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(54) TRAINING APPARATUS

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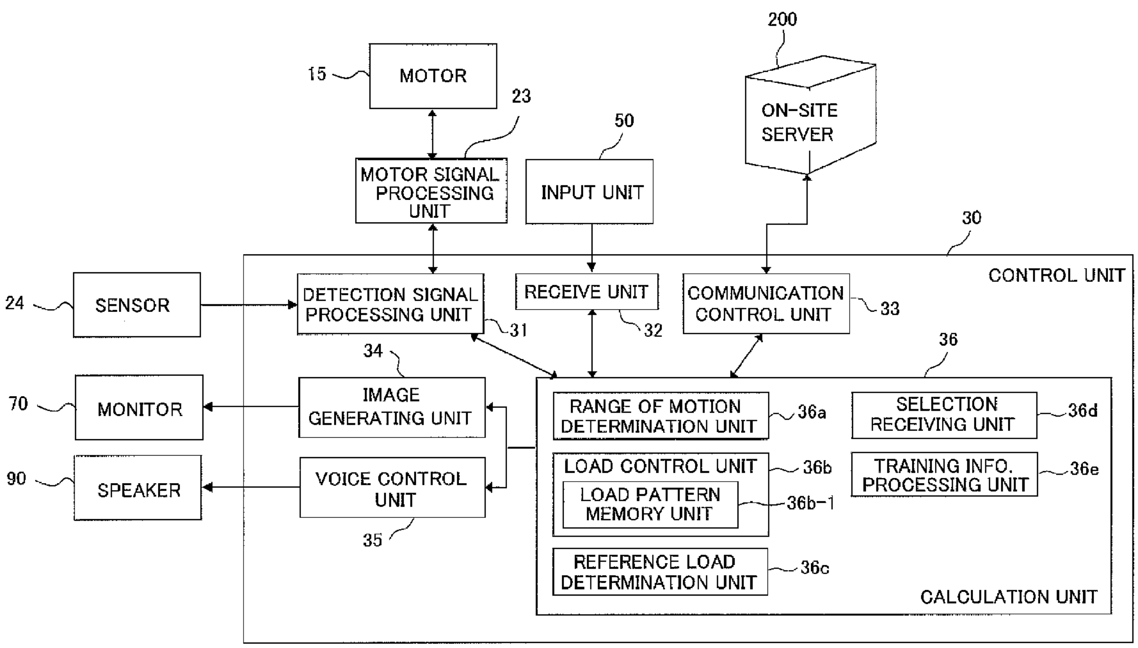
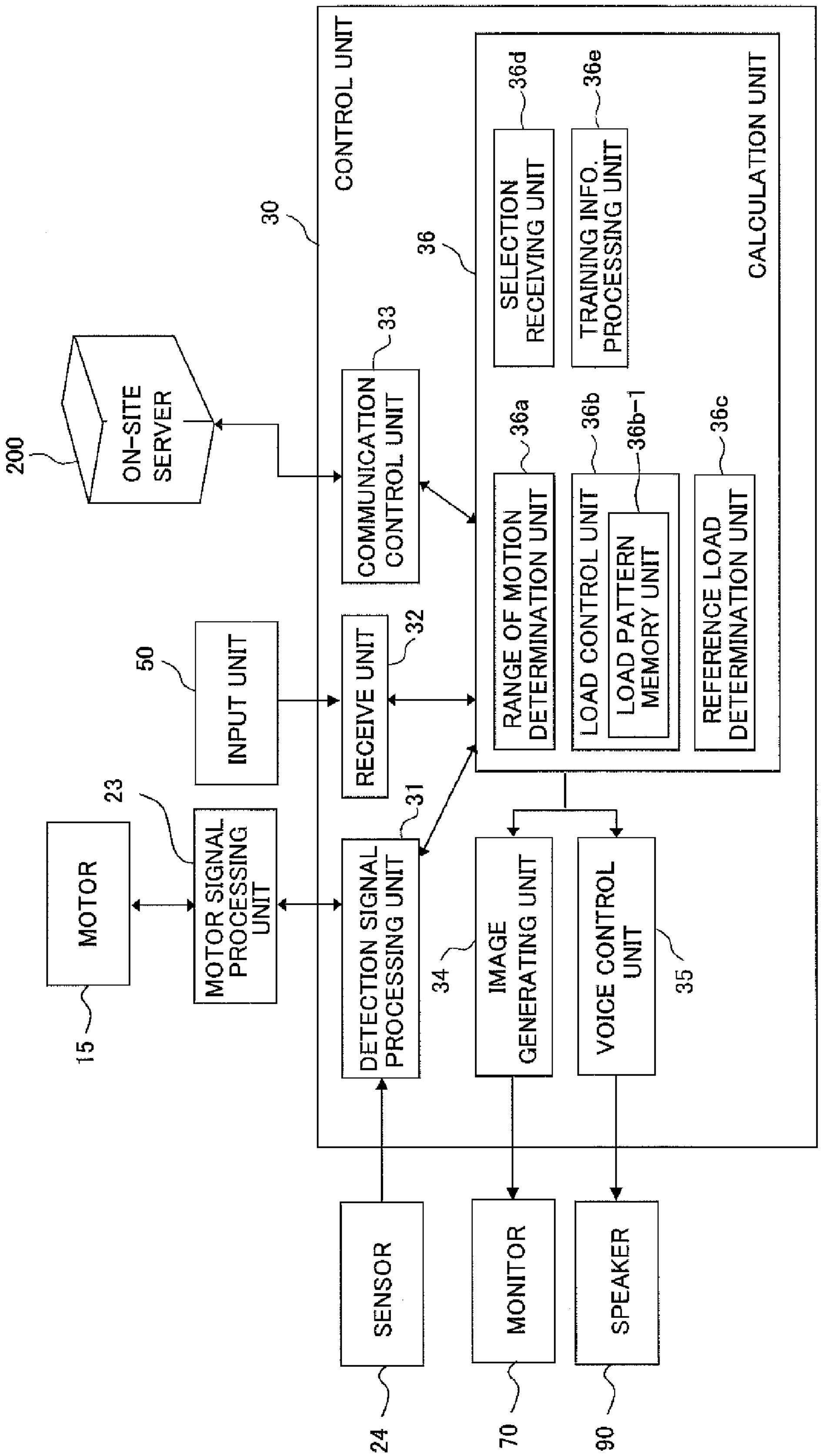
(57) **ABSTRACT**

A training apparatus is disclosed that will enable a trainee to exercise with a load that is suited to his or her physical build in the forward path and return path of a repetitive exercise. A motor applies a load to a bar (corresponds to a moving unit) that moves repetitively due to a trainee's exercise. The load that is applied by the motor is not fixed, but rather varies during the repetitive exercise. The width of the repetitive exercise, i.e., the width of the range of motion of the bar, takes into account differences in the physique of individual trainees. Consequently, varying the method by which the load changes in accordance with the width of the range of motion makes it possible to apply a load that is suited to the physique of each individual trainee, thereby enabling each trainee to exercise effectively.





CONTROL UNIT
30
CALCULATION UNIT
36
SELECTION RECEIVING UNIT
36d
TRAINING INFO. PROCESSING UNIT
36e
RANGE OF MOTION DETERMINATION UNIT
36a
LOAD CONTROL UNIT
36b
LOAD PATTERN MEMORY UNIT
36b-1
REFERENCE LOAD DETERMINATION UNIT
36c
ON-SITE SERVER
200
COMMUNICATION CONTROL UNIT
33
INPUT UNIT
50
RECEIVE UNIT
32
MOTOR
15
MOTOR SIGNAL PROCESSING UNIT
23
DETECTION SIGNAL PROCESSING UNIT
31
IMAGE GENERATING UNIT
34
VOICE CONTROL UNIT
35
SENSOR
24
MONITOR
70
SPEAKER
90

Fig. 1

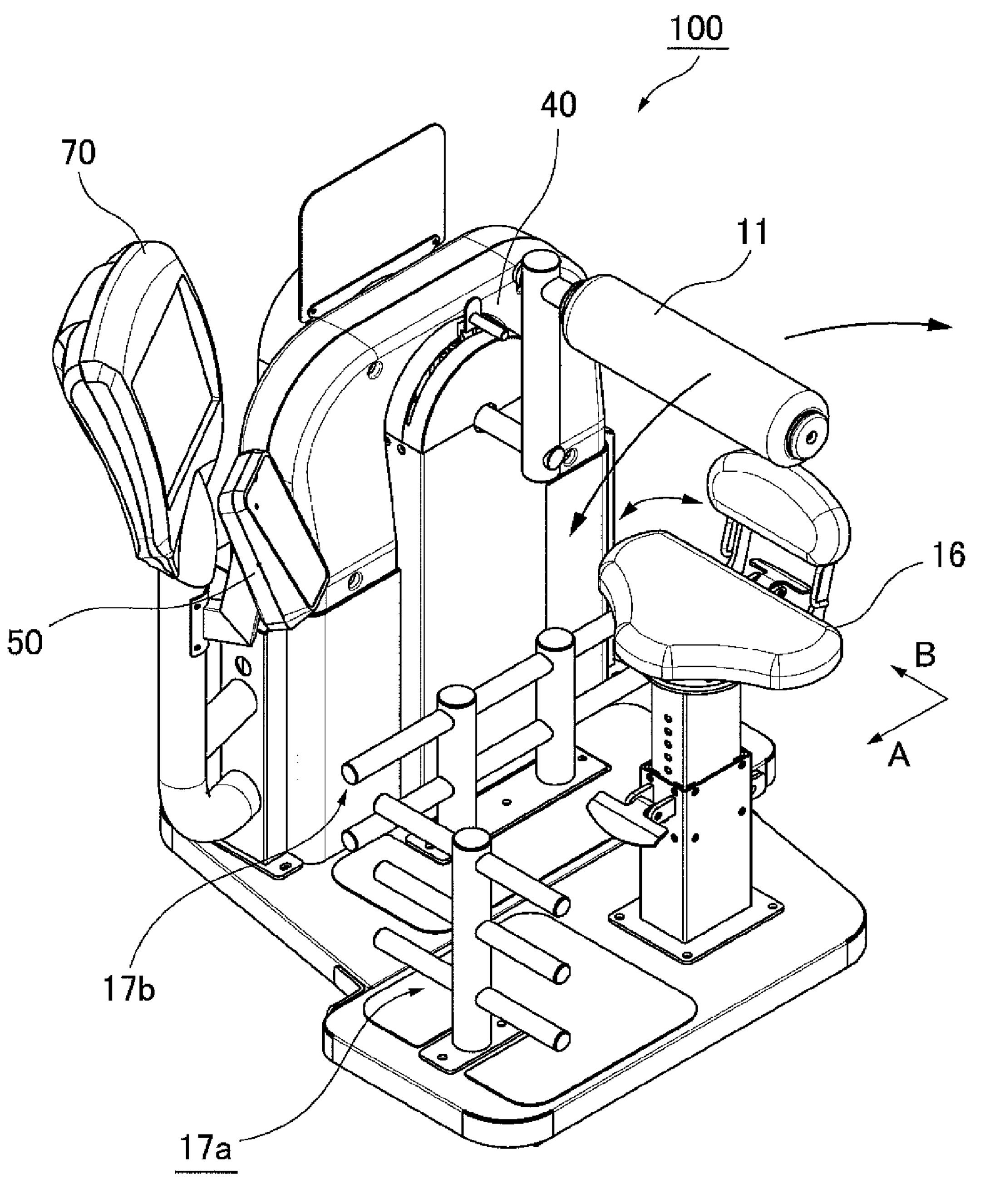


Fig. 2

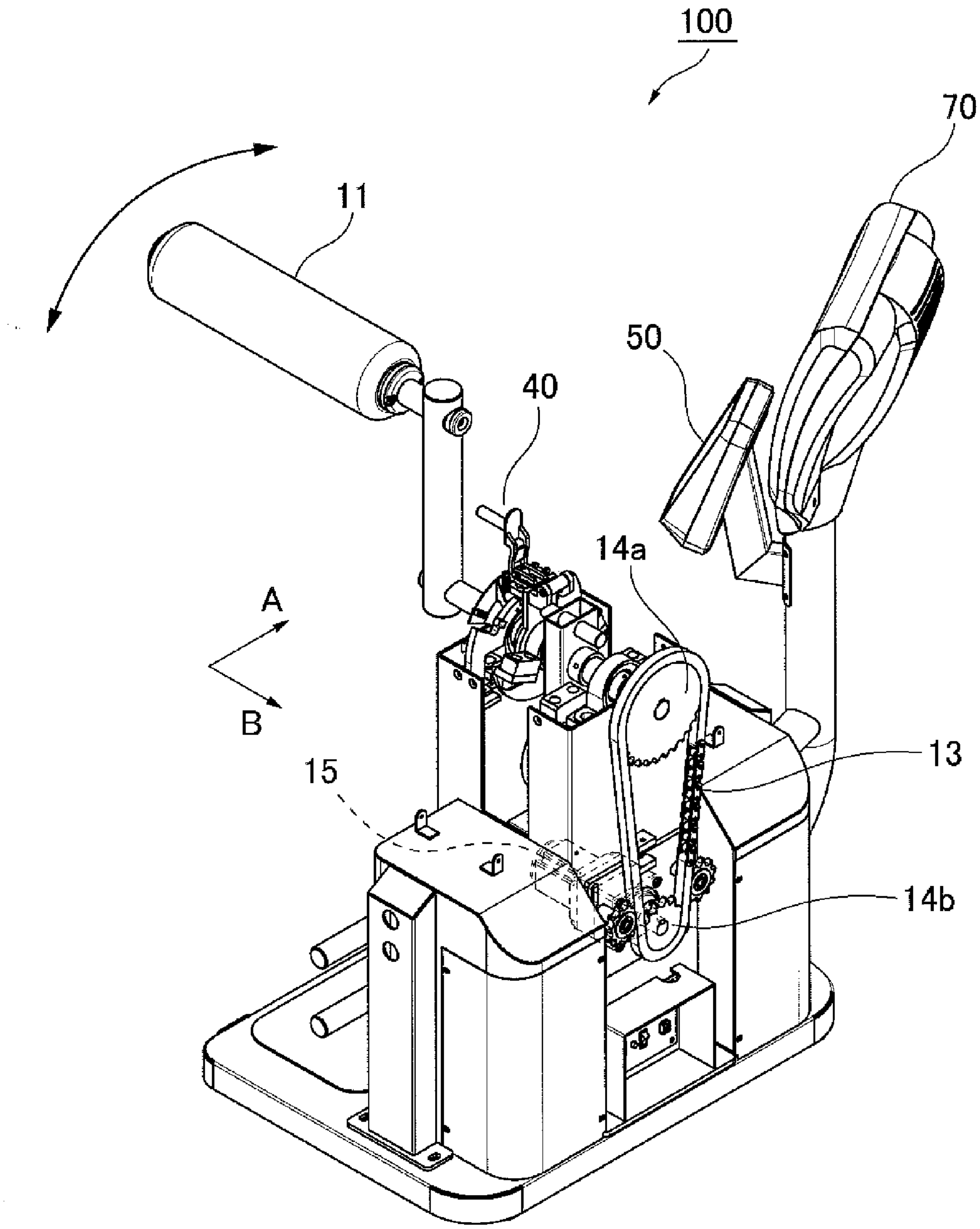


Fig. 3

TRAINEE ID	
GENDER AGE BODY WEIGHT BODY FAT PERCENTAGE	BASIC PERSONAL DATA
ABDOMINAL MUSCLES 1 RM ABDOMINAL MUSCLES RANGE OF MOTION BACK MUSCLES 1 RM BACK MUSCLES RANGE OF MOTION RIGHT OBLIQUES 1 RM RIGHT OBLIQUES RANGE OF MOTION LEFT OBLIQUES 1 RM LEFT OBLIQUES RANGE OF MOTION	SUPPLEMENTARY PERSONAL DATA

Fig. 4

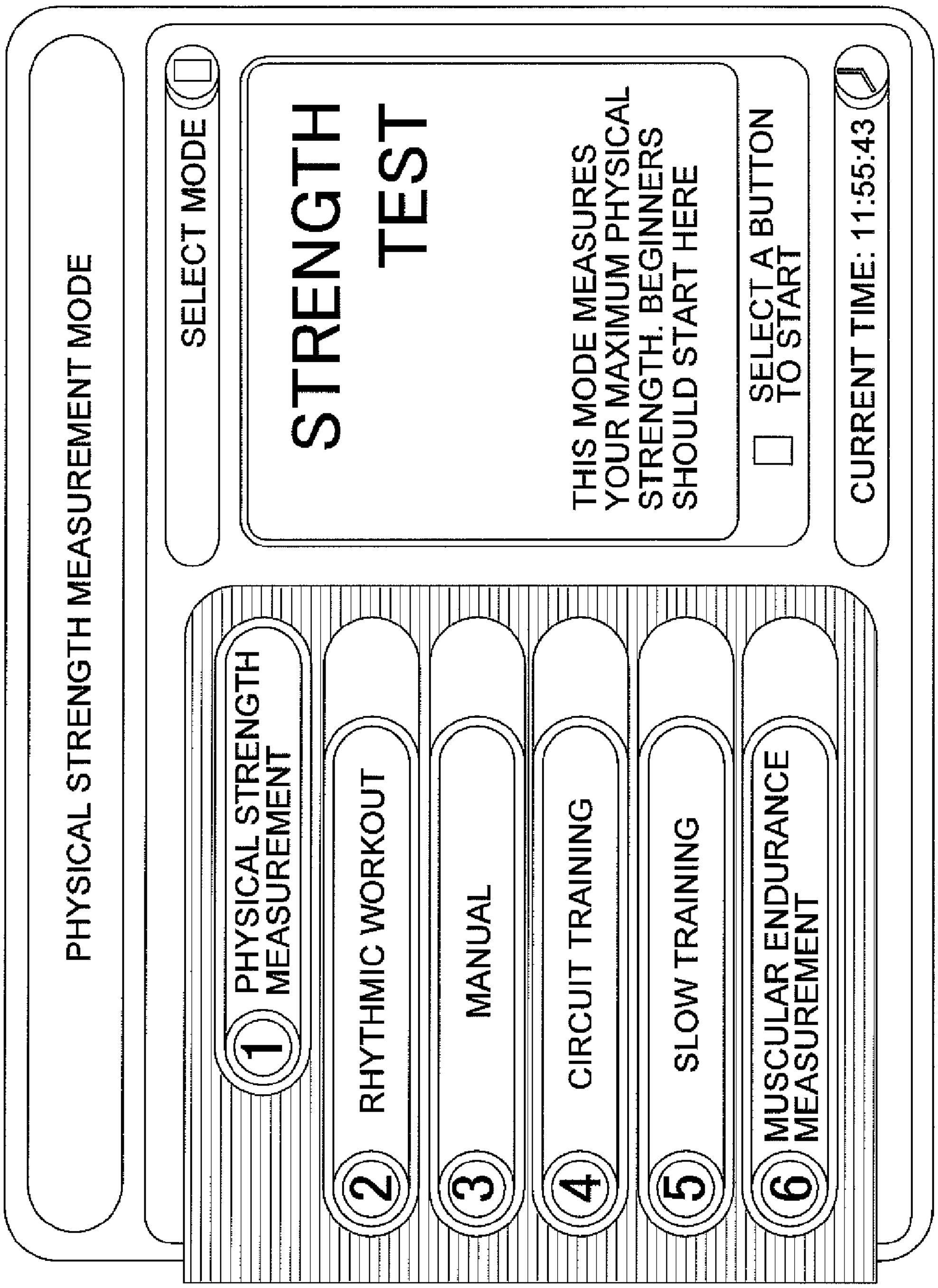

PHYSICAL STRENGTH MEASUREMENT MODE
1 PHYSICAL STRENGTH MEASUREMENT
2 RHYTHMIC WORKOUT
3 MANUAL
4 CIRCUIT TRAINING
5 SLOW TRAINING
6 MUSCULAR ENDURANCE MEASUREMENT
SELECT MODE
STRENGTH TEST
THIS MODE MEASURES YOUR MAXIMUM PHYSICAL STRENGTH. BEGINNERS SHOULD START HERE
SELECT A BUTTON TO START
CURRENT TIME: 11:55:43

Fig. 5

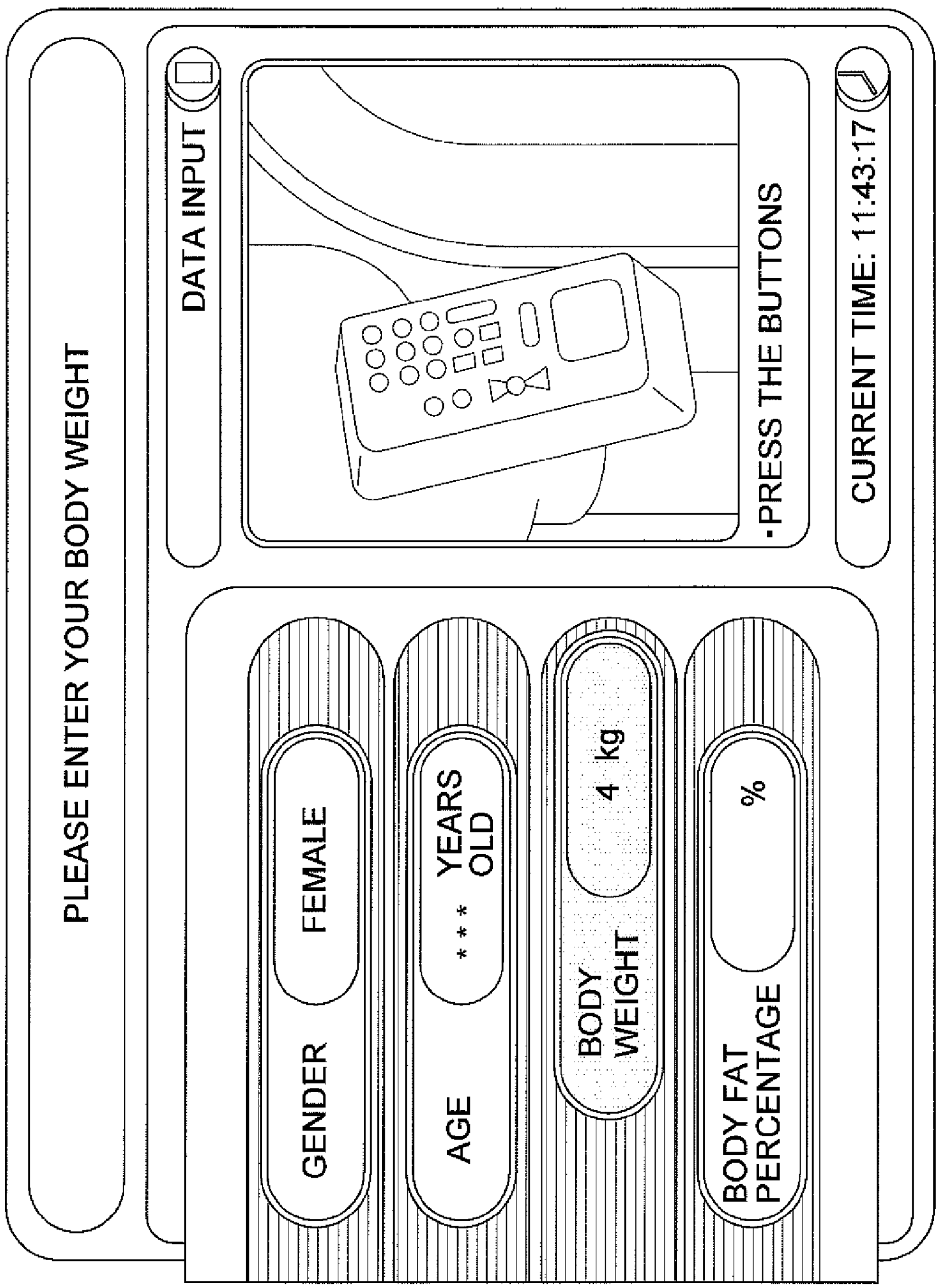

PLEASE ENTER YOUR BODY WEIGHT
DATA INPUT
·PRESS THE BUTTONS
CURRENT TIME: 11:43:17
GENDER
FEMALE
AGE
* * *
YEARS OLD
BODY WEIGHT
4 kg
BODY FAT PERCENTAGE
%

Fig. 6

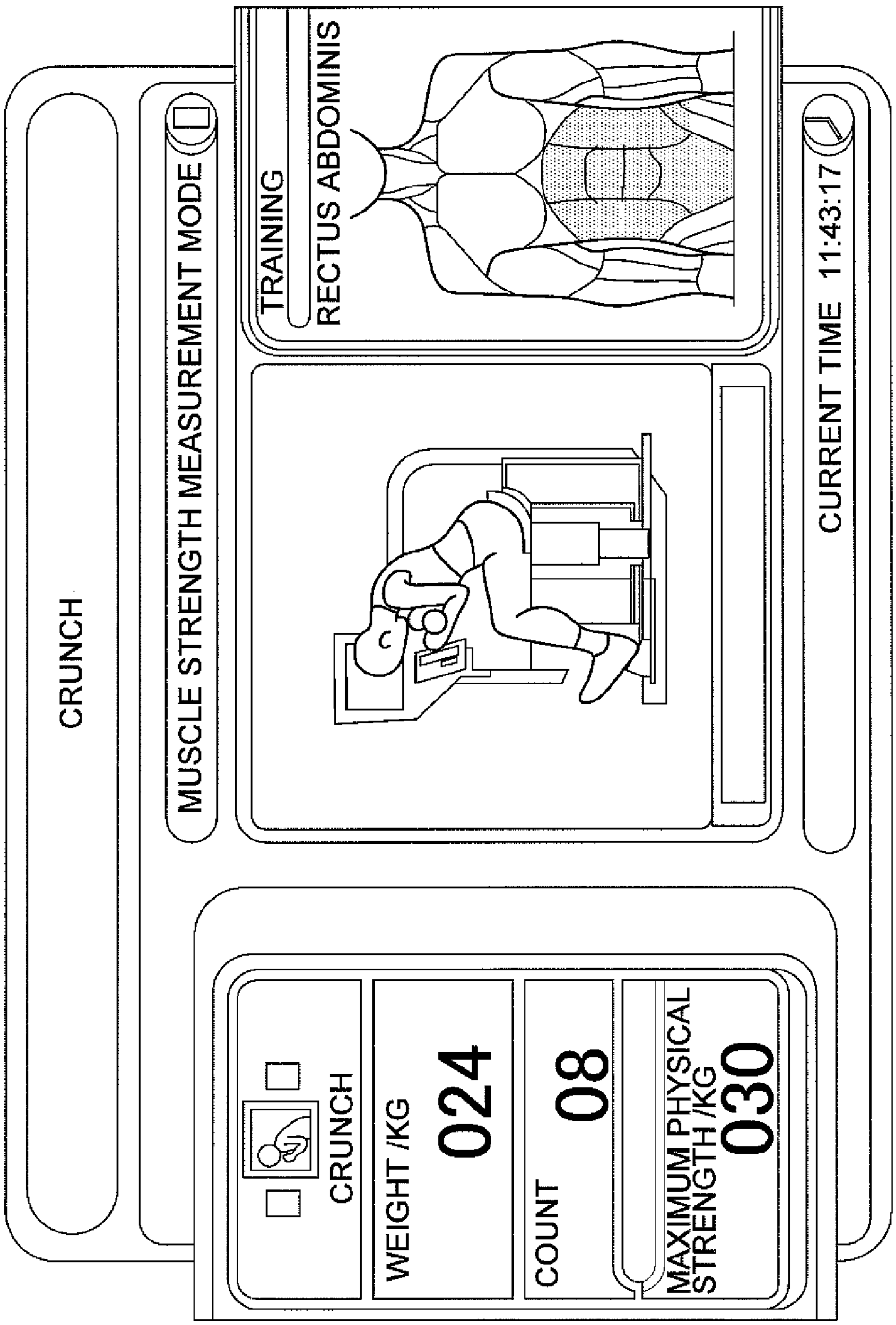

CRUNCH
MUSCLE STRENGTH MEASUREMENT MODE
TRAINING
RECTUS ABDOMINIS
CURRENT TIME 11:43:17
CRUNCH
WEIGHT /KG
024
COUNT
08
MAXIMUM PHYSICAL STRENGTH /KG
030

Fig. 7

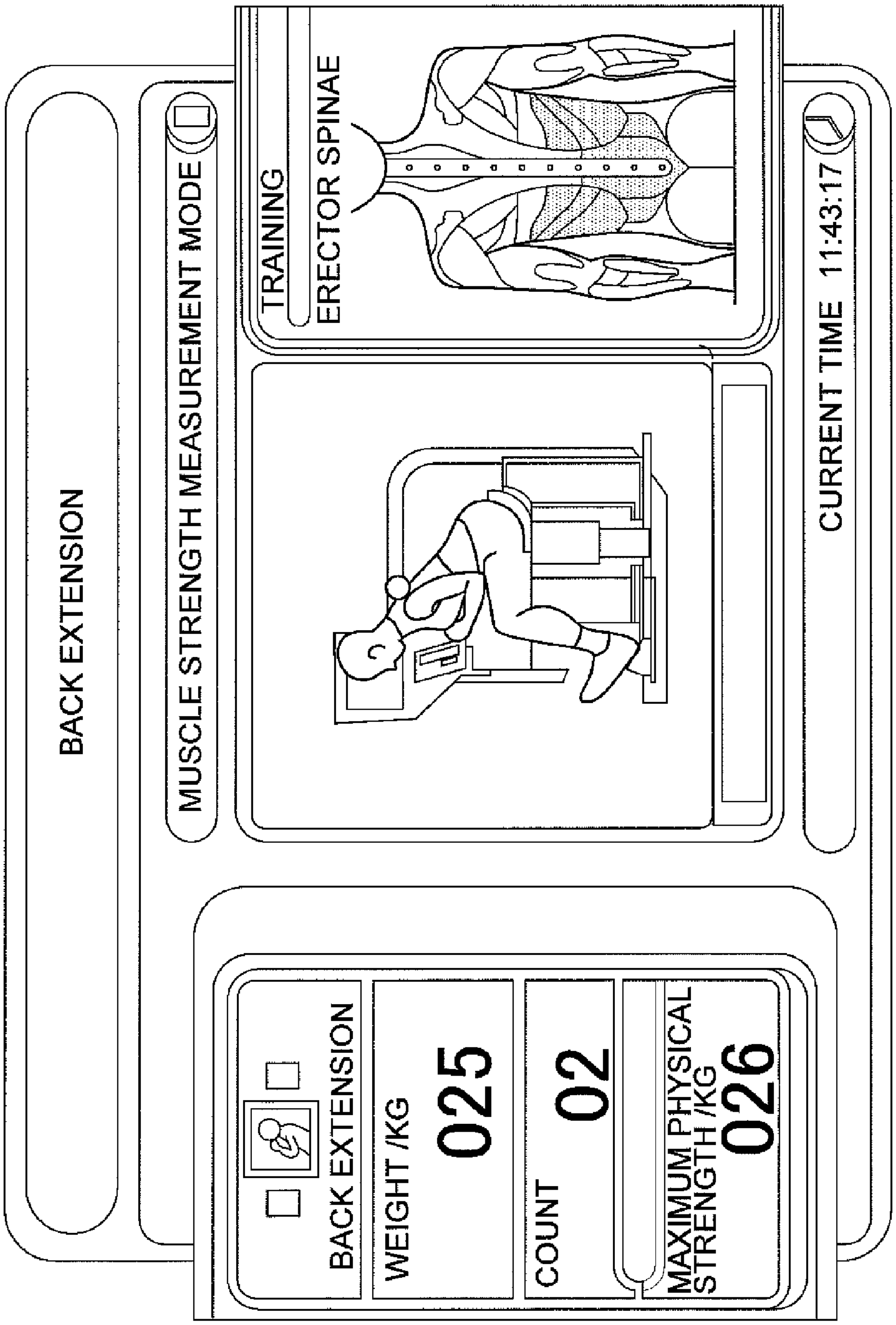

BACK EXTENSION
MUSCLE STRENGTH MEASUREMENT MODE
TRAINING
ERECTOR SPINAE
CURRENT TIME 11:43:17
BACK EXTENSION
WEIGHT /KG
025
COUNT
02
MAXIMUM PHYSICAL STRENGTH /KG
026

Fig. 8

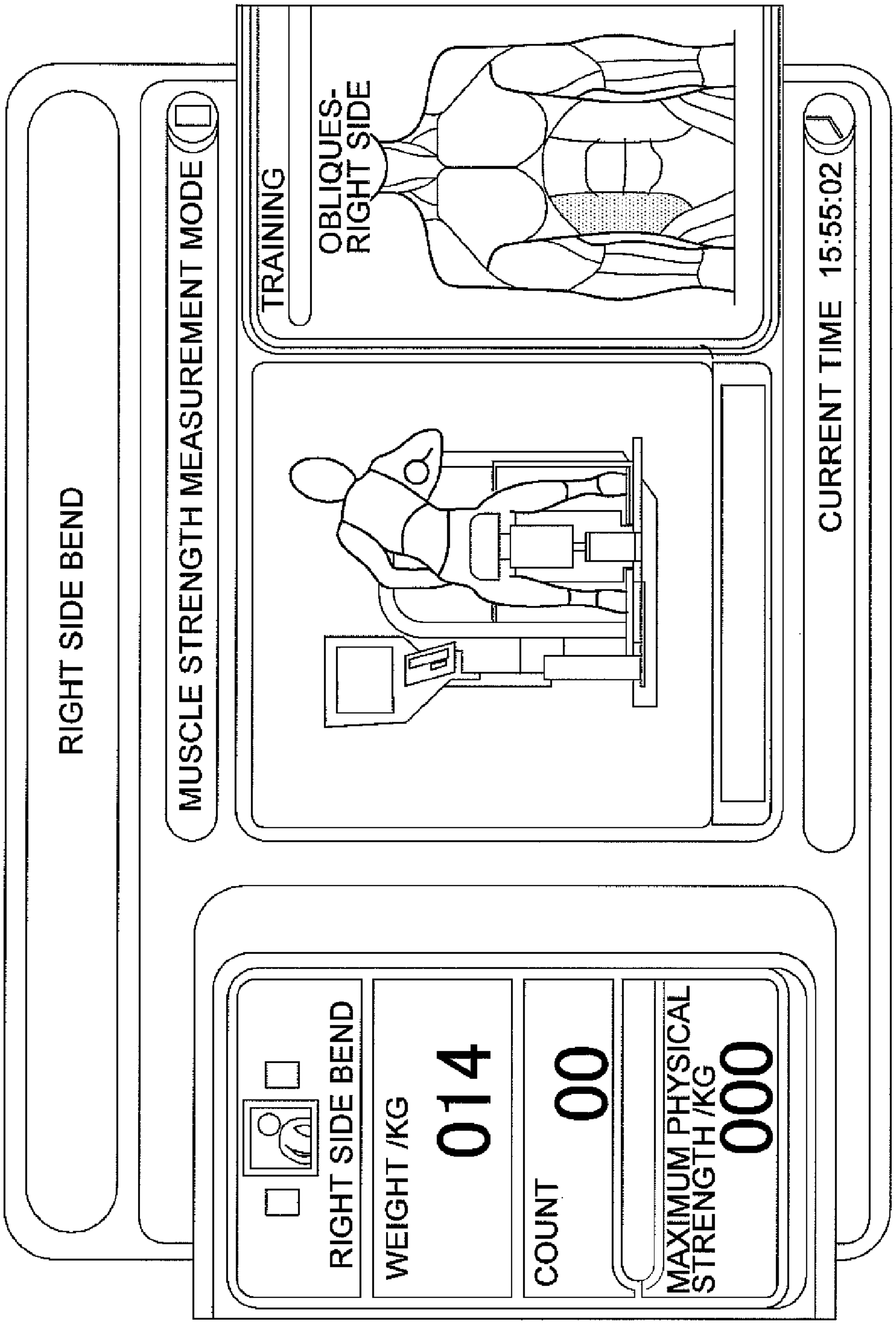

RIGHT SIDE BEND
MUSCLE STRENGTH MEASUREMENT MODE
TRAINING
OBLIQUES-
RIGHT SIDE
CURRENT TIME 15:55:02
RIGHT SIDE BEND
WEIGHT /KG
014
COUNT
00
MAXIMUM PHYSICAL
STRENGTH /KG
000

Fig. 9

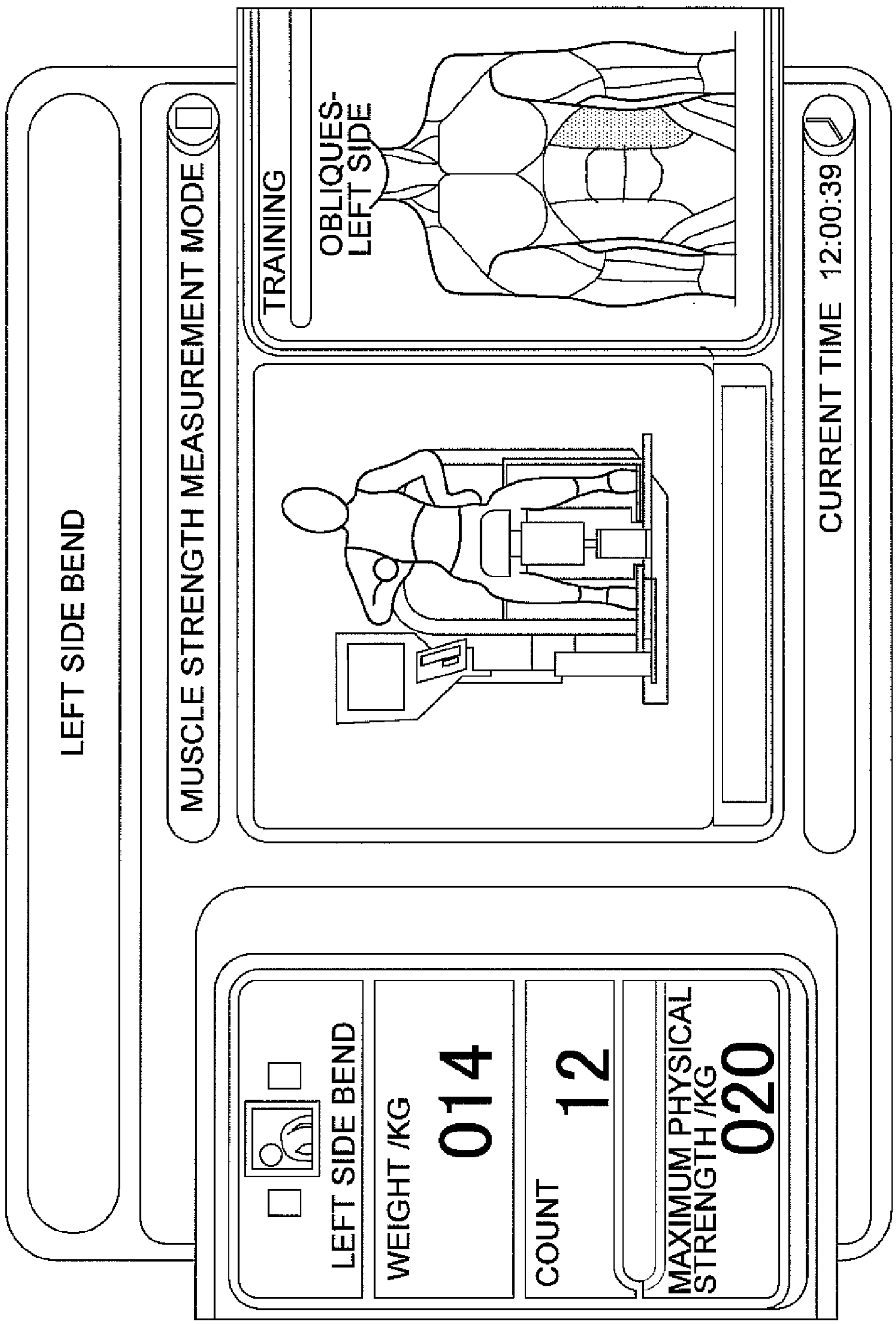

LEFT SIDE BEND
MUSCLE STRENGTH MEASUREMENT MODE
TRAINING
OBLIQUES-
LEFT SIDE
CURRENT TIME 12:00:39
LEFT SIDE BEND
WEIGHT /KG
014
COUNT
12
MAXIMUM PHYSICAL
STRENGTH /KG
020

Fig. 10

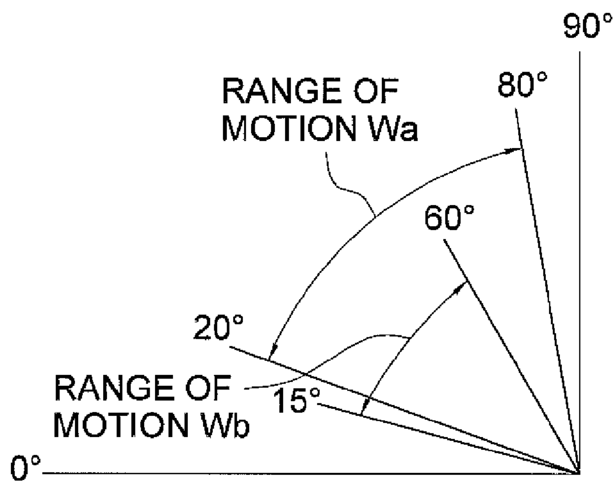


Fig. 11A

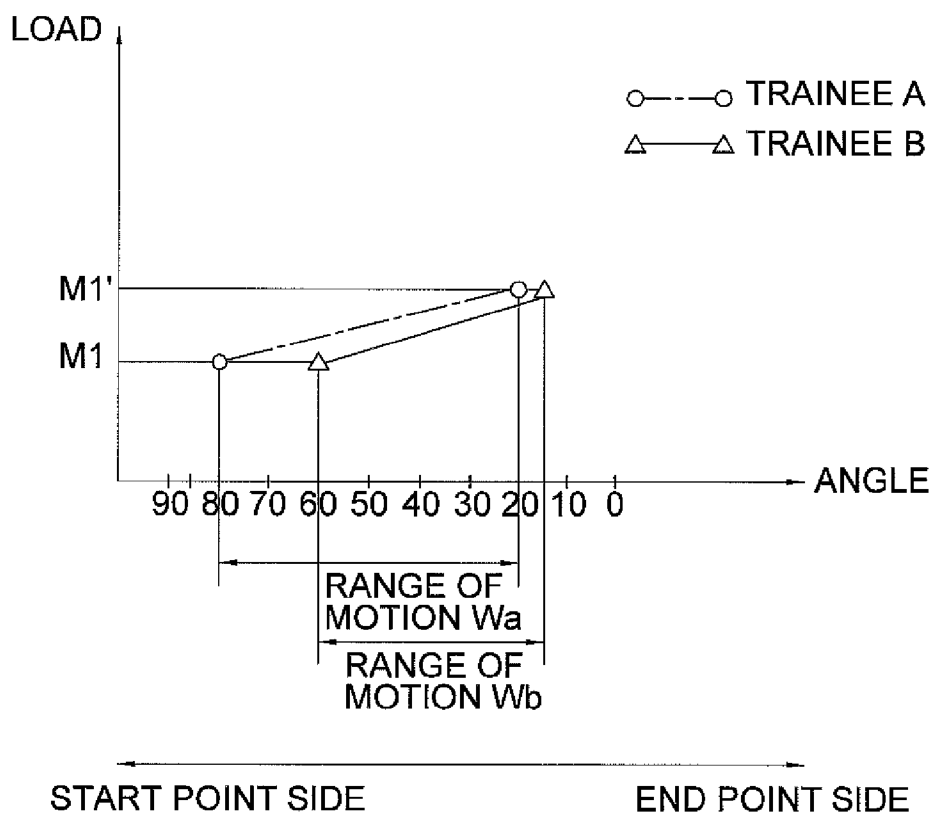


Fig. 11B

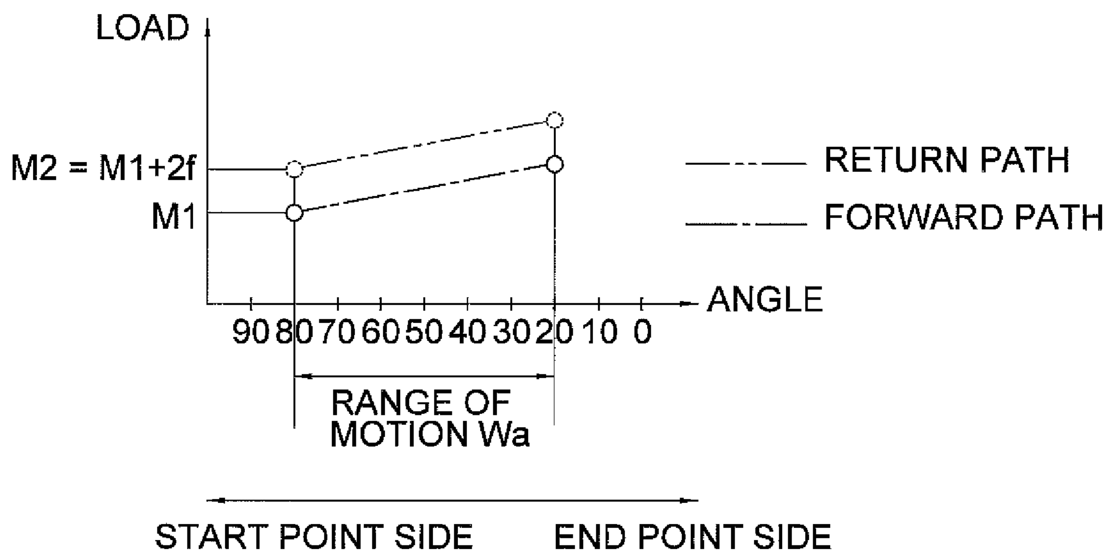

LOAD
M2 = M1+2f
M1
RETURN PATH
FORWARD PATH
ANGLE
90 80 70 60 50 40 30 20 10 0
RANGE OF MOTION Wa
START POINT SIDE
END POINT SIDE

Fig. 12

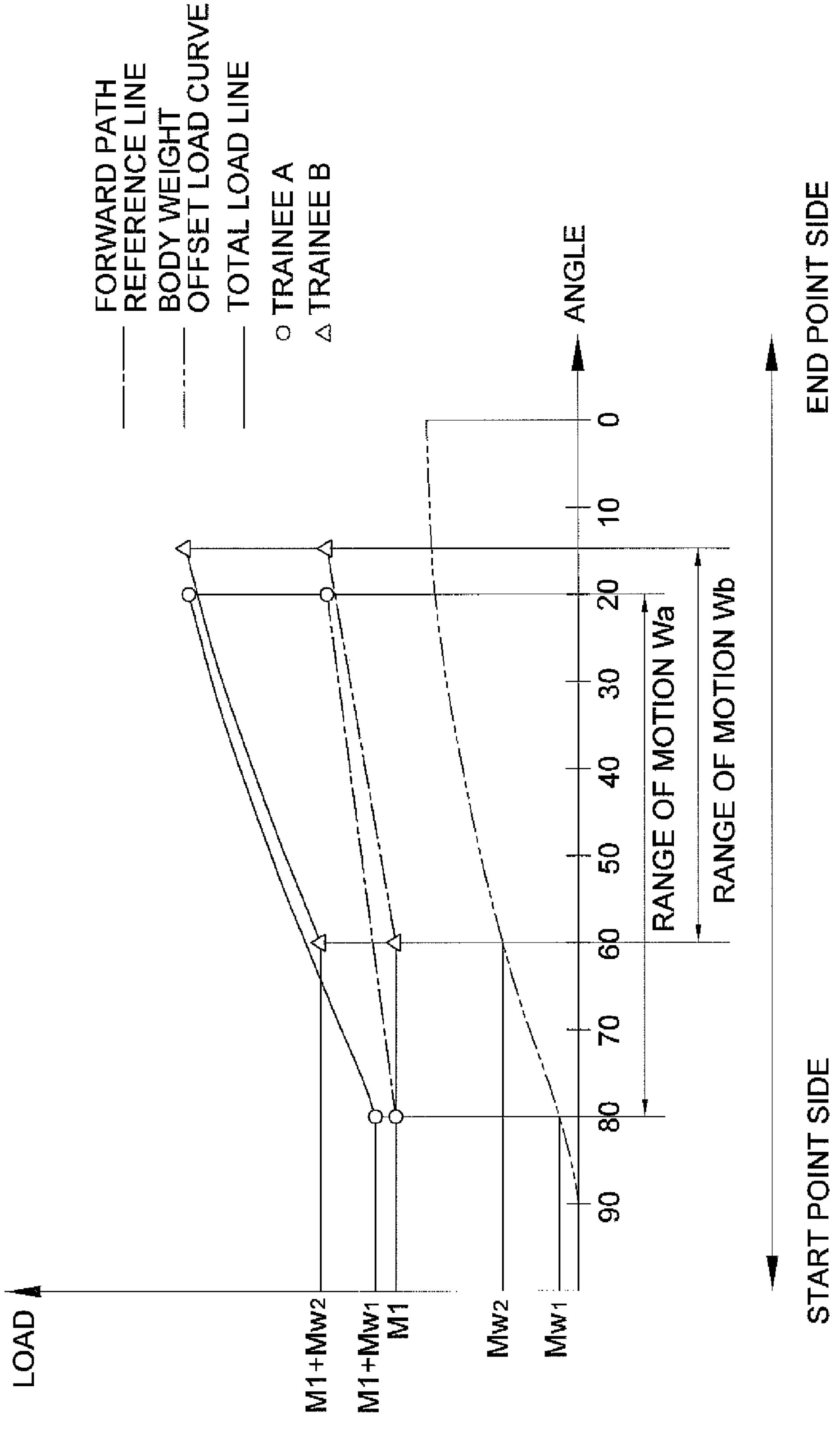

FORWARD PATH REFERENCE LINE
BODY WEIGHT OFFSET LOAD CURVE
TOTAL LOAD LINE
○ TRAINEE A
△ TRAINEE B
LOAD
M1+Mw2
M1+Mw1
M1
Mw2
Mw1
ANGLE
0
10
20
30
40
50
60
70
80
90
RANGE OF MOTION Wa
RANGE OF MOTION Wb
START POINT SIDE
END POINT SIDE

Fig. 13

REFERENCE LOAD	ANGLE (°)	BASE LOAD (A)(kg)	BASE LOAD (B)(kg)	BODY WEIGHT OFFSET LOAD (kg)	LOAD TAKING BODY WEIGHT INTO CONSIDERATION (A)(kg)	LOAD TAKING BODY WEIGHT INTO CONSIDERATION (B)(kg)
25	0			10.0		
	5			10.0		
BODY WEIGHT	10			9.8		
50	15		37.5	9.7		47.2
	20	37.5	36.1	9.4	46.9	45.5
COEFFICIENT n	25	36.5	34.7	9.1	45.5	43.8
0.2	30	35.4	33.3	8.7	44.1	42.0
	35	34.4	31.9	8.2	42.6	40.1
	40	33.3	30.6	7.7	41.0	38.2
	45	32.3	29.2	7.1	39.4	36.2
	50	31.3	27.8	6.4	37.7	34.2
	55	30.2	26.4	5.7	35.9	32.1
	60	29.2	25.0	5.0	34.2	30.0
	65	28.1		4.2	32.4	
	70	27.1		3.4	30.5	
	75	26.0		2.6	28.6	
	80	25.0		1.7	26.7	
	85			0.9 0		

Fig. 14

(BODY WEIGHT) × (1 − BODY FAT PERCENTAGE/100) × (COEFFICIENT A) × (COEFFICIENT B) = (ESTIMATED 1 RM)

COEFFICIENT A	ABDOMINAL MUSCLES	BACK MUSCLES	LEFT OBLIQUES	RIGHT OBLIQUES
MALE	0.87	0.90	0.48	0.48
FEMALE	0.80	0.83	0.48	0.48

COEFFICIENT B	AGE					
	~ 25	26 ~ 35	36 ~ 45	46 ~ 55	56 ~ 65	66 ~
MALE	100	94	91	85	77	69
FEMALE	100	96	93	87	81	74

Fig. 15

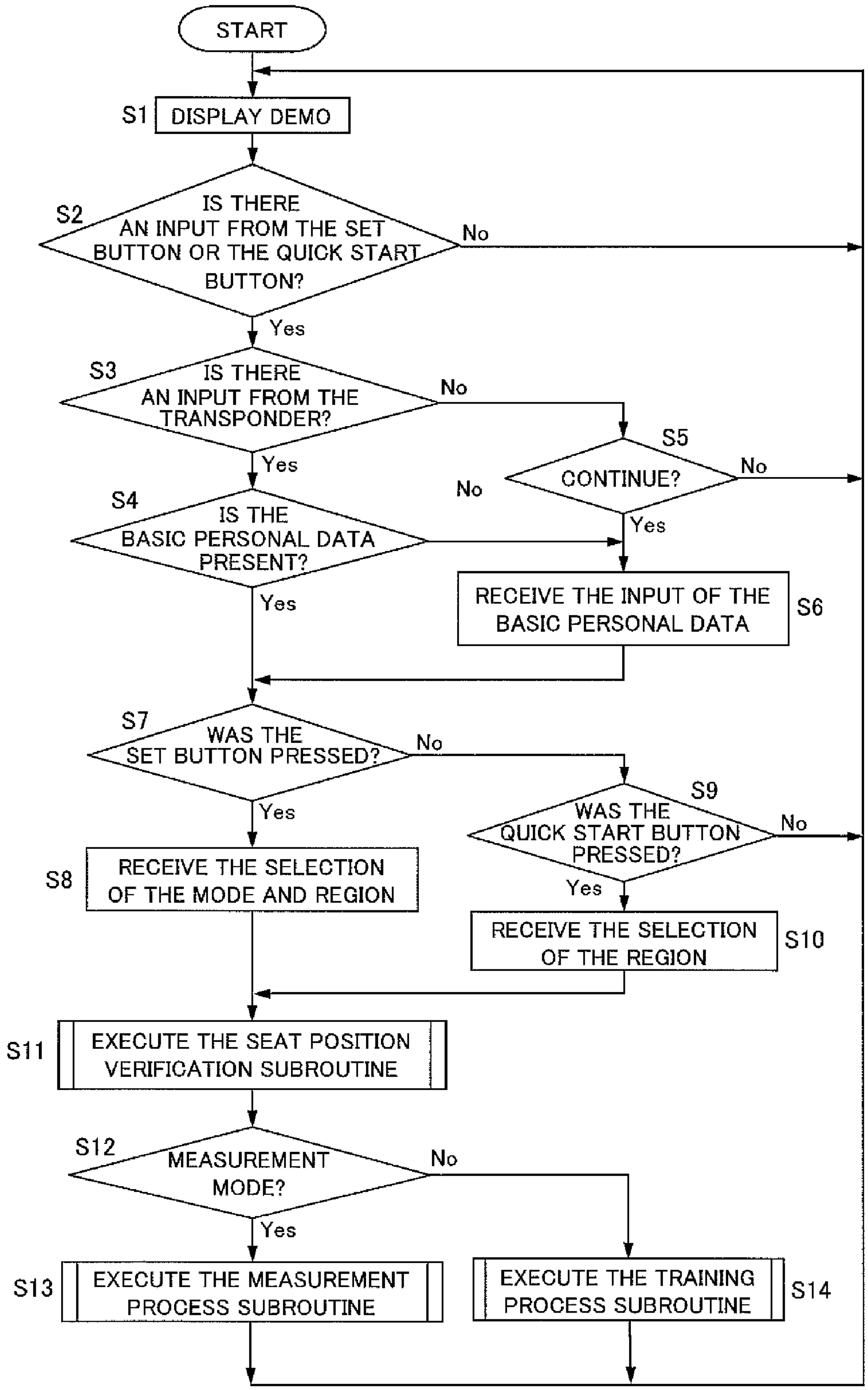

START
S1
DISPLAY DEMO
S2
IS THERE AN INPUT FROM THE SET BUTTON OR THE QUICK START BUTTON?
No
Yes
S3
IS THERE AN INPUT FROM THE TRANSPONDER?
No
S5
CONTINUE?
No
Yes
S4
IS THE BASIC PERSONAL DATA PRESENT?
No
Yes
RECEIVE THE INPUT OF THE BASIC PERSONAL DATA
S6
S7
WAS THE SET BUTTON PRESSED?
No
Yes
S9
WAS THE QUICK START BUTTON PRESSED?
No
Yes
S8
RECEIVE THE SELECTION OF THE MODE AND REGION
RECEIVE THE SELECTION OF THE REGION
S10
S11
EXECUTE THE SEAT POSITION VERIFICATION SUBROUTINE
S12
MEASUREMENT MODE?
No
Yes
S13
EXECUTE THE MEASUREMENT PROCESS SUBROUTINE
EXECUTE THE TRAINING PROCESS SUBROUTINE
S14

Fig. 16

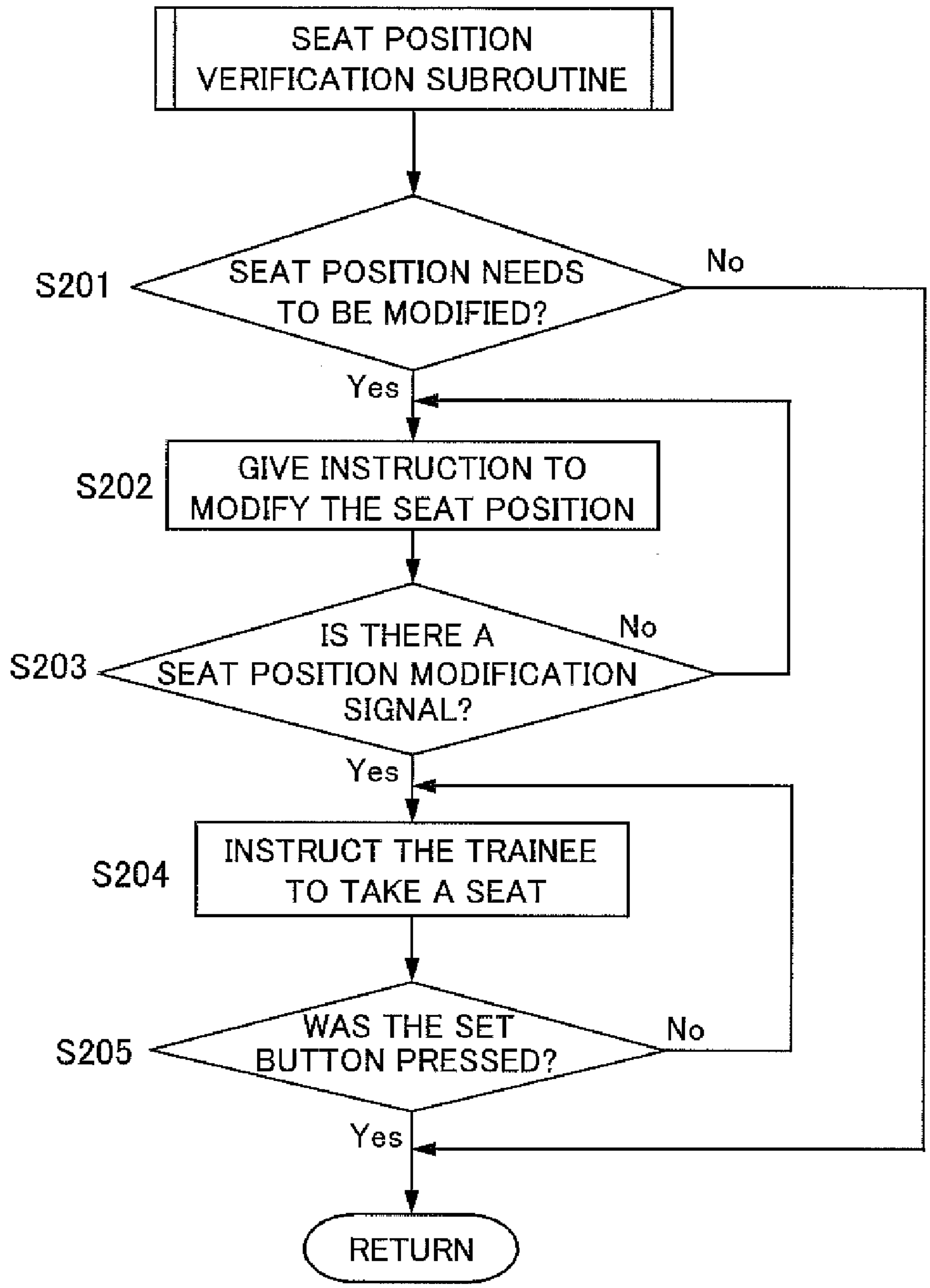

SEAT POSITION
VERIFICATION SUBROUTINE
S201
SEAT POSITION NEEDS
TO BE MODIFIED?
No
Yes
S202
GIVE INSTRUCTION TO
MODIFY THE SEAT POSITION
S203
IS THERE A
SEAT POSITION MODIFICATION
SIGNAL?
No
Yes
S204
INSTRUCT THE TRAINEE
TO TAKE A SEAT
S205
WAS THE SET
BUTTON PRESSED?
No
Yes
RETURN

Fig. 17

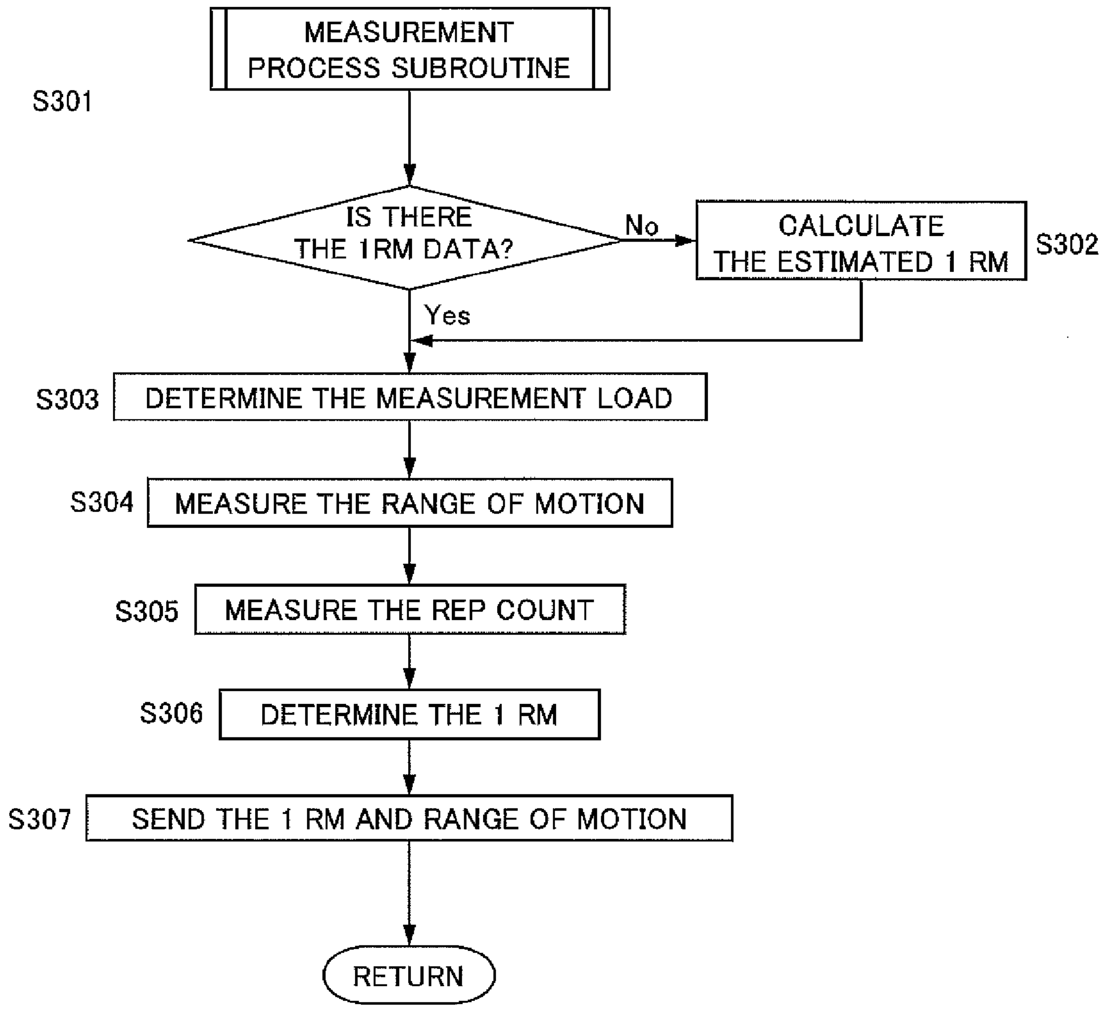

MEASUREMENT PROCESS SUBROUTINE
S301
IS THERE THE 1RM DATA?
No
CALCULATE THE ESTIMATED 1 RM
S302
Yes
S303
DETERMINE THE MEASUREMENT LOAD
S304
MEASURE THE RANGE OF MOTION
S305
MEASURE THE REP COUNT
S306
DETERMINE THE 1 RM
S307
SEND THE 1 RM AND RANGE OF MOTION
RETURN

Fig. 18

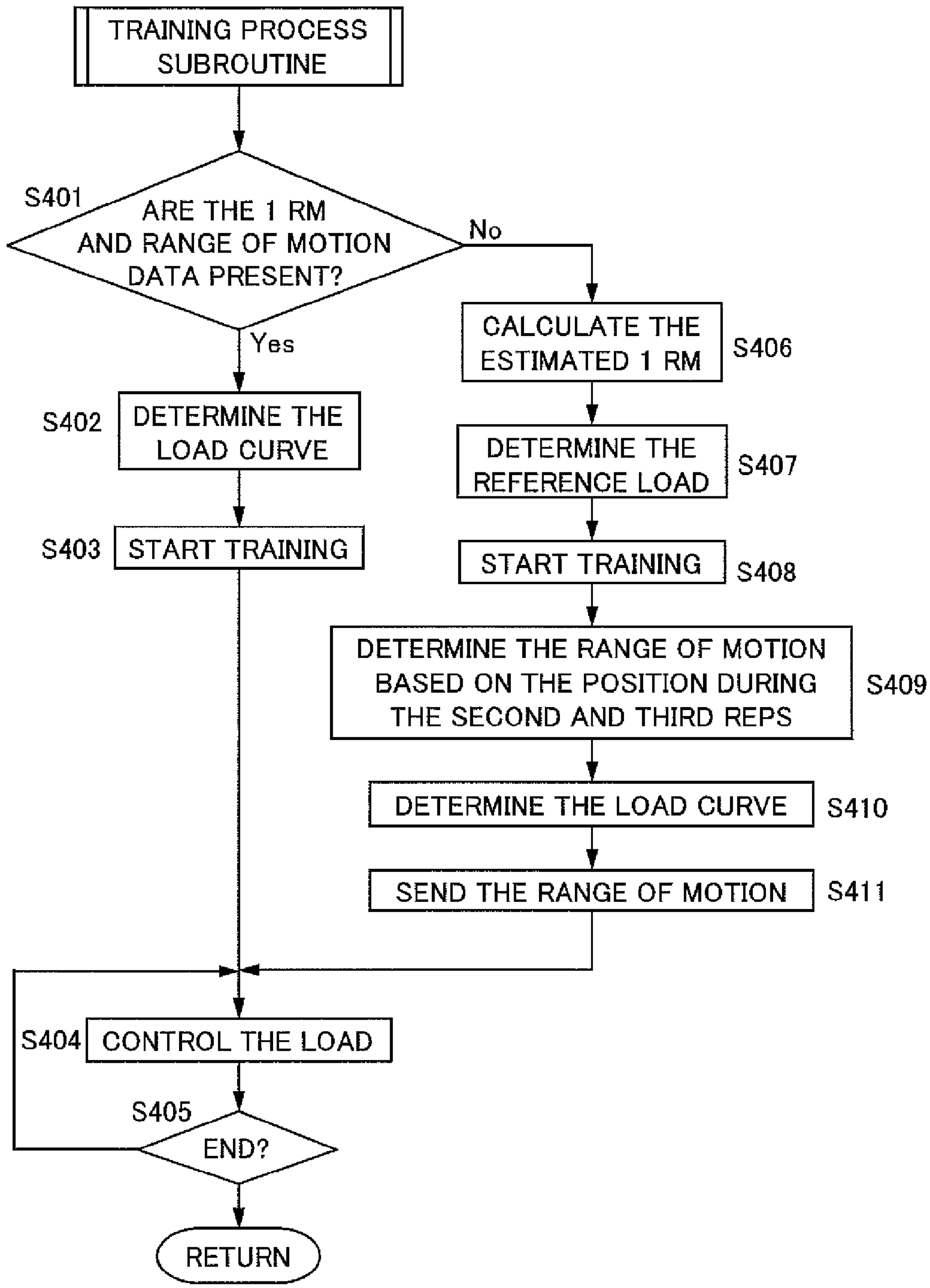

TRAINING PROCESS SUBROUTINE
S401
ARE THE 1 RM AND RANGE OF MOTION DATA PRESENT?
No
Yes
S402
DETERMINE THE LOAD CURVE
S403
START TRAINING
CALCULATE THE ESTIMATED 1 RM
S406
DETERMINE THE REFERENCE LOAD
S407
START TRAINING
S408
DETERMINE THE RANGE OF MOTION BASED ON THE POSITION DURING THE SECOND AND THIRD REPS
S409
DETERMINE THE LOAD CURVE
S410
SEND THE RANGE OF MOTION
S411
S404
CONTROL THE LOAD
S405
END?
RETURN

Fig. 19

TRAINING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Japanese Patent Application No. 2006-061528. The entire disclosure of Japanese Patent Application No. 2006-061528 is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a training machine that is used by an individual to exercise in order to improve physical strength.

[0004] 2. Background Information

[0005] A variety of training machines have been proposed in the past that enable an individual to exercise with an appropriate load. Among these various training machines, there are machines with which a trainee performs repetitive exercise while a load is applied to certain muscles in order to work the muscles that he or she has targeted. For example, Japanese Examined Utility Model Application No. S7-41083 proposes an apparatus for the purpose of training by performing repetitive exercise. This training apparatus uses a direct drive motor as the power source to provide a load that works against the trainee's muscular force, and comprises a muscle load providing apparatus that adjusts the load by controlling the rotation of the direct drive motor in accordance with its torque and rotational speed.

[0006] The load controlling method disclosed in 2006-061528 adjusts the load by controlling the rotation of the direct drive motor in the same manner for every trainee. However, in actuality, individual trainees have different physiques. Differences in physique result in differences in, for example, the amplitude and the width of the rotation of the repetitive exercise. Consequently, the posture taken by each trainee varies when the rotational speed of the direct drive motor is a prescribed fixed value V**1**. However, if the load is applied uniformly to every trainee in accordance with the torque and the rotational speed of the direct drive motor, then the control of the load will be perfect for trainees who have a standard physique, but the change in the load will be inappropriate for trainees who have a build that is smaller or larger than the standard physique. Consequently, the latter trainees cannot exercise appropriately and, therefore, cannot, for example, sufficiently increase the effectiveness of the exercise or are forced into overexertion.

[0007] In view of the above, it will be apparent to those skilled in the art from this disclosure that there exists a need for an improved training machine wherein a trainee can exercise with a load that is in accord with his or her build in the forward and return paths of a repetitive exercise. This invention addresses this need in the art as well as other needs, which will become apparent to those skilled in the art from this disclosure.

SUMMARY OF THE INVENTION

[0008] To solve the abovementioned problems, a first aspect of the invention provides a training apparatus for exercising wherein an electrically powered load generator applies a load to a moving unit that is capable of repetitive motion. This apparatus comprises:

[0009] a range of motion determining unit configured to determine a range of motion, which is a range through which the moving unit performs repetitive motion, in accordance with a trainee; and

[0010] a load controlling unit configured to vary the load, which is applied to the moving unit by the load generator, in accordance with the position of the moving unit in the determined range of motion.

[0011] To take the trainee's physique into account in the range of motion, a load that is suited to the trainee's physique is applied by varying the load in accordance with the position in the range of motion, and thereby the trainee can be made to exercise effectively. The range of motion is preferably determined by measurement. This is because the range of motion that is obtained by measurement can take into account the trainee's physique, joints, etc. The range of motion of each individual trainee is measured at least once, and is preferably measured continuously or intermittently. For example, it may be measured at prescribed time intervals, or prior to or at the start of every exercise. If the range of motion is measured prior to or at the start of every exercise, then it is possible to apply a load in accordance with the trainee's condition, which changes daily, and therefore the trainee improves his or her form when performing exercises.

[0012] The method of varying the load is not particularly limited. For example, a reference load is applied at the start point of the forward path in an abdominal muscles exercise, wherein the trainee leans his or her upper body forward, and a terminal load (terminal load>reference load) is applied at the end point of the forward path. When performing a forward bend exercise, it becomes easier for the trainee to exert his or her abdominal muscles at the end point of the forward path and, consequently, the training becomes commensurately easier; therefore, the load is conversely increased just to the extent that the training has become easier, and it is therefore possible to maintain substantially the same training effect throughout the entire repetitive exercise and thereby make the trainee train effectively. In addition, for example, the load is increased in the vicinity of the center of the forward path in a barbell exercise. The reference load is applied at the start point and the end point of the forward path, and the reference load×N ($1<N<2$) is applied in the vicinity of the center of the forward path. Applying a heavy load at the sticking point in a barbell exercise makes it possible to effectively stimulate the target muscle.

[0013] A training apparatus according to a second aspect of the invention provides a training apparatus according to a first aspect of the invention, further comprising a reference load determining unit configured to determine a reference load, which is a load that is suited to the trainee. In this apparatus, the load controlling unit gradually varies the load applied to the moving unit in a range of values that are greater than or equal to the reference load, which was determined by the reference load determining unit, and less than N times ($1<N<2$) the reference load.

[0014] Because the load curve is determined based on the range of motion and the reference load, the reference load is preferably determined by measurement. For example, the trainee's 1 RM is measured, and the reference load is set to a value that is the product of the measured 1 RM and a prescribed coefficient. Of course, instead of determining the reference load by measurement, the reference load may be associated in advance with the trainee's body weight, gender, age, body fat percentage, and the like, and thereby the reference load may be determined based on the trainee's individual body data. Furthermore, the abovementioned load curve also includes changes in the load that vary linearly. In other words, it also includes the case wherein the forward path and the return path of the moving unit both vary linearly.

[0015] A training apparatus according to a third aspect of the invention provides a training apparatus according to a second aspect of the invention, further comprising a long and deformable power transferring member that transfers the load of the load generator to the moving unit. In this apparatus, the load controlling unit increases the load generated by the load generator and applied to the moving unit at an arbitrary position along the return path of the repetitive exercise so that it is greater than the load generated by the load generator and applied to the moving unit at the identical position along the forward path of the repetitive exercise. The increase in the load along the return path is adjusted commensurate with the decrease in the load due to the kinetic frictional force generated by the power transferring member along the return path.

[0016] The magnitude of the load that is generated by the motor varies between the forward path and the return path. Let us consider an example of a training apparatus for abdominal muscles exercise, which is performed by leaning the upper body forward, wherein the training apparatus is constituted so that a motor is used as the load generator, and a load is applied to the moving unit by coupling the motor and the moving unit with a chain.

[0017] In the forward path, a kinetic frictional force f is generated by the coupling part of the chain structure. The kinetic frictional force f is generated when the trainee tries to lower the moving unit forward, and is generated in the direction opposite the direction in which the object is moved. Because of the kinetic frictional force f, the total load F**1** that is felt by the trainee is the sum (M**1**+f) of the load M**1**, which is applied to the moving unit by the motor, and the kinetic frictional force f.

[0018] In the return path, the trainee moves so as to raise his or her upper body upward while lightly pushing back the moving unit, which is trying to return to the near side. At this time, the total load F**2** felt by the trainee is lighter than the load M**2** that is applied to the moving unit by the motor. This is because the motor continuously applies a load in the upward direction, which is the direction in which the moving unit is pushed. Accordingly, if the loads M**1**, M**2** that are applied to the moving unit by the motor are the same value, then the load in the return path will be lighter than that in the forward path. Accordingly, if the value of the load that is applied by the motor in the return path is, for example, M**2**=(M**1**+2f), then the load applied by the motor will change between the forward path and the return path. The magnitude of the 2f load is, for example, approximately 5 kg. Thereby, the trainee can be made to feel a load that is substantially uniform in both the forward path and the return path.

[0019] A training apparatus according to a fourth aspect of the invention provides a training apparatus according to a second or third aspect of the invention, wherein the load controlling unit configured to linearly increase the load of the moving unit as it moves from the start point to the end point of the repetitive motion in accordance with the positional change of the moving unit, and linearly decrease the load of the moving unit as it moves from the end point to the start point of the repetitive motion in accordance with the positional change of the moving unit.

[0020] For example, in the abovementioned abdominal muscles exercise, the load increases the more the upper body is leaned forward, and decreases the more the upper body is raised upward. Even in this case, if the chain structure couples the motor and the moving unit, then the load generator can apply a load to the moving unit that takes the generation of the kinetic frictional force f into account and is greater in the forward path than in the return path. In addition, if the variation of the load is made linear in this manner, the design of the load control can be simplified. Namely, the change in the load can be unambiguously determined based on the data of the reference load, the terminal load, and the trainee's range of motion, as discussed in detail later.

[0021] A training apparatus according to a fifth aspect of the invention provides a training apparatus according to a first aspect of the invention, wherein the load controlling unit varies the load that is applied to the moving unit based further on a body weight offset load, which changes in accordance with the body weight of the trainee and the position of the moving unit in the range of motion.

[0022] By applying a load that takes into account the effect of body weight when the trainee's posture is such that the body weight can become a resisting force with respect to the load, it is possible to provide a proper stimulus for the target muscles. For example, in the abovementioned abdominal muscles exercise, the more the upper body leans, the more that the weight of the upper body acts as resisting force against the load. Accordingly, if the horizontal position is taken as the base position and the angle that the upwardly inclined upper body (actually, the moving unit, such as the bar) makes with respect to the base position is assigned to θ, then the body weight offset load=body weight×a×cos θ, where $0<a<1$. Actually, the equation for deriving the body weight offset load and its value vary with, for example, the exercise type and the structure of the training apparatus.

[0023] A training apparatus according to a sixth aspect of the invention provides a training apparatus according to a first aspect of the invention, further comprising a selection receiving unit configured to receive the selection of any one among a plurality of exercise types. In this apparatus, the load controlling unit comprises a load pattern storage unit that associates and stores the exercise type and the variation pattern of the load, and varies the load that is applied to the moving unit based on the variation pattern that corresponds to the selected exercise type.

[0024] The method of varying the load can be changed in accordance with the exercise type. Thereby, it is possible to effectively vary the load for each type of exercise and to improve the effectiveness of the exercise. For example, if the exercise is the abovementioned abdominal muscles exercise, then the load in the forward path is increased linearly, and the load in the return path is decreased linearly. If the exercise is the barbell exercise, then the load in the forward path is first increased linearly and then decreased linearly, and the load is maintained at a fixed value in the return path.

[0025] According to the present invention, the exercise effect of each individual trainee can be enhanced because the load can be varied in accordance with the trainee's physical build.

[0026] These and other objects, features, aspects and advantages of the present invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses a preferred embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Referring now to the attached drawings which form a part of this original disclosure:

[0028] FIG. **1** is a training apparatus according to the first embodiment of the present invention.

[0029] FIG. **2** is one example (a front perspective view) of the training apparatus in FIG.

[0030] FIG. **3** is one example (a rear perspective view) of the training apparatus in FIG. **1**.

[0031] FIG. **4** is a conceptual explanatory diagram of personal data accumulated in the server in FIG. **1**.

[0032] FIG. **5** is one example of a menu screen that receives the selection of the mode.

[0033] FIG. **6** is one example of a personal data input receiving screen.

[0034] FIG. **7** is an indication screen (abdominal muscles exercise).

[0035] FIG. **8** is an indication screen (back muscles exercise).

[0036] FIG. **9** is an indication screen (right obliques exercise).

[0037] FIG. **10** is an indication screen (left obliques exercise).

[0038] FIG. **11** explains the principle upon which the method of determining the load curve is based. Drawing (A) shows the ranges of motion Wa, Wb, which differ in accordance with the different trainees A, B. Drawing (B) is one example of abdominal muscle exercise load curves in accordance with ranges of motion Wa, Wb.

[0039] FIG. **12** is a load curve that takes the kinetic frictional force f, which is generated by the chain shown in FIG. **3**, into consideration.

[0040] FIG. **13** is a load curve that takes a body weight offset load into consideration.

[0041] FIG. **14** is an example of specific values of loads.

[0042] FIG. **15** is an explanatory diagram that shows one example of an equation for deriving the estimated 1 RM.

[0043] FIG. **16** is a flow chart that shows one example of the flow of a main routine, which is executed by the calculation unit in FIG. **1**.

[0044] FIG. **17** is a flow chart that shows one example of the flow of a seat position verification subroutine, which is executed by the calculation unit in FIG. **1**.

[0045] FIG. **18** is a flow chart that shows one example of the flow of a measurement process subroutine, which is executed by the calculation unit in FIG. **1**.

[0046] FIG. **19** is a flow chart that shows one example of the flow of a training process subroutine, which is executed by the calculation unit in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0047] Selected embodiments of the present invention will now be explained with reference to the drawings. It will be apparent to those skilled in the art from this disclosure that the following descriptions of the embodiments of the present invention are provided for illustration only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

[0048] In a training apparatus according to the present invention, a motor applies a load to a bar (corresponds to a moving unit) that moves repetitively due to a trainee's exercise. The load that is applied by the motor is not fixed, but rather varies during the repetitive motion. The width of the repetitive motion, i.e., the width of the range of motion of the bar, takes into account differences in the physique and flexibility of individual trainees. Consequently, varying the method by which the load changes in accordance with the width of the range of motion makes it possible to apply a load that is suited to the physique and body of each individual trainee, thereby enabling the trainee to exercise effectively.

First Embodiment

Training Apparatus Configuration

[0049] FIG. **1** is an explanatory diagram that shows the hardware configuration and the functional configuration of a training apparatus **100** according to the first embodiment of the present invention. The hardware configuration and the functional configuration of the training apparatus **100** will now be explained successively, referencing FIG. **1**.

(1) Hardware Configuration

(1-1) Overall Configuration

[0050] The training apparatus **100** is installed in, for example, a facility such as a health club, and is connected to an on-site server **200**. The server **200** accumulates personal data of trainees and transmits such in response to requests from the training apparatus **100**. Furthermore, in the present embodiment, the server **200** is only installed in a facility such as a health club, but an off-site server (not shown) can also be provided that connects on-site servers nationally or globally. Membership data may be accumulated in such an off-site server and each on-site server may access that data.

[0051] The training apparatus **100** comprises a torque motor **15** (corresponds to a load generator), a motor signal processing unit **23**, a sensor **24**, a control unit **30**, an input unit **50**, a monitor **70**, and a speaker **90**. The torque motor **15** applies the load to the bar (discussed later). The motor signal processing unit **23** transmits data regarding, for example, the rotational direction, the rotational speed, and the rotational count of the torque motor **15** to the control unit **30**. The sensor **24** is provided at a prescribed location of the training apparatus **100** and detects, for example, the orientation of the seat (discussed later). The control unit **30** is a computer that comprises, for example, a CPU, ROM, RAM, and a hard disk. The functions of the control unit **30** will be discussed later in detail. The input unit **50** has a function that receives the input of data, which can be implemented by, for example, a receiver unit of a transponder as well as a numeric keypad unit or a card reader. The monitor **70** and the speaker **90** each function as a reporting unit that reports information, such as announcements and exercise guidance for the trainee, and outputs images and speech in accordance with a program that is stored in the control unit **30**.

(1-2) One Example of the Training Apparatus

[0052] FIG. **2** and FIG. **3** depict one example of the exterior of the training apparatus **100**. The training apparatus **100** in this example has a structure wherein a trainee who is seated on a seat **16** can work the abdominal and back muscles and the left and right oblique muscles by repetitively moving a bar **11** (corresponds to the moving unit) about a rotary shaft.

[0053] The bar **11** is rotatable about the rotary shaft and is coupled to a chain **13**. The chain **13** is looped on two pulleys **14***a*, **14***b*. The pulley **14***b* shares a rotary shaft with the torque motor **15**. When the trainee swings the bar **11**, the chain **13** moves and the pulleys **14***a*, **14***b* thereby begin to rotate. At this point, the torque motor **15** applies torque to the pulley **14***b*, which impresses a load upon the bar **11**. Furthermore, it is also possible to use, for example, a servomotor or a stepping motor instead of the torque motor. In addition, a load may be applied to the bar **11** by using, for example, a solenoid brake in place of the motor.

[0054] The seat **16** can rotate between an A direction and a B direction in the figure. The A direction in the figure is at a right angle to the B direction. The trainee exercises facing the A direction or the B direction in the figure. With the seat **16** in a first position at which it is oriented in the A direction as shown in FIG. **2**, the trainee performs an abdominal muscle exercise by placing his or her feet on a footrest **17***a*, hugging the bar **11**, and then pushing it with his or her upper body forward and downward, or performs a back muscle exercise by pushing the bar **11** upward with his or her back. With the seat **16** in a second position at which it is oriented in the B direction in FIG. **2**, the trainee performs a left obliques exercise by placing his or her feet on a footrest **17***b*, tucking the bar **11** under his or her left side, and then pushing it downward, or performs a right obliques exercise by tucking the bar **11** under his or her right side and then pushing it downward.

[0055] The sensor **24** (refer to FIG. **1**) is provided below the seat **16**, detects the direction of the seat **16**, and sends a detection signal to the control unit **30**.

[0056] A stopper **40** is provided in order to set a mechanically movable limiting point for the bar **11** when each type of training is performed. Using the stopper **40** to provide a mechanically movable limit for the presumed range of exercise during training makes it possible to avoid situations wherein an overload is applied to the trainee's body as a result of overdoing the exercise, or wherein the trainee performs a sudden action. Although omitted from the drawings, the mechanically movable limiting point of the bar **11** is preset in accordance with, for example, each of the abovementioned exercises, i.e., abdominal muscle exercise, back muscle exercise, and left and right obliques exercise. The modification of the setting of the limiting point is manually performed by the trainee. If the stopper **40** is lifted to an upper part, then the fixed state of the stopper **40** is released. The bar **11** is fixed at each limiting point by moving it to the relevant limiting point and, at that point, dragging the stopper **40** downward. The position of the stopper **40** shown in FIG. **2** and FIG. **3** is set when the trainee performs back muscle exercise.

[0057] Furthermore, with abdominal muscle exercise and left and right obliques exercise, the more the trainee leans his or her upper body in the forward direction or in the lateral direction, the easier it is for the trainee to exert his or her abdominal muscles or obliques muscles and, consequently, the easier it is for the trainee to push the bar **11** downward. Furthermore, the more the trainee leans his or her upper body downward, the more that the weight of the upper body itself becomes a resisting force that pushes the bar **11** downward and thereby functions to assist the force of the muscles. Consequently, the load varies with abdominal muscle exercise and left and right obliques exercise so that the load increases the more the bar **11** is pushed downward. The method of varying the load is discussed later in detail.

(2) Functional Configuration

(2-1) Control Unit

[0058] The following explains the functions of the training apparatus **100**. The functions of the training apparatus **100** are implemented by the control unit **30**. The details of the control unit **30** will now be explained, referencing FIG. **1** once again. The control unit **30** has the functions described in (a) through (f) below:

[0059] (a) a detection signal processing unit **31** that processes detection signals from the motor signal processing unit **23** and the sensor **24**, and sends them to a calculation unit **36**;

[0060] (b) a receive unit **32** that receives input signals, such as personal data, inputted by the unit **50**, and sends them to the calculation unit **36**.

[0061] (c) a communication control unit **33** that sends and receives personal data to and from the server **200**;

[0062] (d) an image generating unit **34** that generates display data and sends such to the monitor **70**;

[0063] (e) a speech control unit **35** that generates voice data and sends such to the speaker **90**; and

[0064] (d) a calculation unit **36** that controls each unit in the control unit **30** by executing a program stored in, for example, ROM (not shown).

(2-2) Calculation Unit

[0065] The calculation unit **36** comprises a range of motion determination unit **36***a*, a load control unit **36***b*, a reference load determination unit **36***c*, a selection receiving unit **36***d*, and a training information processing unit **36***e*. The load control unit **36***b* further comprises a load pattern storage unit **36***b*-**1**. The following explains the function of each unit.

(2-2-1) Personal Data

[0066] FIG. **4** is a conceptual explanatory diagram of personal data that is acquired from the server **200** by the training information processing unit **36***e*. First, personal data will be explained because various functions that are discussed later are implemented based on personal data.

[0067] Personal data includes a trainee ID, basic personal data, and supplemental personal data. The trainee ID is an identifier that identifies the trainee. Basic personal data is information about the trainee's body such as his or her gender, age, body weight, and body fat percentage.

[0068] Supplemental personal data includes information that is needed in order to determine the estimated 1 RM (repetition maximum), which is discussed later. Supplemental personal data is, for example, the trainee's 1 RM (repetition maximum) and the range over which he or she can move the bar **11**, and is stored for each training type. Supplemental personal data is acquired by the training apparatus **100** by performing measurements and is sent to the server **200**. When measuring the 1 RM and the range of motion for the type of training about to be performed, a load curve is determined based on a reference load, which is derived from the 1 RM, and the range of motion. Conversely, when there is no supplemental personal data for the type of training about to be performed, the estimated 1 RM is calculated based on the basic personal data and the range of motion is measured immediately after the start of training. Furthermore, the load curve is determined based on the range of motion and the reference load, which is derived from the estimated 1 RM. The determination of the load curve is discussed later in detail.

(2-2-2) Selection Receiving Unit

[0069] The selection receiving unit **36***d* receives the selection of, for example, various modes, which are discussed later, and the training type. FIG. **5** shows an example of a menu screen that is output by the selection receiving unit **36***d* to the monitor **70**. The menu screen receives the selection of any of a variety of modes. In this figure, a measurement mode ("physical strength measurement mode" in the figure) is selected. With the measurement mode, the 1 RM, the range of motion, and the like, which are supplemental personal data, are measured for every training type. This menu screen additionally receives the selection of the modes "rhythmic workout," "manual," "circuit training," "slow-paced training," and "muscular endurance measurement." Furthermore, although not shown, the selection receiving unit **36***d* receives the selection of the training type in each mode, i.e., "physical strength measurement mode," "rhythmic workout," "manual," "circuit training," and "slow-paced training." With the present training apparatus **100**, the training types are abdominal muscle exercise, back muscle exercise, right obliques exercise, and left obliques exercise.

(2-2-3) Training Information Processing Unit

[0070] The training information processing unit **36***e* receives the input of basic personal data and executes, for example, a training process for each mode and a training method explanation process.

[0071] FIG. **6** is a personal data input receiving screen that is output to the monitor **70** by the training information processing unit **36***e*. This screen receives the input of basic personal data that was input via the input unit **50**. The inputted basic personal data is sent to the on-site server **200** and written to a storage space (not shown) thereof.

[0072] FIG. **7** is an indication screen that is output to the monitor **70** by the training information processing unit **36***e* if "abdominal muscle exercise" is selected as the training type. In the figure, "crunch" indicates that the training type is "abdominal muscle exercise."

[0073] FIG. **8** is an indication screen that is output to the monitor **70** by the training information processing unit **36***e* if "back muscle exercise" is selected as the training type. In the figure, "back extension" indicates that the training type is "back muscle exercise."

[0074] FIG. **9** is an indication screen that is output to the monitor **70** by the training information processing unit **36***e* if "right obliques exercise" is selected as the training type. In the figure, "right side bend" indicates that the training type is "right obliques exercise."

[0075] FIG. **10** is an indication screen that is output to the monitor **70** by the training information processing unit **36***e* if "left obliques exercise" is selected as the training type. In the figure, "left side bend" indicates that the training type is "left obliques exercise."

(2-2-4) Load Control Unit

[0076] The load control unit **36***b* determines a load curve based on the range of motion of the bar **11** and the reference load, and adjusts the value of the load that is applied by the torque motor **15** to the bar **11** based on that determined load curve. Furthermore, the range of motion determination unit **36***a* determines the range of motion and the reference load determination unit **36***c* determines the reference load, which are both discussed later in detail. To simplify the explanation, the following takes up an example of a case wherein the training type is abdominal muscle exercise.

[0077] FIG. **11** is a diagram for explaining the principle upon which the method of determining the load curve is based. Here, the load curve also includes linear variation. The load control unit **36***b* determines the load curve in accordance with the width of the trainee's range of motion. The load curve defines the load value in accordance with the position in the range of motion. The load value is preferably greater than or equal to the reference load and in a range that does not exceed twice the reference load. The method of varying the load can be appropriately set by, for example, the training type and the configuration of the training apparatus **100**.

[0078] FIG. **11**(A) shows ranges of motion Wa, Wb, which differ in accordance with different trainees A, B. In this figure, the position of the bar **11** when it is at the highest point is 90°, and the position of the bar **11** when it is rotated 90° downward therefrom is 0°. The range of motion Wa of the trainee A is 80°-20° and the range of motion Wb of the trainee B is 60°-15°.

[0079] FIG. **11**(B) shows one example of abdominal muscle exercise load curves in accordance with the ranges of motion Wa, Wb. To simplify the explanation, the reference loads in this example when the trainees A, B train are the same value M1. According to the present load curves, the load values linearly increase from M1 to M1' when the bar **11** moves from the start point to the end point of the ranges of motion, and linearly decrease from M1' to M1 when the bar **11** moves in the reverse direction. The width of the range of motion Wa of the trainee A and the width of the range of motion Wb of the trainee B. i.e., the amplitudes of the bar **11**, are different, and the slopes of their load curves consequently differ. Accordingly, the load value based on the load curve for the trainee A and the load value based on the load curve for the trainee B differ even when the bar **11** is at the same position. Thus, the load curve is determined in accordance with the width of the range of motion, which differs for each trainee, and it is therefore possible to optimize each individual trainee's exercise and to improve the efficiency of his or her exercise by controlling the load applied to the bar **11**. The load M1' at the end point of the range of motion is called a terminal load. The terminal load value M1' is N ($0<N<1$) times the reference load M1. When performing a forward bend exercise, it becomes easier for the trainee to exert his or her abdominal muscles at the end point of the forward path and, consequently, the training becomes commensurately easier; therefore, the load is conversely increased just to the extent that the training has become easier, and it is therefore possible to maintain substantially the same training effect throughout the entire repetitive exercise and thereby make the trainee train effectively. Furthermore, the same applies for left and right obliques exercise.

[0080] In the above example, the load varies linearly, which simplifies the design of the load control as the line of the linear variation can be simply derived if the reference load M**1**, the terminal load M**1'**, and the ranges of motion (Wa, Wb) are determined. If the load varies other than linearly, e.g., if the load varies curvilinearly, or if the load varies, albeit linearly, so that its maximum increase is at the center of the range of motion (as in a barbell exercise), then data that is prestored in the load pattern storage unit **36***b*-**1** can be referenced and a correspondence made therewith (refer to other embodiment (A), which is discussed later).

[0081] FIG. **12** is a load curve that takes into consideration a kinetic frictional force f, which is generated by the chain **13**. To simplify the explanation, a load curve will be explained wherein the kinetic frictional force f has been added to the load curve of the trainee A in FIG. **11**(A). The load curve indicated by the chain line in the figure is that of the forward path, and the load curve indicated by the chain double-dashed line is that of the return path. The load curve of the forward path coincides with the load curve shown in FIG. **11**(B). The load curve of the return path is determined so that it is higher than the load of the forward path at the same position by a fixed value of 2f. As shown in this drawing, the load curve may differ for the forward path and the return path.

[0082] It is preferable to take the kinetic frictional force f into consideration for the following reason. In the forward path, when the trainee is about to push the bar **11** forward, a kinetic frictional force f is generated by the chain **13**. Consequently, a total load F**1** that is felt by the trainee is the sum of the load M**1**, which is applied to the bar **11** by the motor, and the kinetic frictional force f, i.e., F**1**=(M**1**+f).

[0083] In the return path, the trainee returns his or her upper body to the start point side while lightly pulled back the bar **11**, which is trying to return to the near side. This is because the torque motor **15** continuously applies a load in the direction in which the bar **11** is pushed upward. At this time, a total load F**2** felt by the trainee is lighter than the load M**2** applied to the bar **11** by the torque motor **15**. In actuality, the value is the difference of the kinetic frictional force f from the load M**2**, i.e., on the order of F**2**=(M**2**−f). Accordingly, if the loads M**1**, M**2** that are applied to the bar **11** by the torque motor **15** are the same value (M**1**=M**2**), then the load in the return path will be lighter than that in the forward path (F**2**<F**1**). Accordingly, the load that is applied by the torque motor **15** in the return path is set to M**2**=(M**1**+2f). Thereby, the total load F**2** that is felt by the trainee in the return path is F**2**=(M**2**−f)=((M**1**+2f)−f)=(M**1**+f)=F**1**. Thereby, the trainee can be made to feel a uniform load in the forward path and the return path, and an effective load can be applied to the trainee's muscles even in the return path. Furthermore, the difference in the loads of the forward path and the return path can be appropriately set based on the structure of the training apparatus **100**.

[0084] FIG. **13** is a load curve that takes the impact of body weight and posture on training into consideration. Applying a load that takes into account the effect of body weight when the trainee's posture is such that the body weight can become a resisting force with respect to the load makes it possible to provide a proper stimulus for the target muscles. For example, when using the present training apparatus **100** for abdominal muscle exercise, the more the upper body moves downward, the more the weight of the upper body acts as a resisting force with respect to the load (i.e., the easier the exercise becomes for the trainee). This applies likewise to left obliques and right obliques exercises. Accordingly, to offset that resisting force with respect to the load, it is preferable to further increase the load as the bar **11** descends to the end point side. The increase in the load is called the body weight offset load. The body weight offset load can be represented by the following equation. The equation for deriving the body weight offset load and its value can be appropriately set based on, for example, the exercise type, the training mode, and the structure of the training apparatus **100**.

$$(\text{Body weight offset load})=(\text{body weight})\times a\times\cos\theta$$

[0085] Therein, 0<a<1.

[0086] The angle θ indicates the position of the bar **11** (if the horizontal position is taken as the base position, then it is the angle of the bar **11** with respect to the base position).

[0087] The load curve represented by the chain line in FIG. **13** is identical to the load curves of the trainees A, B shown in FIG. **11**(B). The chain double-dashed line in FIG. **13** represents the body weight offset load. To simplify the explanation, the body weights of the trainees A, B are identical and a single body weight offset load curve is shown. The load curve represented by the solid line is the sum total of the base load, which is defined by the load curve shown in FIG. **11**(B), and the body weight offset load.

[0088] FIG. **14** is an explanatory diagram that shows examples of specific load values. Each base load of each of the trainees A, B is associated with an angle, which indicates a position of the bar **11**. In the present example, the reference load M**1** is 25.0 kg and the terminal load M**1'** is 37.5 kg. The body weight offset load varies with the angle in a range of 0-10.0 kg. As a result of taking the body weight offset load into consideration, the load for the trainee A varies in the range of 26.7-46.9 kg when the bar **11** moves in the range of 80°-20°. The load for the trainee B varies in the range of 30.0-47.2 kg when the bar **11** moves in the range of 60°-15°.

(2-2-5) Range of Motion Determination Unit

[0089] The range of motion determination unit **36***a* determines the range of motion, which is needed to determine the load curve, by performing a measurement. The range of motion is determined for each training type and each trainee.

[0090] For example, before training starts, the range of motion determination unit **36***a* can measure the range of motion in the measurement mode ("physical strength measurement mode" in FIG. **5**). The measured range of motion is written to the personal data in the server **200** and is used to determine the load curve when training is performed. If the range of motion is measured in the measurement mode, then the range of motion is measured by applying a small load of approximately 3.0-5.0 kg to the bar **11** and monitoring the position of the bar **11** for at least one rep. In so doing, the range of motion data, which represents the measured range of motion, is sent to the server **200** and written to the supplemental personal data. If range of motion data has already been written for the identical training type, then it is overwritten with the latest range of motion data.

[0091] In addition, for example, if range of motion data is not included in the personal data for the training type at the start of such training, then the range of motion determination unit **36***a* may measure the range of motion. Specifically, after repetitive exercise begins, a start point S and an end point E are preferably determined based on the respective average values of start points S**2**, S**3** and end points E**2**, E**3**, which are the points of the second and third reps of the first three reps. The range interposed between the measured start point S and end point E constitutes the range of motion. The measured range of motion data is sent to the server **200** and written to the personal data. In other words, if training is about to begin when range of motion data for that training does not exist in the personal data, then the range of motion is initially measured when the training starts. It is advantageous that the trainee can train without having to measure the range of motion in a measurement mode, e.g., the "physical strength measurement" mode in FIG. **5**.

[0092] Based on the above, the range of motion determination unit **36***a* can measure the range of motion in accordance with each trainee so that a measurement is performed at least once for each individual training type and for each individual trainee. Accordingly, it is possible to acquire ranges of motion that reflect differences in, for example, the physique and the flexibility of the trainees, and thereby to determine load curves that are suited to the physique and body of the trainees. With a training apparatus that does not set the range of motion and causes the bar **11** to perform a rep in a prescribed fixed range at the start of training, there are cases wherein, for example, an elderly person cannot sufficiently bend forward and, because he or she cannot push the bar **11** forward and downward, is assigned a training menu that he or she cannot handle (e.g., the number of reps he or she performs is not counted). On this point, according to the present embodiment, the range through which that elderly person can move the bar **11** is determined by the training apparatus, and therefore training is performed with the forward and return paths set to that range, which makes it possible for him or her to perform training efficiently and without overexertion. In addition, there are also cases wherein, instead of performing repetitive exercise over a wide range of motion, the trainee wishes to perform numerous reps of repetitive exercise over a narrow range of motion, but such an exercise cannot be accommodated if the range of action is decided from the start. Furthermore, if the training apparatus is one wherein weights are used, then there is also a possibility that the trainee will perform repetitive exercise over a narrow range of motion based on his or her own judgment, and there is therefore a possibility in this case that the setting of the terminal load cannot be increased or that the number of reps cannot be counted. In contrast, with the present embodiment, the trainee can purposefully set the range of motion in the "physical strength measurement mode" or in some other training mode, and therefore training can be performed in his or her desired range of motion and the number of reps he or she performs can be accurately counted.

[0093] Furthermore, the range of motion determining method is not limited to the present embodiment. It is preferable to use a method that is appropriate to the structure of the training apparatus and to the training type.

(2-2-6) Reference Load Determination Unit

[0094] The reference load determination unit **36***c* calculates the reference load, which is needed to determine the load curve, from the 1 RM value. The reference load is a value that is the product of the 1 RM value, which is included in the personal data, and a prescribed coefficient, e.g., 0.8, and is empirically derived in accordance with the structure of the training apparatus **100**. Like the range of motion, the reference load is determined for each training type and for each trainee. In addition, the reference load determination unit **36***c* can determine the 1 RM, which is needed to derive the reference load, by measuring or calculating as follows.

[0095] For example, prior to the start of training, the reference load determination unit **36***c* measures the 1 RM in the measurement mode ("physical strength measurement mode" in FIG. **5**). The measured 1 RM is written to the personal data in the server **200** and is used to determine the load curve during training. If the 1 RM is not measured in the measurement mode, then the reference load determination unit **36***c* calculates the estimated 1 RM based on the basic personal data of the trainee and a prescribed equation.

[0096] FIG. **15** is an explanatory diagram that shows one example of an equation to derive the estimated 1 RM. In the present example, the estimated 1 RM is derived by the following equation.

$$(\text{Estimated 1 } RM)=(\text{body weight})\times(1-\text{body fat percentage}/100)\times(\text{coefficient } A)\times(\text{coefficient } B)$$

[0097] Therein, the coefficient A varies with the training type and gender and is empirically derived. The coefficient B varies with age and gender and is empirically derived.

[0098] Furthermore, the reference load determination unit **36***c* applies the measurement load and measures how many reps the trainee performed with the bar **11**, and converts the measurement load to the 1 RM based on a prescribed conversion table (not shown). Here, the measurement load is set to, for example, a magnitude of 75% of the estimated 1 RM. Furthermore, if there is 1 RM data in the on-site server **200** that was acquired in the past for that trainee, then a magnitude of, for example, 75% of that 1 RM is used as the measurement load. The rep count when under the measurement load and coefficients for deriving the 1 RM are associated in the prescribed conversion table. For example, if ten reps is the limit when under the measurement load, then the 1 RM is derived by 1 RM=measurement load/0.75. In addition, for example, if the limit is four reps when under the measurement load, then the 1 RM is derived by 1 RM=measurement load/0.9. The value of the derived 1 RM is sent to the server **200** and written in the supplemental personal data. If a 1 RM value already exists for the identical training type, then it is overwritten with the latest value.

[0099] In addition, for example, when starting training without going through the measurement mode, if the 1 RM for that training type is not included in the personal data, then the reference load determination unit **36***c* may calculate the estimated 1 RM and set the reference load to the product of that calculated value and a prescribed coefficient. In other words, if the 1 RM value for some training does not exist in the personal data when that training is about to start, then the estimated 1 RM is determined by calculation prior to the start of the training and the reference load may be derived directly therefrom. It is advantageous that the trainee can train without having to measure the 1 RM in the measurement mode.

[0100] Based on the above, the reference load determination unit **36***c* derives the reference load in accordance with the trainee based on the 1 RM or the estimated 1 RM. Accordingly, the trainee's individual characteristics can be taken into account in the reference load. Deriving the load curve based on the reference load derived in this manner and the range of motion that reflects the trainee's physique makes it possible to determine a load curve that is suited to each trainee.

[0101] Furthermore, the reference load determining method is not limited to the present example. It is preferable to use a method that is suited to the structure of the training apparatus and the training type.

Process Flow

[0102] The following explains an embodiment of the process executed by the calculation unit **36** of the training apparatus **100**. To simplify the explanation, an example of a case will be considered wherein abdominal muscle exercise has been selected as the training type. The calculation unit **36** broadly executes (1) a main routine, (2) a seat position verification subroutine, (3) a measurement process subroutine, and (4) a training process subroutine.

(1) Main Routine

[0103] FIG. **16** is a flow chart that shows one example of the flow of the main routine executed by the calculation unit **36**. The main routine, for example, acquires personal data, receives the mode selection, the training type selection, etc., and switches the process in accordance with the mode.

[0104] Step S**1**: When the training apparatus **100** starts up, the calculation unit **36** starts a demonstration that shows an overview of a training method.

[0105] Step S**2**: While the demonstration is executed, the calculation unit **36** stands by for the input of a set button or a quick start button. The set button and the quick start button are provided to the input unit **50** (not shown).

[0106] Steps S**3**-S**6**: The calculation unit **36** either acquires the personal data from the server **200** or has the trainee input such. Specifically, if a user ID is input from the transponder during the demonstration (S**3**), then the calculation unit **36** acquires personal data that corresponds to the inputted user ID from the on-site server **200**. If there are no omissions in the basic personal data within the acquired personal data (S**4**), then the process transitions to step S**7**. If there is no input from the transponder (S**3**), then the calculation unit **36** outputs a notification to the effect that it cannot authenticate the trainee and therefore inquires as to the trainee's intention to continue the process (S**5**). If there is an intention to continue, then a data input screen (refer to FIG. **6**) is displayed and the input of basic personal data is received (S**6**). In addition, if there are any omissions in the basic personal data that was acquired from the on-site server **200**, then the input of basic personal data is received from the data input screen (S**4** and S**6**).

[0107] Steps S**7**-S**8**: If the set button was pressed during the demonstration (S**7**), then the calculation unit **36** receives the selection of the mode and the training type (noted as the region in the figure) from the trainee (S**8**).

[0108] Steps S**9**-S**10**: If the quick start button was pressed (S**9**), then the calculation unit **36** sets the "manual mode" and receives the selection of the training type (noted as the region in the figure) from the trainee (S**10**). In addition, the calculation unit **36** may receive the setting of, for example, a target count and a target time.

[0109] Step S**11**: The calculation unit **36** executes the seat position verification subroutine, which is discussed later. This process determines the seat position in accordance with the region of the training about to be performed.

[0110] Step S**12**: The calculation unit **36** determines whether the mode received in step S**8** is the measurement mode (noted as the "physical strength measurement" mode in FIG. **5**), and the process proceeds to step S**13** if it is the measurement mode and proceeds to step S**14** if it is otherwise.

[0111] Step S**13**: The measurement mode was selected, and therefore the calculation unit **36** executes the measurement process subroutine, which is discussed later. In this process, the calculation unit **36** measures the 1 RM and the range of motion and sends the measurement results to the server **200**.

[0112] Step S**14**: A mode other than the measurement mode was selected, and therefore the calculation unit **36** executes the training process subroutine, which is discussed later. In this process, the calculation unit **36** performs training in accordance with the mode. In addition, the calculation unit **36** measures the range of motion and calculates the estimated 1 RM as needed.

(2) Seat Position Verification Subroutine

[0113] FIG. **17** is a flow chart that shows one example of the flow of the process of the seat position verification subroutine executed by the calculation unit **36**. If the process transitions to step S**11** in the abovementioned main routine, then the following process begins.

[0114] Steps S**201**, S**202**: The calculation unit **36** determines whether it is necessary to modify the seat position based on the region of the training about to be performed, i.e., based on the training type (S**201**). If a modification is necessary, then the process transitions to step S**202** whereupon the calculation unit **36** outputs a screen to the monitor **70** that instructs the trainee to modify the seat position. If a modification is not necessary, then the process returns to the main routine.

[0115] Steps S**203**, S**204**: The calculation unit **36** stands by for the seat position (specifically, the seat direction) to be modified (S**203**); if the seat **16** is rotated and set to the correct position, then the calculation unit **36** outputs a screen to the monitor **70** that instructs the trainee to sit down (S**204**). The modification of the seat position is determined by the detection of a signal from the sensor **24**, which was discussed above.

[0116] Step S**205**: The calculation unit **36** stands by for the trainee to press the set button (S**205**) whereupon the process returns to the main routine.

[0117] The above process makes it possible to have the trainee sit in the seat **16** at a position that is appropriate for, for example, the training type and the mode selected by the trainee.

(3) Measurement Process Subroutine

[0118] FIG. **18** is a flow chart that shows one example of the flow of the process of the measurement process subroutine executed by the calculation unit **36**. If the process transitions to step S**13** in the abovementioned main routine, then the following process is started.

[0119] Step S**301**: If the trainee's past 1 RM data is included in the personal data that was acquired from the on-site server **200**, then the calculation unit **36** uses that 1 RM data.

[0120] Step S**302**: If the trainee's past 1 RM data is not included in the personal data that was acquired from the on-site server **200**, then the calculation unit **36** calculates the estimated 1 RM based on the trainee's basic personal data and a prescribed equation (discussed above).

[0121] Step S**303**: The calculation unit **36** sets the measurement load to the past 1 RM data or to a load that is set to a value that is slightly smaller than the product of the calculated estimated 1 RM and a prescribed coefficient (0<coefficient<1). In the present embodiment, 0.75 is used as one example of the abovementioned coefficient.

[0122] Step S**304**: Continuing, the torque motor **15** applies a small load of, for example, 3.0-5.0 kg, and the calculation unit **36** measures the range of motion. Furthermore, for example, the start point and the end point positions are detected when the bar **11** is moved through one rep, and these points are used as the range of motion data.

[0123] Step S**305**: The torque motor **15** applies the measurement load to the bar **11**, and the calculation unit **36** measures the number of reps that the trainee performs. The number of reps can be detected by acquiring, for example, the rotational direction and the rotational count of the torque motor **15** from the motor signal processing unit **23**.

[0124] Step S**306**: The calculation unit **36** converts the past 1 RM data or the estimated 1 RM to the 1 RM based on the number of reps measured in step S**303** and on the prescribed conversion table (not shown).

[0125] Step S**307**: The calculation unit **36** sends the acquired 1 RM value and the range of motion data to the server **200** along with the trainee ID. Thereby, the range of motion data and the 1 RM of the corresponding training type in the personal data are accumulated in the server **200**.

[0126] The process discussed above is performed for the training type that was specified in step S**8** of the main routine. The above process measures the 1 RM and the range of motion for the specified training type and can accumulate the measurement results as personal data.

(4) Training Process Subroutine

[0127] FIG. **19** is a flow chart that shows one example of the flow of the process of the training process subroutine executed by the calculation unit **36**. If the process transitions to step S**14** in the abovementioned main routine, then the following process is started.

[0128] Steps S**401**-S**402**: If a mode other than the measurement mode is selected, then, prior to the start of training, the calculation unit **36** determines (S**401**) whether the 1 RM and the range of motion data for the selected training type are present in the personal data. If it is determined that they are, then the reference load is derived from the 1 RM, and the terminal load is derived from the reference load. Furthermore, the load curve is determined (S**402**) based on the reference load, the terminal load, and the width of the range of motion. If it is determined that the 1 RM and the range of motion data for the selected training type are not present, then the process proceeds to step S**406**, which is discussed later.

[0129] Step S**403**: The calculation unit **36** starts the training program for the selected training type. The training program is executed independently of the main routine and the present subroutine. For example, if the "slow-paced training" mode or "circuit training" is selected, then a training program is started that controls the output of, for example, screens and speech in accordance with the settings of, for example, the target count and the training region selected by the trainee. In addition, if the "rhythmic workout" mode is selected, then a program is started that outputs, for example, screens and speech in accordance with a prestored pattern that corresponds to the selected region. After the training process ends, the calculation unit **36** saves the training result in the on-site server **200**. Furthermore, with the abovementioned training program, a virtual training character on the monitor **70** performs the exercise so as to guide the actual trainee, as shown in FIG. **7** through FIG. **10**. At that time, both the movement and the position of the training character are set so that they change in accordance with the range of motion that was set above. Specifically, in the case of a trainee whose forward inclination during abdominal muscles exercise is shallow, e.g., his or her range of motion is only 90°-45°, the training character on the monitor **70** is also set so that it assumes a forward bend posture only in the range of 90°-45°. Thereby, the actual exerciser can verify his or her own pace and range of action of the exercise while viewing the action of the training character.

[0130] Steps S**404**-S**405**: The calculation unit **36** starts to control the load in accordance with the load curve, which was determined in step S**402**. In other words, the position of the bar **11** is detected, the value of the load that corresponds to the detected position is read from the load curve, and the torque motor **15** is controlled (S**404**) so that a load that corresponds to the read value is applied to the bar **11**. This process continues (S**405**) until the training program ends, whereupon the process returns (S**1**) to the demo screen display.

[0131] Steps S**406**-S**407**: If it is determined that the 1 RM and range of motion data are not present for the training type that was selected in step S**401**, then the calculation unit **36** calculates (S**406**) the estimated 1 RM and sets the reference load (S**407**) to the product of the calculated value and a prescribed coefficient.

[0132] Step S**408**: The calculation unit **36** starts the training program of the selected training type. Like in step S**403**, the training program is executed independently of the main routine and the present subroutine.

[0133] Step S**409**: The calculation unit **36** monitors the position of the bar **111** and, after the start of repetitive exercise, determines the start point S and the end point E based on the respective average values of the start points S**2**, S**3** and the end points E**2**, E**3** for the second and third of the first three reps. Furthermore, the calculation unit **36** determines the range of motion to be the range interposed between the determined start point S and end point E.

[0134] Step S**410**: The calculation unit **36** derives the terminal load from the reference load that was calculated in step S**406**. Furthermore, the calculation unit **36** determines the load curve based on the reference load, the terminal load, and the width of the measured range of motion (S**410**).

[0135] Step S**411**: The calculation unit **36** takes the estimated 1 RM as the 1 RM and sends the range of motion data to the server **200**. Thereby, the range of motion data for the corresponding training type in the personal data is accumulated in the server **200**. Thereafter, until the training program ends, the calculation unit **36** controls the load (S**404**, S**405**) based on the determined load curve.

[0136] Based on the above process, if the value of the 1 RM for the selected training type and the range of motion data are present in the personal data, then the load curve is determined based thereon. If not, then the reference load is derived by calculation, the range of motion is measured, and thereby the load curve is determined. Accordingly, it is possible to control the load so that it is appropriate to the characteristics of a trainee without necessarily measuring the 1 RM and the range of motion in the measurement mode. In particular, it is possible to modify the magnitude of the change in the load with respect to the change in the position of the bar **11** in accordance with the width of the range of motion, which takes differences in the physiques of trainees into account.

[0137] The training apparatus according to the present invention applies a load to the bar **11** in accordance with the load curve, which was determined based on the reference load and the measured range of motion. Consequently, it is possible to modify the magnitude of the change in the load with respect to change in the position of the bar **11** in accordance with the width of the range of motion, which takes differences in the physiques of the trainees into account. It is preferable to derive the reference load by measurement because the load can be changed by taking differences in the physiques of trainees as well as differences in muscular force into consideration. Furthermore, if the load curve is determined taking the body weight offset load into consideration, then it is possible to mitigate the effects of the trainee's body weight and posture on the training, and to apply a load of a value that is suited to the individual trainee with appropriate timing.

Other Embodiments

[0138] (A) The load is preferably changed by a method wherein the load changes in accordance with, for example, the training type, or changes in accordance with the training mode on a singular training apparatus. Thereby, it is possible to effectively change the load for each type of exercise and to improve the exercise effect. For example, with a barbell exercise, the vicinity of the center of the range of motion is a sticking point, at which it is difficult for the trainee to exert his or her strength. It is preferable to gradually increase the load as the barbell (moving unit) moves from the start point to the center of the forward path so that the load increases in the area of the sticking point, and to gradually decrease the load as the barbell moves from the center to the end point of the forward path. Specifically, the reference load is applied at the start point and the end point, and a load that is equal to the reference load times **1.3** is applied in the vicinity of the center. It is thereby possible to perform the barbell exercise efficiently. In addition, if a load curve is prepared in advance for each training mode and the load curve is changed in accordance with the training mode on a singular training apparatus, then it is preferable to store the load curve data, i.e., the load pattern, which was set in accordance with each training mode, in advance in the load pattern storage unit **36*b*-1**, and to determine the load curve based on the load pattern that corresponds to the selected mode. The data stored as the load pattern includes, for example, the arithmetic expression of the load curve itself and the arithmetic expression of the body weight offset load.

[0139] (B) The range of motion is preferably determined by measurement, but the present invention can be adapted even if the range of motion is determined based on personal data. For example, a table is created in advance wherein standard range of motion data is associated with personal data such as the height, age, and gender of the trainee. Based on the trainee's table and personal data, it is possible to determine the range of motion by reading the range of motion data from the table, which can also be used to determine the load curve.

[0140] (C) The present invention encompasses a program for executing the method discussed above on a computer, as well as a computer readable storage medium whereon such a program is recorded. Herein, the program may be downloadable. Examples of storage media include a computer readable/writable flexible disk, a hard disk, semiconductor memory, a CD-ROM, a DVD, and a magneto-optic disk (MO).

[0141] The present invention can be adapted to a training apparatus for an individual to exercise with an exercise load that is optimal for the individual.

General Interpretation of Terms

[0142] In understanding the scope of the present invention, the term "configured" as used herein to describe a component, section or part of a device includes hardware and/or software that is constructed and/or programmed to carry out the desired function. In understanding the scope of the present invention, the term "comprising" and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. The foregoing also applies to words having similar meanings such as the terms, "including", "having" and their derivatives. Also, the terms "part," "section," "portion," "member" or "element" when used in the singular can have the dual meaning of a single part or a plurality of parts. Finally, terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. For example, these terms can be construed as including a deviation of at least ±5% of the modified term if this deviation would not negate the meaning of the word it modifies.

[0143] While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing descriptions of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

1. A training apparatus that is provided for exercise, wherein an electrically powered load generator applies a load to a moving unit, which is capable of repetitive motion, comprising:

a range of motion determining unit configured to determine a range of motion, which is a range through which the moving unit performs repetitive motion, in accordance with a trainee; and

a load controlling unit configured to vary the load, which is applied to the moving unit by the load generator, in accordance with the position of the moving unit in the determined range of motion.

2. A training apparatus as recited in claim **1**, further comprising:

a reference load determining unit configured to determine a reference load, which is a load that is suited to the trainee;

wherein,

the load controlling unit gradually varies the load applied to the moving unit in a range of values that are greater than or equal to the reference load, which was determined by the reference load determining unit, and less than N times ($1<N<2$) the reference load.

3. A training apparatus as recited in claim **2**, further comprising:

a long and deformable power transferring member that transfers the load of the load generator to the moving unit;

wherein,

the load controlling unit performs the steps of:

increasing the load generated by the load generator and applied to the moving unit at an arbitrary position along the return path of the repetitive exercise so that it is greater than the load generated by the load generator and applied to the moving unit at the identical position along the forward path of the repetitive exercise; and

adjusting the increase in the load along the return path commensurate with the decrease in the load due to the kinetic frictional force generated by the power transferring member along the return path.

4. A training apparatus as recited in claim **2**, wherein

the load controlling unit linearly increases the load of the moving unit as it moves from the start point to the end point of the repetitive motion in accordance with the positional change of the moving unit, and linearly decreases the load of the moving unit as it moves from the end point to the start point of the repetitive motion in accordance with the positional change of the moving unit.

5. A training apparatus as recited in claim **1**, wherein

the load controlling unit varies the load that is applied to the moving unit based further on a body weight offset load, which changes in accordance with the body weight of the trainee and the position of the moving unit in the range of motion.

6. A training apparatus as recited in claim **1**, further comprising:

a selection receiving unit configured to receive the selection of any one among a plurality of exercise types;

wherein,

the load controlling unit comprises a load pattern storage unit that associates and stores the exercise type and the variation pattern of the load, and varies the load that is applied to the moving unit based on the variation pattern that corresponds to the selected exercise type.

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