LINEAR AND ANGULAR MEASUREMENTS

REMOTE DETERMINATION OF THE POSITION
OF AN OBJECT IN THE COORDINATE SYSTEM
OF A MOBILE PLATFORM

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This article examines three variants of the solution of the problem of remotely determining the position of an object in the coordinate system of a mobile platform on the basis of projections of vectors of magnetic induction measured on the platform. The induction is created by transmitting antennas located on the object. There is no contact coupling between the platform and the object, and the solution eliminates the effect of the position error due to the nonorthogonality of the direction of the radiation and the direction of reception of the magnetic fields by the transmitting and receiving antennas.

The solution of the problem of determining the position of an object in the coordinate system of a mobile platform can be used to determine the coordinates and orientation of aircraft, spacecraft, and submerged vessels, such as during their rendezvous and during runway approaches. The solution can also be used to determine the coordinates and orientation of a diver relative to the ship or a miner relative to the surface, and it can be employed in the design of helmet gages to track the position of the helmet of a pilot relative to the chosen coordinate system of an airplane or helicopter [1–3].

In one well-known instrument [1], the position of a distant object is remotely determined on the basis of nine measured parameters of an electromagnetic field radiated by three antennas in three mutually orthogonal directions. The determination is made with information on one of the position parameters or orientation parameters of the receiving antennas on one object relative to the transmitting antennas on a second object. In the instruments described in [2, 3], the coordinates and orientation of an object relative to a mobile platform are determined in the presence of a contact coupling between the object and the platform and information on the octant in which the object is located in the chosen coordinate system.

In this article, we describe a method that provides for remote determination of the coordinates and orientation of an object in the coordinate system of a mobile platform in the absence of a contact coupling between the object and the platform and any information on the position and orientation of the object. We will also examine a magnetometric method that eliminates the error made in determining the coordinates and orientation of an object relative to a mobile platform due to the nonorthogonality of the direction of radiation and the direction of reception of the magnetic fields by the transmitting and receiving antennas.

An instrument for solving the given problem can be made in one of three variants. Figure 1 presents a block diagram of an instrument for remote determination of the position of an object. The three variants of the instrument are realized by changing the connections between its parts.

1. In the first variant, the receiving part of the instrument consists of three three-component transducers 2–4, nine amplification-conversion units 6, 8, 10, 12, 14, 16, 18–20, a computer 21, and a reference-voltage generator 5. All of these parts are located on a mobile platform 1 which is rigidly connected with the axes of the Cartesian coordinate OXYZ. The transmitting part of the instrument includes an alternating-voltage generator 29 and three induction coils 23, 24, 27 with mutually orthogonal axes. The coils and the generator form sources of variable magnetic fields. The coils and generator are rigidly attached to the object 22 and are rigidly connected with the Cartesian coordinate system O'X'Y'Z'. Coil 23 is located on the O'X' axis at
Fig. 1. Block diagram of an instrument for remote determination of the position of an object: 1) mobile platform; 2–4) three-component transducers; 5) reference-voltage generator; 6–20) amplification-conversion units; 21) computer; 22) object; 23–27) induction coils; 28) source of variable magnetic fields, formed by coils 24–26; 29) alternating-voltage generator.

The distance $d_x$ from the origin of the coordinates $O'$, coil 27 is located on the $O'Y'$ axis at the distance $d_y$ from point $O'$, and coil 24 is located at the origin of system $O'X'Y'Z'$.

We will examine the operation of the first variant of the instrument for remote determination of the position of an object in the coordinates of a mobile platform under the condition that the sensitivity axes of each three-component transducer 2–4 are mutually orthogonal. The axes of coils 23, 24, and 27 do not have to be exactly mutually orthogonal and can deviate several degrees from orthogonality. Alternating currents flow through the coils from generator 29 and create variable magnetic fields with the frequencies $f_1, f_2, f_3$.

Each of the transducers 2–4 has three mutually orthogonal induction coils whose axes intersect at one point in space, that point being the geometric center of symmetry of each of the induction coils of the corresponding transducer. Alternating voltages are induced in the coils of transducers 2–4. Each of these voltages is proportional to the projection of the vector of magnetic induction created by coils 23, 27, and 24 with the corresponding frequencies $f_1, f_2, f_3$. These frequencies will be des-