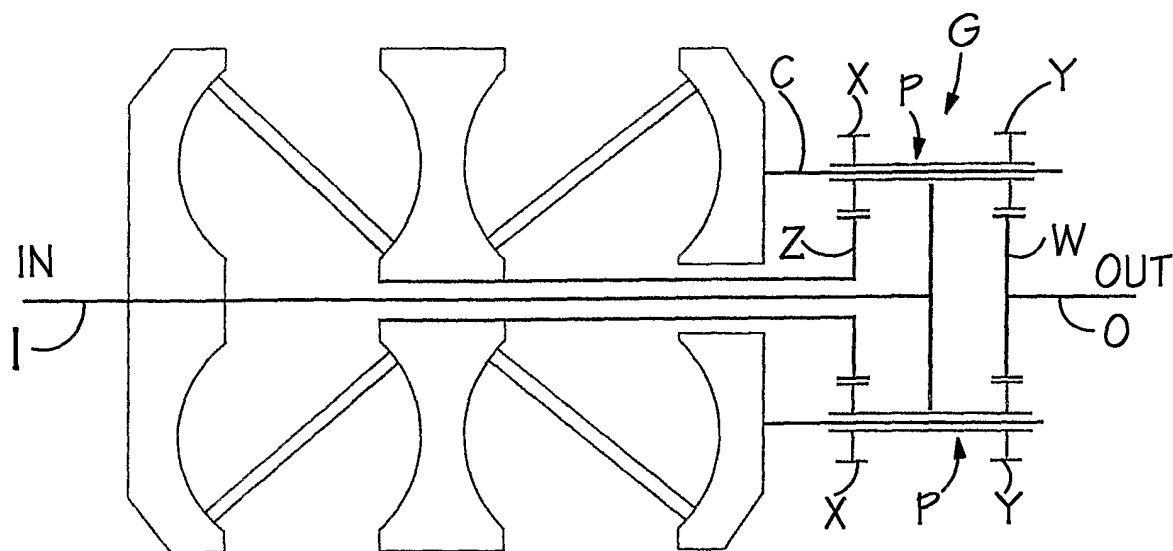


FIG.4. PRIOR ART

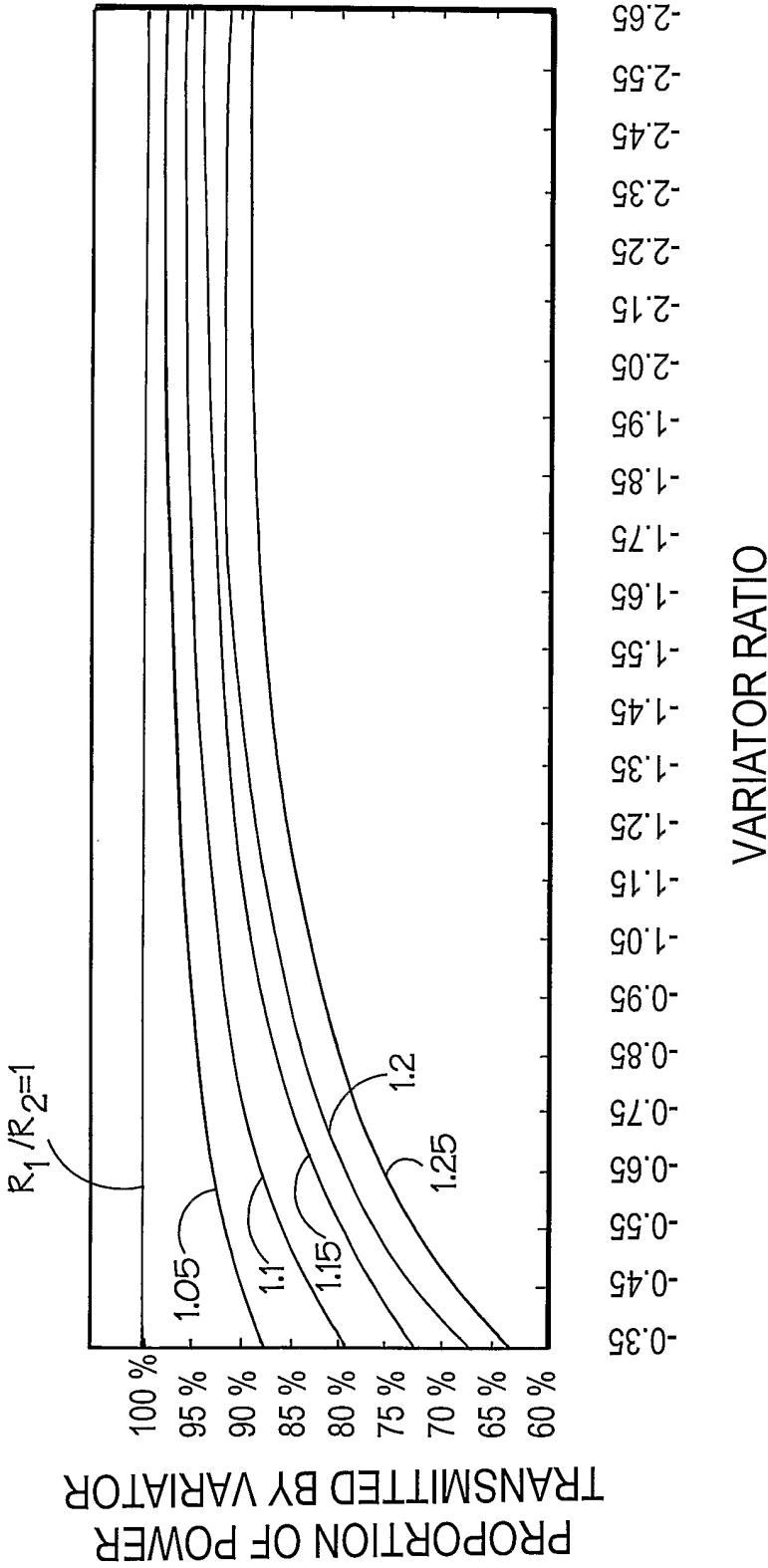


FIG.2.

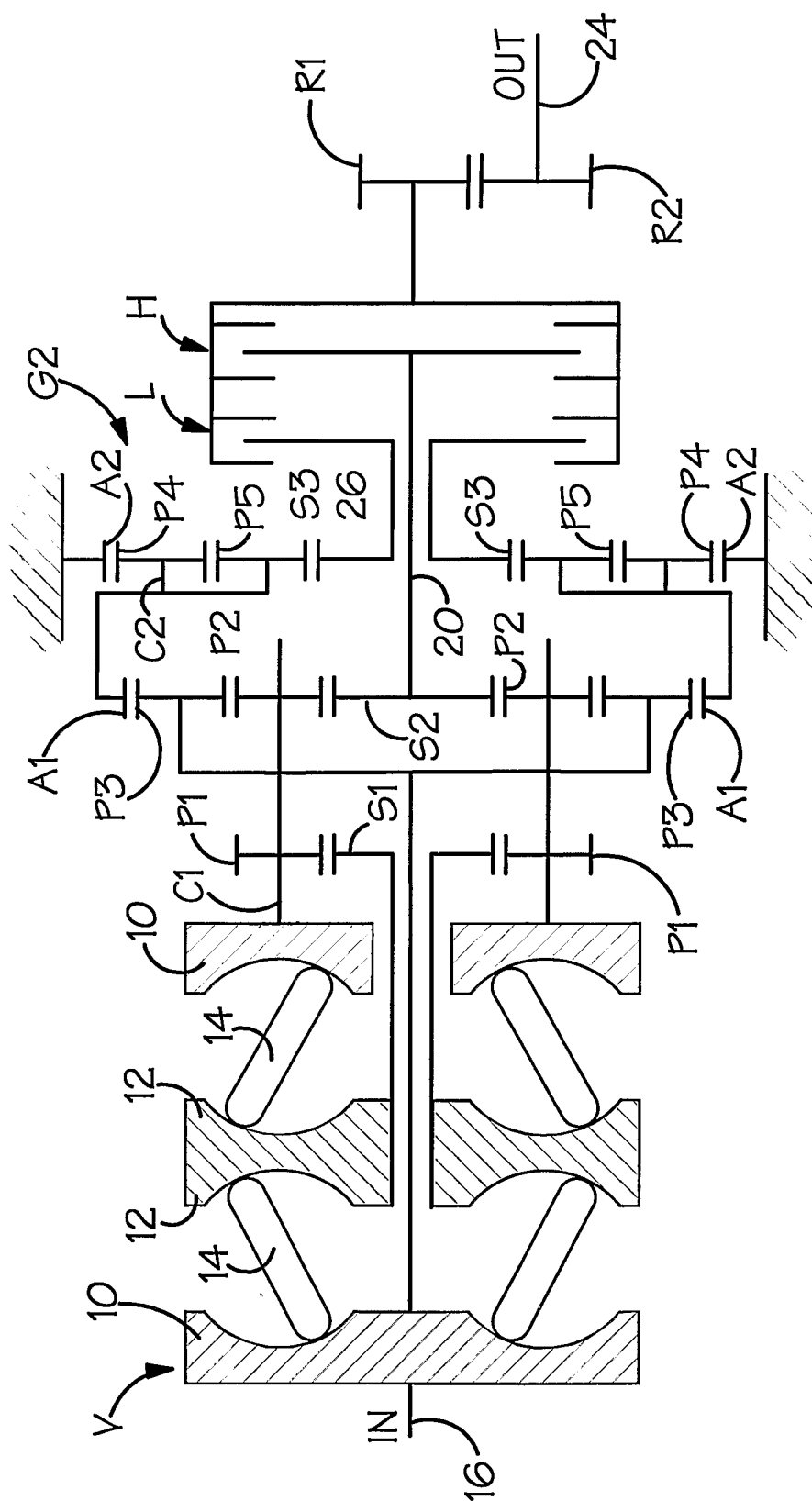


FIG. 3.

INTERNATIONAL SEARCH REPORT

Application No

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H37/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 026 424 A (ISUZU MOTORS LIMITED) 9 August 2000 (2000-08-09) paragraph '0023! - paragraph '0025! paragraph '0039!; figure 1	1-3
X	US 2002/019285 A1 (HENZLER STEFFEN) 14 February 2002 (2002-02-14) paragraphs '0023!, '0024!, '0038! claim 17; figure 3	1-3
A	US 2002/169048 A1 (HENZLER STEFFEN ET AL) 14 November 2002 (2002-11-14) paragraph '0033! - paragraph '0036! paragraphs '0046!, '0047!, '0051!, '0052!; figure 8 ----- -/--	2,3

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Application No

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