STUDY OF THE PROPERTIES OF THE TOP AND ITS COMPLEX MOTION BY EXPERIMENTAL METHOD

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The top is rotated and carefully put down on a horizontal plane. Immediately on touching the ground, the top spins in the spot by quick bouncing. Often the top vacillates — tilts — to any side. After trembling from inner stresses, the top straightens up, the rotation increases and it continues spinning in the spot.

A rotated top dropped in any sense on a horizontal base has an angle less than 90° at the moment of touch with the base. After touching the base, the top proceeds with bouncing progressive motion along the spiral circles. Due to inner stresses, the axis gradually straightens up causing shorter bouncing, the spirals being reduced and finally the top spins in the spot.

When a rotated top is put on a slant base, it starts progressive bouncing motion immediately after touching the slant base. Thereon the rate of rotation and progressive speed are alternately increased and decreased.

When a slant base is lowered, the progressive speed abruptly decreases. When tilted more, the progressive speed abruptly increases.

If the base is completely lowered on the horizontal plane the top spins in the spot without forward vacillations. If the base is tilted again, the top starts bouncing progressive motion over the again slanted base without rearward recoil.

The rate of progressive motion of the top primarily depends on the angle of tilt of the top speed of rotation, top shape, its size and density of its mass.

If the base with top progressively rotates, turns by 180° α, then on turning of the base, the top briefly spins in the spot, then passes abruptly into progressive bouncing motion.

If a rotated top is dropped in the sphere, it immediately starts bouncing progressive motion along the sphere.

EXPERIMENTAL RESULTS

The conclusions which had been backed up by the results of measuring reveal the knowledge on the existence of a molecular force of the body substance to maintain its balance. It is a force which is liberated by the condensed inner stresses of the body substance, which restores the disturbed balance of the body.

The existence and action of the liberated energy of inner stresses of the body substance for maintaining of its balance accounts for the character of inertia.

INTRODUCTION

The top is a body of a free axis in a complex motion. For study and solution of this problem, two methods are possible : the mathematical method and the other, experimental method with measurings by means of measuring instruments. The top is classified among gyroscopes but it differs essentially therefrom. having a free

rotating axis during the complex motion. Owing to this decisive difference from gyroscopes, the mathematical method used so far proved as inefficient for studying of the top. We shall apply the experimental methods with measurings.

The many-year experimenting with tops of various shapes : disc, ball, ellipsoid, paraboloid, pear-shaped and heart-shaped on a horizontal base, over a slant base in the sphere and on the sphere, enabled to observed very significant phenomena in the complex motion of the top. The tops of various sizes and from various materials have been applied. Measuring with precision measuring instruments enable to prove the phenomena observed in the complex motion of the top and the conclusions made therefrom and finally to make the appropriate hypotheses.

MOLECULAR FORCES OF BODY SUBSTANCE FOR MAINTENANCE OF ITS BALANCE—INERTIA

The changes in the speed of motion of every body must be caused by a force. Without the effect of forces, there cannot be any slowering down of the motion in moving bodies, nor any acceleration of their motion.

The external influence of the medium in which the tops move : gravity, friction, air resistance etc., while permanently breaking, act on the complex motion of tops. These external actions — forces — result in dropping of speed and rotation as well as progressive motion.

It is indispensable to detect the forces causing increase of the speed of rotation and involving progressive motion of the top on a horizontal base over an oblique base in the sphere and on the sphere.

We do not know the external forces which may cause an increase of the speed of rotation as well as its progressive motion. Based on multiple tests with tops, I have come to the belief that these phenomena may be accounted for only by the action of the molecular force of the body substance. Therefore, the force supply source for increasing of the speed of rotation as well as for progressive action of the top, has unavoidably to be detected in the very substance of the top. Realizing thus the problem, one comes to the following hypotheses :—

The centre of gravity of every top is above its base. Hence every top is in unstable balance. A perpendicular line running from the top center of gravity, tilted rotating axis, would fall off its point of support, due to which the top would drop too. At the moment, the rotating axis is taken off its balance by tilting of the axis, inner molecular forces of its substance would act. The condensed inner stresses of the substance of the top liberate energy which acts by impact on the peripheric portions of the top and these actions gradually put upright its tilted axis, changing the speed of rotation. This is the inertia of top.

The liberated energy of inner condensed stresses of the top substance acts also in such a way as to move in bounds the touching portion of its rotating axis at the base of the perpendicular line running from the centre of gravity, to return thus the top into balance.

Owing to the rotation of the top, the direction and sense of its bouncing change also. The bouncing of the top gets vertically sensed to the projection of its rotating axis. In this way the top progressively moves in bounds, in the sense which is depending on the sense of rotation to the right or left with respect to the projection of its rotating axis.

The measuring instruments applied on these tests confirm that the speed of rotation in the top changes, i.e., it is continuously decreased and increased in very short intervals during one single complex motion.

Based on these hypotheses, we are in a position now to explain substantially many properties of the complex motion of a body of a free axis.

Complex Motion of Top on a Horizontal Base

A rotated top is carefully put on a horizontal base. Immediately on touching the base, the top rotates in place by slight bouncing. External influences : gravity, friction, air resistance and other result in frequent hesitating, i.e., its axis slightly inclines to either side.

Every even slight inclination of top causes disturbances of its stability.

At that moment the condensed inner stresses of the top substance liberate the energy — intertia which acts by impact on the peripheric parts of a rotated top. These impacts straighten up the slightly tilted top axis. The impact of liberated energy — inertia of top are manifested by the foregoing trembling of the top after its hesitation.

The liberated energy of inner stresses of top substances — its inertia — also acts by impact on the sides of the rotating top. These impacts of liberated energy accelerate the rotation of top to correspond to the angle of tilt of the rotating axis after its straightening up. The speed of rotation of top after the impact of liberated energy is increased causing its further stable complex motion. These phenomena frequently repeat — top precession.

Table I

Speed of rotation on a horizontal base measured with instrument (per second)

Iron top
26; 30; 25; 32; 25; 30; 26; 30; 32; 25; 32; 26; 30; 32; 29; 30; 26; 25; 28; 30; 25; 28; 26; 25
Wooden ball
40; 42; 38; 41; 42; 40; 38; 40; 42; 40; 35: 38; 41; 40; 33; 40; 41; 40; 33; 41; 42; 41; 38; 41; 37
Iron ball
60; 63; 52; 63; 53; 60; 60; 63; 60; 63; 64; 61; 63; 59; 59; 62; 61; 64; 61; 62; 59; 61; 63; 59
Brass of heart shape
62; 58; 56; 63; 56; 65; 61; 64; 61; 60; 62; 64; 59; 62; 60; 62; 61; 58; 59; 62; 64; 59; 58; 55; 61

Motion of Top along Spiral Circles

The axis of a rotated top dropped in any sense on a horizontal base has an angle less than 90° on touching the base, i.e., it is tilted to the horizontal plane. Therefore, the stable motion of the top is very disturbed.

The condensed inner stresses of the top substance liberate an energy — inertia which acts so that the base of the rotating axis of the top is displaced by bouncing into the base of a perpendicular line running through the top centre of gravity so that the rotating axis of the top at that point would be vertical on the plane. That would result in its stable position.

Due to top rotation, the sense of its bouncing is vertical to the projection of a perpendicular line running through the top center of gravity. Thus the top moves progressively by bouncing along the spiral circles. The condensed inner stresses of the top substance release simultaneously an energy which acts by impact on its peripheric parts. These impacts of released energy — inertia continuously and gradually straighten up the tilted axis of the top.

Due to that gradual straightening up of top axis, disturbance of its stability is less and less. Therefore, the action of the released energy of inner stresses of the top substance are less and less, and consequently the bounces are the shorter. Owing to it, the spiral circles are less and less, i.e., their radii are less and less and finally the top spins in place.

The above analysis of the complex motion of the top in place and along the spiral circles on a horizontal base enables us to conclude that the top inertia, i.e., the liberated energy of inner stresses of the top substance is manifested in two forms :

The First Form — When the angle of tilt of the top axis is slightly changed, then the action of its inertia would follow, i.e., the condensed inner stresses of the top substance release the energy which acts by impact on the top sides, straightening up the slightly inclined axis of rotation. Also the liberated energy acts by impact on top sides to increase the speed of rotation or to decrease it to correspond to the angle of tilt of the axis which causes a stable complex motion of the top.

The Second Form — The second form of a constant effect of top inertia is manifested in releasing of energy of condensed inner stresses in its entire mass, so as to put the point of the bottom part of the top rotating axis by bouncing into the base of a perpendicular line running from the centre of gravity of the top.

Due to permanent action of inertia (second form) the top continuously bounces, either by rotating in place or by moving progressively.

TABLE II

Speed of rotation of top along spiral circles

Form of top & Number of top revolutions
Iron ball : 26; 35; 30; 22; 28; 22; 23; 21; 26; 25; 29; 26; 22; 30; 32; 31; 27; 28; 25; 27
Iron pear : 18; 20; 25; 27; 20; 23; 18; 23; 21; 20; 20; 17; 18; 19; 16; 16; 17; 16; 18; 18; 15; 15; 18 16; 17
Brass heart shaped : 27; 30; 32; 25; 27; 28; 25: 32; 27; 31; 26; 30; 34; 31; 28; 29; 30; 25; 31; 30; 26
Larger heart-shaped wooden : 50; 52; 57; 48; 56; 50; 57; 58; 57; 55; 51; 48; 51; 48: 52; 54; 51; 49; 50; 51; 47

MOTION OF TOP ALONG A SLANT BASE

When a top is rotated and dropped on a slant base, its rotating axis is tilted to the horizontal plane. The tilt of the top axis is same as the angle of the slant base to the horizontal plane. Due to the tilt of the rotating axis of this top, the base of a perpendicular line running from its centre of gravity is spaced from the point of touch of its axis. Therefore, the stable motion of the top in its complex motion is very disturbed.

The condensed inner stresses of top substance — second form of inertia liberate energy so as to place by bouncing the touching part of the top axis into the base of a perpendicular line, running from its centre of gravity. Due to top rotation, its bouncing is vertically sensed to the projection of its axis, It results in bouncing progressive motion of top along the slant base. The speed of rotation of the top, as well as the speed of its bouncing progressive motion are changed, i.e., they increase and decrease in brief intervals.

TABLE III

Speed of rotation of top along a slant base

Brass of pear shape
12 cm tilt : 31; 28; 30; 25; 32; 26; 28; 32; 27; 30; 32; 27; 31; 32; 27; 30; 29; 30

Greater wooden heart-shaped
15 cm tilt : 60; 60; 61; 55; 63; 60; 57; 55; 60; 63; 58; 60; 55; 51; 50; 48; 53; 49; 52

Greater wooden heart-shaped
14 cm tilt : 41; 43; 39; 44; 50; 41; 43; 42; 46; 44; 47; 45; 50; 49; 51; 46; 48; 51; 47

Wooden ball 9 cm
22; 20; 19; 21; 23; 21; 24; 21; 20; 21; 19; 20; 22; 24; 21; 20; 21; 19; 20; 18

LOWERING AND LIFTING OF A SLANT BASE

When a slant base on which the top progressively moves is lowered to horizontal plane, the rotating axis of the top is less inclined to the horizontal plane. A less tilt of the rotating axis of this top causes a slight disturbance of its balance. Due to it, the intensity of the liberated energy of inner stresses — second form of inertia action — and bounces are shorter accordingly. This involves a less progressive speed of top along the now slightly lowered slant base.

If the end of the slant base is again lifted from the horizontal plane, it would cause a greater tilt of the rotating axis of top to the horizontal plane. It results in a stronger intensity of the released energy — second form. Therefore, top bounces are larger, due to which its progressive bouncing speed of motion over a thus titled slant base is increased too.

When the slant base is completely lowered on the horizontal base, the rotating axis of the top is perpendicular to the horizontal base. The top is now in stable balance and suddenly passes into spinning in place with small bounces and the top does not vacillate forward then.

If one end of the base is again tilted to the horizontal plane, it causes tilting of the rotating axis of top again. At that moment the second form of inertia is acting and the top passes from spinning in place into bouncing progressive motion over the again tilted slant base. When passing from spinning in place to another bouncing progressive motion along a slant base it had no rearward jerk.

The method of complex motion of top along a slant base being lowered and again inclined, displays in the most accurate way that the speed of progressive motion of the top primarily depends on the amount of tilt of its rotating axis. A higher tilt of the rotating axis of top results in a higher progressive speed thereof.

If the top axis is perpendicular to the horizontal base, the top does not progressively move but spins in place by bouncing.

Turning of a Slant Base by 180-α

On rotation of the slant base over which the top progressively moves by an angle of 180°-α, the base has at one moment passed through the horizontal position. At that moment the top axis has assumed a vertical position with respect to the plane of the path, i.e., at the moment the top was in balance and therefore, rotated in place. As soon as the rotating axis of the top has become tilted due to rotation of the base, it caused the disturbance of its balance. The liberated energy of inner stresses of top substance caused a greater bouncing of the top which provoked its progressive motion over the now thus tilted base.

The tops move in variable speeds, passing again over the tilted base completely. The base rotates again by an angle of 180°-α. Same phenomena are repeated as on the occasion of the former rotation of the base.

In this way, the base moves by three or more times forward or rearward, viewed from our end by an angle of 180°-α.

A top moving progressively over a tilted base, which rotates as above by an angle of 180° — α with respect to the former angle of tilt, runs progressively a path length several times larger than it would run had not the base rotated. Any time the base is turned, the top starts a new progressive motion, after rotation in the spot, as at the beginning. In this way the top passes progressively a considerably longer path, than if the base had not been turned.

Table IV

Table of speed of rotation of top after turning by 180°

	Wooden ball, tilt 14 cm
I :	25; 30; 33; 30; 25; 24; 26; 30; 26; 22; 25; 24; 25; 21; 25
II :	25; 24; 21; 23; 25; 22; 20; 25; 23; 30; 28; 24; 26; 26; 23; 24
III :	25; 30; 31; 30; 26; 26; 22; 25; 22; 21; 23; 20; 21; 24
	Larger ellipsoid, tilt 12 cm
I :	38; 35; 37; 38; 36; 31; 33; 35; 32; 33; 35; 31; 34; 38
II :	38; 34; 35; 40; 37; 32; 37; 35; 31; 33; 36; 32; 30; 35; 37
III :	38; 35; 31; 34; 35; 31; 30; 33; 36; 33; 31; 35; 33; 38

Complex Motion of Top in the Sphere and on the Sphere

Two concave spheres and a convex one have been applied. Both concave ones have a canopy of 2 m in diameter. The depth of the first sphere was 8.5 m. and of the other one 11.5 m. When the top is rotated and dropped in the concave sphere, the top axis is tilted forward due to the depth of sphere. Therefore, its stable position is disturbed in the complex motion.

Condensed inner stresses of the entire top substance, the second form of inertia, release an energy to put the touching part of the top axis at the base of the perpendicular line running from its centre of gravity. Due to top rotation, its bounces are vertically sensed to its axis projection.

The progressive speed of the top in the deeper sphere is considerably higher than that in the sphere of less depth, because of the hi-her tilt of top axis in the other sphere. A top of a direct rotation has a progressive motion in indirect sense, whilst a top of indirect rotation has a progressive motion in direct sense in the concave sphere.

The complex motion of top in convex sphere is identical to that in concave sphere. Its progressive motion on this sphere is also direct. In indirect rotation the progressive motion is also indirect.

By analysing these phenomena and making conclusions therefrom, which had been ascertained by the results of measuring by means of measuring instruments, a final conclusion is arrived at on the substantiality of the body inertia and its character, unknown to the science so far.

The inertia is a molecular force of the body substance to maintain its balance. This is an energy liberated by the condensed inner stresses of the body substance for maintaining its balance, either in peace or in complex motion of a body.

The tests with the top, on a horizontal base, over an oblique base, in the sphere and on the sphere have been filmed.

Discussion

Phenomena in the complex motion of a top explained herein are an indisputable proof confirmed several hundreds of times by repeated experiments for each individual of these phenomena. All of these phenomena have been most carefully analysed. Causes have been looked for and tested, viz., the forces causing these phenomena.

A most precise analysis of each individual experiment leads to the conclusion that there are no external forces causing these phenomena.

It is unavoidable to come to the knowledge that these forces must be exclusively the inner stresses of top substance. After searching for them the conclusion on the character of inertia was made.

Inertia is a molecular force of the body substance for maintaining its balance. It is the energy liberated by condensed inner strain of a body substance to maintain its balance in motion or at rest.

Each of the phenomena aforementioned in the complex motion of a top is the most precise experimental result of the task set of each individual experiment from which the appropriate phenomenon emanated.

Thus, e.g., for the task: what should happen if a rotated top is dropped on a slant base? An absolutely accurate result is : a rotated top immediately on touching the slant base would pass into a progressive motion over the slant base.

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