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Gyroscope for movement in space

The author, leaning on experimentally known properties of a gyroscope and theoretical data, proves an opportunity without jet moving mechanical system to free space.

Our clause is calculated on a mass audience. We hope, what even that part of the interested readers which never heard a word "gyroscope", easily will understand a principle of work of this device and a way of its use for moving in without basic space.

Our clause, certainly, will be useful and to those who considers itself as the expert in the field of mechanics and in particular - in the theory of a gyroscope.

Let's begin with terminology and we shall show, how it corresponds with an object of research.

The gyroscope can be named a symmetric body, быстровращающееся around of an axis which are passing through a point, conterminous with its center of weights.

In the main parameter on which the characteristic behaviour of a gyroscope depends, its kinetic moment is

$$M_к = J \cdot \omega , \qquad (1)$$

where $J = m{\cdot}r^2$ - the moment of inertia of a body concerning an axis of rotation, r - radius of inertia of a body, Ω - angular frequency of rotation.

On fig.1 the classical scheme of fastening of a gyroscope by means of which it is possible to present its properties well is shown.

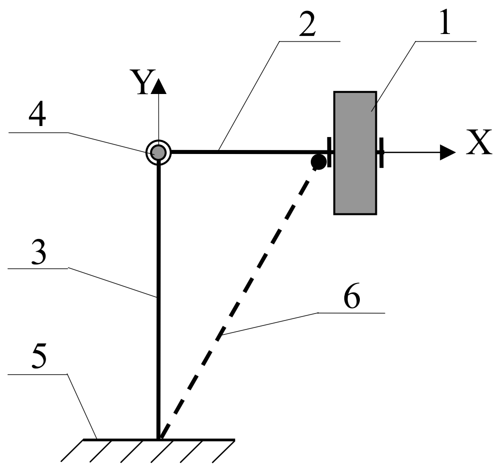

Fig.1

1. The gyroscope (a cylindrical rotor), 2 - a horizontal rack and it an axis of rotation of a gyroscope, 3 - a vertical rack, 4 - the hinge, connecting both racks, 5 -

a terrestrial surface, 6 - a time support, X and Y - orthogonal axes, which beginning coincides with the center of the hinge 4.

Let's untwist a gyroscope up to nominal turns and after that we shall quickly clean a time support 6. As a result there is an effect, which refers to "precession" (the compelled rotation) a gyroscope. Fig.2 explains its details.

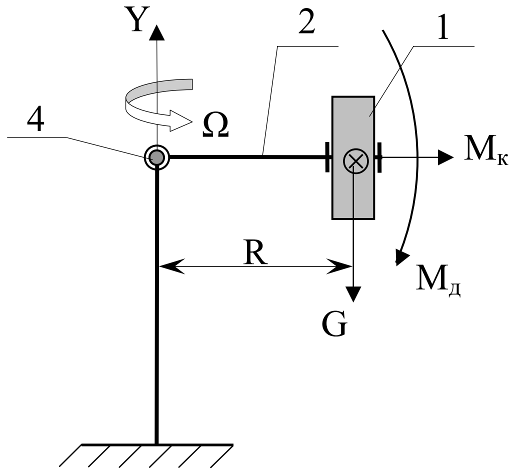

Fig.2

The gyroscope 1 is influenced with force of weight G which creates 4 moment Mд (the operating moment) concerning the hinge

$$M_д = G \cdot R = m_г \cdot g \cdot R, \qquad (2)$$

where m - weight of a gyroscope, g - acceleration of free falling, R - distance from axis Y up to the center of weights ⊗ a gyroscope 1. R is radius of inertia concerning axis Z and a shoulder of moment Mд.

Let's consider, that in a support 4 frictions are not present and there are no other forces which could interfere with free movement.

Under action of constant moment Mд (in view of a condition told above), the gyroscope begins to rotate exclusively only around of axis Y with constant angular speed

$$\Omega = M_д / M_к \qquad (3)$$

Such rotation name precession of a gyroscope (the compelled rotation of a gyroscope), and Ω - frequency of precession.

The parity (3) is established by practical consideration [1]. And it only one of a set of unusual properties with which the behaviour of a gyroscope differs from usual power interaction.

As a result, rotation can be described geometrical system of orthogonal (mutually perpendicular) vectors which instant position is shown on fig.3 (where the $M_г$ - name the gyroscopic moment).

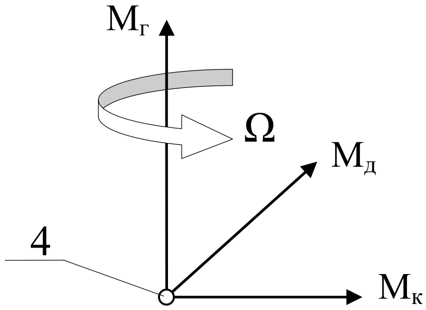

Fig.3

Thus the vector of $M_г$ keeps a constant direction in space, and the orthogonal pair vectors Mк and Mд rotates with frequency Ω around of $M_г$ in perpendicular to it a plane. Numerically, a vector are connected by a following parity of

$$M_г = M_д = M_к \cdot \Omega \qquad (4)$$

Further it is necessary for us to explain sense of radius of inertia. We shall present, that all weight of a body is concentrated in a point which coincides with its center of weights. Thus the moment of inertia of a body concerning some axis is equal to the moment of inertia of dot weight concerning the same axis. Then the distance from dot weight up to the specified axis of rotation refers to as radius of inertia, and numerically it is equal

$$R = (J/m)^{1/2}, \qquad (5)$$

where J - the moment of inertia of a body concerning an axis, m - weight of a body.

If the gyroscope is not untwisted (Mк = 0), radius of inertia of its center of weights ⊗ concerning axis Z and axis Y it is equal R, as shown in fig.4

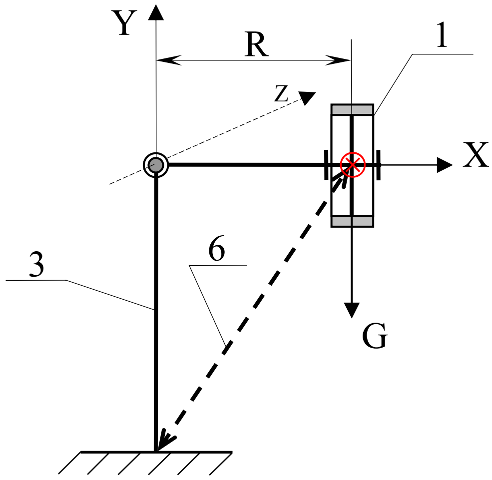

Fig.4

In the theoretical mechanics it is considered to be, that the gyroscope transfers only the center of pressure upon a support. For example (see fig.4) until the support 6 is established, and the gyroscope does not rotate around of axis X (Mк = 0), its center of pressure is on a line of action of force of weight G and coincides with position of the center of weights ⊗. As soon as we shall untwist a gyroscope (thus $M_к \neq 0$) also we shall clean a support 6 the center of pressure will move on a vertical rack 3 (on axis Y).

And time of carry of the center of pressure is equal to time during which the support 6 will be removed. It is considered to be, that such carry occurs instantly [2].

Let's compare two schemes precession of a gyroscope , represented on fig.5

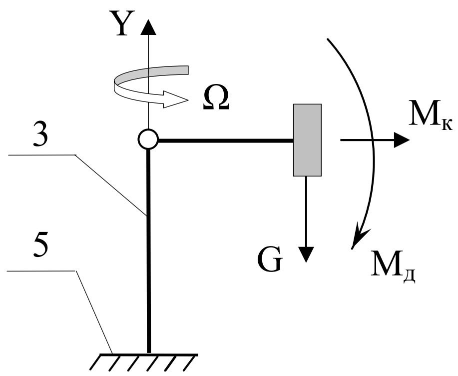

Fig.5a

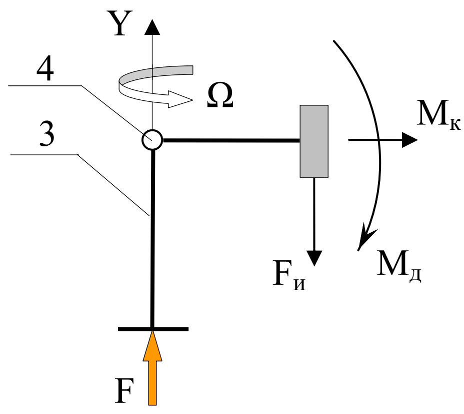

Fig.5**в**

The scheme on fig.5**в** differs from fig.5**a** only that have replaced gravitation of Earth G with force F opposite to it.

According to the third law of Newton, to the center of weights of a gyroscope it will be enclosed equal on size and opposite directed force $F_и$ (force of inertia). In this case the operating moment is numerically equal

$$M_д = F_и \cdot R = F{\cdot}R = m \cdot a \cdot R\,, \qquad (6)$$

where m - full weight of a gyroscope (in the sum with the armature hung on it: an axis, bearings, the case, etc.), a - acceleration of system under action of force F. The way of creation of force F can be any. It does not influence physics of process.

Experiments show, that precession of a gyroscope always occurs around of a line of action of force F which is passing through the center of pressure 4. In other words, it is possible to consider a vector of force F an axis on which perpendicularly rotates a gyroscope established on a bar, in length R.

Both schemes on fig.5 are vectorially asymmetrical. However dynamically they always behave so as if the center of weights of a gyroscope together with the armature hung on it is located precisely on axis Y.

In other words, in a dynamic mode (during precession around of axis Y) it is possible to consider, that the radius of inertia concerning an axis of precession Y - is equal to zero: RY = 0 (simultaneously, thus the radius of inertia concerning axis Z is not equal to zero: $R_Z \neq 0$).

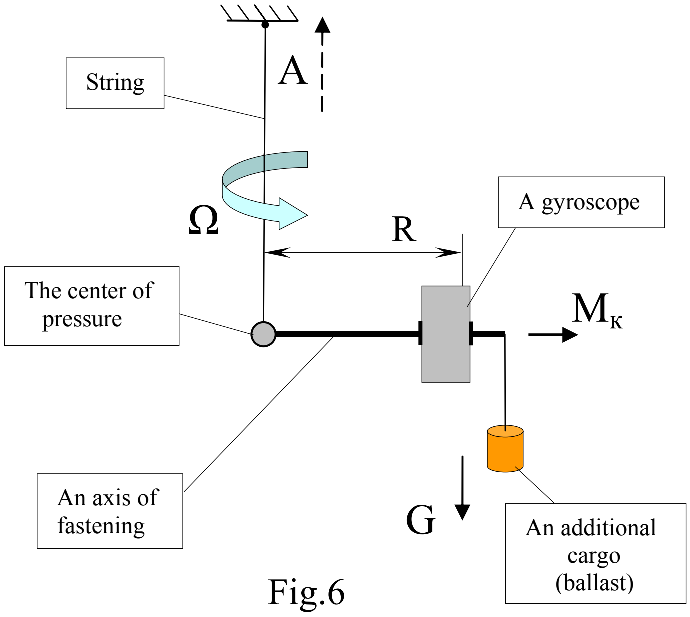

Fig.6

On fig.6 other scheme of experience which unequivocally shows is represented, that the gyroscope during of precession transfers not only the force of weight, but also weight of mass of an additional cargo (ballast) to the center of pressure.

Gyroscope preliminary untwisted in a vertical plane ($M_к \neq 0$), it is suspended on a thin string for the end of its horizontal axis. Thus the additional cargo (ballast) is attached to the opposite end of an axis. The string is adhered to a ceiling of laboratory. G - a direction of gravitation, R - a shoulder of moment Mд, Ω - a direction of precession.

It is possible to complicate experience as follows. We shall put to the top end of a string force F, in a direction A which is shown by a dotted arrow (we shall put to a string longitudinal acceleration). Thus the picture of precession will not change. Frequency of precession Ω only will increase, in exact conformity with the formula (3)

$$\Omega = M_д/M_к = (m_г + m_б)(g + a) \cdot R/M_к\,, \quad (7)$$

where – $m_г$ - weight of a gyroscope, $m_б$ - additional weight (ballast), g - terrestrial acceleration, a - the acceleration enclosed to a string in a direction A, R - a shoulder of moment $M_д$.

Even if we "shall switch off" gravitation (it means, that g = 0), all precession around of a string will equally proceed, until along it accelerating force F is enclosed, because thus the acting gyroscope moment $M_д = (m_г + m_б) \cdot a \cdot R$ will be kept.

Thus, result of action of force F is occurrence of moment Mд and carry of all inert mass located to the right of a string (see fig.6), on a line of action of force F, in a point conterminous with the center of pressure.

It is possible to make the following conclusion of all set of the facts.

Concerning an axis of precession:

a) - the radius of inertia of a gyroscope is equal to zero;

b) - centripetal force $F_ц$ and centrifugal force $\boldsymbol{F}$ on a gyroscope do not operate: $F_ц = \boldsymbol{F} = 0$.

In particular, it means, that during of precession the gyroscope transfers the center of weights together with the ballast hung on it - without jet feedback!

Our conclusion is obvious, evident and easily gives in to check by experience. But it is especially surprising, that in such form it is absent in the annals of theoretical mechanics.

However it is a trouble of theorists, and we, further shall show, how it is possible to use precession a gyroscope for without basic moving to free space (variant).

For explanatories we shall consider the scheme of the device represented on fig.7

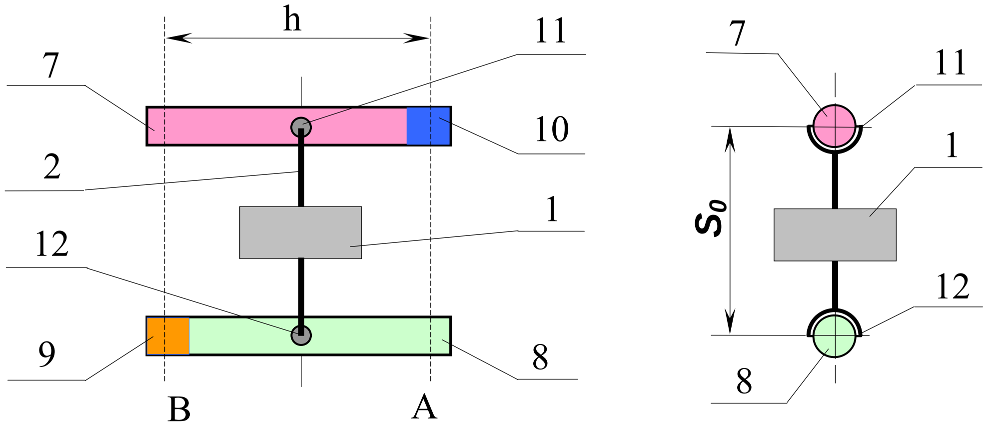

Fig.7

Following designations are entered. 1 - a gyroscope, 2 - an axis on which the gyroscope rotates, 7 and 8 - vibrators, 9 and 10 - mobile weights. The axis 2 is connected to vibrators hinges 11 and 12.

In addition (conditionally it is not shown), the device contains power drives of vibrators, the scheme of management and auxiliary details which are intended for maintenance of necessary geometry of a design. The power drive of the vibrator can be any type.

Its basic purpose - during the necessary moments to create moving weights 9 and 10 with acceleration from one end of the corresponding vibrator in another. Let cases of vibrators 7 and 8 are executed in the form of cylinders, and 9 and 10 - these are massive pistons. We shall name the device gyro-driver.

On fig.8a and fig.8в the scheme of moving of gyro-driver for one full cycle is shown. The designations resulted in figures, do not demand additional explanatories. In a starting position ⟨1⟩ the axis of the cylinder 8 coincides with axis X_0, and an axis of the cylinder 7 - with axis X_1, the gyroscope is untwisted up to nominal turns.

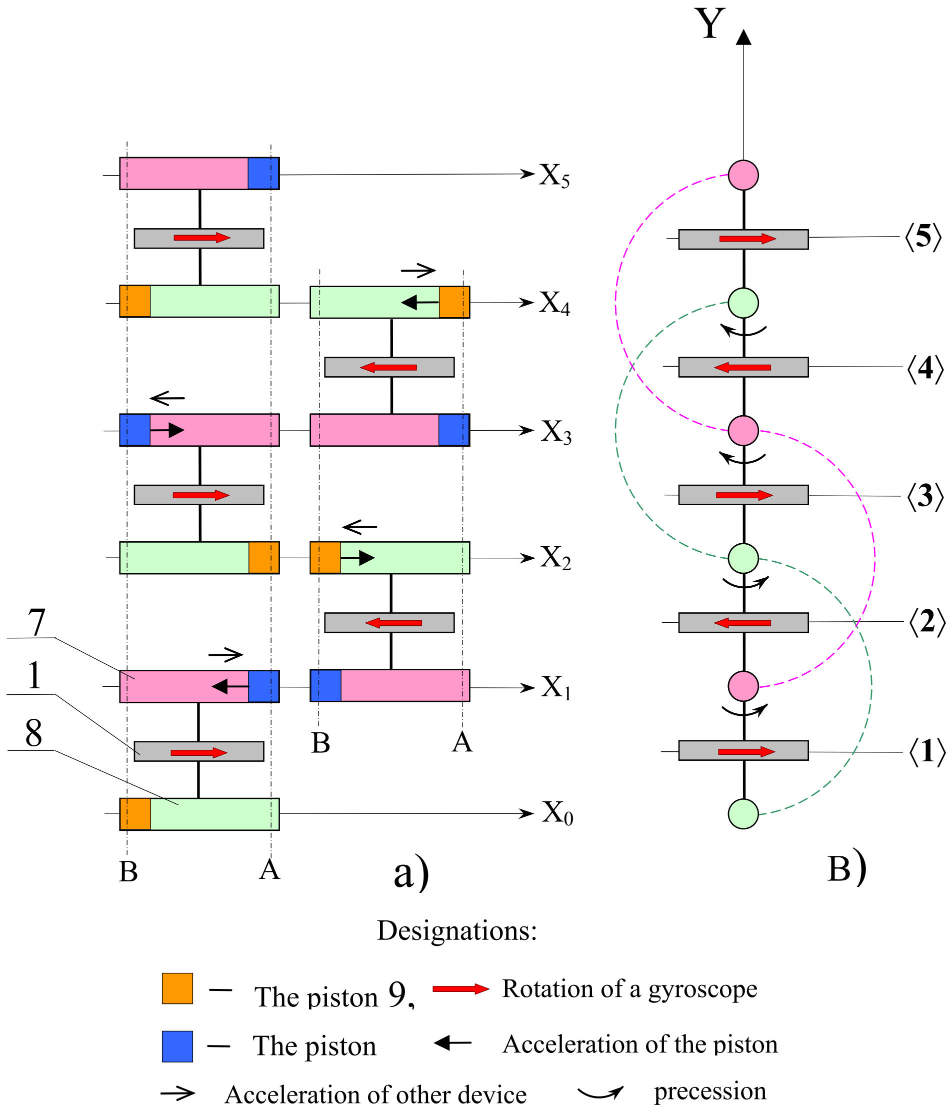

Fig.8

The scheme without jet moving gyro-driver

a) – kind directly, в) – projection to a lateral plane. 1 – gyroscope,

7 и 8 – cylinders (power drives for pistons, accordingly, 10 and 9).

The motion cycle begins that include a drive of the piston 10 and it, under action of the force enclosed to them, with acceleration moves in the cylinder 7 of position A to position of B. According to the third law of Newton, as a result of jet feedback, other part of device with acceleration is displaced in the opposite party. For presentation of figure, we is artificial have increased this displacement along axes X. Such interaction does not change position of the center of weights of system. Thus simultaneously, on weight of a gyroscope, together with mass of the vibrator (cylinder) 8, influences moment $M_д$ under which action the gyroscope begins precessionly rotation - around of axis X_1 (conterminous with an axis of the cylinder 7) counter-clockwise if to look on fig.8в.

Parameters of the device are picked up so that during the moment of a stop of the piston 10 in position B, the gyroscope has turned around of axis X_1 on a corner π (half of a turn).

Thus gyro-driver will borrow in space position ⟨2⟩.

As a result of precession around of axis X_1 the gyroscope without jet feedback transfers mass of gyro-driver on distance S_0. Duration of turn is equal

$$t = \pi/\Omega \qquad (8)$$

Duration of moving of the piston is equal

$$t = (2h/\mathbf{a})^{1/2} . \qquad (9)$$

For maintenance of an operating conditions it is necessary to execute equality between (8) and (9)

$$\pi/\Omega = (2h/\mathbf{a})^{1/2} , \qquad (10)$$

Where **a** - acceleration of the piston. During this time the piston 9 remains in position of B.

The following part of a cycle begins with inclusion of a drive of the piston 9 and it with acceleration moves in the cylinder 8 of position B to position A.

The picture of interaction will be similar described above except that a gyroscope carries out turn - on a half of a turn around of axis X_2 (conterminous with an axis of the cylinder 8), counter-clockwise, if to look on fig.8в.

After the second part of a cycle the device will borrow in space position ⟨3⟩, which corresponds without jet carry of its mass on distance $2S_0$.

Similarly the third and fourth parts of a cycle of turn, accordingly, around of axis X_3 (the piston 10 moves from B in A) and around of axis X_4 (the piston 9 moves from A in B) repeat.

According to a rule of the moments, rotation around of axes X3 and X_4 occurs clockwise if to look on fig.8в.

Thus, one full cycle of moving of the device consists of 4 parts.

As a result it will move in space on distance $S = 4S_0$ and will borrow position ⟨5⟩.

Thus all elements of the device will come in the initial condition, for the beginning the second cycle and all subsequent.

On fig.9, including, trajectories of movement of cylinders 7 and 8 (in a projection to a lateral plane) are shown.

As we see, here the way of moving is identical represented on fig.6 for a case of absence of gravitation.

Distinctive feature of moving of the device is independence of the passed distance S of duration t and speeds V

$$S = S_0 \cdot n , \qquad (11)$$

where n - quantity of parts of the cycle executed by the device.

Duration T of a finding is equal a way in length S

$$T = t \cdot n = t \cdot S/S_0 , \qquad (12)$$

where t - duration of a part of a cycle under the formula (8).

On fig.9 the schedule of dependence of passed way S from time T, where $t_0 = \pi/\Omega$. The schedule has a step appearance.

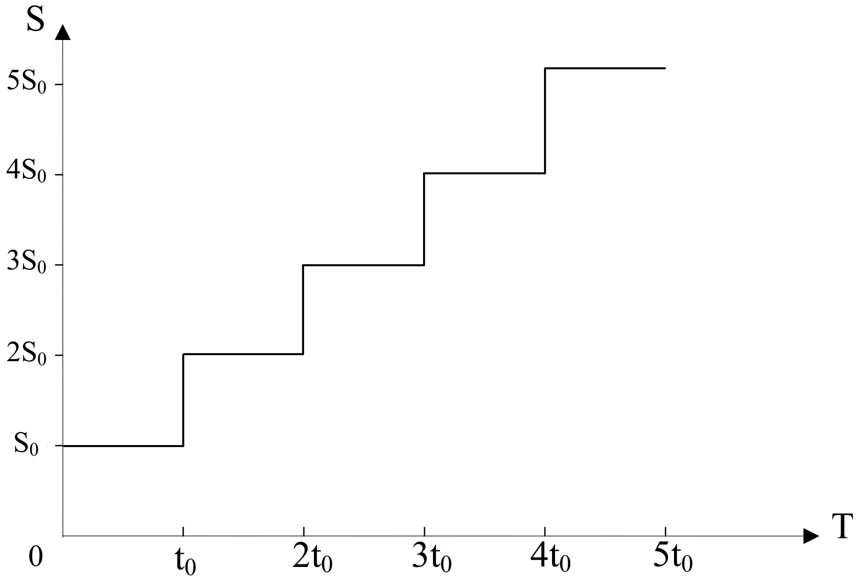

Fig.9
Moving of the center of weights of the device to time.
S - distance, T - time.

On fig.10 the schedule of change of a corner of turn φ from time T .

$$\varphi = |\Omega \cdot t| \cdot n, \quad \text{where} \quad \pi/\Omega \geq t \geq 0.$$

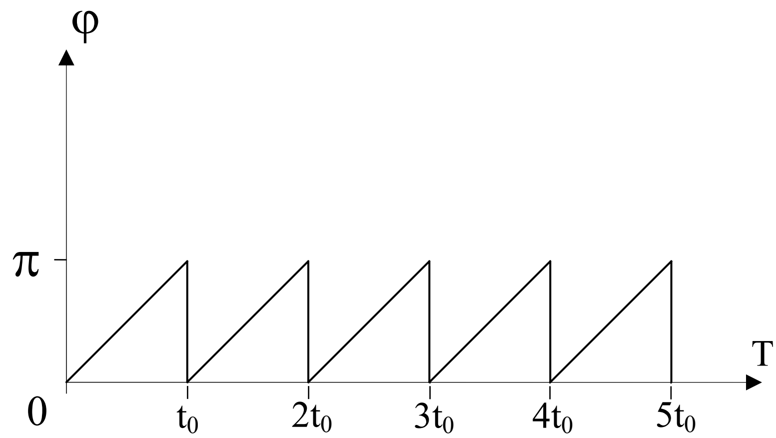

Fig.10
Change of a corner of turn of own axis of a gyroscope concerning an axis X
φ - a corner, T - time.

The physical essence of moving of the device can be described as follows.

The device at any moment has two vectorially not conterminous center of pressure: active and passive which periodically vary places in space.
The gyroscope entering into the device, during the moment of the beginning of turn carries out instant carry of the center of weights of the device to a point of space which coincides with the active center of pressure.
Concerning the last, during time of turn, it is carried out without jet carry of the passive center of pressure to other point of space.

Then the cycle of turn repeats already concerning this new point of space which becomes the active center of pressure.

Let's find numerical expressions for duration of a part of a cycle, for average speed of moving and for capacity of a drive.

For one part of a cycle, duration $t_0 = \pi/\Omega$, the device will move on distance S_0. Simultaneously, for same time the piston will move from one extreme position to another, having passed distance h, according to the equation (9). From the last we find acceleration of the piston

$$a = 2h\cdot\Omega^2/\pi^2 \quad . \qquad (13)$$

Angular speed of turn is equal

$$\Omega = M_д/M_к = F \cdot R/M_к = m \cdot a \cdot R/M_к \,, \qquad (14)$$

where F - the force enclosed to the piston, R - radius of inertia concerning axis Z in absence прецессии, m - mass of the piston, a - acceleration of the piston.
For the scheme on fig.7 we shall accept $R = S_0/2$.
Operating moment Мд is equal

$$M_д = M_к\cdot\Omega = m\cdot a\cdot R = m\cdot R\cdot 2h\cdot\Omega^2/\pi^2 = m\cdot S_0\cdot h\cdot\Omega^2/\pi^2.$$

From it the kinetic moment is found

$$M_к = m\cdot S_0\cdot h\cdot\Omega/\pi^2 \qquad (15)$$

As both $\Omega = \pi/t_0$ having substituted it in (15), we can receive a parity for duration of a part of a cycle

$$t_0 = m\cdot h\cdot S_0/M_к\cdot\pi \qquad (16)$$

Knowing duration of a part of a cycle, we find average speed V of moving of the center of mass of the device

$$V = S_0/t_0 = \pi\cdot M_к/m\cdot h \qquad (17)$$

It is necessary to explain physical sense of this speed.
As already it was spoken above, carry of the center of weights of the device on distance S_0 occurs instantly, to the beginning of turn. Further, during all time of turn, what carry of the center of weights does not occur.
So-called, average speed of moving V, actually sets duration of a pause between points of physical carry of the center of weights. The more V, the more shortly a pause between movings. In this case speed V is the settlement size intended for convenience of calculations of length of a way from time.
For example, time T of a finding in a way in length S is calculated under traditional formula T = S/V and corresponds to the valid duration of moving on distance S. However it is necessary to remember, that time T total quantity of pauses between $n = S/S_0$ cycles of physical moving of the center of weights on a way in length S is real is.
Capacity P of a drive of the device can be found from following expression

$$P = M_к\cdot\Omega^2 = M_к(\pi/t_0)^2 = \pi^4\cdot M_к^3/m^2\cdot h^2\cdot S_0^2 \qquad (18)$$

The dear reader, probably, has paid attention that in the formula (17) speed V is proportional to kinetic moment Mк, and in the formula for speed of precession (3) dependence on it inversely proportional. The reason of distinction consists in necessity of performance of a condition (10).

For example, to increase speed V (to reduce t_0), it is necessary to increase acceleration of the piston (to increase operating moment $M_д$) but that thus the condition (10) was satisfied is necessary to increase, accordingly, and kinetic moment $M_к$.

As an example, we shall find numerical values of key parameters of the device under the scheme on fig.7.

Let's put: h = 1m; S_0 = 1m; m = 2 kg - weight of the piston; the kinetic moment of a gyroscope is equal to $M_к = m_г \cdot r^2 \cdot \omega = 3 \cdot (0,5)^2 \cdot 6 = 4,5$ kg·м^2/sec. Where $m_г = 3$ kg - weight of a gyroscope, r = 0,5m - radius of inertia of a gyroscope, $\omega = 6\ s^{-1}$ - angular frequency of a gyroscope.

Under the formula (16) we find duration of a part of a cycle

$$t_0 = 2 \cdot 1 \cdot 1/4,5 \cdot \pi \approx 0,14 \text{ sec.}$$

Under the formula (17) we find speed of moving

$$V = \pi \cdot 4,5/2 \cdot 1 \approx 7,1 \text{ m/sec.}$$

Under the formula (18) we find capacity of a drive

$$P = \pi^4 \cdot (4,5)^3/2^2 \cdot 1^2 \cdot 1^2 \approx 2,2 \text{ кW.}$$

It is necessary to pay attention that in all formulas there is no full weight of the device. The account of full weight is incorporated by us in a condition, that the radius of inertia concerning axis Z is equal $R = S_0/2$. Research the full weight of the device, to be exact - shows, that its distribution concerning axis Z, influence size of radius of inertia R so influence and size of the operating moment $M_д$ enclosed to a gyroscope.

We carried out modelling of a way of moving with use of the scheme of the device on fig.7 which contained hinges 11 and 12. It has allowed to strengthen presentation and its identity with the scheme on fig.6. However it is necessary to notice, that connection of an axis 2 with cylinders 7 and 8 (see fig.7) can be carried out motionless. Thus in free space action of all moments is kept, and technically the design becomes more technological.

Other remark consists that on all schemes we finished each part from a full cycle of turn of a gyroscope, for a corner $\varphi = \Omega \cdot t = \pi$. Really corner φ can be any size in a range: $\pi > \varphi > 0$.

In this case the trajectory of moving of the center of mass of the device will not be a straight line.

One more remark concerns influences of environment. If environment possesses viscosity, precession a gyroscope the moment of friction $M_{тр}$ enclosed concerning instant position of axis X (for example, relatively of X_1 on fig.8) will counteract. In this case, until the inequality of moments $M_д > M_{тр}$= const, the center of mass of the device will move along axis Y not on a straight line, as shown in fig.8в, and on a screw line. The step of a screw line depends from $M_д/M_{тр}$.

According to modern installations of theoretical mechanics, the device which concerns to a class of the closed mechanical systems here is shown. However we already repeatedly repeated [3, 5, 6], that for forces of inertia there are no closed systems and the present material, we consider, is additional acknowledgement of it.

Theoretically, onboard the device it is possible to carry out full recoverly energy of a drive. In the described device range of moving from size of an onboard stock of energy not.

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