NASA CASE NO. MFS-22758-1

PRINT FIG. 4

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NASA CASE NO. MFS-22758
Marshall Space Flight Center

TECHNICAL ABSTRACT

ANTI-GRAVITY DEVICE

The present invention is an educational toy useful in demonstrating and teaching fundamental concepts regarding the laws of gravity.

Referring to Fig. 1, the device comprises a sphere 10 of radius r resting on top of sphere 12 of radius R. The center of gravity C_g of sphere 10 is displaced from its geometrical center C_t by distance D. The dimensions are so related that $D\left(\frac{R+r}{r}\right)$ is greater than r. With the center of gravity C_g of sphere 10 lying on vertical line 16, as shown, the device is in equilibrium. Also, sphere 10 can rest on top of sphere 12 with line C_gC_t joining the centers of the two spheres inclined to the vertical, as in Figure 3. When sphere 10 is rolled without slippage on the surface of sphere 12, as shown in Figs. 2 and 4, it will return to its equilibrium position upon release so long as it is not rolled past a critical point. This creates an illusion that the sphere 10 is defying the laws of gravity when it rolls back up the surface of sphere 12 or when it rests in equilibrium positions of Figs. 1 and 3. In reality, due to the above noted relationship of D, R and r, the center of gravity of sphere 10 rises from its equilibrium position as sphere 10 rolls a short distance up or down the surface of sphere 12.

The anti-gravity device provides an eye-catching and curiosity arousing means for demonstrating that natural gravitational laws cannot be violated and that what appears to be a defiance of the law is in reality compliance with the law. The working of the device can be filmed and shown as an eye-catching experiment involving laws of gravity.

INVENTOR: Sudarshan Pal Singh

EMPLOYER: National Academy of Sciences

INITIAL EVALUATOR: George Prince, S&E-COMP-SSH

PATENT APPLICATION SERIAL NO. 581,514

FILING DATE May 28, 1975

FIG. 1.

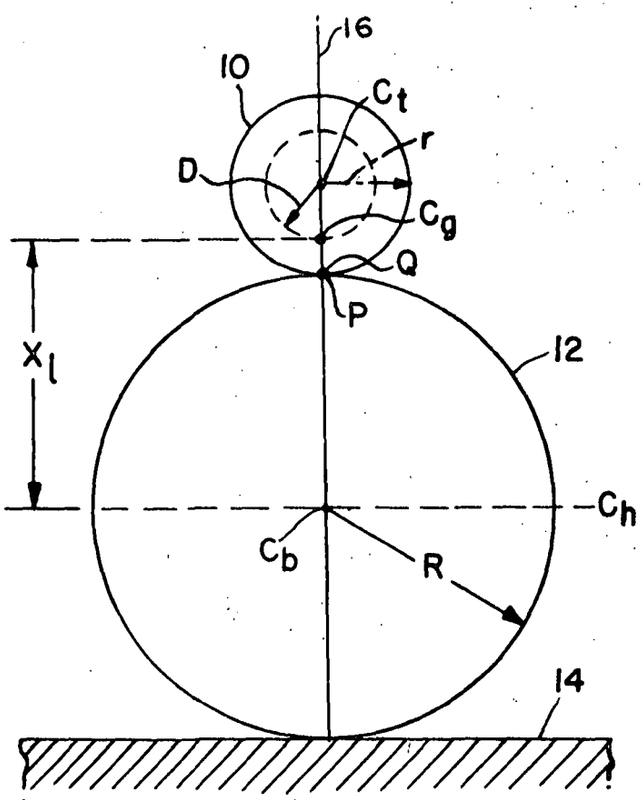


FIG. 2.

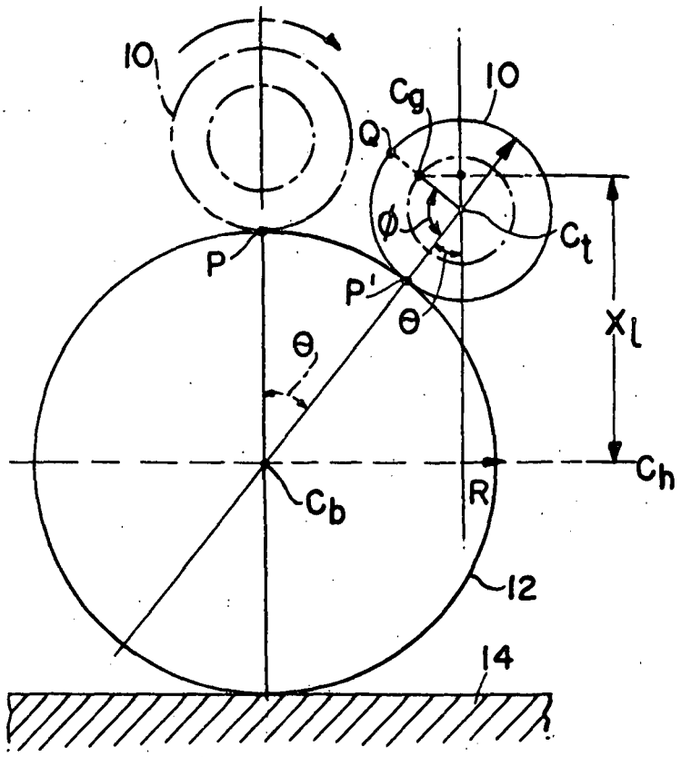


FIG. 3.

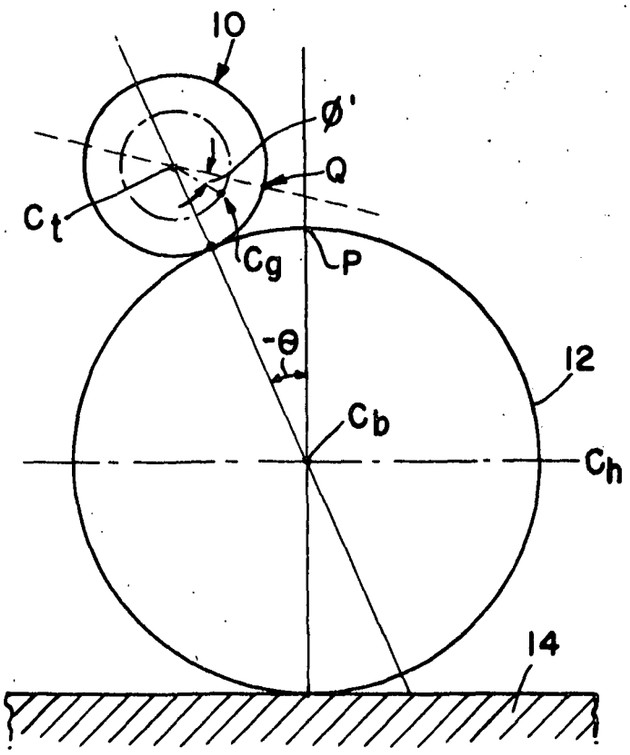
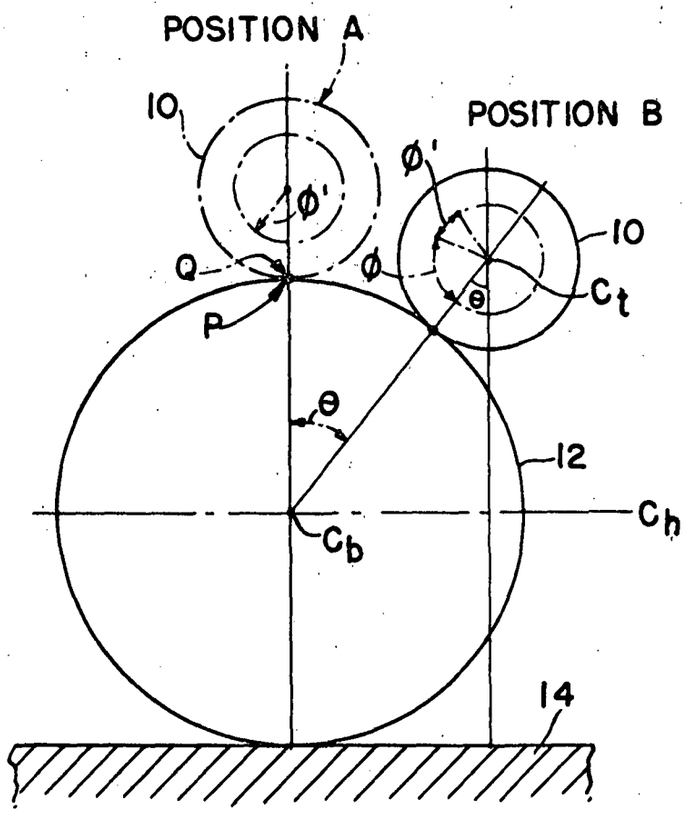


FIG. 4.



NASA CASE NO MFS-22758-1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: James C. Fletcher,
Administrator of NASA,
with respect to an invention of:
Sudarshan Pal Singh

Serial No.: Not Yet Assigned

Filed: Not Yet Assigned

For: DEVICE WHICH APPEARS TO DEFY GRAVITY

PRELIMINARY AMENDMENT TO THE ACCOMPANYING RULE 60 APPLICATION

To the Commissioner of Patents:

This is a preliminary amendment to the accompanying Rule 60 application (Serial No. 462,706, filed April 22, 1974):

In the Specification:

Cover page, line 6, change title to:

--DEVICE WHICH APPEARS TO DEFY GRAVITY--

Page 1, line 1, change title to:

--DEVICE WHICH APPEARS TO DEFY GRAVITY--

Page 7, between lines 10 and 11, insert the following subject matter:

--Equation (9) above can be rewritten as follows taking into account that $K = (R+r)/r$ and the relationship shown in equation (3):

$$D \sin (\theta + \phi) = r \sin \theta \qquad (9A)$$

From Equation (9A), it can be seen that the sphere 10 will be in an equilibrium state whenever the pull of gravity (i.e., line of force), acting on the upper sphere through its centroid Cg, is directed along a line passing through the reaction point at which the two spheres contact each other. For the reasons indicated below, sphere 10 has two states of stable equilibrium, and two states of unstable equilibrium.

Sphere 10 is in an equilibrium state when the line of force coincides with the line interconnecting the geometric centers of the spheres, the state being stable when the elevation of the centroid of sphere 10 is less than the elevation of the geometric center of the sphere (FIG. 1), and unstable when the elevation of the centroid of the sphere exceeds the elevation of the geometric center of the sphere. In addition, sphere 10 is in an equilibrium state when the line of force is not colinear with, but intersects, the line interconnecting the geometric centers of the spheres. The latter state of equilibrium is stable when the elevation of the centroid of sphere 10 is less than the elevation of the geometric center of the sphere, and unstable when the elevation of the centroid of sphere 10 exceeds the elevation of its geometric center (position B of FIG. 4).

Whenever sphere 10 is in a stable state of equilibrium (FIG. 1 or FIB. 3), a predetermined rolling displacement from its position of stable equilibrium (i.e., up to, but not exceeding, its position of unstable equilibrium) will result in the creation of a couple that acts in a sense opposite to the sense of displacement and serves to restore the sphere to its equilibrium position. Such couple is created by the upward reaction force on sphere 10 acting upwardly through the reaction point between the spheres, and the downward gravitational force acting through the centroid of sphere 10. When, however, sphere 10 is in an unstable state of equilibrium, any rolling displacement will create a couple whose sense is the same as the sense of displacement causing sphere 10 to either return to a position of stable equilibrium or simply roll off sphere 12.

An observer viewing the sphere 10 when the latter is perturbed from one of its stable states of equilibrium sees sphere 10 roll [illegible] down on sphere 12 about the equilibrium position with a gradually decreasing amplitude. Because sphere 10 appears

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symetrical (even though it is actually an unsymetrical mass), the observer would expect the perturbed sphere to roll down and off sphere 12. That is does not do this (when the sphere had been in a stable state of equilibrium) is completely contrary to the expectations of the observer, thus creating surprise and amusement.

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Page 7, line 13, delete entire line.

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APPLICATION FOR LETTERS PATENTS

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT Sudarshan Pal Singh, a resident of Huntsville, Madison County, Alabama, has invented certain new and useful improvements in ANTI-GRAVITY DEVICE of which the following is a specification.

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ANTI-GRAVITY DEVICE

Abstract of the Disclosure

The device consists of two spheres, one sphere having the capability of resting on top of the other sphere without falling off, even when either of the spheres is jiggled. The spheres are not fastened together in any way. The center of gravity of the top sphere is displaced from its geometrical center by a certain distance. The top sphere can rest on the bottom sphere with its center of gravity on the vertical line segment joining the geometrical centers of the spheres. Also, the top sphere can rest on the bottom sphere such that the line joining the centers of the two spheres is inclined tothe vertical. In both positions, the top sphere can be rolled up and down on the surface of the bottom sphere to a predetermined maximum angle and, when released, will return to its original position atop the bottom sphere.

Origin of the Invention

The invention described herein was made in the performance of work under NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

Background of the Invention

The present invention relates generally to the field of physical phenomena demonstration, and more particularly to demonstrating the effects of gravity.

Most prior art devices for demonstrating that physical objects obey the laws of gravity only show controlled instances of everyday occurrences, such as dropping an object or rolling a ball down an inclined plane. These effects fail to arouse much interest in the observers, who may be students. Consequently, these devices are often not effective as teaching devices and they tend to lose the attention of observers.

Summary of the Invention

The general purpose of this invention is to provide a device for demonstrating that physical objects obey the laws of gravity. The device has the advantages of being simple and inexpensive to construct as well as having the capability to arouse and stimulate interest in an observer. Often one becomes aware of the existence of a law when an exception to the law is encountered. The present invention provides a device whose operation seems to provide an exception to the law by apparently defying the laws of gravity. An understanding of the working of the device goes toward convincing the observer that natural physical laws cannot be broken.

The device consists of two spheres, one sphere having the capability of resting on top or near the top of the other sphere without falling off, even when jiggled. The spheres are not attached in any way. The center of gravity of the top sphere is displaced from its geometrical center by a certain distance. The top sphere is placed atop the bottom sphere with its center of gravity lying on the vertical line segment which joins the geometrical centers of the two spheres. Also the top sphere can rest close to the top of the bottom sphere with the line joining the centers of the two spheres inclined to the vertical. A predetermined relationship exists between the radii of the two spheres. When the top sphere is rolled on the surface of the bottom sphere, and displaced from its position atop the bottom sphere, it will, when released, return to its position atop the bottom sphere provided it has not been displaced more than a predetermined amount.

This effect, wherein the top sphere rolls upward on the surface of the bottom sphere or wherein the top sphere rests on the bottom sphere, even at an angle to the vertical, creates the illusion that the top sphere is moving against or defying the pull of gravity. This effect arouses interest and

curiosity in those who observe it, allowing the device to be used as an effective educational toy. The working of the device can be filmed and shown as an eye-catching experiment involving the laws of gravity.

Therefore, it is an object of the present invention to provide a device for demonstrating the laws of gravity in an interesting and eye-catching manner.

It is another object of the present invention to provide an effective educational toy for giving an insight into workings of the laws of gravity.

It is a further object of the present invention to provide an educational toy which creates an illusionary anti-gravity effect.

Brief Description of the Drawings

Other objects, advantages, and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings, in which like reference numerals designate like parts throughout the figures, and wherein:

Fig. 1 shows the device in one of its equilibrium conditions.

Fig. 2 illustrates the operation of the device when the top sphere is displaced from its equilibrium position of Fig. 1.

Fig. 3 shows the device in an equilibrium condition with the axis connecting the geometrical centers of the spheres inclined to the vertical axis.

Fig. 4 illustrates the operation of the device when the top sphere is rolled from an initial position of the top sphere with its center of gravity lying off the vertical axis connecting the geometrical centers.

Description of the Preferred Embodiments

Referring to Fig. 1, the device of the invention is shown in one of its equilibrium positions. A top sphere 10 rests atop a bottom sphere 12, with sphere 12 resting on any suitable surface 14. Sphere 10 has a radius r and has its center of gravity C_g displaced from its geometrical center C_t by a distance D. Sphere 12 has a radius R and a geometrical center C_b. Sphere 10 rests atop sphere 12 such that C_g lies along a vertical line or axis 16 connecting C_t with C_b. This line also passes through points P, on the surface of sphere 12, and Q, on the surface of sphere 10, the points P and Q being in contact with each other. For purposes of explanation, a horizontal line C_bC_h is shown passing through C_b. A variable distance X_ℓ defines the vertical distance from line C_bC_h to point C_g.

Referring now to Fig. 2, the sphere 10 is shown as having been rolled, with no slippage between the spheres, to a point P'. In order for the device to operate, the center of gravity C_g of sphere 10 must progressively have moved up from its stable position shown in Fig. 1 (i.e., X_ℓ must be greater). That is, although the sphere 10 has rolled part way down the surface of sphere 12, and C_t is lower, the center of gravity C_g has moved up. When this condition exists, the sphere 10 will, when released, roll back up the bottom sphere to return to its equilibrium position of lower center of gravity. Of course, there is a limit to the distance, or angle, through which sphere 10 can be rolled and still return atop sphere 12. This angle, as well as the stability of the device, is determined by the relationship of various dimensions in a manner which will now be described.

As can be seen in the figures, $X_\ell = R+r - D.$ (1)

The sphere 10 is rolled on the surface of sphere 12 without slipping so that line $C_b C_t$ makes an angle θ with vertical line 16. Let ϕ describe the angle between lines $C_t C_b$ and $C_t C_g$. Since the rolling motion occurs without slippage, arc PP' = arc QP'. (2)

Therefore, $R\theta = r\ \phi$. (3)

The height of C_g above $C_b C_h$ is given by

$$X_\ell = (R+r) \text{ Cos } \theta + D \text{ Cos } \{\pi - (\theta + \phi)\} \quad (4)$$

or, $$X_\ell = (R+r) \text{ Cos } \theta - D \text{ Cos } (\theta + \phi). \quad (5)$$

From equation (3), $\phi = \frac{R}{r}\theta$.

Substituting in (5)

$$X_\ell = (R+r) \text{ Cos } \theta - D \text{ Cos } \left(\frac{R+r}{r} \theta \right) . \quad (6)$$

Letting $K = \frac{R+r}{r}$;

$$X_\ell = Kr \text{ Cos } \theta - D \text{ Cos } K\theta . \quad (7)$$

To determine the minima of X_ℓ for various values of θ, we diffentiate X_ℓ with respect to θ and equate to zero. Thus,

$$\frac{dX_\ell}{d\theta} = Kr (-\text{Sin } \theta) + D K (\sin K\theta) = 0 \quad (8)$$

or, $$D \text{ Sin } K \theta = r \text{ Sin } \theta . \quad (9)$$

Since equation (9) is satisfied for $\theta = 0$, it is an equilibrium position. In general, the equilibrium position is at a θ which satisfies equation (9).

Differentiating equation (8),

$$\frac{d^2X_\ell}{d\theta^2} = -Kr \text{ Cos } \theta + D K^2 \text{ Cos } K \theta . \quad (10)$$

at $\theta = 0$,

$$\frac{d^2X_\ell}{d\theta^2} = -Kr + D K^2$$

$$= K(DK-r). \quad (11)$$

If DK > r, then $\theta = 0$ is a stable equilibrium position, which indicates that provided DK is larger than r, the top sphere will rest on the bottom sphere in a state of stable equilibrium and, if disturbed slightly, will return to its original position.

The range of displacement over which the sphere is stable is determined by solving the above equations to find the maximum values of X_ℓ for the particular spheres involved. As an example, let: r = 1 unit

R = 2 units

D = 0.5 units

Since $K = \frac{R+r}{r}$, K = 3. Minima of $X_\ell = 2.5$ at $\theta = 0$. Maximum of $X_\ell = 2.598$ at $\theta = \pm 30°$.

Since the solution of these equations is somewhat involved, the details are not included herein.

Thus, an anti-gravity device according to the present invention built with the above specifications will result in the top sphere returning to $\theta = 0$ position atop the bottom sphere when it is displaced less than $\pm 30°$.

The device of the present invention can be modified by placing the top sphere on the bottom sphere with the center of gravity of the top sphere not on line 16. Referring to Fig. 4, sphere 10 is placed initially on sphere 12 with the line C_gC_t making an angle ϕ' with line C_tC_b (position A). Sphere 10 is displaced through an angle θ to position B. The equation governing X_ℓ is:

$$X_\ell = Kr \cos \theta - D \cos (K\theta \pm \phi'). \qquad (12)$$

Treating this equation in the manner shown above, and with:

$r = 1$

$R = 2$

$K = 3$

$D = 0.5$

$\phi' = 10^{\circ}$.

X_{ℓ} min = 2.485 (approx.) at $\theta = -10^{\circ}$ (approx.)

X_{ℓ} max = 2.511 (approx.) at $\theta = -29^{\circ}$ (approx.)

and = 2.685 (approx.) at $\theta = +30^{\circ}$ (approx.)

Thus the equilibrium position for the top sphere with initial position and roll as in Fig. 4 is similar to the one shown in Fig. 3.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example, element 12 could be a hemisphere instead of a complete sphere, or both the top sphere and the bottom sphere could be constructed with their centers of gravity away from their respective geometrical centers so that either sphere could rest atop the other. The device could also consist of more than two spheres stacked one above the other. Also variations of values of r, R and D lead to different stability configurations. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

This is the end of the patent specification. There are no claims attached.