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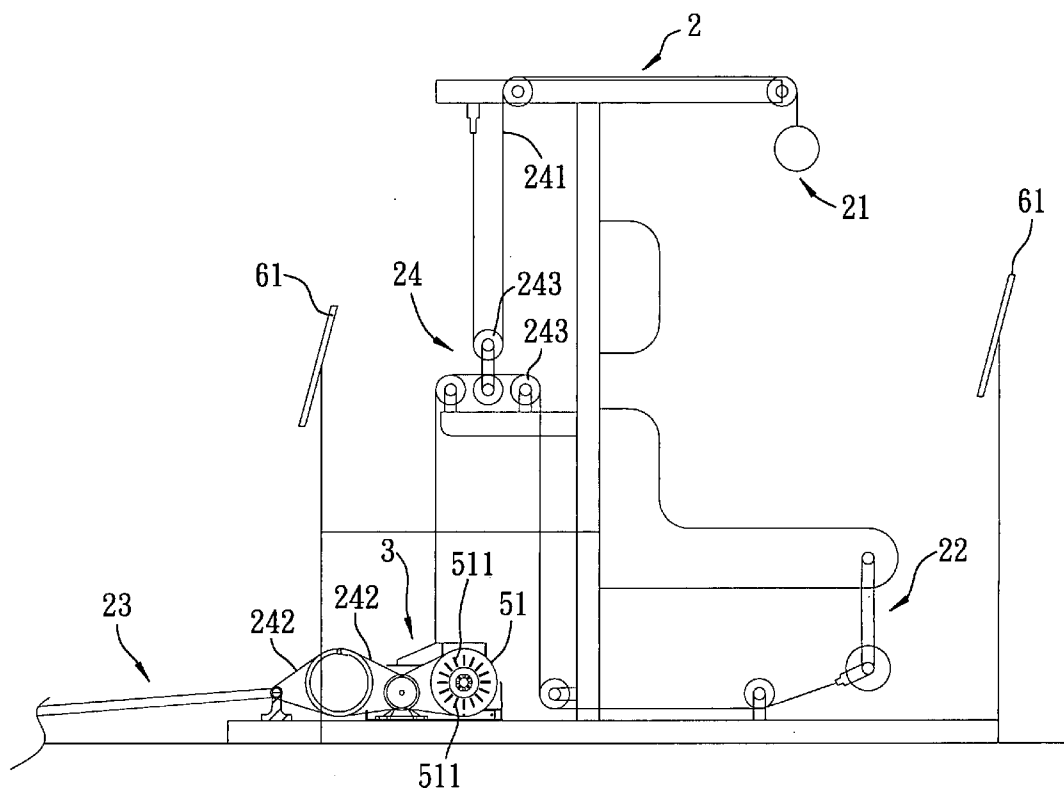
(57) **ABSTRACT**

An apparatus for providing a dynamically variable resistive load during exercise includes a wheel unit, a resistance generator, a torque transfer device, an angle measuring device, and a control unit. The wheel unit rotates in response to exertion of a user-applied force during an exercise stroke. The resistance generator generates a resistive torque for resisting rotation of the wheel unit when the user-applied force is exerted. The torque transfer device transfers a fraction of the resistive torque from the resistance generator to the wheel unit. The angle measuring device detects angular rotation of the wheel unit during each exercise stroke. The control unit, in accordance with the angular rotation of the wheel unit during a current exercise stroke, controls the torque transfer device to adjust the fraction of the resistive torque that is transferred to the wheel unit.

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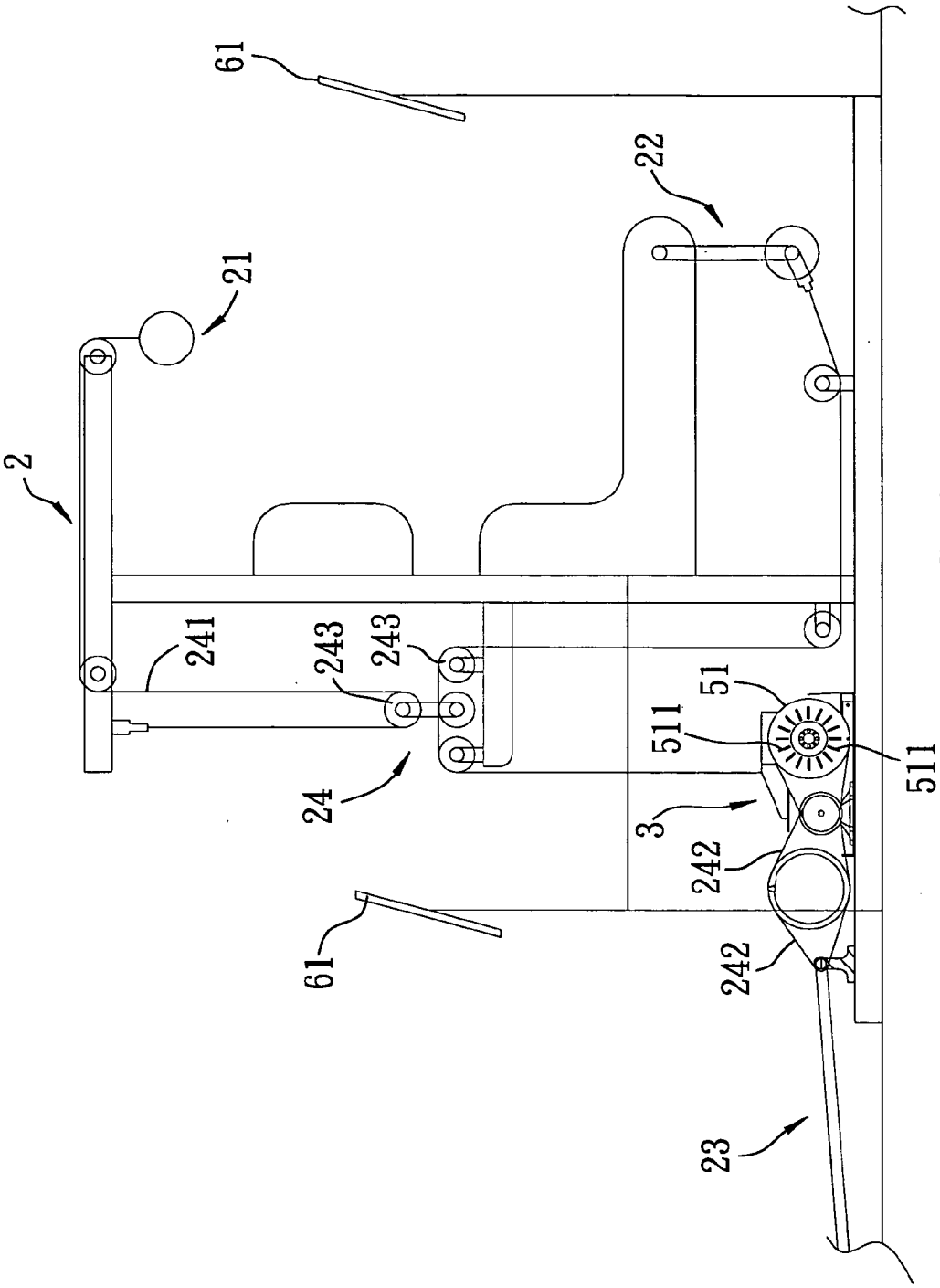
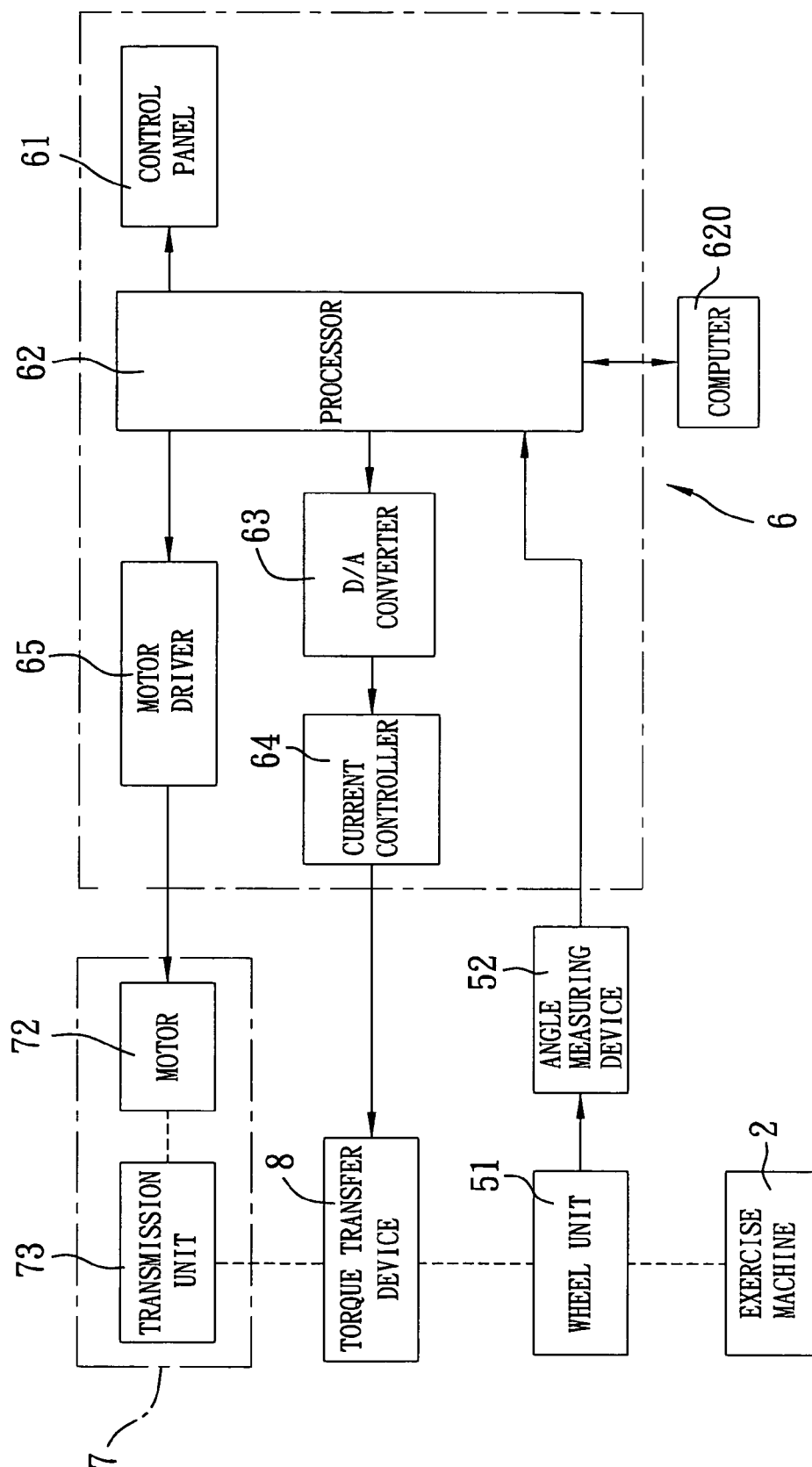


FIG. 1



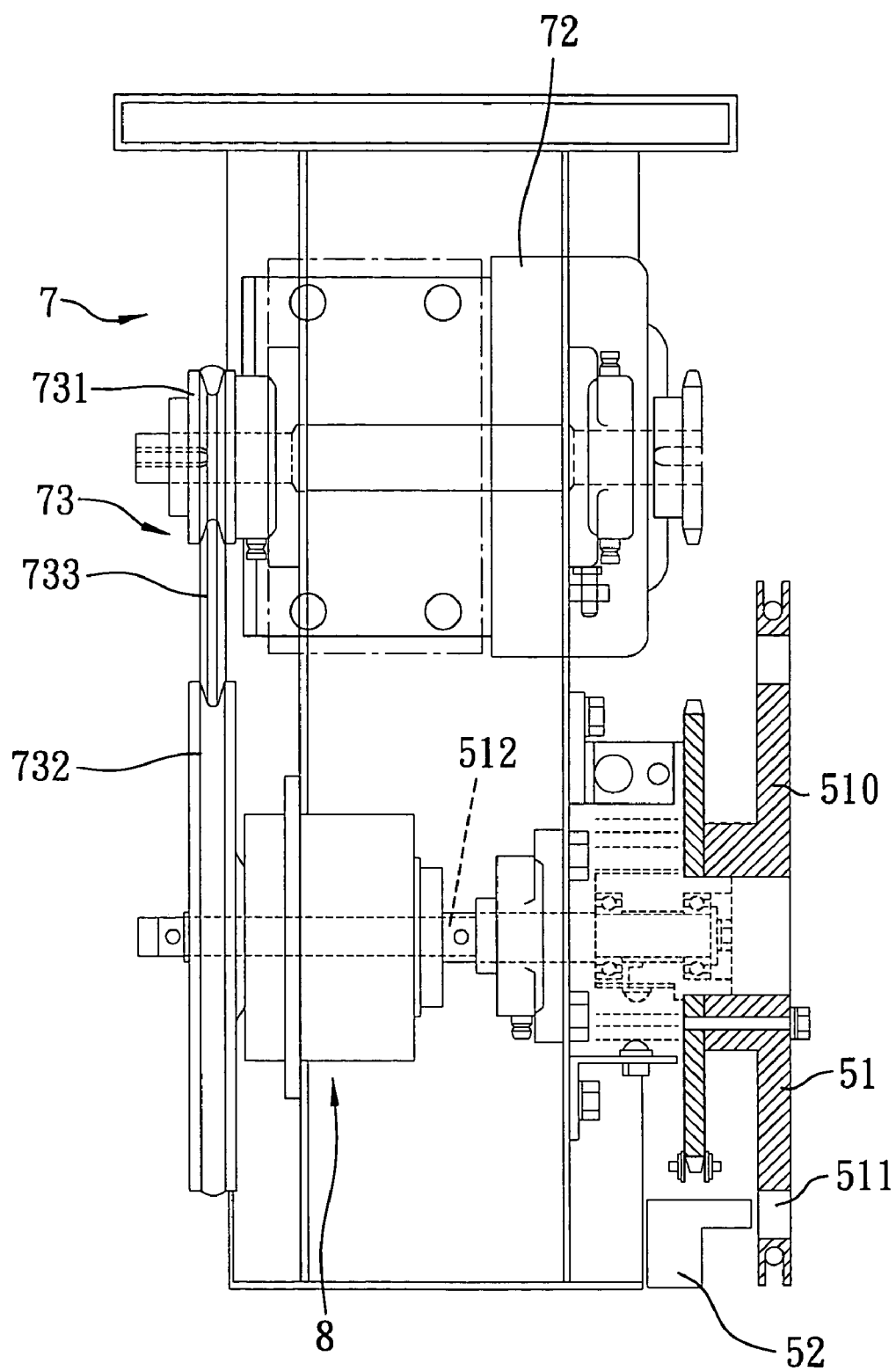


FIG. 3

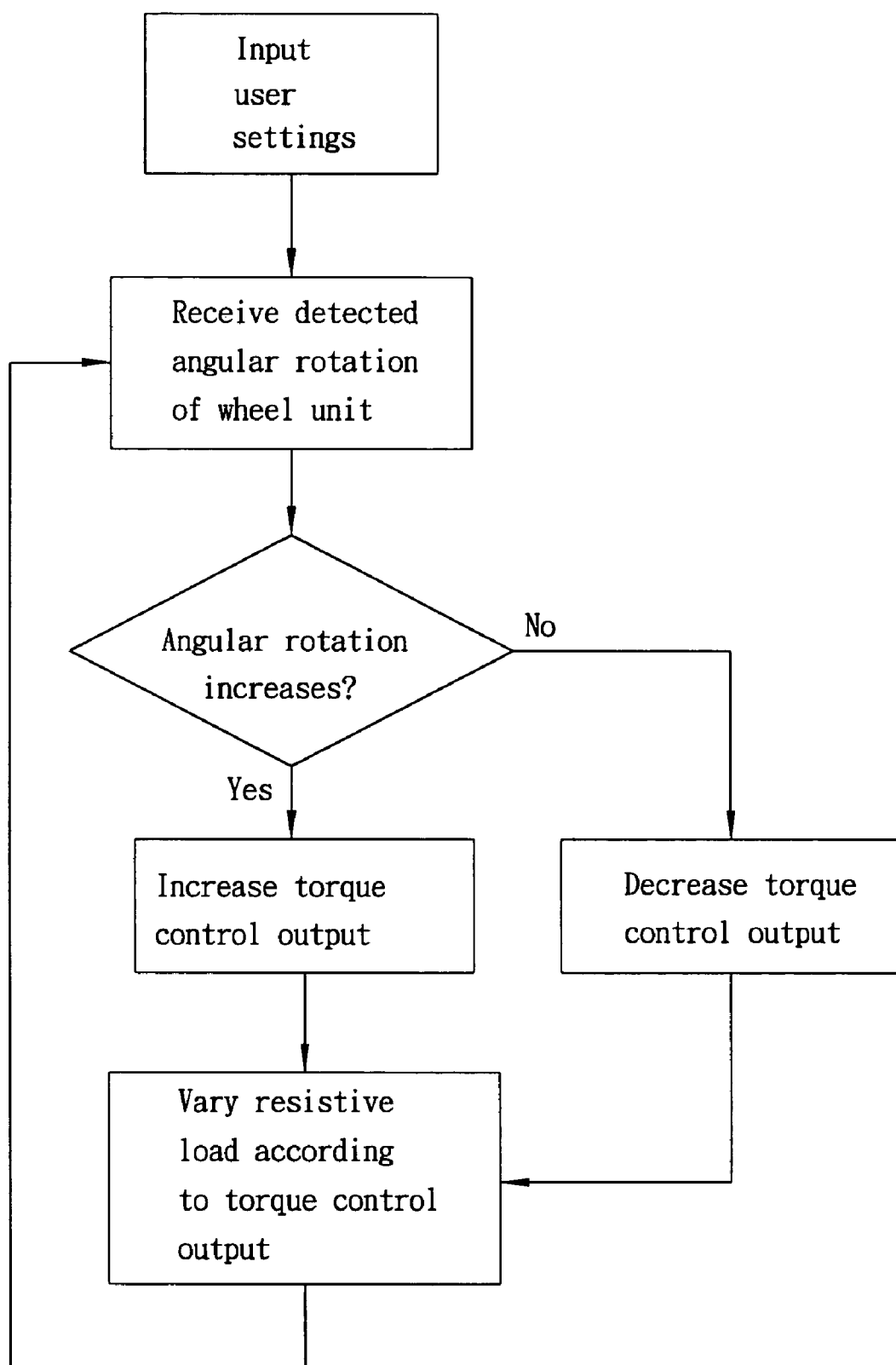


FIG. 4

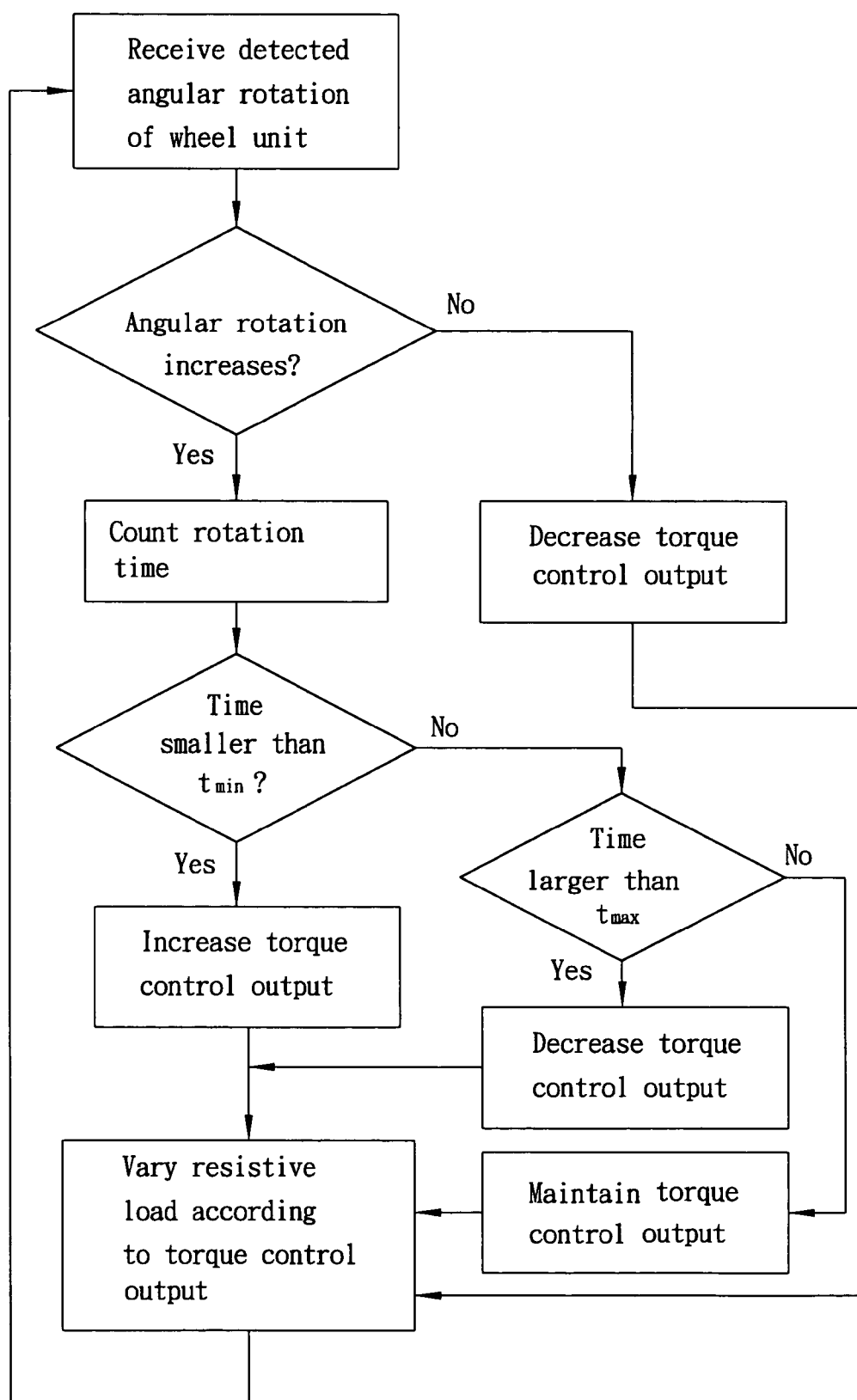


FIG. 5

METHOD AND APPARATUS FOR PROVIDING A DYNAMICALLY VARIABLE RESISTIVE LOAD DURING EXERCISE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to a load for exercise equipment, more particularly to a method and apparatus for providing a dynamically variable resistive load during exercise.

[0003] 2. Description of the Related Art

[0004] A known apparatus for providing a resistive load during exercise includes a wheel unit, a resistance generator, an electrically controlled torque transfer device, and a control unit. The wheel unit is operable so as to rotate in response to exertion of a user-applied force during an exercise stroke. The resistance generator, such as an electric motor, is operable so as to generate a resistive torque for resisting rotation of the wheel unit when the user-applied force is exerted. The torque transfer device, such as an electromagnetic mechanical particle clutch, couples the resistance generator to the wheel unit, and is operable so as to transfer a fraction of the resistive torque from the resistance generator to the wheel unit. The control unit is coupled to the resistance generator so as to control activation of the resistance generator and direction of the resistive torque generated by the resistance generator. The control unit is further coupled to the torque transfer device, and controls operation of the torque transfer device in order to gradually increase the fraction of the resistive torque that is transferred to the wheel unit with reference to a predetermined load variation curve during each exercise stroke.

[0005] While the aforesaid known apparatus provides a variable resistive load during exercise, it does not take into account the actual physical condition of the user during exercise. As a result, when the resistive load is too heavy, the user is likely to get injured due to over-exertion.

SUMMARY OF THE INVENTION

[0006] Therefore, the object of the present invention is to provide a method and apparatus for providing a dynamically variable resistive load during exercise that can overcome the aforesaid drawback of the prior art.

[0007] According to one aspect of this invention, there is provided a method for providing a dynamically variable resistive load during exercise. The method is implemented using an apparatus which includes a wheel unit that is operable so as to rotate in response to exertion of a user-applied force during an exercise stroke, a resistance generator that is operable so as to generate a resistive torque for resisting rotation of the wheel unit when the user-applied force is exerted, and an electrically controlled torque transfer device that couples the resistance generator to the wheel unit and that is operable so as to transfer a fraction of the resistive torque from the resistance generator to the wheel unit. The method comprises the steps of:

[0008] a) detecting angular rotation of the wheel unit during each exercise stroke; and

[0009] b) in accordance with the detected angular rotation of the wheel unit during a current exercise

stroke, controlling the torque transfer device to adjust the fraction of the resistive torque that is transferred to the wheel unit.

[0010] According to another aspect of this invention, there is provided an apparatus for providing a dynamically variable resistive load during exercise. The apparatus comprises a wheel unit, a resistance generator, an electrically controlled torque transfer device, an angle measuring device, and a control unit. The wheel unit is operable so as to rotate in response to exertion of a user-applied force during an exercise stroke. The resistance generator is operable so as to generate a resistive torque for resisting rotation of the wheel unit when the user-applied force is exerted. The torque transfer device couples the resistance generator to the wheel unit, and is operable so as to transfer a fraction of the resistive torque from the resistance generator to the wheel unit. The angle measuring device detects angular rotation of the wheel unit during each exercise stroke. The control unit is coupled to the torque transfer device and the angle measuring device. In accordance with the angular rotation of the wheel unit detected by the angle measuring device during a current exercise stroke, the control unit controls the torque transfer device to adjust the fraction of the resistive torque that is transferred to the wheel unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Other features and advantages of the present invention will become apparent in the following detailed description of the preferred embodiment with reference to the accompanying drawings, of which:

[0012] **FIG. 1** is a schematic side view of a multi-function exercise machine that incorporates the preferred embodiment of an apparatus for providing a dynamically variable resistive load according to the present invention;

[0013] **FIG. 2** is a schematic block diagram of the preferred embodiment;

[0014] **FIG. 3** is a schematic side view of the preferred embodiment;

[0015] **FIG. 4** is a flowchart to illustrate operation of a control unit of the preferred embodiment; and

[0016] **FIG. 5** is a flowchart to illustrate operation of a modified control unit of the preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] Referring to **FIG. 1**, the preferred embodiment of an apparatus **3** for providing a dynamically variable resistive load according to the present invention is shown to be incorporated in a multi-function exercise machine **2** that includes a known pull unit **21**, a known leg extension unit **22**, and a known tread unit **23**. A transmission device **24** is provided to couple the apparatus **3** to each of the pull unit **21**, the leg extension unit **22** and the tread unit **23**. The transmission device **24** includes rope means **241** coupled to the pull unit **21** and the leg extension unit **22**, belt means **242** coupled to the tread unit **23**, and a set of pulleys **243** for controlling transmission direction of the rope and belt means **241**, **242**.

[0018] With further reference to **FIGS. 2 and 3**, the apparatus **3** of this embodiment includes a wheel unit **51**, a

resistance generator 7, an electrically controlled torque transfer device 8, an angle measuring device 52, and a control unit 6.

[0019] The wheel unit 51 is coupled to the rope means 241 and the belt means 242 of the transmission device 24. The wheel unit 51 is thus operable so as to rotate in response to exertion of a user-applied force on any one of the pull unit 21, the leg extension unit 22 and the tread unit 23 during exercise. In this embodiment, the wheel unit 51 includes a wheel shaft 512 mounted rotatably on the exercise machine 2, and an optical encoder wheel 510 mounted co-rotatably on the wheel shaft 512 and formed with a plurality of angularly displaced radial slots 511.

[0020] The resistance generator 7 is mounted on the exercise machine 2, and includes an electric motor 72 that is operable so as to generate a resistive torque for resisting rotation of the wheel unit 51 when the user-applied force is exerted. A known transmission unit 73, which includes two transmission wheels 731, 732 and a transmission belt 733 trained on the transmission wheels 731, 732, is used to transmit the resistive torque generated by the motor 72 to the torque transfer device 8.

[0021] The torque transfer device 8 couples the transmission unit 73 of the resistance generator 7 to the wheel shaft 512 of the wheel unit 51, and is operable so as to transfer a fraction of the resistive torque from the resistance generator 7 to the wheel unit 51. In this embodiment, the torque transfer device 8 includes a conventional electromagnetic mechanical particle clutch. Since the feature of the invention does not reside in the specific construction of the known torque transfer device 8, details of the same are omitted herein for the sake of brevity.

[0022] The angle measuring device 52 is mounted on the exercise machine 2 proximate to the wheel unit 51, and serves to detect angular rotation of the wheel unit 51 during each exercise stroke when the pull unit 21 or the leg extension unit 22 is in use. In this embodiment, the angle measuring device 52 includes a known photoelectric sensor associated operably with the optical encoder wheel 510 of the wheel unit 51. Preferably, the radial slots 511 of the optical encoder wheel 510 are formed at 10-degree intervals.

[0023] The control unit 6 is coupled to the torque transfer device 8, the angle measuring device 52 and the resistance generator 7, and includes a control panel 61 for inputting user settings, a processor 62 connected to the control panel 61 and the angle measuring device 52, a motor driver 65 connected to the processor 62 and the electric motor 72 of the resistance generator 7 for controlling activation of the electric motor 72 and direction of the resistive torque generated by the electric motor 72, a digital-to-analog (D/A) converter 63 connected to the processor 62, and a current controller 64 connected to the D/A converter 63 and the torque transfer device 8 for controlling operation of the torque transfer device 8.

[0024] The control panel 61 can be operated to select the type of exercise to be performed by the user, i.e., which one of the pull unit 21, the leg extension unit 22 and the tread unit 23 is intended to be used, and a target resistive force value for the exercise to be performed by the user. The control panel 61 can be disposed in front of the pull and leg extension units 21, 22, or in front of the tread unit 23 to facilitate user operation.

[0025] Depending on the type of exercise to be performed, the processor 62 controls activation of the electric motor 72 of the resistance generator 7 through the motor driver 65 such that the resistive torque generated by the resistance generator 7 can resist rotation of the wheel unit 51 due to application of the user-exerted force on the selected one of the pull unit 21, the leg extension unit 22, and the tread unit 23.

[0026] The processor 62 has predetermined load variation curves for the different types of exercise stored therein. Since the feature of the present invention does not reside in the load variation curves, which are obtained through known techniques, a detailed description of the same is omitted herein for the sake of brevity. The processor 62 receives the user settings inputted through the control panel 61, and calculates different resistive load values with reference to the user settings and the load variation curve for the type of exercise to be performed by the user. Thereafter, with further reference to the angular rotation of the wheel unit 51 detected by the angle measuring device 52, the processor 62 generates varying torque control outputs that correspond to the calculated resistive load values.

[0027] The D/A converter 63 receives the torque control output of the processor 62, and converts the same into an analog control signal. The current controller 64 subsequently converts the control signal into a control current that is supplied to an electromagnet (not shown) of the torque control device 8. In response to the control current, the torque control device 8 adjusts the fraction of the resistive torque that is transferred from the resistance generator 7 to the wheel unit 51, thereby resulting in a variable resistive load during exercise.

[0028] FIG. 4 is a flowchart to illustrate operation of a preferred implementation of the control unit 6. In the flowchart of FIG. 4, it is assumed that the leg extension unit 22 was selected by the user, and the user inputted 30 kilograms as his target resistive force value. During an exercise stroke, the user exerts a force to move the leg extension unit 22 with the use of his legs such that the user's legs are moved from an initial position, where the user's legs stand uprightly on the ground, toward a fully extended position, i.e., the user's legs are substantially horizontal. The angle measuring device 52 detects the angular rotation of the wheel unit 51 during each exercise stroke, and provides the detected information to the processor 62. The processor 62 gradually increases the torque control output thereof with reference to the predetermined load variation curve for the leg extension unit 22 in case of an increase in angular displacement of the wheel unit 51 from an initial position, and gradually decreases the torque control output with reference to the same predetermined load variation curve for the leg extension unit 22 in case of a decrease in the angular displacement of the wheel unit 51 from the initial position. For instance, during an initial stage of a current exercise stroke, the torque control output of the processor 62 can be set to 20% of the target resistive force value. The torque control output is then gradually increased to increase the fraction of the resistive force that is transferred to the wheel unit 51 as the angular displacement of the wheel unit 51 from its initial position increases. When the user's legs are at the fully extended position, the torque control output of the processor 62 can be set to correspond to 120% of the target resistive force value, i.e., 36 kilograms. Thereafter, when the user's legs are

moved from the fully extended position back to the initial position, the processor **62** gradually decreases its torque control output from an initial value corresponding to 40% of the target resistive force value, i.e., 12 kilograms, to a value corresponding to 0% of the target resistive force value (which is the resistive force transferred to the wheel unit **51** when the user's legs are at the initial position). Since the resistive load transferred to the wheel unit **51** varies with the measured angular displacement of the wheel unit **51**, the risk of injury can be reduced to a minimum during exercise.

[0029] Preferably, the processor **62** is configured to control the control panel **61** to show the current resistive load transferred to the wheel unit **51** thereon for user monitoring purposes.

[0030] FIG. 5 is a flowchart to illustrate operation of another preferred implementation of the control unit **6**. In the flowchart of FIG. 5, the fraction of the resistive torque is increased upon detection that the time for the wheel unit **51** to reach a predetermined angular displacement during the current exercise stroke is smaller than a first threshold, and is reduced upon detection that the time for the wheel unit **51** to reach the predetermined angular displacement during the current exercise stroke is greater than a second threshold.

[0031] In the flowchart of FIG. 5, it is assumed that the leg extension unit **22** was selected by the user, and that the standard time period for completing a lifting action of an exercise stroke ranges from 1.6 to 2.4 seconds. During an initial exercise stroke, the torque control output of the processor **62** can be set to correspond to a 20-kilogram resistive load. If the time that took for the user to move his legs from the initial position to the fully extended position is smaller than 1.6 seconds (the first threshold, t_{min}), this indicates that the resistive load is too small, and the control unit **6** controls the torque transfer device **8** to increase the resistive torque transferred to the wheel unit **51** to 25 kilograms for the succeeding exercise stroke. On the other hand, if the time that took for the user to move his legs from the initial position to the fully extended position is greater than 2.4 seconds (the second threshold, t_{max}), this indicates that the resistive load is too heavy, and the control unit **6** controls the torque transfer device **8** to reduce the resistive force transferred to the wheel unit **51** to 15 kilograms for the succeeding exercise stroke. As a result, the resistive load is dynamically varied according to the actual condition of the user during exercise in order to minimize the risk of injury.

[0032] Preferably, the processor **62** of the control unit **6** is adapted to be coupled to an external computer **620** to permit downloading of the load variation curves for the different types of exercise therefrom.

[0033] While the present invention has been described in connection with what is considered the most practical and preferred embodiment, it is understood that this invention is not limited to the disclosed embodiment but is intended to cover various arrangements included within the spirit and scope of the broadest interpretation so as to encompass all such modifications and equivalent arrangements.

We claim:

1. A method for providing a dynamically variable resistive load during exercise, the method being implemented using an apparatus that includes

a wheel unit that is operable so as to rotate in response to exertion of a user-applied force during an exercise stroke,

a resistance generator that is operable so as to generate a resistive torque for resisting rotation of the wheel unit when the user-applied force is exerted, and

an electrically controlled torque transfer device that couples the resistance generator to the wheel unit and that is operable so as to transfer a fraction of the resistive torque from the resistance generator to the wheel unit,

the method comprising the steps of:

a) detecting angular rotation of the wheel unit during each exercise stroke; and

b) in accordance with the detected angular rotation of the wheel unit during a current exercise stroke, controlling the torque transfer device to adjust the fraction of the resistive torque that is transferred to the wheel unit.

2. The method as claimed in claim 1, wherein, in step b), the fraction of the resistive torque is gradually increased with an increase in angular displacement of the wheel unit from an initial position during the current exercise stroke, and is gradually reduced when otherwise.

3. The method as claimed in claim 1, wherein, in step b), the fraction of the resistive torque is increased upon detection that the time for the wheel unit to reach a predetermined angular displacement during the current exercise stroke is smaller than a first threshold, and is reduced upon detection that the time for the wheel unit to reach the predetermined angular displacement during the current exercise stroke is greater than a second threshold.

4. An apparatus for providing a dynamically variable resistive load during exercise, comprising:

a wheel unit that is operable so as to rotate in response to exertion of a user-applied force during an exercise stroke;

a resistance generator that is operable so as to generate a resistive torque for resisting rotation of said wheel unit when the user-applied force is exerted;

an electrically controlled torque transfer device that couples said resistance generator to said wheel unit and that is operable so as to transfer a fraction of the resistive torque from said resistance generator to said wheel unit;

an angle measuring device for detecting angular rotation of said wheel unit during each exercise stroke; and

a control unit coupled to said torque transfer device and said angle measuring device;

wherein, in accordance with the angular rotation of said wheel unit detected by said angle measuring device during a current exercise stroke, said control unit controls said torque transfer device to adjust the fraction of the resistive torque that is transferred to said wheel unit.

5. The apparatus as claimed in claim 4, wherein said control unit controls said torque transfer device to gradually increase the fraction of the resistive torque with an increase in angular displacement of said wheel unit from an initial position during the current exercise stroke, and to gradually reduce the fraction of the resistive torque when otherwise.

6. The apparatus as claimed in claim 4, wherein said control unit controls said torque transfer device to increase the fraction of the resistive torque upon detection that the time for said wheel unit to reach a predetermined angular displacement during the current exercise stroke is smaller than a first threshold, and to reduce the fraction of the resistive torque upon detection that the time for said wheel unit to reach the predetermined angular displacement during the current exercise stroke is greater than a second threshold.

7. The apparatus as claimed in claim 4, wherein said resistance generator includes an electric motor that is coupled to said control unit so as to control activation of said electric motor.

8. The apparatus as claimed in claim 7, wherein said control unit is further operable so as to control direction of the resistive torque generated by said electric motor.

9. The apparatus as claimed in claim 4, wherein said torque transfer device includes an electromagnetic mechanical particle clutch.

10. The apparatus as claimed in claim 4, wherein said wheel unit includes an optical encoder wheel, and said angle measuring device includes a photoelectric sensor operably associated with said optical encoder wheel.

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