Tolley's Domestic Gas Installation Practice

Gas Service Technology Volume 2

Fourth Edition

Edited by
Frank Saxon

Newnes

TOLLEY'S DOMESTIC GAS INSTALLATION PRACTICE

(Volume 2)

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Fourth edition

Edited by

Frank Saxon

Revised by

Route One Training and Development Limited

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Contents

Preface

In carrying out the second update of this title during 1994/95, its editors had encountered much change in the gas industry. During the research for this latest update, it soon became apparent that considerable development is still taking place. Besides changes in standards and Building Regulations, the Gas Safety (Installation and Use) Regulations have been amended and the Health and Safety Commission's Approved Code of Practice (ACOP) has been replaced with the Nationally Accredited Scheme for Individual Gas Fitting Operatives (ACS) in an attempt to standardise the assessment process across the country. Certification under this scheme must conform with European Standard EN 45013. All Certification bodies must operate to the satisfaction of the United Kingdom Accreditation Service (UKAS). The knowledge and experience required for success under the new ACS assessment system is much greater than that required under the old ACOP standard and this will increase the demand for training.

The editor feels that much, if not all, of the information needed by students studying for these qualifications and also by existing operatives, who are required to be assessment tested, will be found in this and the two other volumes of Gas Service Technology. In keeping with the publishers' determination to prevent the subject matter from becoming outdated, this latest revision has been carried out to reflect the important changes to gas installation work brought about by radical changes to two British Standards: BS 5440 Parts 1 and 2 (Flues and Ventilation for Gas Appliances) and BS 5546 (Installation of Gas Heated Hot Water Supplies). In addition, new soundness testing procedures for Liquefied Petroleum Gas (LPG) have been included.

The reader should continue to consult current legislation, standards and manufacturers' instructions, etc.

Wherever possible, reference has been made to statutory obligations, particularly where they relate to safety. The Gas Safety (Installation and Use) Regulations 1998 should be studied in conjunction with the manual to ensure compliance with their requirements.

The installation and servicing methods and procedures described in this volume are believed to be accepted good practice at the time of writing. However, the editor and contributing authors cannot accept responsibility for any problems arising from the use of this information.

I would like to thank all manufacturers of appliances and equipment who have provided photographs, technical drawings and information, and also Blackburn College for the use of their premises and resources.

Finally, I acknowledge Michael Webb, senior editor at Butterworths Tolley, and Chris Leggett of typesetters Letterpart, for all their constructive help in putting together this update.

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CHAPTER 1

Pipework Installation

Chapter 1 is based on an original draft by A. Davis and updated by Route One Ltd (2005)

Introduction

This chapter is concerned with the basic principles of jointing and bending pipes and with the identification of the fittings and fixings associated with their installation.

The pipes, jointing materials and fittings are all the subjects of British Standard Specifications which regulate their composition, size and construction. Reference is made throughout the manual to the requirements of these Standards.

There appears to be no satisfactory explanation why the words ‘pipe’ and ‘tube’ should be used for particular materials. Generally ‘pipe’ is applied to cast iron or steel, i.e. the ferrous metals, while ‘tube’ is used for brass and copper. Lead is always ‘pipe’, and anything flexible is ‘tubing’. British Standards seem to endorse these definitions although at some points they refer to ‘copper pipe’ and to ‘steel pipes and tubes’.

This confusion has resulted in the two words being used synonymously. However, once pipes or tubes have been installed, they immediately become ‘installation pipes’ or ‘pipework’.

Copper Tube

Tubes are produced by drawing, from de-oxidised, non-arsenical copper 99.9% pure. They are made in two grades, both of which are specified in BS EN 1057: 1996.

Table ‘X’

This tube is used for internal installations. It is supplied in half-hard condition in straight lengths of 6 m. Smaller cut lengths can be obtained if required.

Table 'Y'

This is a heavier gauge tube used for external or buried installations. It is supplied in an annealed condition and is available in coils of 10, 25 or 50 m lengths. Where liable to corrosion it should have a factory-bonded plastic sheath. In half-hard condition it is available in straight lengths up to 6 m.

Since 1971, both Table 'X' and Table 'Y' have been in metric sizes based on the *outside diameter* of the tube. They use fittings specified in BS 864: 1983, Part 2, which may be compression or capillary soldered.

The original specifications of Imperial sizes were BS 659: 1967 for the equivalent of Table 'X' tube and BS 1386: 1957 for the equivalent of Table 'Y'. The sizes were based on the *nominal bore* of the tube. Fittings were to BS 864: 1972, Part 1 (all now withdrawn).

Because of the differences between the outside diameter of metric and Imperial sized tubes, it has been necessary to use special adaptors when extending from an old imperial installation in metric tube. Table 1.1 shows the sizes and the adaptors required up to 54 mm.

TABLE 1.1 Sizes of Copper Tube (up to 54 mm (2 in.))

Imperial BS 659 *Nominal bore* (in.)	*Metric BS EN* 1057: 1996 *Outside diameter* (mm)	*Nominal wall thickness* (mm)		*Adaptors required*	
		Table 'X'	*Table 'Y'*	*Capillary joints*	*Compression joints*
1/8	6	0.6	0.8	YES	YES
3/16	8	0.6	0.8	YES	YES
1/4	8	0.6	0.8	YES	YES
–	10	0.6	0.8	NO IMPERIAL EQUIVALENT	
3/8	12	0.6	0.8	YES	NO
1/2	15	0.7	1.0	YES	NO
–	18	0.8	1.0	NON-PREFERRED SIZE	
3/4	22	0.9	1.2	YES	YES
1	28	0.9	1.2	YES	NO
1 1/4	35	1.2	1.5	YES	YES
1 1/2	42	1.2	1.5	YES	YES
2	54	1.2	2.0	YES	NO

Table 'Z' tube is used for waste or sanitation, but not for gas installations. It is a hard drawn, thin wall tube, not suitable for bending. The tube is available in sizes from 6 to 159 mm and the wall thickness ranges from 0.5 to 1.5 mm.

Steel Tube

Steel tube is manufactured to conform to BS 1387: 1985 (1990) and is technically equivalent to the standards issued by the International Organisation for Standardisation (ISO). The nominal size of tube is identified by the letters DN followed by a number. It is a round number loosely related to a metric dimension and it is used on all fittings and components in a piping system. Screw threads used on steel tubes are to BS 21: 1985. Pipe threads for tube fittings where pressure-tight joints are made on the threads (metric dimensions). It is technically equivalent to the ISO standards. The thread size designation is based on the old Imperial sizes, without using the word 'inch' or its abbreviation.

Steel tube is made in three thicknesses or weights, each indicated by a colour band around the tube, Table 1.2. For each nominal size (DN), the outside diameter is the same for all three weights, so the same pipe thread may be used, Table 1.3.

TABLE 1.2 Thickness Series (Weights) of Steel Tube

Weight	*Colour of band*	*Application*
Light	Brown	Not used for gas or water supplies
Medium	Blue	Used for internal gas installations and low pressure water supplies.
Heavy	Red	For gas service pipes, buried or external gas supplies and high pressure water supplies

TABLE 1.3 Dimensions of Steel Tubes (up to DN 50 (50 mm))

Nominal size (DN)	*Designation of thread (BS 21)*	*Approx. outside diameter* (mm)	*Medium weight*		*Heavy weight*	
			Thickness (mm)	*Mass* (kg/m)	*Thickness* (mm)	*Mass* (kg/m)
8	1/4	13.6	2.3	0.64	2.9	0.77
10	1/8	17.1	2.3	0.84	2.9	1.03
15	1/2	21.4	2.6	1.22	3.2	1.45
20	3/4	26.9	2.6	1.57	3.2	1.88
25	1	33.8	3.2	2.43	4.0	2.96
32	1 1/4	42.5	3.2	3.13	4.0	3.83
40	1 1/2	48.4	3.2	3.61	4.0	4.42
50	2	60.3	3.6	5.10	4.5	6.26

Steel tube is now very rarely used for domestic installations or service pipes, it has been replaced by other materials such as copper and polyethylene.

Because the metrication of steel tube has resulted in a change of name but not a change of diameter or thread, no adaptors are necessary when extending from existing supplies.

Plain steel pipe should be used only for gas supplies or closed water circuits, i.e. central heating. All other steel water supplies must be coated externally and internally in accordance with BS 534: 1990 (Water by-laws 51 and 52).

Lead Pipe

Although used extensively in the past for gas and water installations, lead pipe is now prohibited by the Gas Safety (Installation and Use) Regulations 1998 (Part B Section 5(2a)) and Water by-law 9 (see Vol. 1, Chapter 11).

Methods of extending existing lead pipe installations will be dealt with later in this chapter.

Brass Tube

In the past, brass tube, either chrome plated or oxidised, was used extensively in the industry for making the final connection to fires and water heaters. The most common sizes were 1/2 in. (12.7 mm) and 3/8 in. (9 mm) outside diameter. They were threaded with BS 21 1/4 and 1/8 threads, sometimes a non-standard thread of 26 T.P.I. (threads per inch) was used. Special miniature stocks and dies were used together with a rubber lined hand vice.

Brass tube has been superseded by copper tube which is much easier to manipulate and joint.

Stainless Steel Tube

This tube is manufactured to BS 4127: 1994 and is available in the dimensions shown in Table 1.4. It has the same outside diameter as BS 2871 Table 'X' copper tube and can be manipulated and jointed in the same way. However, BS 6891: 1998 recommends that it should only be jointed with type A (non-manipulative) compression fittings complying with BS 864: Part 2 and not by soldering.

TracPipe Corrugate Stainless Steel Tube

This is a semi-rigid corrugated stainless steel tube used as an alternative to copper and steel for gas installations, Fig. 1.1. Manufactured to BS 7838, it is available on long-length reels normally 75 m and in seven sizes (DN 12, DN 15, DN 22, DN 28, DN 32, DN 40 and DN 50).

TABLE 1.4 Dimensions of Light Gauge Stainless Steel Tubes

Size of tube (outside diameter) (mm)	*Nominal wall thickness* (mm)
6	0.6
8	0.6
10	0.6
12	0.6
15	0.6
18	0.7
22	0.7
28	0.8
35	1.0
42	1.1

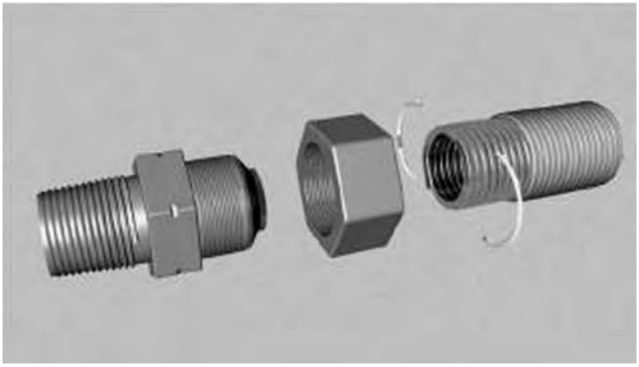

Fig. 1.1 TracPipe connection components

Plumber's merchants will normally supply TracPipe in shorter lengths if required. It is suitable for natural gas, butane or propane at working pressures up to 75 mbar. The pipe is very light and can be installed with a minimum number of joints. Specifications for installation can be found in BS 6891 1998.

Because of its flexibility, pipe supports need to be installed to the recommended distances. Maximum distance between supports for vertical pipe is 3 m for all sizes; horizontal distances are 1.2 m for 12 mm pipe, all other sizes 1.8 m.

The tube comes pre-protected by a polyethylene coating. Any exposed pipework and joints should be wrapped with self-bonding silicon tape which comes in two sizes, 25 mm wide or 50 mm wide. The use of bends or elbows is not required as the tube can be easily formed by hand, using the following guidelines.

Recommended Bend Radius for TracPipe

TracPipe size (mm)	*Recommended* (mm)	*Minimum* (mm)
12	76	15
15	76	20
22	76	25
28	125	76
32	125	76
40	125	76
50	150	102

Note: The bend radius should be measured at the inside of the bend.

The tube is terminated by male BSP taper fittings, which can be installed without the need for special tools. These fittings utilise a compression seal but the sealing rings are unique to TracPipe and cannot be used on normal copper tubing. All joints should be positioned in readily accessible positions.

The pipe must not be used to make the final connection to a moveable appliance such as a cooker or tumble dryer. If the pipe is used to make the final connection to a fixed appliance, then the length of unsupported pipework must not exceed 500 mm.

How to Assemble Fittings to TracPipe®

Cut-to-length Determine proper length. Cut through plastic cover and stainless pipe using a tube cutter with a sharp wheel. Cut must be centred between two corrugations, Fig. 1.2. Use full circular strokes in one direction and tighten roller pressure slightly quarter turn after each revolution. DO NOT OVERTIGHTEN ROLLER, which may flatten the pipe.

Using a sharp knife strip back the cover, strip back the plastic cover about 25 mm back from the cut end to allow assembly of fittings, Fig. 1.3. Caution: Knife blade and cut pipe ends are both sharp. Take care when cutting the cover and handling the pipe.

Install backnut Slide the backnut over the cut end; place the two split rings into the first corrugation next to the pipe cut, Fig 1.4. Slide the backnut forwards to trap the rings.

Fit AutoFlare® Fitting Place the AutoFlare® fitting into the backnut and engage threads. Note that the AutoFlare® fitting is designed to form a leak tight seat on the stainless piping as you tighten the fitting. (The piloting feature of the insert will not always enter the bore of

Fig. 1.2 Cut the TracPipe to length

Fig. 1.3 Strip back the cover

the piping before the tightening operation, but will centre the fitting when tightened.) Using appropriate wrenches, tighten the fitting until insert bottoms and the resistance to wrenching increases greatly. The flare has now been created on the piping end.

Fig. 1.4 Install backnut

Final torque Tighten nut and body as though you were making up a flared tubing joint, Fig. 1.5. Note the relation between hexagonal flats at this point and continue to tighten for two additional hexagonal flats (one-third turn) to obtain required torque and final leak-tight metal-to-metal seal.

Fig. 1.5 Complete final connection

Maximum torques for sealing are given in the table below:

Diameter	*Torque N/m*	*Ft/lbs*
12	65	48
15	68	50
22	73	54
28	122	90
32	284	210
40	365	270
50	447	330

Tape wrap (After Gas Tightness Test) Care must be taken after pressure test to ensure that no stainless steel pipe is visible.

Any portions of exposed stainless steel behind the fitting nut shall be wrapped with self-bonding silicone tape TracPipe P/N FGP-915-10H-12 (25 mm wide), or FGP-915-20H12PO (50 mm wide). This will reduce the possibility of later corrosive attack.

Bundy Tubing

This is a type of mild steel tubing marketed by Bundy (Telford) Ltd. It is used in the gas industry for gas supplies on appliances, e.g. the oven supply on a gas cooker. The tubing is also used for hydraulic brake lines, refrigeration and conveying oil.

Bundy tube is made from mild steel strip which has been copper plated on both sides. The strip is wrapped twice around itself, lengthwise, to form a double walled tube, Fig. 1.6(a). It is then heated in a reducing atmosphere to produce a brazed joint where the copper-covered surfaces are in contact around the whole circumference.

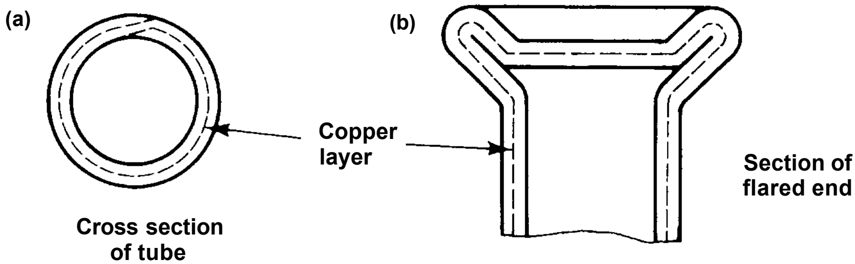

Fig. 1.6 Bundy tubing

The tubing is produced in 3 and 4.5 m lengths and is made with the following outside diameters: 3.18, 4.76, 6.35 and 7.94 mm. The wall thickness for all sizes is 0.71 mm.

It may be bent, coiled, flanged, or swaged and may be jointed by soldering, brazing or compression fittings. Figure 1.6(b) shows an end flared, by the manufacturer, to form a compression joint.

Because of its copper plating, the tube resists rusting and may be mistaken for copper tube. It can be tinned or electro-plated and the makers can supply special lengths bent to any desired shape and fitted with any desired connection.

Plastic Pipe

Polyethylene

Polyethylene (PE) pipes are used extensively for mains and services in the gas and water industries (see Vol. 1, Chapter 12). The following information is permanently and legibly marked along the wall of each length of PE pipe used for distributing natural gas:

(i) Identity of manufacturer
(ii) The letters PE
(iii) Identification of the base polymer (this can be in the form of a code, e.g. X)
(iv) Pipe diameter in millimetres
(v) The word METRIC or the letters MM
(vi) The standard dimension ratio preceded by the letters SDR This ratio is determined by the calculation

$$\frac{\text{Specified minimum outside diameter}}{\text{Minimum specified wall thickness}}$$

(vii) The letters BGC/PS/PL2 (if Phase 2 approval has been given by quality assurance)
(viii) Identification of the shift production line and date of manufacture
(ix) Coiled pipe only – a sequential number, increasing at 1 m intervals along the pipe between 000 and 999 or 0000 and 9999.

Examples of the outside diameters and wall thicknesses of some pipes used for gas distribution are given in Table 1.5.

In addition to their use for mains and services, PE pipes are now being used quite extensively in commercial and industrial situations, as installation pipes when they can be buried underground. PE pipes

TABLE 1.5 Outside Diameter and Wall thickness – PE pipes

			Wall thickness (mm)			
	Outside diameter (mm)		*SDR* 11		*SDR* 17.6	
Pipe size (mm)	*min*	*max*	*min*	*max*	*min*	*max*
25	25	25.3	2.3	2.6		
50	50	50.4	4.6	5.2	2.9	3.3
63	63	63.4	5.8	6.5	3.6	4.1
75	75	75.5	6.9	7.8	4.3	4.9

are adversely affected by sunlight and are only used below ground unless they are protected by a fibreglass cover or some other protective material.

Polyvinyl Chloride (PVC)

Ordinary PVC pipes are suitable only for use on cold water supplies. They become soft at high temperatures and brittle at very low temperatures. Because of their high coefficient of expansion (6 times that of steel pipe) provision for expansion must be made on long pipe runs.

Unplasticised PVC pipe, conforming to BS 3505: 1986 Unplasticised polyvinyl chloride (PVC-U) pressure pipes for cold potable water, is a thin-walled rigid pipe used for water supplies. It is supplied in nominal sizes from 3/8 to 24 (17–610 mm outside diameter) and in 6 or 9 m lengths. The pipes are classified for maximum sustained working pressure as follows:

(a) 9 bar (class C)
(b) 12 bar (class D)
(c) 15 bar (class E).

Table 1.6 gives details of small sizes of class E pipes.

Impact modified or mPVC was used for gas distribution pipes and fittings, it was not suitable for internal gas installations.

TABLE 1.6 Pipe Dimensions for PVC-U 15 bar (Class E) Pipes

Nominal size (mm)	*Mean outside diameter* (mm)	*Mean wall thickness* (mm)
3/8	17.15	1.7
1/2	21.35	1.9
3/4	26.75	2.2
1	33.55	2.5

Other Plastic Pipes

Thermoplastic pipes and fittings are available for use in domestic hot and cold water services and heating systems. The specification for the installation of these pipes and fittings is found in BS 5955: Part 8: 1995. Plastic pipework (thermoplastic materials) specification for the installation of thermoplastic pipes and fittings for use in domestic hot and cold water services and heating systems.

BS 7291 Thermoplastic pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings is in four parts. Part 1: 1990 (1995) gives general requirements. Part 2: 1990 (1995) gives the specification for polybutylene (PB) pipes and associated fittings. Part 3: 1990 the specification for crosslinked polyethylene (PE-X) pipes and fittings and Part 4: 1990 (1995) Specification for chlorinated polyvinyl chloride (PVC-C) pipes and fittings and solvent cement.

Flexible hoses, for appliances that need to be pulled out for cleaning purposes (cookers, clothes driers, etc.) and burning first or second family gases, are made to BS 669: Part 1: 1989. These can be made from butyl, nylon or other plastics which do not absorb hydrocarbons. They can be all plastic or supported by a flexible metal tube or helical metal coil or wire.

Armoured flexible tube is used on commercial and industrial equipment and is covered in Vol. 3.

Flexible hoses for appliances burning third family gases are manufactured to BS 3212 and are made from neoprene. BS EN 549: 1995 covers the specification for rubber type materials for use with first, second and third family gas flexible hoses.

Polythene Pipe

This is a thick-walled pliable pipe which was used only for above ground water services, it was manufactured to BS 1972: 1967.

The standard has now been withdrawn and partially replaced by BS 6572: 1985 Blue polyethylene pipes up to nominal size 63 for below ground use for potable water, and BS 6730: 1986 Black polyethylene pipes up to nominal size 63 for above ground use for potable water.

Black polyethylene pipe is not used below ground, to avoid confusion with buried power cables with black plastic sheathing.

Colour Coding of Plastic Pipes

Distribution pipes for carrying natural gas underground are coloured yellow. Distribution pipes, up to 75 mm external diameter, for carrying potable water underground are coloured blue.

Jointing

Joints between sections of pipe and pipe fittings or appliances must be:

- mechanically strong
- completely gas or water tight
- free from internal obstruction to flow of fluid
- neat and unobtrusive.

There are a number of different forms of joints which may be categorised as follows:

1. Joints which may be easily disconnected and reconnected:
   - screwed joints
   - flanged joints
   - compression joints and unions
   - plug-in connections.
2. Joints which can be disconnected and remade:
   - capillary soldered joints
   - blown joints.
3. Joints which cannot be disconnected and remade:
   - welded joints
   - brazed joints
   - chemical solvent joints.

Joints in this third category are seldom used on internal domestic gas installation pipes.

Screwed Joints

The pipe thread in use for tubes and fittings where pressure-tight joints are made on the threads is the British Standard pipe thread to BS 21: 1985, which is based on ISO 7/1 1982 specification. This thread is a ‘Whitworth’ thread form with an included angle of 55°, Fig. 1.7. The BS Whitworth thread is used in engineering on nuts and bolts and is named after Sir Joseph Whitworth who designed it as a standard thread form for British engineers.

BS 21 pipe threads are indicated by the letter ‘R’. Threads may be internal or external and either parallel or taper. A parallel thread has the same gauge diameter all along the thread. The taper thread has a taper of 1 in 16, i.e. the diameter decreases by 1 mm in 16 mm length.

The type of thread is indicated by subscript letters:

c = internal taper
p = internal parallel
L = external parallel, longscrew.

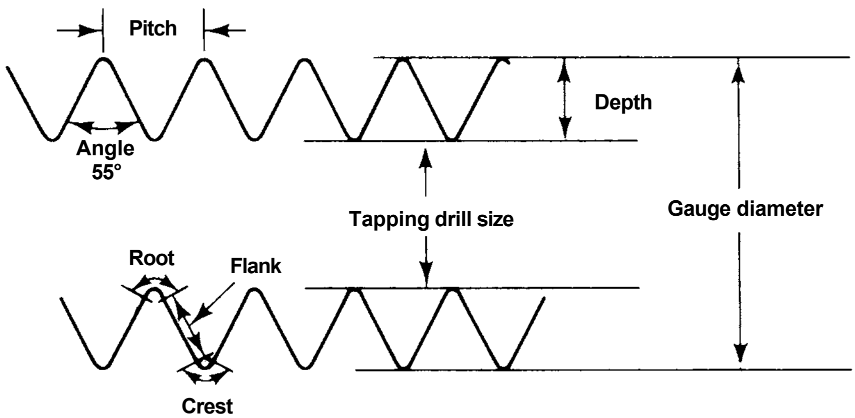

Fig. 1.7 Terms associated with threads

The letter 'R' without a subscript indicates an external taper thread. For example, the threads for 15 mm (1/2 in.) pipe are:

R1/2 = external taper
R_c1/2 = internal taper
R_L1/2 = external parallel, longscrew
R_p1/2 = internal parallel.

The terms associated with screw threads are given in Fig. 1.7.

After the threads have been screwed up hand tight, a wrenching or tightening allowance of about 1 1/2 turns is provided for and damage to the fittings will occur if this is exceeded.

In order to judge the correct length of pipe to cut off, so that it will fit between two fittings, it is necessary to know how much thread will be screwed into the fittings. Table 1.7 gives details of the overall lengths of threads and their pitch, which is the distance the pipe enters the fittings for each complete turn.

For practical purposes, the pitch of pipe threads are approximately:

R1/8 = 1.0 mm
R1/4 and R3/8 = 1.5 mm
R1/2 and R3/4 = 2.0 mm
R1 and over = 2.5 mm.

Pipe fittings, screwed to BS 21, have R_c (internal taper) threads. The couplers or sockets supplied on the pipe are normally screwed with R_p (internal parallel) threads. The steel pipe itself is supplied with R (external taper) threads.

TABLE 1.7 Sizes and Lengths of Pipe Threads

Nominal bore (mm)	*Thread size* (in.)	*Pitch* (mm)	*Approximate length of thread* (mm) *Screwed into fitting*	*Total length cut*
6	1/8	0.907	5	9
8	1/4	1.337	7	11
10	3/8	1.337	9	13
15	1/2	1.814	11	16
20	3/4	1.814	14	19
25	1	2.309	17	22
32	1 1/4	2.309	20	25
40	1 1/2	2.309	20	25
50	2	2.309	23	29

An R pipe thread screwed into a R_c fitting thread makes a perfect joint, Fig. 1.8. All the threads should engage fully.

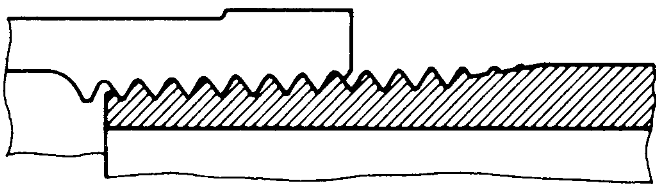

Fig. 1.8 Section through taper-to-taper screwed joint

An R pipe thread screwed into a R_p fitting can also make an acceptable joint, Fig. 1.9. About half the threads are fully engaged but there is a risk of overtightening which would distort the fitting.

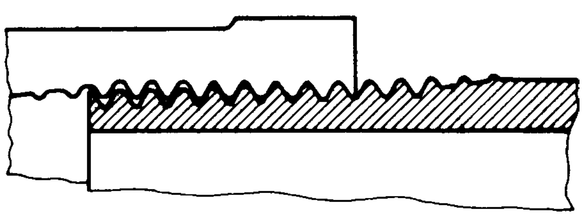

Fig. 1.9 Section through taper-to-parallel screwed joint

An R_L (external longscrew parallel) thread and an R_c fitting (internal taper) cannot make a satisfactory joint. A correctly sized male thread may not even enter the fitting. If it does, because of manufacturing tolerances, only one thread at most will engage.

An R_L pipe thread screwed into an R_p coupler thread can make an acceptable joint with the aid of a backnut, Fig. 1.10. This shows a longscrew with a coupler and a backnut.

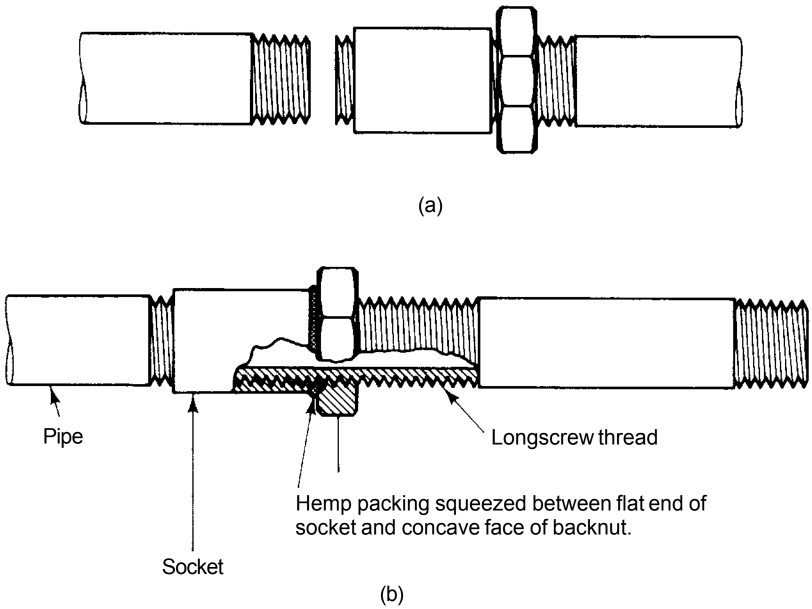

Fig. 1.10 Longscrew with coupler and backnut: (a) joint ready for connection; (b) joint made

The longscrew is used to connect pipe runs together. It consists of a short length of steel pipe with a taper thread at one end and a long parallel thread at the other. An R_c coupler and a backnut are screwed on to the R_L thread. To make the joint, the coupler is run off the parallel thread and on to the pipe thread. Because there is no seal between the coupler and the longscrew threads a soft hemp washer or 'grummet' is covered with jointing compound and compressed between the coupler and the backnut. These joints are only suitable for low pressure supplies.

Pipe threads where pressure-tight joints are not made on the threads should comply with BS 2779: 1986. They are also of Whitworth form and the BS follows the ISO 228/1 and 228/2 recommendations. These threads are parallel fastening threads in thread size designations $^1/_{16}$ to 6.

The threads are used for fastening purposes, e.g. the mechanical assembly of the component parts of cocks, valves and fittings. They are not suitable for pressure-tight seals. The difference between BS 21 and BS 2779 threads is in the tolerances permitted in manufacture. The BS 2779 threads are made with two classes of tolerance on the external threads. These are:

- class A – corresponding to a 'medium' tight fit
- class B – corresponding to a 'free' fit.

For internal threads, Class A tolerance is used.

The threads are designated by the letter 'G', followed by the nominal size and, for external threads, the letter A or B denoting the class of fit.

For example, the threads for thread size designation ½ would be:

- G½ = internal
- G½ A = external, class A
- G½ B = external, class B.

Threads may also be 'truncated', i.e. with the crests cut off square. Truncated threads are indicated by the abbreviation T following the designation. For example:

- G½ T
- G½ A T.

Screwing Pipe

Dies used for cutting threads on domestic installation pipes up to R 1 are usually solid block dies, held in ratchet stocks. Above this size the dies may be solid or adjustable up to R2 and above R2 only adjustable are suitable.

Before beginning to thread the pipe it is essential to ensure that

- the pipe end has been cut square, i.e. at right angles to the pipe
- there are no burrs or obstructions, inside or outside
- there is sufficient straight pipe behind the pipe end to accommodate the stocks and dies when the thread is fully made
- the die block is clean, in good condition and fitted in the stock the right way round
- the guide is a reasonable fit on the pipe. If this is too slack it will be difficult to ensure that the thread is cut parallel with the pipe, particularly with single-handed stocks
- the pipe is fixed securely in a vice or held by a suitable wrench
- a supply of the appropriate lubricant is available.

When cutting tapered threads the die block should be screwed on until the face of the die is flushed with the end of the pipe. On larger sizes of pipe, the thread so formed will be shorter than that cut on the pipe by the manufacturer. To continue cutting would, however, only produce parallel threads which would not engage with the fitting and could very well prevent the taper threads from engaging.

The dies should not be reversed in order to produce a parallel thread.

Jointing Materials

Jointing compounds, for first, second and third family gases, should conform to BS EN 751–1: 1997. They have the double purpose of acting as a lubricant and sealing up the helical path which occurs between the roots and crests of the mating threads. Only the external thread should be coated with the compound. If remaking a disconnected joint both internal and external threads should be cleaned before recoating and connecting.

Unsintered Polytetrafluoroethylene (PTFE) tape can be used for sealing pipe threads to BS 21, used in pipework systems carrying second family gases. British Standard BS EN 751–3: 1997 deals with the use of this tape, and the standard laid down in British Gas publication IM/16 should be followed.

Although tape manufactured to BS EN 7786: 1995 is not recommended for use on threads complying to BS 21 for use with first and second family gases, it is acceptable for use with third family gases.

The pipe thread should have a single wrap with a 50% overlap, Fig. 1.11.

Polytetrafluoroethylene is also manufactured as a paste and is supplied in tubes.

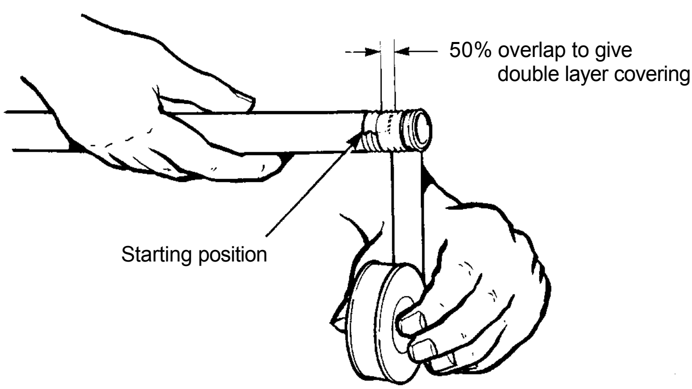

Fig. 1.11 Applying PTFE tape to a pipe thread

When making screwed joints on water supplies, hemp and an approved jointing compound (not containing linseed oil) can be used. Some water authorities deprecate the use of hemp. It may not be necessary on good machine-cut threads to use jointing compound, particularly on brass fittings. A few strands of hemp may be wound round the roots of the thread in a clockwise direction, if water begins to percolate through the joint the hemp swells up and seals the cavity. If excessive amounts are applied it may be either forced out of the joint or the fittings may be distorted.

Union Joints

'Unions' are a form of compression joint. There are a number of different types and they may be used for jointing different kinds of pipe. Essentially they consist of three parts, Fig 1.12.

These are:

1. the lining, A
2. the boss, B
3. the cap or nut, C.

The joint between the lining and the boss may be:

- tapered or conical
- flat
- spherical.

The tapered joint is usually ground-in to give a perfect seal when the cap forces the lining and the boss together, Fig. 1.12(a).

The flat seating is sealed with a washer, usually of neoprene or a similar material, Fig. 1.12(b).

The spherical surfaces allow for connecting pipes which are not in the same plane, Fig. 1.12(c).

Unions used on steel pipe are made from malleable iron (m.i.) or brass.

Flexible Couplings

These are pipe couplings in which the joints are formed by rubber rings, compressed on to the surface of the pipes, Fig. 1.13. They allow the pipes partial freedom of movement. They should be fitted with metal continuity rings to ensure that no part of the installation is electrically isolated.

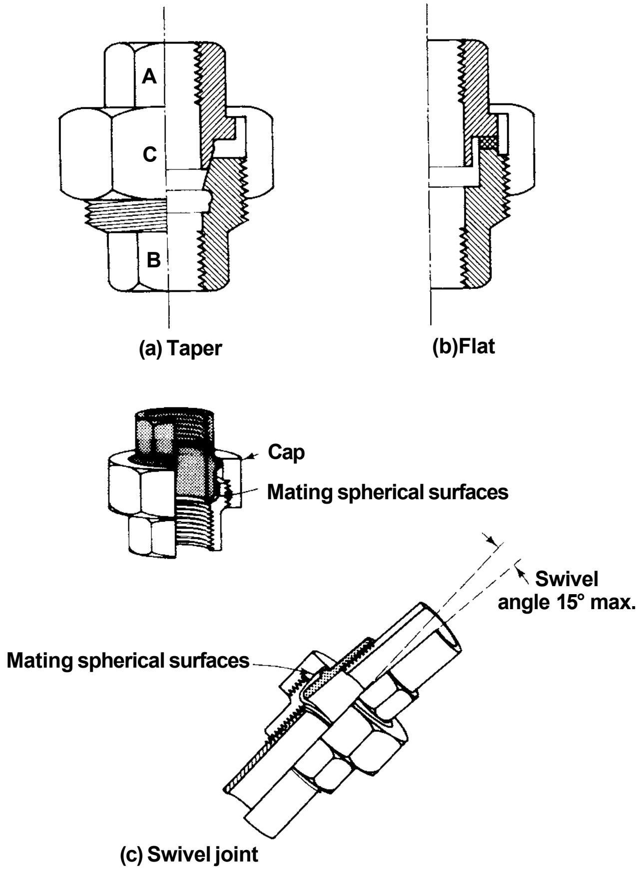

Fig. 1.12 Union joints: (a) taper, ground-in joint; (b) flat joint with washer; (c) spherical joint (swivel joint)

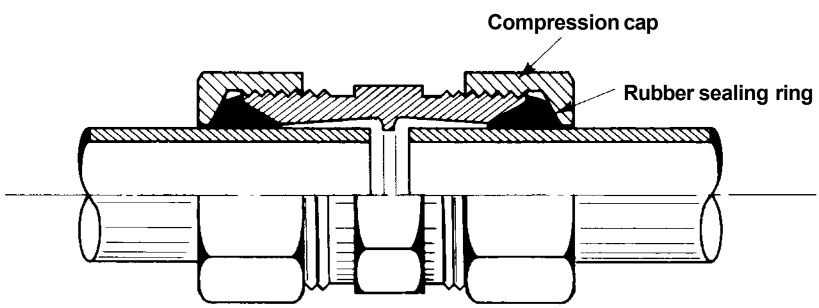

Fig. 1.13 Flexible coupling

Flanged Joints

Flanged joints on steel pipe are hardly ever used on domestic installations and seldom used on gas installations below 50 mm. They will be dealt with in Vol. 3, Chapter 1. There are, however, a number of flanged joints on appliances and control devices where the joint consists of two flat surfaces with a washer compressed between them. The mating surfaces are held together by screws or nuts and bolts. An example is shown in Fig. 1.14(a).

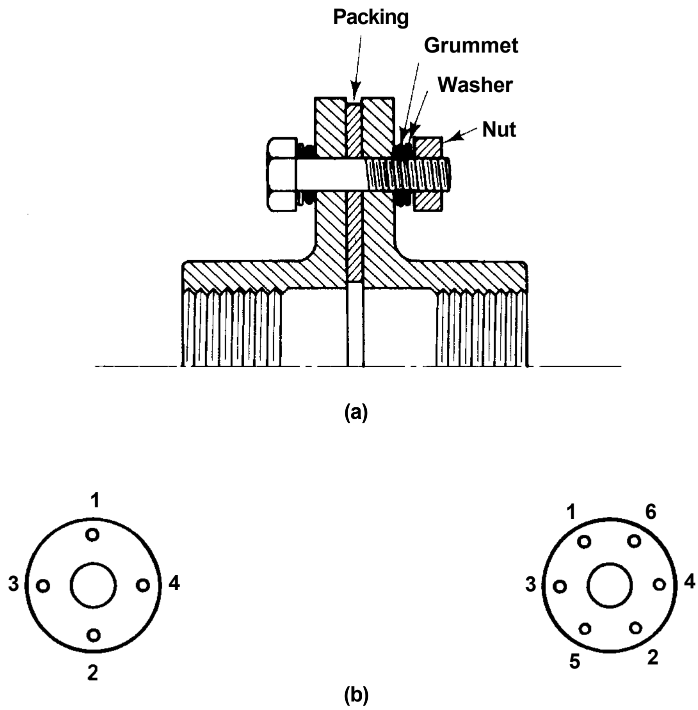

Fig. 1.14 Flanged joint: (a) section through joint; (b) sequence of tightening bolts

The sealing washers are usually made from rubber for water joints and materials such as cork or brass for gas.

Flanges must be tightened down evenly to avoid strain. The screws or bolts should be tightened a little at a time and in sequence diagonally across the flange, Fig. 1.14(b).

Figure 1.15 shows another application of a flanged joint.

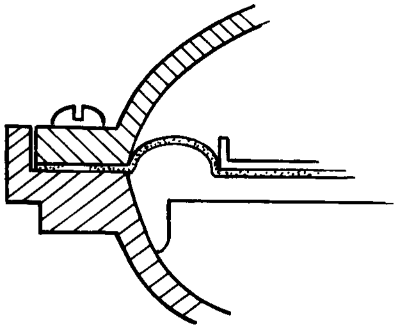

Fig. 1.15 Flanged joint used in construction of a governor

Plug-in Connectors

These devices allow an appliance to be quickly and easily connected to an internal installation. Fig. 1.16 shows an example of a plug-in connector, with a 12 mm flexible tube and a smaller diameter tube which will connect to the same plug-in connector. Flexible tubes are supplied in 12 and 15 mm sizes for domestic cookers and in smaller sizes for lower gas rated appliances. All sizes of flexible tube will fit the standard plug-in connector. Flexible tubes for use with natural gas are manufactured from butyl. Flexible tubes carrying low pressure LPG mixtures are manufactured from neoprene.

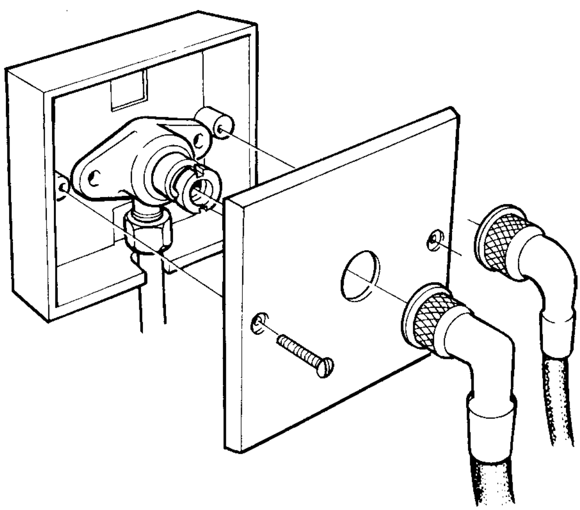

Fig. 1.16 Plug-in connector (BF & S Ltd)

Figure 1.17 shows a cooker fitted to a plug-in connector. It should be noted that the flexible tubing must not be subjected to a continuous strain such as acute bending, tension or compression. Plug-in connectors will be dealt with further in Chapter 3.

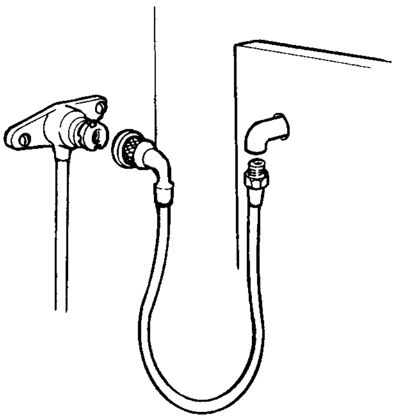

Fig. 1.17 Method of installing flexible tube to a cooker

Soft Soldered Joints

Solder has been described in Vol. 1, Chapter 12. Soldering can only be carried out effectively if the metal surfaces are properly prepared, suitably fluxed, heated to the correct temperature and joined by an appropriate solder. The essential points to be noted are:

1. *Surfaces*
All metals acquire a coating of oxide when exposed to the atmosphere. This must be cleaned off by scraping, filing or rubbing with clean steel wool. The finished surface must be bright, dry and free from grease. Do not touch the surface after you have cleaned it.

2. *Flux*
Immediately after the surfaces have been cleaned they should be coated with the appropriate flux. This stops the metal from becoming oxidised again.

3. *Heat*
Apply heat from the blowlamp or torch evenly around the joint. If solder has to be applied, heat the joint rather than the solder.

4. *Solder*
Select the correct grade of solder for the particular joint. Where joints have exposed clean surfaces, rub the solder over the surface so that, as it melts, it forms a coating on the metal. This is called 'tinning' the metal. When all the surface is tinned, more solder may be added to complete the joint.

5. *Final Cleaning*
The completed joint should be wiped, while still warm, to remove any traces of surplus flux. Some fluxes are acidic and will corrode the pipe if allowed to remain.

Blown Joints

'Blown' joints are so called because they were originally made using a methylated spirit lamp and blowing air through the flame from a tube with a small nozzle. This produced a small aerated flame, the fierceness of which could be regulated by varying the strength of the blown air. The lamp was known as a 'mouth lamp'. It was superseded by the propane torch.

The blown joint was used to joint gas-weight lead pipe and to connect lead pipe to meter and connecting unions or to copper or brass pipes. Although lead pipes can no longer be used for gas installations – Regulation 5(2)(a), The Gas Safety (Installation and Use) Regulations 1998 – it might still be necessary to carry out some emergency repair or connect a copper supply to an existing lead installation pipe. Figures 1.18 and 1.19 show a 22 mm copper pipe connected to a 20 mm lead gas pipe. Fig. 1.20 shows copper pipe branched into an existing lead gas pipe.

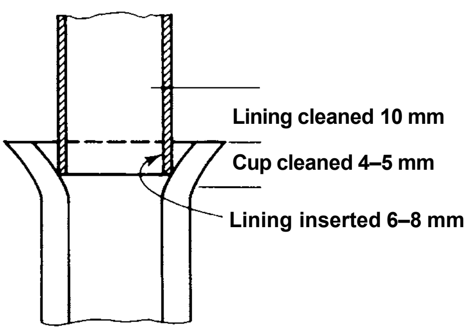

Fig. 1.18 Blown joint, preparation

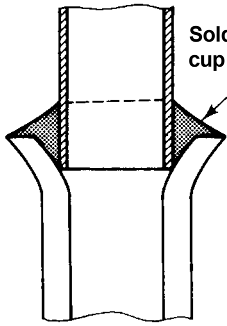

Fig. 1.19 Blown joint, completed

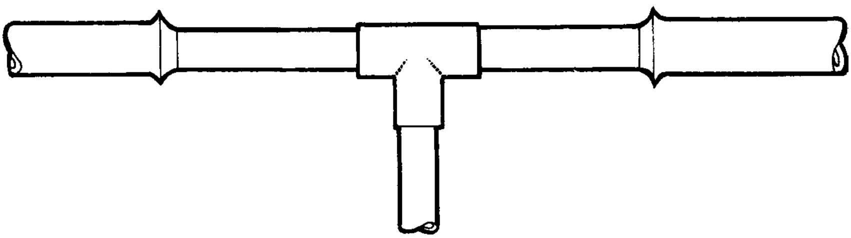

Fig. 1.20 Method of branching a copper pipe into an existing lead gas pipe

The procedure is as follows:

- square the end of the lead pipe with a rasp and drive in a turn pin to make a cup for the lining or other piece of copper pipe
- clean the top edge and the inside of the cup, with a knife, to a depth not greater than the bottom of the lining or copper pipe
- clean the bottom of the lining or the copper pipe to a height of approximately 10–15 mm above the top of the cup using either a file for the lining, or steel wool for the copper pipe
- coat both parts with flux and assemble for soldering
- apply heat to the joint using a small nozzle on the torch and directing the flame at the brass lining or copper pipe. Continue until the solder will just melt when held against the lining or copper pipe
- keeping the solder just clear of the flame, tin the lining or copper pipe and then the edge of the cup
- melt the surplus solder on the lining or copper pipe so that it runs into the cup and add any more necessary to make the joint
- wipe off any surplus flux after the solder has set while the pipe is still hot
- take care to cool the joint before handling.

The traditional method of jointing or branching into water-weight lead pipes was by the plumbers' wiped joint. The prohibition of lead from potable water supplies – by-law 9, Water Supply by-laws – has meant that the wiped joint is no longer used. As with gas-weight lead it might be necessary to repair or branch into an existing water-weight lead supply pipe. Mechanical couplings have been developed, Fig. 1.21, that can be used to introduce an acceptable copper or plastic pipe into the installations.

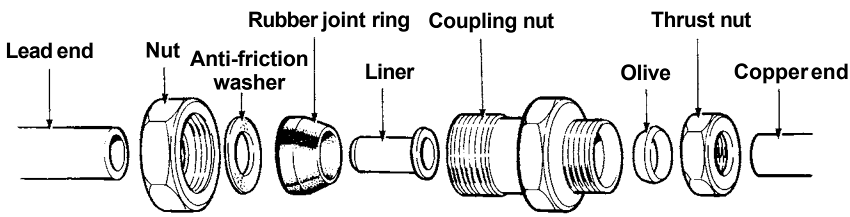

Fig. 1.21 Method of joining a copper or PE pipe to an existing water-weight lead pipe

Capillary Soldered Joints

The capillary soldered joint is used to connect light gauge copper tubes to BS EN 1057: 1996. The joints themselves are specified in BS 864: 1983, Part 2.

A short length of the tube is inserted into the fitting leaving a gap between the outside of the tube and the inside of the fitting between 0.02 and 0.2 mm. Molten solder is drawn into this space by capillary attraction (Vol. 1, Chapter 5).

There are two types of capillary fitting:

- end feed – solder is applied to the mouth of the fitting, Fig. 1.22
- solder ring – the correct amount of solder is contained in an annular ring inside the fitting Fig. 1.23.

Grades A and K solders are recommended for these joints in gas installations, grades B and F are sometimes used but they require the joints to be heated up by about an extra 20°C. A lead-free solder must be used for joints on potable water supply pipes (Vol. 1, Chapter 12).

The flux should be of a type recommended by the manufacturers of the fittings.

Procedure for making the joint is as follows:

- file the end of the tube square and remove any internal or external burrs. Do not file the surface of the tube

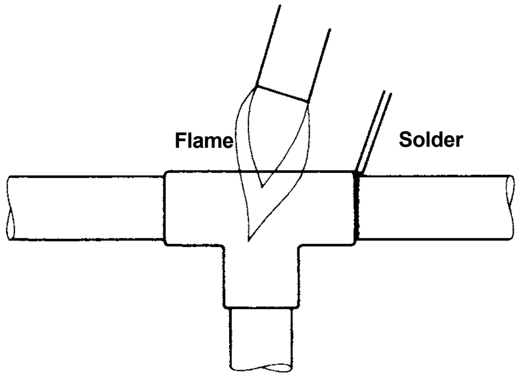

Fig. 1.22 End feed (capillary soldered)

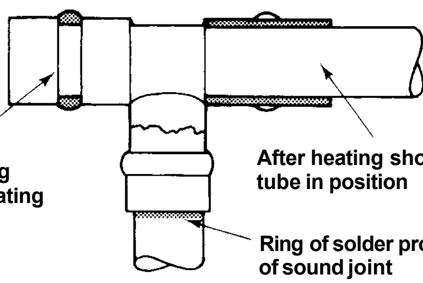

Fig. 1.23 Solder ring (capillary soldered)

- clean the inside of the fitting and about 20 mm of the tube with steel wool or special wire brushes. Do not use emery cloth or sand paper, it leaves a deposit on the surface
- flux both surfaces lightly
- assemble the joint. It may be made in any plane but the tube must fit in squarely and be fully inserted into the fitting
- protect any adjacent surface with a fireproof mat
- heat the fitting evenly, applying solder in the case of an end feed type, until a complete ring of solder is seen at the mouth of the fitting. Do not add more solder to a solder ring type
- wipe off any surplus solder or flux.

Capillary soldered joints may be disconnected by re-heating and may be re-made with added solder. However, excessive heating can cause the solder to alloy with copper and if both fitting and tube are of copper, it will be very difficult to disconnect them. For this reason it is advisable to use the lower melting point solders, A and K.

Copper tube may be jointed by means of a socket formed on the pipe itself. This is done by means of a socket-forming tool (Vol. 1, Chapter 13), which is a steel drift driven into the end of the pipe. The socket so formed is prepared and soldered in the same way as an end-feed fitting.

Compression Joints

Compression fittings conform to BS 864: Part 2, 1983, for light gauge copper and stainless steel pipe and Part 5, 1990 for plastic tubes. They are of two types:

- type A, non-manipulative, Fig. 1.24
- type B, manipulative, Fig. 1.25.

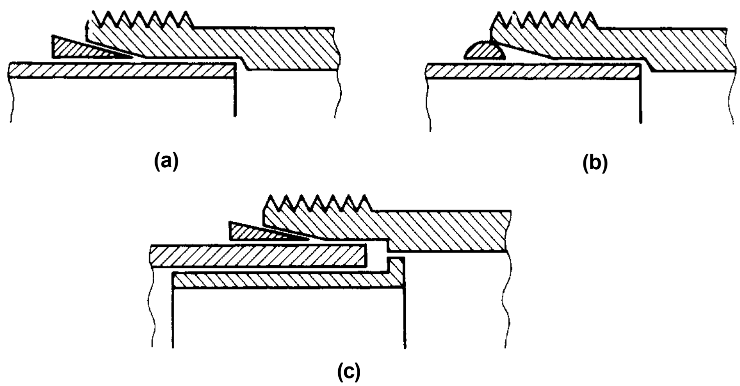

Fig. 1.24 Type A, non-manipulative compression joint

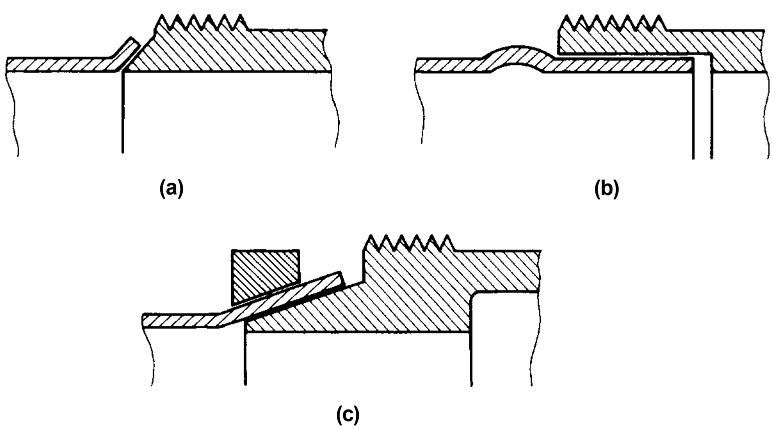

Fig. 1.25 Type B, manipulative compression joint

Type A

On these joints a compression ring usually made of metal and called an 'olive' is slipped over the pipe and then compressed on to it by tightening the cap on to the boss. The force of the compression distorts the olive and also the pipe when a metal olive is used, so forming a sound joint.

These fittings should generally be used on annealed tubes.

Type B

Type B fittings require the tube to be 'manipulated', i.e. bent, usually by opening out the end, Fig. 1.25(a) and (c). The bent section of tube is gripped between the cap and the boss of the fitting.

These fittings should not be used on tubes above 28 mm size.

Making compression joints

The end of the pipe must be clean and not scratched or distorted. It must be squarely cut and all burrs should be removed. The cap should be tightened sufficiently to form a sound joint, but not over-tightened and the pipework should not be strained when the joint is made.

Some people prefer to smear the joint lightly with jointing compound before assembling it. This is not necessary but it does, perhaps, act as a lubricant between the surfaces as the joint is tightened.

Plastic Tube Joints

Plastic tubes may be jointed by:

- compression fittings, Fig. 1.24(c), Fig. 1.25(c)
- solvents, for PVC tubes
- welding or fusion, for PE pipes, using specially designed electric heaters or some other heating medium.

Pipe Bending

The direction of a pipe run can usually be changed by using a fitting, e.g. a 'bend' or 'elbow' (see section on Pipe Fittings). In this way, corners may be turned and obstacles avoided. However, there are some times when fittings, which generally change the pipe direction by 90° (occasionally by 45%), do not provide the angle required and the pipe must be bent.

Pipe bending, or 'setting', as it is commonly called, has a number of advantages to offer over the use of fittings. These are:

- less resistance to the flow of gas or water
- neater

- less costly, generally, in both labour and materials
- fewer joints and potential sources of leakage
- irregular contours may be followed.

One point which must be borne in mind is that, if too many sets are used instead of fittings, it may be very difficult to remove or disconnect the pipework on a subsequent occasion.

Various types of bends or sets are shown in Fig. 1.26.

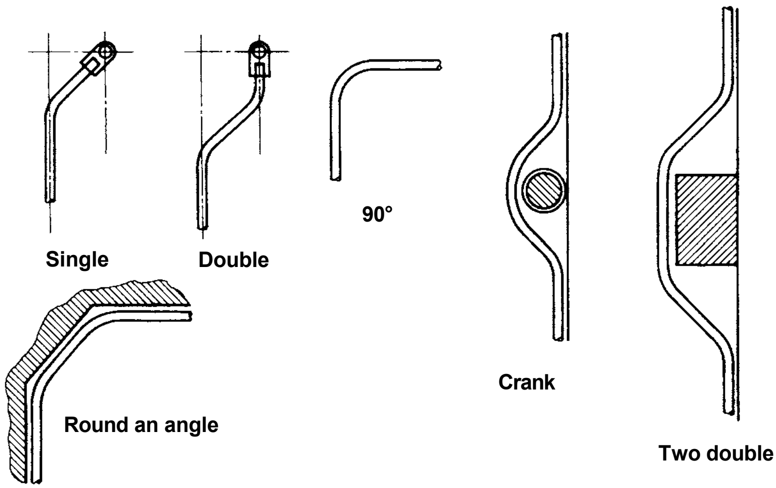

Fig. 1.26 Pipe sets and bends

Single and double sets are those most frequently required. For example, when setting out from a wall on to an appliance connection, when setting over a skirting board or when lining up a pipe run with an appliance.

The 90° bend is not so frequently used, perhaps because it needs a bit more skill than fitting an elbow!

Crank sets may be used to cross over circular obstacles and rectangular ones require two double sets. A succession of single sets may be needed round a bay or a corner fireplace.

Manual Pipe Bending

The objective of pipe bending is to produce a bend with an even radius which follows the contours of the wall or obstruction accurately and as closely as is practicable. The bend should be neither squashed nor kinked.

Both light gauge copper and steel pipe up to 22 and 20 mm sizes respectively can be bent manually quite successfully, indeed most of the bends required on the district are produced in this way.

Medium and heavy weight steel pipe may be bent by means of a bending eye, Fig. 1.27(a), and without any loading to support the wall of the pipe.

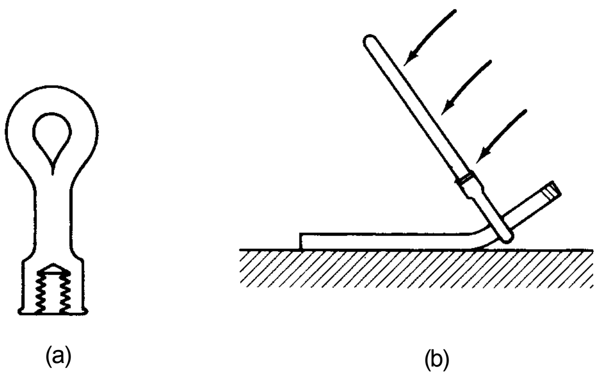

Fig. 1.27 (a) Bending eye; (b) bending method

Copper tube needs to be supported by bending springs but, being thinner and softer, may be bent round the knee, using suitable protection. Bending springs generally fit inside the pipe, but the very small sizes need external springs (Vol. 1, Chapter 13).

Whilst small, neat bends are ideal it is advisable not to attempt to bend to too small a radius. On steel pipe this is likely to lead to kinks and on copper pipe it may result in a bend which is difficult to adjust to the final dimensions and difficulty in removing the spring.

As a rough guide manual bends should be made to an inside radius of five times the outside diameter of the pipe. This is, e.g. 110 mm for 15 mm steel which has an outside diameter of 21.6 mm and 75 mm for 15 mm copper tube. Since measurements are more easily taken from the beginning of a bend, it is necessary to work from the length of pipe to be bent, rather than the radius itself.

For a bending radius of 5 × outside diameter (OD) the lengths of pipe to be bent are:

- 90° bend, length = 8 × OD
- 45° bend, length = 4 × OD
- 30° bend, length = 3 × OD (actually 2.6, so round off the answer downwards).

For example, on 15 mm copper tube, which is a very commonly used size, the bending lengths are:

- 90° bend, length = 120 mm
- 45° bend, length = 60 mm
- 30° bend, length = 40 mm.

Marking out pipe for bending can be done in a variety of ways. One of the best methods is to make a drawing or a 'template' of the bend required. This is easily done in a workshop but seldom possible in customers' premises. So you need to be able to work without a drawing.

Actually, it is very simple. A folding 600 mm rule can be opened to the angle of set required. And any flat surface, like a wall or floor, can act as a straight-edge or base line from which measurements can be taken. (But do not put dirty pipe against the best wallpaper!) Alternatively, another length of straight pipe can be used when measuring the depth of a set.

Methods of marking out some simple sets to accurate dimensions are given below.

90° Bends

Measure the distance into the corner, subtract the outside diameter of the pipe and make a mark, Fig. 1.28.

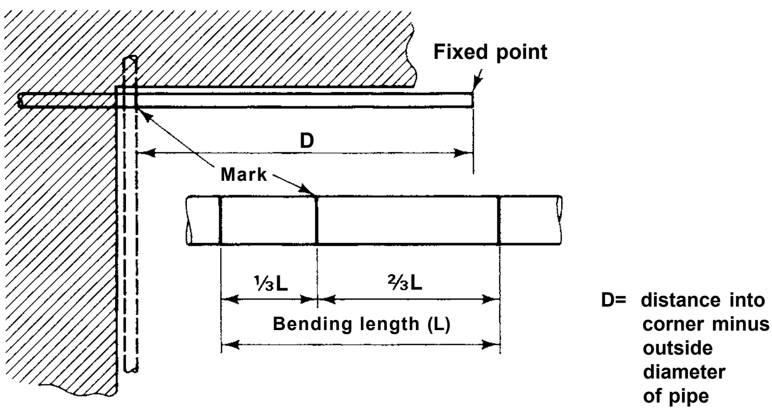

Fig. 1.28 Marking out 90° bend

Measure the bending length from this mark, 1/3 forwards, 2/3 backwards and mark this on the pipe. For example, 15 mm copper tube will be 40 mm forwards, 80 mm backwards, 120 mm total bending length.

Bend the tube exactly within these marks to an even radius and the bend will fit accurately in the corner.

Single Sets

For single sets measure from the fixed point to the start of the bend. Add on the bending length and bend the tube between the marks, to the angle required, Fig. 1.29.

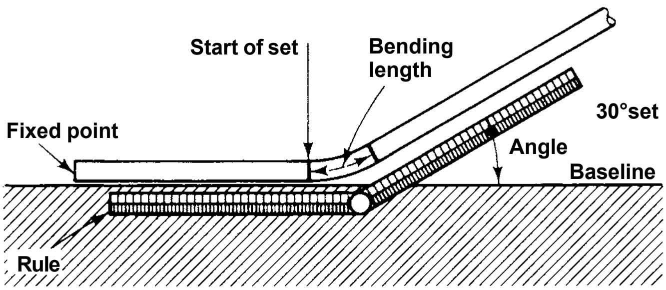

Fig. 1.29 Marking out single sets

Double Sets

First, make a single set.

Hold the pipe against a flat surface or baseline and measure the depth of set required by a rule held at 90° to the baseline.

The mark on the pipe, from the edge of the rule, is the centre of the bend.

Measure half the bending length on each side of the centre mark. For example, 15 mm copper tube is marked 20 mm on each side of the centre line, for a 30° set as shown.

Bend between the marks until both bends are parallel, Fig. 1.30.

Bending Copper Tube

All manual bending calls for some measure of physical strength and this varies with individuals. Generally 6 and 8 mm tubes can be bent in the two hands, with the thumbs supporting the inside of the bend. 12 and 15 mm can be bent round the knee. To prevent injury, a leather knee-pad or a pad made of folded rag should be used. The ability to bend tubes of above 15 mm diameter will depend on personal strength.

Some people find it possible to bend 22 mm on the knee, others may find it necessary to anneal the tube first or bend it through a hole in a wood batten.

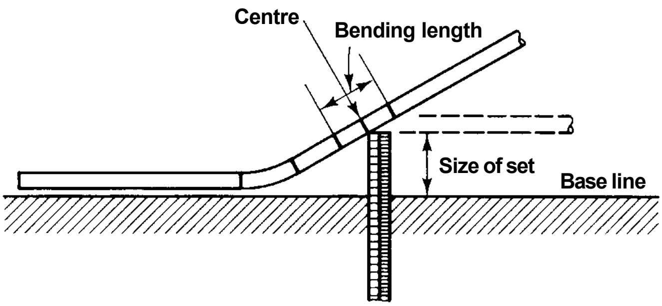

Fig. 1.30 Marking out double sets

The procedure for bending is as follows:

- mark out the bend
- insert the spring so that it is located in the position of the bend required
- slightly over-bend the tube and then ease back to the desired dimensions, in order to free the spring
- pull the spring out, if necessary, by inserting a tommy bar or stout screwdriver blade through the eyelet and turning it to contract the spring while pulling at the same time.

It is possible to make bends in tubes at a considerable distance from the ends. To do this, the spring must have a length of strong cord or wire attached through the eye so that it may be pulled out. Great care must be taken to avoid kinking the tube between the spring and the end or pinching the spring in the bend.

If this does occur, it will necessitate cutting the tube to get the spring out and may damage the spring as well.

Bending Steel Pipe

Up to 15 mm nominal bore pipe can be bent manually, using a bending eye, Fig. 1.27(a). 20 mm can also be bent manually, but it takes a great deal of strength and not everyone can do it successfully unless the eye is secured to a bench or truck and other pipes are used for leverage.

The bending eye is made of cast steel and is tapped to take a piece of pipe or a steel tubular handle. Figure 1.27(b) shows it being used to bend a piece of 15 mm pipe to form a 90° bend.

Bending must be spread evenly throughout the bending length. This is done by pushing down on the bending eye until the pipe touches the floor, Fig. 1.27(b). Then move the bending eye back about 25 mm and repeat until the pipe again touches the floor. Continue to the end of the bending length when the 90° bend will be completed.

This method has the advantage of safety and accuracy. There is less likelihood of the eye slipping and keeping the pipe on the floor avoids having a long length swinging about.

The bending eye may be used in the reverse position as shown in Fig. 1.31. This gives the operator more leverage, but it is more difficult to control. The method must be used when making the second bend of a double set.

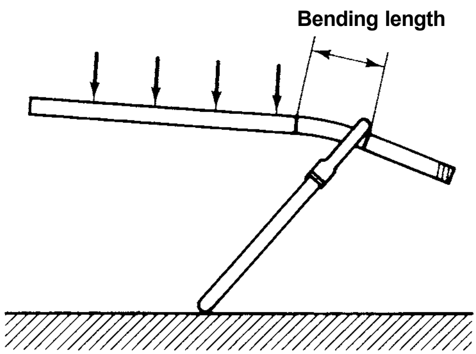

Fig. 1.31 Reverse bending method

Machine Bending

Using a machine not only takes the effort out of bending, it enables bends to be made to a smaller, neater radius. And all bends, for the same size of pipe, are exactly the same radius. The major advantage of a machine is that it enables bends to be made quickly and accurately to dimensions, with less waste. With manual bending it is often the practice to make a bend and then cut both ends of the pipe to the required lengths. With a machine it is usually possible to position the bend relative to one end of the pipe and then only cut the other to the dimension required.

The machines themselves were introduced in Vol. 1, Chapter 13. It now remains to describe methods of using them.

There are a number of ways in which pipe may be marked out for bending. A few simple, practical methods have been included.

Light Gauge Tube Bending

Details of the machine are shown in Fig. 1.32. The pipe to be bent is located in the fixed former as shown in Fig. 1.32(a). Measurements may be taken from:

- the outside edge of the former, which will correspond to the outside of the pipe, when bent
- the inside of the former, which will be in line with the inside edge of the pipe after bending.

Methods of making the various sets are given below.

90° Bends

1. Measure the distance from the end of the pipe to the outside of the bend required, Fig. 1.33.
2. Mark a line across the pipe at this point. (The inside of the bend may be used if this is more convenient.)

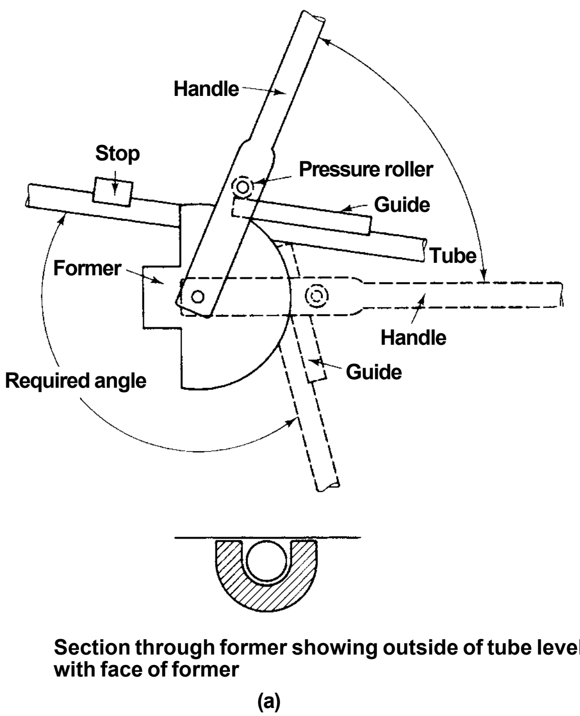

Fig. 1.32 Copper bending machine: (a) pipe in fixed former

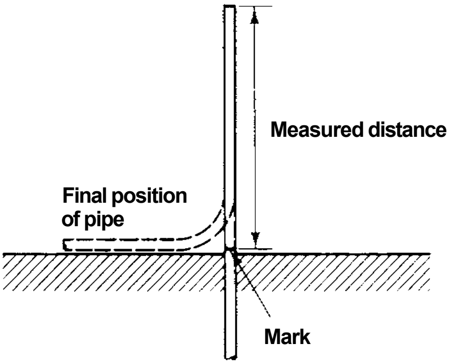

Fig. 1.33 Marking out 90° bend

3. Place the pipe in the machine with the measured piece to the back and held in the stop.
4. Pull the pipe into the former and adjust its position so that a square, held against the pipe and in line with the mark, is just touching the outer (or inner) edge of the former, Fig. 1.34.
5. Place on the straight former or guide and make the bend by pulling on the handle until the pipe is bent to 90°.

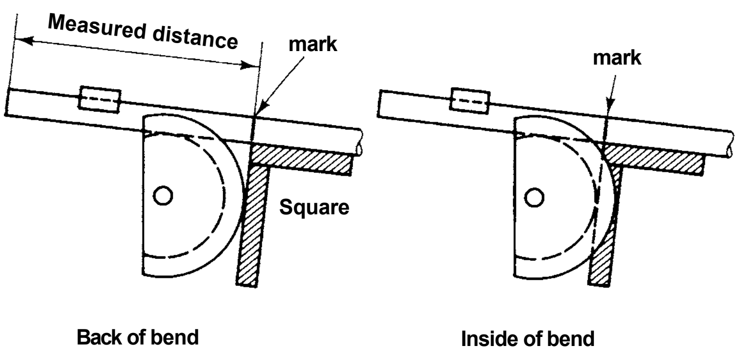

Fig. 1.34 Locating pipe in the former

Single Sets

These need to be measured from the point at which the set will start, Fig. 1.35.

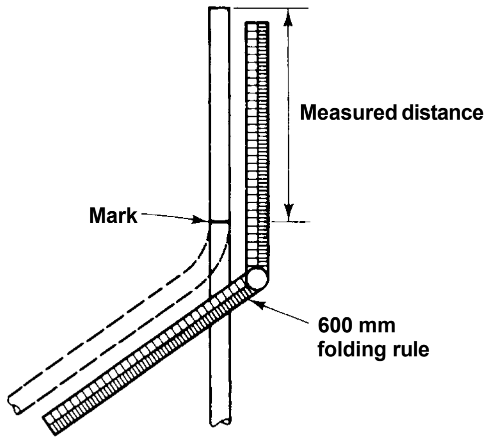

Fig. 1.35 Marking out single set

The mark is now made on the pipe at this point. It must then be placed in the former in line with the spot where the bend will begin.

This spot can be found by placing a piece of pipe in the former and lining up a square with the pipe and the centre of the former, Fig. 1.36. Alternatively, a simple way of locating the pipe is as follows:

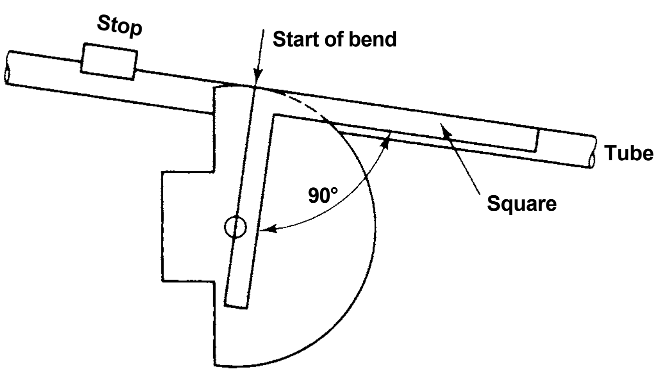

Fig. 1.36 Locating pipe in the machine

- place the guide on the pipe with its end in line with the marks on the tube
- insert the guide and tube into the machine until the guide just touches the roller, Fig. 1.37.

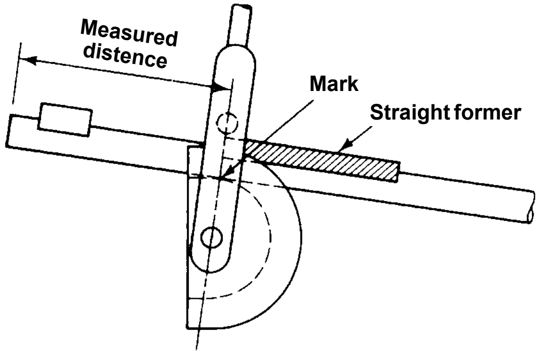

Fig. 1.37 Alternative method of setting up machine

The angle of the bend may be judged by opening out a 600 mm folding steel rule to the angle required, Fig. 1.35.

Double Sets

To make a double set, first make a single set as above. It is usual to make the angle about 45° if the width of the set is 50 mm or over and 30° if it is less than 50 mm.

Then mark out the second set as shown in Fig. 1.38.

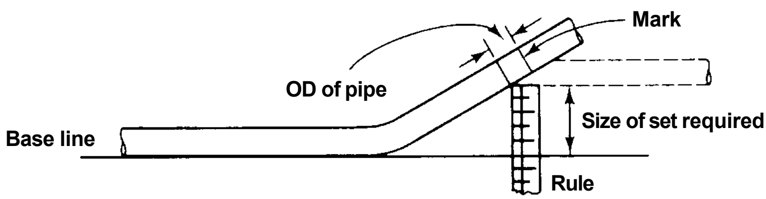

Fig. 1.38 Marking out double set

- hold the pipe against a flat surface or base line
- place the rule at 90° to the base line and measure the depth of set required
- mark the pipe where it touches the end of the rule
- add on one pipe diameter and make a mark on the pipe
- place the pipe in the machine, Fig. 1.39
- hold the rule vertically against the face of the former and adjust the pipe so that the second mark and the edge of the rule coincide
- set the tube until the second set is parallel with the first.

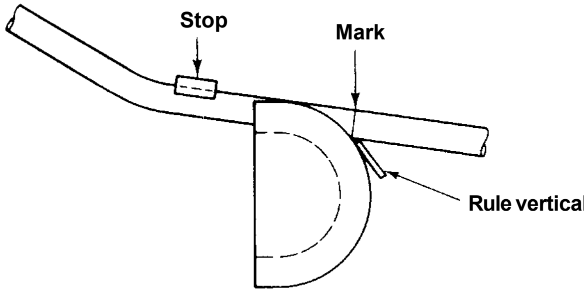

Fig. 1.39 Locating pipe in the machine

Crank Set

This is merely an extension of the double set as follows:

- make a single set
- mark out as for double set
- open folding rule to same angle as the single set
- make the centre bend to match this angle, Fig. 1.40

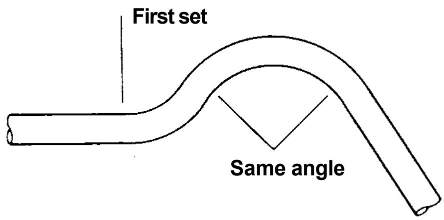

Fig. 1.40 Crank set

- place the outside of the centre bend on the base line with the straight pipe parallel to it, Fig. 1.41

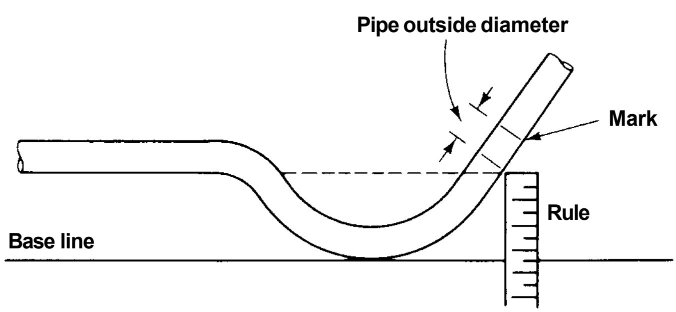

Fig. 1.41 Completing crank set

- mark off third bend as for a double set
- make the third bend to line up with the first.

Angle Sets

To set around an angle:

- make a template or drawing of the angle, Fig. 1.42(a)
- lay the tube along the base line and make a pencil line on the tube to correspond with the first angle, Fig. 1.42(b)

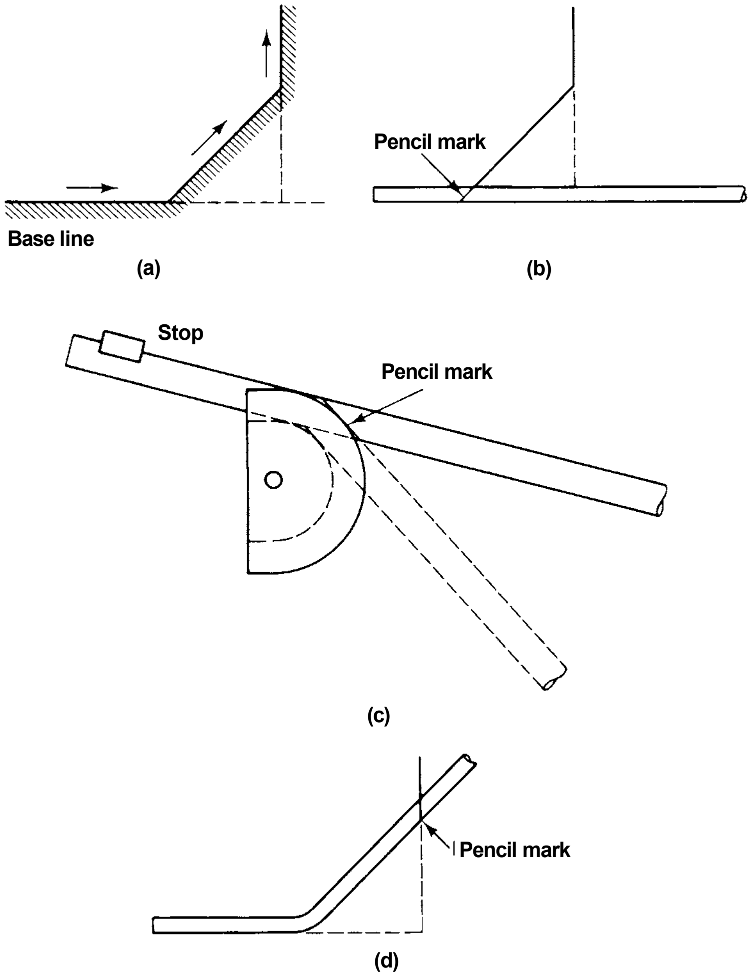

Fig. 1.42 Marking out sets round an angle: (a) template; (b) marking out first set; (c) locating pipe in the machine; (d) marking out second set

- place the pipe in the machine with the pencil line against the outside edge of the fixed former, Fig. 1.42(c)
- set the tube to the angle required using a folding rule as a gauge
- mark out the second set using the hypotenuse as the base line, Fig. 1.42(d)
- set the tube to the required angle as before.

Bending by Hydraulic Machine

These machines are used for steel pipe. The smaller ones will bend pipes from 15 to 50 mm. The larger sizes can take up to 80 or 100 mm pipes.

Because, on ram-type machines, the former moves to bend the pipes, it is necessary to base the system of marking out on the centre of the bend, i.e. the centre of the former.

When making double or crank sets, it is necessary to use a spirit level to ensure that the second or third bends are in the same plane as the first one.

Any pipes with welded seams should be placed in the machine with the seam uppermost.

90° Bends

When working from a fixed point, measure the distance from that point to the centre line of the final position of the pipe. Subtract the diameter of the pipe and mark that distance on the pipe, Fig. 1.43.

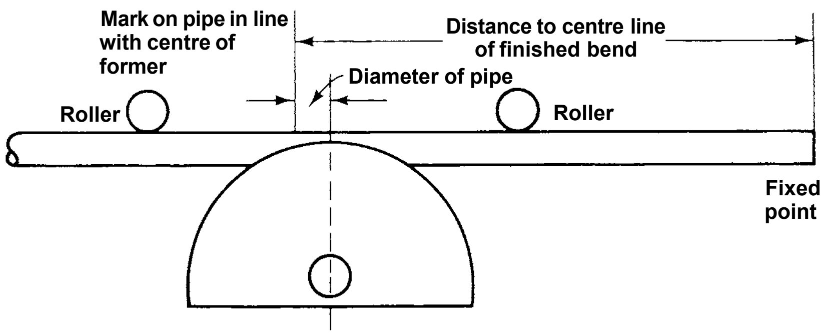

Fig. 1.43 Marking out 90° bend

Place the pipe in the machine with the mark in line with the centre of the former.

Single Sets or Angle Sets

For sets of 45° or less use the following procedure:

- lay the pipe in the required position or against a template, Fig. 1.44

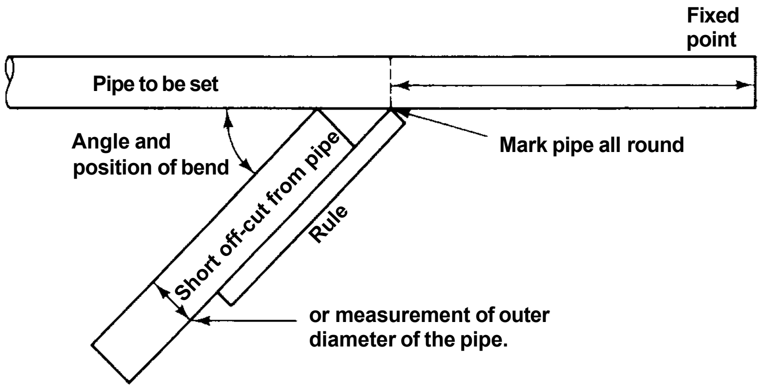

Fig. 1.44 Marking out single set

- lay a short off-cut to the angle and in the position required
- hold a rule with its edge against the off-cut and mark around the pipe where the corner of the rule touches it
- place the pipe in the machine with the mark in the centre of the former.

Double Sets

Make a single set as above, then:

- hold the pipe against a flat surface or base line
- place a rule at 90° to the base line and measure the depth of set required, Fig. 1.45

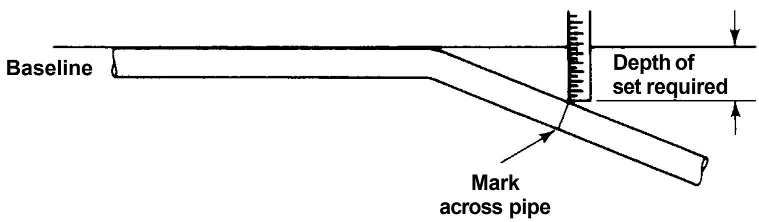

Fig. 1.45 Marking out double set

- mark the pipe where it touches the edge of the rule
- place the pipe in the machine with the mark in the centre of the former and level both ends
- bend the pipe until the second set is the same angle as the first and the pipe ends are parallel, Fig. 1.46.

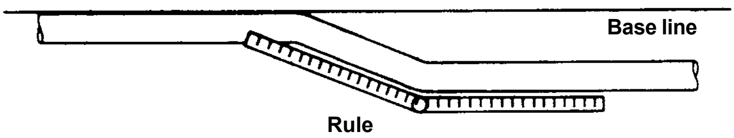

Fig. 1.46 Matching the angles

Crank Sets

To find the angle for the centre set, use two rules as in Fig. 1.47. Set a 600 mm folding rule to 587 mm for obstacles up to 50 mm diameter. The distance 'X' is approximately 1/4 of the diameter of the obstacle.

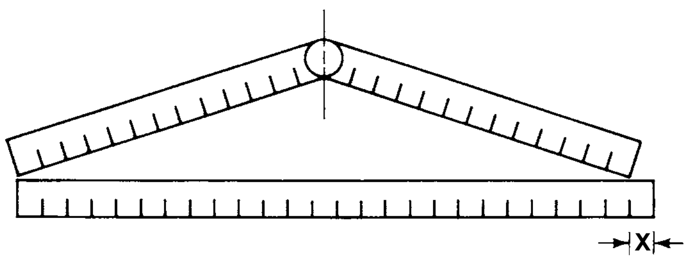

Fig. 1.47 Marking out crank set, angle of centre set

If this fraction is increased, in order to make a tighter set, it will not be possible to replace the two outer formers in their correct position when the other two sets are made. If the formers are replaced in position for a smaller size of pipe, there is a risk of damaging the machine.

Having made the centre set in the position required, continue as follows:

- place the pipe against a flat surface or base line, Fig. 1.48
- make sure that the angles are the same on both sides of the set
- measure the depth of sets required and mark round the pipe at those points; depth of set equals depth of obstacle, plus clearance

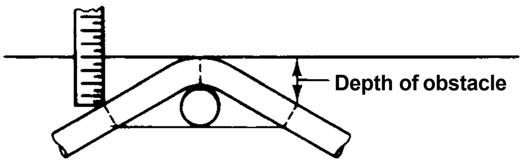

Fig. 1.48 Marking out crank set, position of side sets

- replace the pipe in the machine with one of the marks against the centre of the former and the ends level
- bend until the angle of the set corresponds to the angle set on a folding rule, Fig. 1.49
- make the third set to the same angle in a similar manner.

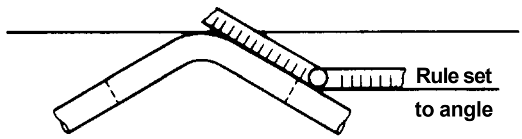

Fig. 1.49 Marking out crank set, angle of side sets

Pipe Fittings

(BS 143, and 1256: 1986, malleable iron and cast copper fittings for screwed pipe)

Fittings are specified by the following characteristics:

- size of pipe or thread – 1/2, 15 mm, etc.
- type of thread – internal, female (f), external, male (m); taper or parallel, R, R_c, R_L, R_p
- type of material – malleable iron (mi), copper (Cu)
- type of fitting – coupler, elbow, tee, etc.

Figure 1.50 shows three of the most common forms of fitting used.

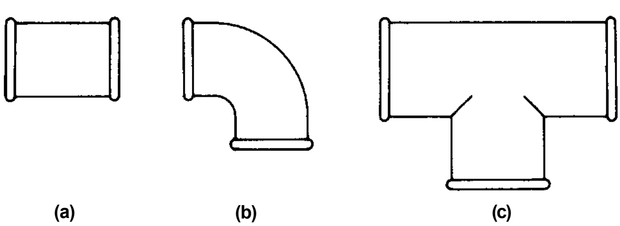

Fig. 1.50 Pipe fittings: (a) coupler; (b) elbow; (c) tee

These are:

- coupler, also known as a 'socket'. Used for jointing two straight lengths of pipe
- elbow, for turning a pipe run through 90°
- tee, for connecting a branch into a straight pipe.

Fittings which take one size of pipe only are specified by quoting that size once. For example, $^1/_2$ elbow or $^3/_4$ tee.

Reducing fittings with only two outlets are specified by quoting the larger size first. For example, $^3/_4 \times {}^1/_2$ elbow, $1 \times {}^3/_4$ coupler.

Tees are always specified by the two ends on the run first and the branch last. For example, $^1/_2 \times {}^1/_2 \times {}^3/_4$ tee. If there is a reduction on the run, the larger end is quoted first, e.g. $^3/_4 \times {}^1/_2 \times {}^1/_2$ tee.

Figure 1.51 shows a number of less common fittings and the order in which the outlets should be quoted.

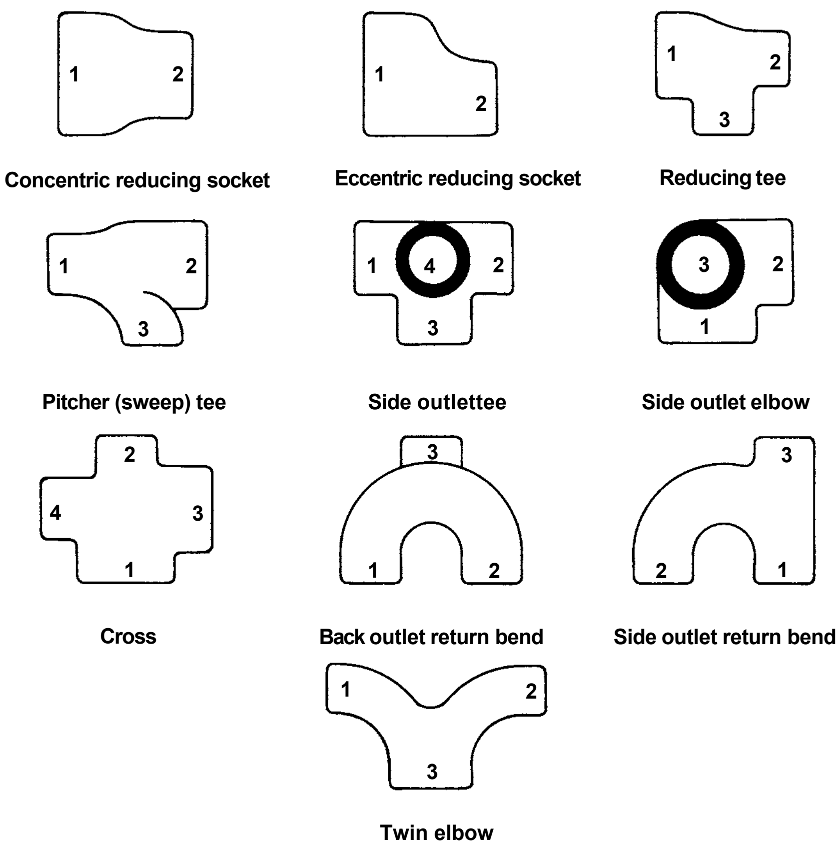

Fig. 1.51 Pipe fittings, method of describing outlets

FIXINGS

Nails

Nails are used extensively in building construction and furniture. They are normally made from mild steel but some are available in other materials to suit special applications.

Nails are specified by their length and form, e.g. 50 mm oval brads. Quantities are traditionally ordered by weight, although some retailers may sell them by number.

Commonly used types of nails are as follows:

Oval Brad

A type of wire nail with an elliptical section and a small head which can be punched below the surface leaving only a small hole, Fig. 1.52(a). It should not split the wood if driven in with major axis parallel to the grain. Used for general purposes it is available in lengths from 12 to 150 mm.

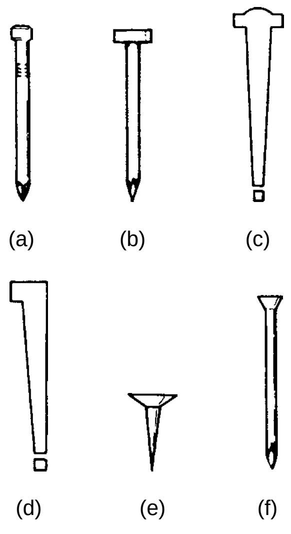

Fig. 1.52 Types of nails: (a) Oval brad; (b) Wire nail; (c) Cut clasp nail; (d) Floor brad; (e) Clout nail; (f) Masonry pin

Wire Nail

Also known as a 'French nail', this is used for rough work and has great holding power. It cannot be punched below the surface. Available sizes are 20–250 mm, Fig. 1.52(b).

Cut Clasp Nail

Punched from sheet metal, it must be driven into wood with its long side parallel to the grain, Fig. 1.52(c).

Floor Brad

A cut nail used for securing floorboards. It has a projection at the head and is tapered on one side only, Fig. 1.52(d).

Clout Nail

This has a large, thin, flat head which makes it useful for securing roofing felt or plaster boards, Fig. 1.52(e).

Carpet Tacks

These are similar in shape to small clout nails but they are a cut nail and are always blued.

Masonry Pin

This is made from tempered alloy steel and is used for fixing timber to brickwork, Fig. 1.52(f). The pins snap easily and the following precautions must be taken:

- wear goggles when fixing
- hit pins square to the end
- use light taps to drive pins home.

Wood Screws

Wood screws are made from steel or brass and may be plain or finished in a variety of ways including:

- blued
- bronzed
- chromium plated
- black japanned.

They range in size from No. 1. approximately 1.7 mm diameter, up to No. 32, approximately 12.7 mm diameter. Lengths may vary from 6 mm for No. 1s up to 230 mm for No. 32s.

When ordering wood screws specify:

- quantity
- length

- size number
- type of head
- finish or material.

For example, 100, 25 mm, No. 8, roundhead, brass.
Types of head are:

- countersunk, Fig. 1.53(a). For fixing wood or thick metal; the head finishes flush with the surface
- roundhead, Fig. 1.53(b). For securing thin metal parts, e.g. pipe clips or appliance brackets
- raised head, Fig. 1.53(c). Normally used on plated screws for a better finish
- dome head, Fig. 1.53(d). Used to give a very neat finish, they are countersunk screws drilled and tapped to take the dome
- coach screws, Fig. 1.53(e). These have a square head to take a spanner. Available in large sizes and used for heavy work
- screw eyes, Fig. 1.53(f). Used for a number of purposes including providing a securing point for a rope lashing a ladder.

When a wooden panel has to be unscrewed fairly frequently it is an advantage to fit brass cups to take the countersunk screws which secure it, Fig. 1.53(g).

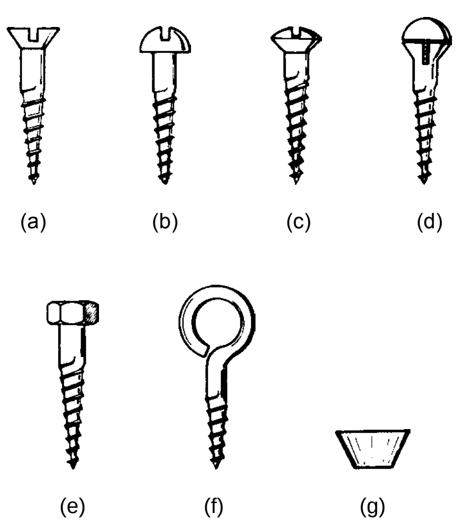

Fig. 1.53 Types of heads: (a) Countersunk; (b) Roundhead; (c) Raised head; (d) Dome head; (e) Coach screws; (f) Screw eyes; (g) Brass cups

Machine Screws

Machine screws are made to be screwed into threads tapped in holes in metal or plastic. Like bolts, they may sometimes carry nuts, but they have threads extending to the head, while bolts have a plain section before the thread starts. Metric sizes conform to BS 4183: 1967 (obsolescent), partially replaced by BS EN ISO 1580: 1994 and BS EN ISO 7045: 1994.

Types of Thread

There are many (actually 210) different types of thread still being used. So care must always be taken to ensure that the right thread of screw is being used for any particular tapped hole or nut. If it does not screw in easily by hand at first, it probably does not fit. Any attempt to tighten it with a spanner will probably ruin the thread on the screw and in the hole.

Types of thread in common use are as follows.

1. *British Standard Whitworth (BSW)*
This has a fairly coarse thread with an angle of 55°. It is used for general work where it is not likely to be subjected to vibration and where a strong thread is required. Sizes are from 1/8 to 6 in.

2. *British Standard Fine (BSF)*
Of Whitworth form but with a finer pitch, so less liable to come loose if subjected to shock or vibration, this has been used extensively on engines and machinery. Sizes are from 3/16 to 4 1/2 in.

3. *British Association (BA)*
This is based on a Swiss (Thury) thread and has an angle of 47 1/2°. It is in metric units and some sizes may be interchangeable with metric screws. Used for screws below 6 mm diameter it is found on electrical components, instruments and small appliance parts. Sizes range from the smallest, No. 25, 0.254 mm diameter, pitch 0.07 mm, to the largest, No. 0, 6.0 mm diameter, pitch 1.0 mm.

4. *Unified Threads*
Established in 1949 to provide interchangeability of components between America, Canada and the UK, this included three series of threads:

- UNC – Coarse
- UNF – fine
- NEF – extra fine.

5. *ISO Threads*

The International Standards Organisation threads to be used in engineering are as follows:

ISO metric coarse (BS 3643 Part 1, 1981, Part 2, 1981).
Sizes, up to 64 mm with varying pitch and a constant pitch series 1.6 mm to 300 mm.

ISO inch coarse (UNC) (BS 1580 Parts 1 and 2, 1962 (1985)).
Sizes, 1/4 to 4 in. with varying pitch and a constant pitch series 5/16 to 6 in.

ISO inch fine (UNF) (BS 1580 Parts 1 and 2, 1962 (1985)).
Sizes, 1/4 to 1 1/2 in. with various constant pitches.

Metric Threads

Metric diameters are specified by the letter M followed by a number giving the diameter in millimetres. For example, M5 represents 5 mm diameter.

Types of Screw Head

Similar to the heads of wood screws, these are shown in Fig. 1.54. In addition, the cross-slotted or recessed heads available are shown in Fig. 1.55. These are often used in components which are assembled by power screwdrivers.

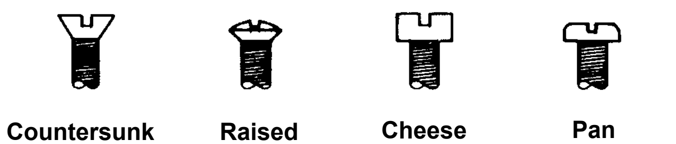

Fig. 1.54 Types of screw head

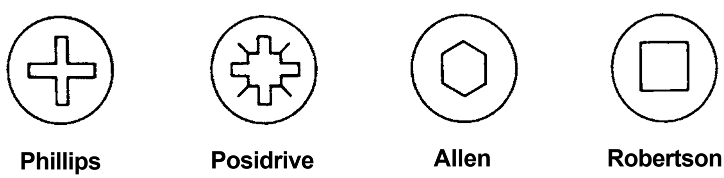

Fig. 1.55 Recessed screw heads

Types of Screw

As well as the standard screw which has a parallel thread throughout its length, the following types have their particular uses.

Set screw Usually pointed or designed to fit into a specially shaped recess, Fig. 1.56(a). Used to hold one component relative to another. For example, holding a pulley on a shaft.

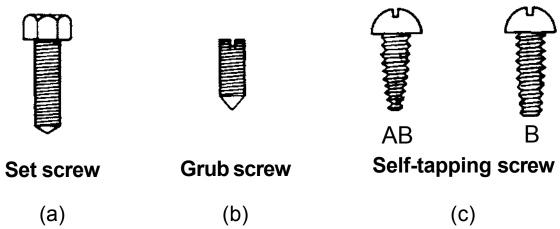

Fig. 1.56 Types of screws

Grub screw Used for the same purpose as the set screw, this has no projecting head and may be screwed below the surface of the component, Fig. 1.56(b). The screw may have a slotted or a recessed head for an Allen key.

Self-tapping screws There are several types of self-tapping screws, the most common being AB and B, Fig. 1.56(c).

Type AB has a widely spread thread and gimlet point. It is used in light sheet metal, metal clad and resin impregnated plywood and soft plastics. It supersedes Type A which had a coarser thread and is now obsolete.

Type B has the same thread as AB but the point is blunter. It is used in light and heavy metal sheet, non-ferrous castings and other materials for which AB may also be used.

Tapping screws are available in numbered sizes, similar to wood screws and are detailed in BS 4174: 1972 (obsolescent), partially replaced by BS EN ISO 1749: 1994 and BS EN ISO 7049: 1994.

Ordering Machine Screws

When specifying metric machine screws quote:

- quantity (number)
- material
- type of head

- diameter and length
- plating.

For example, 10, steel, countersunk, M5 × 16 zinc plated.

Bolts

The length of thread on a bolt varies with the diameter. It may be from about 30% of the length of the bolt on small diameter bolts and could be 80% of the length of larger bolts.

Where the head of the bolt is large enough, it has ISO M and a number indicating the grade of steel, formed on the head. Nuts have a dot to indicate metric and another mark to show the grade. For example, the number 88 indicates a high-tensile steel. This is shown on a nut by a bar situated 120° clockwise from the dot.

The standard bolt has a hexagon head, Fig. 1.57(a). The dimensions of the head are related to the diameter of the bolt. The heads of BSW and BSF fasteners are the same for the same diameter of the bolt.

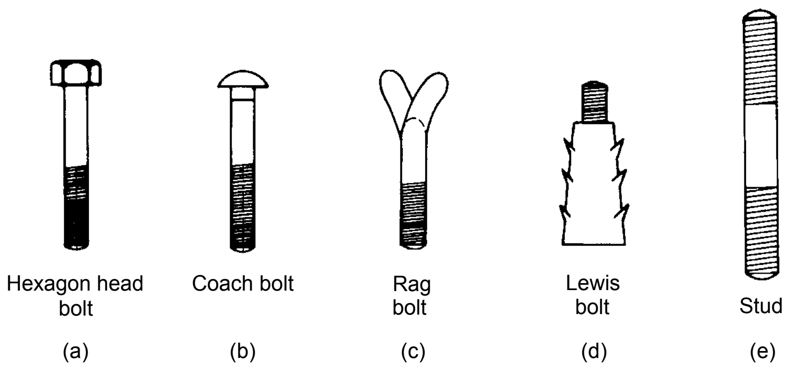

Fig. 1.57 Types of bolts

Spanners designed for imperial sizes of fastener will not fit on metric fasteners or vice versa.

There are a number of special bolts as follows:

Coach Bolt

This is used for securing timber, Fig. 1.57(b). The head is domed and immediately below it is a square section which is pulled into the wood as the nut is tightened. This prevents the bolt from turning.

Rag Bolt and Lewis Bolt

Rag bolts and Lewis bolts are set in walls and floors, Fig. 1.57(c) and (d). Both are secured with cement mortar or placed into the concrete in the position required.

Studs

One end is screwed into a tapped hole leaving the remainder projecting like a bolt, Fig. 1.57(e). Studs are used where a flanged joint is required on the machined surface of an appliance or engine component.

Nuts

Nuts are usually square or hexagonal and they are usually made to the same dimensions as the head of the bolt on which they fit.

Locknuts, Fig. 1.58(a), are half as thick as an ordinary nut. They are 'locked' by tightening against the main nut.

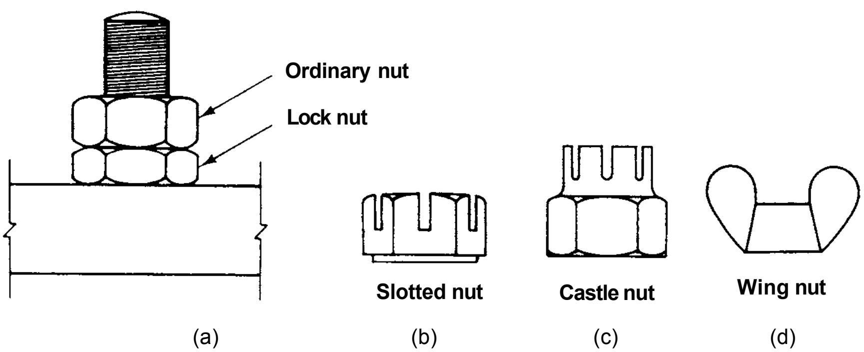

Fig. 1.58 Types of nuts: (a) Locknut; (b) Slotted nut; (c) Castle nut; (d) Wing nut

Slotted or castle nuts, Fig. 1.58(b) and (c), are used in conjunction with a drilled bolt and a split pin. When the nut is in the required position, the split pin is passed through both the hole in the bolt and the slot in the nut and then secured.

Wing nuts, Fig. 1.58(d), may be turned without the aid of a spanner and are often used to secure casings or panels which must be removed for servicing purposes.

Captive nuts, Fig. 1.59, are manufactured from spring steel. They are usually available in three thread forms (BA, metric and self-tapping).

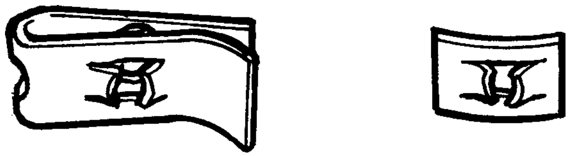

Fig. 1.59 Two types of captive nut (self-tapping)

They are particularly useful for panel fixing where the panels are vitreous enamelled or of insufficient thickness for self-tapping screws.

Washers

Washers are used, under the heads of bolts and nuts, to prevent damage to the article and give the fastenings a flat surface on which to bear, Fig. 1.60(a). They may be used to provide clearance distance between two parts of an object when they would be called 'spacing' washers.

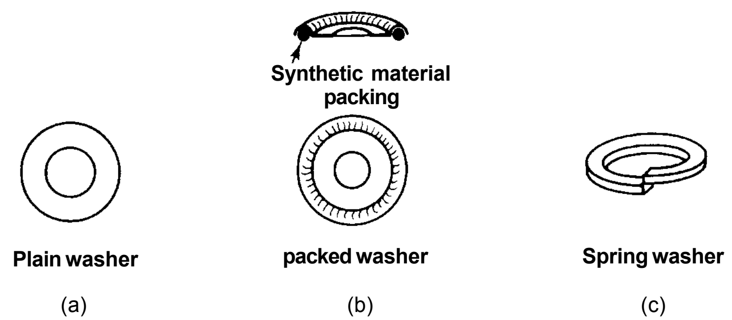

Fig. 1.60 Types of washers

Washers which incorporate a grummet of synthetic material, Fig. 1.60(b), are used on vitreous enamelled sheets to prevent excessive pressure being applied which might cause the finish to chip.

Spring washers, Fig. 1.60(c), are formed from rectangular section spring steel. The sharp corners bite into the material and the nut, so locking them together. Other washers also used to prevent nuts coming loose are the tooth lock washers shown in Fig. 1.61.

Rivets

Where a permanent assembly is required, rivets are used instead of nuts and bolts. Rivets for cold working are made of soft iron, mild steel, copper or aluminium. The common types of head are shown in Fig. 1.62(a).

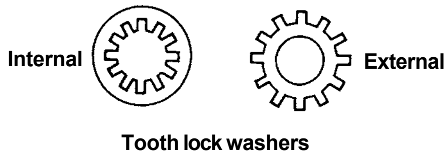

Fig. 1.61

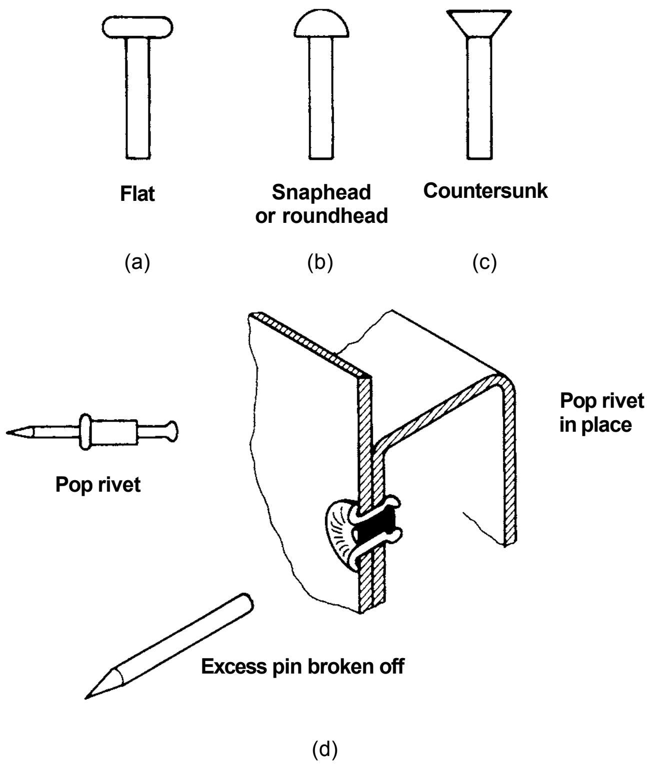

Fig. 1.62 Types of rivets

Flat head rivets are used on thin plates and are commonly made of galvanised iron.

Roundhead rivets, sometimes called snag head or snaphead, are used where countersinking would weaken the material and where a flush finish is not essential, Fig. 1.62(b). A 'snap' is a shaped punch, used to form the head.

Countersunk rivets, Fig. 1.62(c) are used for general work when a flush surface is required. There are many other heads used for special jobs, including cone, steeple, pan, mushroom, oval, globe and button.

The allowances to be added to the length in order to form a head are:

- roundhead, 1¼ times the diameter of the shank
- countersunk, equal to 1 diameter.

Pop rivets are used when only one side of a job is accessible, Fig. 1.62(d). They are inserted by means of a small, hand operated machine. Being hollow, they are not as strong as ordinary rivets.

Pipe Fixings

There have been many types of pipe clips and hooks produced and a few of the more common types are described.

Hooks

Made of malleable iron, these are cheap and easy to fix in wood, stone or brick, Fig. 1.63(a). They are not usually used on exposed pipe runs in domestic premises but are useful for holding pipe in chases or under floors.

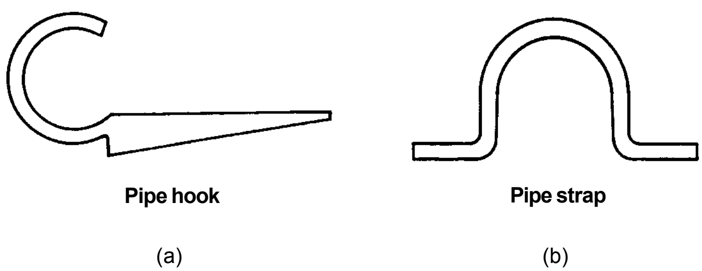

Fig. 1.63 Types of hooks

Straps

Pipe straps, or saddle clips, are usually of galvanised mild steel for steel pipe or copper for copper tube, Fig. 1.63(b). They should be secured by two roundhead screws.

Spacing Clips

These are usually copper and are used where the pipe needs to be kept clear of the surface so as to prevent dirt collecting behind it, Fig. 1.64(a).

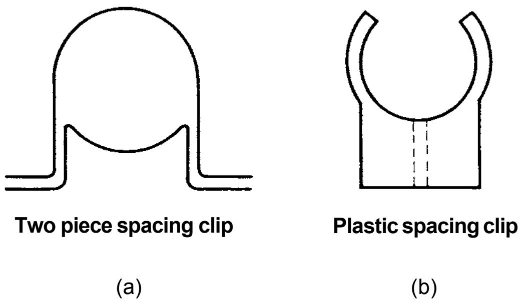

Fig. 1.64 Types of spacing clips

Plastic Clips

There is a variety of plastic clips. Some are made in two parts and completely enclose the pipe, Fig. 1.64(b). Others, like the one illustrated, allow the pipe to be forced into it and are made in one piece.

Split Pipe Rings

These are produced from malleable iron and are made either with extensions for cementing into walls or with back plates for securing to the surface, Fig. 1.65. The plate and the clip may be screwed with R_c 1/4 thread so that a piece of steel pipe may be used as an extension between the backplate and the clip.

Fixing Devices

Types of fixings and their application are as follows:

- solid walls
  - compound fillers
  - wall plugs
  - masonry bolts.
- hollow surfaces
  - toggles
  - anchors
  - battens.

Compound Fillers

These are putty-like compounds which are ideal for use where the hole is ragged, oversized or distorted, Fig. 1.66. The filler is packed

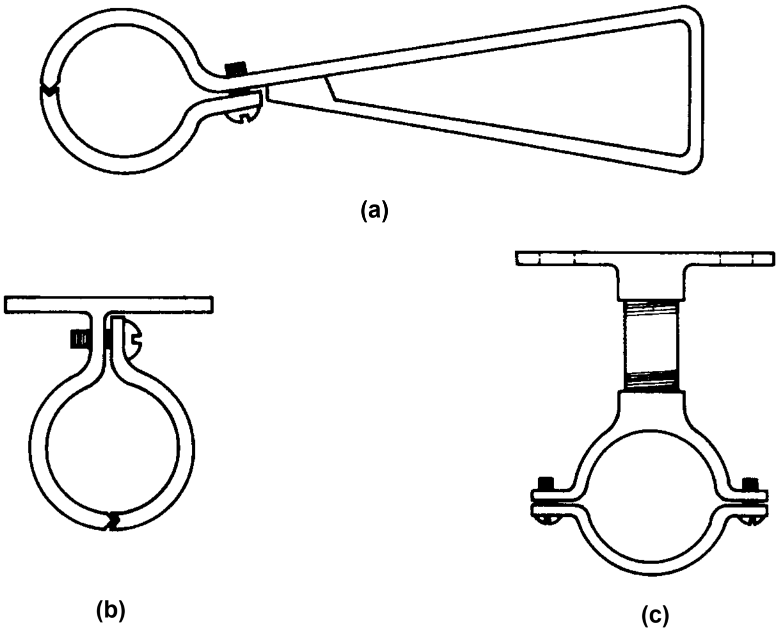

Fig. 1.65 Split pipe rings: (a) building-in; (b) school board; (c) with backplate and spacing nipple

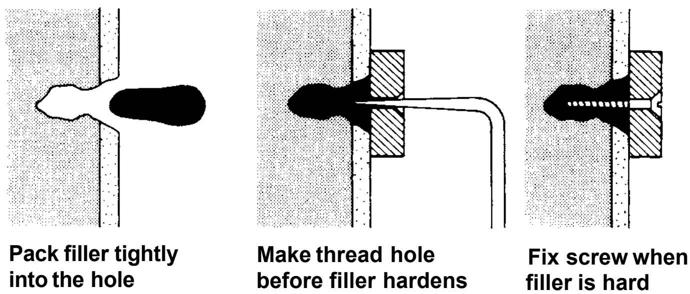

Fig. 1.66 Compound filler

into the hole and a starting hole for the screw is made with the spike provided. When the filler hardens the screw may be driven in.

Wall Plugs

Made from fibre, plastic or metal, they are inserted into drilled holes and are expanded, by the screw, to grip the sides of the hole, Fig. 1.67. These

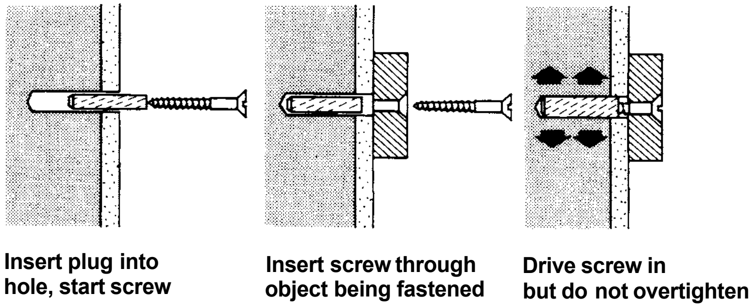

Fig. 1.67 Wall plugs

plugs are made in numbered sizes to fit the same number wood screw. The drilling, plug and screw must be matched for a satisfactory fixing.

Flanged plugs are used for bottomless holes.

Metal plugs, usually of white bronze, are made for use externally or where high temperatures could shrink fibre plugs or soften plastic.

In a tiled wall the plug must be inserted beyond the tile, Fig. 1.68, otherwise the force of the expansion could crack the tile.

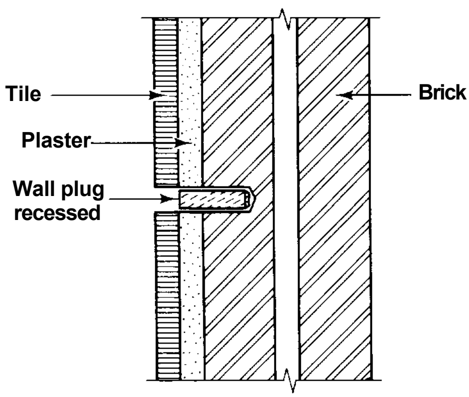

Fig. 1.68 Wall plug in tiled wall

Masonry Bolts

These are used for fixing heavy objects, Fig. 1.69. The hole is bored to the diameter of the plastic insert, which expands as the bolt is screwed home. Sizes range from 5 to 25 mm. There are various heads including hooks, studs and eyelets.

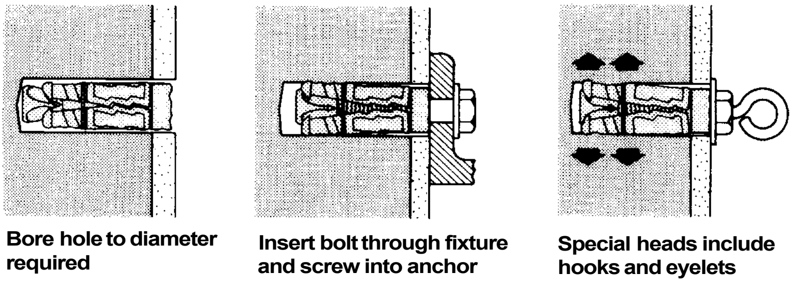

Fig. 1.69 Masonry bolts

Toggles

Many ingenious devices are available for fixing to cavity walls. Two of the most common are gravity and spring loaded toggles, Figs 1.70, 1.71.

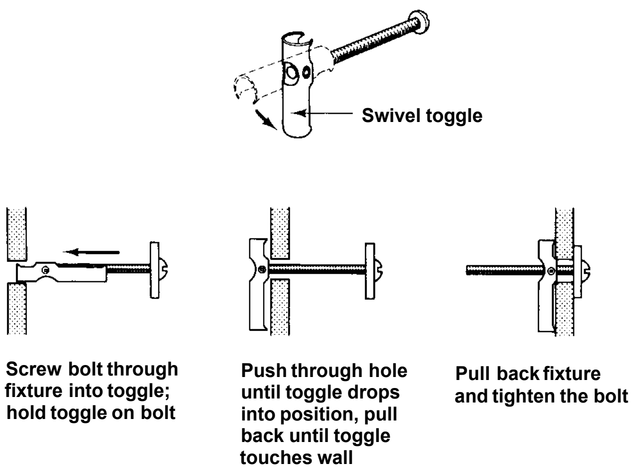

Fig. 1.70 Gravity toggle

Gravity toggles have a swivel toggle which drops down when the bolt has been fed through the drilled hole.

Spring toggles have two spring-loaded arms which expand after being pushed through the hole.

Both toggles will be lost in the cavity if the screws are removed. So the screw must be put through the object to be fixed before the toggle is passed through the hole.

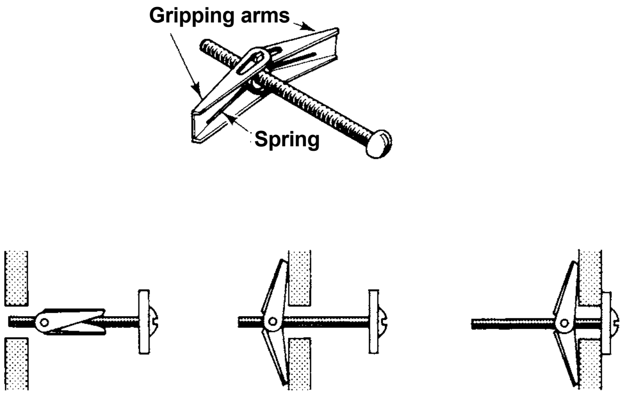

Fig. 1.71 Spring toggle

Anchors

Anchors generally remain in place when the screw is removed. Figure 1.72 shows a collapsible anchor which has metal shoulders drawn against the inside surface as the screw is tightened.

The rubber anchor, Fig. 1.73, is expanded on tightening. It can be used on a solid wall.

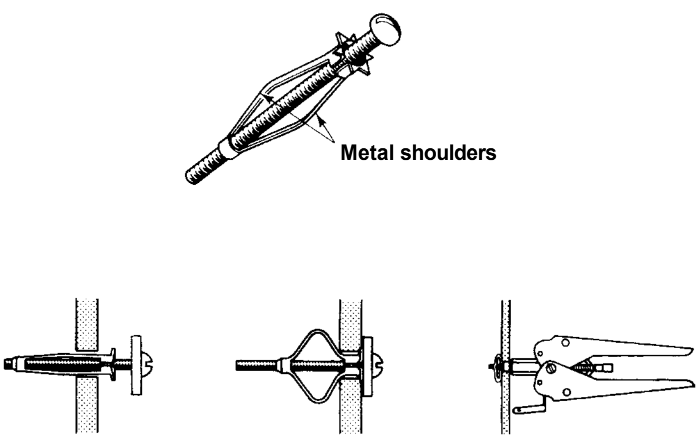

Fig. 1.72 Expanding anchor

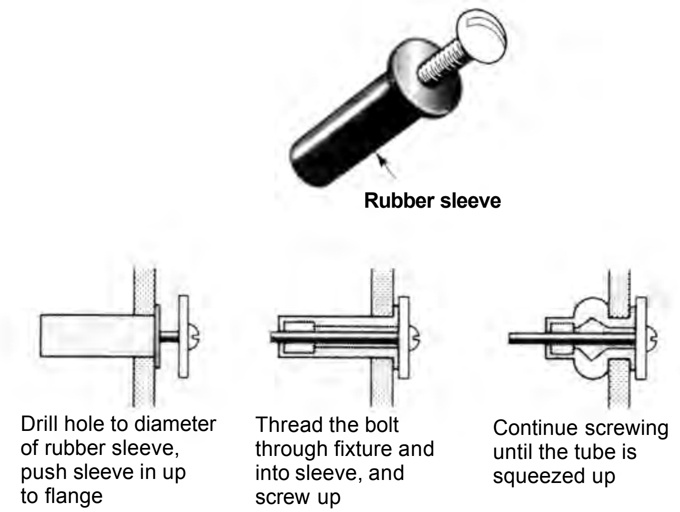

Fig. 1.73 Rubber anchor

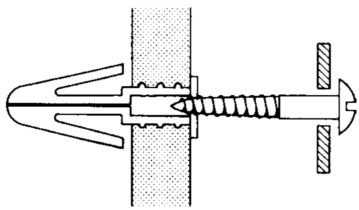

Fig. 1.74 Plastic anchor

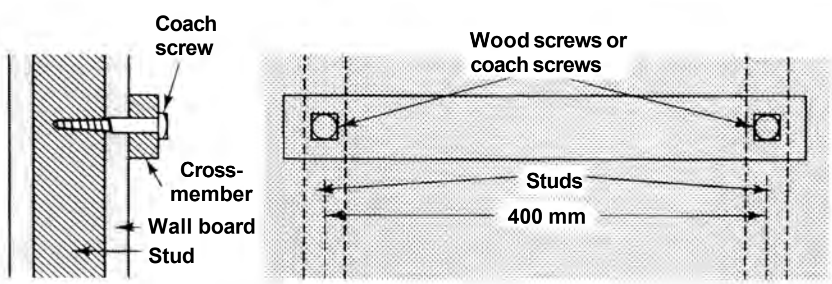

Fig. 1.75 Fixing to partition wall

Plastic anchors use wood screws, rather than machine screws. The gripping arms are pulled on to the wall when the screw is tightened, Fig. 1.74.

Battens

On lath and plaster walls or on plaster board, the wall cladding is not strong enough to support heavy weights, like appliances or meters. It is then necessary to fix a wood batten across the wall and on to the wall joists or 'studding'. Studs are usually 100×50 mm timbers fixed at 400 mm centres, Fig. 1.75. The position of the studs can be found by tapping the wall and listening to the difference between the hollow sound of the cavity and the dull, solid note on the stud. When you have roughly located the studs, check with a bradawl or a small drill before making a large hole.

CHAPTER 2

Building Construction

Chapter 2 is based on an original draft by H. V. Gowers and subsequently updated by E. Thompson (1999) and K. W. G. Blount (2001)

Introduction

There are many different types of buildings. They range from flats to factories, from castles to cottages. Broadly speaking, buildings may be classified into three main groups:

1. residential or domestic
2. industrial or commercial
3. public.

This chapter is principally concerned with domestic building work, although some of the more general information may apply to the other categories.

Building work in England and Wales is controlled by the Building Act 1984. The Building Regulations 1985 made under it came into effect in November 1985 and represented a significant departure from previous ones. The 1985 Statutory Instrument defined only the terms, scope and procedures. Technical requirements were expressed in functional terms in two schedules. The Building Regulations 1991 revoked and replaced the 1985 Regulations and consolidated subsequent amendments to those regulations. These came into force on 1 June 1992. The 1991 Regulations and subsequent amendments made were consolidated into a new version, the Building Regulations 2000, which came into force on 1 January 2001. These are the current provisions. Approved Documents (ADs) prepared by the Department of the Environment, Transport and the Regions give guidance on meeting the requirements.

In Scotland the Building Standards (Scotland) Regulations were introduced in 1990 and subsequently have been amended five times. They are made under the Building (Scotland) Act 1959; technically their effect is similar to the Building Regulations for England and