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Gyro gravimeter of airborne gravimetry system

The scheme of the gyro of the gravimeter is proposed. Gravimeter has two-degree-of-freedom gyro with displaced gravity center along the natural rotation axis and angle-data transduser on the gyro inside coil axis. Torqe motor is connected to the gyro output. It is mounted on the outer gyro coil axis. Computer is introduced in addition.

Gyro gravimeter.

State evaluation algorithms of gyroscopic gravimeter (GG) of aviation gravimetric system (AGS) have developed in terms of least-squares technique (LST) and Kalman-fi1ter (KF) application unlike known works by the aviation gravimetric measurement theory and practice and the seismic equipment. Adequacy of LST and KF methods was verified with digital simulation and experiment. Direct digital simulation and experimental research results of GG state evaluation algorithms have completely verified error formulas, which were received by analytical way. Evaluation errors research was carried out. Their dependence on disturbance parameters and gyro motion initial conditions was ascertained. Optimum relationship of information watch time and gyro motion initial conditions have been determined in sense evaluation error transformation into zero. We showed that evaluation errors are tuned into zero, when information watch time becomes more than three periods of gyroscopic waddling. New type GG, which differs from known types by increase of measurement precision and speed more than in ten times at the expense of error automatic compensation employment in accordance with developed GG state evaluation algorithms has been developed. It is necessary to remove errors of non-linear random vibrations; gyroscopic wobbling damping coefficient inequality to zero because of viscous friction moment influence over the gyro; gyroscopic wobbling non-isochronism; discrepancy of gyroscopic wobbling angular velocity magnitude, which is used in evaluation algorithms with gyroscopic dobblings of gyro interferences which deform the gyro motion law. Influence of these errors can be inadmissibly large when they aren't taken into consideration. Gravimeter has two-degree-of-freedom gyro with displaced gravity center along the natural rotation axis and angle- data transduser on the gyro inside coil axis. Torqe motor is connected to the gyro output. It is mounted on the outer gyro coil axis. Computer is introduced in addition. It is connected with output 'which is one the angle-data outer coil axis. Computer defines revised output signal by interference automatic compensation in accordance which received algorithms [1-5].

In the fields of navigation and guidance, specific force sensors play a leading role in most system mechanizations. Thous, as might be expected, a broad spectrum of specific force sensors have been developed for use in guidance and navigation, but until recently the possibility of their use in gravimetry had been largely ignored. Perhaps the most promising of these instruments is the pendulous gyro accelerometer (PGA). It is interesting to note that a device somewhat similar the PGA was patented in Russia by V.V. Kochegura in 1960.

At the heart of the device is a single-degree of freedom which has been made pendulous by the addition of an unbalancing mass along its spin axis. The gyro wheel is held in a supporting gimbal free to rotate about only one axis, referred to as the output axis. On the output axis is mounted an electromagnetic pickoff which produces a signal proportional to the rotational displacements of the wheel support relative to the platform, and an electromagnetic torquer, which applies torque about the output axis in response to input current. The unbalance mass along the spin axis produces a torque about the gyro output axis, and the resulting rotation about this axis is sensed by the signal pickoff. This signal is amplified and fed to the platform motor which rotates the platform at an angular velocity sufficient to cause a gyroscopic reaction torqe about the gyro output axis which exactly balances the gravity torque. Under these conditions, the angular velocity of the platform is a measure of the specific force acting on the unbalancing mass. The gyro wheel is enclosed and floated in a viscous fluid which provides both support and damping. It is this floated member, referred to as the float of the gyro, which acts as a torque summing device. it is acted on by torques due to the pendulous mass and gyroscopic torques due to the inertial angular velocity about its input axis. Torque may also be applied to the float by application of a command current to the torque generator.

The scheme of the gyro of the gravimeter is proposed (fig. 1). In such a GG, a three-stage gyroscope in the casing (inner frame) 1, located in the cardan suspension, is used as a sensing element in such a way that the center of gravity of the gyroscope 2 is displaced relative to the axis of the inner frame by a distance, and relative to the axis of the outer frame by a distance. The gyromotor in the casing is placed in an outer frame 3, the axis of rotation 4 of which is placed vertically. On the axis 7 of the inner frame 1 is located the electric moment sensor DM 8, to the control winding of which the output of the electric angle sensor (DC) 5 is connected through the integrator 6. On the axis 5 of the inner frame 1 there is an electric sensor DC 11 whose output through the integrator 10 is connected to the winding management of DM 9.

The steady state sensitivity of the PIGA can be shown to be:

$$\frac{\Omega}{a_i} = \frac{P}{H}.$$

Ω - angular velocity of the platform,
a_i - input acceleration,
P - pendulosity of the gyro float about the output axis,
H - gyro wheel angular momentum.

The platform angular velocity is usually read out by means of either an optical or electromagnetic digital encoder. These devices produce a plusetrin whose frequency varies with the platform angular velocity.

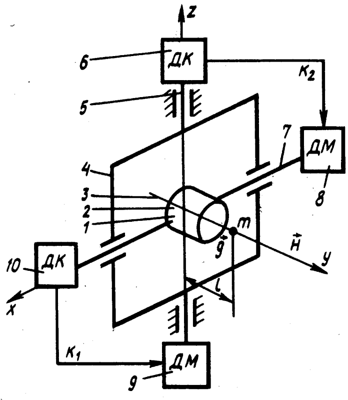

Fig. 1. Gyro gravimeter

If a pendulous gyro accelerometer is carried in an instrumented geographic coordinate frame, there will exist a component of the earth's angular velocity about the sensitive axis, the resulting specific force error will be in the range of a few mgal to a fraction of a mgal depending on the scale factor of the particular instrument. For the instrument described above, the error would be about I mgal at the poles, if the error is significant, it can compensated by either introducing a compensating torque to the gyro float through the torque generator, or by mounting the instrument on a table driven about the vertical so as to null the vertical component of earth rate.

Conclusions

New type GG, which differs from known types by increase of measurement precision and speed more than in ten times at the expense of error automatic compensation employment in accordance with developed GG state evaluation algorithms has been developed.

References

1. Безвесільна О.М. Авіаційні гравіметричні системи та гравіметри: Монографія/ Безвесільна О.М.– Житомир : ЖДТУ, 2007. – 604 с.

2. Bezvesil'naya E.N. Errors of a gyroscopic linear-acceleration sensor / E.N. Bezvesil'naya // Soviet Applied Mechanics. 1990, № 3, P. 62-65.

3. Bezvesilnaya E.N. Investigation of the errors of a mechanical information-measuring system // Soviet Applied Mechanics. – 1990, – № 26 (4), p. 418-423.

4. Bezvesil'naya E.N. Increasing the precision of measurements of free-fall acceleration / E.N. Bezvesil'naya // International Applied Mechanics. 1995, № 2. – P. 92 – 96.

5. Безвесільна О.М.,. – Гіроскопічний прилад. Патент на винахід А.С. № 4325826 СРСР, МКІ, G 01 V 7/02, 1987.