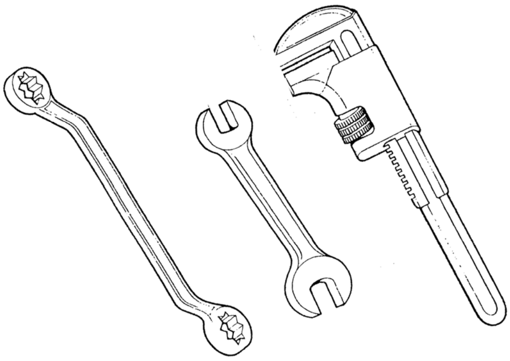
Trade of Plumbing

Module 2: Domestic Hot and Cold Water Service

Unit 8: Water Supply

Phase 2



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Document Release History

Date	Version	Comments
June 2006	V.1.0	
04/03/14	2.0	SOLAS transfer

Module 2 – Domestic Hot and Cold Services

Unit 8 –Water Supply

Duration – 30 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Describe the principles and features of domestic mains water supply.
- Describe the direct and indirect systems of cold water supply.
- Describe the features of water storage cisterns.
- Draw schematic representations of direct and indirect systems of cold water supply and storage cisterns.
- Calculate volume and capacities of storage cisterns.
- Calculate intensity of pressure and total pressure in cold water systems.
- Fit a self-tapping saddle on polyethylene mains water pipe.

Key Learning Points:

Rk	**Principles of mains water supply – water authority mains pipe, tapping, service pipe, stopcock.**
Rk	**Building Regulations - Hygiene.**
Rk	**Water authority byelaws – depth of pipe, materials etc.**
Rk	**Mains water distribution systems.**
Rk	**Connection to the water authority main.**
Rk	**Stopcocks, meters, pipe, fittings.**
Rk	**Protection of pipework.**
Rk	**Direct system of cold water.**
Rk	**Indirect system of cold water.**
D	**Schematic drawings of cold water systems.**
Rk	**Advantages and disadvantages of direct and indirect systems.**
Rk Sc	**Backflow, backsiphonage, contamination and stagnation of water supply.**
Rk M	**Cold water storage cisterns – capacities, materials, siting, connections, insulation etc.**

Rk **Location and identification of isolating valves.**

Rk **Prevention of noise in pipework, water hammer etc.**

P **Problem solving.**

M **Calculation of storage cistern volumes and capacities.**

M **Calculation of intensity of pressure and total pressure.**

Sk **Fitting self-tapping saddle.**

P **Good working practice, working independently.**

Training Resources:

Classroom facilities, information sheets, Building Regulations technical guidance document G – Hygiene, local water authority byelaws, drawing equipment.

Exercise:

- Apprentice to fit a self-tapping saddle on a section of Ø110 mm polyethylene underground mains water pipe. Connect saddle to 21mm high pressure stopcock with heavy gauge polyethylene pipe.

Key Learning Points Code

M = Maths D= Drawing RK = Related Knowledge Sc = Science

P = Personal Skills Sk = Skill H = Hazards

Direct and Indirect Cold Water Supplies

Water mains are pipes of large diameter used to carry potable water from the Water Authorities reservoirs of treated water, to the town or district where it is needed.

Trunk mains, which may be as much as 610mm in diameter, carry the water in bulk and often over long distances to the built-up areas. They then split up into smaller mains and sub-mains, which run beneath the streets and side streets.

The work of laying these mains is highly specialised, and is done only by the trained mainlayers employed by the Water Authority. However, the plumber is also involved in the work, since he must arrange for a suitable connection to be made to the main he can connect a cold water supply to any building.

The Water Authority will usually do the actual tapping of the main and insert the ferrule, but the plumber will be responsible for the service connection to the tapping ferrule, and will have to be on the spot when the work is done. Also, he might be called upon to install smaller diameter mains, for fire fighting services and extensions to mains within the bounds of a large new building.

The water mains supplying the town or district may be in the form of a grid.

This provides a ring circuit and each section can be isolated.

Under Pressure Mains Tapping Machine

A special machine designed to cut into large diameter distribution mains pipes while the water is still in the pipe and under pressure. Before putting the machine in position, the body of a closed SCREW-DOWN FERRULE, with the jointing medium applied to the thread, is fixed into the base of one of the spindles in the headgear of the machine and combined drill and tap in the other (see sketch). The head is lifted on to the pipe and clamped down with a chain sealing off its base with a rubber or leather washer. The ratchet handle is fitted to the spindle with the drill and operated, simultaneously the drill/tap pressure adjusting screw is wound down slowly, this cuts a hole and threads it at the same time into the pipe.

Upon completion the ratchet is reversed and the drill is wound up; note water can now flow into the headgear but no further. By a special design the headgear can now be rotated 180° to align the ferrule with the hole just drilled and tapped. The ratchet handle is fitted to the ferrule spindle and operated, thus tightening the ferrule into the tapping. When the machine is removed from the pipe only the water in the headgear falls to the ground, the connection made seals the pipe. The other component parts of the ferrule are assembled and the pipe is run to a convenient position for an outside stopcock. This section of pipework is known as the communication pipe. When the connection is completed the screwdown ferrule is simply opened using a special key.

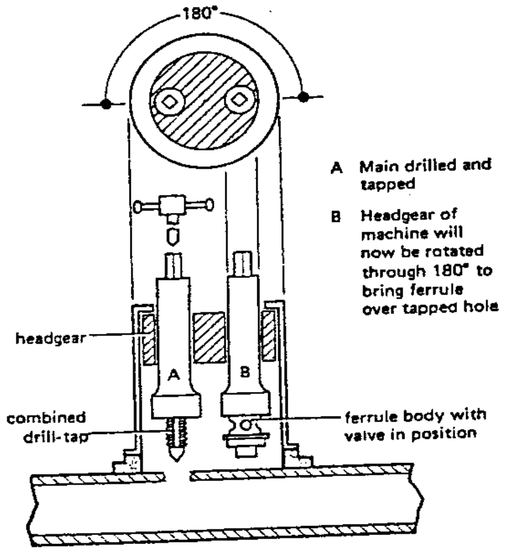
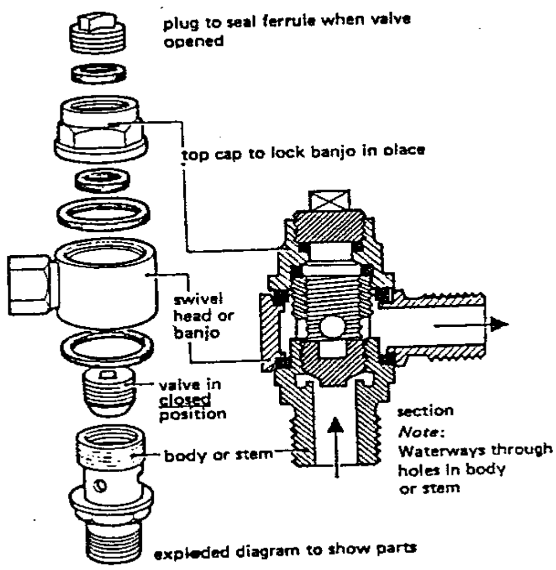


Diagram of tapping machine showing principle of design and operation



Exploded view of screw-down valved ferrule

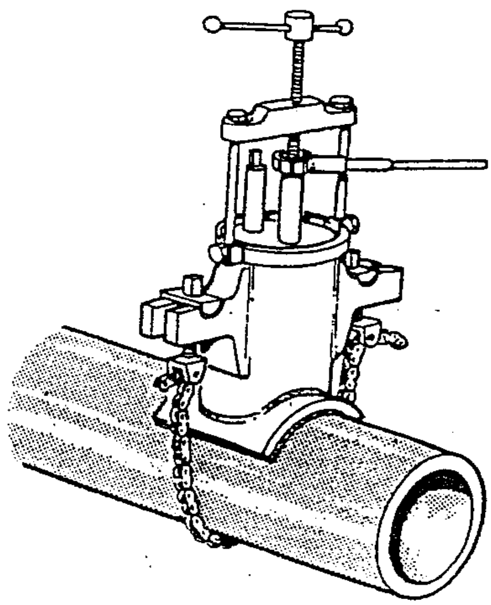


Figure 1. Water Mains Tapping Machine

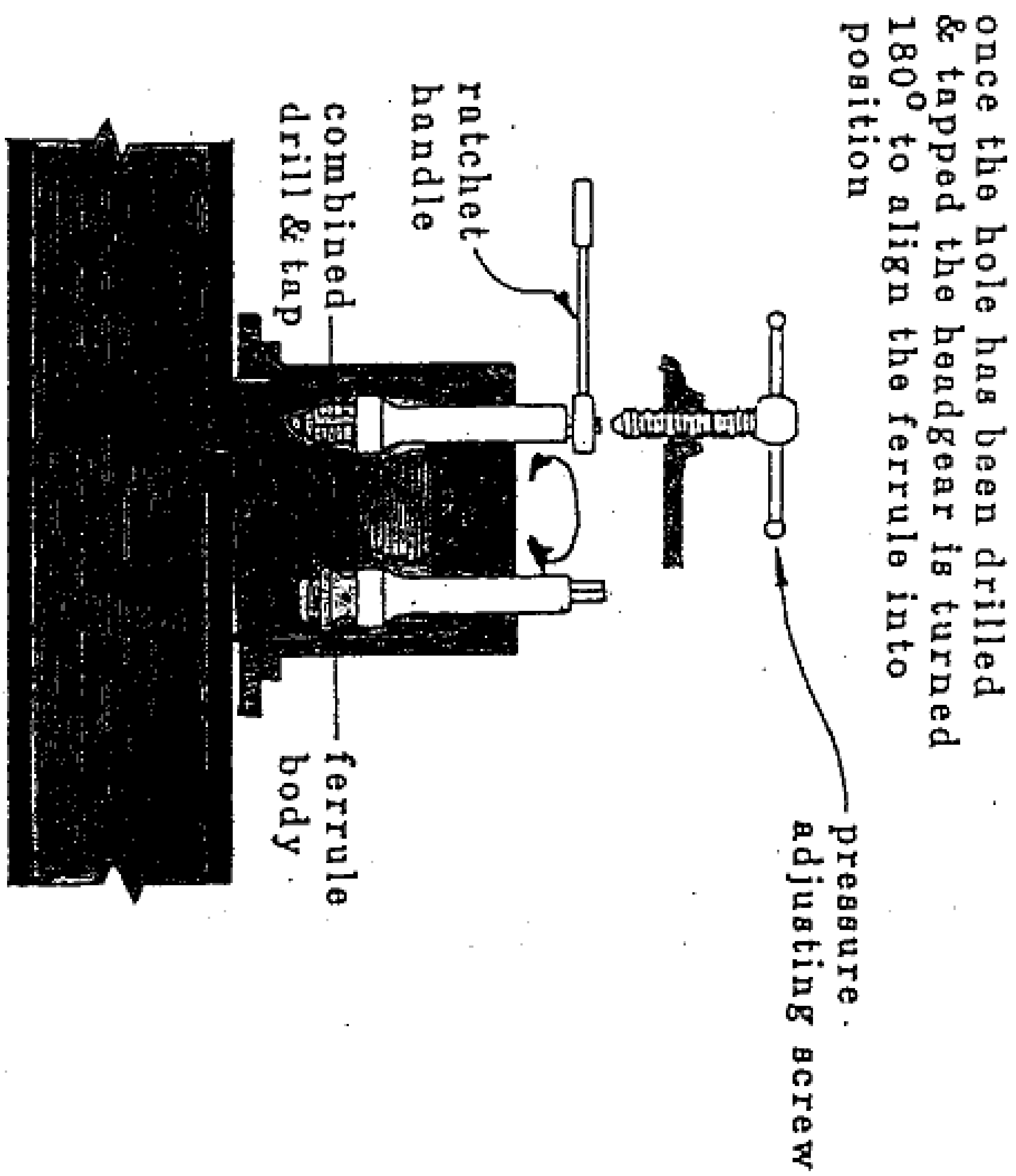


Figure 2. Water Mains Tapping Machine

Water Mains

Local Authorities run water mains from their storage reservoirs to most premises except those in very isolated areas. Water mains are constructed of asbestos cement, PVC or cast iron and are buried to great depths depending upon local conditions but they must have a minimum cover of 900mm beneath roads and 750mm elsewhere in order to prevent damage owing to settlement and/or frost.

Asbestos Cement Mains

These have been used with safety for conveying water which could corrode iron pipes. It can be manufactured in various thicknesses and can withstand the same internal pressures as cast iron pipes. Owing to the much lower mechanical strength of asbestos, special cladding devices are necessary when making service connections.

PVC

Polyvinyl chloride is now becoming more widely used and has sufficient thickness and strength to enable connections to be made.

Cast Iron

Cast iron mains are by far the most commonly encountered and time has proved them to be the most satisfactory. The only real problem is their susceptibility to deterioration in certain corrosive soils, but this can be overcome by taking protective measures.

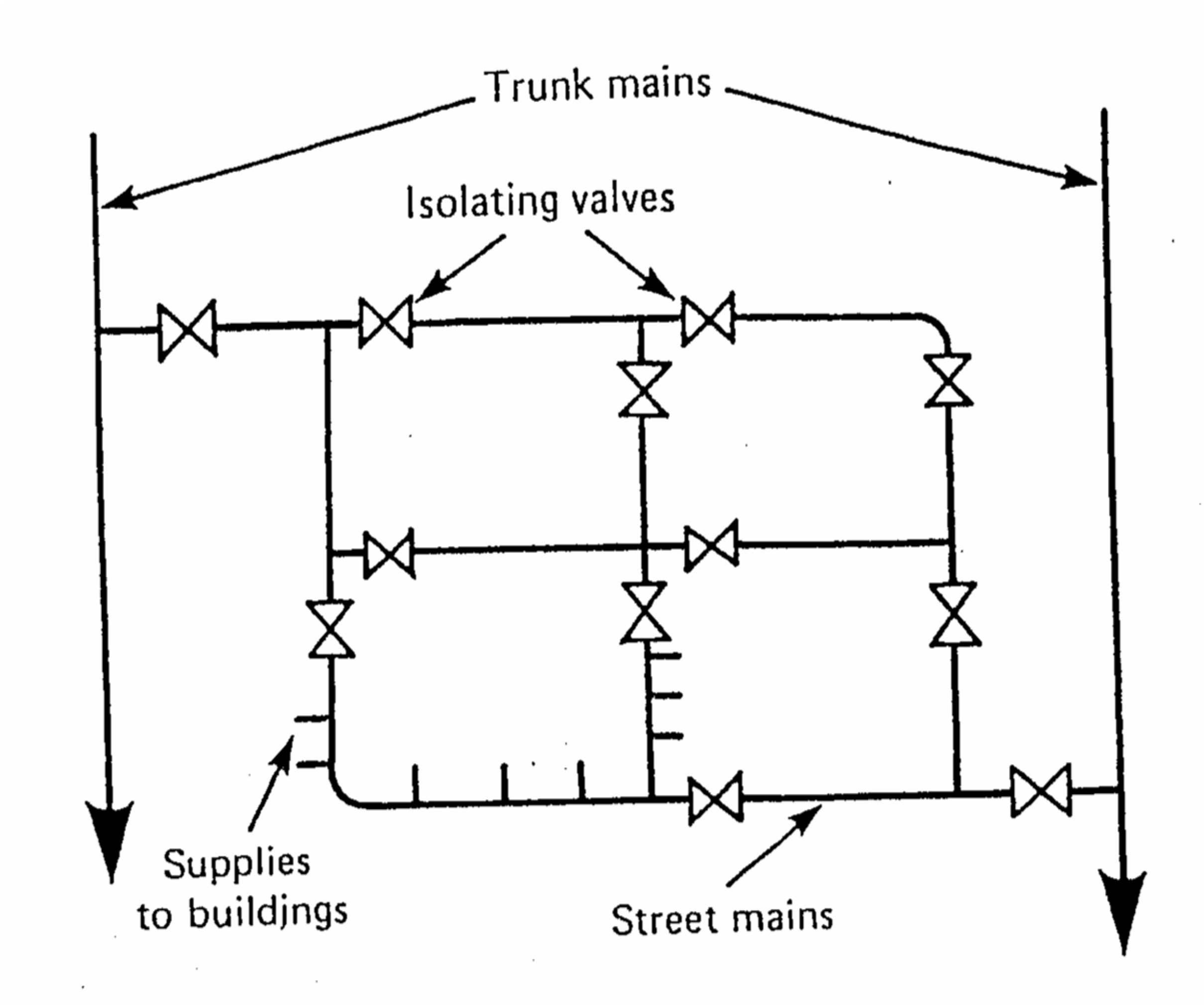


Figure 3. Trunk Mains

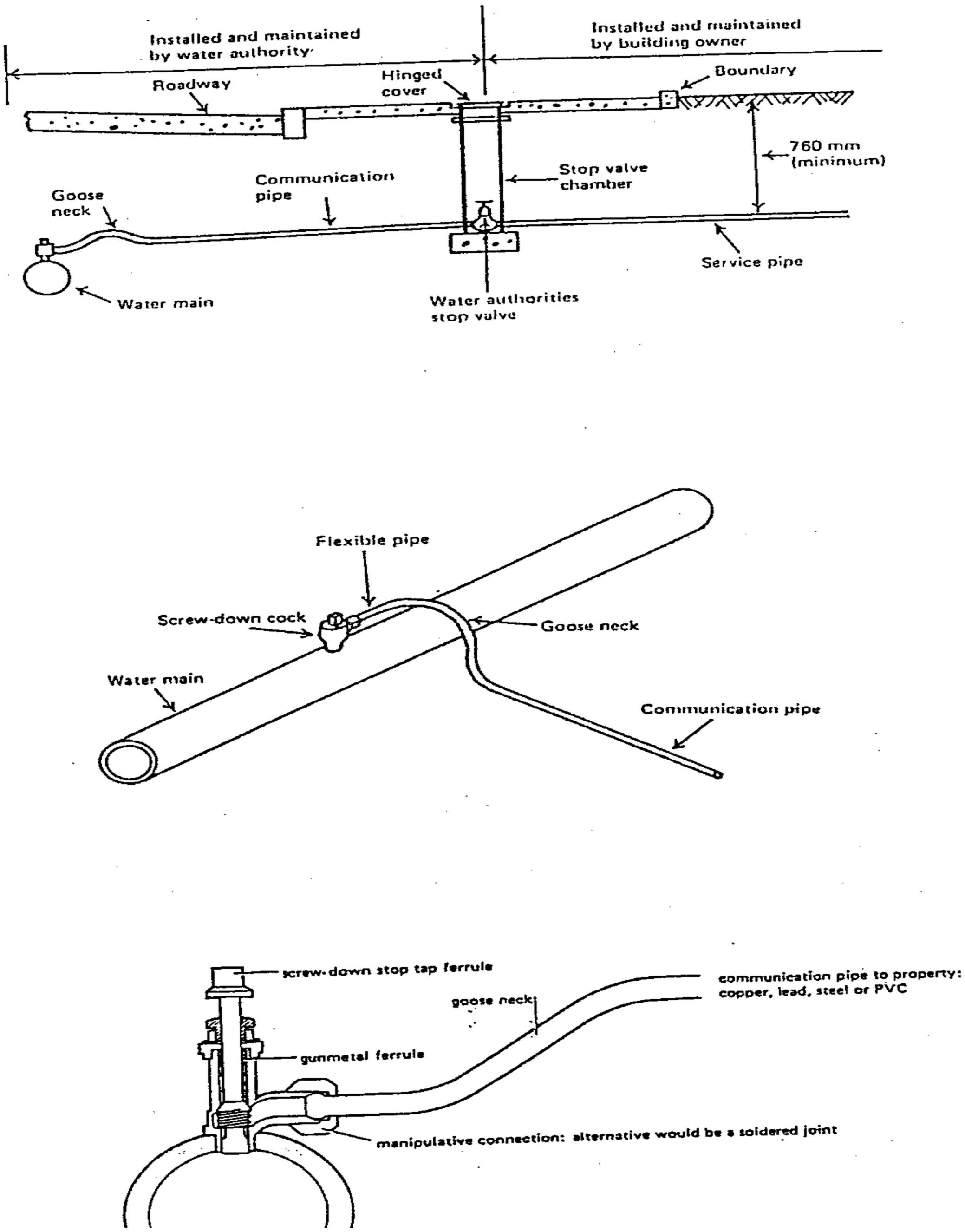


Figure 4. Water Mains

The section of pipework from the water main to the Local Authority stopcock is known as the communication pipe and is connected to the ferrule by means of a goose neck bend. A goose neck is a curve or bend which is purposely put into the communication pipe to allow for ground movement. The pipe from the stopcock to the house is known as the service pipe.

Where the underground pipe passes through the walls or floors of the house it should be sleeved. Both ends of the sleeve should be sealed with mastic to prevent the entry of vermin etc into the house.

The first fitting on the service pipe is the stopcock which allows the householder to control the flow of water into the premises. The pipe from this point on is usually referred to as the rising main, and if possible should be fixed to an internal wall to prevent frost damage. If, however, the rising main has to be run on an external wall it should be well insulated.

The Direct System

In districts where the mains supply is capable of delivering adequate quantities of water at good pressure, the Water Authority may permit a district system of supply to all buildings.

All pipes to the cold drew off points are taken directly from the rising main. There is therefore no risk of possible contamination that may occur when water is stored within the premises.

Figure 1 shows a suitable installation for the average dwelling, supplying a sink, WC, wash basin, bath and cold feed cistern. The capacity of this cistern should be 135 litres.

The Indirect System

In some areas the cold water supply is provided by use of the indirect system – see figure 2. This means that the service pipe rinses through the building to the cold water storage cistern and only **one** draw off point for drinking purposes is permitted. The remaining cold water draw off points are supplied from the storage cistern. The capacity of this cistern should be 227 litres.

The Local Authority regulations on quantities of water stored are based on a 24 hour period. The table below outlines the minimum storage requirements as outlined in the Dublin Corporation Regulations.

The Advantages and Disadvantages of the Direct System

Advantages

- The cold water cistern is required solely to feed the hot water cylinder, and for this reason need only have the same capacity.
- There is a suitable saving in pipework especially in multi-storey buildings. This is due to the rising main supplying all the fittings, and a cold water distribution pipe from the cistern being omitted.
- (Drinking water may be obtained at the wash hand basin taps which in hotels is an advantage.

Disadvantages

- There is a danger of foul water from the sanitary fittings being siphoned back into the main water.
- There is a tendency to have more trouble with water hammer due to points being connected directly to the main.

- During peak periods there is a tendency for the lowering of pressure and with buildings on higher ground a possible temporary loss of supply. If there is a mains burst there is no store of water.

The Advantages and Disadvantages of the Indirect System

Advantages

- There is no risk of back siphonage with this system.
- There is no tendency of water hammer due to the low pressure in the pipework.
- Should there be an interruption in the mains supply there is an adequate store of cold water.

Disadvantages

- Longer pipe runs are required.
- A larger storage cistern is necessary.
- Drinking water is only available at the kitchen sink.

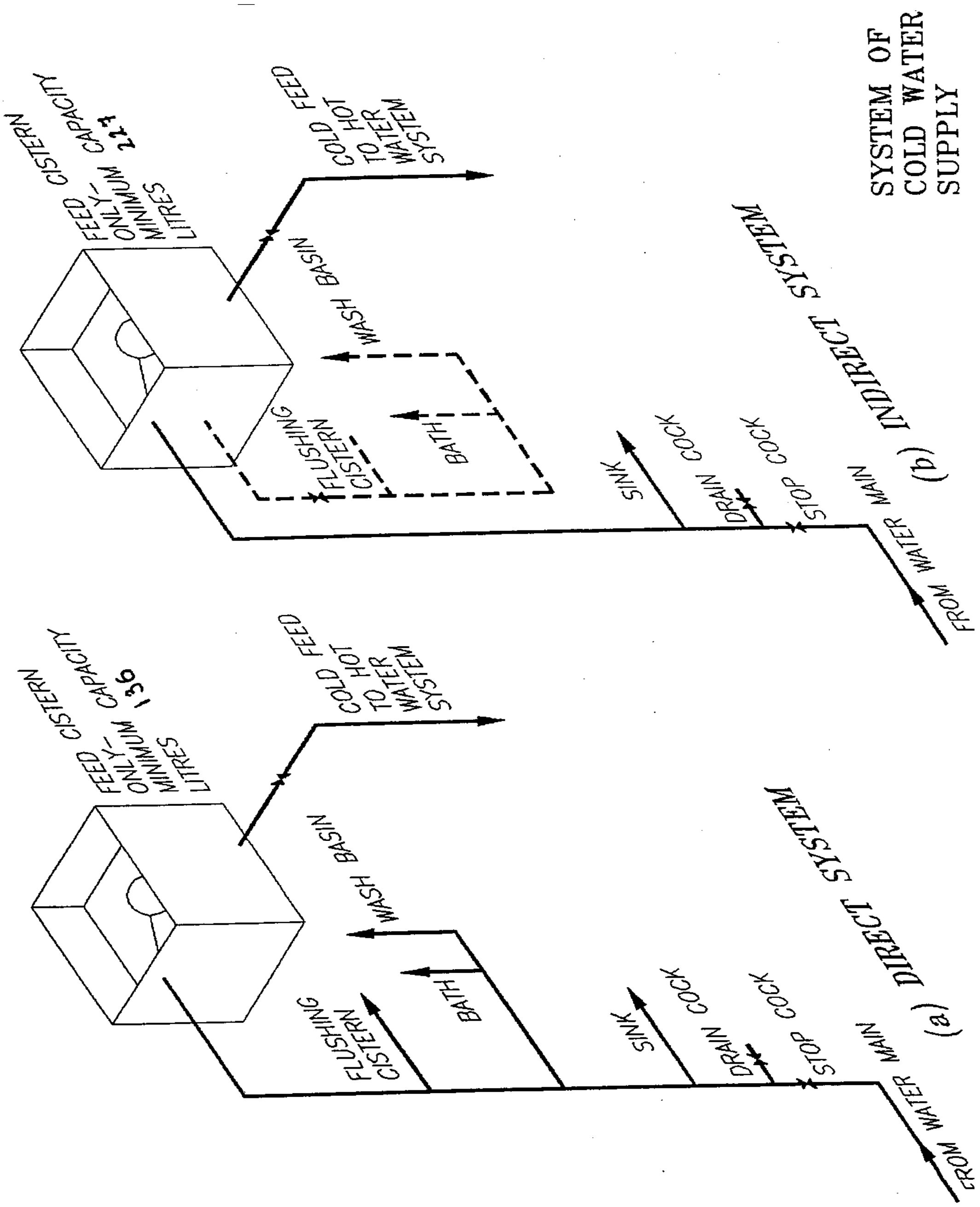


Figure 5. Cold Water Supply System

The following table lists the minimum water storage for domestic purposes, etc.

Table 1. Minimum Water Storage

Dwelling house (up to 3 bedrooms)	136 litres	(30 gals) for cold only
Dwelling house (up to 3 bedrooms)	227 litres	(50 gals) for hot and cold
Dwelling house (4 bedrooms and over)	363 litres	(80 gals) for hot and cold
Dwelling house (having 2 bathrooms)	682 litres	(150 gals) for hot and cold
Factory	45 litres	(10 gals) per head
Flats (bedsitters with communal bathrooms)	90 litres	(20 gals) per head
Flats (self-contained)	227 litres	(50 gals) per flat
Hospitals, maternity per bed	455 litres	(100 gals)
Hospitals, general bed	227 litres	(50 gals)
Hospitals, laundry, per bed, plus staff	136 litres	(30 gals)
Hospitals, staff on duty	45 litres	(10 gals) per head
Hospitals, nurses home and medical quarters	136 litres	(30 gals) per head
Hotels	227 litres	(50 gals) per head
Hotels (having bedrooms with private bathrooms)	1,045 litres	(230 gals) per bedroom
Offices	45 litres	(10 gals) per head
School, day, boys	23 litres	(5 gals) per head
School, day, girls	36 litres	(8 gals) per head
School, boarding	113 litres	(25 gals) per head
Restaurants and Canteens	7 litres	(1½ gals) per meal

These minimum requirements do not include fire-fighting or industrial needs. It is not possible to formulate precise requirements for all types of buildings owing to the variety of fittings and the number of occupants, even between buildings of a similar type. It is therefore important to ensure that adequate storage is provided in all cases.

Positioning of Cisterns in Roof Spaces

In domestic plumbing installations, the cold water storage cistern is usually located in the attic or roof space. The final position of the cistern is important because the weight of the water must be taken into consideration. 227 litres of water weighs one quarter (¼) of a ton, and this weigh **must** be distributed correctly to prevent damage to the structure of the house. To achieve this, the cistern should be located above a load-bearing wall with timber bearers beneath it. These bearers should rest on the ceiling joists and extend beyond the dimensions of the cistern.

The cistern should not be located near the eaves because of the danger of frost damage from cold winds. Ideally it should be sited close to the chimney breast, where it can benefit from the radiant heat emanating from it.

When insulating the attic, the space beneath the cistern should not be insulated. This will allow warm air in the form of convection currents to rise from below.

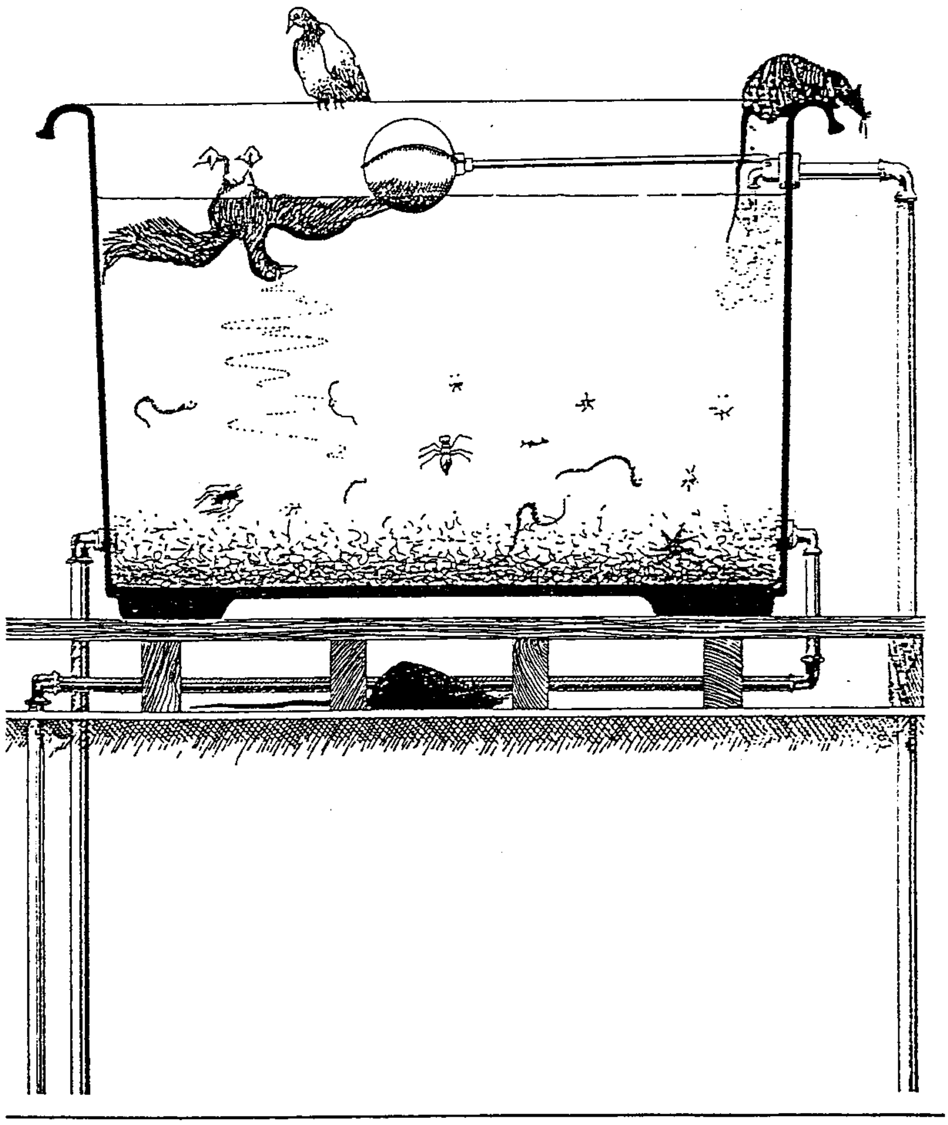


Figure 6. Cistern in a Roof Space

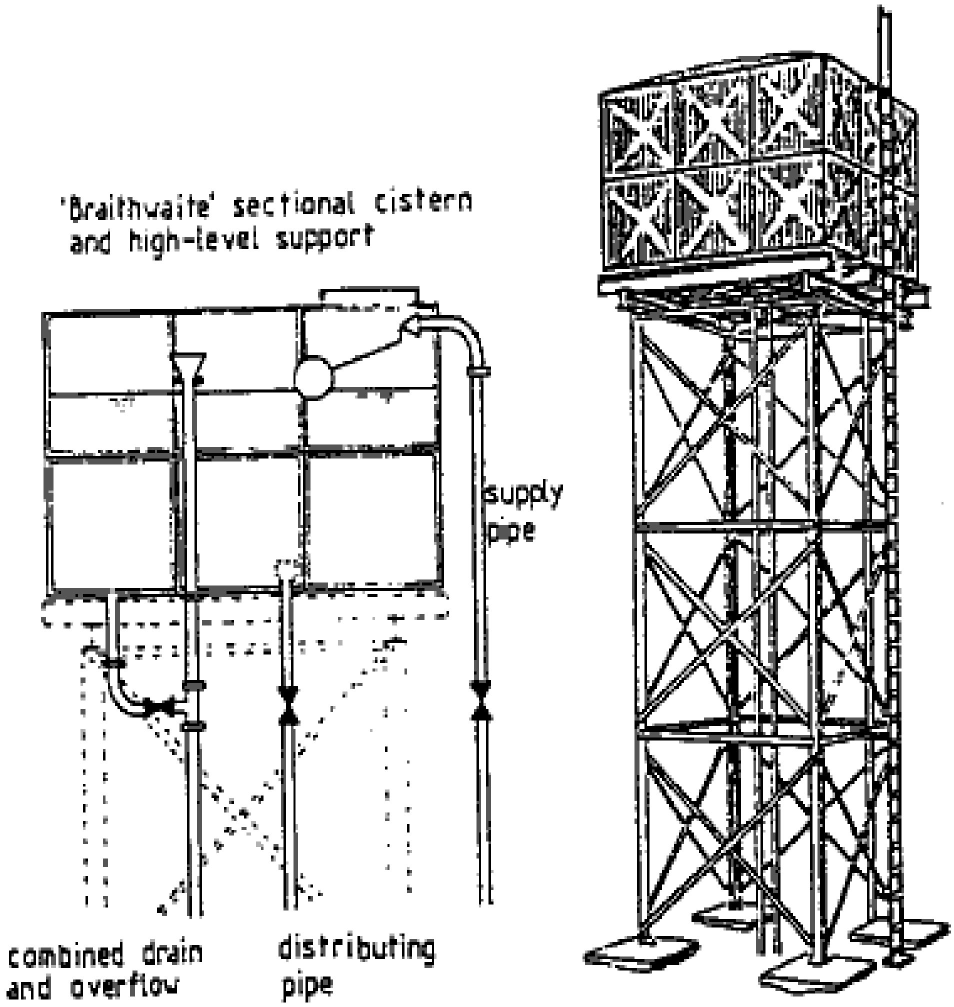


Figure 7. Braithwaite Section Cistern

Cold Water Storage Cisterns and Ball Valves

Cisterns

A cistern is an open topped designed to hold a supply of cold water, which will have a free surface subject only to the pressure of the atmosphere. It should be fixed as high as possible to give adequate pressure flow. A storage cistern is designed to hold a reserve of water to supply the fixtures and fittings located below it.

Material used in the Manufacture of Cisterns

The most commonly used materials which cisterns are manufactured from are listed below:

- Galvanised mild steel
- Plastic materials
- Glass fibre sections

Cisterns of all types should be fitted with a well fitting cover, preferably made of the same material as the cistern. The purpose is to prevent the access of dirt and vermin to the water.

Most Water Authorities allow only one tap to be supplied direct from the rising main. Therefore, cisterns are required for cold water storage. It is unwise to drink water from a cistern, and the single tap off the rising main is to provide a supply of potable water. This tap is usually fitted at the kitchen sink.

Galvanised Mild Steel

Cisterns manufactures in galvanised mild steel have been widely used for many years. They are obtainable in many thicknesses and sizes. They are formed from black mild steel sheet, and then dipping into baths of acid to remove grease and scale. After this they are dipped into a bath of molten zinc and so coated with a corrosion resistant sink of zinc.

This protective hot-dip galvanised treatment has been developed from experiments carried out by Galvani, a scientist after whom the process is named.

During constructive the seams of the cisterns are welded, their top edges are stiffened with an angle curb and the open top corners are braced with corner plates.

They are self supporting and can be suitable and can be situated directly on timber bearers. The holes are cut by means of a tank cutter or expanding bit and the jointing done by means of a grommet, jointing paste and back nut. Nylon washers can be used as an alternative.

Where holes are cut in galvanised cisterns, it is important to remove all the swarf as failure to do this can often result in a serious corrosion of the cistern due to the electrolytic action being set up. Two coats of good quality bituminous paint on the inside of these cisterns will increase their working life considerably.

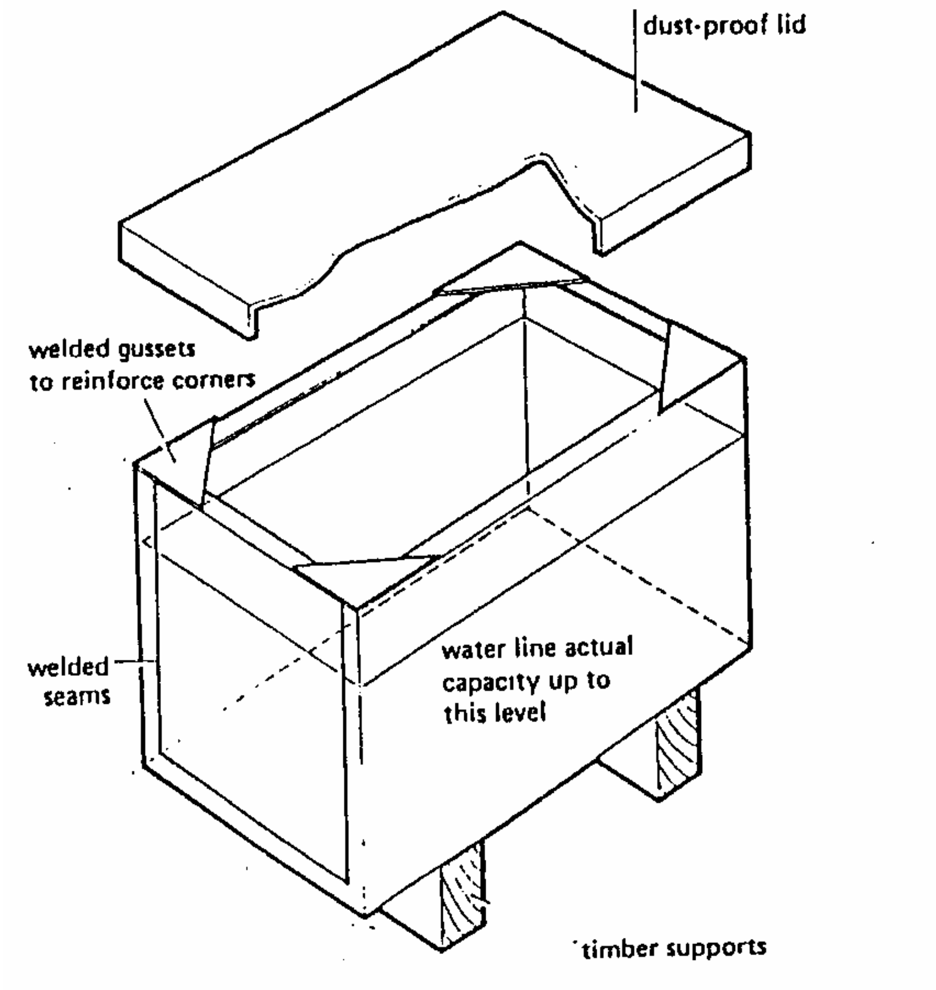


Figure 8. Galvanized Mild Steel Cistern

Plastic Materials

Various plastics are now being extensively used for cold water storage cisterns: Polyethylene, Polypropylene and Polyvinyl Chloride (PVC) to mention just a few. They are strong and resistant to corrosion of all types, virtually everlasting, very hygienic and light in weight. They do not cause, nor are they subject to, electrolytic corrosion, and they have low rates of thermal conductivity – so the stored water retainers its heat longer in cold weather.

These cisterns are quieter in filling that a metal cistern, and this is a useful advantage, particularly when the cistern is sited near bedrooms. Furthermore, they are easy to squeeze through small openings, which is an advantage when the cistern is to be placed in an attic or loft.

Plastic cisterns are manufactured square, rectangular, or circular in shape and are black to prevent algae growth. They must be fully supported by being placed on a solid decking.

Holes to enable pipe connections to be made are cut by circular saw cutters. The jointing is by means of plastic washers but no oil-based paste of any description must be used, because this softens the material and causes it to break down.

Plastic materials are comparatively soft, so care must be taken when handling and fixing. Sharp instruments and tools can easily cut or puncture the cistern. Naked flames and excessive heat will also damage the material.

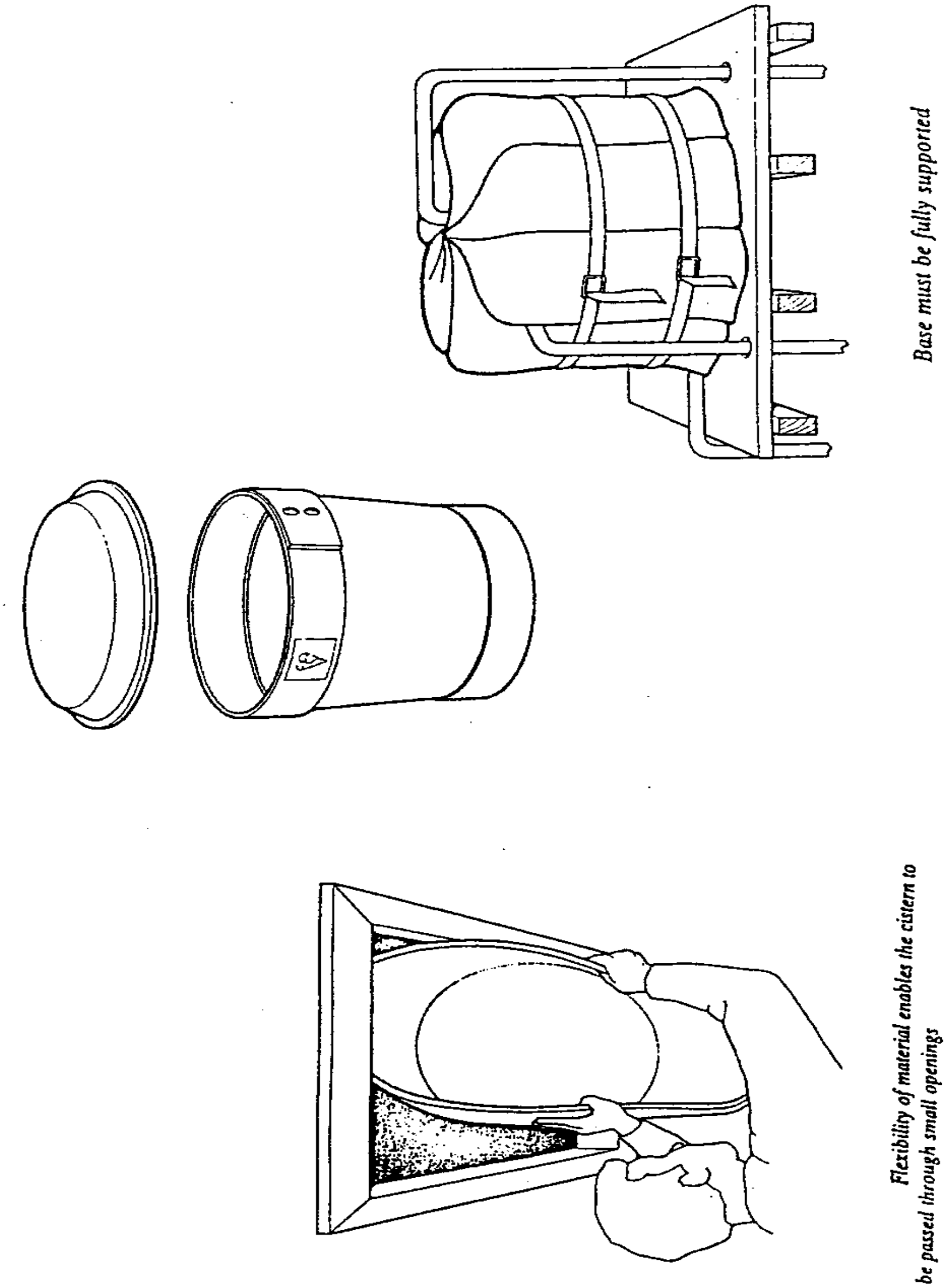


Figure 9. Plastic Cistern

Glass Fibre (GRP)

Glass fibre reinforced plastic (GRP) is a thermosetting material and has been found satisfactory for the manufacture of cistern. It has a greater degree of ragidity than those made of thermoplastic and is suitable for the construction of large cisterns that are built up by using bolted sections.

Generally these provide over 5,000 litres storage and are made up of preformed panels. Sectional storage cisterns are generally assembled on site by specialist contractors. The remarks relating to the support and fitting of thermoplastic cisterns apply equally to those constructed of GRP.

Nominal – Actual – Unstable Capacities

The nominal capacity of a cistern is usually stamped or written on its side, and indicates the amount of water it would hold if filled up to the edge. In reality, the cistern will never be filled to this level.

The actual capacity refers to the amount of water measured from the base of the cistern up to the water line.

The usual capacity is the amount of water of which can be drawn off through the distribution pipe connection. This means the amount of water stored between the invert of the lowest connection and the water line.

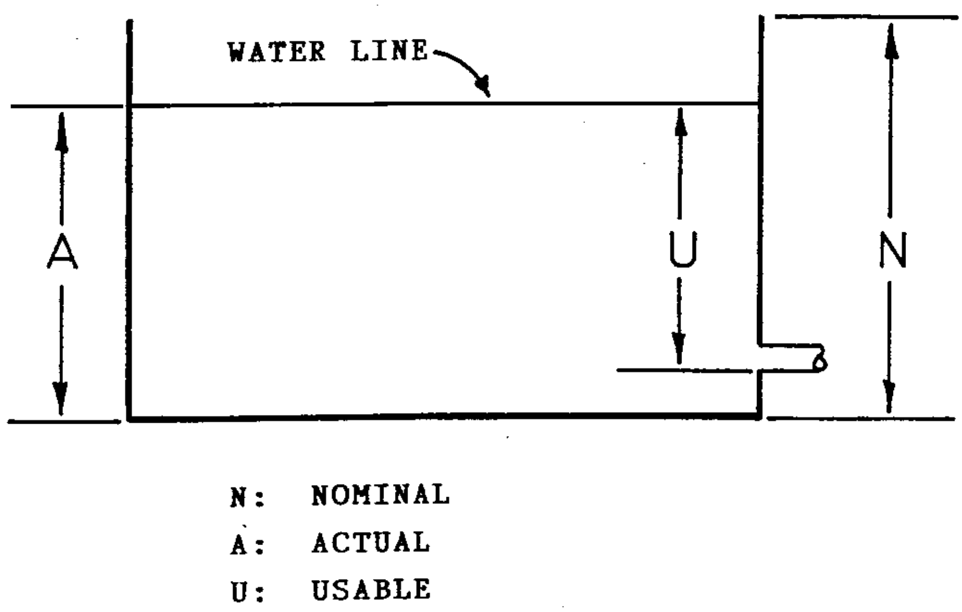


Figure 10. GRP Cistern

Cistern Connections

All cold water storage cisterns have the following connections:

- Rising main supplying the ball valve
- Overflow connection
- Cold water distribution

Ball valves should be fitted as high as it practicable to gain the maximum storage of water.

The overflow pipe should be one size larger than the cistern supply pipe, and located 40mm below the ball valve connection. This is to ensure that the ball valve will never become submerged, should the cistern overflow, which would be a health hazard due to the possibility of back siphonage.

Connections for distribution pipes should be located in the storage cistern in such a way that silt cannot be drawn into the pipes. These connections are usually taken from the side of the cistern 50mm above the bottom.

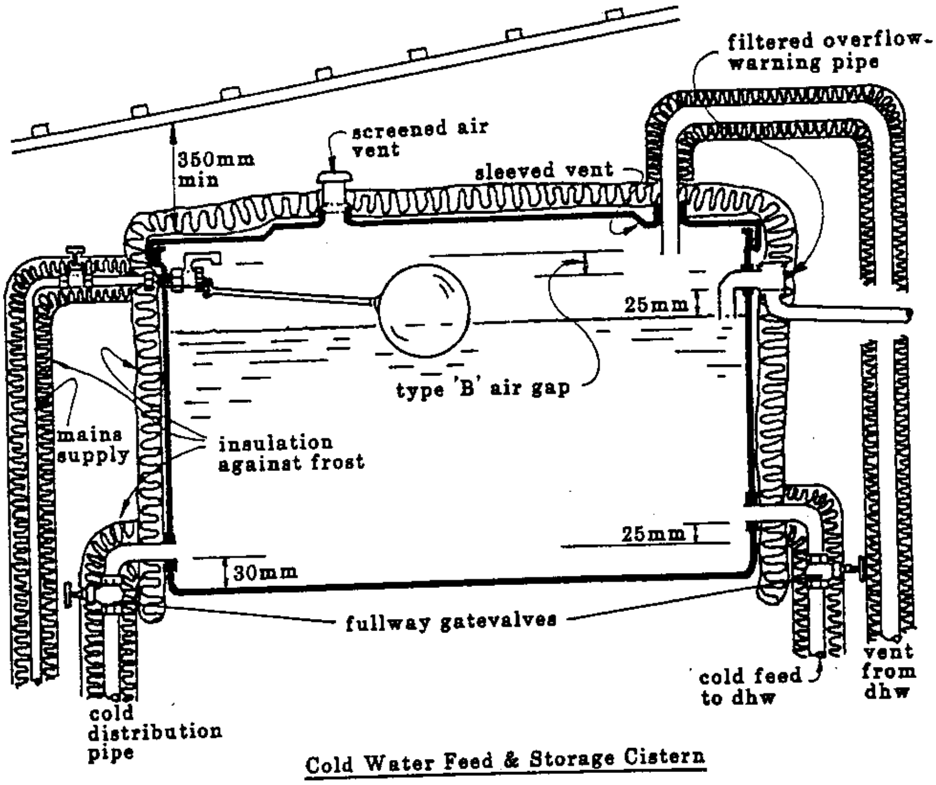


Figure 11. Cold Water and Storage Cistern

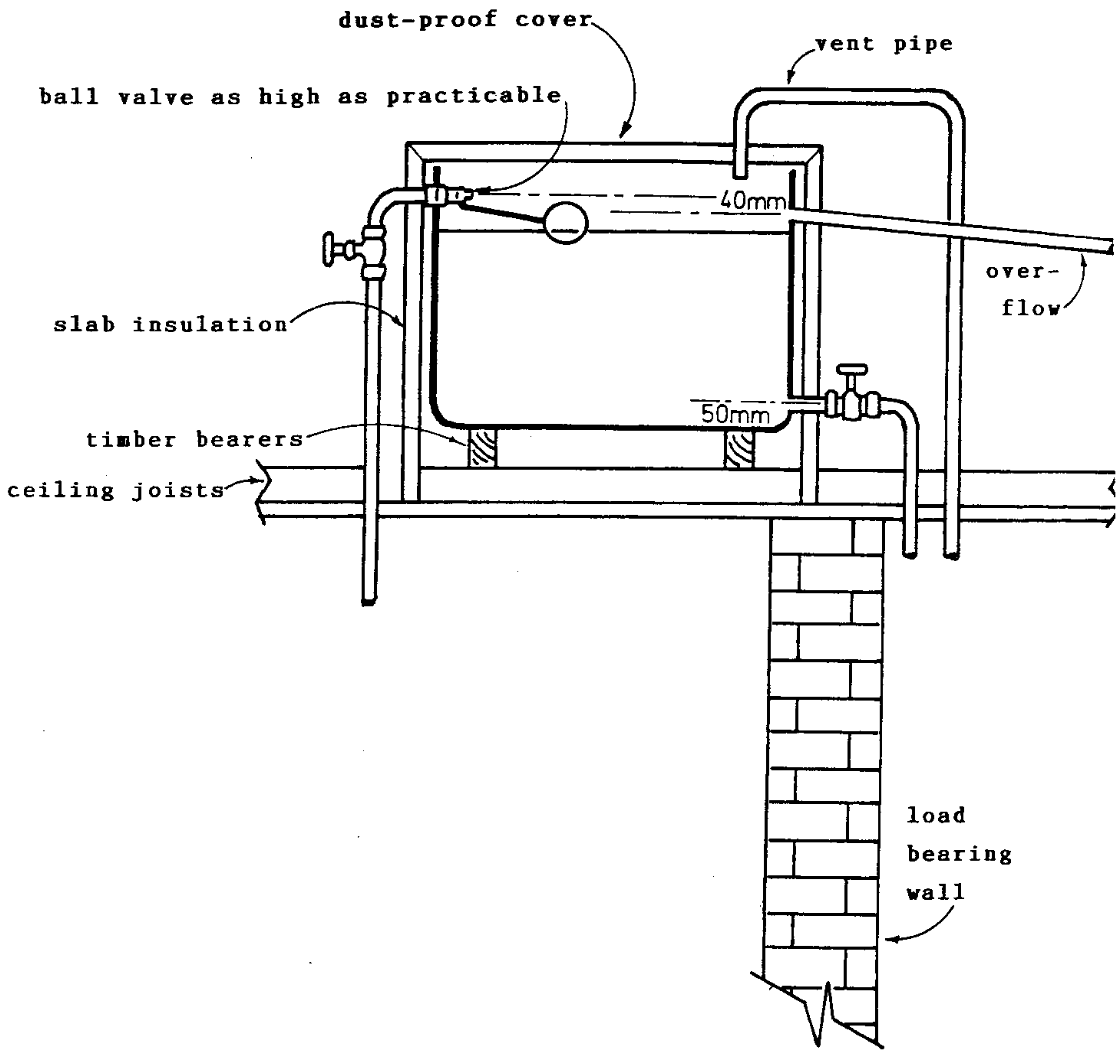


Figure 12. Cross Section of Cold Water Feed and Storage Cistern

Ball Valves

A ball valve is simply a control activated by a lever arm and a float which closes off the water supply when a predetermined level of water has been reached. Ball valves, in term of the definition above, should be called 'Float-Operated /Valves'.

The term 'Ball Valve' is, however, universally applied. There are many different types and it is important to be able to recognise each, to know when and where they should be fitted.

Ball valves are classified as follows:

- High pressure ball valve
- Medium pressure ball valves
- Low pressure ball valves

The visual difference between the three types of valve is in the size of the orifice (the hole through the nozzle). For high pressure water supply the orifice must be small; for medium pressure the size of the orifice will be a little larger; while for low pressure the orifice is larger still, almost full way.

The main types of ball valves are as follows:

- Portsmouth Ball Valve
- Croydon Ball Valve
- Garston Ball Valve
- Equilibrium Ball Valve

Portsmouth Ball Valve BS 1212

This has the advantage of being easily dismantled or removed from the cistern in the case of malfunction, without having to undo the backnuts to remove the body. The parts are renewable and readily accessible. This is particularly important with regards to the nylon seating which can be suitable for low, medium or high pressure, thus making this type of value universal.

Nylon is a chemically inert plastics material and so has a high resistance to mechanical wear, and is now extensively used in place of metal seatings.

The movement of the piston in this type of valve is in horizontal direction and has a much smoother and better action.

Figure 2 is an exploded view showing all the components parts. It will be noted that the outlet is not threaded to receive a silencing pipe. It is now against regulations to fit these, as they may cause back siphonage.

The Portsmouth BS 1212 valve is the only ball valve approved by Dublin Corporation for controlling the flow of water on any incoming water main.

Croydon Ball Valve

The Croydon valve is similar in many respects to the Portsmouth, with one notable exception; the movement of the piston is in a vertical direction. This tends to give the valve a rather jerky and sluggish action. The Croydon valve was used at one time, but has generally been superseded by the other types.

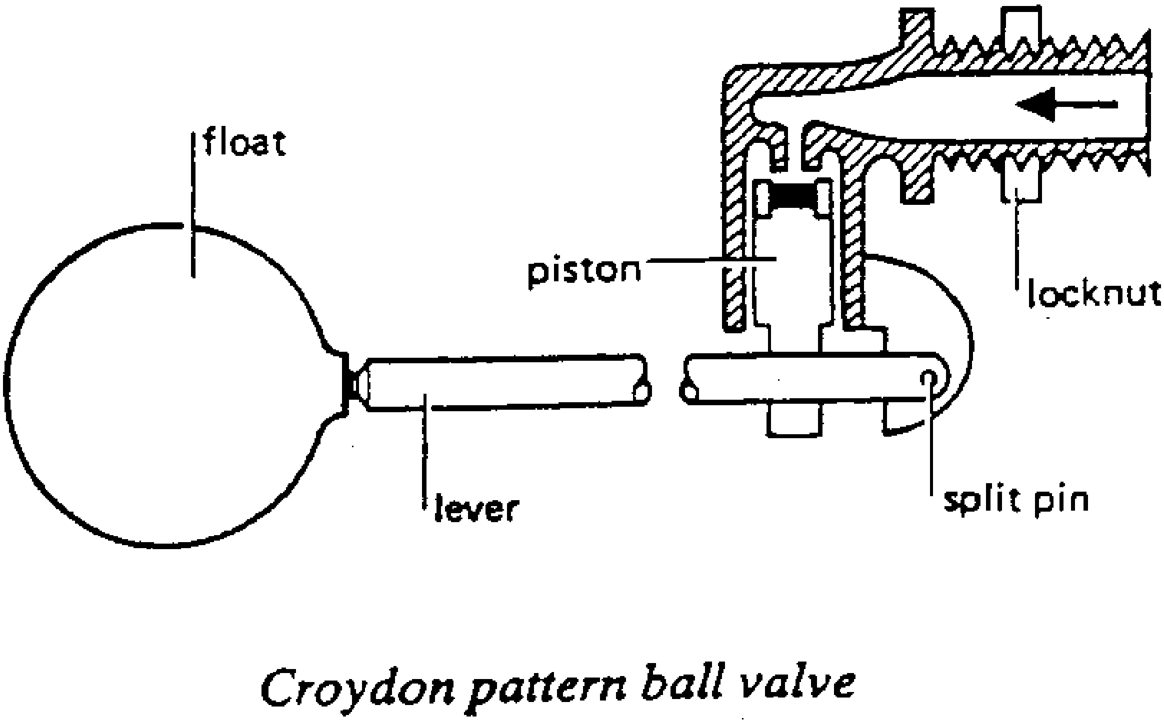


Figure 13. Croydon Pattern Ball Valve

Garston Ball Valve

The Garston ball valve was developed at the Building Research Station at Garston and is sometimes referred to as the BRS valve. It is a diaphragm type ball valve and is constructed mainly of a plastic type material.

Its main advantage are as follows:

- No water touches any working or moving part.
- It has a simple and convenient method of adjustment for the float.
- It has a large inlet chamber which breaks the speed at which the water enters and so reduces wear and noise.
- It also has fewer working parts than the Portsmouth and Croydon valves.

The Garston ball valve is designed specifically to use on low pressure installations.

The following figure shows a sectional view of the Garston valve and figure 2 is an exploded view.

Fig. 1

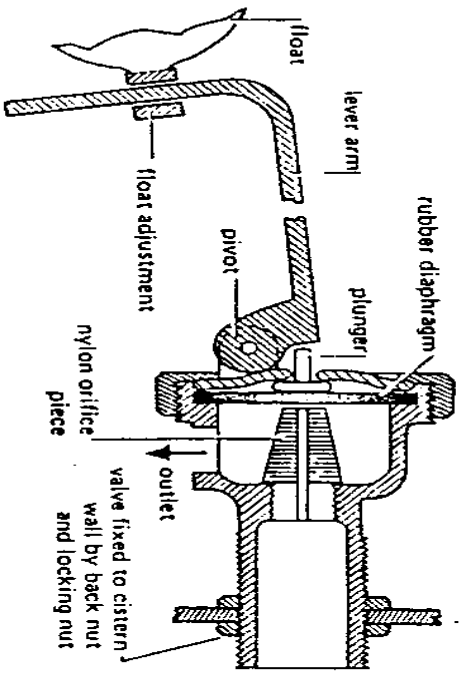


Fig. 2

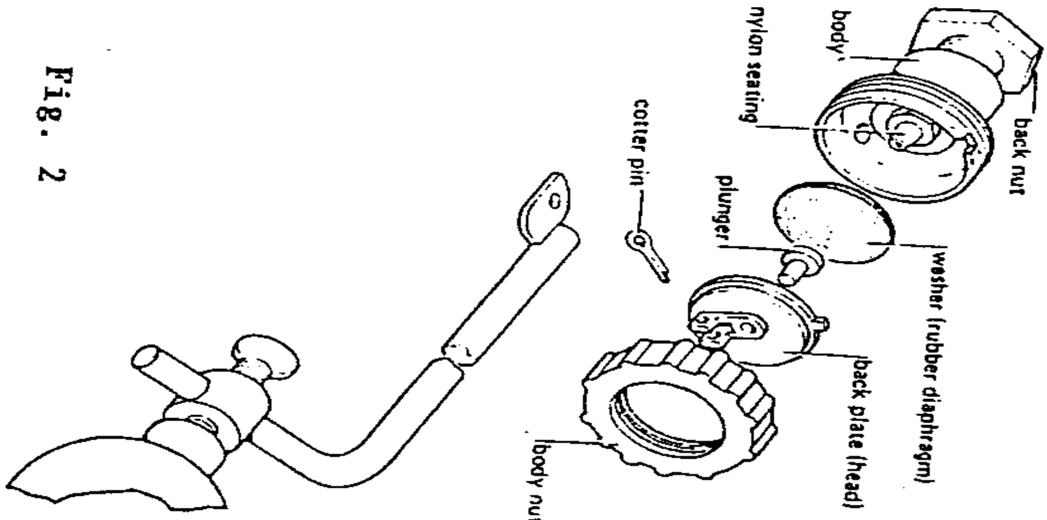


Figure 14. Garston Ball Valve

Equilibrium Ball Valves

Unlike those previously described which rely solely on the force exerted by the float to overcome the pressure of the water, these ball valves utilise the pressure of the water to help them close.

As can be seen there is a waterway through the centre of the piston, one end of which has a cup washer fitted to it, which is very similar in appearance to the type used in cycle pumps. Water passing through the hole in the piston exerts the same pressure on the cup washer (which tends to push he piston towards the orifice) as the pressure of the incoming water tends to push it off. As these pressures are equal they cancel each other out, hence the name 'Equilibrium Ball Valve'.

The float on this type of ball valve has only to lift the arm whereas in the case of ordinary ball valves, the effort provided by the float not only has to overcome the weight of the arm but also the pressure of the water.

Equilibrium valves are used with advantage in areas where very high mains pressures exist and where persistent water hammer may be encountered. All ball valves of 50mm nominal diameter and above are of the equilibrium type. This reduces the size of the float that would otherwise be required to close the piston in an ordinary ball valve of this size.

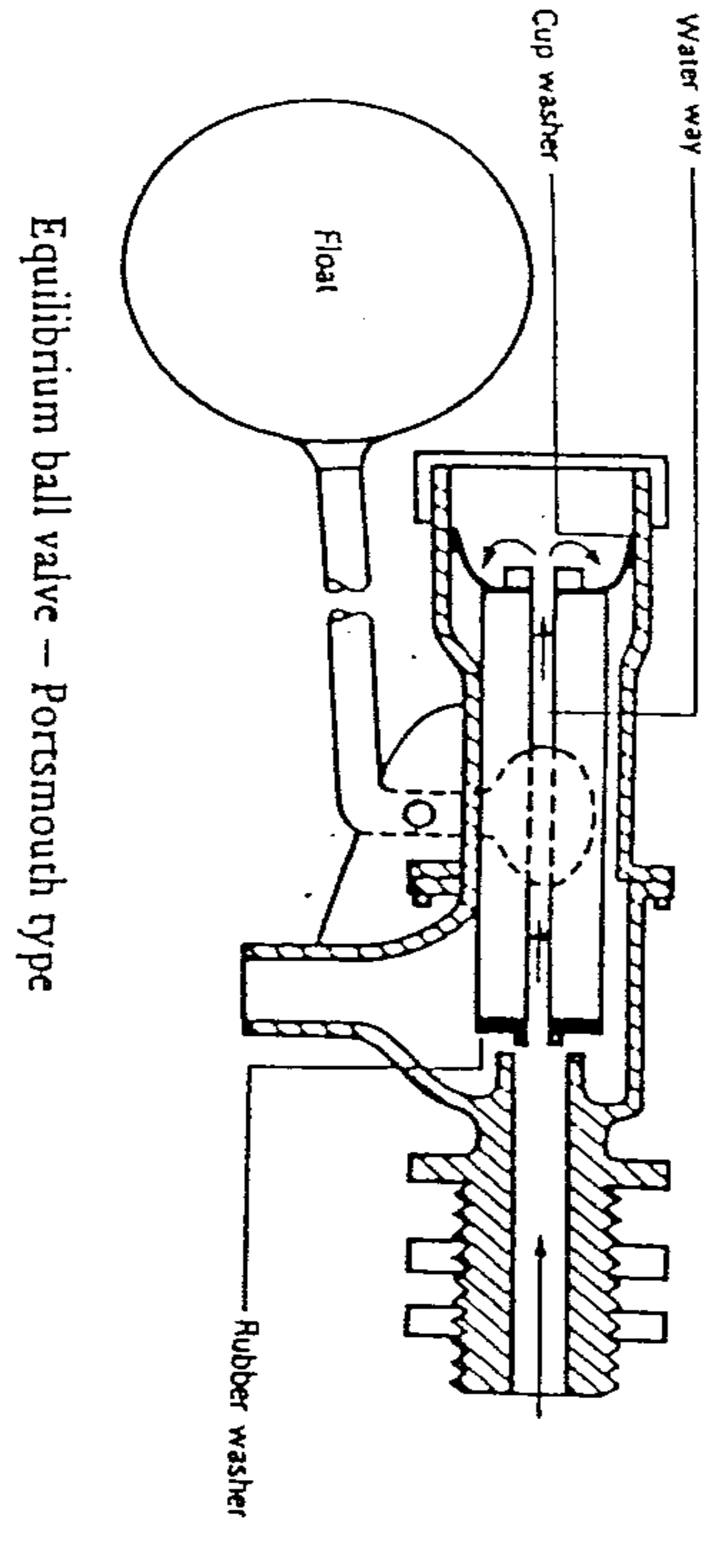


Figure 15. Equilibrium Ball Valve

Ball Valve Problems

One of the first indications of problems with a ball valve is water running from the overflow pipe. Some of the reasons for this are listed below:

- A worn washer which needs replacement.
- A jammed piston due to 'furring' up.
- A damaged or incorrect size orifice.
- A faulty float.

Water Hammer

Water hammer is a hammering noise which occurs in high pressures water pipes caused by surges of pressure. This is not only undesirable from the point of view of noise; it can also cause damage to plumbing systems. Water hammer usually occurs when a high pressure flow of water is suddenly arrested, as in the case of a ball valve closing too quickly, possibly due to an incorrect sized orifice. This has the effect of causing a loud bang or series of bangs throughout the pipework, and momentarily subjecting the whole system to a pressure almost double that of the incoming water. If this is allowed to persist, the excessive pressure can cause a pipe, perhaps already weakened, to start leaking.

Another fault which may generate water hammer is ripples or waves which form on the surface of the water is a cistern. It is these ripples that cause the float to bounce up and down, opening and closing the ball valve. To overcome this problem a larger float can be used, or a damping plate fitted to the float or lever arm is another alternative.

Another method of solving the problem of water hammer would be to fit an equilibrium type ball valve.

Furring

Furring can occur on the wetted moving parts of ball valves, i.e. the piston, the split pin and the lever arm. It only happens in districts where the water has a fairly high degree of temporary hardness. Water evaporates from the wetted parts, leaving behind minute particles of rock-like lime. These build up into layers which prevent the piston and lever from working smoothly. As a result the ball valve does not close easily or properly, and water leaks persistently from the overflow or warning pipe. In the case of the Portsmouth ball valve, furring can often be overcome by replacing the brass piston with one manufactured from nylon or plastic.

Cavitation

Cavitation is a form of erosion, brought about the mechanical wearing away of the ball valve orifice at its seating. The orifice seating becomes pitted or scored as it is gouged away by countless air bubbles which form in the water as it rushes along at high speed, and explode with sharp impingement as they leave the orifice tip. Nylon, a plastic material, is highly resistant to wear and is therefore more resistant to cavitation attack than metals are, and this is another reason why they are sometimes used in Portsmouth type ball valves.

Repairing Ball Vavles

Float-operated valves – ball valves – are the simple devices that control the water into cold storage tanks, central heating feed and expansion tanks, and WC cisterns. Like taps, they are in more or less constant use, so it's not surprising that problems sometimes occur.

Check the chart shown below for symptoms of faults and their likely causes. Leaking overflows need urgent attention, since what starts as a tell-tale drip can quickly develop into a flood – most overflows can't cope with full-scale flow of water (strictly speaking they are only *warning* pipes). The leak may also give rise to damp problems on the wall below.

Before you start a repair, identify what sort of valve you are dealing with (see below) and make sure that the shops are open – you may have to take the valve with you to get replacement parts. Don't forget that the water will have to stay off in the meantime.

Types of Ball Valve

All ball valves work on the same basic principle; an air-filled float, attached to the valve via an arm, rises and falls with the water level in the tank.

Attracted to the arm inside the valve is a plunger and plastic diaphragm (diaphragm type), or a piston with rubber washer (piston type), which closes off the water supply when the level is at the right height.

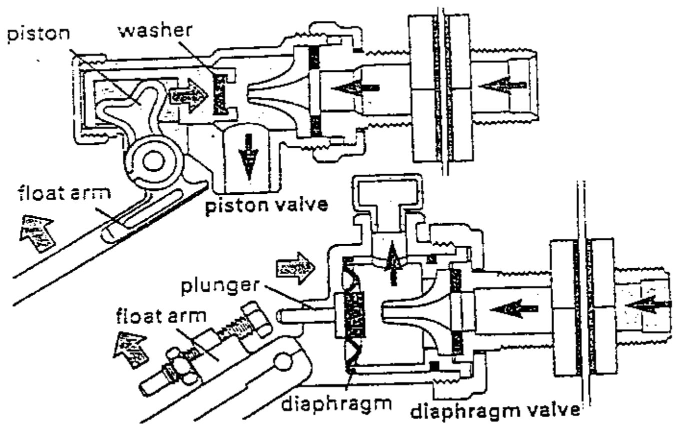


Figure 16. Types of Ball Valve

Identifying Ball Valve Faults

The following table displays some common ball valve faults.

Table 2. Ball Valve Faults

Symptom	Possible Causes	Cure
Valve lets water by, causing overflow	Washer/diaphragm worn	Service valve
	Seat cracked by frost	Service valve
	Valve mechanism jammed due to scale	Service valve or replace
	Leaking float	Empty float and seal or replace
	Valve corroded due to dezincification	Replace valve with dezincification-resistant type
Valve won't let water by causing tank to empty	Valve jammed due to lack of use (very common on C.H. feed and expansion tanks	Service valve
Tanks slow to fill	Valve outlet blocked with grit	Service Valve
	Wrong seat or valve	Replace seat or valve
Extensive noise from valve as tank fills	Wrong seat or valve	Replace seat or valve
	Worn Valve	Service or renew valve
	Water hammer due to high pressure	Turn down pressure or fit different valve
	Float bouncing on surface water	Fit damper to float

'Portsmouth' (piston type)

For many years the standard valve on both tanks and WCs. Older all-brass versions are still common; newer models have a plastic piston and seating which is less prone to scale build-up. The water Byelaws now ban Portsmouth valves from the new installations.

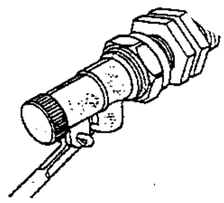


Figure 17. Portsmouth Valve

'Croydon' (piston type)

Rare and now obsolete. Replace with a newer type if faulty.

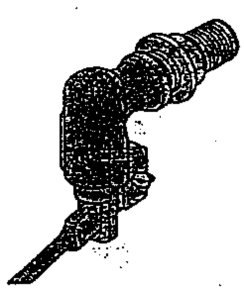


Figure 18. Croydon Valve

'Brass Equilibrium' (piston type)

Similar to the Portsmouth, but with an extra chamber that balances the force of the water pressure rather like a canal lock – resulting in quite, smooth operation. Used in areas with abnormally high or variable water pressure.

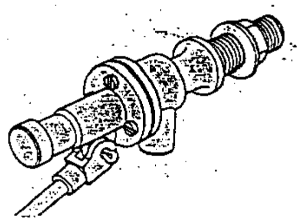


Figure 19. Brass Equilibrium Valve

'Garston' (diaphragm type)

Scale resistant valve, usually plastic but sometimes brass, which has no moving parts in contact with the water. No tools needed for servicing.

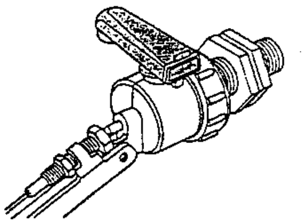


Figure 20. Garston valve

'New Brass Diaphragm' (diaphragm type – BS 1212 part 2)

Similar in operation to Garston, but with its water outlet mounted above the valve to eliminate the risk of back-siphonage.

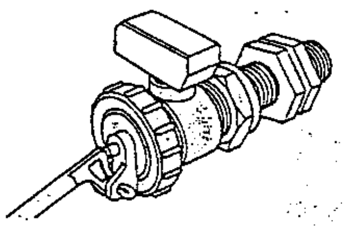


Figure 21. New Brass Diaphragm Valve

'Torbeck' (diaphragm type)

A patented plastic valve for WC cisterns. It has a built-in damper and a collapsible underwater outlet which permits silent filling without risk of back-siphonage. ('Silent filling' tubes on ordinary valves are banned under the Water Byelaws).

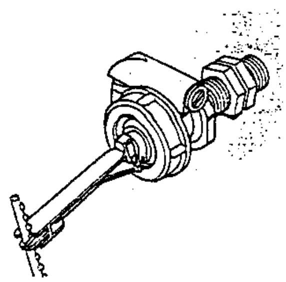


Figure 22. Torbeck Valve

Servicing Ball Valves

Most ball valves can be dismantled for cleaning and servicing, leaving the tail and supply pipe connection undisturbed. This is always preferable, especially if the supply pipe is lead, but it's not worth trying to service a very old or badly scaled-up valve – replace it instead as described overleaf.

New parts – washers, seats, floats – are cheaply available from DIY stores or plumber's merchants. But as with taps, you may need to take the old parts with you. The first step is to turn off the water supplying the valve at the nearest stopcock. Check the water has stopped flowing by pressing down on the float arm.

When unscrewing the valve body, take care not to let it turn or you'll break the seal on the tank/WC cistern and strain the supply pipe connection.

Tools and material: Adjustable spanner, wrench, self-locking wrench, small screwdriver, pliers, PTFE tape.

Serving a Piston Valve

After removing the working part of the valve (see step below), dismantle it following the diagram.

- Remove the split pin and unscrew the end cap, then wriggle out the float arm and slide out the position.
- Hold the position with a screwdriver and unscrew the end. (Newer pistons are in one piece).
- Dig out the old washer; replace it with an identical size and type.
- Replace the seating with one of the same size and pressure rating if it looks worn or is cracked.
- Scour off any scale, then give the piston and body a thorough clean with metal polish.
- Before reassembling, check the condition of the union washer and replace if necessary.

TRADE TIP: Pressure Points

"Most newer ball valves have replaceable seats with the outlet holes sized according to the pressure of the water passing through them.

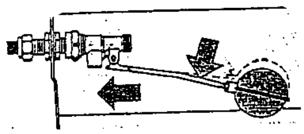
Low pressure seats are for WC cisterns fed from storage tanks. High pressure seats are for storage tanks and WC cisterns fed direct from the mains.

You can also get full-way seats for WC cisterns that fill painfully slowly because the storage tank is too low-down in the house to provide the normal amount of pressure.

Always specify what pressure rating you want when buying new parts or a new valve. Armed with this information, you can also cure a valve that fills too slowly or quickly (and thus noisily) simply by changing the seat accordingly."

TRADE TIP*: In an Emergency*

"At the first sign of a drip from the overflow, bend down the float arm (or on a plastic valve, adjust the arm) so that more pressure is applied on the washer. As with a leaking tap, you could also try turning the washer round the other way."



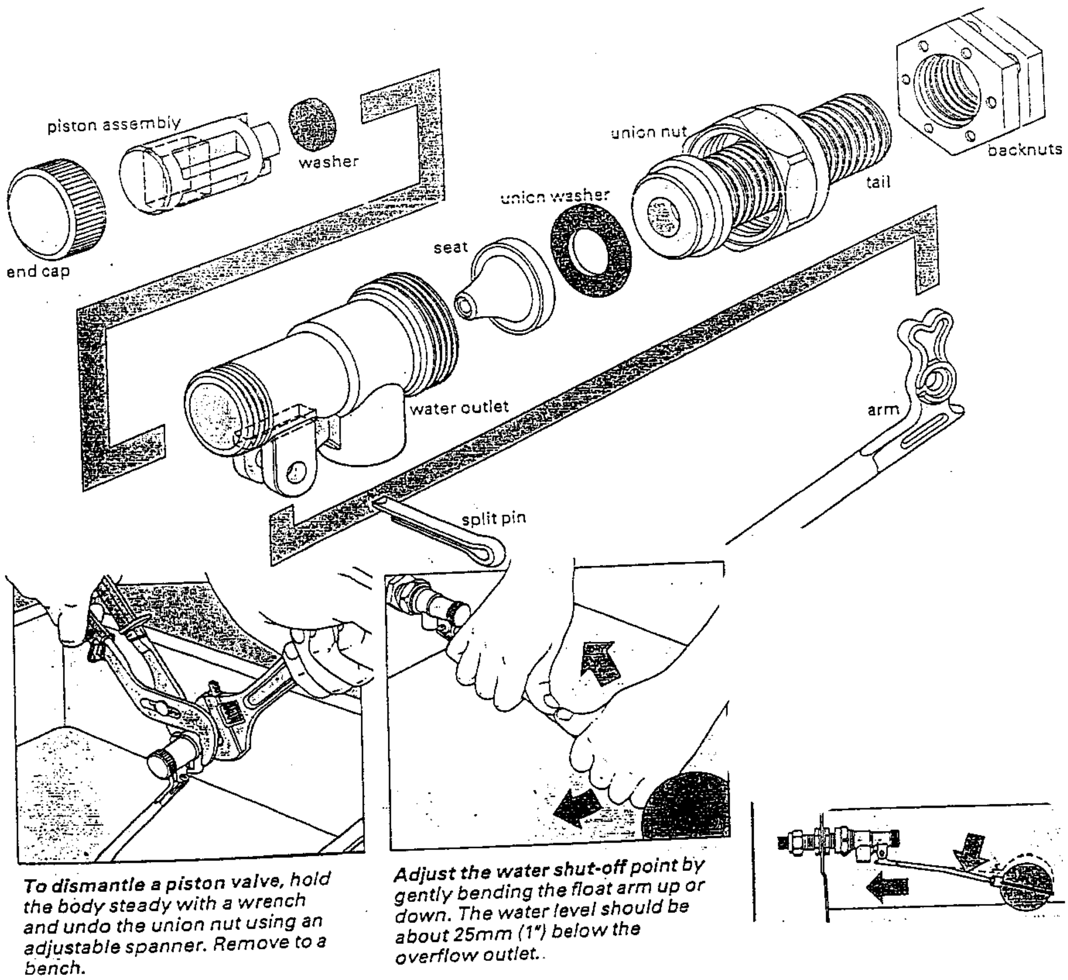


Figure 23. Servicing Ball Valves

Servicing a Diaphragm Valve

- On most diaphragm valves, the diaphragm is immediately behind the retaining nut (see diagram). But on one type the nut is in the middle of the valve (inset), and you have to slide out a cartridge to expose the diaphragm. In this case, take care not to damage the sealing washer behind the seat.
- Dig out the diaphragm with a flat-bladed screwdriver and check that the seats is in good condition.
- The new diaphragm only fits one way, so check the old one to see which side was marked by the seat.
- Reassemble the valve and screw the retaining nut back on by hand. Turn on water and test immediately.

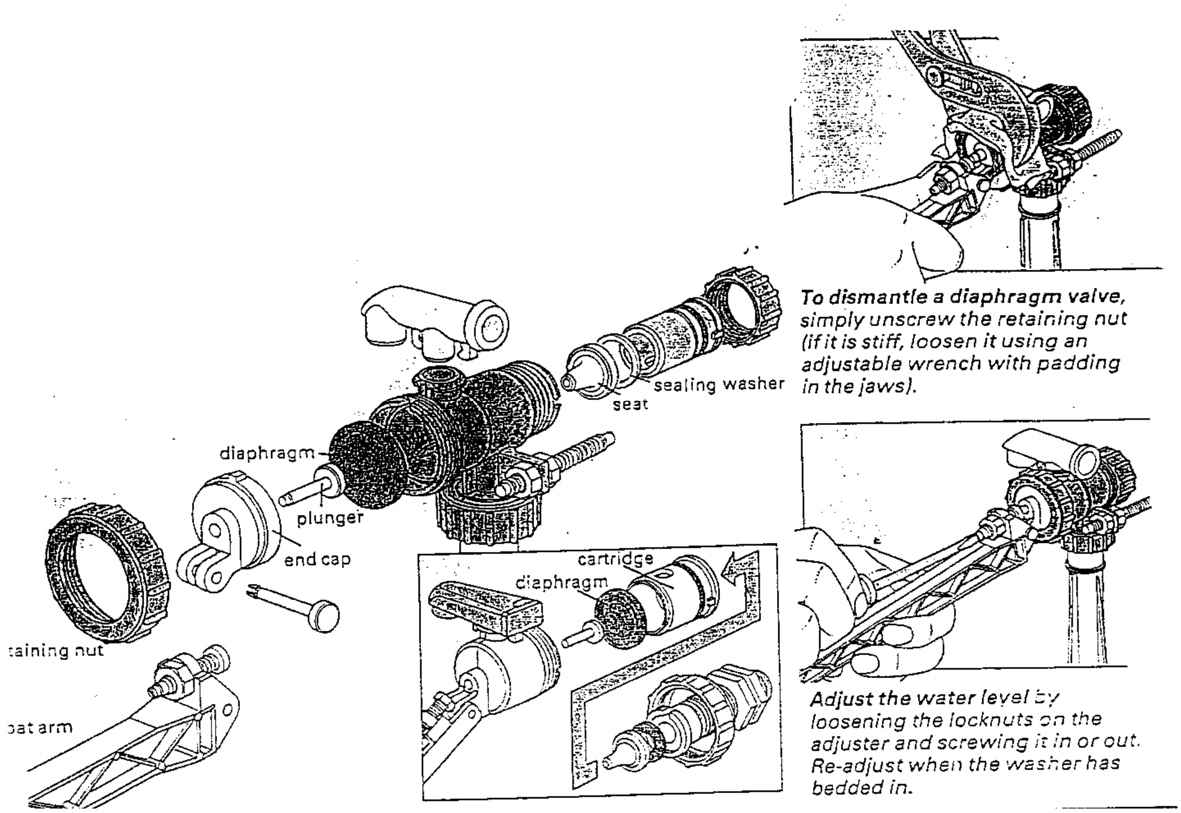


Figure 24. Servicing a Diaphragm Valve

Servicing a Torbeck Valve

A constant drip from the front of the valve during filling is normal, but if you suspect the diaphragm needs replacing:

Unscrew the front of the valve body.

- Dig out the diaphragm and clean in soapy water. It could be that this cures the problem; if not, replace the diaphragm.
- Replace the diaphragm with the white spike pointing towards the valve. Position the bush on the outer edge of the diaphragm on the steel pin fixed to the valve body.
- Replace the front cover, checking that the float arm engages on the plastic pins.
- Adjust the water level by altering the position of the float arm.

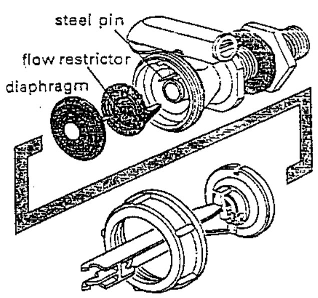


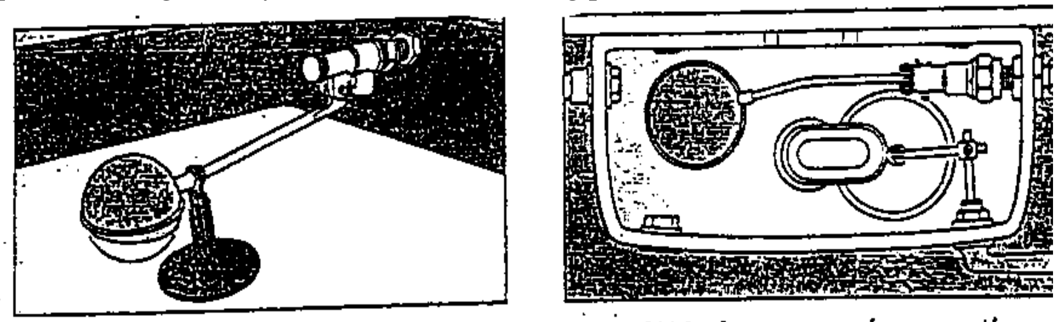
Figure 25. Servicing a Torbeck Valve

Instead of different size seatings the Torbeck valve comes with a choice of flow restrictors for high and medium pressure. But if the valve takes more than 20 seconds to fill, it's more likely that the filter is blocked so check this first. (Early models may not have a filter).

Curing Float Problems

- If the float develops a leak, the valve won't shut off at the correct point. Unscrew the float, empty out the water, and patch the hole with epoxy putty or tie a plastic bag over it. Replace as soon as possible.
- Sometimes – and especially on Portsmouth valves – the float bounces on the ripples as the tank fills, causing water hammer in the supply pipe. You can cure this by fitting a purpose-made damper to the float arm. Alternatively, hang a punctured yoghurt carton in the tank, suspended from the float arm by a length of galvanised wire.

- In a WC cistern, the float may catch on the flushing mechanism causing the valve to jam open. If necessary bend a brass arm so that the float is free to move throughout its travel; plastic arms generally have a choice of fitting positions.



Fit a damper – proprietary or home-made – to the float arm to stop the float bouncing.

On a WC cistern, make sure the float doesn't jam – bend the arm or reposition the float to clear.

Figure 26. Curing Float Problems

Replacing a Valve

New ball valves aren't expensive, so if you can't get the parts to repair the old one (or it isn't worth repairing) then buy a matching replacement. Replacing the entire valve is likely to cause problems, so aim to 'graft' the working part of the new one on to the tail of the old one so that you don't have to disturb the supply pipe. Make sure you fit a new sealing washer where the two halves join.

If you have to replace the entire valve, or you are changing it for another type:

- Try to ensure the new valve has the same length tail as the old one; if not, you may have to modify the supply pipe (see Problem Solver).
- On a WC cistern, the length of the float arm may also be critical (though you can probably swap over the old one).
- Specify whether the valve is for high pressure or low pressure application.
- If you live in a water area where dezincification is a problem, make sure the valve is plastic, or has a DR mark, indicating that it is dezincification –resistant.

Before you start, apply some penetrating oil to the connector nut and valve backnuts. Then, after turning off the water, open a tap lower down in the system to drain any water left in the supply pipe. New valves are often supplies with self-sealing nylon backnuts which don't need washers, but make sure the area around the nuts is clean and free of old jointing compound so that the seals are watertight. On a WC, don't overtighten the nuts.

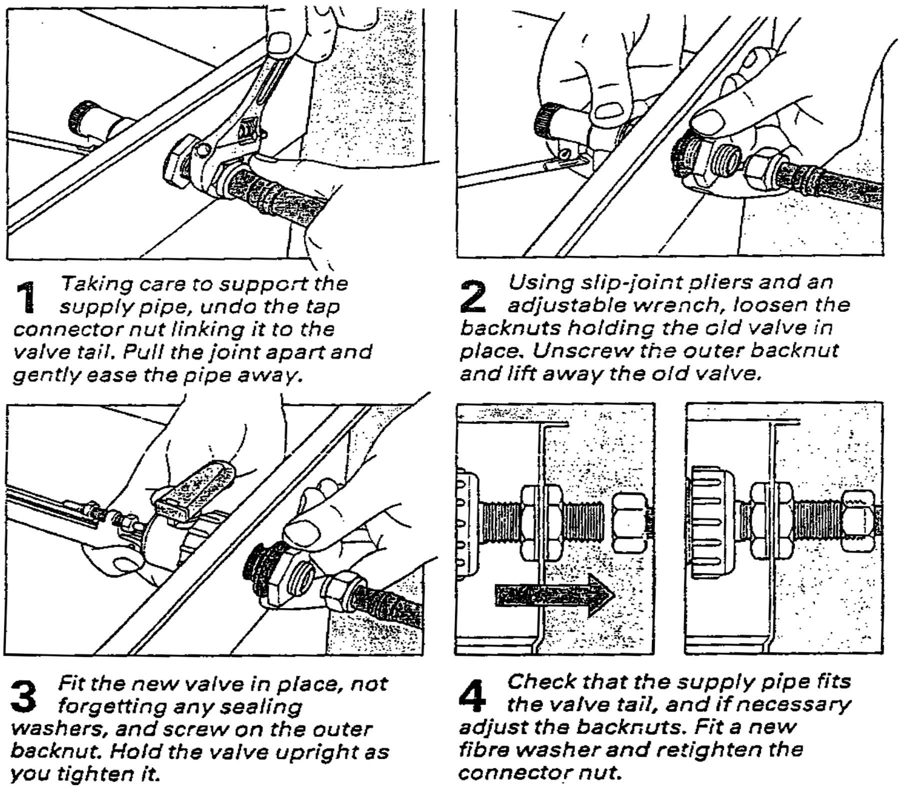


Figure 27. Replacing a Valve

TRADE TIP :Valves with Standpipes

"Some modern WCs require a bottom entry valve, which includes an integral standpipe. Valve operation is identical to the usual side-entry type.

If you're fitting an identical replacement, you should be able to leave the standpipe in place and simply undo the valve at the union. Otherwise, be sure to quote the length of the standpipe when ordering a new valve."

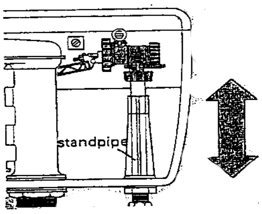


Figure 28. Valve with Standpipe

Problem Solver

Bridging the gap

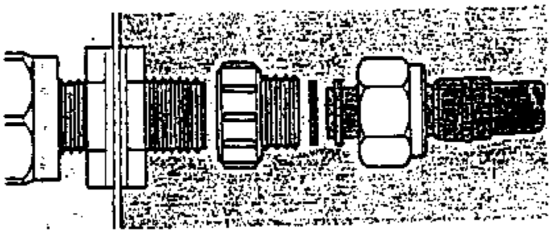
If you can't get a new valve to match up to the existing supply pipe, don't force the pipe it may cause the joint to leak, or weaken others along the run.

Normally, adjusting the position of the backnuts on the valve tail gives you enough room to manoeuvre. Failing this, you may find that a screw-on *tap shank adaptor* is long enough to bridge the gap. Otherwise, you have no option but to saw off the old tap connector and fit a new one, together with a new section of pipe.

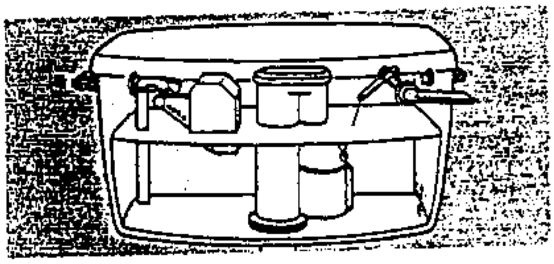
Persistent valve problem

The Keraflo valve is a patented design which uses ceramic discs instead of washers to shut off the water. It is only made to fit WC cisterns, but is claimed to be maintenance free and very reliable.

The valve comes in a basic unit to which you add a side entry connector or a separate standpipe for bottom entry. The fitting procedure is the same as for other ball valves, but you may need an extending arm if the flushing handle restricts the float travel.



You may be able *to bridge a small gap using a tap shank adaptor.*



The Keraflo *ceramic disc ballvalve for fitting to WCs.*

Figure 29. Persistent Valve Problem

Formulae

Volume of Rectangular Cistern: Length (M) X Breadth (M) X Height (M)

The answer will be in cubic metres M^3

Capacity of Rectangular Cylinder: L (M) X B (M) X H (M) X 1000

The answer will be in litres

To calculate the length of the circumference of a circle: πD

To calculate the area of a circle: πR^2

Volume of a cylinder: $\pi R^2 H$ = M^3

Capacity of a cylinder: $\pi R^2 H$ X 1000 = Litres

Intensity of Pressure: Head (M) X 9.8

The answer will be in Kn/M^2

Total Pressure: Intensity of pressure X area acted upon

The answer will be in Kn

Quantity of heat energy = Mass (Kj) X specific heat X temperature rise

The answer will be in Kj

Power = $\dfrac{\text{Kj}}{\text{Seconds}}$ the answer will be in Kw

Important Definitions

Derived units are those which can be expressed in terms of primary units so as to provide more units to work with.

1 Litre of water weighs 1 Kg

1000 Kg = 1 metric tonne

1 cubic metre of water holds 1000 litres and weighs 1 tonne

The boiling point of water = 100°C = 373°K

The freezing point of water = 0°C = 273°K

The maximum density temperature of water = 4°C

Absolute zero = 0°C = -273°C

The specific gravity of water = 1

Specific gravity may be defined as the ratio of the weight of a given volume of any substance to the weight of the same volume of water at 4°C.

An alloy is a metallic substance made by mixing two or more elements, one of which is a metal.

Isaac Newton

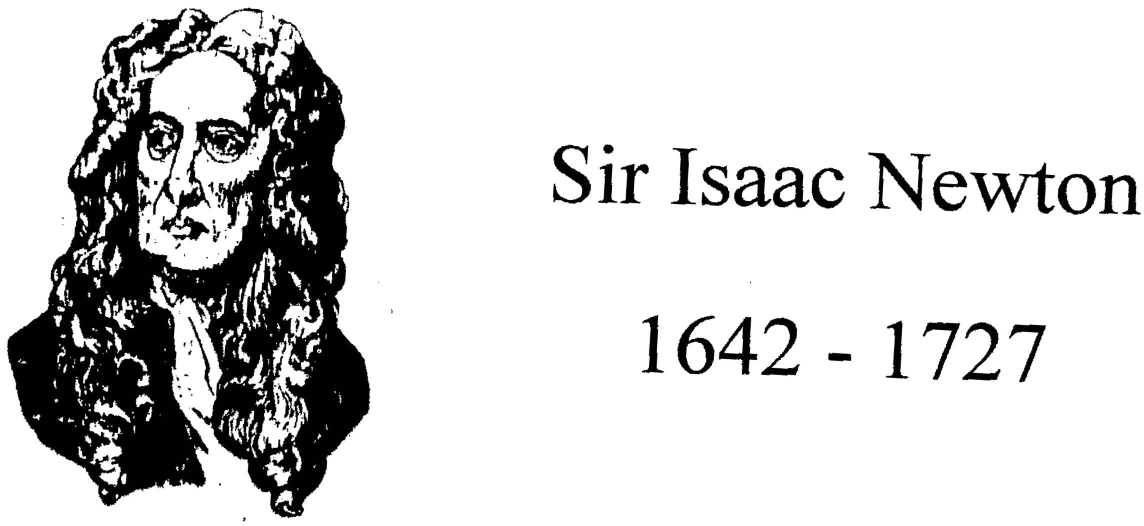


Figure 30. Isaac Newton

Newton was a genius. There is no doubt that his discoveries have become the foundations of modern science. Yet Newton, like all of us, experienced human sufferings and failings. Early in his life, he developed feeling of insecurity and rejection. These fears together with a fear of the unknown spurred him on to learn the laws of nature as he felt God had written them. The precision of his mathematical proofs gave him assurance and comfort. Those proofs and ideas, however, did not spring full-grown from his forehead, but rather were nurtured through tortuous periods of development. Newton had much difficulty relating to his colleagues and unfortunately was involved in several spiteful disputes. In later life, his autocratic domination of London's scientific community brought him some final satisfaction, but even then he seemed to be a man of little mercy and much spite.

Isaac Newton was born prematurely on Christmas Day in 1642. His mother used to remark that he was small enough to fit into a quart pot. Newton's father was a common yeoman in Lincolnshire and died before his son was born. When Isaac was about three, his mother married a local pastor and moved a few miles away, leaving young Isaac in the care of the housekeeper. Newton hated his stepfather for taking his mother away.

Isaac was a small child who was forever being bullied by other children. He was required to help on the farm, but slipped off as much as he could to read. In his leisure he amused himself building model windmills powered by mice, waterclocks, sundials, and kites carrying lanterns which frightened the country folk. It was said that he had the hand of a carpenter as well as the head of a mathematician. A local schoolmaster recognised Newton's abilities and helped send him to Cambridge.

In 1665, the bubonic plague was raging through the English countryside and consequently Cambridge went into recess. At about the same time there was a great fire which destroyed much of London. Many were beginning to feel it was the end of the world. Amid all the turmoil, Newton, now 23, returned to the family farm to study. From his concentration, he developed a theory of coloured light and his theory of fluxlops (calculus). While sitting in his garden, he dreamed up the proof for the law of gravity. This was a marvellously creative time for Newton. As he explained, “I keep the subject constantly before me and wait till the first dawnings open slowly by little and little into the full and clear light”.

Much of Newton’s life was spent in seclusion. He lived an ascetic life, dressed sloppily and rarely went to bed before two or three in the morning. He hated weeks in his garden and was inveterate hypochondriac. There was little laughter in his life and he never married. Newton was an avid follower of the Bible and as he conducted his experiments, it was as though he was wrestling with an evil force. His studies even took him into alchemy.

A large part of Newton’s life was spent quarrelling with fellow scientists. Robert Hooke accused Newton of stealing some ideas about gravity and light. This touched off dispute which lasted for years. Newton usually responded badly and tended to feel he was omnipotent. Leibnitz was another rival. Unfortunately, both Newton and Leibnitz developed calculus at about the same time. Both claimed priority and another dispute was born.

Water Pressure

Water pressure is naturally caused by the weight of water which, under the influence of the earth's gravitational force, exerts pressure on all surfaces which it bears. The higher a column or HEAD of water, the more pressure is exerted at its lowest point. Therefore, it is essential to install feed and storage cisterns as high as possible, giving a good pressure at the draw off points.

The basic unit of pressure or force in the SI system is the Newton. Its name is derived from the 17^{th} century scientist, Isaac Newton. The numerical value of the Newton is very small, and it is therefore more convenient to multiply it by 1,000 so it becomes the kilonewton. So 1,000 newtons = 1 kN

Intensity of Pressure

Intensity of pressure may be defined as that force created by the weight of a column of water acting on $1m^2$.

$$\text{Intensity of pressure} = \frac{\text{Force}}{\text{Area}}$$

Since force is expressed in kilonewtons and area is expressed in m^2

$$\text{Intensity of pressure} = \frac{kN}{m^2}$$

Imagine a cube of water measuring 1m X 1m X 1m, that is $1m^3$. This is 1,000 litres, and since 1 litre weighs 1kg:

1,000 litres weighs 1,000 kg

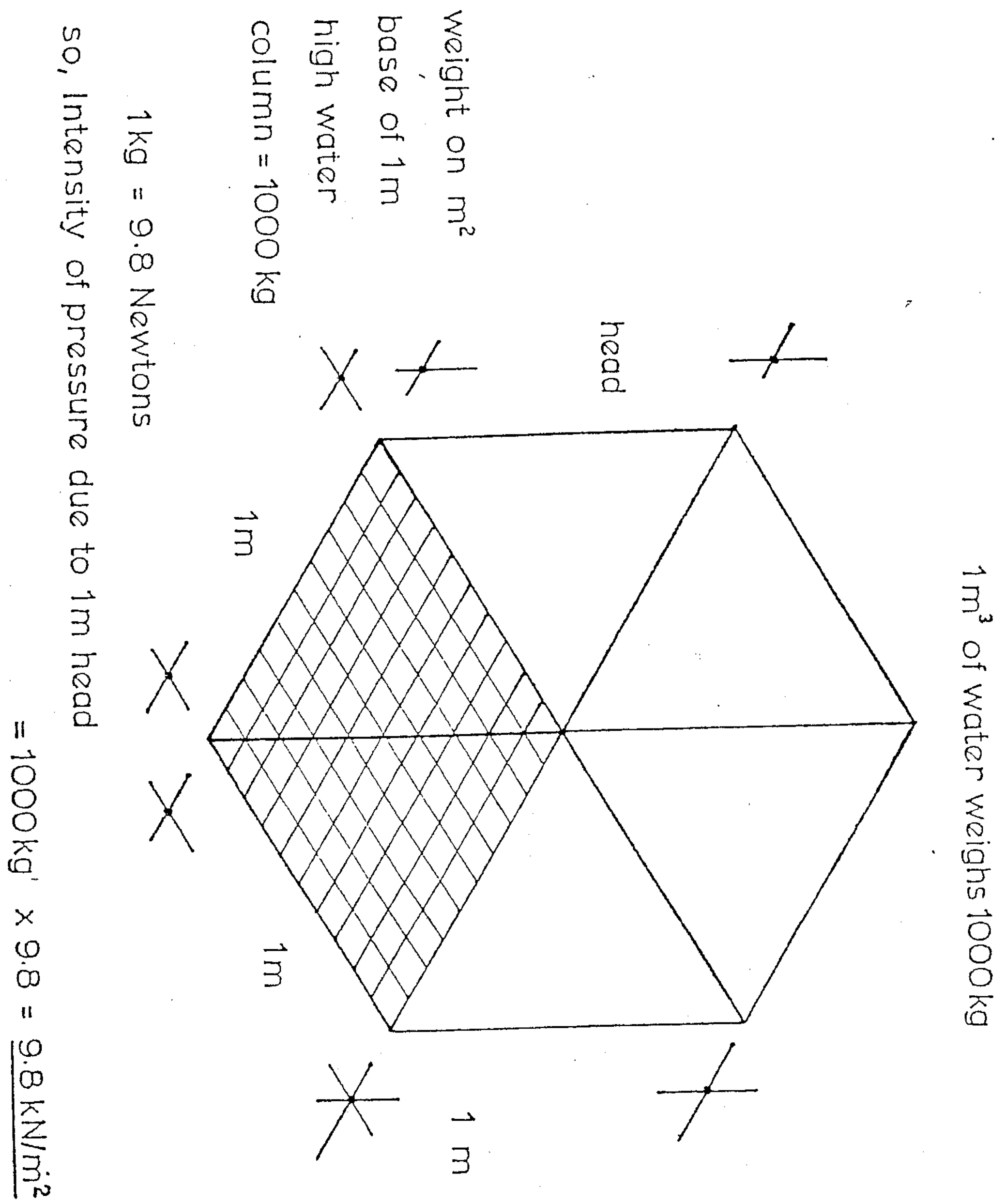


Figure 31. Intensity of Pressure

The pressure acting on $1m^2$ area, 1m high has been measured as 9,800 newtons

Or 9.8 kN / m^2

So intensity of pressure is always expressed in kN / m^2

If a container 1m high exerts a pressure of 9.8 kN / m^2, a container 4m high would exert 4 times as much pressure:

= 4 X 9.8 kN / m^2

= 39.2 kN / m^2

So to calculate the intensity of pressure, multiply the height of the column of water (head) by 9.8 kN / m^2.

The answer will always be expressed in kN / m^2.

Answer the following:

1. What would be the intensity of pressure on a tap fitted 6 metres below a cold water storage cistern?
2. Calculate the intensity of pressure acting on the base of a cold water storage cistern, if the water level is 500mm above it.
3. The base of a boiler is located 4.25m below a feed and expansion cistern. Calculate the intensity of pressure acting on the boiler base.
4. The pressure gauge on a boiler registers 51.45 kN / m^2. What head of water is creating this pressure?

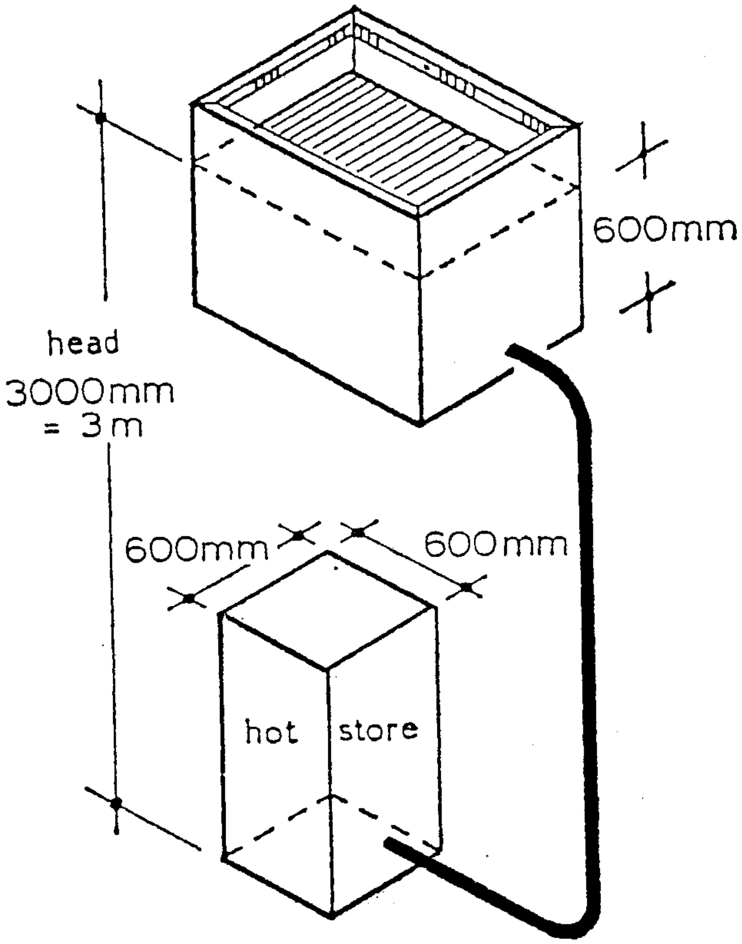


Fig 1

Figure 32. Figure 1 - Storage Cistern

Exercise 1 – Answer:

Intensity of pressure = head (m) X 9.8 kN / m^2

= 5 X 9.8

= 49 kN / m^2

Exercise 2 – Answer:

Intensity of pressure = head (m) X 9.8 kN / m^2

= 1.5 X 9.8

= 14.7 kN / m^2

Exercise 3 – Answer:

Intensity of pressure = head (m) X 9.8 kN / m^2

= 15.25 X 9.8

= 149.45 kN / m^2

Total Pressure

As has already been seen, intensity of pressure is always expressed in kN / m^2 regardless of the surface area upon which it is acting.

But what happens if this area is more or less than 1m^2?

This calculation is known as total pressure and can be used to determine the pressure acting on areas other than 1m^2.

The formula for calculating total pressure is:

Total pressure = Intensity of pressure X Area acted upon
(kN) (kN / m^2) (m^2)

Total pressure is always expressed in kN.

Example 1:

In Fig 1 the intensity of pressure was 29.4 kN / m^2

This was calculated by multiplying the head (3m) by 9.8 kN/ m^2.

However, the base of the hot store tank measures 600mm X 600mm.

To find the total pressure acting on the base we must first calculate the area of the base. (In this case 0.6m X 0.6m = 0.36m^2)

Total pressure = intensity of pressure X area acted upon
(kN) (kN / m^2) X (m^2)
= 29.4 X 0.36
= 10.58 kN

Example 2:

Find the total pressure at the base of a boiler which measures 500mm long, by 300mm wide, fitted 2.5 metres below the water level in a storage cistern.

Intensity of pressure = head (m) X 9.8 kN / m^2
= 2.5 X 9.8
= 24.5 kN / m^2

Total Pressure = intensity of pressure X area acted upon
(kN) (kN / m^2) X (m^2)
= 24.5 X 0.5 X 0.3
= 3.675 kN

Example 3:

A storage cistern measures 3mm X 2mm and contains water 2.5m deep.

Find: (a) The intensity of pressure on its base

(b) The total pressure on its base

Solution (a)

Intensity of pressure = head (m) X 9.8 kN / m^2

= 2.5 X 9.8

= 24.5 kN / m^2

Solution (b)

Total pressure = intensity of pressure X area acted upon

= 24.5 X 3 X 2

= 147 kN

Exercise 1:

A cold water cistern is fitted 4 metres above a 50mm diameter gate valve.

Calculate: (a) the intensity of pressure on the closed gate of the valve.

(b) the total pressure on the gate of the valve.

Exercise 2:

Refer to Fig 2:

Find (a) the intensity of pressure at tap A;

(b) the intensity of pressure at tap B;

(c) the total pressure acting on the manlid C of the hot water cylinder

Example 4:

Find the total pressure acting on the closed gate of 50mm diameter gate valve when the head of water above the valve is 3 metres.

Intensity of pressure = head (m) X 9.8 kN / m^2

= 3 X 9.8

= 29.4 kN / m^2

Total Pressure = intensity of pressure X area acted upon

= 29.4 X πr^2

= 29.4 X 3.14 X 0.025 X 0.025

= 0.057 kN or 57 newtons

Exercise 1 – Answer:

(a) Intensity of pressure = head (m) X 9.8 kN / m^2

= 4 X 9.8

= 39.2 kN / m^2

Total pressure = intensity of pressure X area acted upon

= 39.2 X πr^2

= 39.2 X 3.14 X 0.025 X 0.025

= 0.076 kN

= 76 newtons

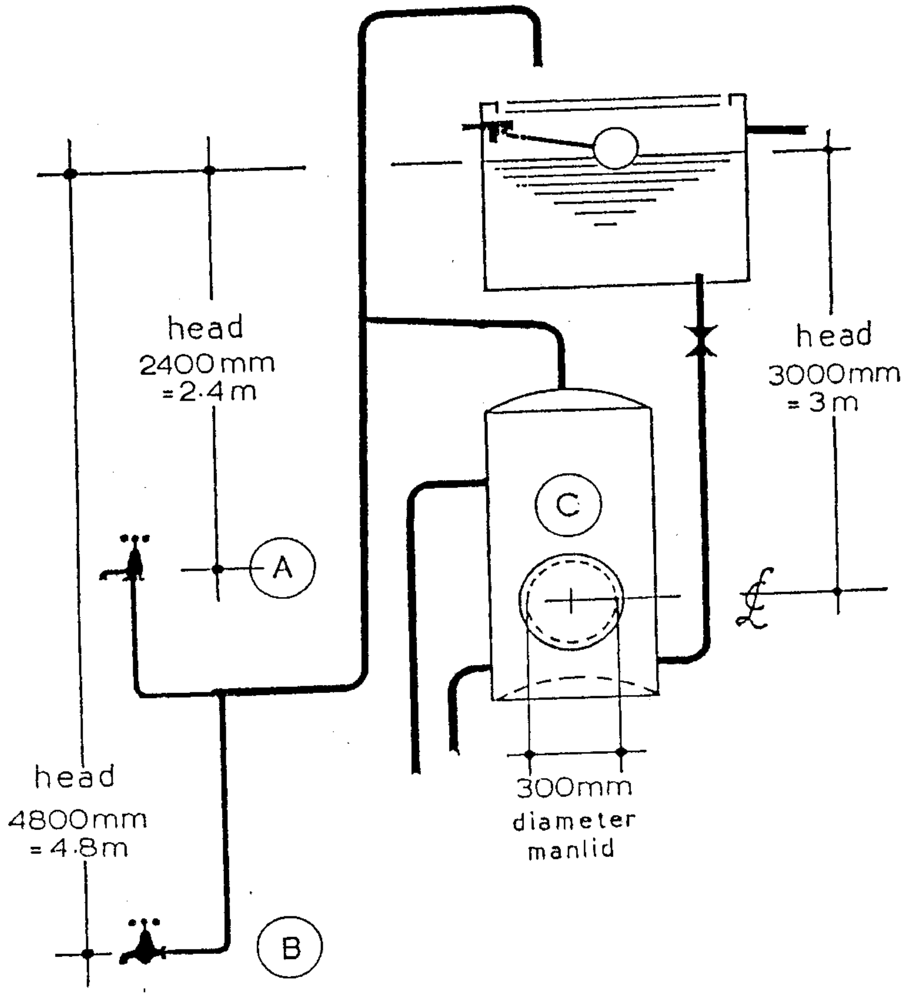


Fig 2

Figure 33. Figure 2 – Pressure Taps

Exercise 2 – Answer:

(a) Intensity of pressure = head (m) X 9.8 kN / m^2

= 2.4 X 9.8

= 23.52 kN / m^2

(b) Intensity of pressure = head (m) X 9.8 kN / m^2

= 4.8 X 9.8

= 47.04 kN / m^2

(c) Intensity of pressure = head (m) X 9.8 kN / m^2

= 3 X 9.8

= 29.4 kN / m^2

(d) Total pressure = intensity of pressure X area acted upon

= 29.4 X πr^2

= 29.4 X 3.142 X 0.15 X 0.15

= 2.078 kN

Self Assessment

Cold Water Storage Cisterns and Float Operated Ball Valves Questions

Answer the following questions:

1. Draw a cold water storage cistern and show the following connections:
    - The overflow operated ball valve
    - Overflow
    - Distribution
    - Cold feed to hot water storage cylinder
2. Why is it necessary to fit the overflow connection below the ball valve connection?
3. How far below the ball valve should the overflow connection be fitted?
4. Explain the terms NOMINAL, ACTUAL and USABLE in relation to cold water storage cisterns. Use a sketch to illustrate your answer.
5. Why is it necessary to fit connections above the bottom of cold water storage cisterns?
6. State 2 advantages of the Garston float operated ball valve.
7. Name 3 types of float operated ball valves.
8. State how float operated ball valves are classified.
9. What are the main advantages of the equilibrium type ball valve?
10. Explain the term "FURRING" in relation to float operated ball valves.

Model answers

A2

This is to ensure that the ball valve will never become submerged, should the cistern overflow, which would be a health hazard due to the possibility of back siphonage.

A3

The overflow connection should be fitted 40mm BELOW the ball valve connection.

A4

NOMINAL – The amount of water a cistern would hold if filled up to the very top edge.

ACTUAL – The amount of water from the base of the cistern up to the water line.

USABLE – The amount of water that can be drawn off through the distribution pipes. The amount of water from the invert of the lowest connection to the water line.

A5

To ensure that silt and dirt cannot be drawn into the distribution pipes. These connections are usually 50mm above the bottom.

A6

(i) No water touches any working or moving part.

(ii) It has a simple and convenient method of adjusting for the float.

(iii) It has a large inlet chamber which breaks the speed at which the water enters and so reduces wear and noise.

(iv) It has fewer working parts that the Portsmouth and Croydon valves.

A7

(i) Portsmouth (B.S.1212 Part 1)

(ii) Croydon

(iii) Equilibrium

(v) Garston

(vi) Torbeck

(vii) New Brass Diaphragm (B.S.1212 Part 2)

A8

High Pressure – Medium Pressure – Low Pressure

A9

To reduce the effects of water hammer. The float only has to lift the arm and therefore does not have to overcome the pressure of the water to enable the valve to close.

A10

When water evaporates from the wetted parts of a ball valve, leaving behind minute particles of rock-like lime which builds up over time. Furring only occurs in districts where the water has a high degree of temporary hardness.

Exercises

1. Draw labelled schematic representations of direct and indirect cold water systems to serve a sink, washbasin, bath, WC and storage cistern in a two storey domestic dwelling. State the advantages and disadvantages of the indirect system of cold water.
2. With the aid of a sketch, show the recommended position for a cold water storage cistern in a roof space and describe the method of insulation.
3. With the aid of a sketch, show the recommended positions for the connections to a domestic cold water storage cistern.
4. When the storage cistern in a direct system is filling, there is excessive noise in the pipework. Give one reason for this occurrence and how it could be rectified.
5. Calculate the capacity of a rectangular tank that is 750mm long, 600mm wide and 600mm high.
6. A cold water storage tank is 2 metres long, 1.5 metres wide and 1 metre high. Find the volume of water the tank will hold if filled completely.
7. Calculate the capacity of water contained in a tank that is 4 metres long, 3 metres wide and 1.75 metres high. The tank will hold water up to 500mm from the top level.
8. Calculate the nominal, actual and usable capacities of a storage cistern measuring 1.5m long X .75 m wide x .73 m high. The water level is 160 mm below the top of the tank. The cold feed connections are 65mm from the bottom of the tank.
9. Calculate the intensity of pressure exerted on the seating of a tap that is fixed 5 metres below the water level of the cistern.
10. A cold water cistern is fitted 4 metres above a 50mm diameter gate valve.

    Calculate:

    a) the intensity of pressure on the closed gate of the valve.

    b) the total pressure on the gate of the valve.
11. Calculate the total pressure acting on the base of a cold water cistern that measures 500mm by 500mm by 400mm.

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