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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F16H 15/04	A1	(11) International Publication Number: WO 93/05318 (43) International Publication Date: 18 March 1993 (18.03.93)

(21) International Application Number: PCT/IT92/00104

(22) International Filing Date: 12 August 1992 (12.08.92)

(30) Priority data:
TO91A000672 3 September 1991 (03.09.91) IT

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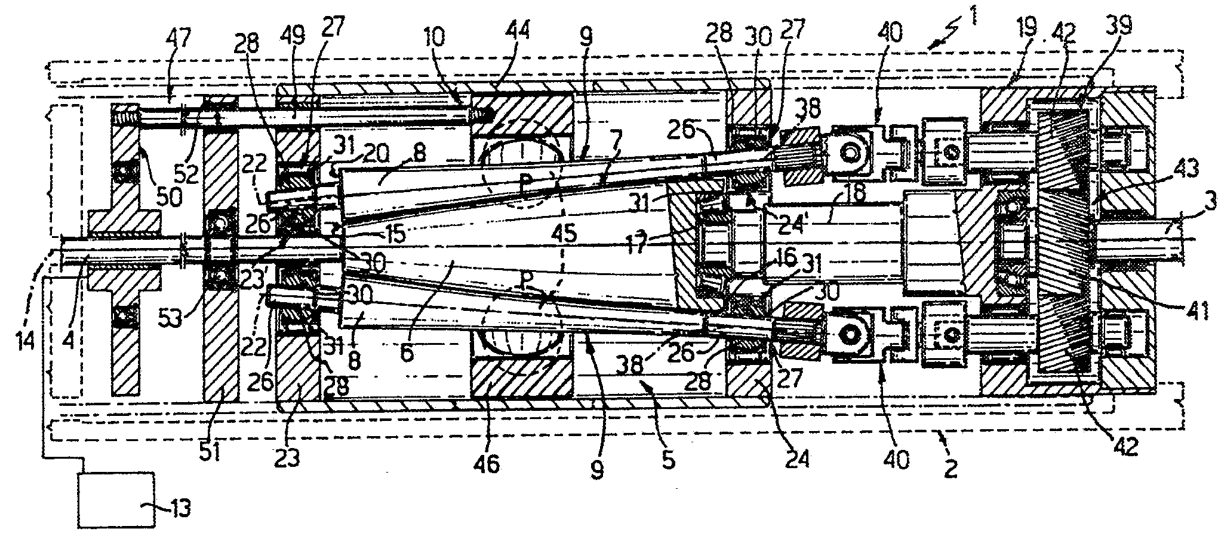
(81) Designated States: AT, AU, BB, BG, BR, CA, CH, CS, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MG, MN, MW, NL, NO, PL, RO, RU, SD, SE, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, SN, TD, TG).

Published
With international search report.
With amended claims.

(54) Title: VARIABLE-SPEED DRIVE, PARTICULARLY FOR VEHICLES



(57) Abstract

A variable-speed drive (1) having an input shaft (3), at least one output shaft (4), and a system (5) for connecting the input shaft (3) to the output shaft (4) and enabling the velocity ratio of the shafts (3, 4) to be varied continuously; which system is defined by a first truncated-cone-shaped rotary body (6) angularly integral with the output shaft (4) and defined laterally by a curved convex surface (7) having a given curve radius, and by a number of second truncated-cone-shaped rotary bodies (8) angularly integral with the input shaft (3) and arranged in a ring about the first rotary body (6). Each second rotary body (8) is defined laterally by a curved concave surface (9) having a curve radius greater than that of the convex surface (7) defining the first rotary body (6), is pressed against the first rotary body (6) by a forcing device (43) defined by a pair of helical gears (41, 42), and is controlled by a device (10) for rocking each second rotary body (8) to and from the axis of rotation (14) of the first rotary body (6), so that the curved surfaces (7, 9) cooperate mutually at a single point of tangency (P).

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VARIABLE-SPEED DRIVE, PARTICULARLY FOR VEHICLES

TECHNICAL FIELD

The present invention relates to a variable-speed drive, particularly for vehicles.

BACKGROUND ART

Known variable-speed drives normally comprise an input shaft, an output shaft, and a pair of conical bodies, each at least angularly integral with a respective shaft, and connected angularly to each other via the interposition of an intermediate element, the movement of which in relation to the conical bodies provides for varying the velocity ratio of the input and output shafts.

Depending on the application, the intermediate element is defined by a further rigid body, normally a cone or cylinder, or by a flexible element designed to cooperate with a lateral surface of the conical bodies.

In most applications in which a rigid body is used, at least part of the generating line of the body cooperates in sliding manner with part of the generating line of the conical bodies.

Though universally adopted, such a design presents a major functional drawback due to the variation in surface speed along the contacting portions of the generating lines resulting in relative slide between the contacting profiles, thus resulting in increased power loss due to friction and, consequently, in reduced efficiency of the variable-speed drive. Relative slide and, consequently, power loss may be reduced by reducing the length of the contacting portion of the generating line so that, at most, the rotary bodies contact at one point only.

Known design solutions for overcoming the above drawback are nevertheless unsatisfactory in terms of power transmission, which can only be increased by increasing the number of movable intermediate elements, thus resulting in an increase in the size and manufacturing cost of the drive.

The increase in cost is due to the fact that, according to the above solutions, one of the conical bodies must necessarily be axially mobile in relation to the other, thus requiring the use of self-compensating axial joints, i.e. capable of exerting predetermined axial pressure as a function of the torque on the conical drive body.

DISCLOSURE OF INVENTION

It is an object of the present invention to provide a variable-speed drive designed to overcome the aforementioned drawbacks, and which, more specifically, provides for a high degree of mechanical efficiency and relatively high power transmission, while at the same time being straightforward in design and cheap to produce.

According to the present invention, there is provided a variable-speed drive for vehicles, comprising an input shaft, at least one output shaft, and means for connecting said input shaft to said output shaft, and enabling the velocity ratio of the shafts to be varied continuously; characterized by the fact that said connecting means comprise a first rotary drive element angularly integral with one of said shafts and defined laterally by a curved surface having a given curve radius; a number of second rotary drive elements angularly integral with the other of said shafts and arranged in a ring about said first rotary element, each said second rotary element being defined laterally and on the side facing said first rotary element by a respective curved lateral surface having a given curve radius; control means providing for mutual cooperation of said curved surfaces at only one point of tangency movable along a generating line of said rotary elements; and means for forcing said curved surfaces against each other at said point of tangency.

BRIEF DESCRIPTION OF DRAWINGS

A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Fig.1 shows a schematic section, substantially in block form, of a first preferred embodiment of the variable-speed drive according to the present invention;

Fig.2 shows a view in perspective of the Fig.1 drive;

Fig.3 shows an enlarged detailed section of the Fig.1 and 2 drive;

Fig.4 shows a cross section of the Fig.3 drive in two different operating positions;

Fig.5 shows an enlarged view of a detail in Fig.3;

Fig.6 shows a partial view in perspective of a detail in Fig.6;

Fig.7 shows a schematic section, substantially in block form, of a second preferred embodiment of the variable-speed drive according to the present invention;

Fig.8 shows a schematic section, substantially in block form, of a third preferred embodiment of the variable-speed drive according to the present invention;

Fig.9 shows a further preferred embodiment of the variable-speed drive according to the present invention;

Fig.10 shows an enlarged exploded view of a detail on the Fig.9 drive;

Fig.11 shows a front section of the Fig.9 detail;

Fig.12 shows a front lateral section of the Fig.9 detail at 90° to the Fig.11 section.

BEST MODE FOR CARRYING OUT THE INVENTION

Number 1 in Fig.s 1 to 3 indicates a variable-speed drive for vehicles, comprising an outer casing 2; an input shaft 3 and output shaft 4 projecting from opposite ends of casing 2; and a system 5 housed inside casing 2, for connecting input shaft 3 to output shaft 4 and enabling the velocity ratio of shafts 3 and 4 to be varied continuously.

As shown in Fig.s 1 to 3, system 5 for connecting shafts 3 and 4 comprises a first truncated-cone-shaped rotary body 6, substantially barrel-shaped and defined laterally by a curved convex surface 7 having a given curve radius; and a number (6 in the example shown) of second substantially truncated-cone-shaped rotary bodies 8 arranged in a ring about first body 6. On the side facing first body 6, each second rotary body 8 is defined laterally by a curved concave surface 9 having a given curve radius greater than that of convex surface 7 laterally defining first body 6.

System 5 also comprises a control device 10 driven by a control system 13 (Fig.3), and which provides for mutual cooperation of curved surfaces 7 and 9 at an axially-variable point of tangency P.

As shown in Fig.1 and particularly Fig.3, first rotary body 6 rotates about axis 14, and presents narrow end 15 connected stably to output shaft 4, and wider end 16 connected, via the interposition of a taper roller bearing 17, to the free end of an elongated cylindrical supporting body 18, the opposite end of which is integral with end portion 19 of outer casing 2.

Second rotary bodies 8 are equally spaced in a ring about first body 6, with wider ends 20 substantially corresponding with narrow end 15 of first body 6, and decreasing in diameter alongside the increasing diameter of first body 6. Second rotary bodies 8 rotate about respective axes 22 diverging by the same angle in relation to axis 14 of first body 6 and towards end portion 19 of casing 2 (Fig.3). As shown in Fig.3, second rotary bodies 8 are maintained in the above position by a pair of supporting disks 23 and 24 on either side of first body 6, extending perpendicular to axis 14, and having respective holes 23' and 24' respectively engaged loosely by output shaft 4 and a portion close to the end portion of elongated cylindrical body 18.

Each second body 8 presents end portions 26 connected to supporting disks 23 and 24 by an articulated joint 27 enabling second body 8 to rock to and from axis 14 of first body 6 and about a number of axes (not shown) perpendicular to axis 14.

As shown in Fig.3 and particularly Fig.s 5 and 6, each articulated joint 27 comprises a first spherical-headed element 28 connected in axially-sliding manner to a respective end portion 26 of second body 8, and engaging a respective spherical seat 30 formed in a second element 31 forming part of articulated joint 27 and secured to supporting disk 23 or 24. Disks 23 and 24 present a number of radial seats 32 (Fig.6), one for each joint 27, and each engaged by a respective second element 31 of joint 27.

Each second element 31 is in the form of a parallelepipedon (Fig.6), and is secured to respective supporting disk 23, 24 by a pair of pads 33 (Fig.6) located on either side of second element 31 and mating with respective guides 35 formed in lateral walls 36 of seat 32, so as to move radially to and from axis 14 of first rotary body 6. Second element 31 also pivots on pads 33 about a pivot 37, so as to rotate about an axis 38 (Fig.s 3 and 6) perpendicular to axis 22 of respective second body 8 and substantially perpendicular to the Fig.3 plane.

As shown in Fig.3, variable-speed drive 1 also comprises a helical gear mechanism 39 between input shaft 3 and second rotary bodies 8; and a number of double universal joints 40 between helical gear mechanism 39 and end portion 26 on the narrow end of each second body 8. More specifically, gear mechanism 39 is housed inside end portion 19 of casing 2, and comprises a first helical gear 41 fitted to input shaft 3; and a second helical gear 42 for each second body 8, meshing with and arranged in a ring about helical gear 41, and angularly and axially integral with a respective joint 40. Gear pairs 41 and 42 define a device 43 for forcing second bodies 8 against first body 6. More specifically, the teeth of each gear 41 and 42 are so inclined as to exert a given pull on respective second body 8, via double universal joints 40, and so grip surfaces 7 and 9 together at contact point P, as explained in more detail later on.

As shown in Fig.3, control device 10 comprises a tubular cylindrical body 44 coaxial with axis 14 of first rotary body 6, housing rotary bodies 6 and 8, and connected to supporting disks 23 and 24 so as to rotate and translate in relation to the same. Control device 10 also comprises a ring of revolving bodies, more specifically, balls 45 equally spaced inside a retainer 46 and located between second rotary bodies 8 and tubular cylindrical body 44, which acts as a reaction element and defines a race for balls 45. Balls 45 are equal in number to second rotary bodies 8, and the curvature of surfaces 7 and 9 respectively defining first and second rotary bodies 6 and 8 must be such that balls 45 remain contacting second bodies 8 and tubular body 44 regardless of the axial operating position of retainer 46 and, consequently, the location of point P along the generating line of rotary bodies 6 and 8. By virtue of the pull exerted by respective gear pair 41 and 42, each second body 8 is thus forced permanently between first body 6 and balls 45, and in such a manner that the action produced between the contact surfaces of bodies 6 and 8 and perpendicular to the generating lines of the same is sufficient for transmitting the input power to variable-speed drive 1.

Control device 10 also comprises an actuating unit 47 (Fig.3) for moving retainer 46 and balls 45 in relation to first and second rotary bodies 6 and 8 and so rocking second bodies 8 to and from axis 14 of first body 6.

As shown in Fig.3, actuating unit 47 comprises a number of control rods 49 (only one of which is shown), and an actuator 50 (shown schematically) fitted in axially-sliding manner to output shaft 4 outwards of supporting disk 23, angularly fixed in relation to retainer 46 of balls 45, and controlled in known manner by system 13 so as to move rods 49 parallel to axis 14 of first rotary body 6.

Each rod 49 presents a first end integral with a peripheral portion of actuator 49; and a second end integral with a peripheral portion of retainer 46 between one ball 45 and the next.

A disk 51 for guiding rods 49 is provided between actuator 50 and supporting disk 23. Guide disk 51 presents a number of peripheral axial holes 52 engaged in sliding manner by respective rods 49, and is connected for rotation and in axially-fixed manner to output shaft 4 via a ball bearing 53, depending on the control device 10 selected.

In actual use, operation of control system 13 provides for moving actuator 50 axially along output shaft 4 and, consequently, for moving rods 49 in the same direction. This results in axial displacement of retainer 46 and balls 45, thus rocking second bodies 8 to and from axis 14 of first body 6, as permitted by articulated joints 27, and so moving contact point P along the generating lines of first and second bodies 6 and 8.

Axial displacement of balls 45 thus provides for rocking second bodies 8 between two limit positions (Fig.4) corresponding to the maximum and minimum velocity ratios of variable-speed drive 1. More specifically, when balls 45 are positioned adjacent to supporting disk 23, this provides for the "direct drive" configuration shown in Fig.4a.

Conversely, when balls 45 are positioned adjacent to supporting disk 24, this provides for the Fig.4b configuration corresponding to maximum reduction by the transmission or "first gear" in the case of a discrete transmission.

Displacement of balls 45 also displaces tubular cylindrical body 44, which, together with retainer 46, slides over the outer lateral surface of supporting disk 23 and guide disk 51, when retainer 46 is located adjacent to supporting disk 23, and over the outer lateral surfaces of supporting disk 24 and end portion 19 of casing 2, when retainer 46 is located adjacent to supporting disk 24.

Conversely, when retainer 46 is maintained in a fixed axial position, cylindrical body 44 is rotated by balls 45 about axis 14 of first rotary body 6 and in contact with the relative supporting disk.

Thus, when balls 45 are positioned according to the required velocity ratio, motion is transmitted from input shaft 3 via helical gear mechanism 39 and double universal joints 40 to second rotary bodies 8, which are forced against first rotary body 6 by respective gear pairs 41, 42, and from bodies 8 to output shaft 4 via first body 6, which, by virtue of the pull exerted by gears 41 and 42 on second bodies 8, is gripped between bodies 8.

The Fig.7 embodiment shows a variable-speed drive 55 similar to drive 1, and the component parts of which are indicated, where possible, using the same numbering system.

In the Fig.7 embodiment, first rotary body 6 is again integral with output shaft 4, which in this case, however, is connected integral with the wider end 16 of body 6.

Second rotary bodies 8 are again arranged in a ring about first body 6, but, in this case, are connected angularly to input shaft 3 by a respective flexible joint 56, known commercially as a helical joint, located between the wider end 20 of each second body 8 and the respective helical gear 42 of gear mechanism 39. Joint 56 comprises two heads 57, and a flexible body 58 in the form of a coil spring for connecting heads 57. In this case also, the teeth of gears 41 and 42 of mechanism 39 are so inclined as to cause first body 6 to penetrate inside second bodies 8 and so produce a high degree of friction between contacting surfaces 7 and 9.

The Fig.8 embodiment shows a variable-speed drive 60 similar to drive 1, and the component parts of which are indicated, where possible, using the same numbering system.

Drive 60 differs from 1 in that output shaft 4 extends from the same side as, and parallel and adjacent to, input shaft 3; is connected integral with the wider end 16 of first rotary body 6; and extends between double universal joints 40.

As shown in Fig.8, gears 42 again mesh with gear 41, which in this case is connected for rotation and in axially-fixed manner to output shaft 4, and is integral with an intermediate gear 61 also rotating in relation to output shaft 4 and in turn meshing with a helical gear 62 fitted to input shaft 3. Gears 41, 42, 61 and 62 define a helical gear mechanism 63 housed inside portion 64 of casing 2, and are secured to portion 64 for exerting said forcing action between rotary bodies 6 and 8.

The Fig.9 embodiment shows a variable-speed drive 80 similar to those described above, and the component parts of which are indicated for the sake of simplicity using the same numbering system.

As shown in Fig.s 9 to 12, drive 80 differs from 1 as regards the design of control device 10, which in this case comprises a ring of revolving bodies, more specifically balls 45, equally spaced inside a retainer defined by an annular cup-shaped element 46, which performs the function of both retainer 46 and, as will be seen, contrast element 44 on drive 1.

Control device 10 is mounted, through the end wall, so as to slide along a number of supporting and guide bars 81 integral with casing 2 and arranged in a ring, parallel to axis 14 of output shaft 4, inside the radial gaps between balls 45.

Between each ball 45 and cylindrical lateral wall 44 of retainer 46, there is provided a rolling element 82 for absorbing all the rolling components which would otherwise be transmitted by balls 45 to retainer 46 and, more specifically, to lateral wall 44 radially outwards of balls 45.

As shown in Fig.s 10, 11 and 12, each rolling element 82 comprises an axial thrust bearing 83, the axis A of which is substantially perpendicular to axis 14 of output shaft 4; and a pair of saddle rollers 91, 92.

Axial bearing 83 consists of a first cylindrical thrust bearing 84, and a second cylindrical thrust bearing 85 coaxial with the first, and between which is provided a number of spherical rolling bodies 86.

Thrust bearings 84 and 85 present a central through seat 87 for housing idle rollers 91 and 92 mounted on respective parallel rolling bearings 97. Rollers 91 and 92 present respective concave outer surfaces 93 cooperating in rolling manner with outer surface 94 of each ball 45, which thus fits between rollers 91, 92 of respective element 82 and the two adjacent second bodies 8 on either side of ball 45.

Bearing 83 also presents a plate 95, screwed on to thrust bearing 85, for retaining rollers 91 and 92 inside seat 87 during operation, on the opposite side to ball 45.

Second thrust bearing 85 is fitted to a first end 100 of a control tie 101 for moving control device 10 along bars 81, and so moving the point of action of balls 45 along outer surface 9 of rotary bodies 8, and, consequently, contact point P between bodies 8 and outer surface 7 of first body 6.

The second opposite end (not shown) of tie 101 is fitted to a drive ring 102 (substituting actuator 50 on drive 1) also mounted in sliding manner on bars 81 and controlled by a known system (not shown) connected, in the example shown, to control system 13.

In actual use, balls 45 are gripped between respective pairs of bodies 8 (Fig.4) and lateral wall 44 of retainer 46, via the interposition of a respective element 82 between each ball 45 and wall 44. Thrust bearings 84 thus rest on wall 44, which, via bearings 84 and rollers 91, 92 on bearing 83, acts as a contrast element for balls 45 in the same way as element 44 on drive 1. In this case, however, wall 44, and consequently retainer 46 as a whole, is not rotated by balls 45, by virtue of the rolling movement of balls 45 being absorbed by rollers 91, 92 and bearing 83; and axial displacement of element 82 by tie 101 is also transmitted to retainer 46, thus varying the velocity ratio as already described.

The advantages of variable-speed drives 1, 55, 60 and 80 will be clear from the foregoing description. In particular, they provide for direct contact of rotary bodies 6 and 8 and, more specifically, at a single point of tangency P, thus drastically reducing, if not totally eliminating, power loss due to friction, and so improving the efficiency of the drive and enabling a maximum velocity ratio of roughly 1:6.

At the same time, the design characteristics of the drive provide for relatively high power transmission for a given size, which is extremely compact even for high power transmission values.

The size, in particular the length, of the drive is further reduced in the case of drive 80 as shown in the Fig.9 embodiment. In fact, whereas on drive 1, for example, displacement of retainer 46 is also accompanied by displacement of reaction element 44, which, being rotated by balls 45, must be supported and therefore long enough to rest on either one of supporting disks 23, 24, thus resulting in a relatively long drive 1, wall 44 of drive 80 forms part of retainer 46, and, by virtue of being prevented from rotating by elements 82, may be supported on the same bars 81 supporting retainer 46, thus enabling a considerable reduction in the length of wall 44.

In addition to transmitting motion between input shaft 3 and second rotary bodies 8, helical gear mechanism 39 on variable-speed drives 1 and 55 obviously also performs the function of a self-compensating axial joint, that is, capable of exerting predetermined axial pressure on second rotary bodies 8 as a function of input power.

To those skilled in the art it will be clear that changes may be made to variable-speed drives 1, 55, 60 and 80 as described and illustrated herein without, however, departing from the scope of the present invention. In particular, a different type of articulated joint may be used for connecting ends 26 of second rotary bodies 8 to respective supporting disks 23 and 24.

Joints 40 and 56 may be replaced by others designed, for example, to support second bodies 8 in the operating position, in which case, supporting disks 23 and 24 on drives 1, 55 and 60 may be dispensed with.

At least part of the action for forcing second bodies 8 on to first body 6 may be performed by flexible joints 56, which, depending on assembly and as a function of torque, may provide for exerting pull or thrust for achieving said forcing action.

Finally, changes may be made to the manner in which second bodies 8 are forced into contact with first body 6. In particular, gears 41 and 42 may provide for exerting only part of the forcing action, the remainder being provided for by balls 45, which may be force fitted between second bodies 8 and cylindrical body 44. Moreover, said forcing action may be partly achieved by providing systems enabling axial displacement of first body 6 in relation to second bodies 8.

In this case, and not only this, supporting body 18 (Fig.9) may be made integral with casing 2 by means of a system enabling bars 81 (or similar) to extend beyond the axial position of gears 42 (e.g. by means of radial ribs), and end portion 19 may be replaced by a ring 119 mounted so as to slide axially along guide bars 81 and body 18, and, like end 19, supporting gears 42 while at the same time securing bodies 8 so that they all move axially together and by the same amount in relation to body 6. In this way, points P are located permanently on the same circumference, regardless of the position of balls 45, thus preventing one or more of bodies 8 from sliding in relation to body 6 and so resulting in premature wear of the device.

A different type of actuating unit 47 may be provided for displacing balls 45; and contrast element 44 need not necessarily be a tubular body as described herein.

Finally, depending on requirements, variable-speed drives 1, 55, 60 and 80 may obviously be so designed as to enable the use of a control motor (not shown) in the high efficiency range, thus improving the "elasticity" of the motor itself.

CLAIMS

1) A variable-speed drive (1; 55; 60), particularly for vehicles, comprising an input shaft (3), at least one output shaft (4), and means (5) for connecting said input shaft (3) to said output shaft (4), and enabling the velocity ratio of the shafts (3) (4) to be varied continuously; characterized by the fact that said connecting means (5) comprise a first rotary drive element (6) angularly integral with one (4) of said shafts (3) (4) and defined laterally by a curved surface (7) having a given curve radius; a number of second rotary drive elements (8) angularly integral with the other (3) of said shafts (3) (4) and arranged in a ring about said first rotary element (6), each said second rotary element (8) being defined laterally and on the side facing said first rotary element (6) by a respective curved lateral surface (9) having a given curve radius; control means (10) providing for mutual cooperation of said curved surfaces (7) (9) at only one point of tangency (P) movable along a generating line of said rotary elements (6) (8); and means (41, 42) for forcing said curved surfaces (7) (9) against each other at said point of tangency (P).

2) A variable-speed drive as claimed in Claim 1, characterized by the fact that said curved surface (9) defining said second rotary elements (8) presents an opposite curvature and a greater curve radius as

compared with said surface (7) defining said first rotary element (6).

3) A variable-speed drive as claimed in Claim 1 or 2, characterized by the fact that said first rotary element (6) is a barrel-shaped taper roller angularly integral with said output shaft (4); and said second rotary elements (8) are taper rollers, each connected angularly integral with said input shaft (3) and so positioned as to present a decreasing diameter alongside the increasing diameter of said first rotary element (6).

4) A variable-speed drive as claimed in one of the foregoing Claims from 1 to 3, characterized by the fact that said control means (10) comprise at least a ring of revolving bodies (45) located between said second rotary elements (8) and a reaction element (44) coaxial with said first rotary element (6) and at least defining a race for said revolving bodies (45); and actuating means (47) for moving said ring of revolving bodies (45) in relation to said first (6) and second (8) rotary elements; said curved surfaces (7) (9) laterally defining said first (6) and second (8) rotary elements being so designed as to maintain said revolving bodies (45) gripped between said second rotary elements (8) and said reaction element (44) regardless of the axial position of said revolving bodies (45).

5) A variable-speed drive as claimed in Claim 4, characterized by the fact that said actuating means (47)

comprise an actuator (50) mounted in axially-sliding manner on the shaft (4) angularly integral with said first rotary element (6); and at least one rod (49) between said actuator (50) and said ring of revolving bodies (45); said rod (49) being connected in axially-sliding manner to a guide disk (51) located between said actuator (50) and said first (6) and second (8) rotary elements, and in turn connected to the shaft (4) angularly integral with said first rotary element (6) via the interposition of a rolling bearing (53).

6) A variable-speed drive as claimed in Claim 4 or 5, characterized by the fact that said revolving bodies (45) are equal in number to said second rotary elements (8); and said reaction element comprises a tubular body (44) extending outwards of said actuating means (47).

7) A variable-speed drive as claimed in any one of the foregoing Claims, characterized by the fact that said forcing means (41, 42) are located between said second rotary elements (8) and the shaft (3) with which said second rotary elements (8) are angularly integral; said forcing means comprising, for each said second rotary element (8), a pair of helical gears (41) (42) meshing with each other and the teeth of which are so inclined as to exert a given force substantially along the axis (22) of said respective second rotary element (8) and such as to force said surfaces (7) (9) into contact with each other.

8) A variable-speed drive as claimed in Claim 7, characterized by the fact that each said pair of gears (41) (42) provides for forcing said respective second rotary element (8) between said first rotary element (6) and said control means (10).

9) A variable-speed drive as claimed in Claim 7 or 8, characterized by the fact that each said pair of gears is defined by a first helical gear (42) angularly integral with a second rotary element (8), and by a second helical gear (41) fitted to the shaft (3) angularly integral with said second rotary elements (8); said gears (41) (42) defining a helical gear mechanism (39) housed inside a portion (19) of an outer casing (2).

10) A variable-speed drive as claimed in Claim 7 or 8, characterized by the fact that said input shaft (3) and said output shaft (4) are parallel and located on the same side in relation to said first (6) and second (8) rotary elements; and each said pair of gears (41, 42) is defined by a first helical gear (42) angularly integral with a second rotary element (8), and by a second helical gear (41) fitted in rotary and axially-fixed manner to the shaft (4) angularly integral with said first rotary element (6), and integral with an intermediate gear (61) in turn meshing with a helical gear (62) fitted to said shaft (3) angularly integral with said second rotary elements (8); said gears (41)

(42) (61) (62) defining a helical gear mechanism (63) housed inside a portion (64) of an outer casing (2).

11) A variable-speed drive as claimed in one of the foregoing Claims from 4 to 10, characterized by the fact that said second rotary elements (8) present respective end portions (26) secured to a pair of supporting disks (23) (24) on either side of said first (6) and second (8) rotary elements; said reaction element (44) extending outwards of and being connectable in rotary and axially-sliding manner to said supporting disks (23) (24); and each said end portion (26) being connected to said respective supporting disk (23) (24) by articulated means (27) enabling said respective second rotary element (8) to rock to and from the axis (14) of said first rotary element (6).

12) A variable-speed drive as claimed in Claim 11, characterized by the fact that said articulated means comprise a spherical articulated joint (27) in turn comprising a first spherical-headed element (28) connected in sliding manner to an end portion (26) of a respective said second rotary element (8) and engaging a respective spherical seat (30) formed in a second element (31) secured to a respective said supporting disk (23) (24); said second element (31) being secured to said respective supporting disk (23) (24) via a pair of pads (33) located on either side of said second element (31) and connected to said supporting disk (23) (24) so as to slide radially to and from the axis (14)

of said first rotary element (6); said second element (31) also pivoting on each said pad (33) so as to rotate about an axis (38) perpendicular to the axis (14) of said first rotary element (6).

13) A variable-speed drive as claimed in any one of the foregoing Claims from 9 to 12, characterized by the fact that it comprises an angle joint (40; 56) between each said second rotary element (8) and said first helical gear (42).

14) A variable-speed drive as claimed in Claim 13, characterized by the fact that said angle joint (40) is a double universal joint.

15) A variable-speed drive as claimed in Claim 13, characterized by the fact that said angle joint (56) is a flexible joint defined by a pair of heads (57) connected by an elastic element (58) in the form of a coil spring.

16) A variable-speed drive as claimed in the foregoing Claims from 13 to 15, characterized by the fact that each said angle joint (40; 56) is located between said first helical gear (42) and the small end of said respective second rotary element (8).

17) A variable-speed drive as claimed in the foregoing Claims from 13 to 15, characterized by the fact that each said angle joint (40; 56) is located between said first helical gear (42) and the broader end (20) of said respective second rotary element (8).

18) A variable-speed drive as claimed in any one of the foregoing Claims from 13 to 17, characterized by the fact that said portion (19) of said outer casing comprises an elongated body (18) extending towards the end (16) of said first rotary element (6) opposite that integral with said shaft (4), between said angle joints (40; 56), and inside a hole (24') formed in the supporting disk (24) adjacent to said angle joints (40; 56); said first rotary element (6) presenting a free end connected to the free end of said elongated body (18) via the interposition of a taper roller bearing (17); said shaft (4) integral with said first rotary element (6) extending through the other (23) of said supporting disks (23) (24) adjacent to said guide disk (51) of said rods (49) and through said guide disk (51).

19) A variable-speed drive as claimed in one of the foregoing Claims from 1 to 3, characterized by the fact that said control means (10) comprise at least a ring of revolving bodies (45) between said second rotary elements (8) and a reaction element (44) coaxial with said first rotary element (6); and actuating means (101, 102) for moving said ring of revolving bodies (45) in relation to said first (6) and second (8) rotary elements; said curved surfaces (7) (9) laterally defining said first (6) and second (8) rotary elements being so designed as to maintain said revolving bodies (45) gripped between said second rotary elements (8) and said reaction element (44) regardless of the axial

position of said revolving bodies (45); a rolling element (82) being provided between each said revolving body (45) and said reaction element (44), for absorbing the rolling components transmitted by said revolving bodies (45) to said reaction element (44).

20) A variable-speed drive as claimed in Claim 19, characterized by the fact that said rolling element (82) substantially consists of an axial bearing (83) with its axis (A) substantially perpendicular to the axis (14) of said output shaft (4); said axial bearing (83) presenting a through seat (87) for housing respective idle rollers (91, 92); said rollers (91, 92) having respective concave outer surfaces (93) cooperating with the outer surface (94) of each said revolving body (45).

21) A variable-speed drive as claimed in Claim 20, characterized by the fact that said axial bearing (83) is fitted to a first end (100) of a control tie (101) for moving said control device (10) and so moving said point of contact (P) between said second rotary elements (8) and said curved surface (7) of said first rotary element (6).

22) A variable-speed drive as claimed in any one of the foregoing Claims, characterized by the fact that said second rotary elements (8) are secured axially to one another.

23) A variable-speed drive as claimed in any one of the foregoing claims from 4 to 22, characterized by

the fact that said ring of revolving bodies is a ring of balls (45).

24) A variable-speed drive, particularly for vehicles, substantially as described and illustrated herein with reference to the accompanying drawings.

AMENDED CLAIMS

[received by the International Bureau on 29 January 1993 (29.01.93) ; original claims 1-4 and 19 amended ; remaining claims unchanged (9 pages)]

1) A variable-speed drive (1; 55; 60), particularly for vehicles, comprising an input shaft (3), at least one output shaft (4), and means (5) for connecting said input shaft (3) to said output shaft (4), and enabling the velocity ratio of the shafts (3) (4) to be varied continuously; said connecting means (5) comprising a first rotary drive element (6) defined laterally by a first curved surface (7) having a given curve radius; a ring of second rotary drive elements (8), each said second rotary element (8) being defined laterally and on the side facing said first rotary element (6) by a respective second curved lateral surface (9) having a given curve radius; a control assembly (10) providing for mutual cooperation of said curved surfaces (7) (9) at only one point of tangency (P) movable along a generating line of said rotary elements (6) (8); and means (41, 42) for forcing said curved surfaces (7) (9) against each other at said point of tangency (P), characterized by the fact that said control assembly (10) comprises revolving means (45) for keeping said curved surfaces (7, 9) into mutual cooperation at said point (P) of tangency, said revolving means (45) having a lateral surface defined by at least a portion of a spherical surface engaging at least one of said curved surfaces (7,9), and able to freely rotate with thereto around its centre of

curvature in order to change the position of said point (P) of tangency without having sliding friction between said drive elements (6, 8) and said control assembly (10).

2) A variable-speed drive as claimed in Claim 1, characterized by the fact that said second curved surface (9) defining said second rotary elements (8) presents an opposite curvature and a differently curve radius as compared with said first surface (7) defining said first rotary element (6).

3) A variable-speed drive as claimed in Claim 1 or 2, characterized by the fact that said first rotary element (6) is a barrel-shaped taper roller angularly integral with said output shaft (4); and said second rotary elements (8) are taper rollers, each connected angularly integral with said input shaft (3) and so positioned as to present a decreasing relative diameter alongside the increasing diameter of said first rotary element (6).

4) A variable-speed drive as claimed in one of the foregoing Claims from 1 to 3, characterized by the fact that said revolving means (10) comprise at least a ring of revolving bodies (45) located between said second rotary elements (8) and a reaction element (44) coaxial with said first rotary element (6) and at least defining a race for said revolving bodies (45); said control assembly (10) further comprising and actuating means (47) for moving said ring of revolving bodies (45) in

relation to said first (6) and second (8) rotary elements; said curved surfaces (7) (9) laterally defining said first (6) and second (8) rotary elements being so designed as to maintain said revolving bodies (45) gripped between said second rotary elements (8) and said reaction element (44) regardless of the axial position of said revolving bodies (45).

5) A variable-speed drive as claimed in Claim 4, characterized by the fact that said actuating means (47) comprise an actuator (50) mounted in axially-sliding manner on the shaft (4) angularly integral with said first rotary element (6); and at least one rod (49) between said actuator (50) and said ring of revolving bodies (45); said rod (49) being connected in axially-sliding manner to a guide disk (51) located between said actuator (50) and said first (6) and second (8) rotary elements, and in turn connected to the shaft (4) angularly integral with said first rotary element (6) via the interposition of a rolling bearing (53).

6) A variable-speed drive as claimed in Claim 4 or 5, characterized by the fact that said revolving bodies (45) are equal in number to said second rotary elements (8); and said reaction element comprises a tubular body (44) extending outwards of said actuating means (47).

7) A variable-speed drive as claimed in any one of the foregoing Claims, characterized by the fact that said forcing means (41, 42) are located between said second rotary elements (8) and the shaft (3) with which

said second rotary elements (8) are angularly integral; said forcing means comprising, for each said second rotary element (8), a pair of helical gears (41) (42) meshing with each other and the teeth of which are so inclined as to exert a given force substantially along the axis (22) of said respective second rotary element (8) and such as to force said surfaces (7) (9) into contact with each other.

8) A variable-speed drive as claimed in Claim 7, characterized by the fact that each said pair of gears (41) (42) provides for forcing said respective second rotary element (8) between said first rotary element (6) and said control means (10).

9) A variable-speed drive as claimed in Claim 7 or 8, characterized by the fact that each said pair of gears is defined by a first helical gear (42) angularly integral with a second rotary element (8), and by a second helical gear (41) fitted to the shaft (3) angularly integral with said second rotary elements (8); said gears (41) (42) defining a helical gear mechanism (39) housed inside a portion (19) of an outer casing (2).

10) A variable-speed drive as claimed in Claim 7 or 8, characterized by the fact that said input shaft (3) and said output shaft (4) are parallel and located on the same side in relation to said first (6) and second (8) rotary elements; and each said pair of gears (41, 42) is defined by a first helical gear (42)

angularly integral with a second rotary element (8), and by a second helical gear (41) fitted in rotary and axially-fixed manner to the shaft (4) angularly integral with said first rotary element (6), and integral with an intermediate gear (61) in turn meshing with a helical gear (62) fitted to said shaft (3) angularly integral with said second rotary elements (8); said gears (41) (42) (61) (62) defining a helical gear mechanism (63) housed inside a portion (64) of an outer casing (2).

11) A variable-speed drive as claimed in one of the foregoing Claims from 4 to 10, characterized by the fact that said second rotary elements (8) present respective end portions (26) secured to a pair of supporting disks (23) (24) on either side of said first (6) and second (8) rotary elements; said reaction element (44) extending outwards of and being connectable in rotary and axially-sliding manner to said supporting disks (23) (24); and each said end portion (26) being connected to said respective supporting disk (23) (24) by articulated means (27) enabling said respective second rotary element (8) to rock to and from the axis (14) of said first rotary element (6).

12) A variable-speed drive as claimed in Claim 11, characterized by the fact that said articulated means comprise a spherical articulated joint (27) in turn comprising a first spherical-headed element (28) connected in sliding manner to an end portion (26) of a respective said second rotary element (8) and engaging a

respective spherical seat (30) formed in a second element (31) secured to a respective said supporting disk (23) (24); said second element (31) being secured to said respective supporting disk (23) (24) via a pair of pads (33) located on either side of said second element (31) and connected to said supporting disk (23) (24) so as to slide radially to and from the axis (14) of said first rotary element (6); said second element (31) also pivoting on each said pad (33) so as to rotate about an axis (38) perpendicular to the axis (14) of said first rotary element (6).

13) A variable-speed drive as claimed in any one of the foregoing Claims from 9 to 12, characterized by the fact that it comprises an angle joint (40; 56) between each said second rotary element (8) and said first helical gear (42).

14) A variable-speed drive as claimed in Claim 13, characterized by the fact that said angle joint (40) is a double universal joint.

15) A variable-speed drive as claimed in Claim 13, characterized by the fact that said angle joint (56) is a flexible joint defined by a pair of heads (57) connected by an elastic element (58) in the form of a coil spring.

16) A variable-speed drive as claimed in the foregoing Claims from 13 to 15, characterized by the fact that each said angle joint (40; 56) is located between said first helical gear (42) and the small end

of said respective second rotary element (8).

17) A variable-speed drive as claimed in the foregoing Claims from 13 to 15, characterized by the fact that each said angle joint (40; 56) is located between said first helical gear (42) and the broader end (20) of said respective second rotary element (8).

18) A variable-speed drive as claimed in any one of the foregoing Claims from 13 to 17, characterized by the fact that said portion (19) of said outer casing comprises an elongated body (18) extending towards the end (16) of said first rotary element (6) opposite that integral with said shaft (4), between said angle joints (40; 56), and inside a hole (24') formed in the supporting disk (24) adjacent to said angle joints (40; 56); said first rotary element (6) presenting a free end connected to the free end of said elongated body (18) via the interposition of a taper roller bearing (17); said shaft (4) integral with said first rotary element (6) extending through the other (23) of said supporting disks (23) (24) adjacent to said guide disk (51) of said rods (49) and through said guide disk (51).

19) A variable-speed drive as claimed in one of the foregoing Claims from 1 to 3, characterized by the fact that said control assembly (10) comprise at least a ring of revolving bodies (45) between said second rotary elements (8) and a reaction element (44) coaxial with said first rotary element (6); and actuating means (101, 102) for moving said ring of revolving bodies (45) in

relation to said first (6) and second (8) rotary elements; said curved surfaces (7) (9) laterally defining said first (6) and second (8) rotary elements being so designed as to maintain said revolving bodies (45) gripped between said second rotary elements (8) and said reaction element (44) regardless of the axial position of said revolving bodies (45); a rolling element (82) being provided between each said revolving body (45) and said reaction element (44), for absorbing the rolling components transmitted by said revolving bodies (45) to said reaction element (44).

20) A variable-speed drive as claimed in Claim 19, characterized by the fact that said rolling element (82) substantially consists of an axial bearing (83) with its axis (A) substantially perpendicular to the axis (14) of said output shaft (4); said axial bearing (83) presenting a through seat (87) for housing respective idle rollers (91, 92); said rollers (91, 92) having respective concave outer surfaces (93) cooperating with the outer surface (94) of each said revolving body (45).

21) A variable-speed drive as claimed in Claim 20, characterized by the fact that said axial bearing (83) is fitted to a first end (100) of a control tie (101) for moving said control device (10) and so moving said point of contact (P) between said second rotary elements (8) and said curved surface (7) of said first rotary element (6).

22) A variable-speed drive as claimed in any one

of the foregoing Claims, characterized by the fact that said second rotary elements (8) are secured axially to one another.

23) A variable-speed drive as claimed in any one of the foregoing claims from 4 to 22, characterized by the fact that said ring of revolving bodies is a ring of balls (45).

24) A variable-speed drive, particularly for vehicles, substantially as described and illustrated herein with reference to the accompanying drawings.

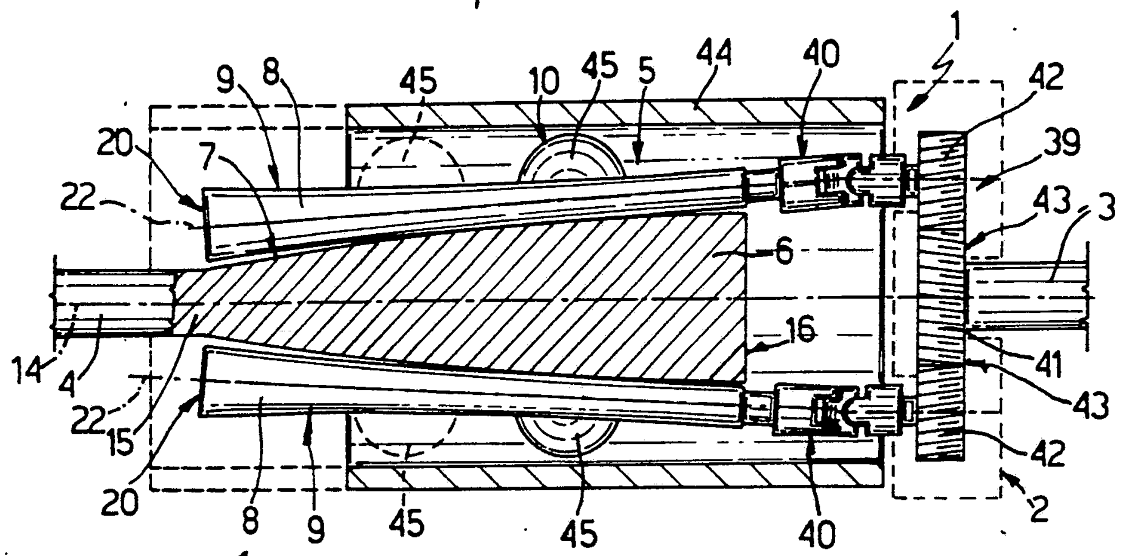


Fig.1

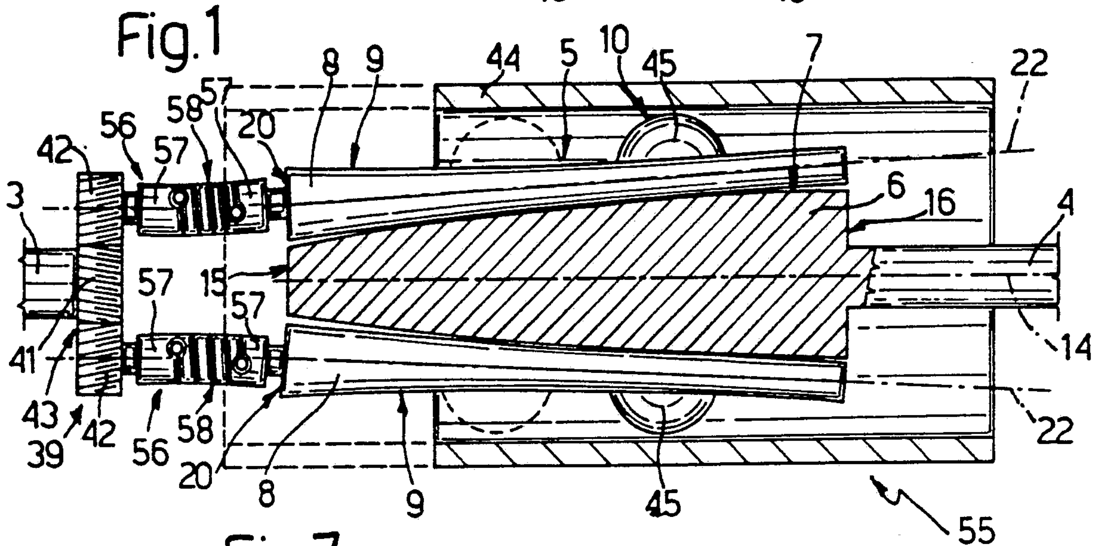
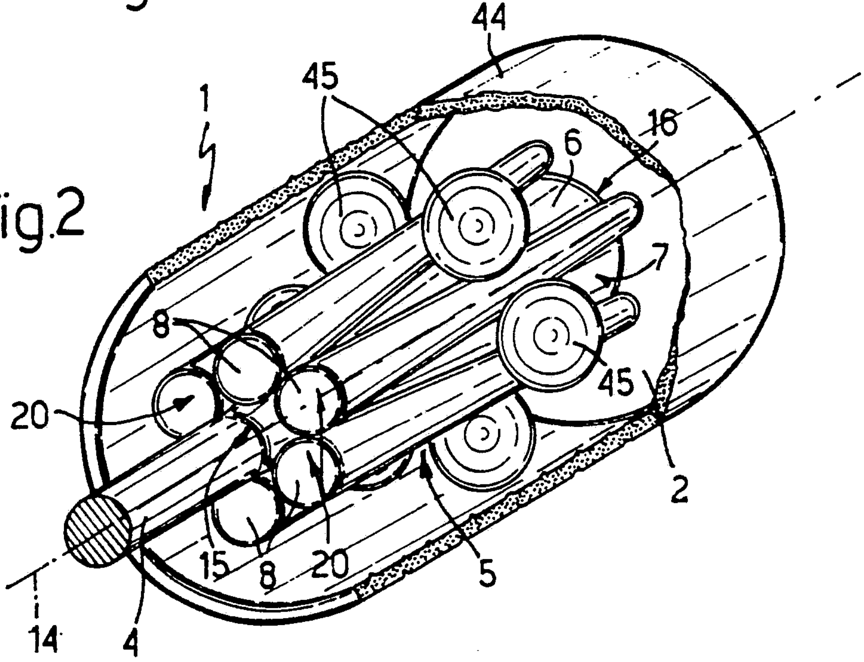


Fig.7

Fig.2



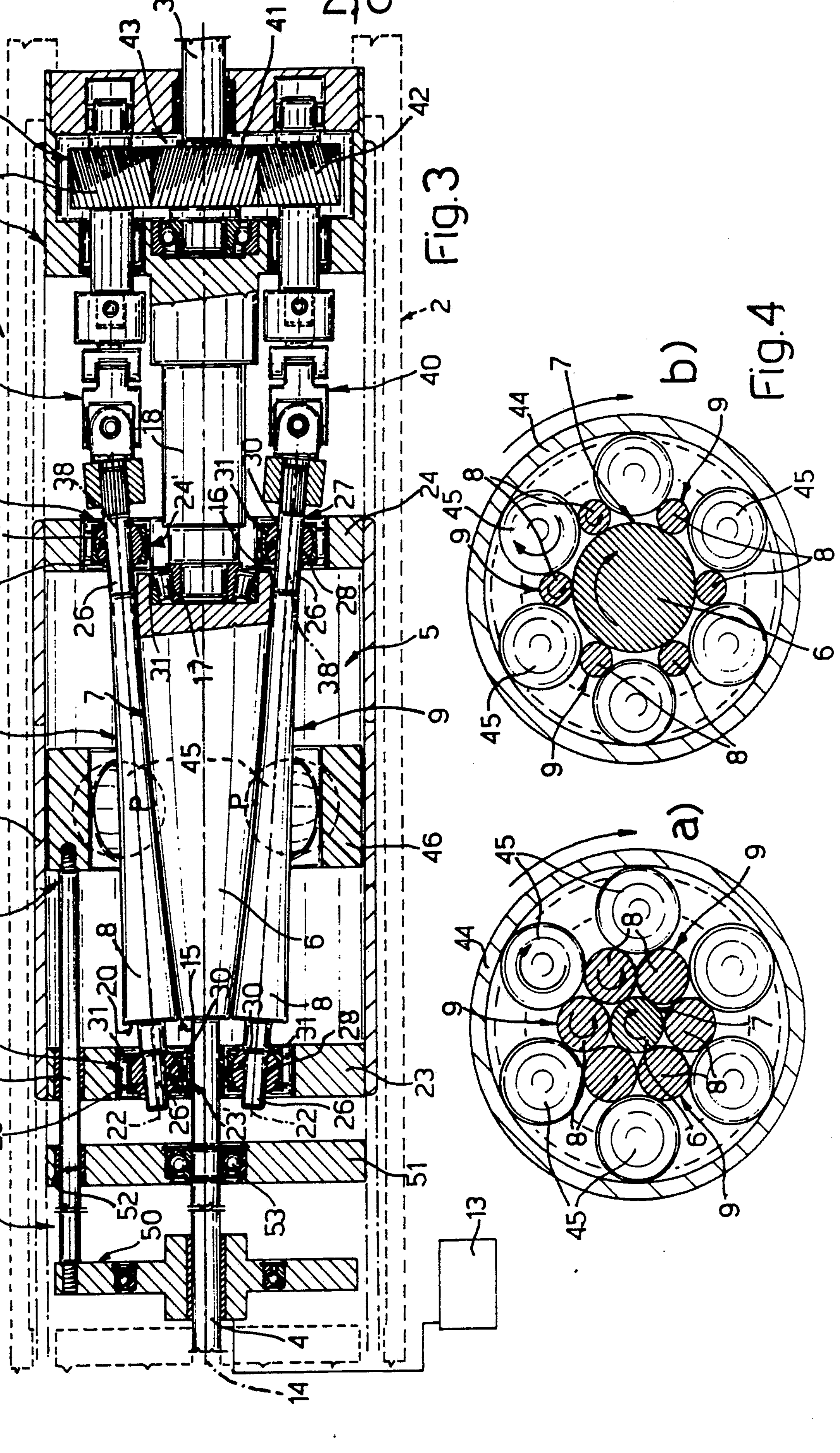


Fig.3

Fig.4

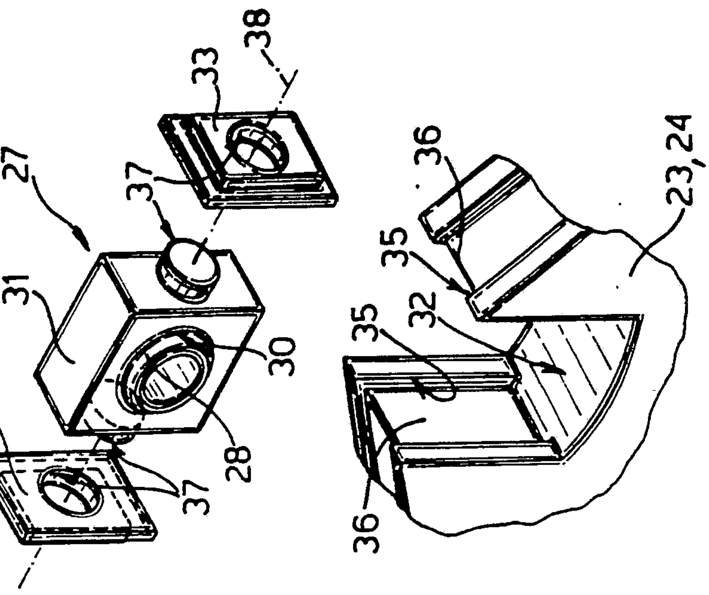


Fig.6

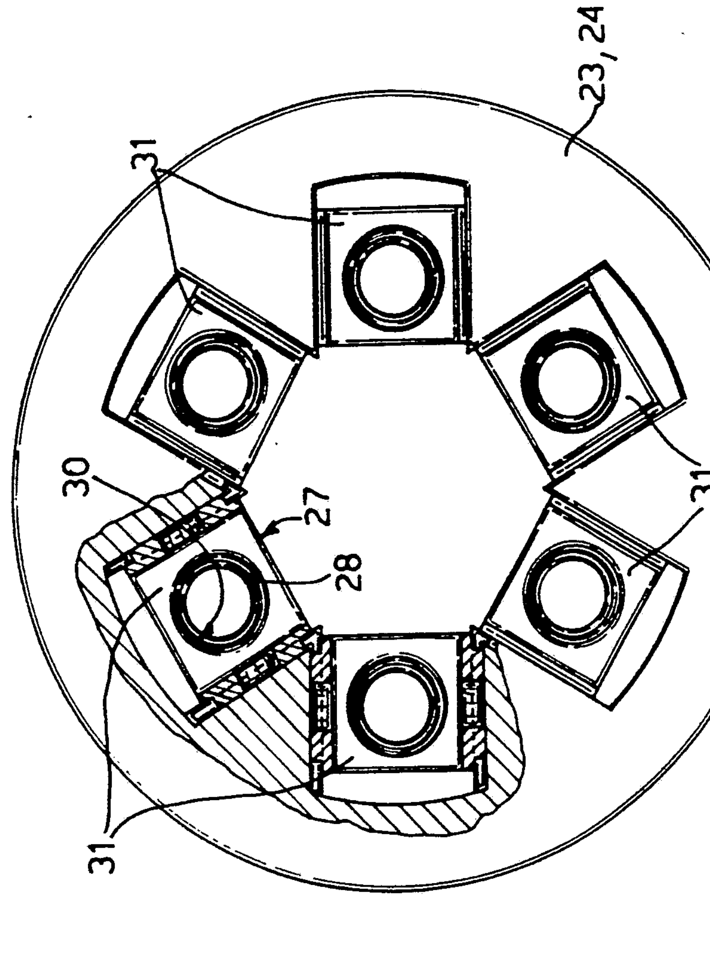


Fig.5

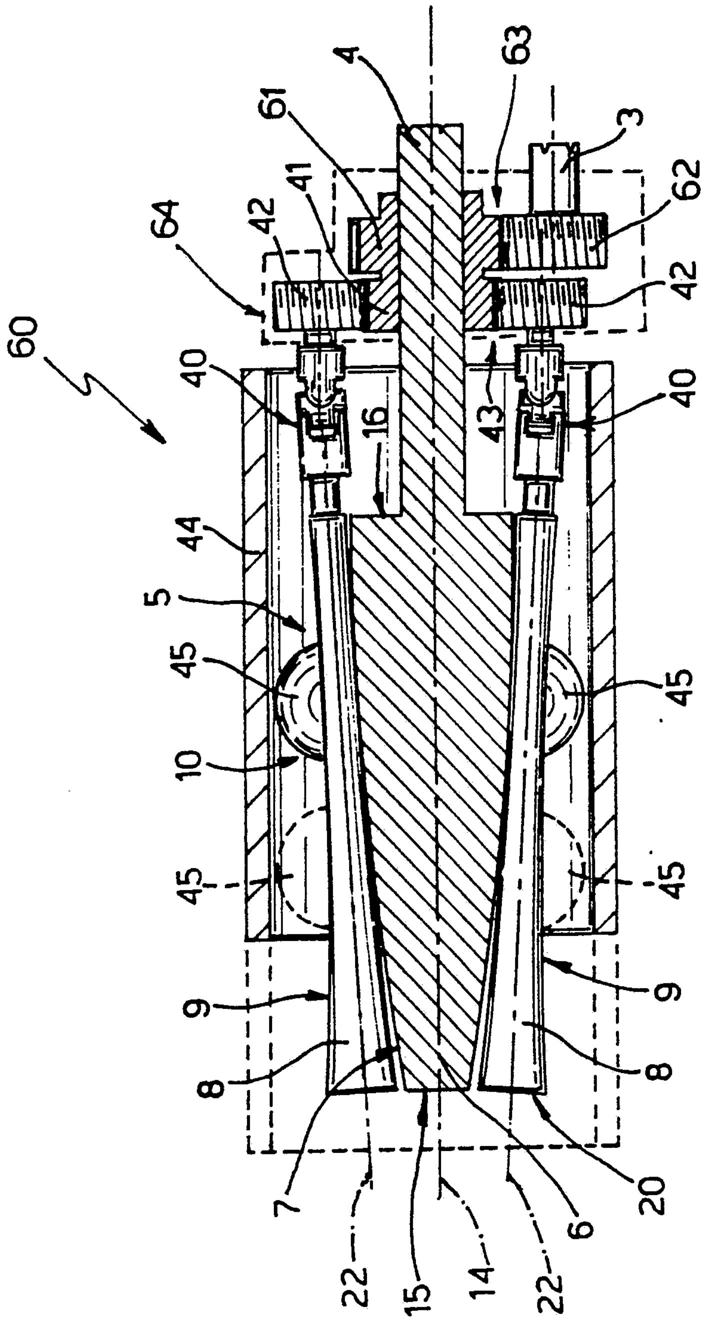

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Fig. 8

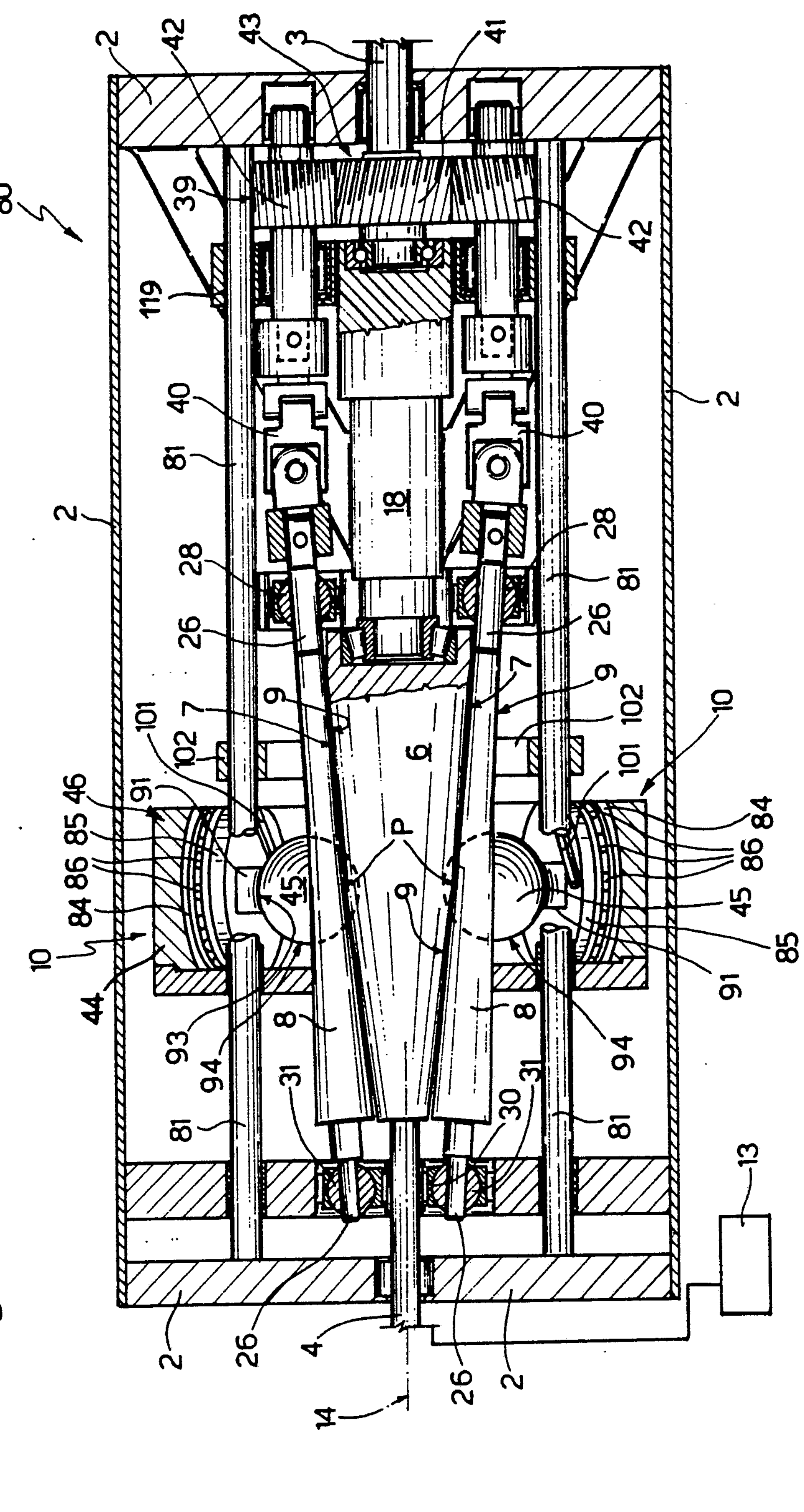
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Fig. 9

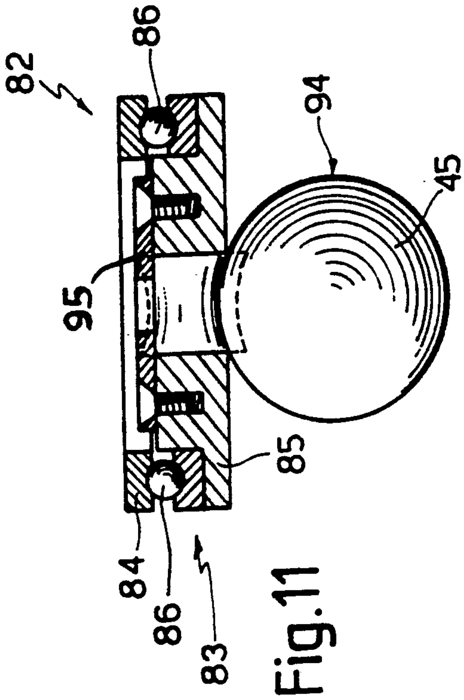

Fig.11

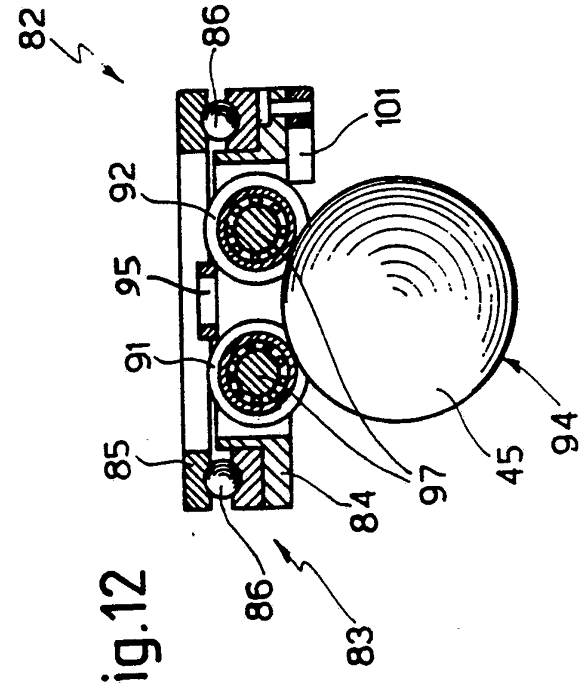

Fig.12

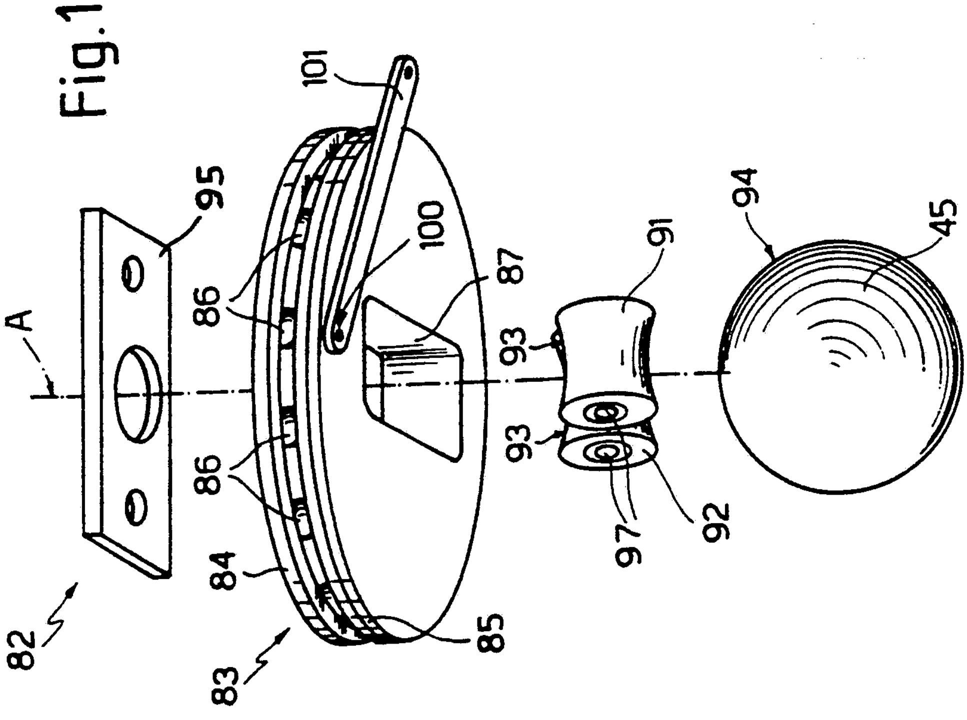

Fig.10

INTERNATIONAL SEARCH REPORT

International Application No PCT/IT 92/00104

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^5: F 16 H 15/04

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^5	F 16 H 15/00, B 60 K 17/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	DE, C, 902 204 (BÜRGEL) 21 January 1954 (21.01.54), see fig. 1.	1-3
A		4,5,7, 11
	--	
A	FR, A, 2 131 114 (CASSIMATIS) 10 November 1972 (10.11.72).	
	--	
A	US, A, 3 910 137 (NEDELJKOVITCH) 07 October 1975 (07.10.75).	
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* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26 November 1992	[illegible]
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	BAUMANN e.h.

ANHANG

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

ANNEX

to the International Search Report to the International Patent Application No.

ANNEXE

au rapport de recherche international relatif à la demande de brevet international n°

PCT/IT92/00104 SAE 64513

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben. Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.

La présente annexe indique les membres de la famille de brevets relatifs aux documents de brevets cités dans le rapport de recherche international visée ci-dessus. Les reseignements fournis sont donnés à titre indicatif et n'engagent pas la responsibilité de l'Office.

Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
DE 902204		keine - none - rien	
FR A 2131114		keine - none - rien	
US A 3910137	07-10-75	DE A1 2357404	22-05-74
		DE B2 2357404	02-12-76
		DE C3 2357404	21-07-77
		FR A2 2218510	13-09-74
		FR B2 2218510	16-01-76
		GB A 1455456	10-11-76
		IT A 1003218	10-06-76
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		FR A5 2207567	14-06-74