

Mechanical Equipment - Course 430.1

VALVES

INTRODUCTION

A smoothly running nuclear station requires that systems within the station function properly. To reach this point of stability, valves are essential pieces of equipment. Not surprisingly, therefore, valves far out-number any other types of plant equipment with the exception of piping components.

VALVE FUNCTION

For a given system, different modes of operation may be required at different times. It may, for example, be necessary to isolate pieces of equipment, throttle pressure to reduce flow or to relieve excess pressure. One type of valve, unfortunately cannot handle all of these duties. Thus, there is one type of valve for a given function as listed in Table 1.

TABLE 1

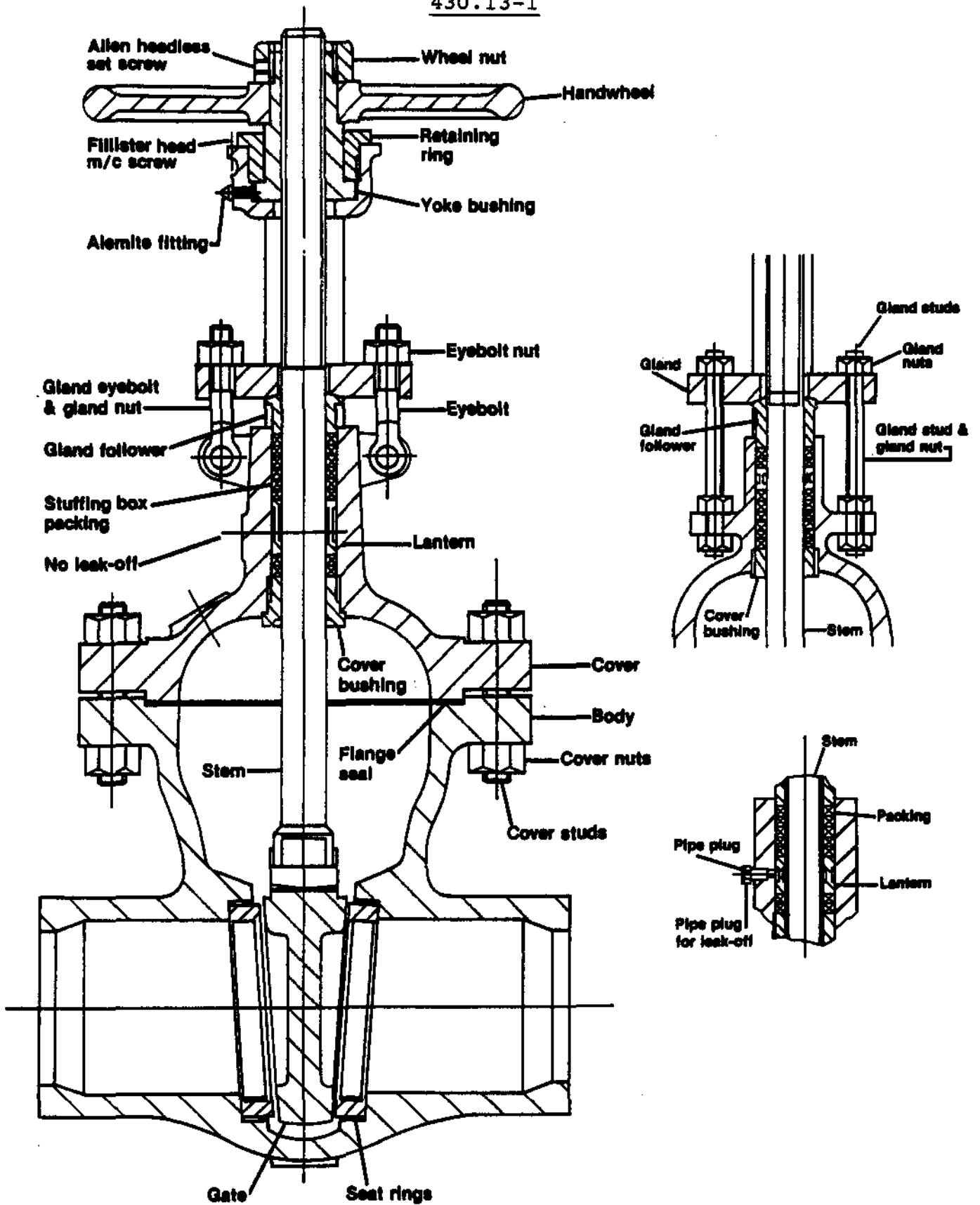
<u>FUNCTION</u>	<u>EXAMPLE OF VALVE USED</u>
1. Isolation	Gate
2. Control or Regulation	Globe
3. Backflow Prevention	Check
4. Pressure Relief	Safety, Relief, Safety, Relief

GATE VALVES

DESCRIPTION

The gate valve is probably the most commonly used type of valve in nuclear power stations. It is intended solely for ON-OFF service (isolation) and not for control. In any position except fully opened or closed, the gate and seat have a tendency to rapidly erode which would prevent tight shut-off.

A typical design of a gate valve appears in Figure 1 showing valve components.

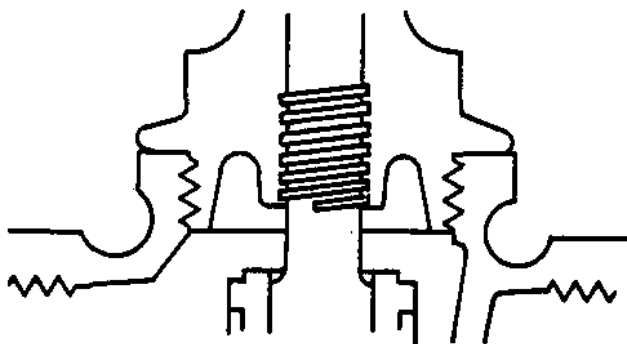


Gate Valve

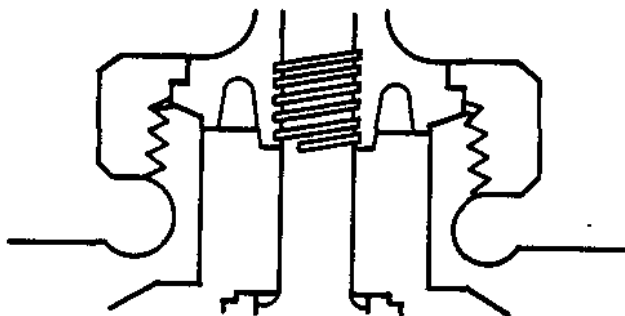
Figure 1

Valve Components

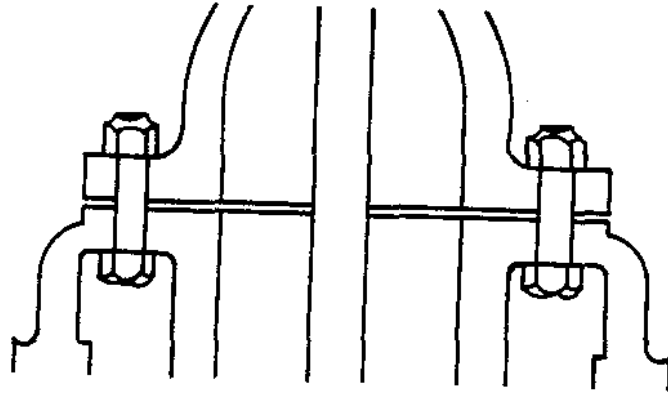
1. Valve Body - part of the valve which contains and regulates fluid flow.
2. Bonnet - is the valve component that gives a closure for the valve body. To gain access to the seat and disc, the bonnet must normally be removed. There are a number of different bonnet types, as indicated below.
 - (a) SCREW - is the simplest type. In this case the bonnet is screwed directly to the body. It is commonly found in smaller valves. See Figure 2.

Screw BonnetFigure 2

- (b) UNION - connects bonnet to body in a manner similar to a standard pipe union employing a gasket for sealing purposes. See Figure 3.

Union BonnetFigure 3

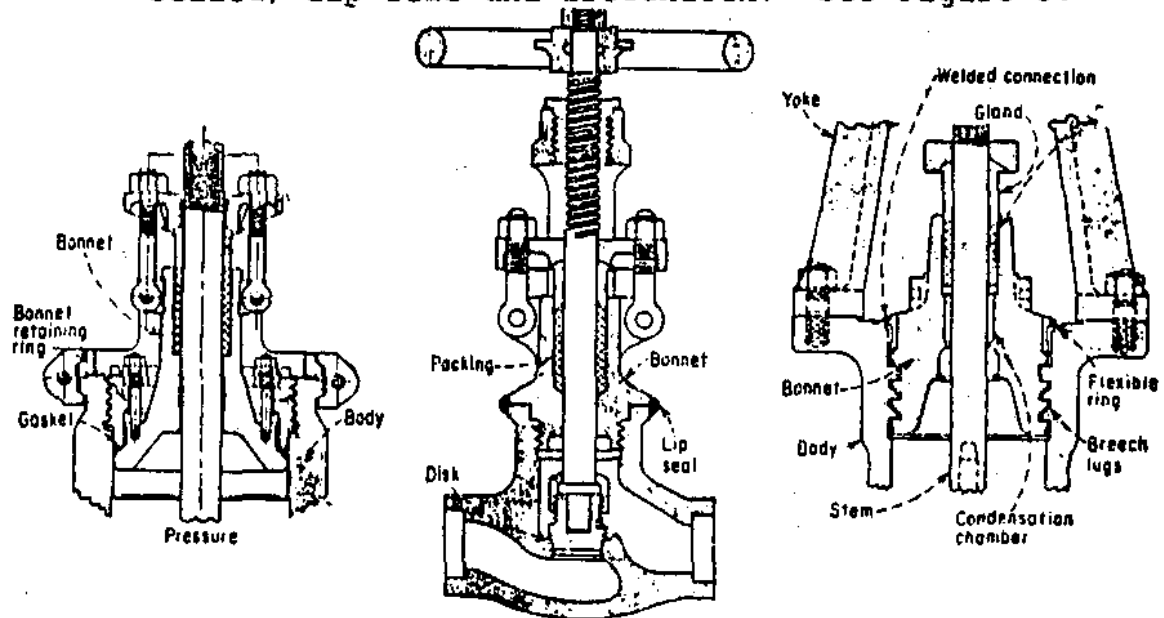
- (c) BOLTED (Flanged) - is used for larger valves whenever corrosive solutions and high temperatures, pressures may be encountered. The bonnet flange is tightened to a body flange using a suitable gasket. See Figure 4.



Flanged Bonnet

Figure 4

- (d) OTHERS - used for high pressures are the pressure-sealed, lip seal and breechlock. See Figure 5.



Section of an outside-screw and yoke valve showing a pressure-sealed bonnet. Pressure presses bonnet against gasket and retaining ring.

Lip seal-bonnet globe valve with outside screw and yoke. Bonnet/body threads carry entire mechanical load, weld acting only to seal against leakage.

Section of valve showing the breechlock joint used for high pressures. The lugs transmit the thrust on the bonnet to the body.

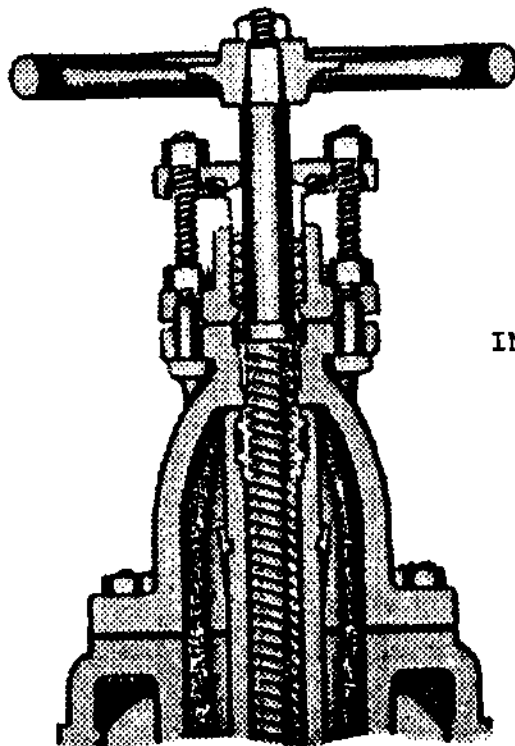
Figure 5

VALVE TRIM (refers to all the wetted parts of a valve excluding the body and bonnet).

3. DISC - is a flat or cylindrical fluid control element which is placed across the fluid pathway to block flow.
4. VALVE SEAT - in order to prevent downstream leakage when the disc is blocking flow there must be a tight fitting closure between the disc and valve seat. There are three types of seals possible.
 - (a) metal-to-metal seal - provides the greatest strength but suffers from seizure and galling due to temperature effects and abrasion.
 - (b) resilient seal - involves pressing a metal surface against a plastic or rubber one. This type of seal is usually used whenever a tight seal is required for fluids containing solid particles.
 - (c) metal-to-metal seal with a resilient insert on one of the surfaces. This type of seal combines features of the other two types.
5. STEM OR SPINDLE - is the part of the valve used to slide the disc across the fluid pathway. The stem usually extends from the disc to the outside of the valve.

Different stem arrangements are possible such as:

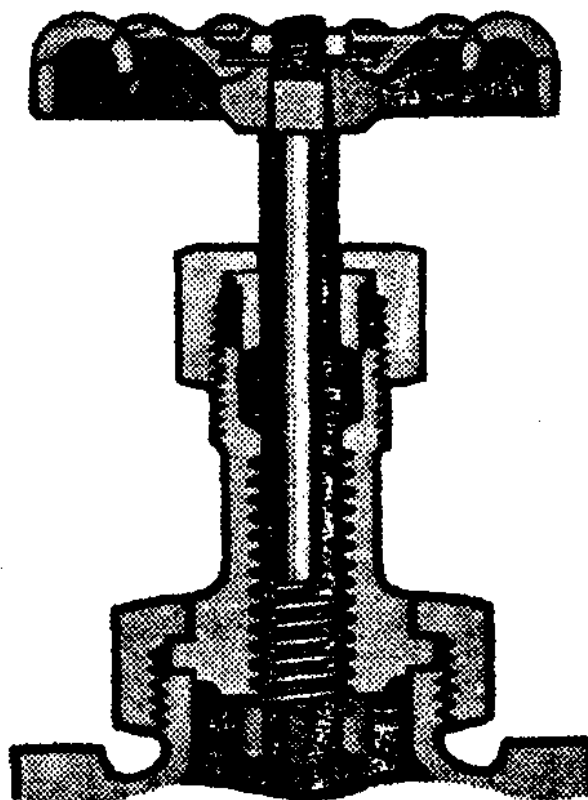
- (a) inside screw non-rising stem - has a disc which rises as stem screws into it. See Figure 6. Since stem screws are held within the body, this is an ideal arrangement especially where headroom is limited.



INSIDE SCREW, NON-RISING STEM

Figure 6

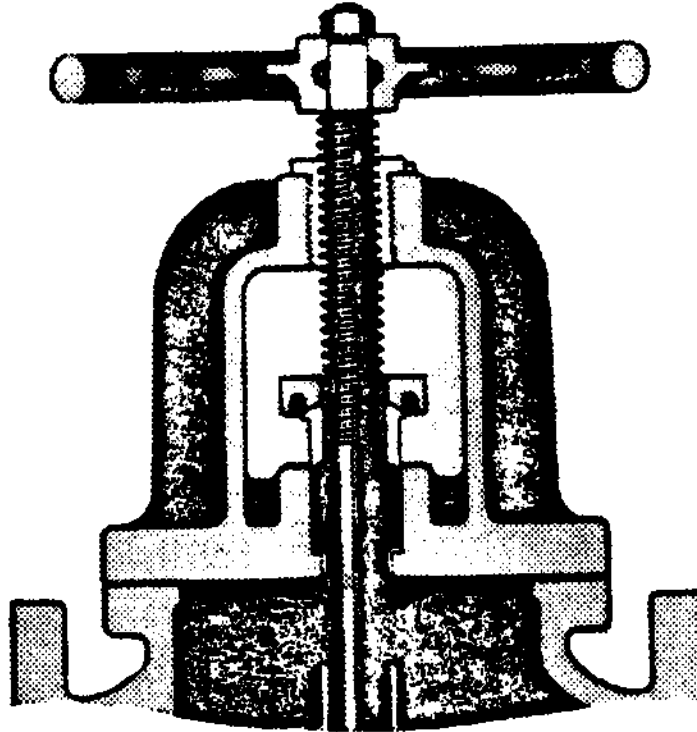
- (b) inside screw rising stem - has a disc which lifts as screw turns. See Figure 7. Steam threads are held within the body. From an operator's viewpoint, therefore, disc position is readily indicated.



Inside Screw, Rising Stem

Figure 7

- (c) outside screw rising stem - is a threaded stem which moves endwise only. Since the threads do not contact fluid, this type of stem is ideal for corrosive and/or high temperature applications. As in (b) the position of the disc is readily indicated. See Figure 8.



Outside Screw - Rising Stem

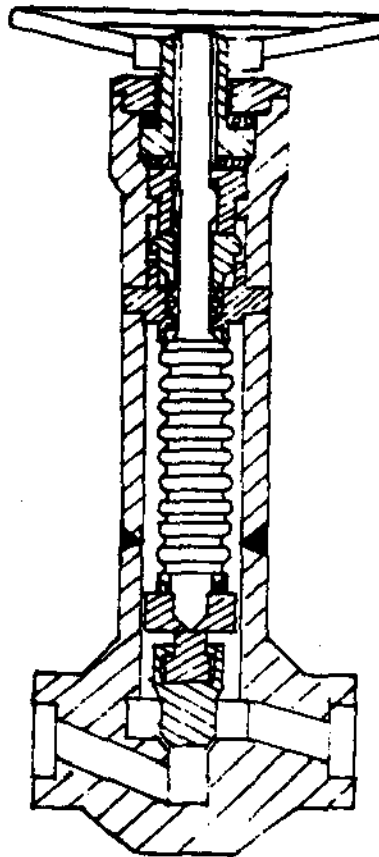
Figure 8

6. **STEM SEALING** - The most common method of sealing valve stems is to use a stuffing box packed with a flexible type of material.

To retain the pressure fluids inside the valve, the packing is compressed within the stuffing box and against the stem by a packing nut or gland.

When there must be absolutely no leakage to the outside, a conventional stem and stuffing box is unsatisfactory. A number of valves that use a packless method of sealing are available, for example:

- (a) diaphragm valve - which will be described later.
- (b) bellows valve which uses a metallic bellows between the body and bonnet. See Figure 9.



Bellows Seal

Figure 9

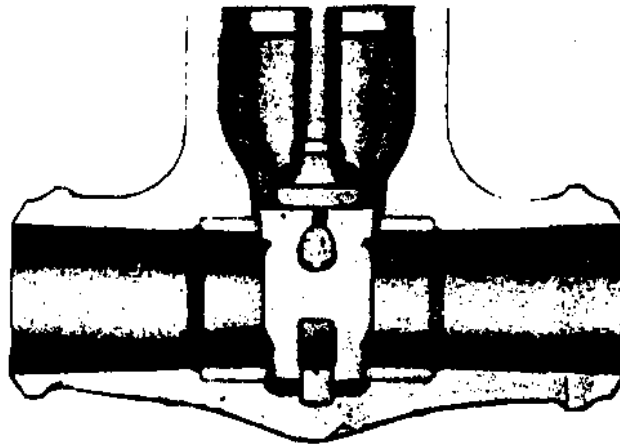
The last two "packless" sealing methods are particularly useful in preventing any heavy water leakage. Valves employing these methods are sometimes referred to as zero leakage valves .

TYPES OF GATE VALVES

When fully opened, gate valves allow straight through flow in a passage that is equivalent to the inside diameter of the associated pipework. Thus, they impose a minimum pressure drop in the fluid flow system.

Gate valves are classified by the type of disc used. The various types of gate valves are listed below:

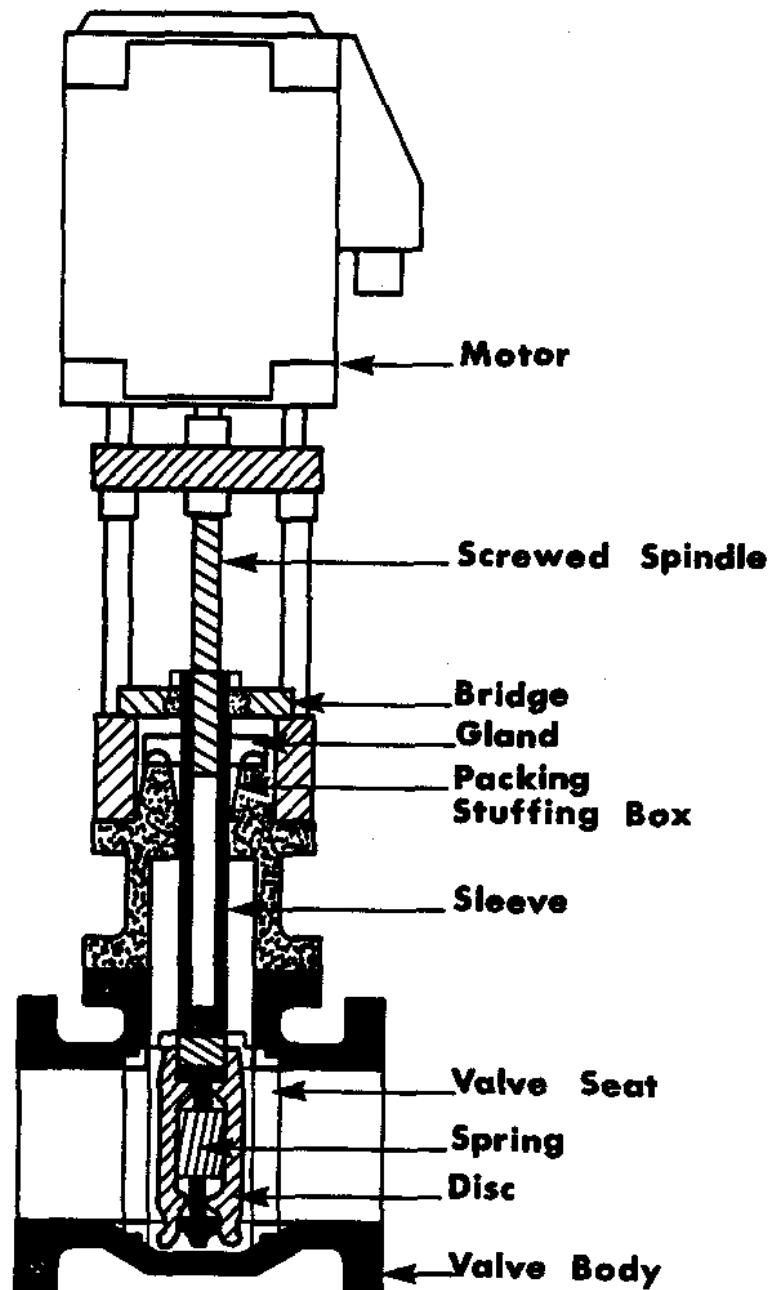
1. **Solid wedge disc with inclined seat** - This type of shape provides a good metal to metal seal but due to the solid disc it suffers from expansion effects because of high temperature operation. The expansion effects result in either valve seizure or poor disc to seat alignment which may lead to leakage. These valves are, therefore, normally found in cold water systems.
2. **Flexible wedge disc** - Figure 10 is a disc partially cut in halves. This disc type overcomes the temperature expansion problem.



Flexible Wedge

Figure 10

- (3) Parallel slide disc valve - Figure 11 - has two discs that are forced apart against parallel seats at the point of closure by a spring. Tight seals result as fluid pressure forces the valve disc against opposing seat.

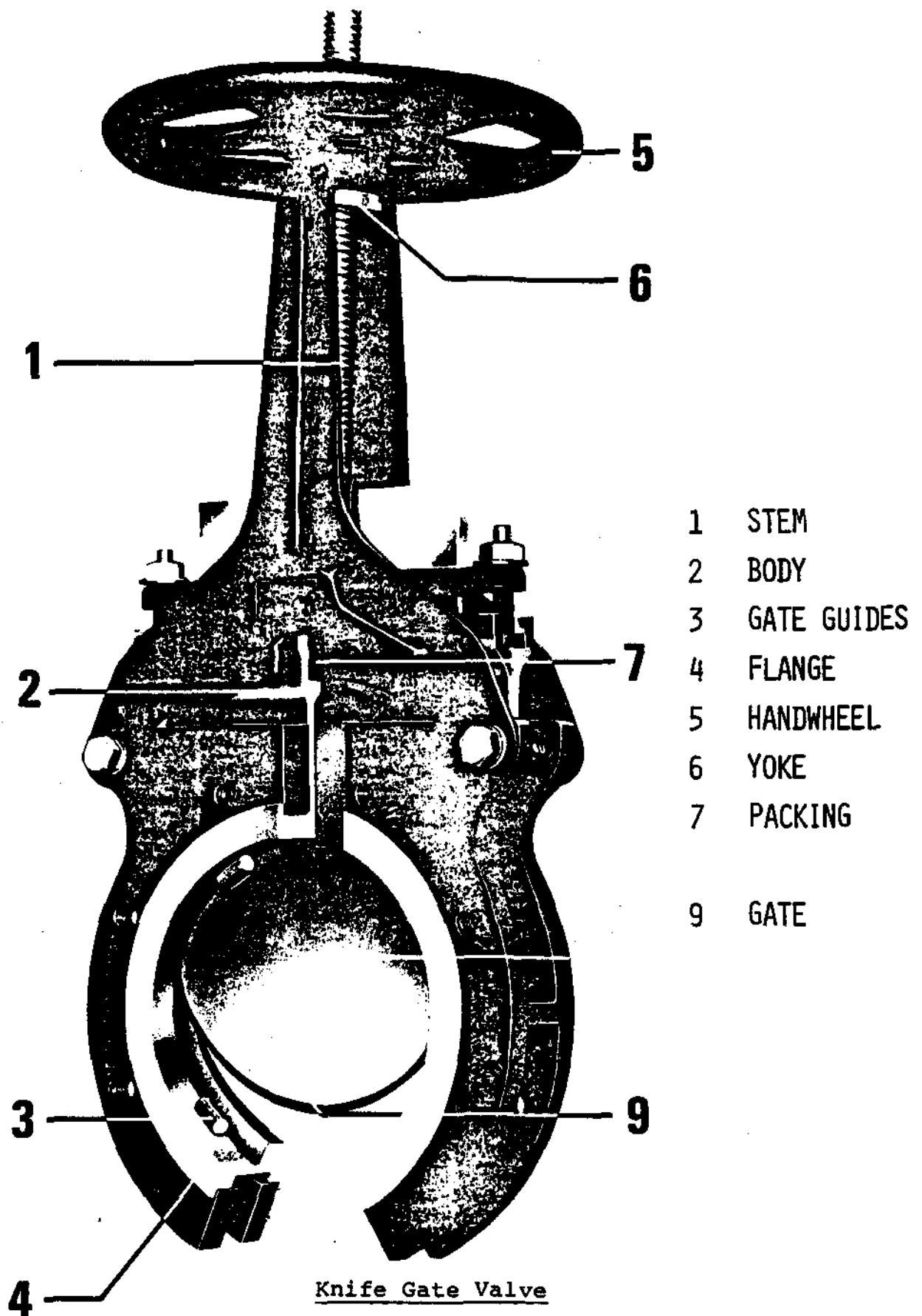


Parallel Slide Valve

Figure 11

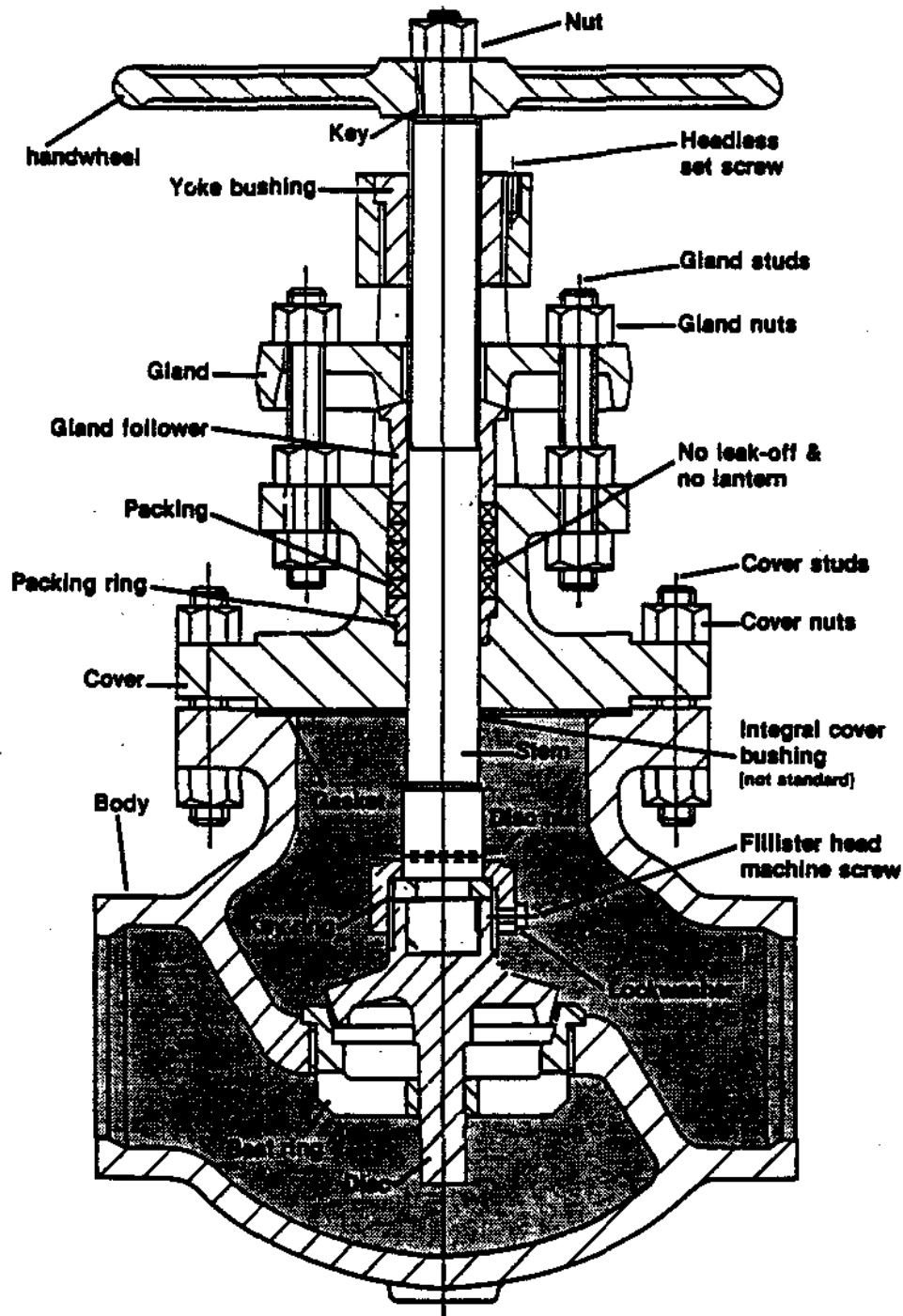
- (4) Knife Gate Valves - Figure 12 - have gates consisting of one or two discs that slide between parallel seats. There is no spreading mechanism: fluid pressure provides effective closure by forcing the downstream surface of the disc against the body seat.

These valves are used in low pressure systems of gases or liquids.



GLOBE VALVES

As mentioned previously, these valves are designed mainly for flow regulation. A typical globe valve, appearing in Figure 13, has basically the same components as a gate valve but obviously with different arrangements, as mentioned below.

Globe ValveFigure 13

- (1) Flow control for example, is accomplished by a plug or disc that seats on an orifice arranged at at 90° angle to the axis of flow passage. Since flow must make two right angled turns, pressure drop through the valve is much higher than in gate valves.
- (2) For liquid service, flow is directed from underneath the plug. An arrow on the body gives correct flow direction. However, with steam, flow is in the reverse of direction of liquid. By directing the steam from above instead of from below, the stem will remain heated and will not contract as much if flow was directed from below. On valve closure, therefore, a tight seal will be maintained.
- (3) Lastly, the valve body is globular in shape.

TYPES

- (a) **Conventional, single ported valve** is a control valve which regulates flow using one plug.

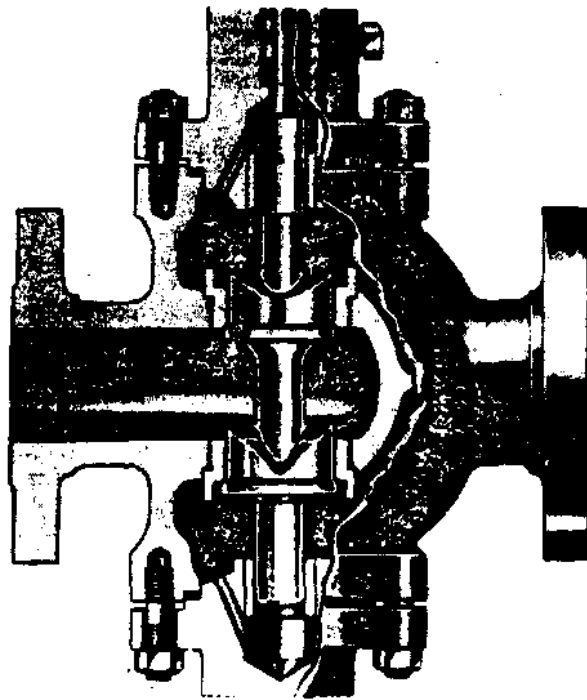
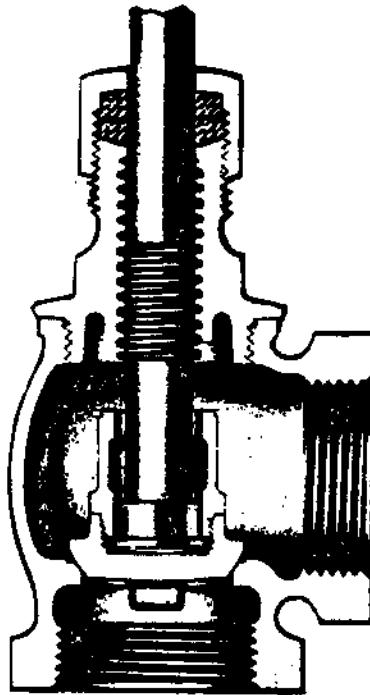


Figure 14

- (b) **Double ported globe valve** - Figure 14, controls flow by the opening and closing of two plugs. The double ported or beat valve is used whenever fine control is required, for example the feedwater regulating valves. Fine control requires that axial forces acting on the stem be balanced. (The flow pushes one plug downward, the other upward.)

Unfortunately, this valve is not tight sealing but is preferred over the single ported valve if leakage is not a problem.



Angle Valve

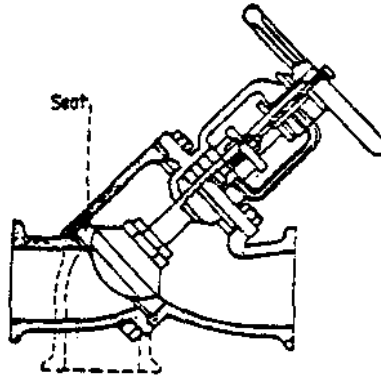
Figure 15

- (c) **Angle valve** - Figure 15, is a variation of the basic globe valve design. The angle valve's body has two ends that are at right angles to each other with the axis of the stem in line with one of the ends. Governor steam valves are good examples of angled globe valves.

Two benefits of using this type of valve are:

- (1) these valves present less of a pressure drop than globe valves, and
- (2) result in a reduction of the number of fittings in a pipe system.

- (d) A **Y Valve** - Figure 16 is similar to a glove valve except the orifice is usually at a 45° angle to the flow path. This design gives a low pressure drop across the valve yet with good throttling characteristics.

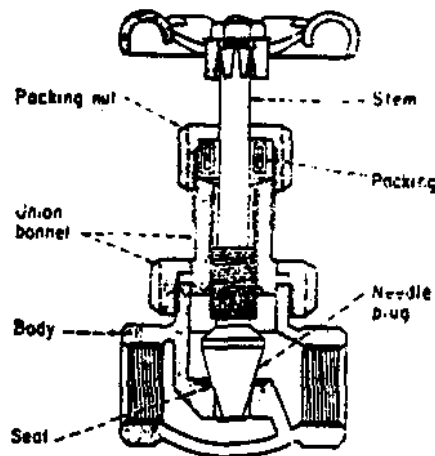


Y valve showing conversion
to angle type

Y-VALVE

Figure 16

- (e) **Needle valves** - Figure 17, allow close regulation of flow. Generally, a small sized valve, it has a tapered needle-like plug that fits accurately into the seat. Close regulation of flow is accomplished because of fine threading.



Needle valve showing needle-
like plug closed

Needle Valve

Figure 17

CHECK VALVES

These valves are designed to prevent the reversal of flow in piping systems. Automatic in operation, opening results because of the pressure of the flowing fluid; closure happens as a result of either back pressure or weight of the check mechanism.

TYPES

- (a) **Swing** - has a disk that is hinged at the top. Suited for both horizontal or vertical pipework, there is little pressure drop across the valve. Refer to Figure 18.

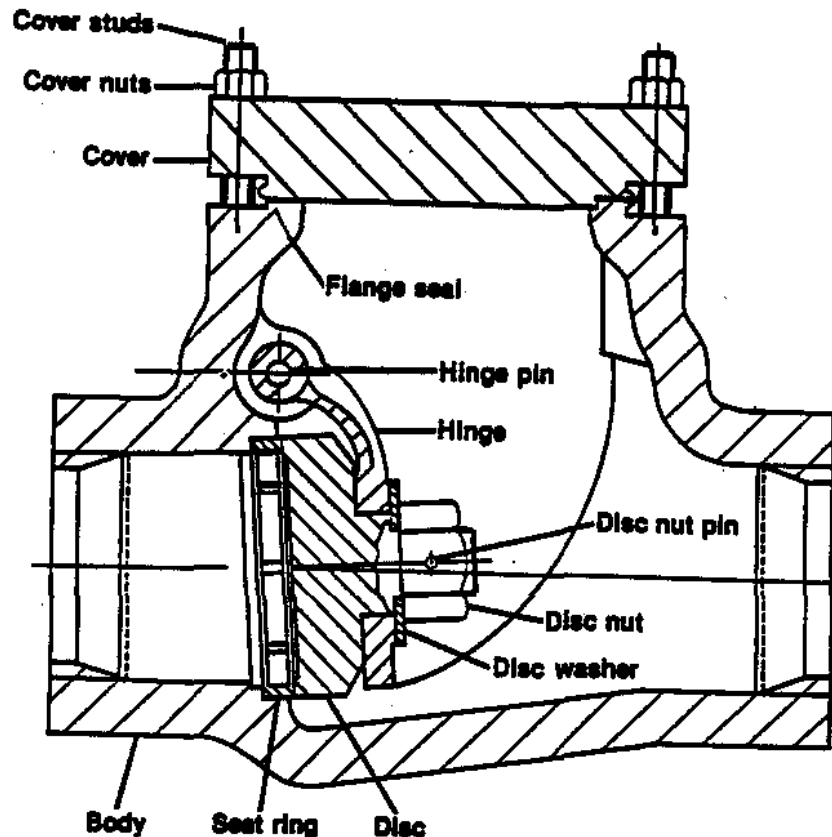
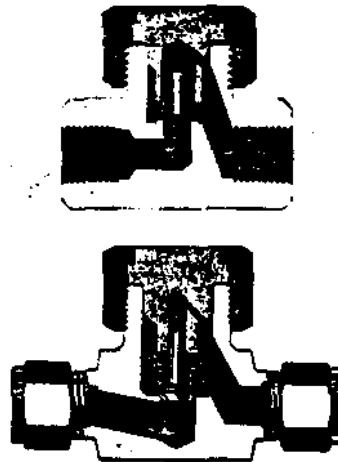


Figure 18

Occasionally swing check valves are equipped with an outside lever and weights to keep the valve from opening until desired pressure is reached. For example, instrumented swing check valves employing a piston actuator attached to an outside lever are found in extraction steam lines to L.P. feedheaters. The instrumental valve ensures quick closure preventing steam returning to the turbine when the turbine must be isolated.

- (b) With lift check valves, a disk or ball is raised within guides by the pressure of the upward fluid flow. When flow reverses, the check device is forced back onto the seat by backflow and gravity.
- (c) The piston type is essentially a disk valve with a dash-pot consisting of a piston and cylinder that provides a cushioning effect during operation. See Figure 19. More commonly found in horizontal pipework, these valves are suitable for services which have frequent changes in flow direction. However, higher pressure drops occur than with the swing type.



Lift Check Valve (Piston)

Figure 19

Check valves serve important roles in the functioning of pumps. If check valves appear on the dischargeable side, reverse rotation of the impeller is prevented. On the suction side, check valves, maintain pumps' prime and are normally referred to as foot valves.

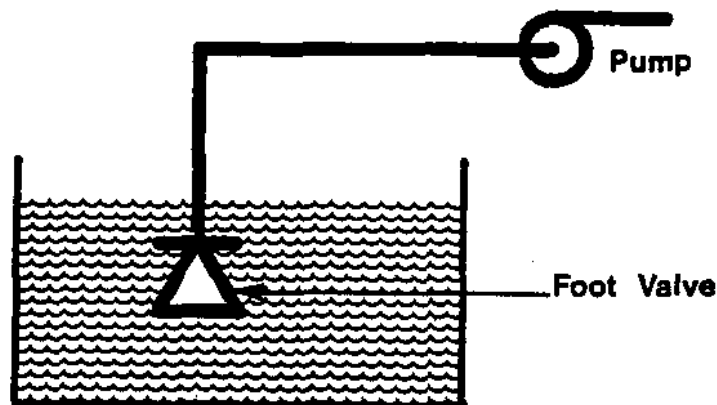
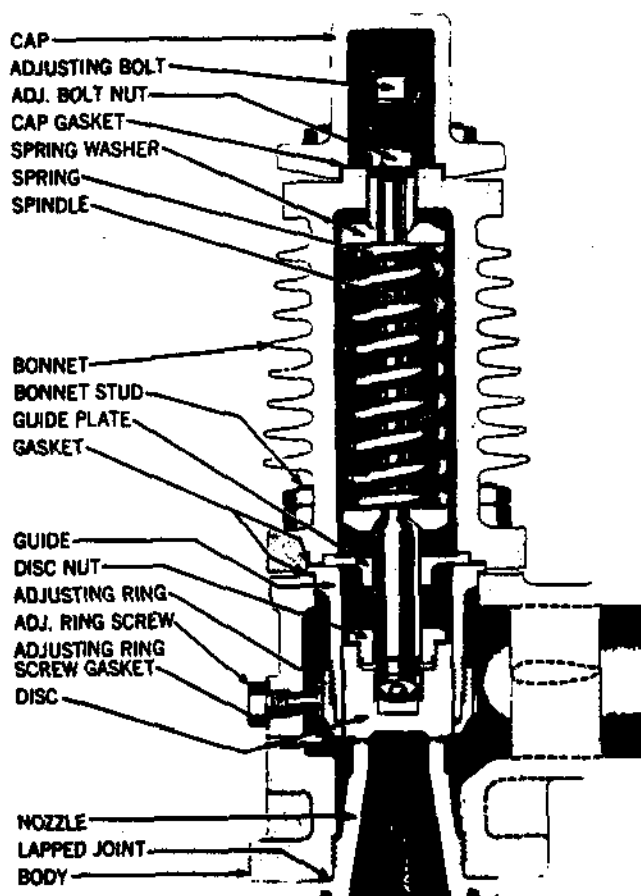


Figure 20

SAFETY AND RELIEF VALVES

Safety and relief valves are used to safeguard pressure systems against operating at dangerously high pressures. Both types automatically discharge fluid to relieve pressure, thus preventing a pre-determined safe pressure from being exceeded.

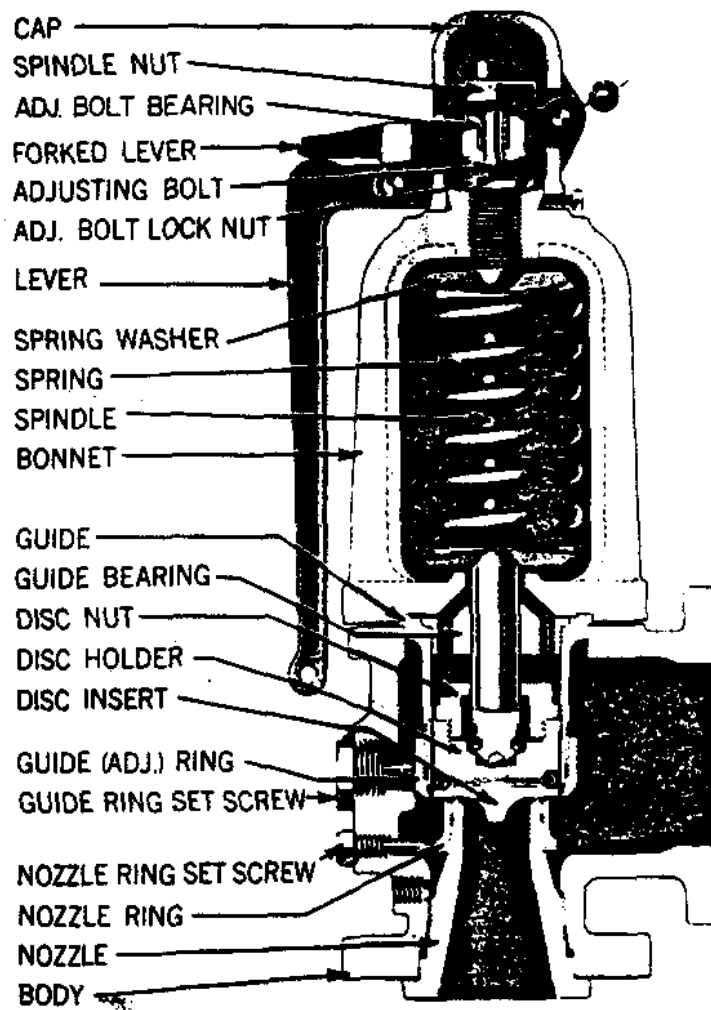
Safety valves are used with gases (or vapours), therefore have full-opening pop action to give immediate relief. Relief valves (Figure 21) are used primarily with noncompressible fluids where a relatively small discharge of liquid provides relief. Safety and relief valves are often designed such that they can be used interchangeably and are appropriately named safety relief valves.



Relief Valve

Figure 21

Both safety and relief valves usually operate by the lifting of a spring loaded disk which permits fluid to pass through. When sufficient pressure acting upward on the disc overcomes the force of the spring the valve opens. In safety valves, the disk over-hangs the seat to offer additional thrust area after the initial opening to produce a faster rise of the disk to the full open position. With relief valves, the area exposed to the over-pressure is constant whether the valve is open or closed, the result being a gradual lifting of the disc to the full open position. A typical safety valve is illustrated in Figure 22.



Safety Valve

Figure 22

Safety relief valves must combine characteristics of both safety and relief valves. For gas service, expansion effects of the gas provides the additional force underneath the disc to achieve popping action for immediate full lift. Liquid service also demands full lift in order to have the nozzle orifice control flow rate. To generate the additional forces underneath the disc, because expansive effects are absent, the liquid's direction of flow is changed 180°. Flow is therefore diverted downward upon contacting the inside of the disc holder skirt. This action adds reactive forces to lift the disc. Figure 23 demonstrates the action of a safety relief valve.

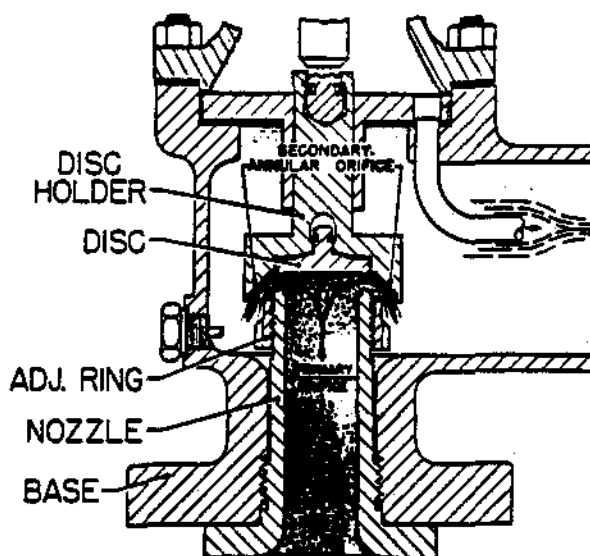


Figure 23

SPECIAL VALVES

BUTTERFLY VALVES

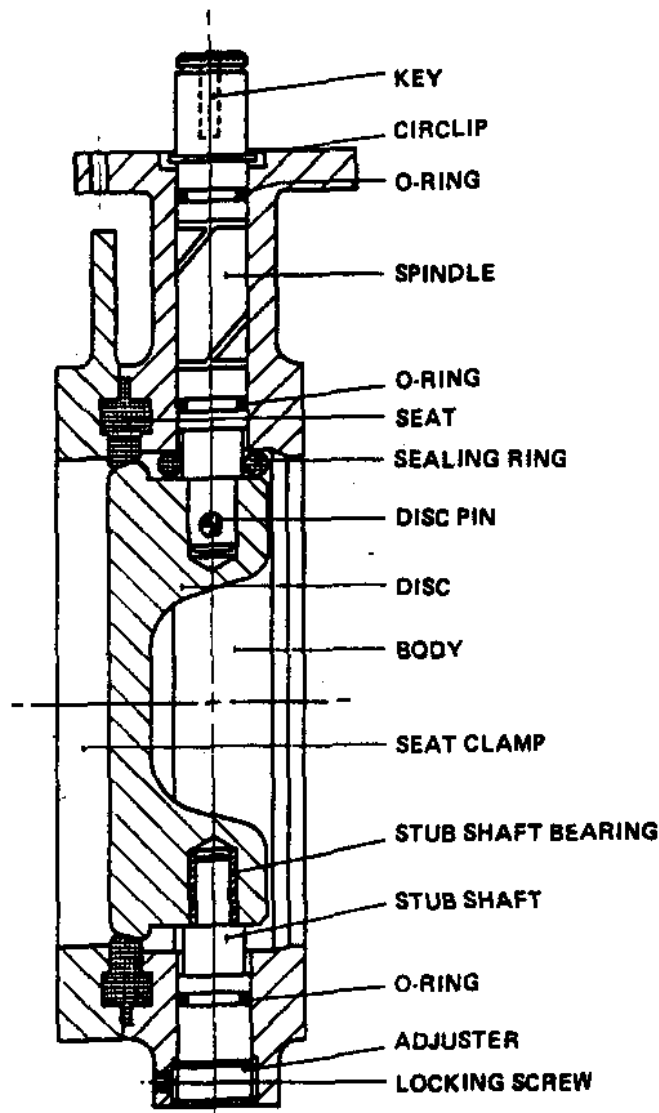
Built on the pipe damper principle, these valves are especially suited for large flows of gases and liquids at relatively low pressures.

Butterfly valves offer a number of advantages, they are:

- (1) present low pressure drops to fluid flow.
- (2) do not permit sediment build-up.
- (3) are easy to install.
- (4) are relatively low priced.
- (5) are fast acting, since on quarter turn changes the valve from fully opened to fully closed.

- (6) are light for their size compared with gate valves.
- (7) can be used for either isolation or control.

The flow control element of this valve is a disc that swings on either a horizontal or vertical axis. In the former case, when the disc lies horizontal, the valve is full open and when the disc approaches the vertical position, the valve is shut. See Figure 24.



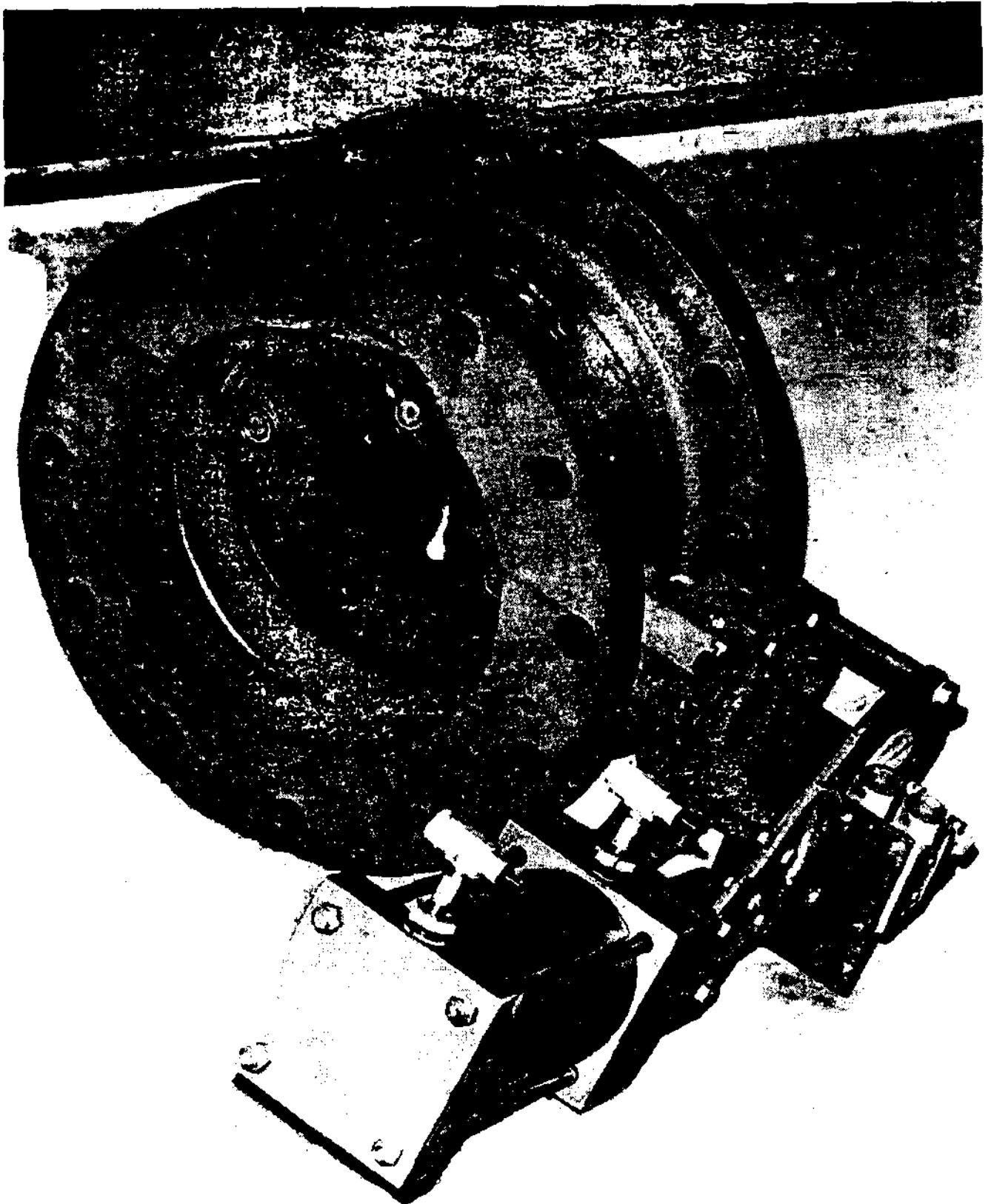
Wafer Design Butterfly Valve

Figure 24

In Figure 24 and Figure 25, the two types of butterfly valves are shown:

- (1) wafer design.
- (2) flange design.

The wafer design is held in place between two pipe flanges by bolts that join the two flanges and pass through holes in the valve's outer casing. The flange design valve has flanged faces that are joined directly to the pipe flanges.



Flange Butterfly Valve (Piston Actuator)

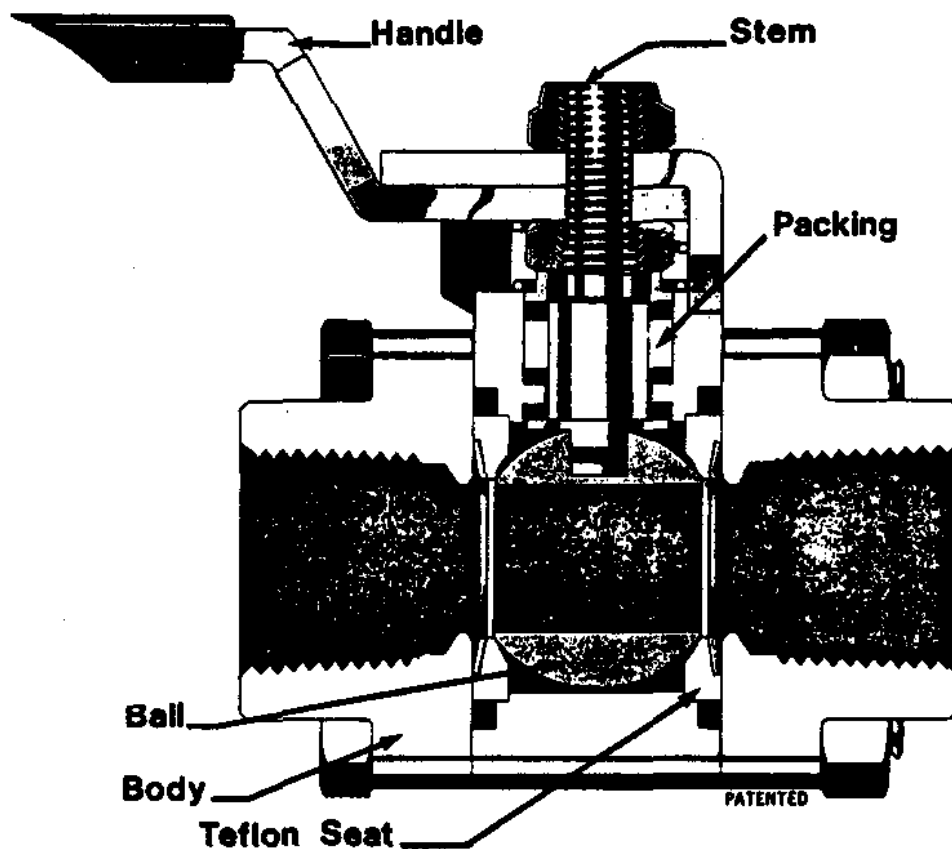
Figure 25

Ordinarily, butterfly valves will not close tightly. Leaks are prevented by using resilient seats or O-ring seats.

In the station, butterfly valves may be found either in an isolation or control function.

BALL VALVES

The ball valve is basically a ball with a hole through one axis that connects the inlet and outlet ports in the body. The ball rotates between resilient seats. In the open position, the flow is straight-through however, turning the ball 90°, completely blocks the passage. Refer to Figure 26.



Ball Valve

Figure 26

In addition to quick, quarter-turn, on-off operation, ball valves are compact, easy to maintain, require no lubrication and give tight sealing with low torque. Goodsealing results because fluid pressure forces with ball against the valve seat. Ball valves can be found for either isolation or control applications.

DIAPHRAGM VALVES

As mentioned previously, the diaphragm valve eliminates stem packing by using a flexible diaphragm to isolate the operating mechanisms from the fluid being handled. It consists basically of a body, bonnet, and flexible diaphragm.

DIAPHRAGM CONTROL VALVES

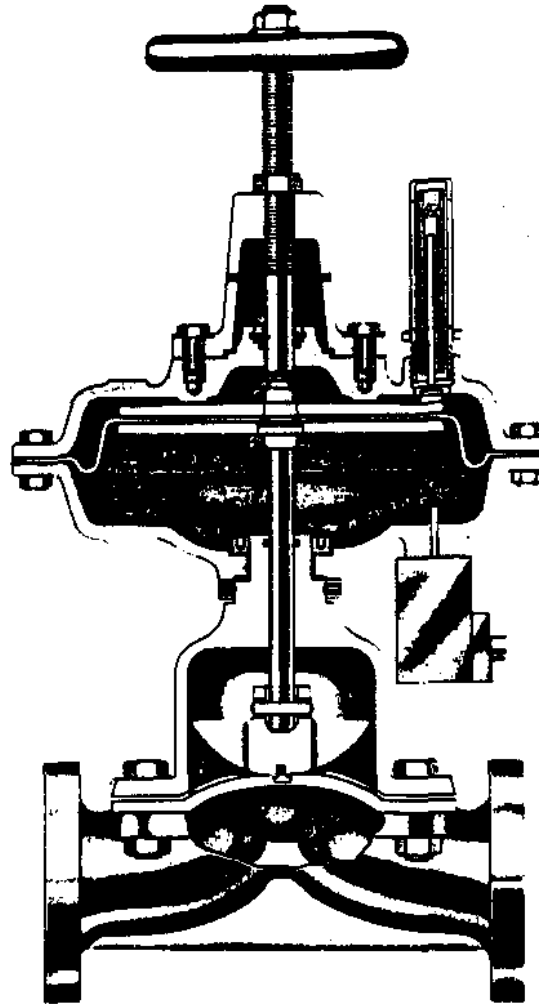
INTRODUCTION: The Conoflow Series HB diaphragm valve maintains a streamlined flow of many hard-to-handle fluids in a leakproof closure. These fluids include corrosive and erosive liquids, slurries, semi-solids, viscous substances, gases, etc. Numerous applications exist in less difficult services where simple packless construction and easy maintenance are desirable. This valve was formerly referred to as a "Saunders Patent-type" after P. K. Saunders, developer of the basic design.

OPERATION: Principle of the Conoflow Series HB diaphragm valve is extremely simple. A resilient, flexible diaphragm is connected to a compressor by a stud molded into the diaphragm. The compressor is moved up and down by the valve stem. Thus, when the compressor is raised, the diaphragm is lifted out of the fluid path to allow streamlined flow in either direction, and is pressed against the body weir when the compressor is lowered. The diaphragm can also be placed in any intermediate position for throttling control.



Diaphragm Valves

Figure 27(a)



Diaphragm Valves

Figure 27(b)

When the valve is opened, the diaphragm is lifted out of the flow passage to allow smooth streamlined flow in either direction. In the closed position, the diaphragm is tightly seated against a weir or contoured area at the bottom of the valve. It may also be positioned at intermediate points in the fluid passage for throttling the flow.

The diaphragm valve is excellent for handling various substances, slurries or corrosive fluids.

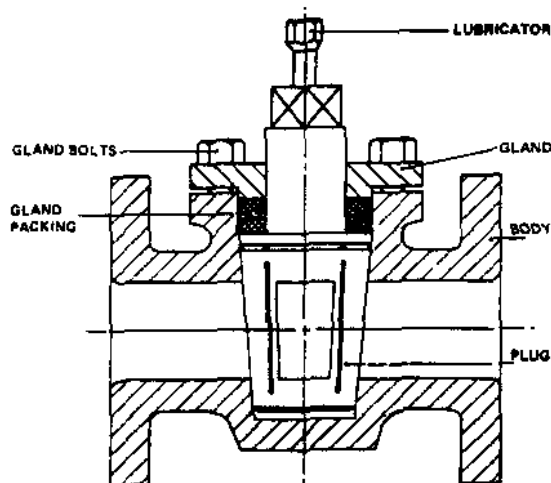
PLUG VALVES

The plug valve is one of the oldest members of the valve family. Like the gate valve it is used for on-off service.

The basic components of the plug valve are the body, plug and cover. The plug which may be either tapered or cylindrical, has an orifice which the fluid passes through. See Figure 28. In operation, the plug may be turned through 90° to allow fluid passage or to present a blank face to prevent flow.

These valves because of their design offer advantages of quick action, minimum installation space, simple operation, and low pressure drops.

The two basic types to be considered are the (1) non-lubricated type which incorporate passages or grooves in which lubricant/sealant can be applied under pressure. This serves to lift the plug for ease of operation.



PLUG VALVE

Figure 28

ASSIGNMENT

1. Name the four functions that valves must provide and an example of the valve type used for each function.
2. What are the consequences of using a gate valve for throttling?
3. Draw and label a typical gate and globe valve. Indicate on the sketch the direction of flow.
4. What type of gate valve would you recommend for:
 - (a) cold water service?
 - (b) high pressure, high temperature steam?Why?
5. What type of globe valve would you recommend for:
 - (a) fine control for large flows of water - regulation?
 - (b) governor steam valve?
 - (c) fine control for low flowrate systems?
6.
 - (a) Name the two types of nonreturn valves used and compare them with respect to leakage and pressure drop across them.
 - (b) What type of valve would you use for a small pressure drop and vertical pipework use?
 - (c) The main boiler feed pumps must not undergo reverse rotation. Would you, therefore, put the valve in suction or discharge pipework?
7. What type of pressure relief valve would be used to depressurize the steam generators? plunger chemical injection pump overpressure relief?

8. (a) Diaphragm valves can be used for what functions?
 (b) What is the main advantage of a diaphragm valve?
 (c) Where would you recommend use of diaphragm valves?

9. A large (approximately 2 metre diameter) butterfly valve is used on the discharge condenser circulating water line.
 (a) What are the other advantages of using butterfly valves?
 (b) What function do you think these valves perform?