**"Gyroskopiya i Navigatsiya" №3, 2000**

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| The conventional requirements to autonomous systems of motion control of space vehicles (SV) on the decreasing of mass and dimensions and power consumption , on reliability augmentation and reduction (decreasing) of the cost have resulted in necessity of transition from the strap-down to gimballess systems of attitude orientation, stabilisation and control. The increasing of accuracy of these systems require precision electrostatic gyroscopes (ESG).  The case of the installation of two ESGs into the attitude orientation system of space vehicles is considered. The vectors of moments of momentum H and H are arranged perpendicularly and parallel to orbital plane or both are in orbital plane. The relations of direction cosines between rotation axis of rotor and axes of the body and also expressions for projections of the drift rate are obtained as a result of the solution of equations of precision motion in an analytical kind. Thus the analysis of influencing only of one of significant in conditions of weightlessness of the revolting factors is in turn carried out: the withdrawing moment from the bias (unbalance) and odd harmonics of rotor nonsphericity, the moment independent of acceleration and a proportional to the fourth harmonic of the rotor shape, the moment from residual magnetic fields. At the same time it is allowed, that the common solution can be sought by a method of a superposition. The evaluation values of drift speed of ESG for the indicated orientations of gyros are adduced, and also outcomes of simulation of relation of the angle between the vectors of moments of momentum from time in a case, when the rotation axes of both ESGs are arranged in the orbital plane of the space vehicle, or when one gyro is in the orbital plane, and the other is perpendicular to it. The analogy between motions of vectors of moments of momentum of ESG, installed in space vehicles according to the indicated orientations and motions of gyros installed on the Earth in "polar" and "equatorial" orientations is considered. The problem of maintenance of a long-lived cycle of continuous construction of the base Inertial Reference (IR) with adequate accuracy taking into account convergences (divergences) of vectors H and H is analysed. The contribution of different sources of errors of the conservative and nonconservative nature to drift and parameters of motion of gyros of attitude orientation system is estimated. | |  |
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| **L.N.Belsky, L.V.Vodicheva** | **Increase of gyrocompassing accuracy by choosing orientations of measuring instrument sensitivity axes** | **21** |
| The technique of optimization of inertial sensor input axes orientations during gyrocompassing is suggested. The criterion of optimization is the minimum of an azimuth determination error. Single-position and the most widely used two-position schemes of gyrocompassing are studied in detail. Introduction of single-position schemes simplifies and makes physically obvious the procedure of optimization for two-position schemes. Complicated schemes are reduced to simple ones.  In a single-position gyrocompassing scheme with a single sensor with measurement errors being independent random variables a scale factor does not affect azimuth determination accuracy at all and a drift influence is minimal if sensor input axis is orthogonal with respect to the measured vector. (2.2), (2.3), (2.4) are expressions for an azimuth estimate, an azimuth estimation error variance and the minimal azimuth estimation error variance.  In a two-position scheme with a single sensor a constant component of a drift does not affect gyrocompassing accuracy. The optimal rotation angle is obtained by minimizing a variance of an azimuth determination error as a function of this angle. (3.3) is the expression for an azimuth estimate, (3.4) is the expression for azimuth estimation error variance. Fig.2,3,4 depict variances of azimuth determination error under rotation angles about /2,  and the optimal one under various relations of error sources. They show that under the same errors for some intervals of azimuth gyrocompassing error is essentially larger for rotation angles about  or /2 than for the optimal angle. Fig. 5 shows optimal angles as functions of azimuth angle.  Single-position scheme with two sensors with orthogonal input axes is reduced to the simplest single-position scheme with a single hypothetical equivalent sensor. In this scheme accuracy improvement can be achieved by optimal integrity of measurements.  Two-position scheme with two sensors is reduced to the simpler two-position scheme with single sensor with optimization by rotation angle and azimuth angle. It is shown that if sensor drift instability is dominated over rotation angle error the optimal value of a rotation angle is equal . If rotation angle error is essentially more than sensor errors the optimal value of a rotation angle is near /2. In other cases the optimal angle reduces azimuth determination error 1,5-2 times. Fig. 6 depicts azimuth determination error variance and optimal angle as functions of error sources ratio. This scheme allows gyrocompassing under unknown latitude with simultaneous eliminating of drifts as well. It is shown at the end of the paper. (6.1) and (6.2) are expressions for azimuth estimate and azimuth estimation error variance. The optimal rotation angle in this case is equal . | |  |
| **A.V.Chernodarov, V.V.Enyutin, A.P.Patrikeev** | **Diagnosing of integrated navigation systems on the basis of combined U-D procedures of filtering and smoothing** | **34** |
| This paper is devoted to the problem of protecting the integrity of integrated navigation systems (NS's), which relies on the serviceability of all the modules of a redundant structure. Here typical modules are the following ones: a strapdown inertial NS, a satellite NS, and also the extended Kalman filter (EKF). This EKF unites, into an integrated structure, measuring aids that are dissimilar in the principle of operation. Moreover, with this EKF, it becomes possible to reveal a discordance among equivalent parameters formed by different NS's. However, from such a discordance, one cannot locate a trouble and determine the cause of it. In order for this diagnosis problem to be solved, we propose that estimates obtained during filtering in forward and backward time should be used jointly. In this case, it appears that the formation of generalized parameters characterizing the state of each module of an integrated navigation system (INS) to the depth of a component of the state vector is quite possible. The diagnosis technology under discussion relies on unified U-D procedures intended for the filtering of observations (see Fig. 3) and for the smoothing of estimates (see Fig. 4). Such procedures maintain the computational stability of solution of direct and adjoint Riccati equations and they permit one to decompose residuals and to process them sequentially. The proposed modification of the conventional smoothing RTS (Rauch-Tung-Striebel) algorithm is meant for the situation where external data necessary for the updating of inertial NS's come in an irregular manner; such a situation is characteristic of maneuverable aircraft. The effectiveness of the algorithms obtained was confirmed by the results of half-scale modeling. | |  |

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| **V.Z.Gusinsky, V.M.Lesyuchevsky, Yu.A.Litmanovich, V.G.Peshekhonov** | **High Precision Ground-Based North Finder** | **49** |
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| The outcomes of research, development and application portable inertial systems of positioning are reported. Micromechanical gyroscopes and accelerometers are used in those systems as inertial sensors with specification presented in table 1. Thermostatic control and modulation increase an accuracy of micromechanical sensors sufficiently. Researches and experiments of thermostatic control, auto compensation and calibration are stated and demonstrated in figures 1 and 2. System operation algorithm computes orientation and navigation of mobile object in real-time that is described with equations 1-8. Those systems utilising in transport monitoring and manual scanning are shown in figures 4-8. | |  |
| **S.F.Konovalov, A.A.Konovchenko, A.V.Polynkov, A.A.Trunov, V.M.Prokofiev, O.S.Kwon, H.G.Moon, J.B.Seo, F.Luc** | **Low-Noise Accelerometer Development Experience** | **68** |
| To solve a number of tasks connected with acoustic prospecting of oil-fields in marine shelf, it is required low-noise geophonic sensors. The pendulous accelerometers of compensation type, having measurement range within 2g, threshold of 10-6 g, natural frequency of 250Hz and noise level in an output signal less 40 n g/(Hz)1/2, can be used as the similar sensor. There is a pendulum in the instrument mobile unit, made of monocrystalline silicon wafer by a method of anisotropic etching. The servo-loop of the instrument is formed by the capacitive pick-off, low-noise amplifier and twin magnetoelectric forcer. A non-traditional mutually perpendicular arrangement of pendulum flexures is used in the instrument. The special measures are attempted to eliminate influence on bias stability of difference in value of coefficients of thermal expansion of materials of a pendulous unit and case members contacting the pendulum. The results of experimental examination of the instrument on test bases of Russia, Korea and France are presented in the paper. | |  |
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**Brief notes**

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| **N.S.Ivanova** | **Peculiarities of determining parameters of the equivalent circuit of a free gyro electric drive** | **99** |
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