



(51) International Patent Classification:

B62M 3/02 (2006.01) **B62M 3/08** (2006.01)
B62M 3/06 (2006.01)

(21) International Application Number:

PCT/BE2017/000048

(22) International Filing Date:

24 November 2017 (24.11.2017)

(25) Filing Language:

Dutch

(26) Publication Language:

English

(30) Priority Data:

BE2016/5882 25 November 2016 (25.11.2016) BE

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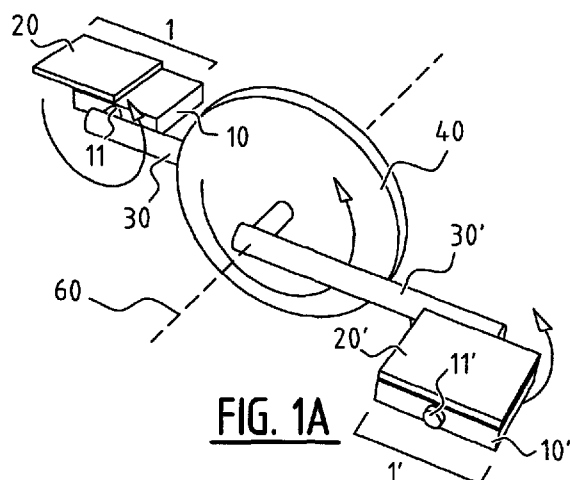
(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP,
KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: PEDAL FOR A PEDAL VEHICLE



(57) Abstract: Pedal (1) for a pedal vehicle, the pedal comprising a bottom part (10), a pedal axle (11) bearing-mounted in the bottom part, and a slidable top part (20) coupled to the bottom part and configured to slide relative to the bottom part, wherein the pedal axle is configured to be mounted on a crank arm (30) of a pedalling device (40) of the pedal vehicle; and the slidable top part is coupled to the pedal axle in a manner such that the slidable top part is displaced relative to the bottom part in controlled manner in dependence of an angular position of the crank arm of the pedalling device during a pedalling cycle of the pedalling device.

Pedal for a pedal vehicle

Field of the invention

The present invention relates to a pedal for a pedal vehicle. The present invention further relates to
5 a pedalling device for a pedal vehicle and to a pedal vehicle.

Background

Pedals for pedal vehicles, such as pedals for a cycle, are typically mounted on a crank arm of a pedalling device. Known pedals are driven by muscle power of a user, for instance a cyclist, so that
10 the crank arm rotates and the pedals describe a fixed circular movement around the pedalling axis of the pedalling device, whereby one or more wheels of the pedal vehicle are driven.

Summary of the invention

Embodiments of the invention have the object of providing a pedal for a pedal vehicle which
15 transmits the force exerted on the pedal by a user to the pedalling device in more efficient manner compared to known pedals for pedal vehicles.

A first aspect of the invention relates to a pedal for a pedal vehicle. The pedal comprises a bottom part, a pedal axle bearing-mounted in the bottom part, and a slidable top part coupled to the bottom part and configured to slide relative to the bottom part. The pedal axle is configured to be mounted
20 on a crank arm of a pedalling device of the pedal vehicle. The slidable top part is coupled to the pedal axle in a manner such that the slidable top part is displaced relative to the bottom part in controlled manner in dependence to an angular position α of the crank arm of the pedalling device during a pedalling cycle of the pedalling device.

25 Because the slidable top part is slid relative to the bottom part in controlled manner, the pedal can describe a movement around the pedalling axis during a pedalling cycle, which movement differs in advantageous and efficient manner from the fixed circular movement described by prior art pedals. Because the sliding displacement is dependent of the angular position α of the crank arm, it
30 is possible to ensure that the slidable top part travels an efficient path around the pedalling axis without additional effort being required here from a user or cyclist. The sliding displacement of the slidable top part thus takes place independently of the forces exerted on the pedal by a user.

In an embodiment the slidable top part is coupled to the pedal axle in a manner such that, during a
35 pedalling cycle, the slidable top part is slid in controlled manner in a sliding direction parallel to a

plane in which the crank arm of the pedalling device rotates during a pedalling cycle of the pedalling device.

Because the slidable top part is slid in a sliding direction parallel to a plane in which the crank arm of the pedalling device rotates, the length of the pedalling lever can be increased or reduced in efficient manner. In many pedal vehicles the sliding direction of the movable top part will substantially correspond to the direction of forward movement of the pedal vehicle. The sliding direction is preferably substantially parallel to the surface on which the pedal vehicle is advanced. Slight variations thereto may occur, subject to an orientation of the bottom part of the pedal during a pedalling cycle and/or to a form of the bottom part of the pedal.

In an embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part runs through a sliding stage in the sliding direction, wherein during the sliding stage:

- the slidable top part slides continuously from a rest position, in which the slidable top part has not been displaced, to an extended position in which the slidable top part has been displaced over a maximum sliding distance; and
- the slidable top part then slides continuously from the extended position to the rest position.

In the rest position, the position of the slidable top part corresponds to the position of a traditional pedal situated at the same angular position. In the extended position, and every position between the rest position and the extended position, the pedalling lever is either increased or reduced relative to the pedalling lever of a traditional pedal. The slidable top part is displaced from the rest position to the extended position in continuous manner. If the crank arm on which the pedal is mounted has an angular position lying in quadrant I or II, the pedalling lever is increased. If the crank arm on which the pedal is mounted has an angular position lying in quadrant III or IV, the pedalling lever is reduced.

In an embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part runs through one complete sliding stage, preferably two complete sliding stages, during a complete pedalling cycle. In an alternative embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part runs through more than two sliding stages during a complete pedalling cycle.

When the slidable top part runs through one complete sliding stage during a complete pedalling cycle, the slidable top part thus reaches the rest position once per pedalling cycle and the maximally displaced position once per pedalling cycle.

- 5 In an embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part runs through a part of a complete sliding stage during a complete pedalling cycle. Half a sliding stage, a third of a sliding stage, a fourth of a sliding stage and so on can thus for instance be run through per complete pedalling cycle. When half of the sliding stage is for instance run through during a complete pedalling cycle, a complete sliding stage will have been run through
10 when two complete pedalling cycles have been performed. It will be apparent to the skilled person that other ratios between pedalling cycle and sliding stage are possible.

- In a preferred embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part reaches the extended position when the angular position α of the crank arm lies
15 between 350° and 170° , preferably between 20° and 160° , more preferably between 30° and 150° , and most preferably between 50° and 140° .

- Positive work is mainly produced within an angular range between 350° (-10°) and 170° . In order to generate the greatest possible moment during this period of positive work, it is advantageous for
20 the pedalling lever to be relatively large within this angular range. This is achieved in that the slidable top part is in the extended state at a determined angular position between 350° and 170° .

- In a preferred embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part reaches the rest position when the angular position α of the crank arm lies
25 between 190° and 350° , preferably between 200° and 340° , more preferably between 210° and 330° , and most preferably between 230° and 320° .

- Negative work is mainly produced within an angular range between 190° and 350° . In order to lose the least possible energy during this period of negative work, it is advantageous for the pedalling
30 lever to be relatively small within this angular range. This is achieved in that, with the exception of when the slidable top part is in the rest position, the slidable top part is displaced within this angular range in the direction of forward movement of the pedal vehicle. A further advantage is that, since the rest position is reached only once per complete pedalling cycle (0° - 360°) and the rest position is reached within the angular range between 190° and 350° , in the angular positions 0° and
35 180° the slidable top part is displaced relative to the bottom part, whereby the so-called "dead points" can be avoided.

In an embodiment the slidable top part is coupled to the pedal axle in a manner such that the slidable top part is displaced such that a length (l) of a pedalling lever, which is formed by the crank arm and the slidable top part, is greater during a pressing stage of the pedalling cycle than during a pulling stage of the pedalling cycle.

Positive work is mainly exerted on the pedal during the pressing stage of the pedalling cycle. By displacing the slidable top part in the sliding direction away from the pedalling axis during the pressing stage the length (l) of the pedalling lever increases. This increases the moment which is generated during the pressing stage (roughly between angular positions 0° and 180° of the crank arm). During the pulling stage (roughly between angular positions 180° and 360° of the crank arm) the slidable top part is displaced in the sliding direction toward the pedalling axis. This reduces the moment during the pulling stage, when negative work is mainly exerted on the pedal.

In a preferred embodiment the pedal axle is coupled by means of a crank and a drive rod arranged on the crank to the slidable top part such that a revolution of the pedal axle relative to the bottom part during a pedalling cycle brings about a sliding movement of the slidable top part.

A crank with drive rod are simple mechanical components which are durable, wear-resistant, efficient and reliable. They are highly suitable for converting a rotation movement into a translation or sliding movement, or vice versa.

In an embodiment the pedal axle comprises a crankshaft of the crank, wherein the crank is driven to rotate by the pedal axle.

Because the pedal axle comprises the crankshaft of the crank, the crank is driven to rotate directly by the rotation of the pedal axle, and no additional transmission is necessary to convert the rotation of the pedal axle into a rotation of the crank.

In a preferred embodiment the pedal axle is coupled by means of a gear transmission to the crank, and the crank is driven to rotate by the pedal axle.

By providing a gear transmission which converts the rotation movement of the pedal axle into a rotation movement of the crank, the crank can be driven to rotate in a plane parallel to the pedal axle. This is advantageous in respect of utilization of space inside the bottom part of the pedal.

In an embodiment the pedal axle comprises a cylindrical worm and the crank comprises a toothed wheel which is oriented substantially parallel to the pedal axle and the sliding direction of the slidable top part and on which is arranged the drive rod which is connected to the slidable top part, wherein the cylindrical worm drives the toothed wheel to rotate.

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In an exemplary embodiment the pedal axle comprises a cylindrical worm and the crank comprises a protruding toothed wheel part oriented substantially perpendicularly of the pedal axle and the sliding direction of the slidable top part, wherein the cylindrical worm engages on the toothed wheel part and wherein the cylindrical worm drives the crank to rotate.

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In a preferred embodiment the toothed wheel oriented substantially parallel to the pedal axle and the sliding direction of the slidable top part is a worm wheel or a bevel gear.

In an exemplary embodiment the toothed wheel part oriented substantially perpendicularly of the pedal axle and the sliding direction of the slidable top part comprises a worm wheel or a bevel gear.

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In an embodiment the bottom part comprises a closed housing in which is received at least a part of the pedal axle which is bearing-mounted in the bottom part.

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In a preferred embodiment the crank and the toothed wheel assembly are received in the closed housing.

In an exemplary embodiment the bottom part comprises at least one guide oriented in the sliding direction of the slidable top part and the slidable top part comprises at least one corresponding guide recess. In this way the stability of the sliding displacement of the slidable top part is increased and the slidable top part does not deviate from the desired sliding direction during the sliding displacement. It will be apparent to the skilled person that the slidable top part can similarly comprise at least one guide oriented in the sliding direction of the slidable top part, wherein the bottom part then comprises at least one corresponding guide recess. Two guides, one on each side, oriented in the sliding direction, of the bottom part or top part, and two corresponding recesses are preferably provided in order to increase the stability of the sliding movement.

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In a preferred embodiment the slidable top part comprises securing means for releasably securing thereon a shoe of a rider of the pedal vehicle.

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In an embodiment the bottom part comprises a sliding surface, wherein in the rest position the slidable top part is situated on the sliding surface, and wherein the slidable top part is configured to slide along the sliding surface and into the extended position.

- 5 During a pedalling cycle the sliding surface is often oriented substantially parallel relative to the surface on which the pedal vehicle is advanced.

In an embodiment the bottom part is substantially wedge-shaped and the sliding surface of the bottom part comprises a surface inclining in the direction of forward movement of the pedal
10 vehicle.

In this way the slidable top part is displaced at an angle relative to the bottom part. The angle at which the slidable top part is displaced depends on the incline of the sliding surface. This angle or incline can be determined in advantageous manner such that during a pressing stage the slidable
15 top part is oriented such that a tangential resultant of the force exerted by a user on the slidable top part of the pedal is greater than the tangential resultant of the force if the slidable top part were oriented substantially horizontally. In this context horizontal orientation is understood to mean an orientation wherein the slidable top part is substantially parallel to the surface on which the pedal vehicle is advanced.

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In an embodiment the maximum difference between the extended position and the rest position of the slidable top part lies between 1 mm and 60 mm.

In an alternative embodiment the maximum difference between the extended position and the rest
25 position of the slidable top part is greater than 60 mm.

A second aspect of the invention relates to a pedalling device for a pedal vehicle, wherein the pedalling device comprises a crank arm on which is mounted a pedal according to any of the above described embodiments.

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A third aspect of the invention relates to a pedal vehicle provided with a pedalling device according to the above described embodiments.

Brief description of the figures

The above and other advantageous features and objectives of the invention will become more apparent and the invention better understood with reference to the following detailed description when read in combination with the accompanying drawings, in which:

- 5 Figures 1A, 1B, 1C show a perspective view of a pedalling device of a pedal vehicle, wherein the pedalling device comprises two pedals according to an embodiment of the invention;
- Figure 2 shows a schematic overview of a pedalling device with a pedal according to an embodiment of the invention;
- Figure 3 shows a cut-way perspective view of an embodiment of a pedal according to the
- 10 invention;
- Figures 4A, 4B, 4C, 4D show respective perspective views of an embodiment of a pedal according to the invention which is mounted on a crank arm of a pedalling device, wherein the crank arm passes through various angular positions;
- Figure 5A shows an embodiment of a pedal axle of a pedal according to the invention;
- 15 Figure 5B shows an embodiment of a crank, embodied as toothed wheel, of a pedal according to the invention;
- Figure 5C shows the co-action of the pedal axle, crank and drive rod according to an embodiment of the invention;
- Figure 6 shows an embodiment of a pedal according to the invention, wherein the slidable top part
- 20 comprises a snap-in portion;
- Figures 7A and 7B show respectively a perspective view and top view of a pedal according to an embodiment of the invention.

Detailed embodiments

- 25 Figures 1A, 1B and 1C illustrate the principle of a pedal 1, 1' according to an embodiment of the invention. Figures 1A, 1B and 1C show a pedalling device 40 of a pedal vehicle, such as for instance a chainring 40 of a cycle, with crank arms 30, 30' connected to spindle 60. The rotation direction of pedalling device 40 is indicated thereon with an arrow. Mounted at the end of each
- 30 crank arm 30, 30' remote from pedalling device 40 is a pedal 1, 1' according to an embodiment of the invention. The pedal 1, 1' comprises a bottom part 10, a pedal axle 11 bearing-mounted in bottom part 10, and a slidable top part 20 which is coupled to bottom part 10 and is configured to slide relative to bottom part 10. Pedal 1, 1' is mounted by means of pedal axle 11 on the crank arm
- 35 30, 30' of pedalling device 40 of the pedal vehicle. A user or rider of the pedal vehicle places his or her foot on the slidable top part 20 of the pedal and exerts a force on the pedal, whereby bottom part 10 will begin to describe a circular movement all the way around spindle 60 during a pedalling cycle. The foot of the rider will ensure that slidable top part 20 remains oriented substantially

horizontally during a pedalling cycle. During a pedalling cycle, pedal axle 11, 11' will hereby rotate about its axis relative to bottom part 10, 10' of the pedal because of the rotation of crank arm 30, 30' and the bearing-mounted coupling between pedal axle 11, 11' and bottom part 10, 10'. Slidable top part 20, 20' is then coupled to pedal axle 11, 11' in a manner such that slidable top part 20, 20' undergoes a controlled sliding displacement or translation relative to bottom part 10, 10' under the influence of the axial rotation of the pedal axle. A controlled sliding displacement, or sliding in controlled manner, is understood to mean that the displacement of slidable top part 20, 20' relative to bottom part 10, 10' is identical for each position during an axial rotation of the pedal axle. This is achieved in that the coupling between crank arm 30, 30', pedal axle 11, 11', bottom part 10, 10' and slidable top part 20, 20' has been developed such that the sliding displacement is dependent only of the angular position α of crank arm 30, 30'. The controlled sliding displacement is hereby further not influenced by force exerted on the pedal, or on the slidable top part 20, 20' thereof, by (a foot of) the user. A crankshaft is highly suitable for converting the rotation movement of pedal axle 11, 11' into a translation movement of slidable top part 20. The coupling between pedal axle 11, 11' and slidable top part 20, 20' is such that the sliding displacement or translation is subject to an angular position α of crank arm 30, 30' during a pedalling cycle. Figures 1A, 1B and 1C illustrate this dependence and show various angular positions of crank arms 30, 30' with respective pedals 1, 1'. It will be apparent to the skilled person that the rotation of crank arm 30, 30' during a pedalling cycle corresponds to the rotation of pedal axle 11, 11' relative to bottom part 10, 10'.

Use will be made hereinbelow of the notation " α " for the angular position of the crank arm, the notation "l" for the length of the pedalling lever and the notations "I", "II", "III" and "IV" for respectively the first quadrant (0°-90°), the second quadrant (90°-180°), the third quadrant (180°-270°) and the fourth quadrant (270°-360°) of the pedalling cycle (0°-360°). These notations are defined in Figure 2. It is thus shown that the angular position α is defined relative to a vertical line perpendicular to spindle 60. This definition applies particularly to traditional cycles, racing bikes, mountain bikes and so on, wherein the cyclist is positioned substantially above the pedalling device and wherein the legs and feet of the cyclist approach the pedal from above. It will be apparent to the skilled person that in pedal vehicles wherein the user is positioned differently, such as for instance in the case of a reclining bike, the operation of a pedal according to embodiments of the invention is similar to the described operation, with the difference that the angular position α is defined differently because of the different position of the reclining cyclist. Quadrants I and II are designated as quadrants where positive work is mainly produced, while in quadrants III and IV negative work is mainly produced. Positive work can be produced in quadrant IV from an angular position of about 350° (-10°). In a pedalling cycle there are two so-called "dead points" or "dead

zones", situated at an angular position of 0° (360°) and 180° . In a traditional pedal the pressure point, where the foot of a cyclist exerts force on the pedal, is perpendicular to crank arm 30 at these angular positions, so that no tangential force is generated on the pedal. The resultant force of the force exerted on the pedal by the cyclist is hereby almost zero when the crank arm is in these angular positions. In a pedal according to an embodiment of the invention these dead points can be avoided by displacing the slidable top part 20, for instance at an angular position α of 350° , such that the pressure point is placed beyond the "dead point". This can have a positive effect on the resultant force. Similarly, at an angular position α of about 170° the slidable top part 20 can be extended so that the pressure point is displaced to a position beyond 180° , which can have a positive effect on the resultant force. The principal and the operation of the invention will become more apparent on the basis of the description below in combination with the following figures.

Figure 1A shows the situation wherein crank arm 30 has reached an angular position α of substantially 90° . At this angular position the slidable top part 20 has been displaced such that the difference between slidable top part 20 and spindle 60 is greater than the distance between bottom part 10 and the spindle. At this angular position the length l of the pedalling lever is increased by the sliding displacement. This increases the moment which can be generated, whereby a rider or cyclist performs more work, as compared to known pedals, by exerting the same physical power on the pedal. It is advantageous to increase the moment of force in quadrants I and II, the quadrants of positive work, by extending the pedalling lever. The length l of the pedalling lever is defined as the distance between spindle 60 and slidable top part 20, on which the foot of a user of the pedal vehicle is positioned. In Figure 2 the length l of the pedalling lever is defined by way of example as the distance between spindle 60 and the centre of slidable top part 20.

At the same time, crank arm 30' is in an angular position α of substantially 270° . In this angular position the slidable top part 20 has not been displaced, or only to minimal extent, relative to bottom part 10. Crank arm 30' is situated on the boundary between quadrants III and IV, the quadrants of negative work. Since negative work is performed in these quadrants, it is advantageous to reduce the moment of force by reducing the length l of the pedalling lever.

Figure 1B shows the situation in which the two crank arms 30, 30' have advanced along the pedalling cycle. Crank arm 30 is situated in quadrant II and slidable top part 20 is still displaced relative to bottom part 10, although the displacement is smaller than at an angular position of substantially 90° as shown in Figure 1A. The arrow at the position of slidable top part 20 shows the sliding direction of slidable top part 20 relative to bottom part 10, and more particularly the current sliding direction for the shown angular position. For the shown angular position this arrow indicates that slidable top part 20 is displaced toward the rest position. In the shown embodiment

pedals 1 and 1' maintain a substantially horizontal position during a complete pedalling cycle. In the shown embodiment the upper surface, or sliding surface, of bottom part 10 is moreover flat, whereby the sliding direction of slidable top part 20, which is displaced over the upper surface of bottom part 10, is directed substantially horizontally.

- 5 Crank arm 30' is situated in quadrant IV and slidable top part 20' has been displaced relative to bottom part 10', while at an angular position of substantially 270° slidable top part 20' had not been displaced, as shown in Figure 1A. The arrow at the position of slidable top part 20' shows the current sliding direction of slidable top part 20' relative to bottom part 10'. For the shown angular position this arrow indicates that slidable top part 20' is displaced away from the rest position.

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- Figure 1C shows the situation wherein the two crank arms 30, 30' have advanced along the pedalling cycle. Crank arm 30 is situated in quadrant II and slidable top part 20 is still in a displaced position relative to bottom part 10, although the displacement is smaller than in the displacement as shown in Figure 1B. The arrow at the position of slidable top part 20 shows the
15 current sliding direction of slidable top part 20 relative to bottom part 10. For the shown angular position this arrow indicates that slidable top part 20 is displaced toward the rest position. Crank arm 30' is situated in quadrant IV and slidable top part 20' has been displaced relative to bottom part 10' over a greater distance compared to the displacement as shown in Figure 1B. The arrow at the position of slidable top part 20' shows the current sliding direction of slidable top part
20 20' relative to bottom part 10'. For the shown angular position this arrow indicates that slidable top part 20' is displaced away from the rest position, in the direction of the extended position.

- Figures 1A, 1B and 1C show successive positions of crank arms 30 and 30' during a pedalling cycle. Throughout the figures the displacement of top part 20 relative to bottom part 10 is maximal
25 in Figure 1A and the displacement successively decreases in Figures 1B and 1C. Throughout the figures the displacement of top part 20' relative to bottom part 10' is minimal in Figure 1A and the displacement successively increases in Figures 1B and 1C.

- Two pedals 1, 1' according to embodiments of the invention were shown in Figures 1A, 1B and
30 1C. It will however be apparent to the skilled person that pedal 1' which is mounted on crank arm 30' can equally well represent a previous or subsequent angular position of pedal 1 during a pedalling cycle. In an embodiment the two slidable top parts 20 and 20' of respective pedals 1 and 1' preferably undergo a corresponding sliding displacement at the same angular position. The principles and the operation of the different embodiments of the invention will be discussed in the
35 following on the basis of one pedal per embodiment. It will however be apparent to the skilled person that a typical pedalling device of a pedal vehicle comprises two such pedals.

Figure 3 illustrates an embodiment of a pedal 1 according to the invention, wherein pedal 1 is situated in quadrant I or II. Pedal 1 comprises a bottom part 10 and a pedal axle 11 arranged bearing-mounted in bottom part 10. Depending on a chosen reference system, bottom part 10 can rotate around pedal axle 11 or pedal axle 11 can rotate around its axis relative to bottom part 10. Pedal 1 is mounted on crank arm 30 by means of pedal axle 11. Using bottom part 10 of the pedal as reference system, pedal axle 11 will rotate around its axis inside bottom part 10 during a pedalling cycle when crank arm 30 rotates around the spindle. Pedal axle 11 is coupled by means of a crank 12 and a drive rod 13 arranged on crank 12 to slidable top part 20. In the embodiment as shown in Figure 3 crank 12 is a disc 12 which is rotatable about a perpendicular line through its central point m, wherein on at least a first side of disc 12, in Figure 3 the upper side of the disc, a coupling means 13a is situated at a distance r from the central point m. Disc 12 forms together with coupling means 13a a crankshaft. The crankshaft is connected at coupling means 13a to a first end of a drive rod 13. The second end of the drive rod is connected at coupling means 13b to slidable top part 20. Coupling means 13a and 13b are for instance screws, bolts or any other equivalent coupling means able to couple the ends of drive rod 13 to crankshaft 12 on one side and slidable top part 20 on the other. In the embodiment shown in Figure 3 the underside of disc 12 is provided with teeth, ribs or ridges 51. Pedal axle 11 in turn comprises a cylindrical worm 11a which can engage on the teeth, ribs or ridges 51 of disc 12 such that a revolution of pedal axle 11 relative to bottom part 10 results in a rotation of crankshaft 12 and brings about a sliding displacement of slidable top part 20 by means of the coupling via drive rod 13. Although one specific gear transmission, i.e. a worm transmission, is shown in the shown embodiment, it will be apparent to the skilled person that alternative gear transmissions can be used for the described application, without detracting from the invention. The embodiment of Figure 3 further also shows a second disc which is provided with teeth 51' and on which the cylindrical worm 11a can engage. This disc is coupled to the disc 12 which serves as crankshaft. The disc is situated under cylindrical worm 11a so that cylindrical worm 11a engages at the underside thereof on the upper side of the disc which is provided with teeth 51'. In this embodiment cylindrical worm 11a of pedal axle 11 thus engages on two toothed wheels 51, 51', which may result in a better transmission. It will however be apparent to the skilled person that one disc 12 suffices for conversion of the rotation movement of pedal axle 11 to a sliding movement of slidable top part 20. It will further be apparent to the skilled person that, despite crankshaft 12 being embodied in the shown embodiment as a disc 12 with an eccentrically placed coupling means 13a thereon, the crankshaft can also be embodied in other, similar ways. In an alternative embodiment cylindrical worm 11a engages on disc 12 via a protrusion (not shown) which is provided at the underside of disc 12 and is provided with a screw thread round which the cylindrical worm 11a engages. In this way the disc surface of disc 12 itself

need not be configured as toothed wheel 51. In an alternative exemplary embodiment coupling means 13a is not connected to slidable top part 20 via a drive rod 13, but a guide channel (not shown) is provided in the slidable top part for guiding coupling means 13a therein. The guide channel is configured here such that a rotation movement of disc 12 brings about a sliding
5 movement of slidable top part 20.

Figures 4A, 4B, 4C and 4D illustrate positions of slidable top part 20 of a pedal according to the embodiment of Figure 3, wherein crank arm 30 is in respective angular positions of substantially 0°, 90°, 180° and 270°. Across Figures 4A, 4B, 4C and 4D crank arm 30, and therefore also pedal
10 1, passes through one complete pedalling cycle. During the pedalling cycle the slidable top part runs through a sliding stage, wherein slidable top part 20 slides continuously from a rest position, in which the slidable top part has not been displaced, to an extended position, in which the slidable top part has been displaced over a maximum sliding distance, and slidable top part 20 then slides continuously from the extended position to the rest position. In the shown pedalling cycle the rest
15 position is reached in Figure 4D at an angle of substantially 270°. Pedal 1 is then situated on the transition from quadrant III to quadrant IV. From this position, slidable top part 20 is displaced in the sliding direction until a maximally displaced position has been reached, when crank arm 30 reaches an angular position of substantially 90°, as shown in Figure 4B. Along the way from an angular position of 270° to an angular position of 90° crank arm 30 passes through the angular
20 position of 0°, which angular position corresponds to a so-called dead point of traditional pedals. It can however be seen in Figure 4A that, at an angular position of 0°, slidable top part 20 has been displaced such that the dead point is avoided. The sliding displacement of slidable top part 20 in the direction of forward movement of the pedal vehicle displaces the pressure point on which force is exerted by a user so that, in contrast to what is the case in traditional pedals, a tangential force is
25 exerted on pedal 1 at an angular position of 0° (360°). Something similar applies to the angular position of 180°. Between the angular position of 90° and the angular position of 270° crank arm 30 passes through the angular position of 180°, which angular position corresponds to a so-called dead point of traditional pedals. It can however be seen in Figure 4C that, at an angular position of 180°, slidable top part 20 has been displaced such that the dead point is avoided. The sliding
30 displacement of slidable top part 20 in the direction of forward movement of the pedal vehicle displaces the pressure point on which force is exerted by a user so that, in contrast to what is the case in traditional pedals, a tangential force is exerted on pedal 1 at an angular position of 180°.

In an exemplary embodiment the slidable top part can be displaced in the sliding direction over a
35 distance of about 20 mm at an angular position of 0°, about 40 mm at an angular position of 90°, about 20 mm at an angular position of 180° and about 0 mm at an angular position of 270°. These

values provide an indication of a possible embodiment wherein the slidable top part runs through a complete sliding stage during a complete pedalling cycle. The most advantageous displacement per angular position depends on factors such as the build, for example the length of the legs, and the manner of pedalling of a user of the pedal vehicle. The distance over which slidable top part 20 is displaced per angular position can thus differ from the above described sample values.

In embodiments of pedal 1 wherein pedal axle 11 is coupled to slidable top part 20 by means of a crank/disc/toothed wheel 12 and a drive rod 13 arranged on crank 12, the distance of the displacement can be adjusted in various ways which will be apparent to the skilled person. This can for instance be done by adjusting the length of the drive rod, by attaching the drive rod to the crank further away from or closer to the central point of crank 12, and so on.

Figures 5A, 5B and 5C show embodiments of respectively pedal axle 11 with cylindrical worm 11a, disc 12 with toothed wheel side 51 and the assembly of pedal axle 11, disc 12 and drive rod 13 in more detail. It will be apparent to the skilled person that these are exemplary embodiments and that modifications to one or more of the components are possible within the context of the invention in order to obtain a similar operation.

Figure 6 shows a further developed exemplary embodiment of a pedal 1 according to the invention. Bottom part 10 of pedal 1 is embodied as a closed housing with a cylindrical recess in which the pedal axle 11 is bearing-mounted. Pedal axle 11 comprises a first part 11a of a gear transmission, for instance a cylindrical worm 11a, which engages on a second part 51 of the gear transmission. Second part 51 of the gear transmission is situated on the underside of disc 12 arranged rotatably in bottom part 10. Situated on the upper side of disc 12 is a coupling means 13a to which is connected a first end of a drive rod 13. The second end of drive rod 13 is connected by means of a coupling means 13b to slidable top part 20 such that a rotation of disc 12 brings about a sliding displacement of the slidable top part. When the pedal passes through a pedalling cycle, pedal axle 11 rotates about its axis inside bottom part 10. The first part 11a of the gear transmission, which is situated on the pedal axle, engages on the second part 51 of the gear transmission, which is situated on disc 12. Rotation of pedal axle 11 results in a rotation of disc 12, which brings about a sliding displacement of slidable top part 20. Slidable top part 20 comprises securing means 25 for releasably securing a shoe of a rider thereon. In Figure 6 securing means 25 are embodied as a so-called clipless pedal, wherein a small plate fastened to the shoe of the rider can be snapped into the securing means. Such securing means can mainly be advantageously applied in pedals according to the invention for for instance racing bikes and/or mountain bikes.

Figures 7A and 7B show respectively a side view and a top view of a pedal 1 according to an alternative embodiment of the invention.

Figure 7A shows the pedal 1, wherein crank arm 30 of pedalling device 40 is in an angular position of between 90° and 180° . Pedal 1 is thus situated in quadrant II. Bottom part 10 of pedal 1 is mounted on crank arm 30 by means of pedal axle 11. Pedal axle 11 is arranged bearing-mounted in bottom part 10. A concentric disc 12 is provided on pedal axle 11 in a plane perpendicularly of pedal axle 11. Provided on disc 12 is a coupling means 13a on which a first end of a drive rod 13 is arranged. The coupling means is situated at a distance r from the central point m of disc 12. The distance r can be adjusted to the requirements of a designer or user. A smaller maximal displacement can be obtained by reducing the distance r . A greater maximal displacement can be obtained by increasing the distance r . The distance r can be adjusted subject to for instance the build of a user or cyclist, the length of the legs, the pedalling technique and so on. In an embodiment a plurality of recesses or bores can be provided for placing coupling means 13a therein, so that the distance r can be adjusted in simple manner. The second end of drive rod 13 is arranged by means of a coupling means 13b on slidable top part 20. In the embodiment shown in Figure 7A drive rod 13 is connected to slidable top part 20 and to a disc 12 which is situated in a plane perpendicularly of pedal axle 11, while in the embodiment shown in Figure 3 drive rod 13 is connected to slidable top part 20 and to a disc 12 which is situated in a plane parallel to pedal axle 11.

The skilled person will appreciate that the invention is not limited to the above described embodiments and that many modifications and variants are possible within the scope of the invention, which is defined solely by the following claims.

Claims

1. Pedal (1) for a pedal vehicle, the pedal (1) comprising a bottom part (10), a pedal axle (11) bearing-mounted in the bottom part (10), and a slidable top part (20) coupled to the bottom part (10) and configured to slide relative to the bottom part (10), wherein
- 5 - the pedal axle (11) is configured to be mounted on a crank arm (30) of a pedalling device (40) of the pedal vehicle; and
- the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) is displaced relative to the bottom part (10) in controlled manner in
- 10 dependence of an angular position α of the crank arm (30) of the pedalling device (40) during a pedalling cycle of the pedalling device (40).
2. Pedal (1) according to claim 1, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that, during a pedalling cycle, the slidable top part (20) is displaced in
- 15 controlled manner in a sliding direction parallel to a plane in which the crank arm (30) of the pedalling device (40) rotates during a pedalling cycle of the pedalling device (40).
3. Pedal (1) according to claim 2, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) runs through a sliding stage in the sliding
- 20 direction, wherein during the sliding stage:
- the slidable top part slides continuously from a rest position, in which the slidable top part has not been displaced, to an extended position in which the slidable top part has been displaced over a maximum sliding distance; and
- the slidable top part then slides continuously from the extended position to the rest
- 25 position.
4. Pedal (1) according to claim 3, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) runs through one complete sliding stage, preferably two complete sliding stages, during a complete pedalling cycle.
- 30 5. Pedal (1) according to claim 3, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) runs through a part of a complete sliding stage, preferably half of a complete sliding stage, during a complete pedalling cycle.
- 35 6. Pedal (1) according to claim 3, 4 or 5, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) reaches the extended position when the

angular position α of the crank arm (30) lies between 350° and 170° , preferably between 20° and 160° , more preferably between 30° and 150° , and most preferably between 50° and 140° .

5 7. Pedal (1) according to claim 3, 4, 5 or 6, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) reaches the rest position when the angular position α of the crank arm (30) lies between 190° and 350° , preferably between 200° and 340° , more preferably between 210° and 330° , and most preferably between 230° and 320° .

10 8. Pedal (1) according to any of the foregoing claims, wherein the slidable top part (20) is coupled to the pedal axle (11) in a manner such that the slidable top part (20) is displaced such that a length l of a pedalling lever, which is formed by the crank arm (30) and the slidable top part (20), is greater during a pressing stage of the pedalling cycle than during a pulling stage of the pedalling cycle.

15 9. Pedal (1) according to any of the foregoing claims, wherein the pedal axle (11) is coupled by means of a crank (12) and a drive rod (13) arranged on the crank (12) to the slidable top part (20) such that a revolution of the pedal axle (11) relative to the bottom part during a pedalling cycle brings about a sliding movement of the slidable top part (20).

20 10. Pedal (1) according to claim 9, wherein the pedal axle (11) comprises a crankshaft of the crank (12), wherein the crank (12) is driven to rotate by the pedal axle (11).

11. Pedal (1) according to claim 9, wherein the pedal axle (11) is coupled by means of a gear transmission to the crank (12) and wherein the crank (12) is driven to rotate by the pedal axle (11).

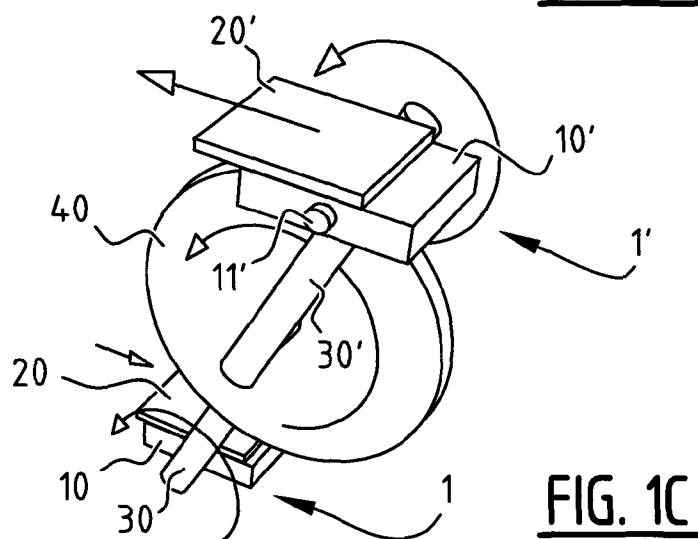
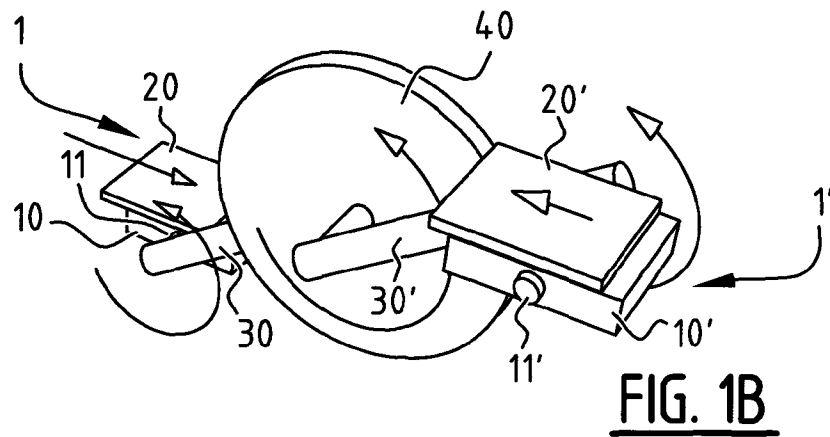
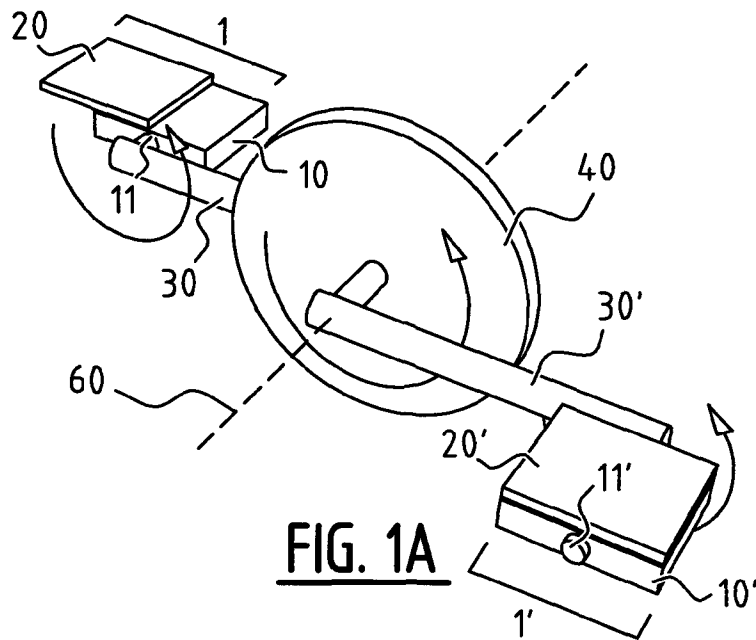
25 12. Pedal (1) according to claim 11, wherein the pedal axle (11) comprises a cylindrical worm (11a) and the crank (12) comprises a toothed wheel (51, 51') which is oriented substantially parallel to the pedal axle (11) and the sliding direction of the slidable top part (20) and on which is arranged the drive rod (13) which is connected to the slidable top part (20), wherein the cylindrical
30 worm (11a) drives the toothed wheel (51, 51') to rotate.

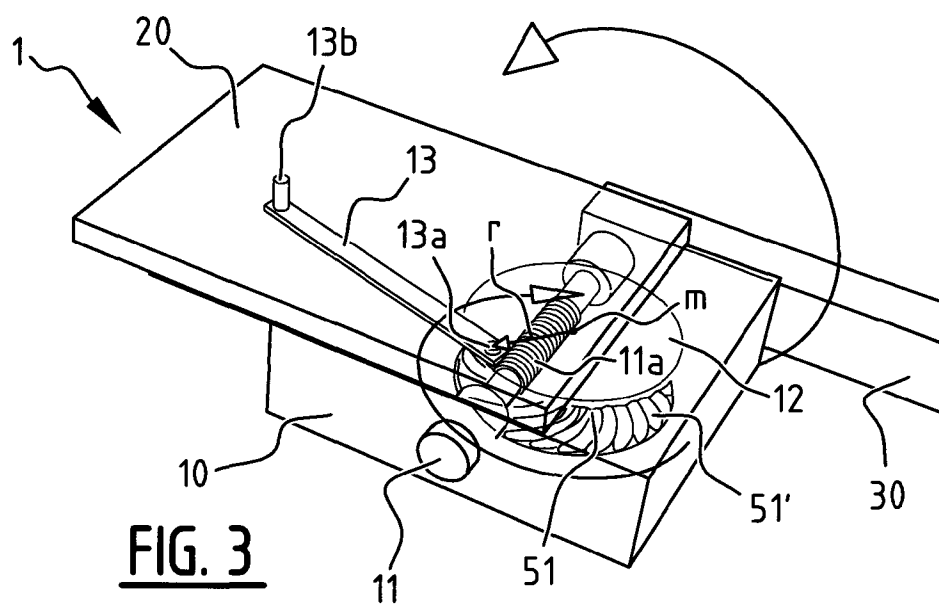
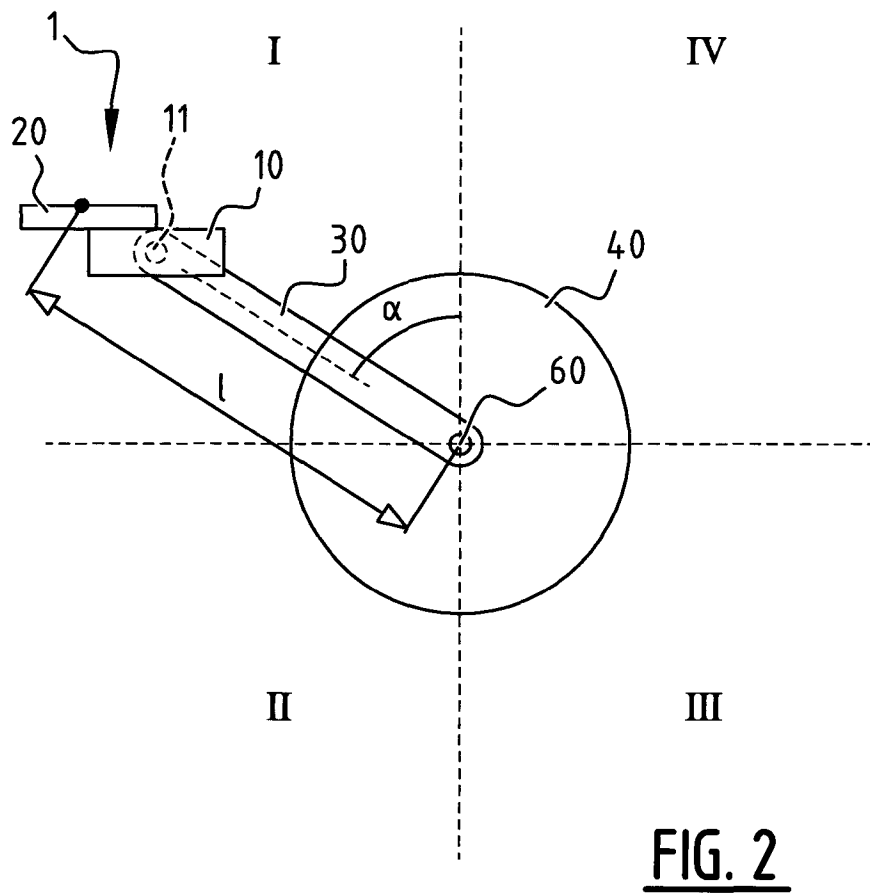
13. Pedal (1) according to claim 11 or 12, wherein the pedal axle (11) comprises a cylindrical worm (11a) and the crank (12) comprises a protruding toothed wheel part oriented substantially perpendicularly of the pedal axle (11) and the sliding direction of the slidable top part (20),
35 wherein the cylindrical worm (11a) engages on the toothed wheel part and wherein the cylindrical worm (11a) drives the crank (12) to rotate.

14. Pedal (1) according to claim 12 or 13, wherein the toothed wheel (51, 51') oriented substantially parallel to the pedal axle (11) and the sliding direction of the slidable top part (20) is a worm wheel or a bevel gear.
- 5
15. Pedal (1) according to claim 13 or 14, wherein the toothed wheel part oriented substantially perpendicularly of the pedal axle (11) and the sliding direction of the slidable top part (20) comprises a worm wheel or a bevel gear.
- 10
16. Pedal (1) according to any of the foregoing claims, wherein the bottom part (10) comprises a closed housing in which is received at least a part of the pedal axle (11) which is bearing-mounted in the bottom part (10).
- 15
17. Pedal (1) according to any of the claims 9-16, wherein the crank (12) and the toothed wheel assembly (51, 51'), respectively, are received in the closed housing.
18. Pedal (1) according to any of the foregoing claims, wherein the bottom part (10) comprises at least one guide oriented in the sliding direction of the slidable top part (20) and the slidable top part (20) comprises at least one corresponding guide recess.
- 20
19. Pedal (1) according to any of the foregoing claims, wherein the slidable top part (20) comprises securing means (25) for releasably securing thereon a shoe of a rider of the pedal vehicle.
20. Pedal (1) according to any of the foregoing claims 3-19, wherein the bottom part (10) comprises a sliding surface, wherein in the rest position the slidable top part (20) is situated on the sliding surface and wherein the slidable top part (20) is configured to slide along the sliding surface and into the extended position.
- 25
21. Pedal (1) according to claim 20, wherein the bottom part (10) is substantially wedge-shaped and wherein the sliding surface of the bottom part (10) comprises a surface inclining in a direction of forward movement of the pedal vehicle.
- 30
22. Pedal (1) according to any of the claims 3-21, wherein the maximum difference between the extended position and the rest position of the slidable top part (20) lies between 1 mm and 60 mm.
- 35

23. Pedalling device for a pedal vehicle, the pedalling device comprising a crank arm on which is mounted a pedal (1) according to any of the foregoing claims.

24. Pedal vehicle with a pedalling device according to claim 23.





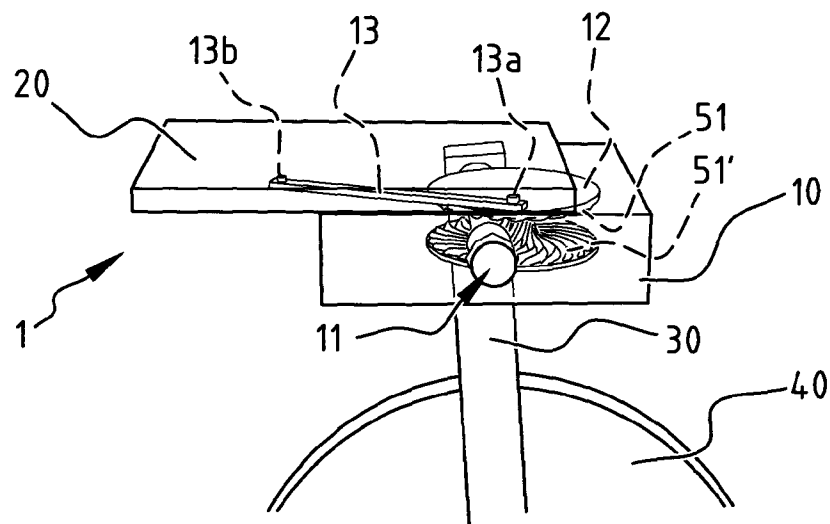


FIG. 4A

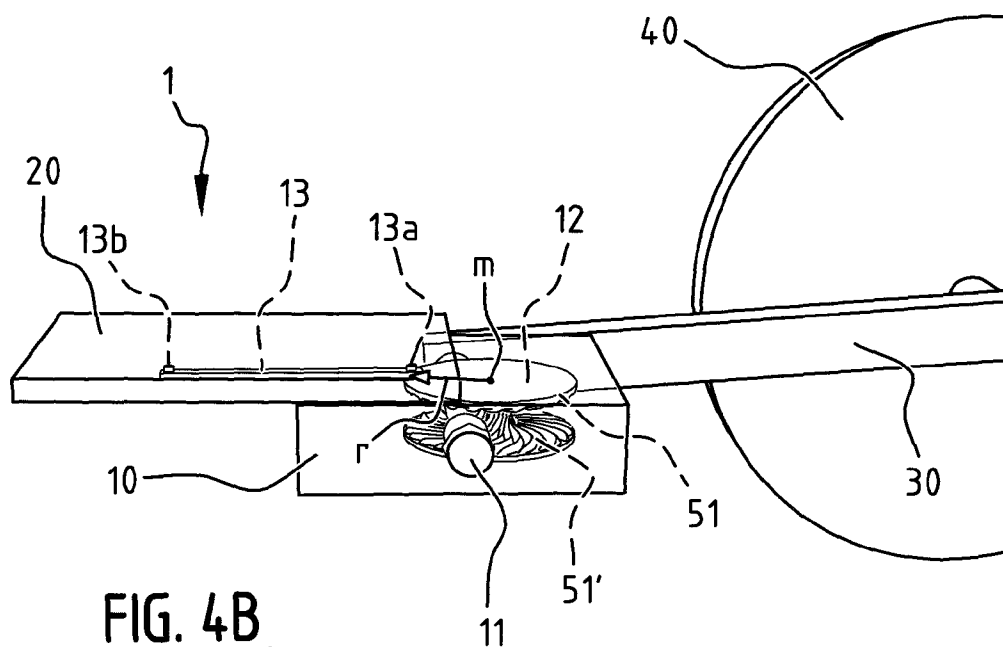
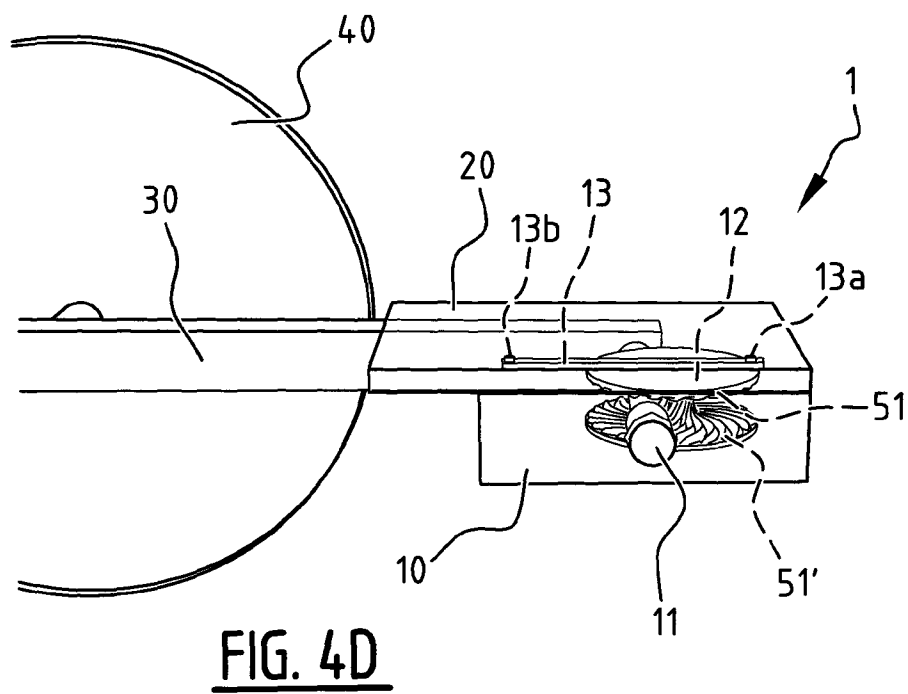
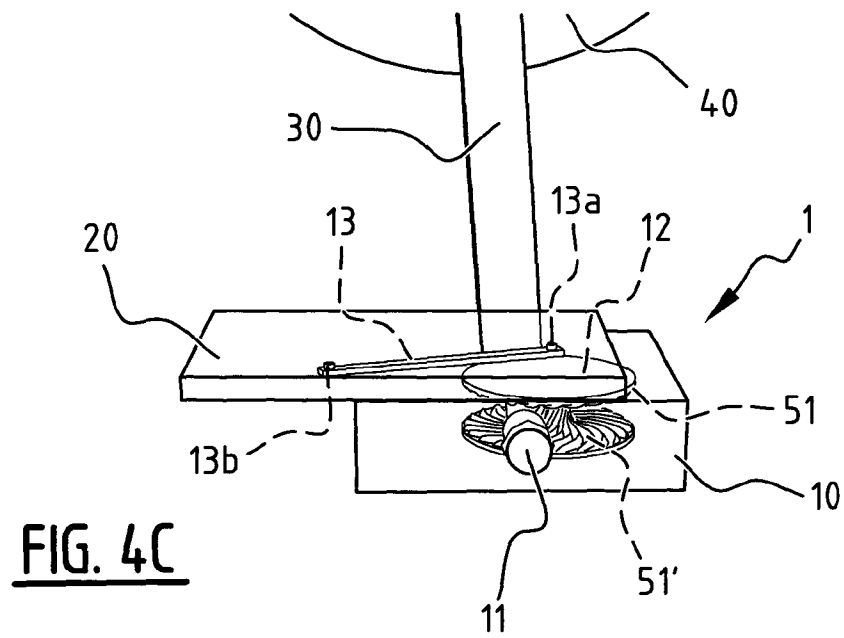
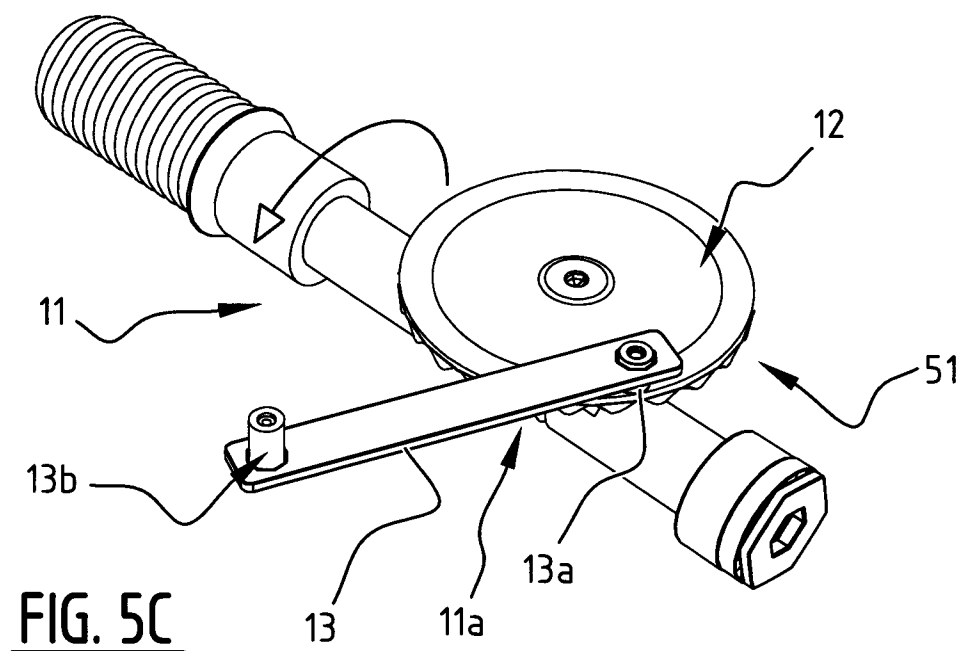
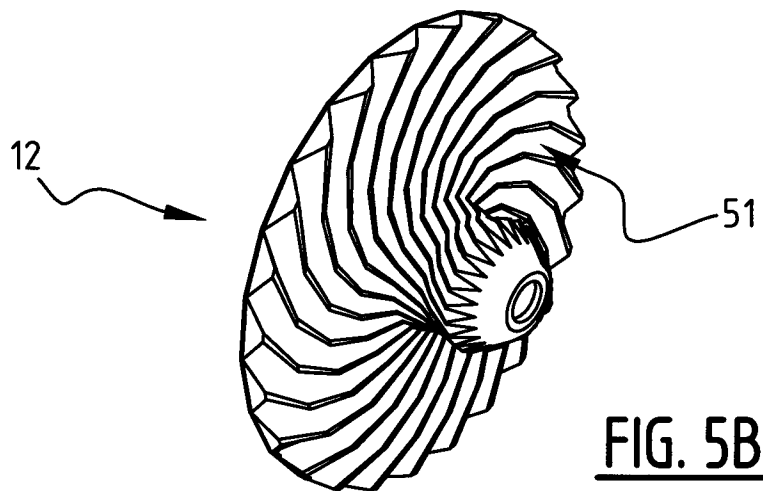
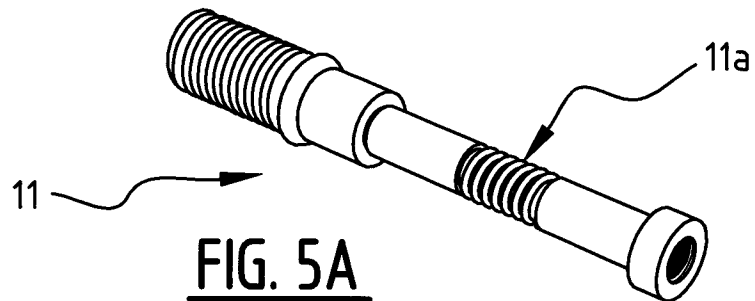


FIG. 4B



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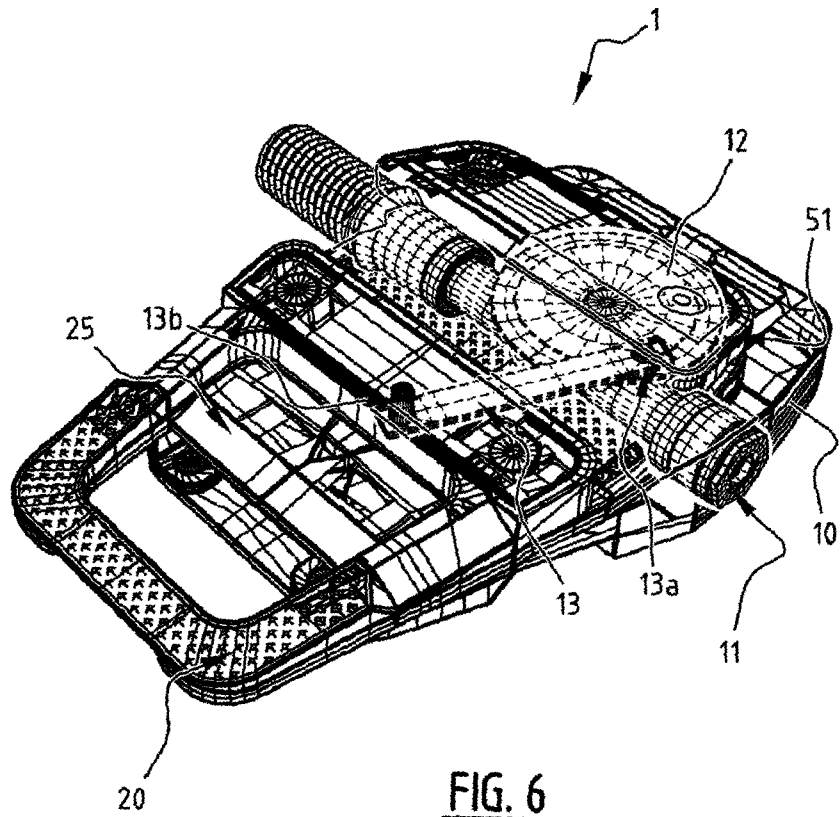
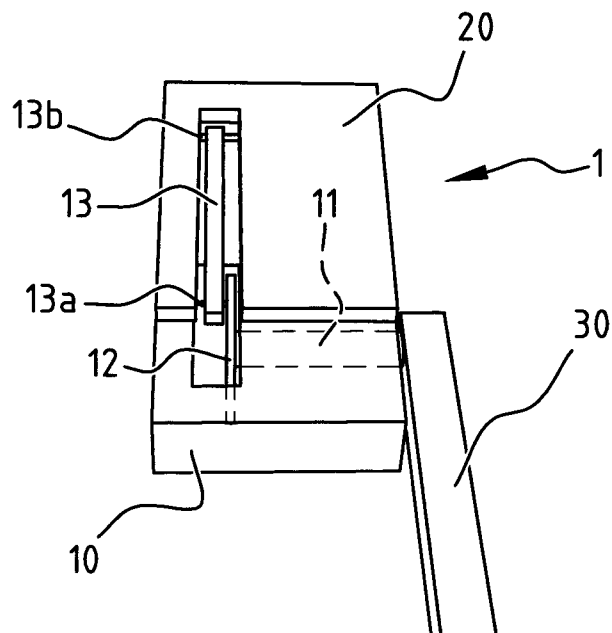
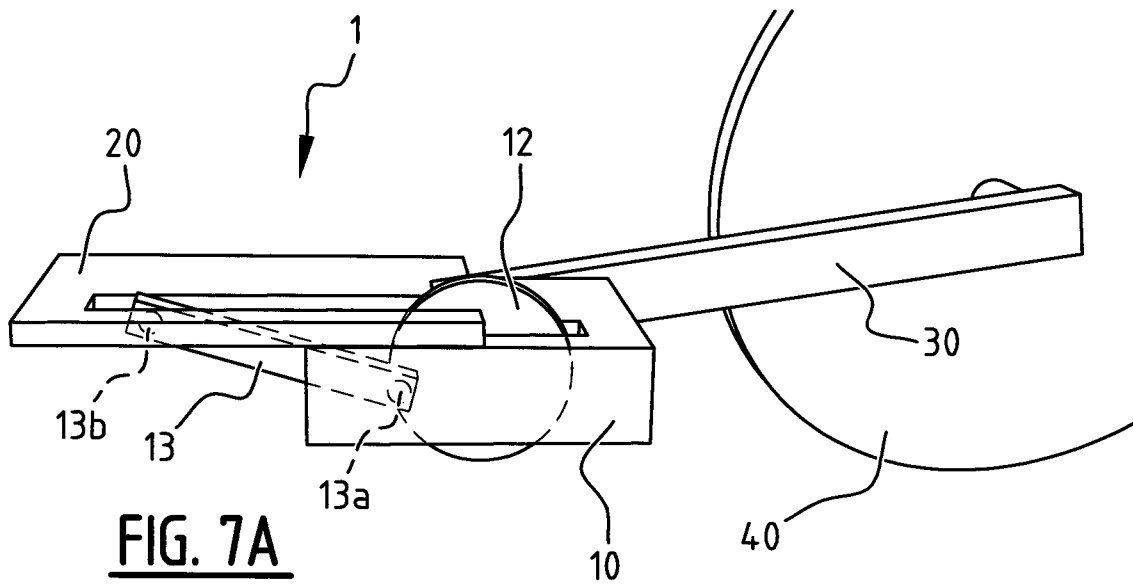


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/BE2017/000048

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62M3/02 B62M3/06 B62M3/08
ADD.

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

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP S63 202594 U (NOT AVAILABLE) 27 December 1988 (1988-12-27) abstract; figures 1-3 -----	1-11,16, 18-24
A	EP 0 519 380 A1 (SHIMANO KK [JP]) 23 December 1992 (1992-12-23) column 1, lines 28-45 column 2, line 34 - column 6, line 52 figures 1-11 -----	1-20
A	US 6 050 154 A (FAN JEENG-NENG [TW]) 18 April 2000 (2000-04-18) column 1, lines 48-63 column 2, line 21 - column 4, line 16 figures 2-9 ----- -/--	1-10,14, 19-21



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

6 March 2018

Date of mailing of the international search report

14/03/2018

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INTERNATIONAL SEARCH REPORT

International application No
PCT/BE2017/000048

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 01/64296 A1 (KIM JWA YOUNG [KR]; CHOI BANG SIK [KR]) 7 September 2001 (2001-09-07) the whole document -----	1-21

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Information on patent family members

International application No

PCT/BE2017/000048

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