SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)
Coimbatore-35

DEPARTMENT OF BIOMEDICAL ENGINEERING

23BMT203 - BIOMEDICAL TRANSDUCERS AND SENSORS

UNIT III- MEASUREMENT OF PRESSURE & BLOOD FLOW

II Year/ IV Sem

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Direct Pressure Measurement

- ✓ Catheters type
- ✓ Diaphragm type

Indirect Pressure Measurement

- ✓ Doppler Ultrasound
- ✓ Applanation Method

Blood Flow Measurements

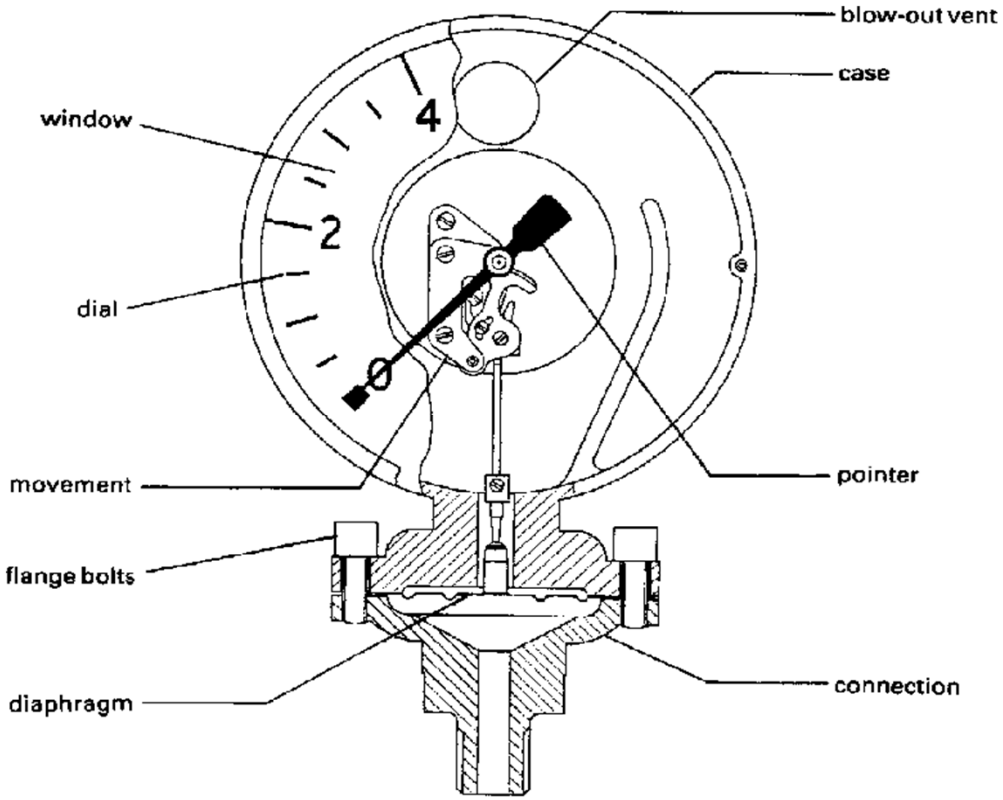
- ✓ Electromagnetic Blood Flow
- ✓ Ultrasonic Blood Flow

Ground Force Measurements

- ✓ Strain gauge type force plate
- ✓ Foot Force Distribution Measurements

Diaphragm type - Direct Pressure Measurement

- A diaphragm-type pressure sensor consists of a thin, flexible membrane that deforms under pressure.
- This deformation is converted into an electrical signal using various transduction methods.



Working Principle - Diaphragm

1. **Diaphragm Structure**
   A thin metal, silicon, or polymer membrane separates the pressure medium from the sensing element.
2. **Pressure Application**
   When pressure is applied, the diaphragm **bends or deflects**.
3. **Sensing Mechanism**
   The deflection is converted into an **electrical signal** using:
   - **Strain gauges**
   - **Capacitive elements**
   - **Piezoelectric crystals**
   - **Optical sensors**
4. **Signal Processing**
   The signal is amplified, conditioned, and displayed as a pressure reading.

Types of Diaphragm Pressure Sensors

A. Capacitive Diaphragm Sensors

- Uses a diaphragm as one plate of a capacitor.
- Pressure-induced diaphragm movement changes capacitance, which is converted into an electrical signal.
- Offers high sensitivity and low power consumption.

B. Strain Gauge Diaphragm Sensors

- Uses strain gauges attached to the diaphragm to measure deformation.
- The strain changes the electrical resistance of the sensor, which is converted into voltage changes.
- Common in industrial and medical applications.

C. Piezoelectric Diaphragm Sensors

- Uses piezoelectric materials (e.g., quartz or PZT) that generate an electrical charge when deformed by pressure.
- Ideal for dynamic pressure measurements such as heartbeats and respiratory monitoring.

Advantages Diaphragm Pressure Sensors

- **High Sensitivity**: Accurately detects even small pressure changes.
- **Compact and Lightweight**: Ideal for space-constrained applications.
- **Wide Pressure Range**: Suitable for low to high-pressure environments.
- **Non-corrosive Options**: Diaphragms can be made from materials like stainless steel or polymers to resist chemical damage.
- **Fast Response Time**: Great for dynamic pressure monitoring.
- **Low Power Consumption**: Especially useful in portable and medical devices.

Disadvantages Diaphragm Pressure Sensors

- **Limited Overpressure Tolerance**: May be damaged if exposed to excessive pressure.
- **Temperature Sensitivity**: Performance can vary with temperature changes unless compensated.
- **Mechanical Fatigue**: Long-term use may cause diaphragm wear or drift.
- **Calibration Requirement**: Needs periodic calibration for accurate readings.
- **Fragility**: Thin diaphragms can be punctured or ruptured in harsh conditions.

Applications Diaphragm Pressure Sensors

- **Medical Devices**: Blood pressure monitoring, ventilators, catheter-based systems.
- **Automotive**: Manifold air pressure (MAP) sensors, fuel systems.
- **Industrial Process Control**: Fluid and gas pressure monitoring in pipelines.
- **HVAC Systems**: Airflow and pressure regulation.
- **Aerospace**: Cabin pressure control, fuel systems.
- **Consumer Electronics**: Barometers in smartphones and wearable tech.

Comparison of Catheter Sensors and Diaphragm Sensors

Feature	Catheter-Based Pressure Sensor	Diaphragm-Type Pressure Sensor
Primary Use	Internal body pressure monitoring	Industrial and medical pressure sensing
Placement	Inserted into the body (arteries, brain, bladder)	Mounted externally or internally in systems
Size	Miniaturized (MEMS, Fiber Optic)	Varies (microscale to macroscale)
Accuracy	High (critical for medical applications)	High but depends on the transduction method
Sensitivity to EMI	Fiber optic types are immune	Capacitive and strain gauge types are sensitive
Common Applications	Medical procedures, ICU monitoring	Industrial, automotive, and medical systems