Paper No. 94, Bulletin of the Indian Society of Earthquake Technology, Vol. VII, No. 3, pp. 133-136 Sep. 1970

DESIGN OF A STRONG MOTION ACCELEROGRAPH

A. R. Chandrasekaran*, Member & S. P. Gupta**

INTRODUCTION

Till recently the installation of strong motion accelerographs in India is very meagre and practically non-existant. River valley projects have now taken an initiative to locate a few stations in order to collect data for designing future structures and strengthening existing structures. This paper describes the design and development of a three component strong motion accelerograph made essentially of indigenous components.

Various designs of accelerographs, have been examined and a new design made which could be made of available components.

The instrument consists of the following : Three electromagnetically damped torsion pendulums, a horizontal pendulum starter, a mechanical clock, a lamp source, a camera in which photographic paper moves at the same speed as a drive roller in it and a control panel. The instrument is meant to be installed in a dark room.

The instrument operates only when a strong ground motion exceeding a particular threshold level occurs. The pendulum starter then closes an electrical contact thereby putting the entire instrument into operation. The instrument automatically cuts itself off a few seconds after the last contact is made in the pendulum starter.

The instrument is powered by a wet storage battery so that it is independent of supply from mains.

The instrument is somewhat large in size so that each component is easily accessible for inspection and maintenance. Plate 1 shows a view of the instruments indicating the various components.

The instrument is termed as "RESA" which is an acronym for Roorkee Earthquake School Accelerograph.

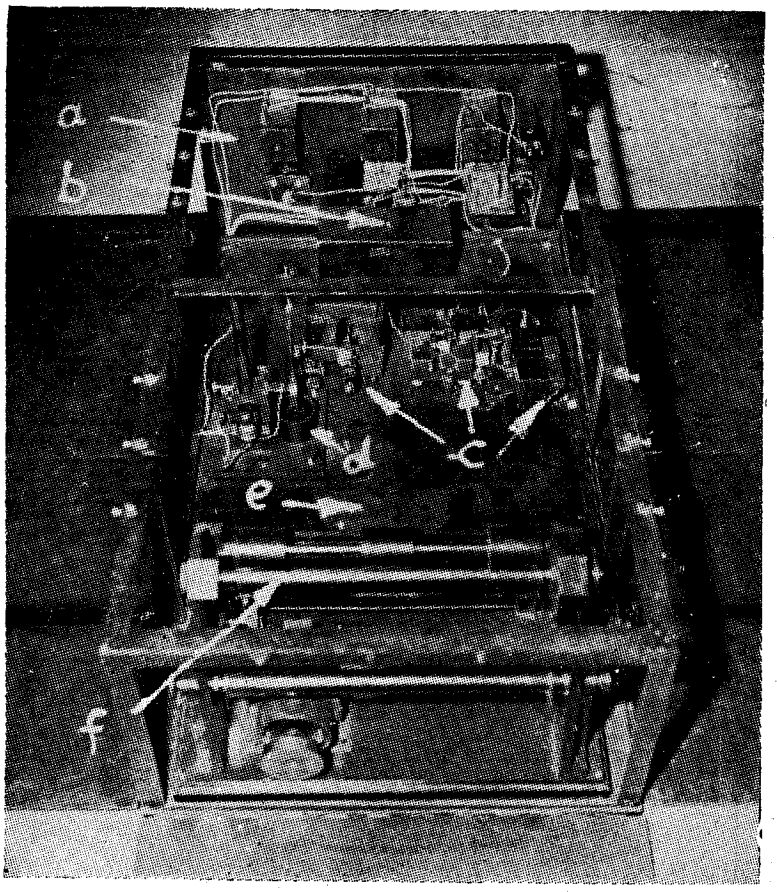
ACCELEROMETER

The accelerometer is a torsion pendulum, consisting of a copper vane suspended on a taut wire which supplies the restoring force. A lens-mirror is mounted on the vane and it reflects an image of the lamp filament to the camera where the rotation of the vane is recorded as a displacement of the trace.

The instrument consists of three accelerometers, two horizontal and one vertical. The two horizontal accelerometers are set at right angles to each other so that one records motion parallel to the longitudinal axis of the instrument while the other records motion

* Professor of Structural Dynamics, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, U.P.

** Research Technician, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee, U.P.



(a) Control Panel

(b) Timing Device

(c) Accelerometers

(d) Starting Device

(e) Light Source

(f) Camera

Plate 1. View of Accelerograph from Top

transverse to it. The vertical accelerometer records vertical motion. The natural frequency of the accelerometer can be adjusted to have values between 18 to 20 cps.

The accelerometers are electro-magnetically damped. The amount of damping can be varied by a wire wound potentiometer. The percentage of critical damping is adjusted to have a value between 0.65 to 0.70.

A fixed mirror attached to each accelerometer traces a straight line on the record to serve as a reference or base line. The accelerometers are provided with three levelling screws and a locking stud. The lens-mirror set-up is front aluminised for better optics.

By disconnecting the electro-magnet circuit, free vibration test can be easily carried out. The procdeure for carrying out such a test is given in a manual[1].

For determination of sensitivity, tilt table tests are carried out.

CAMERA

The camera is a motor driven device to wind photographic paper from a give-up spool and passing through a drive roller mounted in front of an aperture to a take-up spool. A pressure roller is used so that there is no slipping of the paper on the drive roller and to keep the speed of the paper uniform. The paper is driven at a nominal speed of 20 mm/sec. and this speed is adjustable. A 12 volt D.C. electro-magnet type reduction geared

motor is used to move the drive roller as well as the take-up spool through suitable mechanical arrangements. A clutching device between the motor and the drive roller provides means of releasing the drive spool from the motor for loading and unloading of paper. The drive roller also operates two micro-switches. One of the micro-switches has two sets of contacts. One set, controlling the duration of each automatic run while the other, operates a counting relay located on the control panel. The other micro-switch acts as a circuit breaker and can be used as a safety device in the event of failure or when the instrument has run out of paper.

A cylindrical lens alongwith a horizontal aperture is mounted in front of the camera and it converts the image of the lamp filament, as reflected by the accelerometer mirrors, to a point on the photographic paper. A shutter is provided to close the aperture in front of the camera.

TIME MECHANISM

Time marking device is a modified hand wound clock with double spring funner. A lens mirror on this clock reflects an image of the lamp filament to the camera and a special "eclipsing arm" mounted on the escapment shaft of the clock interrupts light to the mirror for one half of each second.

The clock is operated by an electromagnetic relay, which releases the eclipsing arm wheel of the clock.

STARTING DEVICE

The starting device consists of an oil damped pendulum having silver points on the lower ends which operates the starting circuit when pendulum swings. On the base of the starting pendulum, three levelling studs have been provided to enable the pendulum to be levelled to ensure uniform gap in the starting device. A controlled vertical movement is provided so that the starting gap can be adjusted to any desired value. An indicating lamp has also been provided, which when it glows, indicates that the gap is closed.

The horizontal pendulum has a natural period of 0.8 second and a damping of the order of 30% One revolution of the gap control knob is equivalent to a radial gap of 0.002 cm.

Any starting device will have its own dynamic characteristics and various combination of acceleration magnitude, time duration and wave shape may cause sufficient relative motions to cause operation. The optimum combination of characteristics for a given seismic area will need to be determined by experience. The desired operating characteristics of a starter can be expressed only in terms of transient response and this is difficult to do in any generality. A detailed discussion on starting devices has been given by Hudson[2].

Till experience indicates otherwise, a gap 0.05 cm may be kept in these starters as is done in U. S. C. G. S. starters[2].

CONTROL PANEL

The control panel houses relays, potentiometers, indicating meter and switches When the pendulum of the starting device swings and closes the electrical contact, it holds a micro-sensitive relay. This relay in turn holds the main relay which operates the camera motor,

time marking device, lamp, accelerometer magnets and paper counting relay. The micro-sensitive relay can also be operated by an external start when the instrument is in 'check' position. The functioning of main components of the instruments like motor, lamp, accelerometer, clock and starter can be test checked when the instrument is in 'check' position and the indicating meter will show the status of the components.

ACKNOWLEDGEMENT

The authors received active encouragement and guidance at every stage of this work from Dr. Jai Krishna and we are grateful to him.

The Investigation and Planning Circle, U. P. Irrigation Department, Dehra Dun sponsored the project initially and gave impetus to this work.

This paper is being published with the kind permission of Director. S. R. T. E. E., University of Roorkee.

REFERENCES

1. Chandrasekaran, A.R. and Gupta, S.P., "Manual on Roorkee Earthquake School Accelerograph Model I", Earthquake Engineering Studies, S.R.T.E E., University of Roorkee, April 1970.
2. Hudson, D. E., "Ground Motion Measurements in Earthquake Engineering", Proc. Symposium on Earthquake Engineering, Vancouver B.C. Canada, Sept. 1965.