Electromechanical Gyroscope-Accelerometer (invention)

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Summary: this paper proposes a new, simple design of a gyroscope with operating principles used to create an accelerometer with a number of advantages compared to its predecessors. Special electric circuit to measure acceleration is based on electromagnetic induction principles, ensuring high accuracy of measurements. The proposed device allows to measure acceleration of linear as well as curvilinear motions.

Key words: Gyroscope, Hollow Sphere, Regular Tetrahedron, Weight Ball, Bifilar Coil, Electromagnetic Induction.

Introduction: mechanical motion is an integral part of everyday human life. Uneven (irregular) motion, with acceleration as main cinematic feature, is predominant in nature. Therefore, measuring acceleration at different points of movement trajectory is important aspect in the research of the parameters of mechanical motion.

Mechanical gyroscope accelerometer [1] was selected from existing gyroscopic accelerometers to serve as a design reference for the proposed electromagnetic gyroscope accelerometer.

Main Body:

The proposed device consists of 3 (three) parts: hollow sphere (1), regular tetrahedron (2), and a steel weight ball (3). These are arranged so that the tetrahedron rests on the steel weight ball and its apexes touch the inner surface of the hollow sphere (Fig. 1, 2, 3, 4). The apexes can freely move/slide along the inner surface of the hollow sphere.

The idea of the invention is as follows:

1. When the apparatus is either stationary or during the linier movement at constant velocity, the base of the regular tetrahedron remains horizontal (gyroscope*). The gyroscopic feature of the invention can be used in the design of tools and equipment which require horizontality while in operation.

* Gyroscope: a device with a part (component) which maintains initial orientation for every possible change in the position of the device itself.

2. Deviation angle α of the regular tetrahedron’s height from the vertical line determines the magnitude of the acceleration ($A = g \cdot tg\alpha$) and, with proper calibration, can be measured at any given point along the trajectory of an accelerated motion.

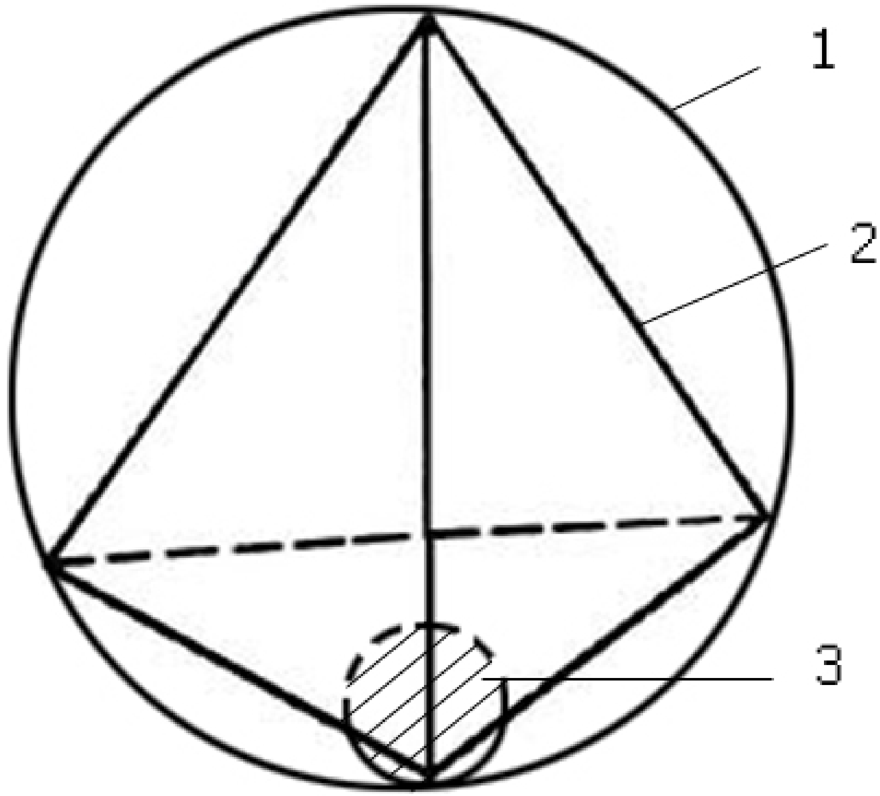


Figure 1

1. Hollow sphere
2. Regular tetrahedron
3. Weight ball

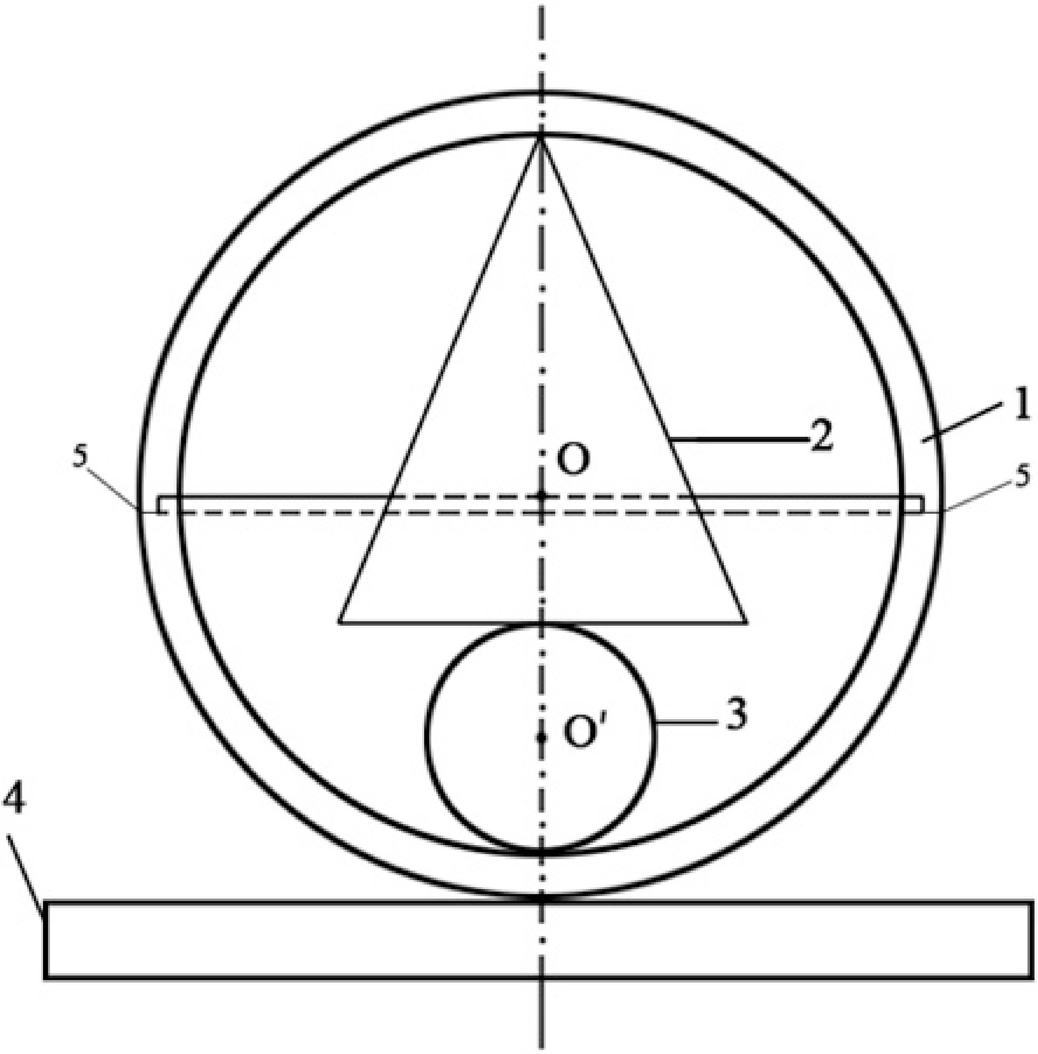


Figure 2

Vertical diametrical cross section of gyroscope.

1. Hollow sphere
2. Regular tetrahedron
3. Weight ball
4. Horizontal base for gyroscope to roll (revolve) on and maintain initial position.
5. Connection point of upper and lower hemispheres of the hollow sphere (1) (the connection is achieved using Matryoshka (Russian doll) principle.

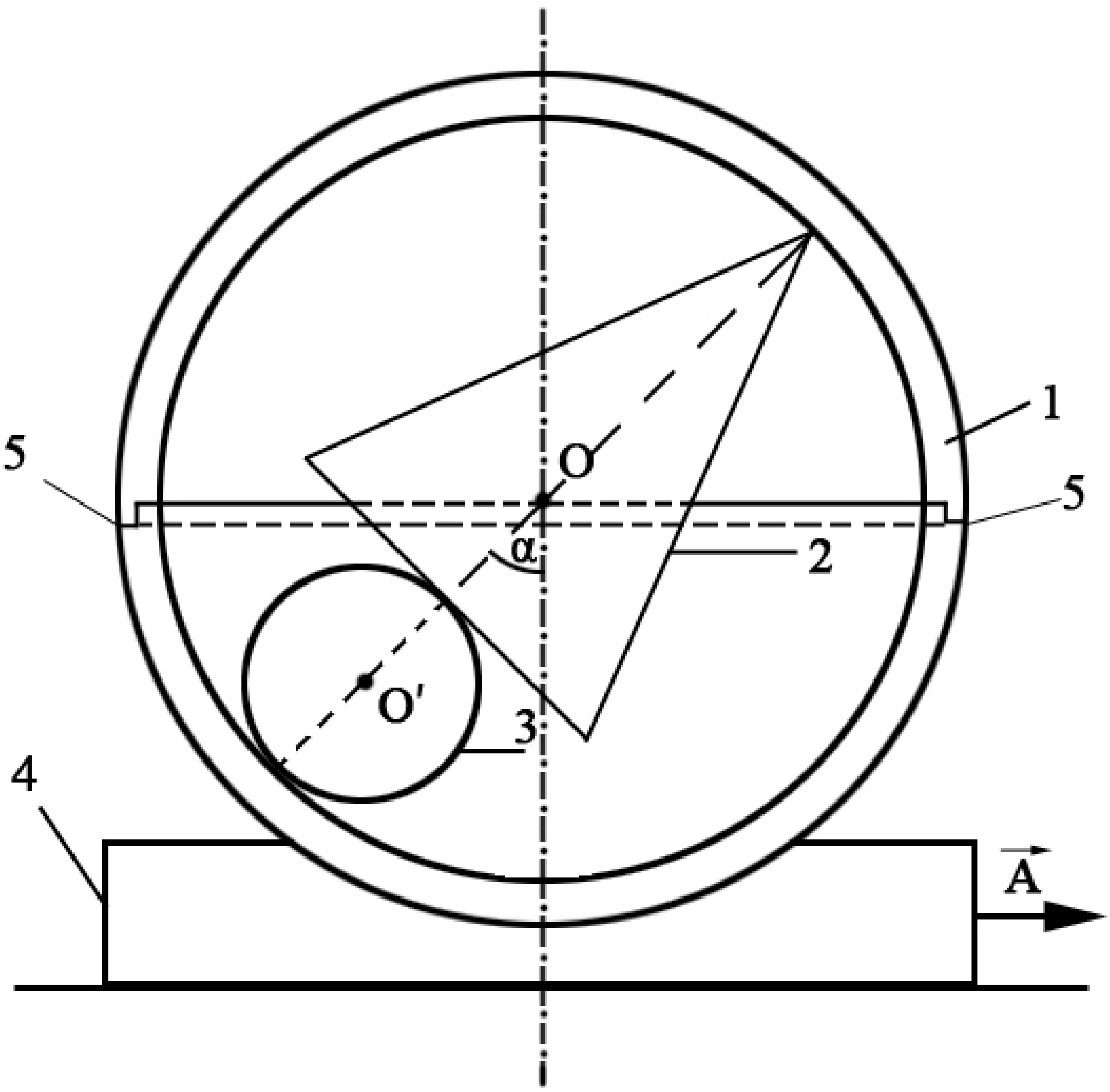


Figure 3

Electro-mechanical gyroscope-accelerometer: mechanics

Fig 3 shows diametrical vertical cross section (parallel to the surface of the diagram) of the gyroscope firmly attached to the base (4), both moving with the acceleration of $\vec{A}$. α – deviation angle of the weight ball from vertical line.

1. Hollow sphere
2. Regular tetrahedron
3. Weight ball
4. Base
5. Connection point of upper and lower hemispheres of the hollow sphere

O – Centre of the hollow sphere

O'- Centre of the weight ball

α – Deviation angle of the weight ball

Schematic diagram of measuring acceleration

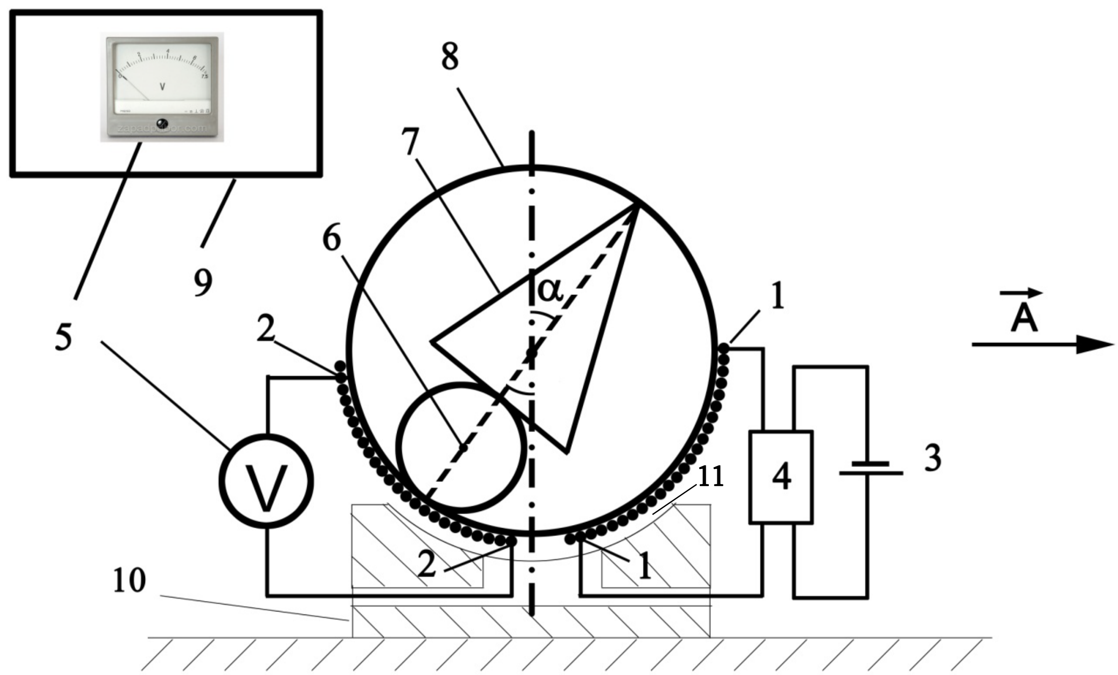


Fig 4

Fig 4 represents electromechanical schematic diagram of measuring acceleration

$(A = g \cdot tg\alpha)$:

1. Primary Bifilar coil roll
2. Secondary Bifilar coil roll
3. Source of Direct Electric Current (charge)
4. Power Inverter
5. Voltmeter - graduated in acceleration units (calibrated)
6. Weight ball (M) made from material of magnetic property (iron, steel, cobalt etc.)
7. Light weight tetrahedron (m < M)
8. Hollow sphere
9. Device box
10. Base with which the device is fixed in the box (9) and moves with it at the acceleration of $\vec{A}$
11. Space between the base and coils – filled with dual component filler, ensuring firm connection between the device and the base.

α – Deviation angle of the weight ball from vertical line

$\frac{M}{m} > 1$- empirically determined ration (M – weight ball mass, m – tetrahedron mass)

Advantages compared to existing analogues: the improvements presented below are in comparison to the most similar device - "Mechanical Gyroscope-Accelerator" [1] (Fig. 5).

1. Simplicity of mechanical structure (three parts as opposed to six)
2. Accuracy of measurement (electric indication instead of mechanical)
3. Measuring acceleration of linear as well as curvilinear motions at any point of movement trajectory.
4. Real time scanning of acceleration (using recording device)
5. Smaller size

Measuring Acceleration

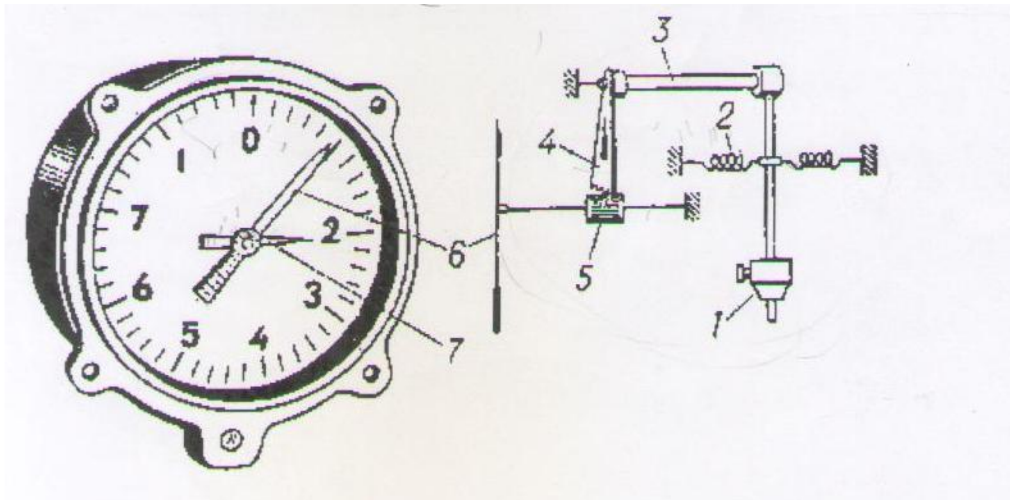
In the direction of the south pole, from the notional equator, insulated electrical cable roll is wound bifilarly on the outer surface of the hollow sphere. Alternative electric current is applied to one of the coils (notionally - primary one), while induction generated Electric Driving Force (EDF) is measured on the secondary coil.

EDF generated in the secondary coil changes in relation to the position of the weight ball and is gauged by voltmeter (5, Fig. 4). The weight ball's angle of deviation from the vertical determines the magnitude of acceleration ($A = g \cdot tg\alpha$). Consequently, if voltage gauged is appropriately calibrated and voltmeter graduated in units of acceleration (volt $\rightarrow$ m/s^2), the voltmeter will show the value of acceleration in m/s^2. That is, on the one hand α-angle of weight ball's deviation from the vertical determines the value of acceleration ($A = g \cdot tg\alpha$), on the other hand it measures the magnitude of EDF (voltage) in the secondary coil. Therefore, the voltmeter reading directly reflects positional change of the weight ball, representing the value of acceleration (in case of calibrated voltmeter).

The voltmeter is graduated so that one unit of scale corresponds to one unit of acceleration - 1 m/s^2. The voltmeter can also be graduated in g units ($g = 9{,}8066\ \mathrm{m}/s^2$).

The hollow sphere is filled with liquid of certain viscosity in order to suppress vibrations during the operation of the device (viscosity is determined empirically).

The device readings can be transmitted over any realistic distances using existing technologies.



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Mechanical Gyroscope-Accelerator [1] – the closest analogue to the proposed invention

Conclusion: the mechanical part (gyroscope) of the proposed electromechanical gyroscope-accelerometer represents a universal scheme for any device that strictly requires horizontality when operational (for example: geodetic and navigational equipment).

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Literature

1. International patent: Patent US6293148