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A request for correction of the description has been filed pursuant to Rule 139 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) METHOD OF OPERATING A FITNESS BICYCLE

(57) The invention relates to a method for operating a fitness bicycle (1) comprising a wheel (3), which has an electric drive (5) and two pedals (4a, 4b) for electrically and mechanically driving the wheel (3), respectively, by a user (20) with a physical impairment in one of his two lower extremities (21a, 21b). According to the method, in a measure a) at least one measurement parameter (M1, M2, M3) characterizing the movement of the wheel (3) is determined by means of a sensor system (6) while a first one (4a) of the two pedals (4a, 4b) is actuated by the user's (20) lower extremity (21a), which does not have the physical impairment. According to the method, in a measure b) the electric drive (5) is controlled by a control/regulation device (12) of the fitness bicycle (1) as a function of the at least one determined measurement parameter (M1, M2, M3), while a second (4b) of the two pedals (4a, 4b) is actuated by the lower extremity (21b) of the user (20) which has the physical impairment.

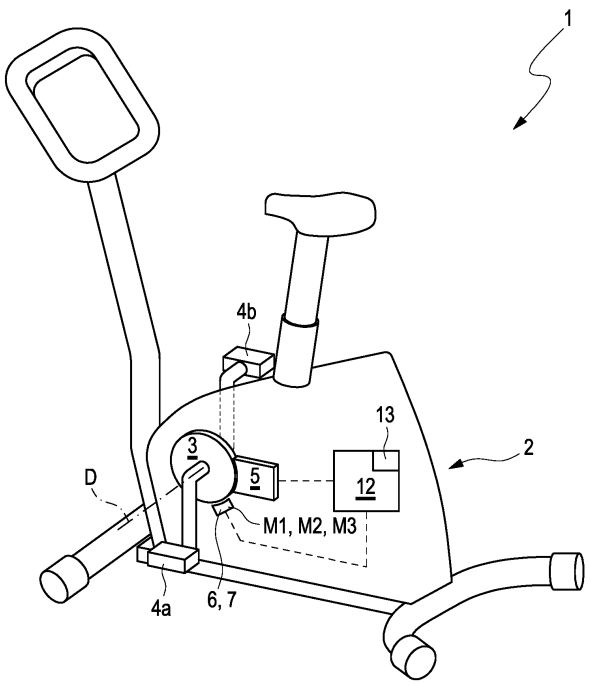

Fig. 1

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Description

[0001] The invention relates to a method for operating a fitness bicycle having at least one wheel, comprising an electric drive and two pedals for electrically and mechanically driving the wheel, respectively, by a user having a physical impairment in at least one of his two lower extremities. The invention further relates to a fitness bicycle that is set up/programmed to perform this method.

[0002] Fitness bicycles with two pedals for driving one wheel of the fitness bicycle and with additional electric drive can also be used by users with a physical impairment in one of their two lower extremities. This means that the two pedals for mechanically driving the wheel are usually operated asymmetrically by the user - due to the physical impairment - during a full rotation of the wheel, since by means of the physically and thus also functionally impaired lower extremity in comparison to the other, unimpaired extremity, typically only a reduced torque can be generated by the user to drive the wheel. The resulting asymmetrical motion sequence can complicate training on the fitness bicycle to a not inconsiderable extent and reduce the desired training effect.

[0003] It is an object of the present invention to create an improved method for operating a fitness bicycle which addresses the problem explained above.

[0004] This object is solved by the subject matter of the independent patent claims. Preferred embodiments are the subject matter of the dependent patent claims.

[0005] The method according to the invention serves for operating a fitness bicycle having at least one wheel, which has an electric drive and two pedals for electrically or mechanically driving the wheel, by a user with a physical impairment in one of his two lower extremities.

[0006] The basic idea of the invention is to determine at least one measured variable characterizing this rotational movement during the rotational movement of the wheel, while the user of the fitness bicycle is pressing the pedal assigned to his unimpaired extremity. This information is taken into account when controlling an electric drive of the fitness bicycle to additionally drive the wheel - i.e. in addition to the drive by the mechanical pedal actuation of the user - while the pedal assigned to the impaired extremity is actuated by the user. In this way - by appropriate control of the electric drive, in particular with regard to the drive line generated by the drive and supplied to the wheel or the drive torque generated by the drive and supplied to the wheel - the existing impairment in one of his two lower extremities can be compensated. In this way, a user with physical impairment can exercise effectively by means of a fitness bicycle. In connection with the present invention, the two lower extremities include not only the user's pelvis and hip joint, but also his thigh, knee joint, lower leg with tibia and fibula, ankle joint, and also his foot with ankle, metatarsus and toes.

[0007] Moreover, the present invention also supports rehabilitation. For example, the muscles of a person's legs after a fracture can partially ortrophy. In this case, the method according to the invention will help facilitate rehabilitation

[0008] In detail, the method according to the invention comprises two measures a) and b). In a first measure a) at least one measurement parameter characterizing the movement of the wheel is determined by means of the sensor system, while a first of the two pedals is actuated by the lower extremity of the user, which does not have said physical or functional impairment. In a second measure b), the electric actuator is controlled as a function of the determined measurement parameter, while a second of the two pedals is actuated by the lower extremity of the user having said physical or functional impairment. The two measures a) and b) can be executed alternately one after the other iteratively, i.e. several times. By recording the measured variable, it is possible to simulate how the functionally impaired lower extremity would behave if there were no impairment. By controlling the electric drive accordingly, it can compensate for the impairment so that the bicycle moves as if a user without physical impairment in his two lower extremities were exercising on the fitness bike. This provides an improved training effect for a user with a physically or functionally impaired extremity.

[0009] In a preferred embodiment, the following are determined in the course of measure a) at least the following three measured variables are determined: Pedal crank angle, pedal torque, cadence. Said measured variables, in particular a combination of two or even all three measured variables, allow the rotational movement of the wheel to be characterized particularly precisely during measure a), which has an advantageous effect on the control of the electric drive in measure b).

[0010] Particularly preferably, the at least one measured variable is determined as a function of time in measure a). In this way, temporal changes in the at least one measured variable that occur during the rotation of the wheel or the pedals can also be taken into account for the control of the electric drive.

[0011] In an advantageous further development, in which a full rotation of the pedals about a predetermined axis of rotation corresponds to an angle of rotation of 360°, the full rotation is composed of a first and a second partial rotation, each of which corresponds to an angle of rotation of 180°. In this further development, measure a) is executed during the first partial rotation and measure b) during the second partial rotation. The procedure will thus adapt the control of the drive at each individual revolution to the actuation of the two pedals that occurred during the respective revolution.

[0012] In a preferred embodiment, in measure b) a drive power provided by the electric drive for driving the wheel is set or/and varied as a function of the at least one measurement parameter. If the user exerts a different amount of torque on the two pedals - due to the impairment of one of the two extremities - this can be compensated for by the drive torque provided by the electric

drive during measure b).

[0013] According to an advantageous further development of the method according to the invention, a control/regulation device of the fitness bicycle controls the electric drive in such a way that at least one measurement parameter determined in measure a) substantially maintains the parameter value determined in measure a) during measure b).

[0014] Particularly expediently, in measure a) the at least one measured parameter can be determined over at least two, preferably from several, partial rotations. The measured data obtained in this way can then be taken into account for the control of the electric drive in measure b).

[0015] In another preferred embodiment, the measurement data is evaluated by means of machine learning. Here, the result of the evaluation is taken into account for the control of the electric actuator in measure b). In this way, the provision of additional drive torque by the electric drive can be optimized over time as a function of the amount of pedal actuation performed by the user.

[0016] Particularly preferably, machine learning can be performed with the aid of a neural network. This neural network can be implemented in the control system, in particular as a computer program product. In this way, machine learning can be integrated into the control/regulation device and thus into the fitness bicycle in a cost-effective manner.

[0017] In another preferred embodiment, the result of the evaluation can be stored so that it can or will be taken into account in a subsequent use of the fitness bicycle by the same user.

[0018] The invention further relates to a fitness bicycle, in particular an exercise bike. The fitness bicycle according to the invention comprises a wheel which is drivable by means of two pedals of the fitness bicycle. Furthermore, the fitness bicycle comprises an electric drive for driving the fitness bicycle, in particular its wheel. Furthermore, the fitness bicycle comprises a sensor system for determining at least one measurement parameter characterizing the movement of the wheel.

[0019] Furthermore, the fitness bicycle comprises a control/regulation device which is set up/programmed for carrying out the method according to the invention presented above. The advantages of the method according to the invention explained above are therefore transferred to the fitness bicycle according to the invention.

[0020] Further important features and advantages of the invention will be apparent from the sub-claims, from the drawings and from the accompanying figure description based on the drawings.

[0021] It is understood that the above-mentioned features and those still to be explained below can be used not only in the combination indicated in each case, but also in other combinations or on their own, without leaving the scope of the present invention.

[0022] Preferred examples of embodiments of the invention are shown in the drawings and are explained in more detail in the following description, wherein the same reference signs refer to identical or similar or functionally identical components.

[0023] They show, schematically in each case:

Fig. 1 an example of a fitness bicycle according to the invention,

Fig. 2 a flow chart illustrating the method according to the invention with several snapshots illustrating the rotational movement of the wheel.

[0024] Figure 1 illustrates an example of a fitness bicycle 1 according to the invention in the form of an exercise bike. The fitness bicycle 1 comprises a body 2, on which a wheel 3 is rotatably mounted about an axis of rotation D. The wheel 3 can be driven by the two lower extremities 11a, 11b - not shown in Figure 1, cf. Figure 2 only - of a user 20 of the fitness bicycle 1 by actuating two pedals 4a, 4b of the fitness bicycle 1 which are drivingly connected to the wheel 2. Furthermore, the fitness bicycle 1 comprises an electric drive 5, also indicated only schematically in Figure 1, for driving the wheel 3 of the fitness bicycle 1.

[0025] A sensor system 6 arranged on the body 2 adjacent to the wheel 3 with sensors 7 not shown in more detail serves to determine three measured variables which characterize the movement of the wheel 2.

[0026] Furthermore, the fitness bicycle 1 comprises a control/regulating device 12, which is operatively connected to the sensor system 6 or its sensors 7, for controlling the electric drive 5. In addition, the control/regulating device 12 is set up and programmed for carrying out the method according to the invention, which will be explained below by way of example using Figure 2.

[0027] The method according to the invention serves for operating the fitness bicycle 1 by a user 20 indicated in Figure 2 with a physical impairment in one of his two lower extremities 21a, 21b. Purely by way of example, a first, left lower extremity 21a including the left knee joint 22a of the user 20 operating the left pedal 4a does not exhibit any functional or physical impairment. In contrast, a second lower right extremity 21b operating the second pedal 4b is impaired in the right knee joint 22b of the user 20.

[0028] The exemplarily explained method comprises two measures a) and b). In a first measure a), three measured variables characterizing the rotational movement of the wheel 3 are determined as a function of time by means of the sensor system 6 (cf. Fig. 1) - purely exemplarily - during the rotational movement of the wheel 3. In the example scenario, the three measured variables pedal crank angle M1, pedal torque M2 and cadence M3 are determined in the course of action with the aid of the sensors 7 of the sensor system 6. This is done while a first 4a of the two pedals 4a, 4b is operated by the left lower extremity 21a of the user 20, who has no physical or functional impairment.

[0029] In a second measure b), the electric actuator 5 is controlled as a function of the determined measured variables M1, M2, M3 (cf. figure 1), while a second 4b of the two pedals 4a, 4b is actuated by the right lower extremity 21b with the functionally impaired right knee joint 22b of the user 20.

[0030] In this regard, the measurement data obtained in measure a) by means of the sensor system 6 is taken into account for the control of the electric drive 5 in measure b). In particular, a drive power provided by the electric drive 5 for driving the wheel 3 can be adjusted and, if necessary, varied.

[0031] In the example, the control/regulation device 12 controls the electric drive 5 in such a way that at least one, preferably all, of the measurement parameters determined in measure a) substantially maintains value of the measurement parameter determined in measure a) during measure b). Said measurement data can preferably be evaluated by means of machine learning. The machine learning in turn can be done with the help of a neural network. In this case, the neural network may be integrated as a computer program product in the control/regulation device 12 of the fitness bicycle1. The result of said evaluation can be stored in a memory unit 13, for example present in the control/regulation device 12, so that it can be or is taken into account in a subsequent use of the fitness bicycle by the same user 20.

[0032] The two measures a) and b) can be executed alternately one after the other iteratively, i.e. several times, over several 360°. By recording said measured variable, it can be simulated, so to speak, how the functionally impaired lower extremity would behave if no impairment were present. By controlling the electric drive accordingly, the impairment can be compensated for by the latter, so that the bicycle moves as if a user without physical impairment in his two lower extremities 21a, 21b were exercising on the fitness bicycle 1. This provides an improved training effect for a user with a physically or functionally impaired extremity.

[0033] Figure 2 illustrates the sequence of movements during a full 360° rotation of the wheel 3 or of the two pedals 4a, 4b about the axis of rotation D (cf. Figure 1) along a direction of rotation DR (cf. Figure 2) and shows for this purpose several snapshots of the user 20 or of his two lower extremities and shows for this purpose several snapshots I to VIII at different angles of rotation of the wheel 2 or of the pedals 4a, 4b. The full rotation about a 360° angle is divided in Figure 2 into two partial angles (marked in Figure 2 with "α1" and with "α2"), whereby the first partial angle α1 can be smaller than 180° by up to 10° and the second partial angle α2 can be smaller than 180° by up to 10°. The two partial angles α1 and α2 complement each other in any case to form the full angle of 360°. The snapshots I to IV correspond to a first partial rotation T1 of the wheel 3 or the pedals 4a, 4b corresponding to the first partial angle α1. Measure b) with snapshots V to VIII of Figure 2, on the other hand, is performed during the second partial rotation T2 corresponding to the second partial angle α2.

Claims

1. Method for operating a fitness bicycle (1) having a wheel (3), which bicycle (1) has an electric drive (5) and two pedals (4a, 4b) for electrically and mechanically driving the wheel (3), by a user (20) with a physical impairment in one of his two lower extremities (21a, 21b),

   - according to which, in a measure a), at least one measurement parameter (M1, M2, M3) characterizing the movement of the wheel (3) is determined by means of a sensor system (6) while a first (4a) of the two pedals (4a, 4b) is actuated by the lower extremity (21a) of the user (20) which does not have the physical impairment,
   - according to which, in a measure b), the electric drive (5) is actuated by a control/regulating device (12) of the fitness bicycle (1) as a function of the at least one determined measured variable (M1, M2, M3), while a second (4b) of the two pedals (4a, 4b) is actuated by the lower extremity (21b) of the user (20) which has the physical impairment.

2. Method according to claim 1, **characterized in that** in measure a) at least the following three measured variables (M1, M2 M3) are determined:

   1) pedal crank angle;
   2) pedal torque;
   3) cadence.

3. Method according to claim 1 or 2, **characterized in that** the at least one measurement parameter (M1, M2) in measure a) is determined as a function of time.

4. Method according to any one of claims 1 to 3, **characterized in that**

   - a full 360° rotation of the two pedals (4a, 4b) about a predetermined axis of rotation (D) is composed of a first and a second partial rotation (T1, T2), each corresponding to an angle of rotation (α1, α2) of approximately 180°; and **in that**
   - the measure a) is carried out during the first partial rotation (T1) and the action b) is carried out during the second partial rotation (T2).

5. Method according to any one of the preceding claims,

characterized in that
in measure b), a drive power provided by the electric drive (5) for driving the wheel (3) is set or/and varied as a function of the at least one measurement parameter (M1, M2, M3).

6. Method according to one of the preceding claims,
characterized in that
the open-loop/closed-loop control device (12) controls the electric drive (5) in such a way that at least one measurement parameter (M1, M2, M3) determined in measure a) essentially maintains the parameter value determined in measure a) during measure b).

7. Method according to one of the preceding claims,
characterized in that
the at least one measurement parameter (M1, M2, M3) is evaluated by means of machine learning and the result of the evaluation is taken into account in the control of the electric drive (5) in measure b).

8. Method according to claim 7,
characterized in that
the machine learning is performed with the aid of a neural network.

9. Method according to claim 7 or 8,
characterized in that
the result of the evaluation is stored so that it can be or is taken into account in a subsequent use of the fitness bicycle (1) by the same user (20).

10. Fitness bicycle (1), in particular exercise bike,

- with a rotatable wheel (2) which can be driven by means of two pedals (4a, 4b) of the fitness bicycle,
- with an electric drive (5) for additionally driving the wheel (3),
- with a sensor system (6) for determining at least one measured variable characterizing the movement of the wheel,
- with a control device (12) cooperating with the sensor system (6), which is set up/programmed to carry out the method according to one of the preceding claims.

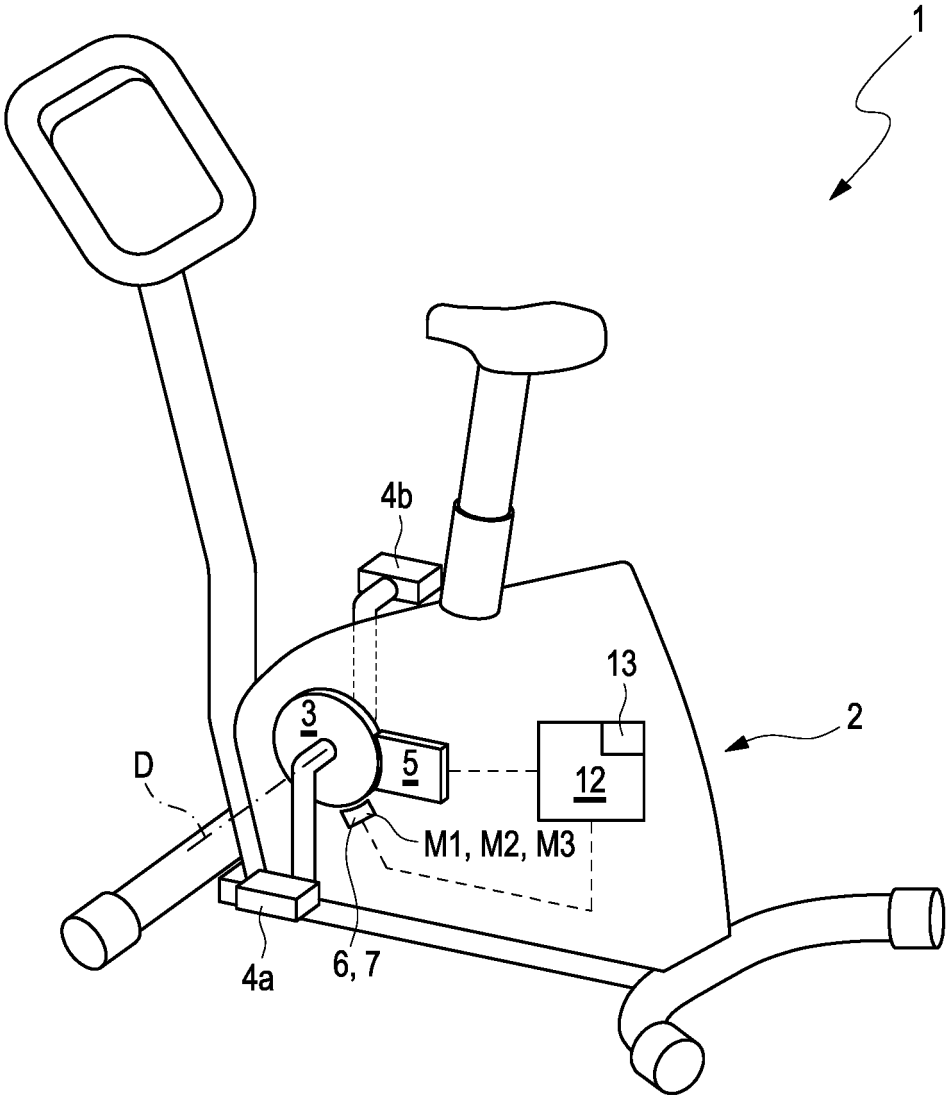
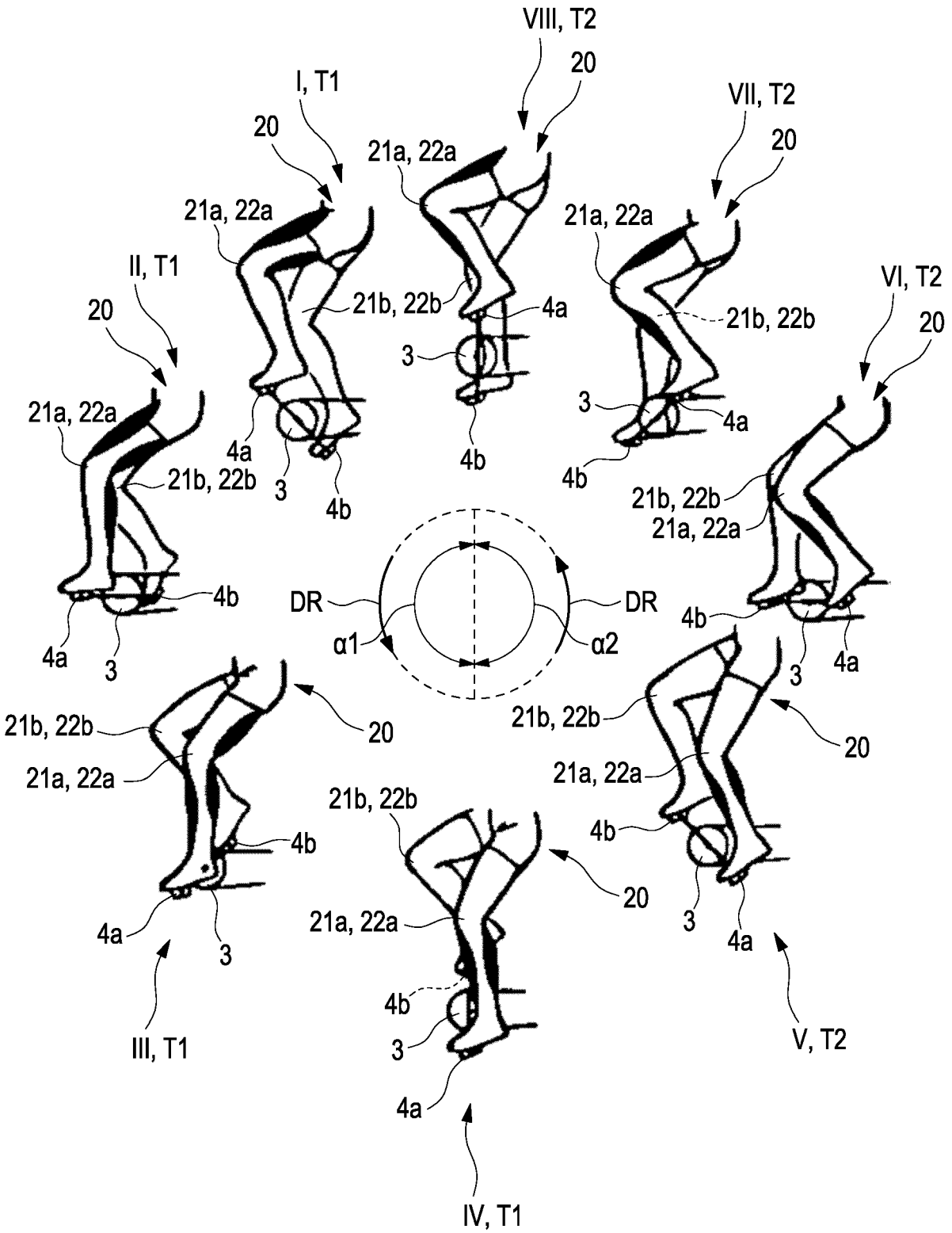


Fig. 1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III, T1
V, T2
IV, T1

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 8313

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2019/001184 A1 (SCHINDLER-IVENS SHEILA [US] ET AL) 3 January 2019 (2019-01-03) * paragraph [0012] - paragraph [0015]; figures * * paragraph [0031] - paragraph [0033] * * paragraph [0042] * * paragraph [0056] *	1-6,9,10 7,8	INV. A63B22/06
Y	WO 2020/185769 A1 (ROM TECH INC [US]) 17 September 2020 (2020-09-17) * paragraph [0126] - paragraph [0127] *	7,8	
X	US 2019/358483 A1 (FUCHS ANDREAS [CH]) 28 November 2019 (2019-11-28) * paragraph [0033] - paragraph [0038]; figures * * paragraph [0047] * * paragraph [0056] * * paragraph [0082] - paragraph [0084] * * paragraph [0140] * * paragraph [0154] *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
Y	US 2022/105384 A1 (HACKING S ADAM [US] ET AL) 7 April 2022 (2022-04-07) * paragraph [0070] - paragraph [0071] *	7,8	A63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 December 2022	Squeri, Michele

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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23-12-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019001184 A1	03-01-2019	CN 111164004 A	15-05-2020
		EP 3645379 A1	06-05-2020
		US 2019001184 A1	03-01-2019
		WO 2019005292 A1	03-01-2019
WO 2020185769 A1	17-09-2020	CN 113747950 A	03-12-2021
		EP 3938060 A1	19-01-2022
		WO 2020185769 A1	17-09-2020
US 2019358483 A1	28-11-2019	NONE	
US 2022105384 A1	07-04-2022	US 2020289045 A1	17-09-2020
		US 2020289046 A1	17-09-2020
		US 2020289881 A1	17-09-2020
		US 2020289889 A1	17-09-2020
		US 2022105384 A1	07-04-2022
		US 2022105385 A1	07-04-2022

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