A NEW VIBRATION METER

by

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Digest of
Thesis Presented to the Faculty of the Graduate School
of Saint Louis University in Partial Fulfillment of the
Requirements for the Degree of Master of Science(Research)

1954

DIGEST

A three component portable vibration meter was designed and constructed by the Sprengnether Instrument Company for the purpose of measuring vibrations from quarry blasts, heavy industrial machinery and/or other artificial sources. Instruments of this type must satisfy two basic requirements: (1) serviceability and ease of operation under all field conditions, and (2) the production of a response or output which faithfully describes the variation of the input or motion being measured. The purpose of this paper is to describe not only the theory and construction, but also present a series of static and dynamic calibration tests used in the determination of the instrument constants. From the point of view of the fundamental requirements, this investigation proposes to determine the suitability of the instrument for measuring artificial vibrations.

The instrument is a three-component mechanical - optical seismograph. Each component has a single degree of freedom in one of the three mutually perpendicular axes. It is completely self-contained in a case twenty four and one half inches long, ten inches wide and eight inches deep and weighs approximately thirty four pounds. The case contains four separate, but coupled sub-systems:

1.) Three mechanical pendulum systems.

2.) An indicating or optically recording system.

3.) A spring drive which moves the recording paper.

4.) A timing mechanism.

The pendulum system consists of two inverted pendulums to measure motion in the horizontal directions and a vertical pendulum to measure the vertical component of the vibratory motion. The pendulum inertia elements are cylindrical masses of brass weighing approximately 350 to 400 grams. Copper damping vanes are attached to the ends of the inertia elements and swing between the poles of two al nico magnets that are fixed to the frame when the pendulums are in motion.

The horizontal component mirror systems consist of two vertical spindles on jeweled bearings. They are coupled to the inertia masses by means of a boom, pulley and thread arrangement. The vertical component system consists of an inclined fixed mirror and a movable mirror rotating about a horizontal spindle. This system is so oriented as to rotate the plane of the reflected light parallel to the light rays from the horizontal component systems. The light source is a battery operated filament.

The timing unit, designed by Dr. Joseph Volk of Saint Louis University is a modified commercial vibrator circuit which modulates a gas tube. The timing marks are photo-registered the full width of the recording paper.

The recording drum is a cylindrical cartridge which holds approximately fifteen feet of photographic paper. It is geared to a spring-drive motor which rotates the drum at an approximately constant speed of 7.14 centimeters per second.

The calibration tests included:

1) Determination of the free period of each component.

2) Determination of the reduced pendulum length of each component.

3) Determination of the damping of each component.

4) Determination of the linearity of the optical system.

5) Determination of the linearity of the trace amplitude with the angle of rotation of the pendulums.

6) Determination of the static magnification of each component.

7) Determination of the dynamic magnification and static magnification from dynamic response tests.

8) Theoretical determination of the dynamic response curves.

The new vibration meter appears to be quite suitable for its designed purpose. It satisfies the conditions of portability, constant power supply, constant operation over a varied temperature range, and ease of operation. It faithfully responds to the vibratory motion in the frequency range required with sufficient magnifying power to record the minimum amplitudes expected.

TABLE OF CONSTANTS

	Units	Vertical	Longitudinal	Transverse
Mass	gms.	412.30	358.50	360.4
Reduced Pendulum Length	cm.	7.27	6.8	6.8
Equivalent Pendulum Length	cm.	10.10	7.8	9.3
Free Period	sec.	0.6	0.5	0.6
Damping		0.23	0.24	0.13
Spring Constant		5.4 lb/in.	1.12 in.lb./Rad.	1.24 in.lb./Rad.
Static Magnification (Average)		328	249	277