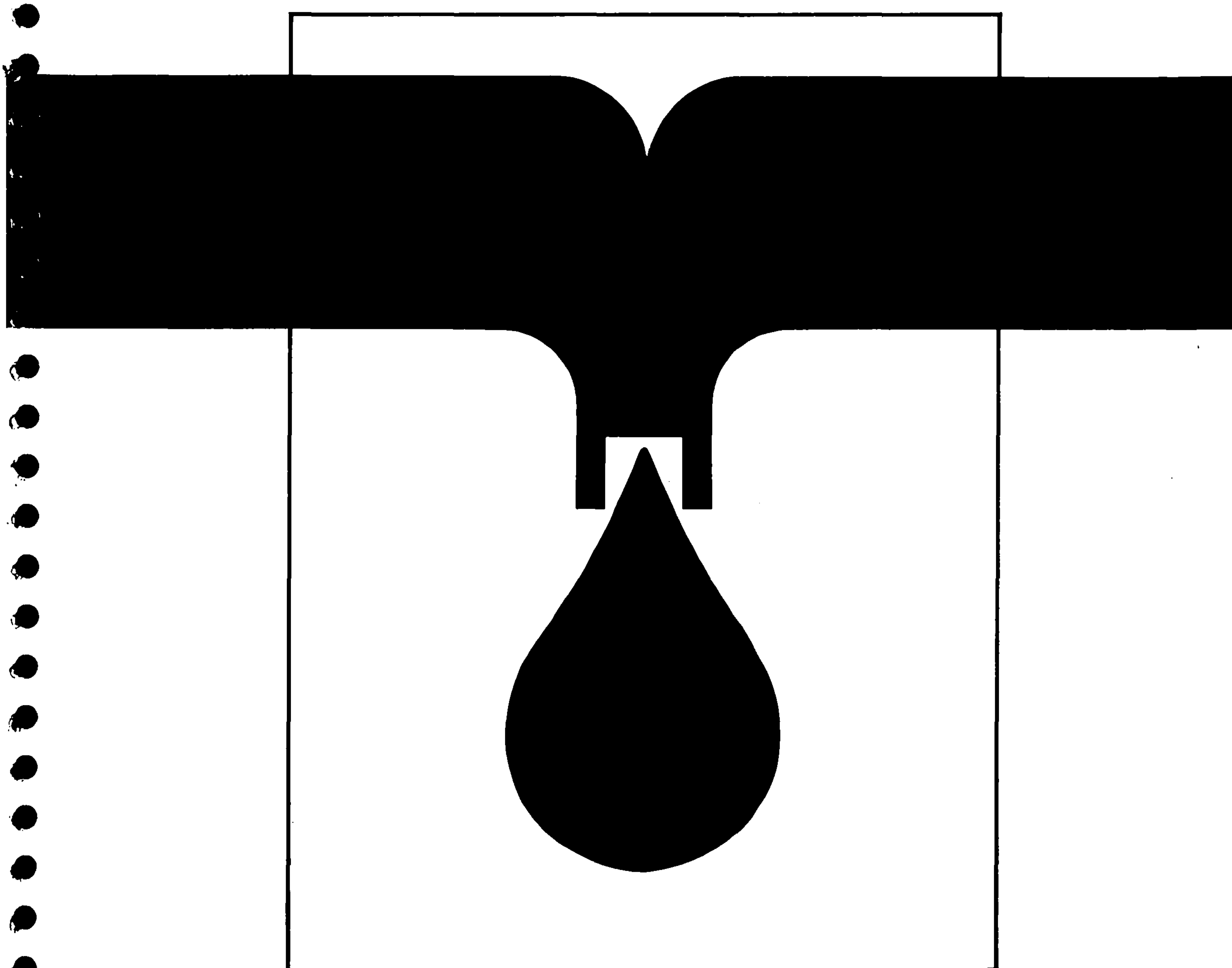
TRAINING MODULES
FOR
WATERWORKS PERSONNEL



Special Knowledge

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Design, functioning, operation, maintenance and repair of pipe fittings

Foreword

Even the greatest optimists are no longer sure that the goals of the UN "International Drinking Water Supply and Sanitation Decade", set in 1977 in Mar del Plata, can be achieved by 1990. High population growth in the Third World combined with stagnating financial and personnel resources have led to modifications to the strategies in cooperation with developing countries. A reorientation process has commenced which can be characterized by the following catchwords:

- use of appropriate, simple and – if possible – low-cost technologies,
- lowering of excessively high water-supply and disposal standards,
- priority to optimal operation and maintenance, rather than new investments,
- emphasis on institution-building and human resources development.

Our training modules are an effort to translate the last two strategies into practice. Experience has shown that a standardized training system for waterworks personnel in developing countries does not meet our partners' varying individual needs. But to prepare specific documents for each new project or compile them anew from existing materials on hand cannot be justified from the economic viewpoint. We have therefore opted for a flexible system of training modules which can be combined to suit the situation and needs of the target group in each case, and thus put existing personnel in a position to optimally maintain and operate the plant.

The modules will primarily be used as guidelines and basic training aids by GTZ staff and GTZ consultants in institution-building and operation and maintenance projects. In the medium term, however, they could be used by local instructors, trainers, plant managers and operating personnel in their daily work, as check lists and working instructions.

45 modules are presently available, each covering subject-specific knowledge and skills required in individual areas of waterworks operations, preventive maintenance and repair. Different combinations of modules will be required for classroom work, exercises, and practical application, to suit in each case the type of project, size of plant and the previous qualifications and practical experience of potential users.

Practical day-to-day use will of course generate hints on how to supplement or modify the texts. In other words: this edition is by no means a finalized version. We hope to receive your critical comments on the modules so that they can be optimized over the course of time.

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and
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It is my sincere wish that these training modules will be put to successful use and will thus support world-wide efforts in improving water supply and raising living standards.

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Eschborn, May 1987

Title: Design, functioning, operation, maintenance and repair of pipe fittings

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1. Introduction

1.1 Pipe fittings in the strict sense of the term are either shutoff or throttle devices which regulate or block off the flow in pipes. These fittings are operated by an external source of power.

Fittings which are controlled without external power include, for example, backsiphonage preventers, bleeding or ventilating valves.

Fittings in the wider sense, or accessories for fittings, include extension and expansion elements, which permit correct installation.

Dirt traps (screens, filters) are used to guard against contamination.

Simple fittings were in use even in earlier times, e.g. gates for open ditches. Devices of this type are still common today in hilly areas for the irrigation of meadows. They are also used for power channels.

Gates of this type represent the origin of the gate valve.

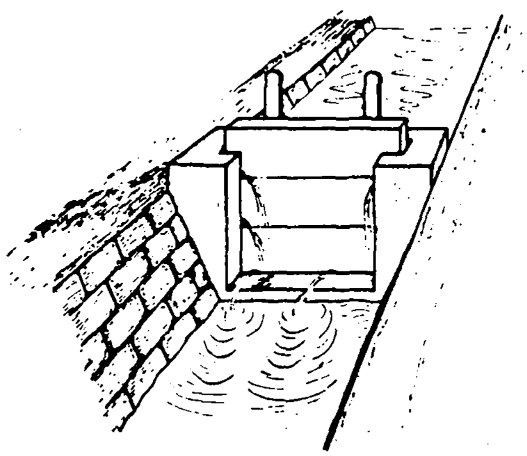


Fig. 1: Gate

The plug in a well trough or in a barrel is likewise the forerunner of a valve. The plug A shown in Fig. 2 is slightly conical and is pushed firmly into the round outlet of the trough to close it.

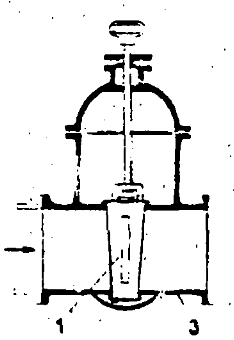
Fig. 2: Plug

1.2. Classification of fittings according to the direction of movement of the shutoff element

- Movement perpendicular to the main direction of flow

These shutoff devices are known as gate valves. Fig. 3 shows a gate valve in the closed position:

1. Shutoff element
2. Slot
3. Body



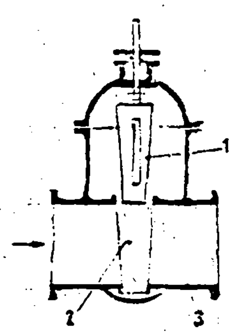


Fig. 3: Gate valve (closed)

Fig. 4: Gate valve (open)

In Fig. 4 the gate valve is open. The shutoff element (1) is pushed into the slot (2) of the pipe-like flow section or body (3) to stop the flow.

- Movement of shutoff element parallel to flow, in the same or opposite direction.

Shutoff devices of this type are known simply as valves.

Fig. 5 shows a straightway valve in the closed position. The water pressure can act on the valve disc from below or from above. When the valve is open (Fig. 6) the flow medium is diverted to a considerable extent.

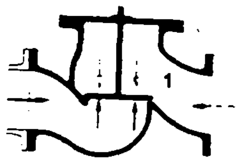


Fig. 5: Straightway valve (closed)

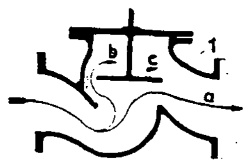


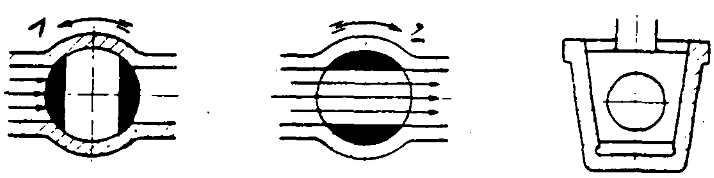
Fig. 6: Straightway valve (open)

The diversion of the flow, and thus the resistance, can be substantially reduced if the body and valve disc (1) are of a special shape (inclined valves, angle valves, piston valves, hydrants, annular piston valves).

- Fittings with rotating or swinging shutoff element

In this case the axis of rotation is perpendicular to the pipe axis.

The shutoff element takes the form of a cylindrical or conical peg or of a ball, and has a hole allowing fluid to pass through.

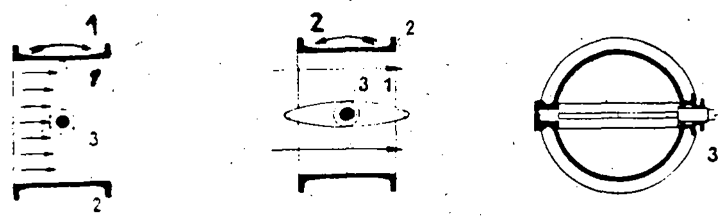


1 = Open
2 = Closed

Fig. 7: Cock

Fittings of this type are known as cocks.
Fig. 7 shows a cock in the open and closed positions. A special type used for large nominal diameters is known as a globe valve.

- If the shutoff element takes the form of a flat or lenticular disc, this flap-type valve is known as a butterfly valve, swivel damper, annular valve or similar.



1. Disc
2. Body
3. Shaft

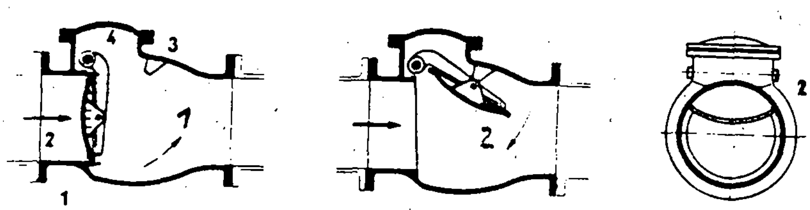
A B A = closed
B = open

Fig. 8: Butterfly valve

Fig. 8 shows a butterfly valve of this type in the closed and open positions. The outer edge of the disc (1) is sealed with respect to the cylindrical valve body (2). The shaft (3) passes through the centre of symmetry of the shutoff element.

- Axis of rotation outside the flow cross-section

In the flap-type valve shown in Fig. 9, the pivot (4) is situated at the top of the body. The flap performs a swinging movement.



1. Body
2. Flap
3. Cover
4. Pivot

A B A = closed
B = open

Fig. 9: Non-return valve

The medium flows through the flap-type valve in one direction only.

In the closed position the water exerts pressure on the back of the flap disc.

Flap-type valves of this design are known as non-return valves.

A pipe fitting may be operated either by means of external power, e.g. manual operation, electrical operation, hydraulic operation for the open, intermediate and closed positions, or by means of automatic movement without an external source of power. The movement is effected as a result of a change in the pressure and flow velocity of the flow medium. The effect of the flow medium is reinforced - without intervention on the part of the operating personnel - by means of weights, diaphragms, springs or a hydraulic drive (non-return valve with lever and weight, float valves).

Requirements to be fulfilled by pipe fittings:

- Minimal diversion of the flow medium in the body of the fitting
- Constant cross-sectional area of flow when fully open
- Tight seal when in closed position
- Sturdy construction of body, shutoff element and stem
- Use of suitable materials
- Must be able to operate perfectly after lengthy period of non-use
- Careful manufacture of sealing faces and slide faces

- Easy access to control elements (handwheels, control valves, stuffing boxes etc.)
- Ease of replacement in the case of parts subject to wear on account of extremely frequent operation

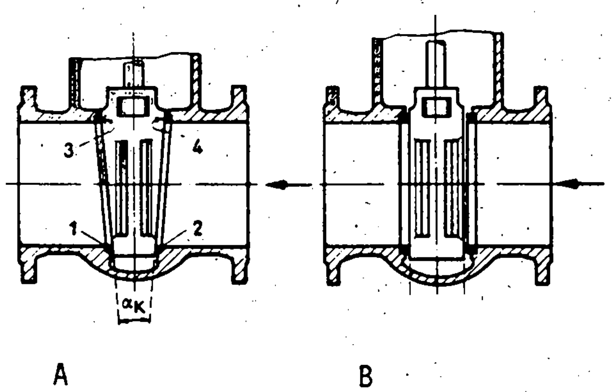
2. Gate valves

The function of gate valves is to shut off or permit in full the flow of a medium through pipes.

Gate valves are divided into three categories: wedge gate valves, parallel gate valves with metal seal and wedge gate valves with compression seal.

Gate valves with compression seal are used primarily for small and medium nominal diameters up to around DN 500.

In wedge gate valves the two seating faces 1 and 2 in the valve body and 3 and 4 on the shutoff element (Fig. 10) are inclined towards each other at an acute angle α_K.



1 Seating face
2 Seating face
3 Valve body
4 Valve body

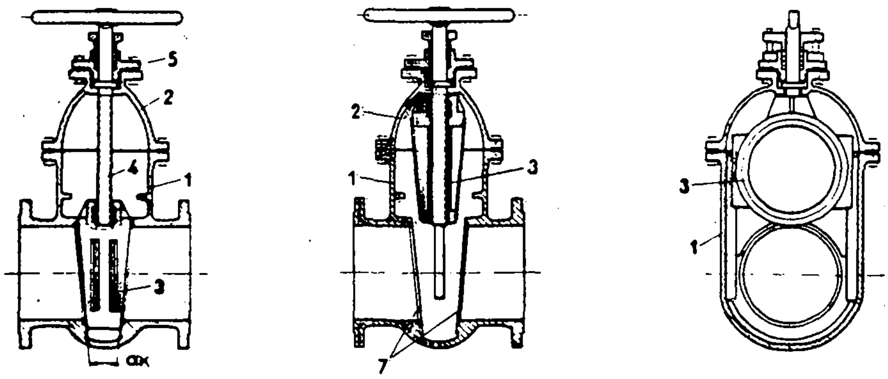
A = Wedge type
B = Parallel type

Fig. 10: Gate valves

In parallel gate valves the seating faces are parallel to each other.

In the wedge gate valve the seating faces of the shutoff element move away from the corresponding seating faces in the valve body after a short opening stroke. In the parallel gate valve they slide on each other throughout the entire stroke.

A gate valve consists of three main parts: the body, the shutoff element and the actuating elements.



1. Body
2. Cover
3. Shutoff element
4. Stem
5. Stuffing box

A B

A = Closed
B = Open

Fig. 11: Wedge gate valve

The power is introduced via the stem 4, which is perpendicular to the pipe axis.

The cross-section of the body and of the cover changes according to the operating pressure.

DIN standards stipulate the body lengths in the case of gate valves made of cast iron or cast steel.

Gate valves of large nominal diameters and for high pressures are expensive, with the result that butterfly valves are generally used from DN 300 upwards.

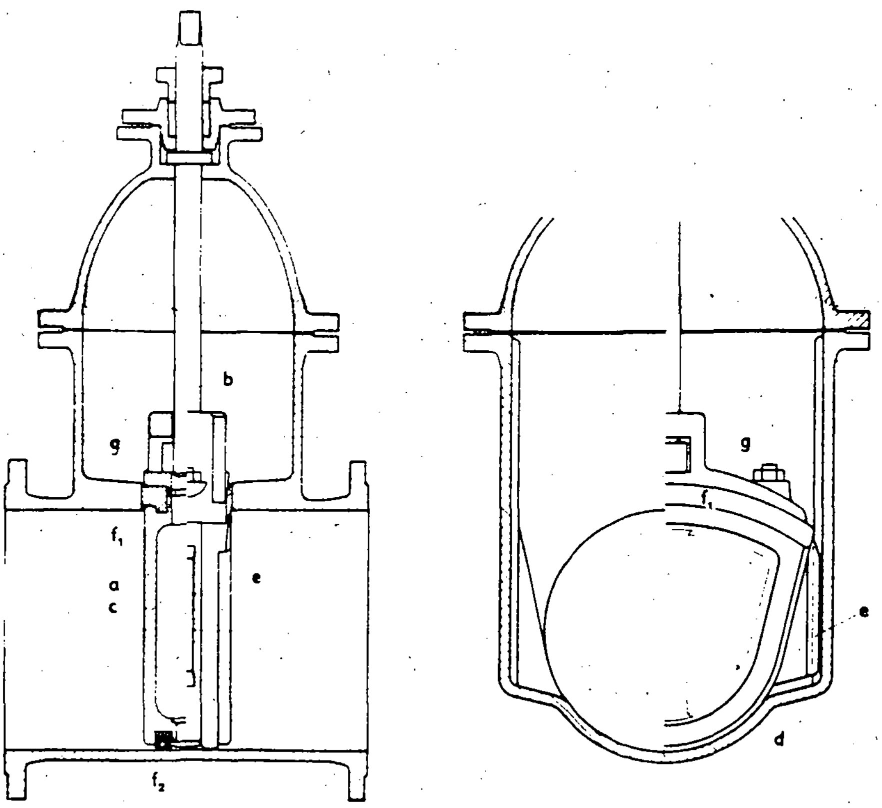
In addition to bsorbing the pressure of the flow medium, the flanges used for securing the valve cover to the valve body must also absorb the pressure of the stem during the last part of the closing process.

- Parallel gate valves are shutoff devices with parallel sealing faces.
  During the entire stroke the sealing faces on the outflow side slide against each other.

Gate valves of this type are seldom used in water supply systems, as the one-sided water pressure and the large friction surface necessitate a considerable amount of power for opening and closing.

- Gate valve with compression seals

The compression-seal gate valve (Fig. 12) has a totally straight flow passage (when open). The design of the shutoff element (a) corresponds to that in the parallel gate valve. Inside the shutoff element is a cavity (c) to accomodate the stem (b). The shutoff element is guided by two gibs (e). The compression seal consists of two rings (f). These seals are forced against the contact surfaces of the valve body, perpendicular to the flow, in the lower part of the body and at the side walls.



a Shutoff element
b Stem
c Cavity
d Body
e Jointing surfaces
f Seal rings

Fig. 12: Gate valve with compression seals

It is not advisable to use the compression-seal oval-body gate valve for pressures in excess of 16 bar and nominal diameters greater than 300 mm due to the vulnerability of the seal.

The closing forces of the compression-seal gate valve are somewhat greater towards the end of the stroke than in the case of wedge gate valves.

However, the compression-seal gate valve has an advantage in that no recess is required on the bottom of the body. No deposits can settle when the valve is open.

Another type of compression-seal gate valve is represented by the diaphragm-type gate valve, which is shown in Fig. 13 in the closed and open positions.

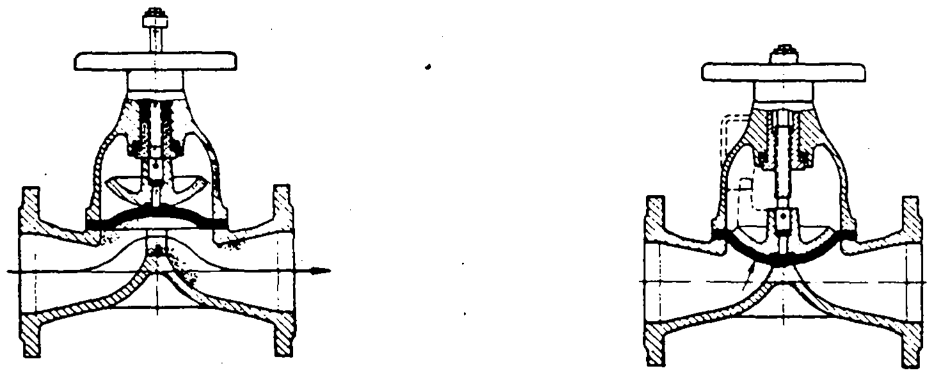


Fig. 13: Diaphragm-type gate valve
(open) (closed)

The diaphragm is secured between the body and the cover and is deformed to a considerable extent when the valve opens and closes. This can lead to cracking in the event of continous operation. The diaphragm can, however, be replaced without removing the entire fitting.

The shutoff element is moved by a stem or, in the case of hydraulic or pneumatic drive, by a piston rod.

A distinction is made between two types of stem:

Stem with thread inside the valve body

Stem with thread outside the valve body

In the case of gate valves with stem thread inside the valve body, the threaded section is immersed in the flow medium. This non-rising stem performs only a rotary movement and no longitudinal movement.

The condition of the flow medium determines the thread's friction coefficient.

The stem emerges into the open air at the top of the cover and is sealed by means of a stuffing box. The packing is compressed by the gland and thereby pressed firmly against the outer diameter of the stem shaft.

Worn seals can be made tight once again by tightening the gland.

External stems can be lubricated and are therefore generally easier to operate.

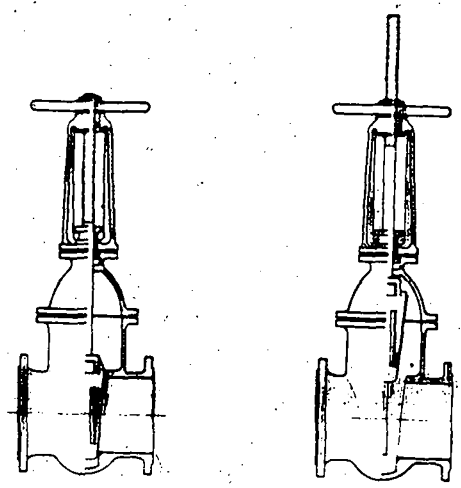


Fig. 14: Gate-valve stem
inside outside
the valve body

The external stem is more suitabel than the internal stem for absorbing compressive or tensile forces acting outside the centre of the stem.

Stems, packing and seals should be kept in store so as to permit necessary repairs.

3. Valves

Like gate valves, ordinary valves are used to shut off the flow in pipelines and are often also used to throttle the flow.

In this type of fitting, the flow is diverted to a greater extent than is the case with gate valves or cocks.

The seating faces of such valves fit closely on each other.

In the case of a high degree of flow diversion, corrosion (cavitation) must be expected on the seating faces or on the adjacent wall at certain flow velocities.

Valves of this type generally consist of three main components: the body (mostly in two parts), the shutoff element and the stem (or guides in the case of automatic valves).

The seating rings of valves are of numerous different types and have flat or conical sealing faces. The sealing faces themselves are made primarily of bronze or stainless steel. Compression seals are also used for low pressures.

- Straightway valves
  The inlet and outlet ports are opposite each other in the same axis

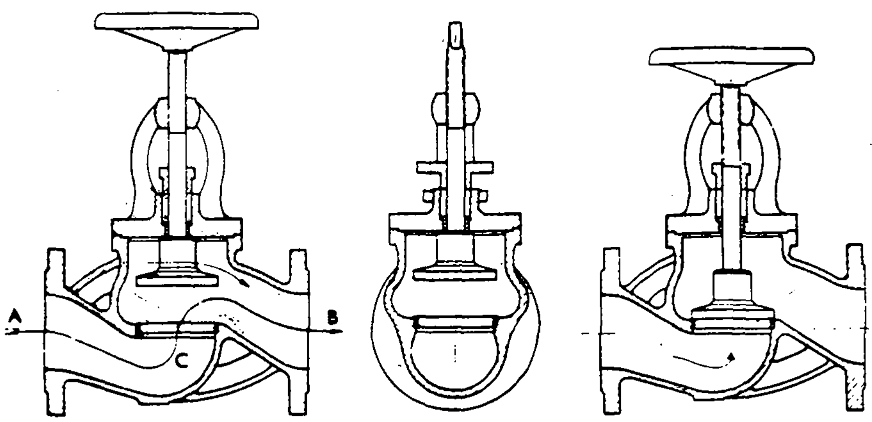


Fig. 15: Straightway valve
Open — Closed

Advantages: Small sealing face
Simple design

Disadvantage: Considerable flow diversion

- Inclined valves
  In these valves the diversion of the flow medium is considerably improved and the flow resistance is smaller.

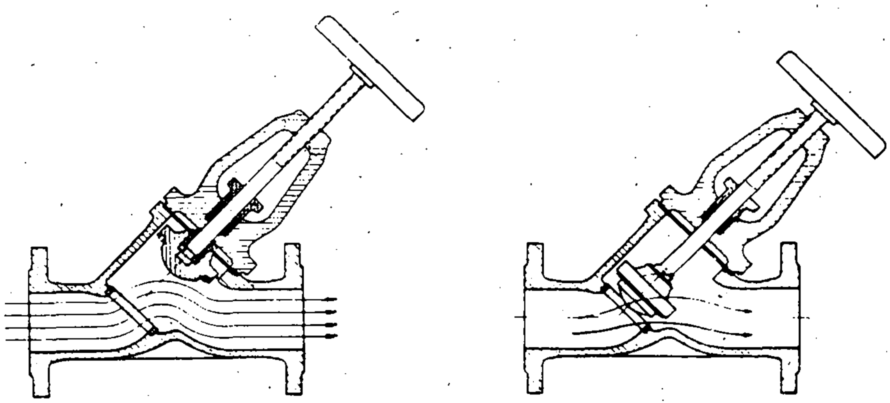
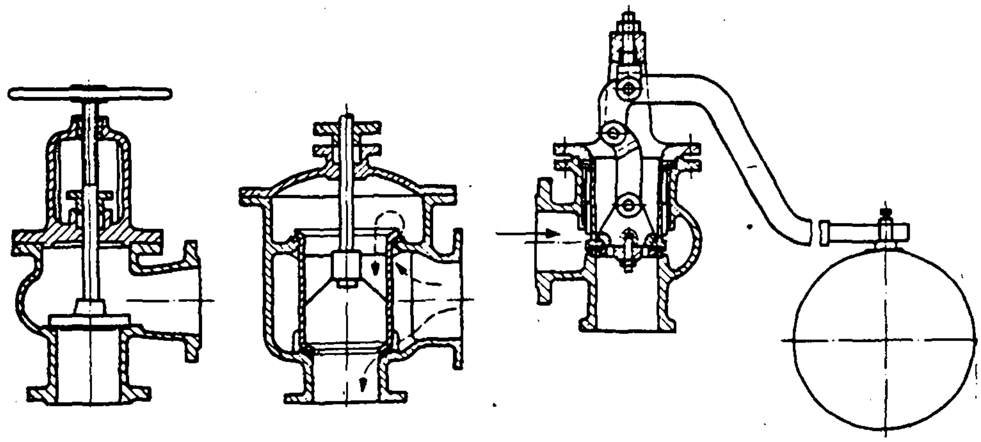


Fig. 16: Inclined valve

Disadvantage: The travel of inclined valves is considerably greater than that of straightway valves. Operation is poorer than for straightway valves in the case of larger nominal diameters.

- Angle valves
  The inlet and outlet ports are at right angles to each other.



1 2 3

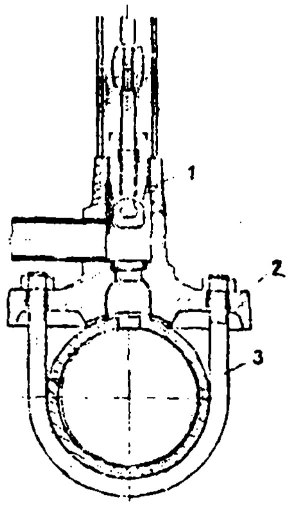
Fig. 17:

1 Angle valve 2 Double-seating valve 3 Float-type discharge valve

Angle valves also include double-seating valves (17.2) and float-type discharge valves (17.3).

- Saddle clips

The saddle clip with valve is a special type of angle valve. It is used for tapping pressurized pipelines.



1. Stem with drilling head
2. Body
3. Retainer

Fig. 18: Saddle clip

The body of the saddle clip with valve incorporates two strong cast iron lugs at the inlet port; these lugs project beyond the outer diameter of the pipe to be tapped.

The saddle clip is secured to the pipe by means of the U-shaped retainer.

The saddle clip is generally installed in the ground. The stem is extended and the turnkey insolated from the ground by means of a surface box.

Saddle clips are availabel for all pipe materials.

- Hydrants

A distinction is made between two main groups: underground hydrants and standpost hydrants.

Underground hydrants (Fig. 19) are installed completely in the ground or in shafts. Their location is indicated by signs in appropriate places and by the surface box or shaft cover.

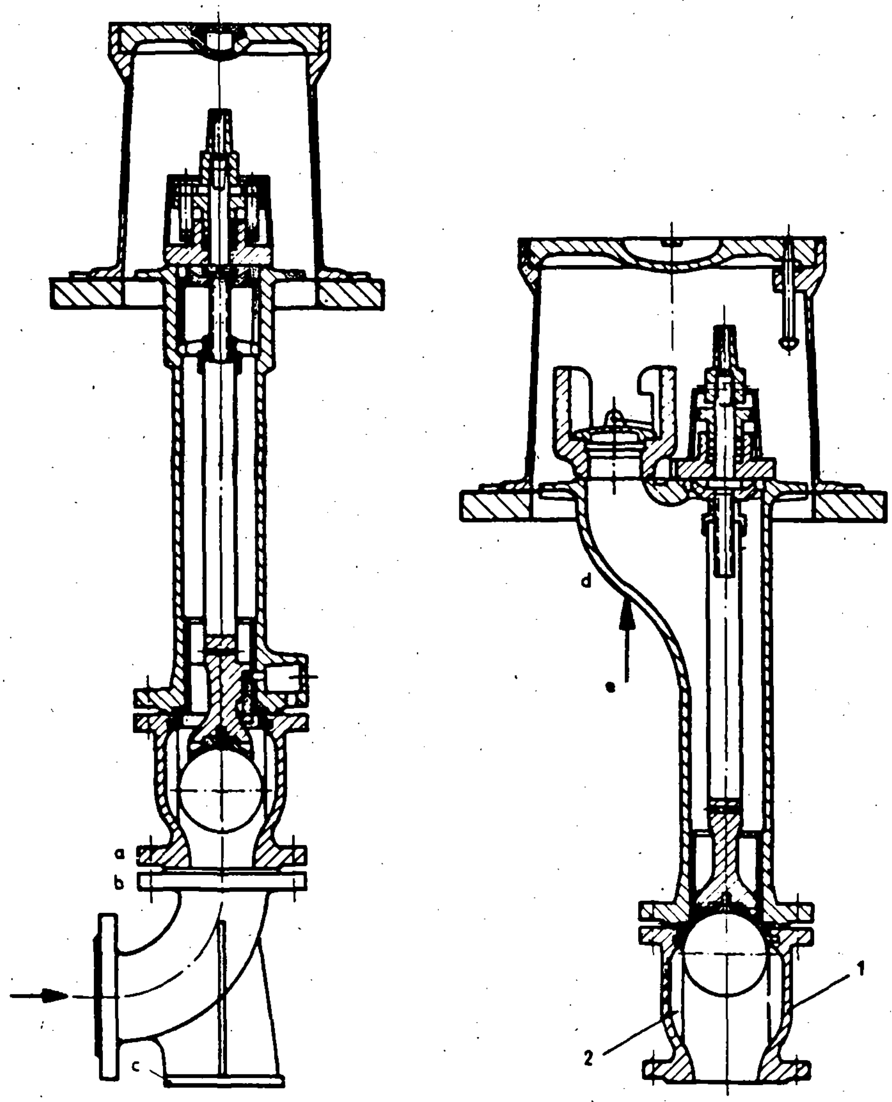
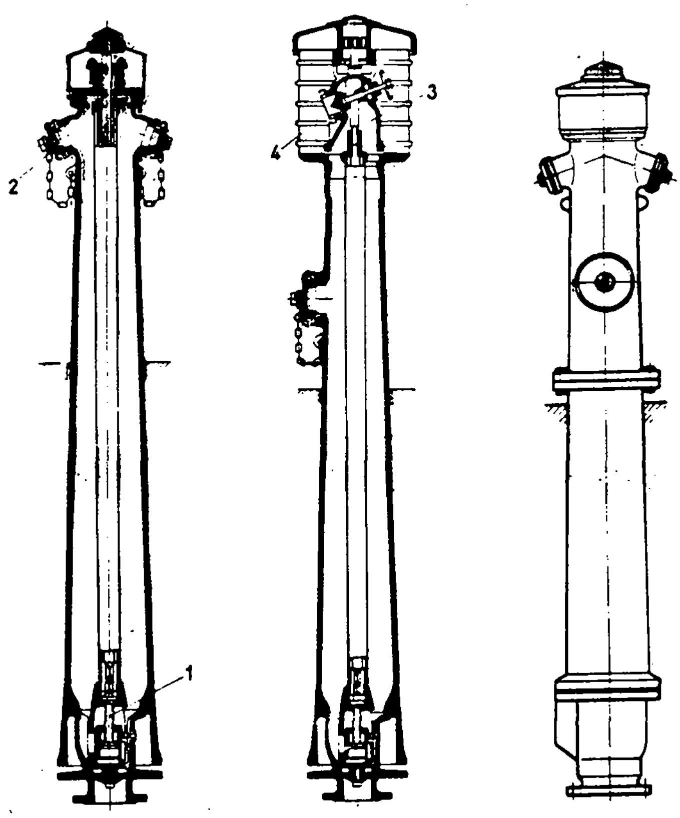


Fig. 19: Underground hydrant

The top of the pillar of an underground hydrant has a projecting extension on one side; on this extension is the fixture permitting attachment of a standpipe for the withdrawal of water.

At dead ends, a 90° bend is installed between the hydrant and the horizontal transmission main.

Standpost hydrants (Fig. 20) have a considerably longer pillar, the lower part of which extends into the ground, while the upper part projects out of the ground such that it is easily visible.



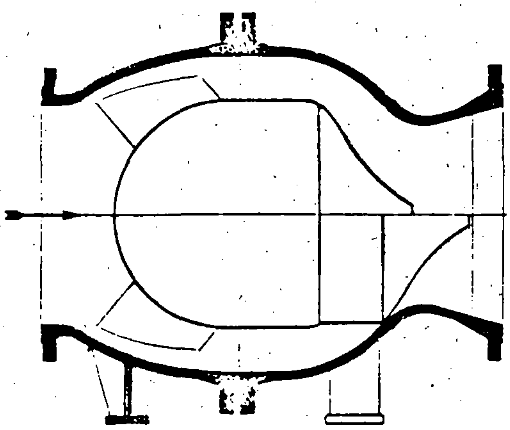
1. Casing
2. Coupling
3. Valve
4. Cover

Fig. 20: Standpost hydrant

At the top of a normal standpost hydrant are two branches with couplings (2), permitting the connection of fire hoses. The two outlets are often fitted with valves (3). The valves are protectecd by means of a cover (4) so as to prevent unauthorized access.

- Annular piston valve

The annular piston valve is a special type of valve.



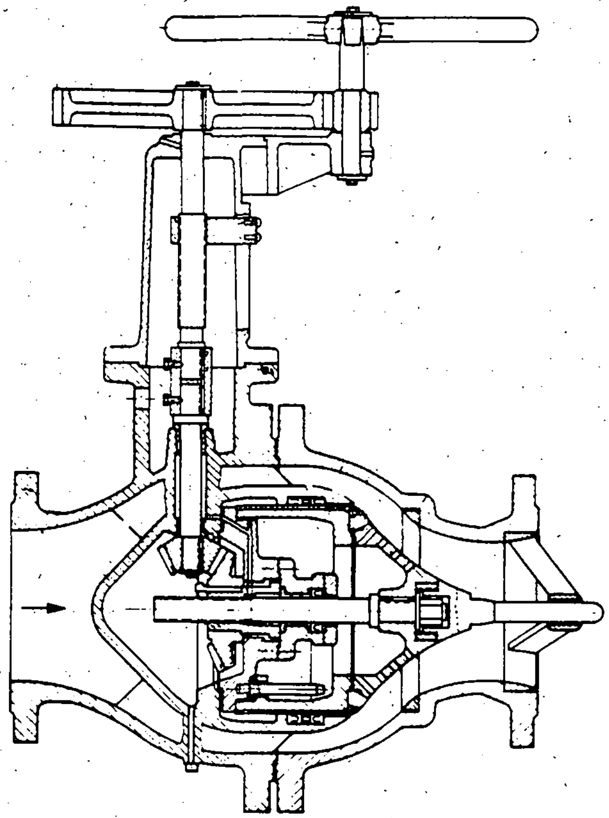


Fig. 21: Annular piston valve

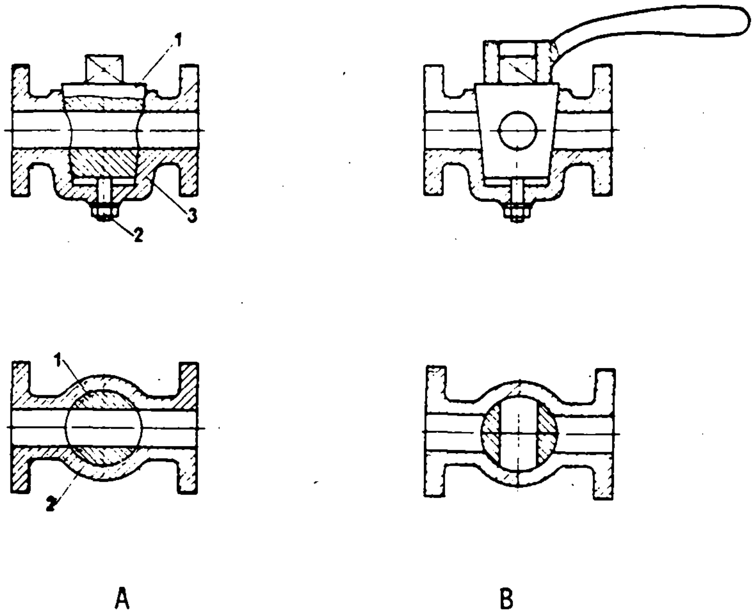
The cylindrical flow of water in the pipe is converted into an annular flow in the body of the valve. At the point where it leaves the valve body the annular flow once again becomes a cylindrical flow corresponding to the diameter of the pipe.

The small degree of diversion in the body of the annular piston valve represents the prerequisite for a considerable reduction in flow resistance under throttling conditions by comparison with conventional valves.

4. Cocks

Cocks are primarily fitted in fluid lines to shut off the flow and in some cases to throttle it. They require little space and, when fully open, have a circular cross-section which corresponds to the diameter of the pipe.

Cocks can be regarded as gate valves with cylindrical or conical sealing faces.



1. Plug
2. Threaded stem
3. Body

A = Open
B = Closed

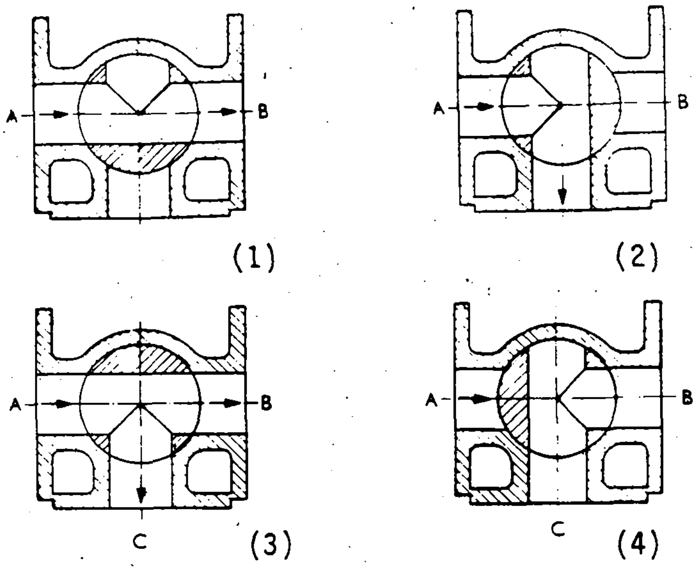
Fig. 23: Cock

Fig. 23 shows a cock in the fully open and fully closed positions.

The plug (1) is drawn tightly into the conical bore of the body (3) by a threaded stem (2) at the tapering end of the cone such that a tight seal is created with the cock in the closed position.

The torque required for operating cocks is generally somewhat greater than that necessary for gate valves with the same nominal diameter.

The angle of rotation of the plug is usually limited to 90° by stops on the body.
- Three-way cocks (Fig. 24) are a special design.



A
B Directions
C of flow

(1) A-B open
(2) A-C open
(3) A-B-C open
(4) Closed

Fig. 24: Three-way cock

A three-way cock makes it possible to route the flow medium from A to B or from A to C.

In special cases it is also possible to route the flow from A to B and C simultaneously.

A similar function is performed by four-way cocks, which will not be discussed in detail here.

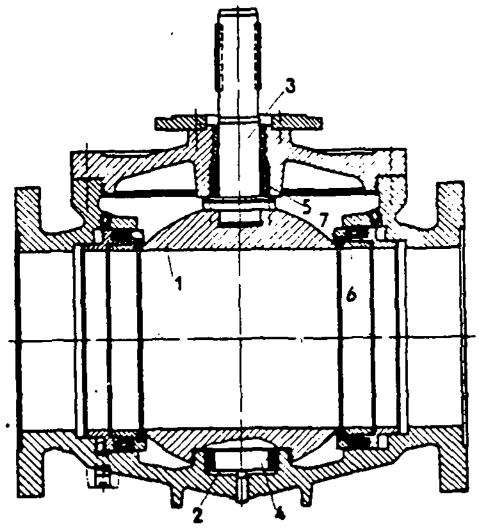
- Globe valves, ball cocks

The small pressure loss of cocks has led to the development of ball cocks.

Fig. 25 shows a ball cock. The ball (1) has a non-rusting surface.

The bore corresponds to the nominal diameter of the pipe.

The ball is guided in the valve body



1. Ball
2. Spindle
3. Spindle
4. Needle bearing
5. Needle bearing
6. Seal ring
7. Gasket

Fig. 25: Ball cock

by two spindles (2 and 3), which run in needle bearings (4 and 5). A seal is provided on each side of the ball by two rings (6) which slide into each other; an abrasion-resistant gasket (7) is fitted in the rings in each case.

The ball cock can be installed horizontally or vertically. The drive is mounted in the usual manner on the spindle (3) which extends into the open air; it consists of a worm-gear transmission unit or, in the case of larger nominal diameters, an ordinary toothed-gear mechanism.

Ball cocks are not suitable for use as throttling devices.

Annular piston valves should be used to throttle the fluid flow.

5. Flap-type/butterfly valves

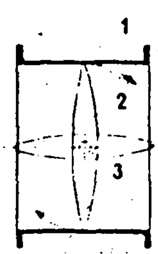
Like gate valves and ordinary valves, the function of these devices is to permit or shut off the flow of fluid through pipelines.

This category comprises those shutoff devices in which the shutoff element primarily takes the form of a circular disc and rotates about an axis in the valve body. Such fittings are known by various names, e.g. swivel dampers and butterfly valves.

Only in exceptional cases can they be used as throttling devices in fluid lines because they give rise to high flow resistances, generally accompanied by loud noise, when in throttling positions.

Their advantages over gate valves are that they require little space, and in particular have a small height, as well as requiring substantially shorter closing times with the exertion of the same force on the handwheel.

A simple valve of this type is shown in schematic form in Fig. 26. It consists of three main parts: the body (1), the rotatable shutoff element (2) which is installed in the body and is securely connected to the shaft (3), and the drive.

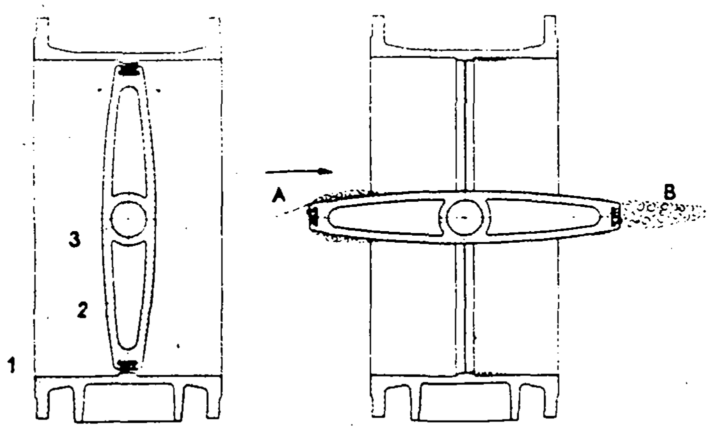


1. Body
2. Shutoff element
3 Shaft

Fig. 26: Butterfly valve

Rotation of the shaft in the direction of the arrow causes the disc to move such that the valve is opened.

Valves of this type are used in applications where the "fully open" and "fully closed" positions are required.



1. Body
2. Shutoff element
3. Shaft

Fig. 27: Butterfly valve
(closed) (open)

Fig. 27 shows a butterfly valve with a large nominal diameter in the closed and open positions, and indicates a number of design features. The valve provides a tight seal even in the case of a changing direction of flow.

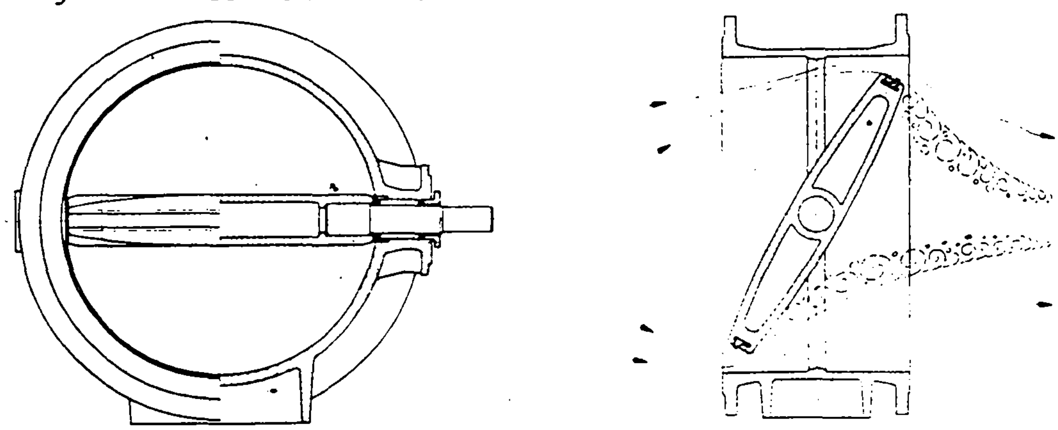
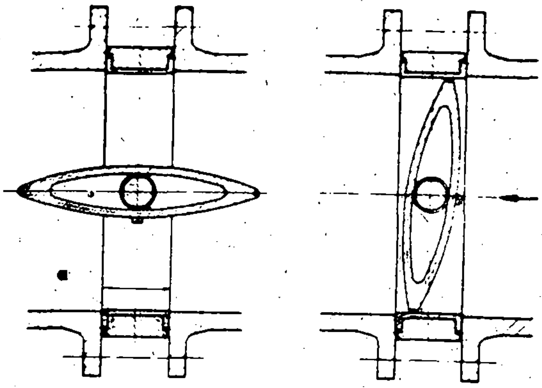


Fig. 28: Butterfly valve
(in throttling position)

Fig. 28 shows the disc in a position which throttles the flow to a considerable extent. The circular flow cross-section at the valve body inlet is reduced to two crescent-shaped flow areas.

In annular valves of this type the valve body is reduced to a narrow ring (Fig. 29).



a Seal ring

Fig. 29: Annular valve

The valve body has no flanges and is gripped between the flanges of the connecting pipe sections. The interior walls of the body of such annular valves are lined with a flexible seal ring (a).

Butterfly valves with small nominal diameters are made of cast iron, while the interior components are largely made of non-rusting materials. Butterfly valves with larger nominal diameters are made of welded steel and in some cases have eccentrically mounted discs (Fig. 30).

A particular advantage of such valves is that for large diameters, the flexible seal can be renewed from inside the pipe.

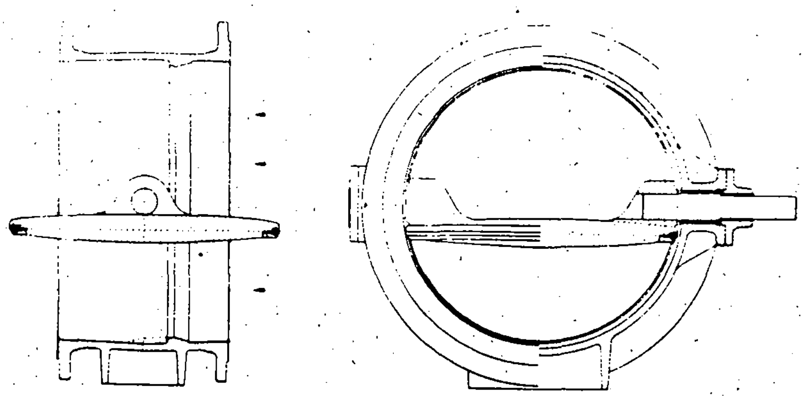


Fig. 30: Eccentric butterfly valve

- Drive systems for pipe fittings

The function of drive systems is to move the shutoff elements of pipe fittings by means of the introduction of a force (from outside). Drive systems should be designed such that they can overcome the forces and torques occurring at the stem or shaft (with full pressure on one side) during the opening and closing processes. An adequate, reliable drive system is of major importance in the case of pipe fittings which remain in the same position for many months or even for many years. Many fittings with a large nominal diameter do not fulfil these requirements when full pressure is exerted on one side and can often be actuated only if the pressure is relieved to a considerable extent.

Drive systems for pipe fittings can be classified in two main groups:

Drive systems using hand power, motor power or gravity
Hydraulic (water, oil) and pneumatic drives.

Both of these types can be used for rectilinear and rotary movement of the shutoff element for the purpose of both opening and closing the device.

Drive systems which use gravity (by means of a falling weight etc.) are suitable only for one direction of movement (opening or closing). They are used in particular for isolation valves, backsiphonage preventers etc.

The most common control element used for fittings having a threaded stem is the handwheel. The greater the nominal diameter of the pipe fitting, or the greater the stem diameter and the operating pressure, the larger the handwheel diameter must be. In the case of manual operation, the force exerted on the circumference of the handwheel should not exceed 15 - 20 kp per hand. Two men can operate a single wheel in the case of handwheels with a larger diameter if there is sufficient space. For some types of pipe fittings, handwheels are equipped with control handles. In order to permit rapid actuation of a fitting, the rims of handwheels having a small or medium diameter are sometimes equipped with a rotatable handle perpendicular to the plane of the wheel.

Pipe fittings installed in the ground or in underground chambers have an operating key instead of a handwheel. This consists of an iron bar, the lower end of which has an enlarged section with a conical square hole which can be attached to the conical square on the end of the stem or on the stem cap. The other end of the operating key takes the form of a double-arm lever. One end of the lever is somewhat tapered and slightly offset to permit the removal of the covers of surface boxes and shafts.

Extension pieces of any type should never be used; for example, pipes are sometimes attached to the handles of operating keys and handwheels operated with longer iron bars. As a result of the increased torque, this will inevitably result in damage to the spokes or rim of the handwheel (fracture). Moreover, damage may commonly be caused to the upper end of the stem (bending) or to the thread (shearing).

In the case of most pipe fittings to be installed in the ground (gate valves up to approximately DN 800), the usual earth cover of 1.5 m above the pipe means that a stem extension is necessary; this consists of the turnkey with a coupling sleeve at the bottom and a square at the top.

At high pressures, shutoff devices with large nominal diameters require very long opening and closing times when manually operated on account of the extensive transmission. In machinery houses, therefore, electric-motor drives with standby manual drive system are often used instead of manual systems in order to reduce the operating times. Additional intermediate gears are necessary because the electric motors have high speeds.

Fig. 31 shows a wedge gate valve with top-mounted electric drive.

A particular advantage of electric drives is that they can be operated both at the fitting's point of installation and from greater distances.

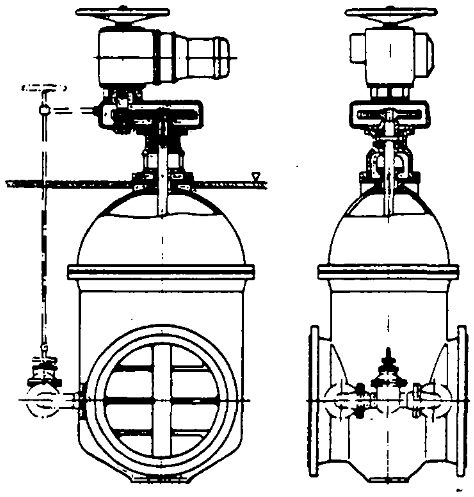


Fig. 31: Wedge gate valve with top-mounted electric drive

In order to facilitate operation (and in particular to reduce the amount of time required), gate valves with a large nominal diameter installed in long-distance pipelines or in municipal mains can be operated by means of a portable or mobile electric drive unit. The required power is supplied by a spark-ignition or diesel engine, which forms part of the mobile drive unit.

- Hydraulic and pneumatic drive systems

The hydraulic drive system comprises a cylinder (1) with a piston (2) on which the control medium acts from two directions; this cylinder is mounted on the cover (3) of the pipe fitting (Fig. 32). The piston is connected to the shutoff element by means of the piston rod (4). The space between the piston rod and the housing is sealed by means of sleeves or O-rings (5). When the control medium is introduced via port 6 the valve is closed, while if it is introduced via port 7 the valve is opened.

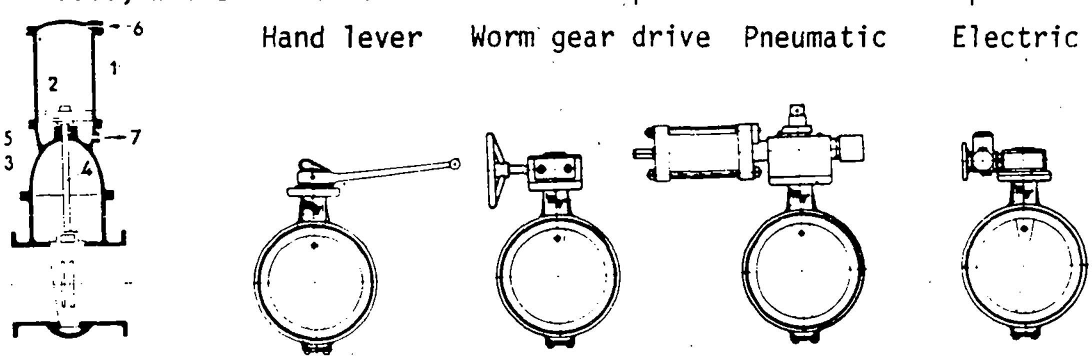


Fig. 32: Types of drive system

Fig. 32 also shows butterfly-type valves with various types of drive: hand lever, worm gear drive, pneumatic cylinder and electric drive.

In drive systems for pipe fittings in which the shutoff element rotates the piston is extended by means of a rack. This rack transforms the rectilinear movement into rotary movement via a gear segment which is securely connected to the shaft of the shutoff element.

6. Backsiphonage preventers

These are shutoff devices which open automatically, without the application of power from outside, when a medium starts to flow in a pipe section and which close automatically - as a result of their own weight or of a spring, a diaphragm or a special loading weight - when the flow ceases, thereby preventing the medium from flowing back.

In normal operation, the medium flows through backsiphonage preventers in one direction only. The devices are installed both downstream of the delivery port of a pump (on the discharge side - backsiphonage preventers for discharge lines) and on the intake side of the pump (on the suction side - backsiphonage preventers for suction lines).

Backsiphonage preventers are often referred to as non-return valves, reflux valves, check valves or similar. When the device closes there may be an impact or thrust, which is undesirable and may even be dangerous for the discharge line and the shutoff device itself.

The requirements imposed on backsiphonage preventers for suction lines differ considerably from the operation conditions for those in discharge lines. There are therefore also a number of major differences between the devices used for these two purposes.

Backsiphonage preventers for discharge lines

Main types: simple valves and flap-type/butterfly valves

Backsiphonage preventers in discharge lines for the most part fall into one of two basic categories: devices with shutoff elements performing a rectilinear movement (simple valves) and devices with shutoff elements performing a swinging or rotating movement (flap-type or butterfly valves).

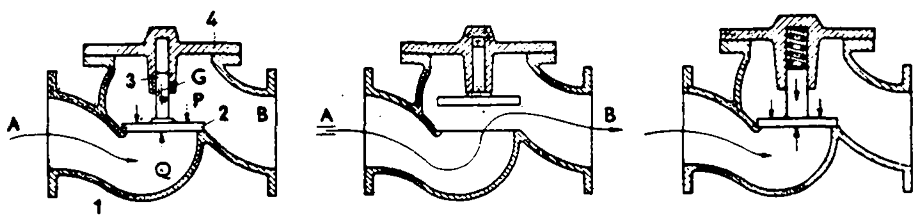
- Simple valves as backsiphonage preventers

Fig. 33 shows, in schematic form, a valve in the closed position. The valve body (1) is of roughly the same shape as that of an ordinary straightway valve. The shutoff element (2) rests on the seat in the valve body; secured to the shutoff element is a pin (3), which is guided in a sleeve in the cover (4). In the closed position, the pressure Q in the inlet port A is smaller than the pressure P in the outlet port B (with the line filled but without flow). The shutoff element is pushed in the direction of the arrows P onto the seat.

For the valve to be opened, a force Q must act on the underside of the shutoff element; this force must be greater than the water pressure P + dead weight G + friction R in the valve guide.

$$Q > (P + G + R).$$

The weight G refers to the weight as weighed, less buoyancy.



A Inlet port
B Outlet port
1 Valve body
2 Shutoff element
3 Pin
4 Cover

Fig. 33: Non-return valve

The diagram in the centre of Fig. 33 shows the valve in the fully open position. The shutoff element is lifted by the flow and the medium then flows through the valve body in the direction A - B, being considerably deflected in the process. As a result of this deflection, the flow is not distributed evenly at the edge of the valve; the shutoff element attempts to tilt, thereby increasing the friction R in the valve guide.

In order to be able to initiate the closing process when the flow ceases or becomes reduced, the forces G + P acting in the "closing" direction must be greater than the pressure on the underside of the valve Q + friction R.

$$(G + P) > (Q + R).$$

In small valves, a spring is often added to reinforce G (shown on the right of Fig. 33).

The highly curved cross-sectional area of flow creates a high pressure loss. Backsiphonage preventers of the straightway type therefore have only relatively small nominal diameters. The flow resistance can be substantially reduced if the valve body is of the angle type. In inclined backsiphonage preventers (Fig. 34), both the travel and the friction in the guide are increased. On account of the slightly inclined direction of movement, the dead weight of the moving component makes only a minimal contribution to the execution of the closing movement.

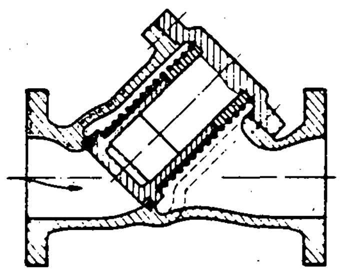


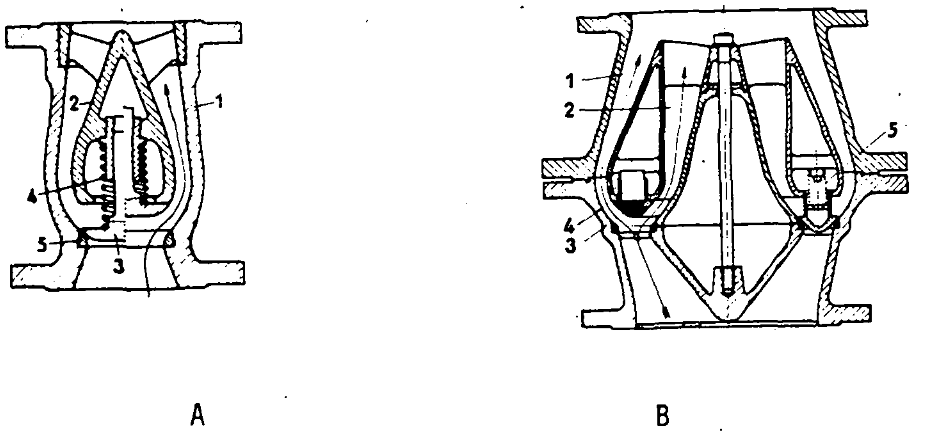
Fig. 34: Inclined backsiphonage preventer

- Nozzle valves

Fig. 35 shows a backsiphonage preventer with inlet and outlet ports in the same axis and with an annular cross-sectional area of flow possessing rotational symmetry.

In the case of small nominal diameters, the device known as an annular nozzle valve has cross-sectional areas of flow similar to those of the pressure-compensated annular piston valve.

Backsiphonage preventers of the nozzle type consist of a barrel-shaped housing (1) containing a streamlined body (2). The shut-off element (3) is disc-shaped and is guided by means of a pin in a bushing located in the insert (2). When the line is empty, the valve disc is forced onto the seat by a coil spring (4).



1. Housing
2. Streamlined body
3. Shutoff element
4. Coil spring
5. Valve seat

A = Single stage

B = Two-stage

Fig. 35: Nozzle-type non-return valve

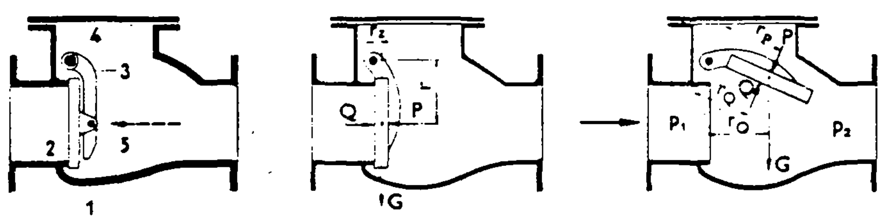
The seat is securely fitted into the housing. The long guide pin means that this backsiphonage preventer can be installed in vertical, horizontal and inclined pipes. The valve disc has a very small closing travel and little kinetic resistance (particularly if installed in a vertical pipe).

The influence of the spring tension causes the shutoff element to operate very rapidly.

For larger nominal diameters (250 mm upwards) the cross-sectional area of flow is divided into two annular channels (1 and 2) (on the right of Fig. 35).

- Flap-type valves as backsiphonage preventers

Standard flap-type valves and flap-type discharge valves



1. Body
2. Disc
3. Lever
4. Shaft
5. Pin

Fig. 36: Non-return valve (flap type)

Fig. 36 shows, in schematic form, backsiphonage preventers with swinging flap in the closed position. The disc (2) is connected to the shaft (4) by means of the lever (3) in the valve body (1). The disc (2) is secured to the lever (3) by means of the pin (5) such that it can swing back and forth.

When the valve is closed and the pipe filled with fluid, the contents of the pipe exert pressure on the back of the disc in the direction shown by the broken-line arrow. To open the valve, the pressure Q generated by a pump must rotate the disc (2) about the shaft (4) with lever arm in the direction of the through-flow. The force P (derived from the content of the pipe) initially acts against the force Q with the same lever arm r. The weight of the disc G acts at the short lever arm r_z in the closing direction. For the start of opening, therefore, the equation is as follows (ignoring friction):

$$Q \cdot r \geqq P \cdot r + G \cdot r_z$$

The diagram on the right of Fig. 36 shows the valve in the fully open position, with the medium flowing in the direction of the arrow. The opening angle is 50 to 70°.

The space between the seat and the disc is sealed off by means of metallic sealing faces or a compression seal. The flexible seal ring, made of leather, rubber or plastic, is held in position at the disc by means of a washer or by a ring made of steel or some other metal. The seat in the valve body generally consists of a caulked-in metal ring. Compression seals are used primarily for low operating pressures. Plastics possessing good strength properties can still be used at medium pressures. In the case of the metallic seal a ring with a roughly rectangular cross-section is caulked into a dovetailed groove.

- Backsiphonage preventers for suction lines

Numerous designs are to be found, with wo basic types prevailing: standard valves and flap-type valves.

Valves with shutoff element moved parallel to the main flow (generally in the vertical direction).

The shutoff element is kept floating by the flow of water. The force required for this purpose remains almost unchanged; it consists of the dead weight of the shutoff element, less buoyancy and including friction in the guides. The resistance coefficient, however, alters with the changing cross-sectional areas of flow during the travel, according to the shape of the valve. As a rule, it is smallest when the valve is fully open and generally attains its maximum value near the closed position.

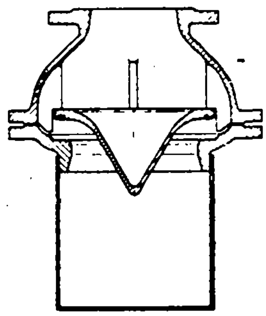


Fig. 37: Suction valve

Rubber non-return elements having no axis of rotation of their own are also used as flap-type non-return valves. The pivot joint or axis of rotation is the flexible rubber disc.

The disadvantage of such devices, however, is the severe wear to which the flexible parts are subjected; the disc must be replaced frequently. These fittings are commercially available under the name "Hydrostop".

7. Automatic air valves

Automatic air valves primarily perform three functions:
- Admission of air to fluid lines during emptying; (the pressure of the atmopspheric air is somewhat higher than the pressure inside the pipe.)
- Expulsion of air from a line during filling; (the pressure inside the pipe is higher than the pressure of the atmospheric air.)
- Discharging of small quantities of air under full internal pressure while a water pipe is in use.

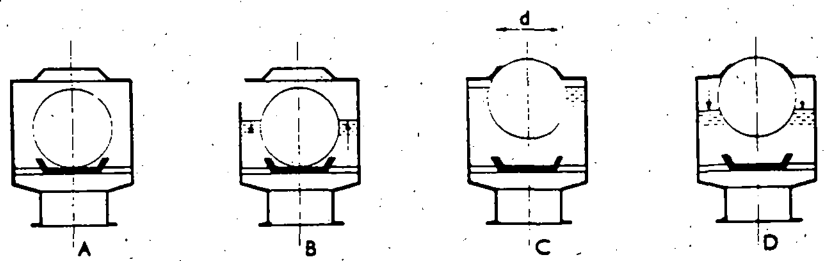
Almost every volume of water contains small quantities of air and gas, which separate in the form of bubbles in the event of pressure and temperature changes or changes of direction in the pipe's vertical plane. These bubbles accumulate primarily at the top of pipes, in manhole connections, in gate valve bodies etc. and constrict the cross-sectional area of flow.

The admission and removal of air in water pipes is today performed automatically in almost every case. The automatic operation of the air valves is essentially influenced by four factors:
1. By the dead weight of the moved parts and by their buoyancy, which is determined by the volume (upon immersion in the fluid).
2. By the shape of the moved parts.
3. By the friction in the guides.
4. By the pressure difference between the air in the pipe and that outside it.

The installation points for air valves are to be determined on the basis of the pipe elevation diagram. They are generally fitted at high points.

- Mode of operation of automatic air valves

Fig. 38 shows a valve of this type - in schematic form - in four different operating phases. The valve consists of a body containing a hollow ball that can float. Diagramm A shows the position of the valve ball when the pipe is empty. The ball rests on a dish connected to the body by means of ribs. Diagram B shows the filling process. The water first flows around the lower part of the ball; as the water level rises (in the direction of the arrows) the ball starts to float. In diagram C the upper part of the ball has reached the valve seat and there is now only a small amount of air in the valve body. The ball is pressed against the seat with the full pressure of the fluid.



A Pipe empty
B Filling
C Ball contacts valve seat
D Water level drops

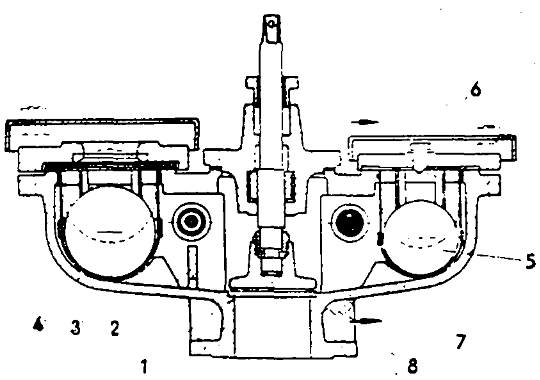
Fig. 38: Air valve

1 = Ball
2 = Dish
3 = Dish support ribs
4 = Body
5 = Ball seat

Should air accumulate in the valve body while water is flowing, the water level drops in the direction of the arrows as shown in diagram D. As long as the fluid in the pipe is under pressure, the valve ball will not leave the seat, even if the entire valve body becomes filled with air (even at a pressure only slightly above atmospheric, the contact force exerted by the ball, generated by the pressure in the pipe, is considerably greater than the dead weight of the ball acting in the opening direction). The valve ball will not leave the seat until the water level falls and the pressure in the pipe drops below atmospheric. If a high partial vacuum occurs in the pipe, the incoming air can attain a considerable velocity.

In order also to allow the air to escape at normal line pressure, use can be made of valves having two balls: a large ball for the filling and emptying processes and a smaller one for the discharge of air during operation.

Fig. 39 shows an air valve with two valve balls in one body. Between the two valve chambers is a shutoff valve (1). The (large) valve ball (4) comes into play only when filling or emptying the pipe. The mode of operation is the same as for the valve shown in Fig. 38. The partition (2) diverts the air flow away from the lower part of the valve ball.



1 Shutoff valve
2 Partition
3 Body
4 Valve ball
5 Valve ball
6 Air outlet (small)
7 Air outlet (large)

Fig. 39: Automatic air valve

When filling or emptying the pipe, the small valve ball (5) is controlled in the same manner as ball (4) by the changing water level in the valve body. The narrow bore (6), however, permits the admission or discharge of only a small jet of air.

The main function of this ball (5) is to permit the discharge of air with a positive pressure in the pipe. The ball is generally hollow and is made of light metal covered with soft rubber. In the closed position the valve ball is pressed firmly against the seat. As soon as a sizeable amount of air has accumulated in the valve body, part of the water is forced back into the pipe and the buoyancy of the ball is thereby reduced, with only a small part of its surface now being immersed in the water (the level of which has now dropped). The air pressure and water pressure acting on the exterior of the hollow ball counterbalance each other almost totally; only the tiny part of the ball's surface opposite the small air relief hole, corresponding to the seal diameter, is forced upwards.

The pressure of the atmospheric air, acting in the opposite direction, is relatively low. The ball drops when its dead weight becomes greater than the total buoyancy of the water. The air flows rapidly out into the atmosphere. When water once again flows into the valve body, the ball receives buoyancy and seals off the small air relief hole.

With this valve too, a check can be made at certain intervals while the pipe is in use to establish whether the valve balls are operating correctly.

8. Special fittings

- Pressure-reducing valves

In water supply systems, pressure-reducing valves replace the break pressure tank and thus help to save on system costs. The function of these valves is:

To transform a fluctuating high pressure into a constant low pressure.

A constant low pressure cannot be achieved with the direct-acting pressure-reducing valves of the conventional type because the low pressure drops as the flow increases.

In order to keep the pressure fluctuations small in the event of changing flows on the low-pressure side, the pilot-operated pressure-reducing valve was developed. It comprises two assemblies: the main valve and the control system. The main valve is a pressure-reducing valve with a spring, which is set to the desired low pressure.

The control system essentially comprises the bypass line with nozzle, the small pressure-reducing valve and the connecting line between the nozzle and the piston chamber of the main valve. It has two functions:

1. Routing of small flows via the bypass.
2. Reinforcement of the opening forces at the main valve and thus keeping the low pressure constant.

If a pressure-reducing valve is to be installed in a pipe, it is advisable to locate it in a chamber between two gate valves. Depending on the local conditions, the following fittings should also be installed:

Dirt trap upstream of the pressure-reducing valve in the high-pressure line.
Safety overflow valve in the low-pressure line.

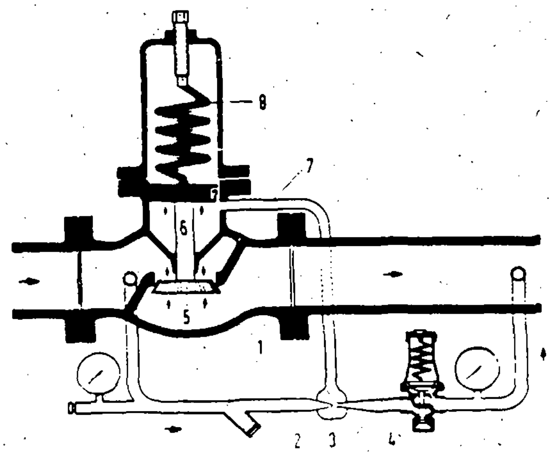
It is a good idea to have a bypass line with manually operated control valve or a second pressure-reducing valve.

The dirt trap can catch foreign bodies in the water, thereby making it possible to avoid problems at pressure-reducing valves, particularly in new systems or after a pipe burst.

The setting should be 1 bar above the low pressure.

Pressure-reducing valves are regulating devices and must be serviced at specific intervals of between one and three years depending on water quality.

In the case of the pilot-operated pressure-reducing valve shown in Fig. 41, a small valve (4) is connected in parallel to the main valve with its poppet (5). The small flows are routed via the "pilot valve" located in the bypass, a principle similar to that used in a compound meter. For larger flows the main valve is switched in, so that both valves are now in operation.



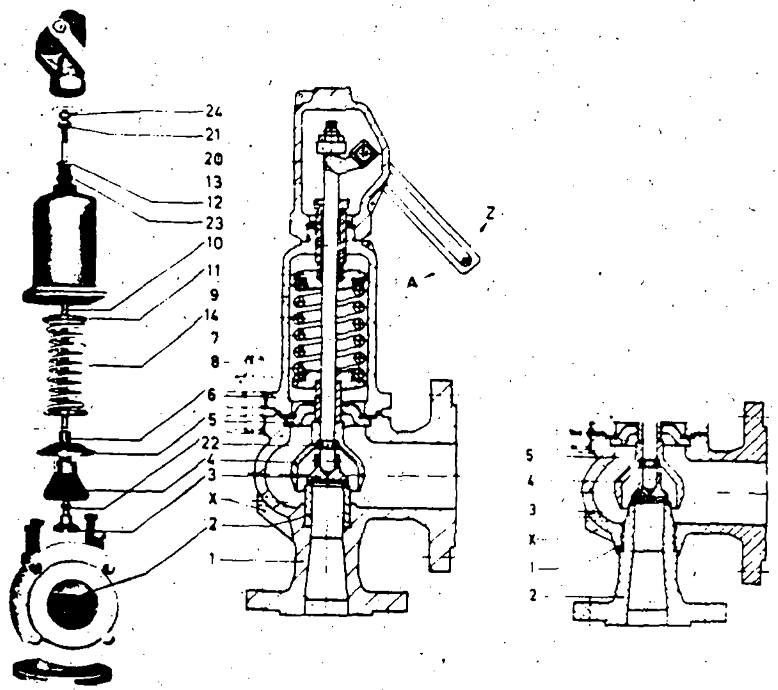
1 Body
2 Bypass line
3 Nozzle
4 Small valve
5 Poppet
6 Counter-piston
7 Control line
8 Spring force

Fig. 41. Pilot-operated pressure-reducing valve

- Safety valves

Safety valves should be installed downstream of pressure-reducing valves in order to prevent damage on the low-pressure side if the pressure-reducing valve fails.

Safety valves are to be selected on the basis of specific requirements and set to the necessary pressure.



1 Body
2 Inlet port and seat bushing
3 Poppet
4 Lift bell
5 Intermediate cover
6 Pressure sleeve
7 Stud bolt
8 Nut
9 Cover
10 Stem
11 Spring plate
12 Clamp bolt
13 Lifting device
14 Spring
15 Lifter
16 Lifting nut
17 Thrust washer
18 Lock nut
19 Check nut

Fig. 42: Spring-loaded safety valve

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