Pulley positioning system for CVT

Pulley positioning system for CVT

A.J. van der Meulen

DCT 2006.28

Traineeship report

Coach(es): P.C.J.N. Rosielle

Supervisor: M. Steinbuch

Technische Universiteit Eindhoven
Department Mechanical Engineering
Dynamics and Control Technology Group

Eindhoven, March, 2006

Table of contents

1 Introduction

The group Constructions and Mechanisms invented a system for mechanically position the pulleys in a pulley-based continuously variable transmission (CVT). Unfortunately the used planetary roller screw is a too expensive part.

1.1 Background

The belt in the CVT transfers the energy from the input shaft to the output shaft by friction at two pulleys at each shaft. Figure 1-1 shows a shaft, a belt and the two conical pulleys.

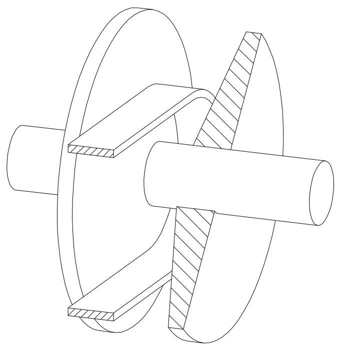


Figure 1-1: The shaft, the belt and the two conical pulleys.

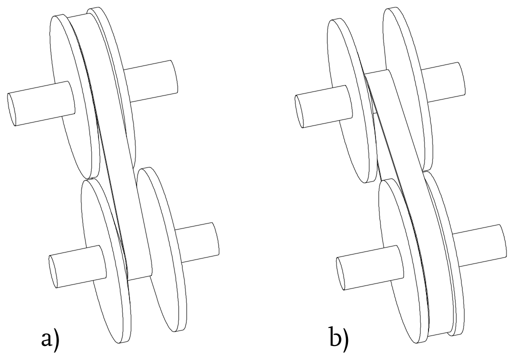


Figure 1-2: Increasing and decreasing the transmission ratio.

Figure 1-2 shows a ratio change between input and output which is achieved by decreasing the distance between the two pulleys at one shaft and increasing the distance between the other two pulleys at the other shaft. To create the force necessary to position the pulleys, the design of the current pulley positioning system uses a double planetary gear set and a planetary roller screw.

1.2 Assignment

The objective of the assignment is to design a less expensive pulley position system, which positions at least one pulley at each of the two shafts.

The system must satisfy the requirements:

a) Axially position the pulley:
   - with 50 kN;
   - over 20 mm;
   - in 1 second (which corresponds to a power of 1000 Watt).

b) No power cost of the actuator during a steady state operation of the transmission.

2 The current system

The current design of the pulley positioning system uses a double planetary gear set and a planetary roller screw. Figure 2-1 shows a part of the diagrammatic overview.

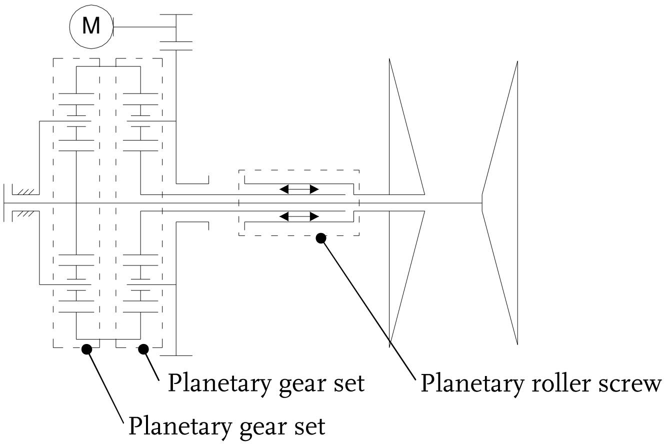


Figure 2-1: Partial overview of the current system. (Source: patent applications, appendix A.)

2.1 Double planetary gear set

A single planetary gear set, shown in figure 2-2, consist of a sun gear, planet gear(s) with its carrier and a ring gear. The sun gear, ring gear or the planet gear carrier can be input, output or can be held stationary. By choosing the right amount of teeth, it is possible to lock one of the three gears, for example the planet gear carrier, and letting the other two, the ring gear and the sun gear, have a 1:1 gear ratio. For a single planetary gear set holds that the rotational directions of the input and output are opposite. Using the opposite output of a single set as input for a second set, joining the ring gears, the same rotational direction and coinciding axes of the input and output can be realized, shown in and 2-3.

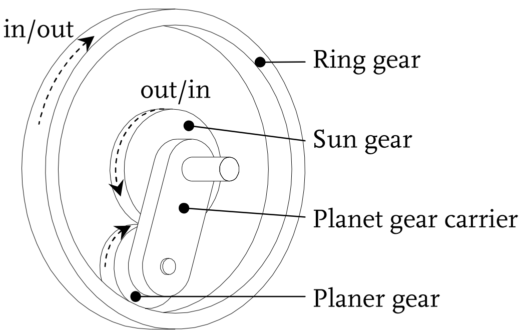


Figure 2-2: A planetary gear set and its possible rotations, planet gear carrier locked.

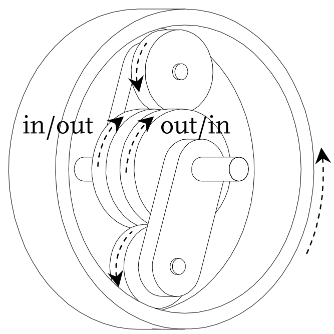


Figure 2-3: A double planetary gear set and its possible rotations, planet gear carrier locked.

2.2 Planetary roller screw

In the system design the electrical motor (M) locks or actuates the planet gear carrier. Actuating the planet gear carrier result in different angular velocity of the screw shaft and the roller nut of the planetary roller screw, shown in figure 2-5, which positions the pulley.

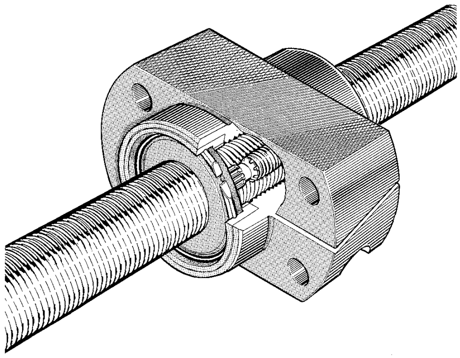


Figure 2-5: Planetary roller screw. (Source: INA publication)

If a less expensive equivalent for the planetary roller screw can be found, the objective of the assignment is achieved. Equal the roller screw, this mechanism must increase force and convert rotational into translational motion. Figure 2-6 shows a mechanism consisting of three wedges placed around an axis. Figure 2-7 shows a mechanism, inspired by the mechanism of the three wedges, using three cams. Figure 2-8 shows a mechanism using a spring coil as a screw.

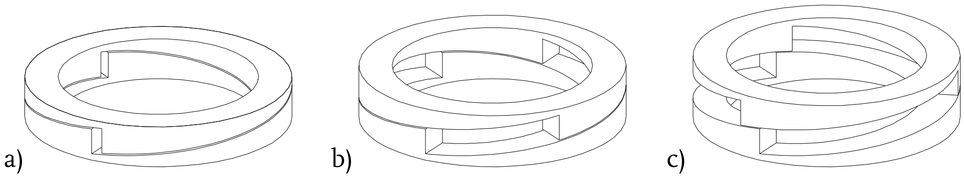


Figure 2-6: Three axial placed wedges. (Source: patent application, appendix A)

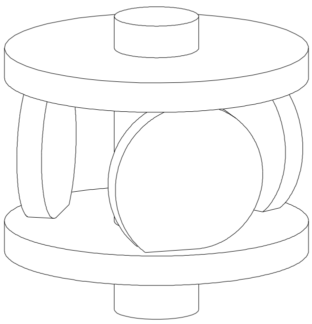


Figure 2-7: Three one way cams.

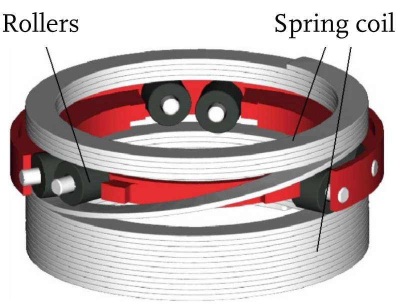


Figure 2-8: Coil transmission. (Source: LuK symposium 2002, appendix A)

Figure 2-9 shows a mechanism, also inspired by the mechanism of the three wedges, using one wedge. In contrast to the other mechanisms which push at three points (surfaces), this mechanism pushes at one point (surface).

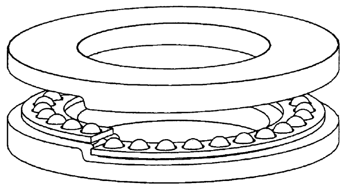


Figure 2-9: One axial placed wedge.
(Source: patent application, appendix A)

The mechanical advantage of the input force and output force is inversely proportional to the input and output distance. The alternatives for the roller screw with their mechanical advantage are placed in table 2-1. Calculations are given in appendix B.

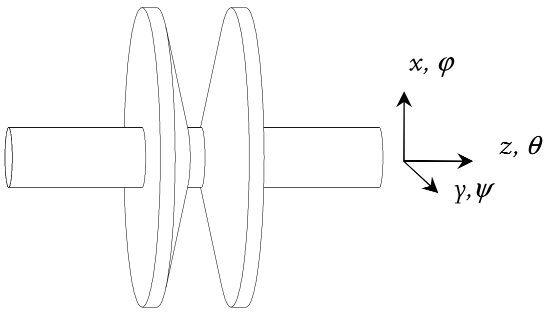
Table 2-1: Alternative mechanisms for the planetary roller screw. The output distance of all mechanisms is set to 20 mm. The values are as accurate as possible estimations.

	Roller screw	Three wedges	One wedge	Coil screw	Cams
Input [mm]	800	200	600	9600	280
Advantage [-]	40	10	30	480	14

Of the mechanisms in table 2-1, only the coil screw achieves a sufficient increment of the force. At this moment, it appears to be that no sufficient functioning equivalent for the roller screw can be found. To find other possibilities to achieve the objective of the assignment, the functioning of the system will be investigated in more detail.

3 Fixing the degrees of freedom

The shaft and the positional pulley have their own degrees of freedom. For the design of the system it is assumed that the shaft is supported by two radial bearings. The pulleys must be fixed to the shaft. Figure 3-1 shows a shaft and the two pulleys, together with their degrees of freedom.



shaft		**positional pulley**
x : fixed	=	x : fixed to the shaft
y : fixed	=	y : fixed to the shaft
z : fixed		z : positional
φ: fixed	=	φ: fixed to the shaft
ψ: fixed	=	ψ: fixed to the shaft
θ: free	=	θ: fixed to the shaft

Figure 3-1: A shaft, the pulleys, and their degrees of freedom.

At least one of the two pulleys at each shaft is positional. If one pulley is fixed to the shaft, it might seem to be possible, not to fix the degree of freedom θ of the positional pulley. Not fixing θ will result in a diagonal route of the force, as illustrated in figure 3-2. The degree of freedom θ must be fixed to the shaft to prevent ineffective use of the belt.

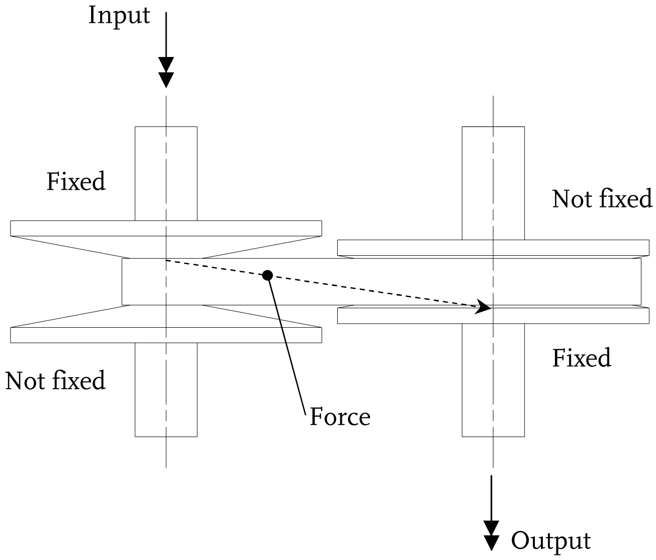


Figure 3-2: The degree of freedom θ of the pulleys at bottom-left and top-right, are not fixed to the shaft.

To fix the five degrees of freedom of the positional pulley, a plain bearing with a certain length, fixing x, y, φ and ψ, and a spline fixing θ can be used, shown in figure 3-3. Supporting the pulley at three points, as shown in figure 3-4, fixes φ and ψ. The plain bearing than only has to fix x and y and therefore can be decreased in length.

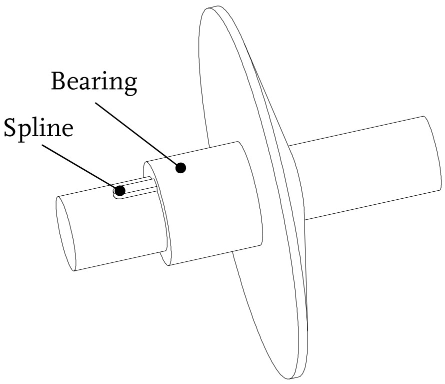


Figure 3-3: The pulley fixed by a bearing and a spline.

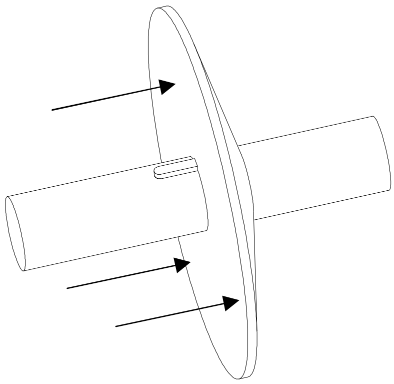


Figure 3-4 Supporting the pulley at three points to fix φ and ψ.

The idea of supporting the positional pulley elastically, by using folded leaf springs as used in the lecture notes of the course 'Constructieprincipes 1, p. 1-23 to 1-27', encounters two problems. As result of the needed dimensions, folded leaf springs do not permit the pulley to move over 10 mm, not to mention 20 mm, and have unfavourable dynamical behaviour.

The current system encounters no disadvantage using a bearing and spline to fix the positional pulley. A different way to fix the pulleys does not seem to be necessary, but is dependant on the construction of the new system.

4 System functions

In this chapter on the basis of the main function and the investigated systems in patent applications, the sub functions will be determined.

4.1 System main function

The main idea of the intended invention is a little whirring electrical engine with low torque and high number of revolutions, moving a pulley over a relatively very short distance with a great force. In other words, a small force F (or momentum M) with a long distance s (or angular distance φ), must be transferred to a rotating shaft and axially push the pulley over a short distance s (= 20 mm) with great force F (= 50 kN) in 1 second.

4.2 Existing system functions

The existing systems all have one mechanism to increase force and convert rotational into translational motion. Examples are the in chapter 2 mentioned planetary roller screw, coil screw and axial wedge. The output power of these mechanisms pushes the pulley. The input to push is the power of an electrical motor or hydraulic pressure.

To fix the pulley, most systems also use the power of an electrical motor or hydraulic pressure. One system, the current system, mechanically locks the position of the pulley by locking the input. All the systems have the support for the force that fixes or pushes the pulley, at the shaft.

4.3 System sub functions

Given these necessary system functions and the fulfilling of those functions by the known systems, it can be noticed that the systems do not use the possibility to support the power to push or to fix the pulley, at the fixed world. In figure 4-1 the sub functions derived from the patent applications and extracted from the main function are illustrated.

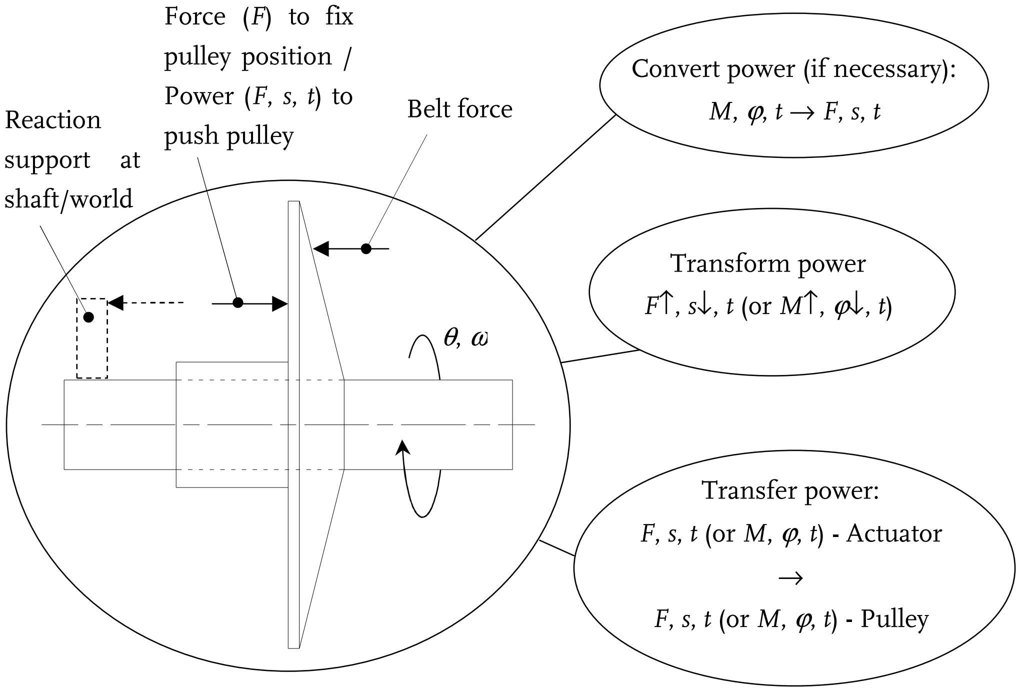
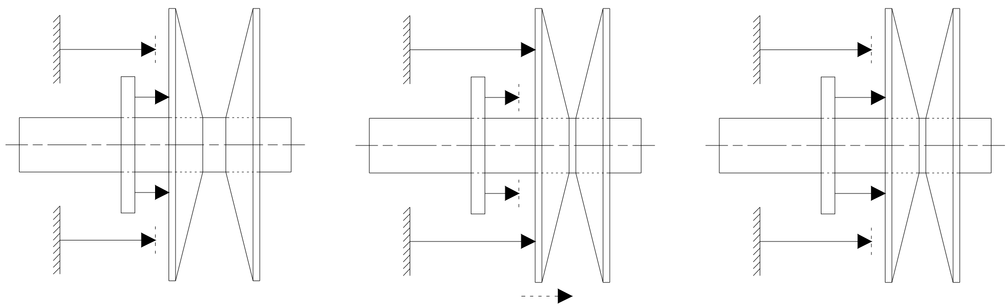


Figure 4-1: An overview the main functions at its sub functions.

A connection from the fixed world to a rotating pulley is achieved by an axial bearing. Due to high axial force combined with the high number of revolutions per minute, an axial bearing causes approximately one third of power loss, a not allowable amount during steady state operation. Therefore during steady state the reaction support of the force to fix the pulley must be at the rotating shaft. Contrary to fixing the pulley, during pushing the pulley, the reaction of the push mechanism can be at the world.

In the case of pushing the pulley from the world, an extra mechanism at the shaft is needed to fix the degree z of the pulley. Illustrated in figure 4-2. The push mechanism also must take back some of its movement.



a) Fixing pulley by a mechanism at the shaft.
b) Pushing by a mechanism at the world.
c) Fixing pulley by a mechanism at the shaft.

Figure 4-2: Pushing the pulley from the world.

Besides supporting the power at the world, the investigated systems also do not use the possibility to decrease the as necessary respected distance of 20 mm to push the pulley. Pushing several times a smaller distance also leads to the desired distance. To handle the limitation of an incremental push mechanism, an extra mechanism is needed to move in the *z* direction; the push mechanism or the point that the push mechanism uses to push. Figure 4-3 shows pushing by increments from the shaft, moving the mechanism. Figure 4-3 shows pushing by increments from the world, moving the push of point.

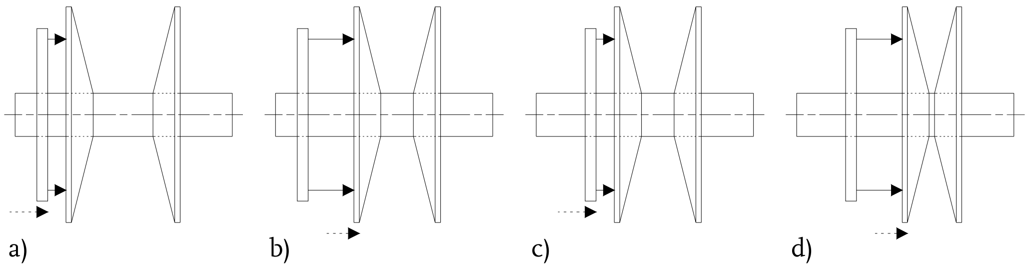


Figure 4-3: Incremental pushing from the shaft.

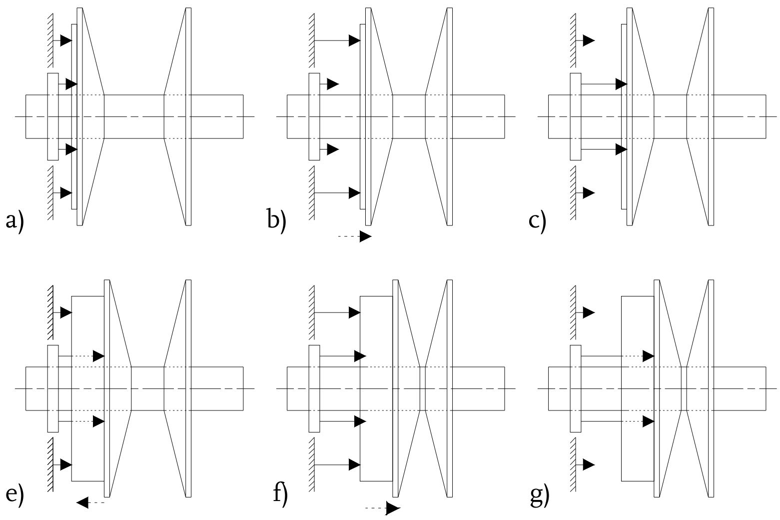


Figure 4-4: Incremental pushing from the world.

The possibilities to push the pulley by increments and push the pulley from the world, result that the system must fulfil an extra sub function.

5 Designing concept systems

This chapter investigates the opportunity of the systems which contains the not used possibilities to fulfil the sub functions. The current systems push from the shaft over the full range of 20 mm, and at the same time fix the position of the pulley.

5.1 Fixing the degree *z* of the pulley

Both using incremental steps for axially position the pulley and pushing from the world, the time the push mechanism is not supporting the pulley requires an extra mechanism to fix the degree *z* of the pulley.

In the current system the principle of a roller nut and screw is used to push and to fix the pulley. By pushing the pulley, the nut and screw cope with a great force while rotating, which requires high demands of the used planetary roller screw. If a roller nut and screw are used to take over the new position of the push mechanism, the rotating of the nut can be 'forceless'.

5.2 Increasing force or momentum

Due to the conservation law, increasing a force will decrease its distance. Principles for trading force for distance are the lever- and wedge-effect, which have their existence in many mechanisms. Figure 5-1 and 5-2 show these effects. Another principle for trading force for distance is using hydraulic pressure, shown in figure 5-3.

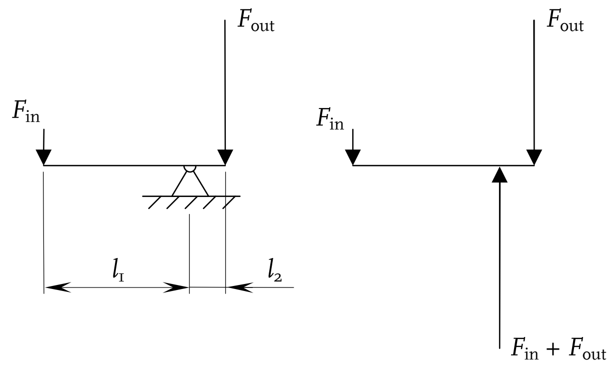


Figure 5-1: The lever-effect. Mechanisms that use this principle are tackles and gears, increasing l_1 or decreasing l_2 will increase the effect ($F_{out} > F_{in}$).

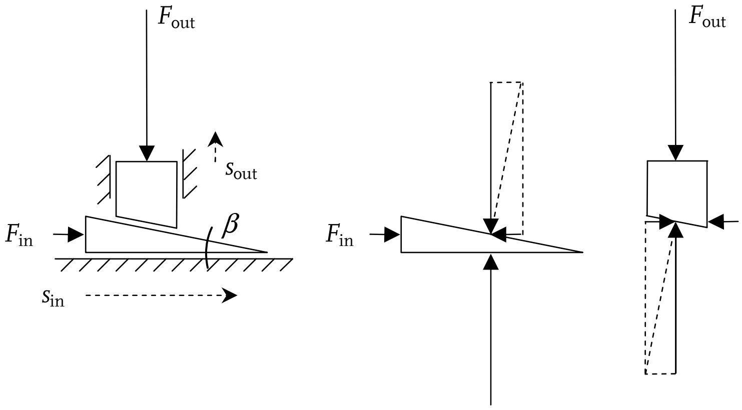


Figure 5-2: The wedge-effect. Mechanisms that use this principle are toggle levers and threads, decreasing β will increase the effect ($F_{out} > F_{in}$).

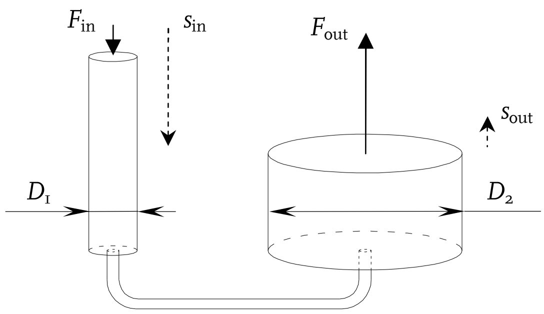


Figure 5-3: Hydraulic pressure. Systems using oil pressure use this principle. Decreasing D_1 or increasing D_2 will increase the effect ($F_{out} > F_{in}$).

By incremental pushing, the mechanical advantage of the current mechanisms can be increased. For example the axial wedge, instead of pushing over 20, can push over 1 mm and so increase its mechanical advantage with a multiplication of 20, becoming 200.

To transform the power, the investigated systems do not use tackles, probably due to the amount of friction. To equal the mechanical advantage of the used roller screw, 40 tackles must be used.

Not having to satisfy the requirements for a push mechanism to push over 20 mm, creates opportunities for mechanisms with a restricted stroke, for example the mechanism as shown in figure 5-4.

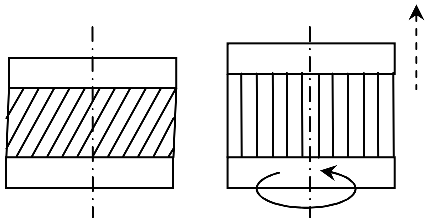


Figure 5-4: Pushing with rods.

5.3 Concept systems

The not used possibility of pushing from the world and of pushing by increments, lead to three other possible systems.

5.3.1 Concept 1: Pushing from the world

Figure 5-5 shows a concept system where an actuator and a double planetary gear set screws a roller nut to fix the degree z of the pulley, after pushed from the world to its position. To fix the degree θ of the output of the gear set to the roller nut, three folded leaf springs can be used.

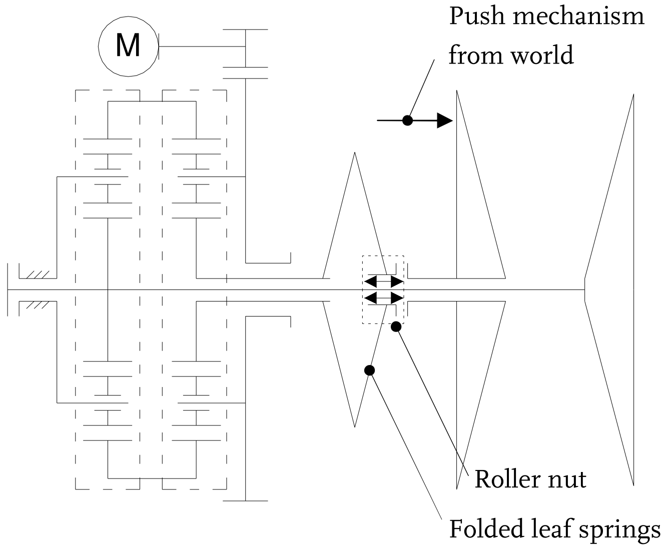


Figure 5-5: Pushing from the world, fixing the degree z by means of a double planetary gear set and a nut and screw.

5.3.2 Concept 2: Incremental pushing from the world

Figure 5-6 show a system, where as in concept 1, a double planetary gear set screws a roller nut to fix the degree z of the pulley. If the pulley is fixed and the push mechanism has token back some of its movement, the force push of point can be moved. The action of fixing the pulley and moving the push of point occur not at the same time, and therefore can be done by using one actuator.

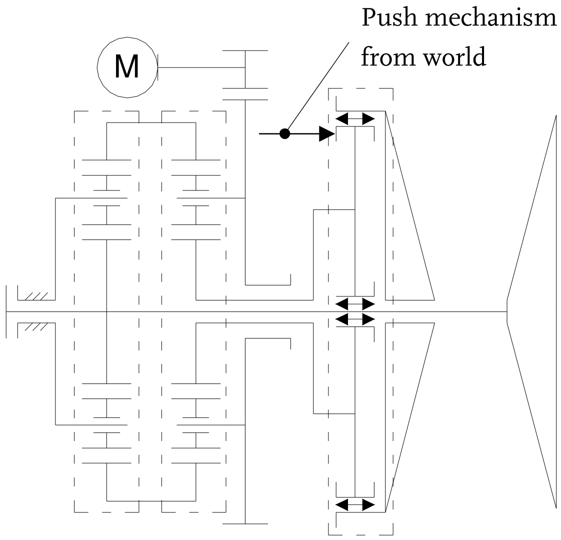


Figure 5-6: Incremental pushing from the world, moving the force push of point.

To realize the functioning of screwing the nut to fix the pulley and to move the push of point, the principle of figure 5-7 is used. In figure 5-8 this principle is translated to the system.

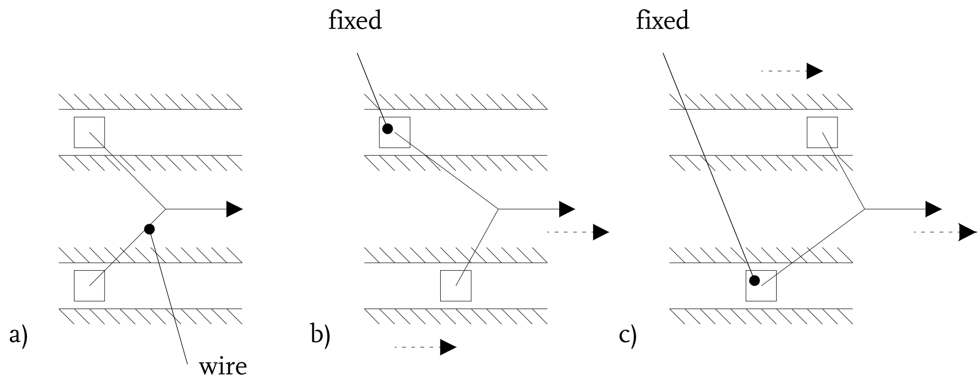


Figure 5-7: Principle to alternately move a body.

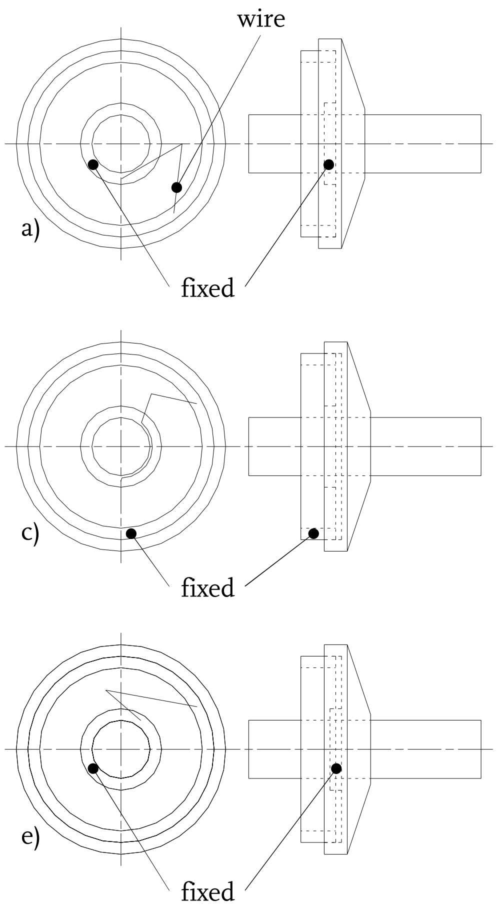


Figure 5-8: Moving the inside and outside screw by a wire connected to the output of the double planetary gear set.

5.3.3 Concept 3: Incremental pushing from the shaft

Figure 5-8 shows a concept system using the mechanics of concept 2 supplemented with the push mechanism of the current design, which now pushes by increments. In figure 5-9 a screw is drawn, but by means of its restricted mechanical advantage, it is more likely to use the (improved) mechanism of the three wedges.

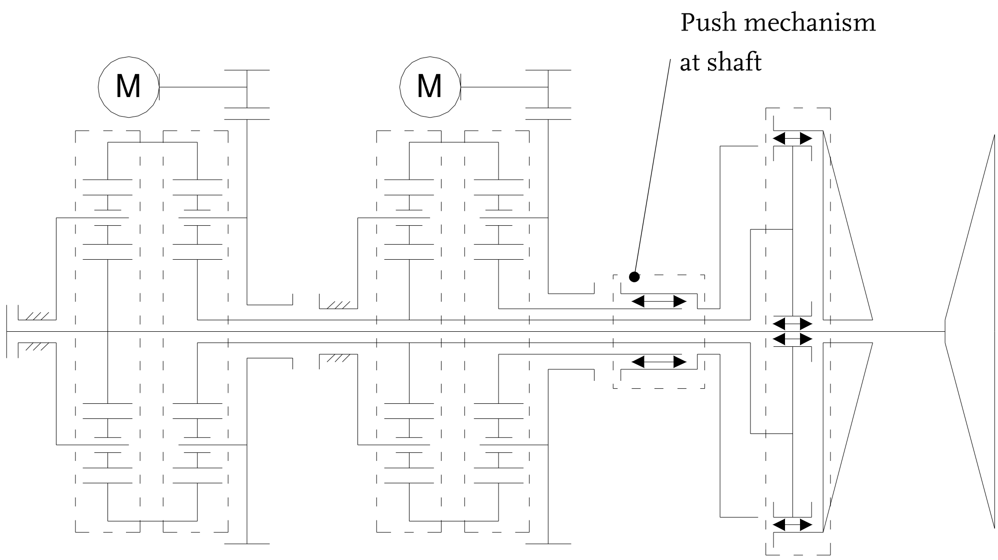


Figure 5-9: Incremental pushing from the shaft, moving the force push of point.

6 Conclusions

In the current system the planetary roller screw fulfils the sub function of converting rotational into translational motion and increasing the force with a multiplication factor of 40. The objective of the assignment can be achieved by finding a less expensive alternative mechanism for the planetary roller screw.

A different possibility to achieve the objective of the assignment is to change the way the sub functions fulfil the main function. The current systems have a push mechanism that pushes from the shaft over the full range of the position. New proposed systems to fulfil the main function are; pushing from the world over the full range, pushing form the world by increments and pushing from the shaft by increments. Due to the restricted time of the traineeship, the feasibility of these opportunities is not investigated in detail to mark an optimal concept system.

References

Constructieprincipes voor het nauwkeurig bewegen en positioneren. Syllabi, Eindhoven.

Kapaan, H. J. e. a., *Poelieset voor een continu variabele transmissie-eenheid*. Patent NL 1011732, SKF Engineering & Research Services B.V., 2000.

Koller, R. en N. Kastrup, *Prinziplösungen zur konstruktion technischer produkt*. Berlin Heidelberg: Springer-Verlag, 1994.

Olschewski, A. e. a., *Device for converting rotary motion into translational motion*. Patent DE 103332685, AB SKF, 2005.

Raber, C., *Antrieb*. Patent WO 0103984, Luk Lamellen und Kupplingbau Gmbh, 2001.

Reik. W. e. a., *New Opportunities for the Clutch?*. 7th LuK Symposium, LuK GmbH & Co, 2002.

Roth, K., *Konstruieren mit Konstruktionskatalogen; Band II Konstruktionskataloge*. 2. Auflage. Berlin Heidelberg: Springer-Verlag, 1994.

Weissflog, D., *Axialstelltrieb, insbesondere zur Variatorbetätigung, Variator sowie CVT Getriebe*. Patent DE 10025978, Torrington Nadellager Gmbh, 2000.

Rosielle, P.C.J.N., Meerakker, K.G.O. van de, *Continuously Variable Transmission*. Patent WO 2004057215, Van Doorne's Transmissie B.V., 2004.

Appendix A

Patent applications

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 July 2004 (08.07.2004)

PCT

(10) International Publication Number
WO 2004/057215 A1

(51) International Patent Classification[7]: F16H 61/00, 9/18

(21) International Application Number: PCT/EP2002/014851

(22) International Filing Date: 23 December 2002 (23.12.2002)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (*for all designated States except US*): **VAN DOORNE'S TRANSMISSIE B.V.** [NL/NL]; Postbus 500, NL-5000 AM Tilburg (NL).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **VAN DE MEERAKKER, Koen, Govert, Olivier** [NL/NL]; Jan van de Capellelaan 106, NL-5642 LG Eindhoven (NL). **ROSIELLE, Petrus, Carolus, Johannes, Nicolaas** [NL/NL]; Kapteynlaan 25, NL-5505 AV Veldhoven (NL).

(74) Common Representative: **VAN DOORNE'S TRANSMISSIE B.V.**; Patent department (AE-CT/EL-P), Postbus 500, NL-5000 AM Tilburg (NL).

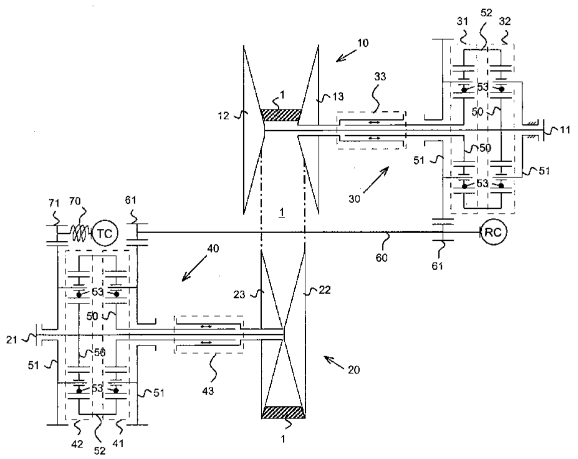
(81) Designated States (*national*): GB, JP, US.

(84) Designated States (*regional*): European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: CONTINUOUSLY VARIABLE TRANSMISSION



(57) Abstract: Continuously variable transmission with electro-mechanical actuation means comprising a ratio control motor (RC) and two displacement systems (30, 40), each associated with one pulley (10, 20) of the transmission and provided with a double planetary gearing (31, 32; 41, 42) and a transforming mechanism (33; 43), which is operatively connected to a displaceable pulley disc (13; 23) of the pulley (10; 20) and to the double planetary gearing (31, 32; 41, 42), the latter being provided with a first gear set (31; 41) and a second gear set (32; 42), each comprising three concentrically rotating components (50, 51, 52), whereby first components (52) of the gear sets (31, 32; 41, 42) are mutually connected, whereby second components (50) of the gear sets (31, 32; 41, 42) are either connected to the respective transforming mechanism (33; 43) or to the respective pulley shaft (11; 21), whereby third components (51) of the first gear sets (31 41) are drivingly connected to the ratio control motor (RC) and whereby a corresponding third component (51) of the second gear set (32; 42) of the displacement system (40) associated with the secondary pulley (20) being drivingly connected to a torque control motor (TC).

WO 2004/057215 A1

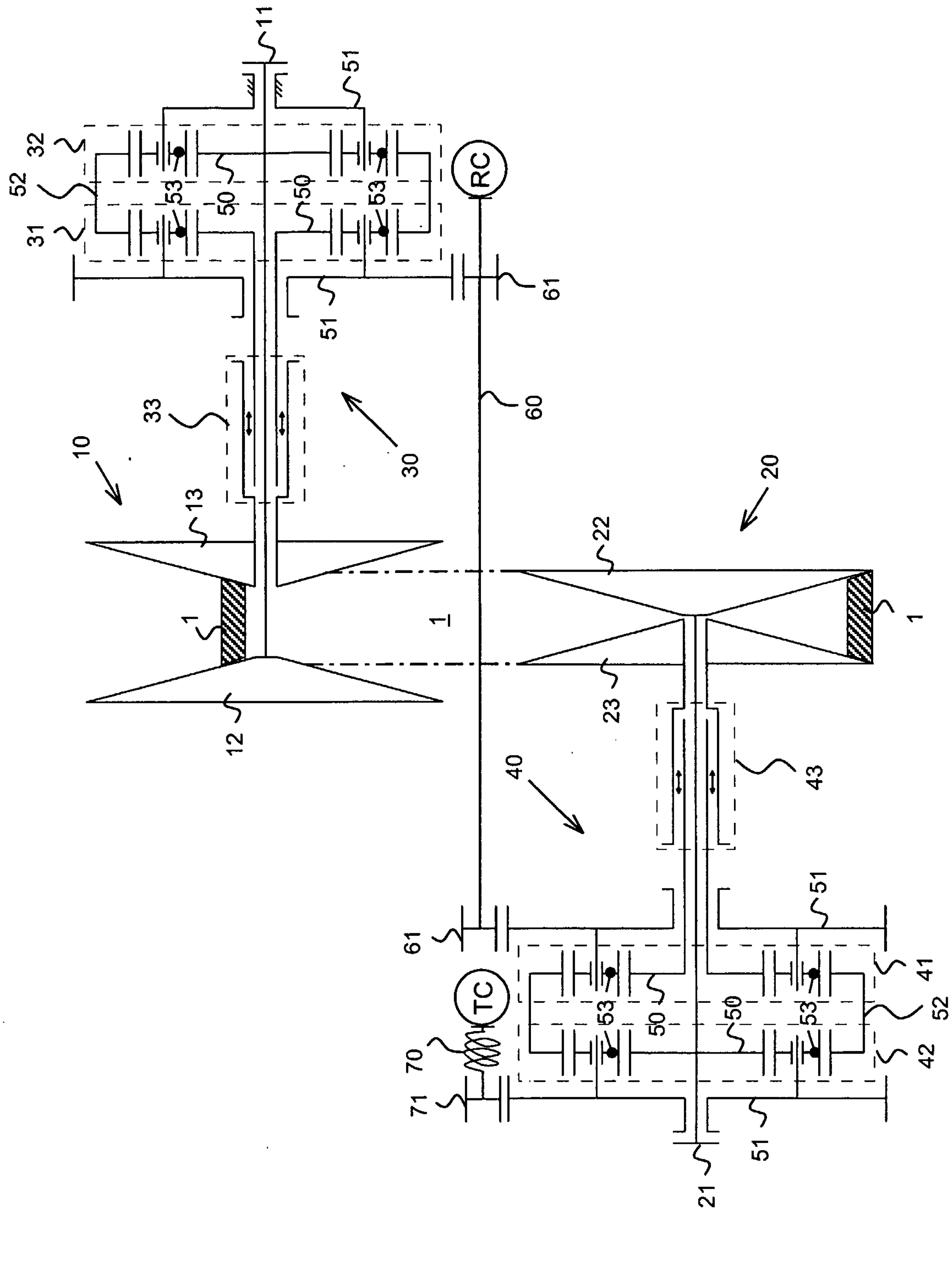
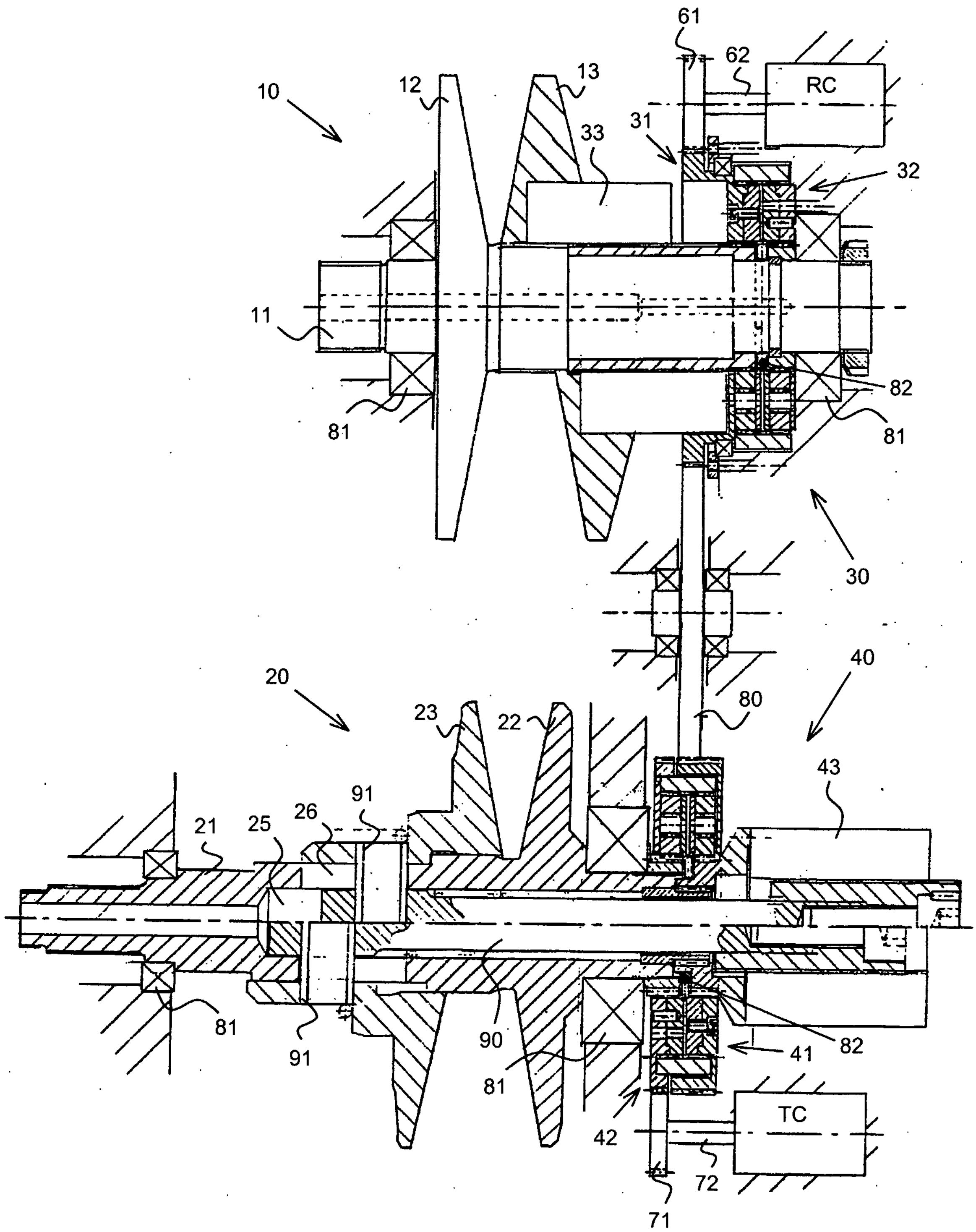

11
51
32
52
53
50
31
RC
61
60
33
30
10
13
1
12
20
22
23
40
43
41
42
TC
70
71
21

FIG. 1



10
11
12
13
33
31
61
62
RC
32
81
82
81
30
20
23
22
80
40
43
21
25
26
91
81
91
90
81
82
41
42
TC
72
71

FIG. 2

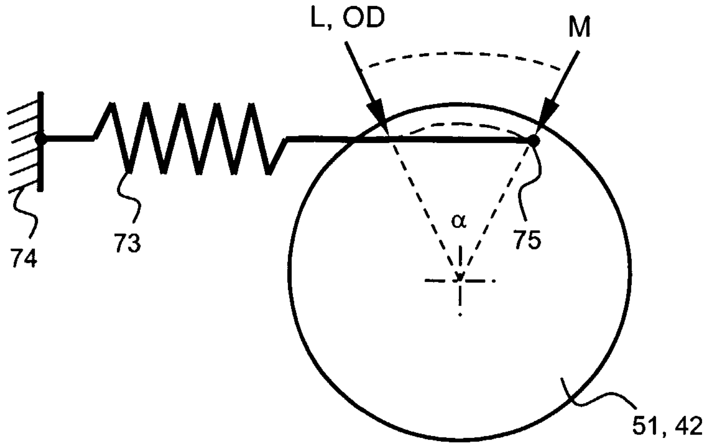


FIG. 3

(12) UK Patent Application (19) GB (11) 2 368 380 (13) A

(43) Date of Printing by UK Office 01.05.2002

(21) Application No 0200655.9

(22) Date of Filing 11.07.2000

(30) Priority Data
(31) 19932505 (32) 12.07.1999 (33) DE
(31) 19963238 (32) 27.12.1999
(31) 10015205 (32) 27.03.2000

(86) International Application Data
PCT/DE00/02275 En 11.07.2000

(87) International Publication Data
WO01/03984 En 18.01.2001

(51) INT CL^7
F16H 19/00 , B23B 31/24 , F16D 23/12 , F16H 55/56

(52) UK CL (Edition T)
F2Q Q6B Q6F
F2L LK L217 L501

(56) Documents Cited by ISA
CH 000511384 A
DE 002821153 A
DE 002311500 A
FR 002383362 A
US 3167671 A

(58) Field of Search by ISA
INT CL^7 B23B , F16D , F16H
EPO-INTERNAL, PAJ

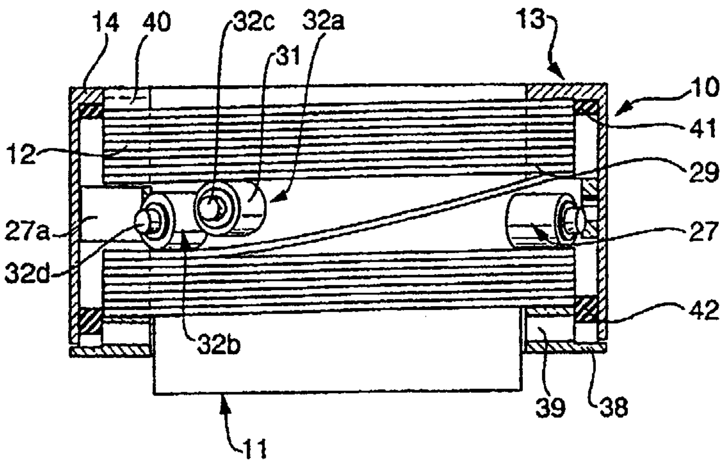
(71) Applicant(s)
LuK Lamellen und Kupplungsbau Beteiligungs KG
(Incorporated in the Federal Republic of Germany)
Industriestrasse 3, 77815 Bühl,
Federal Republic of Germany

(72) Inventor(s)
Christoph Raber

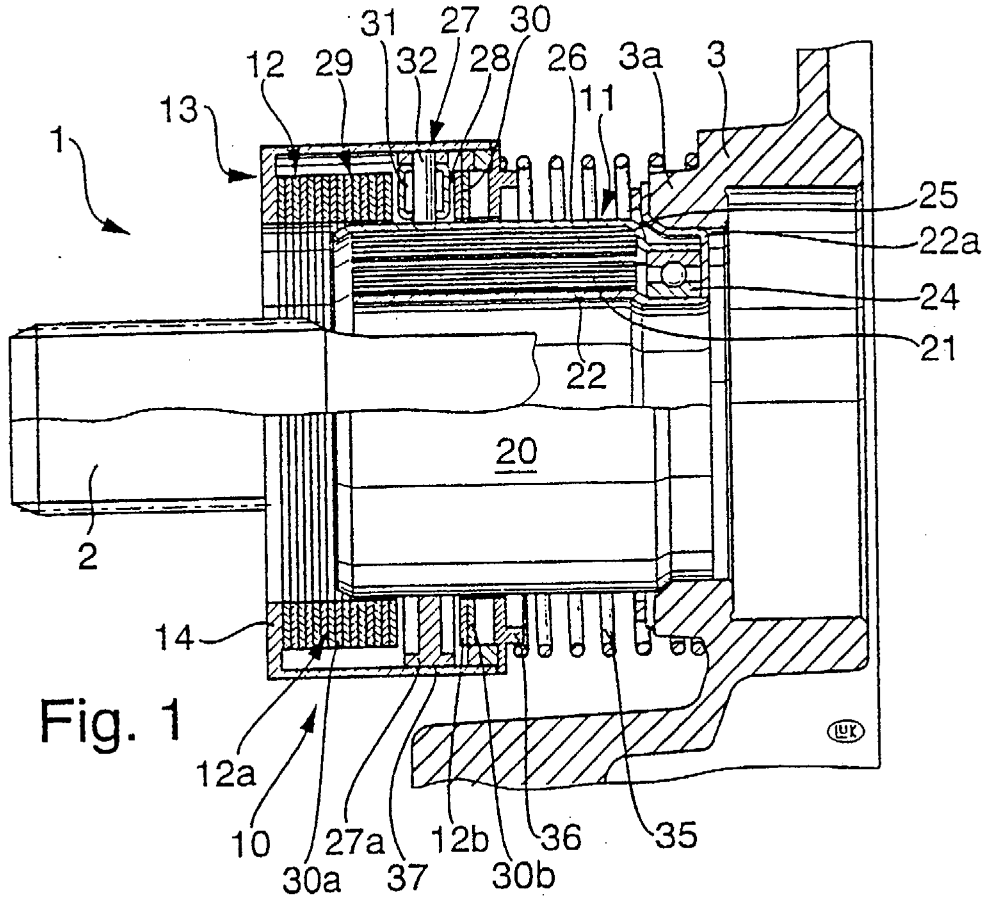
(74) Agent and/or Address for Service
Dummett Copp
25 The Square, Martlesham Heath, IPSWICH, Suffolk,
IP5 3SL, United Kingdom

(54) Abstract Title
Drive

(57) The invention relates to an axial drive for converting a rotational movement into an axial movement. The spring spindle (10) substantially comprises a component (13) with a helical spring (12) rotationally fixed thereto and a component with engaging means (27) which engage radially into the interior of the helical spring (12), said engaging means being configured as a set of studs (32) which are distributed around the periphery. The studs (32a, 32b) make axial contact with the spring band by means of an anti-friction bearing (31) which is positioned on the studs, with one respective set of studs (32a) being used for the pushing direction and one set of studs (32b) for the pulling direction. Each set of studs (32a, 32b) can be adjusted along the spring band (29) in a thread-type manner, so that the spring band is supported without play at each peripheral section. In a preferred embodiment, the sets of studs (32a, 32b) are axially offset in relation to one another at a distance corresponding to the width of the spring band. One longitudinal end of the studs is attached in the component (11) and the other end is attached to a flange (27a) which is connected to the component (11) in a fixed manner using struts (not shown in detail).

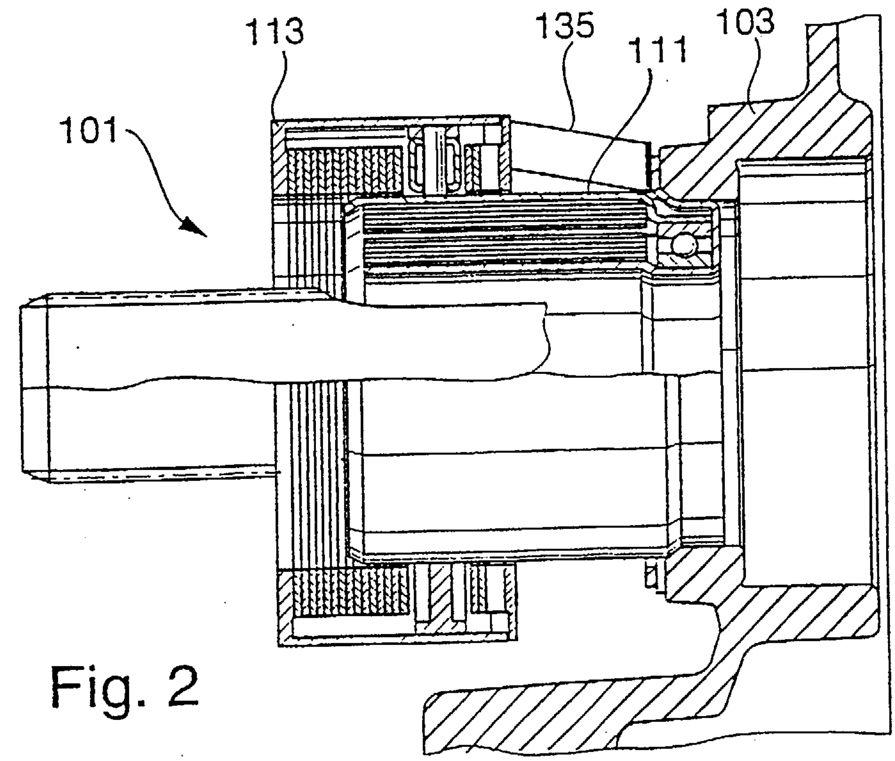


GB 2 368 380 A



1
2
10
11
12
12a
12b
13
14
20
21
22
22a
24
25
26
27
27a
28
29
30
30a
30b
31
32
35
36
37
3
3a

Fig. 1



101
113
135
111
103

Fig. 2

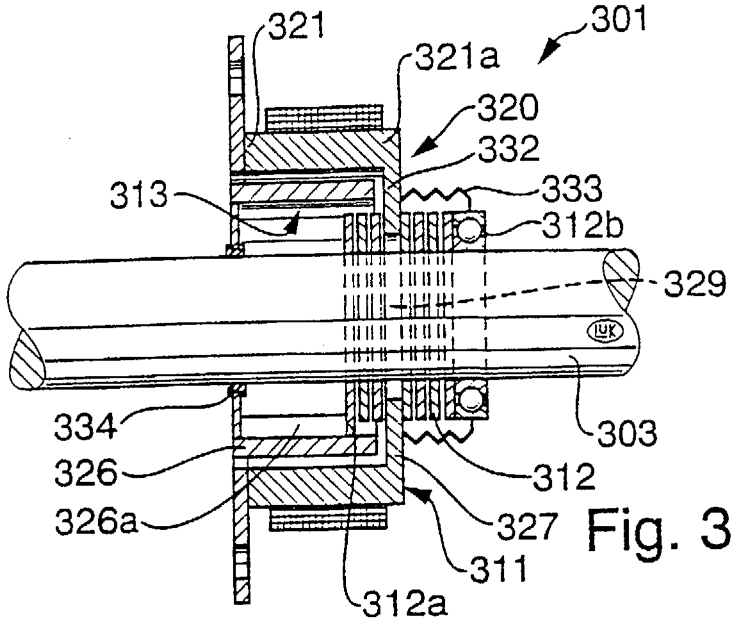


Fig. 3

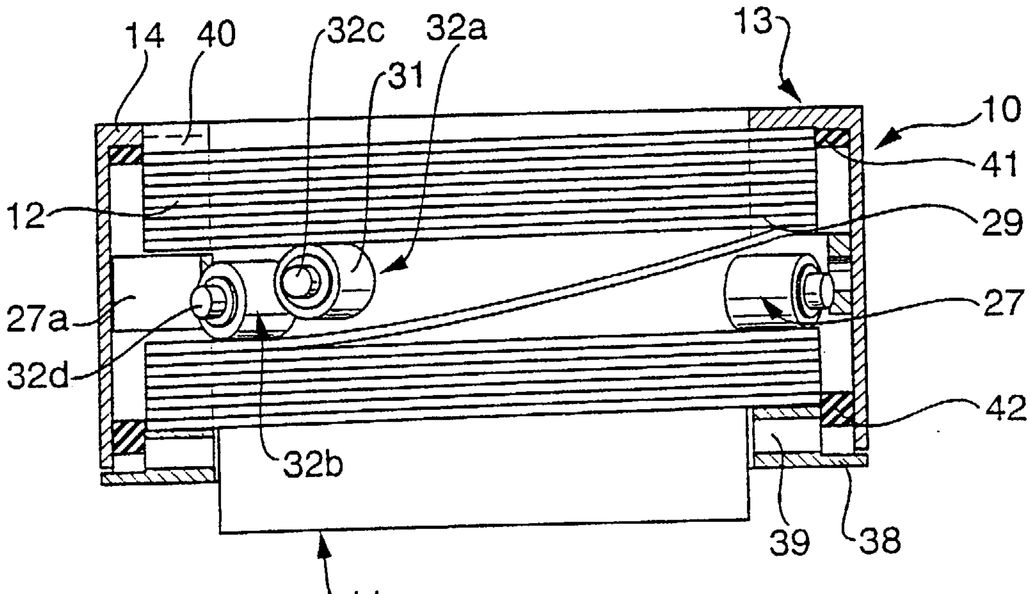


Fig. 4

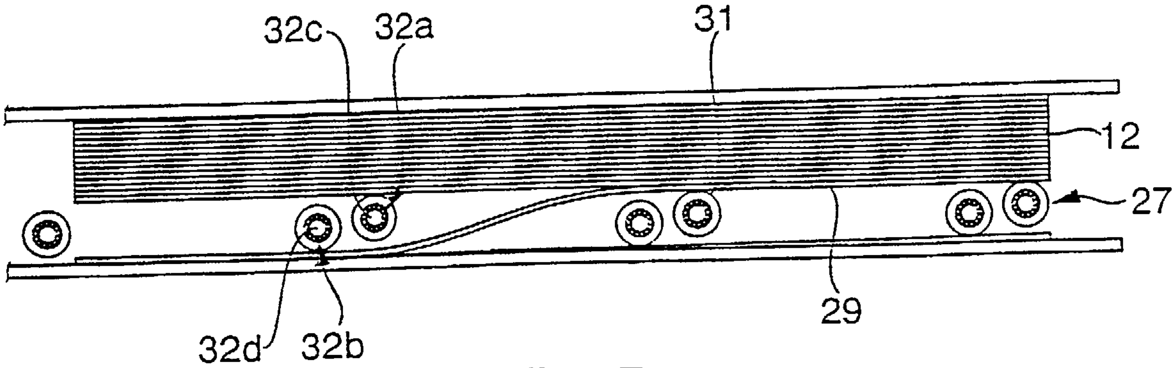


Fig. 5

US 20050050973A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0050973 A1**

Olschewski et al. (43) **Pub. Date: Mar. 10, 2005**

(54) **DEVICE FOR CONVERTING ROTARY MOTION INTO TRANSLATIONAL MOTION**

(75) Inventors: **Armin Olschewski**, Schweinfurt (DE); **Manfred Brandenstein**, Eussenheim (DE); **Barbara Faltus**, Gochsheim (DE); **Hauke Hans**, Ulm (DE); **Koos Zwarts**, VA Nieuwegein (NL)

Correspondence Address:
BURNS DOANE SWECKER & MATHIS L L P
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404 (US)

(73) Assignee: **AB SKF**, Goteborg (SE)

(21) Appl. No.: **10/895,127**

(22) Filed: **Jul. 21, 2004**

(30) **Foreign Application Priority Data**

Jul. 21, 2003 (DE)..................................... 103 33 268.5

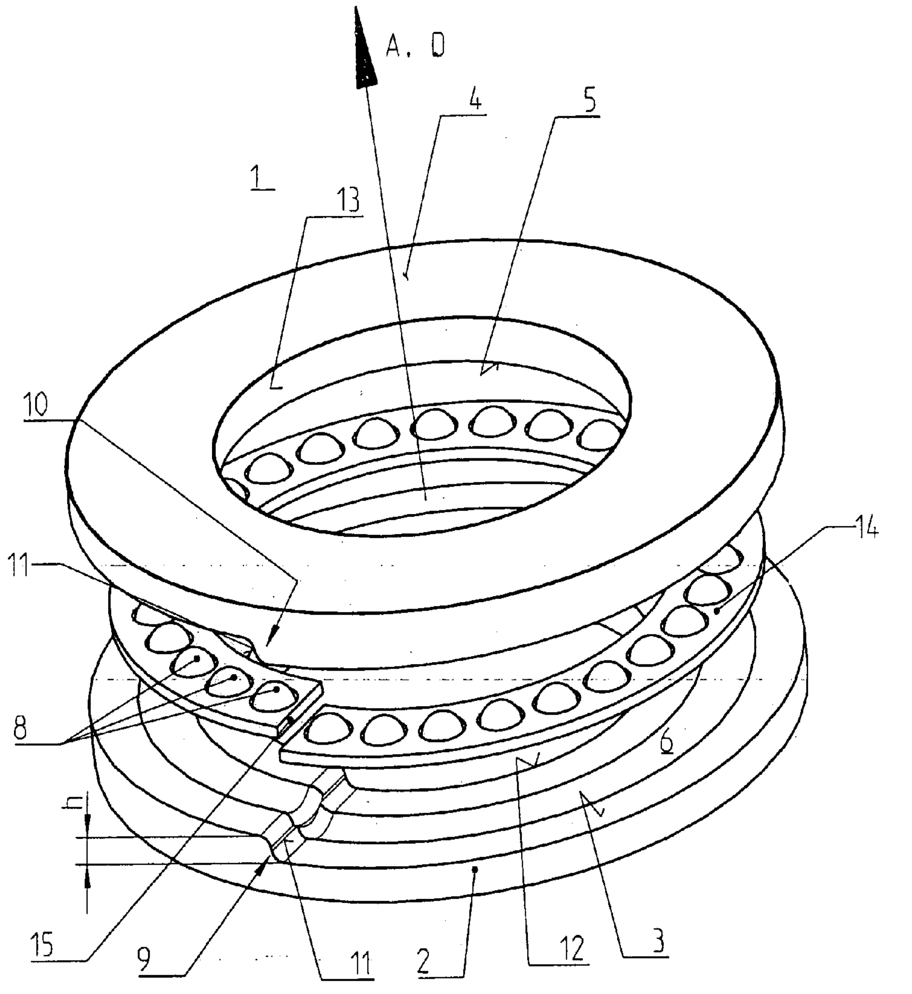
Publication Classification

(51) **Int. Cl.**[7] **F16H 25/08**

(52) **U.S. Cl.** **74/57**

(57) **ABSTRACT**

A device for converting rotary motion into translational motion comprises a first component and a second component, with the second component being arranged to be able to turn around an axis of rotation relative to the first component and to move in the axial direction. Each component is provided with at least one track in which are arranged roll bodies. To produce a relatively high axial force with relatively small dimensions of the device, the tracks are arranged at opposing faces of the two components, with the tracks extending in a circle around the axis of rotation and in a spiral manner with a given pitch over the periphery of the components.



11

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 158 207 A1

(12) **EUROPÄISCHE PATENTANMELDUNG**

(43) Veröffentlichungstag:
28.11.2001 Patentblatt 2001/48

(51) Int Cl.7: **F16H 25/18**

(21) Anmeldenummer: **01111556.5**

(22) Anmeldetag: **11.05.2001**

(84) Benannte Vertragsstaaten:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Benannte Erstreckungsstaaten:
AL LT LV MK RO SI

(30) Priorität: **25.05.2000 DE 10025978**

(71) Anmelder: **Torrington Nadellager GmbH**
33790 Halle Westf. (DE)

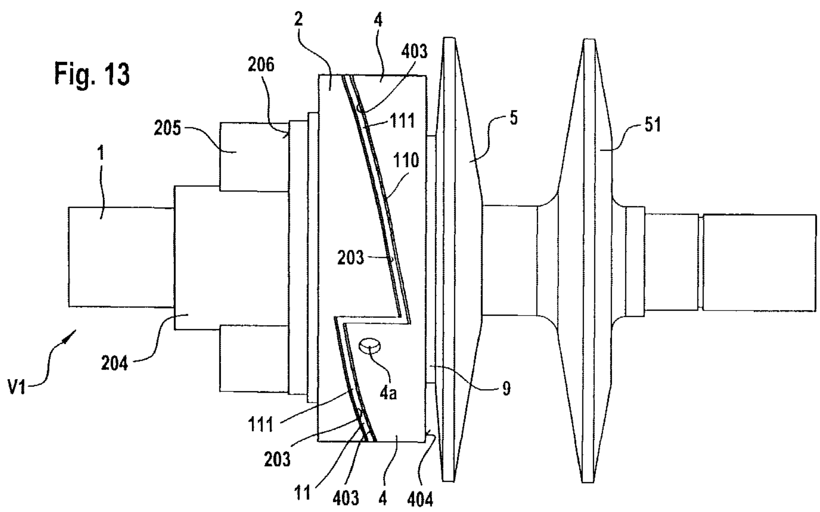
(72) Erfinder: **Weissflog, Dietmar, Dipl.-Ing.**
33378 Rheda-Wiedenbrück (DE)

(74) Vertreter: **Fischer, Matthias, Dipl.-Ing. et al**
Schroeter Fleuchaus Lehmann & Gallo Patentanwälte,
Wolfratshauser Strasse 145
81479 München (DE)

(54) **Axialstelltrieb, insbesondere zur Variatorbetätigung, Variator sowie CVT-Getriebe**

(57) Es wird ein Axialstelltrieb zur Umwandlung einer Drehbewegung in eine translatorische Bewegung, insbesondere für die Steuerung der Axialposition von Variatorscheiben eines stufenlosen Fahrzeuggetriebes (Continuously-Variable-Transmission- oder CVT-Getriebes), vorgeschalgen, der folgende Merkmale aufweist: eine Welle (1), ein gegenüber der Welle (1) axial festgelegtes, um die Wellenachse mittels einer Antriebseinrichtung (P) drehbares Steuerelement (2) mit einem hinteren Ende (201) und einem vorderen Ende (202), mit einem gegenüber dem Steuerelement (2) drehbar gelagerten, gegenüber der Welle (1) drehfesten Hubelement (4) mit einem hinteren Ende (401) und einem vorderen Ende (402), mit einem zwischen dem Steuerelement (2) und dem Hubelement (4) angeordneten, vorzugsweise Wälzkörper tragende, wendelförmige Flügel (111) aufweisenden Flügelkäfig (11), wobei am vorderen Ende (202) des Steuerelements (2) wenigstens drei konzentrische, zum hinteren Ende (401) des Hubelements (4) hin zeigende, wendelförmig ansteigende Rampen (203) und am hinteren Ende des Hubelements (4) wenigstens drei konzentrische, zum vorderen Ende (202) des Steuerelements (2) hin zeigende, wendelförmig ansteigende, zu den Rampen (203) komplementäre, Rampen (403) angeordnet sind, wobei die Wendelform der Flügel der Wendelform der Rampen (203) und (403) entspricht, wobei am vorderen Ende (402) des Hubelements (4) eine Druckfläche (404) zur Übertragung von Axialkräften angeordnet ist.

Fig. 13



EP 1 158 207 A1

Fig. 1

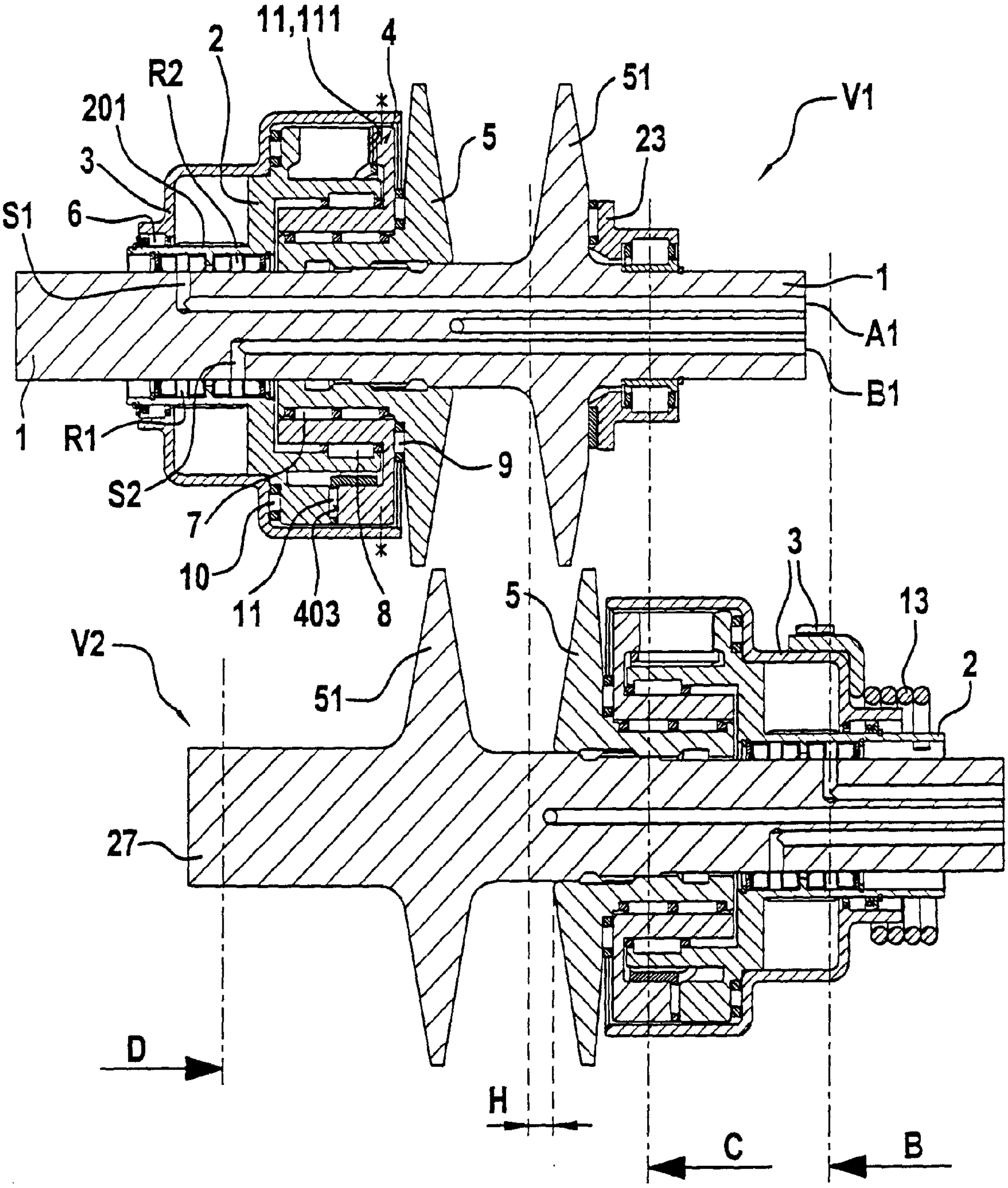
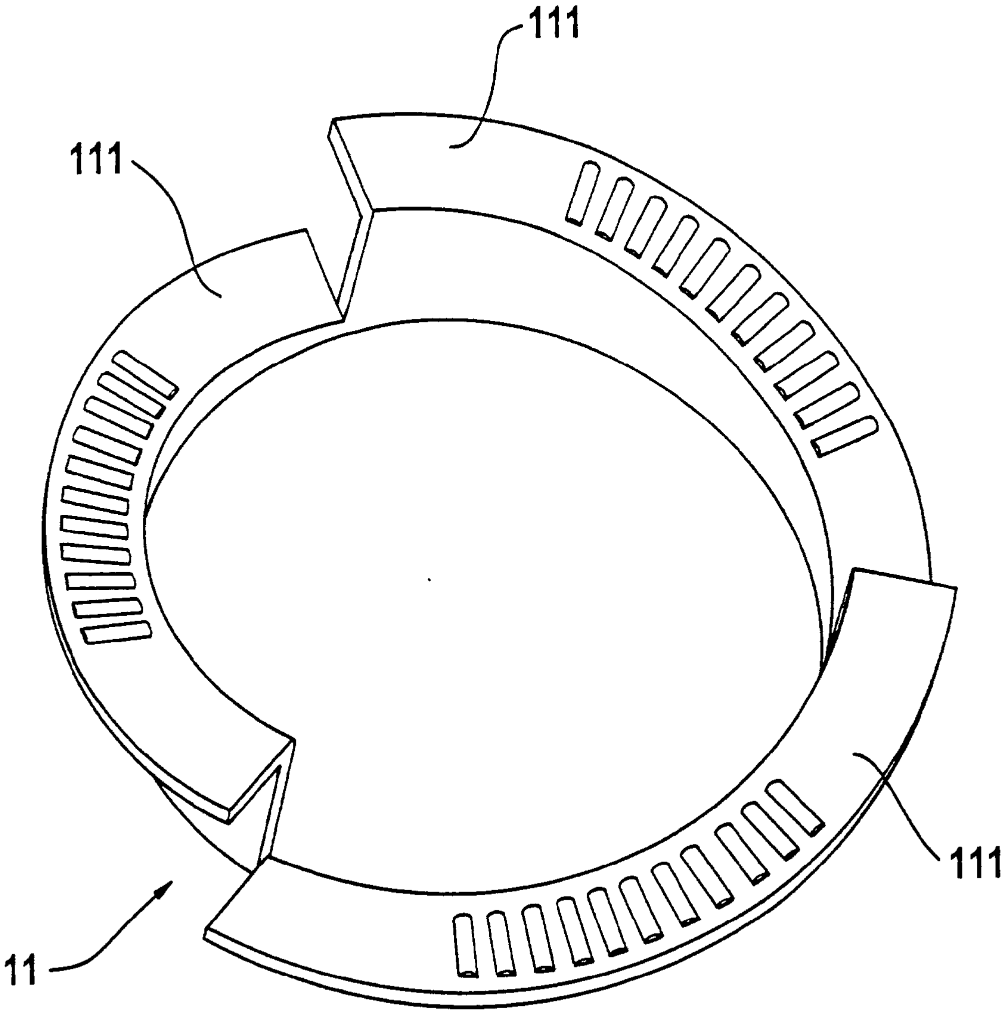

11,111
4
2
R2
201
3
6
S1
51
5
V1
23
1
A1
B1
1
R1
S2
9
7
10
11
403
8
3
13
5
2
V2
51
27
D
H
C
B

Fig. 16



Appendix B

Calculations mechanical advantage

The amount of mechanical advantage *ma* is given by:

$$ma = \frac{a}{b} \qquad (1)$$

In which:

ma	:	mechanical advantage [-]		
a	:	input distance [mm]		
b	:	output distance [mm]	=	20 mm

Planetary roller screw

The input distance *a* of the planetary roller screw used in the current design can be obtained using:

$$a = n \cdot \pi \cdot d \qquad (2)$$

$$n = \frac{b}{p} \qquad (3)$$

In which:

a	:	input distance [mm]		
n	:	number of revolutions [-]		
d	:	diameter [mm]	=	50 mm
b	:	output distance [mm]	=	20 mm
p	:	pitch [mm]	=	4 mm

The mechanical advantage becomes:

$$ma = \frac{785}{20} = 39 \Rightarrow 40$$

Three wedges

The input distance *a* of the mechanism using three wedges can be obtained using:

$$a = \pi \cdot d \cdot \frac{\varphi}{360°} \qquad (4)$$

In which:

a	:	input distance [mm]		
φ	:	angular distance of the wedge(s) [°]	=	120°
d	:	diameter [mm]	=	180 mm

The mechanical advantage becomes:

$$ma = \frac{188{,}5}{20} = 9{,}4 \Rightarrow 10$$

One wedge
The input distance *a* of the mechanism using one wedge can be obtained using:

$$a = \pi \cdot d \cdot \frac{\varphi}{360°} \tag{4}$$

In which:

a	:	input distance [mm]		
φ	:	angular distance of the wedge(s) [°]	=	360°
d	:	diameter [mm]	=	180 mm

The mechanical advantage becomes:

$$ma = \frac{565{,}5}{20} = 28{,}3 \Rightarrow 30$$

Coil transmission
The input distance *a* of the mechanism using a coil transmission can be obtained using:

$$a = n \cdot \pi \cdot d \tag{2}$$

In which:

a	:	input distance [mm]		
n	:	number of coils [-]	=	17
d	:	diameter [mm]	=	180 mm

The mechanical advantage becomes:

$$ma = \frac{9613}{20} = 481 \Rightarrow 480$$

Cams
The input distance *a* of the mechanism using three cams, with a minimum diameter of 80 mm and a maximum of 100 mm, can be obtained using:

$$a = \pi \cdot d \tag{5}$$

In which:

a	:	input distance [mm]		
d	:	(average) diameter [mm]	=	90 mm

The mechanical advantage becomes:

$$ma = \frac{283}{20} = 14{,}1 \Rightarrow 14$$