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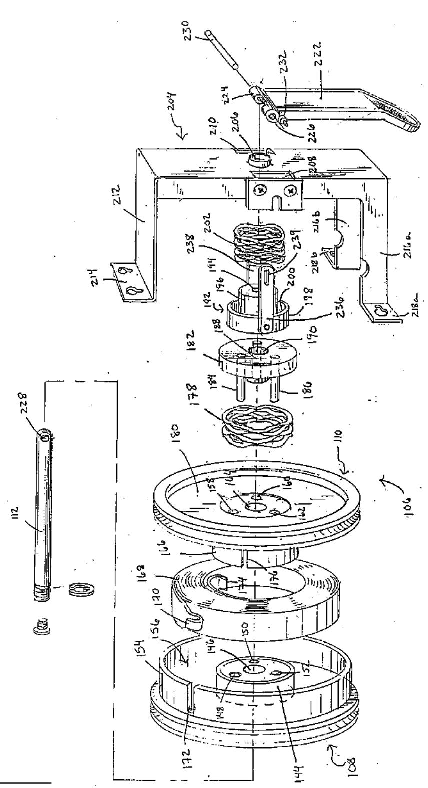
(54) Step exercise apparatus.

(57) A step exercise apparatus comprises a first foot operated pulley (108), a second foot operated pulley (110) and a user selectable lever (222) adapted to operate a resiliently biased connector (182) having pins (184,186) for disengagably entering in apertures(148,150,152 ; 158,160,162) in the pulleys(108,110) so that the pulleys (108,110) are locked together for cooperative rotative movement in an interdependent operative mode at one position of the lever (222) and the pulleys (108, 110) are disengaged one from another for independent rotative movement upon withdrawal of the pins (184,186) from the apertures (148,150,152 ; 158,160,162) in an independent operative mode at a second position of the lever (222).



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FIELD OF THE INVENTION

This invention relates to step exercise equipment which simulates stair climbing and in particular to step exercise equipment in which a mechanical transmission is used to connect reciprocating step action to a source of rotational mechanical resistance.

BACKGROUND OF THE INVENTION

Exercise equipment which simulates stair climbing is an increasingly popular form of exercise. A variety of equipment types have been proposed to meet the demand for step exercise equipment. The most common types of step exercise equipment can generally be divided between those which use a hydraulic mechanism and those which use a mechanical transmission to connect the steps to a source of resistance. Examples of hydraulic step exercise equipment include U.S. Patent Nos. 4,681,316 and 4,685,666. Examples of mechanical step exercise equipment include U.S. Patent Nos. 4,708,338, 4,949,993, 5,013,031, 5,180,351 and 5,135,447.

Mechanical step exercise equipment may be further divided between those with dependent step modes and those with independent step modes. A dependent step mode is characterized by a mechanism in which movement of one step or pedal causes the second step or pedal to move. In contrast, an independent step mode is characterized by a mechanism which permits each step or pedal to move independently of the other step or pedal. U.S. Patent No. 5,013,031 discloses a step exercise apparatus having a dependent stepping mechanism. The two foot levers are connected by a rope which extends over a central idler pulley. Pushing down on one foot lever pulls on the rope and raises the other foot lever. U.S. Patent No. 4,708,388 discloses a stair climbing apparatus which provides an independent step mode of operation. The left pedal is connected to a chain which passes over and engages the teeth of a sprocket. The end of the chain opposite the pedal is attached to a spring which passes over a pulley and then is firmly secured to the frame of the apparatus. The right pedal is similarly configured with its own independent actuating mechanism including a chain, a sprocket, a spring, and a pulley. The springs provide an upward lift which returns the pedals to an elevated position when no downward force acts on the pedals. However, since each pedal has its own actuating mechanism, the pedals operate independently of each other. U.S. Patent No. 4,949,993 also discloses a stair climbing apparatus which provides an independent step mode of operation.

Each mode of operation, independent or dependent step mode, has its own advantages and disadvantages. The independent mode permits the user to control the amount of exercise afforded to each leg. Thus, for example, a user wishing to preferentially exercise and strengthen one leg by, for example, using a step height for one leg that is greater than the other, may do so on an apparatus which provides an independent step mode. An independent step mode may also provide a more rigorous exercise regime. However, an independent step mode frequently requires greater strength and coordination to operate. Thus, an inexperienced user may be discouraged from using an apparatus which provides an independent step mode. In contrast, an apparatus which provides a dependent step mode is relatively easy to use and does not require as much user-coordination. However, because the pedals do not move independently, the user cannot preferentially exercise one leg.

Because the two types of step modes are necessary to satisfy the exercise requirements of the different types of users, a separate exercise apparatus is needed to provide each kind of step mode of operation. This requirement for two types of apparatus increases the cost of providing and using stair climbing exercise equipment.

U.S. Patent No. 5,180,351 discloses a bimodal stair climbing exercise apparatus which provides both an independent and a dependent step mode of operation. The two steps are interconnected by a single cable. The cable extends from one step, is lead over a first pulley mechanism, under a central floating pulley, over a second pulley mechanism, and then is connected to the other step. The floating pulley is suspended in a bracket secured to a vertical spring which is securely attached to the base of the apparatus. The vertical position of the floating pulley is altered by the force applied to the steps. The vertical position of the pulley during operation of the apparatus in turn controls the step mode of operation. When both steps are fully depressed, the floating pulley is stopped in its highest vertical elevation. The elevated position of the floating pulley in effect fixes the length of the interconnecting cable. Because of the fixed length of the cable, moving one step causes the other step to move in the opposite direction thereby providing a dependent step mode of operation. Alternatively, if the steps are operated in the upper portion of their step slots, the spring pulls the floating pulley to its lowest elevation thereby permitting the length of the interconnecting cable to in effect vary. As a result, the two pedals can move essentially independently of each other.

By providing both types of step mode operation within one device, U.S. Patent No. 5,180,351 overcomes some of the disadvantages of having two types of stair climbing exercise apparatuses. However, this device still requires user-coordination to select between the two types of modes. Moreover, even experienced user may become fatigued and lose their ability to control the amount of force exerted on the steps especially when attempting to operate the steps in their upper range of operation in order to maintain independent operation. Thus, the effective use of the apparatus disclosed in U.S. Patent No. 5,180,351 is complicated by the need for sustained user-coordination and effort.

A need therefore exists for a bi-modal step exercise apparatus which provides both an independent and a dependent mode of operation without requiring sustained user-coordination to select the mode of operation.

Mechanical step exercise equipment frequently includes a load mechanism for providing a resistance to the downward motion of the steps or pedals. Various types of load mechanisms have been proposed. For example, U.S. Patent Nos. 4,949,993 and 5,013,031 disclose a band braking system in which a band disposed around a flywheel can be tightened to increase the resistance provided. Other load mechanisms use gear systems to increase the resistive load. For example, U.S. Patent No. 4,708,338 discloses a load mechanism which includes an alternator and a transmission containing a series of gears. Similarly, U.S. Patent No. 5,180,351 discloses a load mechanism which includes an electric motor, a worm drive gear assembly, and a universal clutch. In addition, U.S Patent No. 5,135,447 discloses a load mechanism which includes an alternator and a speed decreasing transmission and U.S. Patent Application Serial No. 07/658,156 discloses a load mechanism which includes an alternator and a speed increasing transmission.

All of these purely mechanical load mechanisms suffer from disadvantages. For example, because each of these mechanisms involves mechanical cooperation between various parts, for example between a flywheel and a band brake, these mechanisms tend to produce friction. The friction and the associated heat can shorten the mechanical life of the various components. Moreover, lubricants are sometimes needed to extend the performance of the moving parts, thus increasing the operating costs of the device. In addition, the mechanical cooperation required by these load devices can produce noise which makes the devices unpleasant to operate.

Load mechanisms which rely on magnetically induced loads have been proposed to overcome some of the disadvantages of purely mechanical load mechanisms. Although not prevalent in currently available step exercise equipment, various kinds of eddy current brakes have been proposed for other types of exercise equipment. For example, U.S. Patent Nos. 5,094,447 and 5,031,901 disclose bicycle exercise equipment which include load mechanisms based on eddy current brakes. The eddy current brakes include opposed sets of permanent magnets which induce eddy currents in an associated metallic flywheel. Similarly, U.S. Patent No. 5,031,900 discloses an eddy current brake which includes a set of opposed electromagnets for inducing eddy currents in an associated flywheel.

The resistive load provided by the eddy current brakes can be altered by moving the brake relative to the metallic flywheel. A variable resistance is advantageous because of the differences in the skill and exercise requirements of various users. U.S. Patent No. 5,031,901 discloses an eddy current brake in which the magnets are secured to a pivotally-mounted arch. The arch is tangentially positioned relative to the rim of the flywheel. The arch is driven by a motor which moves the arch in an arcuate path toward the rim of the flywheel thus changing the displacement between the magnets and the flywheel. Similarly, U.S. Patent No. 5,094,447 discloses an eddy current brake having magnets sets mounted on opposed bridging plates which are secured to a screw-rod driven by a motor. The bridging plates are also pivotally-secured to a portion of the frame. The motor drives the bridging plates and magnets in an arcuate pathway along the faces of the flywheel.

Other methods for varying the position of the eddy current magnets in order to change the magnetic flux have been proposed. For example, U.S. Patent No. 4,826,150 discloses an eddy current brake system in a bicycle exercise apparatus. The eddy current brake includes a fixed disc having a plurality of permanent magnets, a movable disc having a plurality of magnets, and a flywheel positioned between the two discs. The magnetic flux is varied by moving the movable disc inwardly toward or outwardly from the face of the flywheel thereby changing the displacement between the magnet discs. U.S. Patent No. 4,752,066 also discloses an eddy current brake for bicycle exercise equipment. The brake includes a pair of vertically-spaced magnets secured to one face of a movable iron bracket. The bracket is pivotally mounted in two places to a pair of links which in turn are affixed to adjusting screws. The adjusting screws and links act together to move the bracket and magnets in a plane parallel to the face of the flywheel. U.S. Patent No. 4,822,032 discloses an eddy current brake in a combined bicycle and rope-pulling exercise apparatus. The brake includes a U-shaped magnet secured to an adjustment rod. The edge of a flywheel is positioned between the gap separating the magnet arms. The adjustment rod moves the magnet vertically away from the flywheel to decrease the magnetic flux and resistive load.

Moveable eddy current brakes such as those previously described thus provide variable resistive loads which in turn provide greater flexibility for users with different skills or needs. However, the currently available moveable eddy current brakes nonetheless suffer from various drawbacks. Difficulties arise from the relationship between the magnet position relative to the metallic flywheel. Specifically, the magnetic flux is a function both of the displacement between the magnets and the flywheel and of the displacement between the opposed sets of magnets, the so-called "air gap". The change in magnetic flux varies in a non-linear fashion with changes in the air gap. Consequently, moveable eddy current brakes which change the air gap to vary the resistive load suffer from non-linear changes in the magnetic flux. In addition, the magnetic flux varies with the displacement between the centroid of the magnet engagement area and the centroid of the metallic flywheel. Consequently, if the displacement between the magnetic engagement centroid and the flywheel centroid is non-linear, the magnetic flux varies in a non-linear fashion with movement of the magnets. Nonlinear changes in the magnetic flux in turn lead to difficulties in selectively controlling the amount of resistance provided by the eddy current brake.

A need therefore exists for a variable load mechanism which is quiet, not subject to excessive friction and heat, and which provides predictable load control for varying levels of resistance.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a bi-modal step exercise apparatus having a user selectable independent and dependent step mode of operation over the full range of step movement.

Another object of this invention is to provide a bi-modal step apparatus which does not require sustained user-coordination to select between the independent and dependent step modes.

Another object of this invention is to provide a bi-modal step exercise apparatus in which the independent and dependent step modes can be easily selected in a straightforward fashion and in which there can be no inadvertent transition from one mode to the other while a user is exercising on the apparatus.

Another object of this invention is to provide a variable resistive load mechanism which is not subject to excessive wear due to friction and heat.

Yet another object of this invention is to provide a variable resistive load mechanism which does not produce excessive noise.

Another object of this invention is to provide a variable resistive load mechanism which permits the user to selectively control the amount of resistance provided in a predictable fashion.

In keeping with these objectives, a bi-modal step exercise apparatus is provided which includes a crossover pulley mechanism that permits the user to select a dependent mode of operation and an independent mode of operation. The apparatus has a pair of step beams pivotally mounted to the frame of the apparatus. The pivotal mounting permits rotational movement of the beams in a vertical direction. The apparatus has a resistive load mechanism which is secured to the frame and which generates a user resistive load. The step beams are connected to the resistive mechanism by the crossover pulley mechanism which includes two pulleys, each of which is connected by a line to one of the two step beams. The two crossover pulleys can rotate independently of each other to permit the independent operation of the two step beams. The crossover pulley mechanism also includes a spring which causes one pulley to rotate with respect to the other, thereby elevating both step beams when no downward force is exerted on the step beams. In addition, the crossover pulley mechanism includes an engagement mechanism which rotationally engages one crossover pulley to the other crossover pulley. When the pulleys are rotationally engaged, the pulleys rotate synchronously such that the two step beams operate in a dependent mode.

Also in keeping with these objectives, an exercise apparatus is provided which includes a flywheel constructed in part from electrically conductive material and a magnetic mechanism for providing a resistive load by creating eddy currents in the flywheel. The apparatus has an energy application mechanism secured to the frame of the apparatus. The energy application mechanism permits a user to apply aerobic energy to the apparatus. The flywheel is connected to the energy application mechanism. The magnetic mechanism includes a magnet secured to a bracket which is in turn secured to one end of a rack. The magnet is disposed to the flywheel. The rack engages a pinion gear which is driven by a gear motor operatively connected to the pinion gear. The motor-driven rack moves the magnet in a radial direction relative to the flywheel, thereby changing the magnetic flux associated with the magnetic mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a step exercise apparatus according to the invention;

FIG. 2 is a partial rear perspective view of the apparatus in FIG. 1 showing the internal pulley mechanisms of the apparatus;

FIG. 3 is a side elevational view of the apparatus showing the internal pulley mechanisms;

FIG. 4 is an exploded view of the preferred embodiment of a crossover pulley mechanism according to the invention;

FIG. 5 is a sectional view of the crossover pulley mechanism of FIG. 4 configured for an independent step mode of operation;

FIG. 6 is a sectional view of the crossover pulley mechanism of FIG. 4 showing the movement of the springs in the crossover pulley mechanism as the user selects the dependent step mode of operation;

FIG. 7 is a sectional view of the crossover pulley mechanism of FIG. 4 showing a further movement of the springs in the crossover pulley mechanism;

FIG. 8 is a sectional view of the crossover pulley mechanism of FIG. 4 showing the mechanism configured for a dependent step mode of operation;

FIG. 9 is a sectional view along line 9-9 of FIG. 5;

FIG. 10 is an exploded view of an alternative embodiment of a crossover pulley mechanism according to the invention;

FIG. 11 is a partial enlarged view of the detente sleeve of the mechanism in FIG. 10;

FIG. 12. is a partially cut away top plan view of a translatable permanent magnet mechanism according to the invention; and

FIG. 13 is partially cut away side elevation view of the magnet mechanism in FIG 12.

DETAILED DESCRIPTION

FIGS. 1 and 3 illustrate a side view and FIG. 2 is a partial perspective view of a stair climbing exercise apparatus 20 according to the invention. A base 22 provides the supporting structure for the apparatus 20. The base 22 includes a centrally located longitudinal member 24, a front transverse member 26 and back transverse member 28. A vertical post 30 is attached via two short extensions 32 and 34 to the longitudinal member 24. The two short extensions 32 and 34 extend beyond the top of the longitudinal member 24 and are secured to the sides of the longitudinal member 24 by conventional methods, such as bolts. As shown in FIGS. 1-3, the post 30 extends upwardly toward the front of the apparatus 20. Two angled supports 36 and 38 are attached by bolts to the longitudinal member 24 near the front transverse member 26. Each angled member 36 and 38 is attached at its opposite end to the vertical post 30. The base 22, the post 30, the extensions 32 and 34, and the supports 36 and 38 form a frame for the apparatus 20. A control panel 40 is attached to the top of the vertical post 30, as shown in FIG. 2. A handrail 42 is attached to the vertical post 30 just below the control panel 40. When the apparatus 20 is fully assembled as shown in FIG. 1, the internal pulley mechanisms are enclosed within a housing 43.

FIGS. 2 and 3 illustrate the overall configuration of the internal pulley mechanisms of the apparatus 20. A right and a left step beam 44 and 46 are secured by bearings to a rod 48 which extends between two vertical supports 50 and 52. The vertical supports 50 and 52 are attached to and extend upwardly from the front transverse member 26. The bearings permit the step beams 44 and 46 to rotate independently in an essentially vertical plane. A pair of foot pads 54 and 56 are attached to the rear portions of the step beams 44 and 46 and provide a step surface for a user to place his feet.

The right and left step beams 44 and 46 are interconnected via a pulley system which includes a pair of cogged belts 58 and 60, and a pair of cables 62 and 64. The left step beam 46 and the left cogged belt 60 are shown partially cut away in FIG. 2. One end of the right cogged belt 58 is connected to the right step beam 44 and the opposite end of the right cogged belt 58 is connected to one end of the right cable 62. In the preferred embodiment, a partial toothed pulley 66 is secured to the right step beam 44 by an L-shaped bracket 68 and a pair of bolts 70 and 72. The L-shaped bracket 68 is positioned such that a first leg 74 of the bracket 68 parallels the inside surface of the step beam 44. A second leg 76 of the L-shaped bracket 68 is perpendicular to the inside surface of the step beam 44 and is positioned adjacent the bottom of the step beam 44. The bolts 70 and 72 extend through the bracket 68, the pulley 66 and the step beam 44 and thus secure the pulley 66 and the bracket 68 to the step beam 44. Before the bolts 70 and 72 are tightened, one end of the cogged belt 58 is threaded through the space between the pulley 66 and the bottom leg 76 of the bracket 68. Tightening the bolts 70 and 72 thus also secures the cogged belt 58 to the step beam 44. The left cogged belt 60 is secured by the same method to left beam 46. Alternatively, conventional methods such as a pair of clamps can be used to secure the cogged belts 58 and 60 to the step beams 44 and 46.

Intermediate its two ends, the cogged belt 58 engages a clutch pulley 78 which is secured to a one-way clutch 80, as shown in FIG. 3. The clutch pulley 78 and the one-way clutch 80 are mounted on a clutch pulley shaft 82. A pair of brackets 84 and 86 secure the clutch pulley shaft 82 to the post 30. A second clutch pulley 88 engages the cogged belt 60 associated with the left step beam 46. The left clutch pulley 88 is also secured to a one-way clutch 90 as shown in FIG 2. A first drive pulley 92 is fixed to the clutch pulley shaft 82 between the two brackets 84 and 86. The first drive pulley 92 rotates along with clutch pulley shaft 82 which, because of the one-way clutches 80 and 90, rotates in only one direction.

A pair of rotatable engagement idlers 94 and 96 and their associated idler shafts are secured to and extend from the brackets 84 and 86. Each idler 94 and 96 is positioned adjacent one of the clutch pulleys 78 and 88. The idlers 94 and 96 help to ensure that the cogged belts 58 and 60 remain engaged with the cogged clutch pulleys 78 and 88.

The second end of the cogged belt 58 is connected via a belt-cable engagement connector 98 to one end of the cable 62. The connector 98 has a set of teeth on one side which engage the cogged belt 58. The cogged belt 58 is secured to the connector 98 by a bolt 100 which extends through the connector 98 and the belt 58. The connector 98 also has an opening (not shown) through which one end of the cable 62 is secured. The left cable 64 is connected in a similar manner to the left cogged belt 60 by a second connector 104.

The second end of the cable 62 is connected to a crossover pulley mechanism indicated at 106. The crossover pulley system 106 has a front crossover pulley 108 and a back crossover pulley 110 which are rotatably mounted on a central crossover shaft 112 secured to the post 30. The crossover shaft 112 is shown in FIGS. 4 and 10. The front and back pulleys 108 and 110 each have a receptacle (not shown) which engages a barrel terminator (not shown) on the end of each of the cables 62 and 64. As a result, the right cogged belt 58 with the right cable 62 and the left cogged belt 60 with the left cable 64 form lines which connect the right step beam 44 and the left step beam 46, respectively, to the crossover pulley system 106. In the preferred embodiment, the front crossover pulley 108 and the back crossover pulley 110 are constructed from glass-reinforced nylon.

The first drive pulley 92 is connected by a belt 114 to a second drive pulley 116 located near the front of exercise apparatus 20. The belt 114 as well as part of the first drive pulley 92 extend through an opening 118 in the central post 30. The second drive pulley 116 is secured to a shaft 120 which extends between the two angled supports 36 and 38. An engagement pulley 122 serves to maintain sufficient tension in the belt 114 to prevent slippage of the belt 114 on the second drive pulley 116 or the first drive pulley 92. The engagement pulley 122 is mounted on a shaft extending from an engagement arm 124 which is rotatably secured to the shaft 120 in order to maintain alignment with the belt 114. The engagement arm 124 is also secured by a spring 126 to the right angled support 36 above the engagement arm 124. The spring 126 tensions the engagement pulley 122 against the underside of the belt 114. The spring loaded engagement pulley 122 maintains the proper belt tension over the life of the apparatus 20 regardless of the strength of the belt 114. The spring 126 can also be tuned to provide sufficient belt tension for normal usage but allow belt slippage during abusive overloads thereby preventing excessive torque to damage some components of the apparatus 20.

The internal pulley system, as described above, provides a mechanism for connecting the step beams 44 and 46 to the shaft 120 which can have attached to it a source of user resistance as described below.

A flywheel 128 secured to the shaft 120 provides an inertial resistive load when the user operates the exercise apparatus 20. The central portion 130 of the flywheel 128 is preferably constructed from cast iron. The flywheel 128 also has an aluminum ring 132 secured to the central portion 130 by bolts. The first drive pulley 92, which rotates with the clutch pulley shaft 82, drives the second drive pulley 116 which in turn drives the flywheel 128. A translatable permanent magnetic mechanism 134 mounted by brackets 136 and 138 to the central post 30 includes two sets of permanent magnets 140 and 142 that bracket the outer rim portion of the aluminum ring 132 of the flywheel 128. The magnet sets 140 and 142 are best seen in FIGS. 12 and 13. The magnet mechanism 134 varies the amount of resistance by magnetically inducing eddy currents in the aluminum ring 132 of the flywheel 128. The magnetic mechanism 134 is described in more detail in conjunction with FIGS. 12 and 13. Although the preferred embodiment of the invention utilizes an eddy current brake including the flywheel 128 and the magnet mechanism 134 for the resistive load, it should be understood that other mechanisms such as alternators or band brakes can be used.

FIG. 4 shows in exploded form the preferred embodiment of the crossover pulley system 106, including the front and back crossover pulleys 108 and 110, in more detail. Both the front crossover pulley 108 and the back crossover pulley 110 are rotatably mounted on the central crossover shaft 112 which is secured to and extends from the vertical post 30 as illustrated in FIGS. 2 and 3. The front crossover pulley 108 is mounted first and is closer to the front of the apparatus 20 than is the back crossover pulley 110.

The front crossover pulley 108 includes an engagement cylinder 144 which is coaxial with a front pulley central shaft opening 146. Three pin-engagement holes 148-152 extend through the engagement cylinder 144 and are aligned with three holes configured in the front crossover pulley 108. The pin-engagement holes 148-152 are located at an equal radius from the central shaft opening 146 and are irregularly spaced about the central shaft opening 146. The outer wall 154 of the front crossover pulley 108 and the engagement cylinder 144 define a annular cavity 156 within the front crossover pulley 108.

The back crossover pulley 110 is also configured with an engagement cylinder (not shown) identical to the front pulley engagement cylinder 144 and having three engagement holes 158-162 irregularly spaced at an equal radius about a central shaft opening 164. In addition, the back crossover pulley 110 includes a hub 166 which is coaxial with the central shaft opening 164. The hub 166 abuts the outside of the engagement cylinder (not shown) and extends beyond the engagement cylinder to form a hub cavity (not shown). The engagement cylinder 144 of the front crossover pulley 108 fits with the hub cavity formed by the hub 166 of the back crossover pulley 110 when the crossover pulley mechanism 106 is fully assembled. A main return spring 168 is positioned within the front pulley annular cavity 156. A hooked end 170 of the main return spring 168 is attached via a slot 172 in the outer wall 154 to the front crossover pulley 108 and a hooked portion 174 of the other end of the main engagement spring 168 is attached via a slot 176 in the hub 166 of the back crossover pulley 110.

A pin-disengagement spring 178 is positioned on the pulley crossover shaft 112 adjacent an outside surface 180 of the back crossover pulley 110. In the preferred embodiment, the pin-disengagement spring 178 is a wave spring constructed from low carbon steel. A suitable wave spring is available from Smalley Steel Ring Company in Wheeling, Illinois under the tradename SPIRAWAVE. Immediately adjacent the pin-disengagement spring 178 is a pin-plate 182 having a set of three pins 184-188 and a central opening 190 to accommodate the pulley crossover shaft 112. The pins 184-188 are press fit within the pin plate 182 and are irregularly spaced at an equal radius around the opening 190. The spacing of the pins 184-188 is such that in one and only one rotational position can the pins 184-188 be inserted through the back pulley holes 158-162 and into the front crossover pulley holes 148-152. The pins 184-188 extend through the center of the pin-disengagement spring 178 and also serve to retain the pin-disengagement spring 178 between the pin plate 182 and the back crossover pulley 110.

A spring guide 192 abuts the pin plate 182 on the side opposite the back crossover pulley 110. The pulley crossover shaft 112 extends through a central opening 194 in the spring guide 192. The spring guide 192 has a central portion 196 concentric with the shaft opening 194. The central portion 196, together with an outer wall 198 of the guide 192, form a spring socket 200. One end of a pin-engagement spring 202 is contained within the spring socket 200 and the other end of the pin-engagement spring 202 abuts a U-shaped pulley control bracket 204. The pulley crossover shaft 112 extends through the center of the pin-engagement spring 202 and through an opening 206 in the pulley support bracket 204. In the preferred embodiment, the pin-engagement spring 202 is a wave spring constructed from low carbon steel.

The pulley control bracket 204 has two elongated openings 208 and 210 which are adjacent the central opening 206. The bracket 204 includes an upper horizontal leg 212, an upper vertical leg 214, a first pair of lower horizontal legs 216a and 216b which are essentially parallel to the upper horizontal leg 212 and a second pair of lower horizontal legs 218a and 218b which are essentially perpendicular to the first pair of lower horizontal legs 216a and 216b. The upper vertical leg 214 and the lower horizontal legs 218a and 218b are secured to the post 30, as best seen in FIGS. 2 and 3. Conventional methods, such as bolts, can be used to secure the bracket legs 214, 218a, and 218b to the post 30. When the bracket 204 is in position, the upper bracket legs 212 and 214 extend over the front crossover pulley 108 and the lower bracket legs 216a-b and 218a-b extend under the back crossover pulley 110.

As shown in FIG. 4, a lever 222 defines the end of the selectable pulley mechanism 106. In the preferred embodiment, the lever 222 is constructed from glass-reinforced nylon. The lever 222 is configured with two cylindrical hinges 224 and 226 arranged across one transverse edge of the lever 222. The two hinges 224 and 226 are spaced somewhat apart to accommodate a cylindrical opening 228 configured in the end of the pulley crossover shaft 112. The lever 222 is secured to the pulley shaft 112 by first aligning the opening 228 between the two hinges 224 and 226 and then inserting a pin 230 into the continuous channel formed by the hinges 224 and 226, and the opening 228 in the shaft 112.

A finger 232 extends outwardly from one side of the lever 222 and is spaced somewhat apart from and parallel to the lever hinges 224 and 226. A second finger (not shown) is similarly affixed to the opposite side of the lever 222. A connector link 236 serves to connect the finger 232 to the spring guide 192. A second link 238 connects the second finger (not shown) to the opposite side of the spring guide 192. Each link 236 and 238 is rotatably secured to the spring guide 192. The connector links 236 and 238 extend through the elongate openings 208 and 210 in the pulley control bracket 204. The connector link 236 has an elongated opening 239 which engages the finger 232 on the lever 222. A similar opening (not shown) in the second connector link 238 engages the finger (not shown) on the opposite side of the lever 222.

FIGS. 5-8 illustrate the relative geometry of various components of the crossover pulley mechanism 106 as the apparatus 20 is changed from one step mode of operation to the other step mode of operation. Although only one pin 184 and one pin engagement hole 148 are shown, it is to be understood that the other pins 186 and 188 and the other pin engagement holes 150 and 152 are configured in a similar fashion to that illustrated. As shown in FIGS. 5-8, the lever 222 can be used to select between the pin-disengagement spring 178 and the pin-engagement spring 202, thereby selecting between an independent and a dependent mode of operation of the step beams 44 and 46. In a first mode of operation shown in FIG. 5, the pin-disengagement spring 178 pushes the pin plate 182 towards the back of the apparatus 20 thereby preventing the pins 184-188 from engaging the front pulley pin-engagement holes 148-152. If the pins 184-188 do not engage the front pulley openings 148-152, the front and back pulleys 108 and 110 can rotate independently. As a consequence, the right and left step beams 44 and 46, which are connected to the back and front pulleys 110 and 108, can be operated independently of each other.

In a second mode of operation illustrated in FIG. 8, the pin-engagement spring 202 overcomes the pin-disengagement spring 178 and serves to move the pin plate 182 towards the front crossover pulley 108 so that the pins 184-188 are inserted into the front pin-engagement holes 148-152. When the pins 184-188 engage the front pulley pin-engagement holes 148-152, the front crossover pulley 108 and the back crossover pulley 110 are coupled and rotate together like a single pulley. Consequently, the right beam 44 and left beam 46 are coupled to each other such that moving one beam 44 causes the other beam 46 to move in the opposite direction: the beams 44 and 46 operate in a dependent mode.

The lever 222 permits the user to select the position of the pin-plate 182, and therefore which step mode is operable. The step beams 44 and 46 can be operated independently from each other when the front and back pulleys 108 and 110 are not coupled together by the pins 184-188. The front and back pulleys 108 and 110 are uncoupled when the pin-disengagement spring 178 pushes on the pin plate 182 toward the rear of the apparatus 20 thereby disengaging the pins 184-188 from the front pulley 108. This relationship occurs when the lever 222 is pointing straight up as shown in FIG. 5. To change the mode from the independent mode to the dependent mode, the user pushes down on the lever 222 as shown by the arrow 6A in FIG. 6 until the lever 222 essentially parallels the central longitudinal member 24. Pushing down on the lever 222 allows the pin-engagement spring 202 to push against the pin plate 182 and pushes the pin plate 182 towards the front crossover pulley 108.

As the lever 222 continues downwardly as shown in FIG. 7, the force of the pin-engagement spring 202 overcomes the pin-disengagement spring 178 and urges the pins 184-188 against the face of the central engagement cylinder 144 of the front crossover pulley 108. When the user releases the lever 222, the lever 222 falls downward toward the longitudinal member 24, as shown in FIGS. 7 and 8. The user then steps on the apparatus 20 to begin exercising. Stepping on either the right beam 44 or the left beam 46 causes the associated pulley 110 or 108 to rotate. For example, stepping on the left beam 46 causes the front crossover pulley 108 to rotate. When the pulley 108 rotates, the front pulley pin-engagement holes 148-152 rotate relative to the pins 184-188. When the pin-engagement holes 148-152, which are irregularly spaced as illustrated in FIG. 9, are aligned with the pins 184-188 which are also irregularly spaced, the pins 184-188 slide into the corresponding front pulley pin engagement holes 148-152, as shown in FIG. 8, thereby coupling the front and back pulleys 108 and 110. In this configuration, the front and back pulleys 108 and 110 rotate synchronously and the step beams 44 and 46 are coupled together in the dependent mode of operation.

To change from the dependent mode to the independent mode, one merely reverse the sequence of steps. In the dependent mode of FIG. 8, the expansion force of the pin-engagement spring 202 overcomes the compression force of the pin-disengagement spring 178 thereby serving to retain the pins 184-188 in the pin-engagement holes 148-152 in the front crossover pulley 108. In this configuration, the lever 222 does not exert a force on either of the springs 178 and 202 and simply hangs downward from the pin 230. To select the independent mode, the user first raises the lever 222 as shown in FIG. 6, until the lever 222 essentially parallels the central longitudinal member 24. Raising the lever 222 results in a cam action forcing the finger 232 and the second lever finger (not shown) to pull the connector links 236 and 238 rearward which in turn pull back on the spring guide 192. Moving the spring guide 192 rearward from the front crossover pulley 108 overcomes the expansion force exerted by the pin-engagement spring 202. At this point, the pin-disengagement spring 178 exerts the primary force on the pin plate 182. Selection of the independent mode is completed when the user steps on the apparatus 20 to begin exercising. Stepping on one of the beams, for example the left beam 46, causes the associated pulley, such as the front crossover pulley 108, to rotate. When the pulley 108 rotates, the pins 184-188 are extracted from the pin-engagement holes 148-152 by the pin-disengagement spring 178 thereby uncoupling the front and back pulleys 108 and 110. The force exerted by the pin-disengagement spring 178 towards the back of the apparatus 20 pushes the pin plate 182 and the spring guide 192 rearwards and maintains the pins 184-188 in the disengaged state as shown in FIG. 5.

The main spring 168 functions when the apparatus 20 is operated in the independent mode of FIG. 5 which occurs when front and back 108 and 110 pulleys are uncoupled. As described above, the main spring 168 is attached to both the front crossover pulley 108 and the back crossover pulley 110. When the independent mode is selected, a pre-load rotational tension of the main spring 168 causes each crossover pulley 108 and 110 to rotate with respect to the other such that each step beam 44 and 46 is elevated when no weight is applied to the step beams 44 and 46. Thus, for example, both the step beams 44 and 46 will tend to rest at an elevated position. A pair of beam stops 240 and 242 as shown in FIGS. 2 and 3 limit the upward movement of the step beams 44 and 46 and define the rest position of the step beams 44 and 46 when the apparatus 20 is used in the independent mode. The beam stops 240 and 242 are secured to the vertical post 30 and extend outwardly toward the right and left sides of the apparatus 20.

When the user steps down on one of the step beams, such as the left step beam 46, the associated pulley 108 rotates in the clockwise direction which tends to compress the main spring 168. Similarly, depressing the right step beam 44 makes the associated crossover pulley 110 rotate in the counterclockwise direction which also compresses the main spring 168. The main spring 168 experiences the greatest applied compression when both the right and left step beams 44 and 46 approach their lowest position together. When the downward force on both of the step beams 44 and 46 is released, the decompression energy from the main spring 168 elevates the step beams 44 and 46 until their motion is terminated by the beam stops 240 and 242.

FIGS. 10 and 11 illustrate an alternative embodiment of a crossover pulley mechanism 244 according to the invention. The parts of the alternative mechanism 244 which are the same as the parts of the preferred mechanism 106 are labeled similarly. Thus, for example, the selectable pulley mechanism 244 includes the front crossover pulley 108 and the back crossover pulley 110 rotatably mounted on the crossover shaft 112. The pulley mechanism 244 differs from the previously described mechanism 106 primarily in the type of handle used to select either the pin-disengagement spring 178 or the pin-engagement spring 202. The mechanism 244 has a bar handle 246 threadably secured to a shaft sleeve 248. When the crossover pulley mechanism 244 is fully assembled, the shaft sleeve 248 extends through the central opening 206 in the U-shaped bracket 204 toward the back crossover pulley 110. When the mechanism 244 is fully assembled, the pin-engagement spring 202 encompasses on the shaft sleeve 248 and abuts a retaining ring 250 secured within a slot 252 in the front portion of the shaft sleeve 248. The crossover shaft 112 is then inserted into the shaft sleeve 248 to complete the connection between the bar handle 246 and the crossover shaft 112.

An annular detente sleeve 254 is secured to the back side of the U-shaped bracket 204 around the central opening 206. The detente sleeve 254 has a pair of shallow notches 256 and 258 positioned opposite each other and a pair of deep notches 260 and 262 positioned opposite each other, as best seen in FIG 11. Each deep notch 260 and 262 is located approximately 90 degrees from the adjacent shallow notch 256 and 258. The shallow notches 256 and 258 and the deep notches 260 and 262 serve to retain a pair of cylindrical projections 264 and 266 which are secured to a portion of the shaft sleeve 248 near the bar handle 246.

The dependent and independent modes are selected by pulling and rotating the bar handle 246 to place the sleeve projections 264 and 266 into the shallow notches 256 and 258 or into the deep notches 260 and 262. The crossover pulley mechanism 244 is configured for independent operation when the projections 264 and 266 are positioned within the shallow notches 256 and 258. To select the dependent mode, the user pulls on the bar handle 246 to disengage the projections 264 and 266 from the shallow notches 256 and 258. Pulling on the bar handle 246 compresses the pin-engagement spring 202 between the retaining ring 250 and the front side of the U-shaped bracket 204 and decompresses the pin-disengagement spring 178. The user then rotates the handle 246 until the projections 264 and 266 are aligned with the deep notches 260 and 262. The projections 264 and 266 are then placed into the deep notches 260 and 262. The deep notches 260 and 262 permit the shaft sleeve 248 to move towards the crossover pulleys 108 and 110. As a result, the pin-engagement spring 202 applies pressure on the retaining ring 250 and urges the shaft sleeve 248 against the pin plate 182 thereby moving the pin plate 182 toward the front crossover pulley 108 and the pins 184-188 against the face of the engagement cylinder 144 of the front crossover pulley 108. When the user steps on one of the beams to begin exercising, for example the left beam 46, the associated pulley 108 rotates and ultimately brings the pin-engagement holes 148-152 into alignment with the pins 184-188. The pressure exerted by the pin-engagement spring 202 urges the pins 184-188 into the pin-engagement holes 148-152 and couples together the front and back crossover pulleys 108 and 110.

A similar sequence of steps is used to select the independent mode when the selectable pulley mechanism 244 is configured for the dependent mode. Initially, the projections 264 and 266 are positioned in the deep notches 260 and 262. The user pulls on the bar handle 246 to disengage the projections 264 and 266 from the deep notches 260 and 262. Pulling on the bar handle 246 compresses the pin-engagement spring 202 between the retaining ring 250 and the front side of the U-shaped bracket 204 thereby decompressing the pin-disengagement spring 178. The user then rotates the bar handle 246 until the projections 264 and 266 are aligned with the shallow notches 256 and 258 and releases the handle 246 so that the projections 264 and 266 are retained by the shallow notches 256 and 258.

The shallow notches 256 and 258 limit how far the shaft sleeve 248 and associate retaining ring 250 move towards the crossover pulleys 108 and 110. As a result, the pin-engagement spring 202 remains compressed between the retaining ring 250 and the front surface of the U-shaped bracket 204 and as such does not exert pressure on the pin plate 182. The pin plate 182 is then moved away from the crossover pulleys 108 and 110 by the pin-disengagement spring 178. When the user steps on one of the step beams 44 or 46 to begin exercising, the associated pulley 110 or 108 rotates and the pins 184-188 are extracted from the pin-engagement holes 148-152 by the pressure on the pin plate 182. The front and back crossover pulleys 108 and 110 can then rotate independently from each other.

FIG. 12 is a partially cut-away plan view illustrating the preferred embodiment of the translatable permanent magnet mechanism 134 according to the invention and FIG. 13 is a partially cut away side elevation view of the magnet mechanism 134. The magnetic mechanism 134 includes a base guide 268 which is secured to the brackets 136 and 138 shown in FIGS. 2 and 3 and which includes a pair of magnet guide arms 270 and 272. The magnet guide arms 270 and 272 are radially oriented along opposite sides of the flywheel 128, as best seen in FIGS. 2 and 3. As shown in FIGS. 12 and 13 as well as in FIGS. 2 and 3, a magnet housing 274 is slidably affixed to the magnet guide arms 270 and 272. The magnet housing 274 includes a pair of arcuate magnet brackets 276 and 278 which extend from a central member 280 as best seen in FIG. 12. The magnet sets 140 and 142 are secured to the arcuate magnet brackets 276 and 278. The magnet housing 274, including the arcuate brackets 276 and 278, maintains the magnet sets 140 and 142 at a constant displacement from each other. A portion of the aluminum ring 132 of the flywheel 128 is positioned within the gap separating the magnet sets 140 and 142.

In the preferred embodiment, each magnet set 140 and 142 contains four essentially square permanent magnets. One set 142 of four magnets 142a-d is shown in FIG. 13. Each magnet 142a-d in the magnet set 142 has a opposite polarity to the adjacent magnet 142a-d. In addition, each magnet 142a-d has a opposite polarity to the corresponding magnet (not shown) in the opposite magnet set 140 (not shown in FIG. 13).

As shown in FIG. 12, a U-shaped coupling bracket 282 having a pair of bracket arms 284 and 286 extending from a central coupling plate 288 is secured to the central member 280 of the magnet housing 274. The bracket arm 284 includes a pair of guide members 290 and 292 which define a guide arm channel (not shown), as best seen in FIGS. 12 and 2. As shown in FIG. 12 and 3, the bracket arm 286 includes a pair of guide members 294 and 296 which also define a guide arm channel (not shown). The guide arm channels slidably retain the magnet guide arms 270 and 272 and serve to attach the magnet housing 274 to the base guide 268.

A centrally located rack channel (not shown) is configured on one side of the base guide 268. The base guide 268 also includes a pinion gear 298 immediately adjacent the rack channel. The pinion gear 298 is driven by a gear motor 300 attached to the base guide 268 on the opposite side of the rack channel. A potentiometer 302 operatively connected to the pinion gear 298 measures the rotational displacement of the pinion gear 298. The pinion gear 298, gear motor 300 and potentiometer 302 are commercially available as a unit from P&P Industries of Morrison, Illinois. The pinion gear 298 engages a rack 304 mounted within the rack channel. The end 306 of the rack 304 opposite the base guide 268 is secured to the central coupling plate 288 of the magnet coupling bracket 282 and to the central member 280 of the magnet housing 274, as shown in FIG 12.

The gear motor 300 rotates the pinion gear 298 to move the rack 304 and hence the magnet housing 274 and the magnet sets 140 and 142 radially relative to the flywheel 128 as best seen in FIGS. 2 and 3. When the gear motor 300 drives the rack 304 and magnet sets 140 and 142 radially inward toward the center of the flywheel 128, the resistive load of the flywheel 128 increases due to the increased magnetic flux between the aluminum ring 132 and the magnet sets 140 and 142. Similarly, the resistive load decreases when the gear motor 300 drives the rack 304 and the magnet sets 140 and 142 radially outward, away from the center of the flywheel 128. The gear motor 300 is controlled by a control unit 308 mounted to the angled support 36 as shown in FIG. 3. The control unit 308 may be programmed to automatically vary the motion of the rack 304 via the gear motor 300 when the apparatus 20 is used. Alternatively, the control unit 308 may be operatively connected to the control panel 40 to permit the user to select the amount of resistance provided by the flywheel 128.

The translatable magnetic mechanism 134 of the present invention offers several advantages over currently available eddy current brakes used in exercise equipment. The magnet housing 174 maintains the magnets sets 140 and 142 at a constant displacement from each other. Consequently, the magnetic mechanism 134 does not suffer from non-linear changes in the magnetic flux associated with changes in the air gap between the opposed sets of magnets. Second, because the magnets in the magnets set 140 and 142 are essentially square, such as magnets 142a-d, the size of the magnetic engagement area changes in a substantially linear fashion as the magnet sets 140 and 142 are moved radially inward or outward relative to the center of the flywheel 128. Consequently, the position of the magnetic engagement area centroid varies in a substantially linear fashion with changes in the radial position of the magnet sets 140 and 142. The substantially linear change in the position of the centroid of the magnetic engagement area, coupled with the liner, radial movement of the magnet sets 140 and 142 relative to the center of the flywheel 128, helps to ensure that the magnetic flux varies in a substantially linear fashion with changes in the radial position of the magnet sets 140 and 142. Third, because the magnetic flux varies in a substantially linear fashion with changes in the radial position of the magnet sets 140 and 142, there is a substantially linear relationship between the torque provided by the magnetic mechanism 134 and the position of the rack 304. Consequently, the amount of resistance provided by the magnetic mechanism 134 can be selectively controlled in a predictable fashion.

Although the translatable magnet mechanism

134 has been described in terms of the step exercise apparatus 20 of FIGS. 1-3, it will be understood that this mechanism 134 is equally useful in other types of aerobic exercise equipment, bicycles and ski machines that permit a user to apply aerobic energy to a source of load resistance in the apparatus.

Claims

1. A step exercise apparatus (20) comprising a first foot operable mechanism (108) and a second foot operable mechanism (110) and means (182,184,186) for coordinating the mechanisms (108,110) so that the mechanisms are operable independently of one another or are interdependent characterised in that the said means (182,184,186) is adapted to be controlled by a user separately from operation of the mechanisms (108,110) to select whether operation of the mechanisms (108,110) is to be independent or interdependent.

2. Apparatus (20) as claimed in Claim 1 characterised in that the mechanisms (108,110) each comprise a rotary member (108,110) and the rotary members (108,110) are adapted to engage one with another so as to rotate in unison on a common axis and are adapted to disengage one from another so as to rotate independently of one another on the axis, engagement and disengagement of the rotary members (108,110) being effected by operation of the said means (182,184,186).

3. Apparatus as claimed in Claim 2 characterised in that the said means (182,184,186) includes a connector (182,184,186) for disengagably connecting the rotary members (108,110) one to another.

4. Apparatus as claimed in Claim 3 characterised in that the connector (182,184,186) comprises a plurality of pins (184,186) and each of the rotary members (108,110) includes a plurality of apertures (148,150,152; 158,160,162) for receiving the pins (184,186).

5. Apparatus as claimed in Claim 4 characterised in that the said means (182,184,186) includes an engaging biasing device (202) for biasing the connector (182,184,186) so that pins (184, 186) engage in the apertures (148,150,152; 158,160,162) when an interdependent mode has been selected.

6. Apparatus as claimed in Claim 5 characterised in that the said means (182,184,186) includes a disengaging biasing device (178) for biasing the connector (182,184,186) so that the pins (184,186) disengage from the apertures (148,150,152; 158,160,162) when an independent mode has been selected.

7. Apparatus as claimed in claims 5 or 6 characterised in that the said means (182,184,186) includes a user operable lever (222).

8. Apparatus as claimed in Claim 7 characterised in that the lever (222) is biased for urging interengagement of the pins (184, 186) in the apertures (148,150,152; 158,160,162) when the mechanisms (108,110) are in an interdependent mode and for urging disengagement of the pins (184,186) from the apertures (148,150,152; 158,160,162) when the mechanisms (108,110) are in independent mode.

9. Apparatus as claimed in any one of Claims 2 to 8 characterised in that the rotary members (108,110) are biased against rotation on the common axis.

10. Apparatus as claimed in Claim 9 characterised in that the rotary members (108,110) are biased by means of a spring (168) common to both rotary members (108,110).

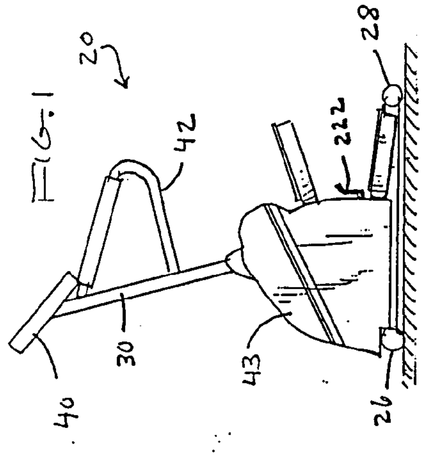

FIG. 1

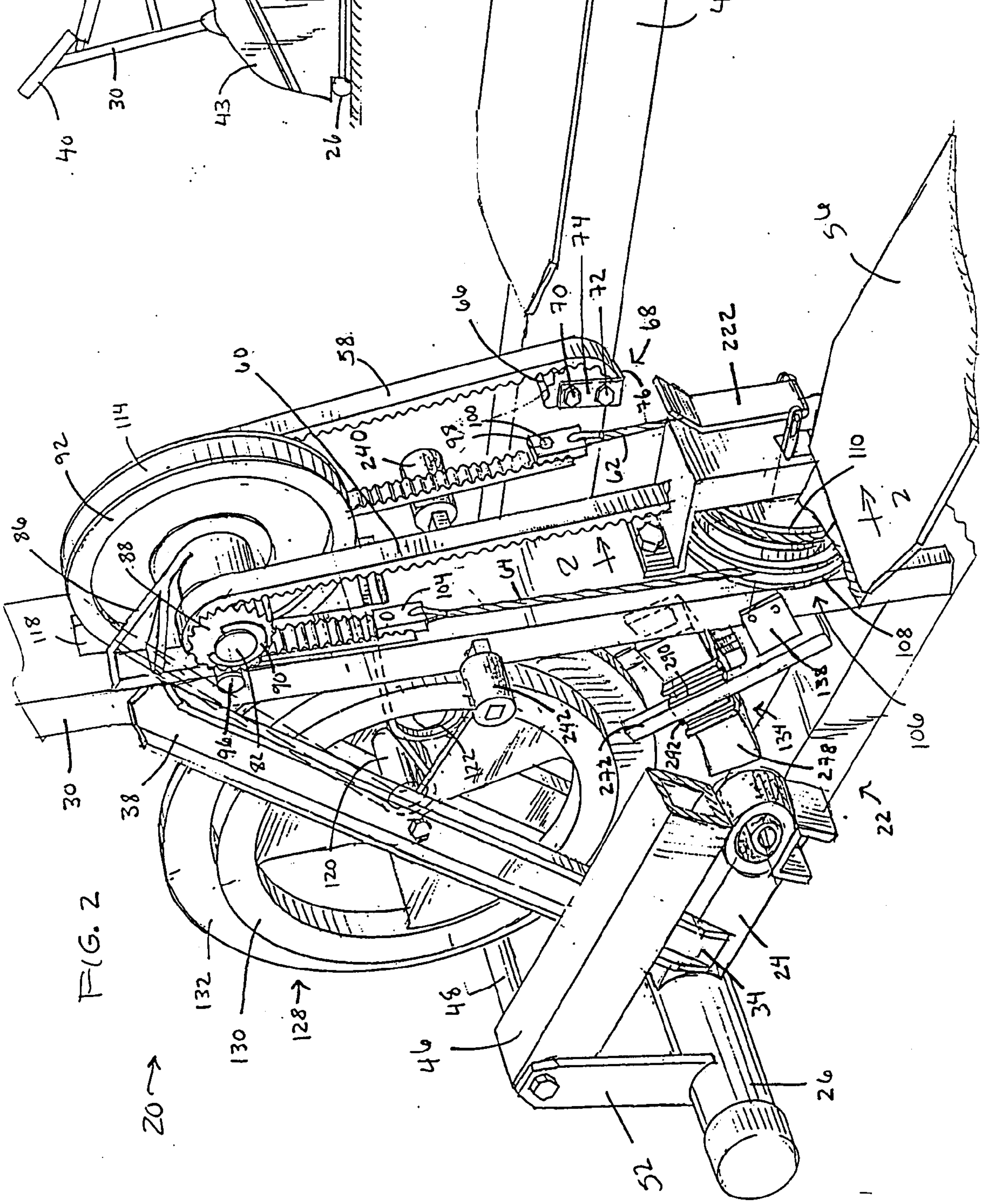

FIG. 2

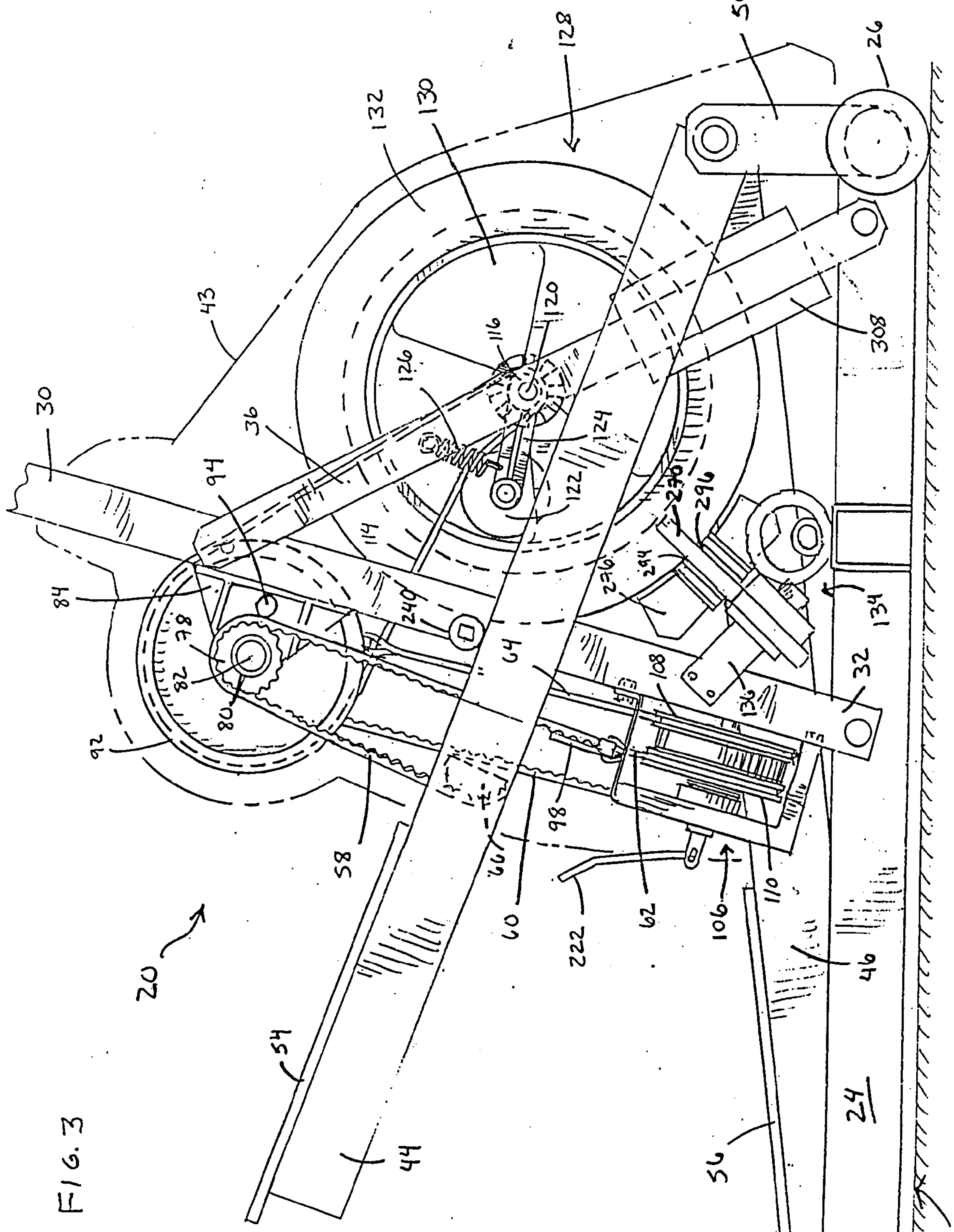

FIG. 3

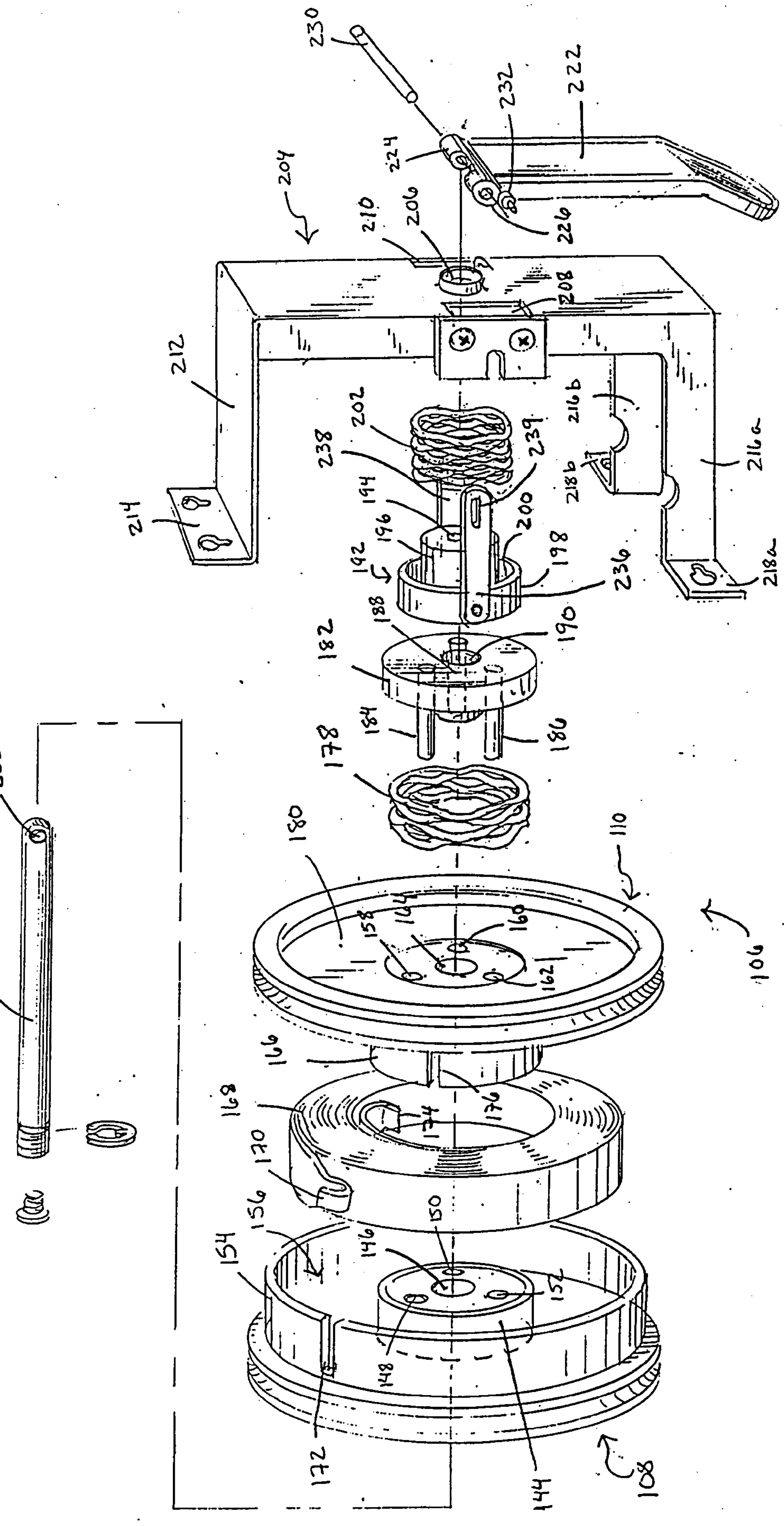
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FIG. 4

FIG. 5

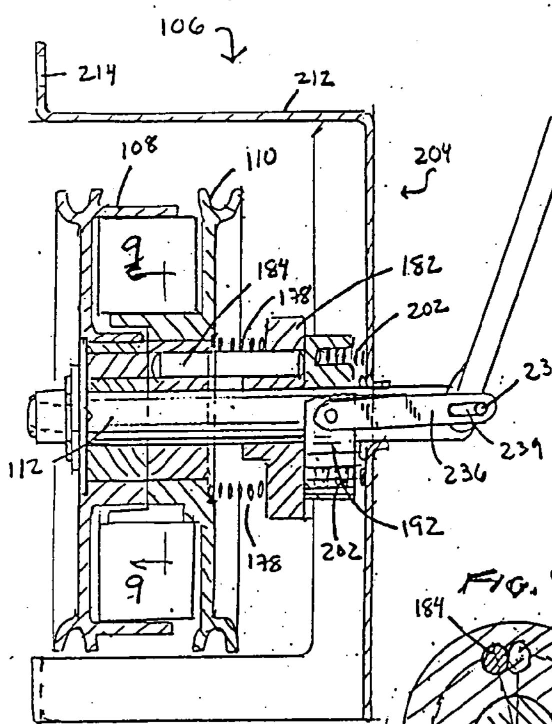


FIG. 6

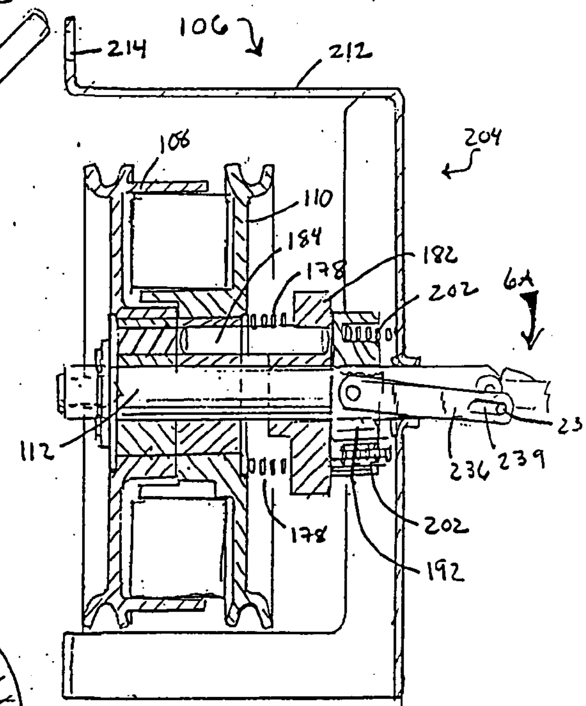
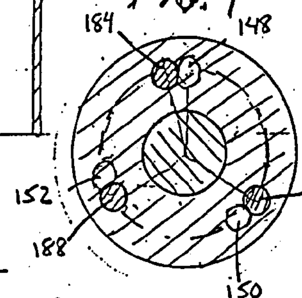


FIG. 9



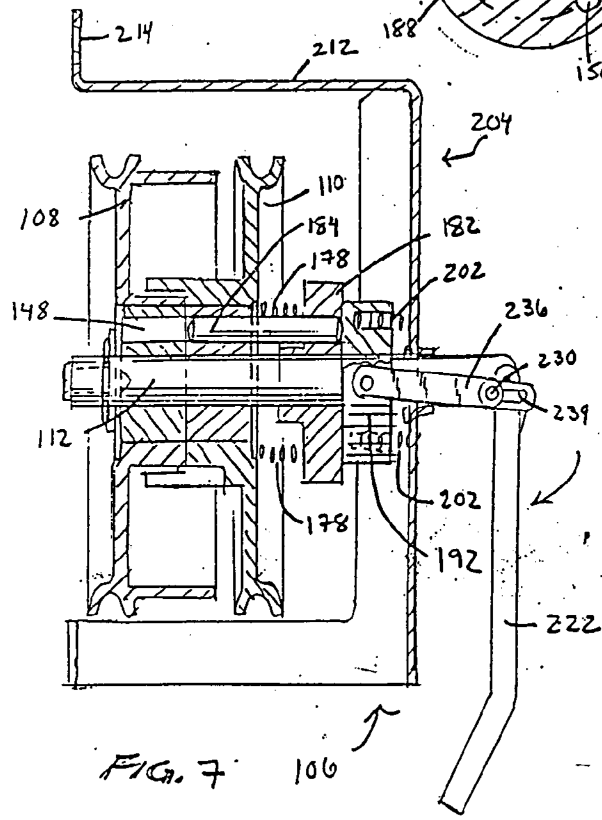


FIG. 7

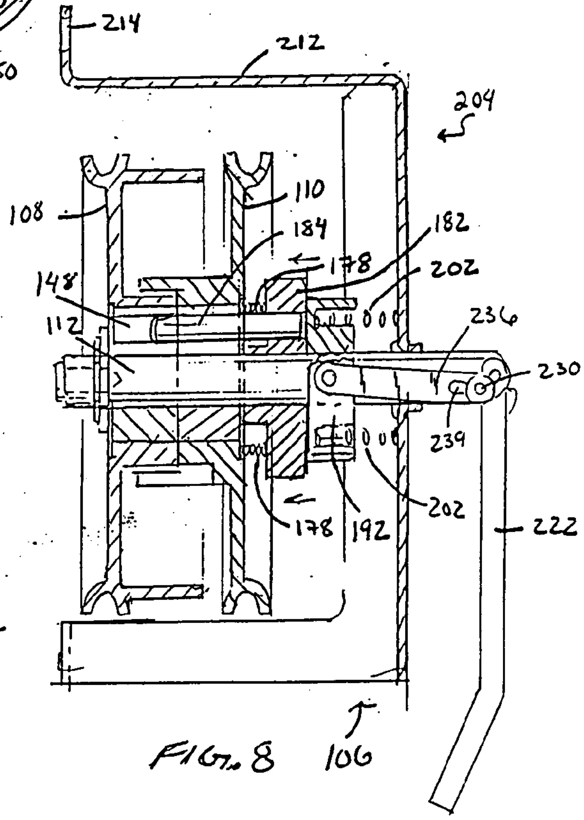


FIG. 8

FIG. 10

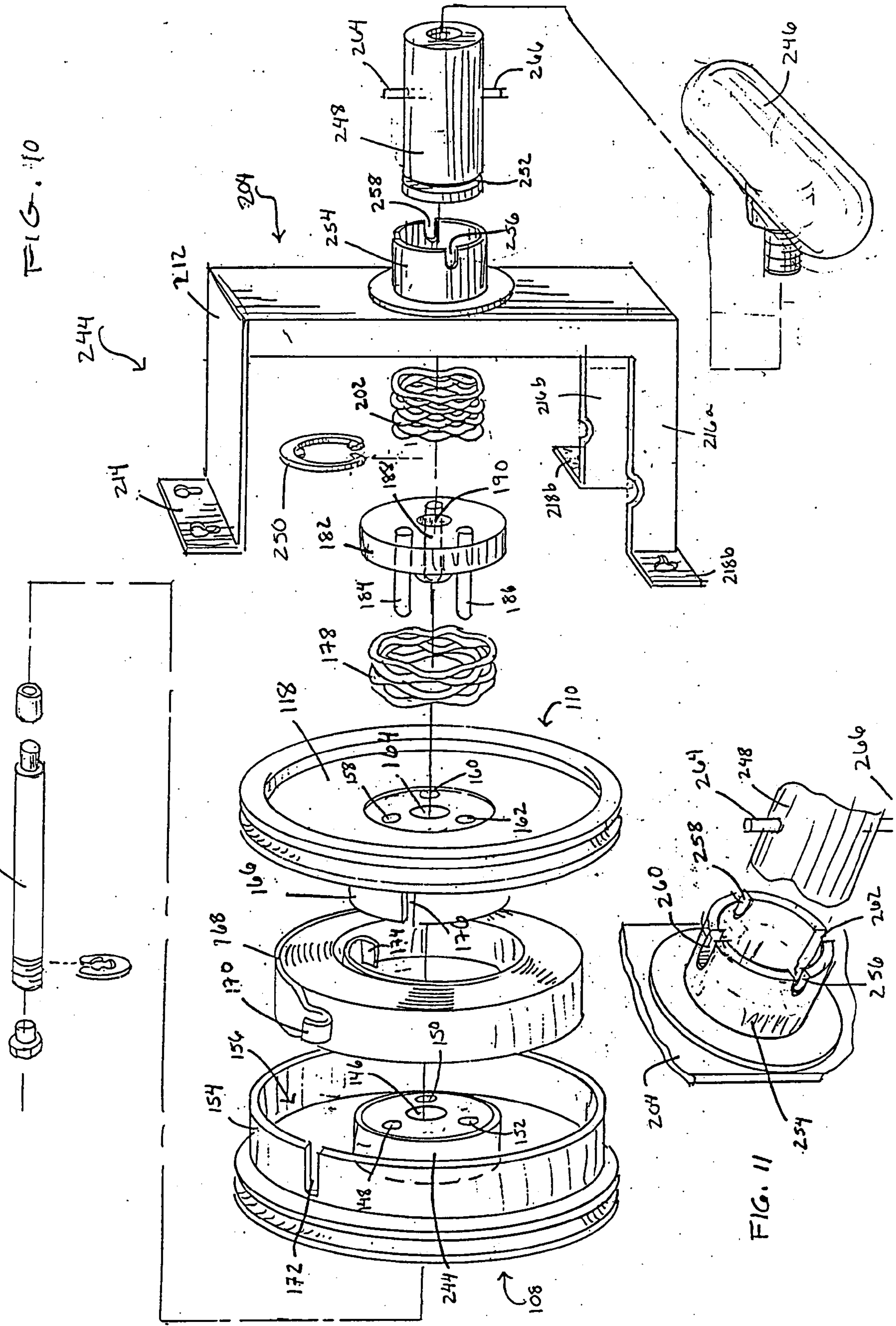

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FIG. 11

FIG. 12

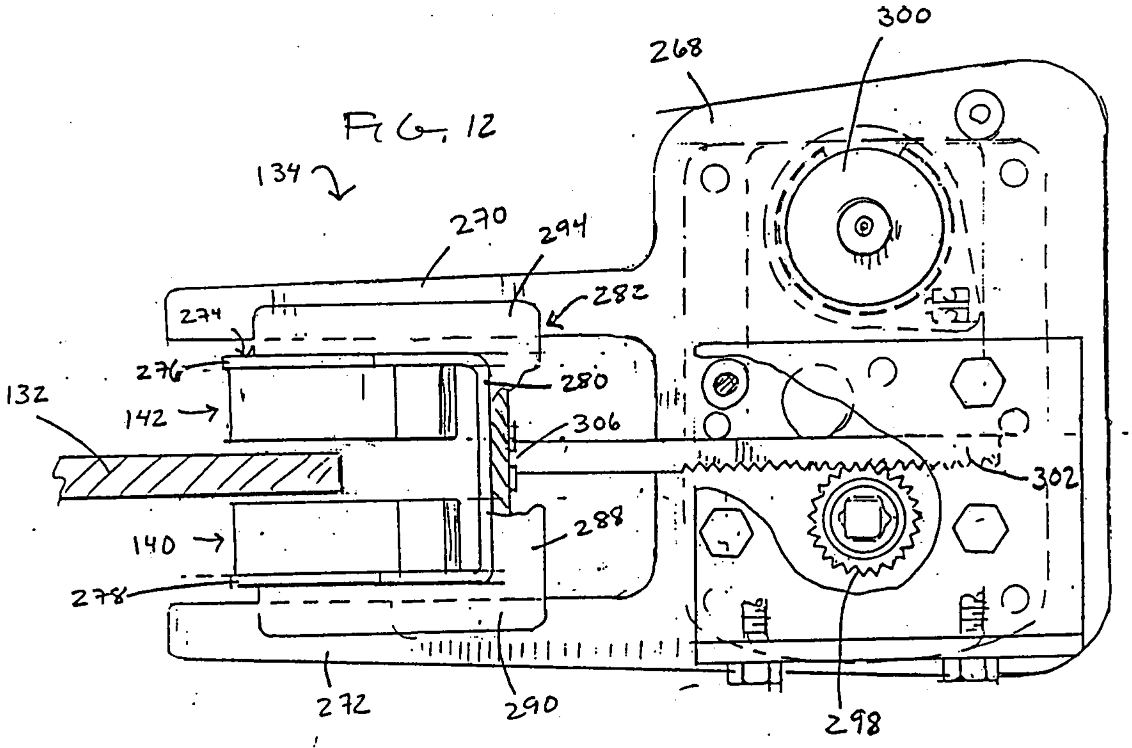
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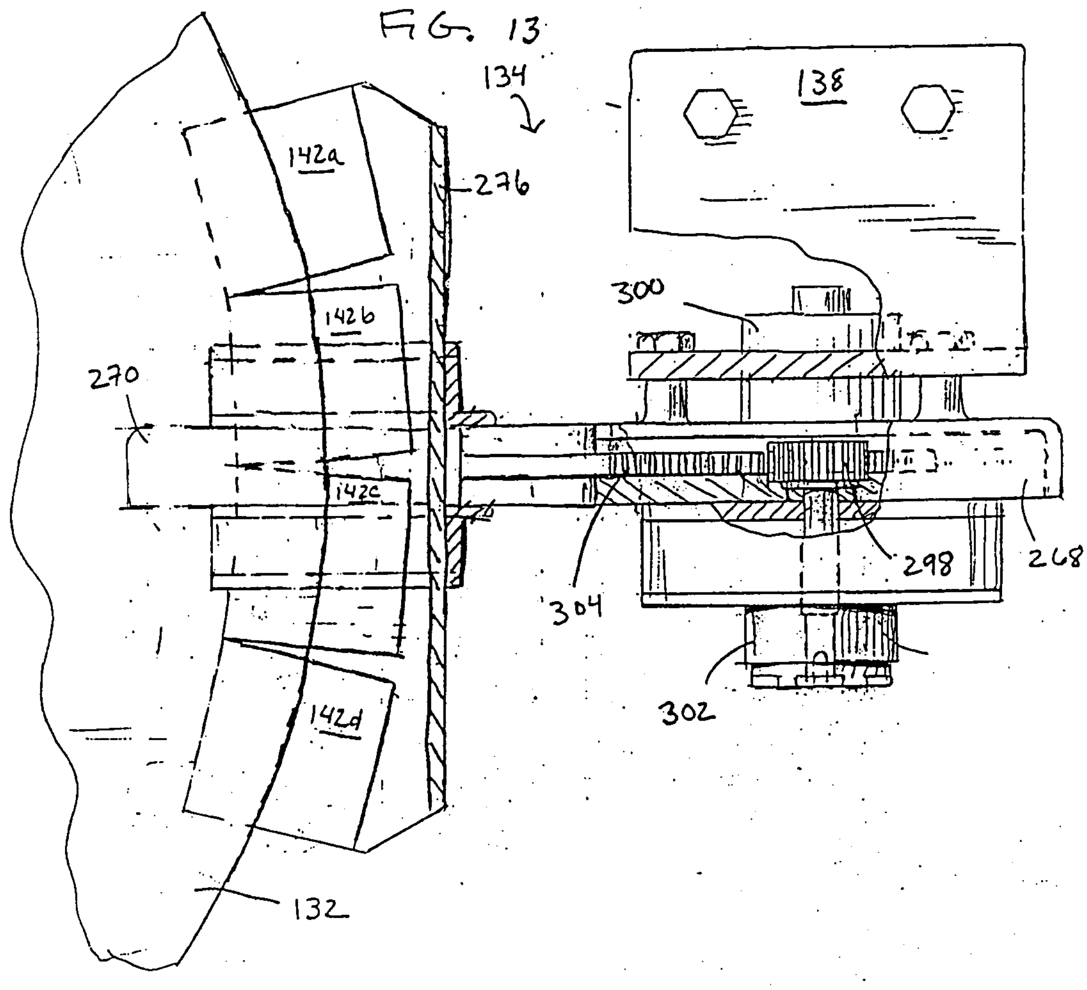
FIG. 13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142d
132

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 2826

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X,D	US-A-5 013 031 (BULL) * column 8, line 50-66; figures * ---	1	A63B23/04 A63B21/005
A	US-A-4 900 013 (RODGERS, JR.) * abstract; figures * * column 10, line 18-22 * ---	1-3	
A,D	US-A-5 180 351 (EHRENFRIED) * column 4, line 5-29; figures * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A63B
A63H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 June 1994	Giménez Burgos, R

CATEGORY OF CITED DOCUMENTS

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