Chapter 10
Vibration Measurement and Applications

10

Chapter Outline

10.1

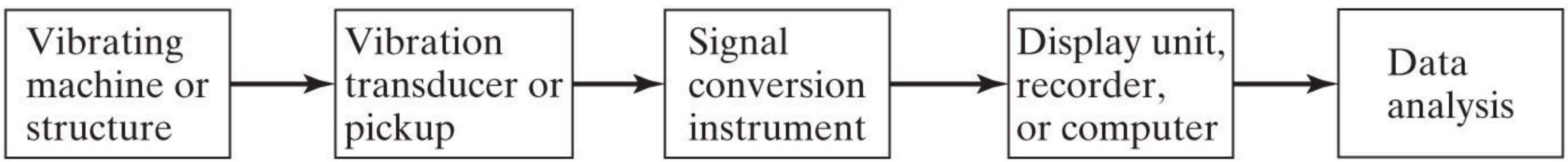
10.1 Introduction

- Why we need to measure vibrations:
  - To detect shifts in ω_n which indicates possible failure
  - To select operational speeds to avoid resonance
  - Measured values may be different from theoretical values
  - To design active vibration isolation systems
  - To identify mass, stiffness and damping of a system
  - To verify the approximated model

10.1 Introduction

- Type of vibration measuring instrument used will depend on:
  - Expected range of frequencies and amplitudes
  - Size of machine/structure involved
  - Conditions of operation of the machine/structure
  - Type of data processing used

  - Any Vibration Measurement Experiment should have:



10.2

10.2 Transducers

- A device that transforms values of physical variables into electrical signals

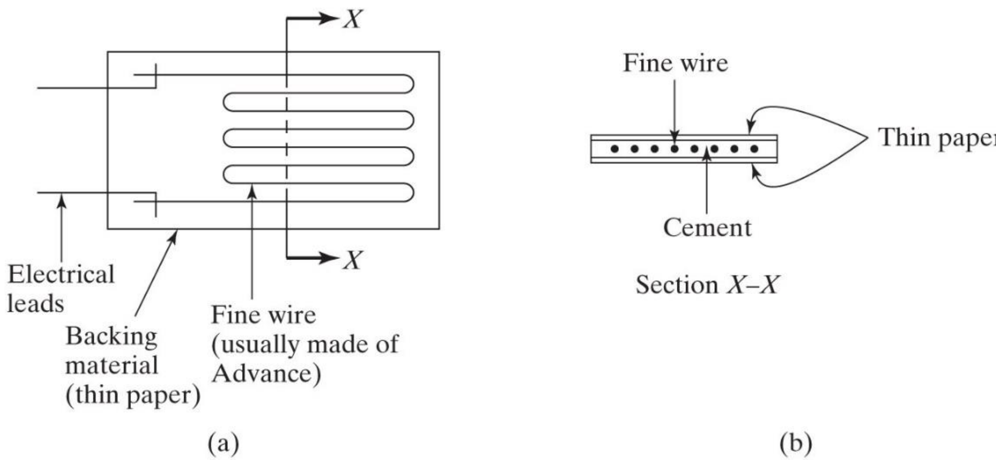
- Following slides show some common transducers for measuring vibration

10.2 Transducers

- **Variable Resistance Transducers**

  Mechanical motion changes electrical resistance, which cause a change in voltage or current

  Strain gage is a fine wire bonded to surface where strain is to be measured.

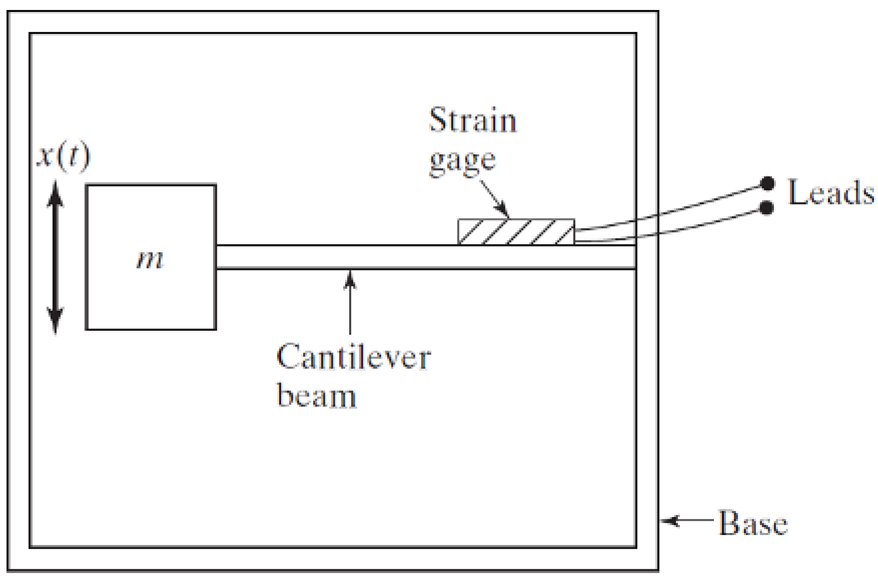


10.2 Transducers

- **Variable Resistance Transducers**

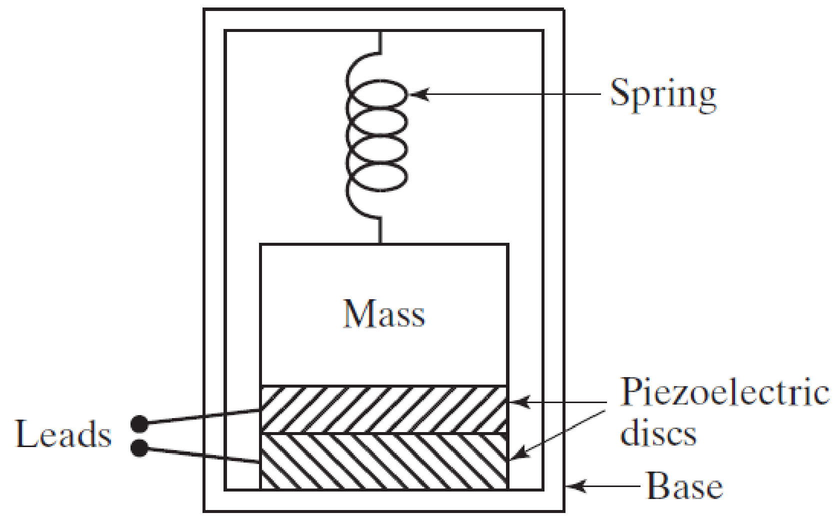
  Strain: $\varepsilon = \dfrac{\Delta L}{L} = \dfrac{\Delta R}{RK}$

  The following figure shows a vibration pickup:



10.2 Transducers

- **Piezoelectric Transducers**



A piezoelectric accelerometer is shown.

Output voltage proportional to acceleration

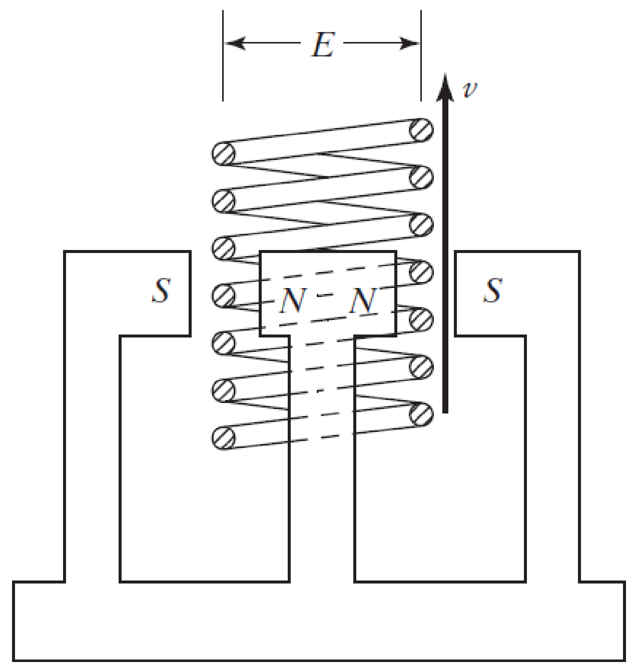
10.2 Transducers

- **Electrodynamic Transducers**

  Voltage *E* is generated when the coil moves in a magnetic field as shown.

$$E = Dlv \qquad Dl = \frac{E}{v} = \frac{F}{I}$$

where D = magnetic flux density
l = length of conductor
v = velocity of conductor relative to magnetic field



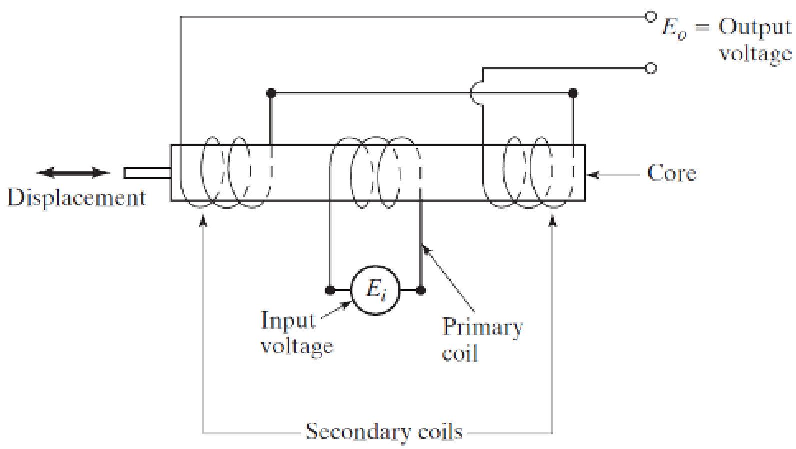
- Electrodynamic transducer measures **velocity**

10.2 Transducers

- **Linear Variable Differential Transformer (LVDT) Transducer**

  Output voltage depends on the axial displacement of the core.

  Insensitive to temp and high output.



Electrodynamic transducer measures **Displacement**

10.3
Vibration Pickups

10.3

10.3 Vibration Pickups

- Three common vibration pickups are:

1. ***Vibrometer*** *which measures deflections (displacements)*
2. ***Vilometer*** *which measures velocity*
3. ***Accelerometer*** *which measures acceleration*

10.4
Frequency-Measuring Instruments

10.4

10.4 Frequency-Measuring Instruments

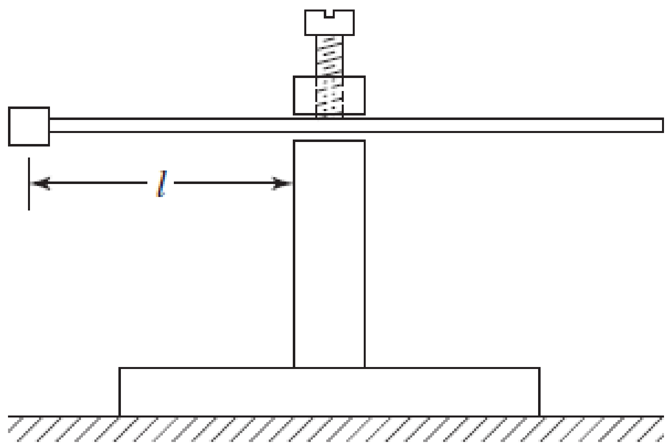
- **Single-reed instrument**

- This instrument consists of a variable length cantilever strip with a mass attached at one of its ends. The other end of the strip is clamped, and its free length can be changed by means of a screw mechanism

- Since each length of the strip corresponds to a different natural frequency, the reed is marked along its length in terms of its natural frequency.

- In practice, the clamped end of the strip is pressed against the vibrating body, and the screw mechanism is manipulated to alter its free length until the free end shows the largest amplitude of vibration.

- When largest vibration is achieved, natural frequency can be calculated, accordingly.



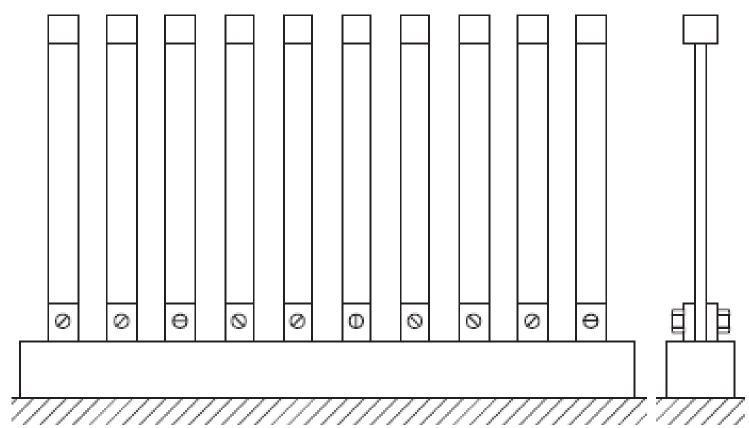
10.4 Frequency-Measuring Instruments

- **Multi-reed Instrument**
- This instrument consists of a number of cantilevered reeds carrying small masses at their free ends

- Each reed has a different natural frequency and is marked accordingly. Using a number of reeds makes it possible to cover a wide frequency range.

- When the instrument is mounted on a vibrating body, the reed whose natural frequency is nearest the unknown frequency of the body vibrates with the largest amplitude.

- The frequency of the vibrating body can be found from the known frequency of the vibrating reed.



10.4 Frequency-Measuring Instruments

- **Stroboscope**
- A stroboscope is an instrument that produces light pulses intermittently.

- The frequency at which the light pulses are produced can be altered and read from the
- instrument.

- When a specific point on a rotating (vibrating) object is viewed with the stroboscope, it will appear to be stationary only when the frequency of the pulsating light is equal to the speed of the rotating (vibrating) object.

- the lowest frequency that can be measured with a stroboscope is approximately 15 Hz

10.5
Vibration Exciters

10.5

10.5 Vibration Exciters

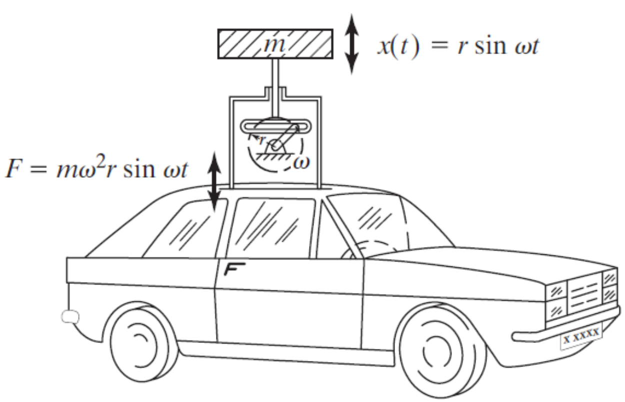
- Used to determine dynamic characteristics of machines and structures and fatigue testing of materials
- Can be mechanical, electromagnetic, electrodynamic or hydraulic type

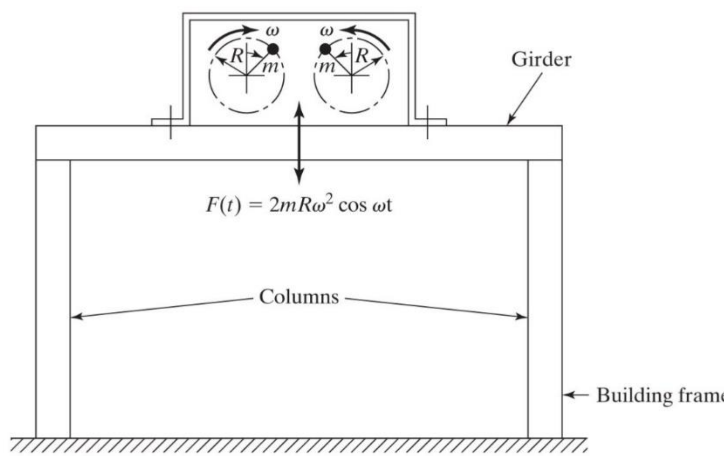
10.5 Vibration Exciters

- **Mechanical Exciters**

1. Force can be applied as an inertia force.

2. The unbalance created by two masses rotating at the same speed in opposite directions can be used as a mechanical exciter.

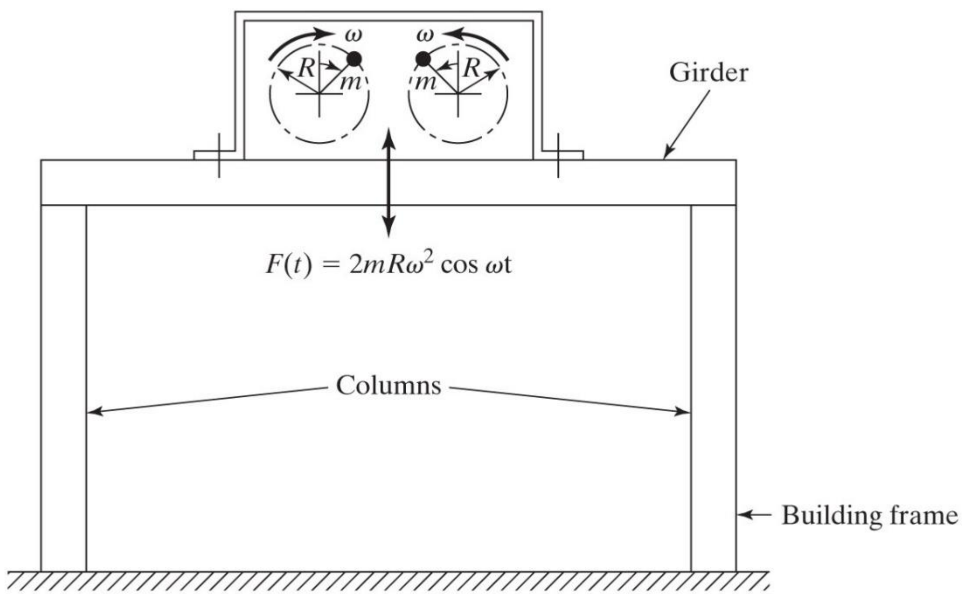




10.5 Vibration Exciters

- **Mechanical Exciters**

  The unbalance created by two masses rotating at the same speed in opposite directions can be used as a mechanical exciter.

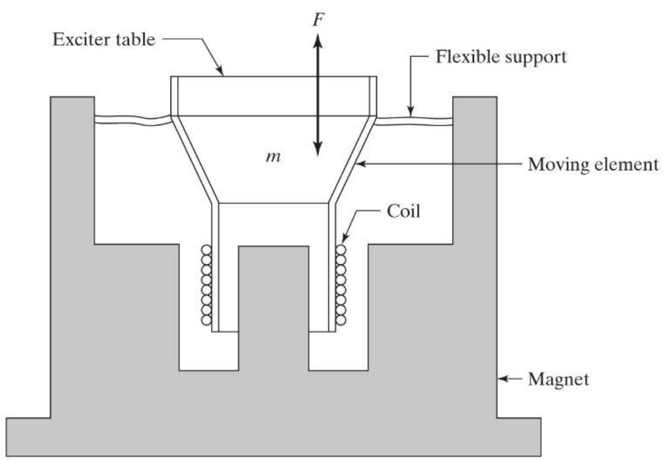


10.5 Vibration Exciters

- **Electrodynamic Shaker**

  The electrodynamic shaker can be considered as the reverse of an electrodynamic transducer.

  2 resonant frequencies are shown below.



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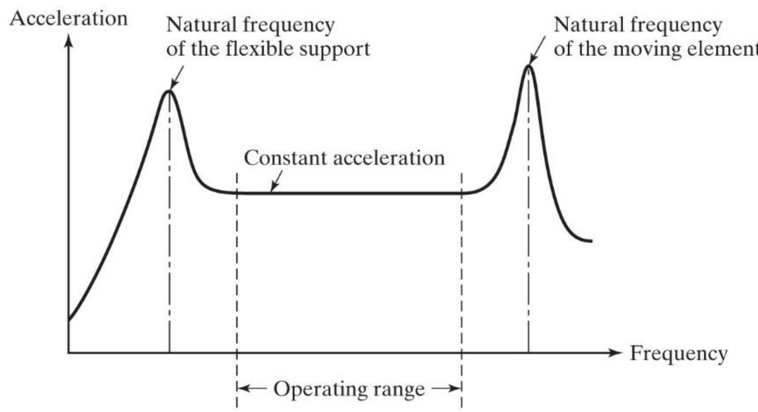

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