

Control Valves

A large industrial control valve is the central focus of the image. It features a light blue pneumatic actuator mounted on top, which is connected to a network of pipes and smaller valves. The main valve body is a large, horizontal, cylindrical component with a flanged end, secured with numerous bolts. The background shows a complex industrial facility with various pipes, scaffolding, and structures under a clear sky.

By

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Control Valve

- Control Valve plays a very important part in industries.
- It controls and distributes pressure, flow, level, temperature etc.
- Control valve may be considered the **MUSCLE** of automatic control.

Types of Valves

- Gate Valve
- Globe Valve
- Plug Valve
- Butterfly Valve
- Diaphragm Valve

Major Parts of a control Valve

- A control valve consists of two major sub-assemblies.
 - A valve body sub-assembly
 - An actuator.
- The valve body sub-assembly is the portion that actually controls the passing fluid.
- It consists:
 - Housing
 - Internal trim
 - Bonnet

Types of Valve Bodies

- Globe Styles

- The most common control valve body style is in the form of a globe.
- Such a control valve body can be either single or double-seated.
- Single-seated valves, are usually employed when tight shut-off is required.
- Tight shut-off in this case usually means that the maximum expected leakage is less than 0.01% of the maximum valve C_v

Single Seated Valves

- Single-seated valves usually have a top guided construction.
- It also allows a somewhat higher flow capacity than top and bottom guided valves for a given orifice size.

Double-seated valve

- A double-seated valve, is generally top and bottom guided.
- Leakage figure approaches 0.5% of the rated C_v .
- It is nearly impossible to close the two ports simultaneously
- Advantage of double-seated construction lies in the reduction of required actuator forces.

Angle Valves

- These Valves are single-seated.
- Used for high pressure drop service.
- Minimum Space required.

Cage Valves

- So-called "top entry" or cage valves have the advantage of easy trim removal.
- Typical top entry valve with unbalanced, single-seated trim.
- The inner valve parts, often referred to as "quick change trim," can easily be removed after removing the bonnet, because of the absence of internal threads.

Rotary Types of Control Valves

- Advantages

- Low weight
- Simple design
- High relative C_v
- More reliable
- Friction-free packing
- Low initial cost.

Rotary Types of Control Valves

- Disadvantage
 - Generally not suitable below 1 to 2 inches.
 - Operating shaft must be designed to support a fairly heavy side-thrust.
 - Leakage problem.

Butterfly Valves

- The most common type of rotary valve used for control is the butterfly valve.
- The typical application range is in sizes from 2 inches through 36 inches or larger, for low or moderate pressures.
- Leakage 0.5% of rated C_v .

Valve Bonnets

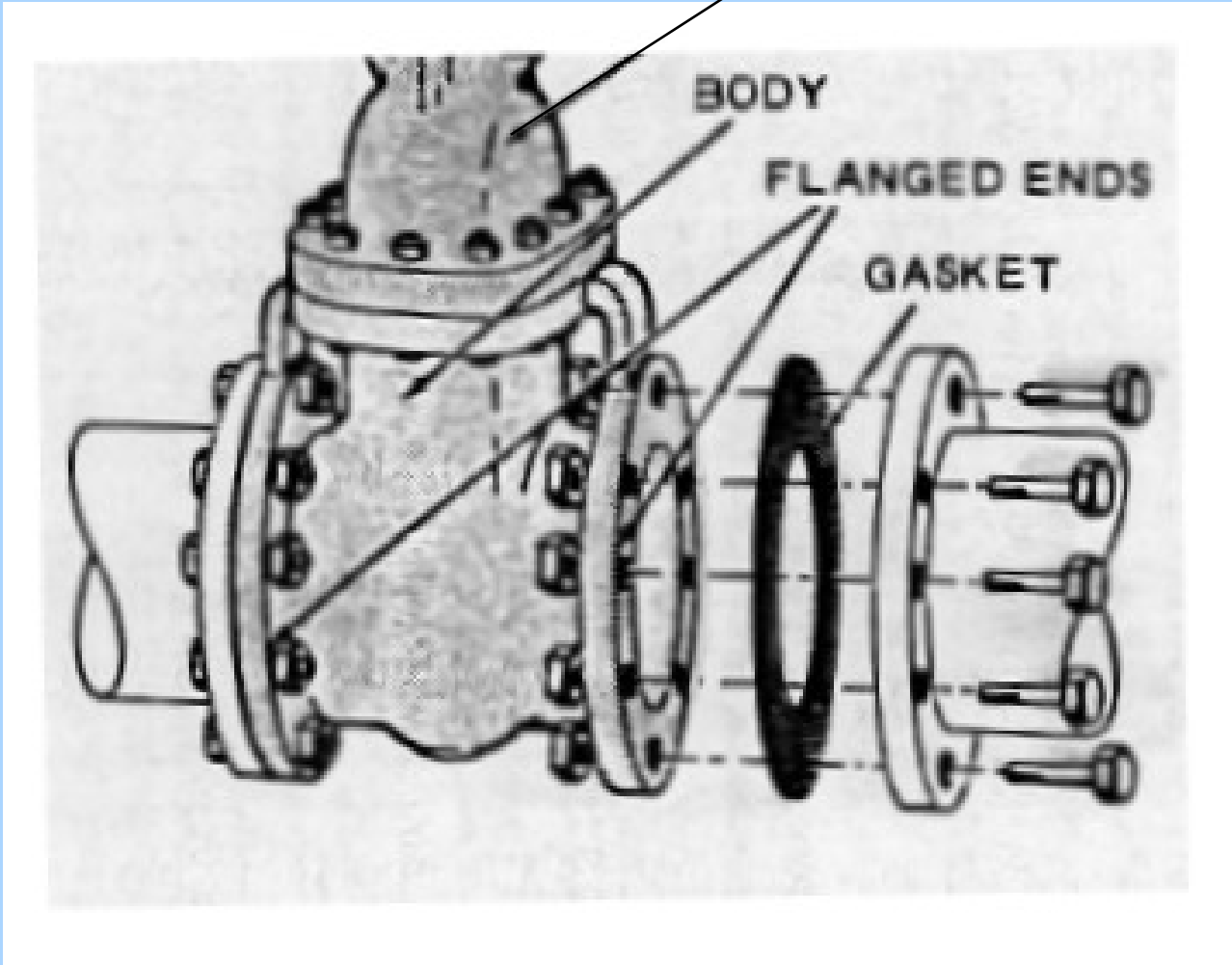
- The valve bonnet or top closure is the removable upper portion of the valve body sub-assembly and is normally connected to the body by high strength bolting.
- It is a pressure-carrying part and is, therefore, subject to the same design requirements as the valve housing.
- Removal of the valve bonnet generally provides access to the valve trim.

Valve Bonnets

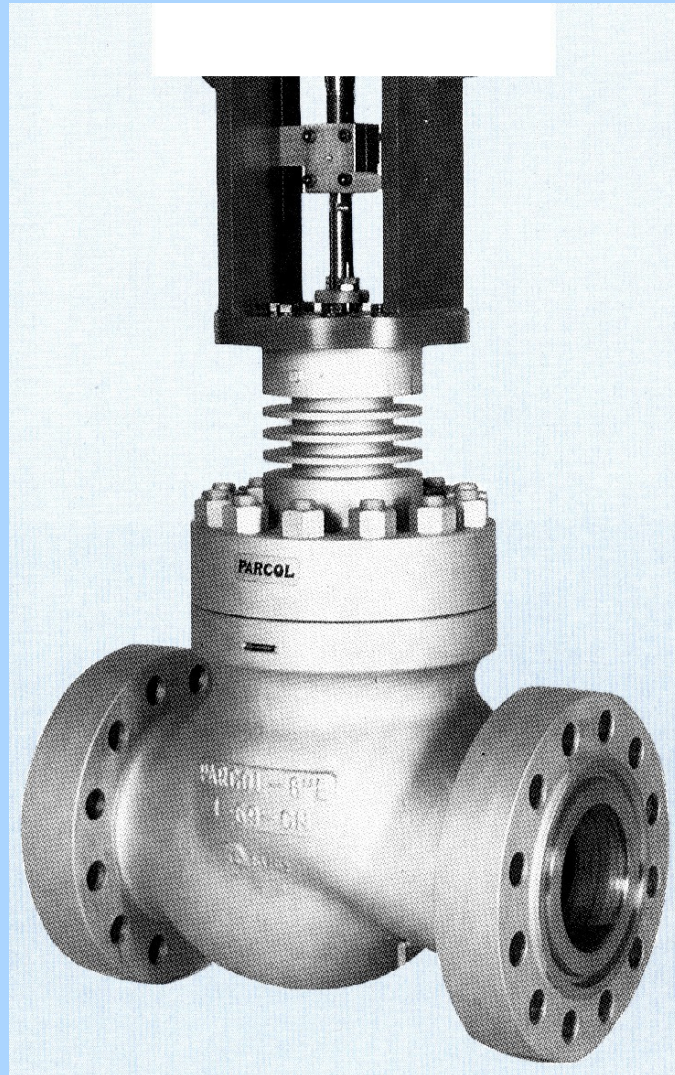
- Some low-pressure valves, particularly in sizes below 2 inches, have a threaded bonnet connection which is more economical than a flanged joint.
- The upper portion of the bonnet contains the valve packing.

Valve Body

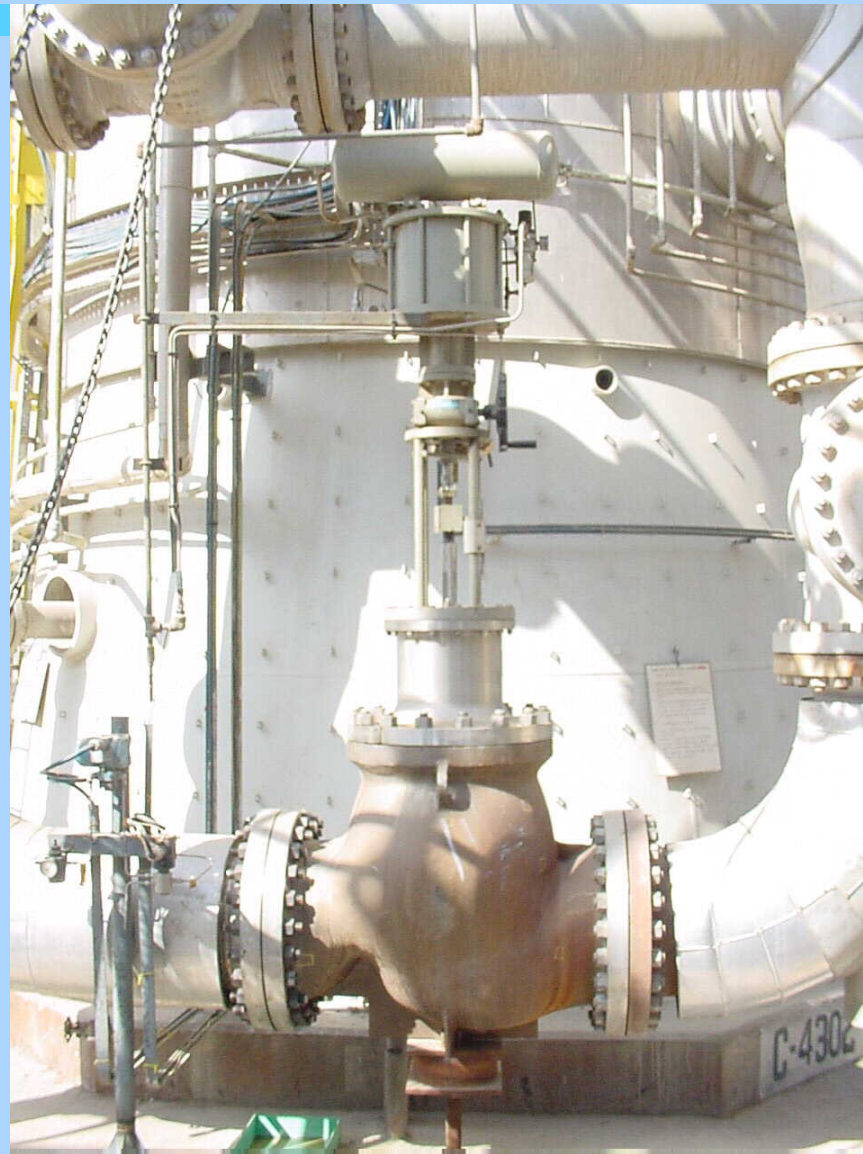
Bonnet



Valve Body



Valve Body



Packing Box Assembly

- The purpose of the packing box assembly is to contain an elastic means for preventing the leakage of a process fluid.
- Suitable adjustments should be provided for varying the compression of the packing material against the surface of the stem.
- The ideal packing material should be elastic and easily de formable.

Packing Box Assembly

- In addition, the packing should be as chemically inert as possible
- Should be able to withstand high pressures and high temperatures.
- Selection must be made from a variety of materials to suit the specific service conditions.

Packing Box Assembly

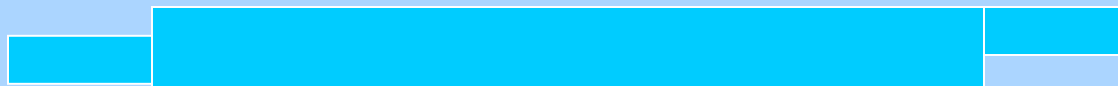
- The assembly consists of a:-
 - Packing flange
 - Packing follower (Bush)
 - Lantern ring
 - A number of equally spaced packing rings.
 - The lantern ring provides a space for the insertion of lubricating grease through an isolating valve.

Packing Material

- Teflon → (PTFE)
- Graphite
- Grafoil
- Asbestos (Now a days it is not being used)
- Teflon Cord
- Graphite cord

Packing Material

- To make rings
- Special Tool or
- With the help of a Electrician knife
- How to cut and paste the rings



Inert Gas as a Packing

- Another approach is to pressurize the area between the two packing with inert gas at a pressure level, slightly higher than the fluid pressure inside the valve.
- In this case, the inert gas might leak into the valve, but no fluid is allowed to leak by the stem.
- This packing arrangement is more reliable.
- Very Expensive

Teflon

- The most popular valve packing material is Teflon.
- Because of its excellent chemical inertness and its good lubricating properties.
- Teflon can be used in solid-molded or turned form (rings).
- Solid rings should be spring-loaded to provide a minimum initial pressure against the stem.
- It can be used below 250°C.

Braided Asbestos

- Braided asbestos is still a popular packing material (even prohibited to use).
- It can be made as split rings.
- Which can be wrapped around the valve stem.
- This type of packing usually used with mica or graphite, particularly in high temperature service.

Grafoil

- A recent addition to the list of available packing materials is Grafoil.
- Grafoil is an all-graphite product that is flexible and has direction-dependent properties.
- It is essentially, chemically inert, except when strong oxidizers are handled.

Valve Trim

- Main Items:
 - Plug
 - Seat Ring
 - Stem
 - Cage
 - Guide Bushing
 - Stuffing Box

Plug

- Types
- Types depends upon flow characteristic:
 - Quick Opening
 - Linear
 - Parabolic or Equal Percentage

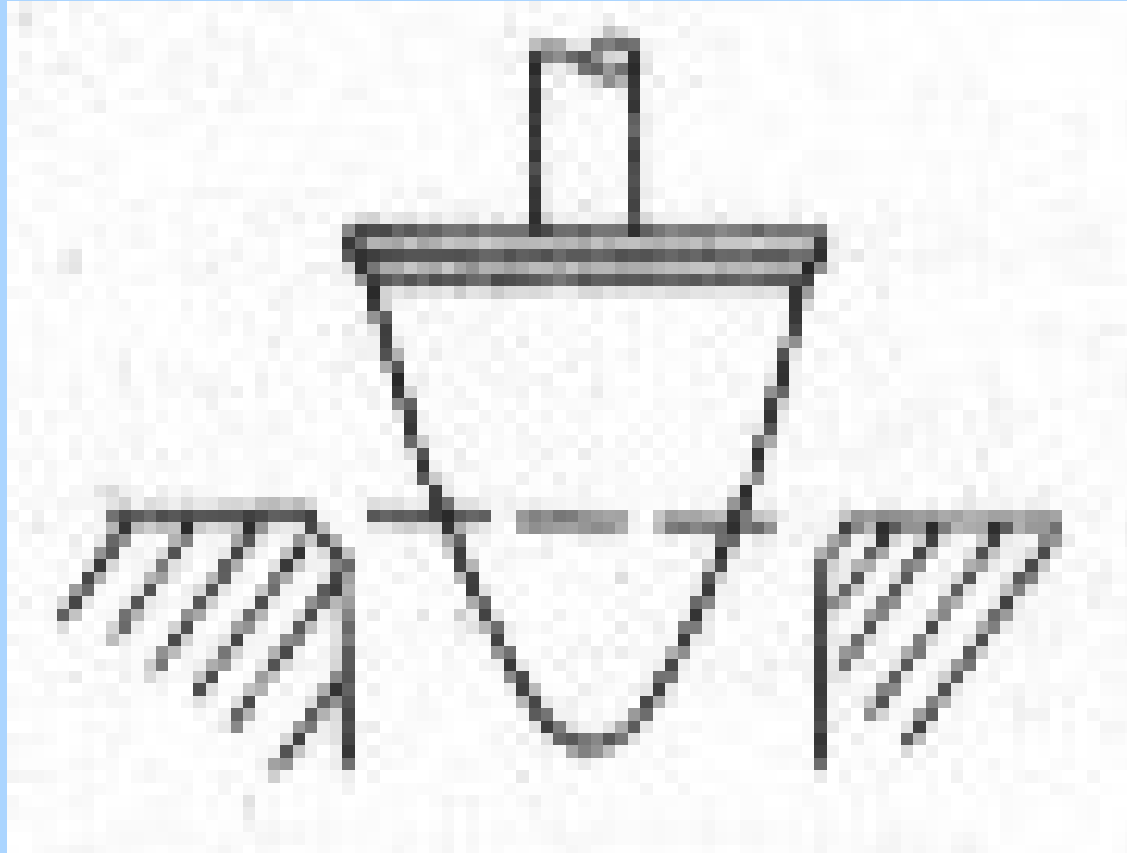
Plug / Seat

- Direct Action Single Seated
- Reverse Action Single Seated
- Direct Action Double-Seated
- Reverse Action Double-Seated

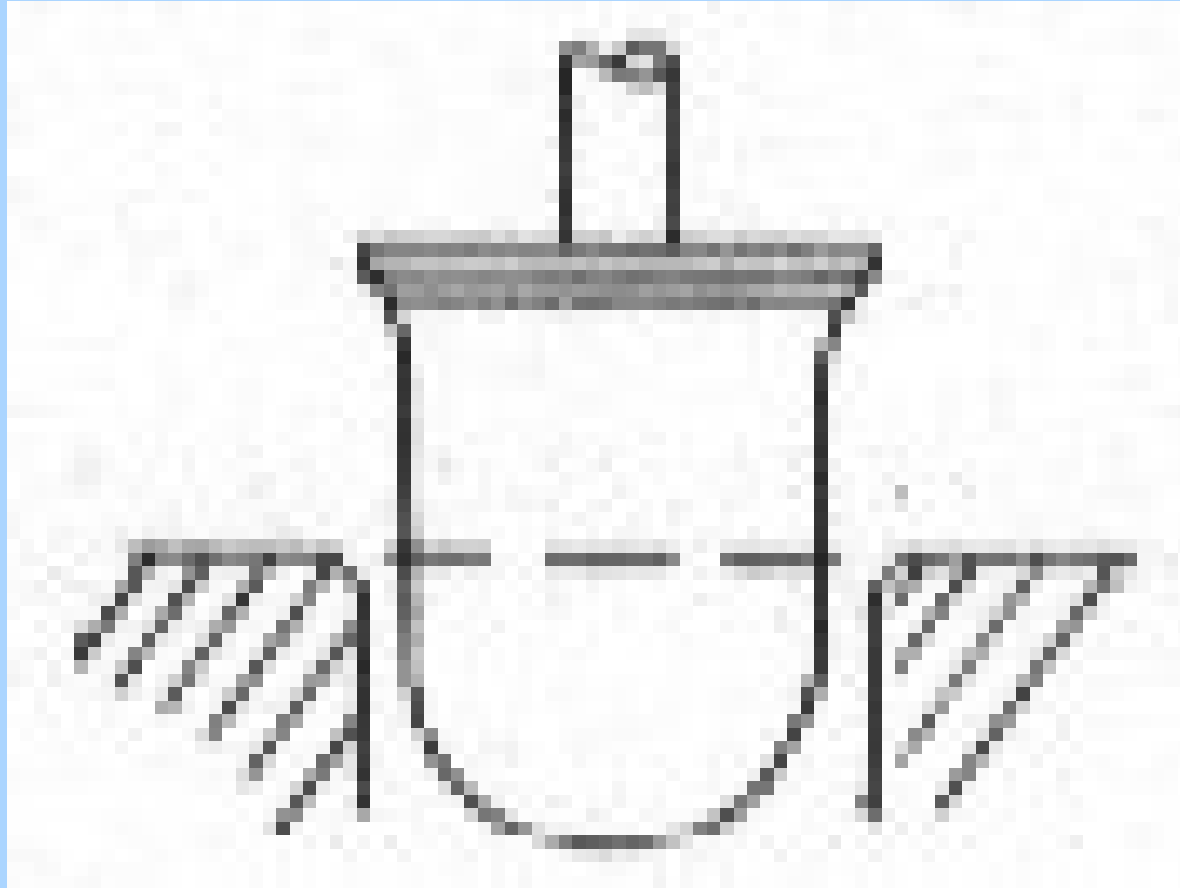
Plug

- Contoured Plug
 - Top Guided
 - Shape of the plug
 - Flat → Quick Opening
 - A bit Conical → Linear
 - Tapered but not conical → Equal Percentage

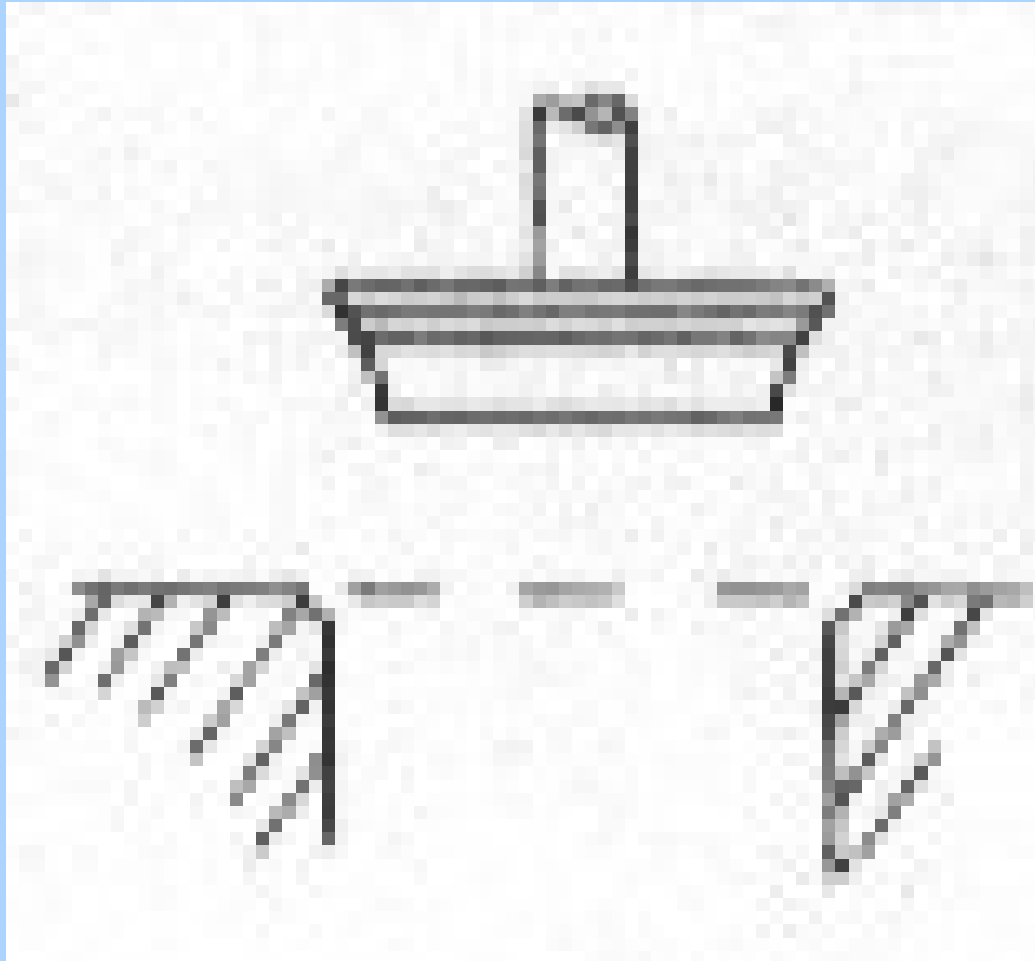
Plug → Linear



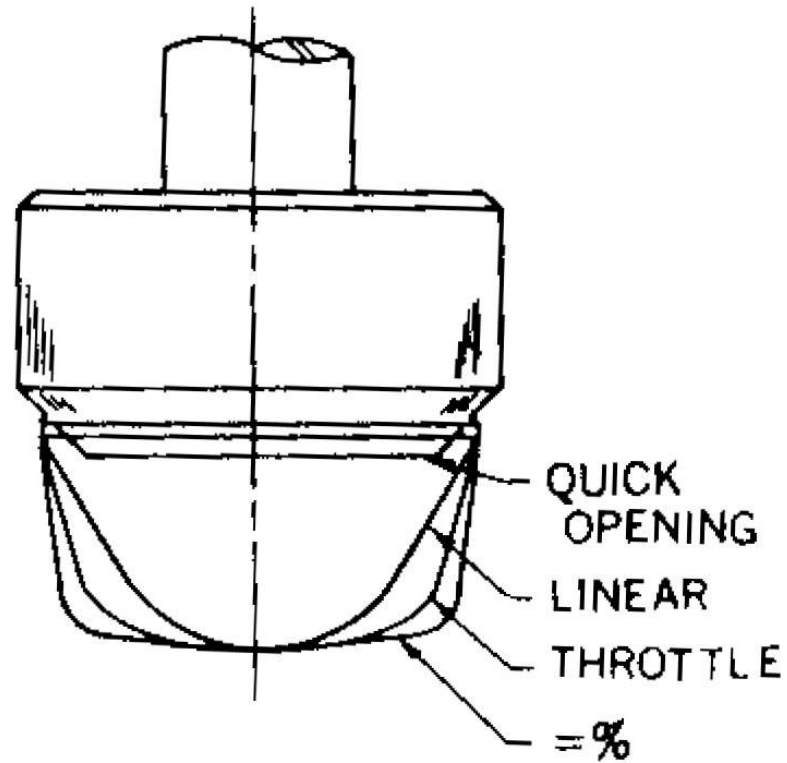
Plug → Equal Percentage



Plug → Quick Opening



Different Shapes of Plugs



Characteristics of Different Plugs

- Valve Opening 30 %
 - Quick Opening $C_v \rightarrow 62$
 - Linear $C_v \rightarrow 30$
 - Equal % $C_v \rightarrow 8$
 - V-Port $C_v \rightarrow 6$

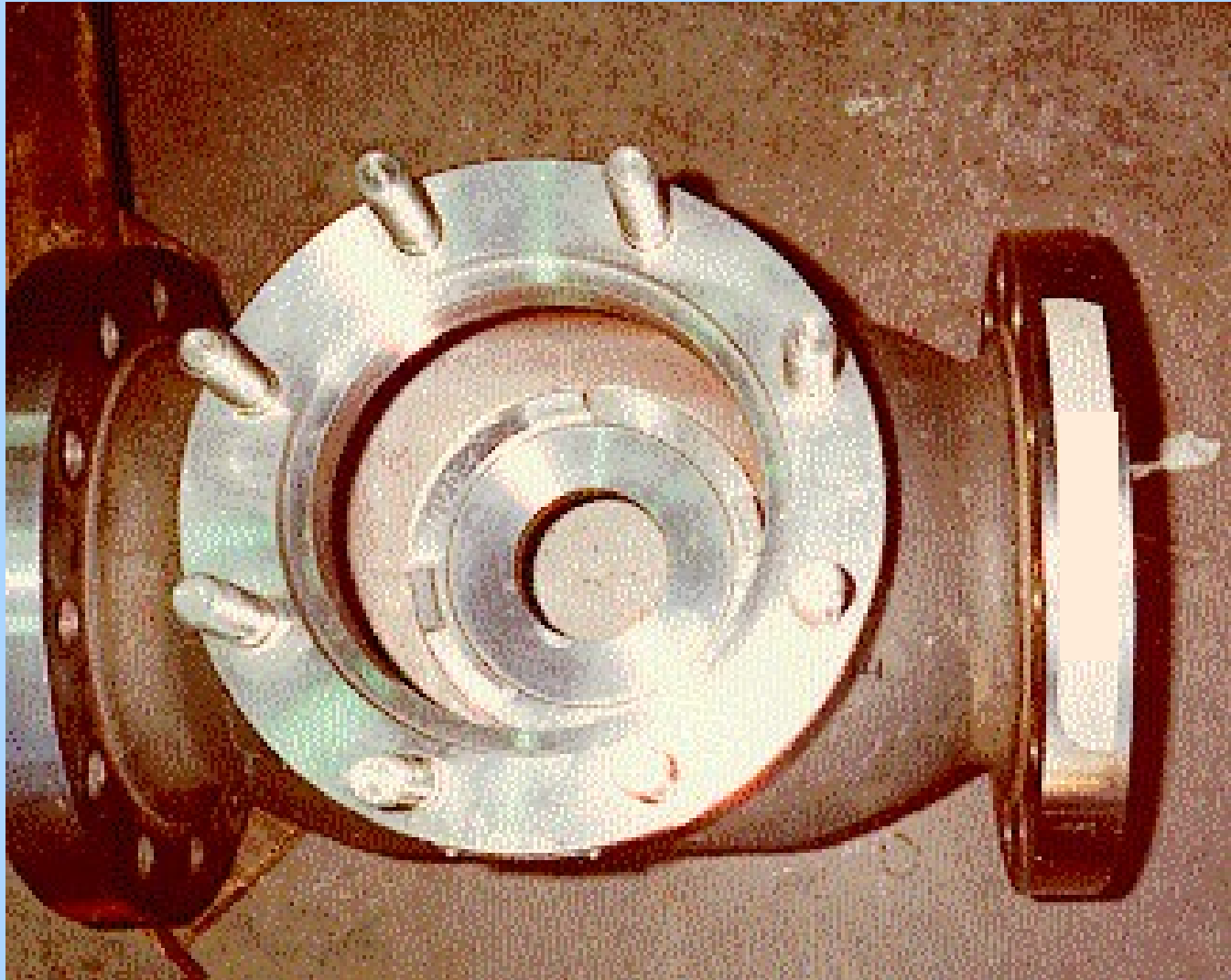
Characteristics of Different Plugs

- Valve Opening 70 %
 - Quick Opening $C_v \rightarrow 90$
 - Linear $C_v \rightarrow 70$
 - Equal % $C_v \rightarrow 33$
 - V-Port $C_v \rightarrow 30$

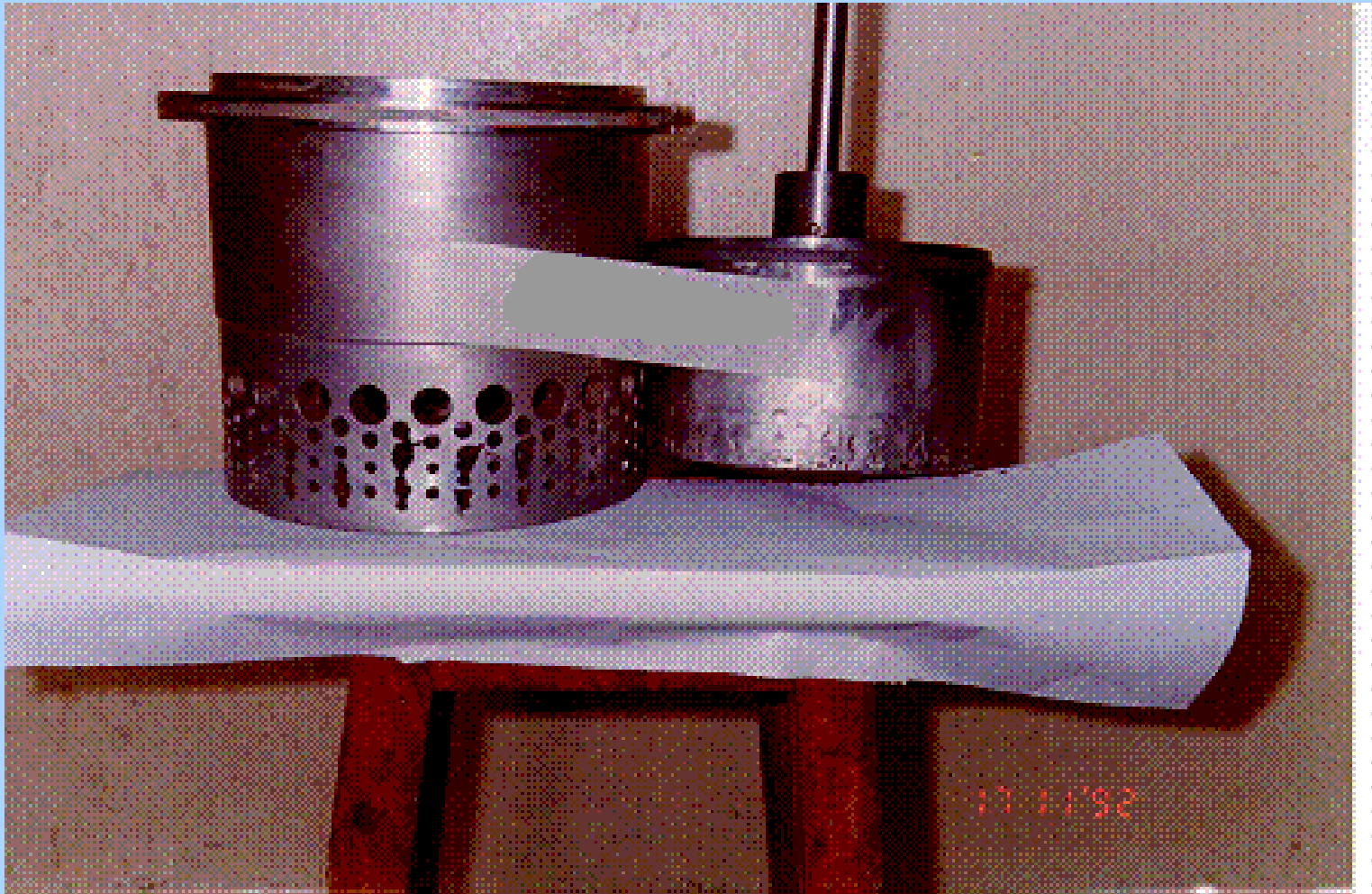
Characteristics of Different Plugs

- Valve Opening 100 %
 - Quick Opening $C_v \rightarrow 100$
 - Linear $C_v \rightarrow 100$
 - Equal % $C_v \rightarrow 100$
 - V-Port $C_v \rightarrow 100$

Valve Body



Plug & Cage



Complete Control Valve

- Actuator
- Diaphragm
- Spring
- Yoke
- Indicator
- Coupling Assembly

Complete Control Valve

- Stem
- Bush
- Check Nut of yoke
- Packing Box
- Bonnet
- Body

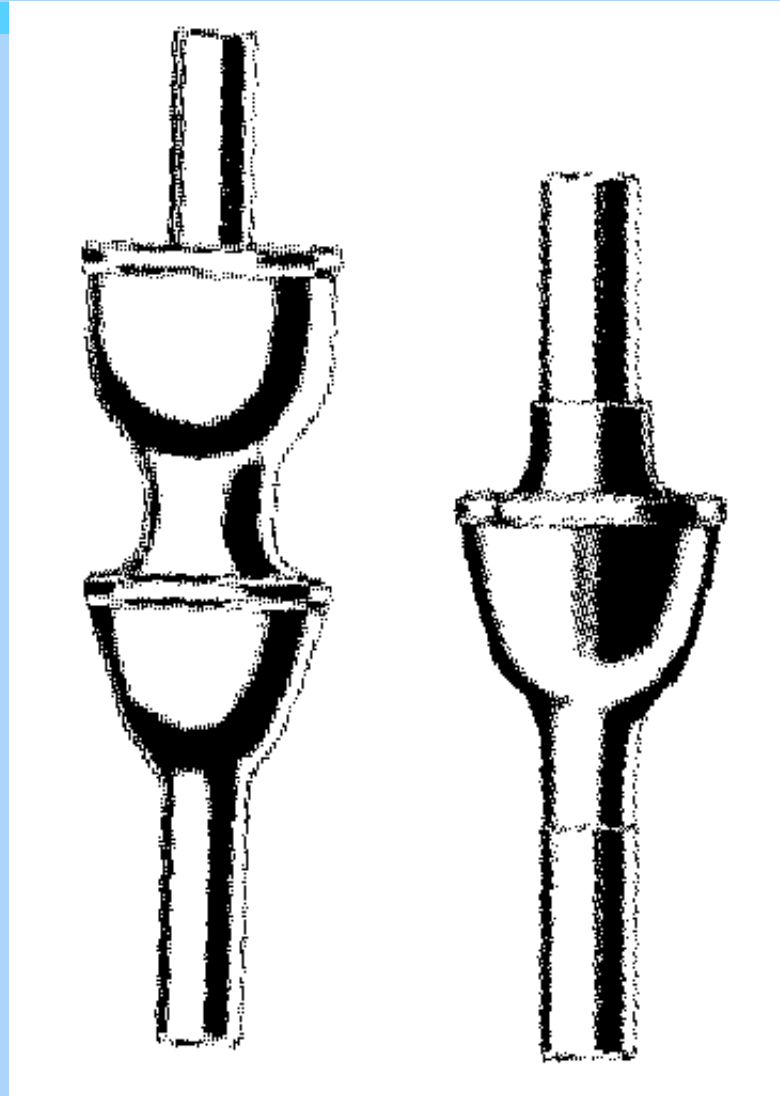
Complete Control Valve

- Plug
- Seat Ring
- Cage
- Gaskets
- Bottom Guide

Plug

- Types
 - Contoured Plug
 - Single Port
 - Double Port
 - Different Shapes
 - V- Port
 - Single Port
 - Double Port
 - Multi-v-port plug
 - Reduces noise

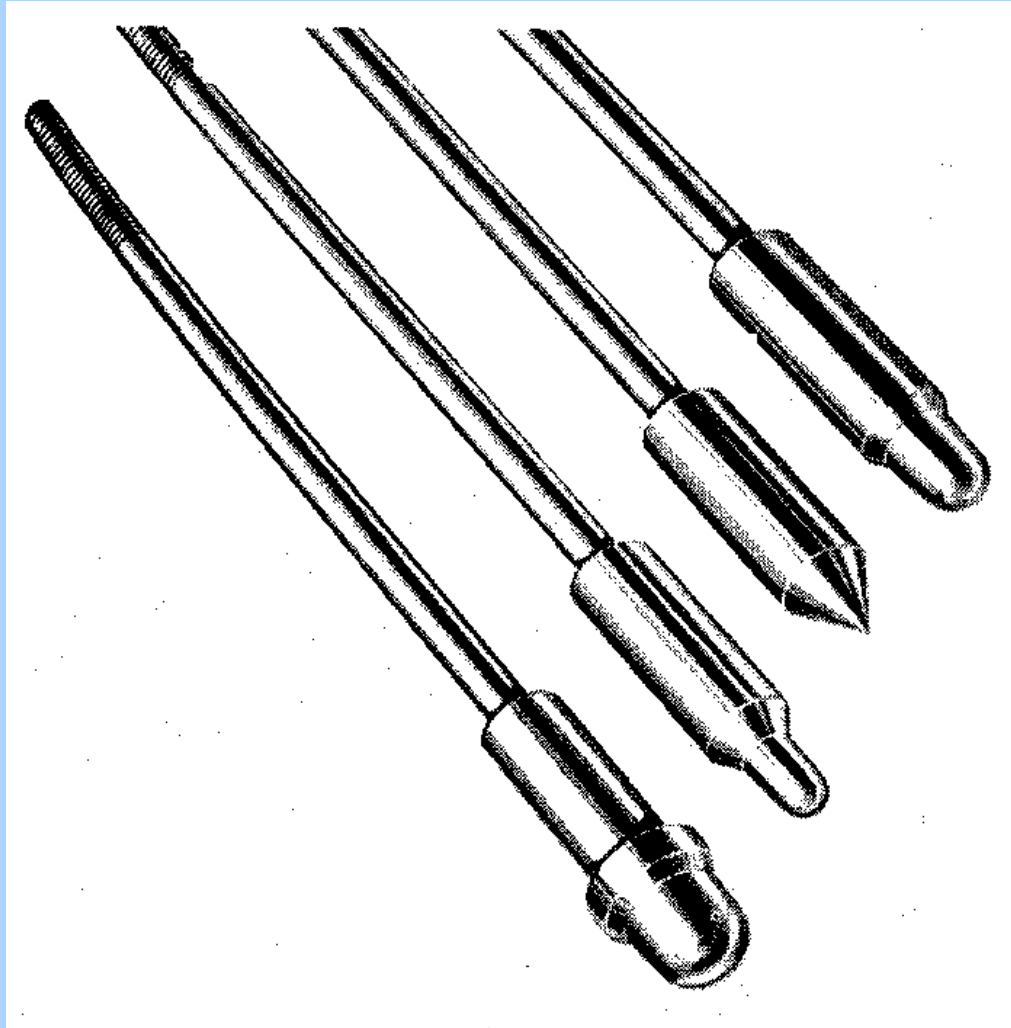
Contoured Plug



Contoured Plug



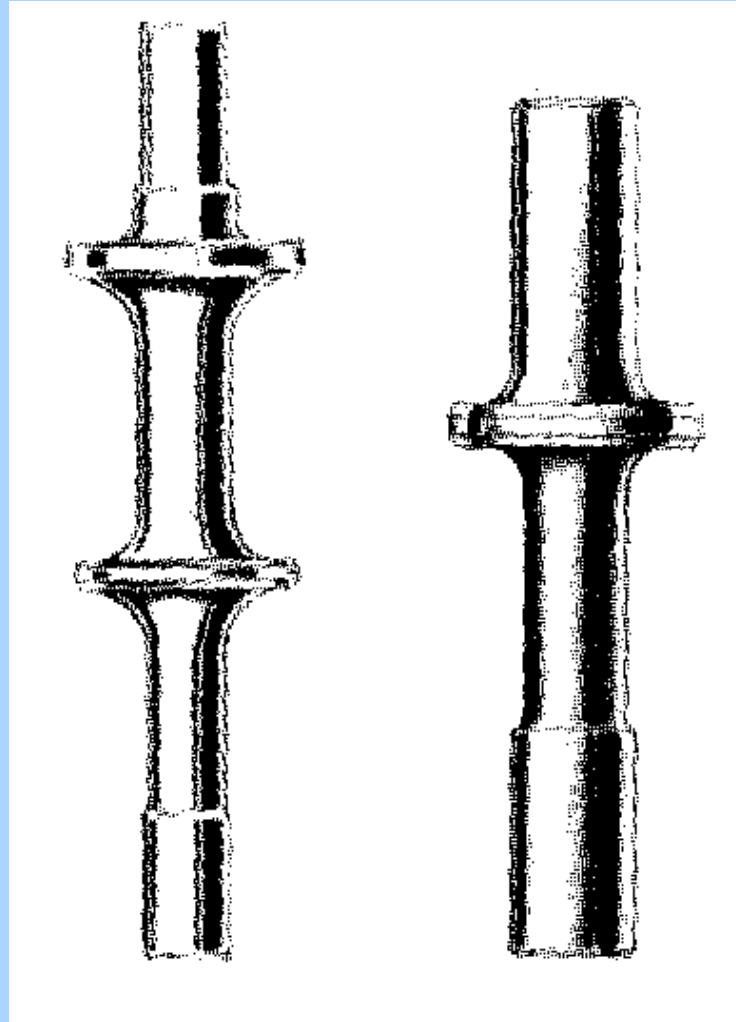
Contoured Plug



Plug

- Disc
 - Single Port
 - Double Port
- Mixed Type
 - (Used to reduced the dynamic unbalance fluid forces)
- Balanced Plug

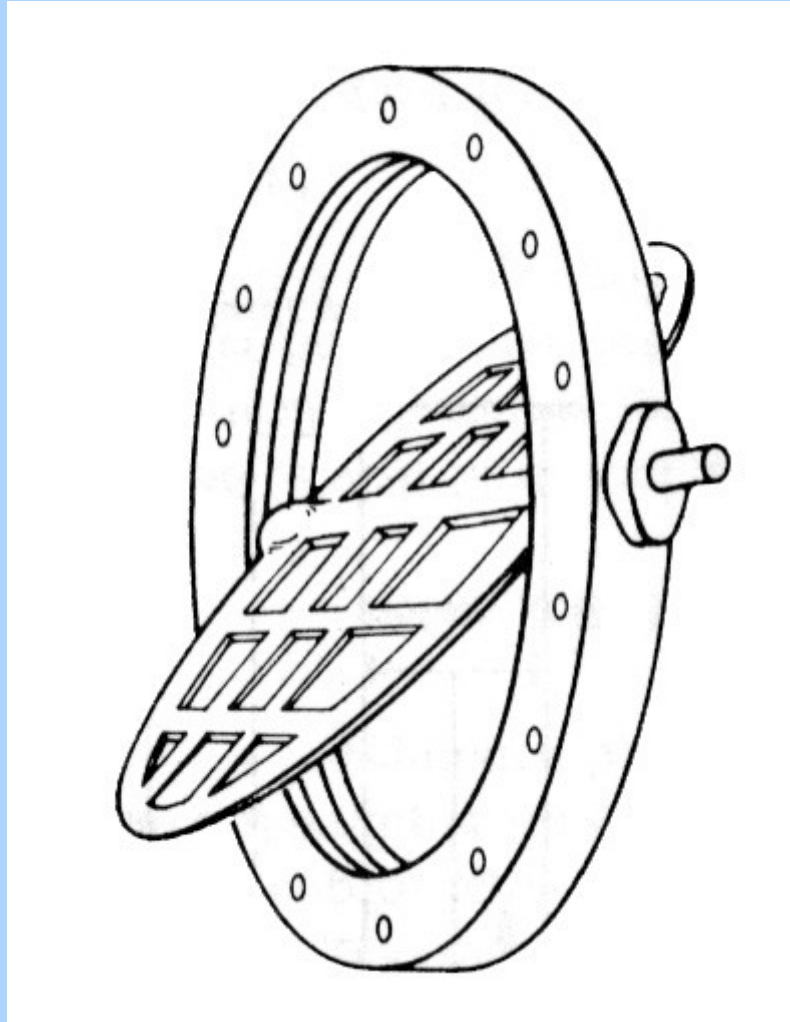
Disc Type Plugs



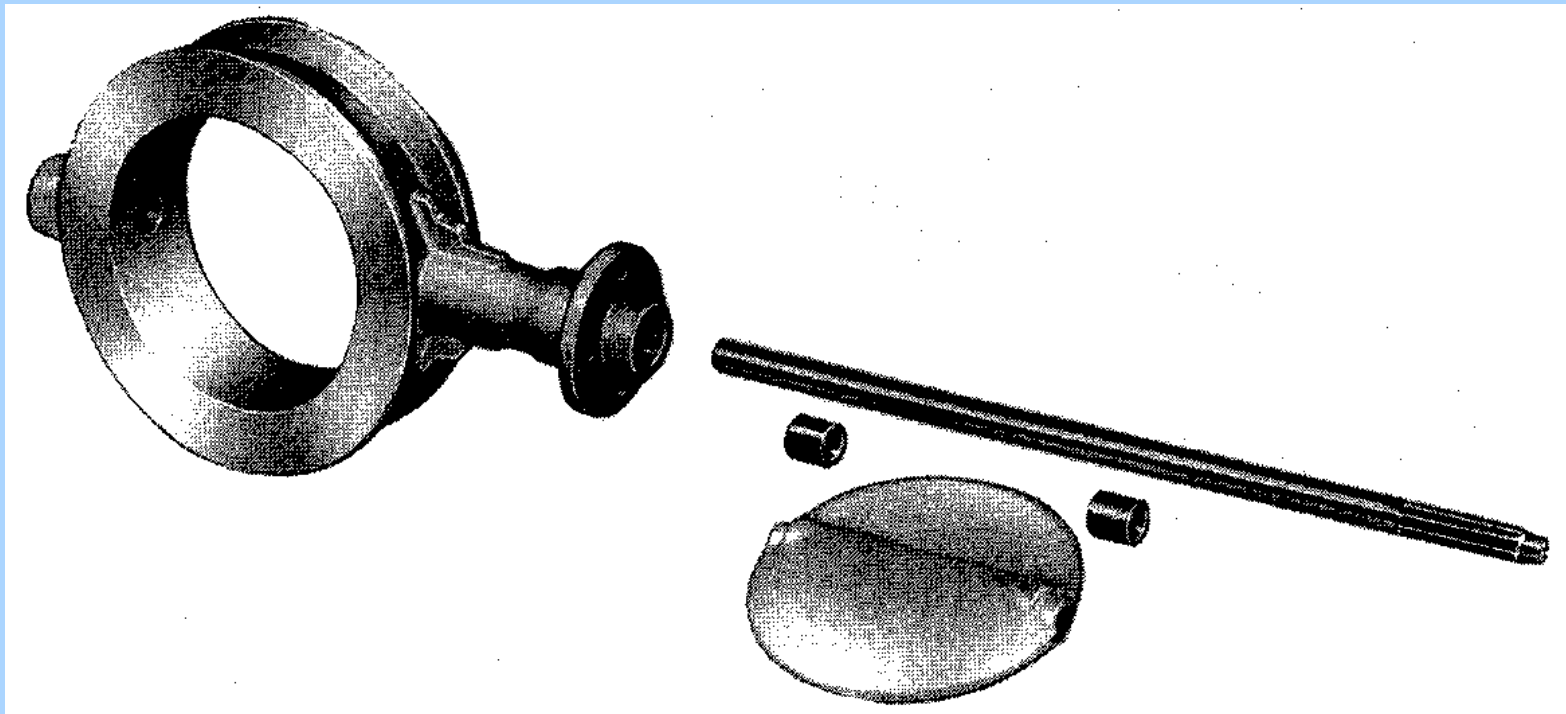
Butterfly Disc

- Butterfly
 - Very simple construction
 - High Capacity with Low Pressure
 - Leakage Class III

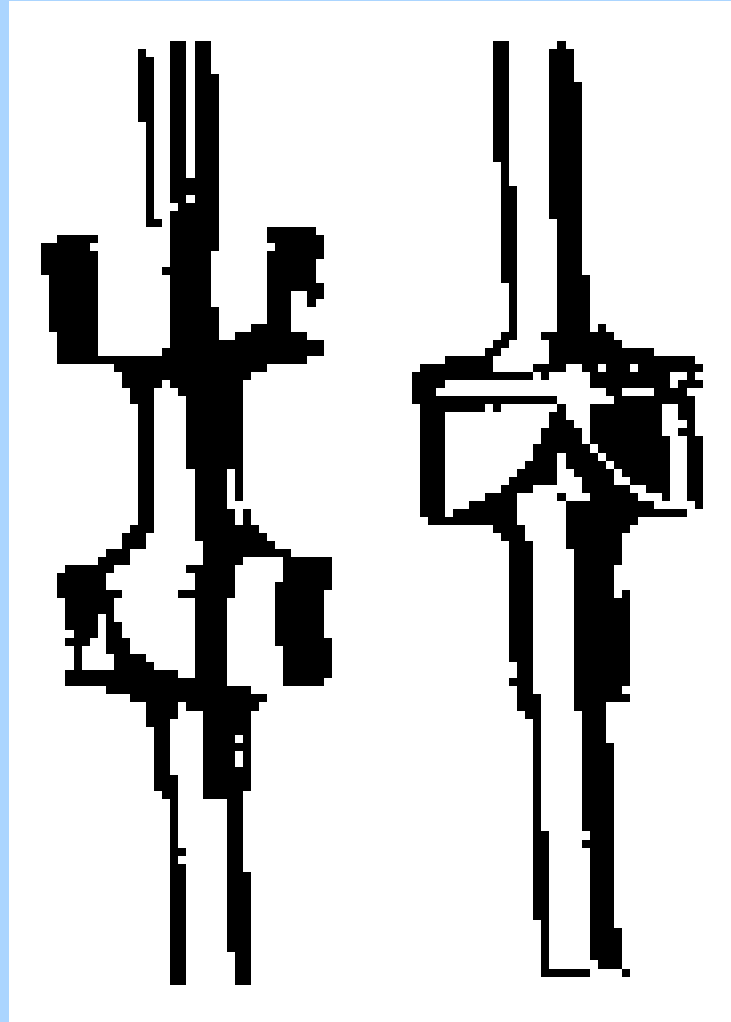
Butterfly Valve



Butterfly



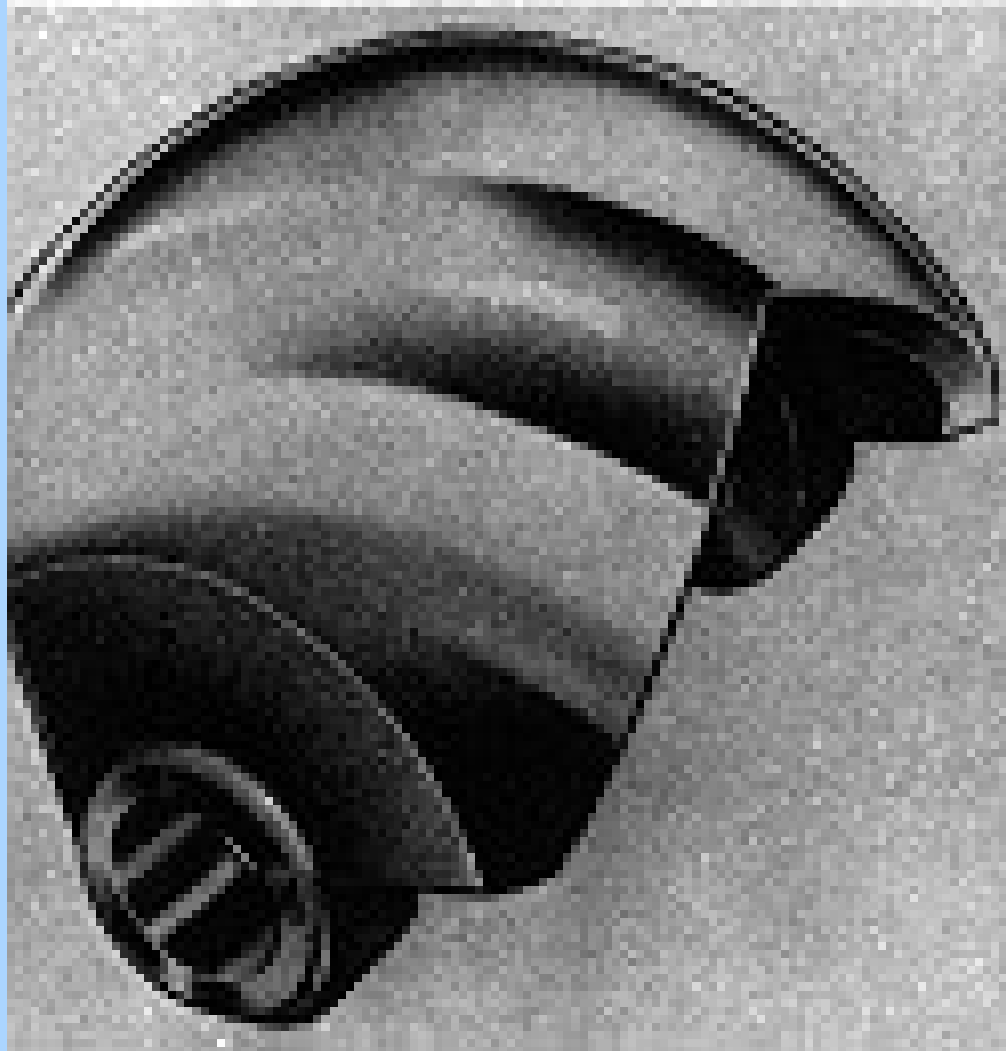
V Port Plug



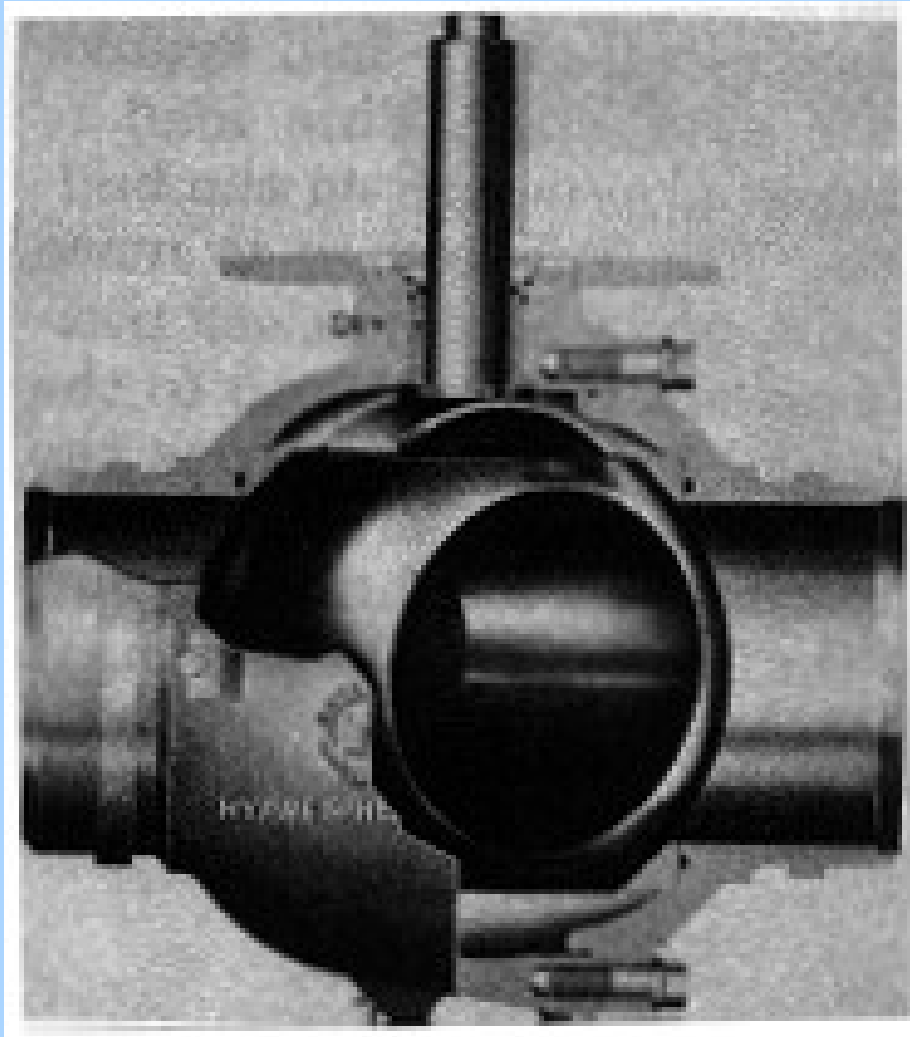
Ball Valve

- These Valves offer the advantages
 - Highest Flow Capacity
 - Low Operating Force
 - Tight Shut Off

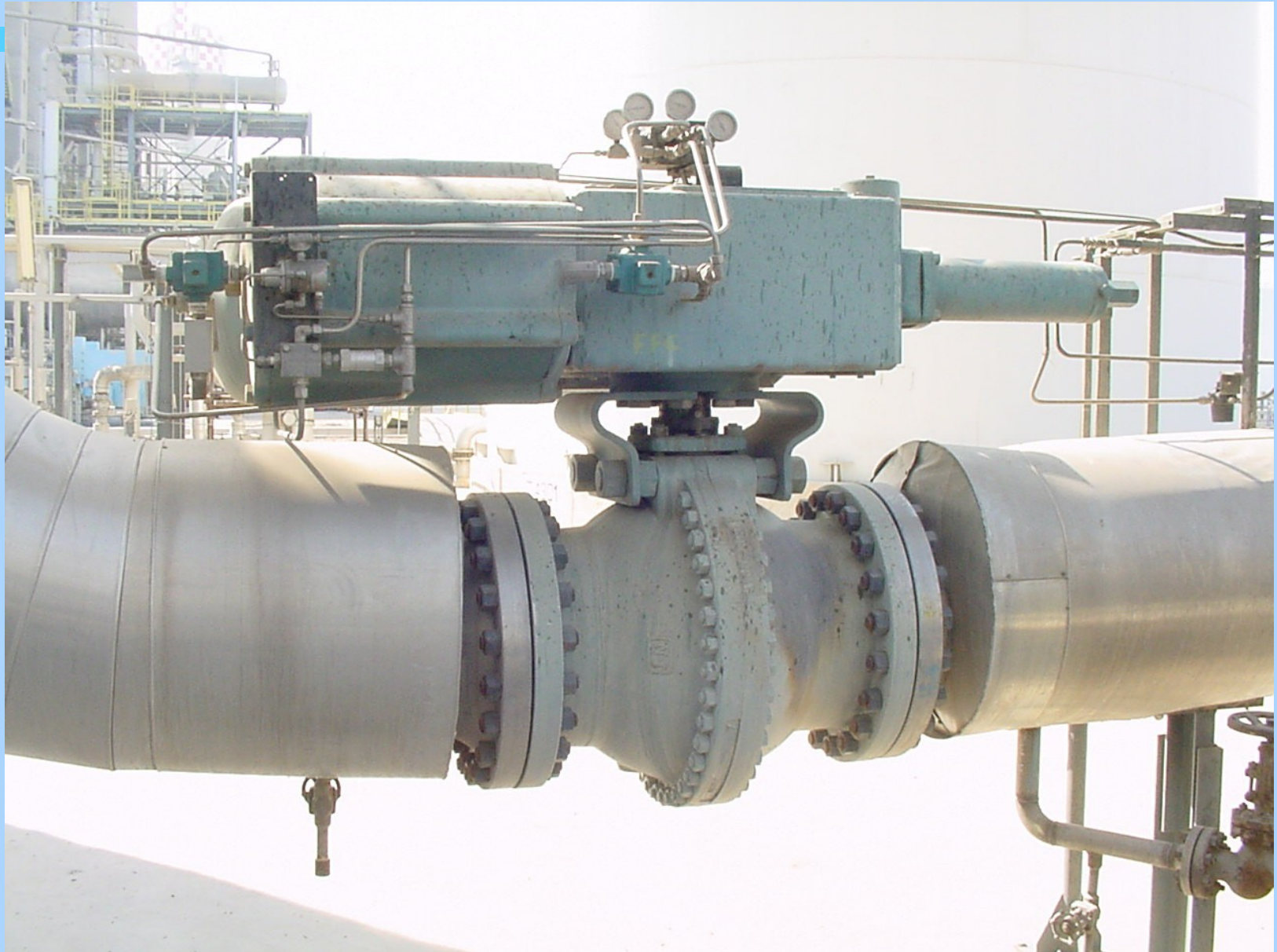
Ball Valve



Ball Valve



Ball Valve



Plug

- Material
 - CS → Carbon Steel
 - SS → Stainless Steel
 - 410 SS
 - 440-C SS
 - 316
 - 304
 - 17-4 PH
 - To improve Hardness
 - Stellite

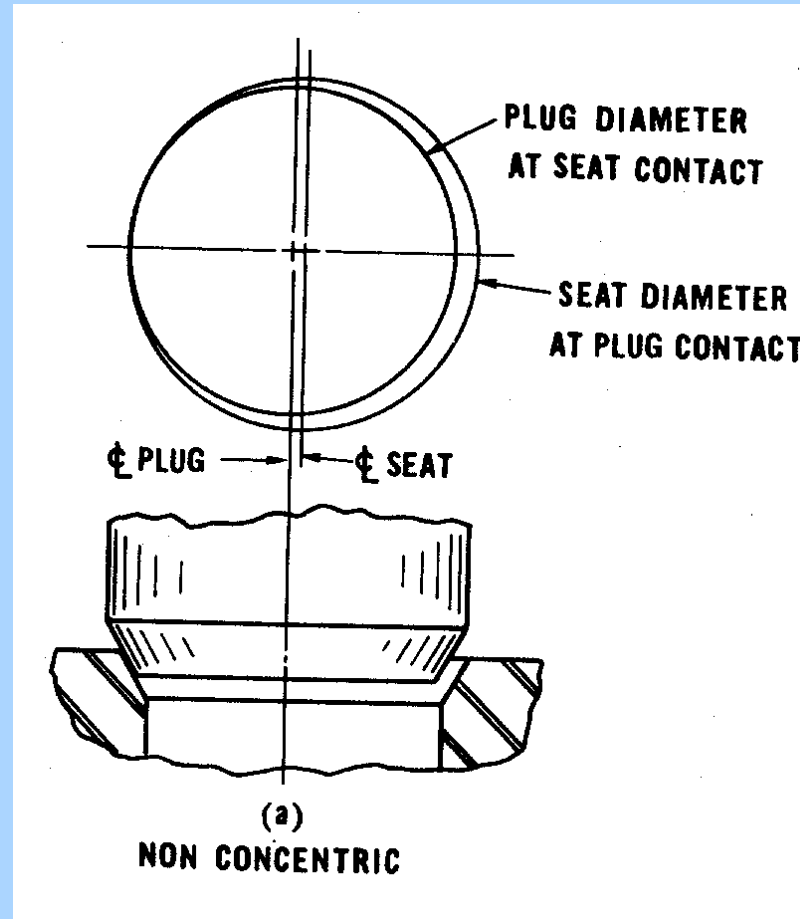
Seat Ring

- Just like a Washer
- Same material as Plug
- With Threads / Without Threads
- Alignment
 - Face to Face
- Stellite

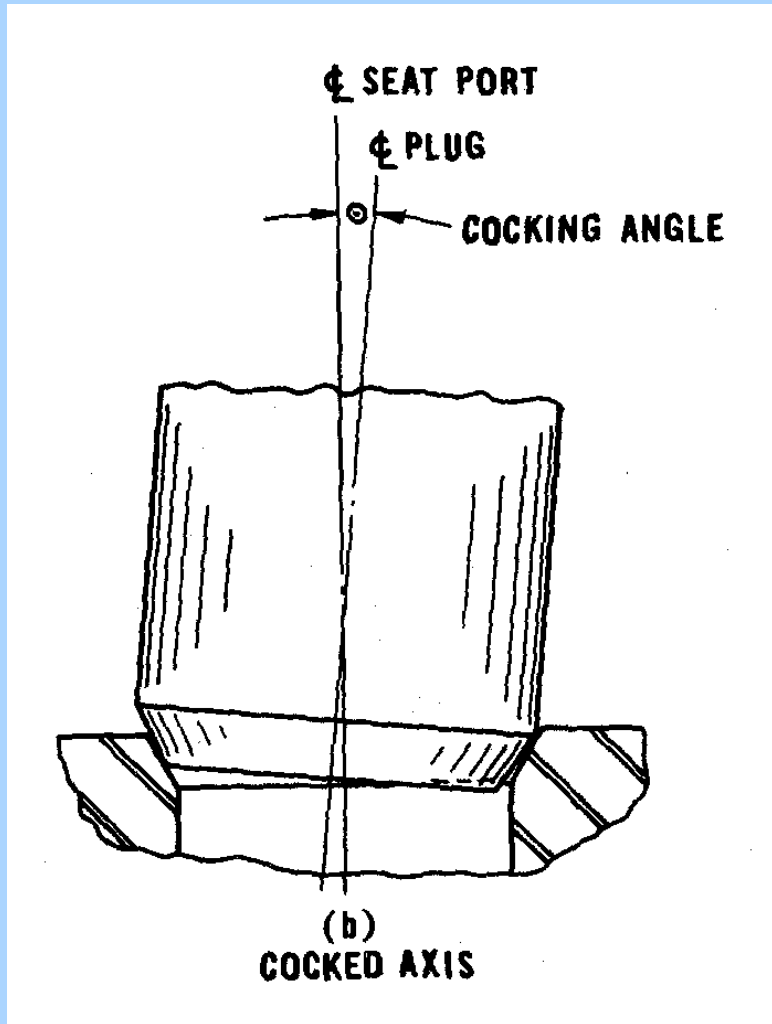
Seat Ring



Alignment



Alignment



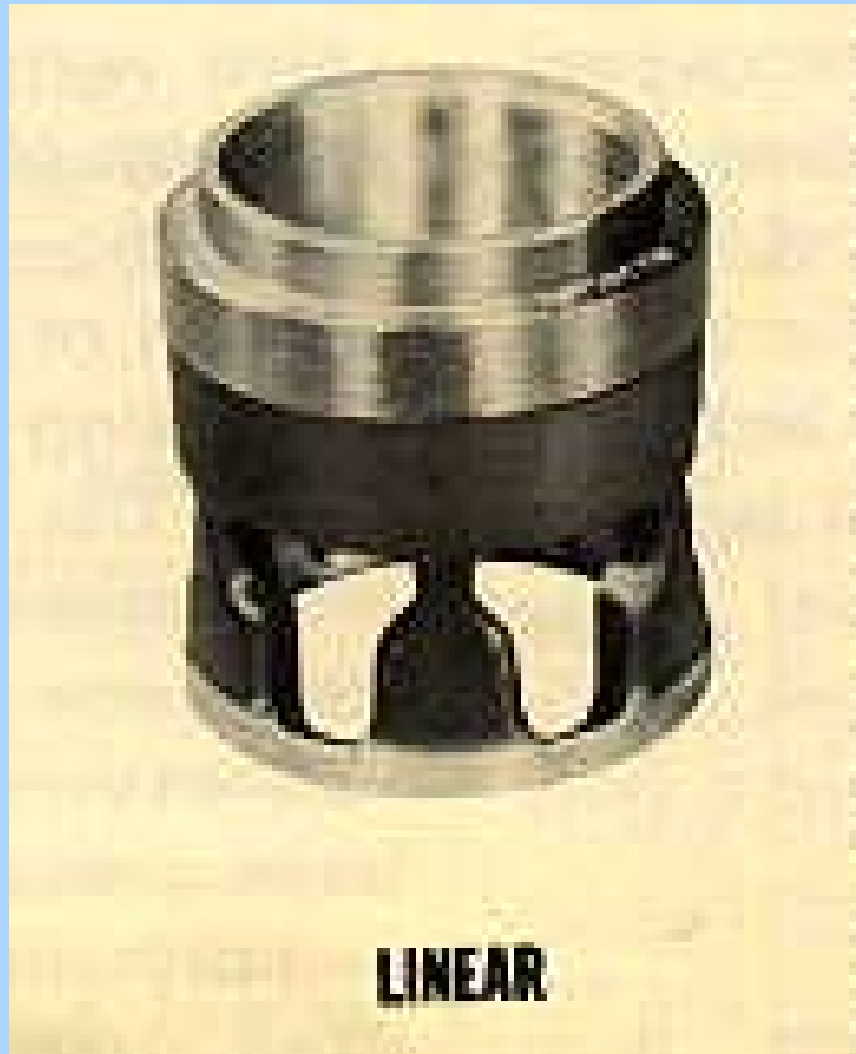
Cage

- A bit less hard material
- But according to the requirement of process
- Guides the Plug
- Reduces the noise (10 to 15 db)
- Quick Opening
- Linear
- Equal Percentage
- Slotted Cage

Quick Opening



Linear



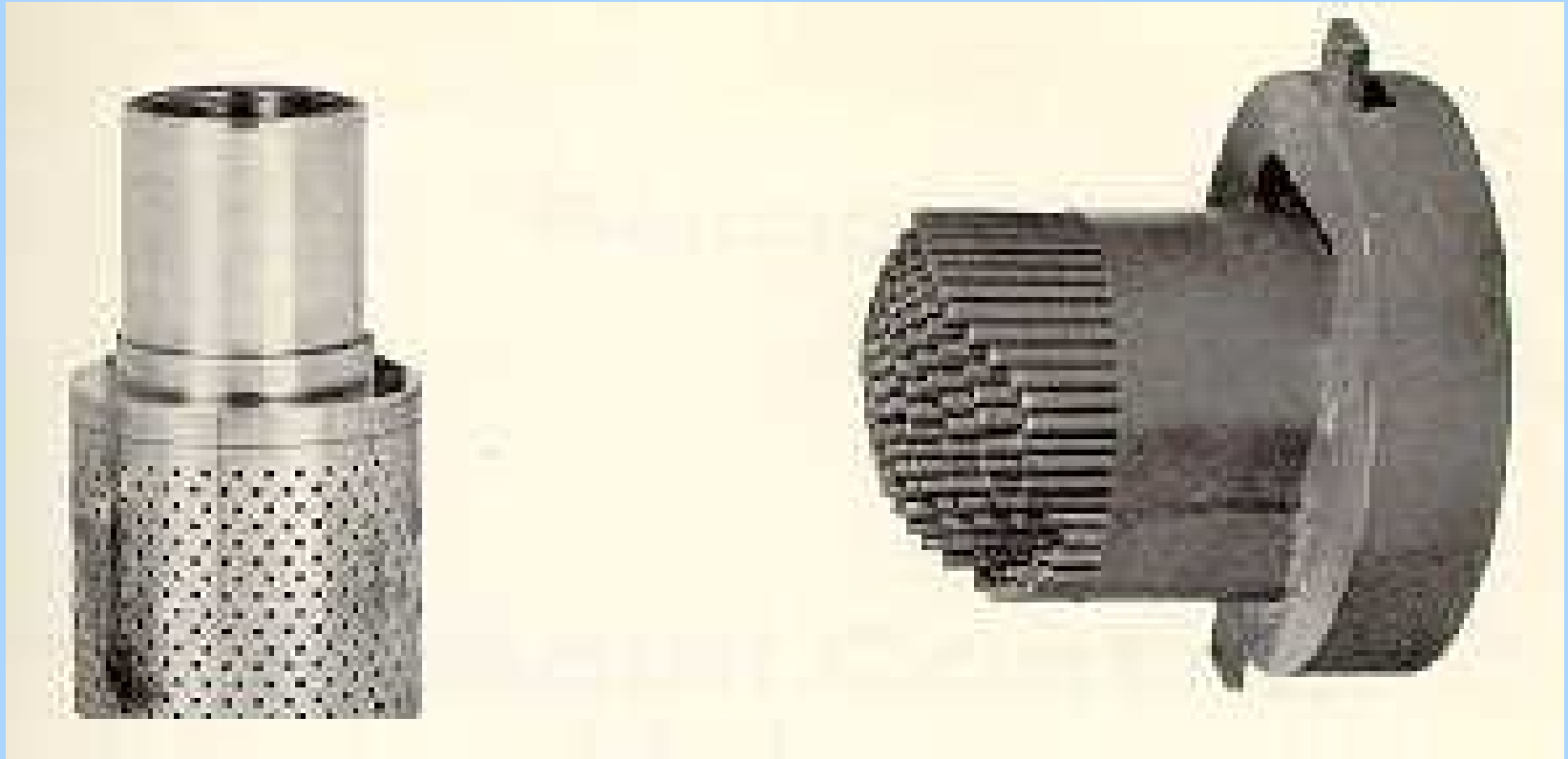
Equal Percentage



Different shape of Cages



Different shape of Cages



Different shape of Cages



Sealing Arrangement

- 2nd Major leakage between plug and cage
- Back up Rings
- Material
 - Graphite
 - Very Careful → Brittle
 - Teflon (PTFE)

Gaskets

- Seat Ring Gasket
- Upper Cage
- Body Gasket
- Material
 - Graphite / Grafoil
 - Asbestos
 - Neoprene

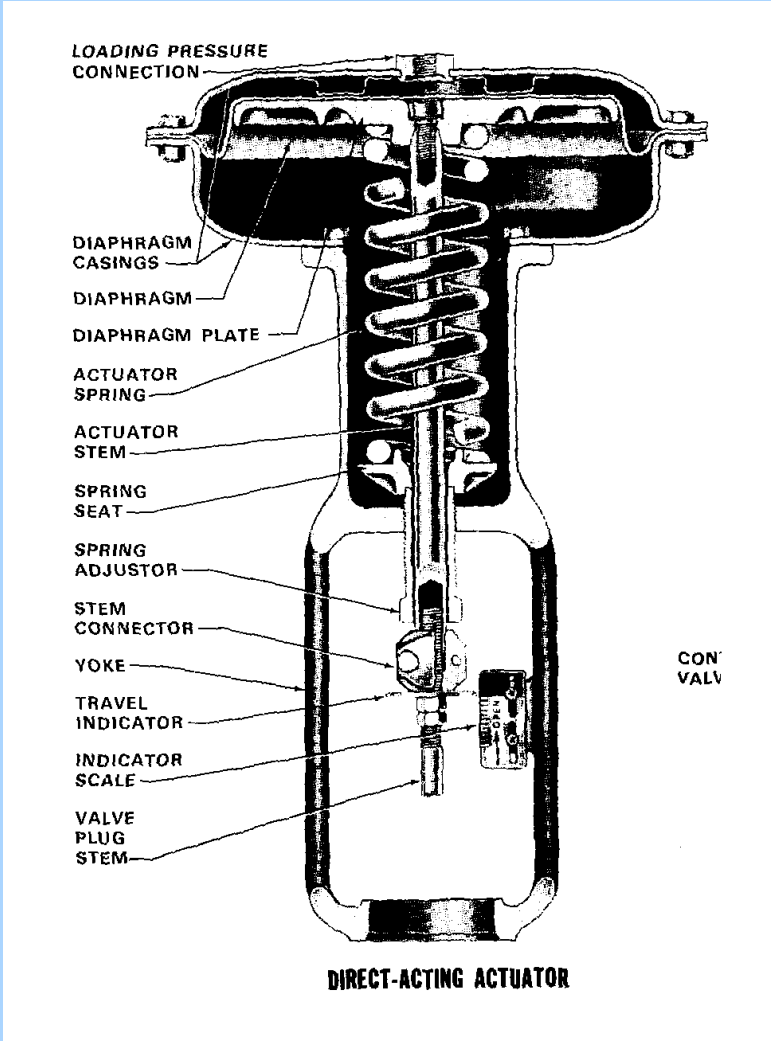
Actuators

- Diaphragm
- Piston
- Direct Action
- Reverse Action

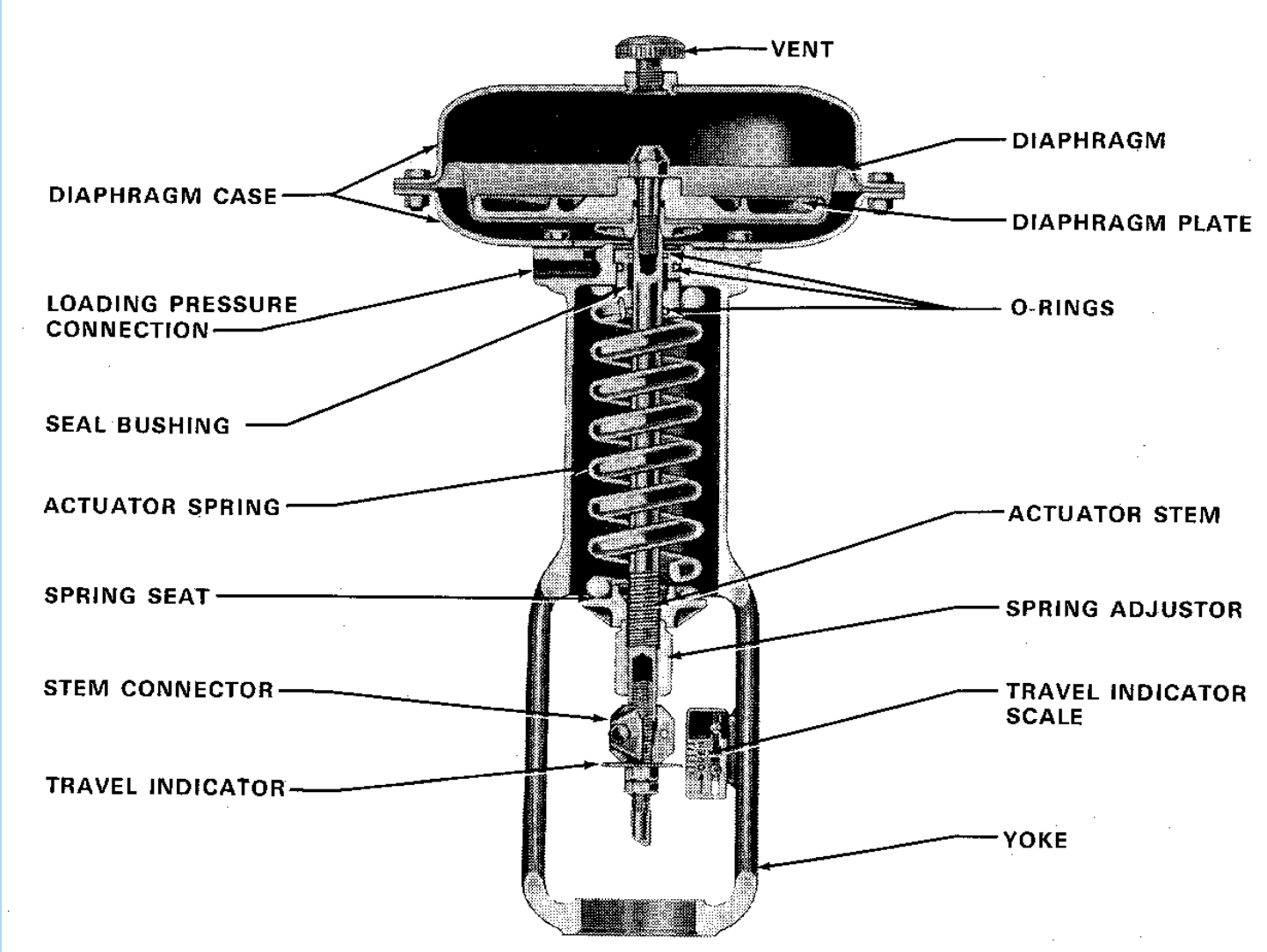
Diaphragm

- Direct Action
- Reverse Action
- Flexible material
 - Rubber
 - Neoprene
 - With Enforced material → Fiberglass, cotton, nylon

Direct Action Diaphragm



Reverse Action



Diaphragm

- Size of actuator depends upon
 - Valve size
 - Process pressures
- Large size
 - Un-necessary expensive
 - Delay
- Under size
 - Might be impossible to open or close the valve 100 %.
- Diaphragm casings
- Diaphragm Plate
- O rings

Piston Actuators

- Piston Actuator → Cylinder Actuator
- For high pressure
- Large diameter of pipe line
- Single Acting with spring
- Double acting

Range Spring

- Diaphragm size
- Bench Set
 - 3 to 15 PSI
 - 6 to 21 PSI
 - 6 to 30 PSI

Yoke

- Linkage between actuator and valve body
- Usually self aligned but needed very carefully to install.
- Tag, Name plate
 - All data about actuator
 - Supply Pressure
 - Bench set
 - Air to open or air to close

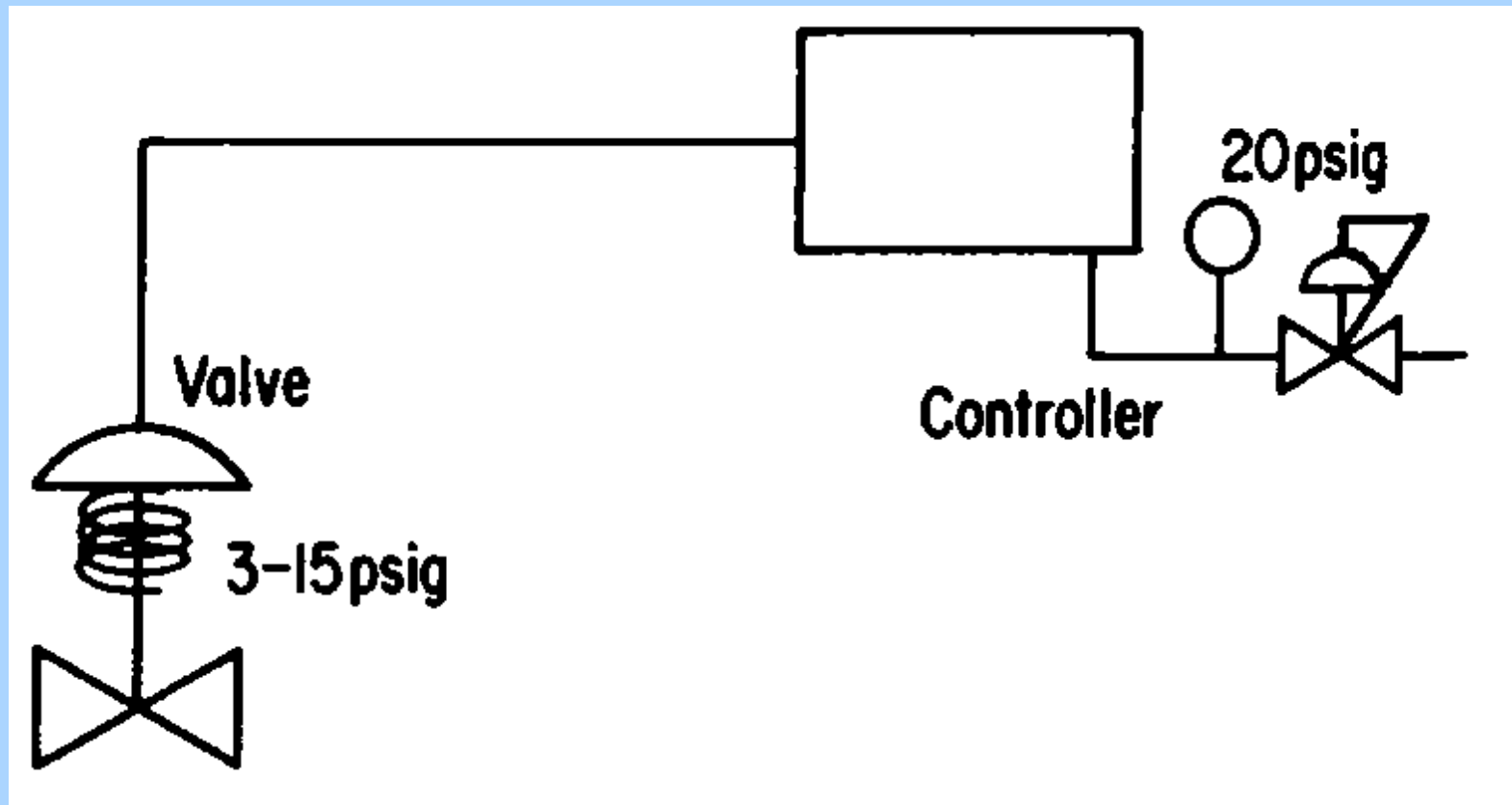
Yoke



Working of Control Valve

- Simple Valve
- Without Positioner
- Bench Set 3 to 15 PSI
- No air supply needed
- Only I/P or controller out put 3 to 15 PSI will operate the Valve.
- Direct Action

Control Valve without Positioner



Positioner

- Main function
 - Just like a controller
 - To cover bench set
 - Quick Response

Positioner

- In put
 - 3 to 15 PSI
- Out Put
 - 3 to 15 PSI
 - 6 to 21 PSI
 - 6 to 30 PSI
 - Depends upon Bench Set of the valve

Application of Positioner

- Common Applications
 - To increase the control valve speed.
 - To operate spring-less actuators
 - Split range operation
 - Reverse action
 - To change the control valve flow characteristics
 - Nature of flow medium
 - For jam type process

Application of Positioner

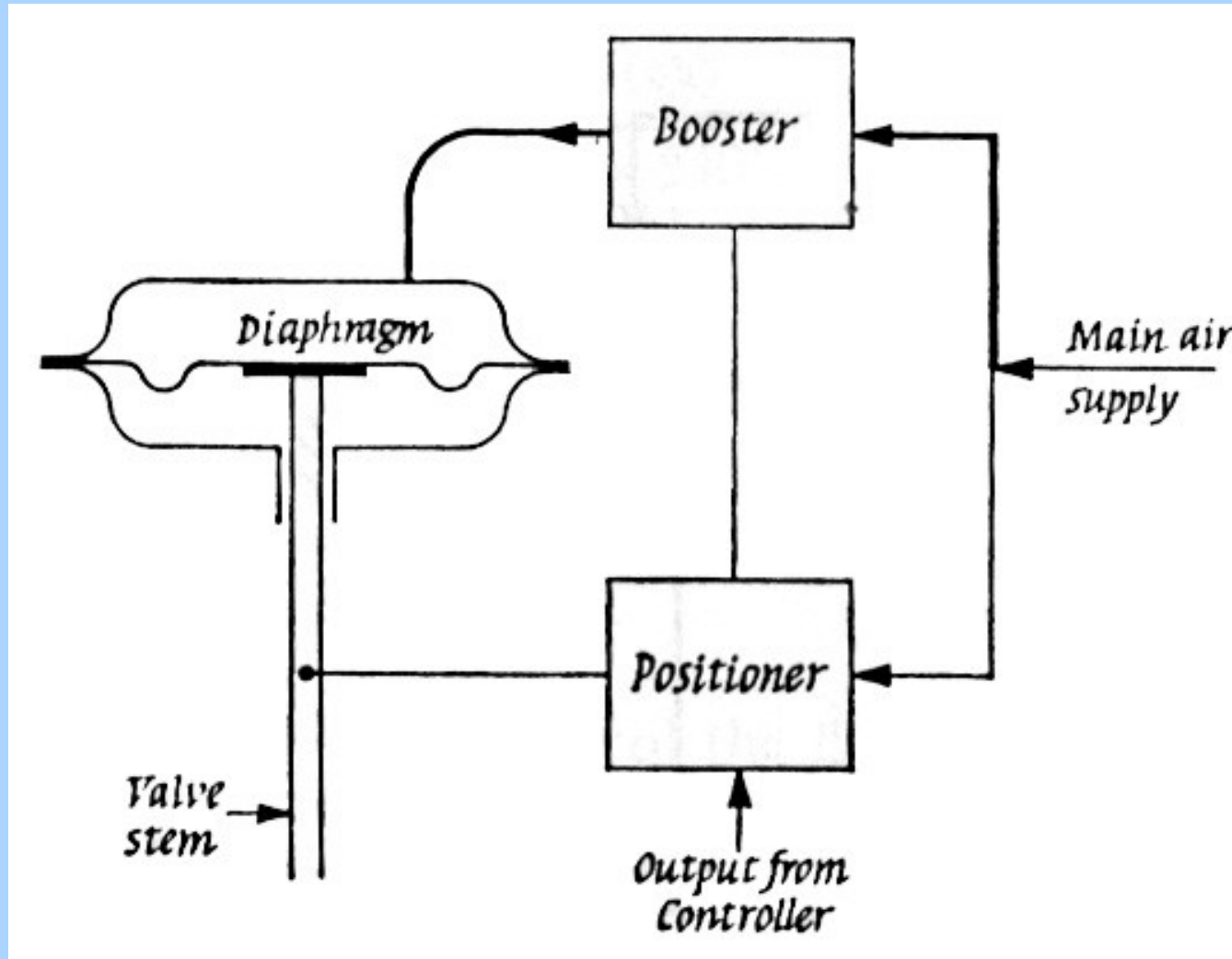
- Limitations

- Adding in the loop a controlling device
 - Loop must have minimum devices
- Expensive
- Can be achieved better results with the help of
- Volume booster
- Pressure booster

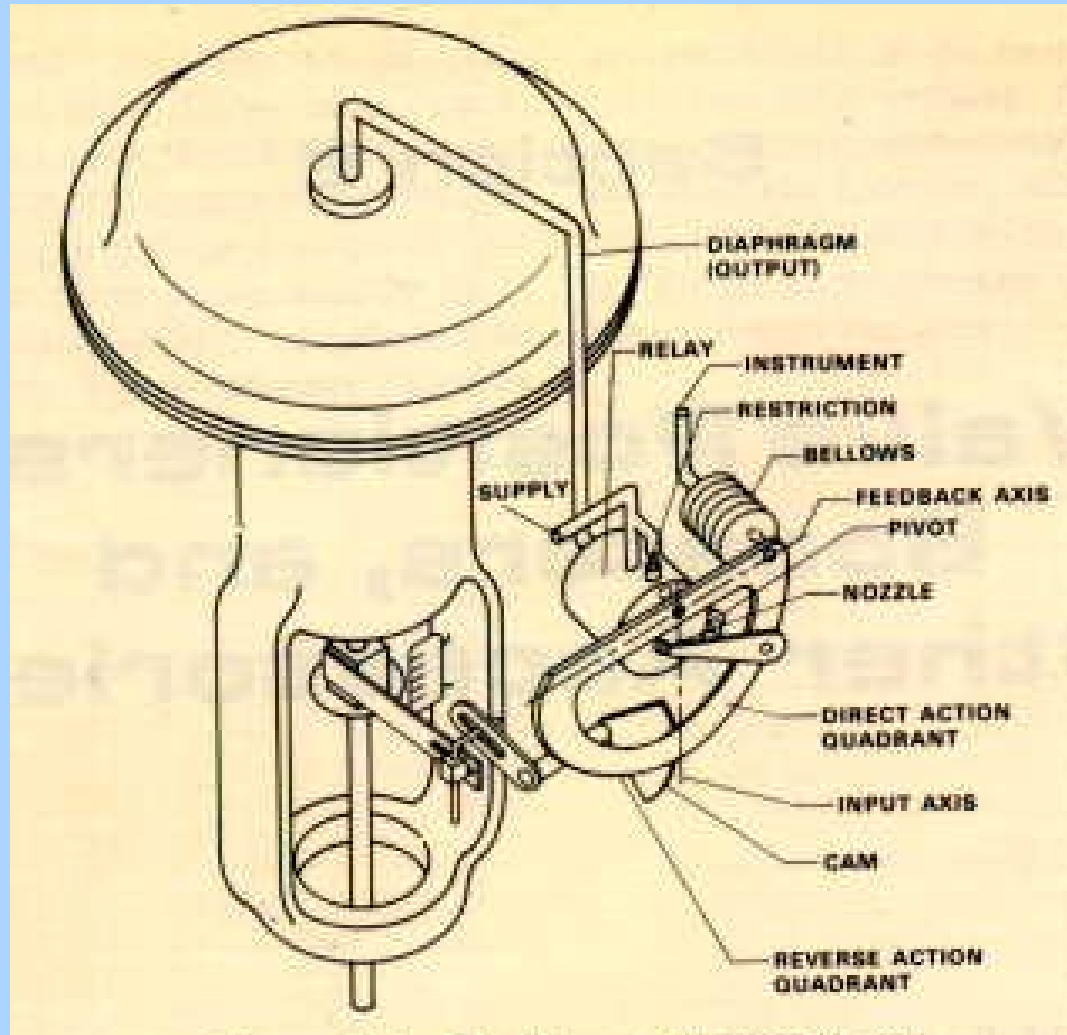
Types of Positioners

- Side mounted
- Top mounted
- Double acting Positioner
- Electronic

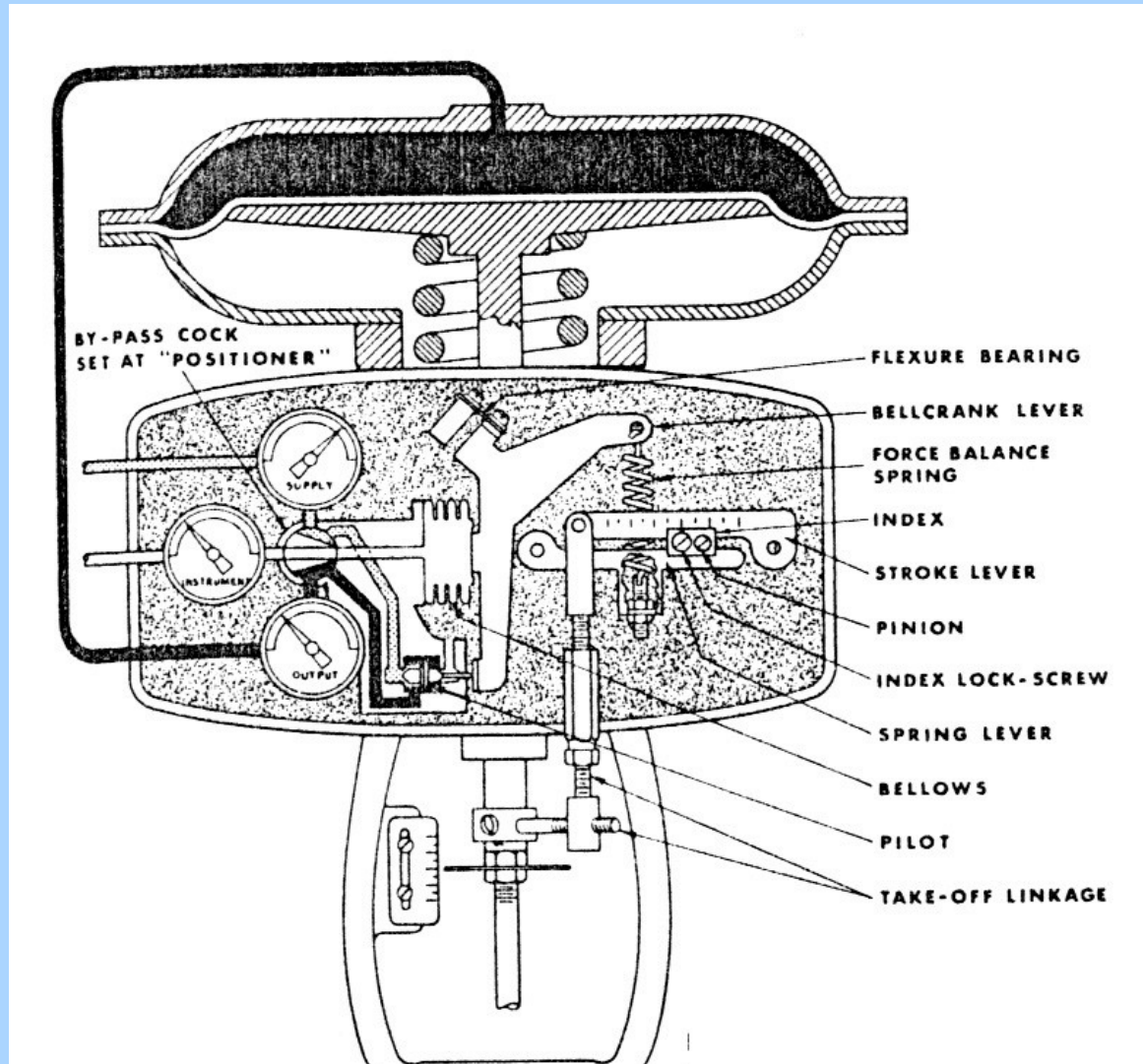
Control Valve With Positioner



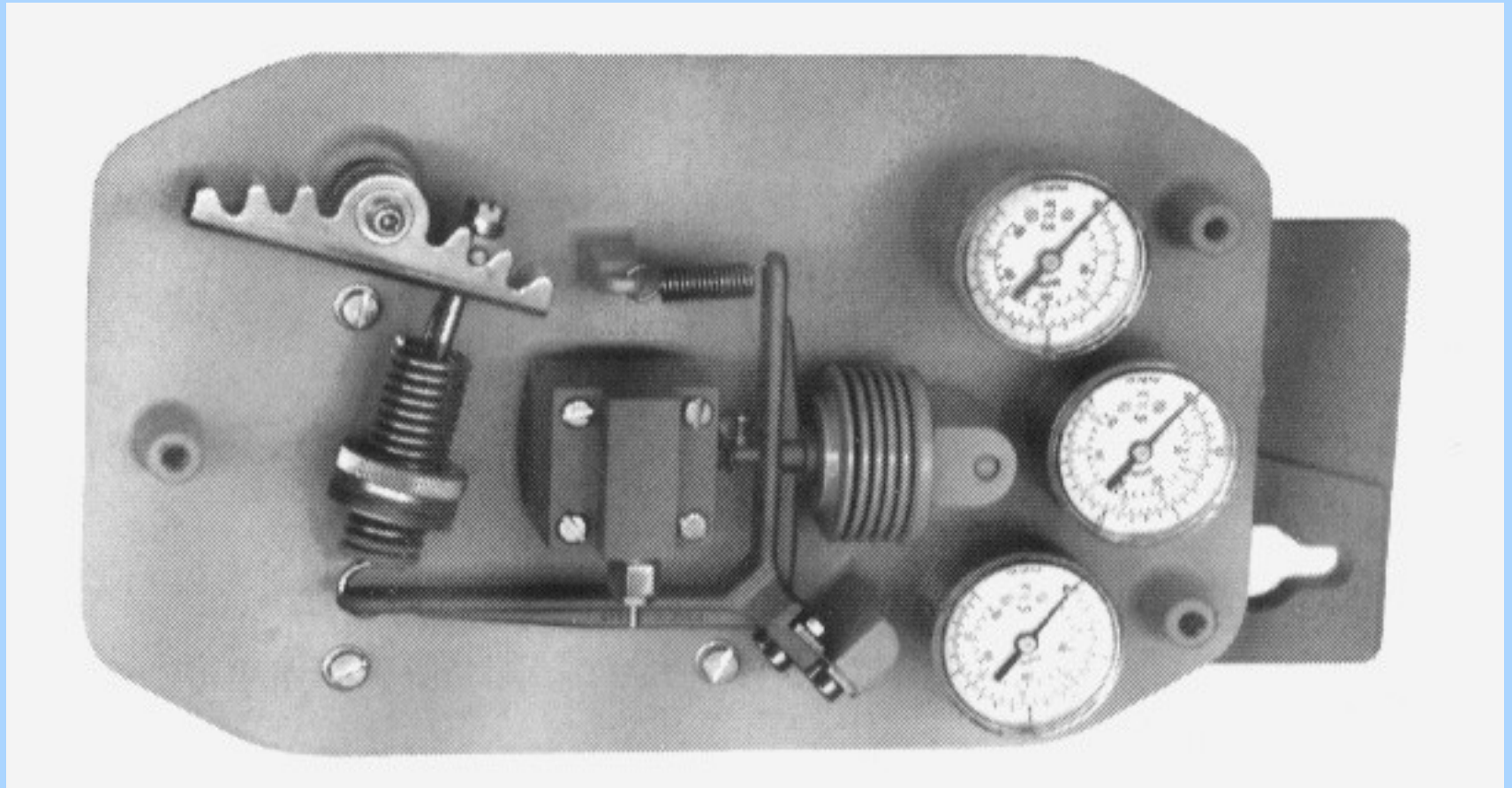
Valve with Positioner



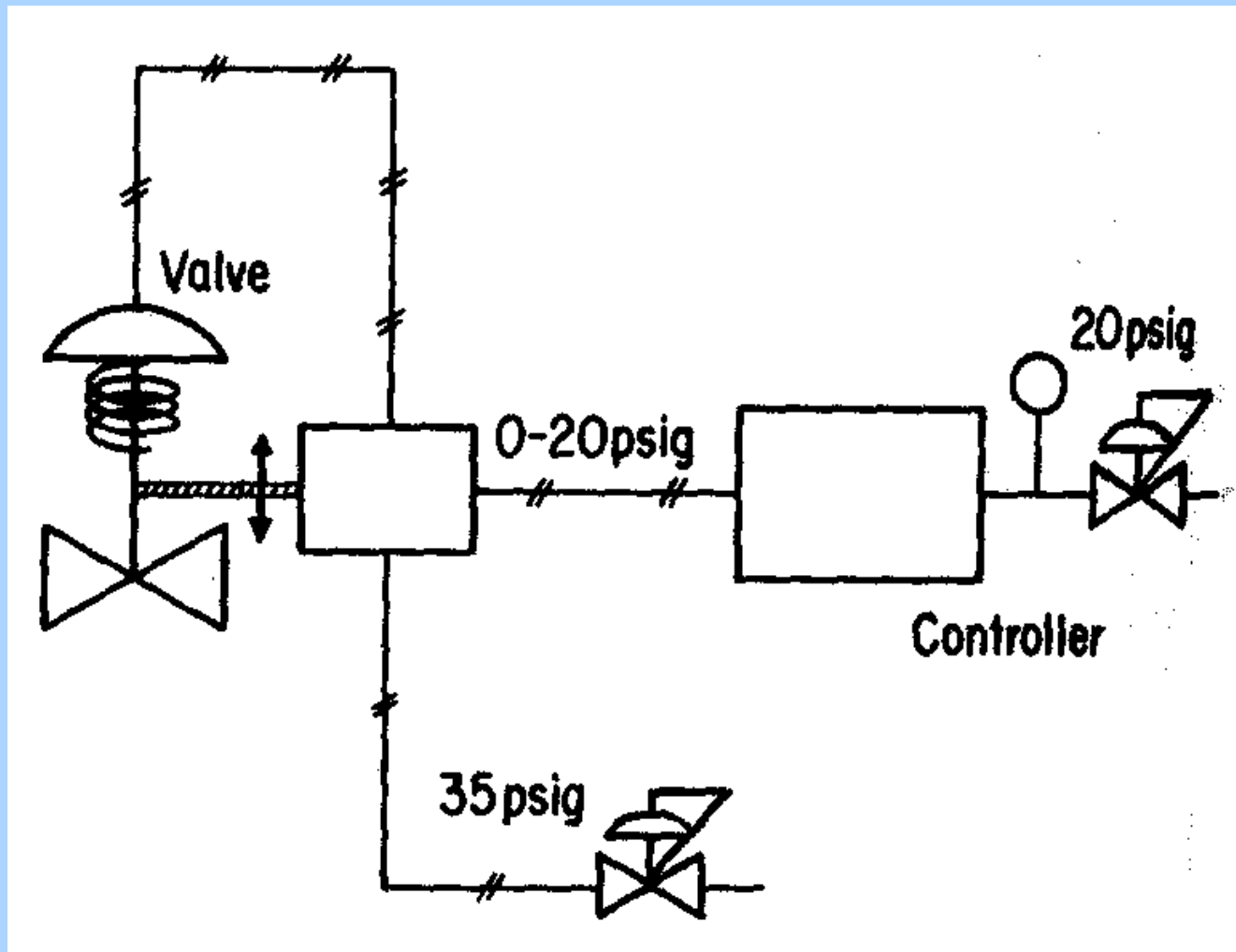
Valve With Positioner



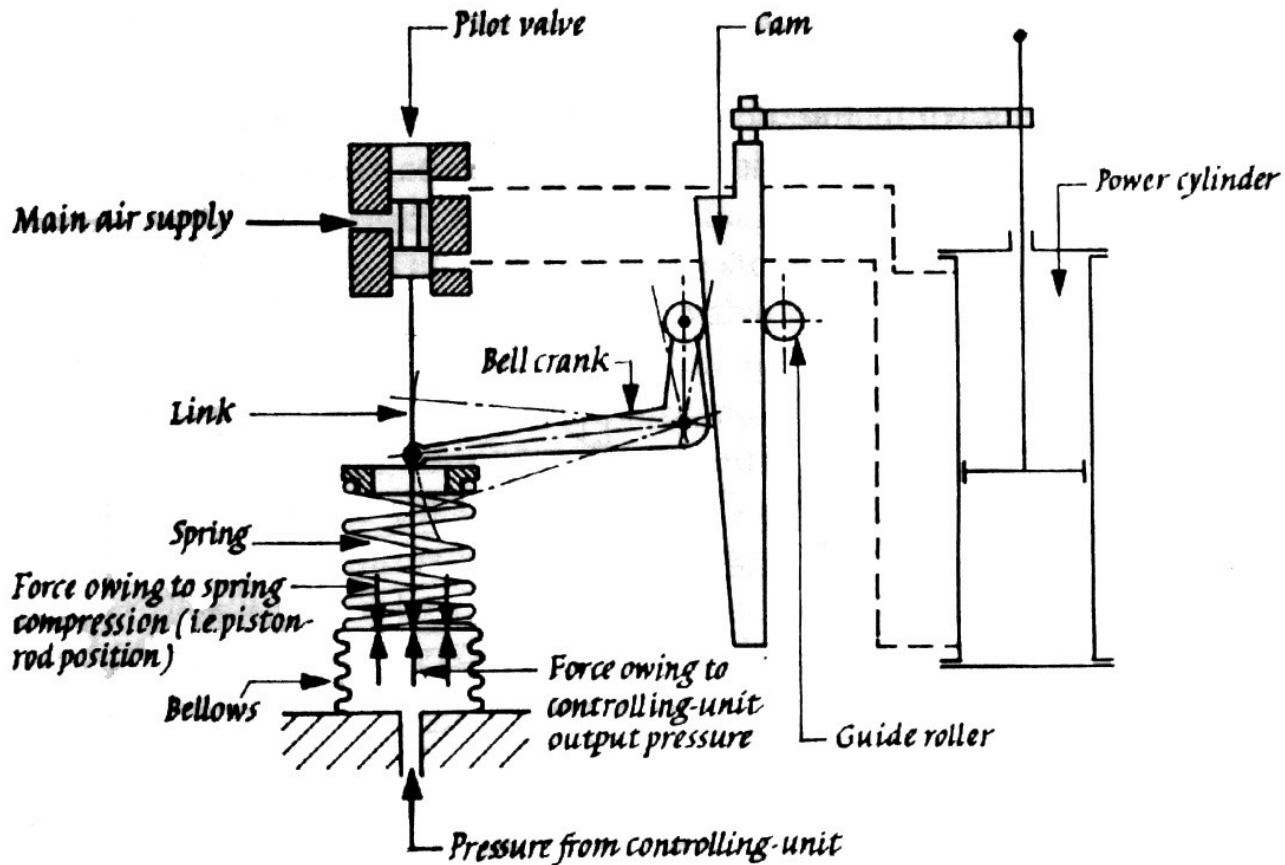
Positioner



Control Valve with Positioner



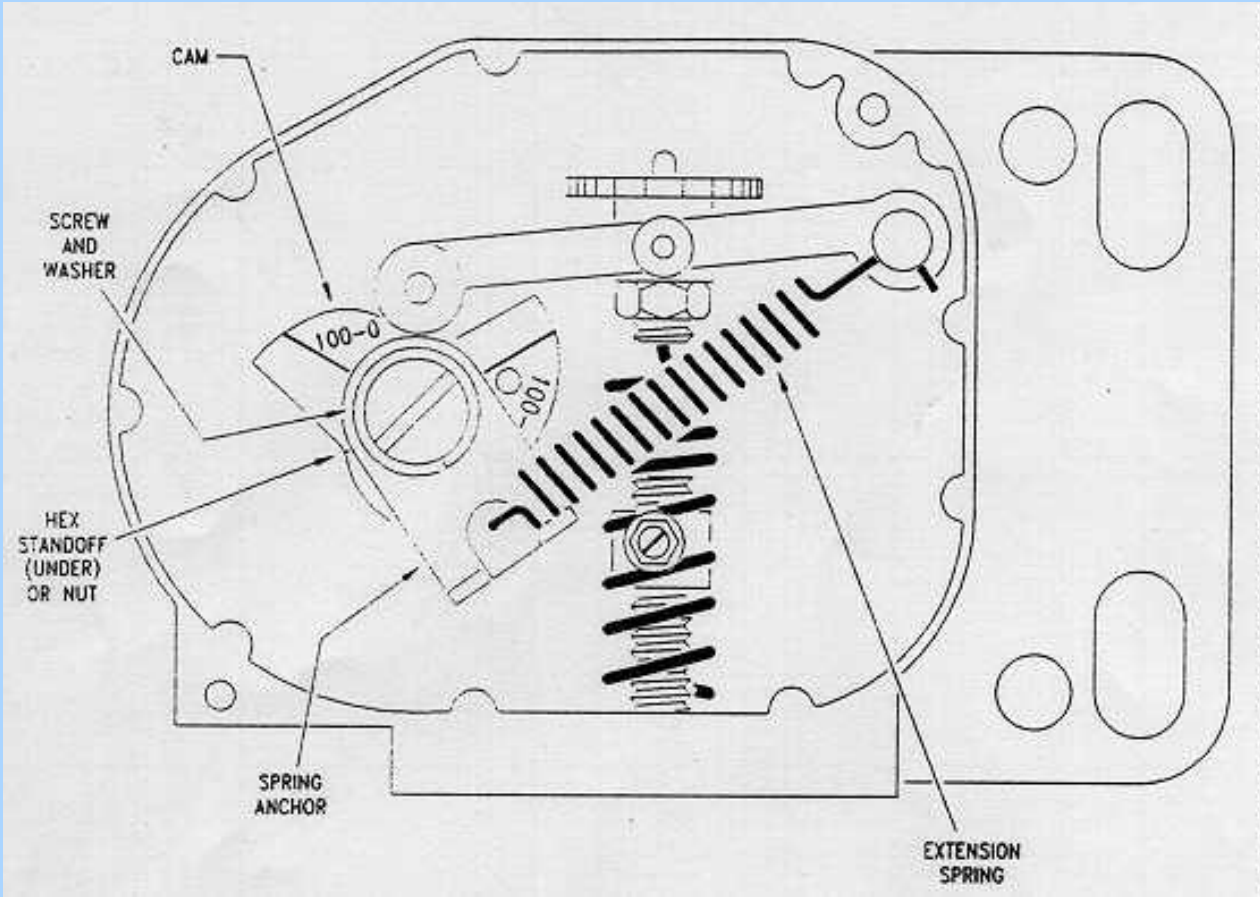
Control Valve with Positioner



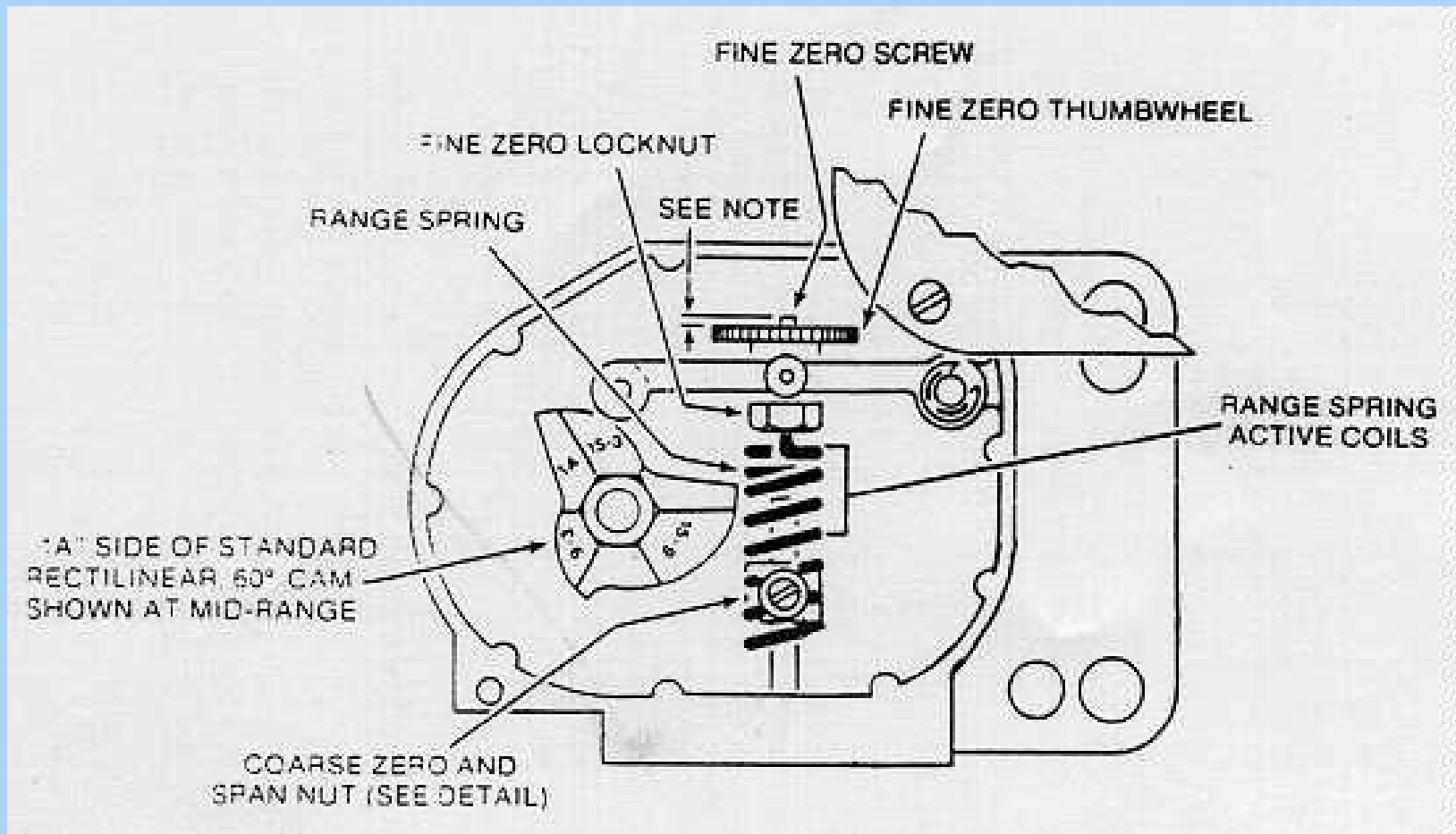
Cams

- Linear
- Equal Percentage
- Quick Opening

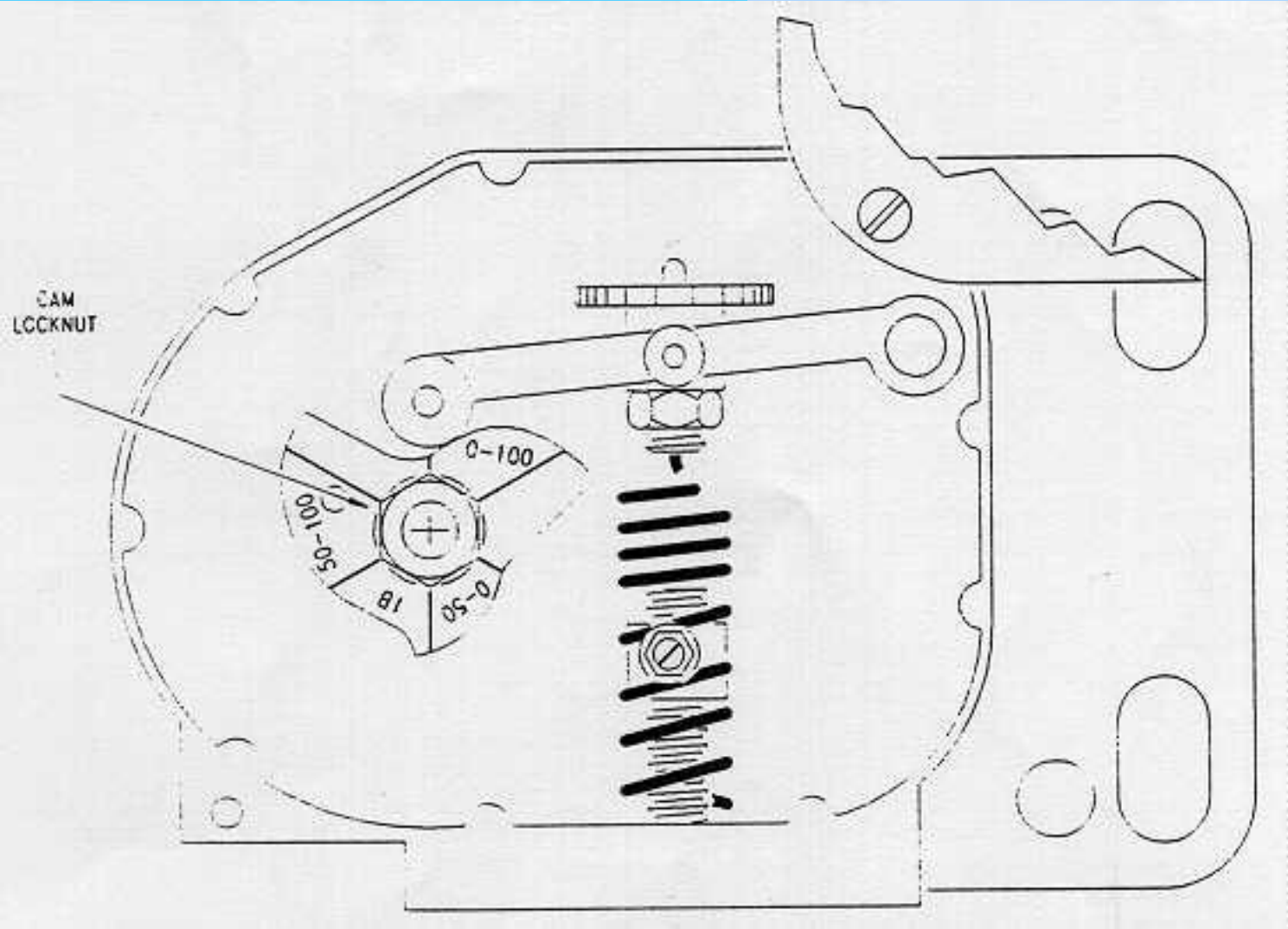
Cams



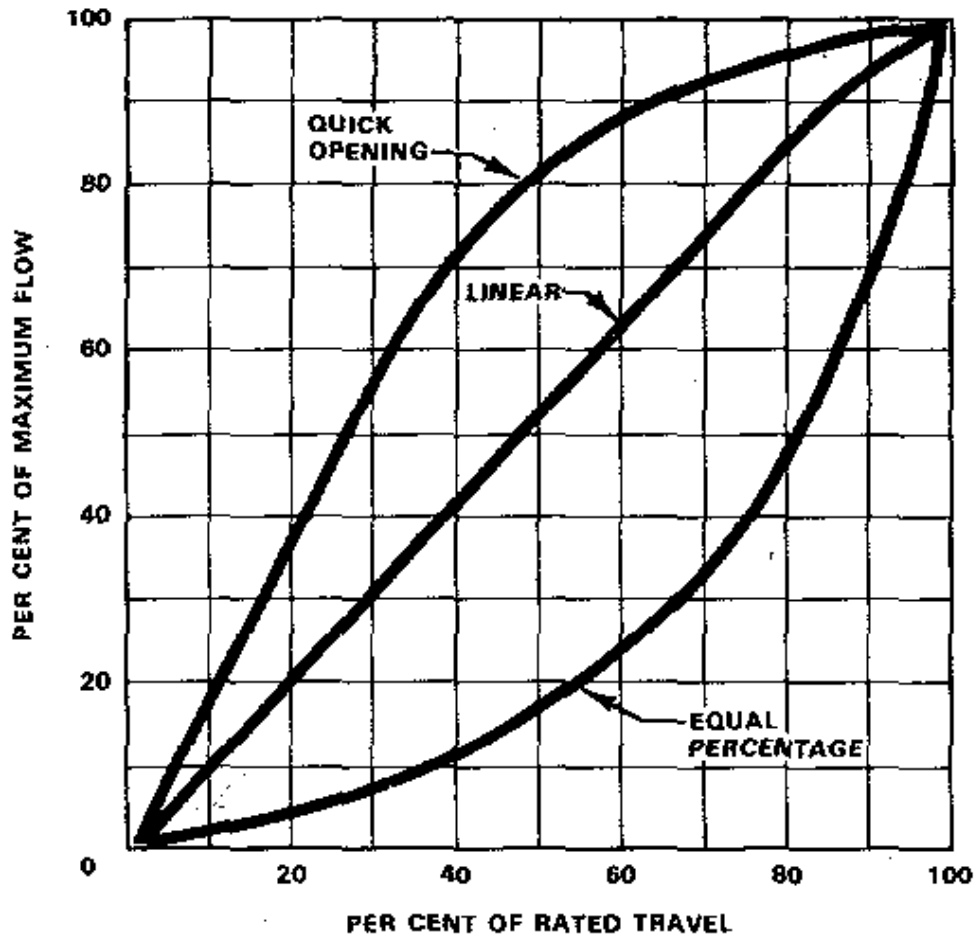
Cams



Cams



Cams



Volume Booster / Pressure Booster

- Volume booster increases volume of air for diaphragm
- To increase the speed of operation
- Almost an essential component of a vent valve
- Pressure booster also used for increasing the speed of control valves by increasing the pressure.

Flashing / Cavitations

- Flashing

- Just like a sand blasting
- Flashing liquid contains vapours
- Vapours acts like a sand and liquid acts like a carrier

- Cavitation

- Two stage phenomenon
- 1st stage → Formation of voids or cavitations with the liquid system

Flashing / Cavitations

- 2nd stage → Collapse or implosion of the cavitation back to the liquid
- Result → Cavitation → Damage of trim material of valves.

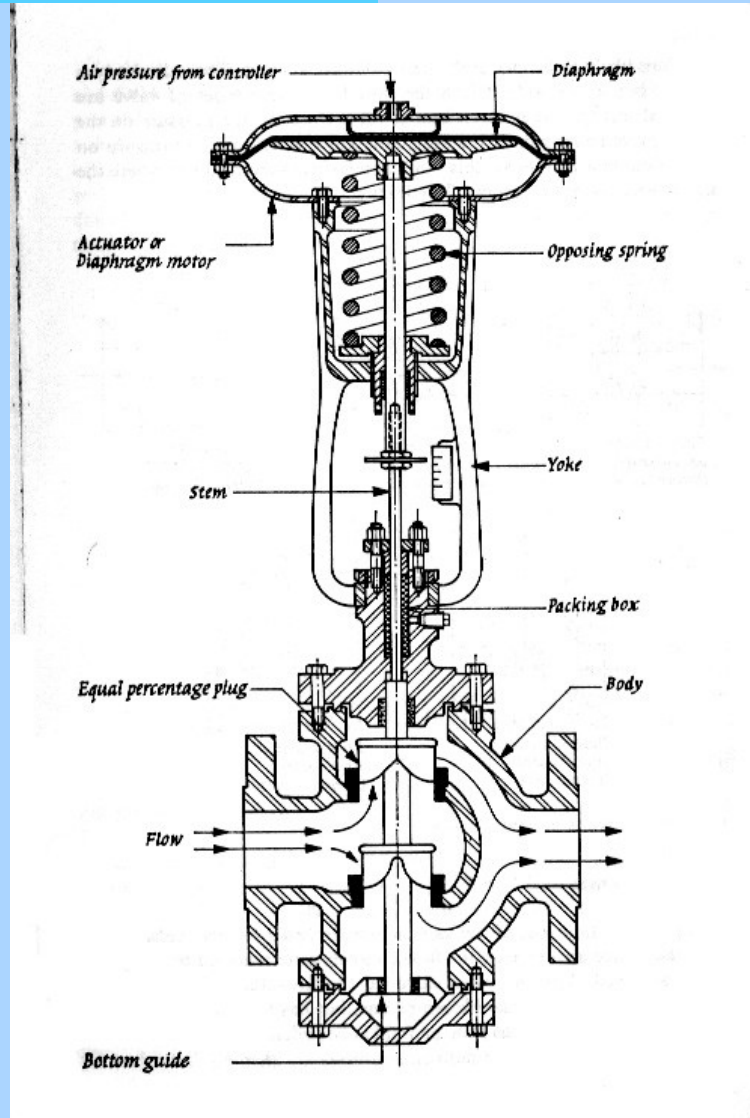
Flashing



Cavitation



Complete Valve



To Inspect Trim Material

- Marking the side of yoke with bonnet
- Marking the side of bonnet with body
- Noting Threads
- Valve is under Bench Set Pressure
- To release the bench spring pressure, apply signal to open the valve
 - Even the valve is faulty and not in operation condition.

Yoke / Bonnet Marking



To Inspect Trim Material

- Loose coupling / Connector
- The lift of valve should be not more than 10%.
- After disconnecting stem & coupling,
Remove Check nut of yoke
- Remove Valve Actuator etc.
- Loose bonnet bolts

To Inspect Trim Material

- Inspect every trim material especially
- Seat Ring
- Plug
- Gaskets
- Body erosions
- Bonnet erosions

To Inspect Trim Material

- Any crack
- Not leave any thing abnormal.
- Replace Glands
 - If OK then insert one or more rings if possible
- Outer surface of seat and plug are usually made harden.
 - If machining is required then be careful about the depth of cut.

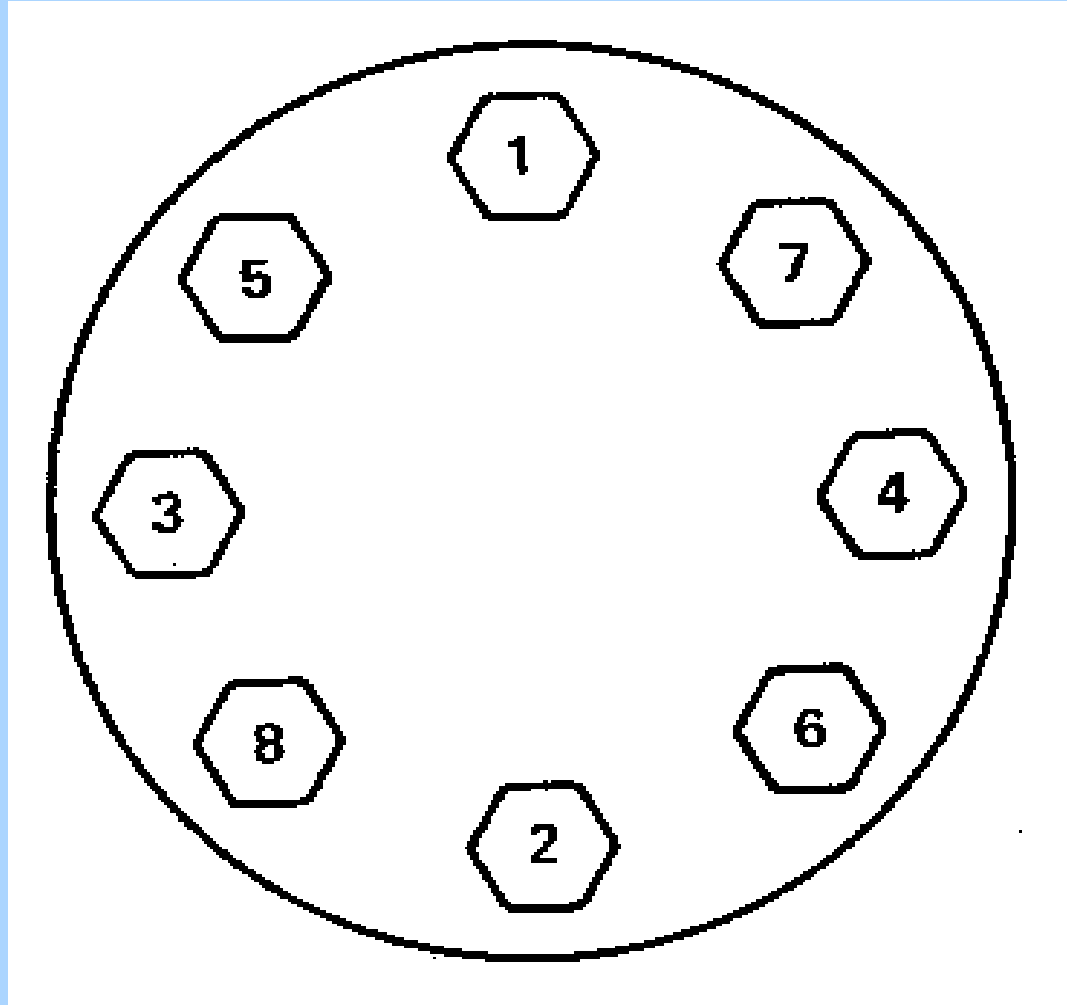
To Inspect Trim Material

- If cage is being used then
- Check its sealing gasket
- Back up rings
- If not original available then locally fabricated should match the material with process.

Sealing Gasket / Back up Ring



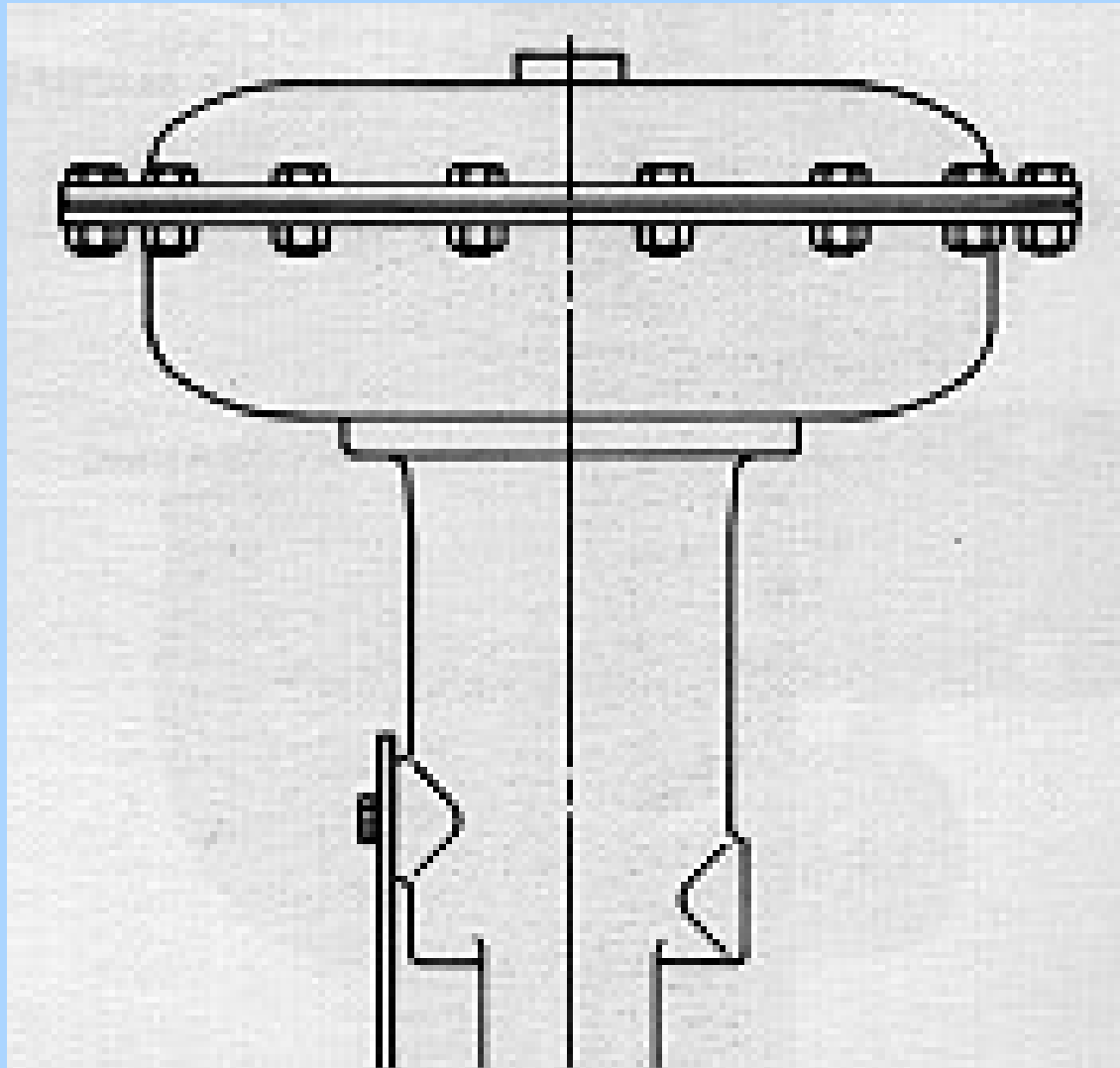
Tightening Procedure



To Dismantle Diaphragm

- Marking
- Spring Force
- Bench Set
- Usually Force becomes minimum, while loosening the nut / bolts
- Four long bolts

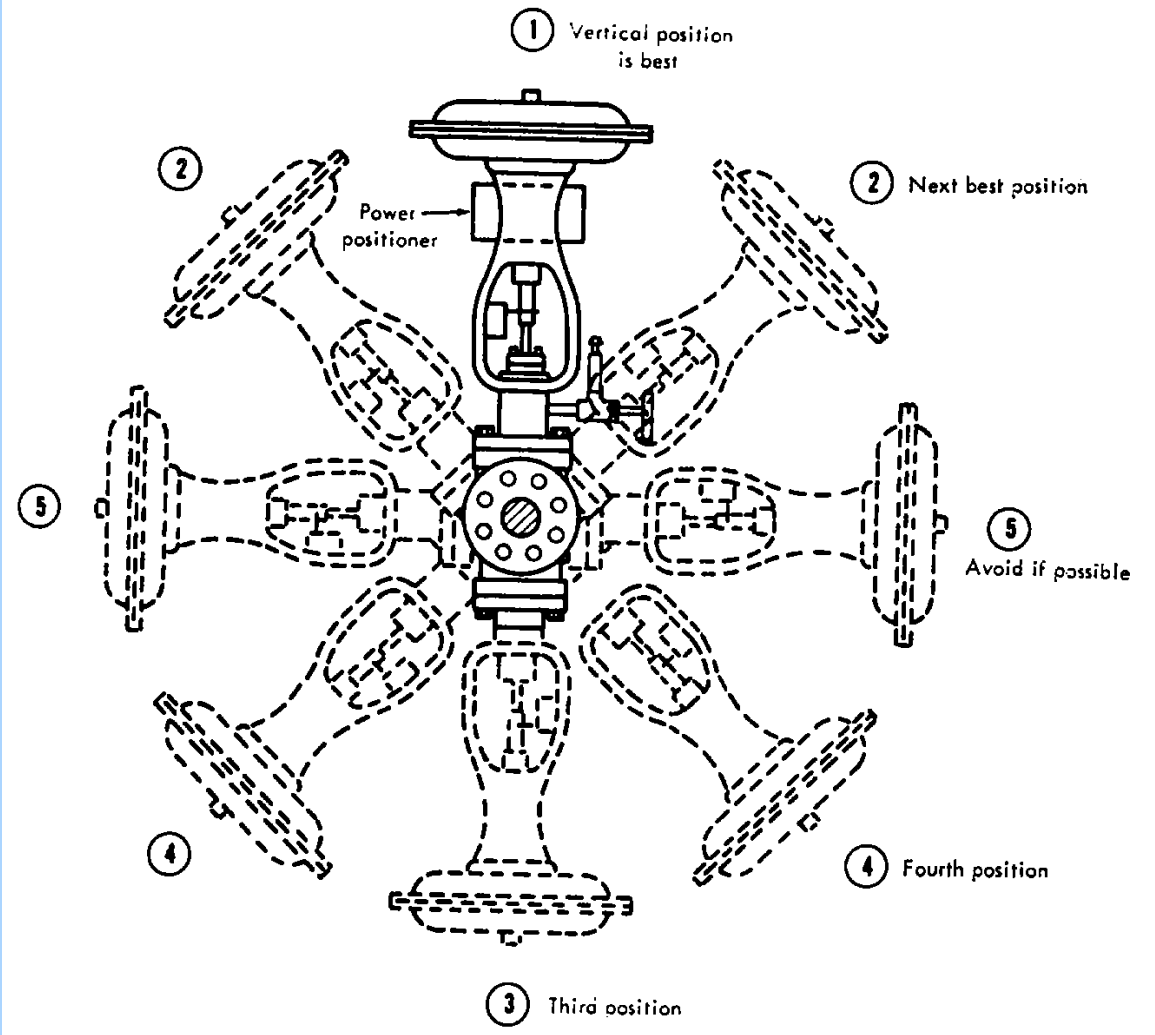
To Dismantle Diaphragm



To Dismantle Diaphragm



Installation



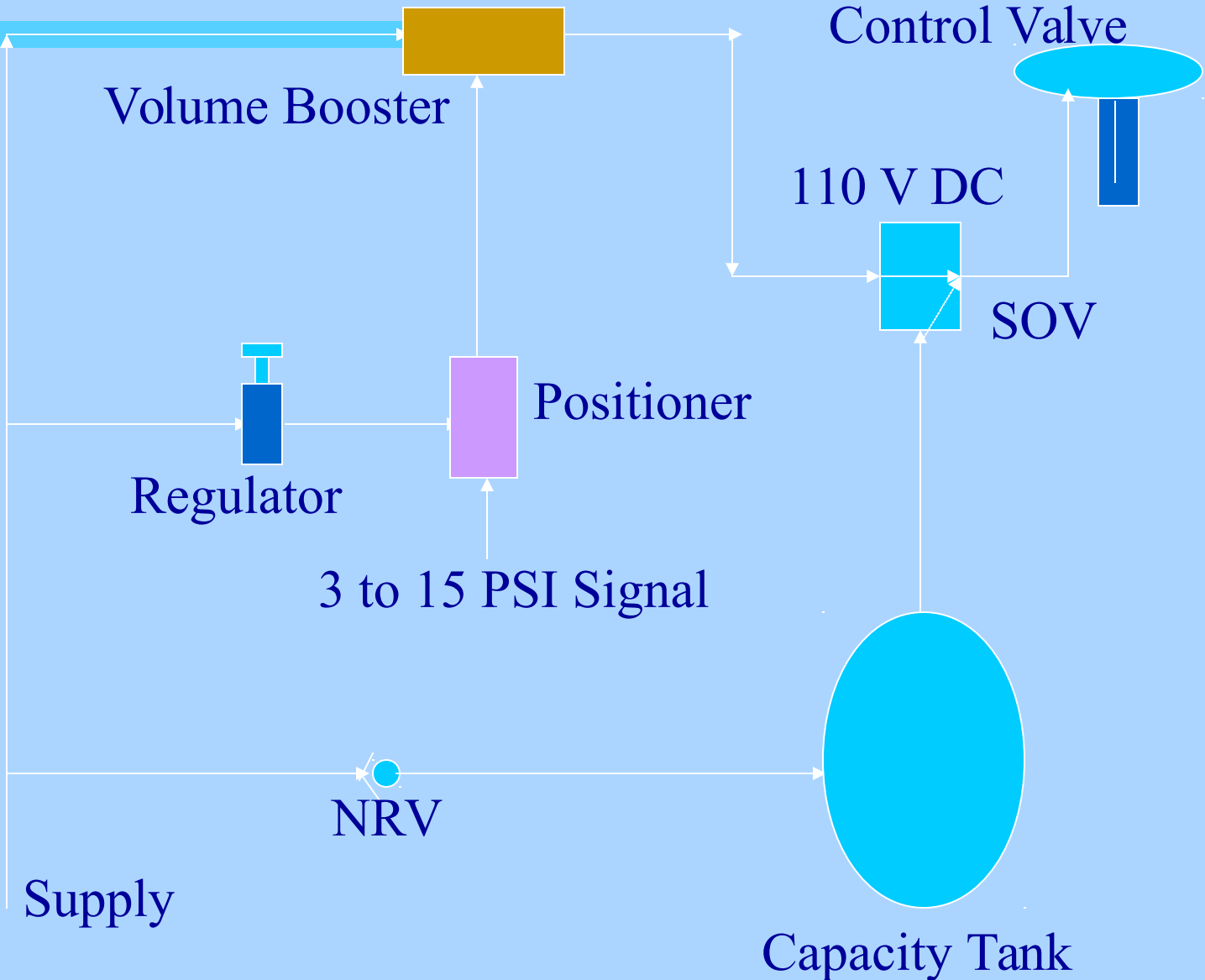
Control Valve With Two H. Wheels



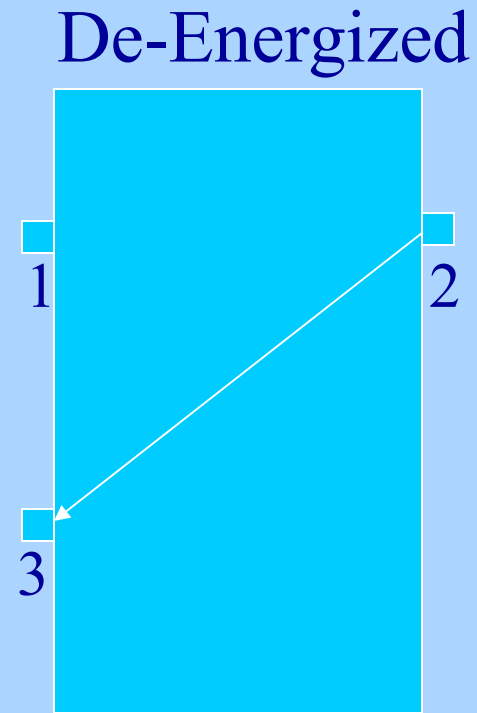
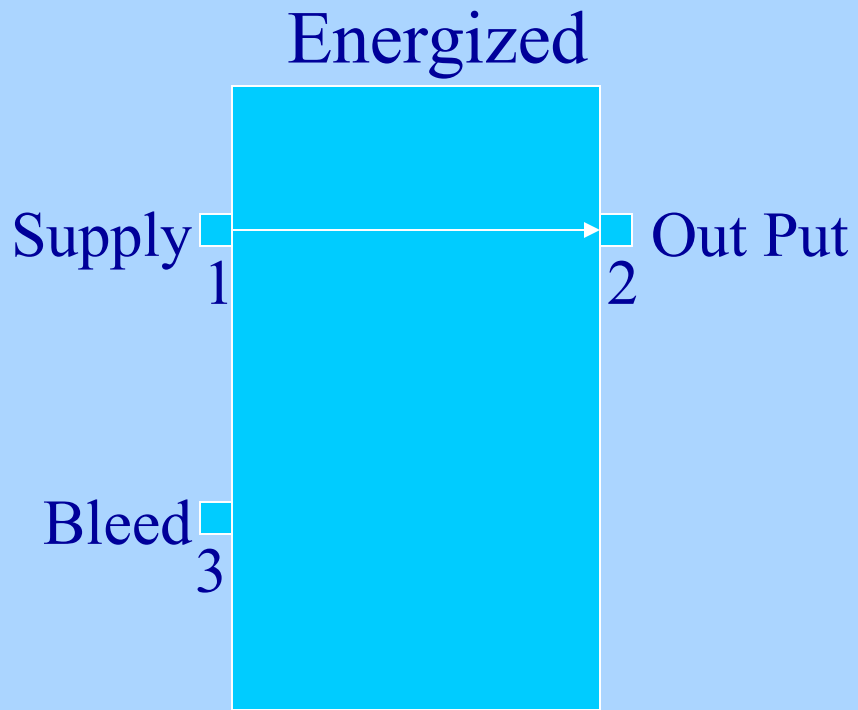
Dryer



Control Valve Loop



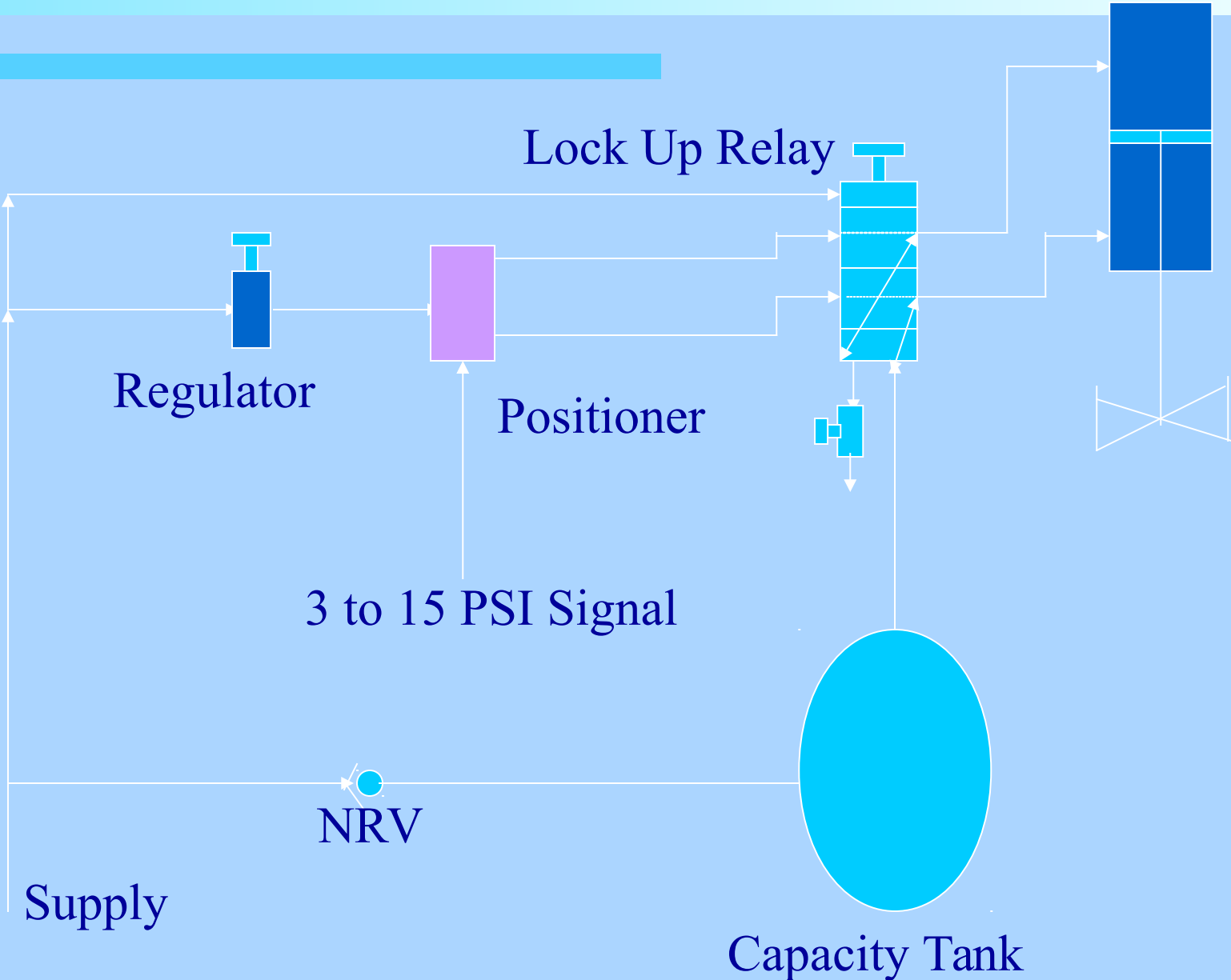
SOV



Precautions

- In case of Electric device such as
 - SOV
 - Must have Explosion proof class.
 - When working at terminal or in J.B.
 - It is in open condition, one must be more careful, because Explosion proof system is violated.

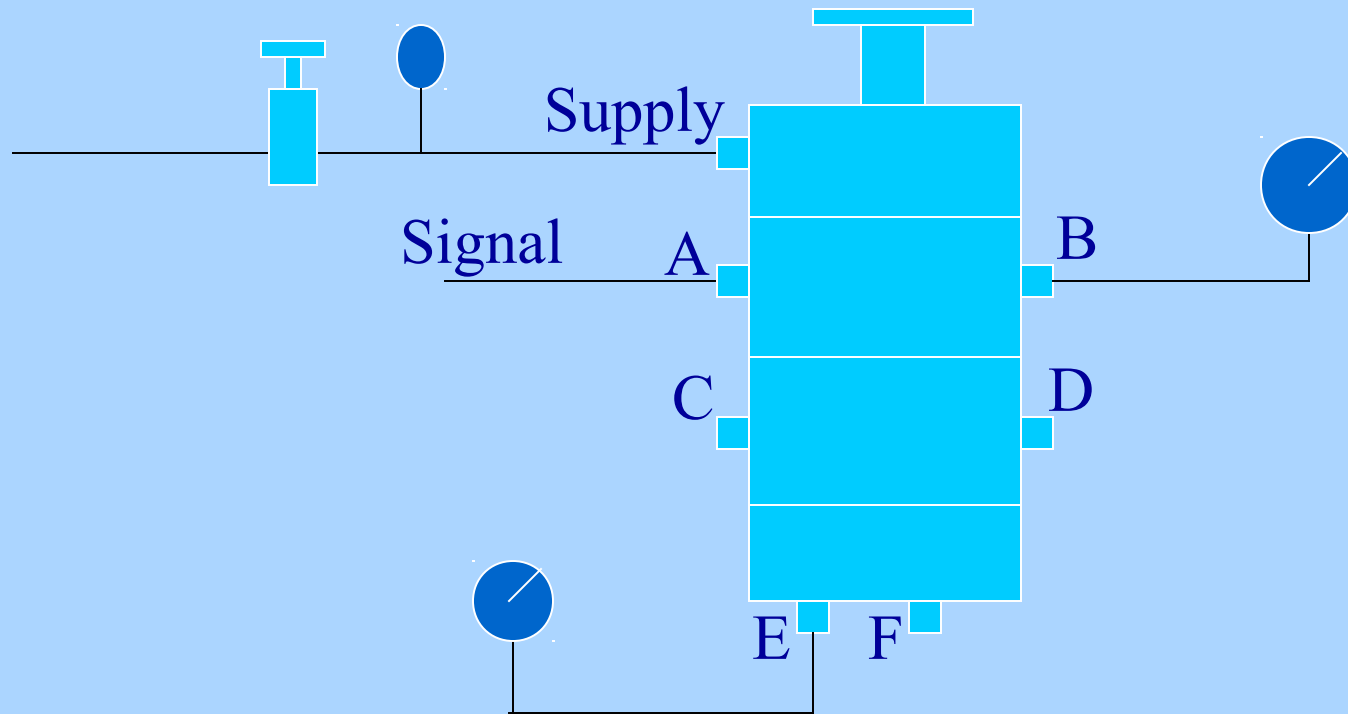
Control Valve Loop



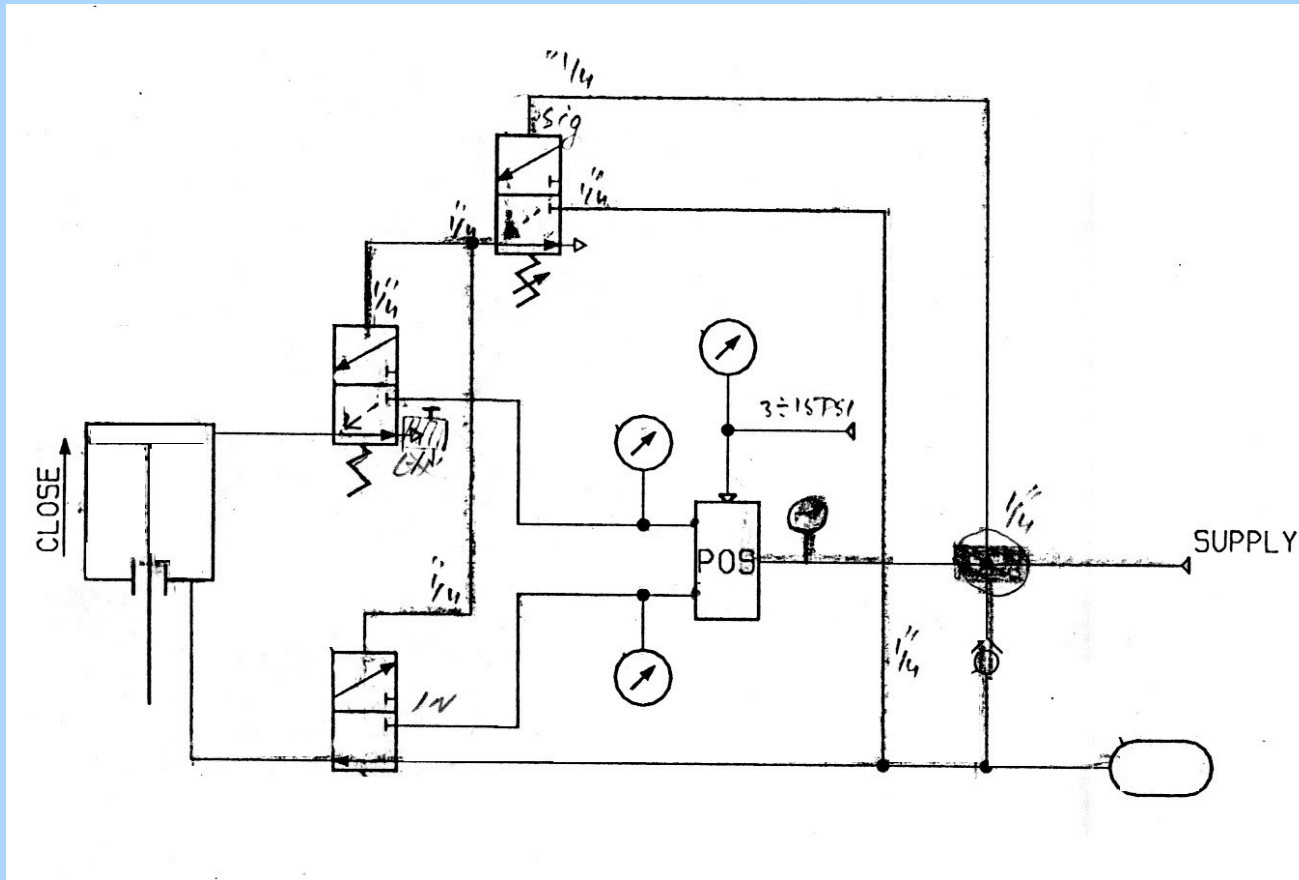
Setting Procedure of Lock Up Device

- To provide Regulated supply.
- Monitor the supply at out put gauge
- No leakage should other ports
- Decrease the set pressure, Port should change its path.
- E Port pressure gauge should indicate the above signal pressure.
- Repeat the same procedure for other ports also.

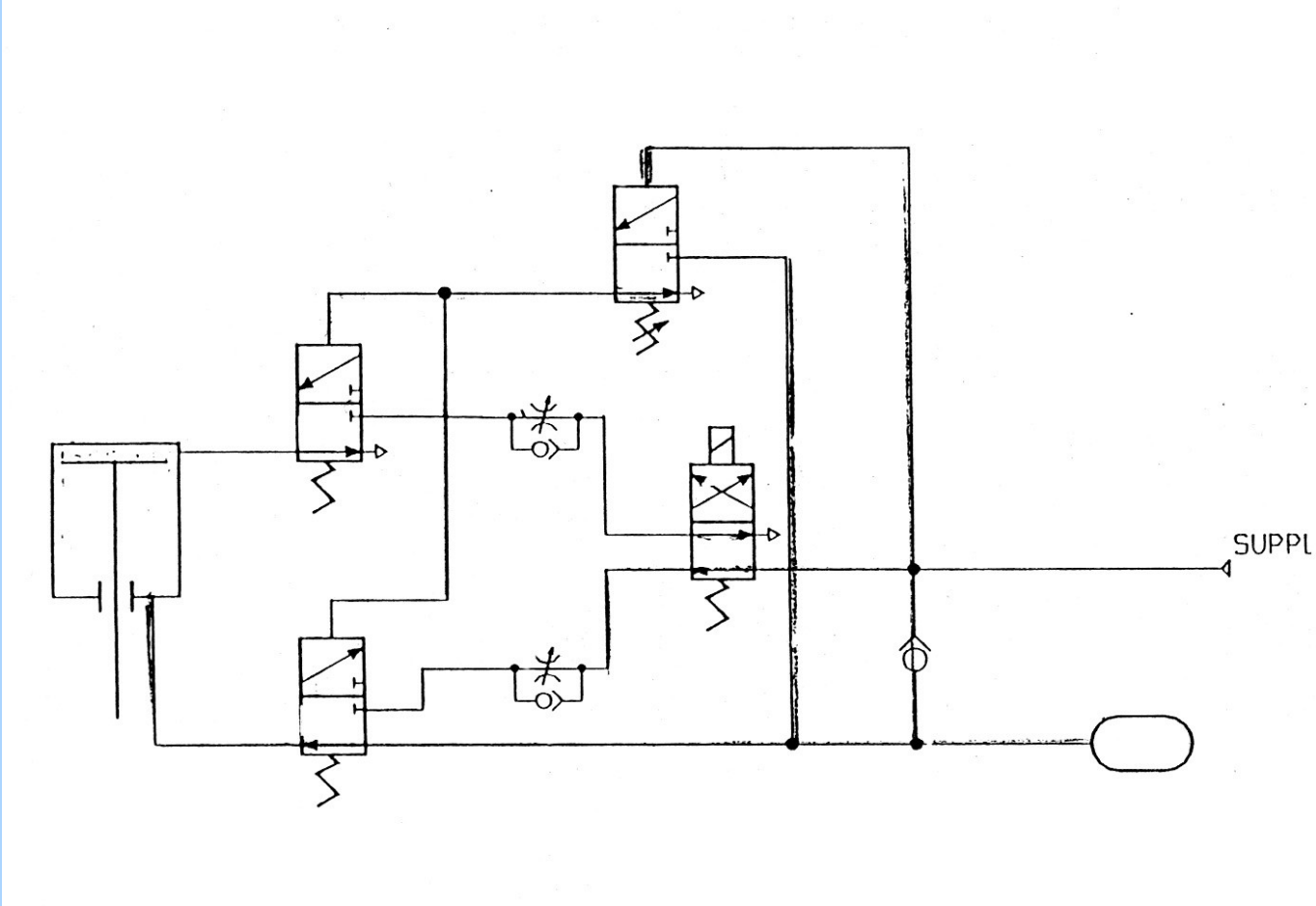
Checking & calibrating Procedure of Lock Up Device



Control Valve Loop



Valve Loop



Hand Jack / Hand Wheels

- Top Mounted
- Side Mounted
- Two Hand Jacks
- Hand Jacks can be used as Stopper
- Must have opened 5%, 10% or should not be closed more than 90%.

Auto/Manual Procedure of Control Valves (A)

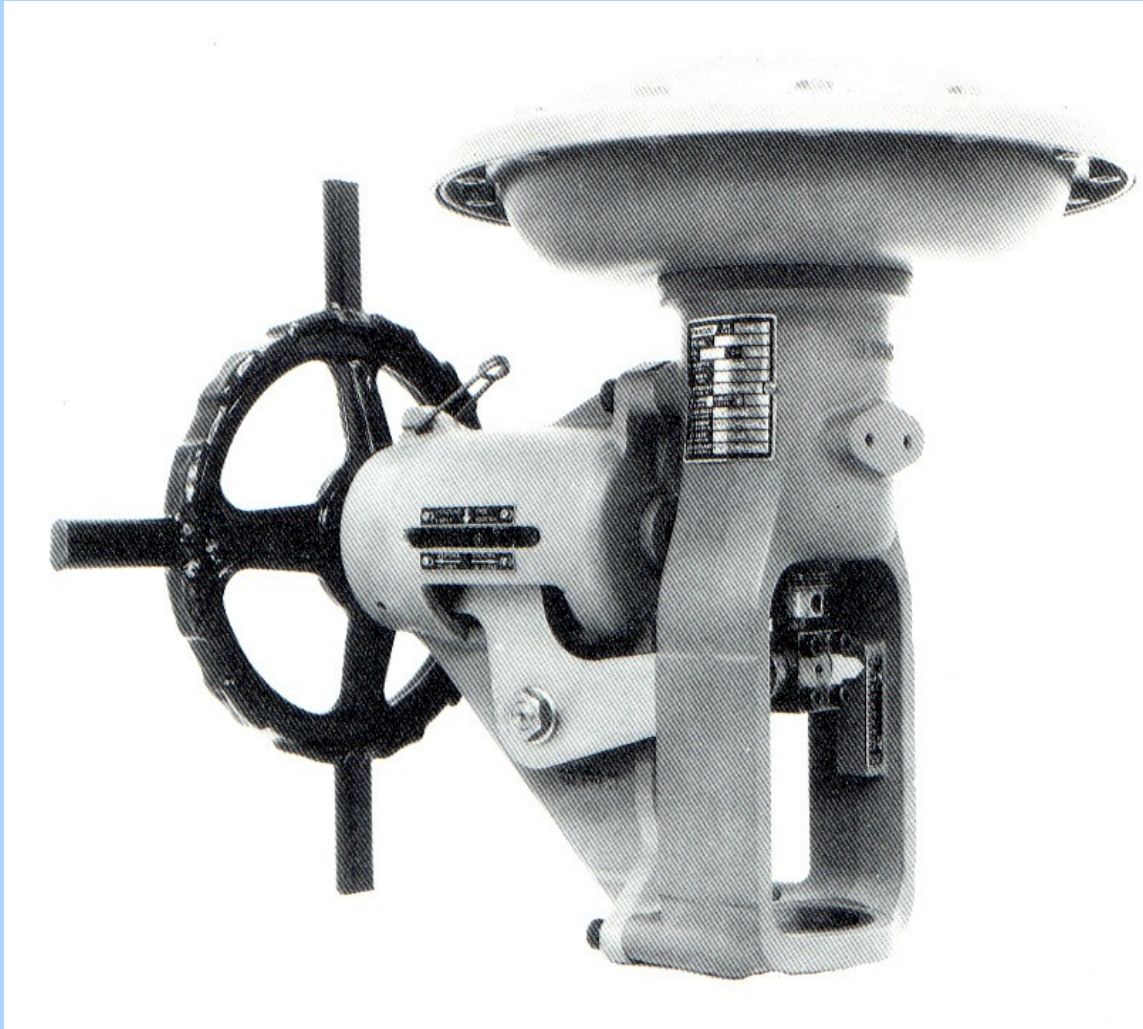
- **Auto to Hand Jack**

- Check the hand jack indicator is in “neutral” position.
- Move the hand jack clockwise / anti-clockwise to engage the lever mechanism.
- Close instrument air supply of control valve.
- Move the hand wheel clock wise or anti-clock wise to open or close the valve.

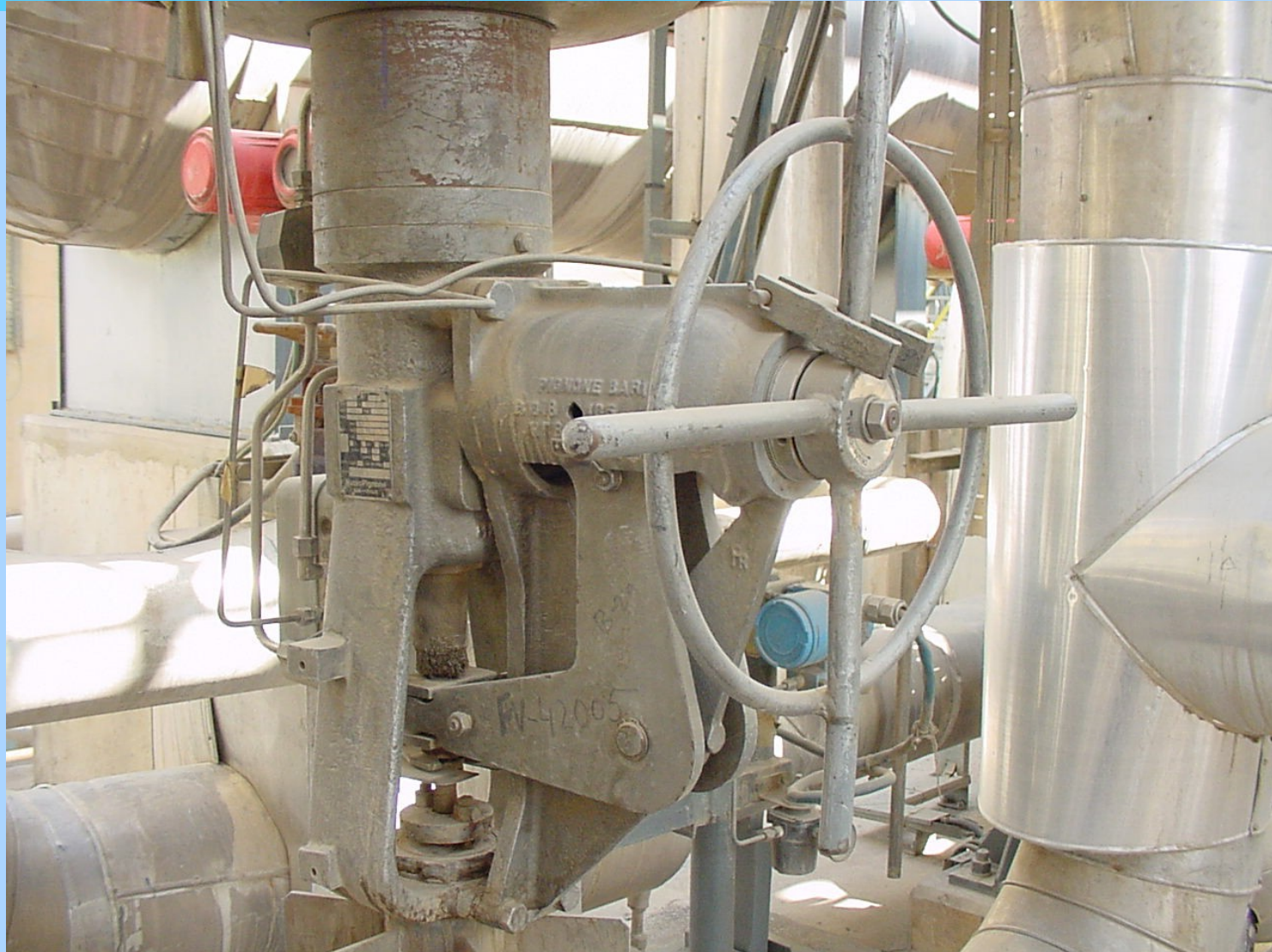
Auto/Manual Procedure of Control Valves (A)

- **Hand Jack to Auto**
- Inform control room crew to give the signal of controller according to the valve opening.
- Open instrument air supply of control valve.
- Move the hand wheel to “neutral” position slowly.
- Check pressure gauge indication of signal to the diaphragm for further confirmation.

Side Mounted Hand Jack



Side Mounted Hand Jack



Auto/Manual Procedure of Control Valves (B)

- **Auto to Hand Jack**
- Move the handwheel clockwise to engage valve stem with handwheel by inserting pin in it.
- Open instrument air by pass valve of piston
- Move the handwheel clockwise / anti-clockwise to open / close the valve respectively.
- Always check the heat of inserting pin.

Auto/Manual Procedure of Control Valves (B)

- **Hand Jack To Auto**
- Close instrument air signal by pass valve.
- Inform Control room crew to give output signal of controller according to the valve opening.
- Remove the pin and disengage the stem and hand wheel.
- Move the handwheel to full anti clock wise position.

Auto/Manual Procedure of Control Valves (B)



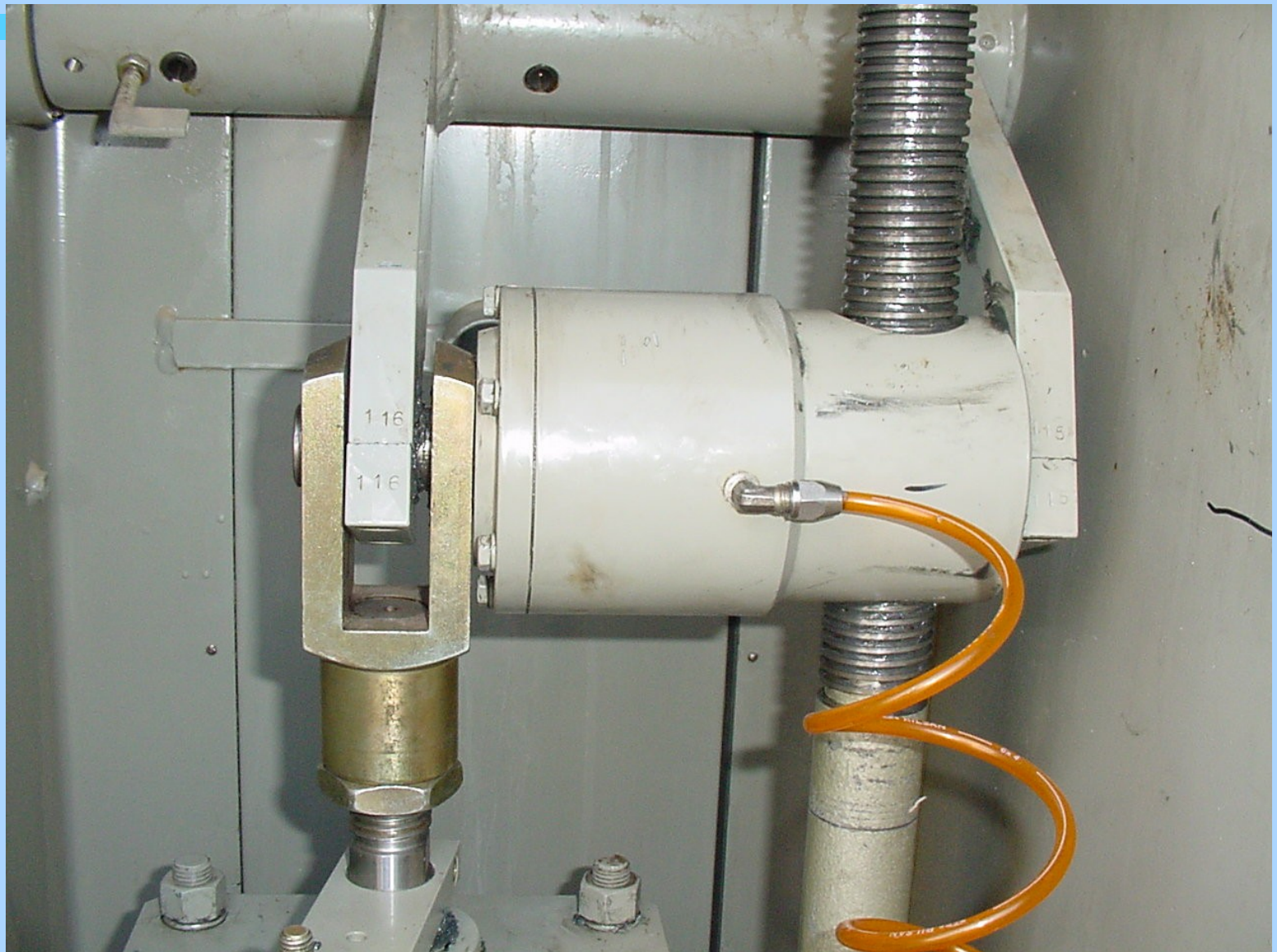
Auto/Manual Procedure of Control Valves (B)



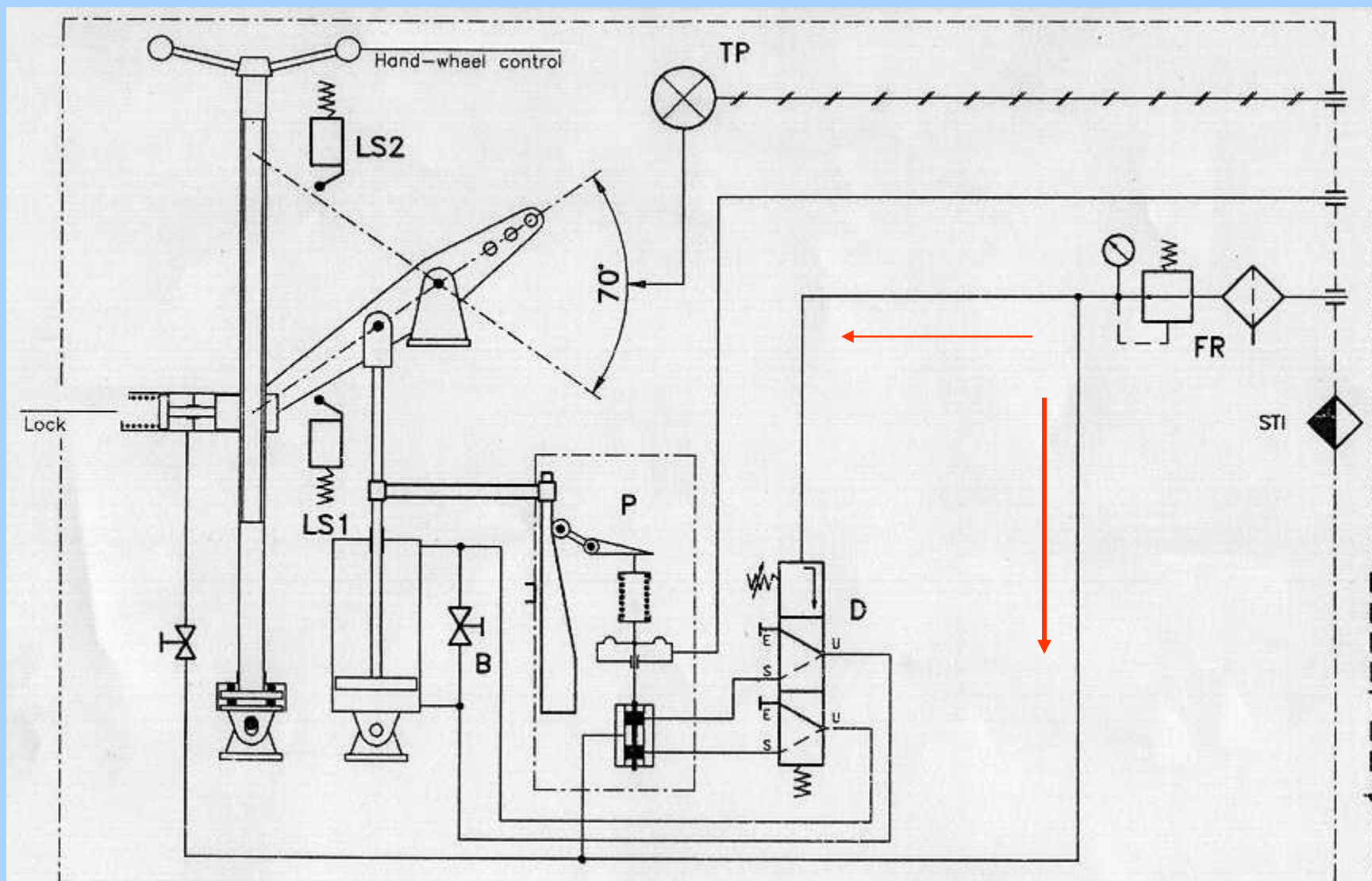
Auto/Manual Procedure of Control Valves (C)



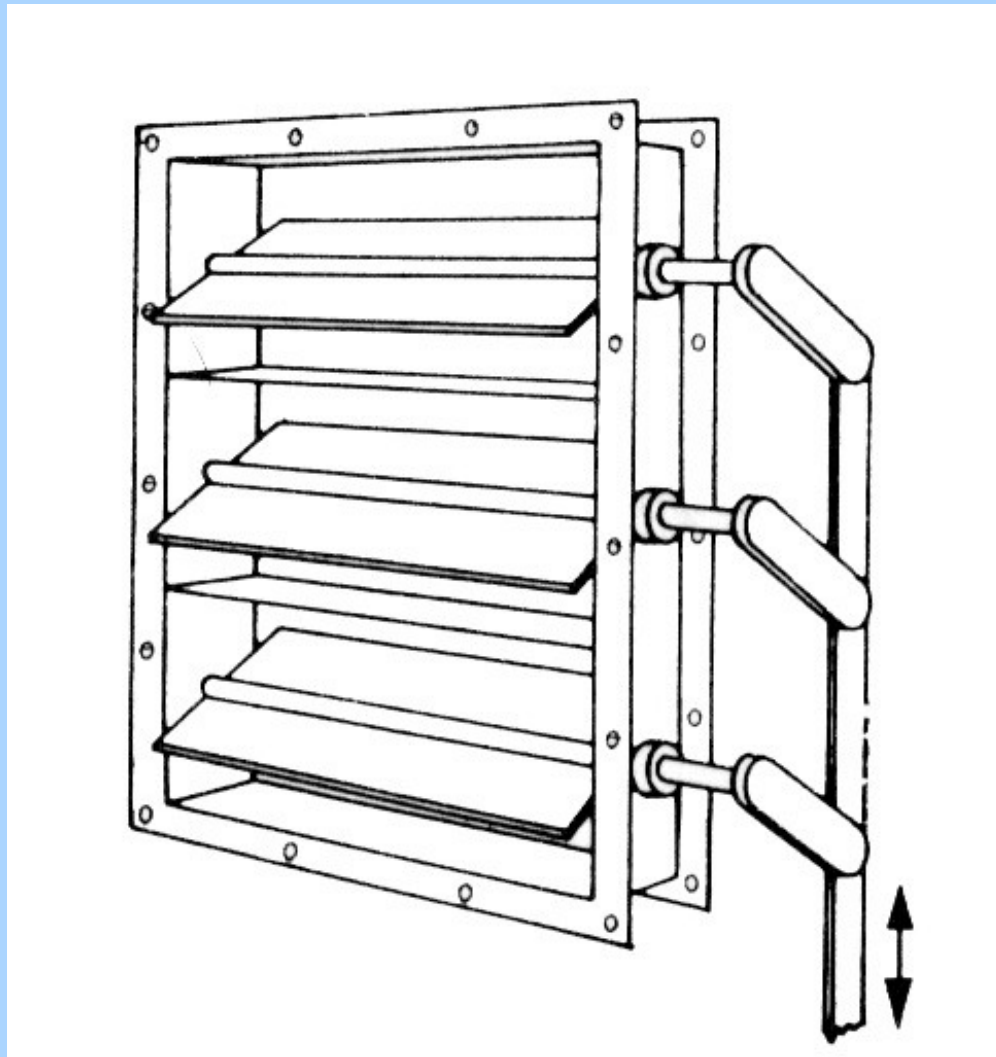
Auto/Manual Procedure of Control Valves (C)



Auto/Manual Procedure of Control Valves (B)



Louver



Different Type of Hand Wheels



Different Type of Hand Wheels



Leakage

- Between:
 - Seat & Plug
 - Cage & Plug
 - Packing Material (Glands)
 - Bonnet
 - Flanges

To Check Valve is Passing

1. Down stream isolating valve
2. Body Temperature
3. Valve Opening Reduces 50% → 35%
4. Abnormal Sound

Valve Sizing

Liquid

$$C_v = Q \sqrt{\frac{G}{\Delta P}}$$

Gases

$$C_v = \frac{Q}{1360} \sqrt{\frac{TfG}{\Delta P(P_2)}}$$

Steam & Vapours

$$C_v = \frac{w}{63.3} \sqrt{\frac{v}{\Delta P}}$$

Valve Sizing

- Where
 - C_v = Flow Rate
 - liquid (gpm)
 - gases (scfh)
 - vapours (lb/h)
 - G = Specific gravity of the process.
 - T_f = Flowing temperature in degree F°
 - ΔP = Process drop in PSI ($P_1 - P_2$)
 - P_1 = Upstream Pressure at valve inlet in PSI absolute
 - P_2 = Downstream Pressure at valve discharge in PSI absolute
 - v = Down stream specific volume in cubic feet per pound

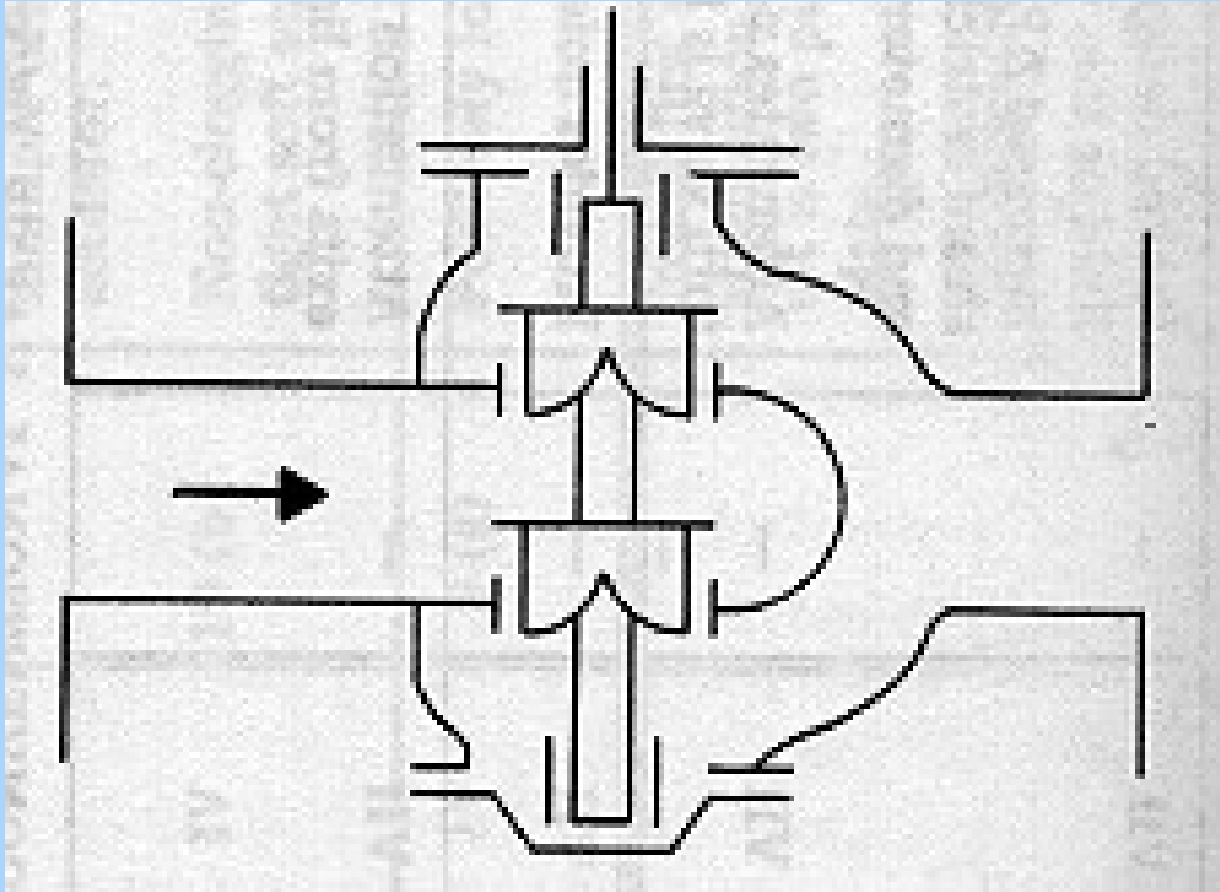
Jacketed Valve



Globe Style

- V-Port
- Double Seated
- $\frac{3}{4}$ " to 24"
- General Service
- Leakage 0.5% of Rated C_v
- Small Actuator Force Required than Single Seat

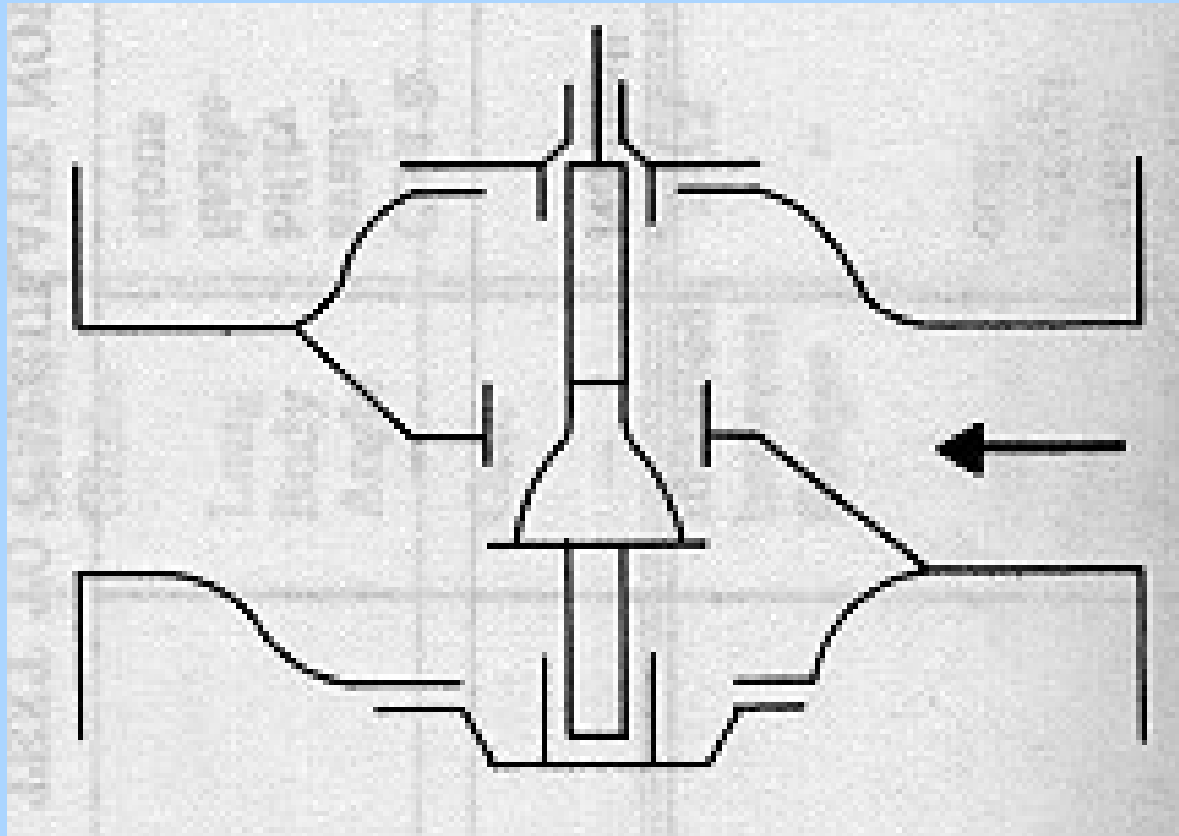
Globe Style



Single Seated

- Single Seated
 - Top and Bottom Guided
- 1 – 16”
- General Service
- Leakage 0.01% of Rated C_v

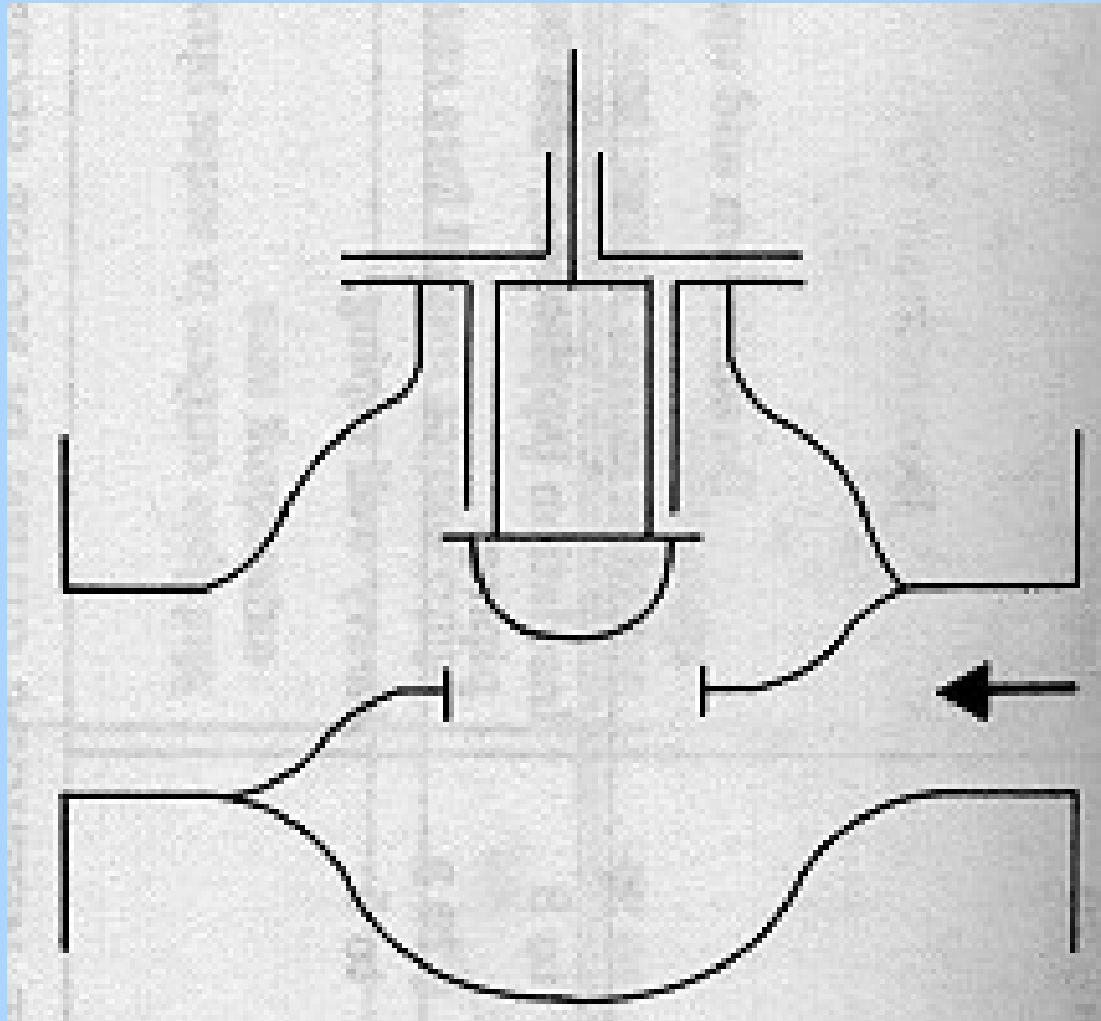
Single Seated



Single Seated

- Single Seated
- Top Guided
- ½ - 16" (30" Max)
- General Service
- Leakage 0.01% of Rated C_v

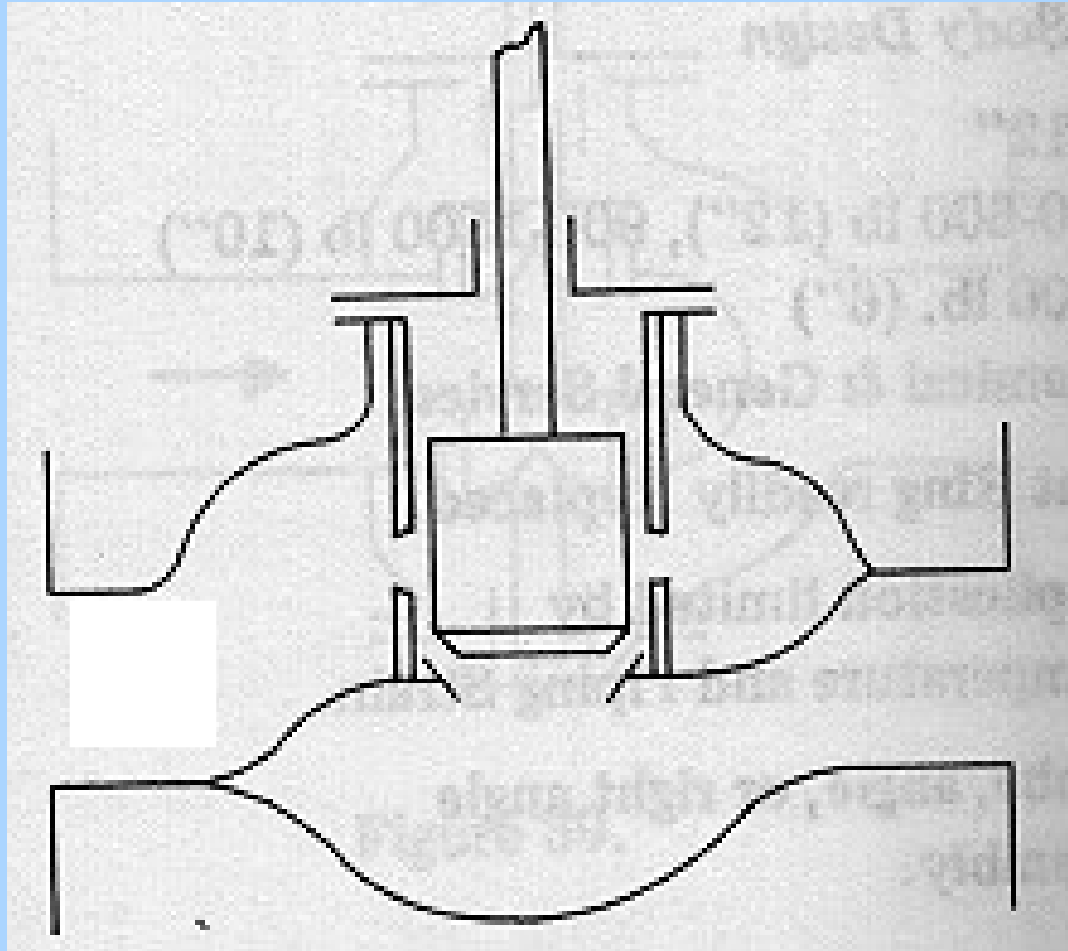
Single Seated-Top Guided



Cage Design

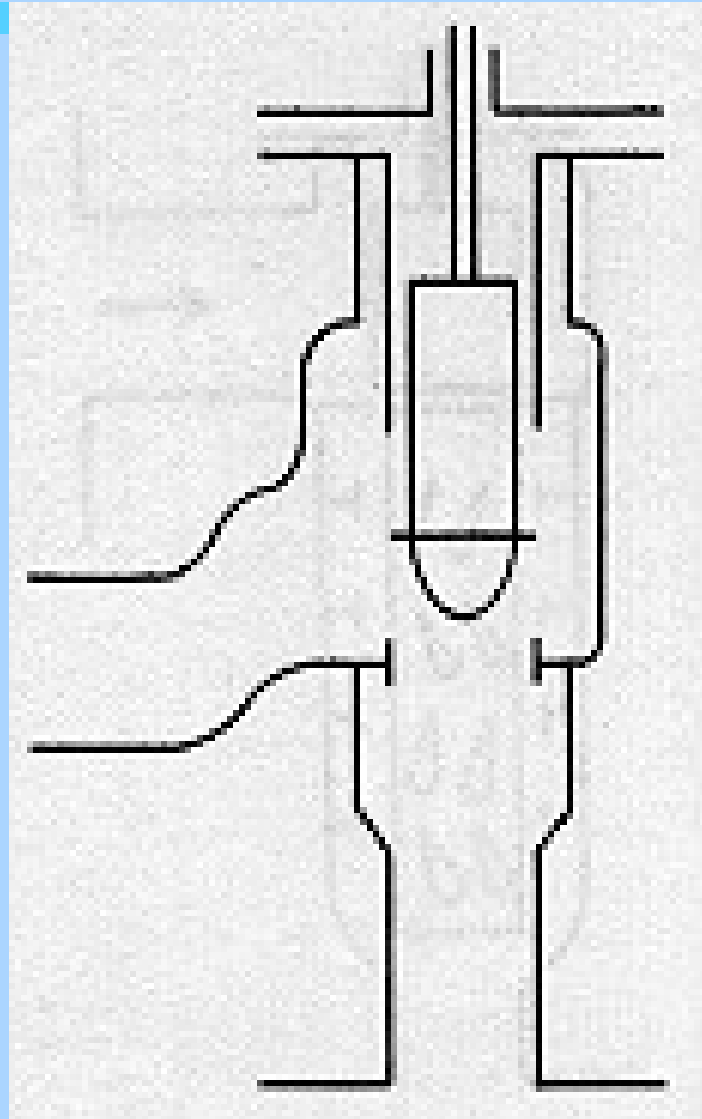
- 1 – 12”
- Better Plug Guiding
- More Stable Throttling
- Quick Change Trim

Cage



Angle

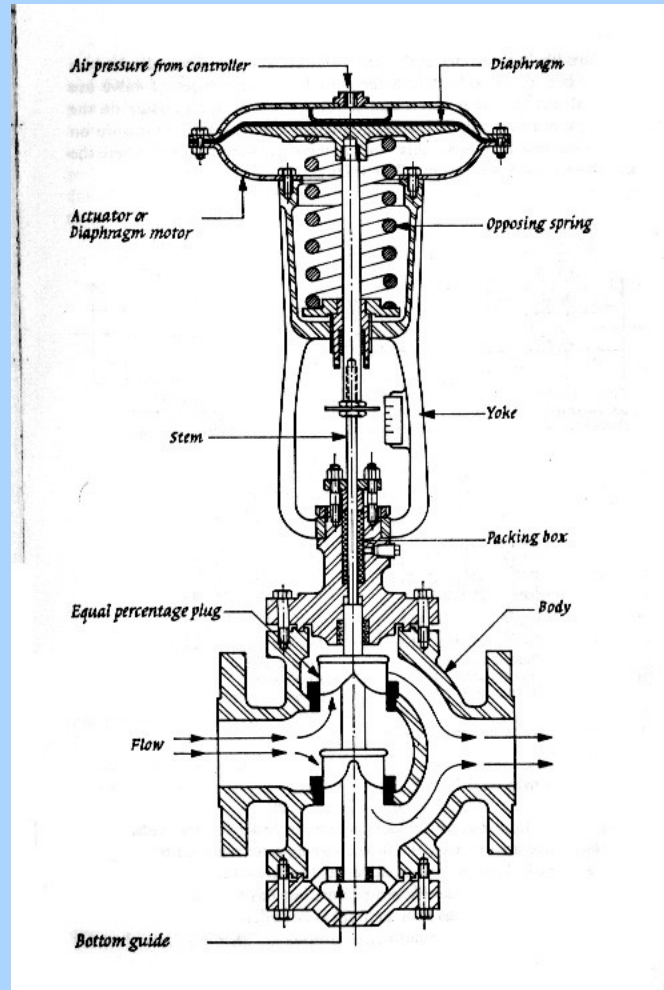
- $\frac{1}{2}$ - 12"



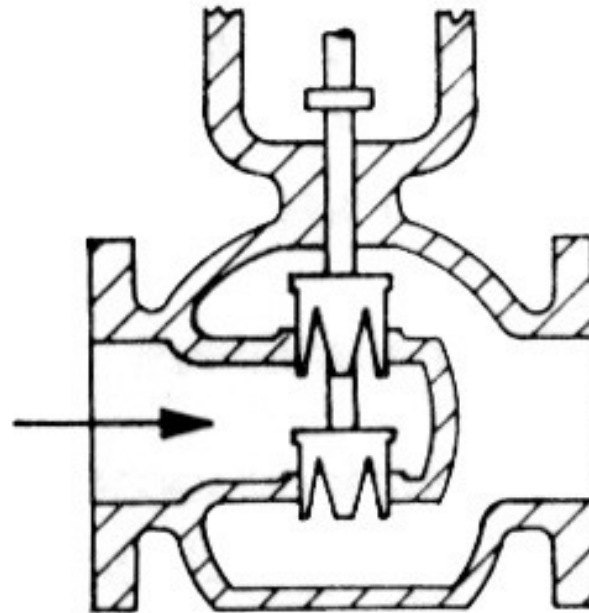
Y Style

- $\frac{3}{4}$ -14"
- Used more frequently in On – Off Service
- Corrosive service

Complete Control Valve

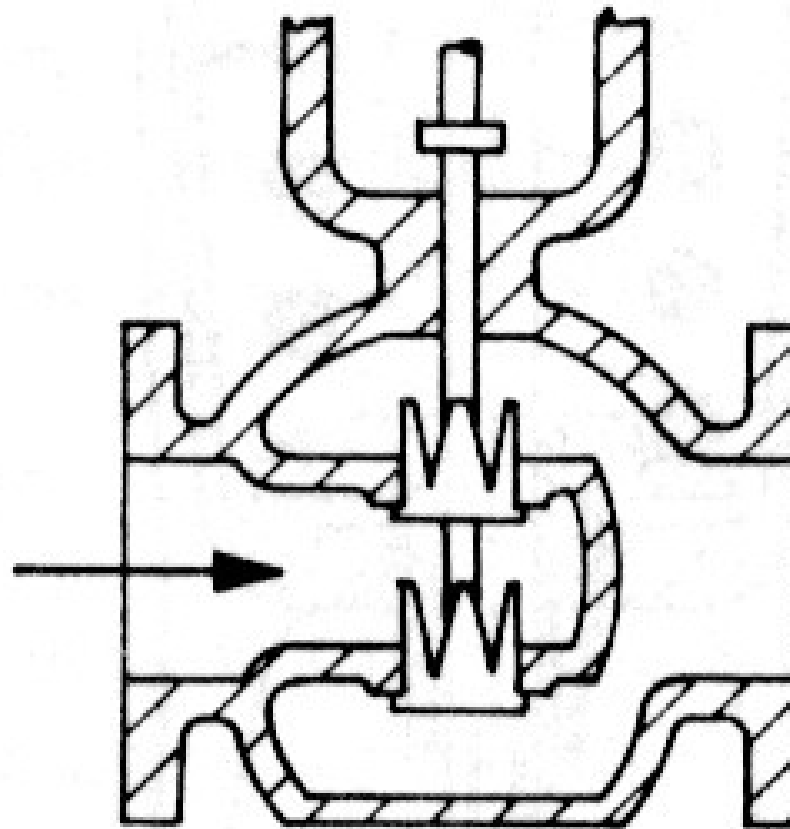


Direct Action Double Seated



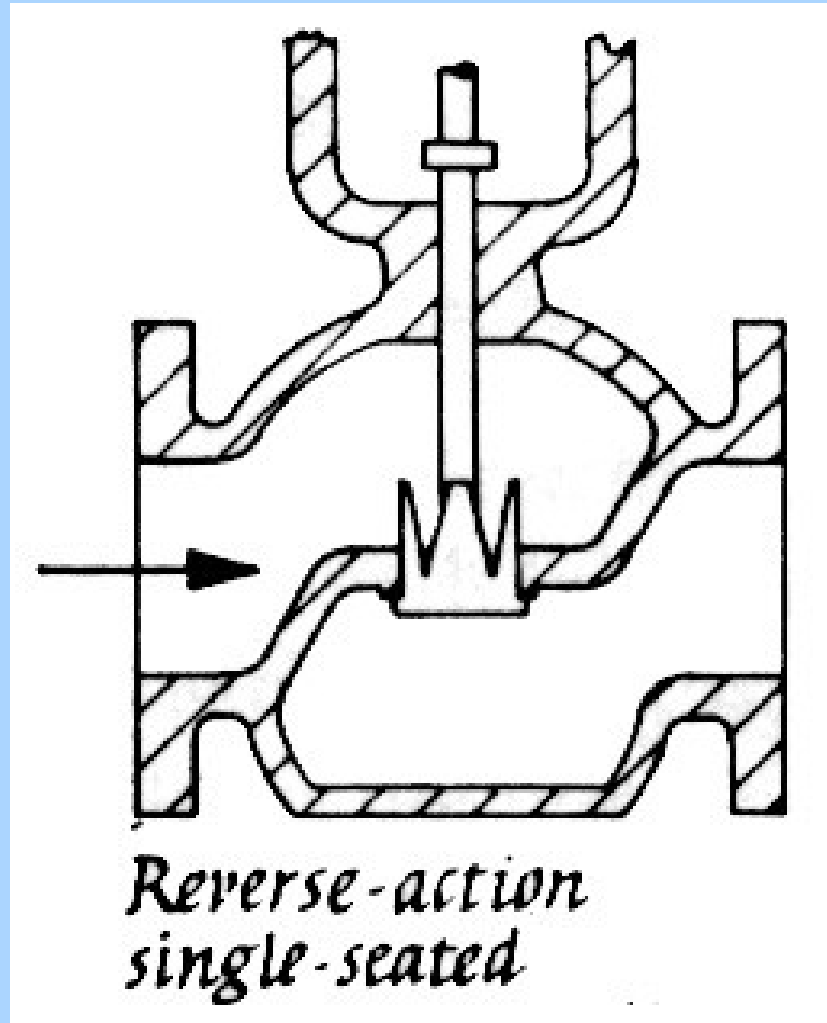
*Direct-action
double-seated*

Reverse Action Double Seated

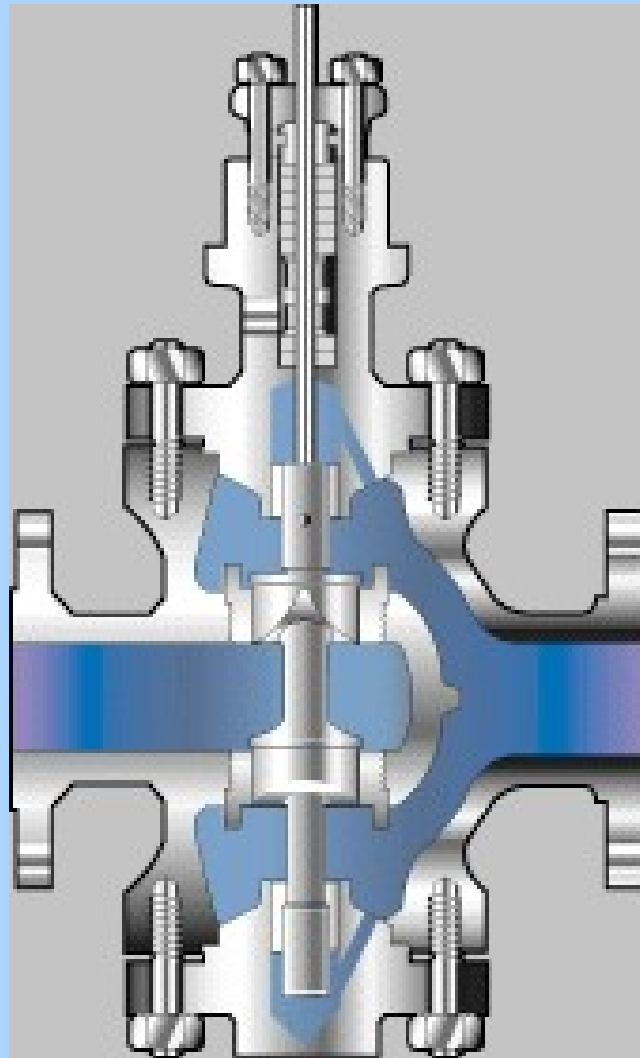


*Reverse-action
double-seated*

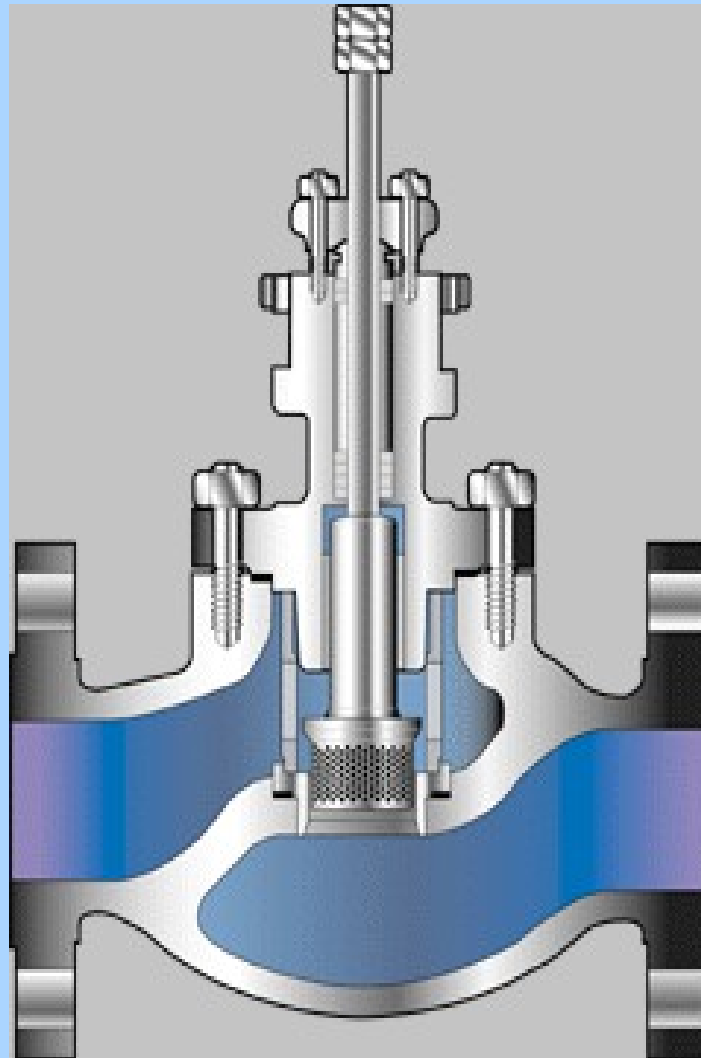
Reverse Action Single Seated



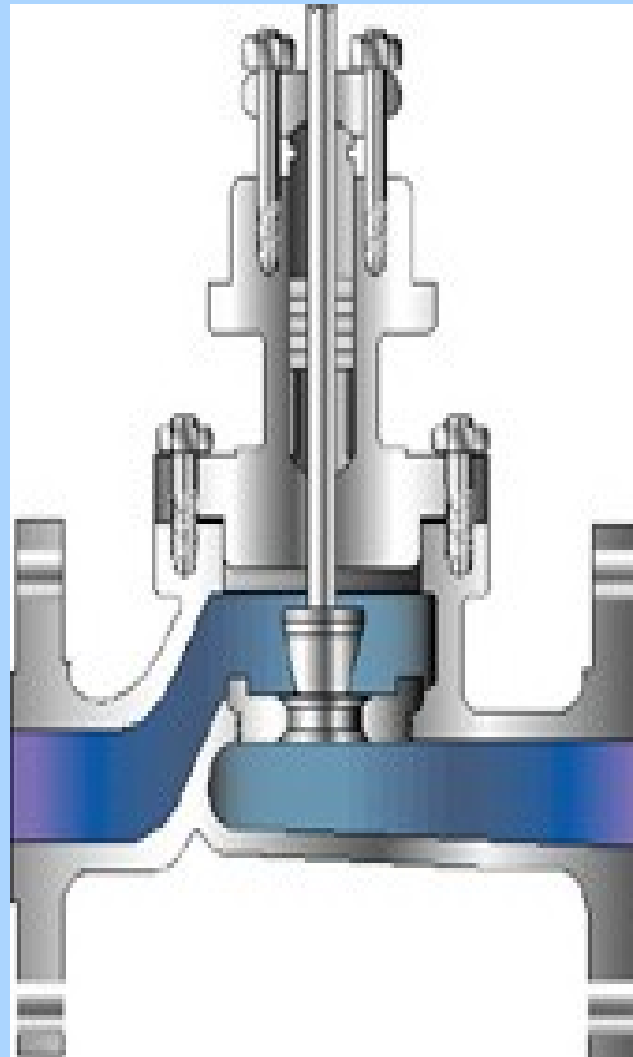
Double Seated – Top & Bottom Guided



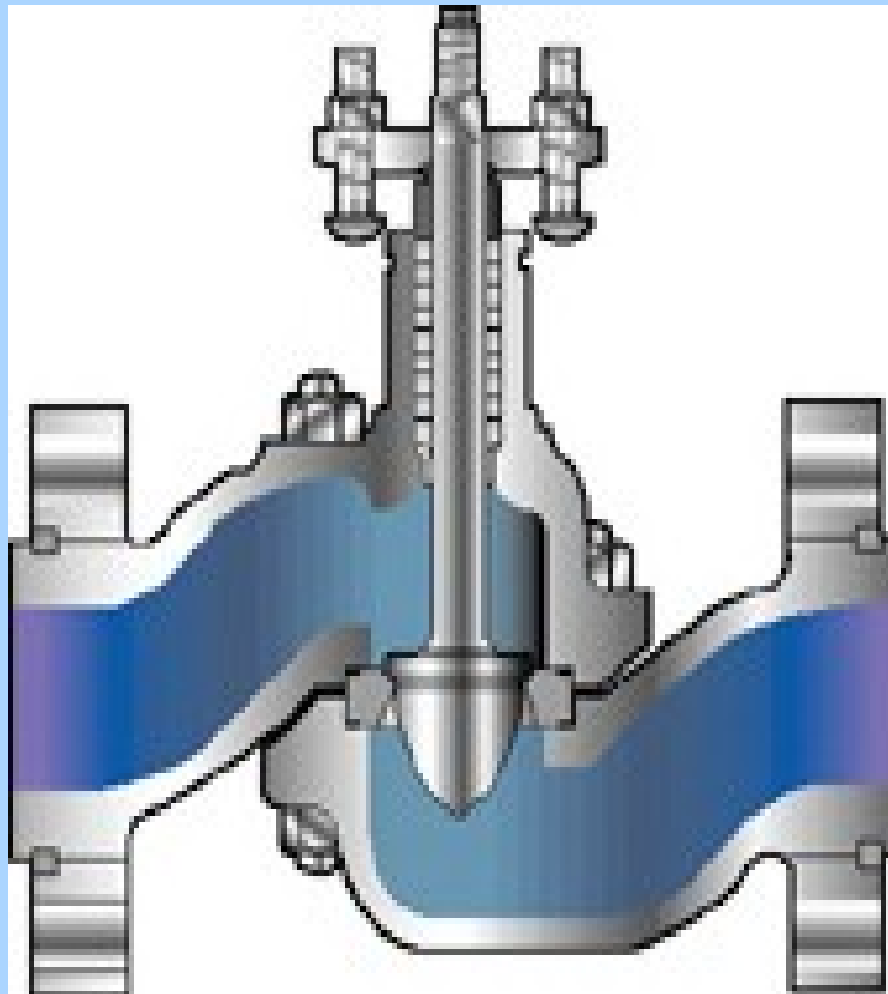
Single Seated - Top Guided



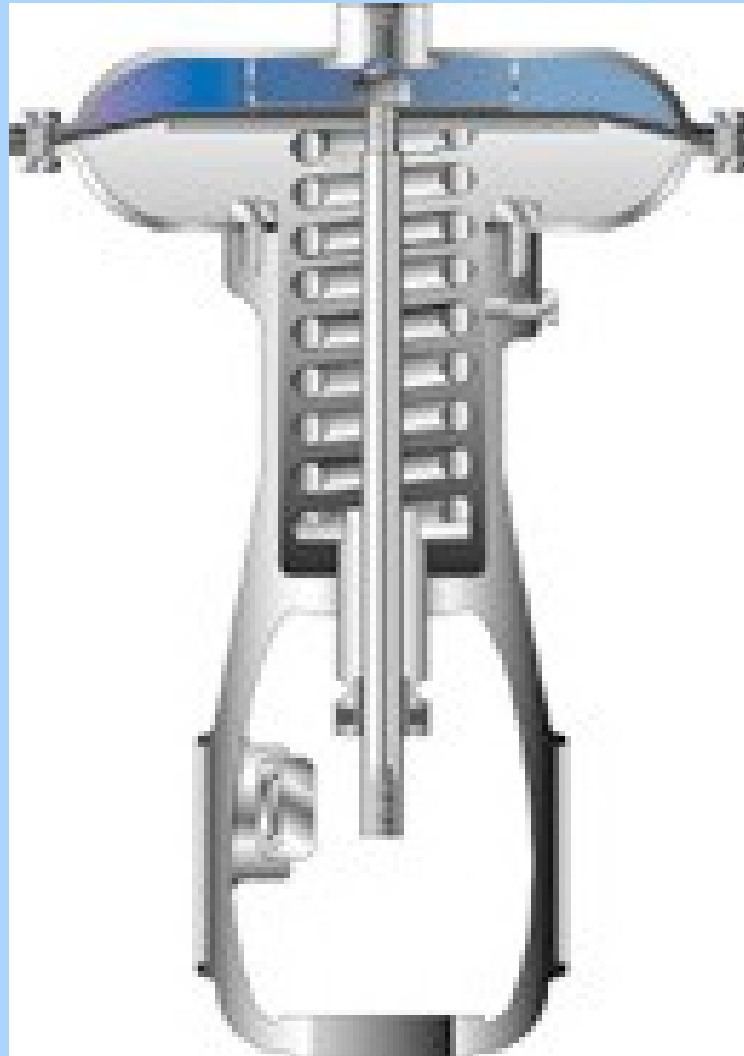
Single Seated



Linear Valve



Direct Action



Reverse Action



3 Way Valve

