THREE-COMPONENT ACCELEROMETER "HEXEMSHEAR"

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This article examines the basic design and functioning of new three-component centered piezoelectric shear accelerometer "Hexemshear" with a single seismic mass. The instrument enjoys several advantages over similar instruments from a methodological viewpoint, such as allowing uniform measurements of all spatial components of vibration. It is shown that known measuring instruments of the same type, designed for the same purpose, do not take equal advantage of current transducer technology and do satisfy the requirement of unity of measurement among the different coordinates.

Measurement of the multidimensional vibration* of engineering objects in vibration diagnostics is one of the most complex types of measurement. The problem is that obtaining quantitative information characterizing vibration as a certain oscillatory process generally requires either a priori adopting a law governing this process — in which case it is sufficient to measure several constant parameters (frequencies, amplitudes, moments of distributions, etc.) — or obtaining experimental data on the quantities describing the process for each moment of time over a sufficiently long time interval. Then various problems of vibration diagnostics can be solved, assuming that additional information is available from other measuring and computing devices. It thus becomes possible to identify and check the correctness of the actions performed by equipment, verify their integrity, and maintain the prescribed production routine. Measurement information on vibration can be used to automatically maintain prescribed or optimum regimes of equipment operation and properly coordinate the work of many different pieces of equipment.

All this poses a rather formidable challenge, since it means establishing new standards for the characteristics of the systems in question and appreciably expanding the classical definitions of the "measurement" of physical quantities. Even if it becomes possible to isolate a procedure that involves pure measurement — such as by representing the control object by one or several bodies — measuring the variables or determining their parameters for each of the six translational and angular components of the vibration of a body may prove difficult and distort the other components or the functional motion of the body (whether or not this motion is oscillatory). In this case, obtaining accurate measurements when the character of the vibration process is complex becomes a matter for independent investigation and loses its normative determinacy.

In any case, the reliability of the final data depends to a considerable extent on the quality of the first link in the measurement chain — the vibration pickup. The latter picks up a mechanical signal from the control object and converts it to electrical form. The distortions, false signals, and noise that accompany this process can be eliminated and lost data can be partially or fully recovered by subsequent links in the chain (measurement system). Thus, in the methodological sense, it is important to attempt to improve vibration pickups so as to incorporate the latest advances in electromechanical transducers and refine standards in design.

The three-component accelerometer "Hexemshear" described below represents just such an improvement. In order to properly evaluate the new elements of its design, compare the features of the unit with known systems, and determine possible applications, it is best if we first review certain principles from vibration measurement in the context of the below exposition.

*By multidimensional, we mean the vibration of an object, approximated by a rigid body undergoing three-dimensional vibration, that can be represented simultaneously by components along and (or) across the axes of a certain system of rectangular coordinates. Instruments designed to measure such vibration can be considered one-component, two-component, three-component, or multi-component, depending on the number of components measured simultaneously.
The inertial instruments employed for vibration measurement [1] use an accelerometer* as the transducer. Accelerometers are the main sensing elements used in industrial vibration-measuring equipment. These multicomponent instruments, enclosed within a single housing, have a number of advantages over other types of devices. They generate measurement data in parallel or in series on all three translational and/or angular components of vibration of the control object. Numerous designs of such transducers have been developed (see [2], for example). However, the transducers themselves are fairly complicated, cumbersome, and expensive. In addition, the inclusion of a large number of mechanical parts of complex shape in one housing and their attachment to the latter produce harmful resonance effects that restrict the working frequency range of the instrument.

*The term "accelerometer" is becoming to be as widely used as the nearly synonymous term "inertial vibration pickup."