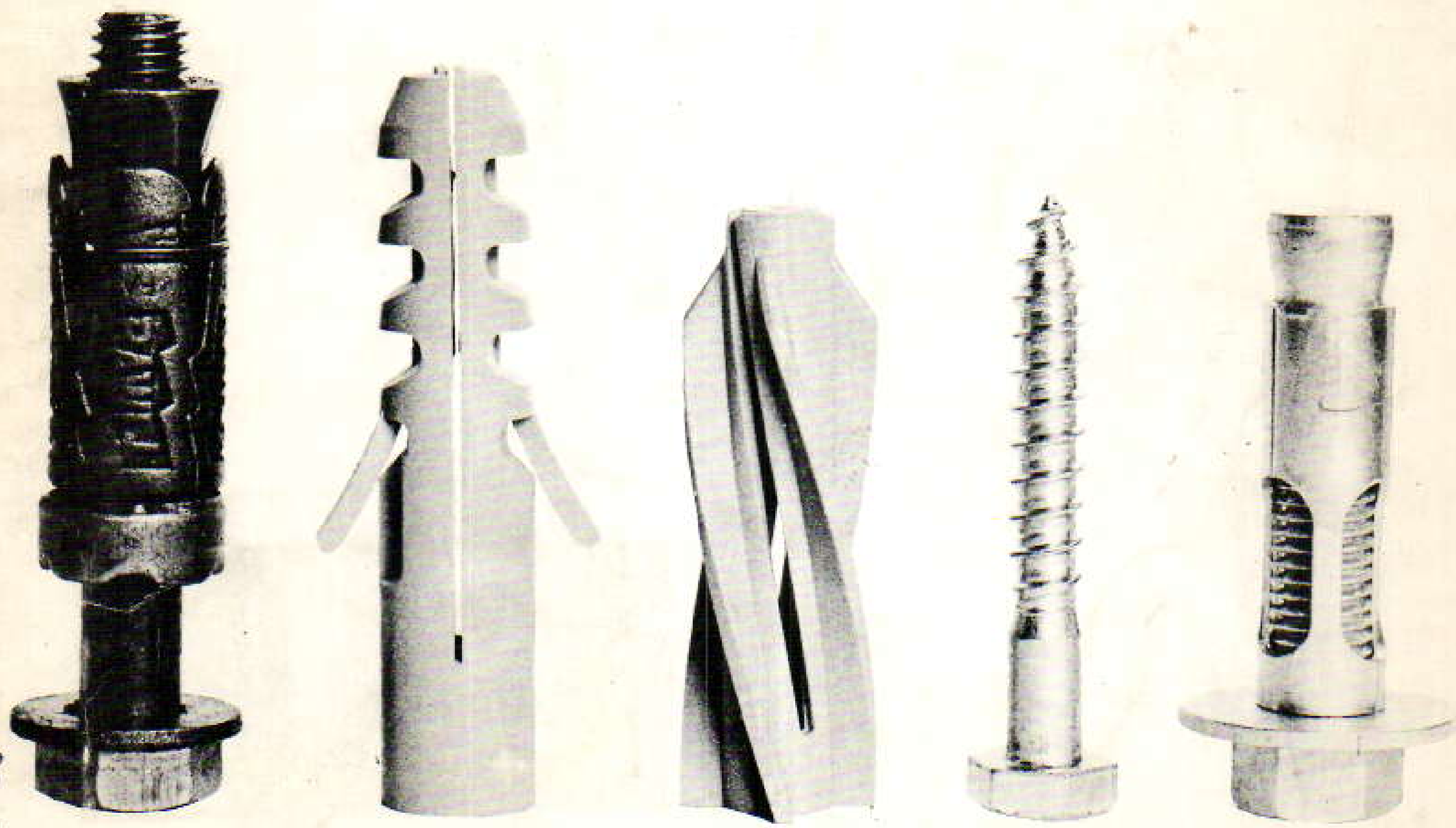
Handbook of

FIXINGS & FASTENINGS

by Bill Launchbury ARIBA



Handbook of
s and Fastenings

Bill Launchbury ARIBA

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Technical study
Fixings 1

Introduction to fixings and fastenings

BILL LAUNCHBURY *introduces and defines his subject, and outlines the principles he has adopted*

1 Basis of handbook

1.01 The range of fixings used in the construction industry is very wide, and the main problem in presenting information is one of limitation. The volume of available literature is vast and relatively uncoordinated: any study in depth tends to involve the whole of general building technology.

1.02 To keep the handbook as concise as possible certain principles have been adopted:
First, the information has been confined to those areas where architects at the detail design stage are most likely to be involved in selection, application and specification. For this reason many processes and devices, prepared for use by specialist sub-contractors have been omitted (eg tile and mosaic laying).
Second, where possible the groupings accepted by the fixings industry have been acknowledged in the 'family' subdivisions of the information sheets in the handbook.

Main terms used

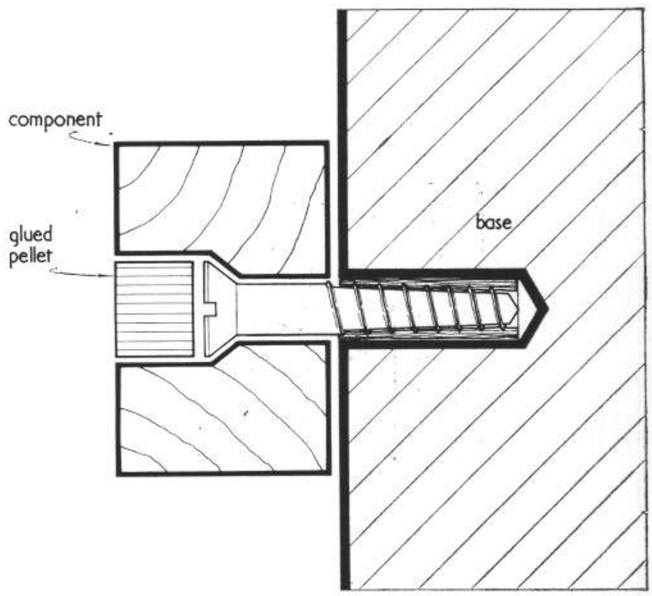
1.03 To analyse the status of the fixing, within the terms of the handbook, it is necessary to examine the conditions which apply:

Component to base material
The condition where a loose member or assembled component is fixed to a stable part of the building **1**. This stable part is referred to as the base material or *base*. The part to be fixed to the base is referred to as the *component* and the device used is called the *fixing* (this device can also be called *fastening*, especially in the US).

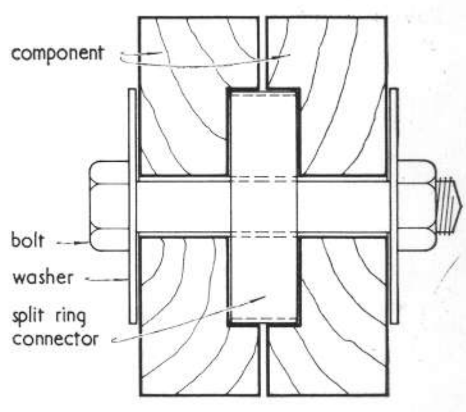
Component to component (similar)
Apart from fixings made to the solid parts of the building, there are others which assist in joining two or more similar members together **2**. These are often within the responsibility of the particular trade, and have been described only where the information can be useful to architects; they include timber connectors and bolts and rivets for steelwork. A comprehensive presentation of information of the latter would involve too much of a departure into engineering, and it has been limited.
Special interlocking devices are not included—nor are those which fall into the category of ironmongery (hinges etc).

Component to component (dissimilar)
The third condition is the assembly of unlike components, and some fixings of this category are included.

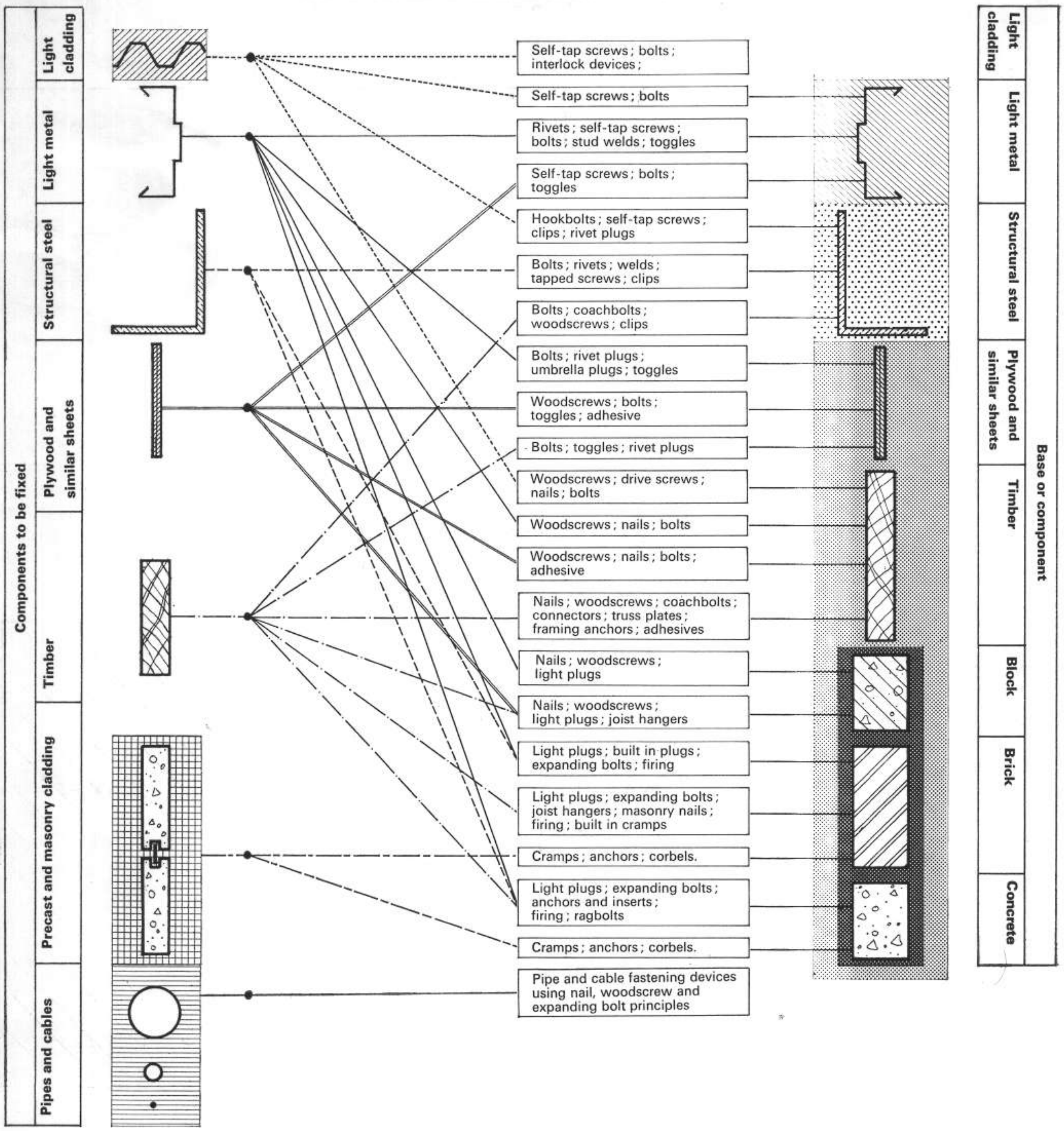
1.04 There are many terms used in the fixings industry. Some are peculiar to that industry, many of which can give rise to confusion. The word 'anchor' for instance is widely incorporated into trade literature to describe a wide range of fixings. A list of terms with definitions is included at the end of the handbook in appendix 1.



1 *Component to base fixing*



2 *Component to component fixing*



3 *Common fixing applications in building. Components to be fixed are shown on left; base material or component on right. Suitable fixings are listed in the appropriate box. Table I gives this information in list form*

Table I Common fixing applications in buildings

Components to be fixed	**Base**	**Method of fixing**
Light cladding	light cladding	self-tap screws; bolts; interlocking devices
	light metal	self-tap screws; bolts
	structural steel	clips; hook bolts; self-tap screws; rivet plugs
	timber	wood screws; drive screws; bolts; nails
Light metal	light metal	rivets; self-tap screws; bolts; stud welds; toggles
	plywood and similar sheets	bolts; rivet plugs; umbrella plugs; toggles
	timber	wood screws; bolts; nails
	blocks	light plugs; woodscrews; nails
	brick	light plugs; built in plugs; expanding bolts; firing
	concrete	light plugs; expanding bolts; anchors and inserts; firing; ragbolts
Structural steel	structural steel	bolts; rivets; welds; tapped screws; clips
	brick	light plugs; built-in plugs; expanding bolts; firing
	concrete	light plugs; expanding bolts; anchors and inserts; firing; ragbolts
Plywood and similar sheets	light metal	self-tap screws; bolts; toggles
	plywood and similar sheets	wood screws; bolts; toggles; adhesive
	timber	nails; woodscrews; bolts; adhesive
	blocks	light plugs; wood screws; nails; joist hangers
Timber	structural steel	bolts; coachbolts; wood screws; clips
	plywood and similar sheets	bolts; toggles; rivet plugs
	timber	nails; woodscrews; coach bolts; connectors; russ plates; framing anchors; adhesives
	blocks	light plugs; woodscrews; nails; joist hangers
	brick	light plugs; expanding bolts; joist hangers; masonry nails; firing; build-in cramps
	concrete	light plugs; expanding bolts; anchors and inserts; firing; ragbolts
Precast and masonry cladding	brick	cramps; anchors; corbels; etc
	concrete	cramps; anchors; corbels; etc

2 Common fixing applications in building

2.01 Types of fixings most encountered and the situations in which they are likely to occur are shown in **3** and listed in table I.
The 'families' shown in **3** by background hatching illustrate groups in which the main information in the handbook is arranged. Some of them are based around the qualities of the component to be fixed (eg masonry or precast concrete panels tied to the structure; light profiled sheets connected to the roof or external wall). Others are generated from the qualities of the base material (eg nails, screws, plugs, expanding bolts etc).

2.02 Clearly this grouping can create inconsistency (eg corrugated sheeting can be fixed to timber or steel purlins) and the nature of the base material becomes a determining factor in the selection of the fixing device. However, this particular problem is controlled by the requirements of water-proofing, rust-resistance and the perforating of, and overall compatibility with, the sheets. The groups used in this handbook are those recognised by the fixings industry.

3 Arrangement of the handbook

3.01 A design guide is included before the information sheets which defines the significant factors influencing selection or application. In most instances the over-riding factors are self-evident, but the guide should provide an *aide-memoire* and identify certain qualities and side effects, both desirable and undesirable.

3.02 The remainder of the handbook consists of general information and details of the fixing devices readily available within the families shown in the contents list.

4 Effect of metrication

4.01 The fixings industry will change to metric sizes more slowly than other sections of the building industry. There is little incentive to rapid change and, in most cases, it is not important to the strength and security of the fixing, nor is there any effect on dimensional co-ordination.
Some fixings are already available in metric sizes: the majority are not. Confusion is inevitable for a year or two as manufacturers gradually switch their ranges from imperial to metric. This handbook attempts to indicate sizes available but some rounding up or down will occur in manufacturers' catalogues. The differences in most cases may be marginal; the fixing principle will remain unaltered. Table II gives a comparison of diameters for nails and screws in inches, millimetres and gauge sizes. Each information sheet throughout the handbook contains a note about the current position for that type of fixing.

Table II *Comparison of diameters (gauges)*

scale of diameters: inches	scale of diameters: millimetres
	0.0
	1.0
1/16	
	2.0
1/32	
	3.0
1/8	
5/32	4.0
3/16	
	5.0
7/32	
	6.0
1/4	
	7.0
9/32	
5/16	8.0
11/32	
	9.0
3/8	
	10.0

woodscrew gauge		nails etc SWG		self-tapping scews A & B gauge		machine screws UNC/UNF		machine screws BA		machine screws ISOMetric	
		20	0.9								
		19	1.0								
		18	1.2								
		17	1.4								
0	1.52	16	1.6								
1	1.78	15	1.8								
2	2.08	14	2.0	2	2.18			8	2.18		
3	2.39	13	2.3					7	2.50	M2.5	2.5
4	2.74	12	2.6	4	2.84	4	2.84	6	2.74		
5	3.10	11	2.9					5	3.20	M3	3.0
6	3.48	10	3.3	6	3.50	6	3.50	4	3.51	M3.5	3.5
7	3.50	9	3.7	7	3.83						
8	4.17	8	4.1	8	4.16	8	4.16	3	4.08	M4	4.0
		7	4.5					2	4.75		
10	4.88	6	4.9	10	4.83	10	4.83			M5	5.0
12	5.59	5	5.4	12	5.49			1	5.31		
		4	5.9					0	6.00	M6	6.0
14	6.30	3	6.4	14	6.15	1/4"	6.40				
16	6.94										
18	7.72					5/16"	7.93			M8	8.0
20	8.43										
						3/8"	9.53			M10	10.0

Solid circles represent diameters at approximately full size. Dimensions in mm are listed to the right of each column; mm/inch scale is 20 × full size
BS specifications allow variations in diameter to allow for manufacturing tolerance and tool wear

Design guide
Fixings and fastenings

How to use this guide

The guide is divided into two main sections: 1 Selection of fixings; 2 References. Section 1 defines significant factors and establishes a procedure to be followed when evaluating and selecting fixings. Section 2 lists legislation affecting fixings and fastenings and notes some basic reference books in a select bibliography. A fuller list of references for more detailed study is given in appendix 3 at the end of the handbook.

1 Selection of fixings

1 Structural requirements

1.01 Calculate loading
Weight of component

Live load	Check statutory requirements (eg imposed lateral load applied horizontally to handrails)
Vibration	In use and during fixing
Shock	Including effects of vandalism

1.02 Evaluate characteristics of component to be fixed
Rigidity

Restrictions on fixing	Positions, spacing, type of fixings
Use of brackets	
Position of holes, slots	Preformed in factory or on site
Possible damage	Tendencies to split, crush, warp, bend, shear or pull through
Possible change of properties	For example chipboard, when wet
Need for special preparation	For example clearance holes

1.03 Evaluate characteristics of base to accept fixing:
Rigidity

Restrictions on fixing	Positions, spacing, type of fixings (eg position of reinforcement in concrete)
Compatability with component	
Possible damage	Tendencies to shatter, crush, bend, shear or pull through (eg shot firing techniques may be influenced by position of reinforcement, choice of aggregate etc. Some structural engineers and contractors limit their use)

Physical composition	Ability to hold nails and screws, resist plug expansion and expansion bolts. (See information sheet FIXINGS 3)
Ductility	Capacity to distribute stress
Special preparation	For example priming or pilot holes or swarf removal or degreasing (important for adhesives)
1.04 Establish if component is to be fixed to more than one base material	This is a common occurrence in wall mounted components in rc framed buildings (eg handrails fixed to concrete and brick or block)
1.05 Check whether component requires additional provisions in base material to accommodate fixing	A common failure is found in flush bolts and kick plates in hollow and semi-solid core doors where insufficient blocking is allowed to carry all screw fixings satisfactorily
1.06 Assess alternative ranges of fixing	From characteristics established above select possible ranges of fixings and preferred spacings

2 Movement

2.01 Movement required after completion:	
None (rigid)	Movement may be due to anticipated structural (base) movement; component movement; thermal movement; working requirements (eg hinge)
One way	
Two ways	
Three ways	
2.02 Movement required during fixing (fixing tolerance):	
One way Two ways Three ways	Movement may be due to, or influenced by large size of component (handling difficulties); manufacturing tolerances; marking and preparation; location problems; timing of fixing; timing of preparation (holes etc); location of other associated components; degree of final accuracy required. Linear fixings giving tolerance in one direction are often used in conjunction with component or intermediate bracket giving tolerance in other directions (eg dovetail anchor slot cast into or mounted on base material. See information sheet FIXINGS 9)

3 External effect

3.01 Check any serious effects due to vibration, noise or dust produced by preparation or fixing:	Devices involving vibration or shock may be restricted in building programme, eg to avoid unnecessary damage to rendering, tiling etc. Vibration may be avoided or minimised by use of screws instead of nails, or diamond drills instead of percussive tools
Structure	
Other components	
Finishes	
Building inhabitants	
3.02 Check any effects on performance of fixing	

4 Durability

4.01 Assess necessary degree of resistance to damage and corrosion:	Nearly all fixing devices are available in a wide range of materials. Corrosion of fixings by inadequate or faulty specifications is one of the most common causes of building failure
Moisture (rain, condensation)	
Steam	

Frost

Chemicals

Ultra-violet light

Oxygen

Electrolysis

Stress

4.02 Establish if applied finish required to guarantee resistance

Painting, plating, galvanising (after cutting and drilling) etc

4.03 Select from available materials

5 Removability and adjustment

5.01 Establish designed life of components
Permanent

Temporary (for re-use)

Temporary (for scrap)

5.02 Establish if component is to be removable

For maintenance, security, replacement (breakages etc)

Not at all

Frequently

Occasionally

Parts only

For example glazing beads

5.03 Establish any periodic adjustment that may be necessary to fixing

5.04 Determine qualities required for removing and adjusting fixings

5.05 Consider use of temporary fixings during erection

Temporary fixings may be needed as an aid to assembly before placing final fixings

6 Appearance

6.01 Establish policy:

It may be necessary to provide in a building owner's manual a complete guide to operation of unseen fixings (eg glazing beads with hidden clips) which can be seriously damaged by incorrect removal

Visible

Invisible

Only removable parts visible

Cleaning

Removability

Security

Cost

6.02 Check compatibility of materials and finishes

Other fixings, same component — Occasional need for matching fixings rather than materials identical to component, where special qualities of strength etc are required. Differences in ageing should be noted

Other fixings, other components

Base material

6.03 Investigate need for site applied 'camouflage'

Painting

Pellets — Metal, wood or plastic

Filling

6.04 Consider costs of alternative finishes

7 Other functions

7.01 Related to fixing performance

Other dissimilar components sharing fixings — Common practice in slab soffits where joint use of common hanger fixings can often provide economies if there is early co-ordination of service run locations and ceiling construction

Other similar neighbouring components sharing or being located by fixing

7.02 Not related to fixing performance

Location of component

Weather barrier

Incorporation of expansion joint

Thermal insulation

Condensation

8 Accessibility

8.01 Check access facilities for all component fixings — A common problem is drilling holes for base of side-string mounted balusters of stair handrails, where special drill devices may be necessary in some cases (see information sheet FIXINGS 11)

8.02 Consider drill bracing — Most drilling operations require the operator to brace himself against drill pressure—work from ladders or unbraced platforms can be difficult and dangerous

8.03 Consider lifting of heavy plant to high levels — For example welding equipment

9 Responsibility

9.01 Establish who is to provide fixing — This information should be clarified on detailed drawings and in bill of quantities

Contractor

Specialist subcontractor

9.02 Establish who is to fix fixing

Contractor; Specialist subcontractor

9.03 Establish who is to carry out preparation

For example drilling, bracing. Contractor; Specialist subcontractor

9.04 Establish who is to mark positions of fixings

Contractor; Specialist subcontractor

9.05 Check responsibility for access

10 Programme

10.01 Establish programme for fixing, or preparation of fixings

If this cannot be left to the contractor to decide

11 Review, final selection and spacing

11.01 Make final appraisal of performance rating and cost

Detailed description of fixings should be given in contract documents where possible, with information on preparation work

11.02 Finalise information on spacing

Spacing recommendations of supports and fixings into supports for various board materials are given in information sheet FIXINGS 1

2 References

12 Legislation

There is no specific legislation relating to fixings and fastenings. Structural safety and security of fixings however must conform to requirements of Building Regulations, Acts and by-laws currently in force. The main ones are listed below

The Building Regulations 1965 [(A3j)]

Regulations covering materials, stability (spacing) and performance

The Building Standards (Scotland) Regulations 1963 [(A3j)]

London Building Acts 1930-39 Constructional By-laws [(Ajn)]

Applies to the inner London boroughs

13 Selective bibliography

1 *Assembly and Fastener Engineering*. Monthly journal, Morgan Grampian.

2 Building fasteners handbook. Supplement to *Assembly and Fastener Methods*, Grampian Press [Xt5] *Out of print*

3 CLEMENTS, R. (ed) *et al.* Manual of light production engineering, vol 1: Assembly methods and types of fasteners. London, 1967, Business Books [Xt5] *Price £6·30*

4 GRIFFITHS, A. (ed). Fasteners handbook, Design Engineering Series. London, 1969, Morgan Grampian [Xt5] *Price £2·75*

5 LAUGHNER, V. and A. HARGAN. Handbook of fastening and joining of metal parts. New York, 1956, McGraw-Hill [Xt5] *Price £5·63, out of print*

BRITISH STANDARDS

BS 1494: part 1 1964, part 2 1967: Fixing accessories for building purposes [Xt5]

BS 1202: part 1 1966, part 2 1966, part 3 1962: Nails [Xt5]

BS 1210: 1963 Wood screws [Xt5]

BS 57: 1951 B.A. screws, bolts and nuts [Xt5]

BS 916: 1953 Black bolts, screws and nuts [Xt5]

BS 499: 1965 Welding terms and symbols [(D4)]

Information sheet
Fixings 1

Nails

This information sheet describes types of nails and their applications. Available sizes, structural strength and relative costs are also tabulated

1 Introduction

1.01 The nail is one of the oldest fixing devices—the earliest known use is at Ur, 2000–3000 BC. At Susa, wheels made around 2000 BC have been discovered with between 200 and 300 copper nails fixing rims of the same metal.
Later, the Romans built up a nail-making industry on a large scale, and possibly there were factories in Britain. In 1961 a store of 875 000 Roman nails totalling 7 tons was discovered in Scotland at Inchtuthil. The modern industry dates from 1565 and is the result of co-operation between a German named Schutz and the English Assay Master, William Humphrey. It grew up mainly in the area of Duxley and Bromsgrove **1**.

1.02 Nails are currently produced in copper and aluminium as well as in various types of steel, of which plain mild steel is by far the most common, used in wire nails. Cut nails are made from black rolled steel. Apart from material and finish, nail design varies in shank section, shank profile and head style.

1.03 Fixing devices are now available, using pressed or stamped sheet metal, to replace traditional timber/timber and timber/masonry jointing methods.

1.04 Types of nail and non-nail fasteners are described and illustrated in tables I and II.

1.05 Table III gives comparative costs of the most widely used nails.

2 Sizes

2.01 There is still a good deal of confusion about the policies of leading nail manufacturers regarding the change to metric. One firm, however (Rylands), is already manufacturing nails in rounded millimetre lengths to diameters of the traditional swg (standard wire gauge); these sizes have been included in the tables. It is probable that swg diameters will eventually be dropped in favour of millimetres. Nails are normally specified by length first (eg 3in × 10 swg or 80 mm × 3 mm).

2.02 BS 1202 contains preferred sizes (imperial) which are still widely adopted by the industry. Tables IV to XV show currently available sizes for most of the nail types in common usage.

1 *The 1736 edition of the* City and country purchaser and builders' dictionary *lists over 30 types of nail, each with a range of sizes classified by the weight per thousand, and many with names still in current use—clasp and clout nails, brads, tacks, etc*

26. *To Toughen Nails.*] Brittle Nails may be toughen'd by heating them hot in the Fire, in a Fire-ſhovel, or the like, and putting ſome Tallow, or Greaſe to 'em; the firſt is beſt.

27. *Of driving.*] There is requir'd a pretty Skill in driving a Nail, for if, when you ſet the Point of a Nail, you be not curious in obſerving to ſtrike the flat Face of the Hammer perpendicularly down upon the Perpendicular of the Shank, the Nail, unleſs it have good Entrance, will ſtart aſide, or bow, or break, and then you will be forced to draw it out again; therefore, when you buy a Hammer, chuſe one with a true flat Face.

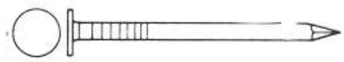
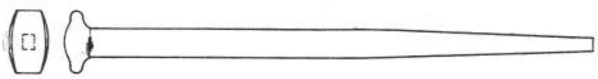
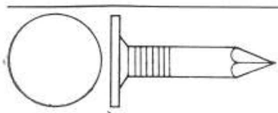
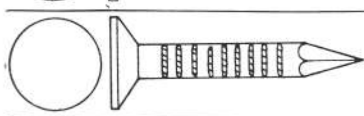
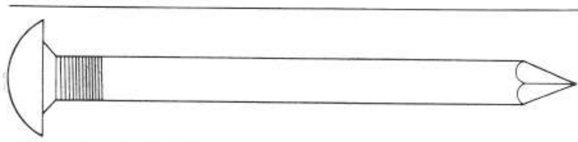
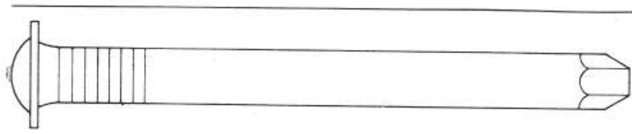
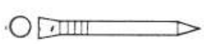
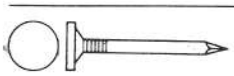
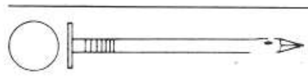
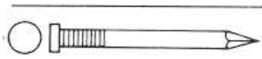
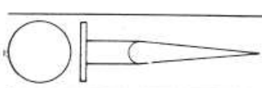
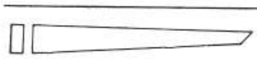
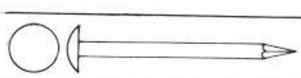
Perhaps it may not be unacceptable to ſome Readers, if I here mention a little Trick that is ſometimes

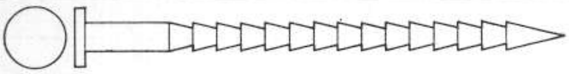
N E

uſed among ſome (that would be thought cunning Carpenters) privately to touch the Head of the Nail with a little Ear-wax, and then lay a Wager with a Stranger to the Trick, that he ſhall not drive that Nail up to the head at ſo many Blows. The Stranger thinks he ſhall aſſuredly win, but does aſſuredly loſe; for the Hammer no ſooner touches the Head of the Nail, but inſtead of entring the Wood, it flies away, or ſtarts aſide, notwithſtanding his utmoſt Care in ſtriking it down-right.

1

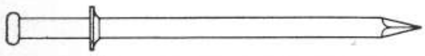
Table 1 *Types of nail*

	Round wire nail: (sometimes known as 'French nail') used for general purpose carpentry mainly in unseen situations. Pilot holes may be necessary to avoid splitting timber
	Purlin nails: 150, 200 and 250 mm long, relatively thin (3·7 mm) copper nails
	Lost head nails: can be punched below the surface and filled—can be obtained with round or oval section of shank, and with alternative brad heads in most sizes. Ovals are less likely to split wood. Round section nails are sometimes used for flooring, instead of cut floor brads
	Cut floor brads: made from flat steel sheet, used to fix floor boarding, flat point cuts wood fibres without wedge action and does not usually split timber
	Cut clasp nail: made from flat steel sheet, used frequently for heavy carpentry and fixings to masonry—difficult to extract
	Clout nails: ('slate nails')—used for roofing, roof felt, external fencing, etc
	Extra large head clout (felt nails)—smaller sizes (max 30 mm) for felt fixing
	Clout head tile peg: steel or aluminium clout with alternative sharp or 'dumped' (blunted) point—for roof tiling
	Nails for corrugated sheet roofing: Round nails Nipple head nails Spring head nails (with washer) } galvanised steel and aluminium with convex heads
	Pipe nails: (chisel point nail)—used to fix rainwater goods into masonry
	Panel pins: small head, fine gauge and easily punched home and filled—for fixing plywood and other joinery
	Hardboard panel pins: (hardboard pins)—obtainable in round or square section shank, both types having diamond profile head which is hidden in the hardboard when driven home
	Lath nail: traditionally for fixing plaster and similar laths to softwood—flat, fairly small head
	Plasterboard nails (jagged shank): countersunk head and indented shank to assist retention
	Gimp pin: small pin with relatively large head. Used for fixing materials to framework in upholstery work
	Cut lath nail: sharp long point—for fixing laths—wedge action may split wood but head holds both sides firmly
	Cedar shake nail: a copper or aluminium pin for fixing cedar cladding
	Tack: for fixing fabric to wood, or carpets to flooring
	Sprig: headless tack for fixing glass into wood frames
	Escutcheon pins: brass convex head pin for fixing escutcheon plates

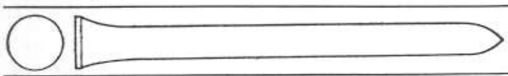


Annular nail: ringed shank provides considerably increased resistance to withdrawal. Used in non-ferrous form for boats and external joinery generally

Helically threaded nail: for roofing, especially corrugated sheet. Thread gives some increased resistance to withdrawal



Duplex head nail: (double head shutter nail)—for temporary fixing where ease of withdrawal is important



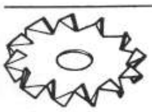
Masonry nail: hardened steel pin to penetrate and hold in masonry and concrete

Staple: usually made from galvanised steel wire—two available point designs (presser and diamond). Tenterhook is staple with one leg longer than the other, allowing easier 'two-stage' fixing

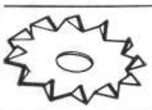
Table II *Non-nail fasteners*

Corrugated joint fastener: for fastening mitred and butt joints in timber; taper draws work together. Available in units or coils. Depths: $\frac{1}{4}$in, $\frac{3}{8}$in, $\frac{1}{2}$in, $\frac{5}{8}$in, $\frac{3}{4}$in, $\frac{7}{8}$in, 1in; width: varying

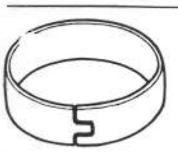
***Bolted connectors:** designed to spread load over a greater distance than with a single bolt*



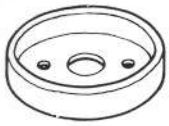
Double sided toothed plate: for permanent timber to timber connections



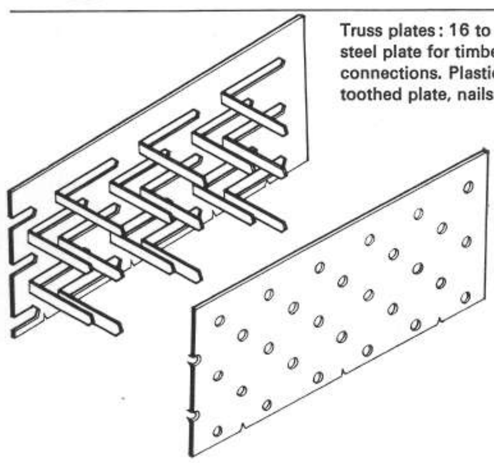
Single-sided toothed plate: dismountable; for timber to metal connections



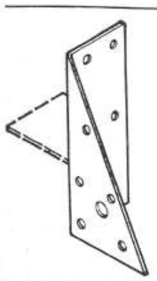
Split ring: for timber to timber connections; higher load capacity than toothed plates. Timber is grooved to receive ring



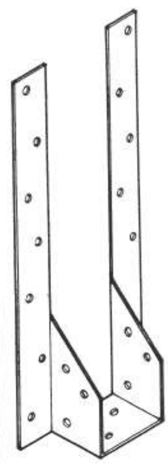
Shear plate: for timber to metal or timber (use double plate). Similar load capacity to split ring



Truss plates: 16 to 20 g galvanised steel plate for timber to timber connections. Plastic is used to fix toothed plate, nails for holed plate

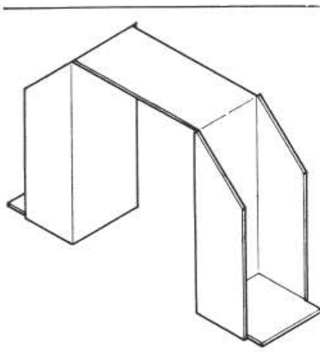


Framing anchor: for joist to joist connections

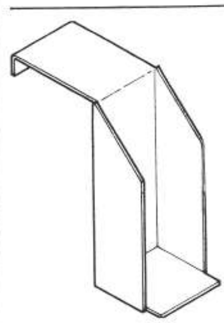


Joist hangers: for timber to brick or timber connections

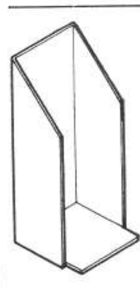
1 joist trimming



2 stirrup over brick or concrete



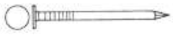
5 to be built into brick



6 to be built into concrete

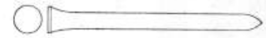
Table III *Sizes of round wire and purlin nails*

Key
- ● Steel nails
- ○ Copper nails
- ⬤ Purlin nails



Length in	mm	0·9 mm 20 swg	1·0 mm 19 swg	1·2 mm 18 swg	1·4 mm 17 swg	0 sg 1·6 mm 16 swg	1 sg 1·8 mm 15 swg	2 sg 2·0 mm 14 swg	3 sg 2·3 mm 13 swg	4 sg 2·6 mm 12 swg	5 sg 2·9 mm 11 swg	6 sg 3·3 mm 10 swg	7 sg 3·7 mm 9 swg	8 sg 4·1 mm 8 swg	9 sg 4·5 mm 7 swg	10 sg 4·9 mm 6 swg	11 sg 5·4 mm 5 swg	12 sg 5·6 mm 4 swg	13 sg 5·9 mm 3 swg	14 sg 6·3 mm 2 swg	15 sg 6·7 mm 1 swg	16 sg 7·0 mm 0 swg	17 sg 7·4 mm	18 sg 7·7 mm	19 sg 8·0 mm
½	12·7	●		●																					
	15				●																				
⅝	15·9				●																				
¾	19·1			●	●	●	●																		
	20				●	●																			
⅞	22·2						●																		
	25					●	●	●																	
1	25·4					●	● ○	●																	
	30						●	●	●																
1¼	31·8					●	●	● ○	●																
1½	38·1						●	●	● ○	●															
	40							●	●	●															
1¾	44·5							●	●	●															
	45							●	●	●															
	50								●	●	●	●													
2	50·8							●	●	●	● ○	●													
2¼	57·2									●	●	●													
	60									●	●	●													
2½	63·5									●	●	●	● ○												
	65									●	●	●	●												
	75										●	●	●	●											
3	76·2									●	●	●	●	● ○											
3½	88·9											●	●	●	●										
	90											●	●	●	●										
	100												●	●	●	●									
4	101·6												●	●	●	●									
4½	114·3															● ○									
	115															●									
	125															●		●							
5	127															●	●	●							
	150																	●	●						
6	152·4												⬤				●	●							
7	177·8																		●	●					
	180																				●				
	200																								●
8	203·2												⬤							●					
9	228·6																			●					
10	254												⬤								●				

Table V *Sizes of masonry nails*



Key
- ▼ Countersunk
- ■ Flat
- ● Round

Length in	mm	3 sg 2·3 mm 13 swg	4 sg 2·6 mm 12 swg	5 sg 2·9 mm 11 swg	6 sg 3·3 mm 10 swg	7 sg 3·7 mm 9 swg	8 sg 4·1 mm 8 swg
¾	19·1		●				
	20					●	
⅞	22·2	▼			▼		
	25	▼	●			● ▼	
1	25·4		● ▼				
	30	▼	●			● ▼	
1¼	31·8		●				
	35	● ▼	●			● ▼	
1½	38·1		●			●	■
	40	▼	●			● ▼	
1¾	44·5		●			● ■	
	45		●			● ▼	
	50		●			● ▼	
2	50·8				▼	● ■	
2¼	57·2					■	
	60		●			● ▼	
2½	63·5					●	
	65		●			● ▼	
2¾	69·9				▼		
	75					● ▼	
3	76·2				▼	● ■	
3½	88·9					● ■	
	100					● ▼	
4	101·6					● ■	

Table VI *Sizes of steel lath nails*

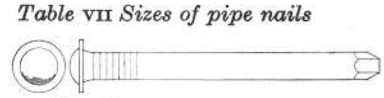
Length in	mm	0 sg 1·6 mm 16 swg	1 sg 1·8 mm 15 swg	2 sg 2·0 mm 14 swg
¾	19·1		■	■
	20	■	■	
⅞	22·2	■	■	■
	25	■	■	■
1	25·4	■	■	■
	30			■
1¼	31·8		■	■
1½	38·1			■
	40			■

Table IV *Sizes of wire steel staples and tenterhooks; sizes of machine tooled staples*

Key
- ▽ Staple
- ▼ Staple (applied by machine tool)
- □ Tenterhook

Length in	mm	Width ⅛ in 3·1 mm	7/16 in 11 2 mm	1 in 25·4 mm	Diameter (gauge) 1·6 mm 16 swg	1·8 mm 15 swg	2·0 mm 14 swg	2·3 mm 13 swg	2·6 mm 12 swg	2·9 mm 11 swg	3·3 mm 10 swg	3·7 mm 9 swg	4·1 mm 8 swg	4·5 mm 7 swg	4·9 mm 6 swg
⅜	9·5	▼	▼												
½	12·7	▼	▼	▼	▽										
⅝	15·8	▼	▼	▼	▽	▽									
¾	19	▼	▼	▼			▽								
⅞	22·2	▼	▼	▼				□							
1	25·4		▼	▼				□	▽						
1¼	31·75		▼	▼								▽			
1⅜	34·9		▼												
1½	38·1		▼										▽		
1⅝	41·27		▼												
2	50·8		▼												▽

Table VII *Sizes of pipe nails*



Key
- ● Steel pipe nail
- ▲ Aluminium pipe nail

Length in	mm	Diameter (gauge) 19 sg 8·0 mm
	50	●
2	50·8	● ▲
2½	63·5	● ▲
	65	●
	75	●
3	76·2	● ▲
3½	88·9	● ▲
	100	●
4	101·6	● ▲
5	127	● ▲
6	152·4	● ▲

Table VIII *Sizes of annular nails*

Key
- ● Steel annular nail
- ▲ Aluminium annular nail
- ■ Bronze annular nail

Diameter (gauge): sg / mm / swg

Length in	mm	0 1·6 16	1 1·8 15	2 2·0 14	3 2·3 13	4 2·6 12	5 2·9 11	6 3·3 10	7 3·7 9	8 4·1 8	9 4·5 7	10 4·9 6	11 5·4 5	12 5·6 4	13 5·9 3	14 6·3 2	15 6·7 1	16 7·0 0	17 7·4	18 7·7	19 8·0
½	12·7	■																			
⅝	15·9	■																			
¾	19·1	■		■		■															
	20			●																	
⅞	22·2	■		■		■															
	25			●																	
1	25·4	■		■		■		■													
	30			●																	
1¼	31·8			■		■		■													
	35											● ▲									
1½	38·1					■		■		■											
	40					●						● ▲									
1¾	44·5					■		■		■											
	50						●					● ▲									
2	50·8					■		■		■		■									
2¼	57·2					■		■		■											
	60							●				● ▲									
2½	63·5					■		■		■		■									
	65							●													
	70											● ▲									
	75									●											
3	76·2									■		■									
	80											● ▲									
3½	88·9											■									
	90									●											
	100											● ▲									
4	101·6											■									
	115											●									
	125													●							
5	127											■									
	150														●						
6	152·4											■									
	180																●				
	200																				●

Table X *Sizes of clout nails*

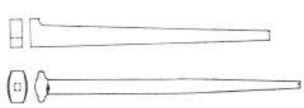
Key
Clout nails
- ● Steel
- ■ Copper
- ▲ Aluminium

Key
Large clout head nails
- ○ Steel
- □ Copper
- △ Aluminium

Diameter (gauge): sg / mm / swg

Length in	mm	0 1·6 16	1 1·8 15	2 2·0 14	3 2·3 13	4 2·6 12	5 2·9 11	6 3·3 10	7 3·7 9	8 4·1 8	9 4·5 7	10 4·9 6
½	12·7			● ▲			○ △ □	△				
	15			●	●		○					
⅝	15·9				● ▲		○ △ □	△				
¾	19·1					● ■ ▲	● △ ○ ▲ □	△ □				
	20					●	△					
	25					●	△					
1	25·4					● ■ ▲	● △ ○ ▲ □	△ □				
	30				●	●	● ○					
1¼	31·8				● ■ ▲	● ■ ▲	● ○ ■ ▲	● ■ ▲			●	●
1½	38·1				● ■ ▲	● ■ ▲	● ○ ■ ▲	● ■ ▲			●	●
	40				●	●	○	●				
1¾	44·5					● ■	● ■ ▲	● ■ ▲				
	45					●		●				
	50					●	●	●	●			
2	50·8					● ■	● ■ ▲	● ■ ▲	● ▲			
2¼	57·2							▲	▲			
	60											
2½	63·5							■	● ▲			
	65								●			
	75								●			
3	76·2								●			
3½	88·9										●	
	90										●	
	100										●	
4	101·6										●	

Table IX *Sizes of cut floor brads and cut clasp nails*



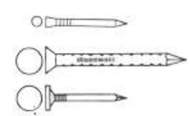
Key
- ● Steel cut floor brad
- ▲ Aluminium cut floor brad
- ○ Steel cut clasp nail

Diameter (gauge): sg / mm / swg

Length in	mm	0·9 20	1·0 19	1·2 18	1·4 17	0 1·6 16	1 1·8 15	2 2·0 14	3 2·3 13	4 2·6 12	5 2·9 11	6 3·3 10	7 3·7 9	8 4·1 8	9 4·5 7	10 4·9 6	11 5·4 5	12 5·6 4
¾	19·1			▲	▲	▲												
1	25·4					○ ▲	▲	▲										
1¼	31·8						○ ▲	▲										
1½	38·1							○ ▲	● ▲	▲								
1¾	44·5							▲	● ▲	▲								
2	50·8								○	● ▲	▲	▲						
2¼	57·2										● ▲	▲						
2½	63·5									○	▲	● ▲	▲					
2¾	69·9											●						
3	76·2										○	● ▲	▲	▲				
3½	88·9											○		▲	▲			
4	101·6													○	▲	▲		
4½	114·3														○	▲		
5	127															○		
6	152·4																○	
7	177·8																○	
8	203·2																	○

Table XI *Sizes of panel pins, plasterboard nails and gimp pins*

Key
- ● Steel panel pin
- ▲ Aluminium panel pin
- □ Hardboard panel pins
- ○ Steel plasterboard nail
- * Gimp pins



Diameter (gauge): sg / mm / swg

Length in	mm	0·9 20	1·0 19	1·2 18	1·4 17	0 1·6 16	1 1·8 15	2 2·0 14	3 2·3 13	4 2·6 12
½	12·7	●	●	● * ▲						
	15		●	●						
⅝	15·9		●	● * ▲	●		▲			
¾	19·1		●	● *	● □ * ▲	● □ * ▲				
	20			●	●	●				
	25				●	●				
1	25·4			●	● □ * ▲	● □ * ▲				
	30					●				
1¼	31·8				●	●				○
1½	38·1					●	●			○
	40					●				
	50							●		
2	50·8							●		
2½	63·5									●
	65									●
	75									●
3	76·2									●

Table XII *Preferred sizes of helical threaded nails*

Key
● Round head
■ Flat head
▲ Pan head
▼ Countersunk

Diameter (gauge)

Length in	Length mm	1 (1·8 mm, 15 swg)	2 (2·0, 14)	3 (2·3, 13)	4 (2·6, 12)	5 (2·9, 11)	6 (3·3, 10)	7 (3·7, 9)	8 (4·1, 8)	9 (4·5, 7)	10 (4·9, 6)	11 (5·4, 5)	12 (5·6, 4)	13 (5·9, 3)	14 (6·3, 2)	15 (6·7, 1)	16 (7·0, 0)	17 (7·4)	18 (7·7)	19 (8·0)	20 (8·4)
½	12·7	■	■	■	■																
⅝	15·9		● ▼	■																	
¾	19·1	■	▼ ■	■ ▼	■																
⅞	22·2	■	▼	■																	
1	25·4		● ▼ ■	▼ ■	● ▼ ■																
	30														●						
1¼	31·8		● ▼	▼	▼ ■	■															
1½	38·1		▼	▼	■	■									▲						
	40				■										● ▲						
1¾	44·5						■														
	50					■									● ▲				● ▲		
2	50·8						■								▲						
2¼	57·2																				
	60						■								● ▲				● ▲		
2½	63·5						■								▲		▲				
	65						■														
	70														● ▲				● ▲		
	75								■												
3	76·2						■								▲		▲		▲		
	80														● ▲				● ▲		●
3½	88·9																▲		▲		
	100										■				● ▲				● ▲		●
4	101·6																▲		▲		
	120														● ▲				● ▲		●
	125												■								
	140														●				● ▲		●
	150													■							
	160														●				● ▲		●
	180															■					●
	200																			■	●
	220																				●
	240																				●
	260																				●

Table XIII *Sizes of roofing nails*

Key
● Round head roofing nail: steel
○ Round head roofing nail: aluminium
△ Nipple head roofing nail: aluminium
▽ Spring head roofing nail: aluminium
▼ Spring head roofing nail: steel

Diameter (gauge)

Length in	Length mm	6 (3·3 mm, 10 swg)	7 (3·7, 9)	8 (4·1, 8)	9 (4·5, 7)	10 (4·9, 6)	11 (5·4, 5)	12 (5·6, 4)	13 (5·9, 3)	
1	25·4	▽ △	▽ △							
1¼	31·8									
1½	38·1									
1¾	44·5		▽ △							
2	50·8		▽ △		▽ △		● ○			
2¼	57·2						● ○			
2½	63·5	▽	▽			▽ △	●	● ○		
	65	▼						●	●	
	75							●		
3	76·2						●	● ○		

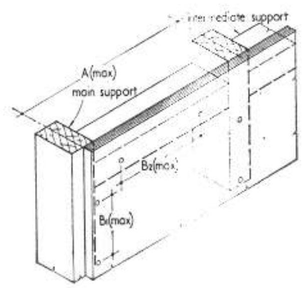


Diagram illustrates critical fixing dimensions of plywood sheathing

Table XIV *Spacing of nails: plywood floor, roof and wall sheathing*

Plywood application	Thickness	Type of fixing: Wire nails		Annularly ringed nails		Staples		Base materials	Critical fixing dimensions: Support centres (A)	Nail centres (B1)	(B2)
	mm	in × swg	mm × mm	in	mm	in	mm		mm	mm	mm
Floor sheathing	12·5	2 × 11	50 × 3	1¾	45			Joists	400	150	300
Ply used as temporary	16	2 × 11	50 × 3	1¾	45			100 mm × 50	600	150	300
flooring finish	19	2¼ × 11	60 × 3	2	50			mm; noggins up	800	150	300
	22	2¼ × 11	60 × 3	2	50			to 1800 mm	900	150	300
	25·5	2½ × 10	65 × 3·25	2¼	60			centres	1200	150	300
	28	3 × 9	75 × 3·65	2¼	60				1350	150	300
	32	3 × 9	75 × 3·65	2½	65				1500	150	300
Roof sheathing	8	1½ × 13	40 × 2·3			⅞	22	Rafters	600 (300*)	150	300
Roof design load based	9·5	1½ × 13	40 × 2·3			1⅛	29		800 (400*)	150	300
on 1·9 kN/m² or less.	12·5	1½ × 13	40 × 2·3			1½	40		1200 (600*)	150	300
Figures are for panels	16	2 × 11	50 × 3			2	50		1350 (800*)	150	300
with edges supported by noggins	19	2¼ × 11	60 × 3						1500 (1200*)	150	300
Wall sheathing	8	1¾ × 13	45 × 2·3					Studs	300 400 600	150	300
	9·5	2 × 11	50 × 3						300 400 600	150	300
	12·5	2 × 11	50 × 3						1200	150	150
Combined sheathing and cladding	9·5 (8·0†)	2 × 11	50 × 3					Studs	300 to 400	150	300
Nails to be rustproof	9·5	2 × 11	50 × 3						600 to 800	150	300
	12·5	2 × 11	50 × 3						1200	150	300

† Figure in brackets shows equivalent thickness of plywood for same span if face grain is at right angles to studs

*Figure in brackets shows recommended centres of main supports when edges are unsupported

Table XV *Sizes of lost head nails*

Key
□ Oval nails (gauge of short axis given)
● Round, steel nails (also available with brad head)
○ Round copper nails
△ Round aluminium nails

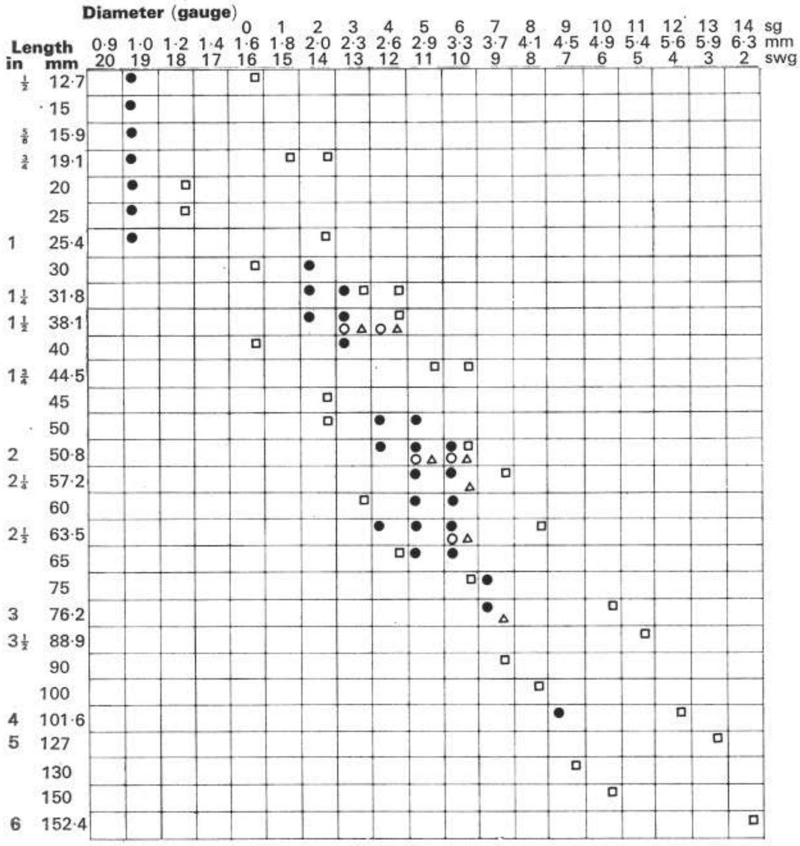


Table XVI *Comparative costs based on a comparison of 76 mm long nails*

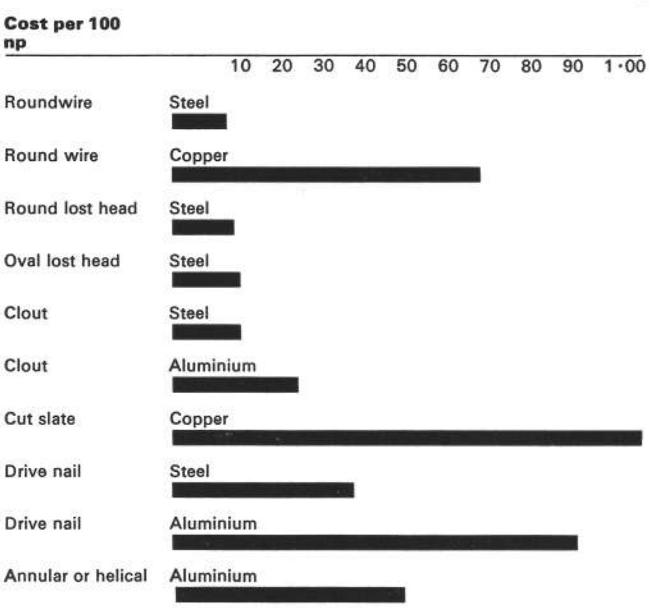


Table XVII *Spacing and length of nails for various constructional details*

Constructional detail	Minimum length of nails mm	Minimum number or maximum spacing of nails
Floor joists		
Floor joists to sill—toe nail	90	2
Header joist to joist	90	2
Header joist to sill—toe nail	90	400 mm centres
Wood or metal strapping to underside of floor joists	60	2
Cross bridging to joists	60	2 each end
Doubled header or trimmer joists	75	300 mm centres
Joist ties to joist	90	2 each end
Tail joist to adjacent head joist	90	5
(end nailed) around openings	100	3
Each header joist to adjacent trimmer joist	90	5
(end nailed) around openings	100	3
Walls		
Stud to wall plate (each end) toe nail	60	4
or end nail	90	2
Doubled top wall plates	90	600 mm centres
Bottom wall plate or sole plate to joists or blocking (exterior walls)	90	400 mm centres
Roof		
Ceiling joist to plate—toe nail, each end	90	2
Roof rafter or roof joist to plate—toe nail	90	3
Rafter plate to each ceiling joist	100	2
Rafter to joist (with ridge supported)	90	3
Rafter to ridge board—toe nail	60	4
end nail	90	3
Collar tie to rafter—each end	90	3
Collar tie lateral support to each collar tie	60	2
Roof strut to rafter	90	3
Roof strut to bearing partition—toe nail	90	2
Partitions		
Double studs at openings, or studs at partition wall intersections and corners	90	780 mm centres
Interior partitions to framing or sub-flooring	90	600 mm centres
Horizontal member over openings in non-loadbearing partitions—each end	90	2
8 mm plywood wall sheathing to supports	45	150 mm centres along edges and 300 mm centres along intermediate supports
8 mm plywood roof sheathing to supports	50	
9·5 mm plywood to supports	50	
12·5 mm plywood to supports	50	
16 mm plywood to supports	50	
19 mm plywood to supports	50	

Note: Ordinary round wire nails are commonly used—3 mm wide for 90 mm nails, 2·5 mm for 60 mm nails. Nails may be 45 mm long if annular grooved.

3 Structural strength

3.01 Comprehensive tables of maximum permissible loads for nails in single shear, and for withdrawal are given in CP 112 (both tables based upon wire nails inserted at right angles to the grain). A comparison between these tables and those for wood screws shows up to three times more resistance to withdrawal for screws. CP 112 notes that 50 per cent more withdrawal resistance can be achieved by the use of annular ringed nails.

3.02 Forest Products Research Bulletin no 41 gives permissible lateral loading for nails in both single and double shear for various species of timber.
Size and spacing of nails for various types of construction are given in tables XIV, XVII and XVIII.

Table XVIII *Spacing of fixings: board and sheet materials on timber studding/joists*

Type of board	**Thickness** mm	**Type of fixing recommended**	**Base material**	**Critical fixing dimensions Maximum support centres (A)** mm		**Maximum nail centres (B)** mm	**Minimum edge space (C)** mm
Plasterboard							
Wallboard	9·5	32 mm × 14 swg (2 mm) galvanised nails, flat head, smooth shank	Joist	400 to 450*		150	13
	9·5	32 mm × 14 swg (2 mm) galvanised nails, flat head, smooth shank	Stud	400 to 450*		150	13
	12·7	38 mm × 14 swg (2 mm) galvanised nails, flat head, smooth shank	Joist	450 to 600*		150	13
	12·7	38 mm × 14 swg (2 mm) galvanised nails, flat head, smooth shank	Stud	600		150	13
Plaster lath	9·5	32 mm × 12 swg (2·6 mm) galvanised clout nails	Joist/stud	400 to 450*		125 approx or 4 per width	13
	12·7	38 mm × 12 swg (2·6 mm) galvanised clout nails	Joist/stud	450 to 600*		125 approx or 4 per width	13
Plaster plank	19·0	57 mm special galvanised clout nails	Joist	750 to 900*		190 approx or 4 per width	13
	19·0	57 mm special galvanised clout nails	Stud	750		190 approx or 4 per width	13
Fibreboard	60 and over	32 mm × 14 swg (2 mm) lath nails, or panel/gimp pins, rust resisting	Stud/batten	400 to 450*		100	13
	12·7	32 mm × 14 swg (2 mm) lath nails, or panel/gimp pins, rust resisting	Stud/batten	450		100 at edge 200 elsewhere	13
	19	38 or 50 mm × 12 swg (2·6 mm) lath nails or panel/gimp pins, rust resisting	Stud/batten	Up to 600		100 at edge 200 elsewhere	13
Woodwool	25	50 mm special galvanised nails	Stud/batten	450		140 or 5 per width	13
	37·5	75 mm special galvanised nails	Stud/batten	450		140 or 5 per width	13
	50	87 mm special galvanised nails	Stud/batten	600		140 or 5 per width	13
Asbestos-wood	3			400		300	13
Sheets must be drilled	5	32 to 38 mm flat head nails		400		300	13
	6	or 12 swg (2·6 mm) screws	Stud/batten	600, 1200†		300	13
	10			600, 1200†		300	13
	13			600, 1200†		300	13
				Semi-compressed	Fully compressed		
Asbestos cement	3				450	300	13
Fully compressed type used for high standards of finish or higher impact resistance	5			400	600	300	13
	6 (min external use)	32 to 38 mm flat head nails or 12 swg (2·6 mm) screws	Stud/batten	600	900	300	13
	10			900	1200	450	13
	13			1200	1500	450	13
	3	12 swg (2·6 mm) wood screws (pre-drilled)	Stud/batten	600		300 in drilled holes	13
	6			600		300 in drilled holes	13
Hardboard	3·2	25 mm × 16/17 swg	Stud/batten	300 to 400*		150	10
	4·8	(1·6/1·4 mm) non-rusting		450 to 500*		150	10
	6·0	hardboard pins		500 to 600*		150	10
Plywood	5	1 in (25 mm) panel pins	Battens	400, 1200†		200	10

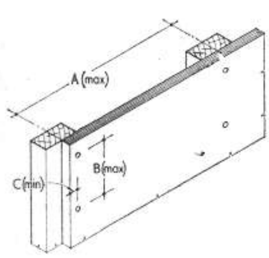


Diagram illustrates critical fixing dimensions of board and sheet materials on timber studding

*Two dimensions based on two grades, one to denote high standards of accuracy, alignment of studs and good dry conditions (grade 1) as against conditions when such standards are not present (grade 2)
†Maximum support centres at right angles to A

4 References

BRITISH STANDARDS INSTITUTION

1 BS 1202: Nails: Part 1: 1966: Steel nails: Part 2: 1966: Copper nails: Part 3: 1962: Aluminium nails [(Ajr)]

2 BS CP 112: 1967: Structural use of timber [(A3j)] *Price £2*

3 BROCK, G. R. The strength of nailed joints. Forest Products Research Bulletin 41. London, 1957, HMSO [Yi]

Information sheet
Fixings 2

Wood screws

This information sheet outlines the characteristics and sizes of screws for wood working

1 Introduction

1.01 Although screw principles had been understood for centuries, it was not until late in the 18th century that cutting devices were developed which allowed screws to be mass-produced. By the 1860s, thread designs were standardised on the basis of specifying the number of threads per inch in Britain (Continental and American practice using metric and other variants). In 1873 the firm of Nettlefold & Chamberlain maintained an annual output of over seven million gross.

2 Characteristics

2.01 The unique clamping effect obtainable with a one-piece fixing in timber makes the screw an indispensable joinery fastening. It has considerably greater withdrawal resistance than standard nails of similar size in side grain conditions[1] and can be easily removed, allowing components to be dismantled.

2.02 Apart from length and diameter, wood screws can vary in head shape, driving profile, thread design, material and finish. Standard and most used heads are given below:

Head shape

Countersunk head

2.03 This is used for general joinery. Countersunk tools prepare timber to receive the head as it is driven home. (Metal and plastic are prepared in the factory to receive countersunk screws.) The perfectly flush finish is invaluable when fixing butt and similar hinges where any head projection would cause binding **1**.

Round head

2.04 This is used to fix metal components which are too thin to incorporate countersunk heads **2**.

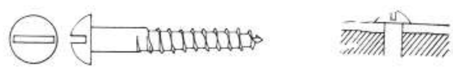
Raised countersunk head

2.05 This requires countersinking to the rim, and is most used with ironmongery where a high standard of finish is required, and also with screw cups where removal and replacement of the component is likely (eg glazing beads, access panels) **3**. Ordinary countersunk screws are also used with cups for this purpose.
An advantage of the raised head type for fixing high standard fittings is that the driver blade does not come into contact with the surface of the fitting, which is therefore less likely to be damaged.

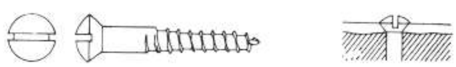
Dome head, or mirror screws

2.06 These are countersunk screws with a tapped hole in the centre of the head to accept a threaded dome which conceals the slotted head. They are used for fixing mirrors and plastic panels **4**.

1 *Countersunk head*

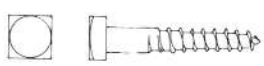


2 *Round head*

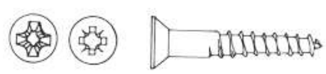


3 *Raised countersunk head*

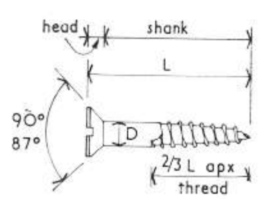
4 *Dome head*



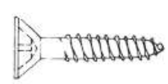
5 *Coach screws*



6 *Recessed head type*



7 *Single spiral thread*



8 *Double spiral thread*

Coach screws

2.07 These are used for heavy construction. The square headed screws are driven into the work and given the final turns with a spanner **5**.

Driving profile

Slotted heads

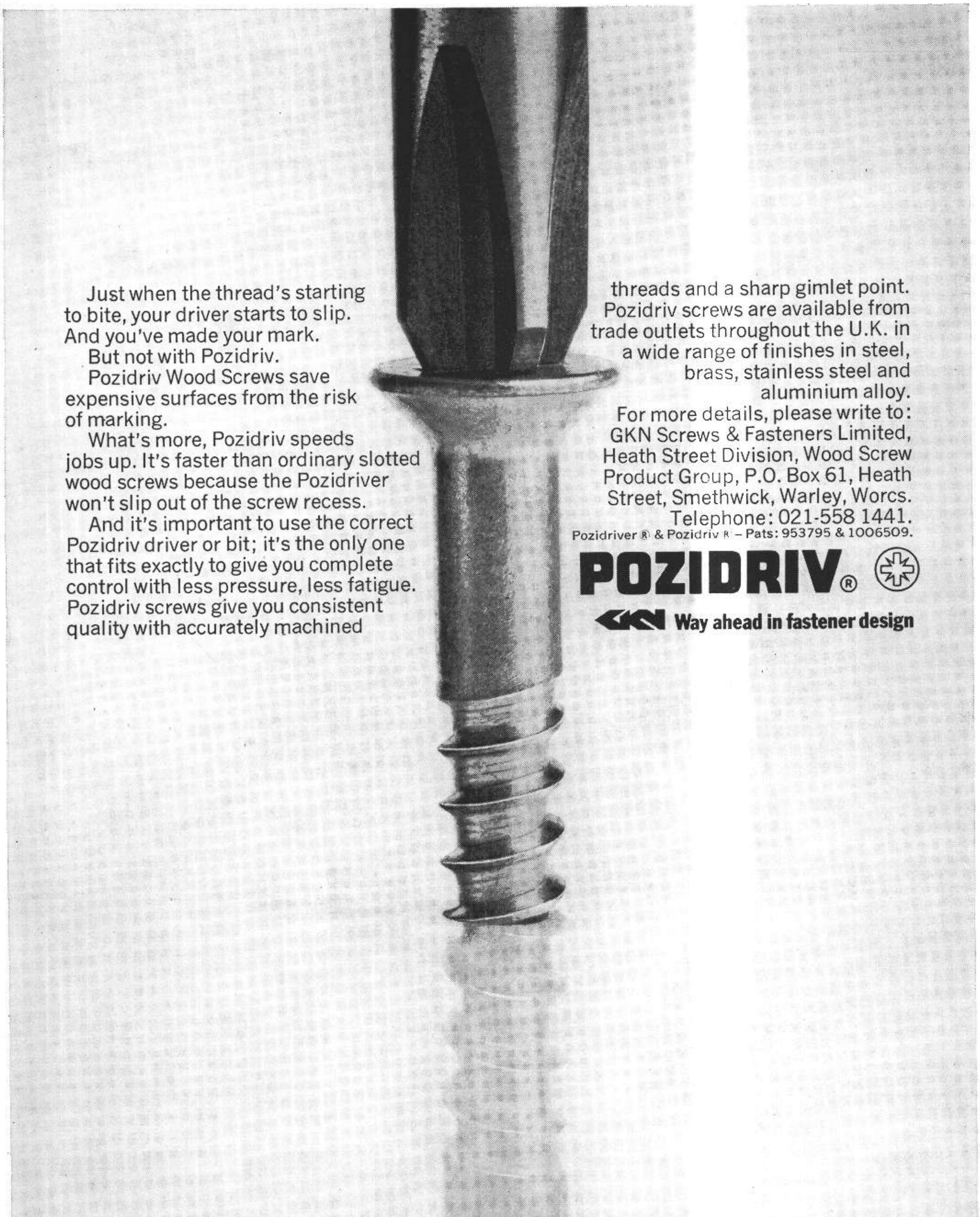
2.08 A single slot cut across the head allows a standard screw-driver to be used **1**.

Slotted and recessed head

2.9 A recessed profile with a cross-slot allows greater purchase and therefore less head damage. Special screw-drivers are required for each.
Examples Phillips recessed profile, GKN Pozidriv.

Clutch head

2.10 A non-removable wood screw. The head is a cross-slot with the anti-clockwise drive face chamfered off. It is used


Just when the thread's starting to bite, your driver starts to slip. And you've made your mark.
But not with Pozidriv.
Pozidriv Wood Screws save expensive surfaces from the risk of marking.
What's more, Pozidriv speeds jobs up. It's faster than ordinary slotted wood screws because the Pozidriver won't slip out of the screw recess.
And it's important to use the correct Pozidriv driver or bit; it's the only one that fits exactly to give you complete control with less pressure, less fatigue. Pozidriv screws give you consistent quality with accurately machined threads and a sharp gimlet point. Pozidriv screws are available from trade outlets throughout the U.K. in a wide range of finishes in steel, brass, stainless steel and aluminium alloy.
For more details, please write to: GKN Screws & Fasteners Limited, Heath Street Division, Wood Screw Product Group, P.O. Box 61, Heath Street, Smethwick, Warley, Worcs. Telephone: 021-558 1441.
Pozidriver ® & Pozidriv ® – Pats: 953795 & 1006509.
POZIDRIV®
GKN Way ahead in fastener design
This is where other screws score heavily.

in eg railway carriages, where there is a risk of vandalism.

Thread design

2.11 The standard traditional thread is a single spiral, the thread being cut for two-thirds of the total length (this applies to all head types and is laid down in BS 1210: 1963[1]). Milled screws are also available with conic core and single spiral thread extending to tip to facilitate centring **7**. Example Britfast screws (Metal Fasteners Ltd).

Double spiral thread

2.12 This recent innovation has a greater proportion of thread length (up to and including 19 mm lengths are threaded completely), and the unthreaded part of the shank is relieved, ie of smaller diameter than that of the threads, which reduces the splitting effect of the conventional thread **8**.
This screw is claimed to be faster driving, self-centring and to have up to 25 per cent more holding power when fixing thin components. For this reason it is particularly suitable for low density chipboard, blockboard and fibreboard. The shank is cylindrical. Example: Twinfast (GKN Ltd).

3 Material and finish

Steel

Self-colour

3.01 This will rust if moisture is present.

Bright zinc plate

3.02 Bright coating suitable for dry interior applications where unpainted, both interior and external when painted.

Sherardised

3.03 Sherardised steel has a dull grey protection coating which provides a good base for painting; may turn brown if not painted.

Black japanned

3.04 This black enamelled screw is suitable for general interior use; externally it must be repainted to avoid corrosion. Most common in round-head style, for fixing low cost black enamelled ironmongery.

Berlin blacked

3.05 This is similar in type and use to japanned but duller in finish; available only in countersunk head style.

Blued

3.06 Blued steel has a dark blue/black oxide coating with protective lubricating oil finish (for temporary protection only; painting is necessary in most applications); available only in countersunk head style.

Electro-brassed

3.07 This shiny yellow simulated brass finish on steel is a cheaper alternative to real brass. For dry interior work only, usually in fixing brass components.

Dark florentine bronze

3.08 A dark (nearly black) finish for interior use with oxidised copper fittings.

Light bronze metal antique

3.09 A mid-brownish-bronze finish for interior use with matching fittings.

Antique copper bronze

3.10 A dark brownish-bronze for interior use with matching fittings.

Nickel plated

3.11 A bright reflective finish which may tarnish and should be used only for dry interior work.

Cadmium plated

3.12 A bright reflective finish which may tarnish and should be used only for dry interior work.

Barrel chromium plated

3.13 A more durable bright reflective finish for fairly dry interior work.

Brass

Self-colour

3.14 A consistent bright yellow non-rusting finish, for all joinery uses and for fixing brass components.

Barrel chromium plated

3.15 A brilliant finish for use with matching components.

Nickel plated

3.16 A brilliant finish for use with matching components. Less durable than chromium plated brass, but more durable than nickel plated steel.

Light bronze metal antique

3.17 A brilliant finish for use with matching components. More durable than light bronze metal antique on steel.

Stainless steel

Self-finish

3.18 This has high resistance to corrosion and discoloration in nearly all atmospheres including coastal and industrial conditions; used in fixing stainless steel and also aluminium components.

Anodised aluminium alloy

3.19 A matt silver-grey finish, used for fixing aluminium components. Some corrosion likely in exterior applications, so this material should be regularly cleaned to slow down this process.

Silicon bronze finish

3.20 A dark brown finish, for all exterior work including boat building; often used for fixing copper and bronze components externally and internally in high-quality work.

Durability

3.21 It should be noted that most finishes on steel screws are decorative rather than protective. The stainless steel or non-ferrous ranges should be used for external applications where good durability is required without regular repainting.

4 Sizes and availability

4.01 Available sizes in wood screws in the above ranges of materials and finishes are shown in tables I to XIX.

4.02 There appears to be some confusion in plans for metricising screw ranges, but an international agreement may shortly be reached to accept the UK method of gauge

Table I *Sizes of countersunk head steel screws*

Length in	mm	Diameter 0 1·6	1 1·8	2 2·0	3 2·3	4 2·6	5 2·9	6 3·3	7 3·7	8 4·1	9 4·5	10 4·9	12 5·6	14 6·3	16 7·0	18 7·7	20 8·4 sg mm
¼	6·4	○	○	○	○	●											
⅜	9·5	○	○	○	●	□●	□●	□●		○							
½	12·7		○	○	□●	□●	□●	□●	□●	□●	○	○					
⅝	15·9			○	□○	□●	□●	□●	□●	□○	○	□●	○				
¾	19·1			○	○	□●	□●	□●	□●	□●	●	□●	○	○			
⅞	22·2					●	□●	□●	●	□●	○	□○	○				
1	25·4			○	○	□●	□●	□●	□○	□●	●	□●	□●	□	○		
1¼	31·8					○	□○	□●	□●	□●	●	□●	□●	○	○		
1½	38·1					○	○	□●	●	□●	●	□●	□●	●	○	○	○
1¾	44·5					○		□○	○	□●	●	□●	□●	○	○	○	
2	50·8					○		□○	○	□●	●	□●	□●	●	○	○	○
2¼	57·2							○	○	□	○	□	□	●	○		
2½	63·5							○	○	□	●	□	□	●	○	○	○
2¾	69·9							○		○		○	○	○	○		
3	76·2							○		●	○	●	●	●	○	○	○
3¼	82·6											○	○	○			
3½	88·9									○		○	○	●	○	○	
4	101·6									○		○	○	○	○	○	○
4½	114·3											○	○	○	○		○
5	127·0											○	○	○	○	○	
6	152·4												○	○	○	○	

Table IV *Sizes of countersunk brass screws*

Length in	mm	Diameter 0 1·6	1 1·8	2 2·0	3 2·3	4 2·6	5 2·9	6 3·3	7 3·7	8 4·1	9 4·5	10 4·9	12 5·6	14 6·3	16 7·0	18 7·7	20 8·4 sg mm
¼	6·4	○	○	○	○	○											
⅜	9·5	○	○	○	●○	●○	○	○	○	○							
½	12·7		○	○	○	●○	●○	●○	○	●○		○					
⅝	15·9			○	○	●○	●○	●○	●○	●○		○					
¾	19·1			○	○	●○	●○	●○	●○	●○	○	●○	○				
⅞	22·2					○	○	●○	○	○	○	○	○				
1	25·4				○	○	○	●○	○	●○	○	●○	○	○			
1¼	31·8					○	○	●○	○	●○	○	●○	●○	○	○		
1½	38·1					○	○	○	○	●○	○	●○	○	○	○	○	
1¾	44·5							○	○	●○	○	●○	○	○			
2	50·8							○	○	●○	○	●○	○	○	○	○	○
2¼	57·2									○		○	○	○			
2½	63·5							○		○	○	○	○	○	○	○	
2¾	69·9									○			○				
3	76·2									○		○	○	○	○	○	○
3¼	82·6																
3½	88·9											○	○	○	○		
4	101·6											○	○	○	○		○

Table II *Sizes of round head steel screws (self-colour and zinc plated)*

Length in	mm	Diameter 0 1·6	1 1·8	2 2·0	3 2·3	4 2·6	5 2·9	6 3·3	7 3·7	8 4·1	9 4·5	10 4·9	12 5·6	14 6·3	16 7·0	18 7·7	20 8·4 sg mm
¼	6·4	○	○	○	●	□		□									
⅜	9·5			○	●	□●	□●	□●		□							
½	12·7			○	●	□●	□●	□●	○	□●		□○					
⅝	15·9			○	○	□●	□●	□●	●○	□●	○	□●	○				
¾	19·1					□●	□●	□●	●○	□●	○	□○	●	○			
⅞	22·2					○	○	□○	○	●○	○	□○	●	○			
1	25·4					●	○	□●	○	□●	○	□●	●	○			
1¼	31·8					○		□●	○	□●	○	□●	●	○			
1½	38·1							□●	○	□●	○	□●	●	○			
1¾	44·5							○		●	○	□●	●	○			
2	50·8							○		○	○	□●	●	○			
2¼	57·2									○		○	○				
2½	63·5							○		○		○	○	○			
2¾	69·9																
3	76·2									○		○	○	○			
3¼	82·6																
3½	88·9												○				

Table V *Sizes of round head brass screws*

Length in	mm	Diameter 0 1·6	1 1·8	2 2·0	3 2·3	4 2·6	5 2·9	6 3·3	7 3·7	8 4·1	9 4·5	10 4·9	12 5·6	14 6·3	16 7·0	18 7·7	20 8·4 sg mm
¼	6·4		○	○	○	●											
⅜	9·5		○	○	●○	●○	●○	●○		○							
½	12·7		○	○	○	●○	●○	●○		●○		○	○				
⅝	15·9			○	○	●○	●○	●○	○	●○		○	○				
¾	19·1			○	○	●○	●○	●○	○	●○	○	○	○				
⅞	22·2					○		○		○		○					
1	25·4					○	○	●○	○	●○	○	○	○	○			
1¼	31·8					○		○	○	●○	○	○	○	○			
1½	38·1					○		○		●○	○	○	○	○	○		
1¾	44·5							○		○		○	○				
2	50·8							○		○	○	○	○	○			
2¼	57·2												○				
2½	63·5									○		○	○	○			
2¾	69·9																
3	76·2									○		○	○	○			

Table III *Sizes of raised countersunk head steel screws (self-colour and zinc plated)*

Length in	mm	Diameter 0 1·6	1 1·8	2 2·0	3 2·3	4 2·6	5 2·9	6 3·3	7 3·7	8 4·1	9 4·5	10 4·9	12 5·6	14 6·3	16 7·0	18 7·7	20 8·4 sg mm
¼	6·4																
⅜	9·5			○	●	□○		●○									
½	12·7				●	□○	□○	□○		●○							
⅝	15·9					□○	●○	□○	○	□○							
¾	19·1					□○	●○	□○	○	□○		●○					
⅞	22·2						●	●		○							
1	25·4					□○	○	□○	○	□○		●○	○				
1¼	31·8					○	○	□○		□○		□○	○				
1½	38·1							●○		□○		□○	○				
1¾	44·5									□○		□○					
2	50·8									□○		□○	○				

Table VI *Sizes of raised countersunk brass screws*

Length in	mm	Diameter 0 1·6	1 1·8	2 2·0	3 2·3	4 2·6	5 2·9	6 3·3	7 3·7	8 4·1	9 4·5	10 4·9	12 5·6	14 6·3	16 7·0	18 7·7	20 8·4 sg mm
¼	6·4																
⅜	9·5			○	○	●○		○									
½	12·7			○	○	●○	●○	●○		○							
⅝	15·9			○	○	●○	●○	●○	○	●							
¾	19·1				○	●○	●○	●○	○	●○		○					
⅞	22·2							●	○	○							
1	25·4					●○	○	●○	○	●○		○	○				
1¼	31·8					○		●○	○	●○		○	○				
1½	38·1							●○	○	●○	○	○	○				
1¾	44·5							○		○		○	○				
2	50·8							○		○		○	○				
2¼	57·2											●					
2½	63·5									○		○	○				

○ Slotted head
● Slotted and recessed head
□ Double threaded screw; slotted/recessed
Thick line encloses BS 1210 preferred sizes.

Table VII *Sizes of sherardised steel screws*

Length		Countersunk head									Round head					Raised countersunk head			
in	mm	4	5	6	7	8	9	10	12	14	4	6	8	10	12	6	8	10	Screw gauge
½	12·7	○		○		●							○						
⅝	15·9	○	○	●	○	○						○	○						
¾	19·1	○		●	●	○		○			○	○	○	○		○	○		
⅞	22·2			○	○	○													
1	25·4	○		●	●	●	○	○	○			○	○	○	○	○	○		
1¼	31·8			○	●	●	○	○	○	○			○	○		○		○	
1½	38·1			○		●	○	○	○	○			○	○	○				
1¾	44·5					○	○	○	○	○				○					
2	50·8					○		○	○	○				○	○				
2¼	57·2							○	○										
2½	63·5					○		○	○	○				○					
3	76·2							○	○	○									
3½	88·9								○	○									
4	101·6								○	○									

Table VIII *Sizes of japanned steel screws*

Length		Countersunk head								Round head									Raised countersunk head		
in	mm	4	5	6	7	8	9	10	12	2	3	4	5	6	7	8	10	12	6	8	Screw gauge
¼	6·4									○		○									
⅜	9·6	○								○	○	○	○	○							
½	12·7	○		○							○	●	○	●	○	○					
⅝	15·9	○	○	○		○						○	○	●	○	●	○				
¾	19·1		○	○	○	○		○				○	○	●	○	●	●		○	○	
⅞	22·2													○	○	○					
1	25·4			○	○	○	○	○				○		●	○	●	●	○		○	
1¼	31·8					○		○	○				○	○	●	●					
1½	38·1				○			○	○					○		●	●	○			
1¾	44·5															○	○				
2	50·8															○	●	○			
2¼	57·2																				
2½	63·5																○				

Table IX *Sizes of nickel plated steel screws*

Length		Countersunk head							Round head							Raised countersunk head					
in	mm	3	4	5	6	7	8	10	2	3	4	5	6	8	10	4	5	6	8	10	Screw gauge
¼	6·4								○		○										
⅜	9·6	○	○						○	●	●	○	●								
½	12·7	○	○	○	○					●	●	○	○	○		○					
⅝	15·9	○	○	○	○						○	○	○	○		●	○	○			
¾	19·1		○	○	○	○	○				○	○	●	●		○	○	●	●		
1	25·4				○	○	○				○		○	○	○			●	●		
1¼	31·8												○	○	○			○	○		
1½	38·1						○	○						○						○	

Table X *Sizes of barrel chromium plated steel screws*

Length		Countersunk head							Round head								Raised countersunk head					
		3	4	5	6	7	8	10	2	3	4	5	6	7	8	10	4	5	6	8	10	Screw gauge
¼	6·4										○											
⅜	9·6	○	○						○	●	○		○									
½	12·7	○	●		○					●	●	○	○		○		●					
⅝	15·9		○	●	●						●	○	●		○		○	○	●			
¾	19·1		●	○	●		○				○	○	●	○	●		●	○	●	●		
1	25·4		○		○	○	○				○		●	○	●	○			●	●	●	
1¼	31·8						○	○					○		○	○			○	●	●	
1½	38·1						○	○					○		○	○					●	
2	50·8													○	○							

Table XI *Sizes of cadmium plated steel screws*

Length		Countersunk head							Round head				Raised countersunk head		
in	mm	4	5	6	7	8	10	12	4	6	8	10	6	8	Screw gauge
⅜	9·6								○						
½	12·7	○		○		○			○	○	○				
⅝	15·9	○	○	○		○				○	○				
¾	19·1	○	○	○		○	○			○	○	○	○	○	
1	25·4			○	○	○	○			○	○	○	○	○	
1¼	31·8			○		○	○	○		○	○	○		○	
1½	38·1			○		○	○	○			○	○			
1¾	44·5					○	○				○				
2	50·8					○	○	○				○			
2½	51·2						○	○							
3	76·2						○	○							

Table XII *Sizes of nickel plated brass screws*

Length		Countersunk head						Round head					Raised countersunk head							
in	mm	3	4	6	7	8	10	3	4	5	6	8	4	5	6	7	8	10	12	Screw gauge
3/8	9·6	○	○					○	○											
1/2	12·7	○	○					○	○		○		○							
5/8	15·9		○	○					○	○				○	○					
3/4	19·1		○	○	○	○			○		○	○	○	○	○	○	○			
1	25·4			○		○						○			○	○	○	○		
1 1/4	31·8						○								○		○	○	○	
1 1/2	38·1																○	○		

Table XIII *Sizes of light bronze antique brass screws*

Length		Countersunk head								Round head			Raised countersunk head							
in	mm	3	4	5	6	7	8	10	12	4	6	7	3	4	5	6	7	8	10	Screw gauge
3/8	9·6		○																	
1/2	12·7	○	○		○					○			○	○	○	○				
5/8	15·9		○	○	○									○	○	○				
3/4	19·1		○	○	○	○	○				○			○	○	○	○	○		
1	25·4		○	○	○	○	○	○			○			○		○	○	○	○	
1 1/4	31·8				○		○	○	○							○		○	○	
1 1/2	38·1						○	○										○	○	

Table XIV *Sizes of barrel chromium plated brass screws*

Length		Countersunk head									Round head										Raised countersunk head								
in	mm	2	3	4	5	6	7	8	10	12	2	3	4	5	6	7	8	10	12	14	3	4	5	6	7	8	10	12	Screw gauge
3/8	9·6	○	○	●							○	○	○																
1/2	12·7	○	○	●	○	●					○	○	○	○	○						○	●	●	●					
5/8	15·9		○	●	○	●							○	○	○							●	○	○					
3/4	19·1			●	○	●	○	●					○	○	○	○	○					●	●	●	○	●			
1	25·4			○		●	○	●	○						●	○	○	○	○			●		●	○	●	○		
1 1/4	31·8					○		○	○	○					○		○	○	○					●		●	○	○	
1 1/2	38·1					○		○	○								○	○	○							●	○		
2	50·8																		○	○									

Table XV *Sizes of stainless steel (18/8) screws*

Length		Countersunk head										Round head						Raised countersunk head							
in	mm	2	3	4	5	6	7	8	10	12	14	4	6	8	10	12	14	3	4	5	6	8	10	12	Screw gauge
1/2	12·7	○	○	●	○	●						●	○	○				○	●	●	●				
5/8	15·9			●	○	●		○				○	●	○					○	○	●	○			
3/4	19·1			●	○	●	○	●	○			○	●	○	○				●	○	●	●			
1	25·4			○		●	○	●	●	○		○	●	●	○	○			○		●	●	○	○	
1 1/4	31·8					○		●	●	●	○		○	●	○	○					●	●	●		
1 1/2	38·1							○	○	○			○	●	●	●	○				○	●	●	○	
1 3/4	44·5							○	●	○	○											○		○	
2	50·8								○	○	○			○	●	○						○	○	○	
2 1/2	63·5								○	○	○					○							○	○	
3	76·2										○					○									
3 1/2	88·9										○														

Table XVI *Sizes of aluminium alloy screws*

Length		Countersunk head								Round head							Raised countersunk head						
in	mm	3	4	5	6	7	8	10	12	4	5	6	7	8	10	12	4	5	6	7	8	10	Screw gauge
3/8	9·6	○																					
1/2	12·7		○		○							○					○		○				
5/8	15·9		○	○	○						○	○					○	○	○				
3/4	19·1		○	○	○	○	○	○		○	○	○	○	○			○	○	○	○	○		
1	25·4		○		○	○	○	○	○			○		○	○		○		○	○	○	○	
1 1/4	31·8				○		○	○						○	○	○			○		○	○	
1 1/2	38·1						○	○	○					○	○	○			○		○	○	
2	50·8								○														
2 1/2	63·5								○														
3	76·2								○														

Table XVII *Sizes of mirror and domed screws*

Length		Domed head		
in	mm	8	10	Screw gauge
3/4	19·1	●		
1	25·4	●	●	
1 1/4	31·8	●	●	
1 1/2	38·9	●	●	
2	50·8	●	●	

Plastic or chromium plated tops are also available for 8 gauge screws

Key for tables VII to XVII
○ Slotted head
● Slotted and recessed head
Only BS 1210 preferred sizes are shown

Table XVIII *Sizes of silicon bronze screws*

Length in	mm	Countersunk head 5	6	7	8	10	12	14	16	18 Screw gauge
½	12·7		○							
⅝	15·9		○							
¾	19·1	○	○	○						
1	25·4		○	○	○	○				
1¼	31·8		○		○	○	○			○
1½	38·1				○	○	○	○		
1¾	44·5					○	○	○		○
2	50·8					○	○	○		
2¼	57·2						○	○	○	
2½	63·5						○	○	○	○
3	76·2						○	○	○	○
3½	88·9								○	
4	101·6								○	○
5	127·0									○

Key ○ Slotted head

Table XIX *Sizes of self-colour and zinc plated steel coach screws*

Length in	mm	Self-colour ¼ 6·4	5/16 8·0	⅜ 9·6	½ 12·7	Zinc plated ¼ 6·4	5/16 8·0	⅜ 9·6 in diam
1	25·4	□	□	□				
1¼	31·8	□	□	□				
1½	38·1	□	□	□	□	□	□	□
1¾		□	□	□				
2	50·8	□	□	□	□	□	□	□
2¼	57·1	□	□	□				
2½	88·9	□	□	□	□	□	□	□
3	76·2	□	□	□	□	□	□	□
3½	88·9	□	□	□	□			
4	101·6	□	□	□	□		□	□
4½	114·3		□	□	□			
5	127·0	□	□	□	□			□
5½	139·7			□				
6	152·4		□	□	□			

Key □ Square head

classification for screw diameters, together with the length in metric, eg 8 × 50 would mean size 8 (screw gauge) by 50 mm long screw.

4.03 The range of standard sizes for steel, stainless steel, brass, aluminium and silicon bronze wood screws were laid down in BS 1210:1963[1], but subsequent experience among manufacturers has led to some variation from the British Standard. Only the currently available preferred sizes have been shown in the tables, except in tables I to VI where preferred sizes are enclosed by a thick line. Other sizes are often available at increased cost, and most manufacturers will produce special sizes if sufficient quantities are involved.

5 Costs

5.01 A comparison of prices of the common ranges of wood screws of preferred sizes is shown in table XX.

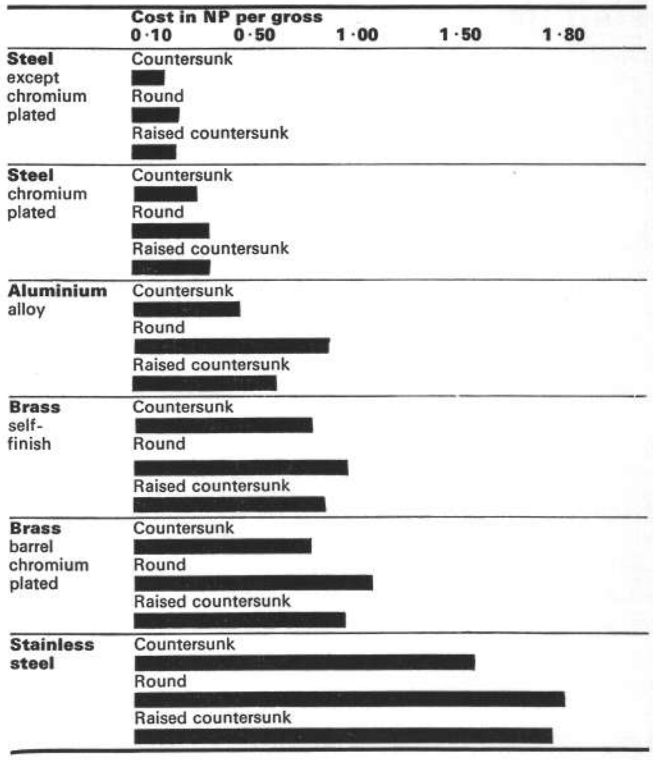
6 Specification

6.01 Screws are now specified by: length, diameter, material, head style (prefixed by method of driving). Eg '1¾in × 8 steel Pozidriv countersunk head wood screw bright zinc plated'. (Thread design should be noted if special.) From July 1971, GKN will follow international practice of indicating diameter (screw gauge) first, followed by length. Other manufacturers may also change.

7 Structural strength

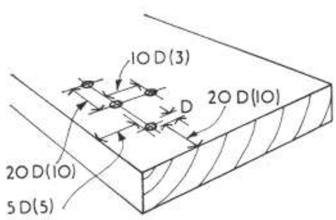
7.01 Tables giving recommended maximum loads and resistance to withdrawal of wood screws inserted at right angles to the grain are shown in BS CP 112: 1967 (tables 25, 26)[2].

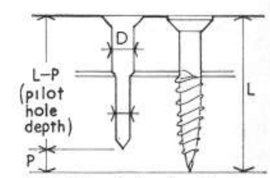
Table XX *Comparative costs based on a comparison of 50 mm × 8 gauge screws. Prices may fluctuate*



7.02 Comparison between pull-out resistance of screws, nails and light plugs in concrete block is shown in information sheet FIXINGS 3 tables I and II).

7.03 Minimum spacing of screws is shown in **14** (from BS CP 112 table 24) but may vary slightly according to type.





15 *Pilot hole depths*

14 *Minimum spacing of screws shown by number of diameters* (D). *Bracketed figures show spacing if holes are predrilled*

7.04 Pilot holes should be long enough to ensure that seven diameters of thread engage in base material (absolute minimum is four diameters). For fixing a wood component, length should be three times the thickness of the component **15**.

7.05 Diameter of the pilot hole should not exceed one-tenth of width of wood into which it is fixed. Pilot holes in softwood should be 70 per cent of screw diameter, and in hardboard, 90 per cent. In chipboard, double spiral screws are preferable, with pilot holes 60 to 90 per cent of screw diameter, depending on chipboard density.
Pilot holes are essential when fixing to chipboard. Screws driven directly into chipboard retain loosened chips within the thread. This considerably lowers holding efficiency.

References

1BS 1210: 1963 Wood screws [Xt6]
2BS CP 112: 1967 The structural use of timber [(2–) Yi8 (k)]

Information sheet
Fixings 3

Light plugs

This information sheet deals with two separate ranges of fixings, light plugs and cavity fixings, designed to support relatively light loads in a wide range of base materials

1 General

1.01 Light plugs, which are inserted into drilled holes, are available in wood, fibre, metal and plastics. They transmit the driving pressure upon woodscrews, coach screws, nails or set screws into sideways or radial thrust. Comparison between maximum pull out loads of nails, wood screws and light plugs is given in table I. Screws and nails are not usually supplied with the plug.

1.02 Cavity fixings form an anchorage behind a thin wall material where rear access is not possible, and are widely used with plasterboard partitions, hollow core boards, sheet facings and hollow clay and concrete blockwork. Fixings are usually supplied complete with screws or bolts, and the ingenuity of the devices requires the fixer to comply accurately with the instructions.

2 Light plugs

Sizing

2.01 In the change to metric the sizing of diameters may be standardised on the basis of the British screw gauge, thereby maintaining the simple method of identifying screw, plug and drill by the same code (eg size 14 gauge woodscrew may be fixed into brick, concrete or concrete block by means of a size 14 plug inserted into a hole formed by a size 14 masonry drill or a 14 percussive hand tool (see information sheet FIXINGS 2, para 6.01).

Plugs and hole-boring tools are generally available in the 'even' gauge numbers (6, 8, 10 etc) and will accommodate the 'odd' gauge screws below these sizes (5, 7, 9 etc). It should however be noted that for maximum withdrawal resistance the largest size recommended for the plug should be used. Table II gives comparison between pull-out resistance of various light plugs.

Materials

Timber

2.02 Traditional wooden plugs are still often used, particularly with nailed fixings. Hardwood plugs should be used for screw fixings. Wooden plugs should twist and grip when driven, and should be treated with preservative when used in potentially damp situations. **1**

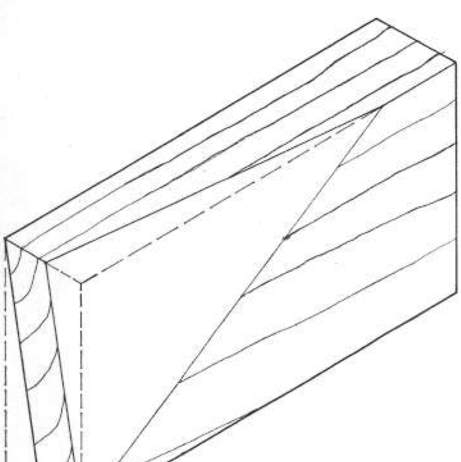
Asbestos fibre compound

2.03 These plugs (eg Rawlplastic; Philplug) are used for plugging into irregular or oversize holes. Reliable fixing can be achieved by this material, which becomes plastic when mixed with water. Formed into a plug, it can be rammed into the hole and the screw inserted immediately. Holding power is not as good as fibre plugs.

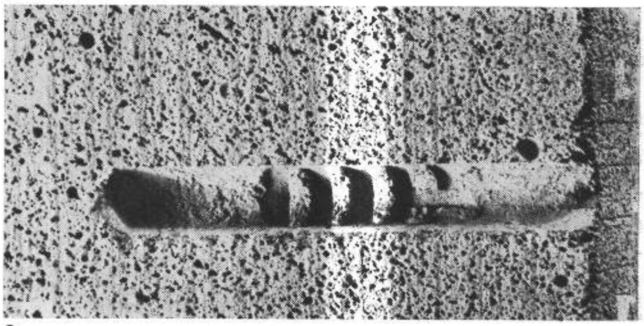
Fibre

2.04 These plugs (eg Rawlplug, Kuli fibre plug), are made of natural fibrous material impregnated with a binding agent, and are designed to accept wood screws and coach screws. Comparison of pull-out resistance of fibre plugs with that for other small fixings is given in table II.

Sizes 8, 10 and 12 are the most used in the domestic market, and 25 mm is the shortest advisable length for carrying any load. The unthreaded shank of the woodscrew must remain clear of the fibre, except where screws which are threaded to the head are specified. Fibre plugs are frequently used when replacing screws in a component such as a door hinge, where the hole in the timber has become oversize but the timber itself is sound. Also they increase pull-out resistance of woodscrews into end grain.



1



2

1 *Shape of traditional wood plug*

2 *Photo showing strong impression of plastic teeth of plug in lightweight building block*

For loads in shear it is recommended that about 75 per cent of the axial (pull-out) figures are allowed. Nails of the appropriate size can be used, in which case about 40 per cent of the screw efficiency can be expected.

The use of fibre plugs is limited only by severe conditions of dry heat. Available sizes are shown in table III.

White metal (zinc alloy)

2.05 These are suitable for conditions of extreme temperature, permanent wetness (eg swimming pools) or high corrosion. Pull-out resistance is about 60 per cent of that of the fibre plug. As the screws themselves must not be affected by the adverse conditions, cadmium plated or stainless steel screws are normally advised. Brass screws must never be used, as they react and cause galvanic corrosion. Available sizes are shown in table IV.

Lead antimony alloy

2.06 These plugs are used for excessively corrosive conditions (battery rooms and factories, plating shops etc), and they require cadmium plated or stainless steel woodscrews. Pull-out resistance is about 50 per cent of the fibre plug. For sizes see table IV.

Aluminium

2.07 There are several designs of pressed aluminium plugs available—these are relatively cheap and fairly resistant to corrosion. For sizes see table IV.

Plastic

2.08 In recent years a fairly large range of plastics plug fixings has been introduced. The materials used include nylon, PTFE (polytetrafluorethylene), acetal resin and polythene. The good spreading characteristics give very effective pull-out resistance, and the materials are tough, and have a high resistance to corrosion and aging. They are particularly effective in providing fixings to the softer concrete blocks **2**. Special designs are available for fixings to strawboard and similar base materials, with specific retention problems. For sizes see tables V to VII.

Drilling

2.09 Holes for plug fixings in base materials such as concrete and hard brick should be prepared by means of a percussive tool (hand or machine).

In the case of tungsten carbide tipped masonry drills it is important to ensure that the bit is sharp.

With hand operated percussive methods (hammer and 'jumper') the weight of the hammer should be suitable for the diameter of hole to be drilled. As a guide, it is recommended that a ¾lb (340 g) hammer used to form holes for screw gauge sizes 6 to 8; and 1½lb (680 g) for size 12 and above.

3 Cavity fixings

3.01 The use of hollow partitions, stud and masonry construction, of skeleton and honeycomb core doors, and of sheet material linings has presented many new fixing problems.

This has led to the introduction of devices, based on the principle of obtaining rear anchorage, and spreading the stress as far as possible, while operating from the face side only.

3.02 Toggle devices

These include spring, gravity, or 'cord-retention' systems. In the latter, a bar with attached cord is fed through the hole, the cord pulls the bar into the correct position at the back of the hole, where it can be locked to receive the screw. Cord retention systems can be unscrewed and refixed without losing the rear part, but with most spring and gravity systems, this part drops into the cavity, and a replacement is necessary for refixing. See tables IX to XV.

3.03 Nylon cavity fixings

The combined toughness and resilience of nylon is used to 'rivet' thin materials together. Nylon is also used to form splayed legs to give back pressure. See tables XVI and XVII.

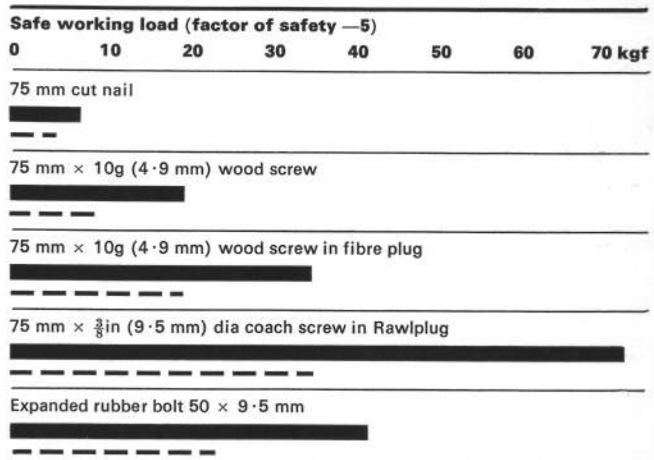
3.04 Rubber cavity fixings

Rubber or neoprene is used to build up a rear anchor by front screw pressure. This fitting is widely used in transport and industrial work where anti-vibration qualities are important. (The screw nail/plastic plug fixing, which has high 'shake-out' resistance, is also widely used in vehicle construction, particularly in jointing glass fibre components.) For sizes see table VIII.

4 Screws

4.01 Wood screws are widely used, particularly with lighter fixings. It is usually possible to use cup screw, hook screw, dome (mirror) screw and other threaded items provided that the diameter is compatible. Set screws and bolts, hooks, pipe clip and other threaded components can also be fixed directly.

Table I Comparison of pull-out loads of nails, screws and light plugs



The diagram shows recommended maximum pull-out loads for various comparable fixings inserted into 64 mm lightweight block, with a dry density of 500 kg/m³ (about one-fifth of that for normal concrete).

Safe working load in normal conditions.

Safe working load for fixtures subject to shock loading or vibration.

All nails and screws fixed without plugs, into concrete blockwork, will lose considerable holding power if overdriven. The use of round wire nails in blockwork is not recommended by some manufacturers. (Pull-out values are 70 to 80 per cent of those for cut nails). All values quoted by manufacturers are based on laboratory, not site, conditions.

Table II Pull-out resistance of various light plugs

Plug type	Concrete block type			
	Dense aggregate 2160 kgf	Granulated furnace slag aggregate 1600 kgf	Pulverised fuel ash aggregate 1490 kgf	Expanded clay aggregate 1070 density kg/m³ kgf
Rawlplug	118	113	91	91
White bronze plug	104	91	50	54
Nylon Rawlplug	113	109	86	86
Delta nylon plug	91	109	82	91
Rawlnut	136	154	91	73

Table III *Fibre plugs for wood screws*

Length in	mm	Diameter: screw gauge 3 (2·3 mm)	4 (2·6)	5 (2·9)	6 (3·3)	7 (3·7)	8 (4·1)	9 (4·5)	10 (4·9)	12 (5·6)	14 (6·3)	16 (7·4)	18 (7·7) / coach screw 5/16	20 (8·4) / coach screw 5/16	coach screw 3/8	7/16	1/2	5/8	3/4
½	12·7	●	—	—	●														
¾	19·1	●	—	—	●	—	●	—	●										
1	25·4	●	—	—	●	—	●	—	●	●	●								
1¼	31·8					—	●	—	●	●	●								
1½	38·1		—	—	●	—	●	—	●	●	●	●	●	●	●	●			
1¾	44·5					—	●	—	●	●	●								
2	50·8					—	●	—	●	●	●	●	●	●	●	●	●		
2½	63·5												●	●	●	●	●	●	
3	76·2														●	●	●	●	●
3½	88·9																	●	
4	101·6																		●

Horizontal line indicates that some plugs will take screws of smaller size (eg 12·7 × 6 sg plug will take screws of 4 to 6 sg), but for maximum withdrawal resistance the largest screw size recommended should be used.
Examples: Rawlplug (Rawlplug Co Ltd)
Kuli Fibre Plug (Ucan Ltd)

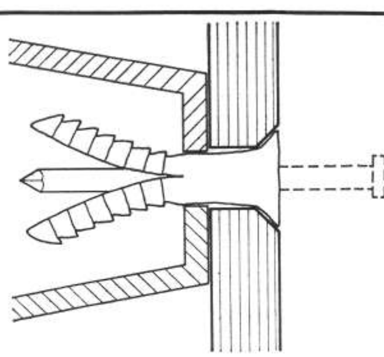
Table IV *Metal plugs for wood screws*

Length in	mm	Diameter: screw gauge 6 (3·3 mm)	8 (4·1)	10 (4·9)	12 (5·6)	14 (6·3)	16 (7·0) / coach screw ¼	18 (7·7) / coach screw 5/16	20 (8·4) / coach screw 5/16	coach screw 3/8	7/16	1/2	5/8
½	12·7	B	B										
⅝	15·9	B	B										
¾	19·1	B	B	B	A								
1	25·4	B	BL	BL	BA	B	B						
1¼	31·8		B	B	BA								
1½	38·1		BL	BL	BLA	BL	B	B	BA	B			
2	50·8		B	B	BLA	BL	B	B	BA	B			
2½	63·5						B	B	BA	B			
3	76·2									B			
3½	88·9												
4	101·6												

Key
B White bronze plugs L Lead plugs A Aluminium plugs

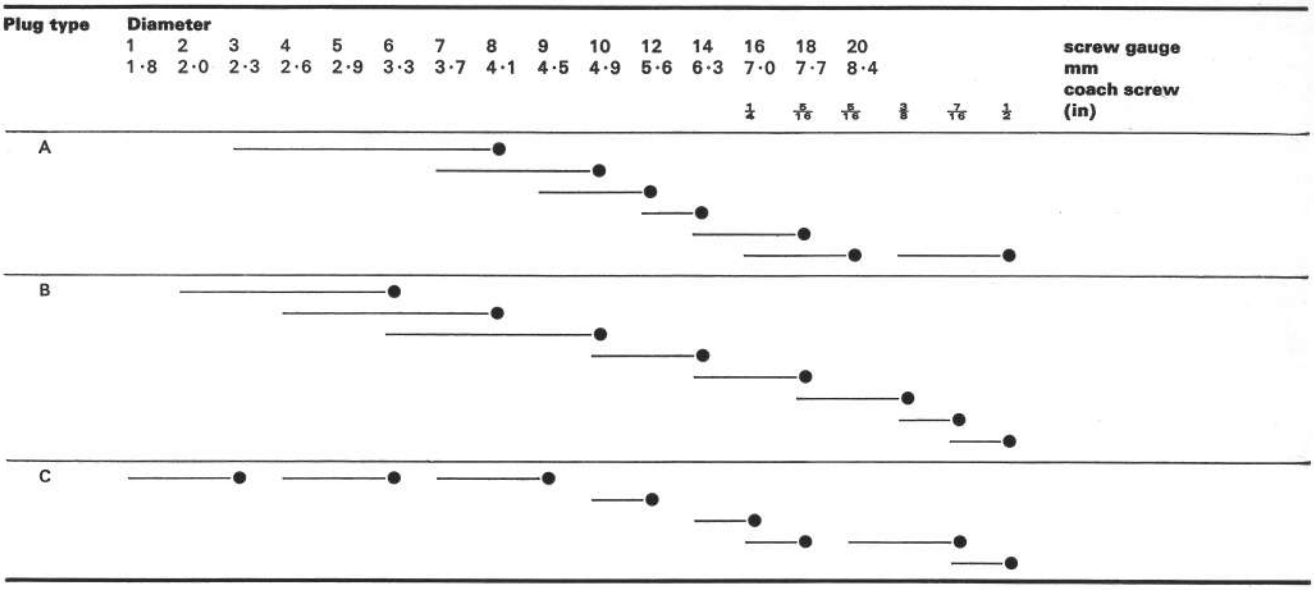
Table V *Sizes of plastic plugs for nails*

Length mm	Hole diameter 6 (4·8mm)					2 (6·4mm) (swg mm)		
Head style	Flush	Round	Flat countersunk	Mushroom	For CP screw	Round	Flat countersunk	Mushroom
8·0				●				
12·7								●
19·1	●			●	●		●	●
25·4	●	●	●	●		●	●	●
38·1		●	●			●	●	
50·8						●	●	●
76·2								●
101·6								●

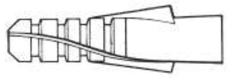


Plastic plugs for nails consist of a nylon rivet with zinc plated drive screw. Wide range of use, including fixing to fibreglass, as plugs in drilled masonry, or in hollow walls where the split parts of the shank open into a butterfly form.
Example: Tap-it plug (US Expansion Bolt Co (GB) Ltd).

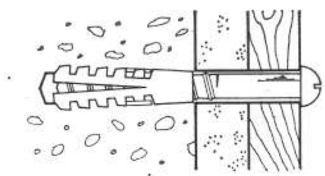
Table VI *Sizes of light plastics plugs for wood screws*



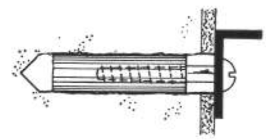
Horizontal line indicates that some plugs will take screws of smaller size, but for maximum pullout resistance, largest screw size is recommended.
A type plug: Delta spiral nylon plug (Rawlplug Co Ltd)
B type plug: Wallplug type S (Fischer Ltd)
C type plug: Thunderplug (Thunder Screw Anchors Ltd)
Perforated plastic sheeting, which is cut and rolled into plug form is also available
Example: Stripfix (Tornado Fixings Ltd).



A *type plug*



B *type plug*



C *type plug*

Table VII *Sizes of plastics plugs for wood screws*

Length	**Hole diameter** 4·8 (4–6–8–10)	6·4 (6–8–10–12)	mm / **screw gauge**
22·3	●		
28·6		●	

Can be used as a plug in drilled masonry, or in hollow block construction, wood or wallboard. Two sizes suit a total of five wood screw sizes (or self tapping screws of similar diameter). Design of plug incorporates 6 split sections—manufacturers claim that only 1/3 of usual torque is necessary to turn screw, with no loss of holding power compared with similar products.
Example: Yellow jacket plastics screw anchor (US Expansion Bolt Co (GB) Ltd).

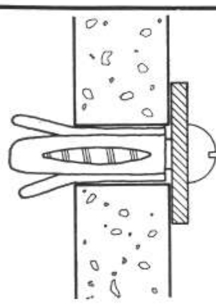
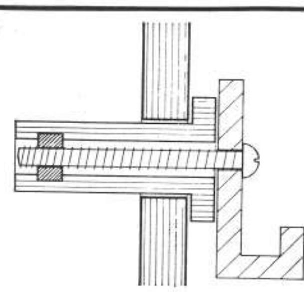
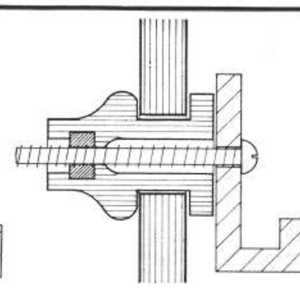


Table VIII *Sizes of rubber cavity fixings*

Minimum wall thickness mm	**Dimensions of fixing** 8·0 / 11·0	9·5 / 8·0	9·5 / 19·1	12·7 / 14·0	9·5 / 25·4	12·7 / 34·9	9·5 / 38·1	19·1 / 57·2	23·9 / 74·7	**mm A / mm B**
1·3	●	●	●	●						
6·4					●					
12·8						●				
19·1							●	●		
25·4									●	

Although originally designed for fixing into solid or hollow masonry, this device has many uses due to its airtight, waterproof and vibration resisting qualities. Available in rubber (suitable for most building fixings), or neoprene (for conditions of exposure to dry heat or hot oil).
Example: Rawlnuts (Rawlplug Co Ltd).





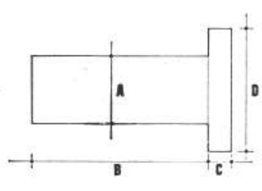
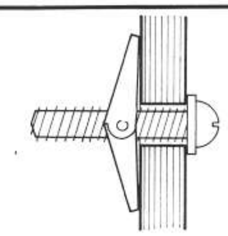


Table IX Sizes of light steel spring toggles

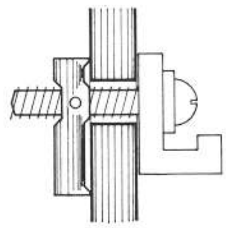
Length	**Screw diameter**			
	6	10	14	**screw gauge**
mm	3·3	4·9	6·3	**mm**
50·8	●	●		
63·5			●	



Length depends on component thickness and cavity space.
Examples: Spring toggle (zinc plated steel) (Rawlplug Co Ltd).

Table X Sizes of light steel gravity toggles

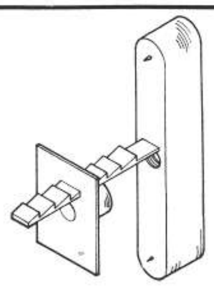
Length	**Screw diameter**			
	6	10	14	**screw gauge**
mm	3·3	4·9	6·3	**mm**
50·8	●	●		
63·5			●	
76·2			●	

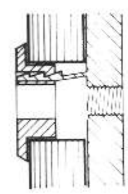


Length depends on component thickness and cavity space.
Examples: Light gravity toggle (zinc plated steel) (Rawlplug Co Ltd).

Table XI Sizes of light nylon cord-retention toggles

Length of bar mm	**Screw diameter** 8 **screw gauge** 4·0 **mm**
31·8	●
57·2	●

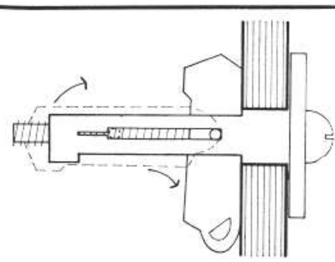




Designed for hollow ceilings, hollow walls and soft building boards. The bar is pushed through the hole and locked into position by the notched nylon strip which is then cut off.
Example: Toggle Type K (Fischer UK Ltd).

Table XII Sizes of light plastic toggle plugs

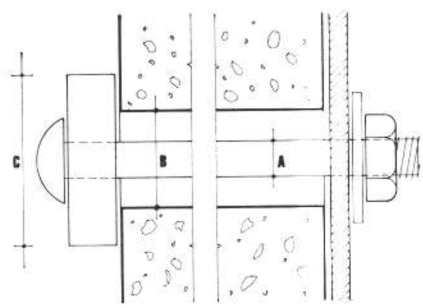
Length of bar mm	**Screw diameter** 10 **screw gauge** 4·9 **mm**
25·4	●



Bar is located by pulling a cord which is tucked behind component. This device is reusable.
Example: Toggle plug (Thunder Screw Anchors Ltd).

Table XIII Sizes of heavy steel toggle cavity fixings

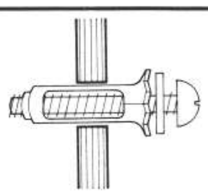
Length		**Coach bolt diameter A**						
		1/4	5/16	3/8	1/2	5/8	3/4	**in**
in	**mm**	6·4	8·0	9·5	12·7	15·9	19·1	**mm**
1 9/16	39·7	●						
2	50·8		●					
2 1/4	57·2			●				
2 3/4	69·9				●			
3 1/2	88·9					●		
3 7/8	98·4						●	

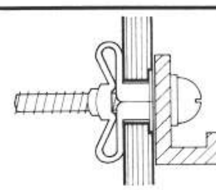


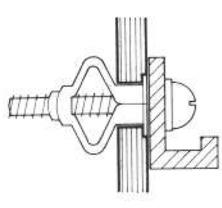
Heavy duty toggle device used with standard coach bolt. Frequently used to fix medium to heavy loads to one leaf of cavity wall.
Examples: 'H' type gravity toggles (Rawlplug Co Ltd).

Table XIV Sizes of light umbrella cavity fixings

Wall thickness	**Screw diameter**			
	6	10	14	**screw gauge**
mm	3·3	4·9	6·3	**mm**
2·4– 9·5	●			38·1 **screw length mm**
4·8–14·3		●		50·8
4·8–20·7		●		38·1
6·4–22·3			●	57·2



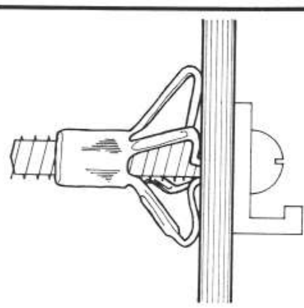




Designed for one-side fixings to plywood, asbestos, insulating and plasterboard, hardboard, these devices allow the screws to be removed and replaced. A special collapsing device is available to speed the fixing operation if a number are involved. Hook bolts are available.
Wall thickness is critical, as effective tightening may not be possible if the wall is too thin.
Examples: Rawlanchors (Rawlplug Co Ltd).

Table XV *Sizes of light umbrella cavity fixings*

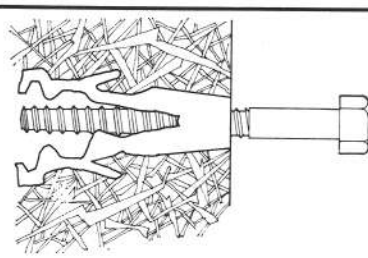
Wall thickness mm	Screw diameter 6 / 3·2	10 / 4·8	14 / 6·4	screw gauge mm
0– 4·0	●	●		30·0 **screw length mm**
5·0–12·0	●			40·0
5·0–14·0		●		45·0
9·0–15·0			●	55·0
15·0–22·0	●	●		55·0



Same applications as table XIV.
Examples: Steel or brass Fast Brolly (DOM Products Ltd).

Table XVI *Sizes of nylon cavity fixings*

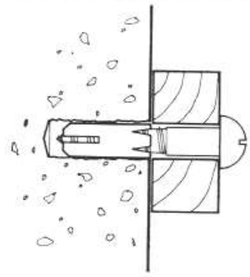
Use	Dimensions of fixing 5 **Length (mm)** 16 **screw gauge** 7·0 **screw diameter (mm)**
To fix materials to woodwool slabs	●

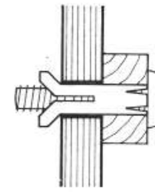


Note: Woodwool has limited carrying capacity
Examples: Wallplug Type S12D (Fischer UK Ltd).

Table XVII *Sizes of nylon cavity fixings*

Use	Dimensions of fixing 9·5 / 4 / 2·6	9·5 / 8 / 4·1	9·5 / 10 / 4·9	25 4 / 12–16 / 5·6–7·0	**Length of rivet (mm) / screw gauge / screw diameter (mm)**
To rivet materials of 6 mm minimum combined thickness	●	●	●		
To rivet materials into blind holes	●	●	●		
To rivet materials into hollow brick				●	





To rivet materials of less than 6 mm use self-tapping screws. Length of screw = length of rivet plus thickness of component to be fixed.
Example: Wallplug Type P (Fischer UK Ltd).

Table XVIII *Sizes of light/medium expansion plugs for set screws and bolts (non-ferrous)*

Length mm	Screw diameter 8 / 4·1	10 / 4·9	14 / 6·3	20 / 8·4	**screw gauge mm**
20·0	●				
22·0		●			
28·5			●		
38·0				●	

Non-ferrous metal (in this case, brass) expansion device. Screw driven wedge forces split walls of shell against masonry. Nylon pad prevents wedge from returning up the shell. Screw is removable.
Example: Rawlset (Rawlplug Co Ltd).

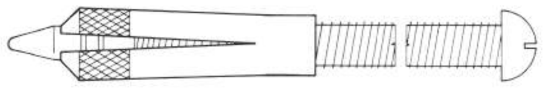


Table XIX *Sizes of light/medium expansion plugs for set screws and bolts (brass)*

Length mm	Screw diameter 14 / 6·3	20 / 8·4	9·5	12·7	**screw gauge mm**
25·4	●				
30·2		●			
34·9			●		
39·7				●	

Brass expansion device.
Example: Expansion plug (Ucan Products Ltd).

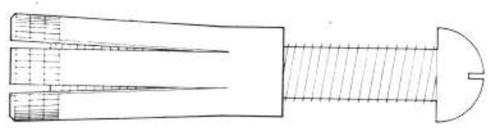
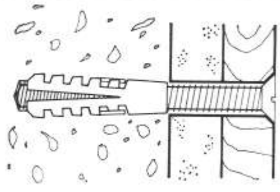


Table XX *Sizes of light/medium expansion plugs for machine screws*

Length mm	Screw diameter 8 / 4·1	10 / 4·9	14 / 6·3	20 / 8·4	22 / 9·5	12·7	**screw gauge mm**
30·2	●						
34·9		●					
41·3			●				
50·8				●			
69·9					●		
81·0						●	



Nylon expansion device. Machine bolt screws into full depth of plug, therefore depth is unlimited. Bolt must fill entire length of plug, and cuts its own thread into interior of nylon shell.
Example: Wallplug Type M-S (Fischer UK Ltd).

Information sheet
Fixings 4

Heavy masonry fixings

This information sheet deals with that class of fixing which would require more than a wood screw and plug, and a bolt larger than 6 mm diam. Its scope is restricted to those fixings which are applied after completion of the base element. Where location of fixing requirements can be ascertained sufficiently early, cast-in fastenings may be preferable; these are dealt with in information sheet FIXINGS 5

1 Introduction

1.01 The basis of this information is table I, which sets out the characteristics of the various kinds of heavy masonry fixings, enabling the designer to select the kind of anchor most suitable for his purpose.

1.02 The table is amplified by explanatory notes in the text. Para 2.01 to 2.10 give information on the parameters governing selection of the fixings (these are summarised in the columns of table I); para 3.01 to 3.04 and tables II to XI give information on the kinds of fixings available (these are summarised in the rows of table I). Data given should always be checked against manufacturers' literature.

2 Parameters governing selection of fixings

2.01 Load type

Dead loads are constant and calculable; they apply to almost all fixings.
Variable loads (ie live and superimposed loads, such as wind, snow, people) are not always calculable, and apply to most fixings.
Shock loads (high *degree* of impact) are associated with some reciprocating machinery, and are also a hazard with handrails etc.
Vibratory loads (high *rate* of impact) are associated usually with rotary machinery.
Particular note should be taken of vibratory and shock loads. It is not always immediately apparent that a fixing will be subject to either or both of these. Manufacturers' claims should be studied carefully; some anchors which are nominally suitable for vibratory or shock loads may be capable of sustaining these only if other conditions are satisfied—eg if the hole in the base material is precisely formed.
The direction of application of the load should also be considered: some anchors tighten in the direction of application, others do not.

2.02 Base condition and type

The selection of a fixing depends to a great extent on the condition of the base material. Concrete for instance can be brittle because of age or certain chemical environments; it can be green and weak or still subject to creep or drying shrinkage. It may have been cast in such a way that a high proportion of aggregate is present on or near the surface—this is particularly likely at slab soffits. Prestressed concrete, ultra-high early strength, no-fines and aerated concrete all complicate the choice of fixings. A different type of fixing may be required where spacing is at a minimum, or where the edge of the base material is near and unconfined.
The term 'hard' in table I means sound, dense concrete or masonry; 'soft' refers for example to lightweight concrete blocks. The meaning of 'solid' is obvious; 'hollow' means cellular, or cavitous material as for example no-fines or aerated concrete.

2.03 Corrosion resistance

Both erosion and corrosion should be considered. Certain environments may be critical and will determine the type of fixing to use.
Erosion of the base can be caused by hard anchor materials with certain types of load: steel for instance, is harder than concrete, and a steel friction anchor carrying a vibratory load may erode the concrete base and loosen the fixing.
The durability of the base material must also be considered, particularly in materials such as limestones and sandstones. In this case the preferred type of fixing may be satisfactory if its position is changed.
Fixings may be made of various materials:

1 *Ferrous metals*
Stainless steel is the most corrosion-resistant ferrous metal, and is particularly suited for fixings into concrete. Malleable iron is moderately resistant, but ordinary and high tensile steels are vulnerable. Even plated steel is often damaged during installation; the plating can be stripped off exposing the raw steel to corrosion.

2 *Zinc*
Zinc is normally fairly resistant to corrosion in general use, but is liable to attack by sulphates and chlorides. This should be borne in mind when considering fixings for clay bricks, flues and situations involving gypsum plaster in damp conditions. Zinc may also be attacked by washings from certain timbers such as oak and western red cedar.

3 *Lead*
Lead is normally very durable. It is also the softest of the metals used for anchors, and will be the least likely to erode the base. Like zinc, however, it may be attacked by the washings from certain timbers, and by lichens. If wet conditions persist, lead may be attacked by concrete or Portland cement mortars.

4 *Manganese bronze*
Manganese bronze (high tensile brass) is highly resistant to atmospheric corrosion. In a moist environment, however, galvanic corrosion can take place when in contact with copper, phosphor bronze or aluminium bronze. It is particularly likely to corrode under stress, and is therefore suited to

restraint fixings rather than loadbearing fixings.

5 *Phosphor bronze*
Phosphor bronze has a very high resistance to corrosion, though tensile strength is not as high as for manganese bronze.

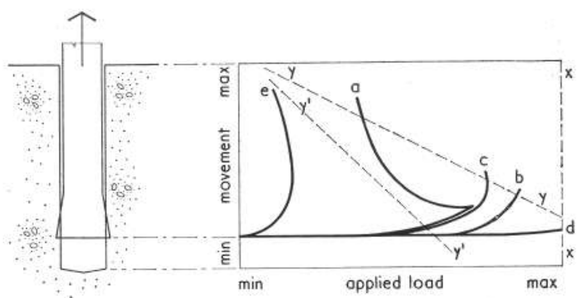
Since heavy fixings are by definition subject to comparatively high stresses, it is worthwhile mentioning the phenomenon known as environmental stress cracking. This occurs when certain materials are subject to stress in various environments which may not necessarily be hostile to the unstressed material. The combination results in cracking. The list below shows the critical situations for some of the metals used in fixings:

Metal	Environment	Hostile agent
Some copper-based alloys eg manganese bronze	Concrete foaming agents Some adhesives Cattle sheds, etc Industrial	Ammonia
Stainless steels	Industrial	Chlorides (80°C+)
High strength steels	Industrial	Nitrates
Lead	Clay bricks Supersulphated concrete Gypsum plaster Flue condensates Industrial	Sulphates

2.04 Maintenance
Although components can be easily removed and replaced with most of the fixings listed in table I, it is not always possible to remove the anchor itself should it become necessary. The table distinguishes between those types which can be removed, and those which cannot and can be maintained only by retightening.
It should be noted that while some fixings develop their maximum holding power during installation, others are not secure until the component is in position and tightened.

2.05 Phasing
The degree of accuracy of location of a fixing depends to some extent on the stage of work at which it is installed. A cast-in socket, for example, must be fixed to the formwork. Its position must be known at an early stage of the work; it will be positioned by an operative who may have no knowledge of the component to be fixed; it may be displaced or deflected by the placement of the concrete; and it is liable to damage before the component is to be secured. A through-fixing, on the other hand, is located by the actual position of the component, and is installed after the component is positioned. Cast-in fixings of the stud bolt type are even more susceptible to damage, cause obstruction on the site, and may cause damage to the base if struck and deformed.

2.06 Strength
Manufacturers' data giving figures for strength usually only include figures for ultimate failure under steady tensile loads. The figures shown in table I for strength give a rough comparison of these failure values for ½ in Whitworth (12·7 mm) studs and bolts. Generally the smaller thread sizes up to about ½in (12·7 mm) fail when the bolt snaps, and larger sizes remain secure until the surrounding masonry cone spalls away.
These figures are not entirely satisfactory in the majority of cases, since the load at failure is often not relevant when compared with the performance of the fixing *before* failure; the fixing may be considered to have become unserviceable after a degree of movement caused by partial pullout or lateral displacement has occurred. The behaviour of a fixing under load depends upon its classification, for this purpose, into one of four categories of anchorage.
Class A anchorage: Expansion of a metal shield over a narrow annular band of base material.
Single cone type anchors
Retraction stud bolts
Self drilling anchors
Toothless shell anchors
Stud bolt anchors
Class B anchorage: Expansion of a metal shield over a wide band of base material.
Caulking anchors
Double cone type anchors
Class C anchorage: Expansion of a plastics shield over a wide band of base material.
Mass expansion type anchors
Class D anchorage: The fixing is in continuous contact with the base material and conforms with its profile.
Chemical anchors
All in situ fixings. See INF: Fixings 5.



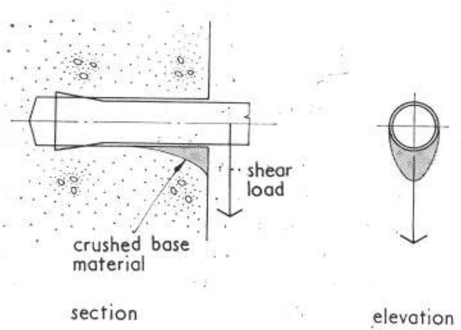
1a *Anchor fixing*
1b *Load/movement curves for axially applied extraction*

The diagram shows **1a, b** load/movement curves for axially applied extraction forces on the four classes above. Class A fixings have a clearly defined peak load after which the frictional resistance to movement decreases rapidly. Class B anchors distribute forces more evenly; holding power is improved and frictional resistance is overcome gradually. Class C anchors are similar to class B except that the plastics shield allows more initial movement by deforming itself and the overall frictional resistance is lower. Class D fixings exhibit negligible movement until failure, although chemical anchors may behave in a manner similar to class C if the bond is inferior. This may occur if dust for instance were present at the interface.
The curve 'E' illustrates the effect that an oversize hole may have on the fixing. It is not uncommon for holes to be drilled to the wrong size on building sites and it may be seen that the behaviour of the fixing may differ considerably in such a case.
The limit x–x represents the ultimate tensile load at failure of the bolt or stud. The line y–y represents the rupture resistance of the base material and y′–y′ that of a lower strength softer base material. The rupture resistance is a function of the surface area of the cone of material surrounding the anchor and so increases with depth. Failure of the base material will occur when the load/movement curve crosses the appropriate y^n–y^n line.
It should be noted that safety factors are usually taken as 5:1 for steady loads and 10:1 for shock loads. Consequently, with service loads at 10 per cent or 20 per cent of failure loads very little difference exists between the classes of fixing on a load/movement basis. Their behaviour differs more as loads are increased, or under other circumstances such as oversize holes.
Although bolts are stronger in tension than in shear, the

Table I Guide to the use of different types of heavy masonry fixings

Type and make	**Load type**				**Base type**				**Durability**	**Maintenance**		**Phasing**		**Class**	**Strength**
	Dead	**Variable**	**Shock**	**Vibration**	**Hard**	**Soft**	**Solid**	**Hollow**	**0 = poor 4 = good**	**Remove**	**Retight**	**Prepositioned**	**Through-fixed**	**Load;mov.**	**Steady tensile load at failure in kg of ½in whit (12·7 mm) bolt**
Caulking anchors															
Rawltamp	●	●	●	●	●		●		4		●	●		B	3060
Rawlplug bolt anchor	●	●	●		●		●		3		●	●		B	3560
Forway, Korker	●	●	●	●	●		●	●	4		●	●		B	3260 (Korker) 4170 (Forway)
Unifix	●	●	●	●	●		●		4		●	●		B	2030
Mechanically expanded anchors															
Rawlbolts	●	●	●		●		●		2	●	●	●		A	5700
Sertbolt and Dynabolt	●	●	●	●	●	●	●		2		●		●	A	3400
Redhead sleeve anchor	●	●	●	●	●	●	●		2		●		●	A	2812**
Forway	●	●	●	●	●	●	●	●	?		●	●		A	4170
Rawlbolt aluminium bronze	●	●	●		●		●		4	●	●	●		A	4540
Rawlplug duplex	●	●	●	●	●	●	●		2		●	●		B	4490
Liebig Safety	●	●	●	●	●	●	●		1, 4*		●	●		B	6625*
Armstrong Wejit	●	●	●	●	●		●		2		●		●	A	3320
Tucker Brabolt	●	●	●	●	●		●		2		●		●	A	2090**
Redhead Wedge	●	●	●	●	●		●		2		●		●	A	2367**
Unifix insit	●	●	●	●	●		●		1		●		●	A	5740
Febolt	●	●	●	●	●	●	●		2	●	●		●	C	3400
Manually expanded anchors															
Self drill Redheads	●	●		●	●		●		2	×	×	●		A	4480
Spit Roc anchors	●	●		●	●		●		2	×	×	●		A	3860
Star self drill shield	●	●		●	●		●		2	×	×	●		A	4850
Rapid big head	●	●		●	●		●		2	×	×	●		A	3270
Rawlplug sabre tooth	●	●		●	●		●		2	×	×	●		A	4090
Ucan self drilling anchors	●	●		●	●		●		2	×	×	●		A	4310
Rotospit	●	●			●		●		2	×	×	●		A	—
Non-drill Redheads	●	●			●		●		2, 4*	×	×	●		A	3460*
Rawlplug silver nugget	●	●		×	●		●		2	×	●	●		A	3860
Stud anchor Redhead	●	●			●		●		2, 4*	×	×		●	A	2550*
Chemical Anchors															
Selfix resin anchor	●	●	●	●	●	●	●	●	4*	×	×			D	*
Rawlplug mix 59	●	●	●	●	●	●	●	●	4*	×	×	●		D	*

* dependent upon anchor material **USA figures based on 27·5 N/mm² concrete



2 *Small area of base material crushed when anchor is loaded in shear*

complete fixing is likely to be at least as strong in shear as in tension and may well be stronger. As with tensile loads however, there may be considerable movement of the fixing before failure; the base material crushes under a small bearing area **2**, allowing the bolt to bend and transfer the load to undamaged material and repeat the cycle. It will be seen that a fixing which has been displaced in this way may not be able to sustain tensile loads as great as those before movement.

2.07 Spacing

Expanding fixings set up compressive stresses in the base material, and in order that these should not be concentrated at some point between two fixings, a minimum spacing should be preserved.

Spacing should also take account of factors such as the position of reinforcement and brick coursing.

2.08 Edge distance

If a fixing is made too near to an unconfined edge of masonry there is a risk of spalling and failure; the surface area of the cone of failure will be reduced on the side of the free edge. The ultimate load will be reduced but the load/movement characteristics should not be affected at low loads.

2.09 Depth

It may be important in some cases to consider carefully the depth required by a fixing of a required strength. Fixings into floors containing damp-proof membranes, or into thin precast panels for example, may render the depth of penetration critical.

3 Types of anchors

3.01 Caulking anchors

These anchors rely upon the expansion of a soft lead alloy shield against the sides of a predrilled hole in the masonry. See table II.

1 *Machine bolt type (eg Rawltamp Korker and Unifix) Class B*

Use: Provision of threaded sockets for machine bolts and screws in masonry. Particularly indicated where low torque or low expansion forces are called for (eg lightweight and soft masonry, floor screeds or near an unconfined edge). High corrosion resistance, so may be used in permanently wet situations. They are particularly useful where the available depth for fixing is at a minimum (eg where any

reinforcement is near the surface). Korkers may be used with hollow materials.
Installation: Drill hole to recommended depth and diameter and blow clear of debris. Rawltamp and Unifix: insert anchor to bottom of hole. Insert caulking tool and expand lead shield with hammer blows. Korker: insert anchor to recommended depth. Insert caulking tool and expand lead shield by turning tool to retract cone.
Materials: Rawlplug use tapered brass flanged nuts with cast lead alloy shield. Korkers and unifix cast zinc alloy threaded cones with lead alloy shields.

2 *Machine stud type* (*eg Rawlplug bolt anchors*) *Class B*
Use: Provision of projecting threaded studs in masonry. Particularly suitable where it is necessary to penetrate to some depth in masonry to spread loads. High resistance to corrosion and may be used in permanently wet situations. If used with bronze bolts, the anchor is resistant to acids, such as lactic acid found on dairy floors, which can cause deterioration in other fixings.
Materials: Rawlplug bolt anchors use heat treated steel segmented cone and cylindrical lead crown.
Installation: Drill hole to depth and diameter recommended (depth is dependent upon strength of masonry, *not* size of anchor); blow hole clear of all debris, assemble bolt and washer to anchor, and insert to bottom of hole with bolt head downwards. Insert caulking tool and expand lead shield with hammer blows. Then position component, fit washer and nut, and tighten.

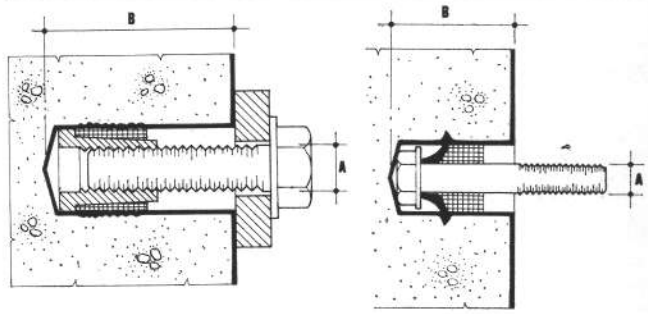
3.02 Mechanically expanded anchors

These anchors rely upon the expansion of a hard metal shield against the sides of a hole. The shield is deformed by the tightening of the nut or bolt insert.

1 *Single cone type* (*eg Rawlbolt loose bolt, and bolt projecting; Sertbolt; Dynabolt; Redhead sleeve anchors; Forway*) *Class A*
See table III.
Use: Provision of a threaded socket or stud for a machine bolt or nut in masonry. The fixing is not usually secure in the masonry until the nut or bolt is tightened (and therefore the component positioned). Maximum expansion takes place where the masonry is strongest; ie at the bottom of the hole. The use of different headed bolts (eg hookbolts, eyebolts, etc) enables this type of anchor to be used in a variety of situations. Forway anchors have one segment of the shield elongated and turned over at right angles to form a closed end to the shield. If this anchor is used in hollow masonry, the bolt may be screwed further into the shield until this segment is contacted and deformed into the cavity, thus providing a profiled fixing in addition to the normal friction grip.
Materials: Rawlbolt: malleable iron shield with steel cone, may be electrogalvanised or cadmium plated; or shield and bolt in aluminium bronze for exterior use. Sertbolt, Dynabolt and Redhead zinc plated steel shield with steel cone and stud. Forway: claimed by the manufacturer to be 'corrosion resistant high strength alloy'.
Installation: Rawlbolt and Forway: drill hole to recommended depth and diameter; insert anchor, position component, insert bolt and tighten. Sertbolt and Dynabolt: position component and drill through to recommended depth in the masonry; insert anchor and tighten.

2 *Double cone type* (*eg Rawlplug duplex stud anchors; Liebig safety bolts*) *Class B and mass expansion type* (*Febolt*). *Class C*
See tables IV and V.
Use: Provision of a threaded stud for hexagonal head nuts

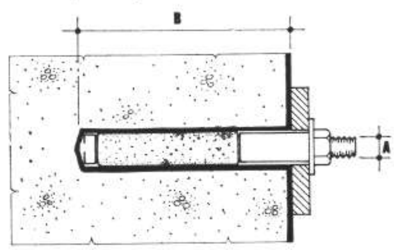
Table II *Caulking anchors*



● Rawltamp (machine bolt anchor) ○ Rawlplug bolt anchor (machine stud anchor)

Depth B in mm	Diameter A in mm* 4·8	6·4	7·9	9·5	12·7	15·9	19·1	25·4	31·8
29	●								
38		●							
41			●						
45				●					
57		○			●				
83				○					
114					○				
140						○			
165							○		
190								○	
229									○

*For imperial equivalents see table III



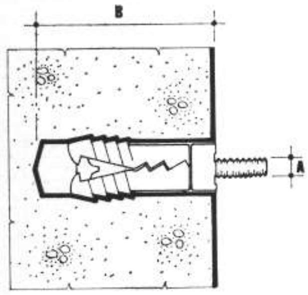
3

3 *Febolt mild steel stud with pvc expansion shield*

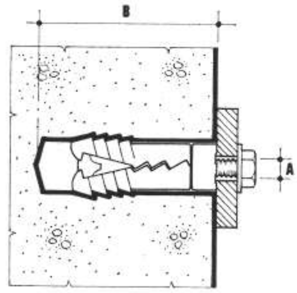
in masonry or rock. The security of the fixing is independent of any secondary member or any surface when the initial expansion is effected. Expansion takes place over the whole area of the shield, and the load applied to the study is distributed over a larger area than with single cone types, thus producing a better fixing in a base material of poor quality. Long studs are available to enable the anchors to be fixed at any depth, away from an irregular or poor quality surface. Liebig safety bolts are also available as a machine bolt type.
Materials: Rawlplug duplex: steel studs with malleable iron shield; may be electrogalvanised or cadmium plated. Liebig safety bolts: high-tensile steel or stainless steel throughout, or shields, cones and distance collars in chromate zinc plated high tensile steel with stainless steel bolts, nuts and washers. Febolts **3** use plastics sleeves which expand laterally as they are compressed longitudinally.
Installation: Rawlplug duplex: drill hole to depth required; insert anchor and turn stud until shield expands to secure fixing; position component, washer and nut. Liebig safety bolt: position component, drill hole through component to required depth in base; insert anchor and tighten.

3 *Retraction Studbolts* (*eg Armstrong Wejit; Parabolt; Redhead; Wedge anchors; Unifix Insit*). *Class A*
Use: Provision of threaded studs in masonry. Particularly indicated where low torque is called for (see also caulking

Table III *Mechanically expanded anchors* (*single cone type*)



Stud Anchor



Threaded socket anchor

Depth B in mm	**Diameter A in mm (inches in brackets)** 4·8 (3/16)	6·4 (1/4)	7·9 (5/16)	9·5 (3/8)	12·7 (1/2)	15·9 (5/8)	19·1 (3/4)	25·4 (1)
16	○							
19	●							
22	□							
25	○	○						
32		■	○					
35	●							
38	■	● △	◘					
41	□ ▲ △ ◇							
44		□		◘				
48			●					
51		▲ △ ◇						
54	■		▲ △ ● ✱ ◇					
57	●			●	◘			
60				▲ △ ◇ ✱	●			
64	□	●			△ ✱			
70			■	●				
73		□						
76	■		●		▲ △ ◇ ✱	△ ✱		
79				▲ △ ✱				
82		■						
86		■	□					
92		●						
98					▲ △ ✱			
101			■		●			
108						△ ✱		
111						● ▲		
133							△	
136							▲	
159						△		
168						▲	▲	
178								△
184								▲

Sertbolt anchors:
● Threaded stud and hexhead nut
■ Countersunk slot
Rawlbolt anchors:
△ Machine bolt
◇ Hook/eye bolt
✱ Aluminium bronze machine bolt
Forway:
◘ Machine bolt
○ Roundhead nut
□ Domehead nut
▲ Threaded stud

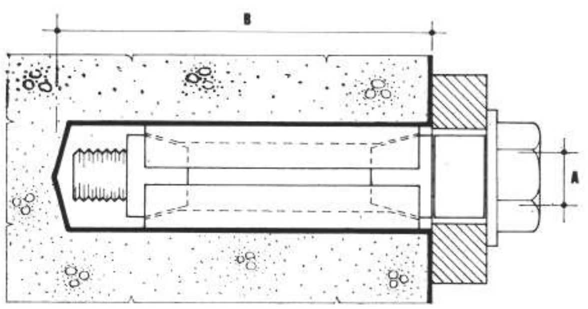
Table IIIa *Mechanically expanded anchors* (*single cone type*) *Phillips Redhead sleeve anchor*

Depth B mm	Diameter A in mm (inches in brackets) 6·4 ($\frac{1}{4}$)	7·9 ($\frac{5}{16}$)	9·5 ($\frac{3}{8}$)	12·7 ($\frac{1}{2}$)	15·9 ($\frac{5}{8}$)	19·1 ($\frac{3}{4}$)
9·5	◘					
19·1	◇◆					
25·4	◇◆■□●▲◘	◇◆○□✱				
31·8	□					
34·9	△					
38·1		△T		○✱		
47·6			△			
50·8					△○✱	○
57·2				△		

○ Hex nut
◘ Acorn nut
◇ Csk slot □ Stainless
■ Csk recessed (Phillips)
◆ Round slot ● Stainless
▲ Round recessed (Phillips)
△ Stud bolt
T Tie wire
✱ Multiple use sleeve

Table IV *Mechanically expanded anchors* (*double cone type*)

Imperial range



Depth B in mm	Diameter A in mm (inches in brackets) 6·4 ($\frac{1}{4}$)	7·9 ($\frac{5}{16}$)	9·5 ($\frac{3}{8}$)	12·7 ($\frac{1}{2}$)	15·9 ($\frac{5}{8}$)	19·1 ($\frac{3}{4}$)	25·4 (1)
50	△ ■ □		○				
60		△ ▲ ■ □		○			
70			△ □ ■				
80					○		
83				△ ▲ ■ □			
100						○	
112					△ ■ □		
115							○
140						△ ■ □	

○ Rawlplug duplex threaded stud
Liebig safety bolts:
△ High tensile steel threaded stud
▲ Stainless steel threaded stud
□ High tensile steel machine bolt
■ High tensile steel eye bolt

anchors). The holding power of the anchor is developed as the ramped shank of the bolt is drawn up past spade shaped wedges (Wejit) or a split collar (Insit), which is then forced into compression against the sides of the hole. These anchors are particularly suited to through-fixing applications where vibration may occur (eg securing machinery). The anchor tends to tighten under vibration or when tensile loads are applied.
Materials: Wejit: galvanised cold drawn steel stud with galvanised steel nut and washer. Insit: high tensile steel bolt with stainless steel collar. Parabolt and Redhead: steel bolt and collar.
Installation: Position component; drill hole precisely through component into base of recommended diameter and to recommended minimum depth; blow hole clear of debris; insert anchor and tighten nut and washer until anchor is secure.

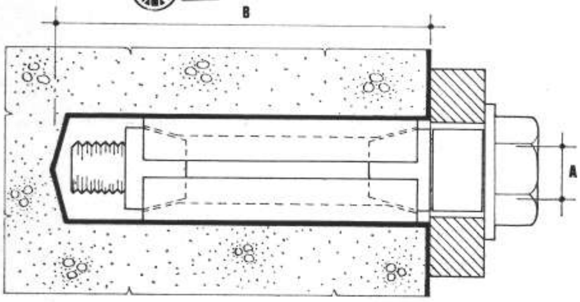
3.03 Manually expanded anchors

These anchors rely upon expansion against the sides of a hole of a deformed shield. The shield is deformed by driving the anchor into a hole or by withdrawing it.

1 *Self-drilling anchors* (*eg Phillips self-drill Redheads; Spit Roc anchors; Star self-drill shield; Rapid big head anchors; Rawlplug Sabretooth; Ucan self-drilling anchors*). *Class A*. See tables VII and VIII.
Use: Provision of threaded sockets for machine bolts in masonry. All the above types are similar and rely upon a shield being expanded by driving it over a hardened conical plug. The anchors are not removable; they are expanded and tightened in the opposite direction to that in which the

Table V *Mechanically expanded anchors (double cone type)*

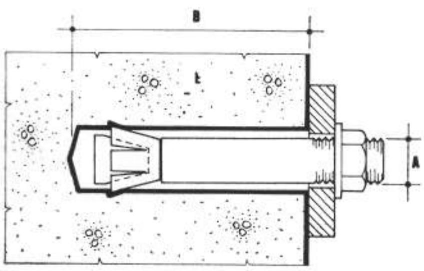
Metric range



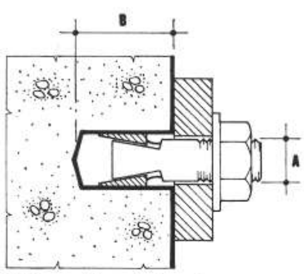
Depth B in mm	**Diameter A in mm** 6	8	10	12	16	20
50	△ □ ■					
70		△ ▲ □ ■				
85			△ □ ■			
100				△ ▲ □ ■		
130					△ □ ■	
160						△ ■ □

Symbols as for table IV

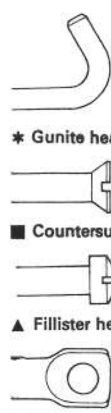
Table VI *Mechanically expanded anchors (retraction type)*



○ Unifix Insit threaded stud



Wejit: △ Threaded stud



∗ Gunite head

■ Countersunk head

▲ Fillister head

◇ Tie wire

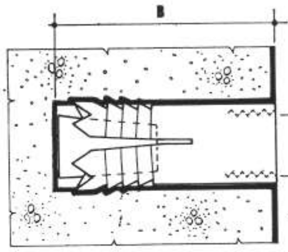
● **Phillips Redhead wedge anchor**

○ **Geo. Tucker Parabolt**

Depth B in mm	**Diameter A in mm (inches in brackets)** 6·4 ($\frac{1}{4}$)	7·9 ($\frac{5}{16}$)	9·5 ($\frac{3}{8}$)	12·7 ($\frac{1}{2}$)	15·9 ($\frac{5}{8}$)	19·1 ($\frac{3}{4}$)	25·4 (1)	31·8 ($1\frac{1}{4}$)
25	○ ●							
29	● △ ■ ▲ ∗							
35		△						
38		○	●					
48			△ ■ ◇ ▲ ∗					
51			○					
57				●				
64				△ ○ ∗				
70					○ ●			
76					△	○		
83						△ ●		
114							△ ●	
127							○	
140								●

Table VII *Manually expanded anchors (self-drilling type)*

Imperial range

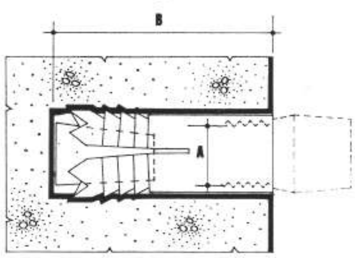


○ Snap-off headed socket
□ Unthreaded tie wire
△ Rod hanger

Depth B in mm	Diameter A in mm (inches in brackets) 6·4 (¼)	7·9 ($\frac{5}{16}$)	9·5 (⅜)	12·7 (½)	15·9 (⅝)	19·1 (¾)	22 (⅞)
25							
29	○	□					
32		○					
35		○					
38	△		○				
48			△				
51				○			
64				△	○		
76					△		
83						○	
95						△	○

Table VIII *Manually expanded anchors (self-drilling type)*

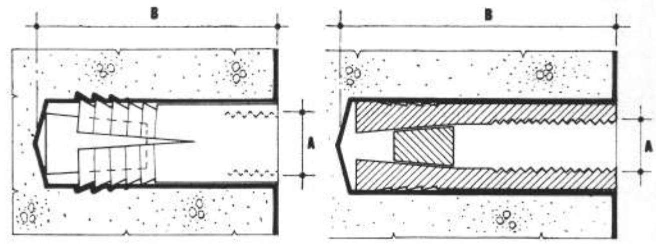
Metric range



Depth B in mm	Diameter A in mm 6	8	10	12	16	20
28	○					
33		○				
39			○			
52				○		
63					○	
83						○

Symbols as for table VII

Table IX *Manually expanded anchors (toothless shell type)*



See para 3.03 part 2 below for description of above types

Depth B in mm	Diameter A in mm (inches in brackets) 6·4 (¼)	7·9 ($\frac{5}{16}$)	9·5 (⅜)	12·7 (½)	15·9 (⅝)	19·1 (¾)	25 (1)
25	○						
30	○						
32			○				
37		○					
40			○				
52				○			
65					○		
81						○	

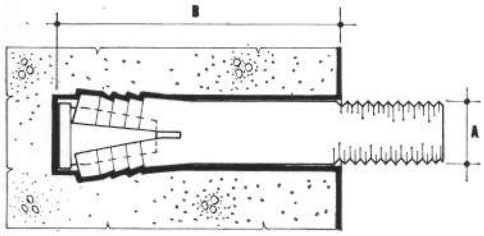
load is applied. Tie wire and rod hanger types are available for suspension fixings. Concrete made with hard aggregates can be difficult.
It is claimed that advances made recently in tool design have enabled installation time to be reduced from minutes to seconds. If this type of tool is used there should be consequent reduction in the 'in place' cost of this type of fixing.
Materials: Case hardened and plated steel shield and hardened steel expander plug.
Installation: Insert anchor without its plug into a percussion hammer chuck; drill anchor into masonry up to end of cylindrical part of shank. Remove anchor and blow hole clear of debris. Insert plug into toothed end of anchor and tap into hole. The shield is now driven over the plug with the power hammer without any rotary movement. Snap off tapered head leaving a threaded socket. Position component, insert bolt and tighten.

2 *Toothless shell anchors (eg Rotospit F; Phillips non-drill Redheads; Rawlplug Silver Nugget). Class A.* See table IX.
Use: Provision of threaded sockets for machine screws in masonry. Similar to self-drilling anchors except that hole must be predrilled.
Materials: Hardened steel shield and plug. Redheads available in stainless steel.
Installation: Drill hole to recommended diameter and depth. Fit anchor onto setting tool, fit plug into shield and insert into hole. Drive shield over plug with hammer, remove setting tool and position component. Insert bolt and tighten.
The Silver Nuggets operate in the opposite direction to others, in that the cone is hammered down into the shield.

3 *Stud bolt anchors (eg Phillips stud anchor Redheads).* See tables X and XI.
Use: Provision of threaded studs in masonry. The holding principle is identical with that of self-drilling anchors—a shell is driven over an expander plug. It is useful where a through-fixing is required which can be secured before the component is finally tightened down, since the security of the anchor is independent of the security of the component. As with self-drilling anchors, however, the direction of tightening of the anchor is opposite to that of the application of the load. The anchor cannot be removed.
Materials: Case hardened and plated steel with hardened steel expander plug, also available in stainless steel.

Table X *Manually expanded anchors (steel stud bolt type)*

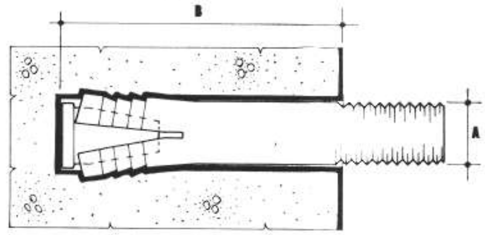
Imperial range



Length B in mm (inches in brackets)	**Diameter A in mm (inches in brackets) 6·4 (1/4)**	**7·9 (5/16)**	**9·5 (3/8)**	**12·7 (1/2)**	**15·9 (5/8)**	**19·1 (3/4)**	**25 (1)**
45 (1 3/4)	○						
51 (2)		○					
57 (2 3/16)	○						
60 (2 3/8)			○				
65 (2 9/16)		○					
70 (2 3/4)				○			
76 (3)			○				
81 (3 3/16)	○						
86 (3 3/8)					○		
90 (3 9/16)		○					
95 (3 3/4)			○				
109 (4 5/16)						○	
110 (4 11/32)				○			
125 (4 15/16)					○		
135 (5 5/16)				○			
160 (6 5/16)						○	
175 (6 7/8)					○		
214 (8 7/16)						○	

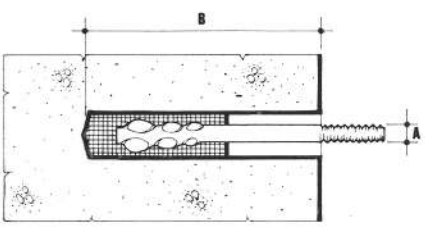
Table XI *Manually expanded anchors (steel stud bolt type)*

Metric range



Length B in mm	**Diameter A in mm 6**	**8**	**10**	**12**	**16**	**20**
45	○					
50		○				
55	○					
60			○			
65		○				
70				○		
75			○			
80	○					
85					○	
90		○				
95			○			
110				○		○
125					○	
135				○		
160						○
175					○	
215						○

All above sizes are available with metric or Whitworth thread



4 *Chemical anchor*

Installation: Position component. Drill hole through component into base to recommended depth, diameter of hole as diameter of stud. Insert anchor and expand with setting tool to protect thread and a few blows of a hammer. Assemble nut and washer.

3.04 Chemical anchors

Examples of chemical anchors **4** are: Selfix resin anchor; Rawlplug Mix 59. Class D.

Use: Provision of threaded studs in masonry and rock. The studs used may be indented bolts (paddle-end); rolled thread studs or deformed reinforcing bars (Rebars) with threads cut into one end. The anchor relies upon the conformity of a hardening polyester resin with a cavity in the masonry, the same resin conforming with the profile of the deformed end of the stud. It can be used and will set under water and is particularly useful for irregular cavities in rock, although the maximum bond strength is developed where the difference in diameter between hole size and bolt size is kept to a minimum, thus ensuring that the maximum length of bolt is encapsulated in the resin. Use is also indicated where low torque or low expansion forces are called for, or near unconfined edges.

Materials: Cartridges containing filled polyester resins separated from measured quantities of hardener and catalyst, and steel studbolts.

Cartridges are available in diameters of 16, 22, 25, 28, 32, 34 and 40 mm.

Installation: Drill hole to recommended depth and diameter and blow clear of debris. Insert resin cartridge and carefully push to end of hole. Fit stud to a drill chuck, insert into hole and penetrate cartridge, rotating at 120 to 600 rpm for 10 to 15 seconds to ensure complete mixing of resin, hardener and catalyst. Position component and fit nut and washer. Full load may be applied after 4, 15 or 30 minutes, depending upon speed of cartridge used.

Information sheet
Fixings 5

In-situ fixings

This information sheet covers fixings which are designed to be positioned prior to pouring the concrete

1 Location

1.01 In-situ fixings are usually positioned prior to pouring the concrete, though some can be grouted into a recess precast in the concrete.

1.02 Design of in-situ fixings must allow for inaccuracies in location of the formwork and inaccuracies due to displacement during pouring and vibration.

1.03 In-situ fixings are ideal for suspended services and ceilings, where there is less need for accuracy in location, and where the situation (eg slab soffit with reinforcement) might exclude use of drilled or fired fixings.

1.04 Protection is essential for cast-in fixings, which are liable to be damaged on site before use, and they may also damage the base material into which they are cast. Cast-in sockets may become clogged with dust, oil or grout and their threads rendered useless; projecting studs in precast panels may be struck, causing spalling of the panel surface.

1.05 All the in-situ fixings in this section fall within the class D load/movement category. (See INF: Fixings 4); ie they exhibit negligible movement before failure.

2 Costs

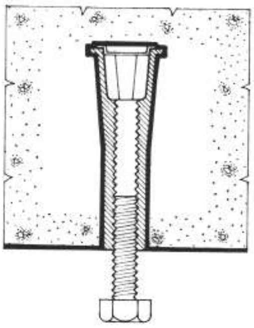
2.01 Cost comparison is difficult as it depends on condition of concrete and tool-bit, and degree of wastage of badly located fixings. In comparisons of costs between drilled iron expanding bolts and drilled and grouted mild steel ragbolts, studies have shown only marginal differences.

2.02 It is also difficult to compare costs of different materials of these fixings, as the copper in alloys, and the nickel and molybdenum in stainless steel, are subject to fluctuations in world market price.

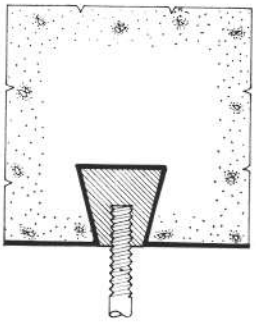
3 Cast-in sockets

3.01 Cast-in sockets are available in a wide range of materials and may be used in most locations. They are usually attached to the formwork by their fixing bolts, but some have nailing plates and seals to keep threads clear during concrete pouring. Sockets for relatively thin slabs, are fixed to reinforcement instead of shuttering **7**.

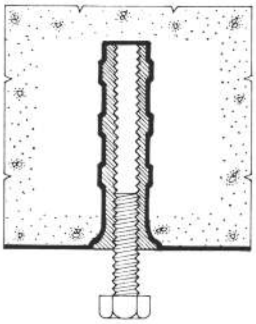
3.02 Other cast-in sockets are available in the form of a looped high tensile steel wire with a coiled steel wire socket welded to the free ends. The coil forms a thread suitable for ½in (12·7 mm) or ¾in (19·1 mm) special bolts **8**.



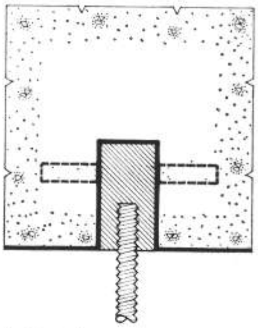
1 *Cast-in socket*



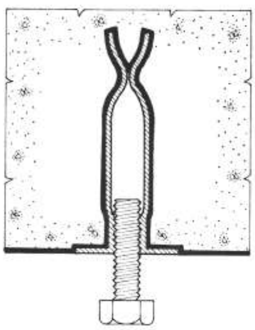
2 *Threaded wedge*



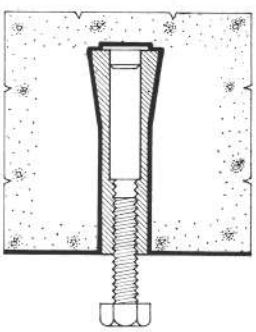
3 *Cast-in socket*



4 *Cast-in socket*



5 *Cast-in socket*



6 *Cast-in socket*

Table I Materials for cast-in sockets

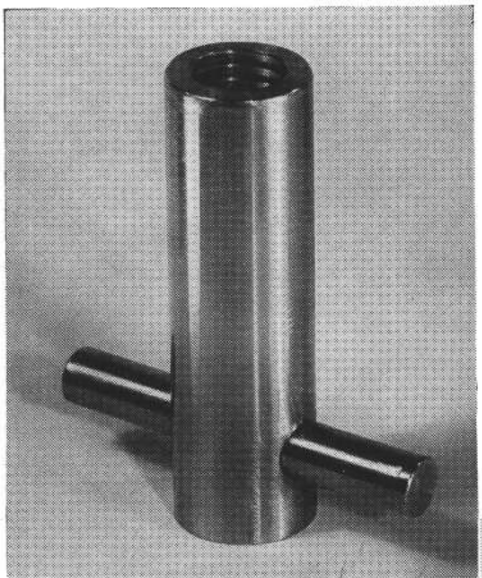
Malleable iron	Mild steel	Zinc coated steel	Cadmium plated steel	High tensile steel	Stainless steel	Aluminium bronze	Manganese bronze	Silicon bronze	Phosphor bronze	Gun metal	Illustrations
●						●	●				1 cast-in socket
						●	●		●	●	2 cast-in socket
●						●	●		●	●	3 cast-in socket
	●				●	●	●		●	●	4 cast-in socket
●											5 cast-in socket
●											6 cast-in socket
●											7 slab type socket
		●	●								8 looped socket
				●							9 threaded wedge

ESTABLISHED 1800

WHITEHOUSE STREET
ASTON
BIRMINGHAM B6 4AS

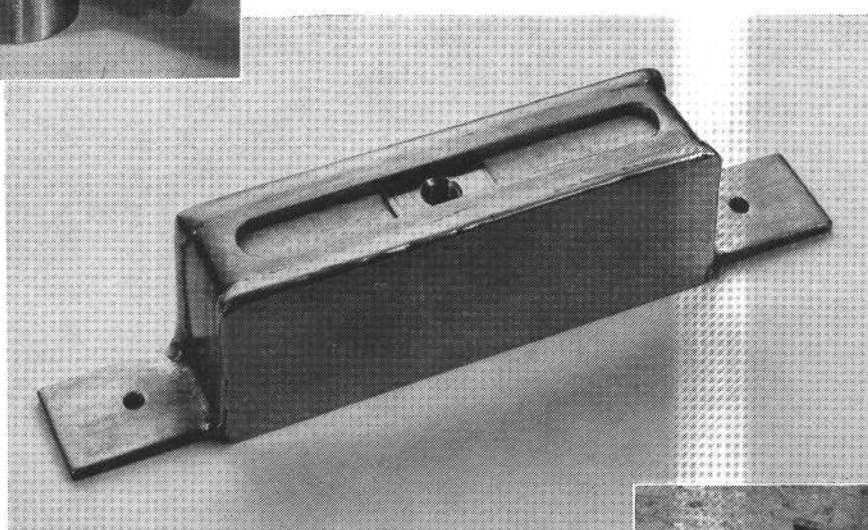
TELEPHONE 021-359 2135 (5 LINES)
TELEX 336658

THOS. JOHNSON (METAL PRESS WORKERS) **LTD**



MASONRY FIXINGS

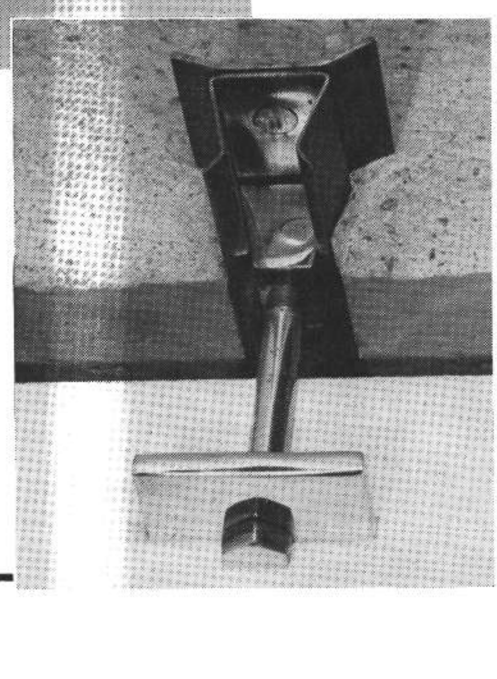
The complete service to architects, builders and masonry contractors for fixings manufactured from stainless steel, phosphor bronze, copper or mild steel to British Standard specifications.



TYPE CIS
A superior bar turned socket manufactured from stainless steel, mild steel or phosphor bronze.

TYPE SF1/HD
"Surefix" Slot
Manufactured from 316 stainless steel. Providing 100 mm (4") of adjustment.

TYPE SC SLOT
For suspension of stone soffit using plate and sliding nut.



A comprehensive range of fixings is shown in our catalogue available free on request. We will be pleased to advise and manufacture fixings to clients' requirements.

3.03 Bolts, washers, and metal components should match socket material to avoid galvanic corrosion, especially when using copper alloys. If this is not possible, insulators such as neoprene washers should be used.

3.04 Threaded wedges may be used for small fixings **9**.

4 Cast-in channels

4.01 Cast-in channels are useful where flexibility and accuracy of location are required (see table II.) Short lengths (usually 150 mm) may be cast into slab soffits to suspend indeterminate future fixtures **10 to 14.** Length allows the fixing to be adjusted, and several fixings may be made to any one channel. Longer lengths up to about 6 m are also available for other locations. Fixings are made either with a special headed bolt which slides in the channel, or with a similar nut with a threaded hole. Various accessories are available.

Table II *Cast-in channels*

Mild steel	Galvanised mild steel	Phosphor bronze	Aluminium	Illustration
		●		10 Harris & Edgar HET 7
●				11 Halfen
●	●			12 Unistrut
●	●			13 Rigifix
	●		●	14 Cablock

5 Deformed rods

5.01 These fixings form a projecting stud and are more suitable for top surfaces of concrete where there is no formwork to penetrate (see table III). They consist of a rod which is threaded at one end and twisted or deformed at the other end to provide better grip in the concrete **15** to **21.** Deformed reinforcing bars are suitable, and softer copper alloy rods can be threaded by forcing on a nut.

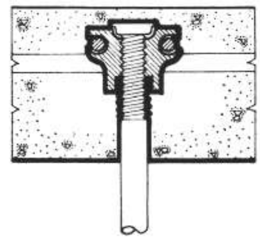
Table III *Deformed rods*

Mild steel	Stainless steel	Phosphor bronze	Silicon bronze	Aluminium bronze	Brass	Illustration
		●	●	●		15 Hook bolt
●	●	●	●	●	●	16 Hex-head bolt
●	●	●	●	●	●	17 Fishtail bolt
●		●	●	●		18 Ragbolt (Lewis bolt)
		●	●	●		19 Plate and ragbolt
●						20 Indented bolt
●						21 Deformed bar

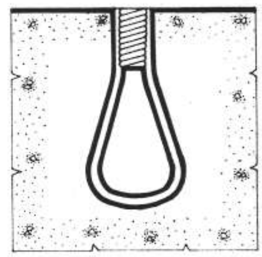
5.02 The Lewis or ragbolt type **18** is now rarely used, since the indented type is reputed to have equal holding power, with no sharp edges to make handling difficult.

6 Fabricated straps

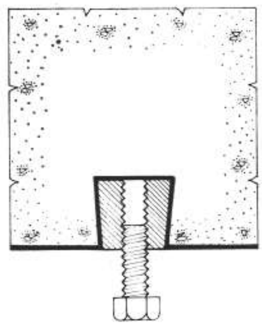
6.01 Galvanised mild steel straps can be fabricated cheaply and easily for nailing to the formwork to provide hangers from slab soffits. They are bent down after the formwork is struck **22, 23.**



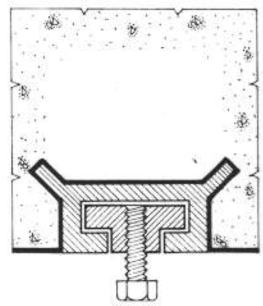
7 *Slab type socket with ears bent round reinforcement (Rawlsocket)*



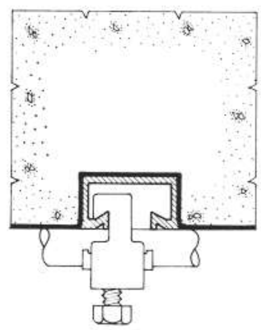
8 *Looped socket (Rawloop)*



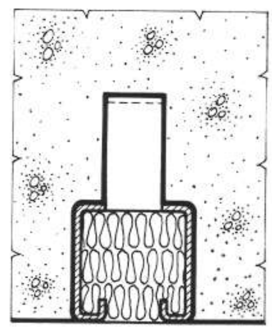
9 *Threaded wedge*



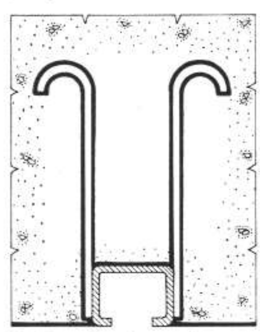
10 *Cast-in channel (Harris & Edgar)*



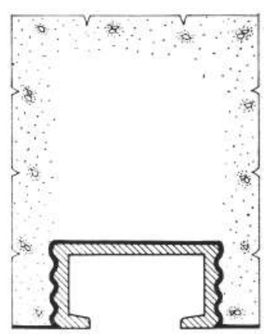
11 *Cast-in channel (Halfen)*



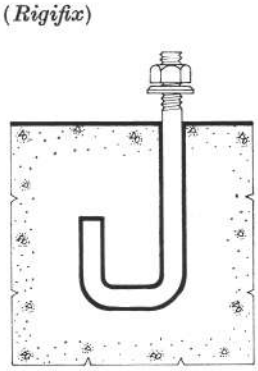
12 *Cast-in channel (Unistrut)*



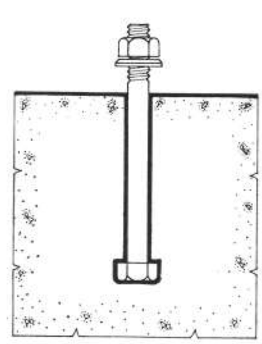
13 *Cast-in channel (Rigifix)*



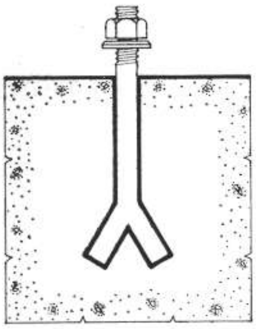
14 *Cast-in channel (Cablock)*



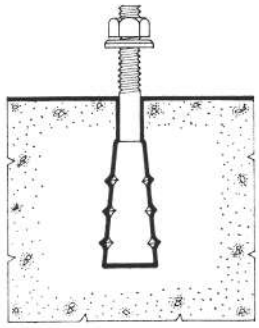
15 *Deformed rod (hook bolt)*



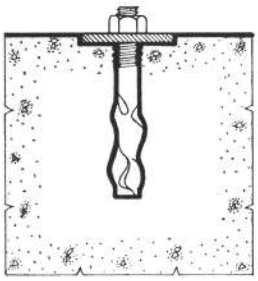
16 *Deformed rod (hex-head bolt)*



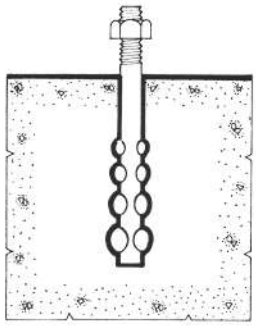
17 *Deformed rod (fishtail bolt)*



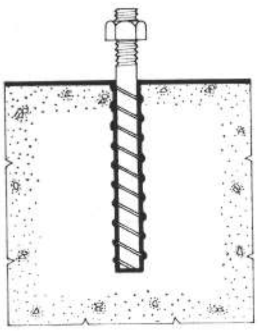
18 *Deformed rod (ragbolt)*



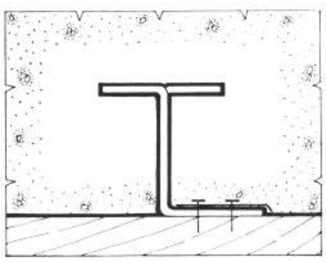
19 *Deformed rod (plate and ragbolt)*



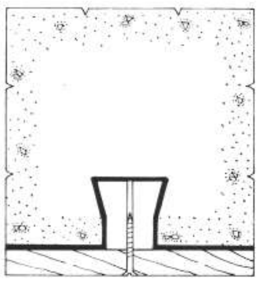
20 *Deformed rod (indented bolt)*



21 *Deformed rod (deformed bar)*



22 *Fabricated strap*



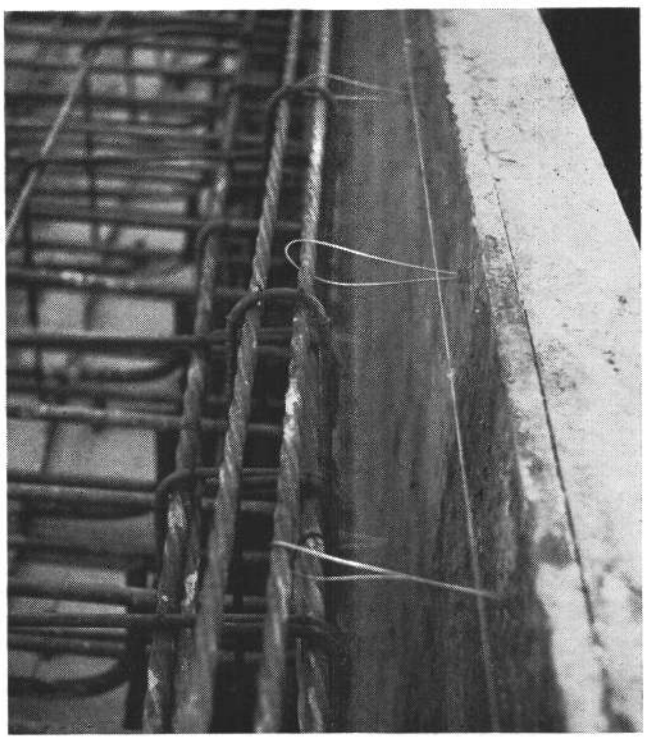
23 *Cast-in block*

7 Cast-in blocks

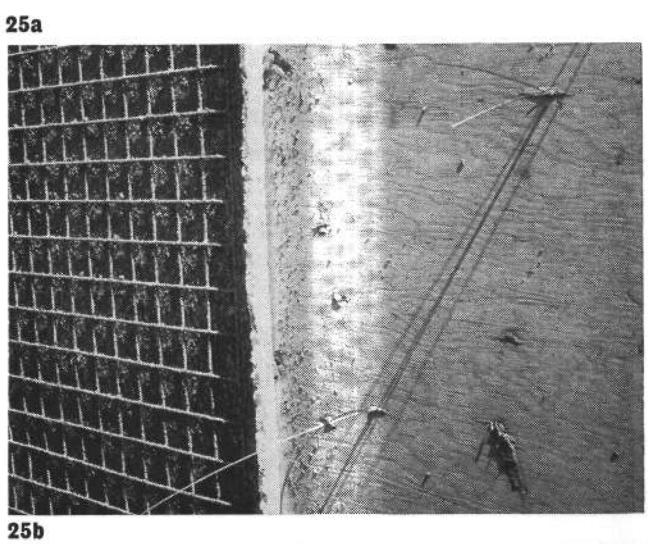
7.01 These blocks nailed or glued to formwork accept screwed or nailed fixings **23**. They may be cast-in near the edge of the concrete, and may even have more than one face exposed. They are available in several sizes and have a 3·2 mm core hole for fixing to the formwork. The whole face of the block may be used after the formwork is struck.

8 Wire ties

8.01 Galvanised mesh can be fixed to the face of reinforced concrete (a continental tiling and rendering practice) by tying stainless steel wires to the reinforcement and pushing the free ends through holes in the shuttering (see photographs **25**). After striking the shuttering these ends are then windlassed around the mesh. The correct quality of wire must be used, to ensure that adequate strength is provided, while giving ductility necessary to avoid breakage during the windlassing operation.



25a



25b

25 *Stainless steel wires fixed through shuttering to steel reinforcement* **a** *to provide fixing to galvanised 50 mm × 50 mm × 10 gauge steel mesh for receiving rendering (for tiling)* **b**. *The wire is windlassed around the mesh and the correct ductility of wire is essential to avoid breakage in tightening*

Second stage metrication
Metric terms with imperial equivalents

CI/SfB			
		Xt6	
UDC		691.88	

SEPTEMBER 1971

unistrut

Concrete Inserts

Now pre-foam filled to prevent ingress of grout and cement during pouring

Continuous slot permits attachment anywhere along the channel run

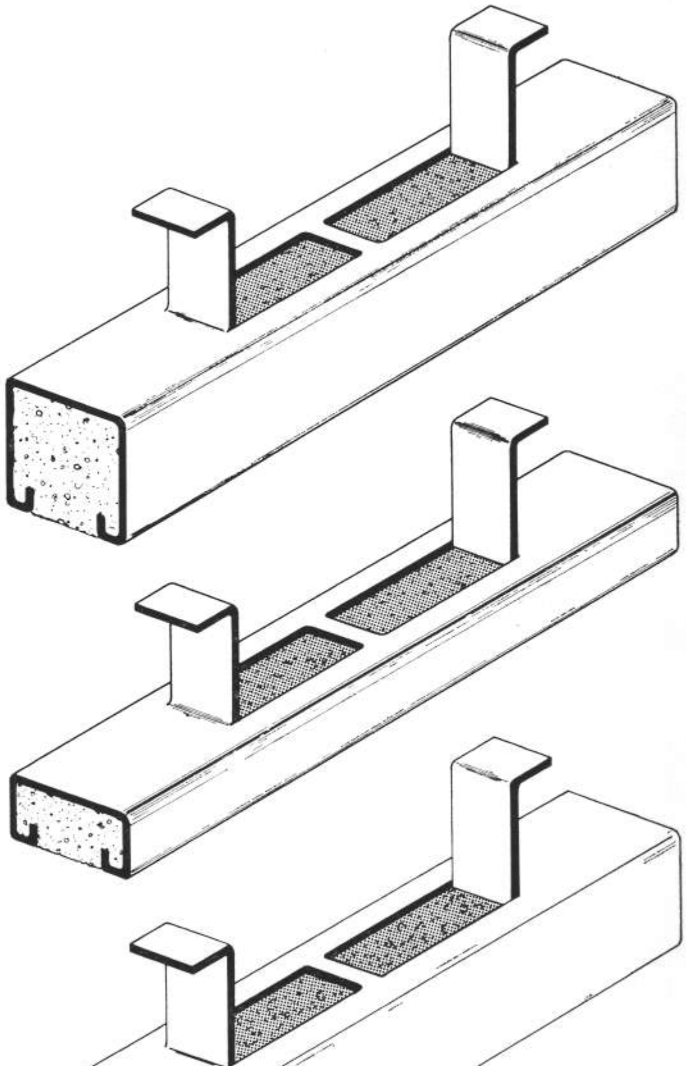
Due to modern techniques with mixes and vibratory systems, a problem arises on the building site of grout and cement entering and subsequently setting hard in anchorages cast in for structural fixings.

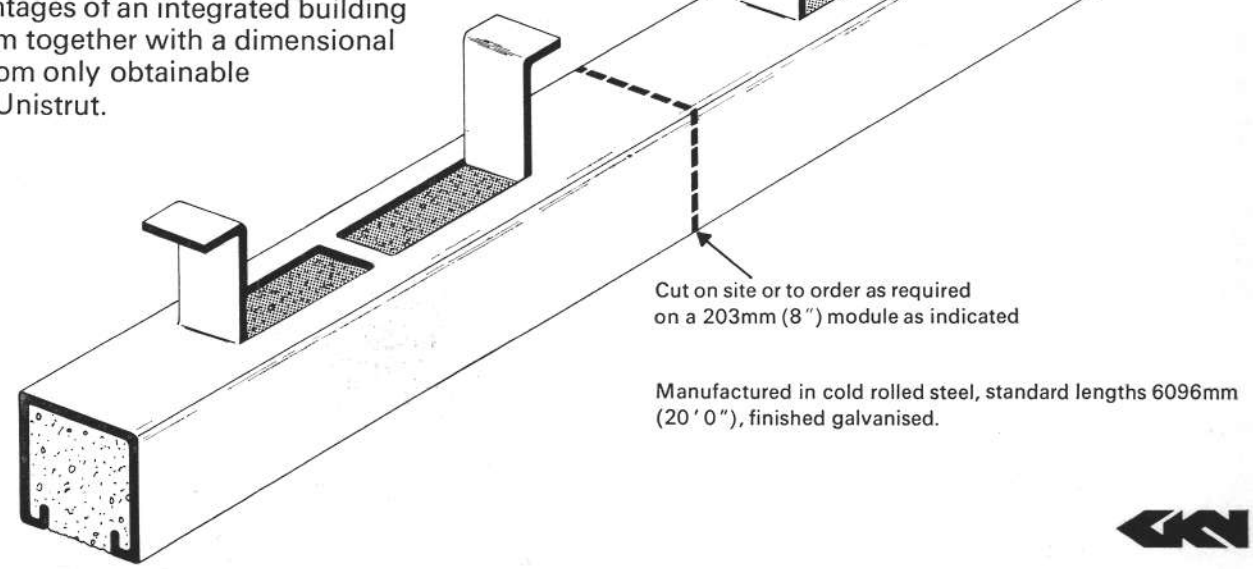
The best method of preventing such ingress has been found by the pre-filling of the anchors with an expanding and waterproof material which resists the entry of cement, but which can be easily cleared after the pouring of concrete has been completed, and the shuttering removed.

A new patented method has therefore been devised for thus filling Unistrut inserts with expanded plastic foam.

Unistrut inserts are now available in standard 6096mm (20'0") lengths, pre-filled with expanded plastic foam for cutting on site or to order as required on a 203mm (8") module, no end caps being required. Short inserts up to 203mm (8") in length can still be made on site by using pre-filled plain channel with standard 'B' type end caps.

The Unistrut Concrete Insert offers all the advantages of an integrated building system together with a dimensional freedom only obtainable with Unistrut.





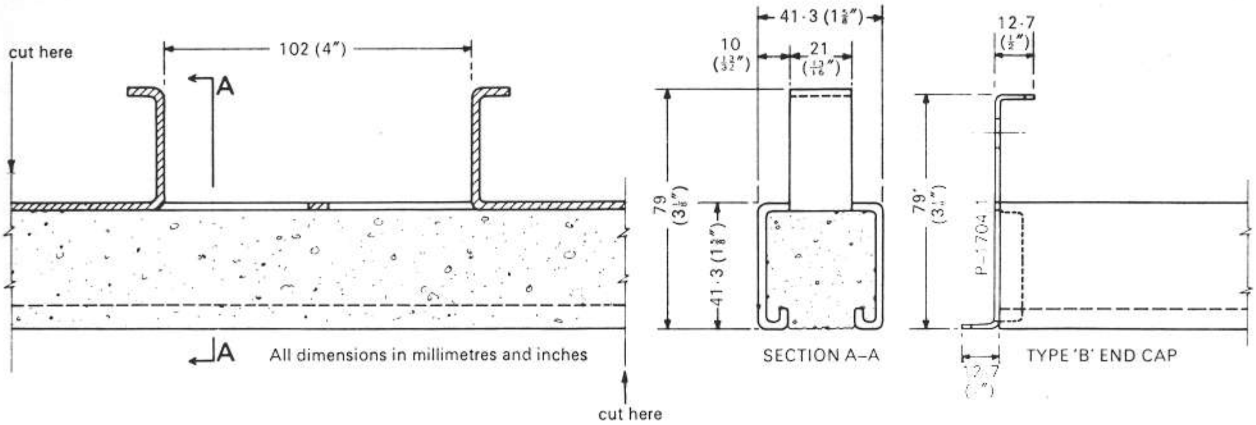
Manufactured in cold rolled steel, standard lengths 6096mm (20'0"), finished galvanised.

GKN

P-3200 Series 41·3 x 41·3 x 2·8 (1⅝" x 1⅝" x ·109") thick steel

Available in standard lengths 6096mm (20' 0")

Weight per 6096mm (20' 0") 18·86kg (41·58lb)
Price: £4·09, 6096mm (20' 0")



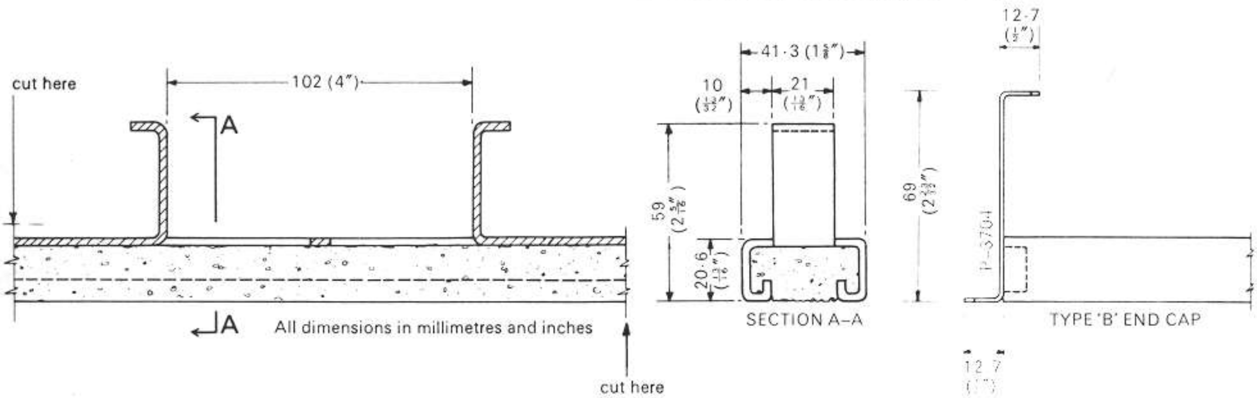
Load data
Because the supporting capacity of inserts depends largely on the strength of the concrete, we cannot guarantee any particular loading. Recommended loading on inserts in average good concrete, with a safety factor of approximately 3 as follows:

76mm (3") 320kg (705lb)
102mm (4") 350kg (772lb)
152mm (6") 450kg (992lb)
203mm (8") 550kg (1212lb)
For inserts 300mm (1' 0") long and over, 900kg (2000lb) per 300mm (1' 0")

P-3300 Series 41·3 x 20·6 x 2·8 (1⅝" x 13/16" x ·109") thick steel

Available in standard lengths 6096mm (20' 0")

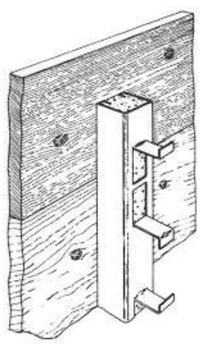
Weight per 6096mm (20' 0") 12·52kg (27·6lb)
Price: £3·04, 6096mm (20' 0")



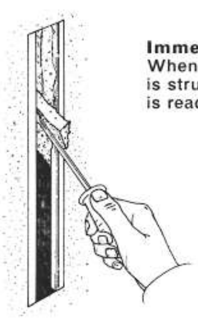
Load data
Because the supporting capacity of inserts depends largely on the strength of the concrete, we cannot guarantee any particular loading. Recommended loading on inserts in average good concrete, with a safety factor of approximately 3 as follows:

76mm (3") 200kg (441lb)
102mm (4") 250kg (551lb)
152mm (6") 325kg (717lb)
203mm (8") 400kg (882lb)
For inserts 300mm (1' 0") long and over, 650kg (1500lb) per 300mm (1' 0")

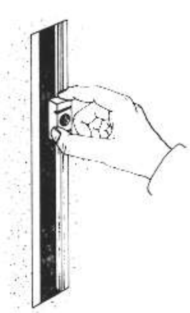
unistrut concrete inserts offer these positive advantages



Easy placing
The Unistrut concrete insert is firmly fixed to the concrete side of shuttering before pouring.



Immediate use
When the shuttering is struck, the insert is ready for use.



Fixing at any point
Piping and other components can be attached at any point of Unistrut's continuous entry channel.

unistrut

GKN

GKN Sankey Limited, 43-45 Broadwater Road, Welwyn Garden City, Hertfordshire
Telephone: Welwyn Garden 26321 (4 lines) Telex: Sankeshel Welyn 24712

Information sheet
Fixings 6

Self-tapping screws and light rivets

This information sheet describes types of self-tapping screws and light rivets which are used in the building industry

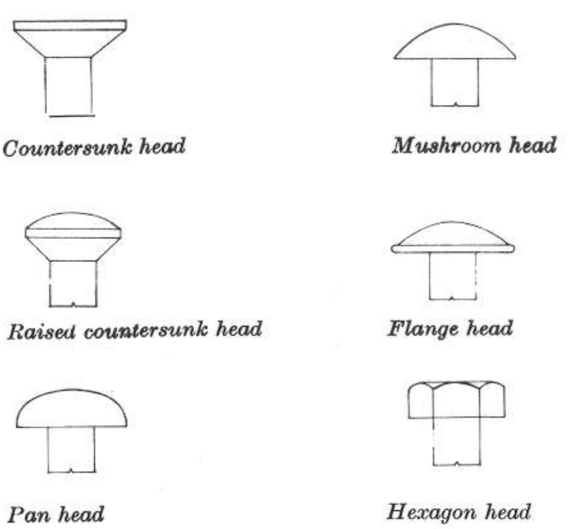
1 Self-tapping screws

Types

1.01 Self-tapping screws produce their own mating threads in the base material into which they are fixed. They can be:
Thread forming The screw forms a thread in metal by deforming the hole in thin sheets or, in thicker material, by making the metal flow round the thread. These screws are the most commonly used and are available with both coarse and fine threads.
Thread-cutting The screw cuts a thread into the base material. These are used more for engineering work.
Self-drilling and self-piercing A thread forming screw which does not need pilot or clearance holes.
Examples of types of screw are given in tables I to IV.

Head style

1.02 Self-tapping screws are made in the following head shapes **1**, and can be obtained with slotted, or Pozidriv driving profiles:



1 *Head shapes of self-tapping screws*

Materials

1.03 Self-tapping screws are usually made of hardened steel or stainless steel.

General applications

1.04 Self-tapping screws are used for fixing into sheet metal and non-ferrous castings, plastics, plywood, asbestos and structural steel. BS 4174[1] shows how screw types are used in most materials.

Structural strength

1.05 Torsional stress specifications and pilot and clearance holes are given in BS 4174[1].

Size

1.06 Sizes of the two most commonly used types of self-tapping screws, with differing head styles, are given in tables V and VI.

2 Light rivets

2.01 Solid copper rivets were used by the ancient Egyptians, but the biggest advances were made during and after the last war in airframe construction, with the introduction of machine placing and clinching. This has led to a much wider use of rivets in many industries, including building.

Types

2.02 There are two main types of light rivets:
Two-sided rivets Those clinched from the rear. Examples of two-side rivets, relevant to building technology, are shown in table VII.
One-sided rivets Blind rivets, for fixing without access to the rear face of the work. Techniques of using blind rivets were developed for the aircraft industry, which demands reliable fixings of sheet metal skins to closed structures.
Examples of one-side rivets, relevant to building technology, are shown in table VIII.

Characteristics

2.03 Available head styles, materials, applications and sizes are included in descriptions of light rivets in tables V and VI.

Table I *Examples of thread-forming self-tapping screws (in pilot holes)*

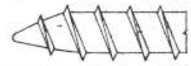
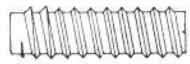
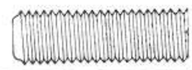
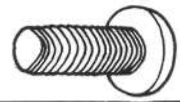
A type: Gimlet point, for thin sheet metal (mild steel up to 18 g (1·2 mm thickness), widely used in motor car manufacture, ventilation ductwork etc	
B type: Usually blunt (or flat) point, but can be obtained with conical point; used in thicker materials, non-ferrous castings, plastics etc, in addition to sheet metal. (A further variation has a fine spaced thread and a gimlet point)	
C type: Pilot point with crested threads and standard machine screw thread pattern	
Taptite: Blunt point similar to B type, tri-lobed shank. This screw will form threads in all metals, die castings and ductile plastics. High resistance to vibration, and used widely in domestic appliances. Example: Taptite for ductile metals, Plastite for ductile plastics (Linread Ltd)	

Table II *Examples of thread-cutting self-tapping screws (in pilot holes)*

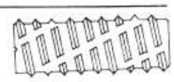
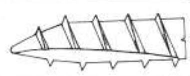
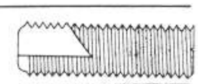
There are two main types: B type thread design with cutting flute at end or from end to head; unified machine screw thread type with flutes at end. These screws have cutting edges or cavities to allow removal of chips cut from the base material	
Y type: Pilot point with crested heads, five rolled cutting flutes for full shank length. Particularly useful in brittle materials	
BT type: Pilot point with crested threads, five spaced threads with a large chip cavity at end of shank	
Type 17: Gimlet point, coarse thread with large chip cavity at point	
D type: Pilot point with crested threads. Standard machine screw thread with slot at point (cutting face of slot is on shank centre line, and an alternative G type is available with slot itself on shank centre line)	
T type: Pilot point with crested threads, standard machine screw thread; large chip cavity at point	

Table III *Examples of self-drilling and self-piercing self-tapping screws (no pilot holes)*

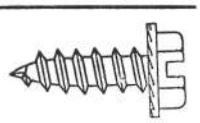
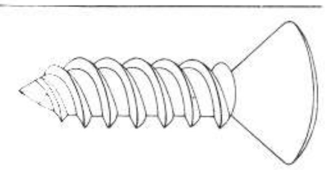
Self-drilling type: Several point forms, including drill point shown. High speed required in drilling (usually 2000-2500 rpm calls for care in operation to avoid damaging surrounding surfaces. Can be used in materials up to and over $\frac{3}{32}$in (2·4 mm) thick. Future designs should drill and fix steel plate up to $\frac{1}{4}$in (6·4 mm) thick. Example: Teks (Linread Ltd.)	
Self-piercing type (Spat screw): Pyramidal point of diamond cross-section. Thread is of twin-start design used at normal screwdriver speed. Extremely effective holding power owing to good thread engagement in pierced (rather than drilled) sheet. Example: Spat (GKN)	

Table IV *Special types of self-tapping screws*

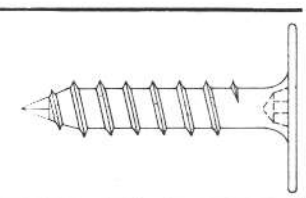
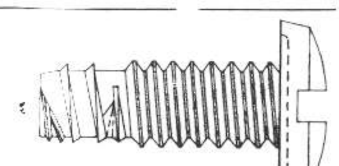
Drywall fastener: Designed to fix through plasterboard, asbestos or similar boards into sheet metal without displaced material being pushed up around the head. Example: Drywall (Linread Ltd.)	
K type: Blunt ended screw with lead-in coarse thread changing to a fine thread below the head; this creates a self-tapping 'captive' screw, as it will not pass the point where thread changes pitch	

Table V *Sizes of steel self-tapping screws—type* A

Length	**Countersunk head**					**Raised countersunk head**					**Pan head**						
mm	4	6	8	10	12	4	6	8	10	12	4	6	7	8	10	12	14
4·8											○ ●						
6·4	○ ●	●	○ ●			○ ●					○ ●	○ ●					
8·0											●	○ ●		○ ●			
9·6	○ ●	○ ●	○ ●			○ ●	○ ●	○ ●			○ ●	○ ●	○ ●	○ ●	○ ●		
12·7	○ ●	○ ●	○ ●	○ ●	●	○ ●	○ ●	○ ●	○ ●	●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●
15·9	○ ●	○ ●	○ ●	○ ●		○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●
19·1	○ ●	○ ●	○ ●	○ ●	●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●
22·2	●	○ ●	●			○ ●	○ ●	○	●	●	●	○ ●	○ ●	○ ●	●	○ ●	●
25·4		○ ●	○ ●	○ ●	●	○ ●	○ ●	○ ●	○ ●	○ ●		○ ●	●	○ ●	○ ●	○ ●	○ ●
31·8		○ ●	○ ●	○ ●	●		○ ●	○ ●	○ ●	●		○ ●	●	○ ●	○ ●	○ ●	●
38·1		●	○ ●	○ ●	●		○ ●	○ ●	○ ●	●		○ ●		○ ●	○ ●	○ ●	○ ●
44·5				●				○ ●	●						●		
50·8				○ ●					●						●		○ ●

Table V *(continued)*

Length	**Mushroom head**				**Flange head**				**Hexagon head**						
mm	4	6	8	10	4	6	8	10	4	6	8	10	12	14	**screw gauge**
4·8									○						
6·4	○ ●				●	●			○	○					
8·0						●	●		○	○					
9·6	○ ●	○ ●	○		●	●	●	●		○	○	○			
12·7	○ ●	○ ●	○ ●	○	●	●	●	●		○	○	○	○	○	
15·9	○	○	○	○		●	●	●		○	○	○		○	
19·1		○	○	○		●	●	●		○	○	○	○	○	
22·2				○											
25·4		○	○			●	●	●			○				

○ Slotted head ● Cross-slotted head

Table VI *Sizes of steel self-tapping screws—type* B

Length	**Countersunk head**							**Raised countersunk head**					**Pan head**							
mm	2	4	6	8	10	12	14	4	6	8	10	14	2	4	6	7	8	10	12	14
4·8	○ ●	○ ●											○ ●	○ ●	○ ●					
6·4	○ ●	○ ●	○ ●					○ ●					○ ●	○ ●	○ ●	○ ●	○ ●	○ ●		
8·0	○ ●	○ ●	●	○					○ ●				○ ●	○ ●	○ ●	○ ●	○ ●	○ ●		
9·6	○ ●	○ ●	○ ●	○ ●	○ ●			○ ●	○ ●	○	○ ●		○ ●	○ ●	○ ●	○ ●	○ ●	○ ●		
12·7		○ ●	○ ●	○ ●	○ ●			○ ●	○ ●	○ ●	○ ●		○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	○ ●	
15·9		○ ●	○ ●	○					○ ●	○ ●	○	○		○ ●	○ ●		○ ●	○ ●	○	○
19·1		○	○ ●	○ ●	○ ●	○	○ ●		○ ●	○ ●	○ ●			○ ●	○ ●		○ ●	○ ●	●	○ ●
22·2			○	○					○						○		○	○		
25·4				○ ●	○ ●	○ ●	○ ●		●	○ ●	○				○ ●		○ ●	○ ●	●	
31·8			○	○ ●	○ ●		●			○							○	○ ●	○ ●	
38·1				○ ●	○ ●	○ ●	○ ●											○ ●		
44·5					○		○ ●													
50·8					●		○ ●													

Table VI *(continued)*

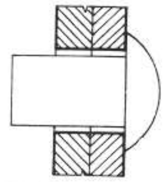
Length	**Mushroom head**				**Flange head**				**Hexagon head**					
mm	4	6	8	10	4	6	8	10	4	6	8	10	14	**screw gauge**
4·8	○	○			●	●			○ ●	○				
6·4	○	○			●	●			○ ●	○ ●	○			
8·0	○		○		●	●			○	○	○			
9·6		○	○	○	●	●	●	●	○	○	○	○	○	
12·7		○		○	●	●	●	●		○	○	○	○	
15·9						●	●	●		○			○	
19·1												○	○	
22·2														
25·4													○	

○ Slotted head ● Cross-slotted head

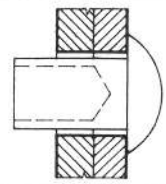
Note: Sizes of plastic covered 12-point head, and cadmium plated hexagon head self-tapping screws for roofing work are shown in Fixings 8 Table III.

Table VII *Examples of two-sided light rivets*

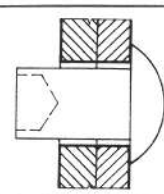
Solid rivets These are inserted into predrilled holes and then clinched either by hand (hammer and rivet snap) or by machine (simple pneumatic tool or automatic feed rivet setter).
Solid rivets are usually cheap, and one length may fix sheets of varied thickness. But clinching requires a good deal of force, careless work can be unsightly, and the operation can be slow compared with other methods. Where speed is not important but high standards of skin continuity are essential (as in the aerospace industry) solid rivets are often favoured. Head styles are listed in BS 641[2] and include snap or round head, pan head, mushroom, flat, and four types of countersunk profile (60° to 140°)
BS 641[2] covers rivets from $\frac{1}{16}$in to $\frac{7}{16}$in diameter



Tubular rivets Solid rivets drilled out at the penetrating end were originally introduced to allow the rivet to penetrate soft materials without predrilling. The thinner mass of metal requires less force to close, allowing lighter and less expensive clinching devices.
Tubular rivets are used to fix sheet materials of varying thicknesses, or in light constructions where additional force could damage the components



Semi-tubular rivets In this type the hollow part is usually less than the shank diameter. The rivet is designed to preserve the shear strength of the solid rivet while allowing the tail to roll back for clinching. Ideal for automatic feed machinery, this range is covered by BS 1855[3] (oval and flat countersunk types from $\frac{1}{16}$in to $\frac{3}{16}$in diameter). Correct length and accurate size of predrilled holes are important



Bifurcated rivets Formed from a solid rivet, this two-prong fixing was designed to penetrate without predrilling. Although primarily for suitcase and similar work in leather, fibreboard and plastics, it can be used, in a single pierce/clinch type of machine, for fixing plywood and thin metal sheet. BS 1855: Part 1[3] covers oval, flat countersunk and flat countersunk bevel heads, from 3 to 16 gauge sizes

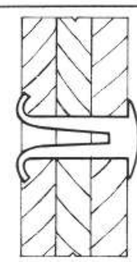
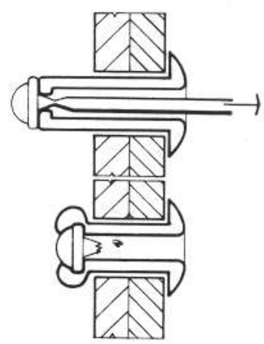
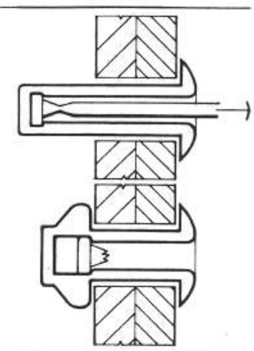


Table VIII *Examples of blind light rivets*

Pop rivets The hollow rivet shell is mounted on a headed steel pin or mandrel. The rivet is inserted into a predrilled hole. The steel pin is gripped in a special tool, which draws it through the rivet, forming a head on the blind side, and pulling the sheet panels tightly together. The steel pin breaks off and is ejected.
The rivets are made from aluminium alloy, monel, mild steel and copper. Heads are available in domed or countersunk (100° or 120°) style, from $\frac{3}{32}$in (2·4 mm) to $\frac{1}{4}$in (6·4 mm) diameters in $\frac{1}{32}$in increments. Pop rivets can join sheets of up to 12·6 mm combined thickness and are used for cladding, ducting and ceiling work.
Example: Avex (Avdel Ltd) 'Pop' rivets (Geo Tucker Eyelet Co Ltd)



Sealed end rivets are water and airtight up to 3450 kN/m². Available in 3·2 mm, 4·0 mm and 4·8 mm diameters.
Examples: Imex (Geo Tucker Eyelet Co Ltd)



Grooved pop rivets are designed for use in soft or brittle materials eg hardboard, plywood, glass fibre, asbestos. This rivet is inserted into a drilled hole, and expands sideways. Available in 3·2 mm, 4·0 mm and 4·8 mm diameters.
Examples: Serrex (Geo Tucker Eyelet Co Ltd)

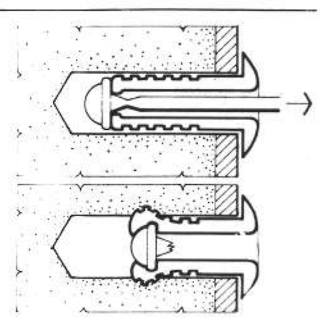
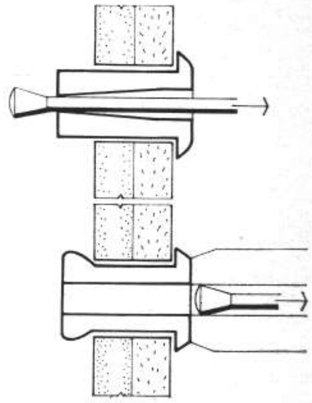
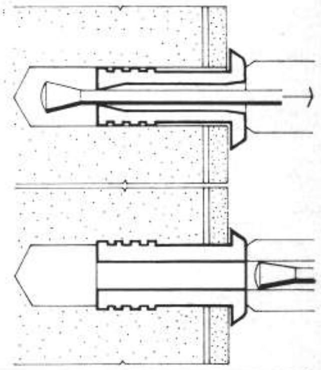


Table VIII *continued*

Automatic feed rivet **The elongated mandrel is pulled straight through the hollow tapered rivet by the rivet gun, and this enables the process to be automated. Speeds of 2000 rivets an hour are possible with this type of automatic feed.**
These rivets are made from aluminium alloys, cadmium plated steel and brass, with snap and countersunk head styles. The hole left in the rivet by the mandrel can be filled by sealing pins of similar material to the rivet. Shank diameters range from 2·4 mm to 6·4 mm, to fasten sheets up to combined thickness of 12·6 mm.
Example: Chobert (Avdel Ltd).
A similar rivet is available specifically for terminal posts in electrical circuit boards.
Example: Avlug (Avdel Ltd)



Expanding plug type rivet **This has a grooved shank which expands as the pin is withdrawn. The fixing is designed as an expanding plug for use in blind holes drilled into wood, plastic, porcelain, steel or aluminium alloys or castings. Snap or countersunk head styles are available, and shank diameters include 3·2 mm, 4·0 mm and 4·8 mm.**
Examples: Grovit (Avdel Ltd)



2 *Fastening aluminium cover strips to prefabricated window frames with 'Chobert' rivets*

References

1 BS 4174: 1967 Self-tapping screws and metallic drive screws [Xt6]
2 BS 641: 1951 Dimensions of small rivets for general purposes [Xt6]
3 BS 1855: 1952 Dimensions of bifurcated, tubular and semi-tubular rivets for general purposes [Xt6]

Information sheet
Fixings 7

Machine screws, bolts, nuts, washers

This information sheet describes the characteristics of threaded fasteners with special reference to the lighter fixings more likely to fall within the total choice and specification responsibility of the architect. The structural aspects of bolts are considered to be outside the range of the handbook

1 Introduction

1.01 The threaded fastener consists of a screw with mating nut, or a screw fixed into a hole which has a mating thread. The components can be fixed and unfixed without being damaged. Rotation of the screw head or nut (tightening torque) builds up tension in the screw shank. Many power tools are available to control the tightening torque and increase the efficiency of the fixing.

1.02 In principle, a screw is threaded to the head whereas a bolt may have part of the shank unthreaded. BS 916[1] defines the acceptable dimensions of unthreaded shank for this type, but in practice threaded fastenings with a diameter greater than 6·4 mm are often classified as bolts, whatever the extent of the thread.

2 Characteristics of machine screws and bolts

2.01 Main variants are: head style and driving profile, thread, point, material and finish, diameter and length.

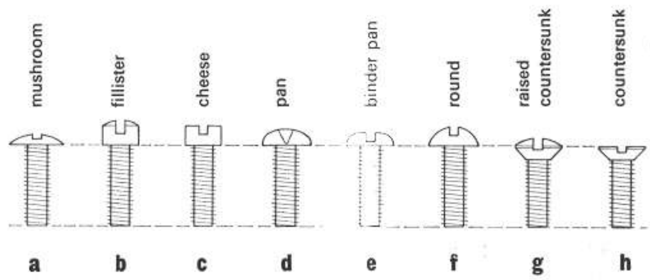
Head style and driving profile

2.02 The cheese head style was a natural result of the manufacturing method of machining screws from solid bars. Though this style is still popular, present production techniques of rolling the shank between toughened dies make it more difficult to form. Head design is influenced by the intended use of the fixing and the degree of force necessary to obtain the right amount of tightening. If the head end of the bolt is prevented from revolving by the friction or mechanical bearing exerted by the material through which it is driven (eg a coach bolt in timber), an unslotted cup head is sufficient. But usually a spanner or screwdriver is needed to hold or turn the head. Many head styles require externally applied wrenches (square, hexagonal or 12-point), but slotted, Phillips and Pozidriv heads are available.

2.03 Internally wrenched heads (socket head) are often chosen for their neat appearance. Some socket screws may be weakened at the wrench points (where the surround metal is weakest), and extra care may be necessary in selection and in tightening. Available head styles are shown in **1 a-h**.

Thread

2.04 There are six common thread styles used in the UK:
BSW (British Standard Whitworth) used in domestic appliances, garden tools and general high-strength engineering assemblies.



1 *Machine screws and bolt head styles*

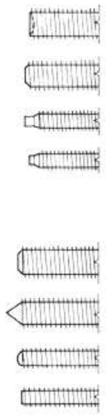
BSF (British Standard Fine) for more delicate assemblies, or where fine adjustment is needed, or for short-thread fixing into brittle materials.
BA (British Association) for electrical switchgear, tv and radio and other domestic appliances.
UNC (Unified Coarse) for motor cars, general high-strength engineering assemblies (similar to BSW).
UNF (Unified Fine) for motor cars, fine adjustment use (similar to BSF).
M (ISO metric) new thread style, intended to be in both coarse and fine, but at present available in coarse only. Description should always include the M prefix, and be in the order: material; type; diameter; length; BS number.
Two thread forms have been standardised by international agreement: ISO metric and ISO inch (unified). These are designed to replace the others, including the continental DIN, CNM and SI metric thread systems. The ISO metric thread is closest to the DIN system, the diameters and thread pitch being interchangeable in many cases.

Point

2.05 The normal point produced from rolling manufacture techniques is a flat rolled end where the last thread rolls over making the end slightly concave.
Where a more positive lead-in is required with machine screws, slightly dearer pointed forms are available **2a-h**.

Material and finish

2.06 Screws and bolts are made from both ferrous and non-ferrous materials. The most common base material is low or medium carbon steel, and the heavier ranges are available in black, bright, high tensile and high strength ranges.



a rolled end

b die point

c full dog point

d half dog point

e 45° chamfer point

f cone point

g round point

h flat point

2 *Styles of machine screw points*

2.07 Larger bolts for external work are often electro-plated or spun galvanised. But the plated finish may affect the thread-making quality.

2.08 Cadmium plating is more expensive than zinc, but has a better appearance. But cadmium is highly toxic and screws plated in this material should not be used in positions where food can be affected.

2.09 Stainless steel is becoming very popular, especially for fixings where corrosion resistance and good appearance are required. Initial cost is relatively high.

Dimensions

2.10 Comparison of the new M (ISO metric) gauges with those of the other standards, and SWG (nails) and British screw (wood screw) gauges, is given in technical study FIXINGS 1, table II. ISO metric diameters are identified by actual millimetre dimensions, the most common being M2·5, M3, M3·5, M4, M5, M6, M8, M10 and M12.

2.11 Preferred lengths (measured from end to underside of head, or to face of fixed component in countersunk styles) are 5 mm, 6 mm, 8 mm, 10 mm, 12 mm, 16 mm, 20 mm and then in 5 mm increments up to 90 mm.

2.12 Preferred diameters for ISO metric black bolts and screws are shown in tables I and II. Sizes of all other machine screws and bolts are given in the British Standards listed in the bibliography.

3 Nuts and washers

3.01 Nuts, of similar materials to the screw or bolt, can be obtained in many thicknesses and profiles, the most common being hexagonal and square.

3.02 Locking devices to withstand loosening by vibration include the established 'castle' principle to accept split-pin or similar locks and many innovations involving special linings, particularly in nylon. The car industry has developed many varieties of captive nut and single-thread nut applications for use in blind assembly situations with machine and self-tapping screws.

3.03 Nylon pellets in specially grooved screws give wedge action.

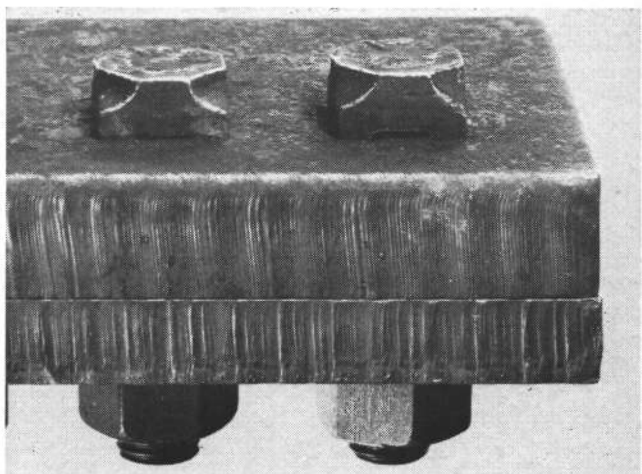
3.04 Washers in many different materials, finishes, thicknesses and diameters are available, including load indicating types. Detailed descriptions are considered to be outside the scope of the handbook.

Table I Sizes of black bolts

Length mm	Diameter M5	M6	M8	M10	M12	M16	M20	M24
25		●						
30		●	●					
35		●	●	●				
40		●	●	●	●			
45					●			
50		●	●	●	●	●		
55								
60		●	●	●	●	●	●	
65						●	●	
70			●	●	●	●	●	●
75								
80				●	●	●	●	●
85								
90				●	●	●	●	●
100				●	●	●	●	●
110								
120				●	●	●	●	●
130					●	●	●	
140						●	●	●
150					●	●	●	
160								●
170								
180					●			

Table II Sizes of machine screws

Length mm	Diameter M5	M6	M8	M10	M12	M16	M20	M24
12		●						
14								
16			●					
20		●	●	●				
25		●	●	●	●			
30		●	●	●	●	●		
35		●	●	●	●	●		
40		●	●	●	●	●	●	
45								
50		●	●	●	●	●	●	
55								
60						●		



3 *Left-hand nut has deformed to show that correct torque has been reached*

3.05 Bolts, washers and nuts have been developed which allow a controlled deformation at specific loading to indicate that satisfactory tightening has been completed.

Reference

1 BS 916: 1953 Black bolts, screws and nuts [Xt6]

Information sheet
Fixings 8

Roofing and cladding fixings

This information sheet shows those fixings designed specifically for corrugated and profiled roof and cladding sheets

1 General

Scope

1.01 Many proprietary sheet systems incorporate fixings with patented interlocking details. These have not been dealt with, but the techniques in all cases are similar and relatively simple.

Waterproof fixing

1.02 Profiled sheets—ie asbestos cement, various metals and plastics—are usually fixed to timber or rolled steel purlins, and all such fixings must be waterproof.

Types of fixings

1.03 Fixings for roofing and cladding are described in BS 1494[1], and include the following types:

1 Hook bolts and nuts (for hooking round steel purlins)—see table I

2 Drive screws (for fixing to timber)—see table IV

3 Washers (for use with screws or nails)—see table II

4 Self-tapping screws (for fixing sheets together and for fixings to steel purlins)—see table III

5 Roofing bolts, nuts and clips (alternatives to hook bolts)—see table V

6 Roofing screws (cone head)

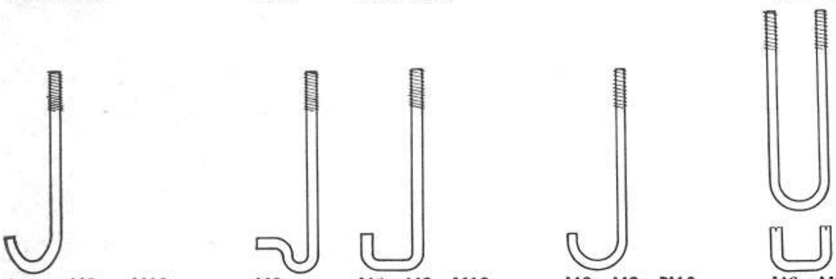
7 Sheeting clips.

1.04 The most common materials used for fixings are aluminium and steel, the latter being treated against corrosion: coated with cadmium or zinc[2] in the case of fixings with machine screw threads, or by electroplating[3], sherardising[4] or hot-dip galvanising[5] in the case of unthreaded or wood-screw threaded devices.

1.05 Plastic screw caps and washers (**A** table II) are now in common use. These are available in many colours, and are particularly used in conjunction with the rapidly growing market of coated cladding sheets.

1.06 Site fixing by stud welding techniques permits the fastening of cladding to steel purlins without drilling or using hook bolts (one method, incorporating a punched-on waterproof cap, is shown in **1**).

Table I Sizes of hook bolts



Length	Diameter Hook bolts			Crook bolts	Square band hook bolts	'J' bolts	Square or round 'U' bolts	
mm	M6 6	M8 8	M10 10	M8 8	M6 : M8 : M10 6 : 8 : 10	M6 : M8 : M10 6 : 8 : 10	M6 : M8 : M10 6 : 8 : 10	ISO Metric mm
60	●	●						
70	●	●	●	●				
80	●	●	●	●				
100	●	●	●	●	●	●	●	
120	●	●	●	●	●	●	●	
140	●	●	●	●	●	●	●	
160	●	●	●	●	●	●	●	
180	●	●	●	●	●	●	●	
200	●	●	●	●	●	●	●	
220		●	●	●	●	●	●	
240		●	●	●	●	●	●	
260		●	●	●	●	●	●	
280		●	●	●	●	●	●	
300		●	●	●	●	●	●	

These bolts are available in steel (bright zinc plated) and aluminium.
Nuts can be square (steel, aluminium) or hexagonal (steel) or with special coloured plastic sealed caps (black, grey or white)

Table II *Washers (for use with screws or nails)*

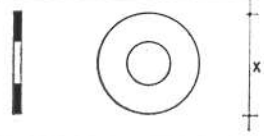
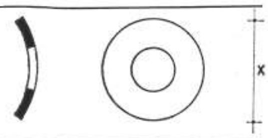
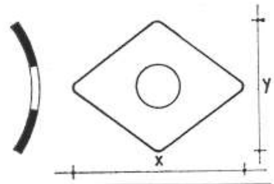
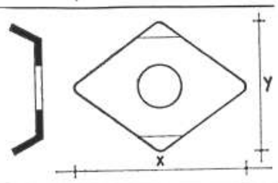
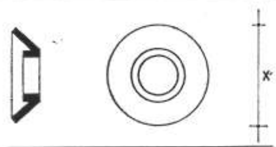
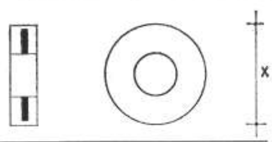
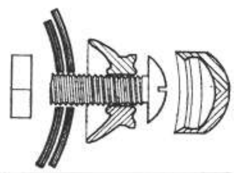
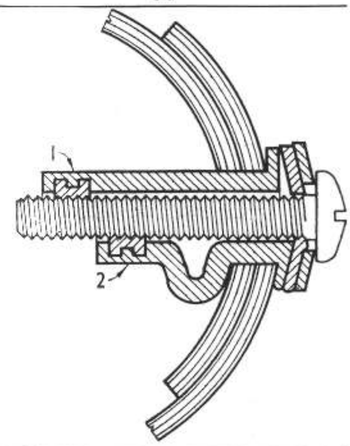
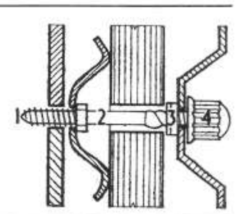
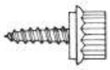
Type	**Material**	**Diameter** M5	M6	M8	M10	**X**	**Y**		
Round flat	Steel, zinc plated	●	●	●	●	15–34			
	Aluminium	●	●	●	●	15–34			
	Pvc, soft		●	●		32			
	Bitumen		●	●	●	22–35			
	Lead		●	●	●	18–24			
Round curved	Steel, zinc plated		●	●	●	18–24			
	Aluminium		●	●	●	18–24			
Diamond curved	Steel, zinc plated		●	●	●	35	35		
	Aluminium		●	●	●	35	35		
	Bitumen		●	●	●	38	38		
Diamond cranked	Aluminium		●	●	●	35	35		
Sleeved conical	Lead		●	●	●	18–24			
Round flat (sealed)	Steel, encased in pvc		●	●		20–35			
Special fixings Selawashers' and covers (British Screw Co Ltd, GKN) to provide waterproof cladding to screws, drive screws and machine screws			●	●				**A**	
'Laplox' grommet fixings (Linread-Fabco Ltd) stainless steel machine screws in neoprene washer. 1 shows before tightening 2 after		9·5 mm ($\frac{3}{8}$in) hole through sheets						**B**	
'Selastud' British Screw Co Ltd, GKN)								**C**	

Table III *Sizes of self-tapping steel screws*

Length	Diameter		screw gauge
	10	14	
mm	4·9	6·3	mm
6		○ ■ ●	
20	□	○ ■ ●	
25		○ ■ ●	
30		○ ■ ●	
35		○ ■ ●	
40		○ ■ ●	
50		○ ■ ●	
60		○ ■ ●	
70		○	
80		○	
100		○	
120		○	
140		○	



12 point head

Hexagon head

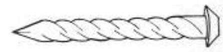
Key
- □ 12 point head (plastic covered steel with pvc sealed washer)
- ○ 12 point head (plastic covered steel similar to □ but self-tapping)
- ■ Hexagon head (cadmium plated steel)
- ● Hexagon head (cadmium plated stainless steel)

Note: Self-tapping screws for work other than roofing shown in Fixings 6

Table IV *Sizes of drive screws*

Length	Diameter			screw gauge
	14	18	20	
mm	6·3	7·7	8·4	mm
35	● ○			
40	● ○			
50	● ○	● ○		
60	● ○	● ○		
70	● ○	● ○		
80	● ○	● ○	●	
100	● ○	● ○	●	
120	● ○	● ○	●	
140	●	● ○	●	
160	●	● ○	●	
180			●	
200			●	
220			●	
240			●	
260			●	

Round head screw



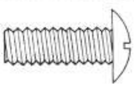
Pan head screw

Key
- ● Round head screws (bright zinc plated steel) can be used with various washers, including plastic with matching sealed covers
- ○ Pan head screws (aluminium) can be used with various washers, including plastic with matching sealed covers

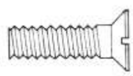
Table V *Sizes of roofing bolts and clips*

Length / Diameter

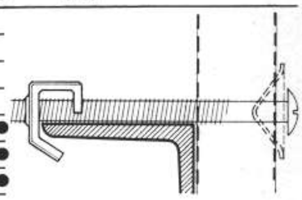
Roofing bolts (mushroom head)



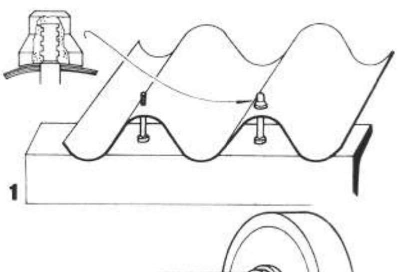
Gutter bolts (countersunk head)



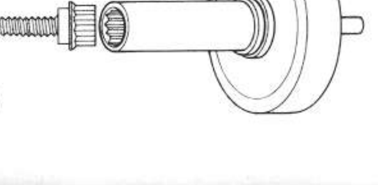
Length	Roofing bolts: Steel, bright zinc plated				Roofing bolts: Aluminium				Gutter bolts: Steel, bright zinc plated			Gutter bolts: Aluminium		ISO metric
	M5	M6	M8	M10	M5	M6	M8	M10	M5	M6	M8	M6	M8	
mm	5	6	8	10	5	6	8	10	5	6	8	6	8	mm
8	●	●			●									
10	●	●			●									
12	●	●	●	●	●	●	●		●	●	●	●		
16	●	●	●	●	●	●	●		●	●	●	●		
20	●	●	●	●	●	●	●		●	●	●	●	●	
25	●	●	●	●	●	●	●	●	●	●	●	●	●	
30	●	●	●	●	●	●	●	●	●	●	●	●	●	
35	●	●	●	●	●	●	●	●	●	●	●			
40	●	●	●	●	●	●	●	●	●	●	●	●	●	
50	●	●	●	●	●	●	●	●	●	●	●	●	●	
60	●	●	●	●	●	●	●	●	●	●	●			
70	●	●	●	●	●	●	●	●	●	●	●			
80		●	●	●		●	●			●	●			
100		●	●	●		●	●			●	●			
120		●	●	●			●			●	●			
140		●	●	●			●			●	●			
160		●	●	●			●							
180		●	●	●										
200		●	●	●										
220			●	●										
240			●											
260			●											
280			●											
300			●											



Oakley clip at end of roofing bolt for fixing bolt to roofing purlin. Clips available with tapped hole or clearance hole (for use with nuts) to suit M6 or M8 bolts
Roofing bolts, available in both materials, with or without matching square nuts or punched on plastic caps, and can be used with Oakley clips
Gutter bolts, available in both materials with square or hexagonal nuts



1



2

1 Waterproof cap on welded stud (Crompton Parkinson Ltd)
2 Driving unit for controlled driving of 12 point plastic head screws

2 References

BRITISH STANDARDS INSTITUTION:

1 BS 1494 Fixing accessories for building purposes. Part 1: 1964 Fixings for sheet, roof and wall coverings [(4–) Xt6]

2 BS 3382:Parts 1 and 2:1961 Electroplated coatings on threaded components. Part 1 Cadmium on steel components, Part 2 Zinc on steel components [Yu1]

3 BS 1706:1960 Electroplated coatings of cadmium and zinc on iron and steel [Yu1]

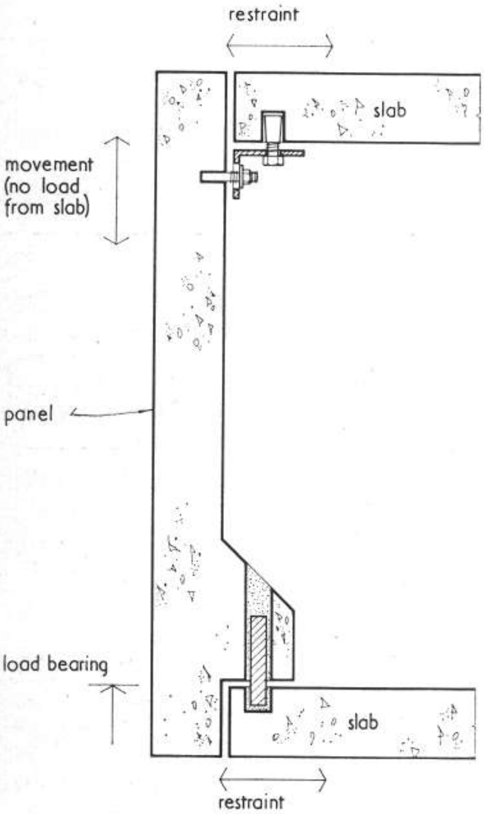
4 BS 729 Zinc coatings on iron and steel articles. Part 2: 1961 Sheradized coatings [Yu1]

5 BS 729: Part 1: 1961 Hot-dip galvanized coatings [Yu1]

Information sheet
Fixings 9

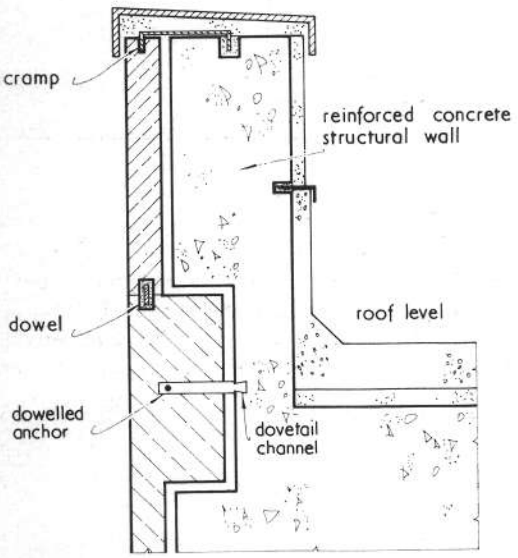
Masonry cramps and anchors

This information sheet covers fixings which are designed to locate or secure a component to a backing. It includes ties for cavity walls, cramps, anchors and dowels for stone and concrete and corbel plates for stone



1

1 ***Cross section through typical panel, showing kinds of loads to be resisted by fixings***



2

1 Loadbearing and restraint fixings

1.01 There are two types of masonry fixings:
Loadbearing fixings, ie those required to withstand dead and variable loads and
Restraint fixings, ie those required to withstand variable loads only.

1.02 The principle of restraint applies to the fixing of panels to backing walls. The dead weight of the component panel must be supported, and the panel must be restrained against the base. Restraint fixings must resist wind pressure which may tend to pull the panel off the building, and counter any inherent instability in the panel's form. Many failures of panel fixings are the direct result of inadequate restraint. See **1**.

1.03 The panel and restraint fixing must not be inadvertently loaded by other parts of the structure: for instance, if a panel rests on a nib at its base, it may be improperly loaded if a badly designed restraint at the top of the panel transfers loads from the floor slab above.

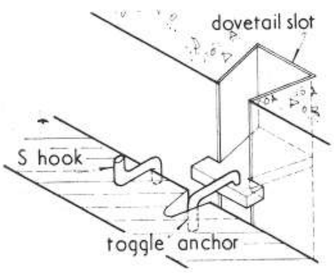
2 Materials

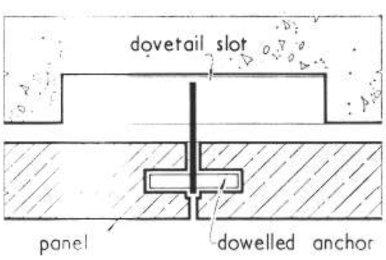
2.01 All fixings described are available in the following materials: copper, phosphor bronze, gunmetal, aluminium bronze, silicon bronze, manganese bronze (high tensile brass), stainless steel, including the relatively new high proof stress stainless steel.

2.02 Wall ties are also available in galvanised steel and plastics.

3 Reference

1 BS 1243: 1964 (revised 1967) Metal ties for cavity wall construction [(21·1) Xt6]





3 4

2, 3, 4, *Typical applications of the fixings shown in table* I *overleaf*

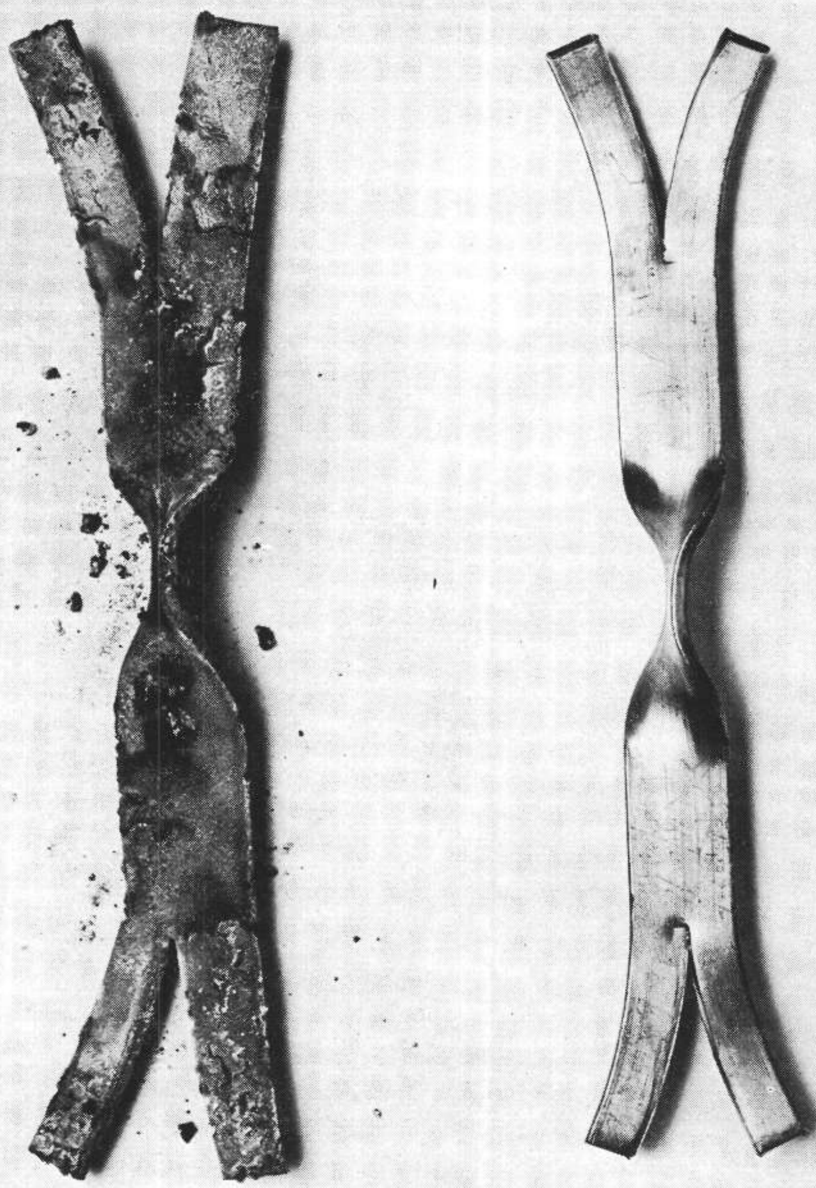


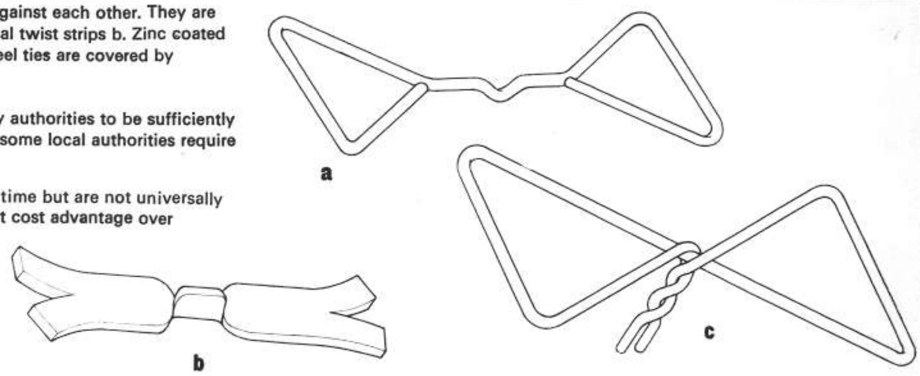
Table 1 Types of masonry fixings

Wall ties are designed to restrain cavity walls against each other. They are available in two forms, butterfly ties a, c; vertical twist strips b. Zinc coated steel, copper and copper alloy, and stainless steel ties are covered by BS 1243[1]

Hot dip galvanised ties are considered by many authorities to be sufficiently durable, especially if coated with bitumen, but some local authorities require all wall ties to be non-ferrous metal

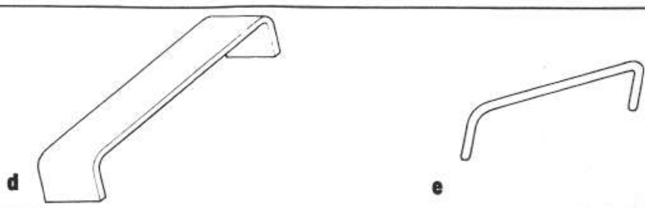
Plastics ties have been on the market for some time but are not universally approved by local authorities and have no great cost advantage over galvanised steel

a Double triangle tie
b Vertical-twist tie
b Butterfly tie



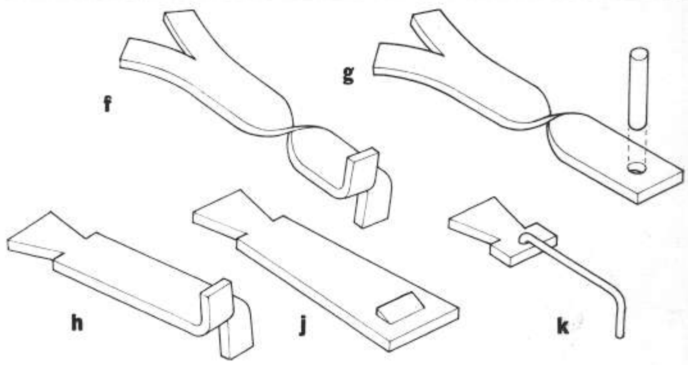
Cramps (*restraint*) are metal bars which join adjacent stones or slabs in a course. Each end of the bar is bent through 90° and embedded in slots or mortises cut into the stones or slabs. If they are grouted into a channel in the slab, at least 13 mm cover should be maintained

d Cramp for thick facing
e Cramp for thin facing



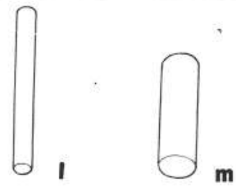
Cavity anchors (*restraint and loadbearing*) These fixings are designed to restrain component panels against a base in the same way as wall ties, except that they are used for dissimilar materials. Anchors can fix stone to concrete, brick or lightweight block; concrete to concrete; or brick to concrete.
Anchors for external concrete cladding slot into a dovetail channel cast into the concrete **3**. Anchors for thin internal facings are usually grouted

f Fishtail masonry anchor—stone/brick
g Dowelled fishtail anchor—stone/brick
h Masonry anchor—stone/channel
j Nibbed brick anchor—channel/brick
k Toggle anchor—thin panel/channel



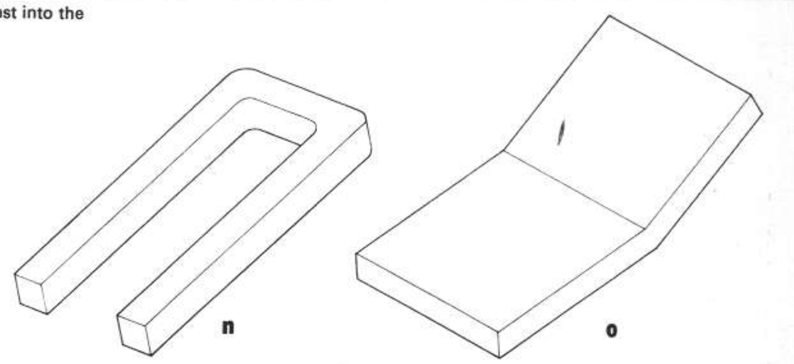
Dowels (*restraint*) These are used in the same way as dowels in joinery: they form a connection—usually vertical—between a component and a supporting nib, and are grouted in

l, m Dowels for different situations

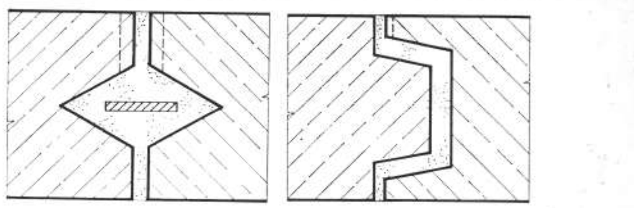


Corbels (*loadbearing*) are plates grouted deeply into pockets cast into the backing and again into pockets cut into the component

o Step corbel
u Cranked corbel



Joggles (*restraints*) are a form of tenon joint used on sides of panels as well as at top and bottom. The components may be connected by cement grout, metal bars, or Valentia slate strips laid in fine cement or oil putty. Vertical dotted lines show grouting hole



Direct fixing (*loadbearing and restraint*) Stone panels are sometimes used as lining to shuttering or as a major part of the shuttering itself, so that they are bonded directly to the concrete base. The joints between the slabs are sealed with mastic to stop grout appearing on the finished surface of the stone. These joints are repointed after the formwork is struck

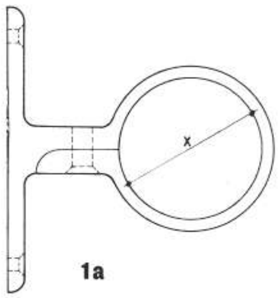
Information sheet
Fixings 10

Pipe and conduit fixings

This information sheet describes the range of fixings available for pipes and conduits with special attention paid to the many fastening devices developed recently

1 General

1.01 Specialisation in some fields of building sub-contracting is leading to individual fixing firms handling a number of separate components. Several ceiling package companies erect lighting and ventilation components, in addition to ceiling membranes. This has brought about some rationalisation of fixing devices to suit differing components. Several families of devices have been developed to cope with fixing service runs.



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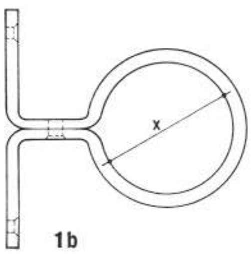

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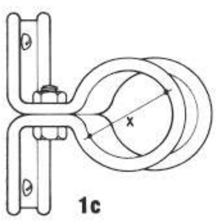

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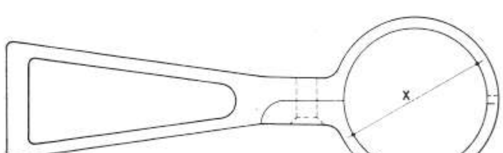

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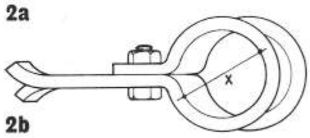

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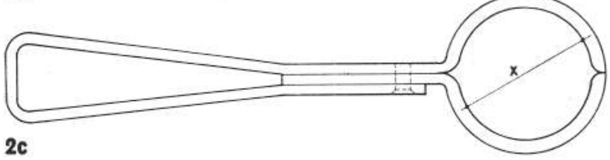

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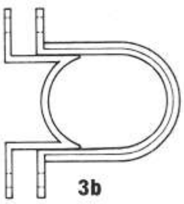
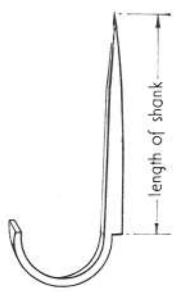
3a



3b

Pipe fixings

1.02 Brackets for pipe fixings, both wall fixed and for building in are covered in the requirement of BS 1494[1]. This BS covers screw fixed brackets for wall mounting **1**; lugged for building **2**; one- and two-piece pipe clips screw fixed for wall mounting **3**; pipe hooks for driving into brickwork **4**; a range of iron, steel and brass back plates **5**; and single and double pipe rings threaded to allow for suspension **6**.
Two-piece pipe clips are available as standard detachable head pieces to various fixing devices, ie expanding bolts for fixing into brickwork and concrete **7**, and attaching to standard fixing channels **8**, in situ or surface mounted **9**.



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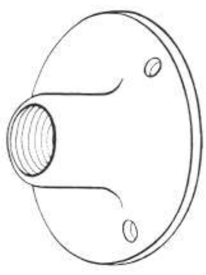

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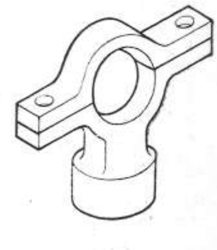

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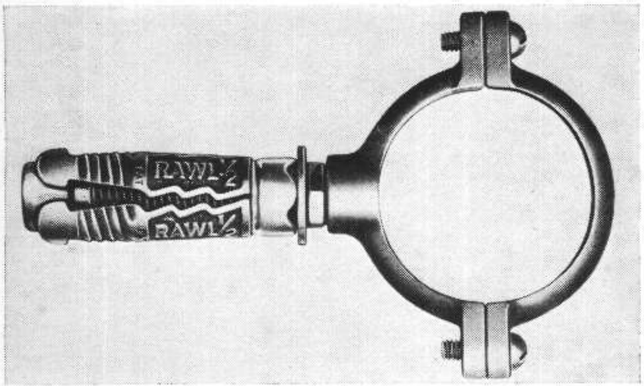
1 *to* **6** *Brackets for pipe fixings* (BS 1494[1])

1 *Wall mounted pipe fixings. Nominal sizes quoted are pipe* IDS. *Bracket diameter* X *equals* OD *of pipe plus tolerance:*
a *malleable iron brackets for steel or wi pipes—nominal sizes ⅜in (9 mm) to 4in (100 mm). Also in cast brass for light gauge copper pipes—nominal sizes ½in (13 mm) to 2½in (63 mm);* **b** *mild steel brackets (ribbed section) for steel or wi pipes—nominal sizes ⅜in (9 mm) to 6in (150 mm);*
3 *mild steel brackets (rectangular section) for steel or wi pipes—nominal sizes ⅜in (9 mm) to 2in (50 mm). Also in brass for copper pipes—nominal sizes ½in (13 mm) to 2in (50 mm)*
2 *Pipe fixings lugged for building in. Nominal sizes quoted are pipe* IDS. *Bracket diameter* X *equals* OD *of pipe plus tolerance:* **a** *malleable iron brackets for steel or wi pipes—nominal sizes ⅜in (9 mm) to 4in (100 mm). Also in cast brass for light gauge copper pipes—nominal sizes ½in (13 mm) to 2½in (63 mm);* **b** *mild steel brackets (rectangular section) for steel and wi pipes—nominal sizes ⅜in (9 mm) to 2in (50 mm). Also in brass for copper pipes—nominal sizes ½in (13 mm) to 2in (50 mm);* **c** *mild steel brackets (ribbed section) for steel or wi pipes—nominal sizes ⅜in (9 mm) to 6in (150 mm)*
3 *Pipe clips:* **a** *one-piece clips in tinned steel for wi pipes—nominal sizes ⅛in (3 mm) to 3in (75 mm) and copper for copper pipes—nominal sizes ⅛in (3 mm) to 2in (50 mm);*
b *Two-piece copper clips for copper pipes—nominal sizes ⅜in (9 mm) to 1½in (38 mm)*
4 *Pipe hooks for lead and iron pipes—nominal sizes ⅜in (9 mm) to 1½in (38 mm)*
5 *Iron, brass and steel back plates*
6 *Single-pipe ring threaded for suspension. Also available as double-pipe rings*



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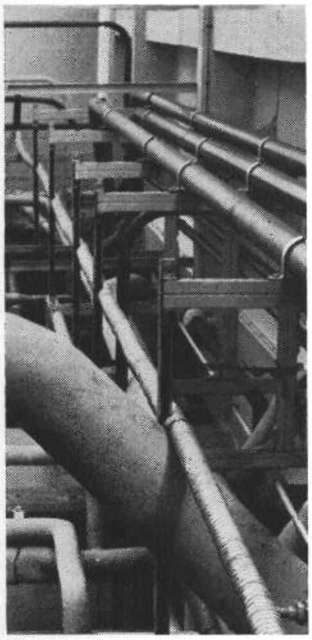

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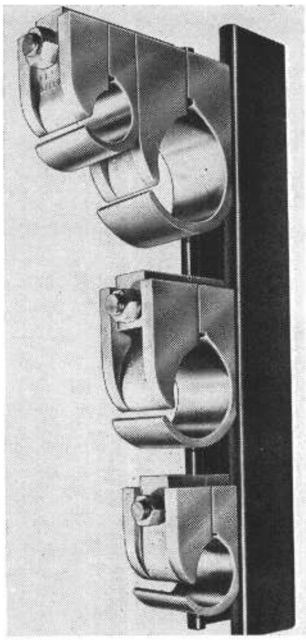

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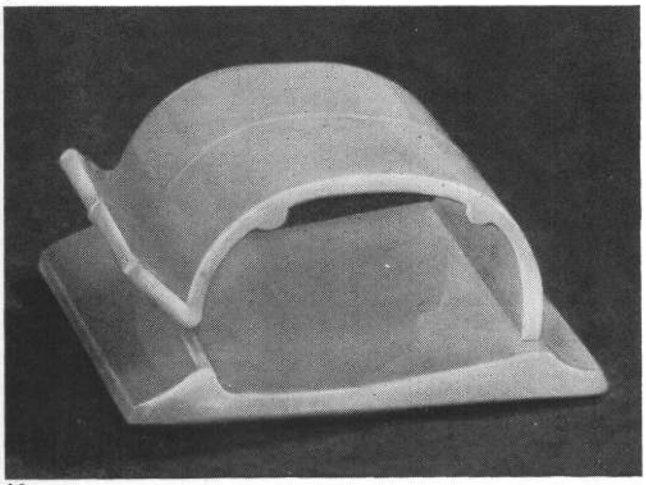

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7 *Two-piece pipe clip as a standard detachable head piece to an expanding bolt fixing (eg 'Rawlbolt' by Rawlplug Ltd) and Phillips* BSP *Selfdrill*

8 *Two-piece pipe clips for attaching to standard channel fixing frames (eg 'Unistrut range' by* GKN *Sankey Ltd)*

9 *Two-piece pipe clips suited to stacking by attaching to built-in standard channel fixings (eg* GKN *Sankey Ltd)*

10 *Nylon saddle slip cable fixing with pressure sensitive adhesive backing (eg* ITW *Ltd)*

11 *Hung steel strap fastening (eg 'Caddy' by W. J. Furse & Co Ltd)*

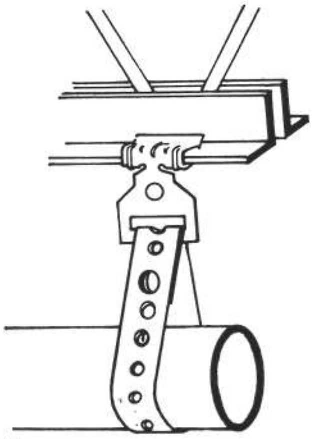
12 *System of steel hangers with heat-treated sprung steel clips incorporated in a suspended ceiling (eg as for* **11**)

Cable and conduit fixings

1.03 In addition to the conventional range of pressed steel and aluminium conduit and cable fixings there are several ingenious clips and saddles designed to provide economies by single screw fixings, or by dispensing with screws or pins and incorporating a base treated with pressure sensitive adhesive **10**.

Other devices

1.04 Considerable use is now made of 'strap' fixings **11**, a technique familiar in packaging and crate-fastening. These are being used for suspension of pipes and ducts, and are made of perforated metal (steel, galvanised or plastic coated; copper or aluminium) fixed with screws, or unperforated metal clamped with a buckle or special tool. A large range of fastening devices has been developed from heat treated sprung steel. These fixings include clips for securing rods to structural steel and for suspending all types of pipes, conduits and ductwork **12**.



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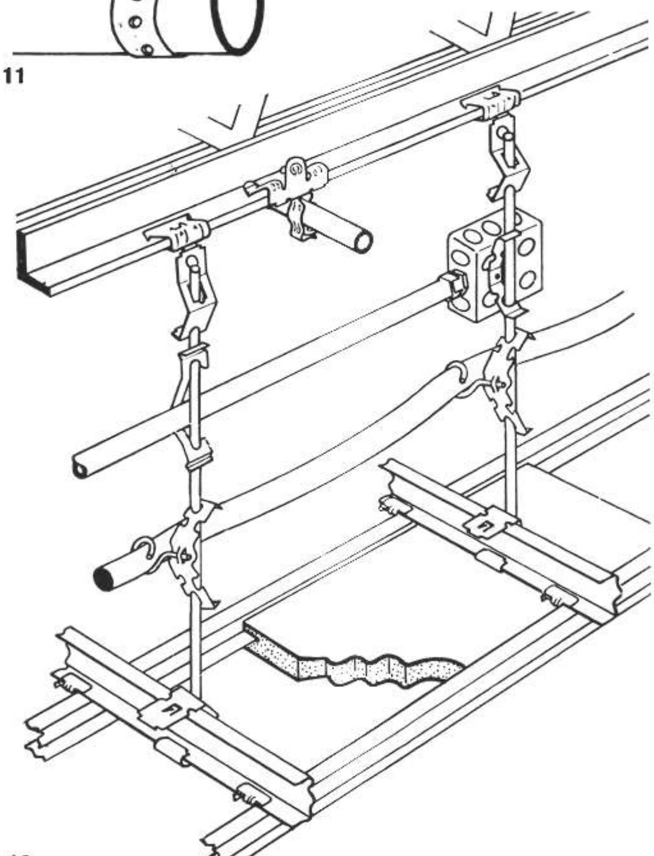

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2 References

BRITISH STANDARDS INSTITUTION

1 BS 1494:1951: Fixing accessories for building purposes [(5–) Xt5]

Information sheet
Fixings 11

Power tools

This information sheet describes types of power tools with particular attention to cartridge fixings

1 Hole boring

Selection of tools

1.01 The majority of tools for boring holes rely on one or more of three types of actions: rotary, percussive or vibratory. The type of action required depends on the quality of the base material, conditions and facilities on site, and the type of fixing to be used.

Rotary drilling

1.02 Rotary drilling **1** is quieter and is often preferred on sites where noise must be restricted. It is a technique suited to softer materials (eg timber) and homogeneous materials (eg common brick, slate, marble, hollow building block). Homogeneous materials permit the necessary continuous and even cutting action.

Hollow block

For hollow blocks, rotary drilling should be used, as more violent methods may cause material to break off the inside of the cavity, reducing the thickness available for the fixing.

Concrete

Rotary drilling is suited to concrete containing soft aggregates if tungsten carbide tipped drill bits **2** are used, though pebbles or flint present in the material may jam the bit and damage it or the tool. Drill bits with trepanning action avoid jamming by cutting an annular slot in concrete or masonry, allowing the core to break off and be ejected down the shaft of the drill bit and out of a slot at the side. Holes up to 38 mm can be bored by this method.

Drilling technique

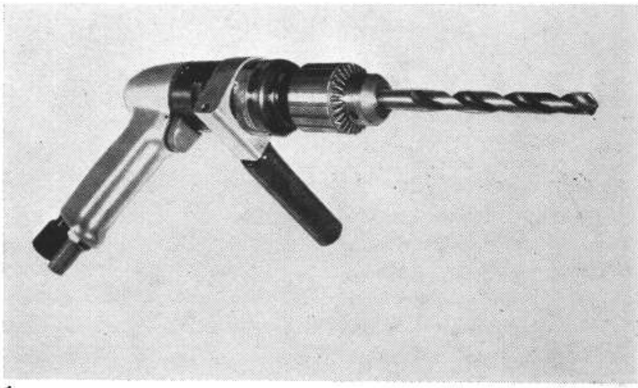
A pilot hole of small diameter bored first enables a second, larger hole to be drilled faster as the drill bit tip has less work and is guided down the existing hole.

Drilling speeds

Drilling speeds for masonry should be low to minimise heat build up at the drill bit tip. Large diameter holes require slower drilling speeds—normal length drill bits of 10 mm diameter can be used at 600 rpm, but reduced to 200 rpm when the diameter is increased to 25 mm. Longer drill bits necessitate slower speeds to prevent whip in the shaft.

Drilling pressure

For diameters up to 13 mm, drilling pressure should be maintained at a constant level and as high as possible without mechanical aids. Larger diameters require the application of some form of leverage, though pressure must not be so great that when combined with high speed, the drill bit tip overheats.

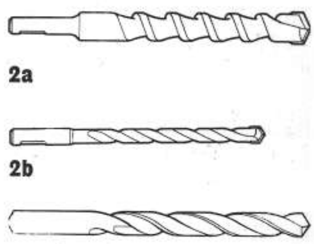


1

1 *Pneumatic-powered rotary drill with masonry drill bit (eg Desoutter Bros Ltd)*

2 *Carbide-tipped masonry drill bits* **a**, **b**; *drill bit for steel* **c**

3 *Tools for drilling into corners (eg as for* **1**)



2a

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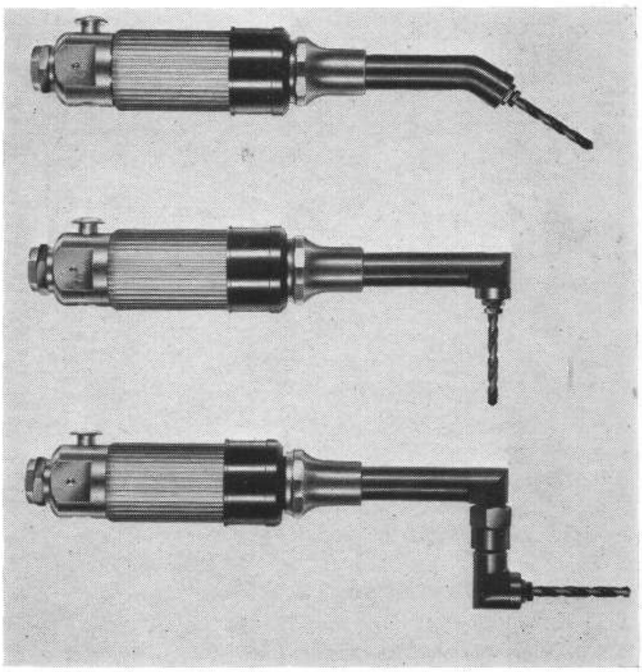


3

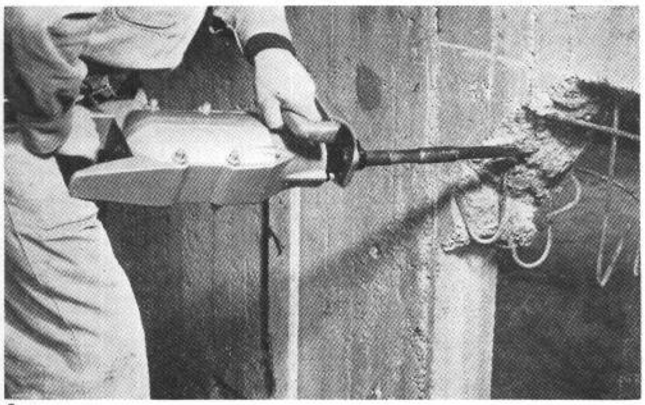
Choice of bit
Rotary drills wear, reducing the drill bit diameter, and allowances should be made if a precise diameter is required with a used drill bit. Cutting angles of drill bit tips used for masonry are different from those for steel **2**, and the same drill bit cannot be used for both materials—a masonry drill bit will be damaged if reinforcement bars are encountered.

Pneumatic and electric tools
Rotary tools powered by electricity are suitable, in their various forms, for all types of materials. Auger bits can be used in slow speed models when drilling timber. Pneumatic high speed drills are only suited to drilling metal, timber, plastics etc. Pneumatic tools are generally lighter than electrical ones, safer to use, and are available with short right-angled heads for drilling in tight corners **3** (eg metal strings to stairwells).

Percussive drilling

1.03 Harder materials (eg engineering brickwork and granite or pebble aggregate concrete) should be drilled with percussive action **4**, as the pounding tool head breaks up hard obstructions in its path.

Drilling action
The pounding action can be combined with rotary motion supplied either by the tool or by hand (manual rotation prevents the tool from binding in the hole, and is recommended for fixings such as self-drilling anchors). Both electrical and pneumatic tools are available for drilling into masonry, with the option of mechanical rotation



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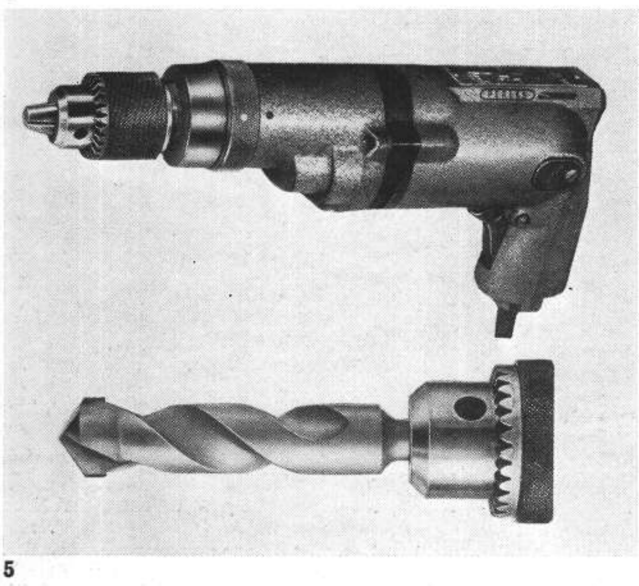


5

4 *Percussive tool (eg Tornado Fixings Ltd)*
5 *Vibratory tool combining rotary and percussive action (eg 'Perles* PSB *137' by Firthbourn Ltd)*

Noise and safety
Percussive drilling is noisy and dusty (especially dusty if pneumatic tools with air debris ejection are used). Safety goggles should always be worn when percussive drilling tools are used (and with all tools when drilling into the underside of masonry).

Drilling technique
Tips of percussion tools require frequent sharpening to maintain efficiency. Holes drilled are slightly larger than the nominal diameter of the tool. Percussion speeds of 1500 to 2500 blows per minute are suitable for masonry, but larger diameters require slower percussive rates to avoid excessive heat build-up. Though the tool heads are robust in use, they can be damaged and are often provided with a protective cap to place over the tip when not in use. To position holes accurately with a percussion drill, templates should be used—eg a piece of timber with a hole or holes of tool head size bored in it.

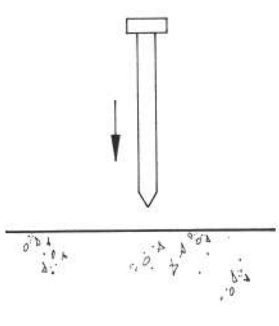
Vibratory drilling

1.04 Vibratory tools **5** combine rotary and percussive action, with the tool head performing a rotary cutting action aided by rapid blows during this motion to improve penetration. Rotary speeds between 500 and 1000 rpm and are used in conjunction with vibratory frequencies of 5000 to 15 000 cycles per minute. If the right combinations of these are used, vibratory tools are capable of drilling most materials (eg concrete, stones, slate, glazed tiles, steel, aluminium, plastics, wood and asbestos). Special drill bits are used for vibratory action, but they can be interchanged with other drill bits if the tool can be switched to rotary action only.

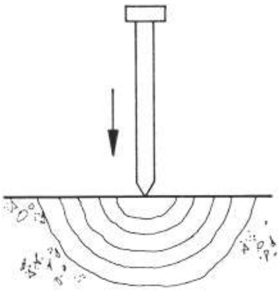
2 Cartridge fixings

Cartridge fixings generally

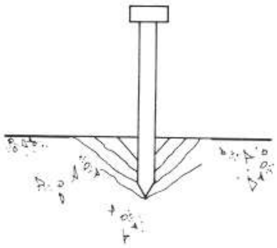
2.01 Cartridge fixings are also termed: displacement fasteners; powder actuated fixings; or explosive or fired fixings. They all depend upon the detonation of an explosive to drive a hardened austempered steel pin into an unprepared base material. The holding power is obtained by the compression of the displaced base material against the sides of the pin.
The deceleration of the pin during penetration causes the conversion of kinetic energy into heat and this tends to fuse the silicates present in concrete into glass, thus forming a chemical bond with the pin in addition to the mechanical one. It has been estimated that the bond of an average fixing is 70 per cent mechanical and 30 per cent chemical.
Pins are available for fixing into concrete or steel. The process by which a fixing is obtained in concrete is a violent one:
1 The pin is accelerated.



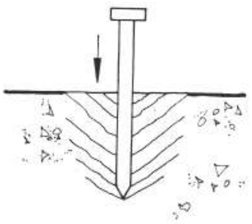
2 Impact sets up stress waves which travel through the concrete.



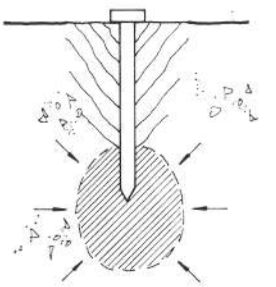
3 Cracks propagate to relieve the stress. These reach the surface creating a cone of loosened material which is liable to spall. There is no holding power at this stage.



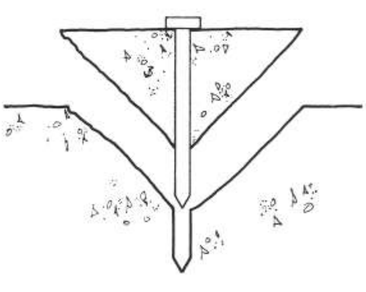
4 Eventually, energy is absorbed to the extent that cracks do not reach the surface. This section of concrete contributes little to the holding power and though it is secure at this stage, it will pull out with the pin at failure.



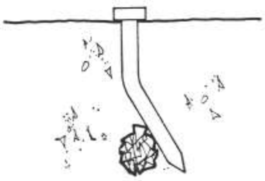
5 When the stress falls below a level at which a crack can propagate, compression of the concrete occurs: the ovoid of concrete around the tip of the pin provides nearly all the holding power of the fixing.



6 Simple and typical pullout failure.



7 If the pin strikes a hard piece of aggregate such as flint, or if it is not fired at right angles to the surface, it may deform or shatter and will have to be replaced. As the replacement should be at least 20 shank diameters distant, this risk renders them unsuitable for fixings which have to be precisely located.

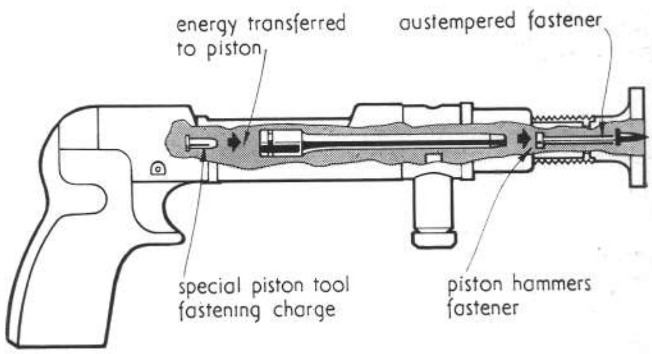


Types of tool

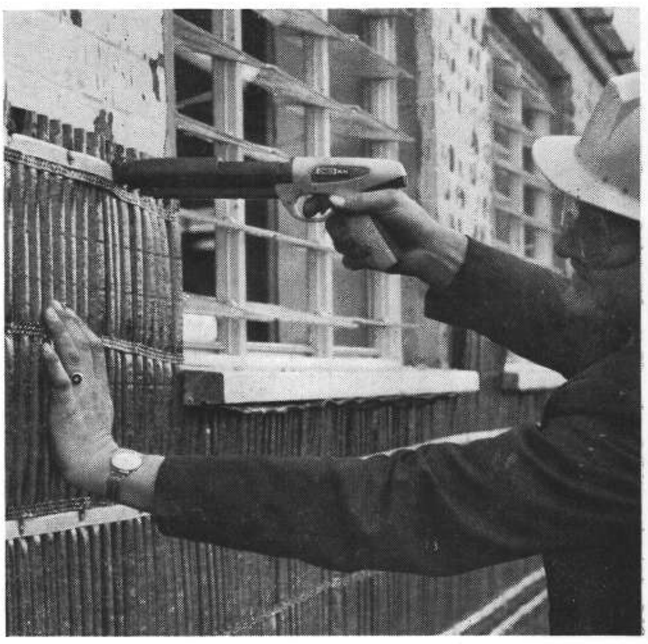
2.02 There are three basic types of tool:
1 Direct acting.
2 Piston actuated.
3 Hammer actuated.

Direct acting
Expanding gases of an explosion propel the pin in free flight along the barrel of the tool. They are high velocity tools with high muzzle energies.

Piston actuated
Piston tools **6** drive the pin at a comparatively low velocity and muzzle energy, using the inertia of a heavy captive piston propelled by the gases of the explosion. Both the foregoing types are trigger operated.



6 *Piston-actuated cartridge tool*



Hammer actuated

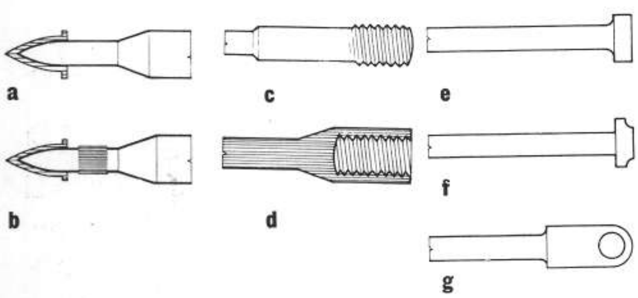
The hammer type is mechanically simpler and cheaper than direct acting and piston actuated tools. It operates on the piston principle, but is held in the hand like a drift, and the head of the tool is struck with a hammer to fire the cartridge.

Cartridges and pins

2.03 Cartridges and pins are specially made for each model of tool and should never be interchanged between models or manufactures. Cartridges are available in a range of strengths for different materials and are colour coded to BS 4078[3]. The weakest cartridge in the range should always be used for the first test shot into any material, and the strength gradually increased through the range until the required degree of penetration is achieved. An overstrength cartridge used with a thin or insubstantial base can cause the pin to penetrate and emerge on the other side in free flight. A tool developed to avoid this danger uses threaded stud-pins. These are screwed into a socket in the piston and held captive while firing. The tool is then unscrewed from the stud. Example: Ramset (Rawl) 'Flite Check'.

Types of pin

Pins are available in two shank patterns: a plain shank with an ogive ballistic tip for concrete **7a** and a similar type with a knurled section of the shank for steel **7b**. A metal or plastics end piece steadies the pin in the barrel and ensures vertical impact—it takes no part in the penetration. A variety of heads is available including male and female threaded studs, nails and eyepins.



7 *Pins are available in two shank patterns* **a**, **b**, *with a variety of heads* **c**, **d**, **e**, **f**, **g**

Cartridge fixings at edges

Pins may deflect towards a free edge of the base, following the path of lowest stress concentrations in the base. Minimum edge distance for pins are set out in table 1 or as follows, whichever is the greater:

1 For firing into concrete: 100 mm with a direct action tool, and 50 mm with a piston tool.

2 For firing into steel: 15 mm with any tool.

Cartridge fixings into concrete

Cartridge fixings should never be applied to concrete less than five days old. For other limitations see table I.

Table I Limiting distances for cartridge fixings into concrete

Edge distance*	× 15 shank diameter	Minimum
Spacing	× 20 shank diameter	Minimum
From reinforcement	13 mm all directions	Minimum
Penetration depth	× 6 shank diameter × 8 shank diameter	Minimum Optimum

* Edge distance is also dependent on material and tool (see para 2.03)

Spacing fixing

Displacement fixings set up compressive stresses in the base material, and for these not to be concentrated at some point between two fixings, a minimum spacing should be preserved. This generally bears a relationship to the diameter of the shank (see table I).

Spacing should also take account of other factors such as the position of reinforcement and brick coursing.

Depth of fixing

It may be important in some cases to consider the depth required by a fixing for a required strength. Fixings into floors containing damp-proof membranes, or into thin precast panels for example, may render the depth of penetration critical (see table I).

Safety

2.04 These tools are similar to firearms and safety must be considered when using them. The pin from a direct action tool is the most dangerous of the three, and hammer actuated tools are usually regarded as the safest—if only because both hands are committed to their use and a more deliberate action is required than with trigger operated tools. The degree of danger depends to a great extent on the operator and is difficult to assess; there are more fatalities with piston tools, partly because they are more common, and partly because wear or malfunction within the tool can result in accidentally high muzzle velocities, or send the pin into free flight.

As a firearm

All tools include safety devices to prevent firing unless the tool is pressed against a substantial surface and within a few degrees of right angles to that surface. It is possible, however, to use the tool as a firearm, and serious or fatal injury could result. Muzzle velocities similar to that of a 9 mm automatic pistol are possible with direct acting tools, and it is estimated that a pin fired from such a tool could cause injury at a range of 500 m.

Splinters and pin deflections

Operators can be in danger from splinters or pin deflections. No attempt should be made to fire into brittle or glazed materials (eg cast iron, glazed tiles, or brittle bricks) as splinters can occur. Safety goggles should always be worn by operators and any bystanders watching the process.

If the pin strikes a hard object in its path, or an inclined plane, it will probably be deflected. In such cases there is a danger of complete flight reversal with the pin emerging from the base to injure the operator or others. The most common cause of flight reversal is from attempts to fire the pin into the crater left by a previous unsuccessful attempt, as the pin is deflected by the sloping side of the crater. To avoid this, correct muzzle guards should always be used.

Performance of cartridge fixings

2.05 There is some controversy as to the performance of cartridge fixings—at least one national contractor has formulated a policy against their use in concrete, and there are several instances of substantial failure. Many failures have been ascribed to incorrect application, but it is difficult to discover precise causes for others. Structural engineers often prohibit their use in slab soffits, as the high concentration of aggregate at this position increases the chance of deformation and failure of the fixings; and with the proximity of reinforcement, additional and unpredictable local stresses are undesirable.

Tests
A study made in 1960 in the US[1] revealed cartridge fixings in concrete to be unsatisfactory because of: frequent misapplication; lack of positive anchorage; and failures in shear and tension. A further study made in 1961 was discontinued as the high rate of failure (33 per cent) made statistical analysis of strength unreliable. Results of another study published in 1964 included a recommendation that cartridge fixings in concrete be limited to a net load of 22·6 kg each in areas receiving ceilings. A correctly applied fixing driven 25 mm into suitable concrete could be expected to fail at a steady pullout load of 1100 to 1300 kg.
If substantial loads are to be carried it is wise to test each fixing in position before the service load is applied.

Performance in concrete
Concrete containing hard aggregates (eg flints) is unsuitable for cartridge fixing. Concrete containing softer aggregates (eg limestone) is more suitable, and the failure rate will be lower as the materials become softer or more consistent (providing that edge distance requirements are satisfied). Fixings into compressible brick are more reliable than into concrete because the material is more homogeneous.
There is some evidence that pins fired into concrete by direct acting tools develop a holding power some 25 per cent higher than that obtainable with piston tools. This is thought to result from the higher velocity which:
1 Results in higher temperatures during deceleration consequently fusing more silicates, strengthening the chemical bond.
2 Shortens penetration time and therefore, the duration of the shock waves. Shock waves can be reflected from pieces of aggregate or surface and if the penetration time is prolonged they can reinforce others in their reflected path.

Performance in steel
Mild steel is much more consistent than concrete and brick, and has quite predictable properties. Pins can be fired into steel with a high rate of success. Failures are often the result of surface contamination of the steel—oil or grease, if present, will reduce the withdrawal strength of the pins. Fixings may be similarly affected if coatings such as plastics or bitumen are driven through the steel with the pin. Many failures in steel are the result of over penetration; if the pin is driven into the steel beyond the smooth section of the shank, withdrawal strength will be reduced.

3 Special tools

Screwdrivers and nut-runners

3.01 Pneumatic and electric hand tools are available for driving screws and nut-running. Power screwdrivers will accept a variety of bits for different sizes and types of screw heads, and may also incorporate a clutch to prevent overscrewing and assist the start. Nut-runners usually have a standard ½ in (13 mm) square drive for a socket wrench, and can be set to slip at a given torque loading. They are also available with an impacting action on a nut.

Self-tapping screw devices

3.02 Some fixing systems provide fast and secure screwed fixings by combining a pneumatic screwdriving tool with purpose designed screws. In one such system, the screws have a four faceted pointed tip; the impact action of the tool forces the point through the metal and the driving action sends the screw fully home. The tool has a variable torque device. Compared with normal self tapping screws in drilled holes it is claimed that this system increases holding power by about 30 per cent, and that resistance to vibration is improved by a factor of about ×30. It is particularly suited to fixing soft materials such as plasterboard to a metal channel. (Example: GKN Spat self-piercing and self-tapping screw. See information sheet FIXINGS 6 table III.)

Torque wrenches

3.03 Hand operated and pneumatic torque wrenches are used to tighten nuts and machine screws to predetermined and precise torques.
Torque multipliers are usually used when it is necessary to remove nuts and machine screws which have become overtight, though their designed use is for tightening large threaded fixings where a long lever would be either unsafe or unmanageable. They consist of a gearbox interposed between lever and socket.

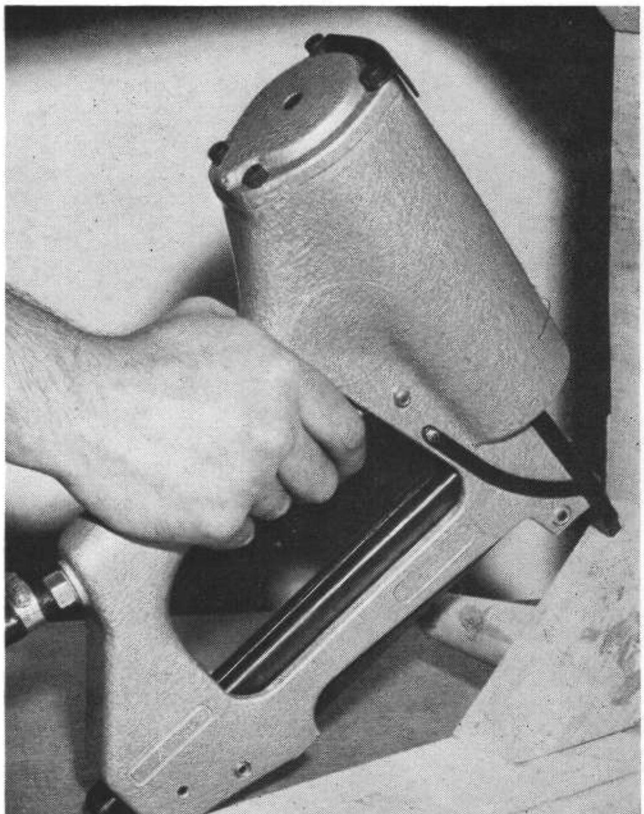
Nailers and staplers

3.04 These machines drive a variety of nails and staples **8** into timber. Larger and more powerful models will also drive concrete nails. They are all pneumatic and are either fed from a hopper through an automatic alignment system or from a detachable slide magazine which is interchangeable with other magazines carrying different types of fixing.

4 Power supply

Electricity

4.01 Electrical tools must be maintained in a safe condition and used with the correct supply. The HM Factory Inspectorate recommends that supplies to tools on sites be 110 V



8

8 *Pneumatic-operated stapling machine (eg 'Air Nailer' by Stapling Centre Ltd)*

single phase supplied from a double wound safety isolating transformer to BS 3535[4], giving a maximum potential to earth of 55 V. A three phase supply is also acceptable, in which case the potential to earth is 63 V. Electric hand tools should comply with BS 2769[5] and plugs, socket outlets and couplers should comply with BS 196[6], BS 1363[7] or BS 4343[8] depending on the supply. Electricity is a cheaper power source than compressed air. Electrical tools should be used in confined spaces where exhaust fumes may be dangerous or unacceptable.
Electric tools are quieter than their pneumatic counterparts since there is no exhaust noise. However, if the supply has to be from a generator, the noise created by it may be almost as great as that with a compressor.

Compressed air

4.02 Pneumatic tools do not involve the same dangers in use as electrical tools. The most common risk is a blast of grit in the eyes from an air exhaust, or injury caused if a pressure nozzle is placed against the skin.
Percussive tools powered by compressors create much more noise than their electrical equivalents, though developments in design have achieved some reduction in recent years.
Size for size, pneumatic tools are generally capable of heavier work, are mechanically simpler than electrical ones, and a more satisfactory percussive action can be obtained. If a pneumatic tool stalls under load, there is no risk of burnout.

References

1 GENERAL SERVICES ADMINISTRATION *Assistant Commissioner, Design and Construction, Public Buildings Service.* Report on powder driven fasteners. Washington DC, 1960, The Administration [Xt5]
2 GENERAL SERVICES ADMINISTRATION *Research and Standards staff, Mechanical and Electrical Branch, Public Buildings Service.* A study of the holding power of powder driven fasteners in overhead concrete slabs. Washington DC, 1964, The Administration [Xt5]

BRITISH STANDARDS INSTITUTION
3 BS 4078: 1966: Cartridge-operated fixing tools [(B5d)]
4 BS 3535: 1962: Safety isolating transformers for industrial and domestic purposes [(62)]
5 BS 2769: 1964: Portable electric motor-operated tools [(B7)]
6 BS 196: 1961: Protected type non-reversible plugs, socket outlets, cable couplers and appliance couplers, with earthing contacts for single phase ac circuits up to 250 volts [(62) Xy] £1
7 BS 1363: 1963: 13 amp plugs, switched and unswitched socket outlets and boxes [(62) Xy]
8 BS 4343: 1968: Industrial plugs, socket-outlets and couplers for ac and dc supplies [(62) Xy] £2

Table II Available cartridge tools, and characteristics

Tool	Piston actuated	Direct action	Hammer actuated	Concrete			Steel			Remarks
				Nails	Studs	Eyes	Nails	Studs	Eyes	
HILTI										
DX100L			●	●	●	●	●	●		
DX300	●			●	●	●	●	●		
DX350	●			●			●			Magazine cartridge feed
DX400B	●			●	●	●	●	●		Suited to concrete
DX400E	●			●	●		●	●		Suited to steel
DX500			●	●	●	●	●	●	●	
DX600	●			●	●		●	●		Spall stop attachment
OMARK 110C	●			●	●			●		
OBO K5	●			●	●	●	●	●	●	
RAMSET (RAWL)										
Tom Thumb		●		●	●	●	●	●		
Duo Jobmaster		●		●	●	●	●	●		Spall stop attachment
Super Jobmaster		●		●	●		●	●		Heavy duty model
Flite Check	●				●			●		Safe for soft base
Piston Set	●			●	●		●	●		
41/60	●			●	●		●	●		
SPIT MATIC		●		●	●	●	●	●		
UCAN										
Little Fred			●	●	●		●	●		
Komet		●		●	●		●	●		
S2	●			●	●					
S3	●			●	●					Longer pins than S2
CT77			●	●	●		●	●		
TORNADO T6		●		●	●	●	●	●	●	

Information sheet Fixings 12

Welding, brazing and soldering

This information sheet describes processes which permanently bond one metal to another without the use of a mechanical fixing device

1 Welding techniques

Background

1.01 The simple process of bonding by heat has been used for centuries. Soldering was the earliest method of joining metals in this manner, and was established in the goldsmiths' trade before 2500 BC. The advanced ironworking techniques used in Asia Minor in the 14th century BC involved a form of welding.

1.02 Metals can be fused together in four ways: by fusion of components and filler metal (eg oxy-acetylene); by non-fusion (eg resistance welding); by fusion of filler metal between solid components (eg soldering); and by solid phase bonding (eg induction). Table I lists these types and shows which are more likely to be used in building.

Table I Types of welding

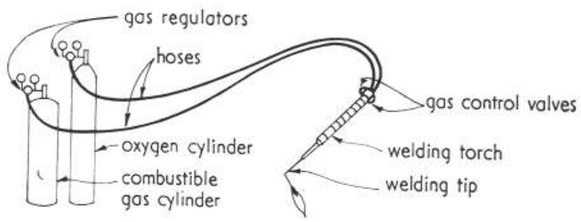
LIKELY TO BE USED IN BUILDING	UNLIKELY TO BE USED IN BUILDING
Fusion of components (with or without filler metal)	
Oxy-acetylene	Plasma arc
Manual metal arc	Submerged arc
Gas shielded (MIG and TIG)	Electron beam
Electrical stud	Continuously coated electrode
Lead burning	
Non-fusion (plastic bonding)	Projection, Seam, Spot } Resistance welding
Fusion of filler metal between solid components	
Braze welding	
Brazing	
Soldering	
No fusion (solid phase bonding)	
	Cold pressure
	Explosive
	Hot pressure
	Friction
	Induction
	Ultrasonic

2 Oxy-acetylene welding

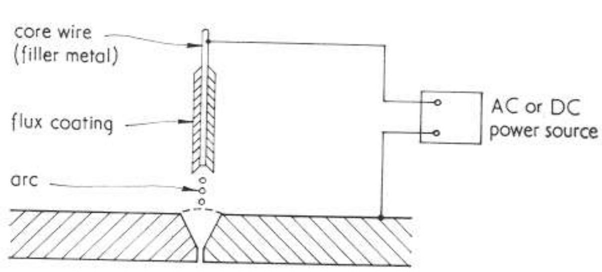
2.01 This was probably the first heat source to be used in fusion processes. A fuel gas, usually acetylene, is burned in an atmosphere of oxygen at the tip of a special torch. Temperature (maximum 3200°C) and flame properties can be varied by adjusting the oxygen/acetylene ratio, but a neutral 1:1 mix of gases suits most metals (eg aluminium). An oxidising flame should never be used on copper or steel.

2.02 Filler metal wire is introduced manually to the molten junction between components. The equipment is cheap, readily available and fairly portable **1**. Gas cylinders (especially acetylene) must be treated with care.

2.03 Oxy-acetylene welds most metals fairly slowly. Good control is possible, and the method is useful for pipework and tubular structures where penetration must be limited. Mainly used for mild steel, it is suitable for aluminium, copper nickel and stainless steels though the flux necessary for aluminium is toxic and makes operator conditions unpleasant. Thicknesses from about 1 to 6 mm can be worked, but care must be taken in welding sheet materials since the slow speed causes high local temperatures, which can distort components.



1 *Oxy-acetylene welding equipment*



2 *Manual metal arc welding process*

3 Manual metal arc welding

3.01 This method uses low-voltage high-current electrical arcs to generate very high temperatures. One electrode is hand held while the other is attached to the component, which is securely bonded to the welding equipment and forms part of the circuit **2**. The process is faster than any other manual technique, and the rate of deposition depends on type and design of the electrode filler metal and its coating of flux.

3.02 High-quality fast welds can be made to most metals, especially mild and stainless steels and nickel alloys. Copper alloys and aluminium should not be welded by this method, as jointing is poor, and operator conditions are extremely unpleasant owing to type of flux used. Thicknesses from about 1·5 mm can be welded.

4 Gas shielded welding

4.01 Fusion methods such as manual metal arc welding rely on flux to protect the molten weld-pool from the atmosphere. A technique was developed, initially for aluminium, where the arc and weld-pool are shielded from the atmosphere by a screen of inert gas. This method has subsequently found a wider range of applications.

4.02 There are two types of gas shielded welding: MIG, with a consumable electrode, and TIG, with a hand fed wire filler.

TIG (tungsten inert gas) welding

4.03 Helium, argon or nitrogen may be used, though argon is most usual since helium is expensive and nitrogen can only be used for copper and alloys. The filler metal should usually match component metal but for some aluminium alloys a dissimilar filler should be used. Well prepared and true butt joints in sheets can often be welded without filler metal. Dc welding equipment is suitable for most metals, but it is necessary to use ac for aluminium to disperse oxide film **3**.

Use

4.04 This may be used for well controlled welds in almost all metals, and is particularly suited to thin sheets and aluminium. Thicknesses of about 6 mm can be joined. The method is faster than oxy-acetylene but slower than other methods. (Example: 'Cromp arc' Crompton Parkinson Ltd.)

MIG (metal inert gas) welding

4.05 This process is similar to TIG welding except that the electrode is continuously fed consumable wire and the power source is always dc. Carbon dioxide is almost universally used as a shielding gas for mild steel, which reduces costs. This technique lends itself to automation in the factory and there are advantages in having a controlled rate of feed for the electrode **4**.

Use

4.06 This may be used for well controlled welds of almost all metals, and is particularly suitable for aluminium alloys, mild and stainless steels, nickel alloys and copper and its alloys. This method is faster than TIG and in its automated form is faster than manual arc methods. The equipment can be made portable, but is less so than TIG since a feed mechanism for the electrode must be incorporated. Thicknesses from 1 mm upwards can be joined.

5 Electrical stud welding

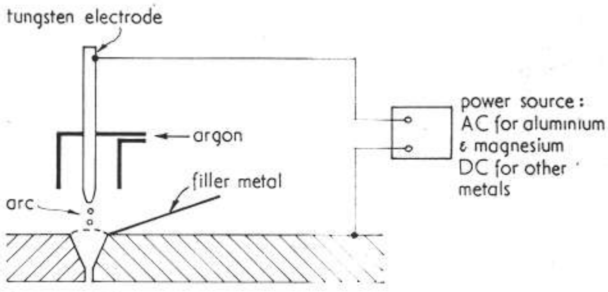
5.01 This technique was originally developed to join wooden decks to steel ships, but is now used more commonly in light assemblies.

5.02 An unwelded stud, held in a special gun connected to its dc power source, touches the component. This sets up a pilot arc and subsequently a power arc, which causes fusion of the head of the stud with the component **5**. The strength of the joint normally exceeds the strength of the stud in both shear and tension. Thin components may be pierced or distorted during fusion, and as a guide the stud diameter should not exceed five times the thickness of the component.

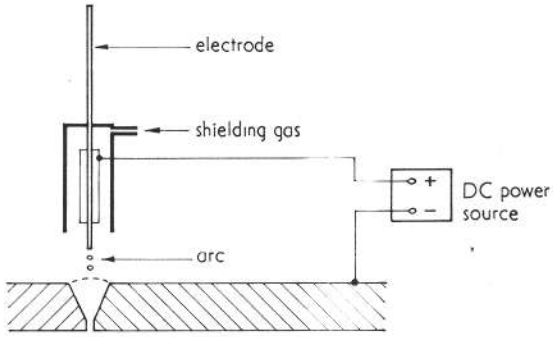
5.03 For stud diameters less than 3 mm and for non-ferrous metals, capacitor discharge equipment is used. These studs have a small projection from the head; a capacitor discharges a current through the stud as it is propelled towards the component. The projection fuses and the impact spreads the molten section over the head and forms a bond with the component **6**.

Use

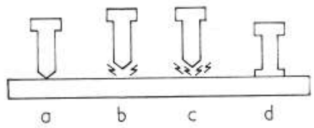
5.04 This may be used for attachment of studs to most metals. Studs can be threaded or take one of many standard forms. Access is required to one side of the component and, depending on thickness, the other side of the component and its finish are undisturbed.



3 TIG *welding process*



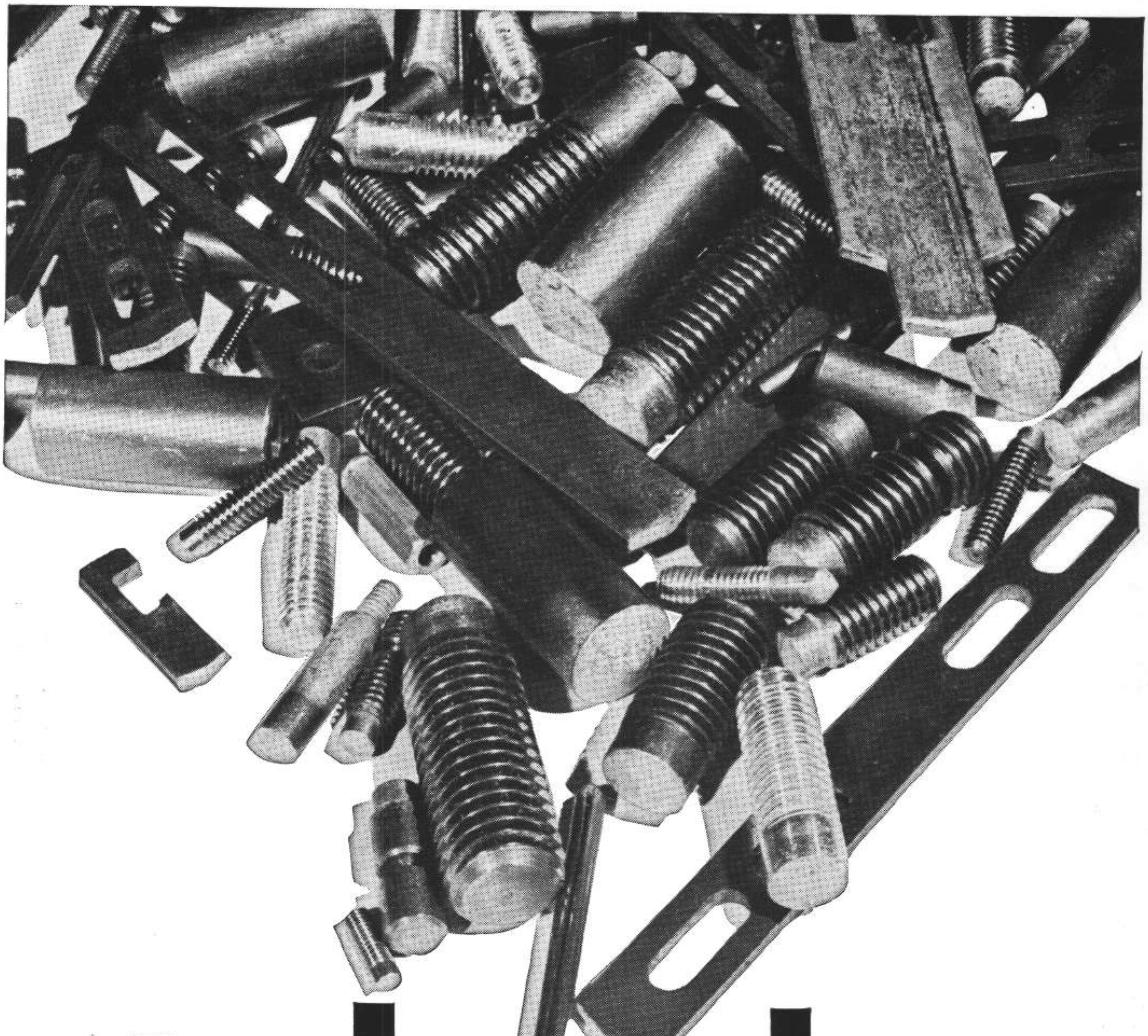
4 MIG *welding process*



a stud in contact with plate
b pilot arc
c power arc
d completed weld

5 *Electrical stud welding process*

6 *Threaded studs are fastened to window stanchions by capacitor discharge equipment*



studs galore

All shapes. All sizes. That's our versatile range of standard studs. If we don't have in stock exactly what you need, studs can be speedily made up to your requirements. And remember, all of these studs can be welded in under a second. Saving time. Saving money. Try us.
P.S. We make stud welding equipments, too.

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CROMPTON PARKINSON STUD WELDING

CROMPTON PARKINSON LIMITED, 50-52 MAREFAIR, NORTHAMPTON NN1 1NY.

Hawker Siddeley Group supplies mechanical, electrical and aerospace equipment with world-wide sales and service.

6 Lead burning

6.01 This is a low temperature process using either oxy-acetylene or oxy-hydrogen flame to join lead components. The components are fused carefully to avoid excessive melting, which would reduce the overall thickness of the sheet. A lead filler strip is applied by hand to complete the joint. The total thickness of the joint should be at least one third greater than the components.

7 Braze welding

7.01 An oxy-acetylene flame heats the components to 800 to 900°C. This fuses the filler metal but not the components themselves, which remain solid. A filler metal of a bead-forming alloy (BS 1453[1]) is introduced by hand but a skilled operator is necessary for satisfactory results.

7.02 This technique can be used on non-deoxidised ('tough pitch') copper, which is unsuitable for fusion welding. This material can be used for pipework instead of the more expensive weldable grade of copper. It is also suitable for galvanised sheet mild steel as the temperature is not high enough to destroy the zinc coating and the joint itself has good corrosion resistance.

7.03 Most metals can be joined in this way. A flux is used during the process, either in a powdered form or as a coating on the filler metal rods.

8 Brazing and soldering

8.01 Brazing and soldering are similar processes. A filler metal is heated to a temperature below the melting point of the component metal. (Brazing fillers melt at temperatures above 450°C, but soldering fillers may melt below 350°C.) Brazing techniques rely on the capillary flow of filler metal along the joint, and very tight joins are not recommended as they will inhibit the flow.

8.02 On site brazing is usually by flame or torch; carbon resistance brazing (supplying heat by carbon electrodes) is possible with thin sheets in the factory. Almost all common metals can be joined, including some dissimilar combinations which are incompatible with fusion methods. Under certain conditions metal and ceramics can be joined.

8.03 The traditional tool for applying solder is the soldering iron with a copper bit. These tools may be heated externally in a flame or internally by electricity. The component metal must be hot enough to enable wetting to take place by the solder, and both surfaces of the joint must be clear and grease-free.

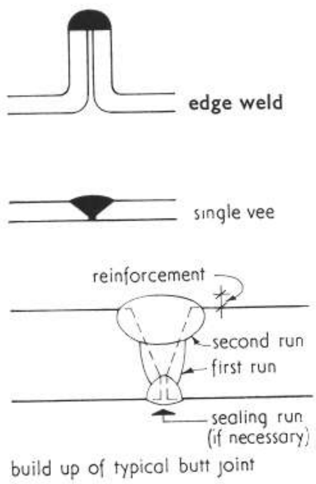
8.04 While heating by iron is useful for fixing small components, larger assemblies must be heated by paraffin blowtorch or a fuel gas/compressed air torch.

8.05 The most common soldered joint in building is the capillary fitting for copper pipework; joint sections are manufactured with a band of solder around the circumference in a formed groove. When the section is heated with a torch, the solder flows out of the groove to form a seal around the adjacent section of pipe.

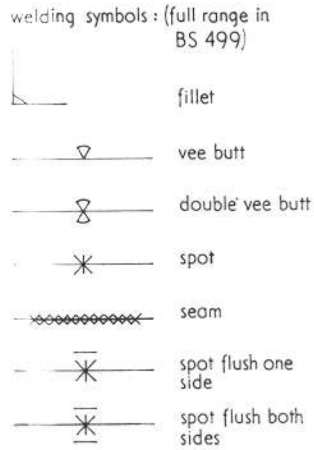
9 Joint design

9.01 Ideally, molten weld metal should be held in place by gravity and the position of the weld should take account of this. Joints may take the form of square butts, vees, fillets, spots or seams **7**. These are simply expressed on drawings by using the standard graphic symbols shown in **8** (from BS 499[3]).

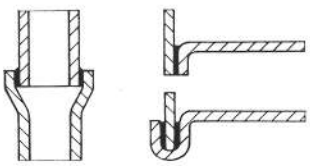
9.02 Joints for brazing techniques should be designed with particular care. Wherever possible, they should take the form of a lap with the length of joint equal to at least three times the thickness of the thinnest component **9**. Butt joints are weaker and should be designed so that the filler metal is in shear rather than in tension when it is loaded **10**. The joint gap should be evenly filled and the filler should have no air pockets. A peg being brazed into a hole in a block for instance should have a vent to allow entrapped air to escape.



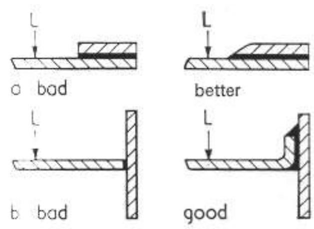
7 *Types of welded joint*



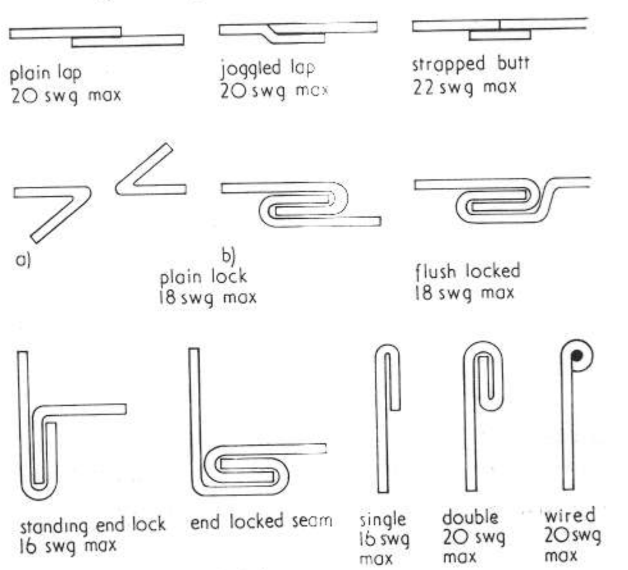
8 *Welding symbols*



9 *Correctly brazed joints*



10 *Loading conditions*



11 *Types of soldered joint*

9.03 Solders have low strength compared with the metals they join. The capillary path of the solder must be maintained and should be as long as possible. Joints can take the form of laps or can be rolled over in a seam, the hard solder being used to stiffen the joint. Lap joints are often riveted, the solder merely forming a seal. Types of soldered joints are shown in **11**.

10 Materials to be joined

Table II shows types of weld suitable for particular metals.

Table II Types of weld suitable for particular metals

● suitable
○ fair

	Type of weld						
Metals to be fixed	**Oxy-acetylene**	**Manual metal arc**	**Tungsten inert gas**	**Metal inert gas**	**Brazing and soldering**	**Braze welding**	**Lead burning**
Mild steel	●	●		●	●	●	
High-yield steels, low-alloy steels	●	●	●	●	●	●	
Stainless steels	●	●	●	●	●	●	
Nickel and alloys	●	●	●	●	●	●	
Copper and alloys	○		●	●	●	●	
60:40 brass	●	●	●	●	●	●	
Aluminium and alloys	○		●	●	●	●	
Magnesium and alloys	●		●		●	●	
Lead							●
Cast iron	●	●			●	●	
Galvanised mild steel					●	●	

Mild steel

10.01 Mild steel is relatively easy to weld. If the sulphur content is high, lime coated or low hydrogen electrodes should be used.

High yield steels, low alloy steels

10.02 The zone immediately outside the joint may crack due to heat. Low hydrogen electrodes should be used, and cracking can be minimised by preheating the components. Joint design is important.

Stainless steels

10.03 Weld decay and corrosion is likely unless the filler metal contains niobium. The hot cracking liable to occur with certain grades can also be minimised by the use of appropriate filler metals.

Nickel alloys

10.04 Contamination by sulphur causes cracking and the joint must be clean. Small runs rather than large deposits improve the quality of the weld by refining the grain of the metal.

Copper and its alloys

10.05 Copper tends to conduct heat away from the joint and the heat input must be high enough to ensure complete fusion at the joint. The joint can be porous if both the filler metal and the component metal are not deoxidised, although the use of braze welding overcomes this problem.

Aluminium and its alloys

10.06 If alloys which cannot be heat-treated are welded in a work-hardened condition, they tend to soften. Heat-treatable alloys suffer from hot cracking, which can be minimised (at the expense of joint strength) by the use of an aluminium/silicon filler metal. Porosity can be caused by contamination of the component or filler metal, or by the entry of air into the argon stream.

10.07 Alloys of zinc/aluminium/magnesium (ZAM) which do not contain copper are fully weldable.

Lead

10.08 The low melting point of lead demands a carefully controlled heat input if total fusion is to be avoided.

Coated metals

10.09 Galvanised steel sheet can be braze welded without destroying the protective zinc coating. Fusion welding would alloy the coating with the steel resulting in weak joints and loss of corrosion protection.

10.10 It is possible to stud weld onto a painted or lacquered surface without prior preparation by the capacitor discharge method; the impact of the tip of the stud effectively cleans the weld area. Disturbance of the surface may be minimal.

References

BRITISH STANDARDS

1 BS 1453:1957: Filler rods and wires for gas welding [(D4)]

2 BS 1719:1969: Classification, coding and marking of covered electrodes for metal arc welding [(D4)]

3 BS 499:2 Parts 1, 2 and 3: 1965: Welding terms and symbols [(D4)]

Information sheet
Fixings 13

Adhesives

This information sheet outlines types of adhesives and describes how and where they are used in building

1 General

1.01 Although simple adhesives, produced from the waste of domestic animals, were used by the ancient Egyptians and Assyrians, great developments have taken place during the 20th century, particularly in the field of synthetic adhesives.

Principles of adhesion

1.02 Bonding is due to *specific* or *mechanical* adhesion. Specific adhesion consists of molecular attraction between the adhesive and the base; this applies to non-porous materials.
Mechanical bond depends on the interpenetration of the adhesive and the base, when this is porous.

Testing

1.03 Adhesive bonds are usually tested for strength in shear, tensile, peel and cleavage loading **1** to **4.**

1.04 Adhesives lack an economic non-destructive test, and most bonds are tested only in use, when failure is informative but undesirable. Ideally the modulus of elasticity of the adhesive should approach that of the base, but this is difficult to achieve, especially when joining different materials.

Advantages

1.05 The bond produced by adhesion is distributed over the surface more evenly than in any other method of joining, therefore causing less stress on any particular part of the joint. It is often quicker (and thus cheaper in terms of labour) to attach components by adhesives than by more traditional methods. As well as the usual means of application both spray and solid stock forms are now available.

2 Classification

2.01 The following codes are applied to adhesives:

WBP—*weather-proof and boil-proof:* Highly resistant to weather, micro-organisms, cold, boiling water and dry heat.

BR—*boil-resistant:* Good resistance to weather but failure under prolonged exposure. Will withstand cold water for many years. Resistant to attack by micro-organisms.

MR—*moisture-resistant:* Moderate resistance to weather; will withstand cold water for long periods, and hot water for short periods. Resistant to attack by micro-organisms.

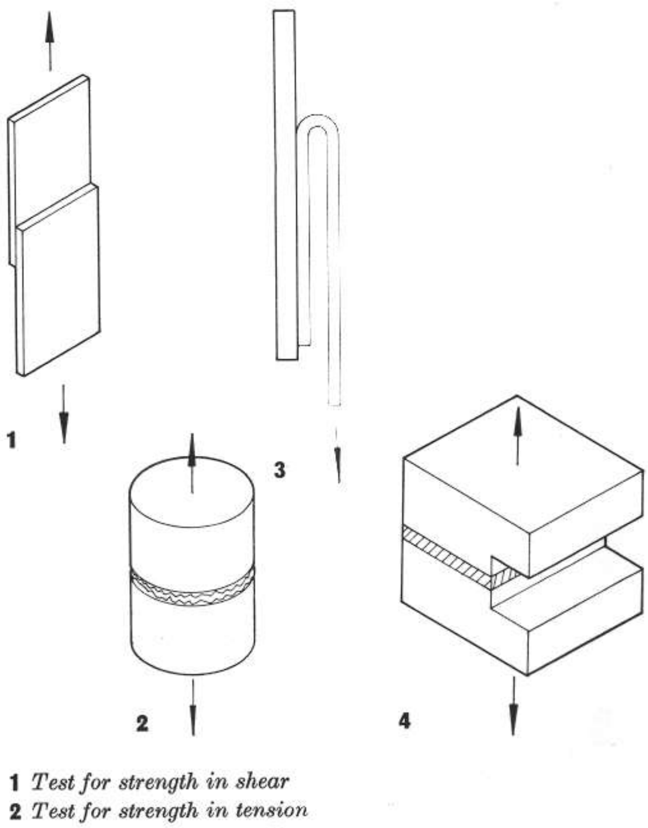
INT—*interior:* Resistant to cold water. Not necessarily resistant to attack by micro-organisms.

3 Types

3.01 Adhesives used in the construction industry are listed in table I and described overleaf.

Table I Types of adhesive used in the construction industry

Basis	Adhesive type	
Animal	Casein	
Mineral	Bitumen	
Synthetic resins	Thermoplastics	Polyvinyl acetate Cellulose derivatives Acrylics Polyamides Polystyrene
	Thermosets	Urea-formaldehyde Phenol-formaldehyde Epoxy resins Furanes Polyurethanes Silicones Resorcinols
Rubber	Natural rubber Synthetic rubber	



1 *Test for strength in shear*
2 *Test for strength in tension*
3 *Test for strength in peeling*
4 *Test for strength in cleavage*

Casein

3.02 This animal glue, based on curdled milk, is treated chemically to produce adhesive. There is little tack and pressure is needed while the glue sets. Casein is slow drying and can be used only for porous surfaces. Chemical additives can improve the water and heat resistance of casein, but a synthetic adhesive is more likely to be used. Casein latex adhesives can be used to bond metals.

Bitumen

3.03 Bitumen is only suitable for low-strength joints, but within this limitation it can bond wood, concrete, glass, metal, wood blocks and felt. Bitumen has a tendency to soften, even in the normal range of temperatures, which can be overcome by the addition of latex or polyvinyl acetate.

Polyvinyl acetate

3.04 This is a thermoplastic synthetic resin of considerable versatility in the field of porous materials. It is used for bonding fresh concrete to old concrete, and for wood joints (especially in America and Europe). With the introduction of standards for use (BS 3544[1] and 4071[2]), pva is becoming more popular in Britain. It is not water resistant and should not be used at temperatures below 0°C without modification.

Cellulose derivatives

3.05 Treated cellulose produces a variety of adhesives. Cellulose acetate can join porous materials and is especially recommended for balsa wood. Being thermoplastic it is unsuitable for load-bearing joints. Cellulose nitrate can join glass, ceramics, metal, wood and some plastics. It may discolour in sunlight, and its water resistance is only moderate. Cellulose ether does not stain and is therefore suitable for paperhanging and applying light veneers.

Acrylics

3.06 Some of the thermoplastic resins in the acrylic group can be used for joining acrylic plastics, glass and metal. In emulsion form they can join vinyl to porous materials (eg wood and paper).

Polyamides

3.07 These are flexible adhesives, and in a modified form are very versatile. They are water and oil resistant but do not stand up well to solvents.

Polystyrene

3.08 This resin is transparent and colourless and has good electrical insulation properties. However, it tends to be brittle and deteriorates rapidly above 75°C. Apart from joining polystyrene plastic to itself it is not normally preferred to more resistant adhesives.

Urea-formaldehyde

3.09 This, the cheapest of the thermosets, is widely used in joinery and in the manufacture of plywood. It is not normally reliable above 60°C, but resistance to boiling water can be achieved by adding more expensive melamine- or resorcinol-formaldehyde. It is resistant to oils and solvents.

Phenol-formaldehyde

3.10 This adhesive is classed as WBP (ie not affected by weather or boiling water). It is therefore particularly suitable for marine situations. It is also available in a cold setting form for joining timber.

Epoxy resins

3.11 These are among the most versatile structural adhesives, and will join most non-porous materials and wood. They will resist oil, water, solvents and mould growth. They have good gap-filling properties, but are expensive and so unsuitable for large scale work such as laminated beams.

Furanes

3.12 This dark-coloured material is used mainly for joining phenolic laminates and also for laying acid-resistant tiles. Gap-filling is good but there is a tendency towards crazing unless modified with other resins. These will also improve its resistance to various chemicals.

Polyurethanes

3.13 Polyurethane is formed from a combination of isocyanates and polyesters. It is one of the most recent adhesives, and can be used to bond metal and rubber. Resistance to water and oil is good, and a temperature of at least 150°C can be tolerated.

Silicones

3.14 Adhesives using organic silicon are used in situations where a high temperature is involved. They are also resistant to water and most acids and salts, but are not widely used due to their high cost. Silicone rubber adhesives can be used for difficult bonds such as polyethylene and polytetrafluoroethylene (ptfe).

Resorcinol-formaldehyde

3.15 This adhesive is used in building for external woodwork, since it is fully waterproof, and it can also withstand low temperatures. It can be combined with various fillers when gap-filling is necessary.

Natural rubber

3.16 Rubber has been used as an adhesive for more than a century. The heat range can be extended by vulcanising, but it is not suitable for structural bonds owing to its tendency to creep.

Synthetic rubber

3.17 The most usual forms of synthetic rubber are based on butyl, neoprene or nitrile. Silicone rubbers are sometimes used. Neoprene based adhesives are used for most contact and impact cements. A special use of nitrile based adhesives is the bonding of pvc.

Proprietary adhesives

3.18 The manufacturers of adhesives publish detailed guides to their various products. Because of the extent of this material and the lack of consistent generic terms which could be applied throughout the industry, no attempt has been made to correlate adhesive types with their respective and numerous trade names.

4 Materials to be bonded

4.01 The bonding properties of adhesives related to various building materials is shown in table II.

Wood

4.02 The main factors to consider in bonding wood are: speed of setting; strength needed in bond; amount of stress; heat and damp to which the bond will be subjected; whether gap-filling is required.

4.03 Casein, the traditional bond for wood joints, has largely been superseded by thermosetting resins. Of these, urea-

Table II *Bonded properties of adhesives related to various building materials*

	Casein	Bitumen	Polyvinyl acetate	Cellulose derivatives	Acrylics	Polyamides	Polystyrene	Urea-formaldehyde	Phenol-formaldehyde	Epoxy resins	Furanes	Polyurethanes	Silicones	Resorcinols	Natural rubber	Synthetic rubber
Soft wood	●	●	●					●	●	●				●	○	○
Hard wood	●	●	●					●	●	●				●	○	○
Internal wood	●	●	●					●	●	●				●	○	○
External wood										○				*		
Plywood								●							○	○
Chipboard								●							○	
Acoustic tiles			●												●	●
Cork	○	●	●		●										●	●
Lino	●	●													●	●
Rubber										○		●	●	●	●	●
Nylon			●							●						
Plastic					○	●				*				●		
Pvc		●	●							○						●
Polystyrene		●	●			●				○					●	●
Polyethylene										○						
Ptfe										○						
Laminates	●		●					●		*	○	●		●	●	●
Ceramics		●	●							*	○				●	
Glass		●			●					*						
Concrete		○	●							*					○	○
Metals	○								*	*		●				●
Plasterboard	●							*						●		
Asbestos cement	●															
Roofing felt	●	●														

Key
○ Moderate
● Good
* Excellent

formaldehyde is the most widely used for wood. Resorcinols are employed for external work (eg wood windows) as they have good resistance to water and low temperatures. Pva is the most popular thermoplastic adhesive.

Metal

4.04 The use of an adhesive for joining metal, in preference to welding, riveting or some other mechanical method, has the advantages of: uniform stress distribution; flush finish to joints; lack of deformation; elimination of electrolytic corrosion, as the metal surfaces do not come into contact.

4.05 Epoxy and modified phenolic resins are the most commonly used adhesives for bonding metals. It is very important to prepare the surface by etching. Epoxies can also be used for joining metal to glass. For metal to rubber bonds polyisocyanate is one of the best adhesives. Metal and wood are often joined with a neoprene based contact cement.

Plastics and rubber

4.06 These materials are collectively known as polymers, and include natural and synthetic rubber and a wide variety of plastics. It is usually possible to establish the type by burning a small amount and noticing the colour of flame and smell. (see table III)

4.07 In this field there are many proprietary adhesives. In general epoxy resins can be used, but there are many variants within this term, and for each plastics parent material there are other possible adhesives. In these cases the maker's directions should be studied carefully for the specific material concerned.

Radio-frequency bonding

4.08 High frequency radiation excites the molecules of the material subjected to it, thereby generating heat. The process is used for bonding such substances as PVC which have a high dielectric loss factor. The same principle can be applied to the cure of thermosetting resins, providing the loss factor of the adhesive is considerably higher than that of the adherent. Bonds can be obtained in as little as six seconds with high frequency bonding, eg 35-70 Mc/s.

Table III *Identification of plastics by flame test*

Plastic	Colour of flame	Smell	Other peculiarities
Celluloid	Fierce white	Camphor	
Cellulose acetate	Yellowish, may spark	Combination of vinegar and burning paper	Brown drops
Cellulose nitrate	Fierce white		
Nylon	Blue	Fresh celery	
Phenol-formaldehyde	No flame	Carbolic odour	Dark colour
Polymethyl methacrylate	Quiet blue	Cheap flowery scent	Remains clear
Polystyrene	Yellow	Marigolds	Smokes
Polyvinylidene chloride (Savan)	Slight green tint	Sweet	Heavy black ash
Polythene	Blue	Waxy	Burns steadily and softens
Pvc	Bluish	Acid when ignited sweet when burning	
Rubber hydrochloride (Pliofilm)	Green	Burnt rubber	Smoky appearance
Viscose (cellophane)	White		Behaves exactly like paper
Urea-formaldehyde	No flame	Fish odour	No change in shape, chars with fierce heat

References

BRITISH STANDARDS

1 BS 3544: 1962 Methods of test for polyvinyl acetate and adhesives for wood [Yt3]

2 BS 4071: 1966 Polyvinyl acetate emulsion adhesives for wood [Yt3]

Appendix
Fixings 1

Definitions

This appendix lists useful definitions of words used in the handbook. Numbered headings refer to information sheets

General

Component A part which, together with other parts, goes to make up an assembly.
Creep Plastic deformation which proceeds slowly and continuously when stress is applied.
Elastic limit The limit beyond which the strain is not wholly recoverable.
Electrolytic (galvanic) corrosion Preferential corrosion of one metal having electrical contact with another metal or conductor.
Fatigue The weakening of a material caused by repeated or alternating loads.
Interface Meeting face of a jointing product and a building component.
Interference The difference between the size of a hole and that of the mating shaft, when the latter is the larger.
Modulus of elasticity (Young's modulus) The ratio of stress to strain within the elastic range.
Plasticity Capacity for undergoing deformation by hot or cold work.
Shear test A test to determine the resistance of one portion to sliding over another.
Strain Deformation produced by a stress and expressed as the change per unit of the original dimension.
Stress Force, per unit area.
Tensile test Test in which two ends of a straight test piece are pulled until fracture occurs.
Ultrasonic test Method of testing by transmitting high frequency vibrations or pulses through a material.

1 Nails

Pitch of nailing The spacing apart of nails in any row.

2 Wood screws

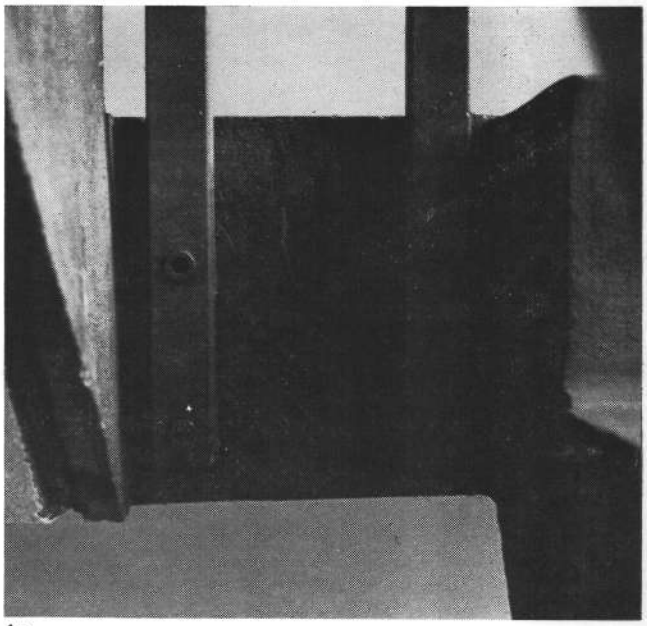
See also 7 Machine screws, bolts and washers.
Taper screw thread A thread formed on the surface of a cone.

4 Heavy masonry fixings

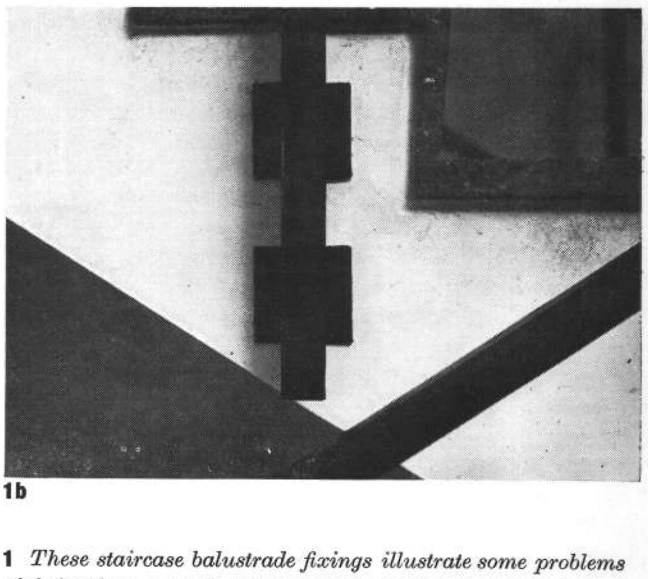
Anchor Device for providing a fixing to a concrete base.
Bolt sleeve A cylindrical or other form through which a bolt passes so as to separate it from the surrounding material.
Spalling The detaching of fragments, usually of flaky shape, from a larger mass by a blow or by the action of weather or pressure.

5 In situ fixings

Cast-in socket A female-threaded socket cast into concrete as a fixing for a bolt.



1a



1b

1 *These staircase balustrade fixings illustrate some problems of fixing into concrete (information sheet* FIXINGS 4). *In* **a**, *bolts requiring drilled holes and therefore tool access, are more easily fixed to the landing than to the flight. In* **b** *where fixings are grouted or expanded into holes cast into the concrete, it is difficult to avoid using clumsy plates to conceal setting-out inaccuracy*

Dovetailed channel Device made from sheet metal and cast into the concrete surface to produce a chase which is narrower at its surface than at its base, into which shaped metal tongues are inserted to form an anchor.
Insert A piece of timber or other material cast into the concrete surface usually to provide a fixing.

6 Rivets and self tapping screws

See 7 Machine screws, bolts and washers.

7 Machine screws, bolts and washers

Crest That part of the surface of a thread which connects adjacent flanks at the top of the ridge.
External (male) screw thread A thread formed on the external surface of a cylinder or cone.
Internal (female) screw thread A thread formed on the internal surface of a hollow cylinder or cone.
Left hand screw thread A thread which, if assembled with a stationary mating thread, recedes from the observer when rotated in an anti-clockwise direction.
Parallel screw thread A thread formed on the surface of a cylinder.
Pitch The distance, measured parallel to the axis, between corresponding points on adjacent thread forms in the same axial plane section and on the same side of the axis. (The pitch in inches is the reciprocal of the number of threads per inch.)
Right hand screw thread A thread which, if assembled with a stationary mating thread, recedes from the observer when rotated in a clockwise direction.
Root That part of the surface of a thread which connects adjacent flanks at the bottom of the groove.
Screw thread The ridge produced by forming, on the surface of a cylinder or cone, a continuous helical or spiral groove of uniform section, such that the distance measured parallel to the axis between two corresponding points on its contour is proportional to their relative angular displacement about the axis.

9 Masonry clamps

Clamp (cramp) Short length of metal or slate suitably bedded into sinkings cut in stones. Used to tie stones to one another or to their backing.

12 Welding, brazing and soldering

Electrode Rod, tube or wire of metal or rod of carbon. The arc is formed between the end of the electrode and either the work or another electrode.
Filler metal Metal added during welding.
Flux Material used during welding to clean the surfaces of the joint chemically and to prevent atmospheric oxidation.
Fusion Melting.
Parent metal Metal to be joined by welding.
Pilot arc Low-intensity arc to facilitate the striking of the power arc.
Power arc Arc which supplies welding heat.
Slag Flux deposit over the weld.

13 Adhesives

The following are not BS definitions
(from *Building fasteners' handbook*, Grampian Press).
Adhesion The state in which two surfaces are held together by interfacial forces, which may consist of valence forces, interlocking action, or both.
Adhesive Any substance capable of promoting and maintaining a surface bond between two materials.
Assembly time The time required for putting together parts and surfaces for bending.
Filler Non-adhesive material added to an adhesive to improve its properties.
Hardener A substance added to an adhesive to promote or control the action by taking part in it.
Joint The location at which two base materials are held together by a layer of adhesive.
Laminate A produce made by bonding together two or more layers of material or materials.
Resin Solid or semi-solid organic substance of natural or synthetic origin, non-volatile and generally of high molecular weight.
Setting time The time taken for the chemical or physical action by which an adhesive changes to a hardened state.
Tack Stickiness of an adhesive.
Thermoplastic Capable of being repeatedly softened by heat and hardened by cooling.
Thermosetting Having property of undergoing a chemical reaction by the action of heat, catalysts, ultraviolet light etc, leading to a relatively infusible state.

Appendix
Fixings 2

Manufacturers and trade names

This appendix lists names of manufacturers in alphabetical order, and also lists trade names in alphabetical order under the appropriate information sheet

A

Armstrong Patents Co Ltd, Swinemoor Industrial Estate, Beverley, Yorkshire (Beverley 885131)

Atlas Preservative Co Ltd, Fraser Road, Erith (Erith 32255)

Arrow Abrasives Ltd, Unit 19, Industrial Estate, Waterlooville, Hants (Waterlooville 51177)

Automated Building Components (UK) Ltd, Trading Estate, Farnham, Surrey (Farnham 22425)

Automatic Pressings Ltd, Haybrook, Halesfield, Telford, Salop (Dawley 6193)

Avdel Ltd, Welwyn Garden City, Herts (Welwyn Garden 28161)

Avon Manufacturing (Warwick) Ltd, Montague Road, Warwick (Warwick 41737)

B

F. Ball & Co Ltd, Barnfields, Leek, Staffs (Leek 2124)

Barber & Colman Ltd, Brooklands, Sale, Cheshire (061-973 2277)

Baxters (Bolts, Screws, Rivets) Ltd, Sheepcote Street, Birmingham 15 (021-643 0105)

Bifurcated & Tubular Rivet Co Ltd, Aylesbury, Bucks (Aylesbury 5911)

Bighead Bonding Fasteners Ltd, Southern Road, Aylesbury, Bucks (Aylesbury 81663)

Borden Chemical Co (UK) Ltd, North Baddesley, Southampton, Hants (Rownhams 2131)

Bosch Ltd, Rhodes Way, Station Estate, Radlett Road, Watford, Herts (Watford 44233)

Bostik Ltd, Ulverscroft Road, Leicester, LE4 6BW (Leicester 50015)

J. Bradley & Co Ltd, Holloway Head, Birmingham 1 (021-643 4781)

Brigityre (GB) Co Ltd, Church Lane, Wolverhampton (Wolverhampton 26471)

British Industrial Fastenings Ltd, Gatehouse Road, Aylesbury, Bucks (Aylesbury 81341)

British Oxygen Co, Hammersmith House, London W6 (01-748 2020)

British Screw Co Ltd, 153 Kirkstall Road, Leeds, LS4 2AT (Leeds 30541)

Building Adhesives Ltd, Federation House, Stoke-on-Trent (Stoke-on-Trent 45411)

C

Cablok Co Ltd, Cablok Works, Monnow Road, London SE1 (01-237 5307)

Camatco Ltd, 31 Fulham Palace Road, London W6 (01-748 7766)

Carr Fastener Co Ltd, Stapleford, Nottingham (Sandiacre 2661)

Celmac Plasclip Ltd, PO Box 23, Hyde, Cheshire (061-368 3542)

Charles (Wednesbury) Ltd, Bridge Works, Wednesbury, Staffs (021-556 2261)

Chemical Building Products, Cleveland Road, Hemel Hempstead, Herts (Hemel Hempstead 4901)

CIBA (UK) Geigy Ltd, Duxford, Cambridgeshire (Sawston 2121)

George Clark (Sheffield) Ltd, 56 Penistone Road, Sheffield, S6 3AE (Sheffield 20171)

Clevedon Rivets & Tools Ltd, Reddicap Trading Estate, Sutton Coldfield (021-354 5238)

Cole Polymers Ltd, 7-15 Lansdowne Road, Croydon, Surrey (01-686 4411)

Cooper & Turner Ltd, Vulcan Road, Sheffield (Sheffield 42091)

Consolidated Pneumatic Tool Co Ltd, 97-107 Uxbridge Road, London W5 (01-567 3411)

Croda Polymers Ltd, New Bedford Road, Luton, Beds (Luton 33511)

Crompton Parkinson Ltd, 39a Hazlewood Road, Northampton (Northampton 30404)

D

Desoutter Brothers Ltd, 54 College Road, Perry Barr, Birmingham (021-356 5064)

Dom Products (Royston) Ltd, Roysia House, Royston, Herts (Royston 44111)

Dunlop Chemical Products Ltd, Chester Road Factory, Erdington, Birmingham (021-373 8101)

E

Evode Ltd, 450 Edgware Road, London W2 (Freefone 4009)

Expandite Ltd, Chase Road, London NW10 (01-965 4321)

Explosive Power Tools, 70 William Street, Ashton-under-Lyne, Lancs (061-330 3904)

F

Firth Cleveland Fasteners Ltd, Treforest, Pontypridd, Glamorgan (Treforest 2211)

Artur Fischer (UK) Ltd, 41 Loverock Road, Reading, RG3 1D2 (Reading 583885)

Feb (Great Britain) Ltd, Albany Road, Manchester, M27 1DT (061-794 2411)

W. J. Furse & Co Ltd, Traffic Street, Nottingham (Nottingham 83471)

G

GKN Screws & Fasteners Ltd, PO Box 61, Heath Street, Smethwick, Worcs (021-558 1441)

Goodyear Chemical Products Ltd, 9 Cheam Crescent, Station Way, Cheam, Surrey (01-643 4812)

H

Harris & Edgar Ltd, Progress Works, 222 Purley Way, Croydon, Surrey (01-686 4891)

G. Harrison & Sons, 152 Ewell Road, Surbiton, Surrey (01-399 3461)

Hermetite Products Ltd, Tavistock Road, Yiewsley, Middx (West Drayton 5511)

Hilti (GB) Ltd, Faulkner House, Faulkner Street, Manchester (061-228 1871)

Huntley & Sparks Ltd, James Estate, Western Road, Mitcham, Surrey (01-648 0121)

I

Industrial Adhesives Ltd, Moor Road, Chesham, Bucks (024-05 4444)

Instrument Screw Co Ltd, 206 Northolt Road, Harrow (01-422 1141)

ITW Ltd, 470 Bath Road, Cippenham, Bucks (Burnham 4333)

J

Thos. Johnson (MPW) Ltd, Whitehouse Street, Aston, Birmingham (021-359 2135)

S. Jones & Co Ltd, Dingwall Road, Croydon, CR9 3DA (01-686 5588)

K

Douglas Kane Group Ltd, Swallowfields, Welwyn Garden City, Herts (Welwyn Garden 21261)

L

Lanarkshire Bolt Ltd, Hamilton, Lanarkshire (Hamilton 21041)

Langham Tools Ltd, 13 Norfolk Place, London W2 (01-723 2295)

T. W. Lench Ltd, Excelsior Works, Rowley Regis, Warley, Worcs (021-559 1530)

C. Lindley & Co Ltd, Englefield Road, London N1 (01-254 6431)

Linread Ltd, PO Box 21, Cox Street, Birmingham 3 (021-236 9822)

London Adhesive Co Ltd, Boreham Wood, Herts (01-953 2992)

Longbottom & Co Ltd, Dalton Lane, Keighley (Keighley 4007)

M

MacAndrews & Forbes Ltd, Pembroke House, 44 Wellesley Road, Croydon, CR9 3QE (01-686 0826)

Metal Centres Ltd, Midland Works, Coneygre Road, Tipton, Staffs (021-557 2844)

Metal Fasteners Ltd, Overton, Basingstoke, Hants (Overton 303)

Metread Ltd, 143 Park Road, Aston, Birmingham 6 (021-327 1803)

Midland Washer Works Ltd, Brandow Way, West Bromwich, Staffordshire (021-553 2186)

Miles Redfern Ltd, Hyde, Cheshire (061-368 2621)

F. Mountford Ltd, Abberley Street, Smethwick, Warley, Worcs (021-558 3101)

Multigrip Ltd, Arterial Road, Leigh-on-Sea, Essex (Southend-on-Sea 525265)

N

National Adhesives & Resins Ltd, Slough, Bucks (Slough 29191)

Thomas Ness Ltd, NCB, Coal House, Lyon Road, Harrow, Middx (01-427 9001)

Nicholls & Clarke Ltd, Shoreditch High Street, London E1 (01-247 5432)

Norbar Torque Tools Ltd, Swan Close, Banbury, Oxon (Banbury 4234)

Nuts & Bolts (Darlaston) Ltd, Foster Street, Darlaston, Staffs (021-526 2201)

O

Omark Direct Fixings Ltd, Erncroft Trading Estate, Rugby Road, Twickenham, Middx (01-892 1759)

P

Pafra Ltd, Bentalls, Basildon, Essex (Basildon 3351)

J. M. Perkins & Smith Ltd, London Road Works, Braunstone, Nr Rugby, Warwickshire (Braunston 351)

Perox Engineering Ltd, Mortimer Street, Trowbridge, Wilts (Trowbridge 2910)

Phillips Drill Co (UK) Ltd, Queenslie Industrial Estate, Glasgow E3 (041-774 2267)

Polybond Ltd, Warsash, Southampton, Hants (Locks Heath 5272)

Power Equipment & Tool Factors Ltd, Norfolk Road, Maidenhead, Berks (Maidenhead 24690)

Prestwich Parker Ltd, Atherton, Manchester, M29 0LD (Atherton 42561)

Precision Screw & Manufacturing Co Ltd, Longacres Willenhall, Staffs (Willenhall 65621)

R

The Rawlplug Co Ltd, Rawlplug House, 147 London Road, Kingston-upon-Thames, Surrey (01-546 2191)

Rylands-Whitecross Ltd, Church Street, Warrington, Lancs (Warrington 31292)

S

Sciaky Ltd, Falmouth Road, Slough, Bucks (01-75 25551)

Shell Chemicals (UK) Ltd, Shell Centre, Downstream Building, London SE1 (01-934 1234)

Solbraze Limited, Bilton Road, Erith, Kent (Erith 41411)

Sovereign Chemicals Ltd, Barrow-in-Furness, Lancs (Barrow-in-Furness 25045)

Special Products For Industrial Techniques Ltd, Fleming House, Fleming Way, Crawley, Sussex (Crawley 23372)

Spirol Pins Ltd, Windmill Road, Sunbury-on-Thames, Middx (Sunbury-on-Thames 86165)

Stanley-Bridges Ltd, Nelson Way, Cramlington, Northumberland (Cramlington 3399)

Stapling Centre Ltd, Goodwood Road, SE14 (01-692 7366)

Stone Manganese Marine Ltd, Woolwich Road, London SE7 (01-858 3277)

T

Tappex Thread Inserts Ltd, Mason's Road, Stratford-on-Avon, Warwickshire (Stratford-on-Avon 4081)

Thor Tools Ltd, Fairbourne House, Oozells Street, Birmingham 1 (021-643 4835)

Thorsman & Co Ltd, Cross Street, Chorley, Lancs (Chorley 4197)

Thunder Screw Anchors Ltd, Victoria Way, Burgess Hill, Sussex (Burgess Hill 6258)

Tornado Fixings Ltd, Colquhoun House, 27/37 Broadwick Street, London W1 (01-437 9641)

Torrington Co Ltd, Torrington Avenue, Coventry, CV4 9AE (Coventry 74241)

Tower Manufacturing Co Ltd, Central Works, Shrub Hill, Worcester (Worcester 27272/3/4)

Trend Industrial Equipment Ltd, 1 Lechmere Road, London NW2 (01-459 5165)

Tretobond Ltd, Tretol House, The Hyde, London NW9 (01-205 6191)

George Tucker Eyelet Co Ltd, Walsall Road, Birmingham 22b (021-356 4811)

U

Ucan Products Ltd, Ucan Works, 27 Lyon Road, Hersham, Walton-on-Thames, Surrey (Walton-on-Thames 40111)
Unibond Ltd, Glebeland Road, Camberley, Surrey (Camberley 3135)
Unistrut division of GKN Sankey Ltd, 43/45 Broadwater Road, Welwyn Garden City, Herts (Welwyn Garden 26321)
US Expansion Bolt Co (GB) Ltd, Polesden Lane, Ripley, Surrey (Ripley 3701)

V

Vito Self Adhesives Ltd, Oldmeadow Road, Hardwick Trading Estate, King's Lynn, Norfolk (King's Lynn 61521/2)

W

Whitehouse Industries Ltd, Monkhill Works, Pontefract, Yorks (Pontefract 4141)
Wolf Electric Tools Ltd, Pioneer Works, Hanger Lane, London W5 (01-998 2911)

Y

Yorkshire Dyeware & Chemical Co Ltd, Black Bull Street, Leeds, LS10 1HP (Leeds 36591)

Z

Zest Equipment Co Ltd, Hendor House, Cray Road, Sidcup, Kent (01-302 0131)

Trade name — *Manufacturer*

1 Nails

Trade name	*Manufacturer*
Avon joist hangers	Avon Manufacturing Co Ltd
Avon framing anchors	
Avon wall ties	
Avon ceiling clips	
Bat joist hangers	Automatic Pressings Ltd
Camplate trusses	Camatco Ltd
Chevron wall ties	
Du-al-clip	MacAndrews & Forbes Ltd
Gangnail fastening plates	Automated Building Components (UK) Ltd
Gripkeen	GKN Ltd
Masco timber connectors	MacAndrews & Forbes Ltd
Rynail	Rylands-Whitecross Ltd
Spit masonry nails	Spit Ltd
Stonum nails	Stone Manganese Marine Ltd
Tapit masonry nails	US Expansion Bolt Co (GB) Ltd
Teco	MacAndrews & Forbes Ltd
Tower Gripfast nails	Tower Manufacturing Co Ltd
Tower masonry fixing nails	
Tower copper nails	
Tower non-nail fasteners	
Tower aluminium wire nails	
Trip-el-grip	MacAndrews & Forbes Ltd
Ucan masonry nails	Ucan Products Ltd
'v' wall ties	Automatic Pressings Ltd

2 Wood screws

Trade name	*Manufacturer*
Britfast	Metal Fasteners Ltd
Metfast	
Nettlefolds wood screws	GKN Ltd
Plastidome mirror screws	
Pozidriv recessed head screws	
Twinfast	

3 Light plugs

Trade name	*Manufacturer*
Celmac Thunderplugs	Celmac Plasclip Ltd
Fast Brolly	Dom Products Ltd
Fischer wallplugs	Fischer (UK) Ltd
Gravity toggles	Rawlplug Co Ltd
Helicoil	Armstrong Patents Co Ltd
Kuli fibre plug	Ucan Ltd
Maso-plugs	J. M. Perkins & Smith Ltd
Nutserts	Avdel Ltd
Plasbloc plugs	Celmac Plasclip Ltd
Plastic Rawlplugs	Rawlplug Co Ltd
Platti-plug	Thorsman & Co Ltd
Rawlnuts	Rawlplug Co Ltd
Rawlplastic	
Rawlplug fibre plug	
Rawlset	
Spring toggles	
SD nylon plugs	Hilti (GB) Ltd
Tapit	US Expansion Bolt Co Ltd
Thunder plug	Thunder Screw Anchors Ltd
WB metal Rawlplug	Rawlplug Co Ltd
Yellow jacket	US Expansion Bolt Co Ltd
Zest toggle bolt	Zest Equipment Co Ltd

4 Heavy masonry fixings

Trade name	*Manufacturer*
BSA anchors	Ucan Products Ltd
Bolt anchor	Rawlplug Co Ltd
Coronet	Cooper & Turner Ltd
Drilanchors	Rawlplug Co Ltd
Duplex stud anchor	
Febolt	Feb (UK) Ltd
Fischer anchor bolts	Fischer (UK) Ltd
Forway	US Expansion Bolt Co
Korker	
Liebig	Armstrong Patents Co Ltd
Loose bolt	Rawlplug Co Ltd
Rapid Bighead	Bighead Bonding Fasteners Ltd
Rawlanchors	Rawlplug Co Ltd
Rawltamp	
Red Head stud anchor	Phillips Drill Co (UK) Ltd
Red Head	
Rotospit	Special Products for Industrial Techniques Ltd
Saber-tooth drill anchors	Rawlplug Co Ltd
Selfix	Chemical Building Products
Sert-bolt	Firth Cleveland Fasteners & Components Ltd
Silver nugget wedge anchors	Rawlplug Co Ltd
Spit Roc anchors	Special Products for Industrial Techniques Ltd
Star self drill shield	US Expansion Bolt Co
Super Drilanchor	Rawlplug Co Ltd
TD anchors	Hilti (GB) Ltd
Uni-fix	Dom Products Ltd
Vari-depth	
Wej-it	Armstrong Patents Co Ltd

5 In situ fixings

Trade name	*Manufacturer*
Asbestos cement inserts	Rawlplug Co Ltd
Cablok	Cable Supports Ltd
Philblock	Rawlplug
Plasblok	Celmac Plasclip Ltd
Rawlsockets	Rawlplug Co Ltd

Trade name	*Manufacturer*
Rigifix	Huntley & Sparks Ltd
Rawloops	Rawlplug Co Ltd
Rawlties	
Unistrut	Unistrut division GKN

6 Rivets and self-tapping screws

Avdelok	Avdel Ltd
Avex	
Chobert	
Imex	Tucker Eyelet Co
Grovit	
Pop rivets	
Rivnut	Linread Ltd
Spat system	GKN Ltd
(Standard rivet types)	Cooper & Turner Ltd
	Clevedon Rivets Ltd
	Bifurcated Rivets Ltd
Taptite	Linread Ltd
Teks	Linread Ltd
'U' type	GKN Ltd
'Y' type	Linread Ltd

7 Machine screws, nuts, washers and bolts

(Fixings British Standards)	Avdel Ltd
	Barber & Colman Ltd
	Baxters (Bolts, Screws, Rivets) Ltd
	J. Bradley & Co Ltd
	British Screw Co Ltd
	Charles (Wednesbury) Ltd
	Firth Cleveland Fasteners Ltd
	Lanarkshire Bolt Ltd
	T. W. Lench Ltd
	C. Lindley & Co Ltd
	Metreads Ltd
	Midland Washer Works Ltd
	F. Mountford Ltd
	Nuts & Bolts (Darlaston) Ltd
	Precision Screw & Manufacturing Co Ltd
	Prestwick Parker Ltd
	Rylands-Whitecross Ltd
	Torrington Co Ltd
	Whitehouse Industries Ltd

8 Roofing and cladding fixings

Colour caps	Linread Ltd
Lap-Lox	
Linread Fabco	
Selabolts	British Screw Co Ltd
Selanuts	
Selascrews	
Selastitchers	
Selastud	
Selawashers	
Sela woodscrews	

9 Masonry cramps and anchors

Trade name	*Manufacturer*
	George Clark (Sheffield) Ltd
	Harris & Edgar Ltd
	Entwistle (Oldham) Ltd
	W. J. Furse & Co Ltd
	G. Harrison & Sons Ltd
	Omark Fixings Ltd
Surefix	Thomas Johnson Ltd
	Perox Engineering Ltd
	Rapid Metal Developments

10 Pipe and conduit fixings

BSP anchors	Phillips Drill Co (UK) Ltd
Caddy	W. J. Furse & Co Ltd
Carrdata	Carr Fastener Co Ltd
Clipfast	Hilti (GB) Ltd
Dot	Carr Fastener Co Ltd
Fastex	ITW Ltd
Fischer saddles	Fischer (UK) Ltd
Hit spring clips	Armstrong Patents Co Ltd
Klip-lok	Ucan Products Ltd
Landco clips	Longbottom Co Ltd
Obo punched strap	Douglas Kane Group Ltd
Plastube	Celmac Plasclip Ltd
Spire fasteners	Firth Cleveland Fasteners Ltd
Spirol pins	Spirol Industries Ltd
Spit clips	Special Products for Industrial Techniques Ltd
Tak-old	Ucan Products Ltd
Uni-klip	Dom Products Ltd

11 Power tools

	Arrow Abrasives Ltd
	Bosch Ltd
	Consolidated Pneumatic Tool Co Ltd
	Desoutter Brothers Ltd
	Explosive Power Tools Ltd
	Hilti (GB) Ltd
	Langham Tools Ltd
	Lench Ltd
	British Industrial Fastenings Ltd
	Norbar Torque Tools Ltd
	Perkins & Smith Ltd
	Omark Ltd
	Phillips Drill Co (UK) Ltd
	Power Equipment and Tool Factors Ltd
	SPIT Ltd
	Stanley-Bridges Ltd
	Stapling Centre Ltd
	Thor Tools Ltd
	Tornado Fixings Ltd
	Trend Industrial Equipment Ltd
	Ucan Products Ltd
	Unimatic Engineers Ltd
	Wolf Electric Tools Ltd

12 Welding, brazing and soldering

Argonaut welding apparatus	British Oxygen Co Ltd
Autolynx electric welding machines	
Cromp-arc	Crompton Parkinson Ltd
Handilynx electric welding machines	British Oxygen Co
Lynx electric welding machines	

Trade name	*Manufacturer*	*Trade name*	*Manufacturer*
Saffire gas welding equipment	British Oxygen Co	Tuftak	Ucan Co Ltd
Solbraze soldering and brazing equipment	Solbraze Ltd	Tufstick	Ucan Co Ltd
Resistance fusion equipment	Sciaky Ltd	Tufbond	
Welding equipment	G. Tucker Eyelet Co Ltd	Unibond	Unibond Ltd
		Univip	
		Vito—(prefix)	Vito Self Adhesives Ltd

13 Adhesives

Aerodux	CIBA-Geigy (UK) Ltd
Aerolite	
Araldite	
Asbestumin	Expandite Ltd
Bal- (prefix)	Building Adhesives Ltd
Bostik	Bostik Ltd
Butterfly	S. Jones & Co Ltd
Casco	Borden Chemical Co Ltd
Clam	London Adhesive Co Ltd
Clipfas	Atlas Preservative Co Ltd
Colegrip	Cole Polymers Ltd
Creteform	Hermetite Products Ltd
Crodabuild	Croda Polymers Ltd
Croid—(prefix)	
CTF—(prefix)	Building Adhesives Ltd
Dunlop—(prefix)	Dunlop Chemical Products Ltd
Durolock	National Adhesives & Resins Ltd
Ductfas	Atlas Preservative Co Ltd
Epephen	Borden Chemical Co (UK) Ltd
Epicoat	Shell Chemicals Ltd.
Evostick—(prefix)	Evode Ltd
Flashband	
Flexel	Expandite Ltd
Flexfas	Atlas Preservative Co Ltd
Flexibond	Yorkshire Dyeware and Chemical Co Ltd
Glasticon	Kelseal Ltd
Glasticord	Kelseal Ltd
Gun-o-prene	Evode Ltd
Indasol	Industrial Adhesives Ltd
Indatex	
Kelseal	Kelseal Ltd
L275	Expandite Ltd
Lagfas	Atlas Preservative Co Ltd
Loctile	Douglas Kane Group Ltd
Marley	Marley Ltd
Miles 311/3	Miles Redfern Ltd
Multigrip	Multigrip Ltd
Nico—(prefix)	Nicholls & Clarke
Pafra	Pafra Ltd
Plastijoint	
Plastiseal	
Pliastic	Expandite Ltd
Plyobond	Brigityre Rubber (GB) Co Ltd
Polybond	Polybond Ltd
Richafix	Building Adhesives Ltd
Saniseal	Expandite Ltd
Sealband	
Seelastrip	
Steoflex	
Styccobond	F. Ball & Co Ltd
Superstik	Expandite Ltd
Synthabond	Thomas Ness Ltd
Synthapruf	

Appendix
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Handbook of

FIXINGS & FASTENINGS

From toggle-anchors to tenter hooks, the Fixings Handbook covers all aspects of fixings and fastenings. It is the first work to present the subject of fixings as a comprehensive whole, and to relate them, in groups of 'families', to the materials they join together. Practical information includes characteristics and range of sizes, types and applications of nails, wood screws, light plugs, heavy masonry fixings, in situ fixings, rivets and self-tapping screws, machine screws, bolts, washers, roofing and cladding fixings, masonry cramps, pipe and conduit fixings, power tools, welding, brazing and soldering, adhesives. This is an essential reference, not only for architects, builders and technicians, but also for do-it-yourself enthusiasts who, are anxious to learn first principles rather than follow rule-of-thumb methods.

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