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(71) Applicants and
(72) Inventors: **LESLEY, Samuel** [GB/GB]; 26 Portway, Steyning, W. Sussex BN44 3QF (GB). **MICHAELIS, Jonathan, Martin** [GB/GB]; 12 Burlington Road, Buxton, Derbyshire, SK17 9AL (GB).

(74) Common Representative: **LESLEY, Samuel**; 26 Portway, Steyning, W. Sussex BN44 3QF (GB).

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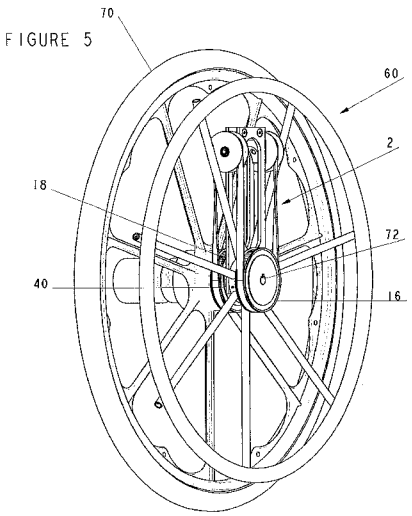
(54) Title: HAND- PROPELLED VEHICLE WITH BELT DIFFERENTIAL

FIGURE 5



(57) Abstract: A hand-propelled vehicle such as a hemiplegic wheelchair, with a single input handwheel (60), two drive wheels (70) and a differential (2). The differential (2) uses a endless toothed belt (12) running over two toothed pulleys (16, 18) coaxial with the handwheel (60), and two planet pulleys (8, 20) with their axes transverse to the handwheel axis (14) and mounted on a planet carrier (4) attached to and driven by the handwheel (60). A simple lightweight structure connects the handwheel (60), the toothed pulleys (16, 18) and the planet pulleys (8,20).

HAND-PROPELLED VEHICLE WITH BELT DIFFERENTIAL

Background

The present invention relates to a differential for a hand-propelled vehicle. More particularly a belt-driven differential for a hemiplegic wheelchair.

Wheelchair users who have hemiplegia (paralysis down one side of their body) find difficulty in walking, and prefer to use a wheelchair. However, propelling themselves manually is difficult because, with only one arm available for propulsion, there is a tendency for the wheelchair to veer away from the intended direction. Typically, the wheelchair may veer 10° to 30° away from the intended direction with each push of the active hand on the adjacent handrim.

A more recent development is the use of a single handrim in conjunction with a differential. (See: Anne Mandy et al, *Energy expenditure, and comfort in a modified wheelchair for people with hemiplegia: A controlled trial*, Disability and Rehabilitation: Assistive Technology, September 2007; 2(5): 255 – 260). The differential supplies equal torque to both driving wheels, allowing the chair to drive in a straight line until the foot steering is used to change the direction. The differential drive is preferred by users because it is far more ergonomic and easy to use than other drive systems.

Differentials using toothed belts are well known. US 5,445,572 and US 5,984,819 use a single belt. Both inventions are intended for powered vehicles. Neither is suitable for a hand-propelled vehicle.

Summary of the invention

Viewed from a first aspect, the present invention relates to a hand-propelled vehicle having a belt-drive differential.

Viewed from a second aspect, the present invention relates to a hand-propelled vehicle having first and second drive wheels positioned one on each side of the vehicle, an input handwheel and a differential, the differential comprising: a planet carrier driveably connected to the handwheel, planet pulleys mounted on the planet carrier, a first toothed pulley coaxial with the handwheel and driveably connected to the first drive wheel, a second toothed pulley coaxial with the handwheel and driveably connected to the second drive wheel, and a toothed belt passing around the toothed pulleys and the planet pulleys, wherein the planet carrier and planet pulleys are positioned outward of the first drive wheel from the hand-propelled vehicle.

As the planet carrier and planet pulleys are positioned outward of the first drive wheel from the hand-propelled vehicle, there is plenty of room to accommodate the toothed belt and allow it to twist through 90° between the planets and the toothed pulleys without excessive strain on the belt. For example, with a strong person providing the driving force to the hand-propelled vehicle, the torque generated by the handwheel can be as high as 30 - 40 Nm. This is well in excess of the input torque to US 5,984,819, which is around 12 Nm, making the differential described in that publication unsuitable for a hand-propelled vehicle. However, by positioning the planet carrier and planet pulleys outward of the first drive wheel from the hand-propelled vehicle, a stronger belt can be used, say 10 mm pitch instead of 5 mm pitch, which requires a longer distance between the planets and the toothed pulleys in order to twist the belt as gently as possible around the pulleys (the axes of planets typically being at

90° to the axes of the toothed pulleys).

Viewed from a third aspect, the present invention relates to a hand-propelled vehicle having first and second drive wheels positioned one on each side of the vehicle, an input handwheel and a differential, the differential comprising: a planet carrier driveably connected to the handwheel, planet pulleys mounted on the planet carrier, a first toothed pulley coaxial with the handwheel and driveably connected to the first drive wheel, a second toothed pulley coaxial with the handwheel and driveably connected to the second drive wheel, and an endless toothed belt passing around the toothed pulleys and the planet pulleys, wherein the centre of mass of the differential is offset from the common axis of the handwheel and the first and second toothed pulleys.

The differentials described in US 5,445,572 and US 5,984,819 are arranged to have their centre of mass coincident with the axis of the wheel by which they are driven to prevent vibration. As the planets must be offset from this axis, counter-balancing of the planets is required in order to achieve this. In the present invention, it has been recognised that the handwheel needs to rotate only at low speeds. So, there is no need to provide a weight to counter-balance the offset mass of the differential. This allows the structure of the differential to be kept to a minimum to save weight. Hence the total mass of the hand-propelled vehicle is reduced, which is an important feature for a hand-propelled vehicle, especially when propelled by only one hand.

The first and second toothed pulleys may be positioned one on each side of the handwheel. The second toothed pulley may be driveably connected to the second drive wheel via a shaft. The first toothed pulley may be directly connected to the first drive wheel.

The differential may have two plates sandwiching at one end of the plates a hub of the handwheel and at the other end of the plates an adjuster, wherein the planet carrier is slideable between the two ends. The planet carrier may be constrained to slide longitudinally along the plates. The differential may then have threaded means for cooperating with the adjuster to move the planet carrier longitudinally along the plates away from the common axis of the handwheel and first and second toothed pulleys.

Also, because the mechanism operates slowly, there is no need to have many teeth on the pulleys. The toothed pulleys can have as few as 24 teeth. US 5,984,819 has toothed pulleys with 'at least 61 teeth'.

Description of the preferred embodiment

The invention will now be described with reference to the following figures:

Figure 1. *General view of the belt-drive differential*

Figure 2. *Differential with outer pulley and belt removed*

Figure 3. *Differential with outer plate removed*

Figure 4. *Differential with handwheel in position*

Figure 5. *Differential and handwheel attached to the drive wheel*

Figure 1 shows the main elements of the belt-drive differential (2). First toothed pulley (18) and second toothed pulley (16) have their axes concentric with main axis (14). First planet (20) and second

planet (8) have their axis (10) transverse to (and in the illustrated embodiment perpendicular and spaced apart from) the main axis (14), and rotate around planet pins (22, 6). The planet pins (22, 6) are mounted in a planet carrier (4). The distance of the planet carrier (4) from the main axis (14) is adjustable via cap screw (3). A toothed belt (12) runs in sequence around first toothed pulley (18), first planet (20), second toothed pulley (16), second planet (8) and back to first toothed pulley (18). [Note: The toothed belt is shown without teeth].

The structure of the differential (2) is shown more clearly in figure 2, which omits the belt (12) and second toothed pulley (16). The structure comprises a hub (40) sandwiched between two plates (32, 34). Also shown are fixing screws (36) and a bearing (38) set in the hub (40). The planet carrier (4) has flanges (30) which constrain the planet carrier (4) to slide up and down the plates (32, 34) when screw (3) is adjusted.

In figure 3, one plate (34) is omitted to show the means of adjusting the tension in the belt (12). Adjuster (52) is fixed between the upper ends of the plates (32, 34). The screw (3) sits freely in a hole in adjuster (52) and screws into planet carrier (4). Clockwise rotation of the screw (3) moves the planet carrier (4) away from the main axis (14) and tensions the toothed belt (12). Flange (30) on planet carrier (4) is shown more clearly than in figure 2. Hub (40) has radial holes (54) into which spokes (64 in figure 4) are inserted.

Figure 4 shows the spokes (64) inserted into the hub (40). A handrim (62) is attached to the spokes (64) to form a handwheel (60). When the handwheel (60) is rotated the differential (2) rotates with it, generating equal torque on the toothed pulleys (16, 18).

Figure 5 shows the handwheel (60) and differential (2) mounted on a first drive wheel (70) of a wheelchair. First toothed pulley (18) is fastened to the first drive wheel (70) with screws. Second toothed pulley (16) is mounted on and keyed to a stub-shaft (72) which runs in bearings (not shown) inside the hub (40) of the differential (2) and inside the first drive wheel (70). Stub-shaft (72) may be connected to a second drive wheel (not shown) on the opposite side of the wheelchair. Hence first toothed pulley (18) drives the first drive wheel (70) and second toothed pulley (16) drives the second drive wheel.

As can be seen in figure 1, the structure of the differential (2) is both simple and lightweight, and can be enclosed within a lightweight cover (not shown) to shield the differential (2) from the wheelchair user's hand and from dust. Before fitting the toothed belt (12), the planet carrier (4) would be moved radially to its position closest to the main axis (14), allowing the toothed belt (12) to be slid into position over the pulleys (16, 18) and planets (8, 20). The planet carrier (4) can then be moved radially outwards from the main axis (14) using screw (3) to tighten the toothed belt (12).

Claims

1. A hand-propelled vehicle having first and second drive wheels positioned one on each side of the vehicle, an input handwheel and a differential, the differential comprising: a planet carrier driveably connected to the handwheel, planet pulleys mounted on the planet carrier, a first toothed pulley coaxial with the handwheel and driveably connected to the first drive wheel, a second toothed pulley coaxial with the handwheel and driveably connected to the second drive wheel, and a toothed belt passing around the toothed pulleys and the planet pulleys, wherein the planet carrier and planet pulleys are positioned outward of the first drive wheel from the hand-propelled vehicle.

2. The hand-propelled vehicle of claim 1, wherein the centre of mass of the differential is offset from the common axis of the handwheel and first and second toothed pulleys.

3. A hand-propelled vehicle having first and second drive wheels positioned one on each side of the vehicle, an input handwheel and a differential, the differential comprising: a planet carrier driveably connected to the handwheel, planet pulleys mounted on the planet carrier, a first toothed pulley coaxial with the handwheel and driveably connected to the first drive wheel, a second toothed pulley coaxial with the handwheel and driveably connected to the second drive wheel, and a toothed belt passing around the toothed pulleys and the planet pulleys, wherein the centre of mass of the differential is offset from the common axis of the handwheel and first and second toothed pulleys.

4. The hand-propelled vehicle of claim 3, wherein the planet carrier and planet pulleys are positioned outward of the first drive wheel from the hand-propelled vehicle.

5. The hand-propelled vehicle of any one of the preceding claims, wherein the first and second toothed pulleys are positioned one on each side of the handwheel.

6. The hand-propelled vehicle of any one of the preceding claims, wherein the second toothed pulley is driveably connected to the second drive wheel via a shaft.

7. The hand-propelled vehicle of any one of the preceding claims, wherein the first toothed pulley is directly connected to the first drive wheel.

8. The hand-propelled vehicle of any one of the preceding claims, wherein the differential has two plates sandwiching at one end of the plates a hub of the handwheel and at the other end of the plates an adjuster, wherein the planet carrier is slideable between the two ends.

9. The hand-propelled vehicle of claim 8, in which the planet carrier is constrained to slide longitudinally along the plates.

10. The hand-propelled vehicle of claim 8 or claim 9, wherein the differential has threaded means for cooperating with the adjuster to move the planet carrier longitudinally along the plates away from the common axis of the handwheel and the first and second toothed pulleys.

11. The hand-propelled vehicle of any one of the preceding claims, wherein the toothed pulleys have only 24 teeth each.

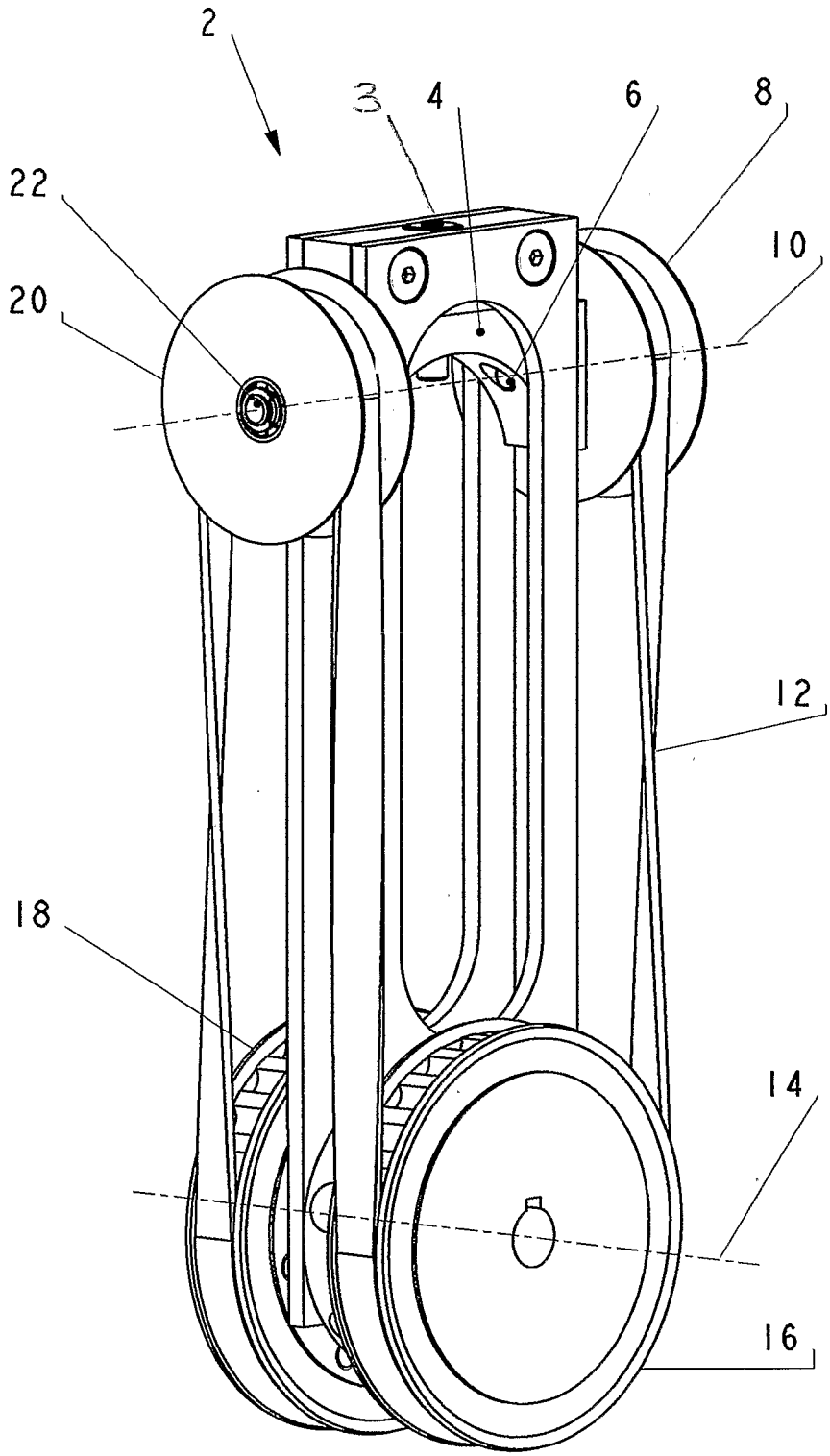


FIGURE 1

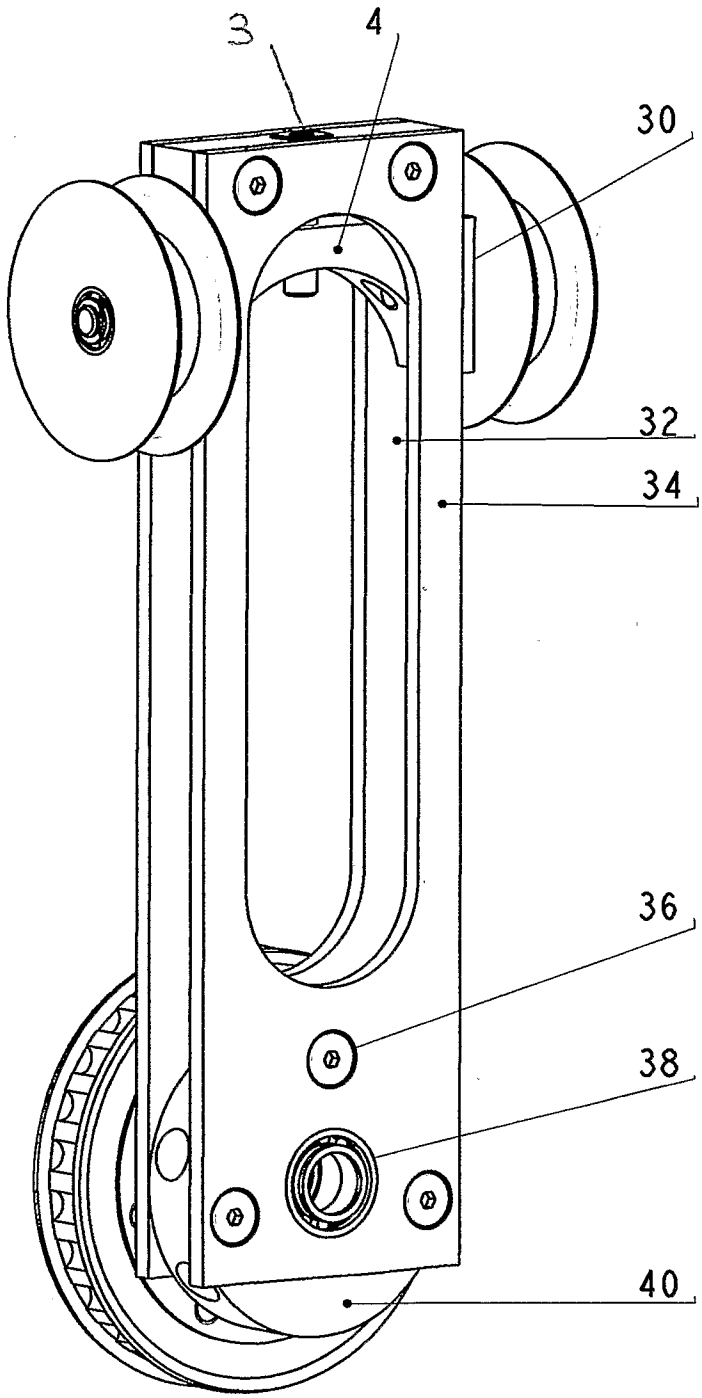


FIGURE 2

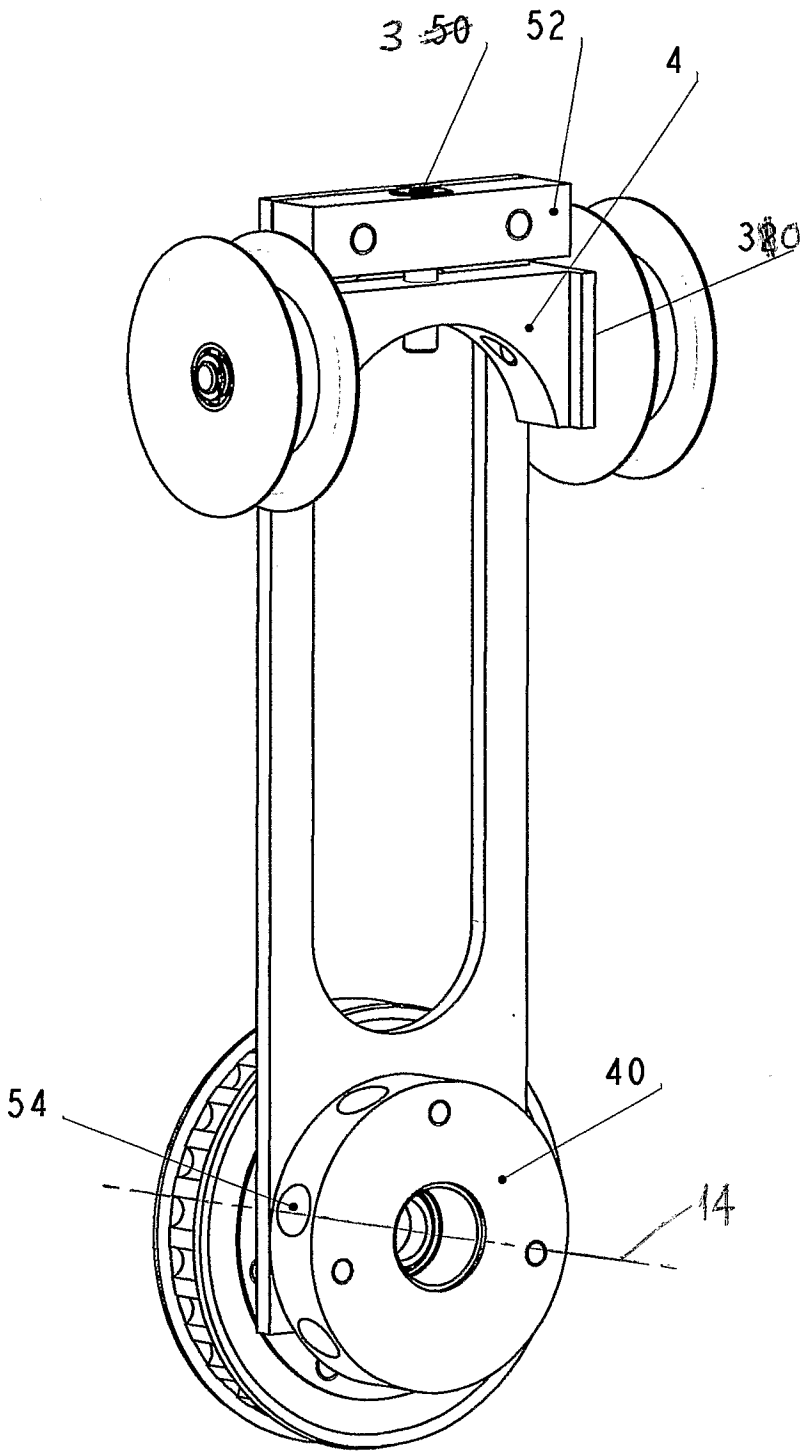


FIGURE 3

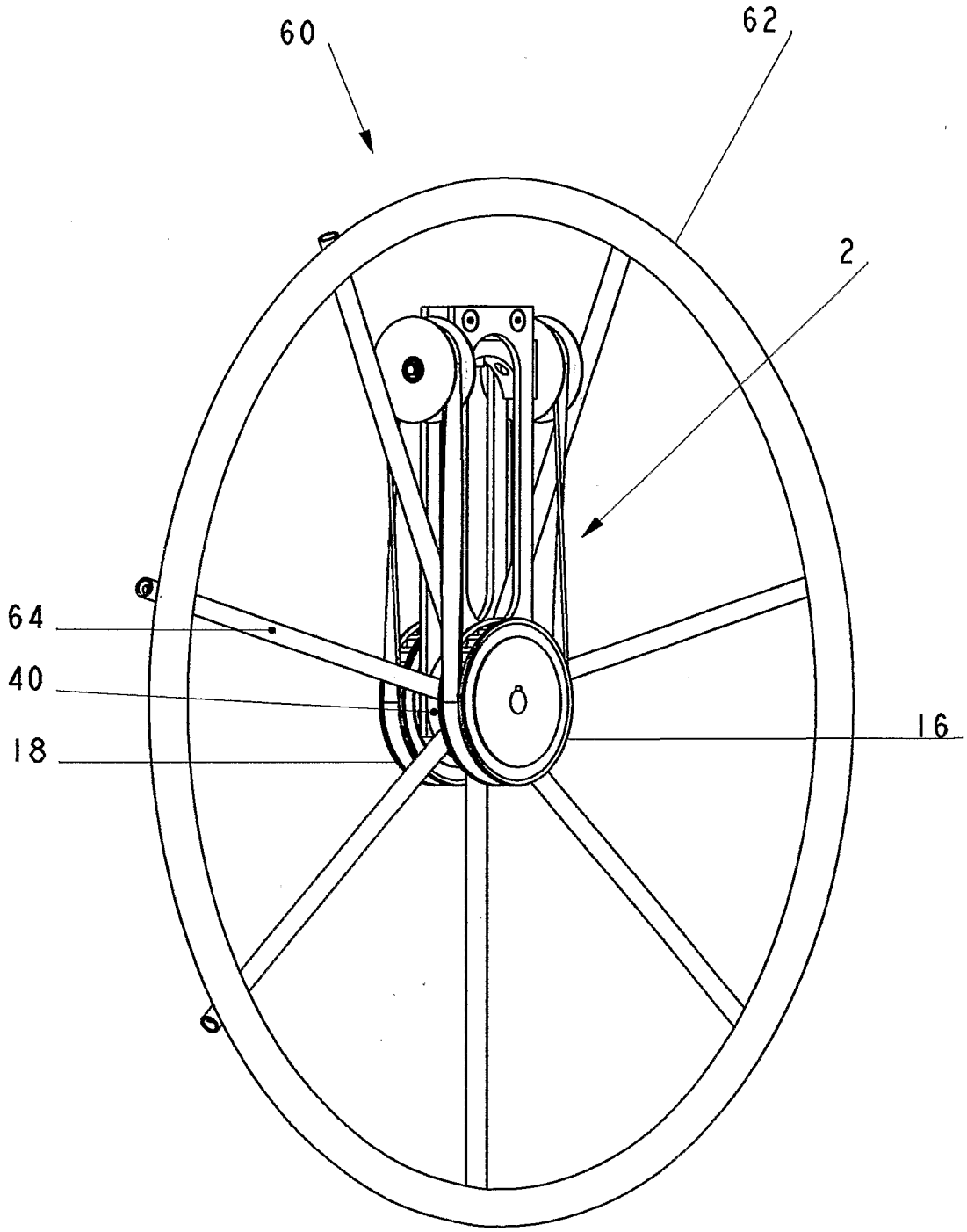


FIGURE 4

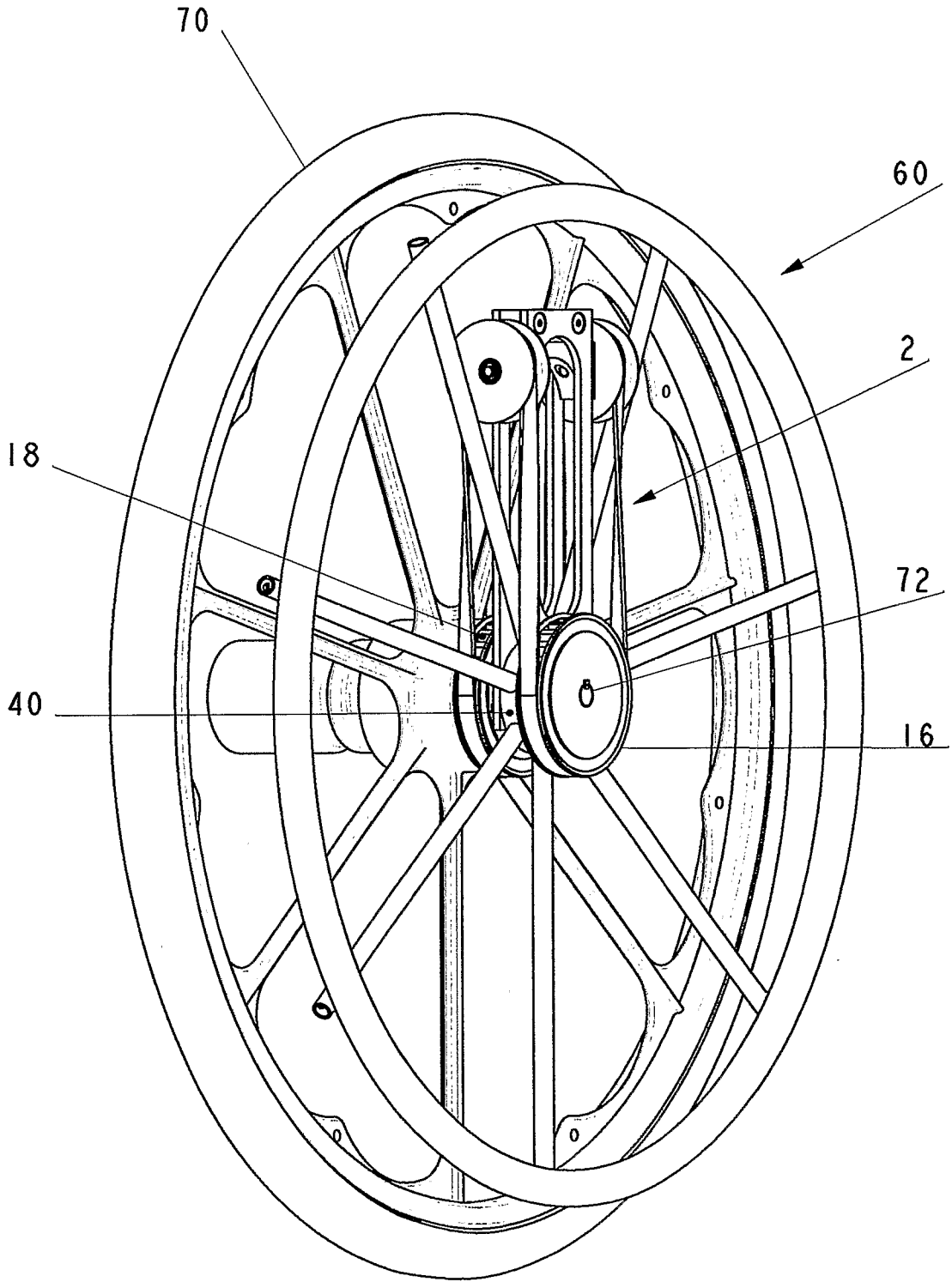


FIGURE 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2009/001181

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62M1/14 B62M9/00 A61G5/02

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B62M A61G F16H

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 3 543 608 A (MEIHAK ROGER W) 1 December 1970 (1970-12-01) the whole document	1-11
A	US 5 984 819 A (MCCOMBER DONALD R [US]) 16 November 1999 (1999-11-16) cited in the application the whole document	1-11
A	US 5 390 753 A (PARKER BRUCE H [US]) 21 February 1995 (1995-02-21) the whole document	1-11

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 August 2009	01/09/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	de Acha González, J

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2009/001181

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 445 572 A (PARKER BRUCE H [US]) 29 August 1995 (1995-08-29) the whole document -----	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

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