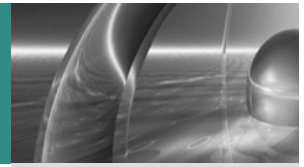
K.N.Toosi
Universit of technology
Control dep.

Ali Alizadeh Kashani

Flow Measurement

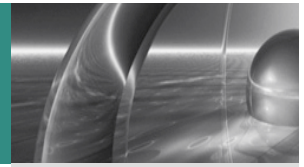
Instrumentation Course
Dr. Taghirad

HeadLines:



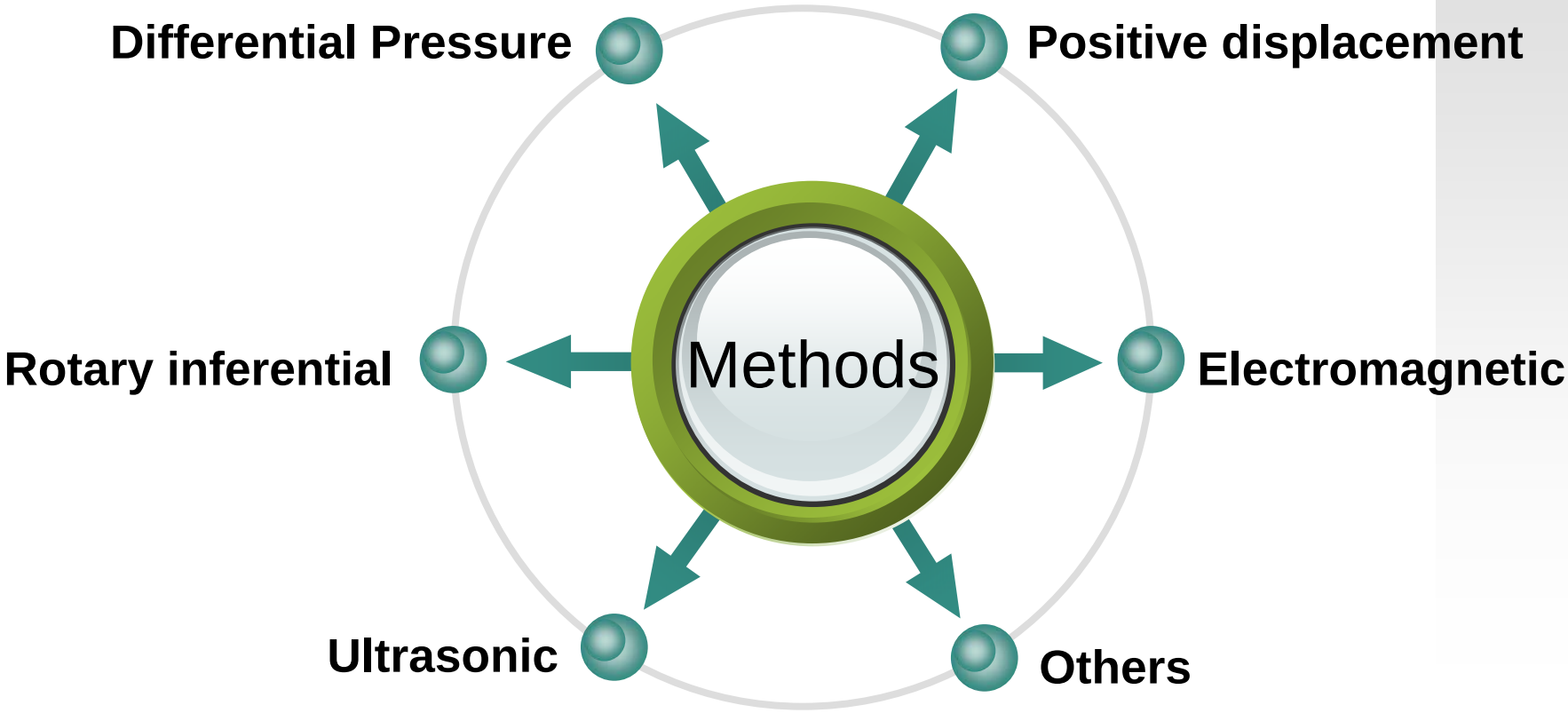
1. Basic Definitions
2. Methods
3. Key Features to Design
4. Market

Basic Definitions



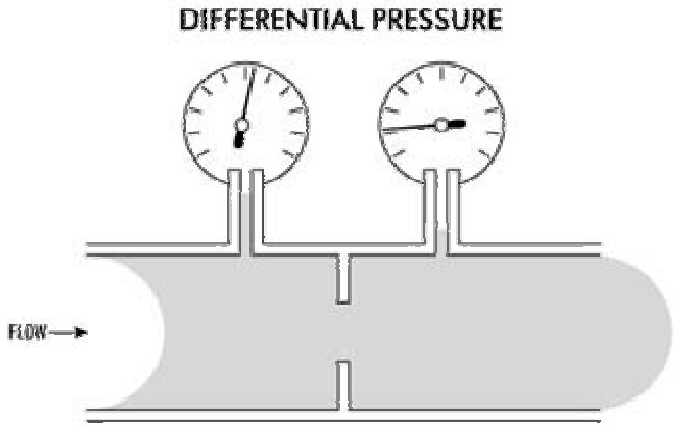
- Mass flow rate
- Volumetric flow rate
- Bernoulli's principle
- Dynamic pressure
- Reynolds Number

Methods


Differential Pressure
Positive displacement
Rotary inferential
Methods
Electromagnetic
Ultrasonic
Others

Differential Pressure Measurement

- Differential pressure flow meters use Bernoulli's equation to measure the flow of fluid in a pipe. Differential pressure flow meters introduce a constriction in the pipe that creates a pressure drop. When the flow increases, more pressure drop is created. Bernoulli's equation states that the pressure drop across the constriction is proportional to the square of the flow rate. Impulse piping route the upstream and downstream pressures to the electronic transmitter that measures the differential pressure to determine the fluid flow.

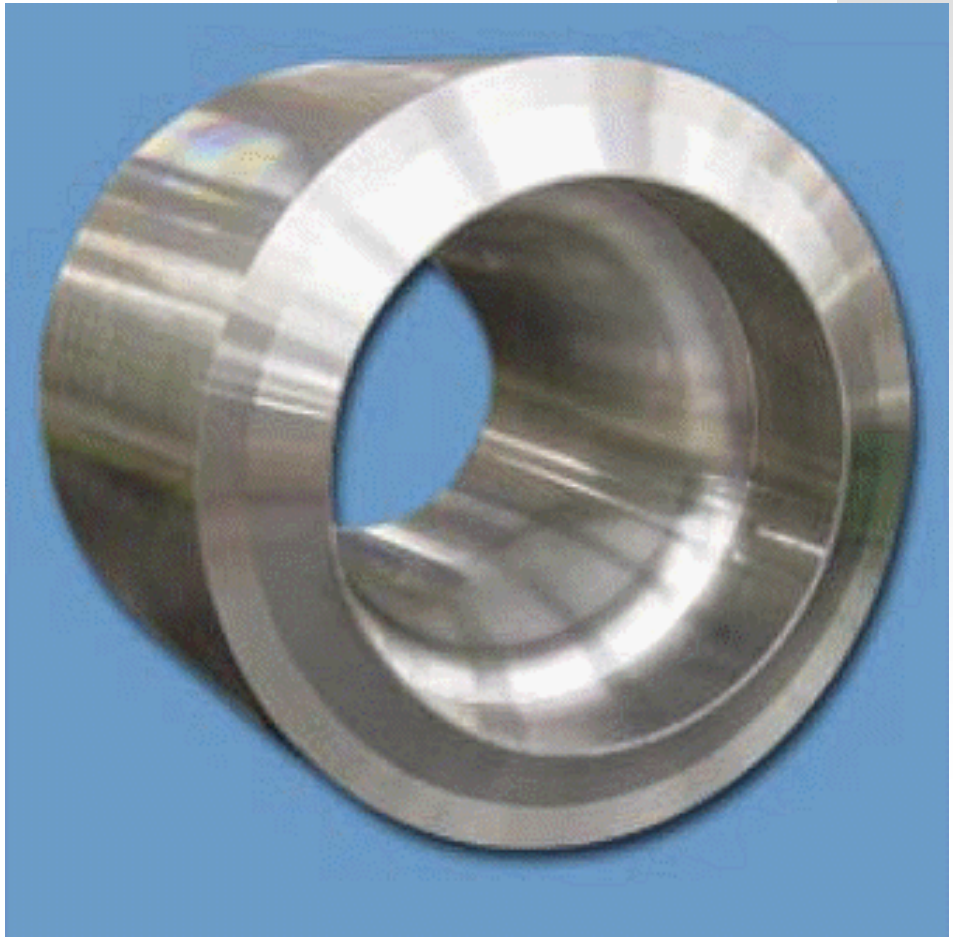


Differential Pressure Measurement

- **Orifice Plate**

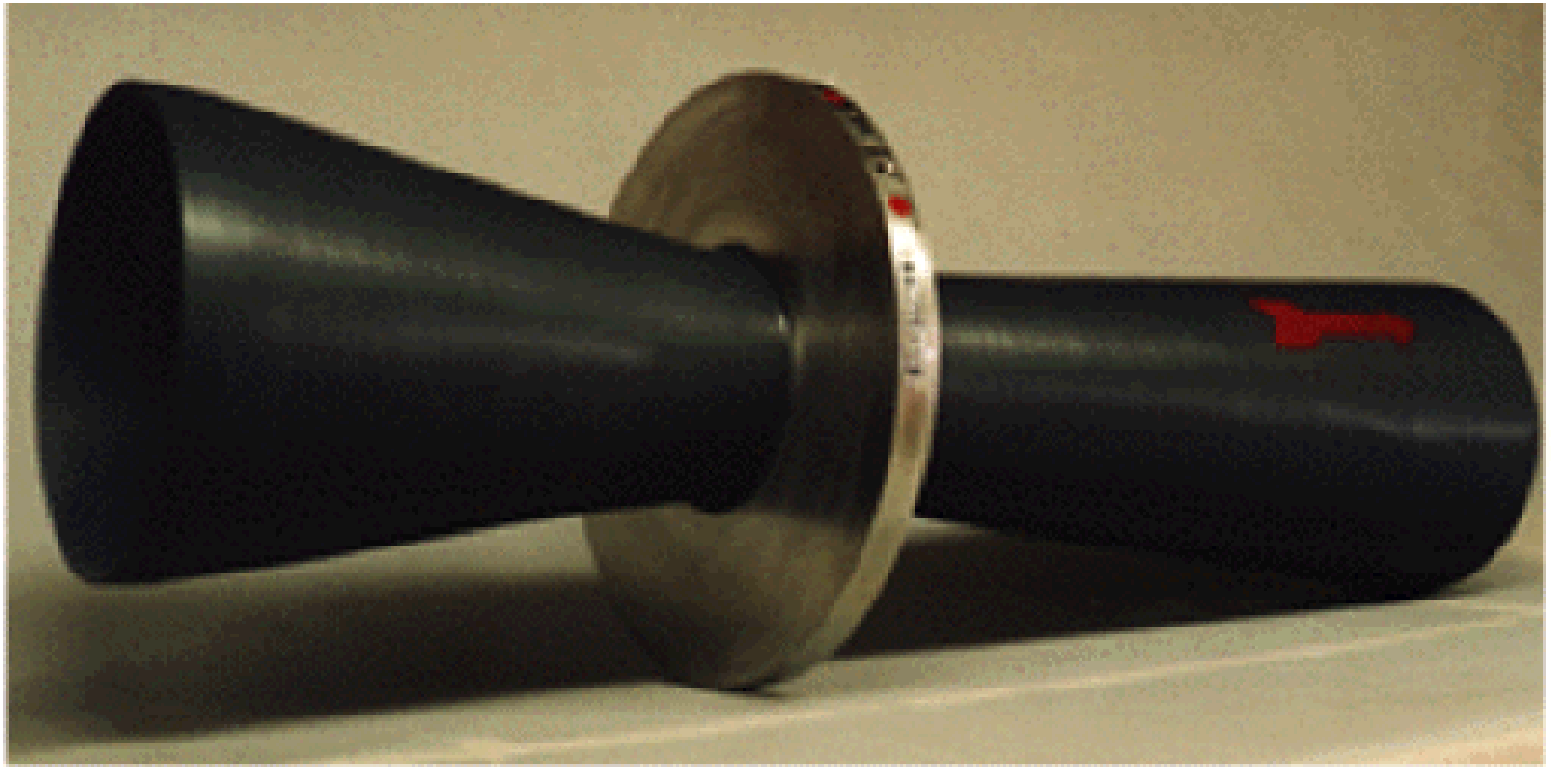
Differential Pressure Measurement

Flow Nozzle



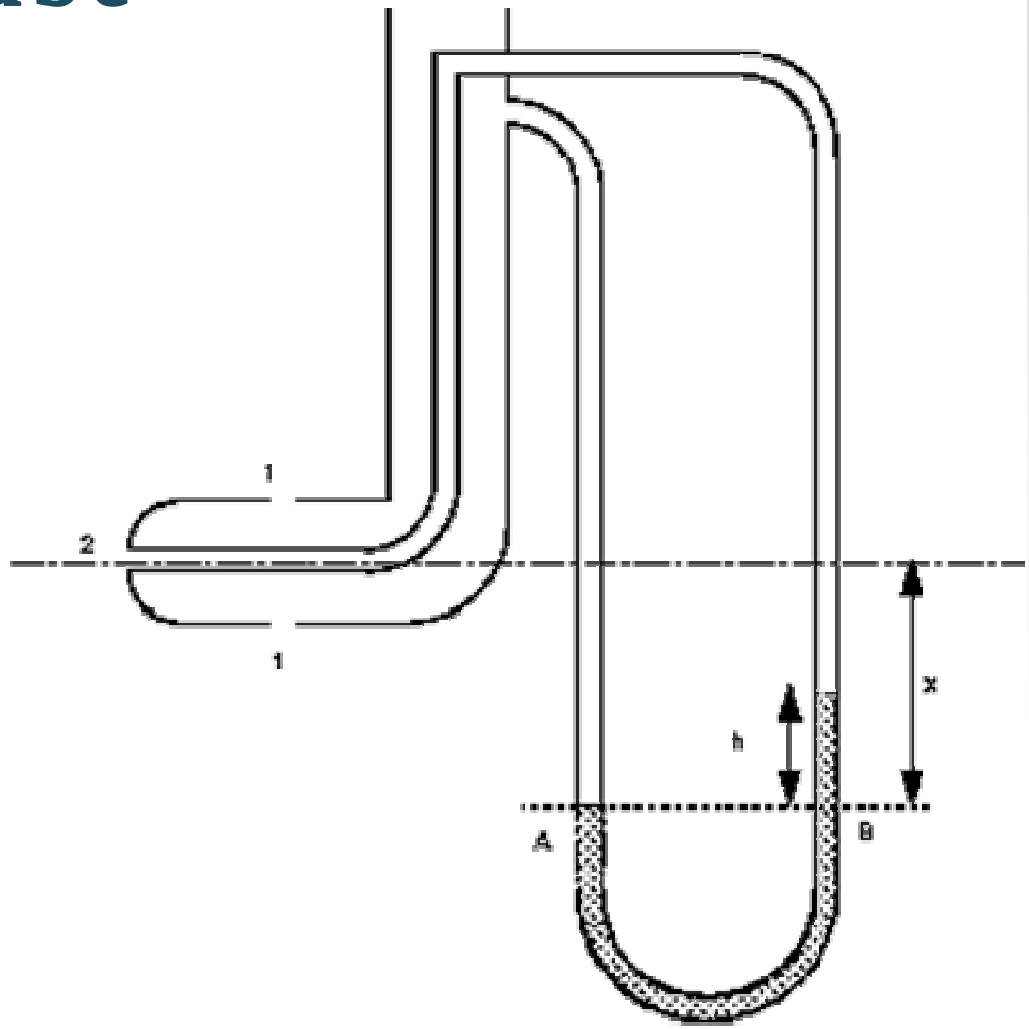
Differential Pressure Measurement

Venturi Tube



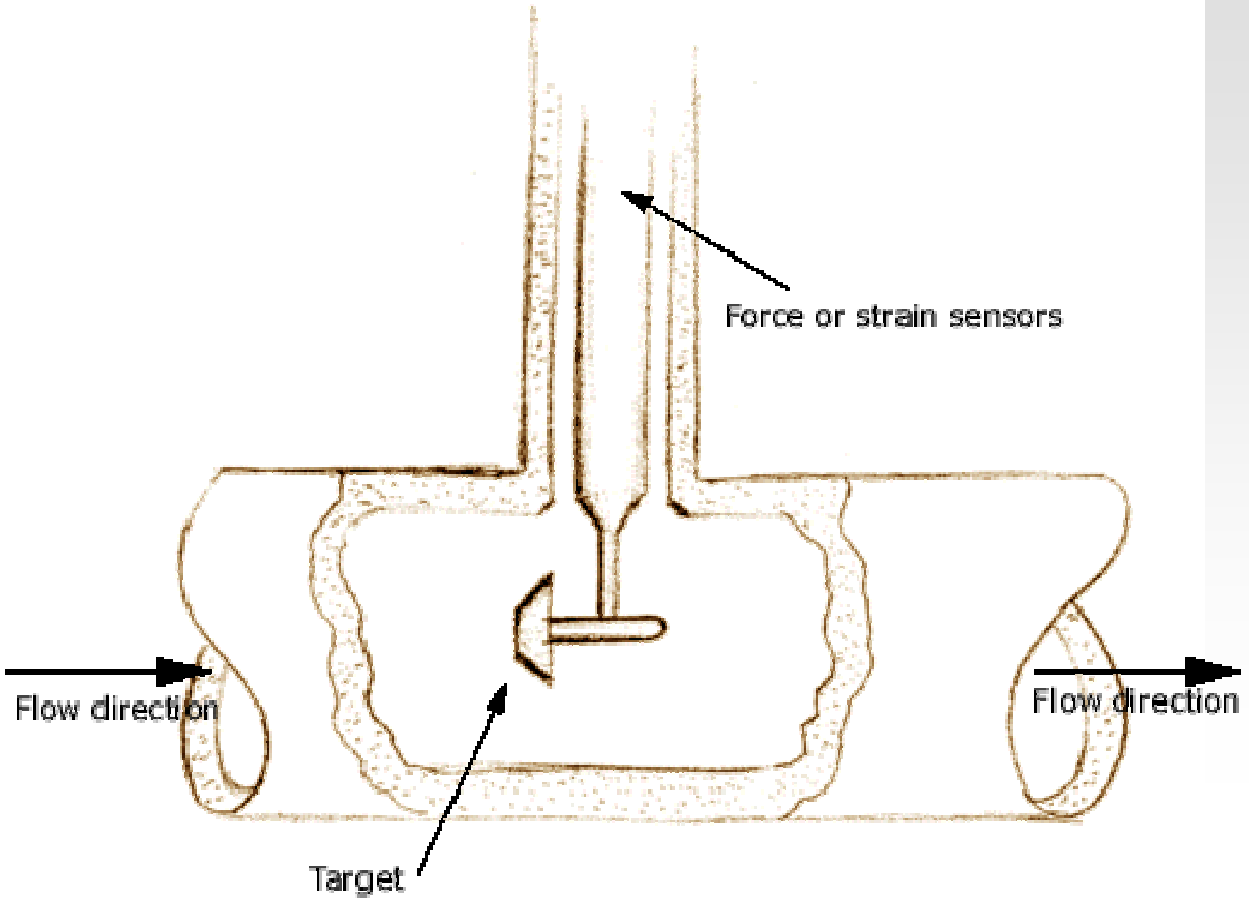
Differential Pressure Measurement

- **Pitot Tube**



Differential Pressure Measurement

Target Flow Meter



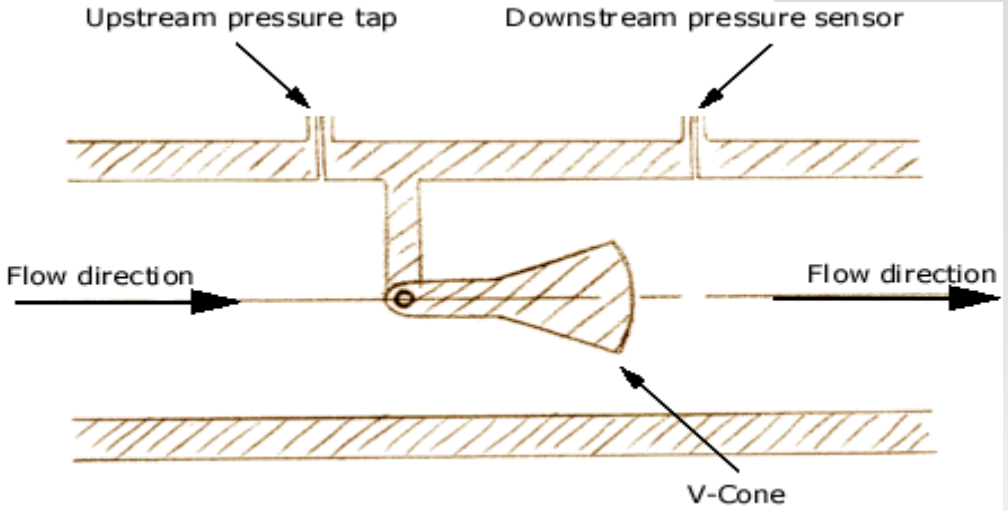
Target flowmeter places a target into the flow pass and measures the force applied by the passing fluid to calculate the volume flow rate.

Differential Pressure Measurement

Segmental Wedge

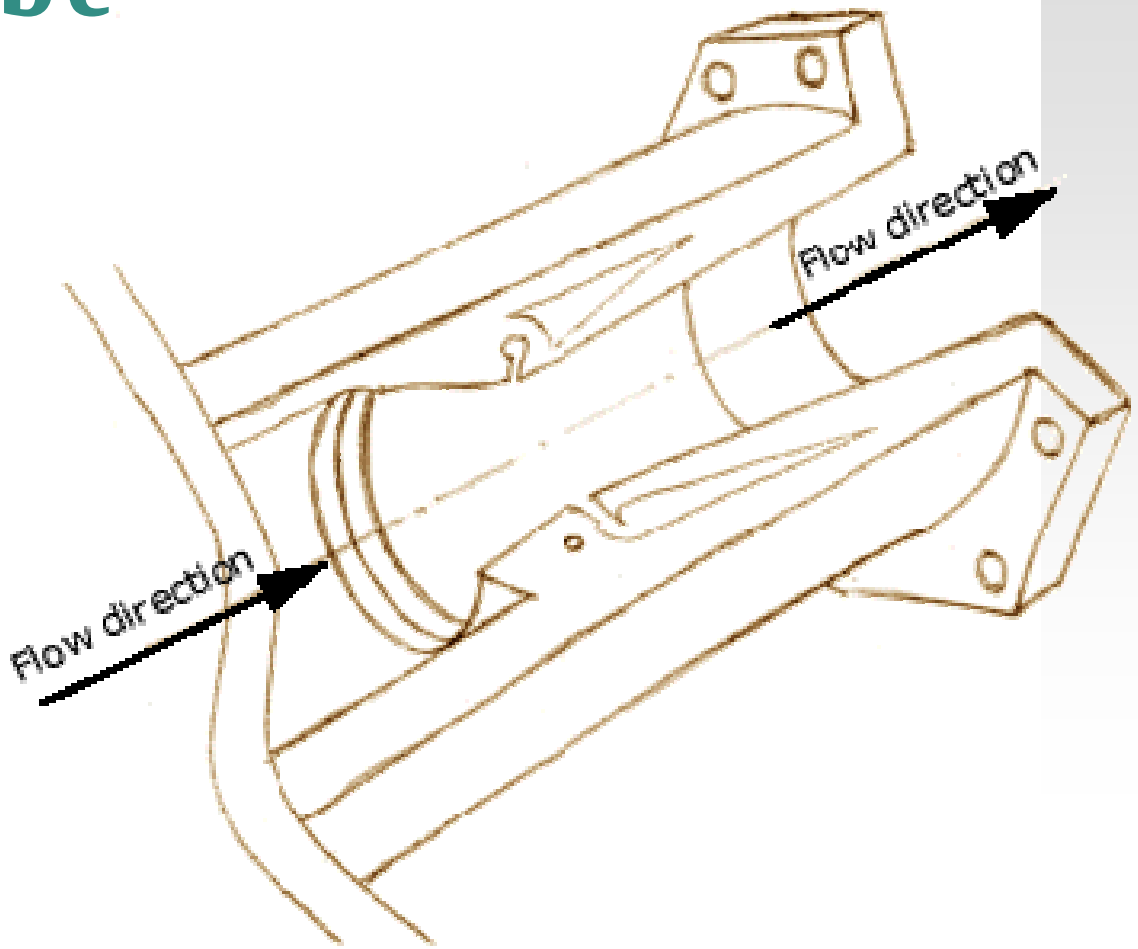
Differential Pressure Measurement

- **V-Cone**



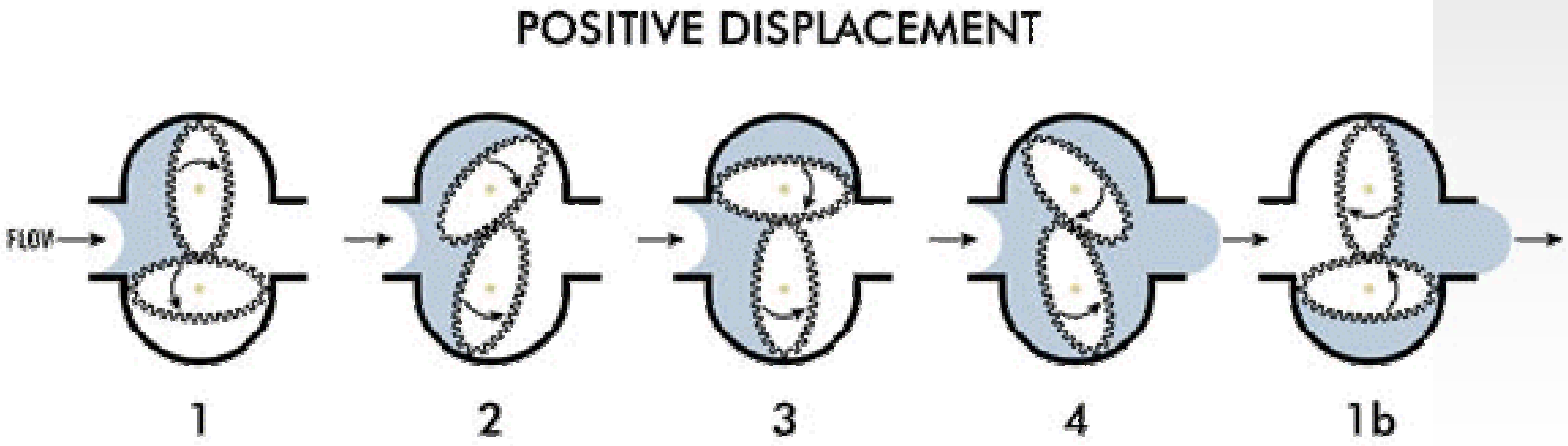
Differential Pressure Measurement

Dall Tube



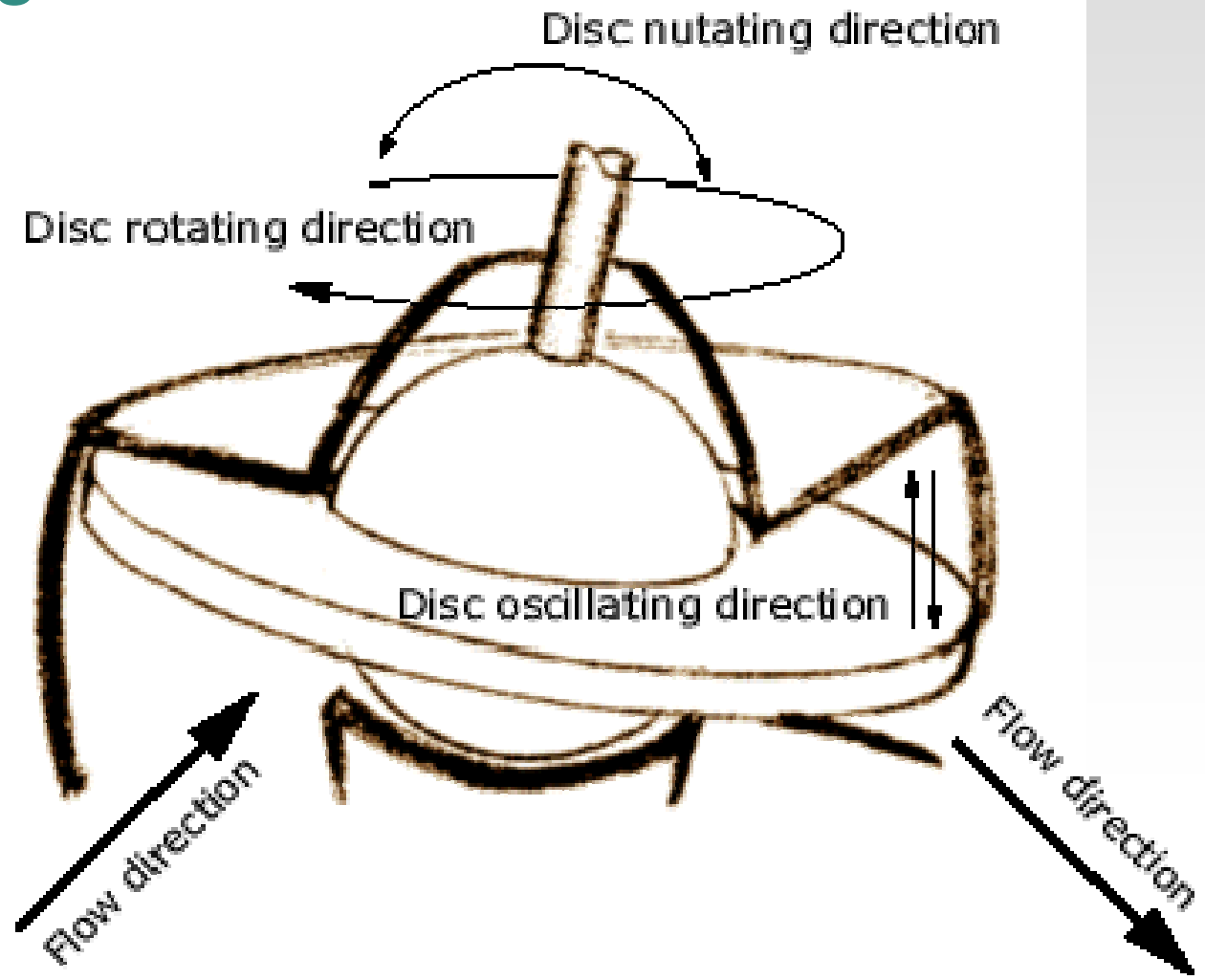
Positive Displacement

- **Positive displacement flow meters, also know as PD meters, measure volumes of fluid flowing through by counting repeatedly the filling and discharging of known fixed volumes.**



Positive Displacement

Nutating Disc



Positive Displacement

Oscillating Piston

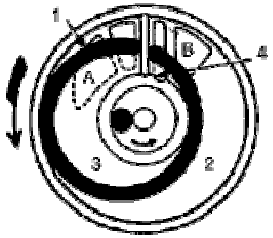


DIAGRAM 1
SPACES 1 AND 3 ARE RECEIVING LIQUID FROM THE INLET PORT, A, AND SPACES 2 AND 4 ARE DISCHARGING THROUGH THE OUTLET PORT B.

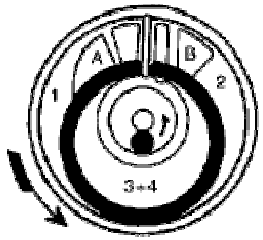


DIAGRAM 2
THE PISTON HAS ADVANCED AND SPACE 1, IN CONNECTION WITH THE INLET PORT, HAS ENLARGED, AND SPACE 2, IN CONNECTION WITH THE OUTLET PORT, HAS DECREASED, WHILE SPACES 3 AND 4, WHICH HAVE COMBINED, ARE ABOUT TO MOVE INTO POSITION TO DISCHARGE THROUGH THE OUTLET PORT.

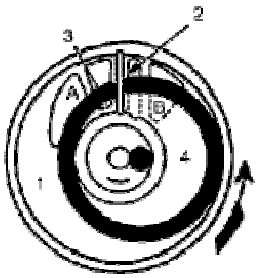


DIAGRAM 3
SPACE 1 IS STILL ADMITTING LIQUID FROM THE INLET PORT AND SPACE 3 IS JUST OPENING UP AGAIN TO THE INLET PORT, WHILE SPACES 2 AND 4 ARE DISCHARGING THROUGH THE OUTLET PORT.

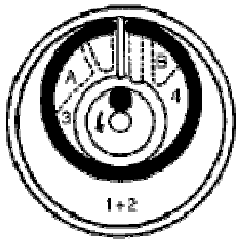
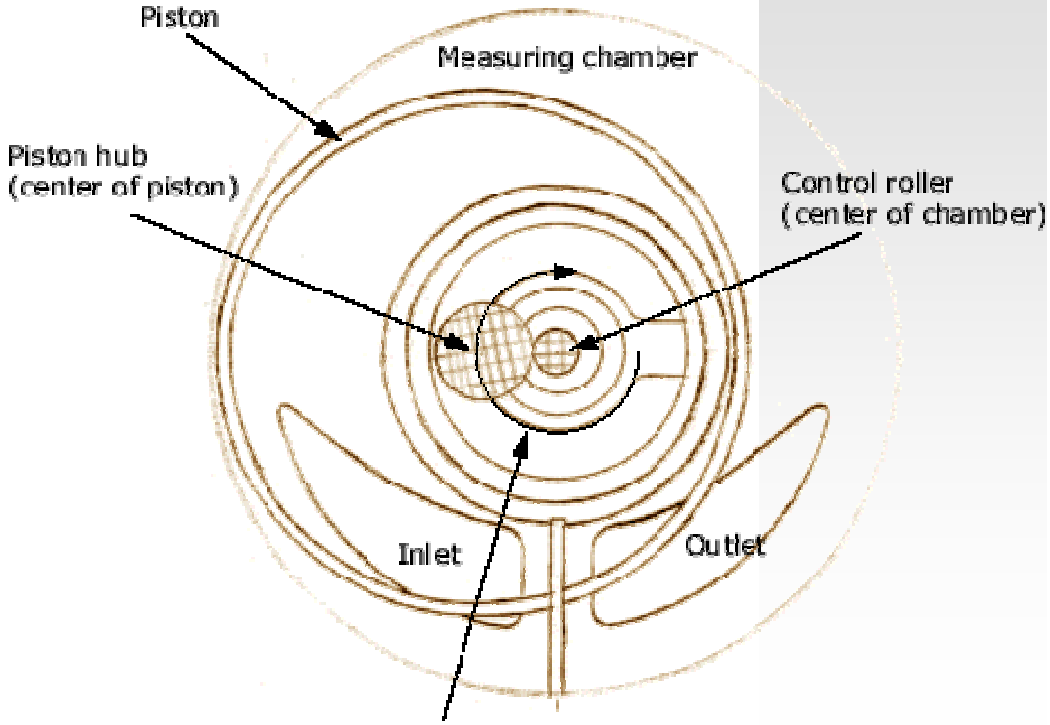


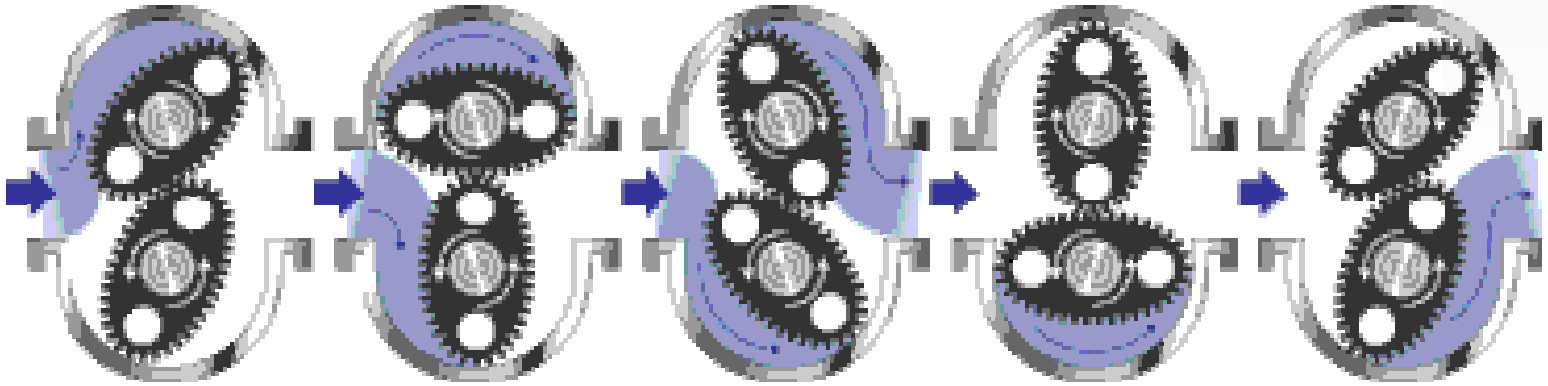
DIAGRAM 4
LIQUID IS BEING RECEIVED INTO SPACE 3 AND DISCHARGED FROM SPACE 4, WHILE SPACES 1 AND 2 HAVE COMBINED AND ARE ABOUT TO BEGIN DISCHARGING AS PISTON MOVES FORWARD AGAIN TO OCCUPY POSITION AS SHOWN IN DIAGRAM 1.



Piston gliding direction:
The piston glides around the control roller like a hula hoop oscillates/spins around the hooper in a circular motion.

Positive Displacement

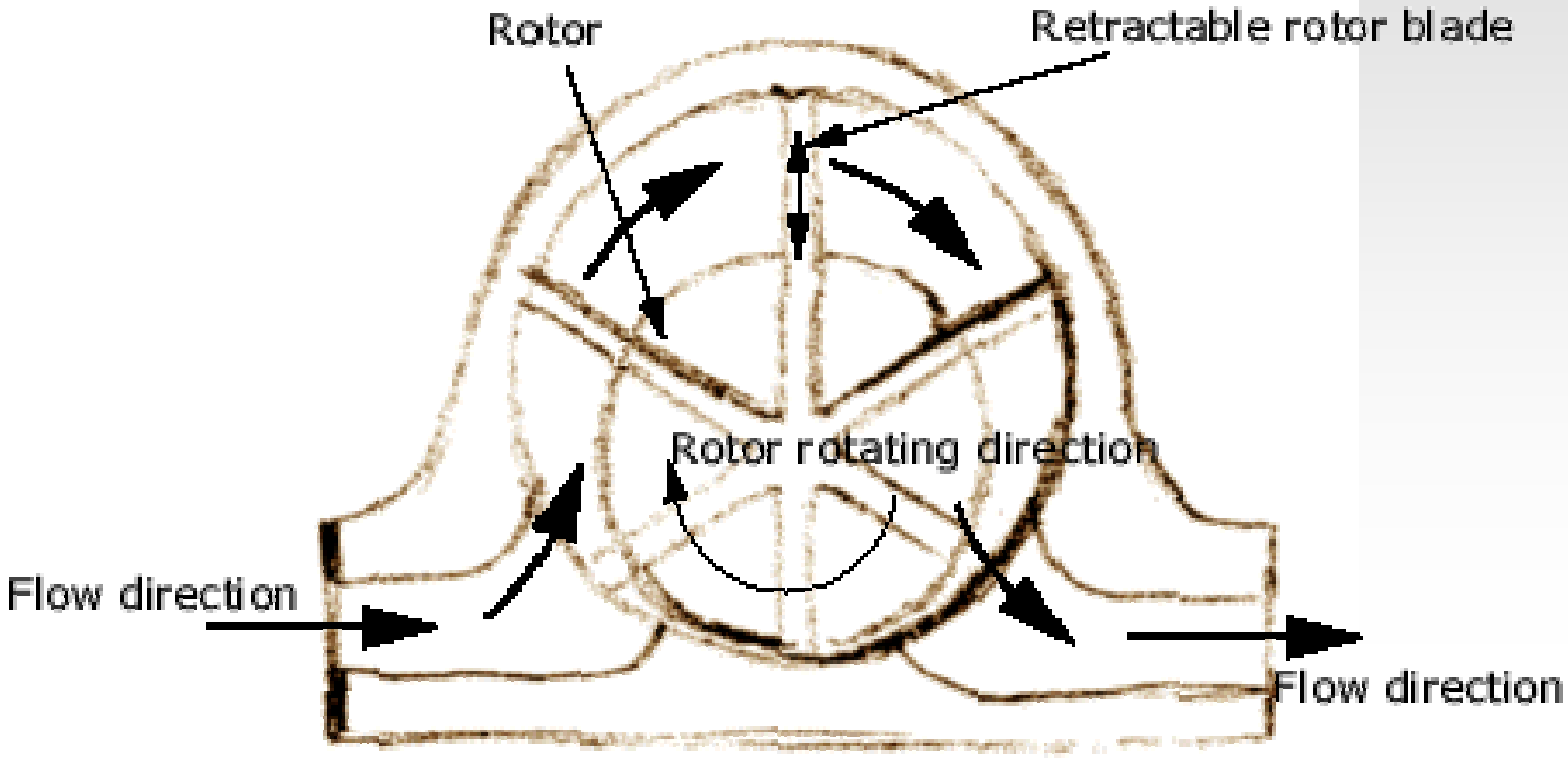
- Oval Gear



Positive Displacement

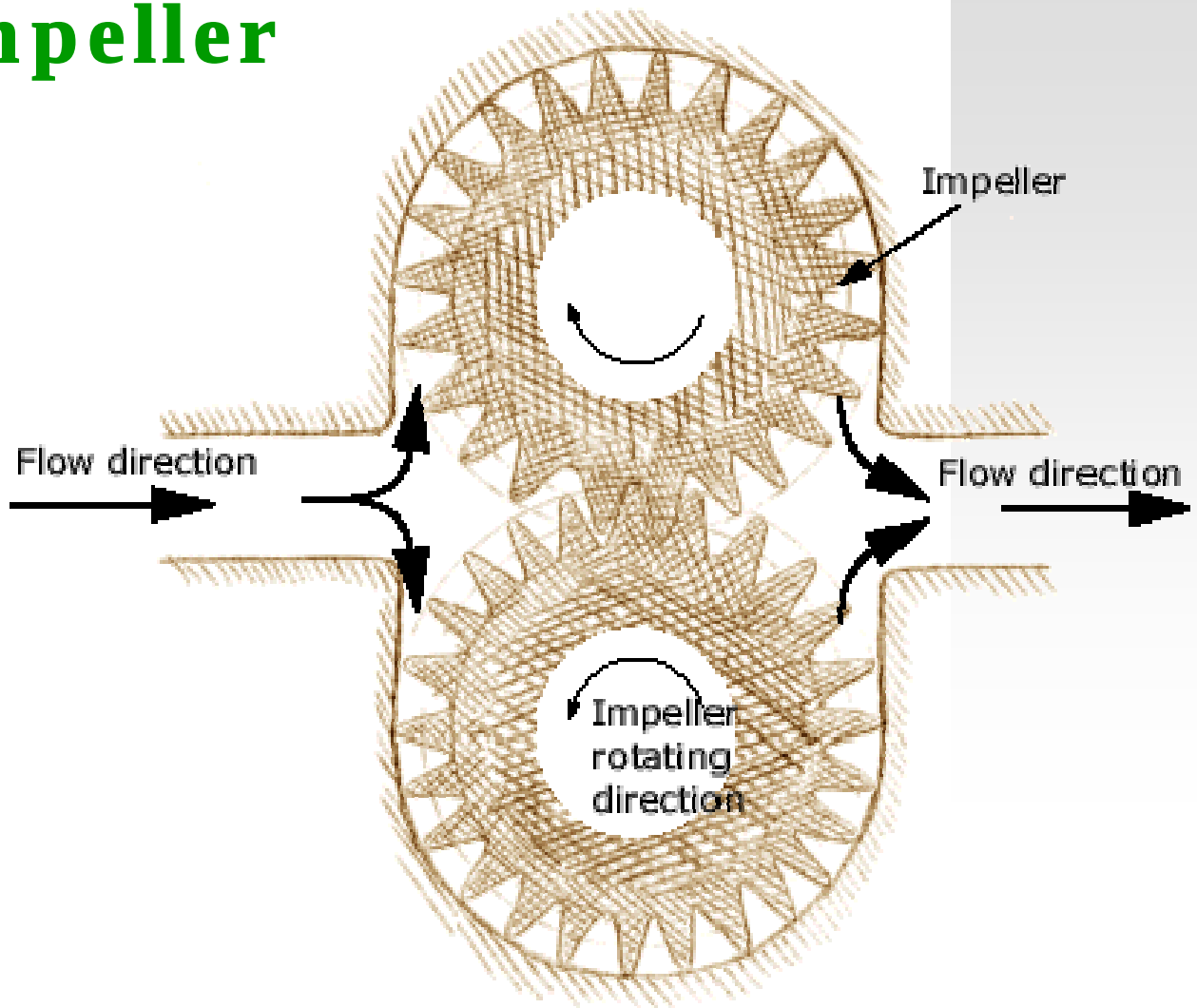
Other Positive Displacement Meters:

- **Rotating Valve**



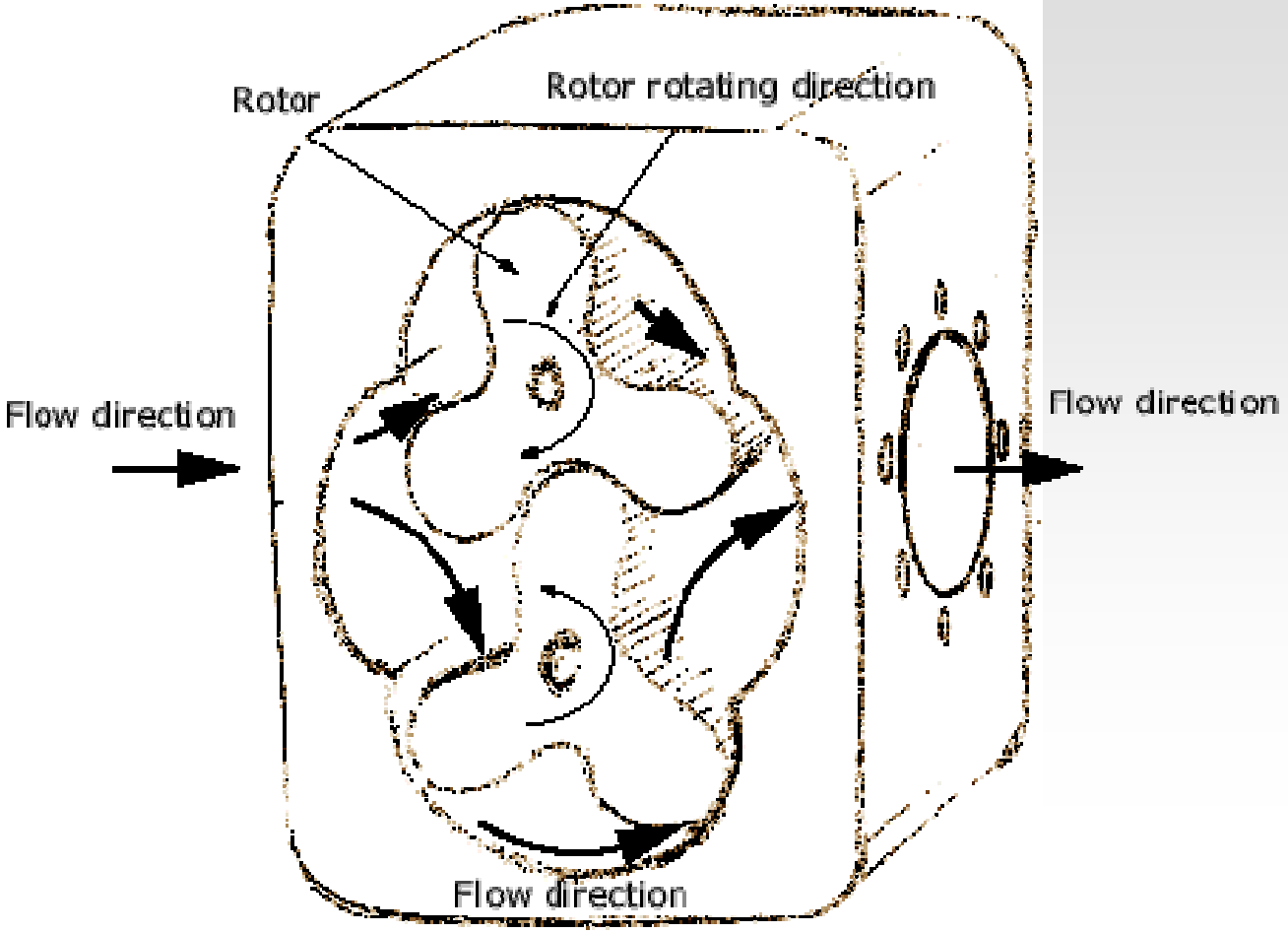
Positive Displacement

- **Rotating Impeller**



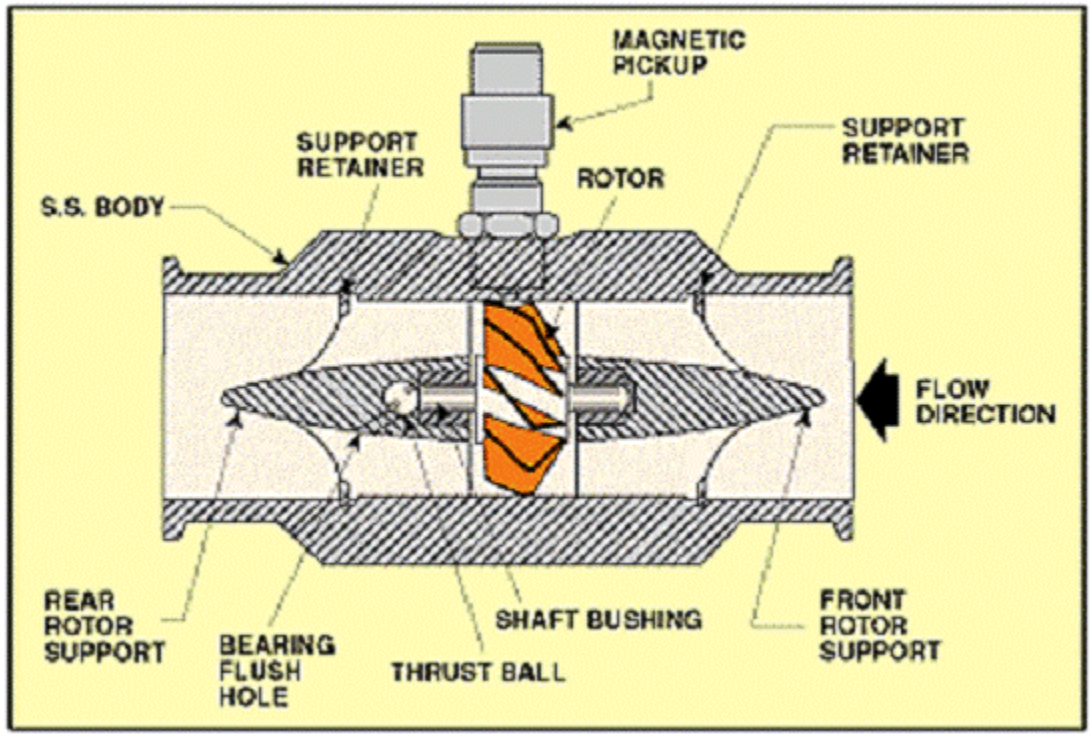
Positive Displacement

Birotor



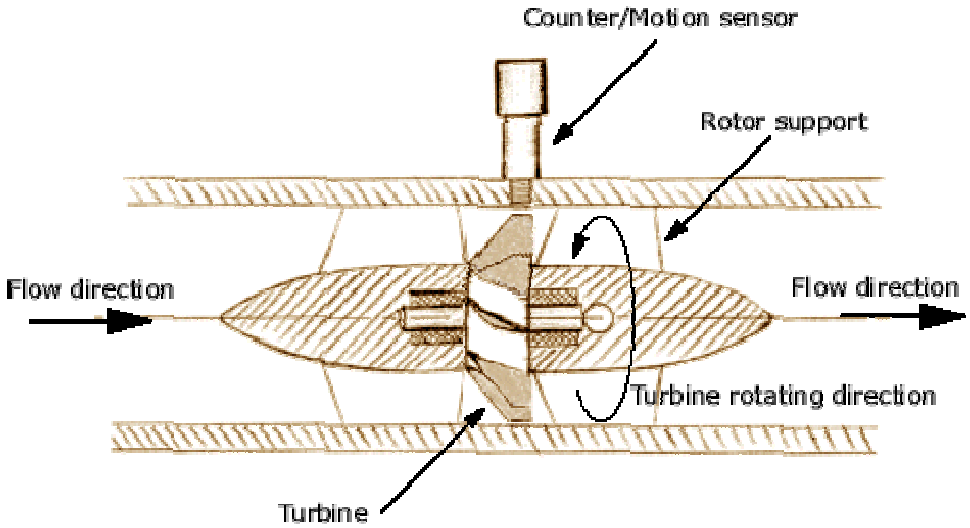
Rotary Inferential Meters

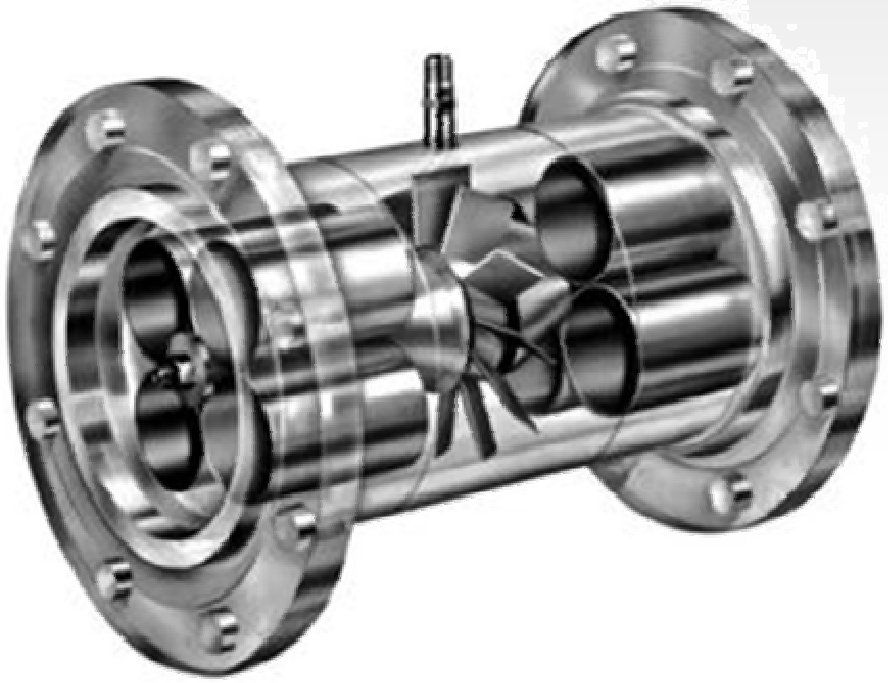
- This group of meters are basically all small hydraulic turbines running at practically no load. they all have runner or rotary element whose speed is proportional to flow rate.



Rotary Inferential Meters

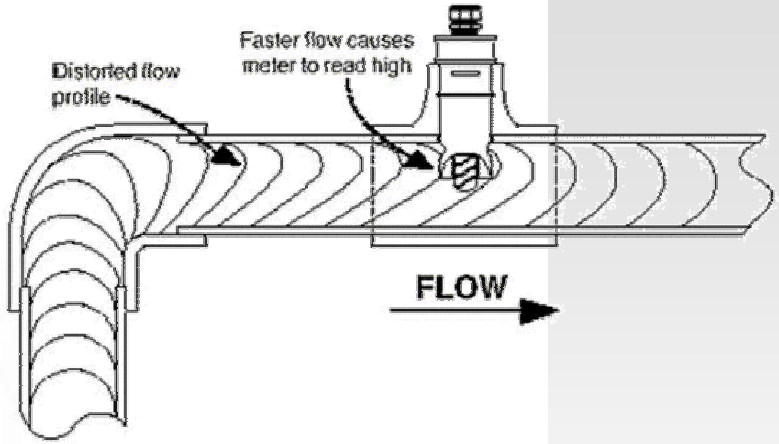
Turbine Flow Meter





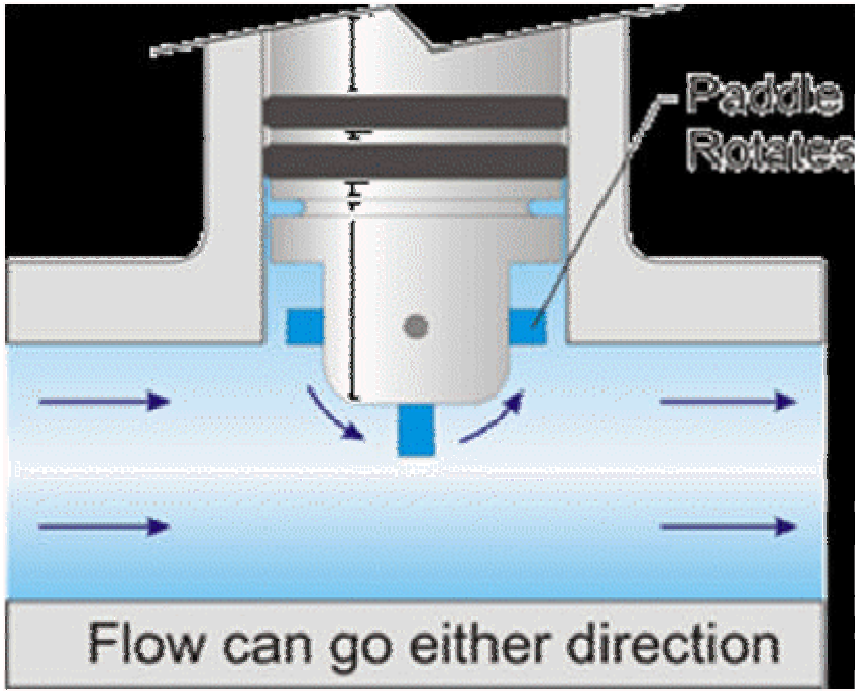
Rotary Inferential Meters

Insertion Type



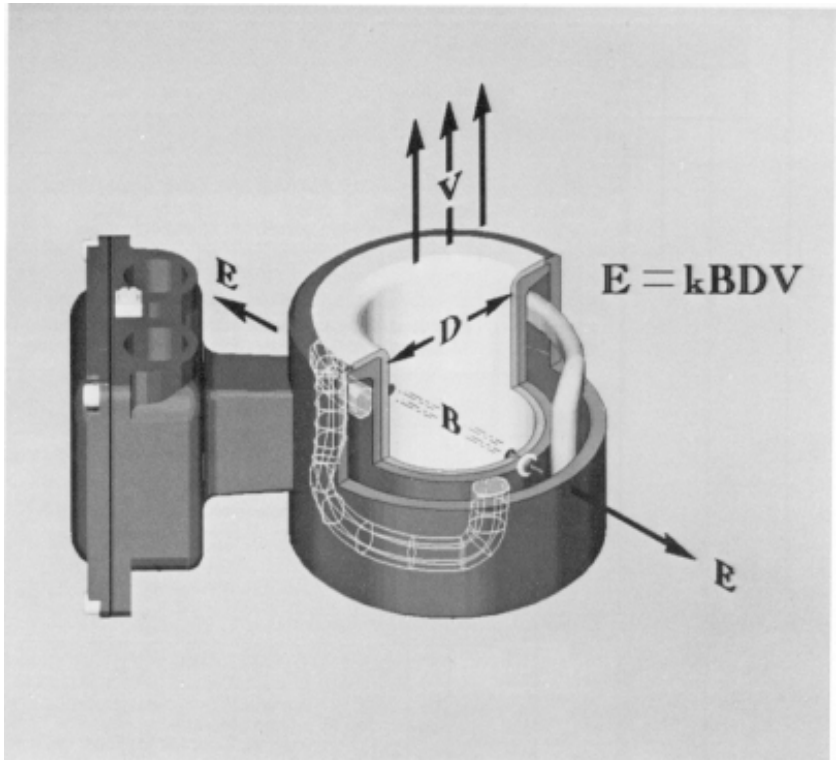
Rotary Inferential Meters

Paddle Wheel

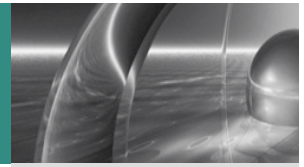


Electromagnetic Flow Meter

- Magnetic flowmeters use Faraday's Law of Electromagnetic Induction to determine the flow of liquid in a pipe. In a magnetic flowmeter, a magnetic field is generated and channeled into the liquid flowing through the pipe. Following Faraday's Law, flow of a conductive liquid through the magnetic field will cause a voltage signal to be sensed by electrodes located on the flow tube walls.



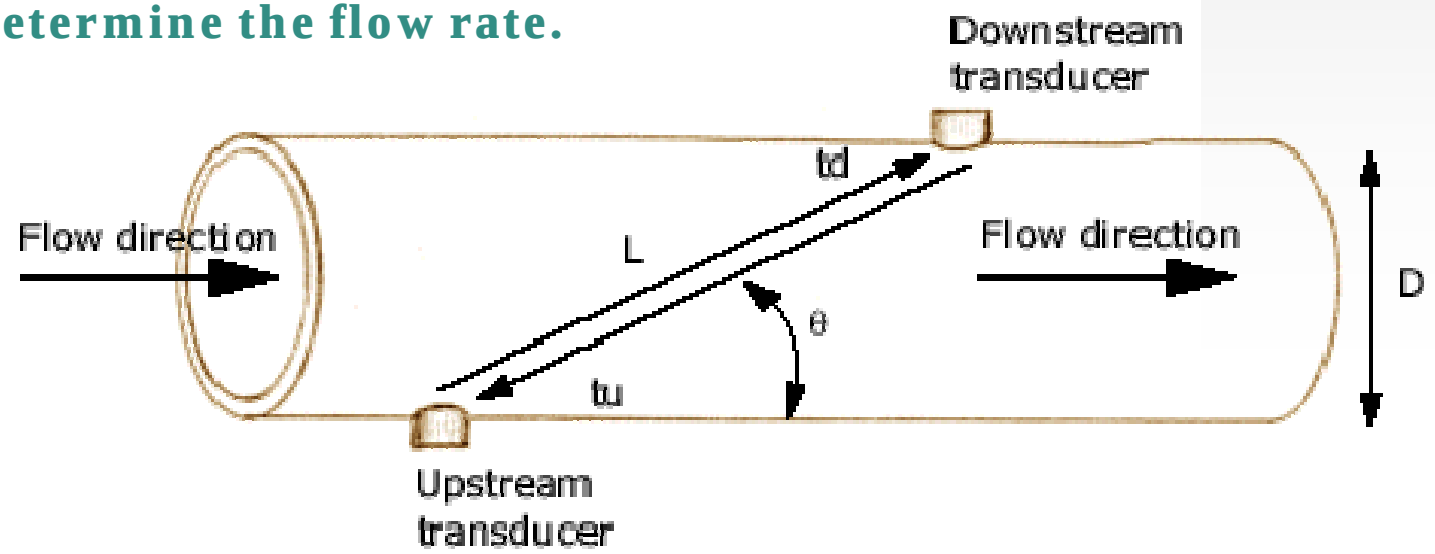
Electromagnetic Flow Meter



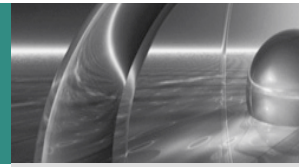
- **Advantages:**
  - Minimum obstruction in the flow path yields minimum pressure drop
  - Low maintenance cost because of no moving parts
  - High linearity
  - Two and multi beam models have higher accuracy than other comparably priced flowmeters
  - Can be used in hazardous environments or measure corrosive or slurry fluid flow
- **Disadvantage:**
  - Requires electrical conductivity of fluid

Ultrasonic Flow Meters

- Transit time ultrasonic flowmeters send and receive ultrasonic waves between transducers in both the upstream and downstream directions in the pipe. At no flow conditions, it takes the same time to travel upstream and downstream between the transducers. Under flowing conditions, the upstream wave will travel slower and take more time than the (faster) downstream wave. When the fluid moves faster, the difference between the upstream and downstream times increases linearly. The electronic transmitter processes upstream and downstream times to determine the flow rate.

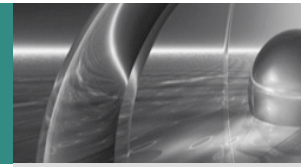


Ultrasonic Flow Meters

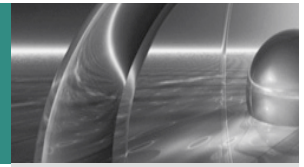


- **Advantages:**
  - No obstruction in the flow path, no pressure drop
  - No moving parts, low maintenance cost
  - Multi-path models have higher accuracy for wider ranges of Reynolds number
  - Can be used in corrosive or slurry fluid flow
  - Portable models available for field analysis and diagnosis
- **Disadvantages:**
  - Higher initial set up cost
  - Single path models may not be suitable for flow velocities that vary over a wide range of Reynolds number

Key Features Of Design

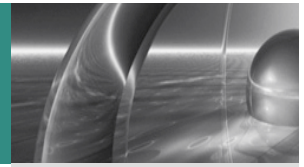


Check List Of Design



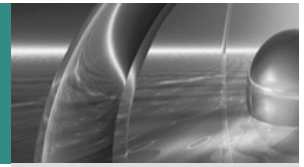
- **Fluid Properties:**
  - Liquid or Gas
  - Temperature and Pressure
  - Density
  - Viscosity
  - Chemical Properties
- **Performance Consideration:**
  - Accuracy
  - Repeatability
  - Linearity
  - Pressure Drop
  - Output Signal Characteristics
  - Response Time

Check List Of Design



- **Economic Consideration:**
  - **Cost Of Owner Ship (i.e. purchase , installation , operation , maintenance , calibration , meter life , sparse)**
  - **Pressure Loss**
- **Environmental Considerations:**
  - **Ambient Temperature Effect**
  - **Atmosphere Of Installation (indoors , Outdoors , corrosive , hot , cold , etc)**
  - **Humidity Effect**
  - **Safety Factors**
  - **Location Of Flow Measurement Device And Piping System (force main , sewer , manhole , channel , or treatment unit)**
  - **Type of Secondary Element (level sensor , pressure sensor , transmitters and recorders)**
  - **Space Limitations and Size Of Device**
  - **Compatibility With Other Flow Measurement Devices If Already in operation at the existing portion of the treatment facility**

Market



- FISHER ROSEMOUNT (Emerson)
- YAMATAKE
- FOXBORO
- ABB
- HIMA
- ENDRESS & HAUSER
- SAMSON

- Irosco
- Faranegar Sanat
- Shuttle Pars
- Fimco
- Hanif
- PATSA
- Tech control

- SANGAN SANAT
- AZMOON MOTAMAM

Thank You !