The torsion magnetic variometer with Kevlar-hanger-based sensor

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Abstract

The construction and operating principle of the torsion magnetic variometer are discussed, some specificities of magnetic sensor such as different variants of hanger systems, brace types and magnet proportions are shown.

Keywords: Torsion magnetic variometer, magnetosensitive element, Kevlar hanger

1. Introduction

Magnetic metering is significant problem in much fields of human being, such as instrument-making, mechanical engineering, geophysics, geology, nondestructive check and others.

There are a lot of devices for measurement of different magnetic field parameters, which uses different effects. In particular devices for measurement of magnetic induction are subdivided into modular (which measures total vector) and component (which measures projections of a vector), fullfield (for getting absolute means of a field induction) and variometers (for getting relative value of a field induction in wide dynamic range amplitude) etc.

Component magnetic variometers are especially interested because they own high sensitivity and also allow metering of the magnetic vector direction. One of the device realizations is magnet which has planar rotational degree of freedom if it's hanged up upon a torsion bar.

2. Torsion magnetometer structure

Torsion magnetometer construction (Fig. 1) represented by magnet 2 suspended by hanger or bracing wire which serve as its pivot pin [1].

The magnet joint with mirror which lets read magnet angular oscillations directly or by transfer them into electric signals in photoelectric transformation schemes with high linearity.

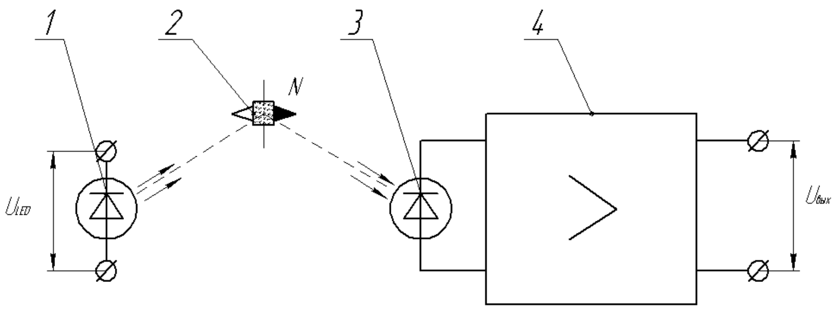

Fig. 1. Torsion magnetometer with photoelectric transformation:
1 – LED, 2 – Magnet, Mirror, 3 – Photodiode, 4 – Amplifier.

3. Composition of the geophysical complex GI-MTS-1

Described above construction is realized in magnetic variometer, part of the geophysical complex GI-MTS-1 [2, 3] (Fig. 2), developed by SPbF IZMIRAN. It allows to by-component registration of magnetic field induction, telluric currents and seismic fields variations.

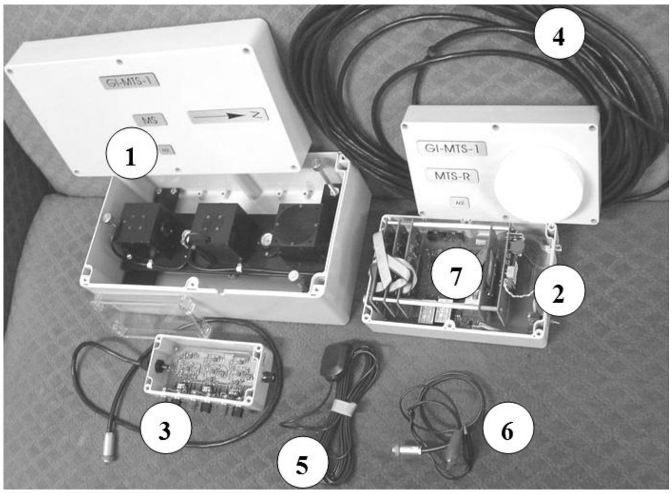

Fig. 2. Geophysical complex GI-MTS-1
1 – Magnetic sensors MS; 2 – Registrator MTS-R, including GPS;
3 – Analog filters AF; 4 – Connecting cable for MS and MTS-R;
5 – Antenna GPS; 6 – Power cable 12 B; 7 – CompactFlash (CF) card.

MS includes three the same sensors (Fig. 3) with co-orthogonal sensitivity axes fixed on single plate.

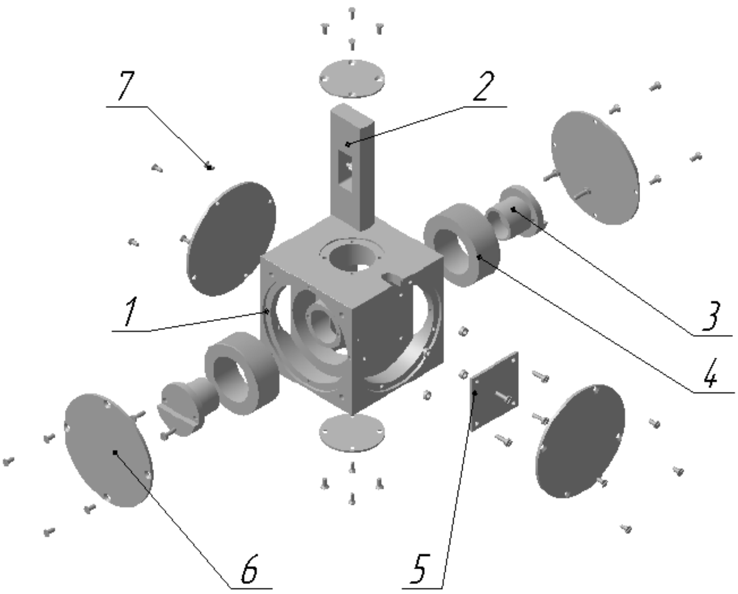

Fig. 3. Magnetic sensor MS
1 – Body («cube»); 2 – Magnetosensitive element body; 3 – Optical elements body; 4 – Coils;
5 – Electric plate; 6 – Lids; 7 – Screws.

4. Torsion variometer of GI-MTS-1 operating principle

The magnetosensitive element of **GI-MTS-1** concept scheme is shown on Fig. 4.

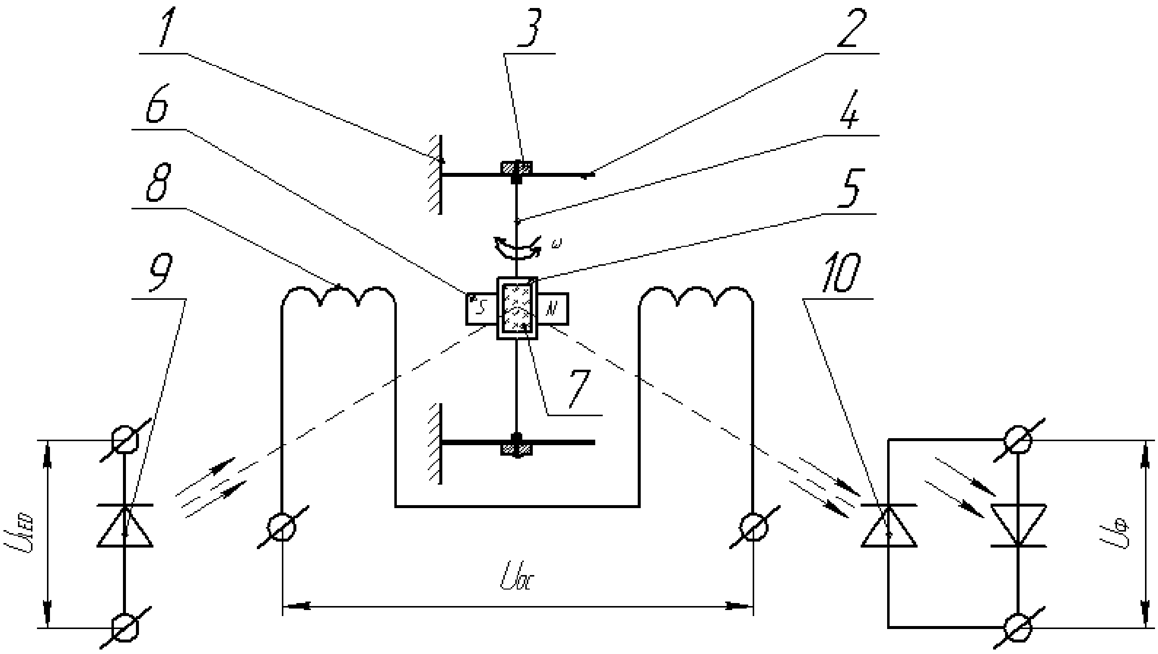

Fig. 4. Magnetosensitive element concept scheme:
1 – Stand, 2 – Plate springs, 3 – Rotative sleeves, 4 – Torsion bar, 5 – Magnet holder, 6 – Magnet,
7 – Mirror, 8 – Coils, 9 – LED, 10 – Photodiode block.

Magnetosensitive element is represented by magnet 6 fixed through holder 5, torsion bar 4, sleeves 3 and plate springs 2 to stand 1. While external magnetic field changes the magnet rotates on torsion bar at the relevant corner. LED 9 illuminates mirror 7 (situated on magnet holder), reflected light percepts by photo diodes 10. So the signal of magnet rotation which is proportional to magnetic field changing generates. Then the signal amplified by electric block goes to registrator MTS-R and to feedback coils 8, which induces additional magnetic field turning magnet back into its base position.

5. GI-MTS-1 construction specificities

The main merit of GI-MTS-1 magnetic variometer magnetosensitive element is its modular construction, it lets operatively repair damaged elements and carry out an experimental tests (alternative modifications tests).

There are following modifications of magnetosensitive elements possible:

- variable magnet materials (vicalloy, SmCo, NeFeB, UNDK, ceramics), formfactor (cylinder, parallelepiped, rhombus) and dimensions ratios (l/d, b/h) of constant magnet using – have an effect on magnetic strength (moment) of magnet, temperature drift, working temperature range, magnetosensitive element sensitivity and natural oscillation frequency;
- different materials (quartz, brass, bronze, Kevlar) and formfactors (filament, funicle, plait) of torsion bars using gives influence on the same characteristics;
- additional construction elements (springs, dampers) reduces oscillation behavior of magnetosensitive element.

6. Characteristics of MS GI-MTS-1

As result of experimental pickup of optimal elements combination we have maximal static sensitivity (0.01 nT in the frequency range from 0.3 till 3 Hz), minimum temperature drift (0.5 nT/^{o}C), wide temperature working range (from minus 20^{o} till plus 50 ^{o}C) working frequency range 0-8 Hz, low mean-square noise level (less then 1 $pT/\sqrt{Hz}$ in the amplitude dynamic range 2000 nT), best oscillation characters through ceramic magnet, hanged by Kevlar braid fixed on plain damping springs.

Additional information: power supply by DC source 12V, power consumption about 1.8 W/h, data registration performed by CompactFlash cards 1-4 Gb, time referencing using GPS signal. Remote data transmission by Bluetooth (wireless) or RS-485 (wired).

7. Conclusion

Operating principle and construction specificities of torsion magnetic variometer are described, optimal magnetosensitive elements (suspension, torsion bar, magnet, damping elements) pickup is mentioned, real device characteristics.

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