United States Patent

Ryan

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[54] **METHOD FOR SIMULATING THE REDUCTION OF GRAVITY**

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[51] **Int. Cl.**.....**A63j 5/12**

[58] **Field of Search**.....35/12 P, 12 C, 12 E; 272/1 R, 272/6, 7, 24; 248/123, 364; 297/273; 182/3, 142, 145; 187/17; 254/178

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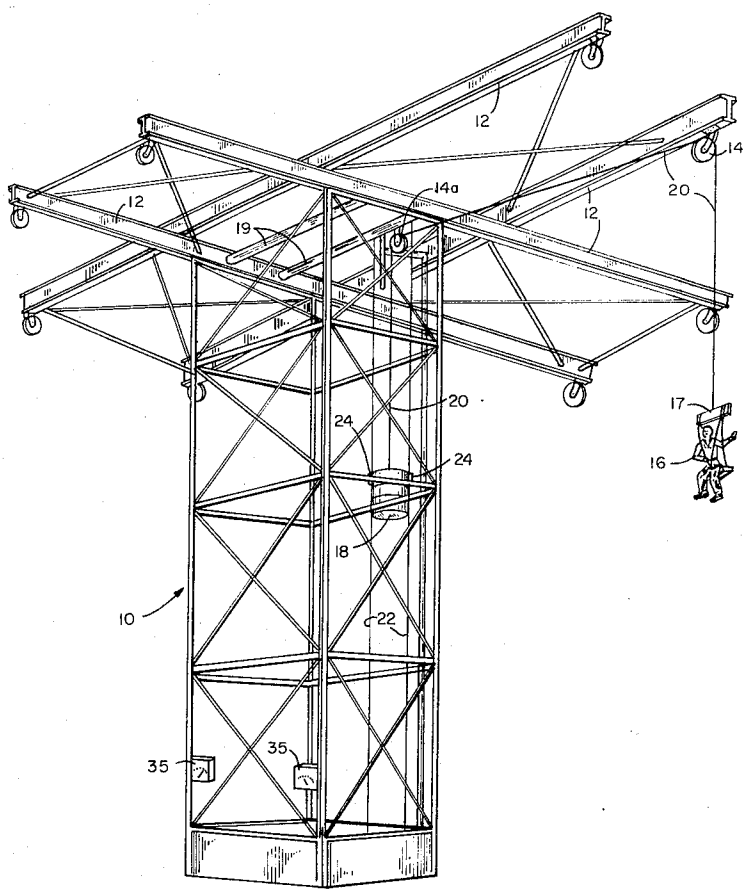
[57] **ABSTRACT**

This invention provides a method and means for simulating the reduction of gravitational forces upon persons. The gravity-reducing effect is achieved by counterbalancing the person through a cable and pulley system having a weight somewhat less than the person. This expedient in fact counterbalances the weight of the person in a manner resulting in an actual reduction of the free acceleration of the person toward the earth, thereby simulating a reduction in the natural gravitational pull. The disclosed embodiment is for an amusement park"ride" device employing this principle.

1 Claim, 3 Drawing Figures



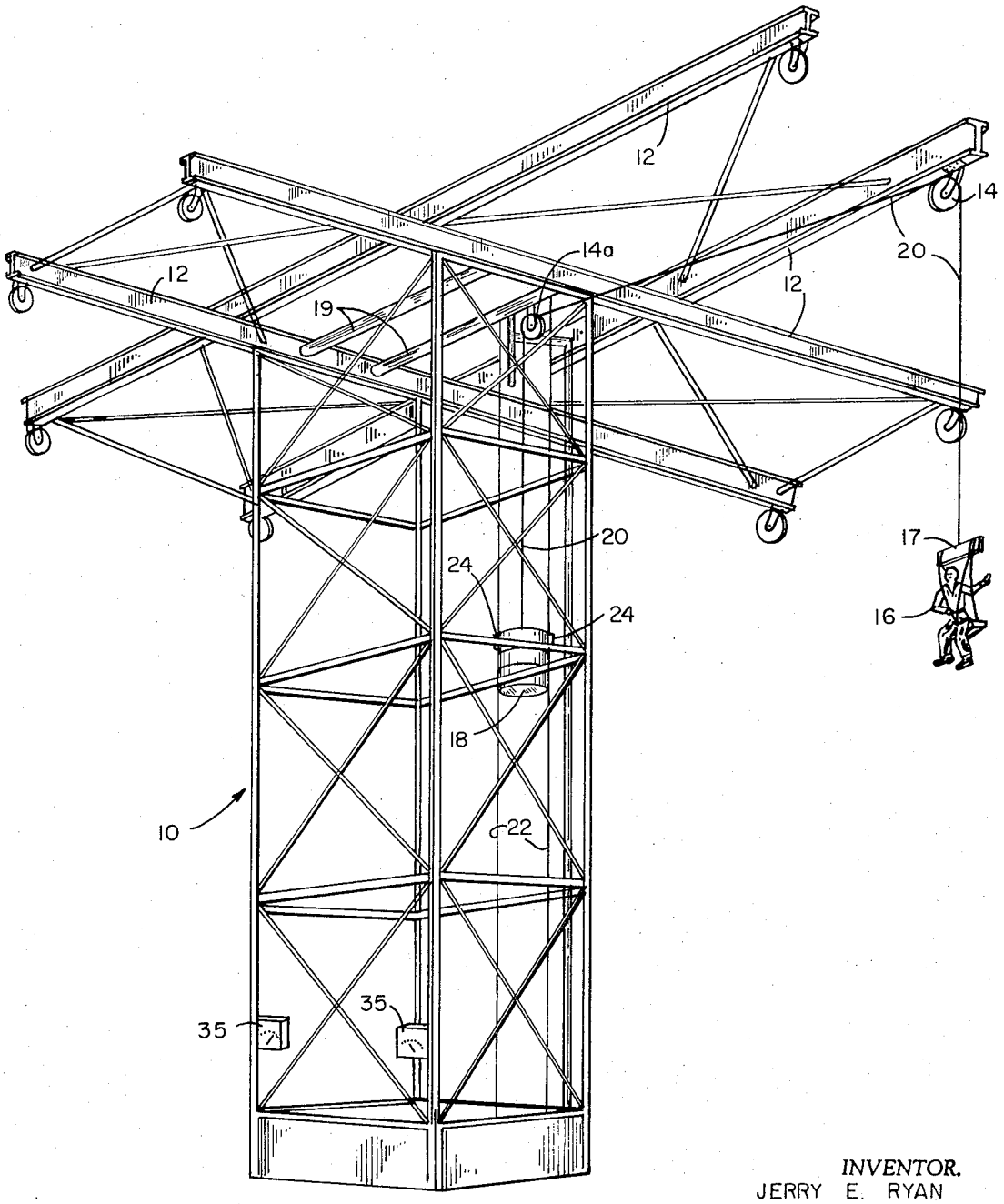


FIG. 1

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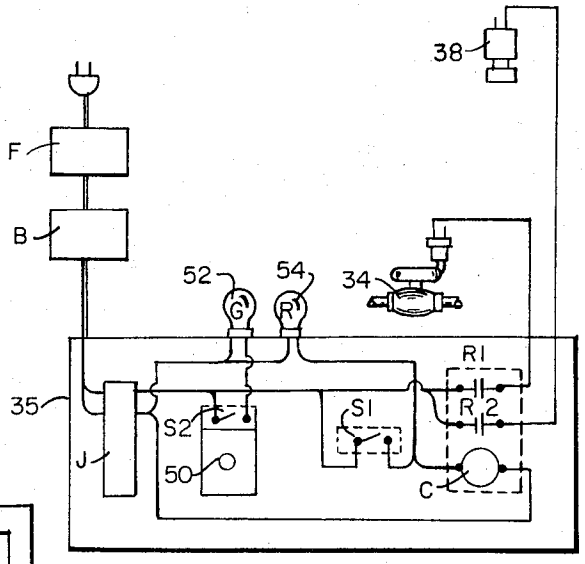

FIG. 3

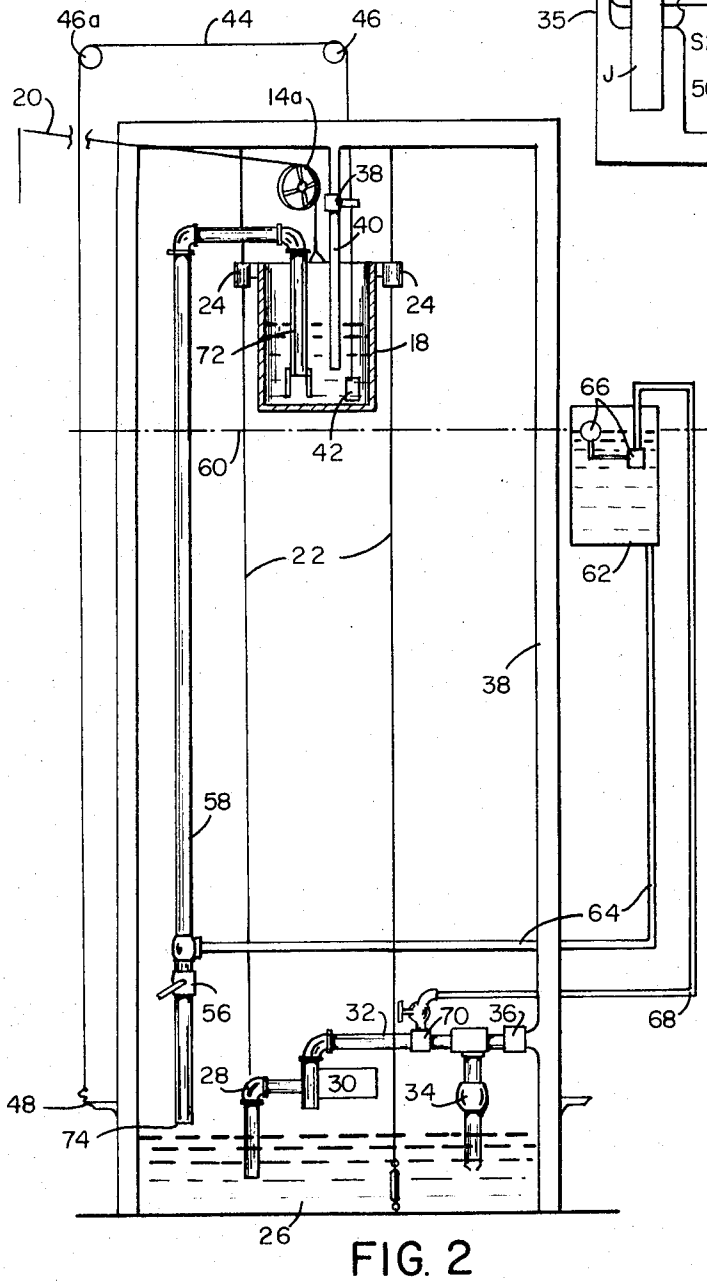

FIG. 2

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METHOD FOR SIMULATING THE REDUCTION OF GRAVITY

This invention relates to improvements in gravity-reducing devices and more particularly but not by way of limitation to a gravity reducing simulator wherein the reduction effect is achieved by a counterbalance means.

Many gravity reducing devices presently available, such as those used in training astronauts and the like, are somewhat expensive and complicated in structure and use. An example is the apparatus shown in the DeBoy et al. U.S. Pat. No. 3,161,968, issued Dec. 22, 1964 and entitled "Task Trainer." Actually, the disclosure of this DeBoy patent relates to a gravity "elimination" simulator, and involves a relatively complicated swivel-type harness mounted on a stand which glides over a floor upon a cushion of compressed air.

A further example in the gravity "reducing" field is the Hewes et al. U.S. Pat. No. 3,270,441 issued Sept. 65 **1966** and entitled "Reduced Gravity Simulator." In the Hewes apparatus the person employing mode the device is suspended at a slight angle from the horizontal by a myriad of ropes to the various portions and limbs of his body, restricting his motion in the vertical (or more properly, radial) mode and allowing only that in the more or less horizontally-inclined (or more properly, circumferential) mode, thereby subjecting the user (in this latter mode of movement) to only the minor component of normal gravitational force. The disadvantages of this type of structure and operation will be obvious.

More sophisticated devices also exist, replete with overhead supports operated by computer-controlled servomechanisms, and the like, such as those understood to be presently employed by NASA, which are of an expensive construction.

By contrast, the present invention provides a relatively simple and inexpensive system to achieve very satisfactory reduced gravity simulation by merely counterbalancing the person by a weight through a pulley system, in accordance with a very simple principle. The principle of the present invention is the fact, as predicted by mathematical theory and confirmed by experimental evidence, that when one weight in a gravitational field is counterbalanced through a simple overhead pulley system with another weight of less mass than the first weight, then the acceleration of the primary weight towards the earth is not that of normal gravitational acceleration, either of the primary weight alone, or of a weight equalling the primary weight subtracted by the counterbalancing weight. (This normal gravitational acceleration is commonly referred to as g, and is valued at about 980 cm/sec^2 for the earth). Instead, by the counterbalancing principle, the primary weight when counterbalanced as described herein falls to the earth at an acceleration less than that of the normal g, which is the same thing as saying that for the weight so counterbalanced, there is simulated an apparent reduction in the gravitational force or field acting thereon.

It is believed that the reduced acceleration of the counterbalanced weight is given by the formula:

$$a = g\left(\frac{l-k}{l+k}\right)$$

where a equals the reduced acceleration, g is the normal gravitational acceleration of the earth (or of the planet whereon the device is to be placed), and k is the ratio of the counterbalancing weight's mass to the primary or counterbalanced weight's mass (said ratio or k to be greater than zero and less than one). Thus, if there be no counterbalance at all, k is zero and a equals g (meaning no simulated reduction in gravity because of a total absence of counterbalancing); or, if the counterbalancing weight equals the primary weight, then k is unity and a is zero (meaning no natural movement at all because of the perfect counterbalancing); and if the counterbalancing weight be one-half that of the primary weight, then k is one-half and a is one-third g. (It should be noted that the formula ignores as negligible any mass in the line and any inertia and friction in the pulley system).

The effect of this simulated reduction in gravity can be physiologically experienced and appreciated by a person whose weight is counterbalanced as described. Such a person does in fact experience an exhilarating partial release from normal gravity, resulting in his ability to make giant "moon" steps and jumps, and gentle descents.

On the basis of the exhilaration and delight experienced by a person employing this system upon himself, the present embodiment takes the form of an amusement park "ride" device; of course, more serious uses can be envisioned, e.g., familiarization of astronaut trainees with lunar gravity.

It is an important object of this invention to provide a method to simulate a reduction in the gravitational force naturally acting upon persons.

It is another object of this invention to provide a method for an amusement park "ride" simulating gravity reduction.

It is a further object of this invention to provide a method for providing a reduced gravity simulator for personnel for other purposes, e.g., for training.

Other and further objects and advantageous features of the present invention will hereinafter more fully appear in connection with a detailed description of the drawings in which:

FIG. **1** is a perspective view of the amusement park embodiment of the invention:

FIG. **2** is a detailed view of the counterbalancing system of the amusement park embodiment of the invention;

FIG. **3** is a schematic of the electrical system of the amusement park embodiment of the invention.

Referring to FIG. **1**, reference numeral **10** refers in general to a tower structure which supports a plurality of overhanging cross-beams **12**, from which overhead pulley systems depend, as will be hereinafter described. It will be noted that there are four cross-beams **12** depicted herein, but there is no limitation as to the number of cross-beams **12** utilized. The opposite ends of each cross-beam **12** overhang the tower **10**, yielding a total of eight cross-beam overhangs, each of which is capable of supporting an outer pulley **14** from which a rider **16** depends as will be hereinafter set forth. Thus, the tower **10** as shown herein can accommodate a total of eight riders **16** at the same time, although for simplicity of description the drawings herein show the tower rigged for only one rider **16**.

The tower 10 and the overhanging cross-beams 12 merely support the system of the present invention. All of the cross-beams 12 are substantially identical and support a similar pulley system and thus only one cross-beam 12 and associated pulley system will be described in detail herein.

The basic system comprises essentially the rider 16, seated or secured in a suitable personnel harness 17 connected to a counterbalancing weight 18 by a suitable cable 20 which runs through the overhead pulley system. The overhead pulley system comprises the outer pulley 14 near the end of the overhanging cross-beam 12, and an inner pulley 14*a* located at substantially the same level as the outer pulley 14 and supported within the periphery of the tower 10 by an interior support beam 19.

The counterbalancing weight 18 is depicted as a barrel; actually, the barrel 18 is merely a container for a quantity of water or the like which constitutes the true bulk and mass of the counterbalance, and which may be readily adjusted in relationship to the weight of the rider 16 as hereinafter described. To prevent lateral oscillations in the weight 18, it is moored to vertical guy wires 22 by any suitable eyelet or loop devices 24 affixed to the rim or sides of the barrel 18.

The weighting and ancillary electrical systems include first a master reservoir of water 26 or the like at the base of the tower 10. This water 26 normally recirculates upwards through the conduit 28 and pump 30 into the conduit 32. The solenoid valve 34 is normally open, so that the water, following the path of least resistance, normally recirculates from the reservoir 26 through conduit-pump-valve path 28–30–32–34 back into the reservoir 26.

This normal or quiescent state is altered when the "ride" begins. First, the rider 16 is fitted into the personnel harness 17 which is first moored at ground level (which means that the barrel 18, which is initially empty, is then near the top of the tower 10).

When the rider 16 is secured, the operator (not shown) closes the normally-open switch S1 located on the instrument panel 35 corresponding to the particular (of eight) riders 16, and conveniently near the base of the tower 10. This causes electrical power from some suitable external source (not shown) which enters the system through a fuse box F, a breaker box B, and a junction panel J to cause relays R1 and R2 (energized by the coil C) to close. When the relay R1 closes, the normally open master valve 34 is closed, whereupon the water previously recirculating back into the reservoir 26 from the conduit 32 is instead driven by the pump 30 through the check valve 36 into the riser pipe 38 up to the top of the tower 10; and at the same time, when the relay R2 closes, the particular one of the eight normally closed solenoid valves 38 (corresponding to the particular barrel 18 which counterbalances the rider 16 depending from a particular overhang member 12) located in the downcomer conduit 40 opens; and thus a stream of water is directed from the reservoir 26 into the counterbalancing barrel 18.

It will also be noted that a fixed weight 42 is lying in the barrel 18 while the barrel is being filled with water. The fixed weight 42 is attached to a string 44 which runs through a second overhead pulley system 46 and 46*a* and which during the filling of the barrel 18 dangles freely down to near the base of the tower 10. When the barrel 18 is filled to where it just begins to overbalance the weight of the rider 16, the operator notices this state by the commencement of lifting of the rider 16 off the ground, at which time the operator opens the switch S1, which opens the relays R1 and R2, which opens the master valve 34 and closes the individual valve 38, which thereby terminates the flow of water into the barrel 18.

With the barrel 18 and the rider 16 are thus just counterbalanced, the operator then takes the free end of the dangling string 44, and pulls it slightly downward and attaches said free end to the fixed hook 48. This causes the weight 42 to be lifted slightly out of contact with the bottom of the barrel 18. This elimination of the weight 42 from counterbalancing contact with the rider 16 causes the rider 16 to outweigh the previously balanced barrel 18 by a weight substantially equal to that of the (removed) weight 42.

Experiment indicates that the most subjective "fun" on the device is experienced when the rider outweighs the counterbalance by about 10–15 pounds. This desired degree of imbalance can be readily achieved by setting the weight of the weight 42 substantially equal to this value (plus weight lost to displacement of the water, of course).

When the rider 16 has been properly secured, and counterbalanced and imbalanced, and the harness 17 unmoored from the ground, the rider is free to begin his "ride" of walking and jumping under the simulated reduced gravity. At the commencement thereof, the operator may throw or close switch S2, which starts an optional timer 50 (also located on the panel 35). During the "ride" a green light may be lighted; when the ride period is over (as for example 3 minutes may be considered a reasonable time) the timer 50 may automatically turn off the green light 52 and turn on the red "stop" light 54, as a signal to the operator.

When the "ride" is over or completed, the rider 16 descends to the ground and gets out of the harness 17, which should again be temporarily moored to the ground in any conventional manner (not shown); and when the barrel 18 is conversely returned to its elevated position near the top of the tower 185 the operator throws the normally closed butterfly valve 56 in the siphon downcoming pipe 58 into the open position.

Prior to the opening of the butterfly valve 56, the siphon pipe 58 has been primed with water to the level 60, which is the same as the water level in the elevated water reservoir 62, which is in fluid communication with the siphon pipe 58 through means of the pipe 64. The elevated reservoir 62 serves the purpose of maintaining the water level 60 in all of the eight individual priming pipes 58, and accomplishes this end by means of a conventional float valve means 66 which regulates the flow of water thereinto from the pipe 68 which leads, through a check valve 70, from the main recirculation conduit 32 of the main water reservoir 26.

Thus, when the butterfly valve 56 is opened, the column of water standing from the valve 56 to the level 60 begins to fall, and in so doing creates a suction in the siphon pipe's upper end 72 which opens in the water contained in the barrel 18. This suction draws the water in the barrel 18 through the siphon pipe's upper end 72

and over into the main stem of the pipe **58**, whereupon said water, along with the previously standing column of water already in the pipe stem **58**, commences a siphon action drawing the remaining water out of the barrel **18**, and discharges same through the butterfly valve **56** and on out the lower end **74** of the pipe **58** back into the main reservoir **26**.

It is to be noted that it is possible for a single operator, standing at the control panel **35** near the base of the tower **10**, to supervise the enharnessing of riders, and to effect their counterbalancing to the desired degree of imbalance at the beginning of a ride, and to unload the counterbalance at the termination thereof, all by simply manipulating the appropriate switches, lines, and valves.

Of course, the counterbalancing could also be achieved by the conventional expedient of simply attaching detachable fixed weights to the counterbalancing end of the cable **20**, in place of the water barrel system as herein described. It would also be possible to provide for hinged overhangs **12**, to allow the rider a greater arc of lateral motion.

From the foregoing it will be apparent that the present invention provides a novel gravity reducing simulator wherein a rider may achieve the sensation of reduced gravitational pull on his body through a counterbalance system which includes a simple counterweight and pulley system. The rider is suspended at one end of a cable which extends over or through the pulley system and into connection at the opposite end with a counterweight member. The counterweight member may be easily altered to properly compensate for the weight of the rider to provide the desired substantially weightless or reduced gravitational effect. The novel apparatus is simple and efficient in operation and economical and durable in construction.

Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications, apart from those shown or suggested herein, may be made within the spirit and scope of this invention.

What is claimed is:

1. A for simulating the reduction of gravity for personnel comprising the steps of counterbalancing the weight of the personnel through an overhead pulley system with a weight less than the weight of the person, adjusting the degree of imbalance between a counterbalance member and the personnel, wherein said step of adjusting the degree of imbalance between the personnel and the counterweight comprises the steps of providing a fluid container for the counterbalance member, placing in the container an auxiliary weight whose weight minus the weight of the fluid displaced by the auxiliary weight is equal to the desired degree of imbalance, filling the container with the fluid until equal balance is obtained between the counterbalance and the personnel, and removing the auxiliary weight from contact with the container.

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