11. *Strong Motion Vibrograph.*

By Nobuji NASU,

Earthquake Research Institute.

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For the purpose of measuring strong vibrations, such as those of the railway bridges, or railway banks, due to the passage of trains, a new instrument has been constructed and tested. The size of the instrument is so minute that it can be installed in small places, for example, the top of the pier and the upper side of the main structural member of a bridge. Three component motions are recorded mechanically on a common recording drum, Figs. 1, 2 and 3.

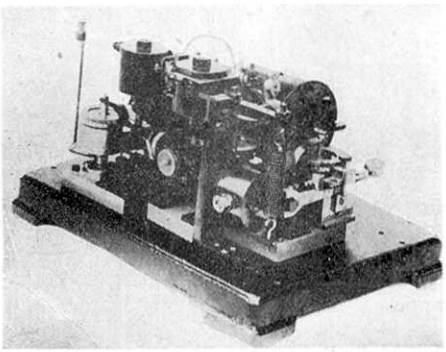

Fig. 1. Strong motion vibrograph.

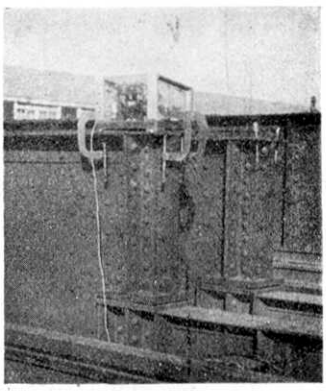

Fig. 2. Vibrograph installed on a plate girder bridge.

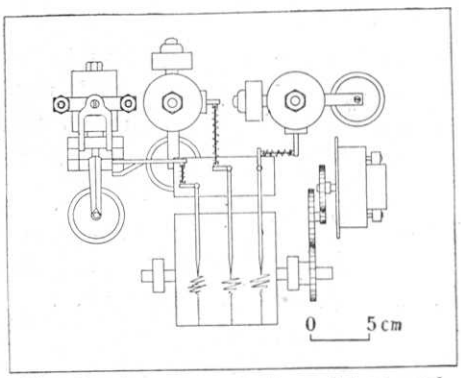

Fig. 3. Arrangement of pendulums and record-receiver.

The horizontal component pendulum has the type of an inverted pendulum as shown in Fig. 4. The axis of rotation is kept constant by the use of the crossed-strip coupling: the strips of each pair lie in a plane, and two planes are arranged at right angles. The movable part of

the pendulum is held in place by these strips with such stiffness as to give a period of 0.4 second. This type of axis of rotation is preferable for the instrument used in the measurement of strong vibration. The bob of the pendulum weighs 1.5 kg., which would be the minimum to overcome friction. To obtain damping, an air-damper is used. But, if desired, it can be secured by means of a liquid-damper. In this case, another piston is used, which moves in either oil or water filled in the

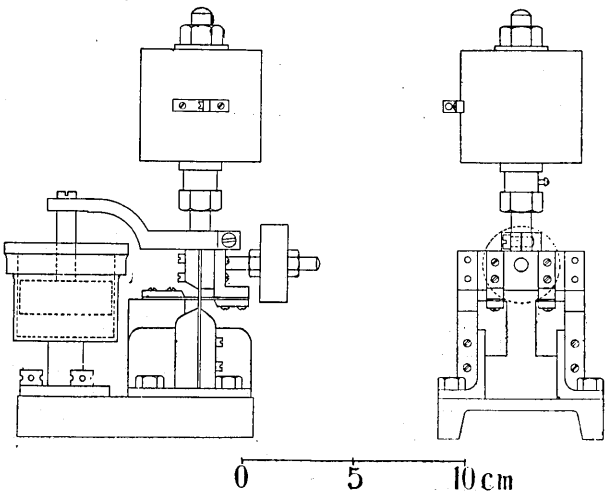

Fig. 4. Horizontal component pendulum.

same receptacle as that of the air-damper. Of course, the clearance between piston and cylinder must be properly chosen according to the fluid employed. Although, the liquid-damper is more or less inconvenient in transportation, it may be sometimes more practicable than the air-damper which necessitates fine adjustment.

In the vertical component pendulum, Fig. 5, the movable part is suspended by a pair of herical springs, the lower ends of which are hooked to the bob of the pendulum weighing 1.45 kg. The damping device is the same as that of the horizontal component pendulum. The period of the vertical pendulum is also 0.4 second.

The motion of each component pendulum is multiplied by means of a lever having a magnification of seven which is suitable for the instrument used in the strong motion-work. In the multiplying lever, a contrivance is made to the index-end so as to be more elastic. Thus, it presses lightly the surface of the smooth paper which is lamp-blacked in petroleum flame. Although, solid friction is increased to a certain

degree, the index-end otherwise is hardly in condition for recording the strong vibration. The index-end which is not made to press the paper is liable to skip when it subjects to the repetition of the strong and rapid vibrations. As the result, the tracing left by the index is not clear, because it is interrupted at places. The pressure at the end of

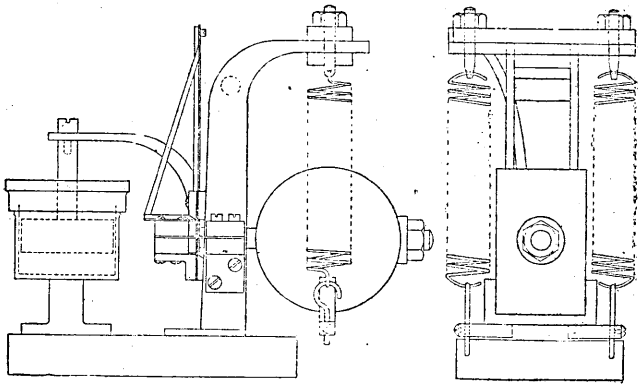

Fig. 5. Vertical component pendulum.

the index, however, should not be so large as the motion of the pendulum is visibly obstructed. To avoid the risk of demolition, the index-end must be held up so that it does not touch the smoked paper when the recording drum is put in or removed from its holder. The contrivance for this purpose is shown schematically in Fig. 6, where P is the index-end; F the small framework supporting the index at the pivotted ends, EE', of the axle. With certain limitations, this framework can turn upward about axis A without injuring the junctions of the short arm of the writing index and the pendulum-bob.

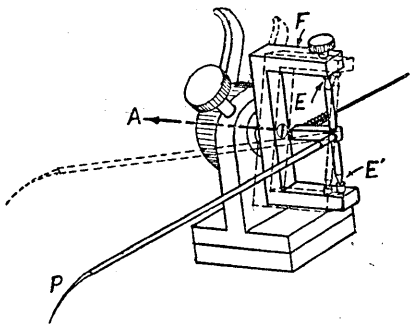

Fig. 6. Framework supporting index.

The recording drum, 10.4 cm. in diameter and 9.4 cm. in length, is driven by a Warren motor, operating on 100-volt, 50-cycle alternating current drawing 6 watts power. But, to secure independence from this current, another source of power has to be used, such that the direct current from an ordinary 6-volt automobil storage battery is transformed to 100-volt alternating current by means of a transformer equipped with a vibrator operated at a fre-

quency of 63 per second. In the former case, the speed of registration is 19.5 mm./sec., while in the latter it is 24.5 mm./sec. By means of a deep helix cut in the spindle the drum is made to translate sideways as it revolves by 7 mm. per revolution so that the registration continues for about 30 seconds.

Three component pendulums and the recording apparatus including the driving motor are contained in a cover made of transparent organic glass plates 10 or 6 mm. thick. In the field, the instrument is fastened to the structure at its cast iron base, 30 cm. × 39 cm., by sea-clamps, Fig. 2. It should be added here that in all parts of the instrument which are liable to become loose, special devices have been made to get rid of this objection.

In the instrument so far mentioned, there lie several troubles which are common in any kind of seismographs adopting the mechanical registration, yet the cheapness of this method of registration is a great recommendation.

Recently, the writer and his assistants, Mr. S. Kawashima and others, made the measurements with this instrument on a plategirder bridge and a bank of the railway. By these measurements, we could successfully determine the natural period and the decay constant of the free vibration of the bridge and further, the attenuation of the ground motion with increasing distance from the center of the track.