CHAPTER 5

AIRCRAFT HARDWARE

INTRODUCTION

The importance of aircraft hardware is often overlooked because of the small size of most items. However, the safe and efficient operation of any aircraft depends upon the correct selection and use of aircraft hardware. This chapter discusses the various types of threaded fasteners, quick-release fasteners, rivets, electrical hardware, and other miscellaneous hardware. You must make sure that items of aircraft hardware remain tightly secured in the aircraft. Therefore, we will discuss proper safetying methods in this chapter.

Aircraft hardware is identified for use by its specification number or trade name. Threaded fasteners and rivets are identified by Air Force-Navy (AN), National Aircraft Standard (NAS), and Military Standard (MS) numbers. Quick-release fasteners are identified by factory trade names and size designations.

When aircraft hardware is ordered from supply, the specification numbers and the factory part numbers are changed into stock numbers (SN). This change is identified by using a part-number cross-reference index.

Q5-1. How is aircraft hardware identified for use?

THREADED FASTENERS

LEARNING OBJECTIVE: Identify common types of threaded fasteners and the methods used to properly install and safety them.

In modern aircraft construction, thousands of rivets are used, but many parts require frequent dismantling or replacement. It is more practical for you to use some form of threaded fastener. Some joints require greater strength and rigidity than can be provided by riveting. We use various types of bolts, screws, and nuts to solve this problem.

Bolts and screws are similar in that both have a head at one end and a screw thread at the other. However, there are several differences between them. The threaded end of a bolt is always relatively blunt. A screw may be either blunt or pointed. The threaded end of a bolt must be screwed into a nut. The threaded end of the screw may fit into a nut or directly into the material being secured. A bolt has a fairly short threaded section and a comparatively long grip length (the unthreaded part). A screw may have a longer threaded section and no clearly defined grip length. A bolt assembly is generally tightened by turning a nut. The bolt head may or may not be designed to be turned. A screw is always designed to be turned by its head. Another minor difference between a screw and a bolt is that a screw is usually made of lower strength materials.

Threads on aircraft bolts and screws are of the American National Aircraft Standard type. This standard contains two series of threads—national coarse (NC) and national fine (NF). Most aircraft threads are of the NF series.

Bolts and screws may have right- or left-hand threads. A right-hand thread advances into engagement when turned clockwise. A left-hand thread advances into engagement when turned counterclockwise.

AIRCRAFT BOLTS

Many types of bolts are used in modern aircraft, and each type is used to fasten something in place. Before discussing some of these types, it might be helpful if we list and explain some commonly used bolt terms. You should know the names of bolt parts and be aware of the bolt dimensions that must be considered in selecting a bolt.

The three principal parts of a bolt are the *head*, *grip*, and *threads*, as shown in figure 5-1. Two of these parts might be well known to you, but perhaps grip is an unfamiliar term. The grip is the unthreaded part of the bolt shaft. It extends from the threads to the bottom of the bolt head. The head is the larger diameter of the bolt and may be one of many shapes or designs.

To choose the correct replacement for an unserviceable bolt, you must consider the length of the bolt. As shown in figure 5-1, the bolt length is the distance from the tip of the threaded end to the head of the bolt. Correct length selection is indicated when the bolt extends through the nut at least two full threads. See figure 5-2. If the bolt is too short, it will not extend out of the bolt hole far enough for the nut to be securely fastened. If it is too long, it may extend so far that it interferes with the movement of nearby parts.

In addition, if a bolt is too long or too short, its grip will usually be the wrong length. As shown in figure 5-2, the grip length should be approximately the same as the thickness of the material to be fastened. If the grip is too short, the threads of the bolt will extend into the bolt hole. The bolt may act like a reamer when the material is vibrating. To prevent this, make certain that no more than two threads extend into the bolt hole. Also, make certain that any threads that enter the bolt hole extend only into the thicker member that is being fastened. If the grip is too long, the nut will run out of threads before it can be tightened. In this event, a bolt with a shorter grip should be used. If the bolt grip extends only a short distance through the hole, a washer may be used.

A second bolt dimension that must be considered is diameter. As shown in figure 5-1, the diameter of the bolt is the thickness of its shaft.

The results of using a wrong diameter bolt should be obvious. If the bolt is too big, it cannot enter the bolt hole. If the diameter is too small, the bolt has too much play in the bolt hole.

The third and fourth bolt dimensions that should be considered when you choose a bolt replacement are head thickness and width. If the head is too thin or too narrow, it might not be strong enough to bear the load imposed on it. If the head is too thick or too wide, it might extend so far that it interferes with the movement of adjacent parts.

AN bolts come in three head styles—hex head, clevis, and eyebolt. NAS bolts are available in

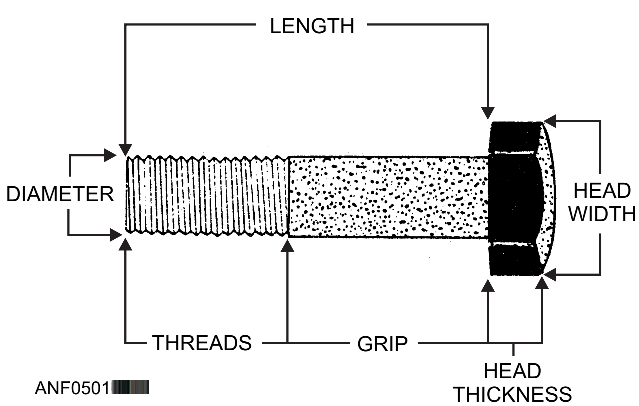

Figure 5-1.—Bolt terms and dimensions.

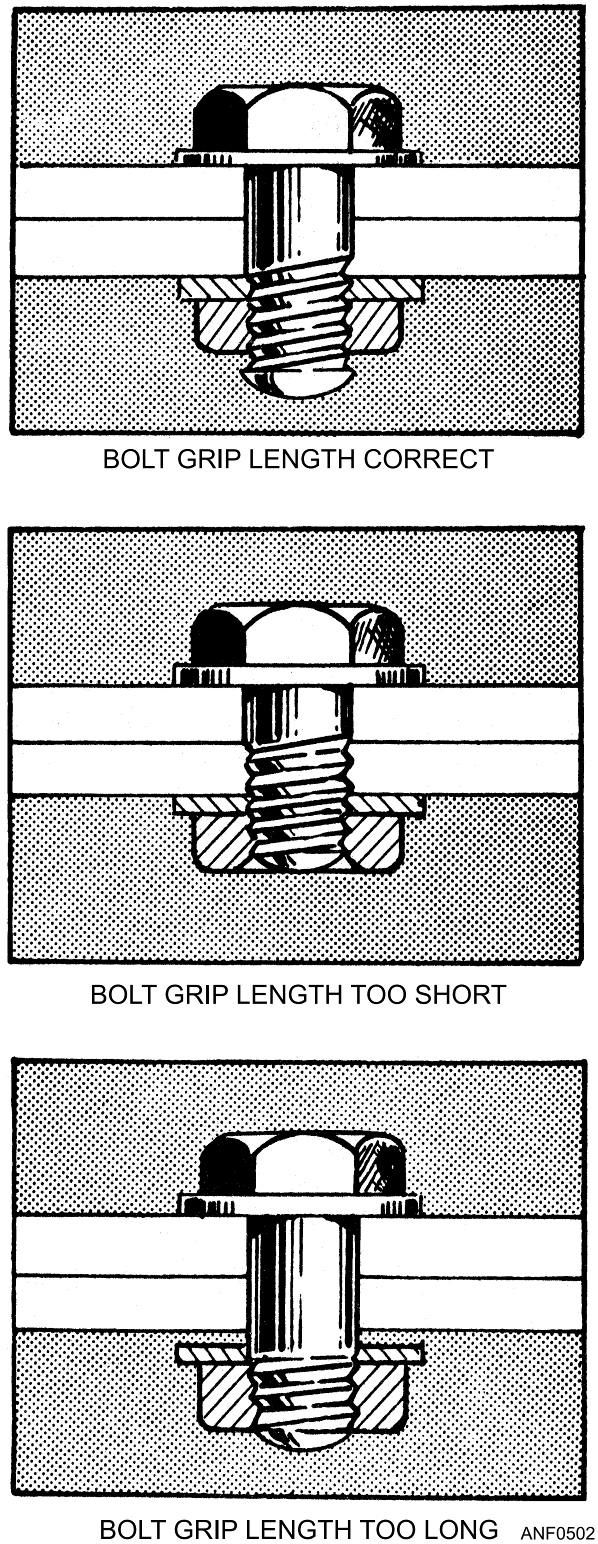

Figure 5-2.—Correct and incorrect grip lengths.

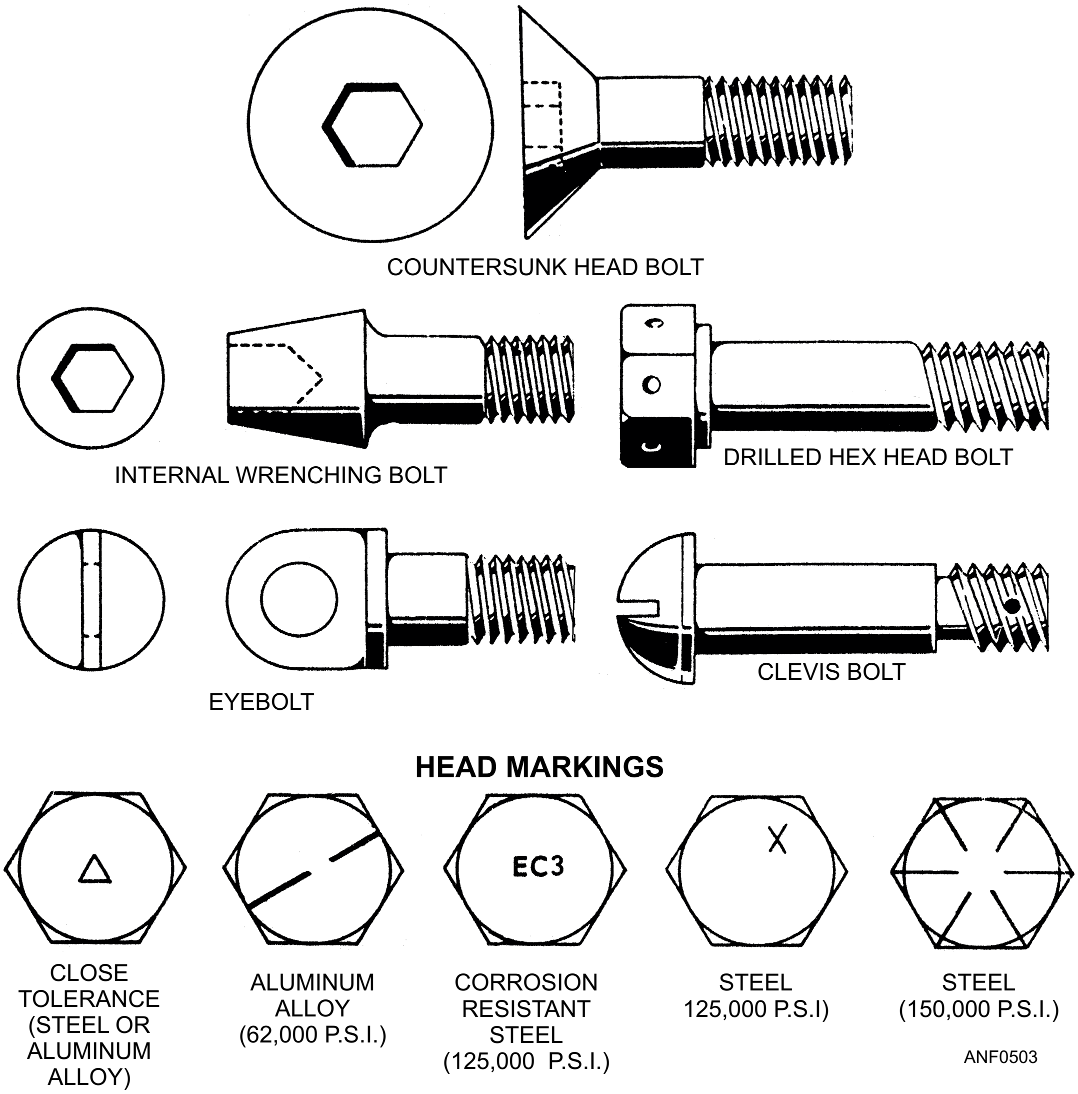

Figure 5-3.—Types of bolts and bolt head markings.

countersunk, internal wrenching, and hex head styles. MS bolts come in internal wrenching and hex head styles. Head markings indicate the material of which standard bolts are made. Head markings may indicate if the bolt is classified as a close-tolerance bolt. See figure 5-3. Additional information, such as bolt diameter, bolt length, and grip length, may be obtained from the bolt part number.

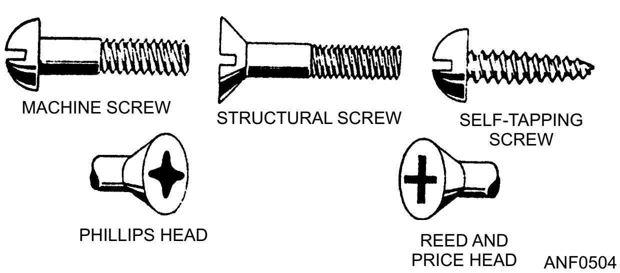

Figure 5-4.—Screws.

SCREWS

The most common threaded fastener used in aircraft construction is the screw. The three most used types are the machine screw, structural screw, and the self-tapping screw, as shown in figure 5-4. Figure 5-4 also shows the three head slots—straight, Phillips, and Reed and Prince.

Structural Screws

Structural screws are used for assembly of structural parts, as are structural bolts. They are made of alloy steel and are properly 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 countersunk head, round head, and brazier head types. See figure 5-5.

Machine Screws

The commonly used machine screws are the round head, flat head, fillister head, pan head, truss head, and socket head types.

Self-Tapping Screws

A self-tapping screw is one that cuts its own internal threads as it is turned into the hole. Self-tapping screws may be used only in comparatively soft metals and materials. Self-tapping screws may be further divided into two classes or groups—machine self-tapping screws and sheet metal self-tapping screws.

Machine self-tapping screws are usually used for attaching removable parts, such as nameplates, to castings. The threads of the screw cut mating threads in the casting after a hole has been predrilled undersize. Sheet metal self-tapping screws are used for such purposes as temporarily attaching sheet metal in place for riveting. Sheet metal self-tapping screws may be used to permanently assemble nonstructural units where it is necessary to insert screws in difficult to get to areas.

> **CAUTION**
>
> Self-tapping screws should never be used to replace standard screws, nuts, or rivets originally used in the structure.

Setscrews

Setscrews are used to position and hold components in place, such as gears on a shaft. Setscrews are available with many different point styles. They are classified as hexagon-socket and fluted-socket headless setscrews.

NUTS

Aircraft nuts may be divided into two general groups—nonself-locking and self-locking nuts. Nonself-locking nuts are those that must be safetied by external locking devices, such as cotter pins, safety wire, or locknuts. The locking feature is an integral part of self-locking nuts.

Nonself-locking Nuts

The most common of the nonself-locking nuts are the castle nut, the plain hex nut, the castellated shear nut, and the wing nut. Figure 5-6 shows these nonself-locking nuts.

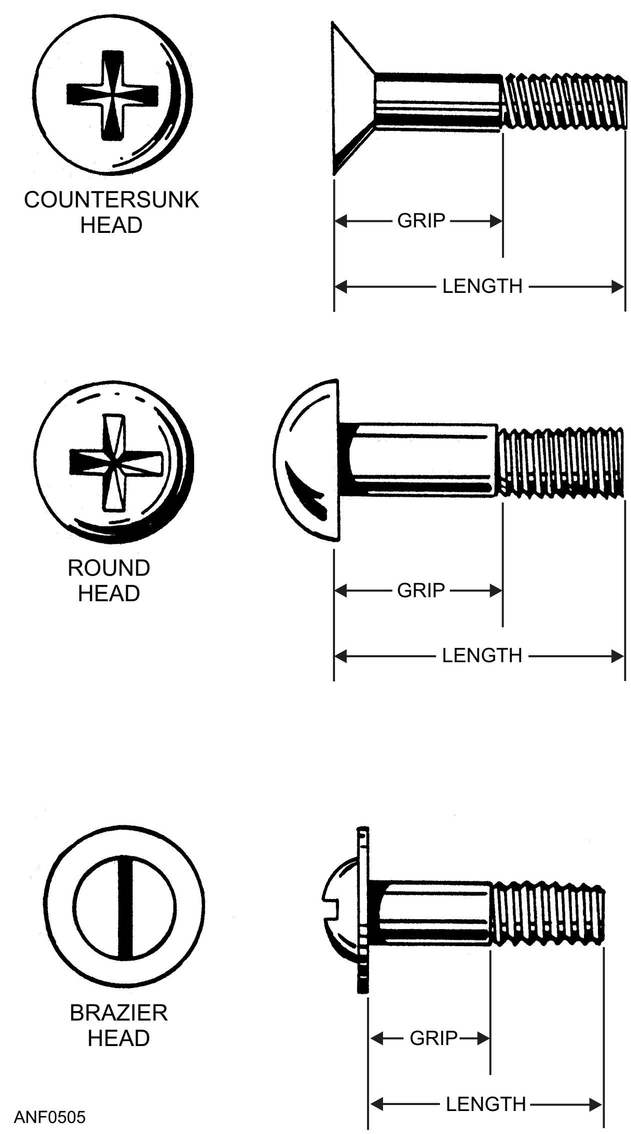

Figure 5-5.—Structural screws.

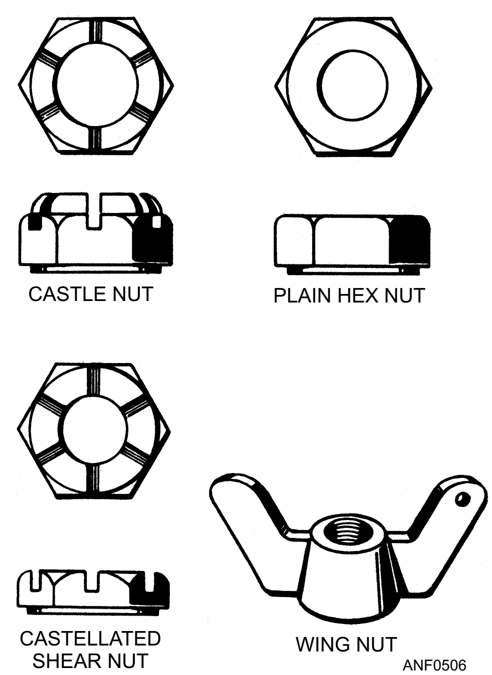

Figure 6-6.—Nonself-locking nuts.

Castle nuts are used with drilled-shank AN hex-head bolts, clevis bolts, or studs. They are designed to accept a cotter pin or lockwire for safetying.

Castellated shear nuts are used on such parts as drilled clevis bolts and threaded taper pins. They are normally subjected to shearing stress only. They must not be used in installations where tension stresses are encountered.

Plain hex nuts have limited use on aircraft structures. They require an auxiliary locking device such as a check nut or a lock washer.

Wing nuts are used where the desired tightness can be obtained by the fingers and where the assembly is frequently removed. Wing nuts are commonly used on battery connections.

Self-Locking Nuts

Self-locking nuts provide tight connections that will not loosen under vibrations. Self-locking nuts approved for use on aircraft meet critical specifications as to strength, corrosion resistance, and heat-resistant temperatures. New self-locking nuts must be used each time components are installed in critical areas throughout the entire aircraft. Self-locking nuts are found on all flight, engine, and fuel control linkage and attachments. There are two general types of self-locking nuts. They are the all-metal nuts and the metal nuts with a nonmetallic insert to provide the locking action. The Boots aircraft nut and the Flexloc nut are examples of the all-metal type. See figure 5-7. The elastic stop and the nonmetallic insert lock nut are examples of the nonmetallic insert type. All-metal self-locking nuts are constructed either of two ways. The threads in the load-carrying portion of the nut that is out of phase with the threads in the locking portion is one way. The second way is with a saw-cut top portion with a pinched-in thread. The locking action of these types depends upon the resiliency of the metal.

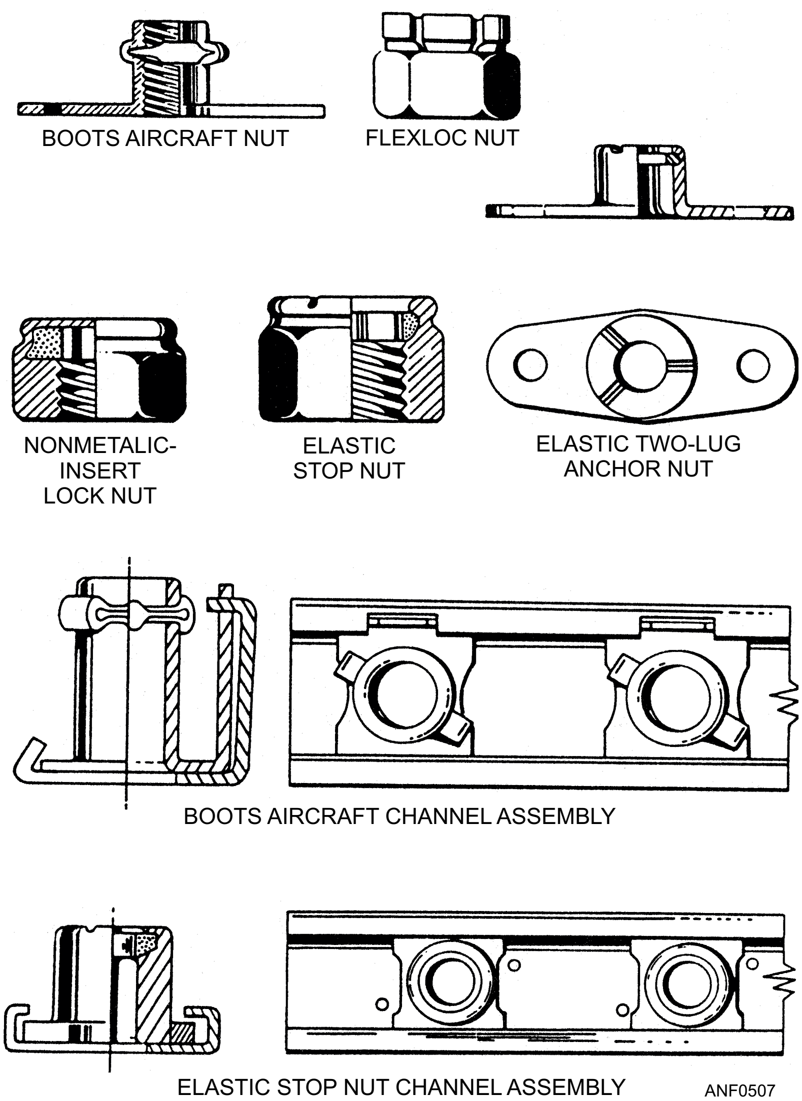

Figure 5-7.—Self-locking nuts.

The elastic stop nut is constructed with a nonmetallic (nylon) insert, which is designed to lock the nut in place. The insert is unthreaded and has a smaller diameter than the inside diameter of the nut.

Self-locking nuts are generally suitable for reuse in noncritical applications provided the threads have not been damaged. If the locking material has not been damaged or permanently distorted, it can be reused.

NOTE: If any doubt exists about the condition of a nut, use a new one!

When you anchor lightweight parts, the sheet spring nut may be used. See figure 5-8. Applications include supporting line clamps, electrical equipment, and small access doors. It is made of sheet spring steel and is cut so as to have two flaps. The ends of these flaps are notched to form a hole that is somewhat smaller in diameter than the screw used. The sheet spring nut has a definite arch that tends to flatten out as the screw pulls the flaps in toward the threads. This flattening action forces the flaps of the nut tightly into the threads of the screw. The springiness of the sheet spring nut pushes upward on the screw threads, binding them and locking the screw in place. With the sheet spring nut, either a standard or a sheet metal self-tapping screw is used.

INSTALLATION OF NUTS AND BOLTS

You must be certain that each bolt is made of the correct material. Examine the markings on the head to determine whether a bolt is steel or aluminum alloy.

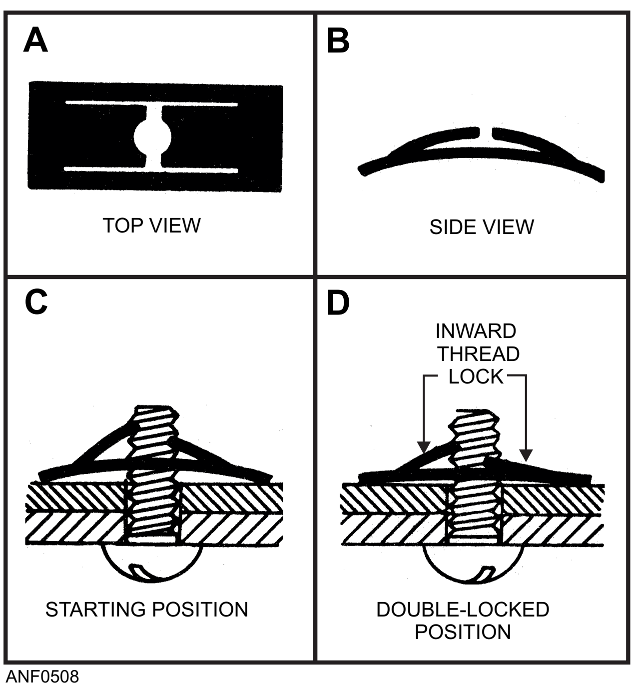

Figure 5-8.—Sheet spring nut.

It is of extreme importance to use like bolts in replacement. In every case, refer to the applicable maintenance instruction manual and illustrated parts breakdown.

Be sure that washers are used under the heads of both bolts and nuts unless their omission is specified. A washer guards against mechanical damage to the material being bolted and prevents corrosion of the structural members. An aluminum alloy washer may be used under the head and nut of a steel bolt securing aluminum alloy or magnesium alloy members. Corrosion will attack the washer rather than the members. Steel washers should be used when joining steel members with steel bolts.

Whenever possible, the bolt should be placed with the head on top or in the forward position. This positioning helps prevent the bolt from slipping out if the nut is accidentally lost.

Make sure that the bolt grip length is correct. Generally speaking, the grip length should equal the thickness of the material being bolted together. Not more than one thread should bear on the material, and the shank should not protrude too far through the nut. Figure 5-2 shows examples of correct and incorrect grip length.

Application of Torque

Torque is the amount of twisting force applied when you are tightening a nut. If torque values are specified in the appropriate manual, a torque wrench must be used. Regardless of whether torque values are specified or not, all nuts in a particular installation must be tightened a like amount. This permits each bolt in a group to carry its share of the load. It is a good practice to use a torque wrench in all applications.

Safetying of Nuts and Bolts

It is very important that all nuts except the self-locking type be safetied after installation. This prevents nuts from loosening in flight because of vibration. Methods of safetying are discussed later in this chapter.

Q5-2. What are the three principal parts of a bolt?

Q5-3. What are the three most commonly used screws in aircraft construction?

Q5-4. What general group of aircraft nuts require an external locking device, such as cotter pins, safety wire, or locknuts?

Q5-5. What is the purpose of placing a washer under the head of a bolt?

TURNLOCK FASTENERS

LEARNING OBJECTIVE: Recognize the three common types of turnlock fasteners (quick-action panel fasteners) and how they operate.

Turnlock fasteners are used to secure plates, doors, and panels that require frequent removal for inspection and servicing. Turnlock fasteners are also referred to as quick-action panel fasteners. These fasteners are available in several different styles and are usually referred to by the manufacturer's trade name. Some of the most common are the Camloc, Airloc, and Dzus.

CAMLOC FASTENERS

The Camloc 4002 series fastener consists of four principal parts—receptacle, grommet, retaining ring, and stud assembly. See figure 5-9. The receptacle consists of an aluminum 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 by the retaining ring. Grommets are available in two types—the flush type and the protruding type. In addition to serving as the grommet for the hole in the access panel, it also holds the stud assembly. The stud assembly consists of a stud, cross pin, spring, and spring cup. The assembly is designed so that it can be quickly inserted into the grommet by compression of the spring. Once installed in the grommet, the stud assembly cannot be removed unless the spring is again compressed.

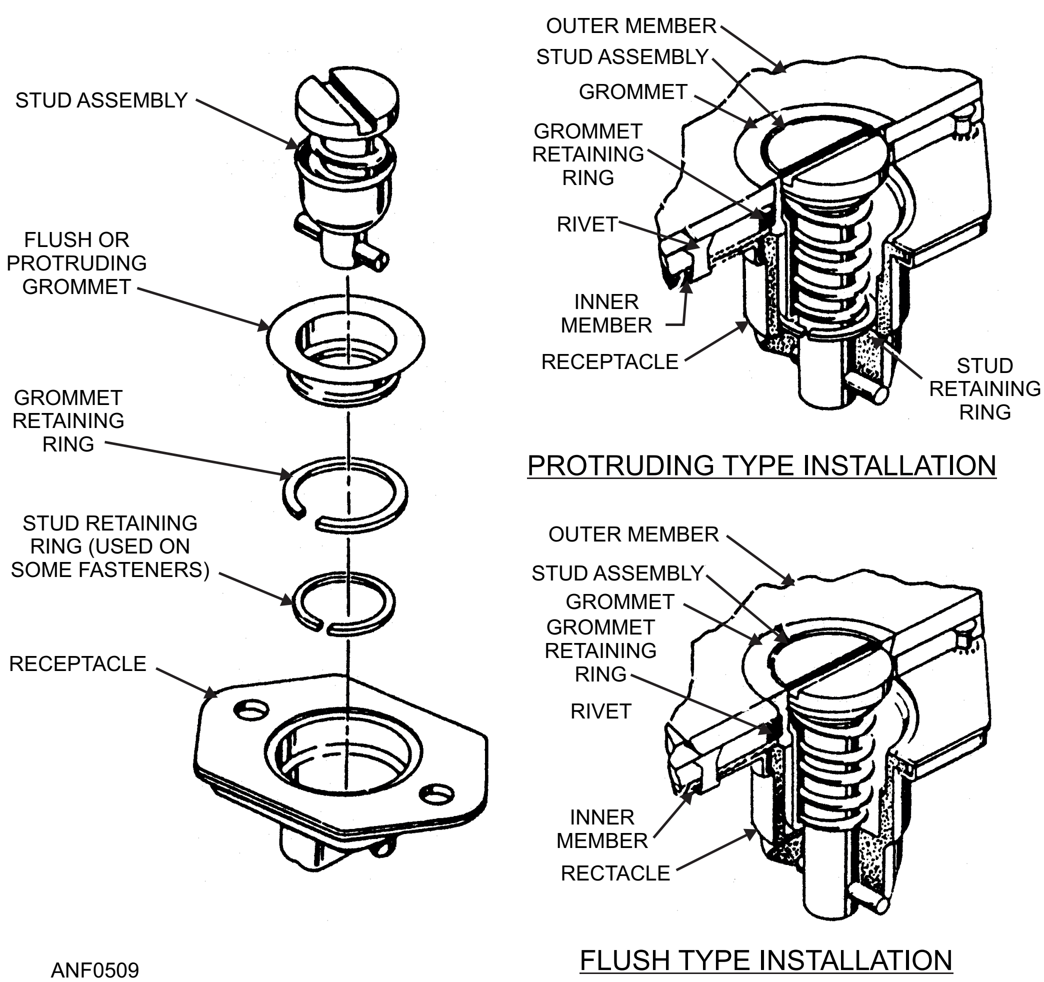

Figure 5-9.—Camloc 4002 series fastener.

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The Camloc high-stress panel fastener, shown in figure 5-10, is a high-strength, quick-release, rotary-type fastener. It may be used on flat or curved, inside or outside panels. The fastener may have either a flush or protruding stud. The studs are held in the panel with flat or cone-shaped washers. The latter being used with flush fasteners in dimpled holes. This fastener may be distinguished from screws by the deep No. 2 Phillips recess in the stud head and by the bushing in which the stud is installed.

AIRLOCK FASTENERS

Figure 5-11 shows the parts that make up an Airloc fastener. Similar to the Camloc fastener, the Airloc fastener consists of a receptacle, stud, and cross pin. The stud is attached to the access panel and is held in place by the cross pin. The receptacle is riveted to the access panel frame.

Two types of Airloc receptacles are available—the fixed type (view A) and the floating type (view B). The floating type makes for easier alignment of the stud in the receptacle. Several types of studs are also available. In each instance the stud and cross pin come as separate units so that the stud may be easily installed in the access panel.

DZUS FASTENERS

Dzus fasteners are available in two types. One is the light-duty type, used on box covers, access hole covers, and lightweight fairing. The second is the heavy-duty type, which is used on cowling and heavy fairing. The main difference between the two types of Dzus fasteners is a grommet, used with the heavy-duty fasteners. Otherwise their construction features are about the same.

Figure 5-12 shows the parts making up a light-duty Dzus fastener. Notice that they include a spring and a stud. The spring is made of cadmium-plated steel music wire and is usually riveted to an aircraft structural member. The stud comes in a number of designs (as shown in views A, B, and C) and mounts in a dimpled hole in the cover assembly.

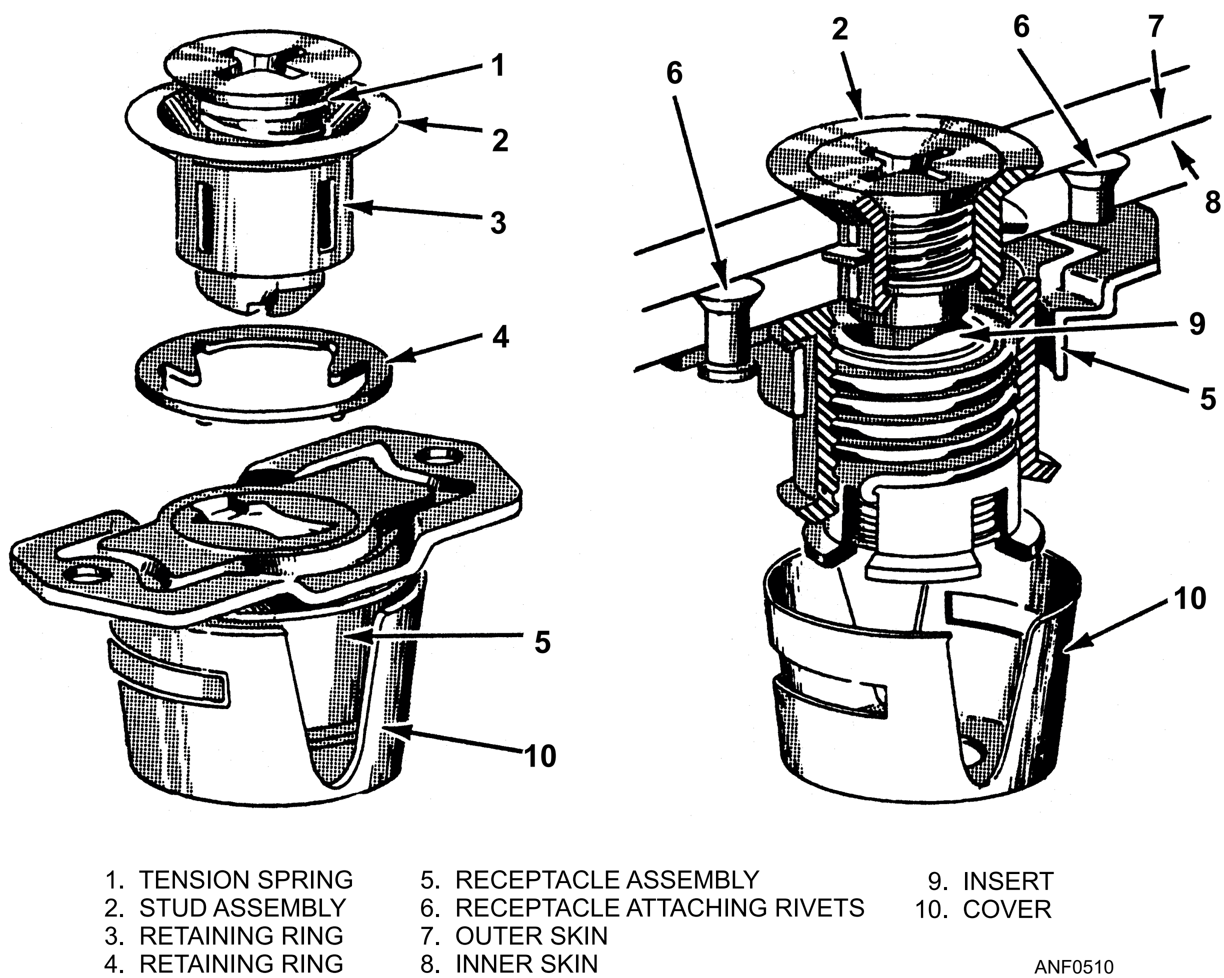

Figure 5-10.—Camloc high-stress panel fastener.

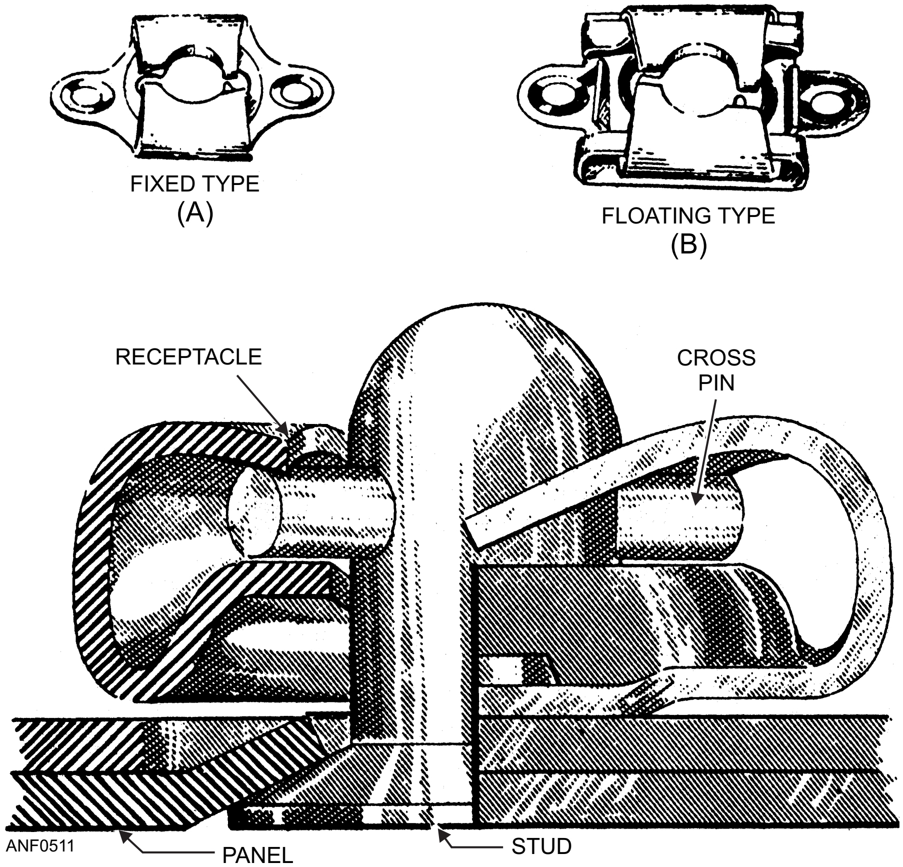

Figure 5-11.—Airloc fastener.

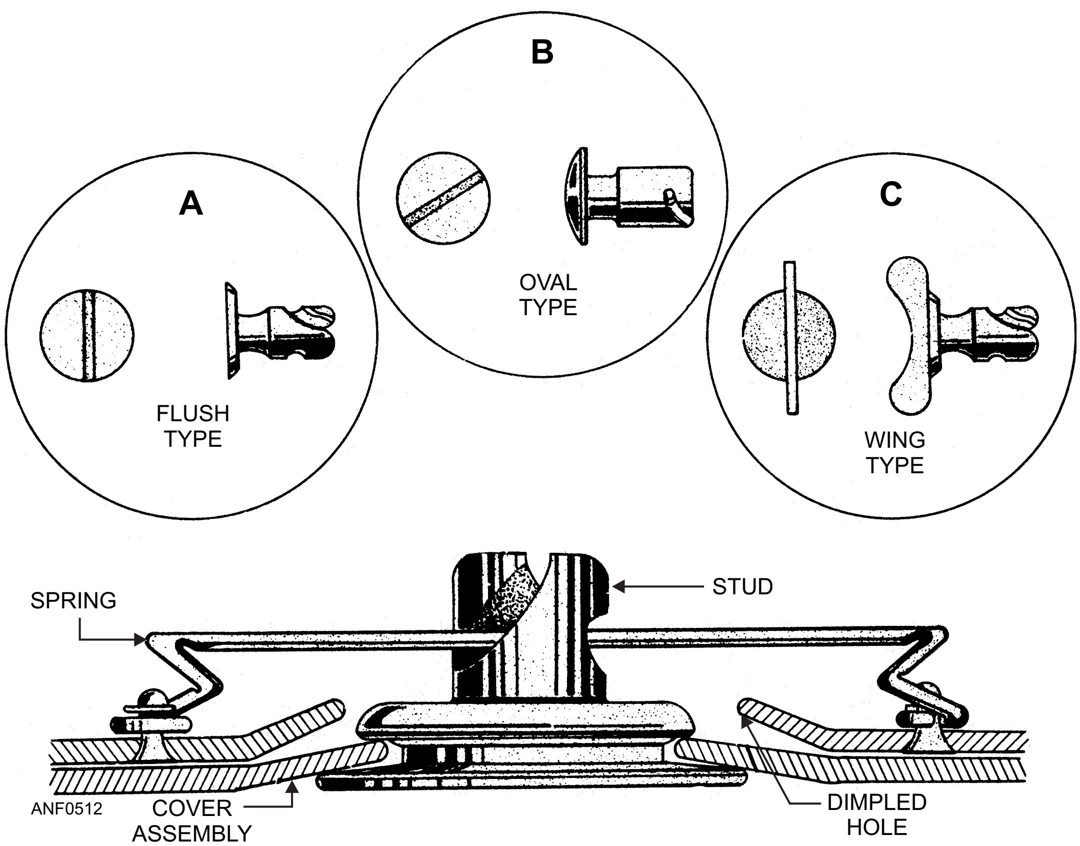

Figure 5-12.—Dzus fastener.

Position the panel or plate on the aircraft before securing it in place. The spring riveted to the structural member enters the hollow center of the stud, which is retained in the plate or panel. Then, when the stud is turned about one-fourth turn, the curved jaws of the stud slip over the spring and compress it. The resulting tension locks the stud in place, thereby securing the panel or plate.

Q5-6. What are the three most common types of turnlock fasteners?

RIVETS

LEARNING OBJECTIVE: Identify the solid rivets, blind rivets, and rivnuts commonly used in aircraft construction.

There are hundreds of thousands of rivets in the airframe of a modern aircraft. This is an indication of how important rivets are in the construction of aircraft. A glance at any aircraft will disclose the thousands of rivets in the outer skin alone. In addition to being used in the skin, rivets are used in joining spar and rib sections. They are also used for securing fittings to various parts of the aircraft, and for fastening bracing members and other parts together. Rivets that are satisfactory for one part of the aircraft are often unsatisfactory for another part.

Two of the major types of rivets used in aircraft construction are the solid rivet and the blind rivet. The solid rivet must be driven with a bucking bar. The blind rivet is installed when a bucking bar cannot be used.

SOLID RIVETS

Solid rivets are classified by their head shape, size, and the material from which they are manufactured. Rivet head shapes and their identifying code numbers are shown in figure 5-13. The prefix MS identifies hardware under the control of the Department of Defense and that the item conforms to military standards. The prefix AN identifies specifications that are developed and issued under joint authority of the Air Force and the Navy. Solid rivets have five different head shapes. They are the round head, flat head, countersunk head, brazier head, and universal head rivets.

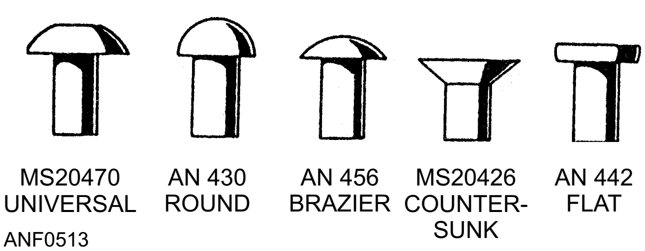

Figure 5-13.—Rivet head shapes and code numbers.

Round Head Rivets

Round head rivets are used on internal structures where strength is the major factor and streamlining is not important.

Flat Head Rivets

Flat head rivets, like round head rivets, are used in the assembly of internal structures where maximum strength is required. They are used where interference of nearby members does not permit the use of round head rivets.

Countersunk Head Rivets

Countersunk head rivets, often referred to as flush rivets, are used where streamlining is important. On combat aircraft practically all external surfaces are flush riveted. Countersunk head rivets are obtainable with heads having an inclined angle of 78 and 100 degrees. The 100-degree angle rivet is the most commonly used type.

Brazier Head Rivets

Brazier head rivets offer only slight resistance to the airflow and are used frequently on external surfaces, especially on noncombat-type aircraft.

Universal Head Rivets

Universal head rivets are similar to brazier head rivets. They should be used in place of all other protruding-head rivets when existing stocks are depleted.

BLIND RIVETS

There are many places on an aircraft where access to both sides of a riveted structural part is impossible. When attaching many nonstructural parts, the full strength of solid-shank rivets is not necessary and their use adds extra weight. For use in such places, rivets have been designed that can be formed from the outside. They are lighter than solid-shank rivets but are amply strong. Such rivets are referred to as blind rivets

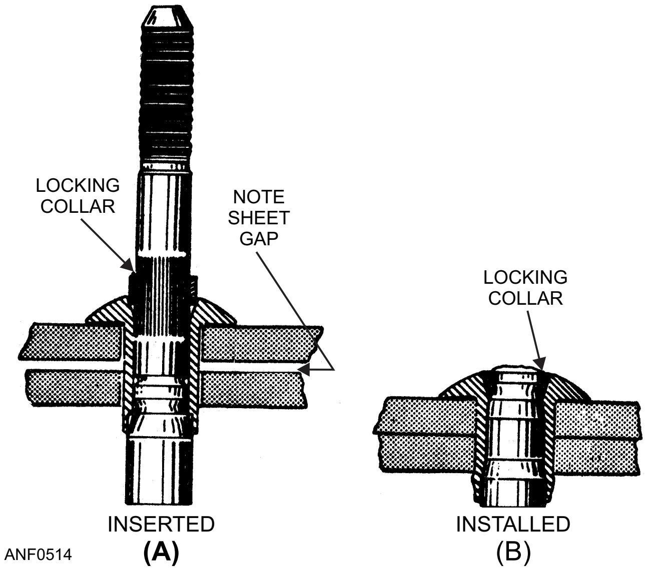

Figure 5-14.—Self-plugging rivet (mechanical lock).

or self-plugging because of the self-heading feature. Figure 5-14 shows a general type of blind rivet.

RIVNUTS

The rivnut is a hollow aluminum rivet that is counterbored and threaded on the inside. The rivet is installed with the aid of a special tool. Rivnuts are used primarily as a nut plate. They may be used as rivets in secondary structures such as instruments, brackets, and soundproofing materials. After rivnuts are installed, accessories can be fastened in place with screws.

Rivnuts are manufactured in two head styles, countersunk and flat, and in two shank designs, open and closed ends. See figure 5-15.

Open-end rivnuts are the most widely used. They are preferred in place of the closed-end type. However, in sealed flotation or pressurized compartments, the closed-end rivnut **must** be used.

Further information concerning rivets may be found in the Structural Hardware Manual, NAVAIR 01-1A-8.

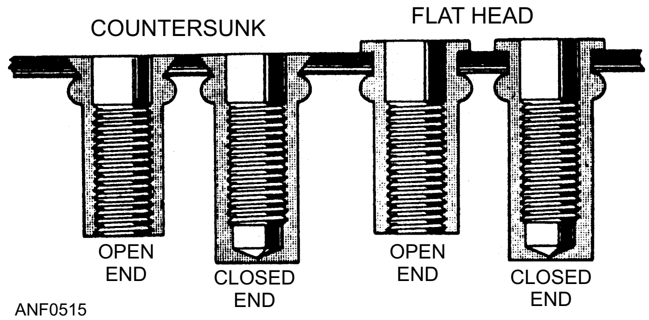

Figure 5-15.—Sectional view of rivnut showing head and end designs.

Q5-7. What are the two major types of rivets used in aircraft construction?

Q5-8. What type of rivets are used where streamlining is important?

MISCELLANEOUS FASTENERS

LEARNING OBJECTIVE: Recognize the miscellaneous fastener used to fasten special purpose units.

Some fasteners cannot be classified as rivets, turnlocks, or threaded fasteners. Included in this category are snap rings, turnbuckles, taper pins, flat head pins, and flexible connector/clamps.

SNAP RINGS

A snap ring is a ring of metal, either round or flat in cross section, that is tempered to have springlike action. This springlike action holds the snap ring firmly seated in a groove. The external types are designed to fit in a groove around the outside of a shaft or cylinder. The internal types fit in a groove inside a cylinder. A special type of pliers is made to install each type of snap ring. Snap rings may be reused as long as they retain their shape and springlike action.

TURNBUCKLES

A turnbuckle is a mechanical screw device consisting of two threaded terminals and a threaded barrel. Figure 5-16 shows a typical turnbuckle assembly.

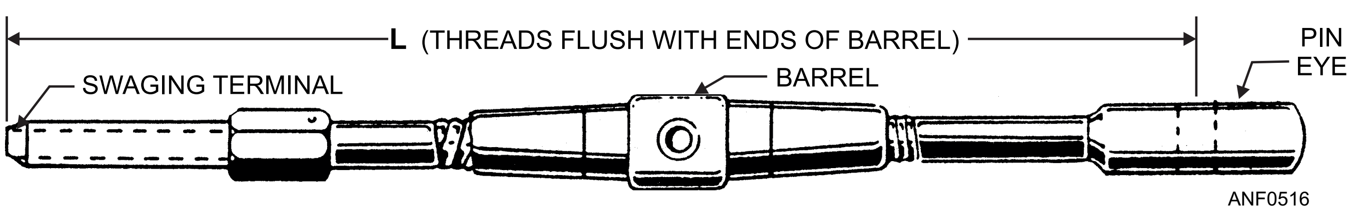

Figure 5-16.—Typical turnbuckle assembly.

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Turnbuckles are fitted in the cable assembly for the purpose of making minor adjustments in cable length and for adjusting cable tension. One of the terminals has right-hand threads and the other has left-hand threads. The barrel has matching right- and left-hand internal threads. The end of the barrel with the left-hand threads can usually be identified by a groove or knurl around that end.

When installing a turnbuckle in a control system, it is necessary to screw both of the terminals an equal number of turns into the barrel. It is also essential that you screw both turnbuckle terminals into the barrel until not more than three threads are exposed.

After you adjust a turnbuckle properly, it must be safetied. We will discuss the methods of safetying turnbuckles later in this chapter.

TAPER PINS

Taper pins are used in joints that carry shear loads and where the absence of clearance is essential. See figure 5-17. The threaded taper pin is used with a taper pin washer and a shear nut if the taper pin is drilled. Use a self-locking nut if the taper pin is undrilled. When a shear nut is used with the threaded taper pin and washer, the nut is secured with a cotter pin.

FLAT HEAD PINS

The flat head pin is used with tie-rod terminals or secondary controls, which do not operate continuously. The flat head pin should be secured with a cotter pin. The pin is normally installed with the head up. See figure 5-17, view C. This precaution is taken to maintain the flat head pin in the installed position in case of cotter pin failure.

FLEXIBLE CONNECTORS/CLAMPS

Some of the most commonly used clamps are shown in figure 5-18. When installing a hose between two duct sections, the gap between the duct ends should be one-eighth inch minimum to three-fourths inch maximum. When you install the clamps on the connection, the clamp should be one-fourth inch minimum from the end of the connector. Misalignment between the ducting ends should not exceed one-eighth inch maximum.

Marman type clamps, commonly used in ducting systems, should be tightened to the torque value indicated on the coupling. Use the torque value as specified on the clamp or in the applicable maintenance instruction manual.

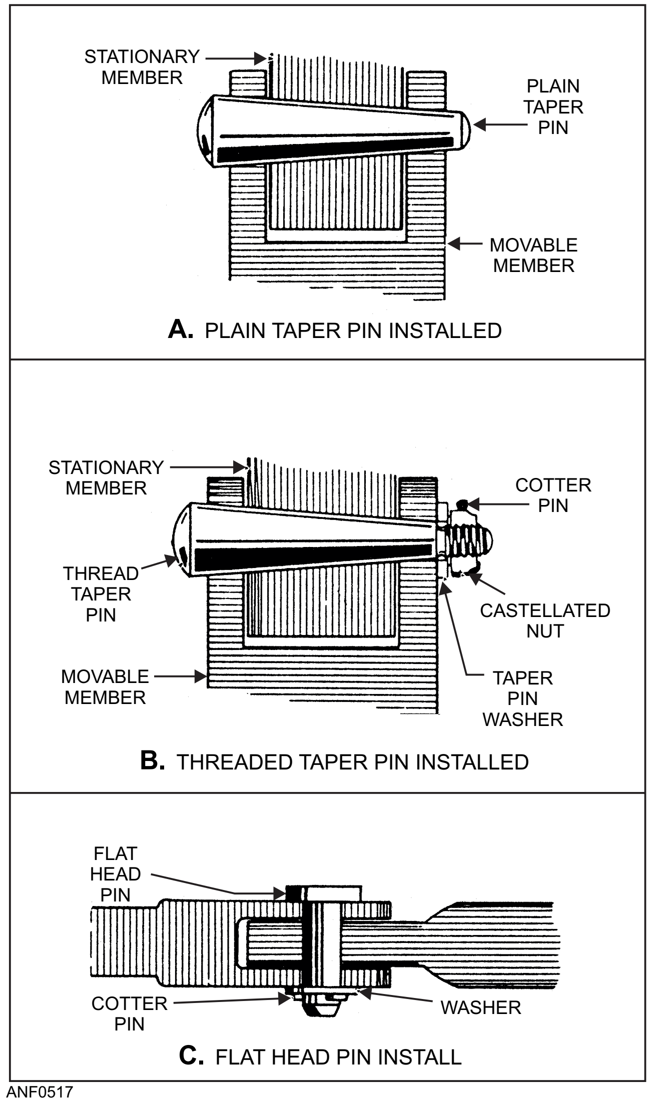

Figure 5-17.—Types of aircraft pins.

Q5-9. *What are five fasteners that are included in the category of miscellaneous fasteners?*

AIRCRAFT ELECTRICAL SYSTEM HARDWARE

LEARNING OBJECTIVE: Identify the special hardware found in an aircraft's electrical system.

An important part of aircraft electrical maintenance is determining the correct type of electrical hardware for a given job. You must become familiar with wire and cable, connectors, terminals, and bonding.

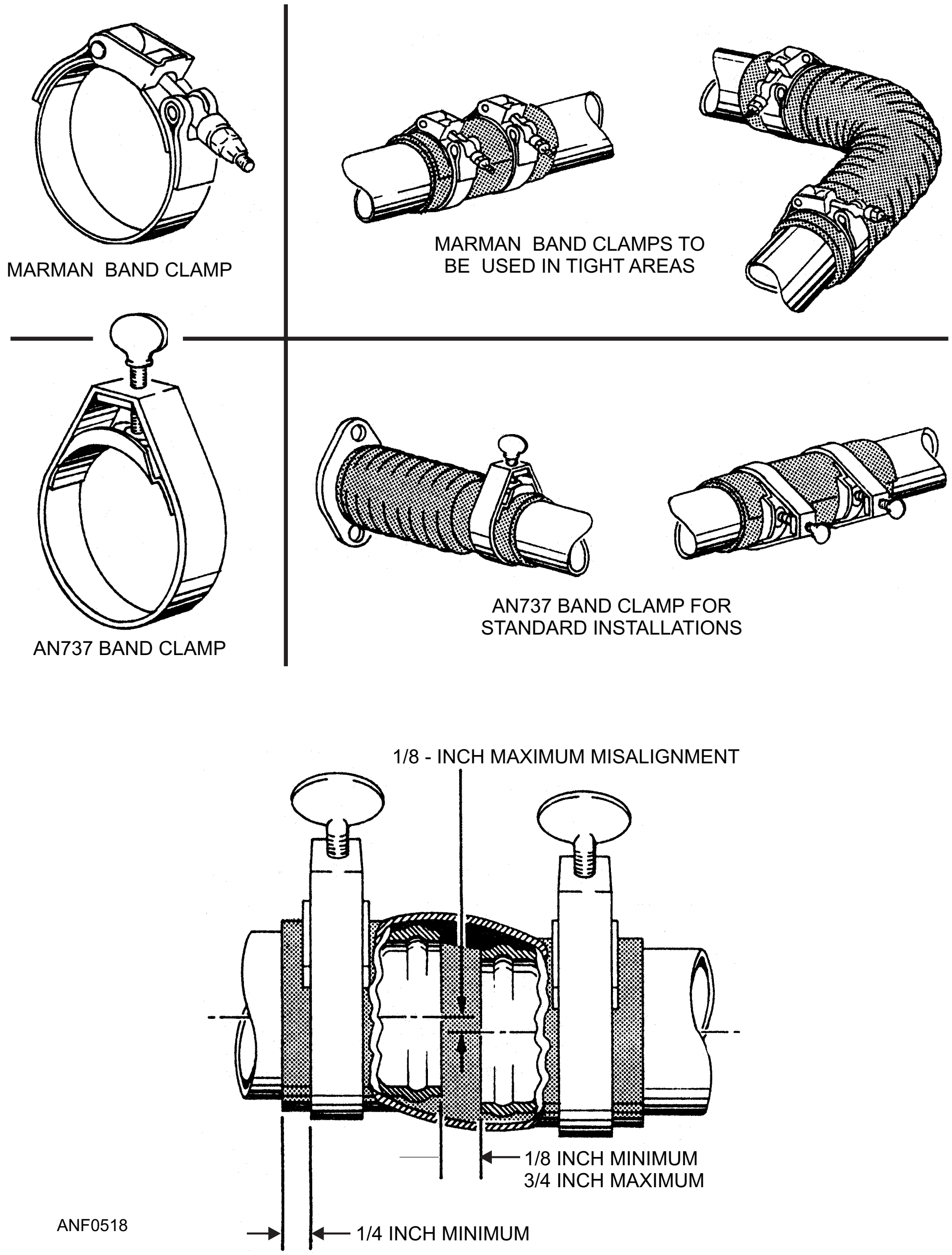

Figure 5-18.—Flexible line connectors.

WIRE AND CABLE

For purposes of electrical installations, a wire is described as a stranded conductor covered with an insulating material. The term *cable*, as used in aircraft electrical installations, includes the following:

- Two or more insulated conductors contained in the same jacket (multiconductor cable)
- Two or more insulated conductors twisted together (twisted pair)
- One or more insulated conductors covered with a metallic braided shield (shielded cable)
- A single insulated conductor with a metallic braided outer conductor (RF cable)

For wire replacement work, the aircraft maintenance instruction manual should be consulted first. The manual normally lists the wire used in a given aircraft.

CONNECTORS

Connectors are devices attached to the ends of cables and sets of wires to make them easier to connect and disconnect. Each connector consists of a plug assembly and a receptacle assembly. The two assemblies are coupled by means of a coupling nut. Each consists of an aluminum shell containing an insulating insert that holds the current-carrying contacts. The plug is usually attached to the cable end, and is the part of the connector on which the coupling nut is mounted. The receptacle is the half of the connector to which the plug is connected. It is usually mounted on a part of the equipment. One type of connector commonly used in aircraft electrical systems is shown in figure 5-19.

TERMINALS

Since most aircraft wires are stranded, it is necessary to use terminal lugs to hold the strands together. This allows a means of fastening the wires to terminal studs. The terminals used in electrical wiring are either of the soldered or crimped type. Terminals used in repair work must be of the size and type specified in the applicable maintenance instruction manual. The crimped-type terminals are generally recommended for use on naval aircraft. Soldered-type terminals are usually used in emergencies only.

The basic types of solderless terminals are shown in figure 5-20. They are the straight, right angle, flag, and splice types. There are variations of these types.

BONDING

When you connect all the metal parts of an aircraft to complete an electrical unit, it is called bonding. Bonding connections are made of screws, nuts, washers, clamps, and bonding jumpers. Figure 5-21 shows a typical bonding link installation.

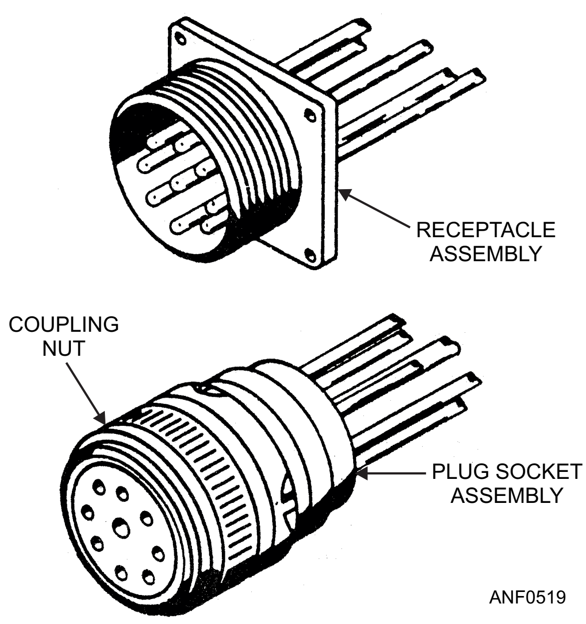

Figure 5-19.—Connector assembly.

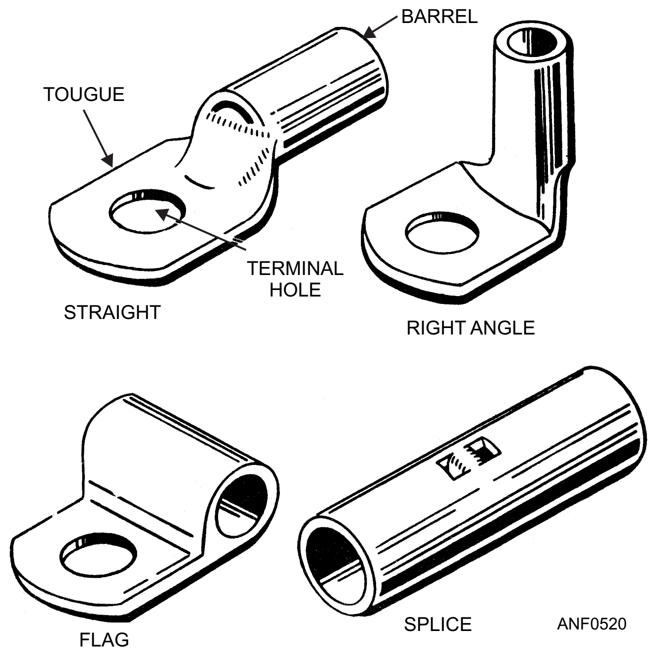

Figure 5-20.—Basic types of solderless terminals.

An aircraft can become highly charged with static electricity while in flight. If the aircraft is improperly bonded, all metal parts do not have the same amount of static charge. A difference of potential exists between the various metal surfaces. If the resistance between insulated metal surfaces is great enough, charges can accumulate. The potential difference could become high enough to cause a spark. This constitutes a fire hazard and also causes radio interference. If lighting strikes an aircraft, a good conducting path for heavy current is necessary to minimize severe arcing and sparks.

Bonding also provides the necessary low-resistance return path for single-wire electrical systems. This low-resistance path provides a means of bringing the entire aircraft to the earth's potential when it is grounded.

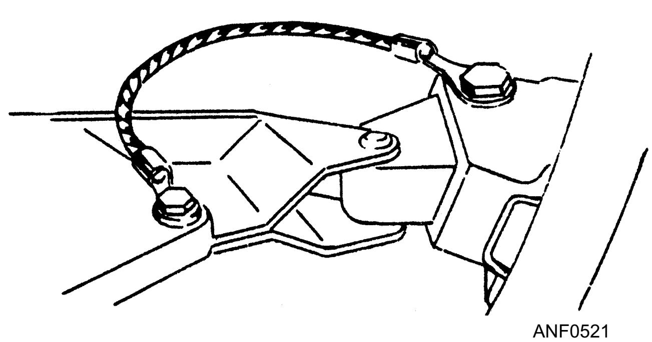

Figure 5-21.—Typical bonding link installation.

When you perform an inspection, both bonding connections and safetying devices must be inspected with great care.

Q5-10. What manual should you consult to find correct replacement wires for a given aircraft?

SAFETY METHODS

LEARNING OBJECTIVE: Recognize the procedures for the safetying of fasteners and electrical system hardware.

Safetying is a process of securing all aircraft bolts, nuts, capscrews, studs, and other fasteners. Safetying prevents the fasteners from working loose due to vibration. Loose bolts, nuts, or screws can ruin engines or cause parts of the aircraft to drop off. To carry out an inspection on an aircraft, you must be familiar with the various methods of safetying. Careless safetying is a sure road to disaster. Always use the proper method for safetying. Always safety a part you have just unsafetied before going on to the next item of inspection. You should always inspect for proper safetying throughout the area in which you are working.

There are various methods of safetying aircraft parts. The most widely used methods are safety wire, cotter pins, lock washers, snap rings, and special nuts. Some of these nuts and washers have been described previously in this chapter.

SAFETY WIRING

Safety wiring is the most positive and satisfactory method of safetying. It is a method of wiring together two or more units. Any tendency of one unit to loosen is counteracted by the tightening of the wire.

Nuts, Bolts, and Screws

Nuts, bolts, and screws are safety wired by the single-wire double-twist method. This method is the most common method of safety wiring. A single-wire may be used on small screws in close spaces, closed electrical systems, and in places difficult to reach.

Figure 5-22 illustrates the following steps required to install a standard double-twist safety wire for two bolts with right-hand threads.

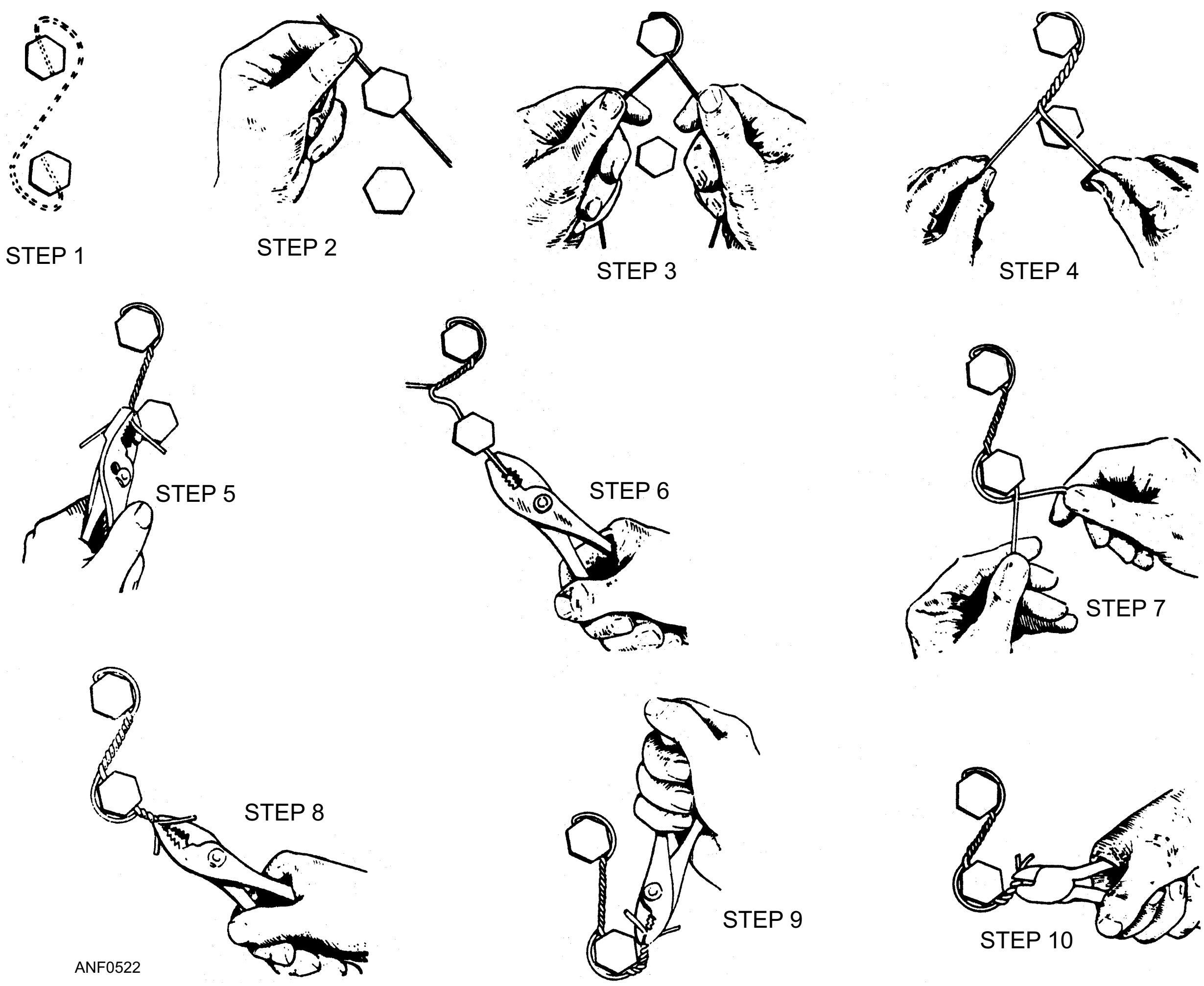

Figure 5-22.—Standard double-twist safety wire installation procedures.

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Step 1. Assemble the unit. Torque the bolts and carefully align the safety wire holes.

Step 2. Insert the proper size wire through the hole in the first bolt.

Step 3. Bend the left end of the wire clockwise around the bolt head and **under** the other end of the wire.

Step 4. Pull the loop tight against the bolt head. Grasp both ends of the wire. Twist them in a clockwise direction until the end of the braid is just short of the second bolt.

Step 5. Check to ensure that the loop is still tightly in place around the first bolt head. Grasp the wire with pliers just beyond the end of the braid. While holding it taut, twist it in a clockwise direction until the braid is stiff.

NOTE: The braid must be tight enough to resist friction or vibration wear, but should not be overtightened.

Step 6. Insert the upper end of the safety wire through the hole in the second bolt. Pull the braid until it is taut.

Step 7. Bring the other end of the wire counter-clockwise around the bolt head and **under** the protruding wire end.

Step 8. Tighten the loop and braid the wire ends in a counterclockwise direction. Grasp the wire with the pliers just beyond the end of the braid and twist in a counterclockwise direction until the braid is stiff. Make sure you keep the wire under tension.

Step 9. With a final twisting motion, bend the braid to the right and against the head of the bolt.

Step 10. Cut the braid, being careful that between three and six full twists still remain. Avoid sharp projecting ends.

Figure 5-23 shows various methods commonly used in safety wiring nuts, bolts, and screws. Examples 1, 2, and 5 of figure 5-23 show the proper method of safety wiring bolts, screws, square head plugs, and similar parts when wired in pairs. Examples 6 and 7 show a single-threaded component wired to a housing or lug. Example 3 shows several components wired in series. Example 4 shows the proper method of wiring castellated nuts and studs. Note that there is no loop around the nut. Example 8 shows several components in a closely spaced, closed geometrical pattern, using the single-wire method.

When drilled-head bolts, screws, or other parts are grouped together, they are more conveniently safety wired to each other in a series rather than individually. The number of nuts, bolts, or screws that may be safety wired together depends on the application. For instance, when you are safety wiring widely spaced bolts by the double-twist method, a group of three should be the maximum number in a series.

When you are safety wiring closely spaced bolts, the number that can be safety wired by a 24-inch length of wire is the maximum in a series. The wire is arranged in such a manner that if the bolt or screw begins to loosen, the force applied to the wire is in the tightening direction.

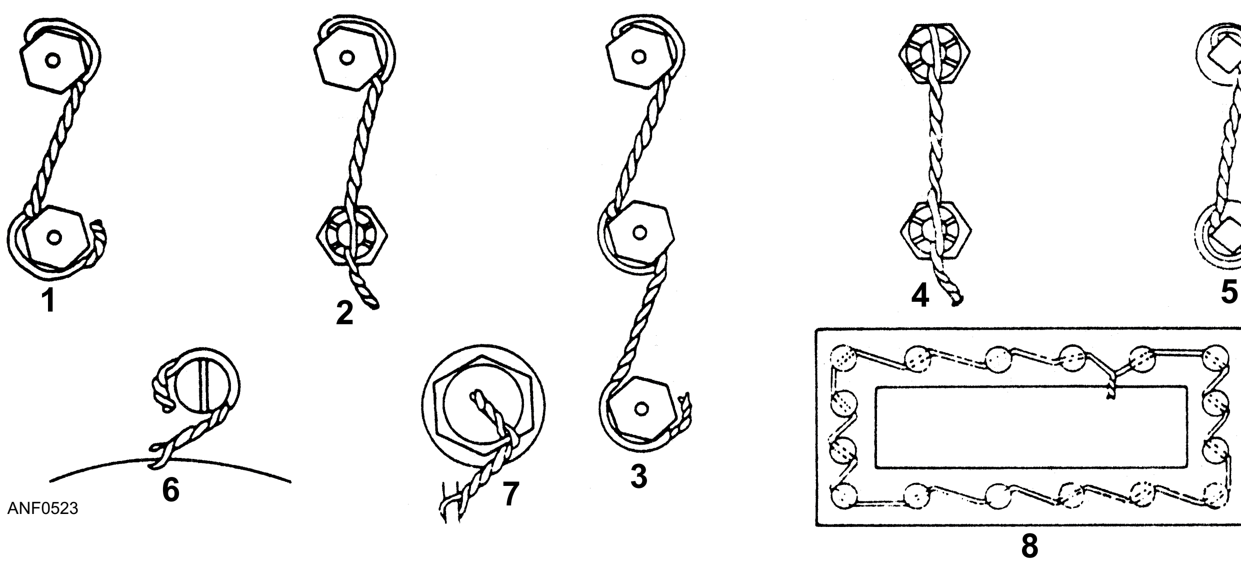

Figure 5-23.—Safety wiring methods.

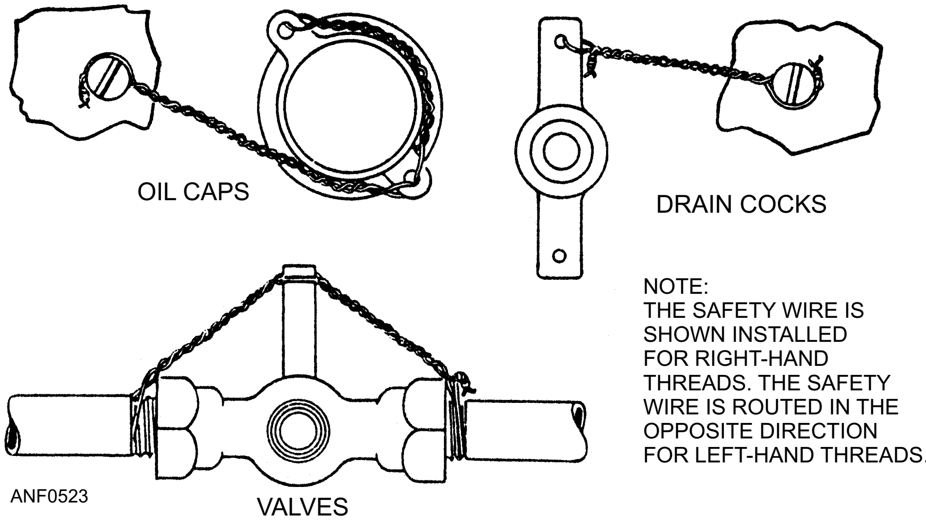

Figure 5-24.—Safety wiring oil caps, drain cocks, and valves.

Torque all parts to the recommended values, and align holes before you attempt to proceed with the safetying operation. Never overtorque or loosen a torqued nut to align safety wire holes.

Oil Caps, Drain Cocks, and Valves

These units are safety wired as shown in figure 5-24. In the case of the oil cap, the wire is anchored to an adjacent fillister head screw. This system applies to any other unit that must be safety wired individually. Ordinarily, anchorage lips are conveniently located near these individual parts. When this provision is not made, the safety wire is fastened to some adjacent part of the assembly.

Electrical Connectors

Under conditions of severe vibration, the coupling nut of a connector may vibrate loose. With sufficient vibration, the connector could come apart. When this occurs, the circuit carried by the cable opens. The proper protective measure to prevent this occurrence is by safety wiring, as shown in figure 5-25. The safety wire should be as short as practicable. It must be installed in such a manner that the pull on the wire is in the direction that tightens the nut on the plug.

Turnbuckles

After you adjust a turnbuckle properly, safety it. There are several methods of safetying turnbuckles. Only two of these methods have been adopted by the military services. These methods are shown in views

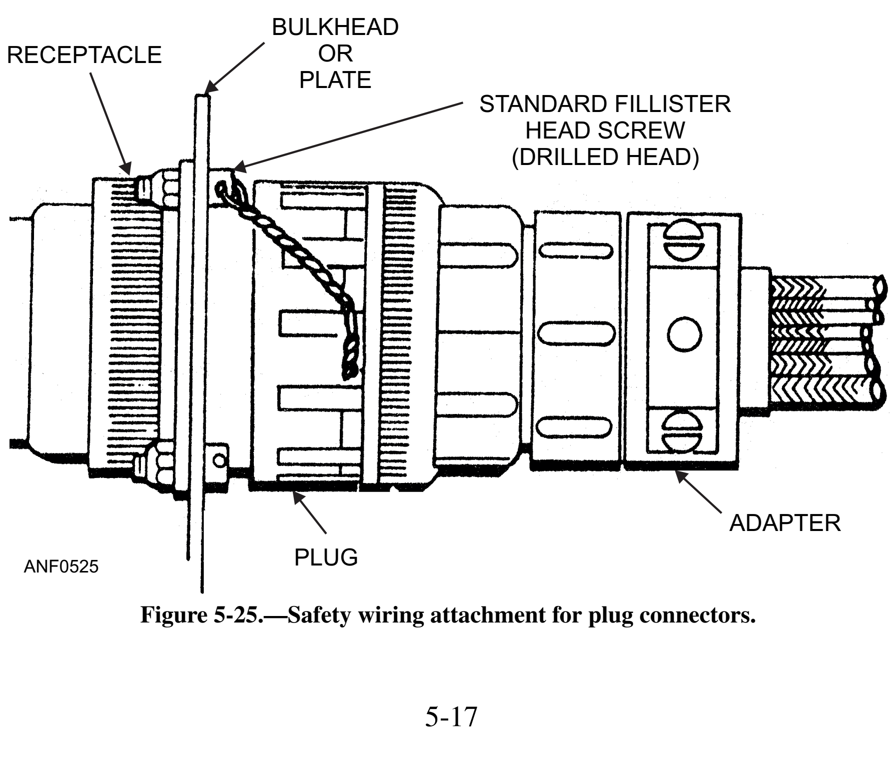

Figure 5-25.—Safety wiring attachment for plug connectors.

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(A) and (B) of figure 5-26. The clip-locking method is used only on the most modern aircraft. An example of an aircraft using this method is the EA-6B. These aircraft use a turnbuckle that is designed for use with the wire clip. The older type of aircraft still use the turnbuckles that require the wire-wrapping method.

Detailed instructions for using both the clip-locking and the wire-wrapping methods of safetying turnbuckles can be found in *Aviation Structural Mechanic (AM)*, NAVEDTRA 14315.

GENERAL SAFETY WIRING RULES

When you use the safety wire method of safetying, follow these general rules:

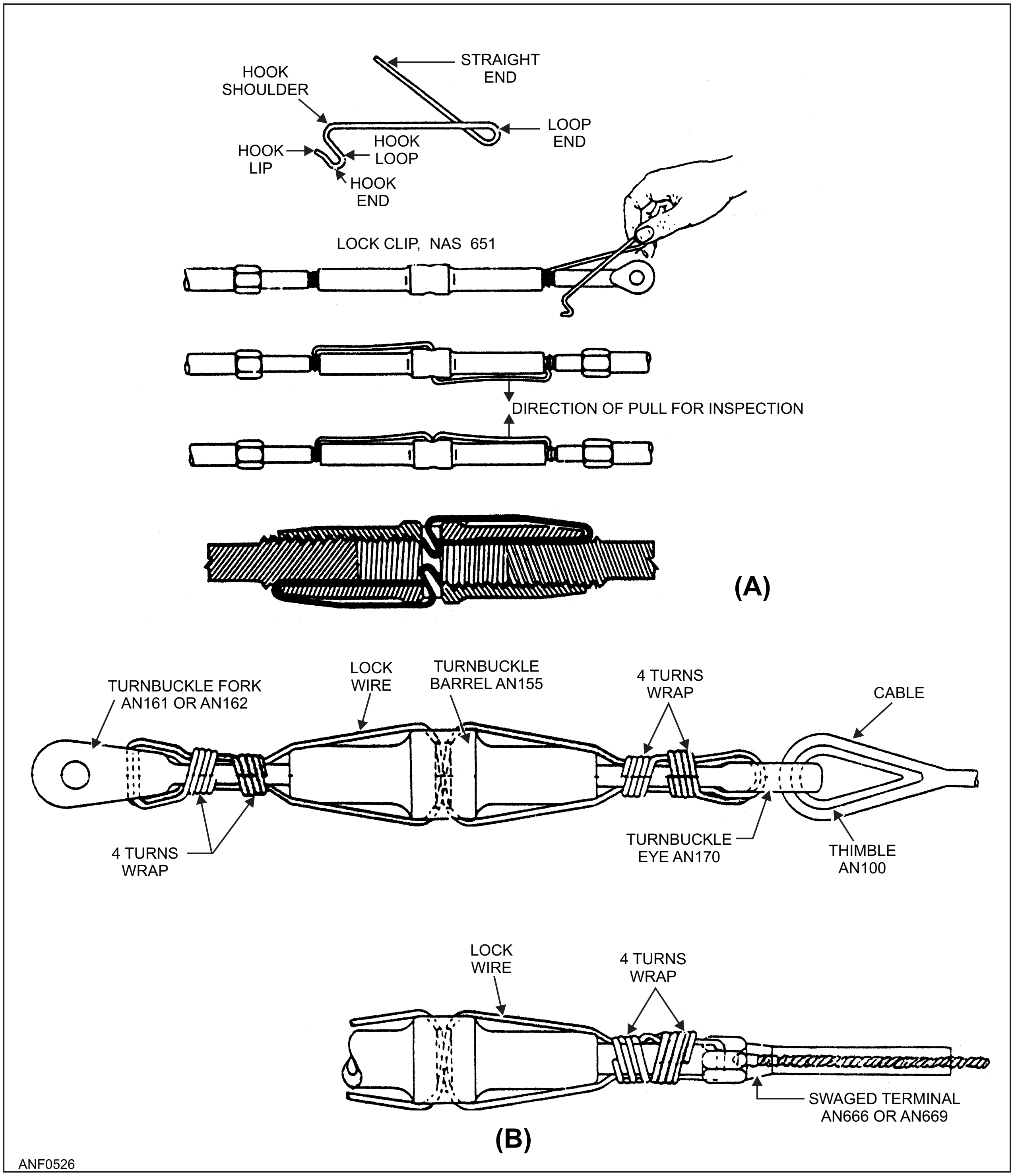

Figure 5-26.—Safetying turnbuckles. (A) Clip-locking method; (B) wire-wrapping method.

1. A pigtail of one-fourth to one-half inch (three to six twists) should be made at the end of the wiring. This pigtail must be bent back or under to prevent it from becoming a snag.

2. The safety wire must be new upon each application.

3. When you secure castellated nuts with safety wire, tighten the nut to the low side of the selected torque range, unless otherwise specified. If necessary, continue tightening until a slot aligns with the hole.

4. All safety wires must be tight after installation, but not under such tension that normal handling or vibration will break the wire.

5. Apply the wire so that all pull exerted by the wire tends to tighten the nut.

6. Twists should be tight and even, and the wire between the nuts should be as taut as possible without being overtwisted.

COTTER PINS

Use cotter pins to secure bolts, screws, nuts, and pins. Some cotter pins are made of low-carbon steel, while others consist of stainless steel, and thus are more resistant to corrosion. Use stainless steel cotter pins in locations where nonmagnetic material is required. Regardless of shape or material, use all cotter pins for the same general purpose—safetying. Figure 5-27 shows three types of cotter pins and how their size is determined.

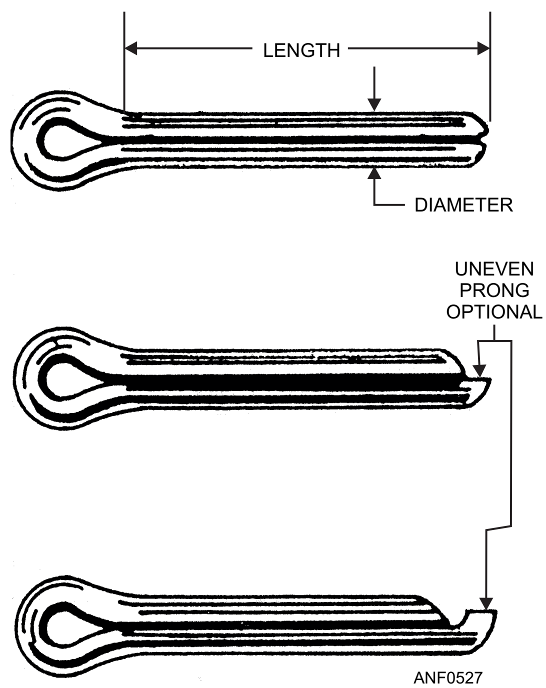

Figure 5-27.—Types of cotter pins.

NOTE: Whenever uneven-prong cotter pins are used, the length measurement is to the end of the shorter prong.

Cotter pin installation is shown in figure 5-28. Use castellated nuts with bolts that have been drilled for cotter pins. Use stainless steel cotter pins. The cotter pin should fit neatly into the hole, with very little sideplay. The following general rules apply to cotter pin safetying:

- Do not bend the prong over the bolt end beyond the bolt diameter. (Cut it off if necessary.)
- Do not bend the prong down against the surface of the washer. (Again, cut it off if necessary.)
- Do not extend the prongs outward from the sides of the nut if you use the optional wraparound method.
- Bend all prongs over a reasonable radius. Sharp angled bends invite breakage. Tap the prongs lightly with a mallet to bend them.

Q5-11. What is the purpose of safetying aircraft hardware?

Q5-12. What is the most common method of safety wiring?

Q5-13. What are the two methods of safetying turnbuckles used by the military services?

Q5-14. What type of cotter pin should you use when nonmagnetic material is required?

WASHERS

LEARNING OBJECTIVE: Recognize the two primary functions of washers as used in aircraft/engine construction.

Washers used in aircraft structures may be grouped into three general classes—plain, lock washers, and

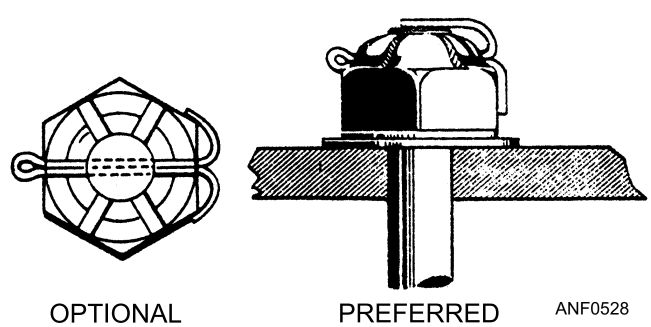

Figure 5-28.—Cotter pin installations.

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special washers. Figure 5-29 shows some of the most commonly used types.

PLAIN WASHERS

Plain washers are widely used under AN hex nuts to provide a smooth bearing surface. They act as a shim in obtaining the correct relationship between the threads of a bolt and the nut. They also aid in adjusting the position of castellated nuts with respect to drilled cotter pin holes in bolts. Plain washers are also used under lock washers to prevent damage to surfaces of soft material.

LOCK WASHERS

Lock washers are used whenever the self-locking or castellated type nut is not used. Sufficient friction is provided by the spring action of the washer to prevent loosening of the nut because of vibration. Lock washers must not be used as part of a fastener for primary or secondary structures.

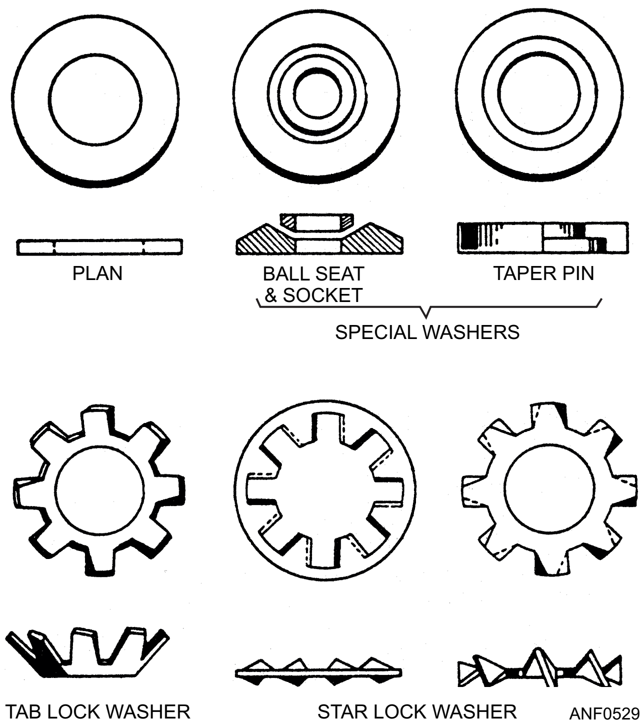

Figure 5-29.—Various types of washers.

Star Lock Washers

The star lock or shakeproof washer is a round washer made of hardened and tempered carbon steel, stainless steel, or Monel. This washer can have either internal or external teeth. Each tooth is twisted, one edge up and one edge down. The top edge bites into the nut or bolt and the bottom edge bites into the working surface. It depends on spring action for its locking feature. This washer can be used only once because the teeth become somewhat compressed after being used.

Tab Lock Washers

Tab lock washers are round washers designed with tabs or lips that are bent across the sides of a hex nut or bolt to lock the nut in place. There are various methods of securing the tab lock washer to prevent it from turning, such as an external tab bent downward 90 degrees into a small hole in the face of the unit, an external tab that fits a keyed bolt, or two or more tab lock washers connected by a bar. Tab lock washers can withstand higher heat than other methods of safetying, and can be used safely under high vibration conditions. Tab lock washers should be used only once because the tab tends to crystallize when bent a second time.

SPECIAL WASHERS

Special washers such as ball seat and socket washers and taper pin washers are designed for special applications.

Q5-15. Washers used in aircraft structures are grouped into what three general classes?

SUMMARY

In this chapter you have been introduced to the various types of aircraft hardware used in naval aircraft and the procedures for maintaining their security. It is essential that the correct hardware be used at all times for the safe and efficient operation of naval aircraft.