Use of low-frequency indicator in physics demonstrations

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We describe in this note the use of a low-frequency oscillographic indicator for lecture demonstrations of the mechanics of translational and rotational motion in mechanical vibrating systems.

To this end we have developed a number of installations that make it possible not only to observe the physical phenomenon, but also to obtain directly on the oscilloscope screen the time dependence of the coordinates of moving bodies. The oscilloscopes used for these experiments should be equipped with long-persistence cathode ray tubes and with a slow sweep in a frequency range from 0.05 Hz to 0.2 Hz. These requirements are satisfied by oscilloscopes S1-4, S1-19, and similar.

Figure 1 shows an installation for demonstrating the time dependence of the path in the case of uniform and uniformly-accelerated motion. The installation consists of a carriage that moves freely on rails whose slope can be varied from 0 to 30°. Mounted on the carriage is a potentiometer pickup, which is coupled through a worm gear to the wheels of the carriage. The potentiometer pickup is a variable resistor of the order of 1 MΩ, with a resistance that varies linearly with its shaft angle (a standard variable resistor VK of type "A"). The pickup is fed from a universal VUP1 rectifier through the circuit of Fig. 2. The output voltage U_{out} is proportional to the angle of the potentiometer-pickup shaft.

Figure 3 shows a diagram of the coupling of the pickup (1) to the worm gear (2, 4) on the carriage platform (3). The worm of the reduction gear is mounted on the wheel axle. The reduction-gear ratio (50 : 1) is chosen such that when the carriage is moved 1750 mm along the rails, the potentiometer shaft rotates through 150°. By varying the slope of the rails it is possible to demonstrate the carriage motion at different accelerations. The voltage from the potentiometer pickup is proportional to the displacement of the carriage along the rails and is applied to the Y plates of the oscilloscope. Figures 4 and 5 show plots of the path against time for uniform and uniformly accelerated motion.

Using the same potentiometer pickup, it is possible to display on the oscilloscope the time dependence of the rotation angle of a body that rotates with uniform speed or with uniform acceleration. The installation is based on the Overbeck pendulum. On one end of the pendulum shaft is screwed a sheave with mutually perpendicular posts, along which loads can be moved, and on the other end of the shaft is fastened the reduction gear. The reduction gear is coupled to the shaft of the potentiometer pickup. The reduction-gear ratio (25 : 1) is chosen such that when a load fastened by a thread to the shaft or to the sheave drops 100 cm, the pickup shaft rotates through 180°. When the pendulum rotates in a clockwise or counterclockwise direction, the electron beam of the oscilloscope is deflected in sychronism upward or downward in a vertical direction, and its displacement in the horizontal direction is proportional to the time of its rotation.

To display the plot of uniform rotation of a pendulum, its shaft is joined with the shaft of an electric motor. A straight line is then obtained on the oscilloscope screen. To demonstrate uniformly accelerated rotation of the pendulum, a load is suspended from its sheave by a string, and can drop freely under the influence of its own weight. The display on the oscilloscope screen is then a parabola. This installation can be used to verify the principal law of rotational motion.

To investigate vibrational motion, the Overbeck pendulum is transformed into an ordinary "mathematical" pendulum. To this end, the posts are unscrewed from the pendulum and a light duraluminum tube 1500 mm long and 6 mm in diameter is screwed in place of one

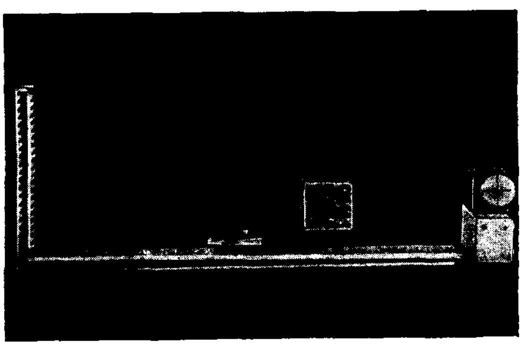

FIG. 1

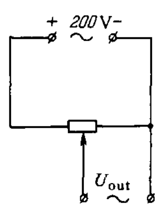

FIG. 2

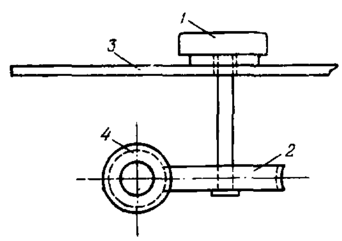

FIG. 3

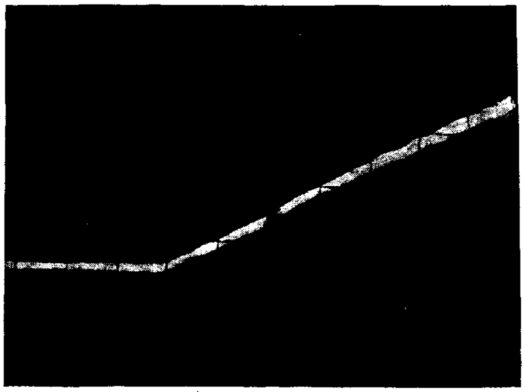

FIG. 4

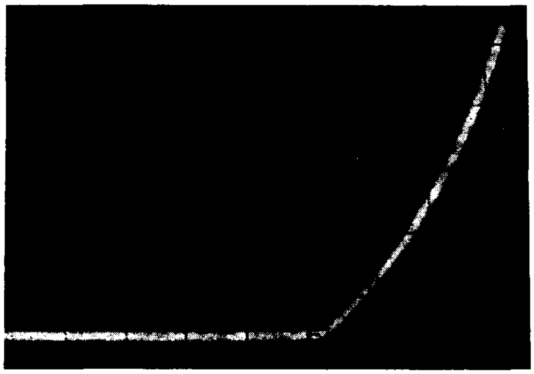

FIG. 5

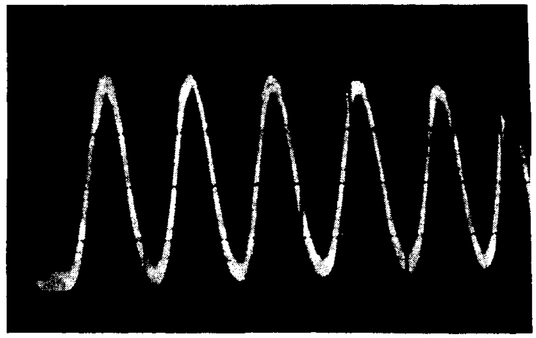

FIG. 6

of them; a lens-like heavy load is mounted on the end of the tube. Setting the pendulum in motion and turning on the time sweep of the oscilloscope, one can display the damped vibrations of the pendulum (Fig. 6). By using two such pendulums it is possible to demonstrate the addition of two mechanical vibrations and the vibrations of coupled pendulums.[2]

[1]W. Stahl, Das Stabpendel—Physikalisches Pendel, Prax. Naturwiss, Tl. 1, Nr. 3, 23 (1974).
[2]N. Ya. Molotkov and V. S. Danyushenkov, Demonstration of the addition of mutually-perpendicular mechanical oscillations, in the book: Dal'nevostochnyĭ fizicheskiĭ sbornik (Far Eastern Physical Collection), Volume 5, Khabarovsk, 1974.

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