## Fasteners Screw Threads

Standards:

Threaded fasteners allow parts to be fastened together with all of the strength that unthreaded fasteners provide

However, unlike rivets and pins, threaded fasteners may be disassembled and reassembled an almost infinite number of times.

Aircraft, bolts, nuts, screws and studs are manufactured to the many, different, International Standards and in a variety of different thread forms,

**U.S. Standards and international standardization organizations are listed below:**

MS – Military Standard

NAS – National Aerospace Standards

AN – Air Force Navy

ISO – International Organization for Standardization

AS – Standard Australia

SAE – Society of Automotive Engineers

ASTM – American Society for Testing and Materials

ANSI – American National Standards Institute

BSI – British Standards Institute

Several types of fasteners are used in aviation, such as the screws, bolts, rivets, pins, studs. etc.

**Similarities:**

Both have threads.

**Differences:**

Screws are weaker.

Screws have looser thread fit.

The screw shank is usually threaded throughout.

Screws do not utilize a nut. A bolt requires a nut to function.

### The Inclined Plane and the Helix

When a continuous inclined plane is cut around the outside (or the inside) of a cylinder, then a spiral (also known as a 'helix') is produced.

The helix angle is important in screw threads, because it dictates the number of threads, which can be cut, per axial linear increment (millimetres or inches) on, or in, the cylinder.

## Screw Thread Terminology

Screw threads are usually formed with a ‘clockwise’ turning groove and are referred to as ‘righthand’ threads,

but there are occasions where the thread is formed with the groove spiralling in an ‘anti-clockwise’ direction and in this instance, they are designated as ‘left-hand’ threads.

Screw Thread: A ridge or uniform section in the form of a helix on the external or internal surface of a cylinder, or in the form of a conical spiral on the external or internal surface of a cone.

External Thread: An external thread is a thread on the outside of a member.

Internal Thread: An internal thread is a thread on the inside of a member.

Major Diameter: The largest diameter of the thread of the screw or nut. The term "major diameter" replaces the term "outside diameter" as applied to the thread of a screw and also the term "full diameter" as applied to the thread of a nut.

Minor Diameter: The smallest diameter of the thread, measured at right angles to the axis.

Pitch: The distance from the center of one crest to the center of the next, measured parallel to the axis.

Depth of Thread: The distance between the root and crest, measured at right angles to the axis.

Half Angle of Thread: The angle included between a side of the thread and the normal to the axis, measured in an axial plane.

Angle of Thread: The angle included between the sides of the thread measured in an axial plane.

Helix Angle: The angle made by the helix, or conical spiral, of the thread at a pitch diameter with a plane perpendicular to the axis.

Crest: The surface of the thread corresponding to the major diameter of the screw and the minor diameter of the nut.

Lead: The distance a screw thread advances axially in one turn. On a single threaded screw the lead and pitch are identical; on a double threaded screw the lead is two times the pitch; on a triple headed screw the lead is three times the pitch,

Root: The surface of the thread corresponding to the minor diameter of the screw and the major diameter of the nut.

Side or Flank: The surface of the thread which connects the crest with the root.

Axis of a Screw: The longitudinal central line through the screw.

Base of Thread: The bottom section of the thread; the greatest section between the two adjacent roots.

Depth of Thread: The distance between the crest and the base of the thread measured normal to the axis.

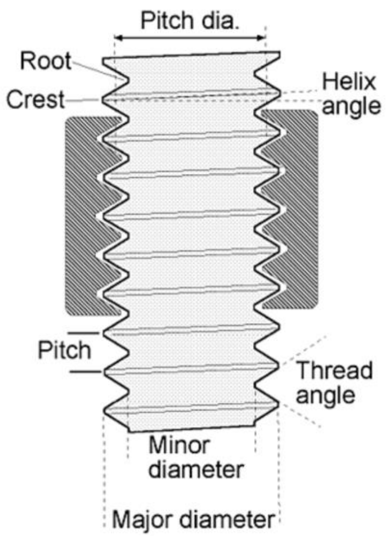
Number of Threads: The number of threads in one inch of length

Length of Engagement: The length of contact between two mated threaded parts measured axially.

Depth of Engagement: The depth of thread contact of two mated parts, measured radially

Lead: The distance a screw moves axially in one complete turn. In the case of multi-start threads, the lead is equal to the pitch multiplied by the number of starts.

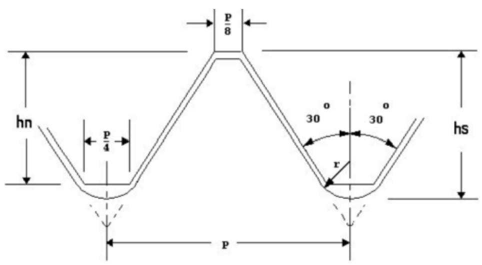
Single Start Thread: Term used when there is only one screw thread cut in the material.




## Screw Thread Forms

The form of a screw thread will depend upon the function for which it is to be used.

Where the thread is used to join components together (nuts, bolts, screws and studs) then the conventional, truncated 'V'-shaped threads, similar to the ISO Metric thread, will be found.



Unified Coarse (UNC) and Unified Fine (UNF) threads may be found wherever their use is appropriate, but special threads, such as UNS (for high-temperature applications) and UNJ (increased fatigue strength) have become more common.

Several Unified thread types exist:

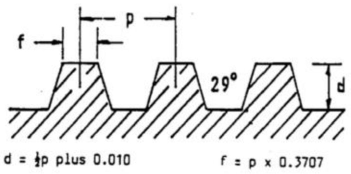
- U.N.C. Unified National Coarse
- (U.N.F. Unified National Fine
- U.N.E.F. Unified Extra Fine
- U.N. Unified with constant pitch regardless of diameter
- U.N.S. Unified with special pitch/diameter combination
- U.N.J.F. Unified Fatigue - Resistant Fine Thread.

Other Thread Forms

The four main systems are ANC, ANF (also referred to as AF), UNC and UNF, with the NC and NF having a finer thread than the UNC and UNF.

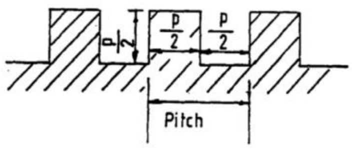
Some specialist threads are used whenever force needs to be transmitted (such as in a lathe lead-screw or a vice). These include the following:

*Acme*



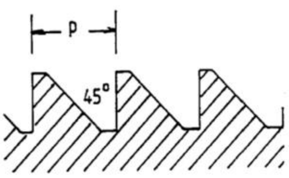

Acme thread form

*Square*




Square thread form

*Buttress*




Buttress thread form

## Classes of Fit

The different thread classes have differing amounts of tolerance and allowance. Classes 1A, 2A, 3A etc. apply to external threads; Classes 1B, 2B, 3B etc. apply to internal threads.

| Class of Fit | Type of Fit |
|---|---|
| 1 | Loose |
| 2 | Free |
| 3 | Medium |
| 4 | Close |
| 5 | Tight |

A Class 1 fit can be tightened, all the way down, by hand (such as with a wing- nut), whilst a Class 4 or 5 fit requires a spanner throughout the tightening operation.

The Class 3 fit is the type mostly employed on aircraft, and would be typical of a thread which is designed for use in a high-temperature environment and may require the application of an anti-seize compound before installation

## Measuring Screw Threads

One method is to identify the screw by means of various marks, normally found on the head of the screw. These marks may give a clue as to which type of thread the screw has (AF, BSF, or Metric etc.). A measurement across the thread crests, using a micrometer, would give the diameter of the screw in question. Finally, the identifying head markings would also give the material from which the screw is made.

Two useful tools may be used for different stages of thread measurement.

The profile gauge can be used to ensure that the tool, which is cutting the thread, is of the correct type.

The pitch gauge can be used to find the thread size by simply fitting the various blades of the gauge against the screw thread until a match is achieved

## Bolts, Studs and Screws

British Bolts

the Society of British Aerospace Companies (SBAC). The following abbreviations (some of which have already, been discussed, are in common use:

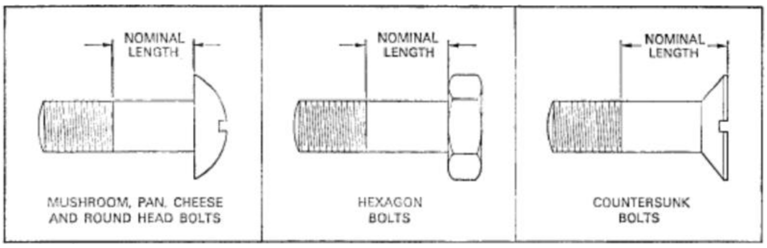
- AGS — Aircraft General Standard
- AS — Aircraft Standards
- Al. Al. — Aluminium Alloy
- BA — British Association
- BSF. — British Standard Fine
- HTS. — High Tensile steel
- HTSS. — High Tensile Stainless Steel
- LTS. — Low Tensile Steel
- SS — Stainless Steel
- UNC. — Unified National Coarse
- UNF. — Unified National Fine.

Identification of BS Unified Bolts

British Standard Unified (BS Unified) bolts are identified by the use of an alpha-numeric code, which provides information relating to the type, material, surface finish, length, diameter and any other important characteristics of the threaded device

Table shows a (very small) selection of aircraft standard bolts and screws with a (shortened) description of the type of device and the materials from which it is made.

| Standard No. | Description | Material |
|---|---|---|
| A102 | Hex. Headed Bolt | HTS. |
| A104 | Hex. Headed Bolt | SS |
| A111 | Hex. Close Tolerance. Bolt | HTS |
| A112 | Shear Bolt | HTS |
| A174 | 100° Countersunk. Head. Bolt | SS |
| A175 | 100° Countersunk. Head. Bolt | Al. Al. |
| A204 | 100° Countersunk. Head. Screw | HTS |
| A205 | Pan Head. Screw | HTS |



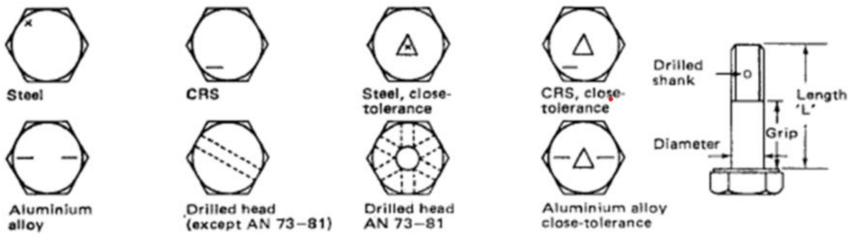

American Bolts

American aircraft bolts and nuts are threaded in the NC (American National Coarse), the NF (American National Fine), the UNC (Unified National Coarse), and the UNF (Unified National Fine) thread series. The item is often coded to give the diameter of the threaded portion and the number of threads per inch (TPI).

Aircraft bolts may be made from HTS, Corrosion-Resistant Steel or Aluminium Alloy. Head types may be hexagonal, clevis, eyebolt, internal wrenching and countersunk, head markings may be used to indicate other features such as close tolerance, aluminium alloy, CRS or other types of steel.

AN Bolts

AN' bolts come in three head styles, Hexagon Head, Clevis and Eyebolts and Table provides an indication of the various code numbers in use.



AN Bolts identification

Diameter: The last figure, or last two figures, of the ‘AN’ number indicates thread diameter, 1 = No. 6, 2 = No.8, 3 = No.10, and 4 = ¼” with subsequent numbers indicating the diameter in 1/16” increments.

EX: Thus an AN4 is a hexagon headed bolt of ¼” diameter and an AN14 is a hexagon headed bolt of 7/8” (14/16”) diameter.

Lengths: The length of a bolt, in the case of a hexagonal headed bolt, is measured from under the head to the first full thread and is quoted in 1/8” increments as a dash number.

EX: AN4 – 12 length 12/8

Position of Drilled Hole: Bolts are normally supplied with a hole drilled in the threaded part of the shank, but different arrangements may be obtained:

Drilled shank = normal coding e.g., AN24 – 15

Un-drilled shank = A added after dash No. e.g., AN24 – 15A

Drilled head only = H added before dash No. (replacing dash) A after dash No. added e.g. AN25H15A.

Drilled head and shank = H added before dash No. e.g. AN25H15

Material: The standard coding applies to a non-corrosion-resistant, cadmium-plated steel bolt. Where the bolt is supplied in other materials, letters are placed after the AN number as follows:

C = Corrosion Resistance Steel C.R.S. e.g. AN25C15

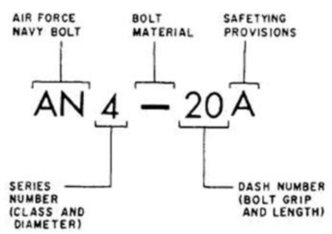
DD = Aluminium Alloy e.g. AN25DD15

Thread: Where the bolt is supplied as either UNF or UNC threads, a UNC thread is indicated by placing an A in place of the dash, e.g. AN24A15

AN’ bolt part number. It starts with the letters AN. Next, notice that a number follows the letters. This number usually consists of two digits. The first digit (or absence of it) shows the class of the bolt. For instance, in figure 5.15, the series number has only one digit, and the absence of one digit shows that this part number represents a general-purpose hex-head bolt. However, the part numbers for some bolts of this class have two digits. In fact, general-purpose hex-head bolts include all part numbers beginning with AN3, AN4, and so on, through AN20. Other series numbers and the classes of bolts that they represent are as follows:

AN21 through AN36 - clevis bolts

AN42 through AN49 – eyebolts



In the case of a series number ending in 0, for instance AN30, the 0 stands for 10, and the bolt has a diameter of 10/16 of an inch.

When used in the part numbers for general-purpose AN bolt, clevis bolts, and eyebolts, this dash indicates that the bolt is made of carbon steel.

With these types of bolts, the letter C, used in place of the dash, means corrosion-resistant steel.

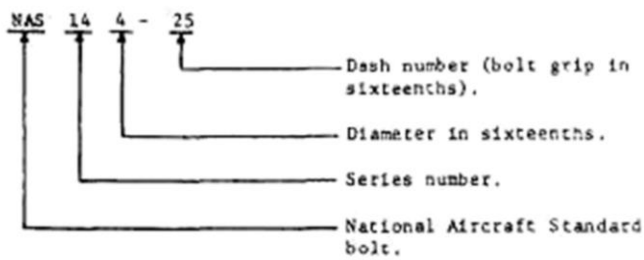
The letter D means 2017 aluminum alloy.

The letters DD stand for 2024 aluminum alloy.

In this instance the number 20 stands for a bolt that is 2 inches long. The last character in the AN number shown in figure 5.15 is the letter A. This signifies that the bolt is not drilled for cotter pin safetying. If no letter were used after the dash number, the bolt shank would be drilled for safetying.

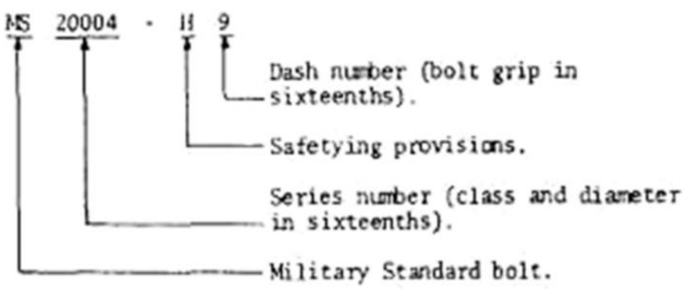
## NAS Bolts

NAS 144-25 bolt (special internal-wrenching type), observe that the bolt identification code starts with the letters NAS. Next, the series has a three-digit number, 144, The first two digits (14) show the class of the bolt. The next number (4) indicates the bolt diameter in sixteenths of an inch. The dash number (25) indicates bolt grip in sixteenths of an inch.




## MS Bolts

the MS indicates that the bolt is a Military Standard bolt. The series number (20004) indicates the bolt class and diameter in sixteenths of an inch (internal-wrenching, 1/4-inch diameter). The letter H before the dash number indicates that the bolt has a drilled head for safetying. The dash number (9) indicates the bolt grip in sixteenths of an inch.



## Special Bolts

The hexagon headed aircraft bolt AN3 – AN20 is an all-purpose structural bolt used for applications involving tension or shear loads where a light drive fit is permissible.

Alloy steel bolts, smaller than 3/16" diameter, and aluminium alloy bolts smaller than ¼" are not used on primary structure. Other bolts may be used as follows:

Close Tolerance Bolts: These bolts are machined more accurately than the standard bolt. They may be hexagon headed (AN173 – AN186) or have a 100º countersunk head (NAS80 – NAS86). They are used in applications where a tight drive fit is required (the bolt requires the use of a 340g - 400g (12oz – 14 oz) hammer to drive it into position.

Internal Wrenching Bolts: (MS 20024 or NAS 495) these are fabricated from high-strength steel and are suitable for tensile or shear applications. The head is recessed to allow the insertion of a hexagonal key used for installing or removing the bolt. In Dural-type material, a heat-treated washer must be used to provide an adequate bearing surface for the head.

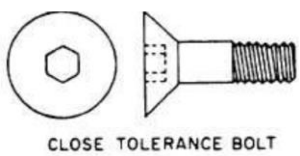
Clevis Bolts: The head of a clevis bolt is round and either slotted, for a standard screwdriver, or recessed, for a cross-pointed screwdriver. This type of bolt is used only for shear loads and never in tension. It is often inserted as a mechanical pin in a control system.

Seven additional types of bolt heads are shown in figure 5.15. Notice that view A shows an eyebolt, often used in flight control systems.

A

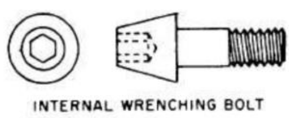

View B shows a countersunk-head, close- tolerance bolt.

B



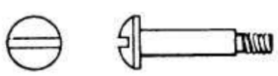

View C shows an internal-wrenching bolt. Both the countersunk-head bolt and the internal-wrenching bolt have hexagonal recesses (six-sided holes) in their heads. They are tightened and loosened by use of appropriate sized Allen wrenches.

C



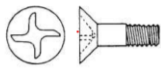

View D shows a clevis bolt with its characteristic round head. This head may be slotted, as shown, to receive a common screwdriver or recessed to receive a Reed-and-Prince or a Phillips screwdriver.

D



View E shows a torque-set wrenching recess that has four driving wings, each one offset from the one opposite it. There is no taper in the walls of the recess. This permits higher torque to be applied with less tendency for the driver to slip or cam out of the slots.

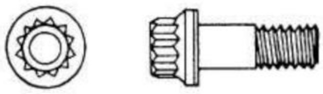
E



TORQ-SET HEAD RECESS

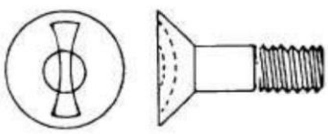
View F shows an external-wrenching head that has a washer face under the head to provide an increased bearing surface. The 12-point head gives a greater wrench gripping surface.

F



EXTERNAL WRENCHING BOLT

View G shows a hi-torque style driving slot. This single slot is narrower at the centre than at the outer portions. This and the centre dimple provide the slot with a bow tie appearance. The recess is also undercut in a taper from the centre to the outer ends, producing an inverted keystone shape.

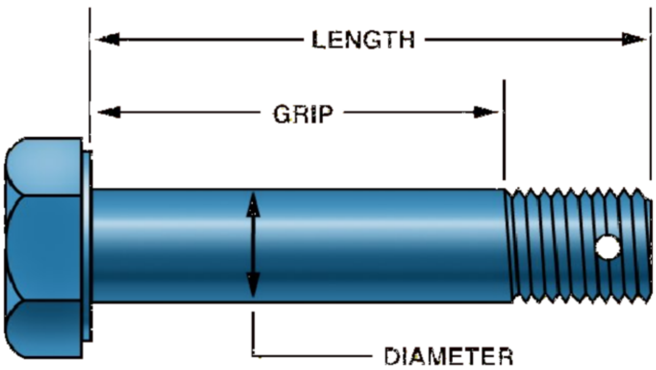


HI-TORQUE BOLT

These bolts must be installed with a special hi-torque driver adapter. They must also be driven with some type of torquelimiting or torque-measuring device. Each diameter of bolt requires the proper size of driver for that particular bolt. The bolts are available in standard and reduced 100-degree flush heads. The reduced head requires a driver one size smaller than the standard head.

## Metric Bolts

The identification of a Metric bolt is by the use of the diameter in millimetres, immediately after the capital letter 'M'. In this way, M6 represents a 6 mm-diameter bolt. The length is also shown in millimetres, so the bolt M6-15 will be a 6 mm- diameter bolt, which is 15 mm long. The basic terminology, for identifying bolts of the Metric system, involves the nominal length, the grip length and diameter.



## Nuts

Aerospace standard nuts are made in a variety of shapes and sizes. They can be made of cadmium-plated carbon steel, stainless steel or anodised 2024–T aluminium alloy and can have right- or left-hand threads

As a general rule, nuts are manufactured from the same material as the bolt or screw to which they are attached, with the exception of high-tensile steel bolts, with which, mild steel nuts are used. Figure 5.16: Metric bolt dimensio

As they do not have any identifying marks or lettering, they are usually identified by their colour and their constructional features. Familiar types of nuts include:

Castle Nuts: which are used with drilled shank hexagon-headed bolts or studs, eye-bolts and clevis bolts. They are fairly rugged and can withstand large tensile loads. The slots (castellations) are designed to accommodate a split (cotter) pin.


Castle Nut

Slotted Nuts: are similar in construction to the castle nuts and are used in similar applications, except that they are normally used for engine use only

Plain Hexagon Nuts: are of rugged construction and suitable for large tensile loads. Since they require an auxiliary locking device, their use on aircraft is limited.


Plain Hex Nut

Light Hexagon Nuts: are a much lighter nut, used for miscellaneous light tensile requirements.

Plain Check (or Lock) Nuts: are employed as locking devices for plain nuts, for threaded rod ends and for other devices

Wing Nuts: are used where the desired tightness can be obtained merely with using the fingers and where the assembly is frequently removed.


Wing Nut

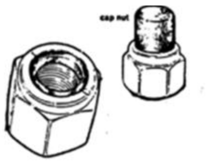
Stiffness and Anchor Nuts

An ordinary standard nut will depend upon friction between the engaging threads to ensure its tightness. The enemy of this system is vibration, which can cause the nut to slacken off, and in extreme cases, unwind itself completely from the bolt or screw.

In areas where this might occur, locking devices are used. These either increase the frictional resistance between the threads, or take the form of positive securities that prevent any movement of the nut once they have been applied.

Stiffness and anchor nuts (refer to figure 5.18) employ various means of increasing the friction forces between the threaded devices and common types include:

Nyloc: This looks like a standard hexagonal nut, but has a plastic insert in the counterbored end. This insert is initially unthreaded and has an internal diameter slightly smaller than the nut thread, so that, as the nut is screwed on the bolt, the plastic insert is displaced and a high degree of friction is created. Another type of plastic 'stop' nut is named the 'Capnut'. This type is completely sealed and is used in pressurised compartments and fuel and oil tanks etc.




Nyloc & Nyloc Cap Nut

Oddie: The top of this nut has a slotted end, consisting of six tongues, which form a circle slightly smaller than the bolt or stud diameter. As the nut is turned, a friction load is imparted onto the threaded device.

ODDIE

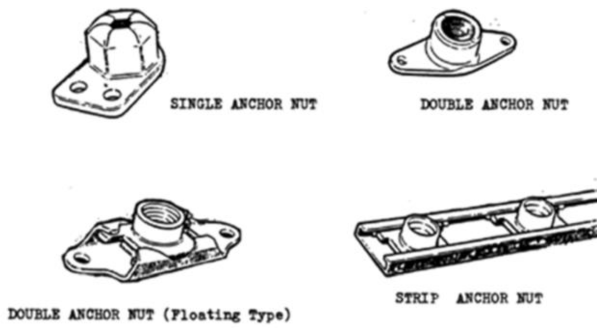
Philidas: This nut has a circular crown which is slotted horizontally in two places The thread on the slotted part is slightly 'out of phase' with the rest of the thread, so that increased friction is achieved when the nut is turned.

PHILIDAS

Aerotight: Similar to the Philidas in appearance, except that the slots are vertical. Its locking method is also similar.

Lightweight: The locking section of this stiffnut is slightly oval in shape and so causes increased friction when the thread passes through it.


Anchor nuts and Strip nuts: Anchor nuts are supplied with single or double attachment points and may be either fixed or floating in a cage. The anchor nut may be a single unit stiffnut, integral with the base plate, or it may be an assembly, comprising stiffnut, cage and base plate.

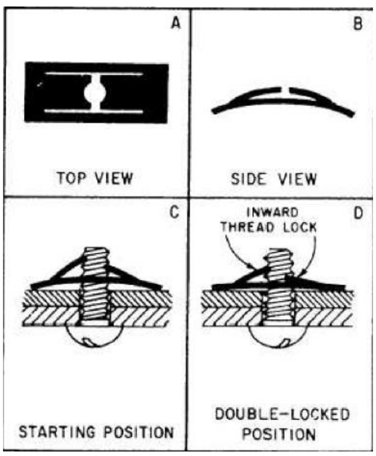



Single attachment types are used in corners or where space is limited and have two adjacent fixing points. Double anchor nuts have a hole either side of the stiffnut. They are fitted to the structure by riveting.

Sheet Spring Nuts

These nuts are used with standard and sheet metal self-tapping screws to support line clamps, conduit clamps, electrical equipment, and access doors.

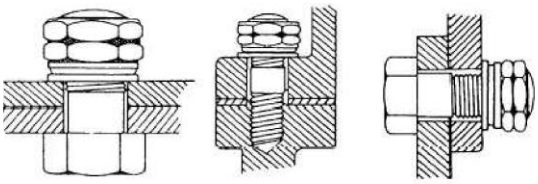
The most common types are the float, the two-lug anchor, and the one-lug anchor. The nuts have an arched spring leek that prevents the screw from working loose. They should be used only where originally used in the fabrication of the aircraft.




Point-Wrenching Nuts: These nuts are generally used where a nut with a high tensile length is required. These nuts are installed with a small socket wrench. They are usually self-locking.

Shear Nuts: These nuts are designed for use with devices such as drilled clevis bolts and threaded taper pins that are normally subjected to shearing stress only. They are usually self-locking.

Klincher locknuts: are used to ensure a permanent and vibration proof, bolted connection that holds solidly and resists thread wear. It will withstand extremely high or low temperatures and exposure to lubricants, weather, and compounds without impairing the effectiveness of the locking element. The nut is installed with the end that looks like a double washer toward the metal being fastened. Notice in figure 5.20 that the end that looks like a double hexagon is away from the metal being fastened.



## Screws

Screws are probably the most commonly used threaded fastener in aircraft construction. They differ from bolts in that they are generally made from lower-strength materials

They can be fastened by a variety of tools, including screwdrivers, spanners and Allen keys.

Most screws are threaded along their complete length, whilst some have a plain portion for part of their length.

difference in terminology between the British and American names for screw heads. What the British refer to as a 'countersunk -headed' screw, the Americans call a 'flat-head' or 'flush' screw. Similarly, 'mushroom-headed' screws are known as 'truss-heads' in the USA.

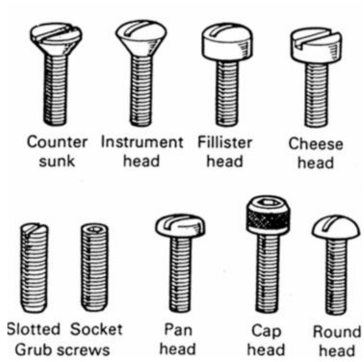
## Machine Screws

Machine screws are used extensively for attaching fairings, inspection plates, fluid line clamps and other light structural parts.

The most common machine screw used in aviation is the fillister-head screw, which can be wire-locked using the drilled hole in the head.

The flat-head (countersunk-head) screw is available with single or cross-point slotted heads.

The round-head screw and the truss-head (mushroom-head) screw, provide good holding properties on thin metal sheets.



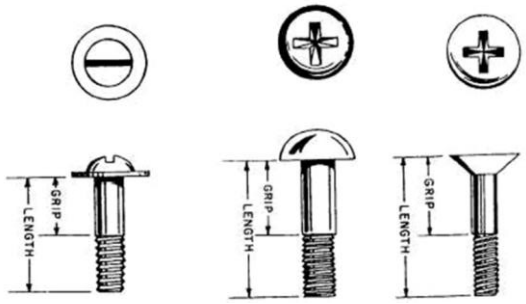
## Structural Screws

Structural screws are used for assembling structural parts.

They are made of alloy steel and are heat treated.

Structural screws have a definite grip length and the same shear and tensile strengths as the equivalent size bolt.

They differ from structural bolts only in the type of head. These screws are available in round-head, countersunk-head, and brazier-head types, either slotted or recessed for the various types of screwdrivers.




## Machine Screws

The commonly used machine screws are the flush-head, round-head, fillister-head, sockethead, pan-head and truss-head type.

Flush-Head - Flush-head machine screws are used in countersunk holes where a flush finish is desired. These screws are available in 82 and 100 degrees of head angle, and have various types of recesses and slots for driving.

Round-Head - Round-head machine screws are frequently used in assembling highly stressed aircraft components.

Fillister-Head - Fillister-head machine screws are used as general-purpose screws. They may also be used as cap screws in light applications such as the attachment of cast aluminium gearbox cover plates.

Socket-Head - Socket-head machine screws are designed to be screwed into tapped holes by internal wrenching. They are used in applications that require high-strength precision products, compactness of the assembled parts, or sinking of the head into holes.

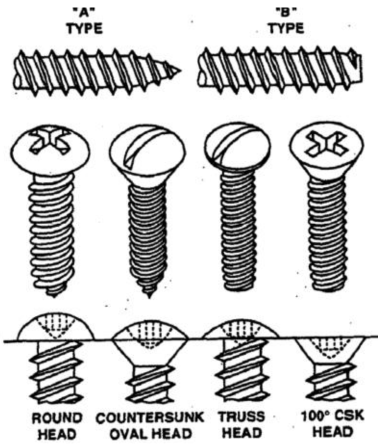
Pan- and Truss-Head - Pan-head and truss- head screws are general-purpose screws used where head height is unimportant. These screws are available with cross-recessed heads only.

## Self-Tapping Screws

Self-tapping screws (refer to figure 5.23) have coarse threads and are used to hold thin sheets of metal, plastic and plywood together. The type A screw has a gimlet (sharp) point, and the type B has a blunt point with threads that are slightly finer than the type A.

There are four types of head in normal use:

• round head • countersunk oval-head • truss or mushroom-head • flat countersunk-head.

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**Locking Devices** The problems associated with threaded devices, and the effects of vibration on their security, were discussed previously, when the use of stiffnuts and anchor nuts was considered. In addition to using methods which increase the friction between threads, there are several other ways in which the integrity of a threaded joint can be assured.

## WASHERS

A washer is a thin plate with a hole that is normally used to distribute the load of a threaded fastener, such as a screw or nut.

Other uses are as a spacer, spring (Belleville washer, wave washer), wear pad, preload indicating device, locking device, and to reduce vibration (rubber washer).

Washers usually have an outer diameter (OD) about twice the width of their inner diameter (ID).

Washers are also important for preventing galvanic corrosion, particularly by insulating steel screws from aluminium surfaces.

### Type of Washers

1. plain washers, which spread a load, and prevent damage to the surface being fixed, or provide some sort of insulation such as electrical.

2. spring washers, which have axial flexibility and are used to prevent fastening loosening due to vibrations

3. Lock washers, which prevent fastening loosening by preventing unscrewing rotation of the fastening device, locking washers are usually also spring washers.

Spring Washers

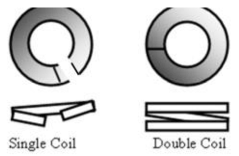
These washers are available in a variety of forms (refer to figure 5.36). In some instances (particularly with light alloy assemblies), spring washers are assembled with plain facing washers between the spring washer and the component. This is done to prevent damage to the surface finish when the spring washer is compressed although, with steel assemblies, the plain washer is usually omitted.

It is good practice to renew spring washers during overhaul or repair. This procedure is most essential in engines and engine components as well as where units have reciprocating parts; such as in compressors or pumps.

In normal circumstances, however, spring washers can be re-used if they have retained their 'springiness' and 'sharpness'. Types of spring washers include:

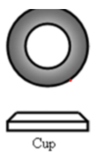
Single and Double Coil Washers: Manufactured from rectangular-sectioned steel sheet and formed into a portion of a helix.

the single and double coil are the most common types of spring washer to be found on aircraft components.




Crinkle Washers: Crinkle washers are usually manufactured from either copper alloy or corrosion- resistant steel. They are often used in lightly loaded applications such as instruments and electrical installations.


Cup Washers: Cup (or Belleville) washers are manufactured from spring steel and are 'dished' to form a spring of high rating. The flattening of the washer, during tightening, exerts an axial load to the nut, which will resist any tendency of the nut to lose torque. Assembly should always be in accordance with the manufacturer's instructions.

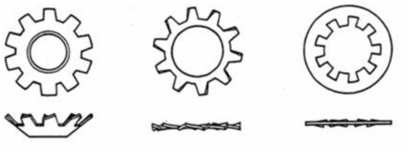



Shake-Proof Washers

Flat washers of this type (refer to figure 5.37), are manufactured from steel or phosphor bronze and are used in place of spring washers. In some circumstances conical shake-proof washers are used for locking countersunk screws.

Either the internal or the external diameters can be serrated, the serration being designed to bite into the component and nut to prevent rotation.

All shake-proof washers should be used only ONCE. It is rare for these washers to be specified in assemblies where an anti-corrosion treatment of the components has been specified, as this could damage the treatment.



Tab Washers

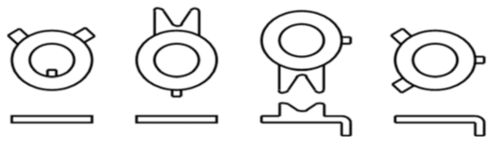
Tab washers (refer to figure 5.38), are normally used on plain nuts.

The washers are manufactured from thin metallic sheet material and have two or more tabs projecting from the external diameter.

They can also be designed for locking two or more nuts.

When the washer is installed, one tab is bent against the component or inserted into a hole provided. whilst a second tab is bent against the flat (or flats), of the nut, after it has been torqued down correctly.

Multi-tab washers can be re-used until all tabs have been used once.



Studs

Studs are metal rods that are threaded at both ends.

In general they are used where it is not possible, or desirable for a bolt to be used.

most studs are produced in a standard form, with variants used for special purposes.

It will be appreciated that the security of a stud depends upon the friction between its thread and that of the tapped hole (the 'metal' thread) into which it is inserted.

If this friction fails to hold the stud, it will work loose and all precautions to prevent the nut from slackening will be negated.

Standard Studs - By far the most widely used stud is the standard (plain, or parallel) type, in which the diameter of the whole stud, along its length, is constant. Standard studs are classified by the thread type, diameter and overall length. The 'metal' thread is, usually, finished very slightly oversize to give a tight fit into the tapped hole.

Other variants of the standard stud are available for use in circumstances that require special consideration.

To meet special requirements, the various types of standard studs may also be supplied with non-standard lengths of plain portion and 'metal' end. A simple method of fitting and removing a stud is by running two plain nuts down the 'nut' end of the stud and cinching (locking) them together using two spanners. The stud can then be screwed into or removed from the material. Breaking the cinch then separating and removing the nuts completes the operation.

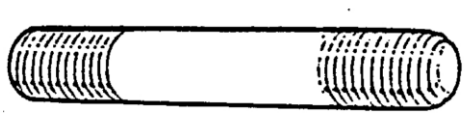


Figure 5.25: Standard stud

Waisted Studs - Waisted studs are used where reduction of weight, without the loss of strength, is of paramount importance. The diameter of the plain portion of the stud is reduced to the minor diameter of the end threads,

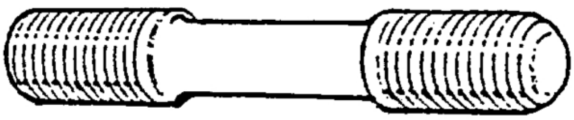


Figure 5.26: Waisted stud

Stepped Studs - This type affords a stronger anchorage than the standard 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.

Stepped studs are also used as replacements for standard studs when the tapped studhole has to be re-drilled and tapped with a larger thread, due to damage

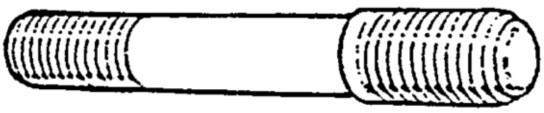


Figure 5.27: Stepped stud

**Shouldered Studs**

**Used where maximum rigidity is required.**

**The shoulder seats firmly on the surface of the metal and gives additional resistance to sideways stresses.**

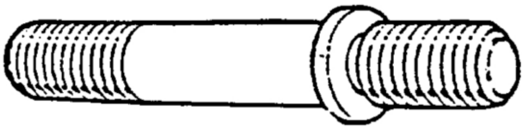


Figure 5.28: Shouldered stud

Thread inserts are a means of providing a stronger anchorage, for bolts, screws or studs, in the comparatively softer metal alloys (aluminium, magnesium, bronze), wood, plastics or composite materials. They may also be used when it is necessary to do a repair to a threaded hole that has suffered damage.

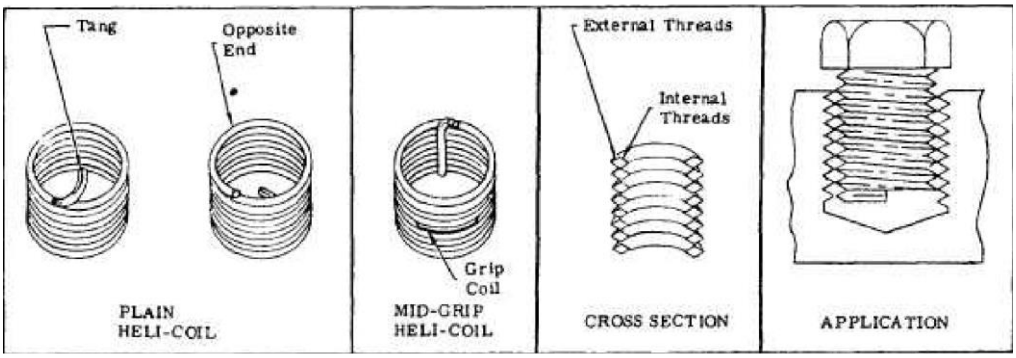
There are two basic types of thread insert (Wire and Thin Wall), but the designs of each type will vary according to the many manufacturers or to the environment in which the fastener must operate.

There are two types of wire thread inserts. See figure 5.29. One is the plain insert, made with a tang that forms a portion of the bottom coil offset, and is used to drive the insert. This tang is left on the insert after installation.

Wire thread inserts consist of a very accurately formed helical coil of wire,

which has a diamond (rather than a round) cross-section and is usually made from corrosion-resistant steel or heatresistant nickel alloy.

Specifically sized drills, taps and thread gauges (provided by the insert manufacturer) are required to form the tapped holes for the inserts and another special tool is necessary to insert the wire coils correctly into their prepared holes.




The second type of insert used is the self-locking, mid-grip insert, which has a specially formed grip coil midway on the insert. This produces a gripping effect on the engaging screw. For quick identification, the self-locking, mid-grip inserts are dyed red.

Figure 5.30: A self-locking wire thread insert

## Thin Wall Inserts

Thin wall inserts appear in a variety of designs, materials and surface finishes and consist of a thin tube, which is threaded internally and may, or may not, be threaded externally. Similarly, special tools are required from the manufacturer to prepare the holes for the inserts and various methods are adopted to secure each particular type of thin wall insert into its hole. Thin Wall inserts include:

Key-Locked Inserts: Key-locked inserts are threaded both internally and externally and, after being screwed into the prepared hole, are (as their name implies), locked into their holes by tiny wedges or keys. The keys are then pressed (or hammered) into place between the insert and the wall of the hole.

Swaged Inserts: Swaged inserts are also threaded internally and externally and are, again, screwed into the hole before a tool is used to deform (swage) the insert so that it is locked into the hole.

Ring-Locked Inserts: Ring-locked inserts, with internal and external threads, are screwed into holes which are counter bored, to allow a special lock-ring to be installed, (after the insert) and yet another special tool is used to complete the locking action of the lock-ring.

Bonded Inserts: Bonded inserts are, usually, only internally threaded (to hold the bolt, screw, stud etc.) and are secured in the prepared hole by the use of adhesives.

Dowels and Pins

Dowels and pins used in aircraft can include the Roll Pin, Clevis Pin, Split (Cotter) Pin, and Taper Pin.

Dowels While not usually used as fasteners, dowels are rods or pins of the appropriate material which are fixed (often permanently) in one of the components of a joint such that the protruding shank of the dowel locates with a corresponding hole in the item being attached, thus ensuring accurate assembly.

Two examples of the use of dowels may be found where a Propeller Control Unit

Roll Pins

Roll pins (refer to figure 5.32) are often used to secure a pulley to a shaft or to provide a pivot for a joint where the pin is unlikely to be removed. A roll pin is normally made from flat spring steel that is rolled into an incomplete cylindrical shape that allows the pin to compress when it is pressed into the hole and creates a spring action that holds the pin tight within the bore of the hole. To remove a roll pin it must be driven from the hole with a correct-sized punch.

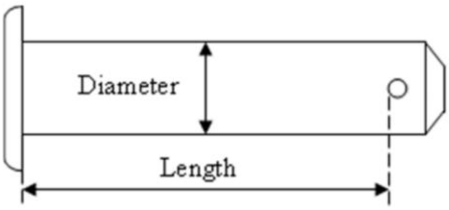
ɡure 5.32: Roll pin

Clevis Pins

## Clevis Pins

Clevis or flat-head pins (refer to figure 54) are used for hinge pins in some aircraft control systems. They are made of cadmium-plated steel and have grip lengths in 1/16-inch increments.

When a clevis pin is installed, a plain washer is usually placed over the end of the shank and a cotter (split) pin is inserted, through the pre-drilled hole in the clevis pin, to lock it in place.




## Taper Pins

Taper pins are used in joints that carry shear loads and where the absence of clearance is essential.

The threaded taper pin is used with a taper pin washer and a shear nut if the taper pin is drilled, or with a self-locking nut if undrilled.

When a shear nut is used with the threaded taper pin and washer, the nut is secured with a cotter pin.

Both the plain and threaded taper pins have a taper of 1 in 48 and are used in various locations during aircraft construction.

They are designed to carry shear loads and are manufactured from high-tensile steel.

The pins do not allow any loose motion or play and are used for joining tubes and attaching collars to shafts.

The plain taper pin is forced into the hole, which is reamed to the specified size with a Taper Pin Reamer, and is held in place by friction alone. To ensure security, it can also be wire locked in place, by passing the lock wire through the pre-drilled hole in the pin then securing the wire around the shaft.

Plain taper pins, which have no lock wire holes, may have their smaller ends peened, after being installed, to secure them in their holes.

Some taper pins can be found with a split small end, which can be spread much like a split pin, to prevent it loosening. These pins are sometimes referred to as bifurcated taper pins.

All taper pins are measured by the diameter of their small end and their overall length.

## Lock Plates

In certain circumstances, the torque applied, the thread, or the type of nut, being used may not guarantee that the nut would not unwind in use (such as during vibration). Lock plates (refer to figure 5.39) are used where positive retention of a nut is required.

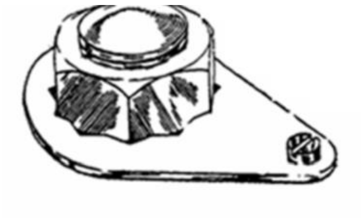


Figure 5.39: A typical lock plate

The nut is torque loaded and then (only if necessary) turned a small amount, (< 1/12 revolution) until its flats to align with the hole in the lock plate.

The plate usually has 12 faces to allow for this adjustment.

The plate is then placed over the nut and the small setscrew fastened into the tapped hole adjacent to the nut. Removal of the nut simply involves removing the setscrew, lifting off the plate and unwinding the nut.

Note: A Tab washer could be used to do the same task. The lock plate is used where the nut is frequently removed – the plate can be used indefinitely providing it retains a good fit with the nut.

## Split (Cotter) Pins

These pins (refer to figure 5.40) are usually manufactured from either cadmium-plated carbon steel or from corrosion-resistant steel.

Their primary purpose is to lock slotted and castellated nuts as well as for securing clevis pins.

The nuts are locked onto their bolts by passing the pin through the hole in the bolt and the nut castellation.

The legs of the pin are spread in one of two methods.

Whilst either of these methods will secure the nut to the bolt, different airworthiness authorities prefer one method to the other.

The pins are measured by diameter and length. It must be noted that the nuts must never be over-torqued to get the holes into line. The nut must either be backed-off, if this is permitted, or washers added under the nut.

Often a stated torque value will be over a small range rather than a set figure. This allows very small movement of the nut to facilitate alignment of the locking pins. Details of the correct method for each task will be in the AMM.

## Locking Wire

Wire-locking (or 'Safetying' as it is known in the USA), is the commonest form of locking in use throughout the aircraft industry. The wire is usually made of corrosion-resistant steel or heatresistant nickel alloy. Fine copper wire is also used for some special locking operate.

The wire is normally classified by its diameter in increments of 'Standard Wire Gauge' (SWG) or 'American Wire Gauge' (AWG).

The most usual gauge used is 22 SWG

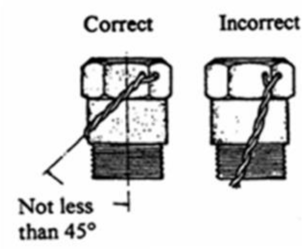
Wire-locking is a positive method of securing items such as bolts, pipe unions, turnbuckles and nuts

Components designed to be wire-locked have holes in the appropriate positions to enable the lock wire to pass through.

When installing the wire it should not span a distance of more than 75 mm (3 in) without being supported.

There should be approximately eight turns to every 25.4 mm (1 in) length of wire and no length of more than 9.5 mm (3/8 in) should be left untwisted.

to the  The angle of pull, or approach (refer to figure 5.41), should be not less than 45 rotational axis.

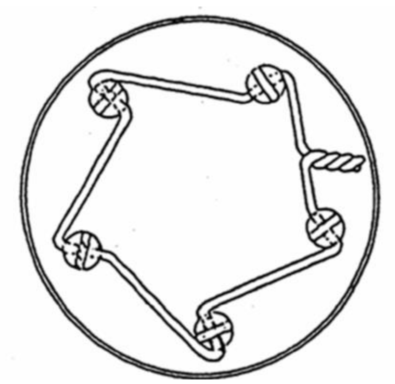



When the wire has been passed through the last hole, the wire must be pulled tight and the twisting continued for at least 12 mm – 13 mm (½ in).

The wire is then cut and the end doubled under, to prevent personnel getting 'snagged' or badly cut.

Some forms of wire-locking are done with a single strand of the specified wire, especially in cases of where a complete ring or similar formation of nuts is found (refer to figure 5.42). The wire is passed in sequence, through the holes in their respective nuts and bolts (or screws), until the wire ends meet.

Again the wire must be threaded so that any tendency, of a nut or bolt, to attempt to slacken off, will add tension to the wire.



There are a number of different types of wire-locking used on turnbuckles and the AMM must be consulted to find which method is specified. Methods used include the single wrap and single wrap spiral as well as the double wrap and double wrap spiral.

The single wrap and single wrap spiral use a single strand of the appropriate wire that passes through the hole in the centre of the turnbuckle, finishing up wrapped around each end.

The single wrap spiral also uses a single piece of wire that is spiralled around the turnbuckle barrel and passed through the centre hole twice

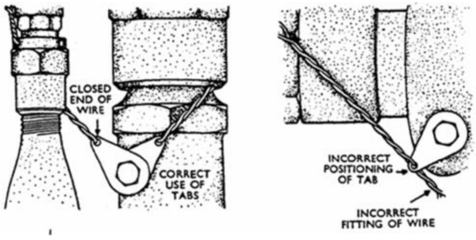
Two pieces of wire are used in the double wrap method, which are basically two single wraps, one in each direction.

A double wrap spiral consists of two single wrap spirals, again one in each direction.

## Use of Locking Wire with Locking Tabs.

When locking tabs are used, they should be installed in such a way that the tabs and the wire are in complete alignment (refer to figure 5.43).

Whenever possible, the closed end of the wire should be in the tab and the twisted end at the component to be locked, although the exact method may be found in the AMM.




## Thin Copper Wire

Thin copper wire is used to hold some switches and levers in a ‘set’ position and, thus, prevents the accidental operation of those switches which control certain critical systems such as emergency circuits.

When the switch is required to be operated, then a deliberate movement is made, which will break the copper wire and permit movement of the switch.

A secondary purpose of copper wire is as an indicator or ‘witness’, where a broken wire indicates that the switch or control has been operated.

This method is employed on systems where it is necessary to know when a system has been operated (such as in a Fire Protection system).

## Quick-Release Fasteners

Special fasteners have been designed to hold fairings, cowlings and inspection panels in position and to allow their rapid removal and replacement during servicing.

## Dzus Fastener

DZUS fasteners are available in two types. A light-duty type is used on box -covers, access hole covers, and lightweight fairings.

The heavy-duty type is used on cowling and heavy fairings.

The main difference between the two Dzus fasteners is a grommet, which is only used on stud assembly. See figure 5.44. The receptacle is an aluminium alloy forging mounted in a stamped sheet metal base.

The receptacle assembly is riveted to the access door frame, which is attached to the structure of the aircraft.

The grommet is a sheet metal ring held in the access panel with the retaining ring. Grommets are furnished in two types:

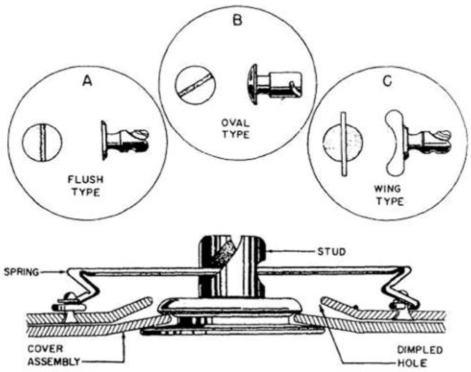
the flush type

the protruding type.

Besides serving as a grommet for the hole in the access panel, it also holds the stud assembly.

The stud assembly consists of a stud, a cross pin, a spring, and a spring cup.

Once installed in the grommet, the stud assembly cannot be removed unless the spring is again compressed.




## Oddie Fasteners

Oddie fasteners (refer to figure 5.45) have a central stud, which is held in position in the panel with a rubber washer or a coiled spring.

A two-legged clip is fastened to the fixed component (usually with rivets).

The stud is bullet-shaped and has two recesses opposite each other at the joint end.

The fastener is locked by positioning the recess in line with the legs of the spring, and then pressing the stud home. This is achieved by ensuring the screwdriver slot is in line with marks on the panel.

There should be a definite click as the fastener engages. A quarter turn of the stud will release it from the spring, and free the panel.

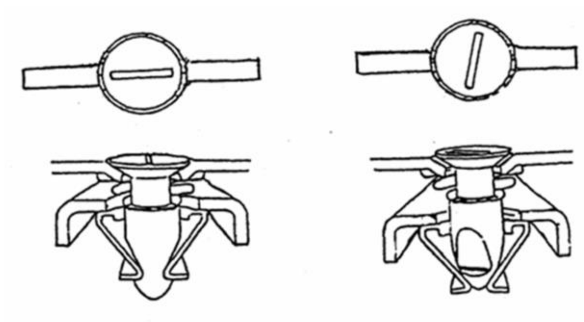


Figure 5.45: Oddie fastener

## Camloc Fasteners

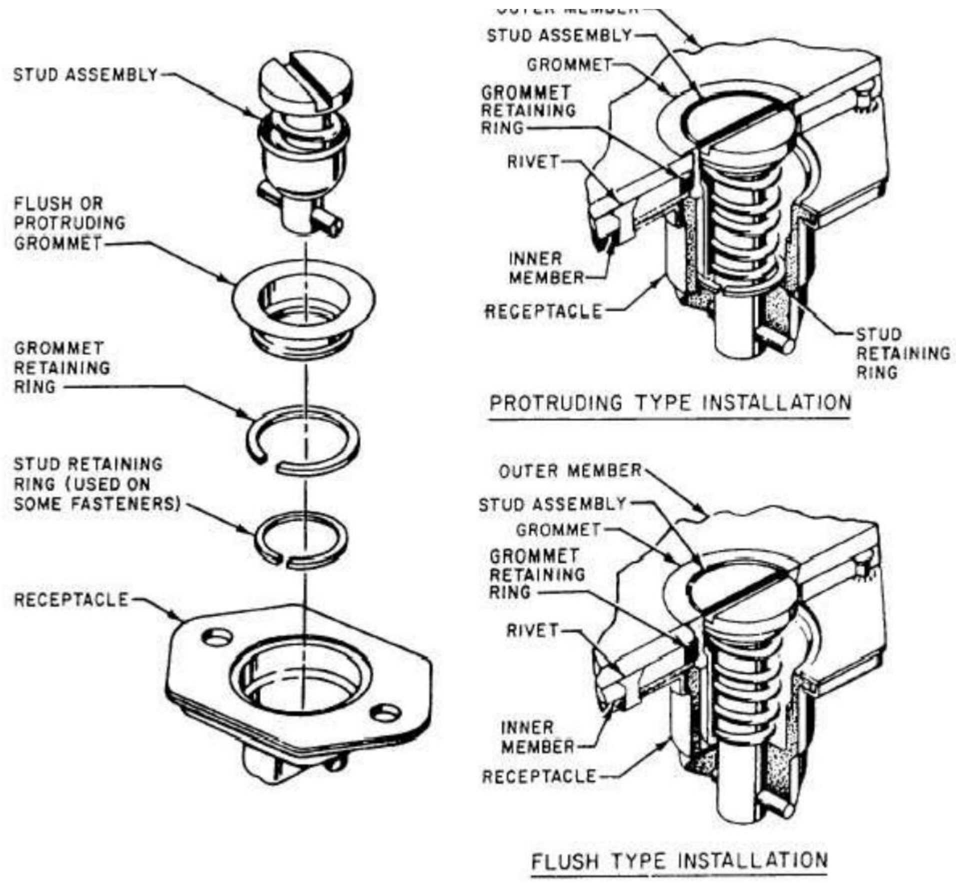
Camloc fasteners (refer to figure 5.46) consist of a spring-loaded stud assembly and a receptacle.

The stud assembly is fastened to the removable panel whilst the receptacle is fastened to the airframe.

To lock the fastener, the stud is pushed against its spring with a screwdriver and given a quarter of a turn clock-wise.

As a result, the cross-pin, on the stud, rides up a cam in the receptacle and draws the two components together.

Finally the stud spring pulls the cross pin into a locking groove at the end of the cam. The fastener is unlocked by a quarter turn anti-clockwise when the stud spring causes the stud to snap outwards.




Airloc Fasteners Airloc fasteners (refer to figure 5.47) consist of a stud with a cross-pin in the removable cowling or door, and a sheet spring-steel receptacle in the structure.

The fastener is locked by turning the stud through a quarter turn. The pin drops into an indentation in the receptacle and holds the fastener locked.

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