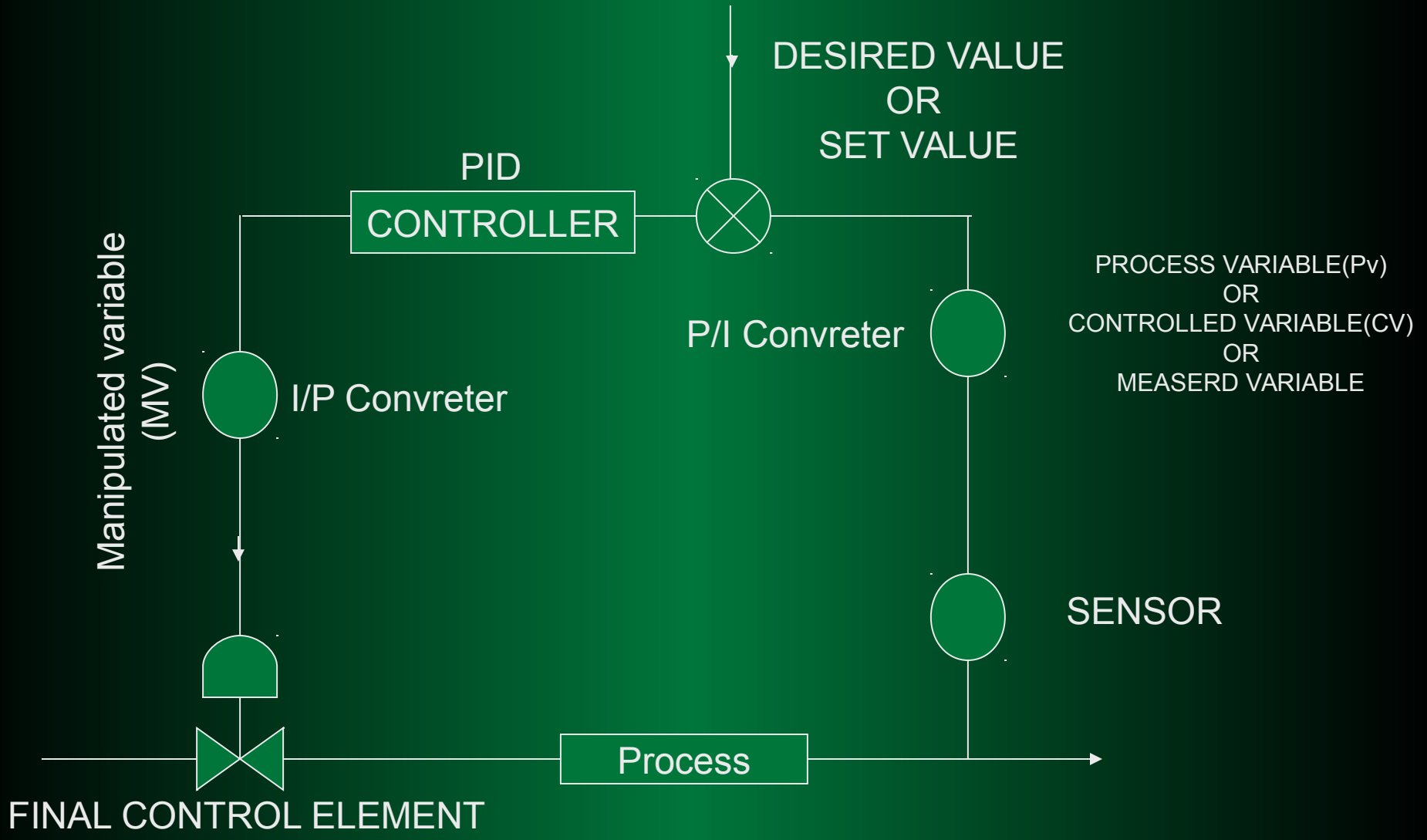
Process Control & Instrumentation

MEROX Block

Process Control Concepts

- Process Control is to maintain certain process variables (PV) of a process at a desired level (Set Values)
- Instruments are used to obtain information about the process variables (PVs)
- Controller (a software program resident in DCS) calculates the difference between SV and PV and accordingly sends a signal, called Manipulated Value (MV) to final control elements (Valves, Vanes etc.).



TYPICAL CONTROL LOOP

Process Control Concepts

- Automatic Control: Process Variables are controlled by DCS resident Controller with out the intervention of an operator except setting of SV
- Controller modes include Auto Mode, Man Mode, Cascade Mode & Computer Mode
- Types of Controllers include Feed Back and Feed Forward
- Controller Tuning parameters include P (Proportional), Integral (I) and D (Derivative) a

Pressure Measurement

- Absolute Pressure: Measured over total vacuum/zero absolute
- Atmospheric/Barometric Pressure: Pressure exerted by Earth's atmosphere
- Differential Pressure: Difference between two pressures
- Gauge Pressure: Pressure over the atmospheric Pressure
- Hydrostatic Pressure: Pressure exerted by a liquid column

Pressure Measurement

- Line Pressure/Working Pressure/Static Pressure: Pressure exerted by a flowing fluid on the pipe surfaces
- Dynamic Pressure: Pressure exerted by a flowing fluid parallel to the flow direction
- Vacuum: Pressure below the atmospheric pressure
- Compound Pressure: Measured from a reference which is neither atmospheric nor total vacuum

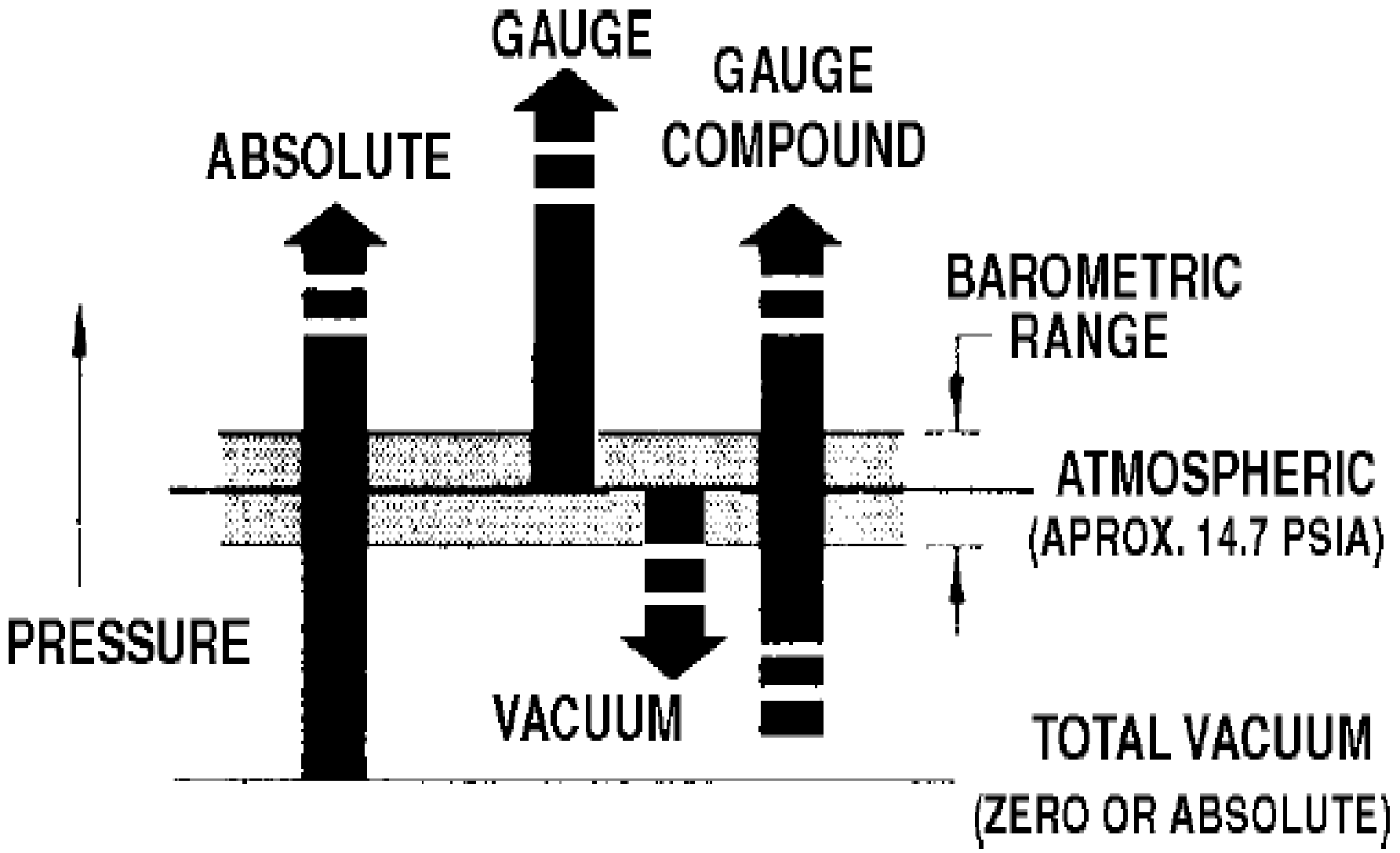


Fig. 4.12 Definitions of pressure

Pressure Measurement Devices

- Pressure is a force applied/distributed over a surface.
- Pressure measurement is used for pressure itself, flow, level and even temperature
- All measurement systems consists of :
  - Primary Element which indirectly/ indirectly in contact with fluid and interacts with pressure changes
  - Secondary Element which translates this interaction into values for use in indication, recording and control

Pressure Measurement Devices – Secondary Elements

- Mechanical Transducers
  - Bellows
  - Bourdon Tubes
  - Diaphrams
  - Force Balanc

Pressure Measurement Devices – Secondary Elements

- Electronic Transducers
  - Variable Capacitance
  - Variable Reluctance
  - Vibrating Wire
  - Variable Resistance

Mechanical Transducers

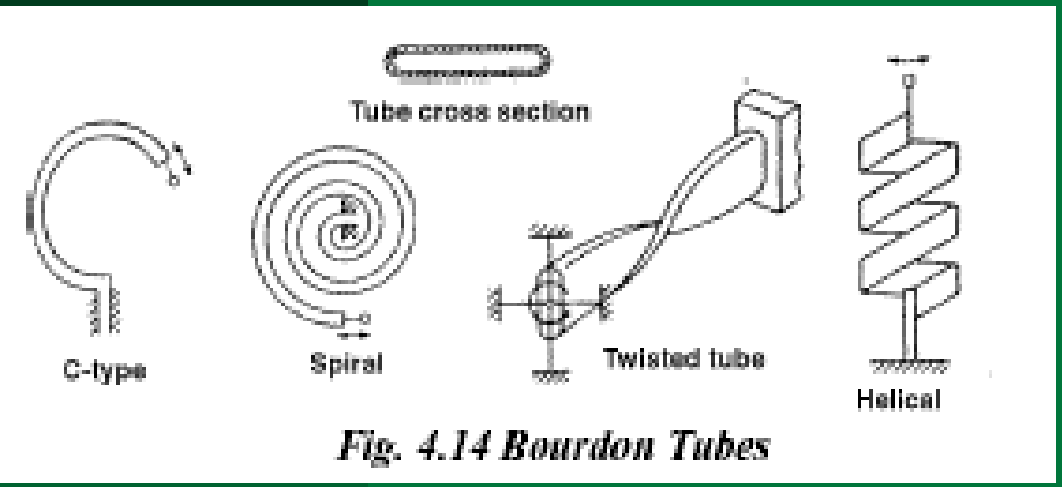


Fig. 4.14 Bourdon Tubes

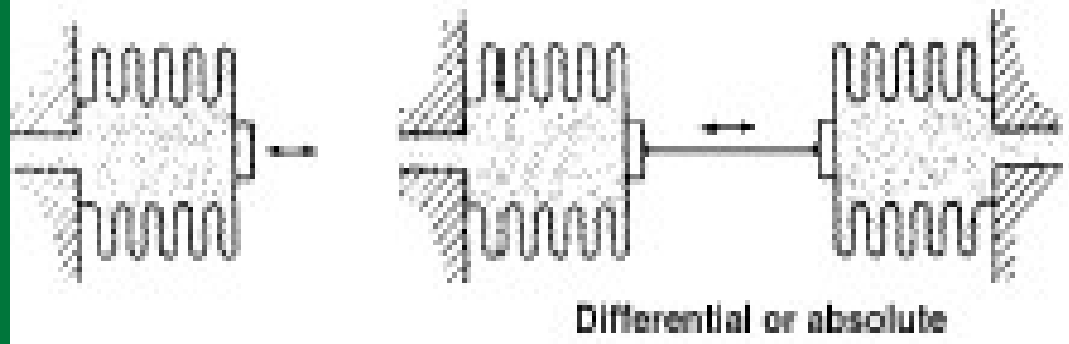


Fig. 14.13 Bellows

Level Measurement

- Level measurement is divided into two groups: Direct Level and Pressure-operated
- Direct Level Measurement:
  - Hook type
  - Sight Glass
  - Float Gauging
- Pressure-Operated Measurement: Use is made of the fact that pressure does not depend on the cross-sectional area of a vessel, in stead it depends on liquid height and density

Direct Level - Level Gauges

Level Gauges

- Directing Level reading device
- Types : Transparent and Reflux
- Transparent type is used for:
  - Caustic, Acidic, Heavy HC services, High pressure
  - Coated with protective Mica
- Reflux type is used for light services:
  - Non-corrosive, non-viscous, Clear HC
  - It has special optical property for clear demarcation

Level Gauges

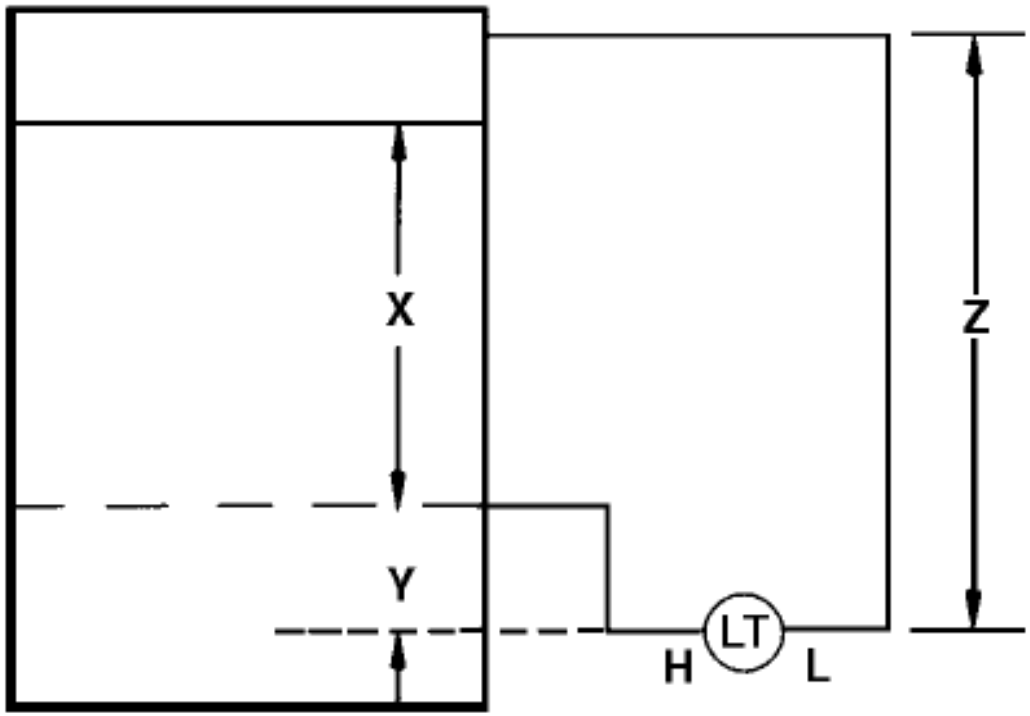
- While commissioning, open the Jerguson valve partially till the gage is pressured up / warmed up.
- While in service, jerguson valve shall be fully in open condition
- Quarter turn valves for quick isolation
- Have special ball-checks for auto shut-off in case of glass breakage

Closed Vessels – Differential Pressure Approach

- $h = P / \rho g$
- In closed vessles, pressure above the liquid affects the pressure measured at the bottom
- To measure the true level, the vessel pressure must be subtracted.
- Making a pressure tap at the top of the vessel and connecting this to LP side accomplishes this
- Dry Leg: If gas is non-condensable
- Wet leg: Condensed Liquid introduces error. Hence calibrated with a reference liquid.

Level Measurement in Closed Vessels

CLOSED VESSELS



Temperature Measurement

- Temperature is degree of hotness/coldness on a definite scale
- $^{o}C = 5/9 (^{o}F - 32)$
- Most reliable methods of measurement:
  - Bimetallic
  - Thermocouples
  - RTD

Temperature Measurement

- All temperature gages uses bimetallic principles
- Bimetallic Principles:
  - Metals change in volume in response to temperature
  - and different metals respond differently to change in temperature
- Its accuracy is not as good as a glass thermometer

Temperature Measurement Bimetallic Gage

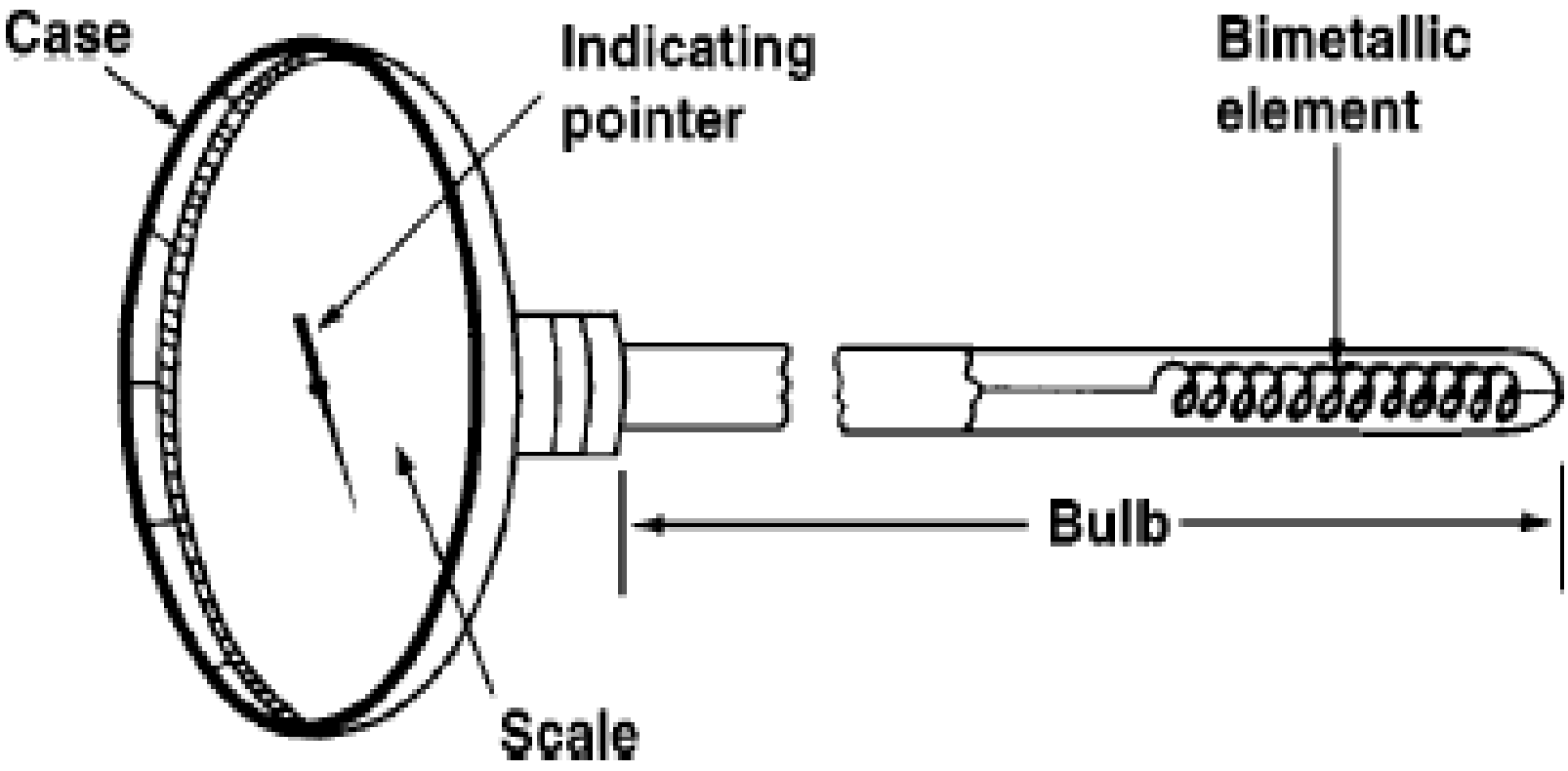
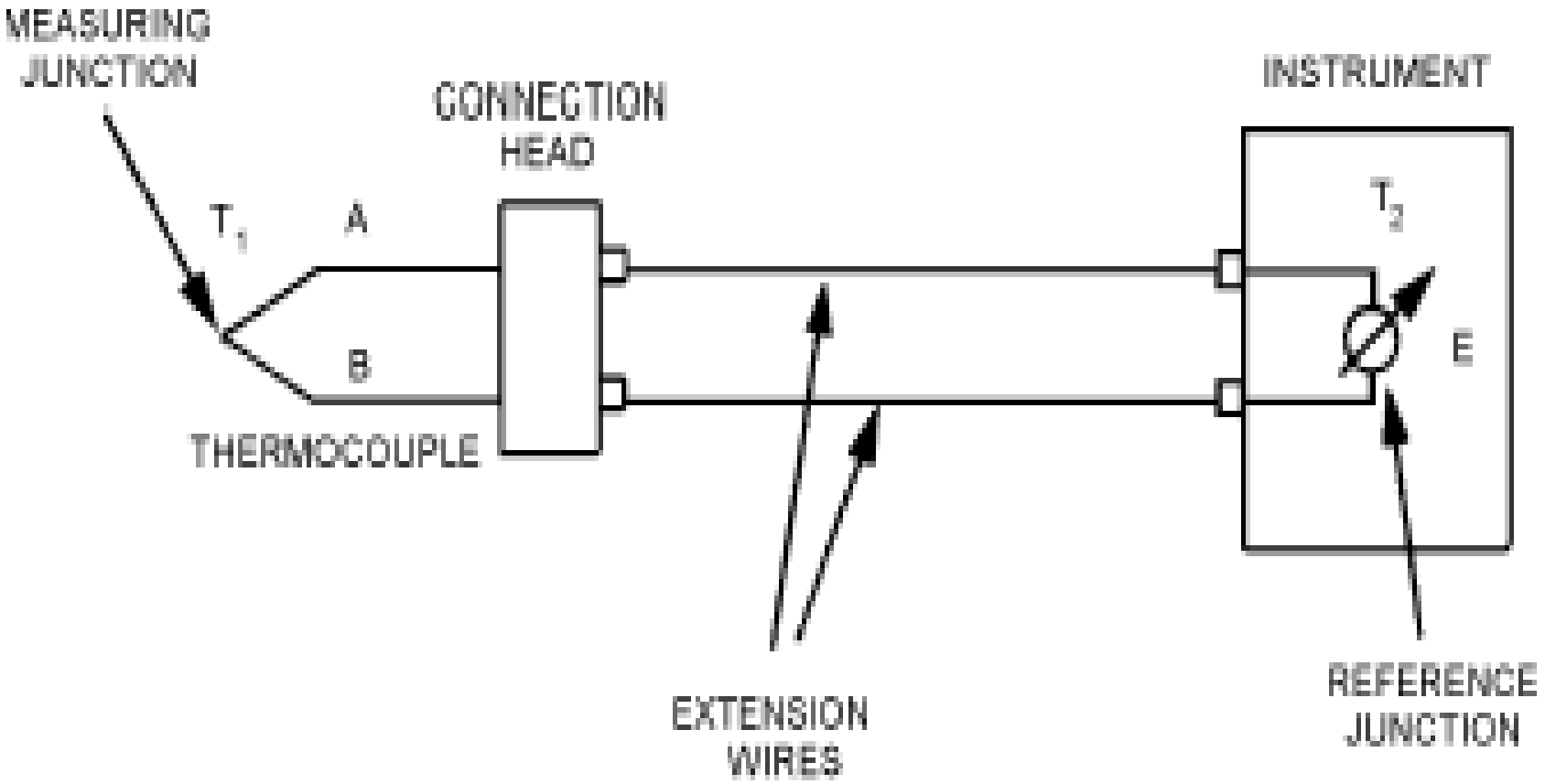


Fig. 5.2 A typical bimetallic themometer

Thermocouples



Thermocouples

- It is a thermoelectric temperature measuring device
- It is formed by pressing two dissimilar metals in series
- When the junctions are at different tempertures, emf is generated
- Measuring junction/hot junction is inserted into the medium of which temperature is inserted
- Cold Junction/Reference junction is inserted in the measuring device

Thermocouples -Types

- J type:
  - Iron-Constantan
  - Low Range
- K Type:
  - Chromel -Alumel
  - Clean and oxidizing services
- E Type:
  - Chromel-Constantan
  - Vacuum, mildly oxidising, inert services
- T type:
  - Copper-Constantan
  - Sub zero termperatures
- Others include: B, R, S, W

Resistance Temperature Detectors

- Uses the change in resistance in response to change in temperature
- Resistance depend on metal size and resistivity of the metal

Flow Measurement

- Most commonly used methods for flow measurement:
  - Head type
  - Area Type
  - Mass Flow Meters

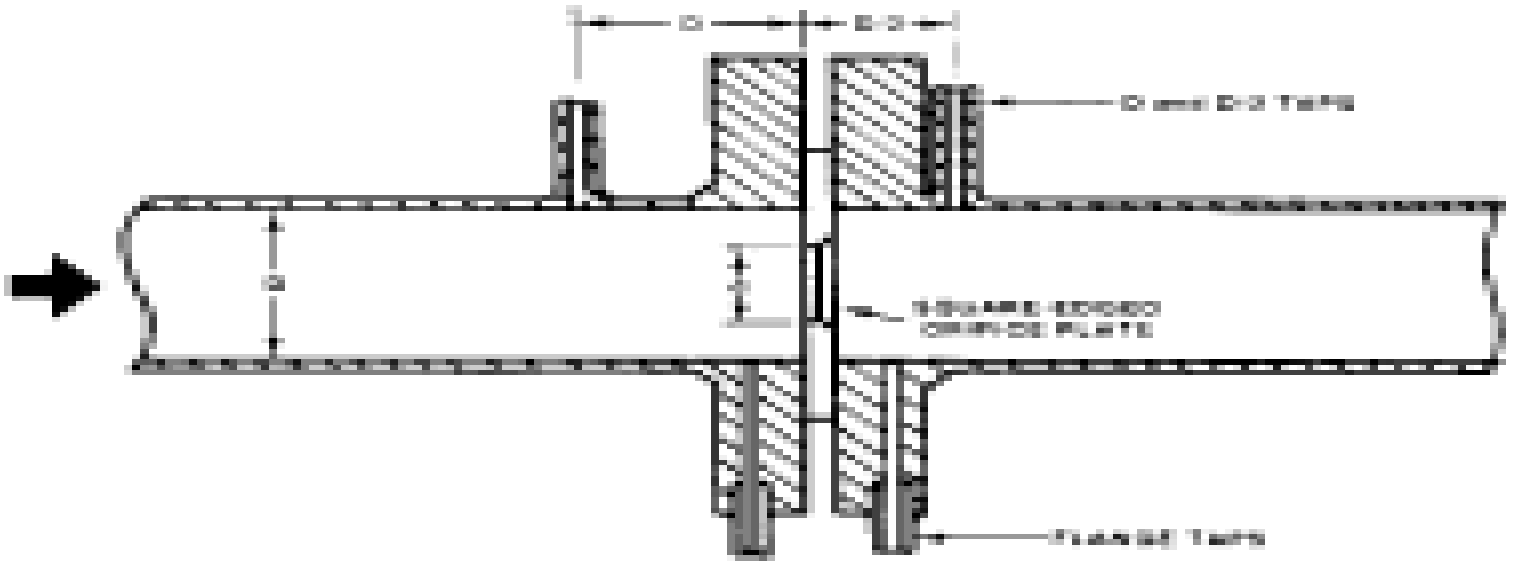
Flow Measurement

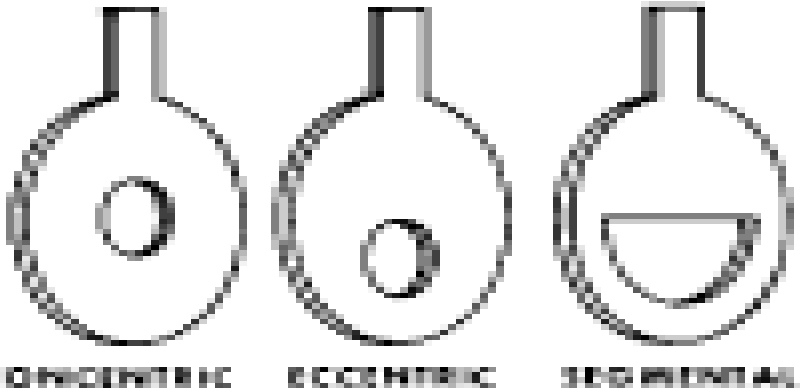
- Head Type:
  - A restriction of known dimension is introduced in the flow line
  - Thus, pressure drop created, which is measured
  - Sub-Type:
    - Orifice &
    - Venturi

Flow Measurement

- Orifice
  - Orifice may be concentric or eccentric
  - Orifice plats constricts the flow to produce a differential pressure
  - The result is a high pressure upstream and a low pressure down stream
  - Dp is proportional to the flow
  - Orifice meters are inexpensive

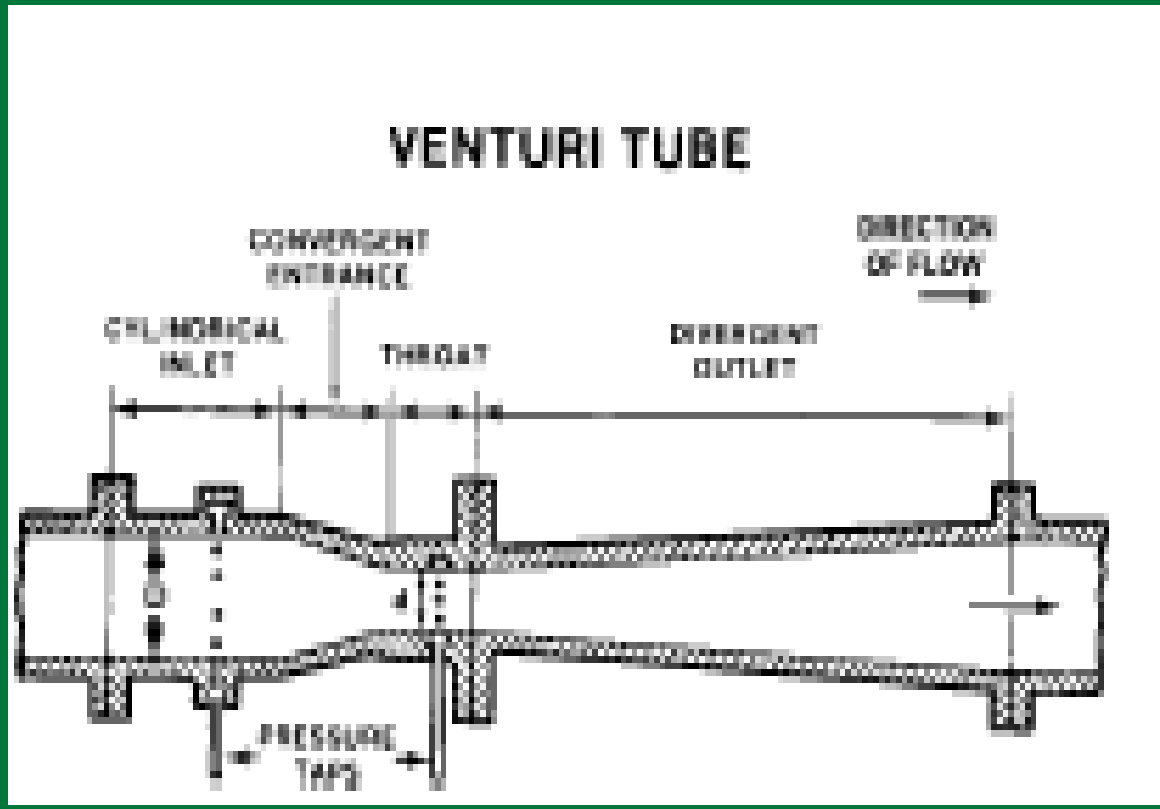
THIN PLATE ORIFICE METER





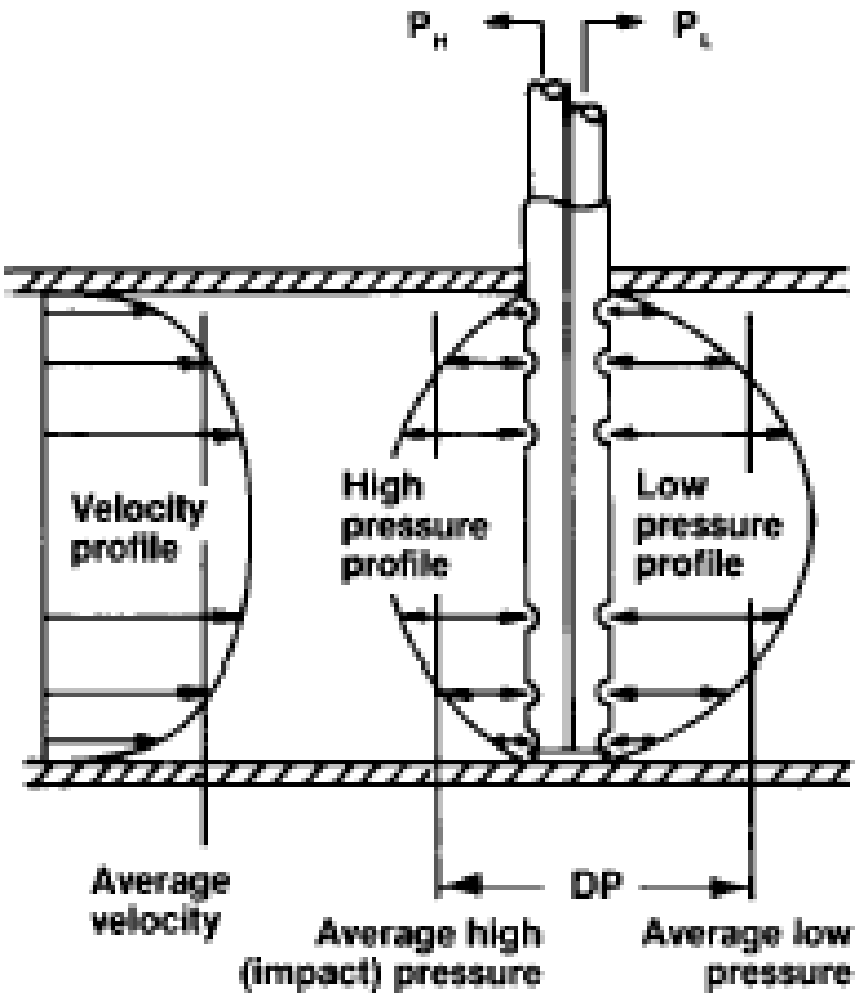
Flow Measurement

- Venturi
  - Low Pressure
  - Highly accurate
  - Big Size Pipe



Annubar

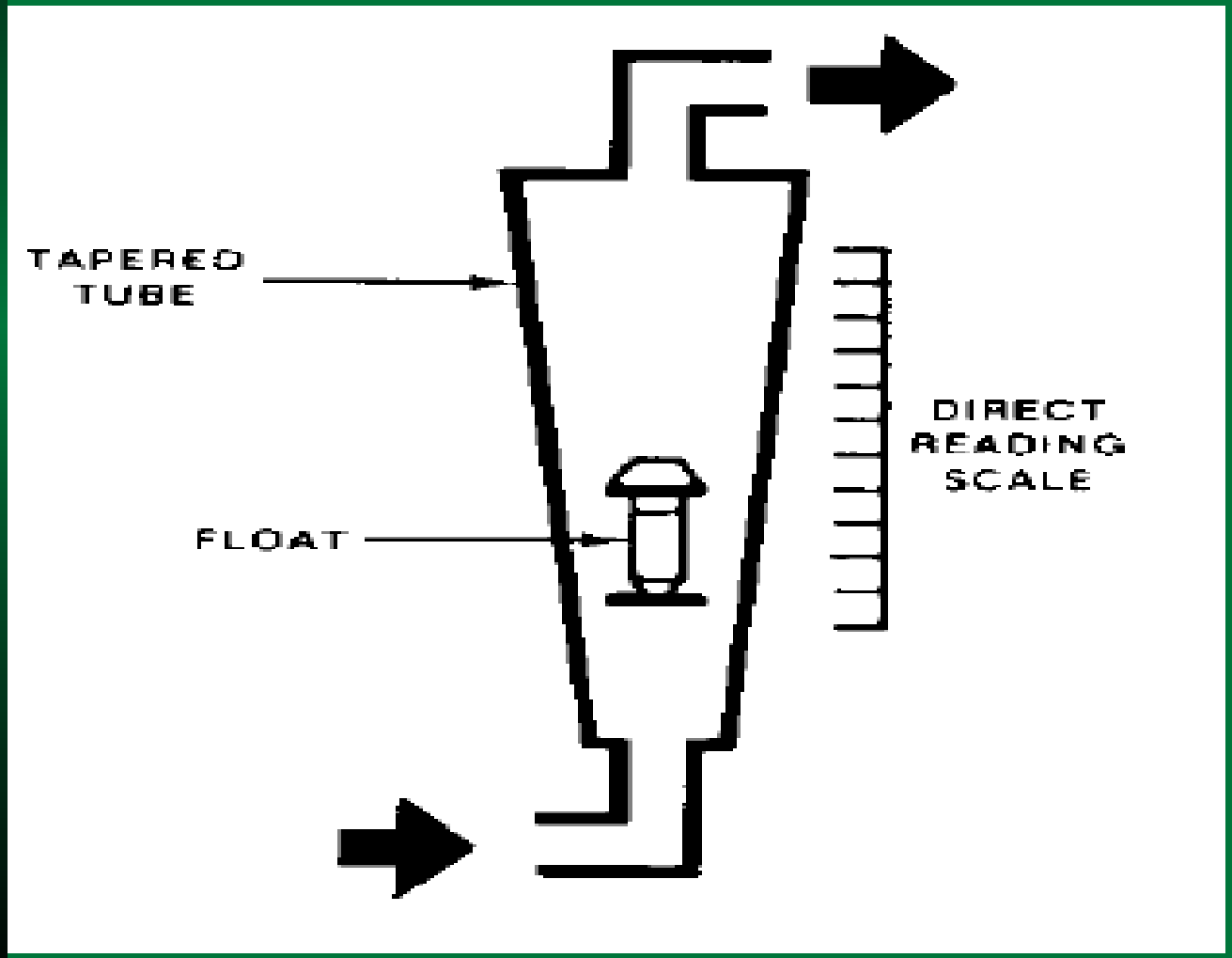
- Uses Pitot Tube Principle
- Flow is proportional to pressure drop
- Uses multiple ports



Flow Measurement

- Area Meters:
  - In head flow meters, the restriction area kept constant generating a pressure differential
  - Where as in area meter, a variable area holds differential pressure constant
  - Change in area is a measure of flow rate
  - Ex.: Rotameter

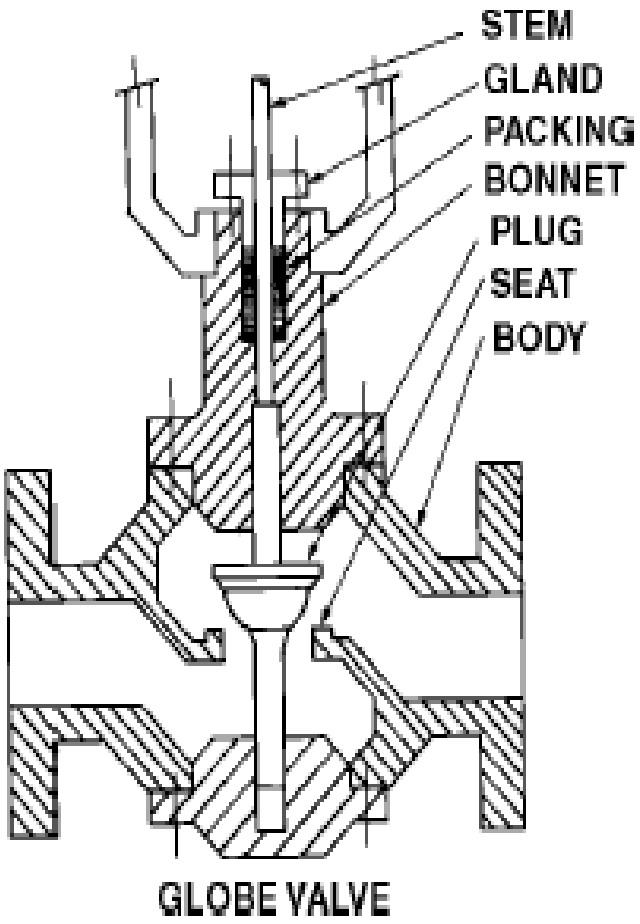
Rotameter- Suitable for low flows



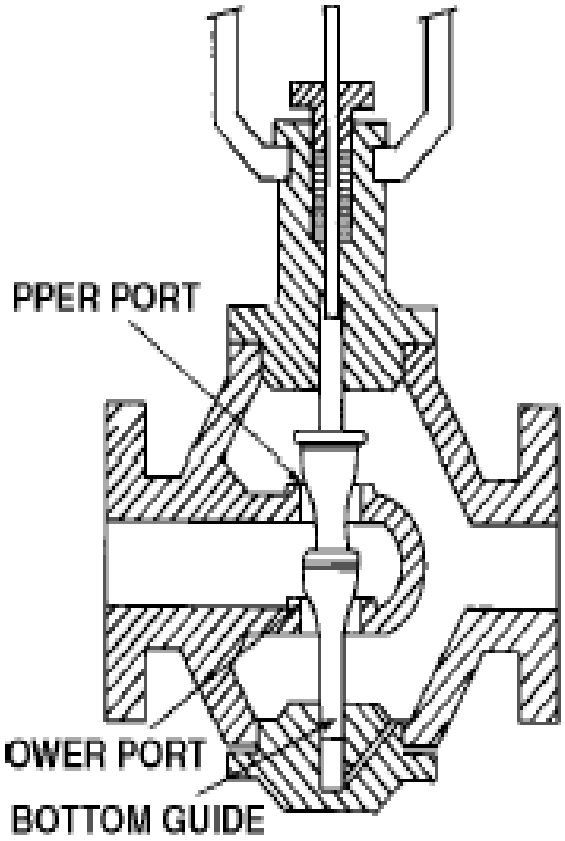
Valves – Valve is a variable Orifice !

- Valve Types:
  - Plug-in-seat
  - Rotatable Plug
  - Rotating Vane
  - Eccentric Rotation
  - Cage-guided
  - Deformable Flow Passage

Globe Valve – Plug-in-seat



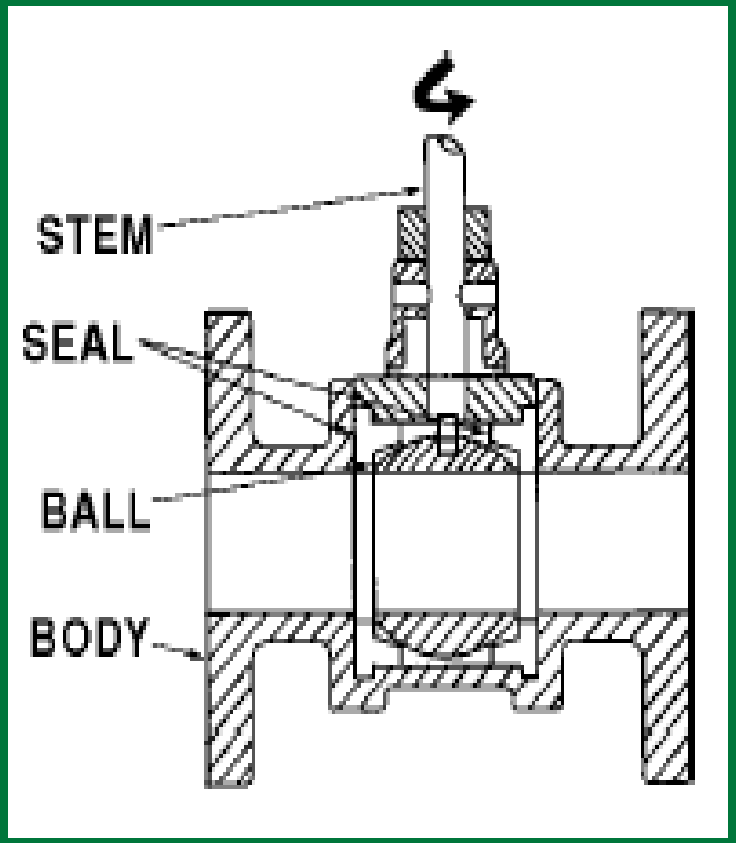
GLOBE VALVE



GLOBE VALVE, DOUBLE PORTED

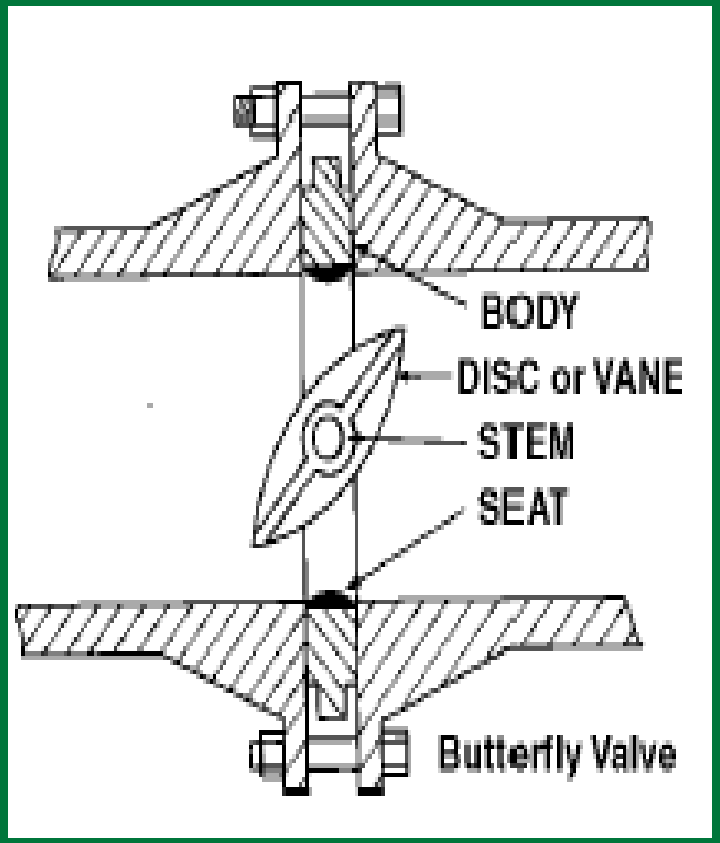
Ball Valve/Plug Valve - Rotatable Plug

- Plug/ball rotated
  Through a quarter
  of a turn
- The ball has a passage



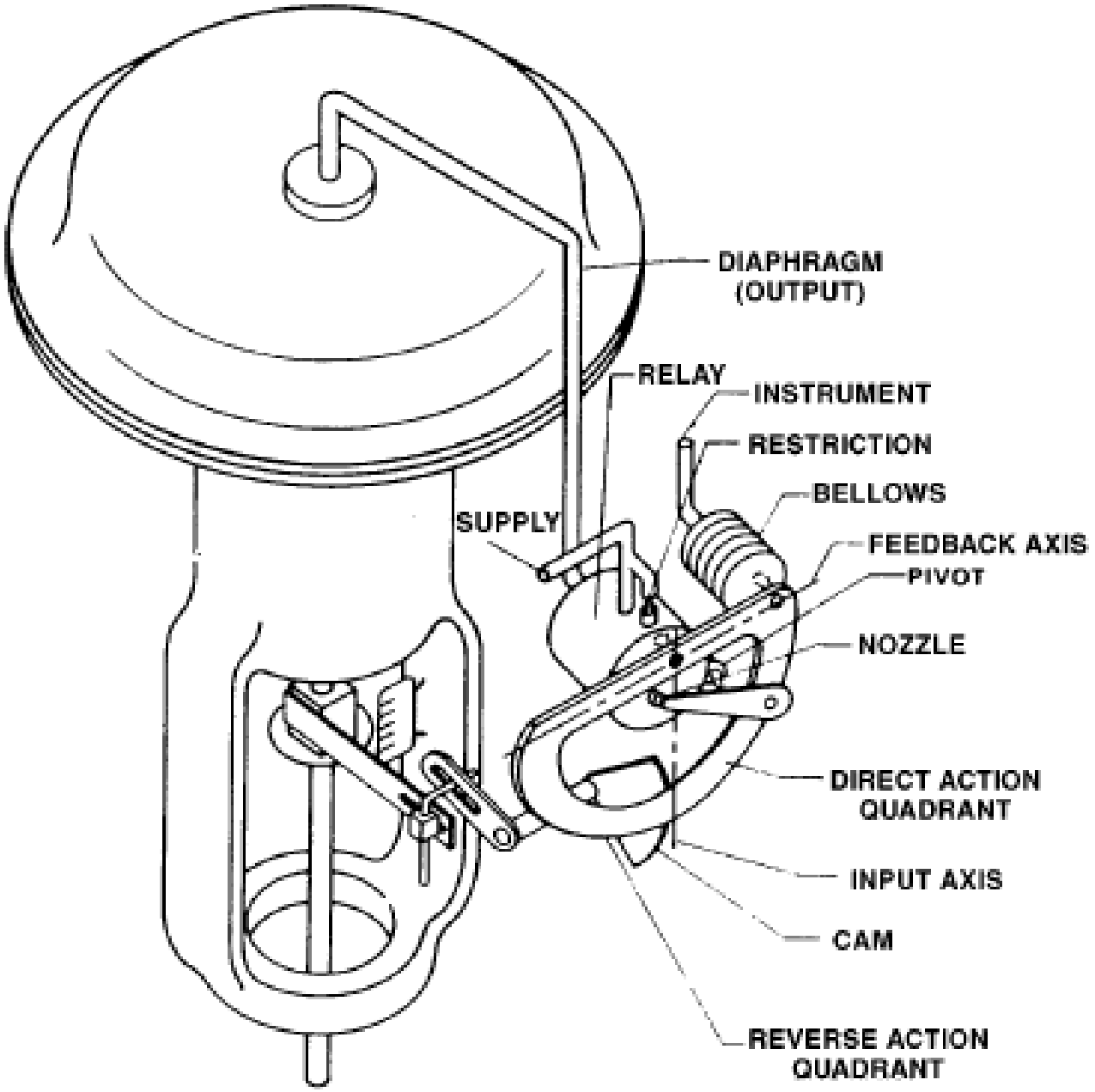
Butterfly valve/ Dampers – Rotating Vane

- Quarter turn operated
- Leakage prone



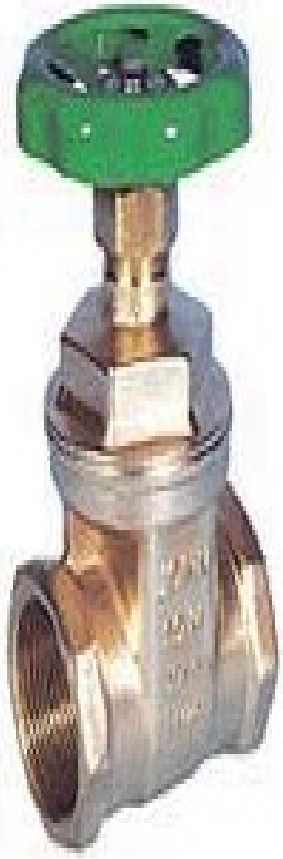
Valve Accessories

- Actuators: Translates control signal into action, eg.:Motors, Diaphrams, solenoids, cylinders
- Transducers and Positioners: Convert electronic signals into pneumatic/hydraulic pressures that control actuators/valves
- Positioner is used when more accurate positioning of valve steam is required



Postioner Schematic for
Diaphragm Actuator

Basic Valve Types

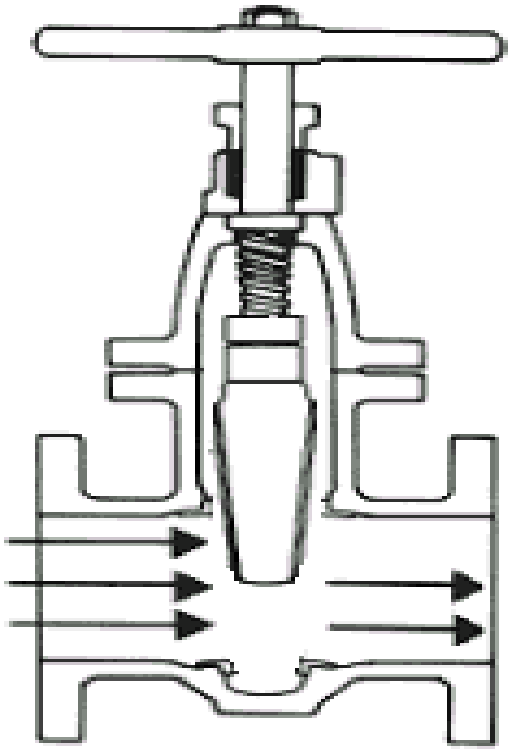


Gate Valve

Commonly used in industrial piping for stop or isolating - to turn on and shut off the flow as opposed to regulating flow. Gate valves are named from the gate-like disc which operates at a right angle to the path of the flow.

Basic Valve Types

Gate Valve

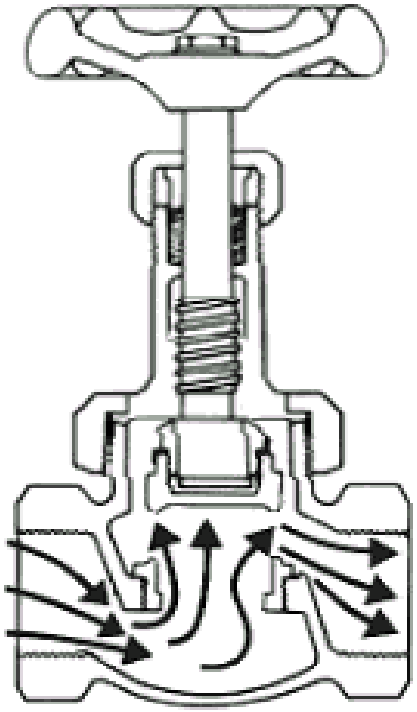


There are two basic designs of gate valves, inside screw stem and outside screw stem.

- Seating is perpendicular or at right angles to the line of flow - meets it head on.
- Repeated movement of the wedge near the point of closure, under high velocity flow, may create a drag on the seating surfaces and cause galling or scoring on the downstream side.
- A slightly opened wedge may also cause turbulent flow with vibration and chattering of the wedge.

Globe Valve

The flow path through globe valves follows a changing course, thereby causing increased resistance to flow and considerable pressure drop. Because of the seating arrangements, globe valves are the most suitable for throttling flow. The valve is named after its globular body.



Globe valve seating is parallel to the line of flow. All contact between seat and disc ends when flow begins. These are advantages for more efficient throttling of flow, with minimum wire drawing and seat erosion.
Globe valves are generally ideal for throttling, and preferable for frequent operation.

Basic Valve Types

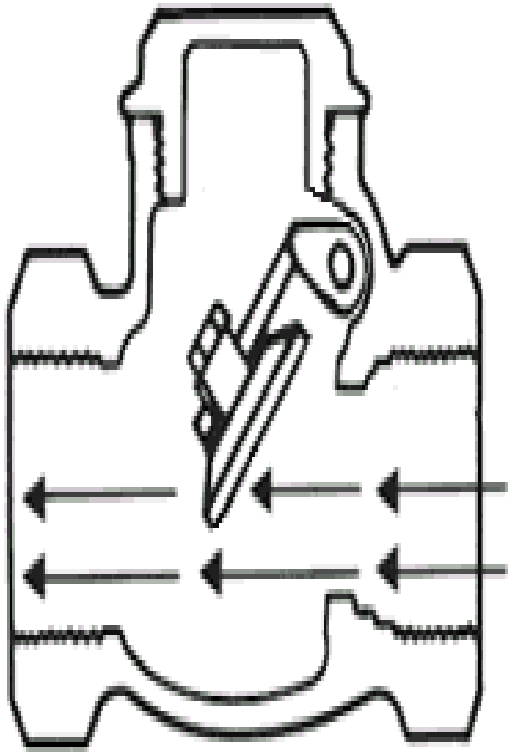
Check Valve

SWING CHECK VALVE

LIFT CHECK VALVE

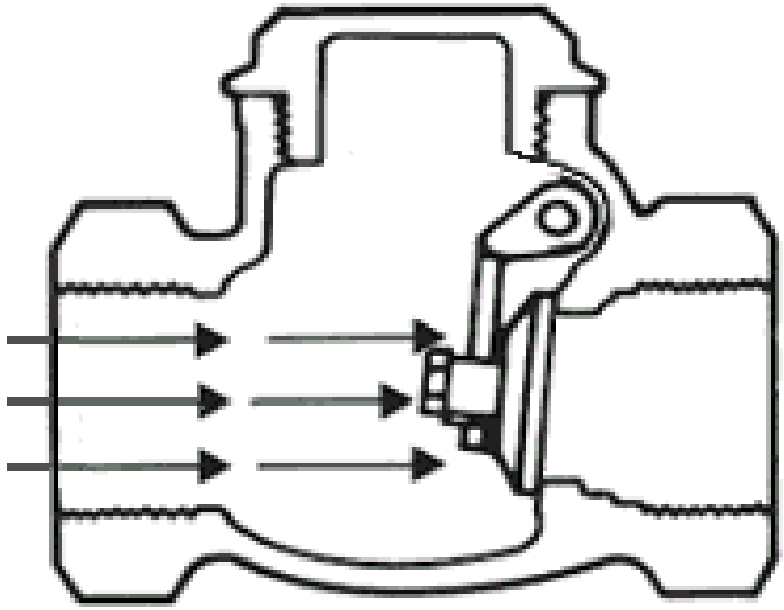
Check Valves are designed to automatically prevent the reversal of flow in a pipeline system. They control the direction of flow, rather than throttling or isolating flow as other valve designs do. Reverse flow may create problems or it could cause damage to equipment. Check valves are sometimes known as reflux valves.

Swing Check Valves



This type of check valve uses a hinged mounted disc that swings open and closed with flow. They can be used in the horizontal and vertical (flow upwards) position.

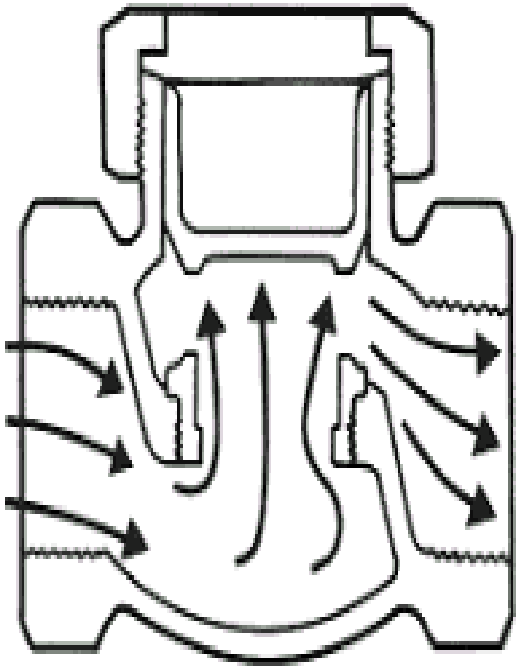
The swing check is the most commonly used design of check valves as they do not restrict flow.



Lift or Piston Check Valves

This type of check valve uses a piston rather than a hinge mounted disc to prevent the reversal of flow. This provides a cushioning effect during the operation of the valve. They must only be used in a horizontal position.

Lift check valves, like globe valves are flow restricting, therefore they are generally used as companions to globe valves.



JOHN FIG. 430

Dual Flap Check Valves

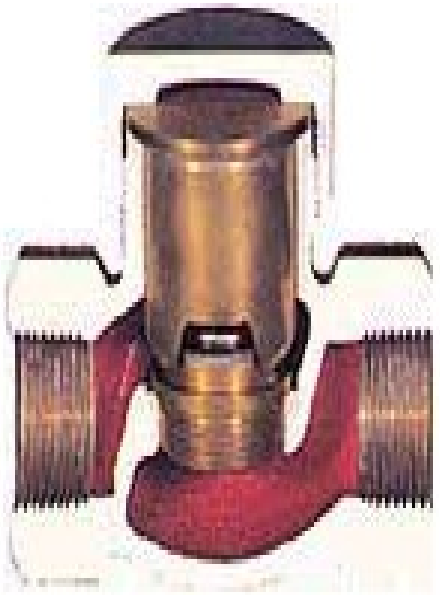
These check valves are of wafer design and fit between flanges. The valve discs are in two halves and are held in the closed position by a stainless steel spring.

The reaction of the stainless steel spring quickly and quietly shuts the valve off before the flow in the line can reverse and water hammer is virtually eliminated.

The valve can be installed in horizontal or vertical lines.

Air Check Valves

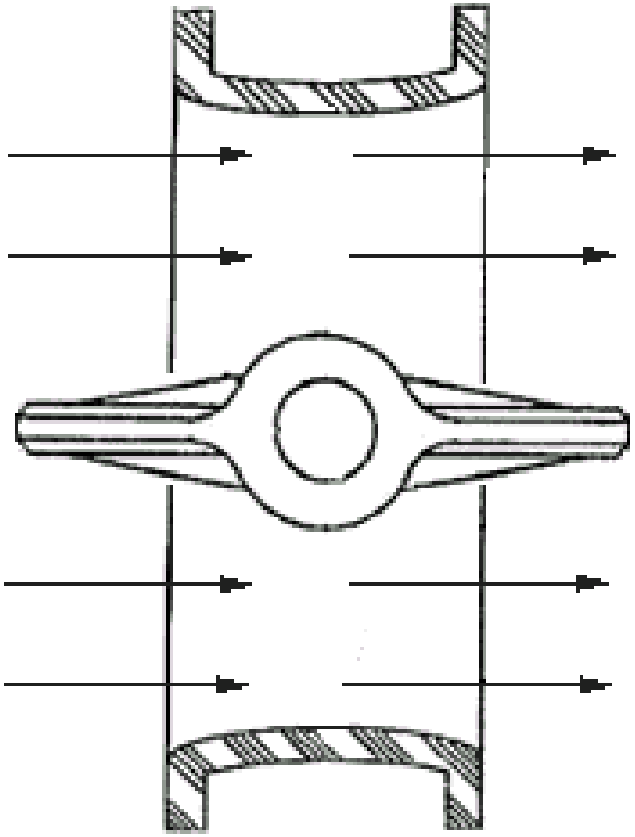
These are check valves specifically designed for compressed air services. The disc is manufactured from flat stainless steel and is held against the seat by a spring. The spring holds the disc against the seat whilst the compressor is idling or in-operative. It is recommended that the valve be located at least 3 metres from the compressor.



JOHN FIG. 551

Basic Valve Types

Butterfly Valve



Butterfly Valves are of the quarter turn family and are so designed because a 90 degree turn of the operator fully opens or closes the valve.

. In some cases, they may be used for non-critical throttling applications. They are lighter in weight than conventional valves.