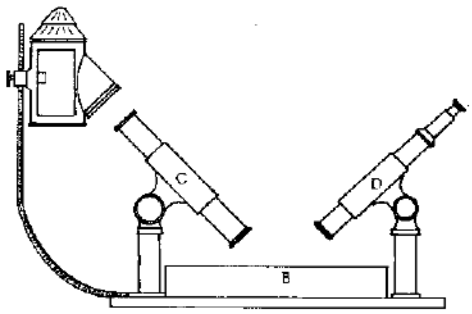
History of seismometers

132 Chang Hêng Seismoscope

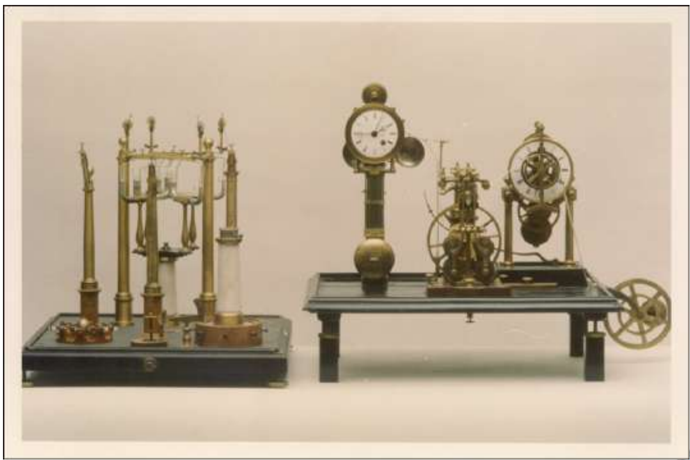
1751 Bina (Italy) simple pendulum above tray of sand

Nicholas Cirillo employed simple pendulums in an investigation of a series of earthquakes in Naples in 1731. He found the amplitude of oscillations to decrease with the inverse square of the distance

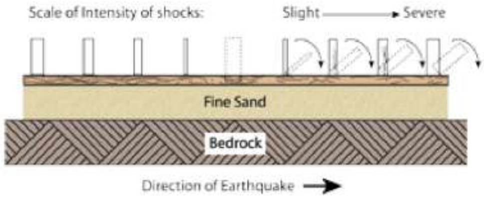
1852 Robert Mallet (Ireland)



1856 Palmieri (Vesuvius/Italy) collection of seismoscopes

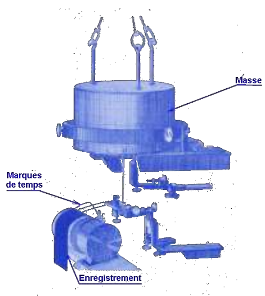


1870 Comrie Earthquake House



- *Upright Cylinder Seismoscope*
- A different approach was tried in the 1870s, based on upright wooden
- 'skittles'. These boxwood cylinders were all of the same height but of
- different diameters so that they had various degrees of stability. It
- was expected that the size of the quake would relate to the size of
- cylinder overthrown, and that the quake's direction would be shown
- by the way in which the cylinders fell, and were 'recorded' in the
- sand. Unfortunately the earthquake activity again subsided, and the
- instrument never functioned. By around 1900 the building, which
- had become known as "Earthquake House", fell into disrepair and no
- evidence of the original seismoscope remained, except

VICENTINI 1895-1899 (Padua Italy)



vertical :

consists of an undamped flexible blade

•mass 50 kg (1100 lb)
•period 1-2 s

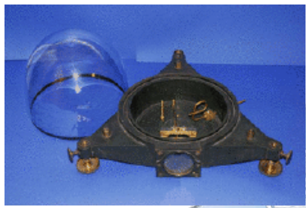
horizontal :

consists of an elementary pendulum

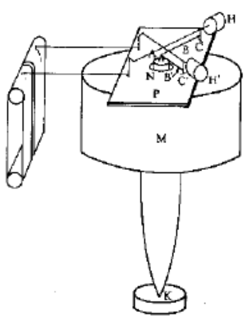
•mass 100 kg (2200 lb)
•period 2 s

1889 Rebeur-Paschwitz(Potsdam/Germany)

observes distant earthquake with astronomic pendulum,



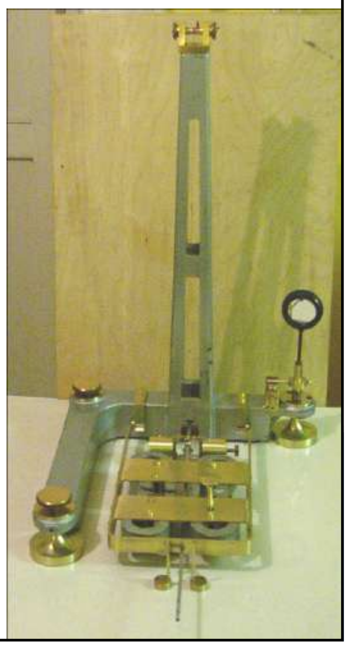
1900 Wiechert inverted pendulum



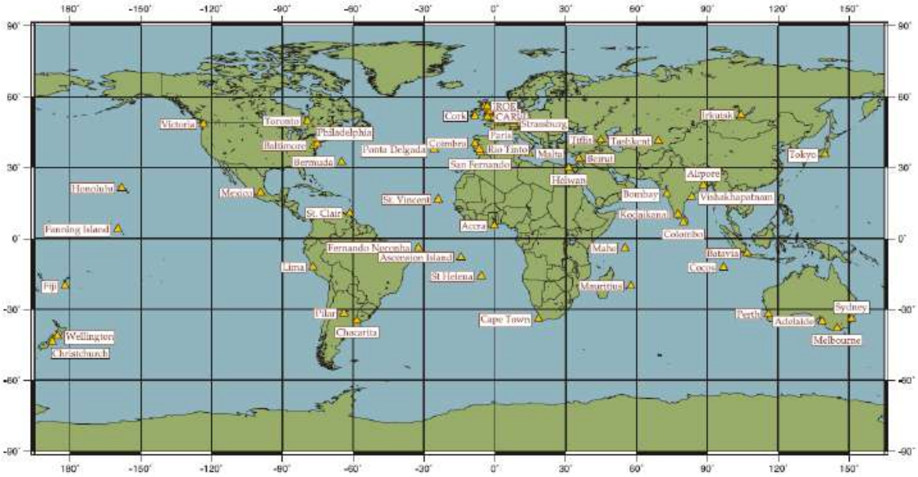
1000kg mass

Milne 1904 Shide UK

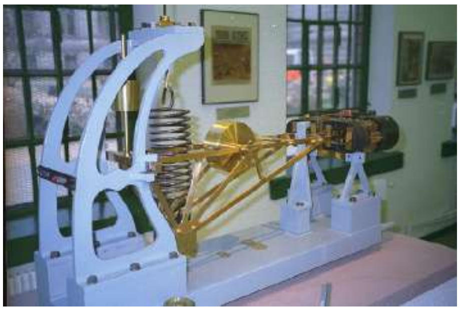
Milne-Shaw 1908



Milne Shide network 1910



Galitzine 1903-10 (St Petersburg)



vertical :

•mass 7 kg (15 lb)
•period 12 s

•mass 10 kg (22 lb)
•period 24 s

Wood Anderson 1925 (USA)

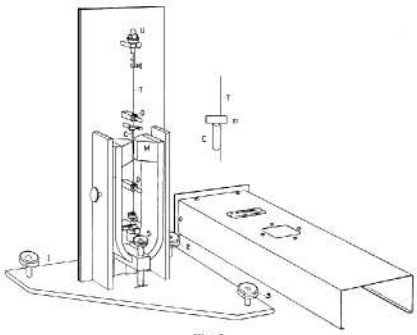
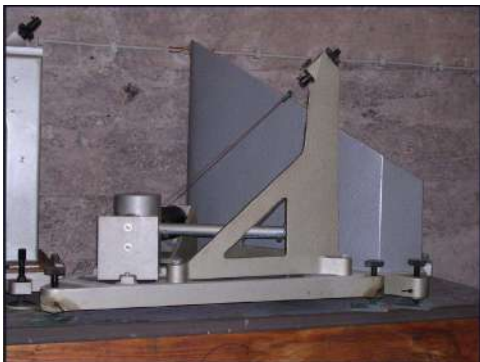


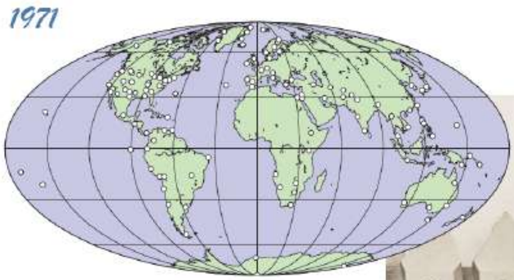
Fig. 2

Richter Magnitude 0 = 1micrometer displacement on WA seismogram at 100km

WWSSN-LP sprengnether



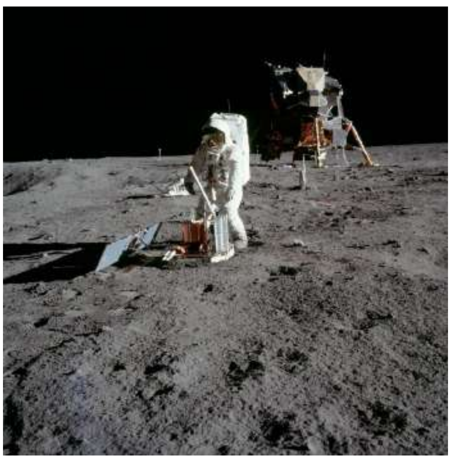
WWSSN

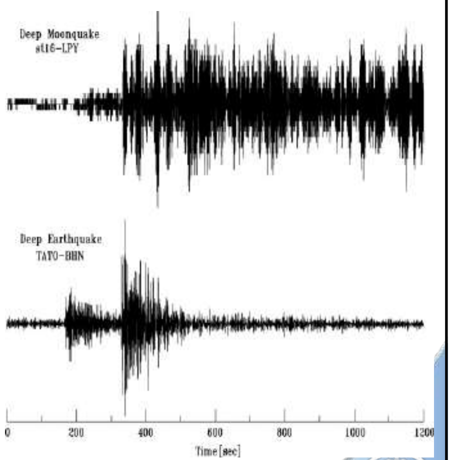


(Top) Stations of the World-Wide Standardized Seismograph Network (WWSSN), installed 1962–1971.

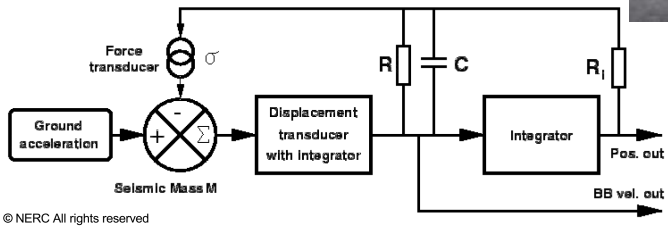
(Right) The WWSSN System, including seismometers, galvanometers, drum recorders, and timing console.

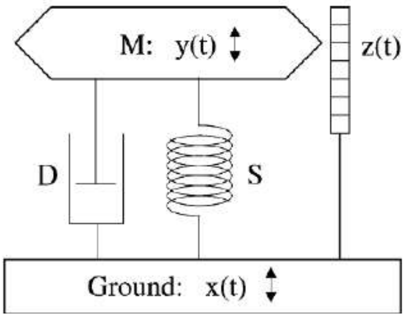
Lunar seismology





Broad-band seismometery



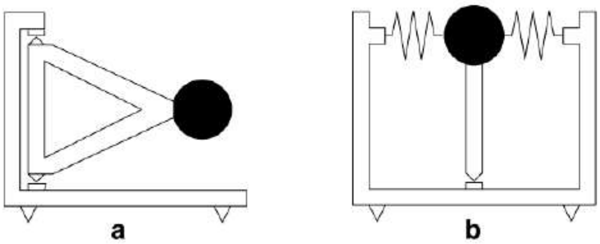


We assume that the seismic mass is constrained to move along a straight line without rotation (i.e., it performs a pure translation). The mechanical elements are a mass of M kilograms, a spring with a stiffness S (measured in Newtons per meter), and a damping element with a constant of viscous friction D (in Newtons per meter per second). Let the time-dependent ground motion be $x(t)$, the absolute motion of the mass $y(t)$, and its motion relative to the ground $z(t) = y(t) - x(t)$. An acceleration $\ddot{y}(t)$ of the mass results from any external force $f(t)$ acting on the mass, and from the forces transmitted by the spring and the damper:

$$M\,\ddot{y}(t) = f(t) - S\,z(t) - D\,\dot{z}(t)\,. \tag{5.16}$$

Since we are interested in the relationship between $z(t)$ and $x(t)$, we rearrange this into

$$M\,\ddot{z}(t) + D\,\dot{z}(t) + S\,z(t) = f(t) - M\,\ddot{x}(t)\,. \tag{5.17}$$



The simplest example of a pendulum is a mass suspended with a string or wire (like Foucault's pendulum). When the mass has small dimensions compared to the length ℓ of the string so that it can be idealized as a point mass, then the arrangement is called a mathematical pendulum. Its period of oscillation is $T = 2\pi\sqrt{\ell / g}$ where g is the gravitational acceleration. A mathematical pendulum of 1 m length has a period of nearly 2 seconds; for a period of 20 seconds the length has to be 100 m. Clearly, this is not a suitable design for a long-period seismometer.