

SECTION 1, CHAPTER 4

FASTENING DEVICES

List of Contents

	<i>Para.</i>		<i>Para.</i>
General	1	Stiffnuts	29
SCREW TYPE FASTENING DEVICES		Self-Tapping Screws	32
Introduction	3	Fitting Self-Tapping Screws	37
Bolts and Screws	5	Standard Wood Screws	40
Nuts	6	SOCKETED FASTENING DEVICES	
M.O.S. Code or Part Numbers	7	Conduit Fitting	42
A.G.S. Nuts and Bolts	8	Taper Pins	45
Studs	12	Fitting Taper Pins	46
Fitting and Removal of Studs	14	Keys and Keyways	49
Locking Devices	18	Splined and Serrated Drives	53

List of Illustrations

	<i>Fig.</i>		<i>Fig.</i>
Common Screw-Type Fastenings	1	Peening and Centre-Pops	14
Typical Forms of Bolt- and Screw-Heads	2	Hexagonal Stiffnuts	15
Types of Nuts	3	Self-Tapping Screws	16
Studs	4	Slip-Joint Conduit Couplings	17
Stud Box	5	Fitting Taper Pin	18
Stud Insertion and Extraction Tool	6	Drilling Solid Shaft for Taper Pin	19
Screw Extractor	7	Hollow Saddle Key	20
Split Pin	8	Flat Saddle Key	21
Spring Washer	9	Gib-Headed Key	22
Tab Washer	10	Feather Key	23
Locking Plate	11	Woodruff Key	24
Locking Wire	12	Splined Drive Shaft	25
Circlips	13	Serrated Drive Shaft	26

General

1. Engineering products consist of various individual parts assembled together to form working units. The methods adopted for retaining the individual parts in position vary according to requirements and circumstances: some parts, such as structural items, are unlikely to require subsequent dismantling during the useful life of the equipment, and these may be permanently secured by such processes as welding or brazing; other parts may be likely to require removal for overhaul or replacement at very wide intervals, and to facilitate such removal without detracting from operational efficiency or reliability these parts may be

finished to very fine limits and assembled by pressing or driving into housings or over bosses forming part of the non-wearing "carcase" or structure. These techniques, however, are primarily manufacturing processes, and the tradesman engaged on normal servicing duties is unlikely to come into contact with them to any notable extent. The day-to-day work of the servicing tradesman is associated, to a much larger extent, with the techniques adopted for securing together those parts which require more frequent dismantling—these techniques are based, almost without exception, on the use of various forms of fastening devices in which simplicity of operation is allied to a high degree of reliability and efficiency.

2. Fastening devices used for Service purposes have been standardized as far as possible to ensure the maximum of interchangeability, and they are made to rigid specifications which agree, in the majority of cases, with British Standards specifications—for example, hexagonal headed bolts for aircraft purposes are made to B.S. 2A15 if of high-tensile steel, to B.S. 6A1 if of low-tensile steel, or to B.S. A17 if of aluminium alloy. This chapter deals with such standardized devices as nuts, bolts, screws, studs, keys, circlips and socket fastenings which are in general use in Service equipment.

SCREW-TYPE FASTENING DEVICES

Introduction

3. The screw thread is adapted for use in fastening devices in the form of bolts, screws, studs and nuts. Technically, a bolt is a cylindrical bar with a male thread at one end and a head of larger diameter than the bar at the other—the surface of the bar between the head and the beginning of the thread is plain. If the thread is continued to a point close to the head, the item is no longer regarded as a bolt and is known as a set-screw, often abbreviated to “screw”. A stud is a cylindrical bar which has a male thread at either end and a plain central portion, while the term “nut” may be applied to any shaped block that has a female thread and is used in conjunction with a bolt or stud to form a screw pair.

4. Fig. 1 shows the manner in which bolts, screws and studs are used as fastening devices. For bolt-type fastening, clearance holes are made in both components and a bolt, having a plain portion almost equal in length to the combined thickness of the two components, is passed through the aligned clearance holes and is secured by a nut.

Screw and stud fastenings are used in circumstances where, for one reason or another, it is not practicable to drill right through one of the components; a clearance hole is made through one, and a tapping size hole, which is subsequently tapped out to the thread of the screw or stud, is drilled into the other. In the case of the screw fastening, the nominal length of the screw (from the underside of the head to the extreme end of the shank) must not exceed the combined depths of the clearance and threaded holes, otherwise a rigid assembly cannot be obtained. In the stud fastening, one end of the stud, generally known as the “metal” end, is screwed into the tapped “blind” hole, and the clearance hole of the second component is passed over the exposed part of the stud—a nut on the exposed thread at the ‘nut’ end of the stud then holds the second component in place. Here also the depth of the threaded hole must be ample to allow full engagement of the ‘metal’ thread, so that the plain portion of the stud is close to the surface of the ‘metal’. As a general rule, the ‘metal’ thread of a stud is finished slightly oversize; this gives a tight fit in the tapped hole and ensures that the stud remains in position when the nut securing the second (clearance hole) component is removed. Some of the advantages to be obtained from the use of studs instead of screws are the saving of weight (shank diameter reduced to root diameter), avoidance of damage to the threads in the blind hole which might be caused by removal and replacement of a screw, and the use of threads at the metal end which are larger in diameter than the rest of the stud.

Bolts and Screws

5. Bolts and screws are made of high-tensile steels (both stainless and otherwise), mild steel, brass, light alloys, and other metals; the material used naturally depends

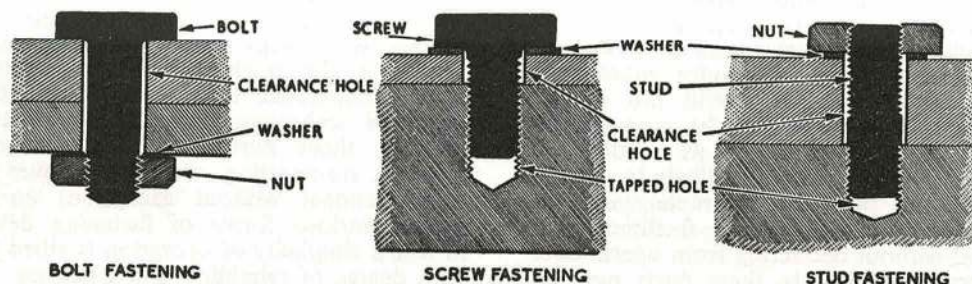


Fig. 1. COMMON SCREW-TYPE FASTENINGS

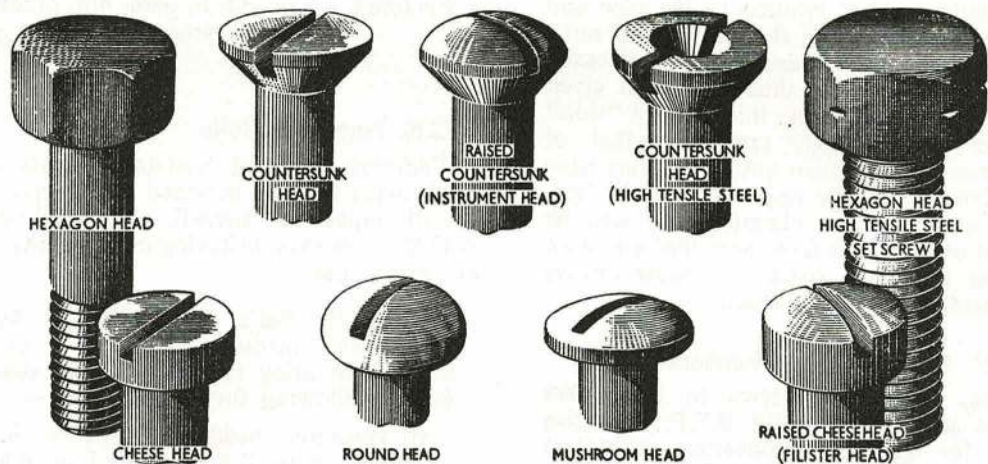


Fig. 2. TYPICAL FORMS OF BOLT- AND SCREW-HEADS

on the purpose for which the individual bolt or screw is required. Various forms of head are in common use (Fig. 2), and in all cases the dimensions of the head are standardized for each type, the basis being the nominal diameter of the bolt or screw shank. Standard hexagon-head B.A. bolts and screws, for example, have a width across the flats of the basic hexagon equal to the nominal diameter (D) of the shank $\times 1.75$, with a thickness equal to $D \times 0.75$; cheese heads for the same range have a diameter of $1.75D$, a thickness of $0.7D$, and a slot depth of $0.375D$. The length of thread on a bolt or screw is also standardized; again quoting the standard B.A. range, the length of thread on the end of a bolt is equal to $3D$ (this measurement includes any bevelling or rounding with which the end may be finished), while B.A. screws are threaded to within a distance of $1\frac{1}{2}$ pitches from the underside of the head if the total (nominal) length of shank is $3D$ or below, or $2\frac{1}{2}$ pitches if this measurement exceeds $5D$. B.S.W. and B.S.F. machine (bright steel) bolts to British Standards Specification No. 1083 have a length of thread equal to $2D$, while screws to this specification are

threaded to within a distance of two pitches from the underside of the head.

Notes. 1. The nominal diameter of a bolt or screw is the standard major diameter of the screw thread.

2. The nominal length of a bolt is the measurement between the underside of the head (or the top of the head in the case of a countersunk head) and the extreme end of the shank; the 'effective' length is equal to the nominal length less the length of thread. The nominal length of a screw is as for a bolt.

3. Countersunk screws are threaded up to the slope of the underside of the head.

Nuts

6. Standard nuts are hexagonal in shape, the basic hexagon of the nut having the same dimensions across the flats as has the corresponding hexagonal bolt or screw head. Fig. 3 shows the four types of standard nut in general use. As in the case of bolt and screw heads, the dimensions of nuts

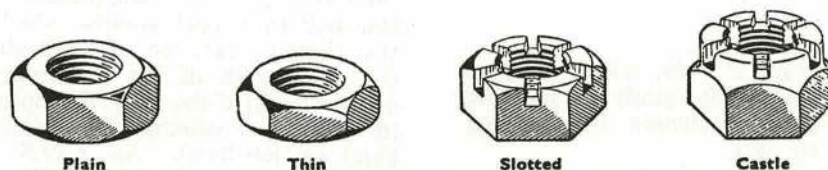


Fig. 3. TYPES OF NUTS

are standardized in relation to the type and size of thread used in the item; plain nuts, slotted nuts, and the base hexagons of castle nuts are of the same thickness for a given size of thread, while the thickness of "thin" nuts is approximately two-thirds that of the corresponding plain nuts. All nuts have a 30° chamfer on the upper face of the hexagon, and a similar chamfer may also be formed on the other face; nuts that are to be used as lock nuts (para. 24) must always be chamfered on both faces.

M.O.S. Code or Part Numbers

7. Nuts, bolts and screws to B.S. 1083 (Bright steel, B.S.W. and B.S.F., hexagon head, for general engineering purposes) are identified by Ministry of Supply Part Numbers which bear a definite relation to the thread, dimensions and material. The part number comprises a combination of letter-and-numeral symbols; the basis of the code is as follows:—

(a) First symbol (letter) indicates form of thread—F for B.S.F. thread, W for B.S.W. thread.

(b) Second symbol (letter) indicates nature of component—B for bolt, N for nut, S for set-screw.

(c) Third symbol (numeral) indicates component type—1 for hexagon-head bolt or screw or for plain nut, 2 for thin nut, 3 for castle nut, 4 for slotted nut.

(d) Fourth and fifth symbols (numerals) together indicate major diameter of thread in sixteenths of an inch.

(e) Sixth symbol, preceded by an oblique stroke:—

(i) If numeral (bolts and screws only) indicates the length in eighths of an inch.

(ii) If letter (nuts only) indicates the grade of material.

(f) Seventh symbol (letter) is applicable to bolts only and indicates the grade of material—screws to this specification are of one grade only.

Examples.

FB106/8D $\frac{3}{8}$ in. $\times$ 1 in. B.S.F. hexagon head bolt, grade D material (tensile strength 45 tons per sq. in.)

WS104/8 $\frac{1}{4}$ in. $\times$ 1 in. B.S.W. hexagon head set-screw.

FN106/K $\frac{3}{8}$ in. B.S.F. plain nut, grade K (tensile strength 28 tons per sq. in.).

A.G.S. Nuts and Bolts

8. "Aircraft General Standard" parts are small items that are supplied for general use in all types of aircraft. The following A.G.S. screw-type fastening components are in general use:—

(a) A.G.S. Bolts. Available in high-tensile and medium-tensile steels or in aluminium alloy (up to $\frac{1}{4}$ in. in diam.) in the following forms and sizes:—

(i) Hexagon head—6 B.A., 4 B.A., 2 B.A., $\frac{1}{4}$ in. B.S.F. up to 1 in. B.S.F. by steps of $\frac{1}{16}$ in.

(ii) Countersunk head—4 B.A. to $\frac{1}{2}$ in. B.S.F. (steps as above).

(iii) Mushroom head—4 B.A. to $\frac{5}{16}$ in. B.S.F.

(iv) Round head—4 B.A. to $\frac{1}{4}$ in. B.S.F.

(b) A.G.S. Nuts. Available in sizes to fit A.G.S. bolts in the following materials:—

(i) Mild and Stainless Steel. All standard types: plain and thin nuts in all sizes for steel bolts: slotted nuts from 2 B.A. up; castle nuts from $\frac{1}{4}$ in. up.

(ii) Aluminium Alloy. Plain nuts from 4 B.A. up to $\frac{3}{8}$ in. B.S.F.; slotted nuts from 2 B.A. up to $\frac{3}{8}$ in. B.S.F.

(iii) Brass. Plain nuts for B.A. sizes 0 to 10 (even numbers plus 1 B.A.); thin nuts for all A.G.S. bolts sizes from 4 B.A. up.

The thread of a suitable A.G.S. bolt may be extended by careful use of the appropriate die if circumstances call for a fully-threaded shank portion.

9. All A.G.S. nuts and bolts are identified for provisioning by means of reference numbers which are shown on the containers, packages, etc., in which the items are supplied. Such a reference comprises the number of the specification to which the items are made, followed by a part number which indicates the thread diameter, the effective length (i.e. the length of the unthreaded portion of the shank) if the items are bolts, the type (if nuts), and whether the thread is right-hand or left-hand. All A.G.S. parts are made to standard specifications, and the inclusion of the specification number allows

identification of the nature and material of the items in the package: e.g., hexagon-head high-tensile steel A.G.S. bolts, machined from the bar, are produced in accordance with specification B.S. 2A.15, and the group symbol "Z", when used as a suffix to the specification number of steel items, indicates that the steel is stainless. The part number, which follows the specification number and may be separated from it, in the case of nuts, by an oblique stroke, is based on the following code:—

(a) The thread diameter is indicated by a single letter, in accordance with Table 1.

A.16Z/ETL B.S. specification A.16 refers to steel nuts; Z shows stainless steel: part number ETL indicates a thin nut (T) with left-hand thread (Suffix L), $\frac{1}{4}$ in. B.S.F.

10. A.G.S. hexagon-head bolts of $\frac{1}{4}$ in. and above carry the part number only on the face of the head: grooves cut in the corners of a hexagon head indicate high-tensile steel, while an aluminium alloy bolt of this type is identified by two parallel lines embossed on the head face. Non-hexagon

Table 1

Diameter	B.A.			B.S.F.											
	6	4	2	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
Letter	A	B	C	E	G	J	L	N	P	Q	S	U	W	X	Y

(b) If the item is a bolt, the effective length (in tenths of an inch) is indicated by numerals preceding the thread size letter.

(c) If the component is a nut, the type is indicated by the symbol "P", "T", "S" or "C", according to whether the nut is plain, thin, slotted or castle.

(d) A left-hand thread is indicated by the symbol "L" used as a suffix to the part number—absence of such a suffix is an indication of a right-hand thread.

Examples.

6A.1. 25J Specification B.S. 6A.1. refers to mild steel bolts with hexagon heads: the part number identifies the bolt as $\frac{3}{8}$ in. B.S.F., right-hand thread (J with no suffix) of effective length 2.5 in.

2A.15.Y.31J High-tensile steel bolt, hexagon head, to B.S. specification 2A.15; non-stainless steel, $\frac{3}{8}$ in. B.S.F. right-hand thread, 3.1 in. effective length.

A.18 E.P. B.S. specification A.18 refers to aluminium alloy nuts: part number indicates a plain nut, $\frac{1}{4}$ in. B.S.F. with right-hand thread.

high-tensile steel bolts are identified by a countersunk dimple in the face of the head; bolts of these types, irrespective of size or material, do not bear the part number on the head. Steel nuts over $\frac{3}{8}$ in. bear the part number on one face of the hexagon, as do brass nuts over $\frac{5}{8}$ in.; all smaller sizes of these nuts, and all aluminium alloy nuts, do not bear the part number. Aluminium alloy nuts can be recognized as such by a washer face on the base.

11. In view of the absence of distinctive markings on the smaller A.G.S. components, it is recommended that all packages containing such items should be opened carefully to preserve the full reference number intact, and the parts kept in the original package. Where this is not practicable, the parts should be kept in small containers clearly marked with the relevant details. Always replace a damaged or unserviceable component with an item of the same reference number, unless there are direct instructions to the contrary.

Studs

12. Studs, like other screw-type fastenings, are largely standardized, although special studs may be used in certain circumstances. By far the most widely used type of standard

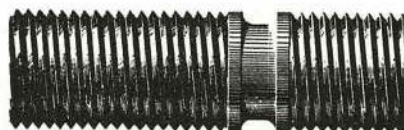
stud is the plain or parallel type (Fig. 4), in which the diameter of the unthreaded portion is the same as the major diameter of the screw thread at either end, with the threads merging smoothly into the plain part. The basis of standardization in studs is the diameter of the plain portion: the length of thread at the 'metal' end is standardized at the plain diameter, the length of the plain portion is half the plain diameter, while the length of the 'nut' thread is graded, usually in steps of $\frac{1}{8}$ in. for B.S.W. and B.S.F. studs. Standard plain studs are classified by the thread type, the diameter, and the overall length. As previously stated

stud has a plain portion of $\frac{1}{2}$ in. diameter, a $\frac{1}{4}$ in. thread on the 'nut' end, and a $\frac{5}{8}$ in. thread on the 'metal' end. Stepped studs are also used as replacements for plain studs when the tapped stud-hole, because of damage, has to be re-drilled and tapped with a larger thread.

(c) **Shouldered Studs.** This type is used where maximum rigidity of assembly is of prime importance. The stud is machined from oversize bar, and a projecting shoulder is left between the 'metal' end thread and the normal-diameter plain portion; this shoulder seats firmly on the surface of the 'metal' and gives



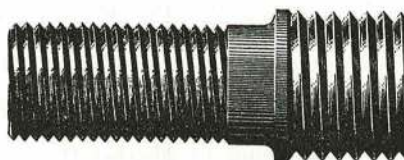
STANDARD STUD



WAISTED STUD



SHOULDERED STUD



STEPPED STUD

Fig. 4. STUDS

(para. 4), the 'metal' thread is usually finished slightly oversize to give a tight fit in the tapped hole.

13. Other variants of the standard stud are available for use in circumstances that require special consideration: the following variants, which are also shown in Fig. 4, have a reasonably wide application:—

(a) **Waisted Studs.** These are used where reduction of weight without loss of strength is of paramount importance: the diameter of the plain part of the stud is reduced to the minor diameter of the end threads, thus lightening the stud without impairing its effective strength.

(b) **Stepped Studs.** This type affords a stronger anchorage than the plain type if the 'metal' end of the stud has to be housed in soft metal. The thread of the 'metal' end is one size larger than that of the 'nut' end, e.g. a $\frac{1}{4}$ in. B.S.F. stepped

additional resistance to sideways stresses. The clearance hole in the second component, through which the 'nut' end and plain part of the stud passes, must be machined at the inner end to give clearance to the stud shoulder.

Note. To meet special requirements, the various types of standard studs may also be supplied with non-standard lengths of plain portion and 'metal' end.

Fitting and Removal of Studs

14. A stud must be a good fit in the hole tapped to receive it, and it should remain in position when the nut is removed. Where the thread of a stud has suffered slight damage it may be possible to restore it to a serviceable condition by careful use of the appropriate die-nut, but studs with seriously damaged threads, bent or distorted studs,

and studs that are not a good tight fit in their housings should, as a general rule, be removed and new ones fitted. Detailed instructions for stud fitting and replacement in specific equipments are often given in the Reconditioning Instructions of the relevant Air Publication—only the general aspects of stud fitting and removal are dealt with in subsequent paragraphs.

15. Fitting. A stud may be fitted with the aid of a stud box, by a special stud inserting tool which holds the plain part in a friction grip, or by fitting lock-nuts on the exposed thread and using a spanner on the upper nut. A stud box in its simplest form, is just a rather deep hexagonal nut with an ordinary bolt screwed into one end; the stud, which is entered into the other end, is prevented from turning in the stud box by setting up the bolt against the end of the stud, and the stud box is then turned by a spanner to screw the stud home firmly. The type of stud box shown in Fig. 5 has a stepped hole, with threads of different diameter at either end; these threads are usually of "preferred" sizes, e.g. 0B.A./2B.A., and by changing the lock bolt as requisite a stud box of this type can be used with two sizes of stud.

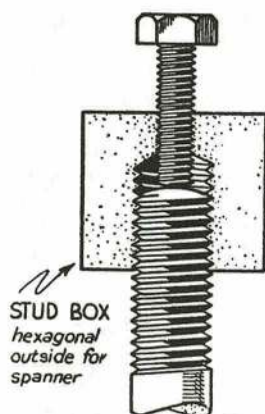


Fig. 5. STUD BOX

16. Stud Insertion Tool. The tool shown in Fig. 6 enables studs to be inserted or removed without imposing any strain on the screw thread, since the plain part of the stud is held in a friction grip. When the tool is assembled, the cam followers are contained within the cage and are free to move radially within the limits of the slotted holes; the end plate is pressed into the end of the

tool and is located by peening. When using the tool, the stud is passed through the hole in the end plate until its plain part is positioned within the hole in the cage, and the locating screw is then adjusted to prevent further entry of the stud into the tool. On rotating the tool body the cage tends to remain stationary owing to the light frictional grip of the cam followers on the stud shank; the rotating cam forces the followers inwards to provide a tight grip on the stud shank, and the stud then turns with the tool in the direction of rotation.

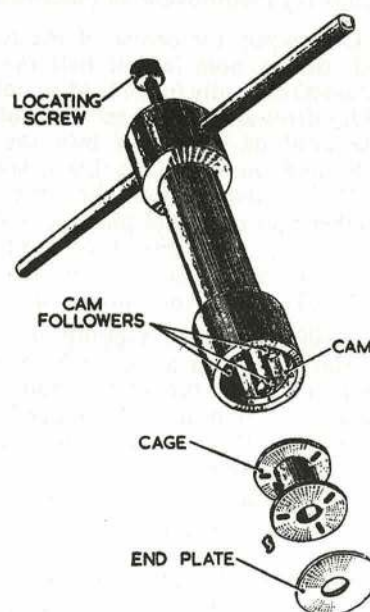


Fig. 6. STUD INSERTION AND EXTRACTION TOOL

17. Removal of Studs. The procedure to be followed when removing studs depends largely upon the state of the particular stud:—

- (a) **Undamaged Studs.** These may be removed by the use of locknuts, using a spanner on the lower nut, or by using the tool described in the previous paragraph.
- (b) **Damaged Studs.** If the thread is damaged to such an extent that locknuts cannot be fitted, use the stud tool; if this is not available, file flats on the stud and use a spanner or tap wrench to remove it.
- (c) **Broken Studs.** If the stud is broken at a point above the surface of the component, proceed as in (b). Studs that are



Fig. 7. SCREW EXTRACTOR

broken flush with or below the surface of the component must be dealt with according to the accessibility of the remainder of the stud, the size of the stud, and the availability of special tools, etc.; the following methods are all practicable:—

(i) Centre-pop the centre of the broken stud, drill a hole (about half the stud diameter) centrally in the broken portion, lightly drive a square taper drift into the hole until its edges cut into the stud body, and unscrew by using a spanner on the squared end of the drift. Remember that no useful purpose is served by driving the drift too hard—this merely expands the stud in the hole and makes removal more difficult.

(ii) Drill as in (i) a tapping size hole, tap this hole with a thread of opposite hand to that of the stud thread, insert a matching bolt into the tapped hole, and remove the remains of the stud by screwing up the bolt.

(iii) Drill a hole as in (ii), and then use a wrench to operate a screw extractor for removal of the stud. A screw extractor (Fig. 7), often known as an “Ezy-out”, looks like a coarse left-hand taper tap.

(iv) As a last resort, drill right through the remainder of the stud with a drill that is slightly smaller than the core diameter of the stud, and very carefully re-tap the hole, picking up the original thread.

(v) If none of the foregoing methods are practicable, it may be permissible to drill out the broken portion of the stud and re-tap the stud hole one size larger to take an oversize or stepped stud.

Locking Devices

18. Screw-type fastening devices have a tendency to unscrew when subjected to vibration and varying stresses. Various forms of locking devices are used to counteract this tendency; those in general use are described in the following paragraphs.

19. **Split Pins.** These are mild steel or alloy steel pins which pass through holes in bolts or studs to secure the nuts in position. They are used with slotted or castle nuts, and they must be a good fit in both hole and slot—the pins are secured by bending the legs as shown in Fig. 8. A split pin, after removal, should always be discarded and a new pin fitted in its place.

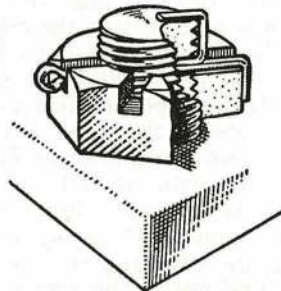


Fig. 8. SPLIT PIN

20. **Spring Washers.** These are obtainable as single coils of square-section spring with sharp corners (Fig. 9), or as double coils of flat spring. A plain washer separates the spring washer from the face of the component, thus preventing damage to that surface on compression of the spring washer when the nut is tightened. There is no objection to using a spring washer a second time if it is still springy and retains its sharp corners.

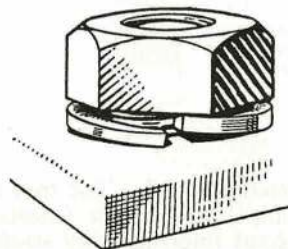


Fig. 9. SPRING WASHER

21. **Shakeproof Washers.** The action of a shakeproof washer is similar to that of the spring washer: the saw-tooth serrations on the faces of the washer permit the nut

to ride over them when screwing up, but they tend to bite into the nut metal when the latter tries to unscrew.

22. Tab Washers. These are thin metal washers with two or more tabs or projections: one tab is bent over the work (Fig. 10), or fits into a hole in the work or against a projection, while the other is bent against a face of the nut. It is not permissible to straighten the tabs of a two-tab washer and use the washer again.

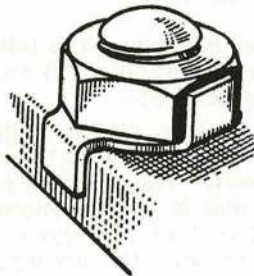


Fig. 10. TAB WASHER

23. Locking Plates. These are thin metal plates which are fitted over nuts when the latter have been fully tightened (Fig. 11): the plate is then located by one or other of various methods which do not require it to be bent or stressed. A locking plate may be used repeatedly providing it remains a good fit on the nut.

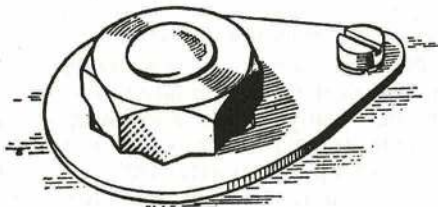


Fig. 11. LOCKING PLATE

24. Lock Nuts. These are standard hexagonal nuts, usually of the thin type, which are screwed down tightly against the normal securing nuts (plain) after the latter have been properly tightened. Both faces of lock nuts should be chamfered to 30°.

25. Locking Wire. Suitable gauge wire is often used as a locking device, particularly for set-screws (Fig. 12). Its use involves the heads of the screws, etc., being drilled, and the lay of the wire must be such as to oppose any tendency of the locked parts to

unscrew. New, uninked wire must be used each time for locking purposes.

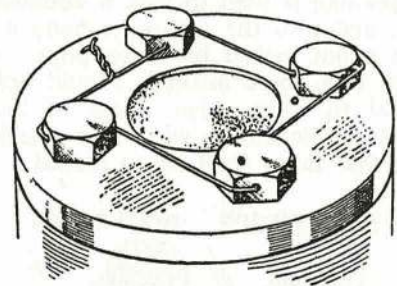


Fig. 12. LOCKING WIRE

26. Circlips. These items, which are made of spring steel, are often used for securing circular screwed parts—they act like split-pins without passing across diameters. The circular portion of the circlip fits into a groove or channel in one of the screwed parts: the bent end passes through aligned holes in the two components to lock them together (see upper item of Fig. 13). Another form of circlip, used for locating a plain cylindrical component in a cylindrical bore, is also shown: in this case the circlip is housed in a groove cut into the wall of the bore and projects from the surface sufficiently to prevent lateral movement of the inner component—this type is often of rectangular cross-section. Circlips should always be discarded after removal and replaced by new, un-used items.

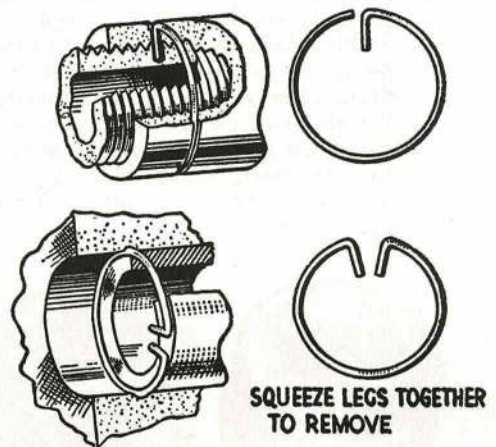


Fig. 13. CIRCLIPS

27. Peening and Centre-Pops. Where it is not practicable to lock a screwed item by one or other of the methods already des-

cribed, peening and centre-popping may prove acceptable alternatives. Fig. 14 shows how peening is used to lock a countersunk screw, and also the nut on a bolt: it also shows a nut locked by centre-pops. As a general rule, these methods should only be resorted to when other forms of locking are not practicable, or when it is specifically stated that items shall be so locked.

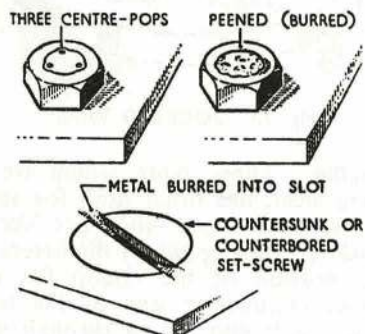


Fig. 14. PEENING AND CENTRE-POPS

28. **Varnish.** Small nuts and screws may be rendered shakeproof by means of shellac varnish. The varnish, which should be applied to the screw head or to the nut and exposed thread of the bolt or stud, sets hard on drying: heat should be applied to melt the varnish before attempting to unscrew any component which has been treated in this way.

Note. Although it is stated in preceding paragraphs that certain types of locking device may, subject to their being in good condition, be re-fitted after removal, the Servicing Schedules of certain Service equipments do not permit this practice. In such cases, always abide by the Servicing Schedule or other official instructions.

Stiffnuts

29. A stiffnut is a nut that incorporates a device to produce friction between the nut and the screw thread on which it is mounted: the friction is independent of the load on the end face of the nut and is of such a value that the nut may be considered to be self-retaining. There are two distinct categories of stiffnuts, viz. hexagon stiffnuts, which are used in the normal manner, and anchor stiffnuts, which are permanently secured on inner surfaces so that bolts can be inserted from the outside.

30. **Hexagon Stiffnuts.** The following types of hexagon stiffnut (Fig. 15) are extensively used in the Service:—

(a) **Nyloc.** This nut is counterbored at one end and spun over to retain a moulded nylon insert. The insert is not threaded initially, and it has an internal diameter slightly less than the minor diameter of the nut thread. On assembly, the bolt displaces the nylon in forming a thread and a high degree of friction is set up between the load-carrying sides of the threads in contact.

(b) **Oddie.** The top of this nut is counterbored and slotted vertically to form six tongues which are depressed inwards to form a circle with a diameter slightly smaller than the minor diameter of the nut thread. As the nut is screwed on the bolt, the thread of the latter displaces the tongues upwards and a friction load is applied to the contacting thread faces.

(c) **Philidas.** This nut has a circular crown which is slotted horizontally in two places, one slot being above and diametrically opposite to the other—each slot forms an arc of approximately 270°. The two sections thus formed are depitched downwards and inwards to apply a load between the thread faces on assembly.

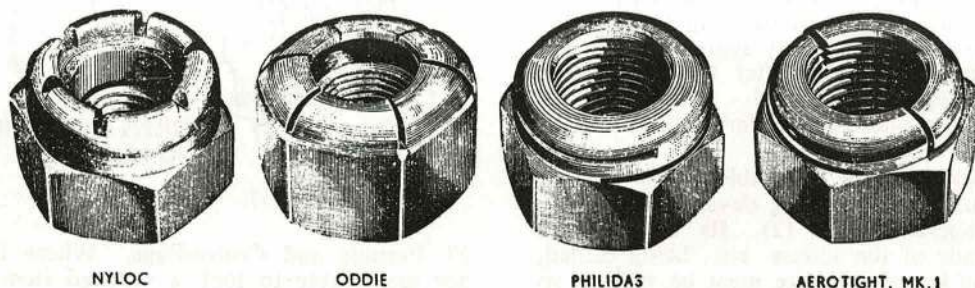


Fig. 15. HEXAGON STIFFNUTS

(d) **Aerotight.** This nut also has a circular crown, but in this case the crown is first slotted vertically across the diameter, then horizontally from each vertical cut through 150° in an anti-clock direction (viewed from the crown end). The wings thus formed are depitched downwards and inwards to apply a load between the thread faces on assembly.

31. Anchor Stiffnuts. These items are supplied with single or double anchor points, and may be either fixed or floating in a cage. The fixed-anchor stiffnut may be one unit—stiffnut integral with base plate—or it may be an assembly comprising a stiffnut, a cage, and a base plate. The floating-anchor stiffnut may comprise a stiffnut integral with a housing and mounted in an attachment plate, or the stiffnut and the housing may be separate items mounted in the attachment plate. Single anchor stiffnuts have two adjacent rivet holes for attachment to the structure, while double anchor types have a rivet hole on either side of the stiffnut.

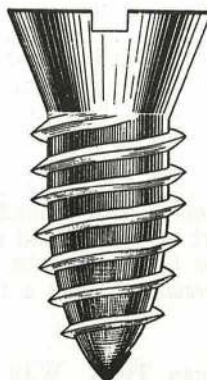
Self-Tapping Screws

32. Considerable difficulty may be experienced when mounting a component on thin sheet metal if the back of the supporting surface is not accessible—normal nut-and-bolt fastening is not practicable, and the gauge of the metal may well be such that holes drilled through it cannot be satisfactorily tapped to give a sound basis for set-screw fixing. In such circumstances it is often necessary to make use of self-tapping screws, which are capable of providing a

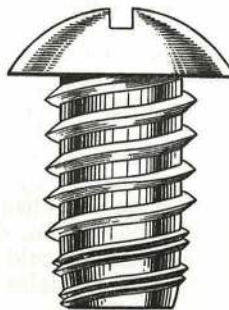
shakeproof fastening to quite thin metal without any form of locking device. Several varieties of self-tapping screws are in general use; those used in the R.A.F. being the Parker Kalon (P-K) and Barber and Colman types (Fig. 16).

33. P-K Type A. This type of self-tapping screw, which is made of hardened steel, has a bullet-shaped shank with a widely-pitched thread extending from the pointed "tail" of the screw to its head: various types of head, such as countersunk, round, mushroom, etc., are available. Type A screws are supplied in seven numbered sizes: the smallest size, No. 4, has a diameter of 0.112 in. and is suitable for use on 28–20 B.G. metal (0.015 in.—0.0312 in.); the largest size, No. 14, has a diameter of 0.251 in. and is suitable for 24–18 B.G. metal (0.0247 in.—0.0495 in.). The length of shank ranges from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. for No. 4 screws, and from $\frac{1}{2}$ in. to 2 in. for No. 14 screws; intermediate sizes have somewhat different ranges.

34. P-K Type Z. The shank of a Type Z self-tapping screw has the same general formation and threading as a Type A, except that the tail is much blunter and the first few spirals of the thread are double and of lesser depth than those of the remainder of the threading. Eight numbered sizes are available: No. 2 size, the smallest, has a diameter (shank) of 0.086 in. and is suitable for use on 28–16 B.G. metal (0.0156 in.—0.0625 in.); No. 14 size, the largest, has a diameter of 0.243 in. and is suitable for use on 22–6 B.G. metal (0.0312 in.—



P-K TYPE A



P-K TYPE Z



P-K TYPE U



B&C TYPE I

Fig. 16. SELF-TAPPING SCREWS

0.1981 in.). Type Z screws, like Type A, are available with several types of head with screwdriver slots, and with various lengths of shank in each size.

35. P-K Type U. This type of self-tapping screw is used to make permanent fastenings when securing components to heavy-gauge material. The screw is generally similar to a snap-head rivet, but its shank has several widely-pitched helical threads which run from an undercut at the tail to beneath the head of the screw; the undercut tail forms a pilot end which helps to maintain the screw in a vertical position during insertion. All Type U screws have round unslotted heads; they are supplied in ten alternative diameters, ranging from 0.059 in. to 0.239 in., screws of each diameter being available in a variety of lengths.

36. B & C Type 1. These self-tapping screws are made in standard sizes with various B.A., B.S.F., B.S.W., A.N.F., A.N.C., U.N.F., and U.N.C. threads; the tapped holes which result from the use of Type 1 screws are exactly to British, American or Unified thread forms, as appropriate, and the self-tapping screws may be replaced, whenever necessary, by ordinary standard machine screws of the appropriate threading. The shank of the screw has a blunt, slightly tapered tail, and is threaded overall: a slot in the tail of the shank ensures that swarf is cleared from the threading as the screw is driven home. Various forms of screw head, each slotted for screwdriver operation, are available. Type 1 screws with British thread formations are available in sizes from 6 B.A. up to $\frac{1}{8}$ in. B.S.F.; all are of mild steel, case-hardened and cadmium plated.

Fitting Self-Tapping Screws

37. Parker-Kalon Type A and Type Z. When two thicknesses of light gauge metal sheet are to be secured together by self-tapping screws of these types, the necessary holes for receiving the screws should be pierced or drilled the same size in both sheets; piercing is preferable to drilling, since the resulting burrs are nested together and greater areas of engagement for the threads are presented. The sizes of screw holes for the various sizes of screws vary with the thickness of the sheet and according to whether the holes are to be drilled or pierced; this information is available in tabular form

in A.P. 1464B (General Engineering), Vol. 1. Pierced holes should be used, whenever practicable, when securing a component that is provided with clearance holes to a light-gauge sheet; if this is not practicable the holes should be drilled, using a drill one size smaller than that specified in the tables. For securing two plates of heavy-gauge material together, or for attaching a component to a solid section of material, clearance holes should be drilled in the outer sheet (the sheet which will receive the heads of the screws) or the component, and the appropriate screw holes, as laid down in the tables, should be drilled in the inner sheet, or section—the clearance holes enable tighter joints to be made by the screws. When the screws are being inserted, the screwdriver and the screws must be at 90° to the work.

38. P-K Type U. As a general guide, these hammer-drive self-tapping screws should only be used if the thickness of the material into which the screws are to be driven is at least equivalent to the outside shank diameter of the screws that are to be used. If the material does not fulfil this requirement, Type A or Type Z self-tapping screws should be used in lieu. Reliable fastenings are only obtainable if the holes in the work are of the correct size; the appropriate sizes of holes for tapping and clearance are tabulated in A.P. 1464B, Vol. 1, but when using these tables it should be remembered that the use of a drill one size larger than that listed for a particular size of screw may be advantageous if the material into which the screws are to be driven is very hard. Conversely, a drill one size smaller than the listed size may give better results in very soft material. All holes for Type U screws must be drilled: holes of similar diameter in the parts to be joined are preferable when securing two metal sheets, or when securing a component to sheet metal, but clearance holes in a component, if already in existence, are acceptable if the sheet metal on which it is to be mounted is sufficiently thick to take a substantial thread. When a fastening is to be made to a solid section, the part to be fastened to the section should always have clearance holes, as this enables the screws to make a tighter junction.

39. Barber and Colman Type. With these self-tapping screws the necessary holes should be drilled the same size in both of the components that are to be secured

SOCKETED FASTENING DEVICES

together. The size of hole appropriate to each size of screw for use in steel and non-ferrous metals is given in tabular form in A.P. 1464B, Vol. 1, and it should be noted that the size of drill stipulated in these tables is in fact rather larger than the standard tapping-drill size used in ordinary internal threading for a machine screw of corresponding size and type. As with other self-tapping screws, the screwdriver and screw must be at 90° to the work when the screw is being driven home.

Standard Wood Screws

40. The standard form of wood screw has a tapered shank with a wide-pitched thread extending from the pointed tail of the screw; usually the thread extends over about two-thirds of the shank. Wood screws are classified by type, gauge, and length: the type is related to the form of head, i.e. countersunk, raised countersunk, or round head; the gauge is related to the diameter of the thick end of the shank; the length is the measurement taken from the point to the widest diameter of the head. Gauges of standard wood screws range from 0 (0.052 in. diam.) by steps of 0.014 in. to 32 (0.5 in. diam.); screws of each gauge are available with any of the three standard forms of head and in a variety of lengths. Mild steel, brass and light alloys (for the smaller sizes only) are used in the manufacture of wood screws.

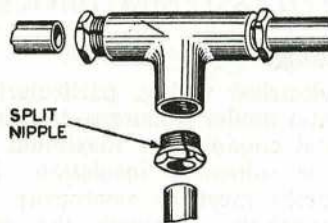
41. Wood screws, except in the smaller sizes, should not be driven into solid wood, since the 'wedging' action may split the wood and the very considerable opposition offered to the screw may result in it being sheared. The correct procedure is to drill a pilot hole for the reception of the screw: this hole should have a depth corresponding to the length of the screw, and its diameter should be approximately that of the core diameter of the screw at a point midway along the threaded portion. A correctly drilled pilot hole does not have any adverse effect on the holding qualities of the fastening; in addition to safeguarding both wood and screw, it also ensures correct alignment of the screw when driving home. Where very hard timber, such as oak or teak is involved, the diameter of the pilot hole may be safely increased to give easier action; greasing of the screw is also advisable in such circumstances.

Conduit Fittings

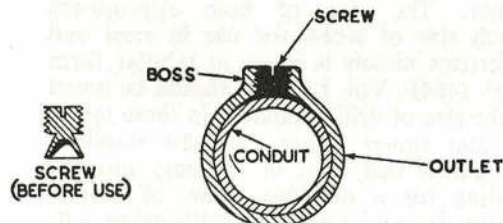
42. Much electrical wiring, particularly in workshops and similar situations, is enclosed in rigid metal conduits for maximum protection of the vulnerable insulation. Such conduit systems must be electrically continuous throughout, although the joints between the various parts, such as individual lengths of conduit and the metal distribution, fuse and switch boxes need not necessarily be watertight or airtight. The methods adopted for securing together the various component parts of a conduit system depend on the gauge of the conduit being used: heavy-gauge tubing can accept an external thread of sufficient depth to ensure a sound joint of screwed type, but this is not practicable with light-gauge tubing.

43. **Heavy-Gauge Conduit.** Where the ends of conduits can take a reasonably substantial thread without unduly weakening the tube wall, joints between conduits and the various forms of boxes are often made through the medium of internally-threaded nipples which are cast integrally with the boxes. Alternatively, clearance holes capable of accepting the conduit may be cut in the sides of the box, and the conduit may then be secured by lock nuts on either side of the box wall. Individual lengths of conduit may be coupled together by internally-threaded sleeves, elbows or T-pieces, but wide use is also made of small coupling boxes, having detachable front covers and two or more outlets, either of the threaded-nipple or lock-nut type. British Standard Conduit Threads are used for all screwed conduit fittings.

44. **Light-Gauge (Slip) Conduit.** Where the gauge of the tubing is such that effective external threads cannot be formed on the ends of the conduit, slip-joint fittings are employed. One very widely used form of slip-joint fitting makes use of boxes or coupling units having internally-threaded outlets: a split nipple, which is externally threaded with a taper thread and has a hexagon head, is passed over the end of the conduit (this end, incidentally must be scraped clean); the conduit end is then entered into the threaded outlet, and the nipple is then screwed home into the outlet so that the tapered thread causes it to grip the conduit in a vice-like grip. A second form



SPLIT-COLLAR METHOD



SET-SCREW METHOD

Fig. 17. SLIP-JOINT CONDUIT COUPLINGS

dispenses with the internally-threaded outlet: the outlet in this case has a smooth internal bore, but carries a drilled and tapped boss which houses a special screw with a cup-shaped projection on the lower end, as shown in Fig. 17. The cleaned conduit end is entered into the outlet bore, the screw is then driven home in the boss, and by virtue of its special shape the cup-shaped projection, after making contact with the conduit, expands as it grips, the expanded end of the screw making an excellent vibration-proof lock.

Taper Pins

45. Taper pins are used to secure socketed joints in tubular or solid shafting, particularly when the shafting is required to transmit relatively light mechanical effort in both directions of rotation: a typical use is in remote-control shafting. The pins, which are driven into tapered holes drilled through the diameters of the two components after socketing together, have a standard taper of 1 in 48; they are usually made of mild steel, and are classified by length and the diameter at the small end.

Fitting Taper Pins

46. **Tubular Work.** To fit a taper pin in a tubular section, drill from opposite sides across the diameter of the tube with a drill

$\frac{1}{8}$ in. smaller than the small end of the taper pin that is to be used. With a taper reamer of the correct size, enlarge the holes until the pin can be pushed through by hand until its small end is flush with the outer surface of the tube (Fig. 18). Support the tube firmly on either side of the small end of the pin, then drive the pin firmly home.

47. **Solid Work.** The procedure for fitting taper pins in solid shafts is much the same as for tubes, except that the hole is drilled straight through the shaft from the side that is uppermost on the drilling table. Excessive work with the reamer may be avoided by "stepping" the hole (Fig. 19); to do this, the hole is first drilled to normal size, i.e. $\frac{1}{8}$ in. less than the diameter of the pin at the small end, then one end of the hole is enlarged by a drill whose diameter approximates to that of the pin at a point halfway along its length. Care must be taken to ensure that the larger drill does not penetrate too far—one third of the shaft diameter is a fair allowance—otherwise an internal channel will be left in the hole after it has been reamed out to the proper size.

48. **Locking Taper Pins.** The small ends of taper pins may be solid plain, solid threaded, or split. Plain pins, after being driven home, are secured by peening over the small end. Pins with threaded small

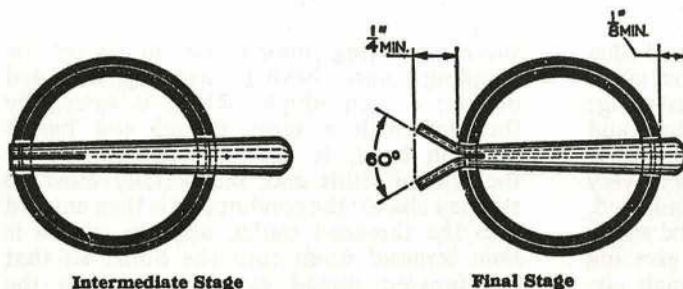
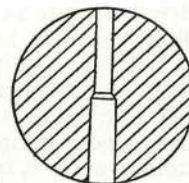


Fig. 18. FITTING TAPER PIN

Fig. 19.
DRILLING SOLID SHAFT
FOR TAPER PIN

ends are secured by lock nuts on the threads; in this connection it should be clearly understood that the nut is simply a locking device, it is not a means of drawing in the pin—the pin must be driven home tightly before tightening the nut. Split-end pins are secured by opening out the two parts of the small end (Fig. 18); a correctly fitted split taper pin should have the large end at least $\frac{1}{8}$ in. proud, the small end, before opening to lock, should project at least $\frac{1}{4}$ in., and part of the split should be inside the wall of the tube—the split ends must be opened across the tube, not along its length.

Keys and Keyways

49. Where considerable mechanical power has to be transmitted from a shaft to a hub, or vice versa, the two components are socketed together and are secured by means of one or more keys and keyways. The key is a solid piece of metal of rectangular or square cross-section, uniform width, and uniform or tapered thickness; it fits into a matching recess which is formed between the shaft and the hub. This device is produced in many variations, some of which are described in subsequent paragraphs; they are generally acceptable in circumstances that do not call for frequent removal of the shaft from the hub.

50. **Taper Keys.** These are made with a standard taper of 1 in 100 on the thickness, the tapering face of the key matching the taper of the recess or keyway formed in the bore of the hub. The ability of the key to resist relative axial movement between the hub and the shaft depends on the snugness of the fit of the key in the keyway; careful fitting is essential, and the key, after having been fitted, should remain undisturbed except in an emergency. The following types of taper key are in common use:—

(a) **Hollow Saddle Key.** This type of key is hollowed to suit the radius of the shaft; when driven into position its taper provides a friction grip between hub and shaft that is capable of taking a moderate load. The absence of any form of keyway on the shaft should be noted (Fig. 20).

(b) **Flat Saddle Key.** This form of taper key is rectangular or square in section, and bears on a flat formed on the shaft (Fig.

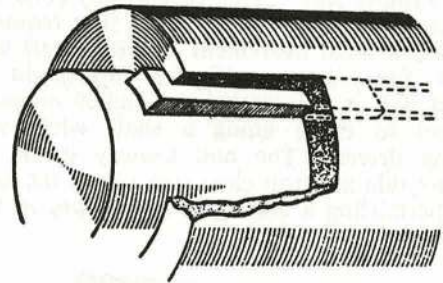


Fig. 20. HOLLOW SADDLE KEY

21). It provides a more positive grip between shaft and hub than is achieved by the hollow saddle key.

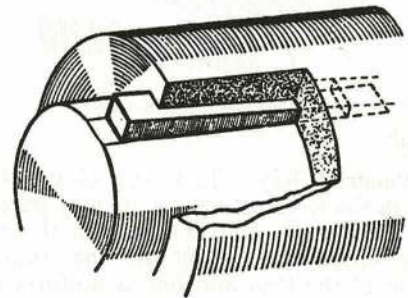


Fig. 21. FLAT SADDLE KEY

(c) **Plain Taper and Gib-Headed Keys.** These forms of taper key fit into keyways which are formed partly in the shaft and partly in the hub; they are capable of transmitting much greater power than either of the saddle types. The gib-headed key (Fig. 22) is used in circumstances where it is not practicable to use a key drift for eventual removal of the key when the occasion arises.

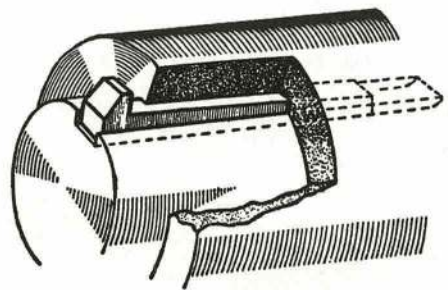


Fig. 22. GIB-HEADED KEY

51. Feather Key. This type of key (Fig. 23) is used in circumstances where it is required to allow axial movement between shaft and hub—for example, a feather key might be used if it is necessary for a pulley or gear-wheel to move along a shaft while still being driven. The hub keyway is cut to allow side and top clearance round the key, so permitting a sliding fit of the key in the keyway.

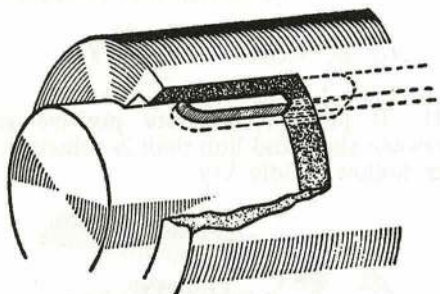


Fig. 23. FEATHER KEY

52. Woodruff Key. This key (Fig. 24) is made in the form of a segment of a parallel-sided disc; it fits into a cavity in the shaft which conforms closely to the rounded portion of the key, and into a uniform keyway in the hub in such a manner as to provide a push fit on the sides and a clearance fit at the top of the key. Woodruff keys may be fitted to parallel or tapered shafts.

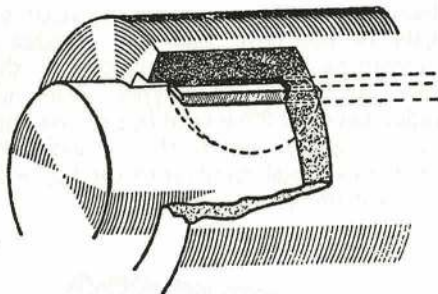


Fig. 24. WOODRUFF KEY

Splined and Serrated Drives

53. In engineering practice, a common method of keying together rotating components is by means of splined or serrated drives and couplings. Such drives will transmit high power and also allow easy dismantling and assembling.

54. Splined Drive. A spline is an integral feather key projection machined on a shaft or in a hub, and is usually of uniform rectangular cross-section—the splines on the shaft mate with recesses in the hub, and the dimensions are such as to provide a sliding fit. Splined shafts usually have at least four splines on each member (Fig. 25).

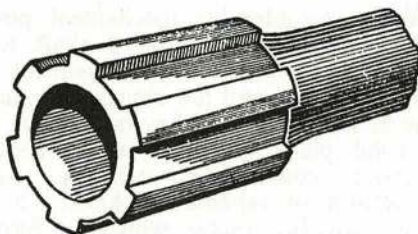


Fig. 25. SPLINED DRIVE SHAFT

55. Serrated Drive. Although basically similar in principle to the splined drive, the serrated drive makes use of truncated triangular projections (Fig. 26) on the shaft and hub; as in the case of the splined device, hub and shaft mate together on a sliding fit. This type of drive is used on parallel and tapered shafts.

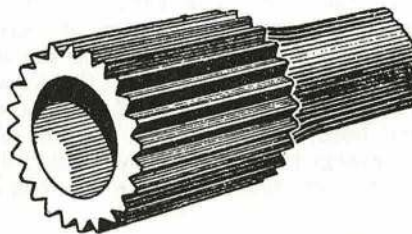


Fig. 26. SERRATED DRIVE SHAFT

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