Fasteners

IMPORTANCE OF FASTENERS/PART 1

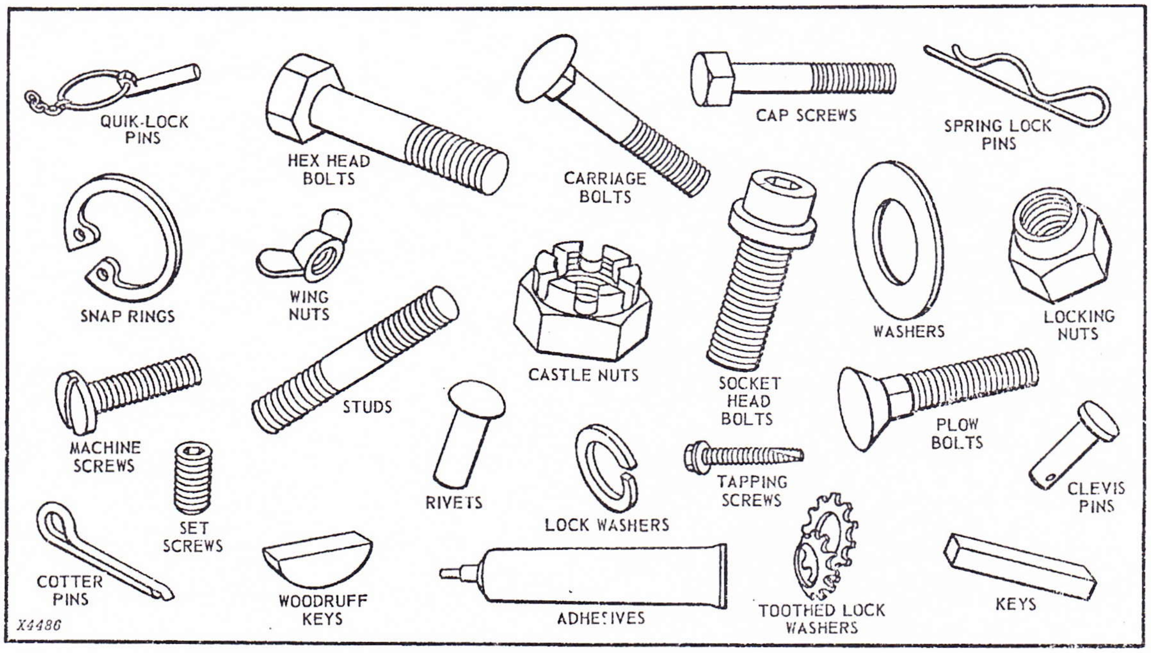

Fig. 1 — Typical Fasteners Discussed in This Manual

INTRODUCTION

Almost since the dawn of civilization, man has used fasteners to hold together the things he makes. Probably first came rope-like vines or reeds, leather thongs (Fig. 2) and simple wooden pegs. Gradually, as the need arose, he developed other more sophisticated fasteners until now there is a host of them — some simple like buttons, safety pins, zippers, paper clips, nails (Fig. 3); others more complicated or developed for a special need such as high-strength bolts, lock nuts, keys.

Today few products could be made without fasteners. They are an important part of our everyday living and are encountered in almost everything we make or repair.

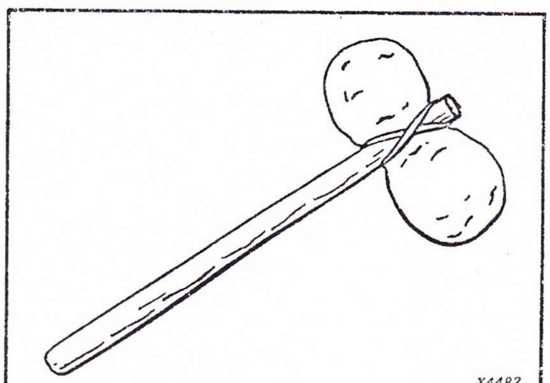

Fig. 2 — A Primitive Stone Ax. A Leather Thong Fastens the Head to the Handle.

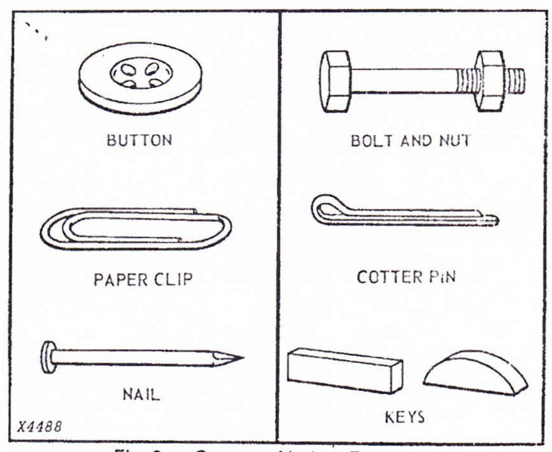

Fig. 3 — Common Modern Fasteners

WHY FASTENERS?

Fasteners are used today in manufactured products for a number of very important reasons:

They simplify manufacture. Because of their complexity, many components and assemblies cannot be made in one piece; they must be made of two or more parts (Fig. 4), held together by fasteners. Thus fasteners greatly simplify manufacture.

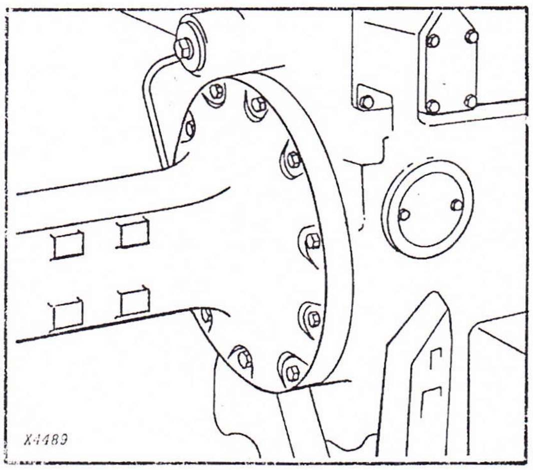

Fig. 4 — Tractor Rear Axle Housing Fastened to Differential Housing with Cap Screws

They simplify repairs. Fasteners also simplify the jobs of maintenance and repair; by removing the fasteners (Fig. 5), an assembly can be separated into the individual parts for inspection, repair or replacement.

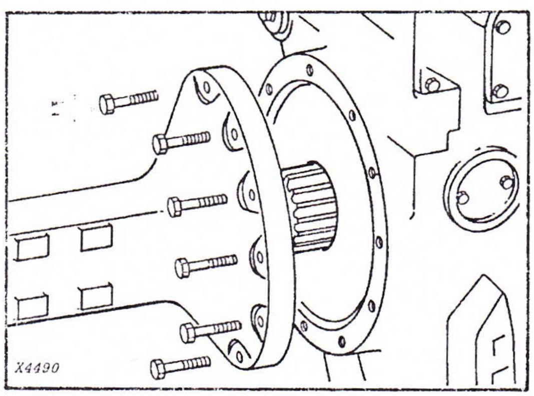

Fig. 5 — When Fasteners are Removed, the Assemblies Can Be Separated into Individual Components

They provide safety. Many fasteners also serve as safety devices. Such items as lock washers, cotter pins, lock wire, jam nuts assure that an assembly, once put together, will stay that way with little possibility of its coming apart.

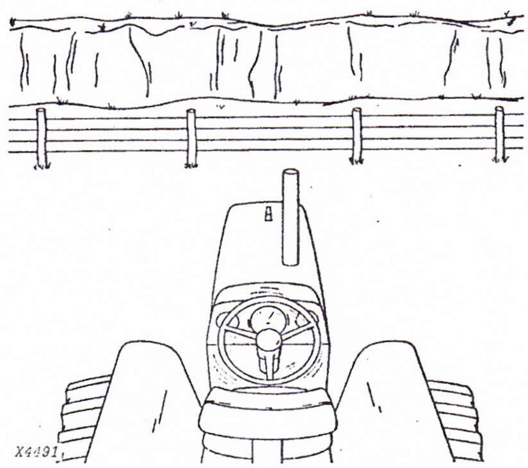

Fig. 6 — Fasteners Are Safety Devices

Think what would happen if someone forgot to install a small, cheap cotter pin in the steering mechanism of your car or tractor, permitting a nut to come loose and fall off! Certainly your safety would be in extreme jeopardy (Fig. 6).

FASTENERS MUST HAVE MANY QUALITIES

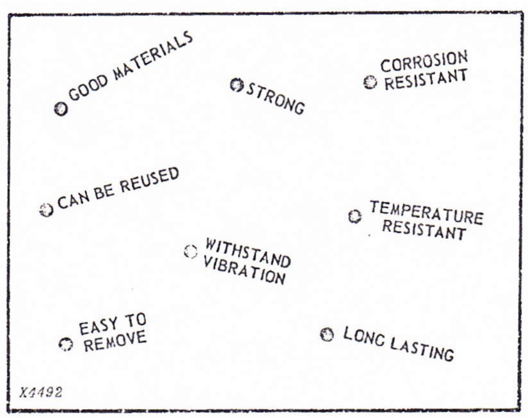

Fig. 7 — Some Requirements for Satisfactory Fasteners

Self-tapping Screws, which cut their own thread (Fig. 2:4), and *Sheet Metal Screws* (Fig. 2:5), which are used to fasten panels, are two other popular types of screw.

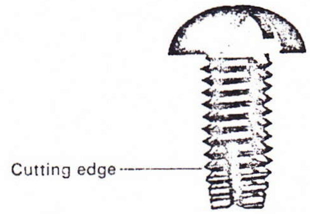

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Fig. 2:4 Self-tapping Screw

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Fig. 2:5 Typical Sheet Metal Screws

The *Hexagon Bolt* (Fig. 2:6) is identical to the hexagon cap screw, except that a nut is used to hold the assembled parts together. The distinction between the two is not always made. For instance, mechanics and manuals often refer to cylinder head bolts, while these are, in fact, screws.

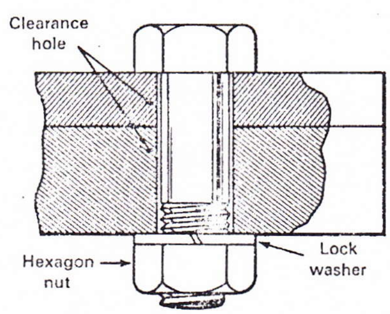

Fig. 2:6 Hexagon Bolt

Set Screws

Set screws (Fig. 2:7), whether of the Allen-head, hex-head, square-head, or slotted type, have a pointed tip to lock or "set" pulleys, gears, handles, and knobs in position on a shaft. The set screw is always at right angles to the shaft. Especially long set screws, which are usually spring-loaded to maintain their adjustment, are employed as linkage stop screws where frequent resetting is required (e.g., throttle or idle stop screws).

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Fig. 2:7 Set Screw

Studs and U-Bolts

Studs (Fig. 2:8) have no heads and are threaded at both ends. In many cases they feature a coarse thread at one end for turning into brittle materials such as cast metals or plastics, and a fine thread at the other end to accommodate steel nuts. U-bolts (Fig. 2:9), which are essentially U-shaped studs, are used to clamp around such parts as exhaust pipes and axle housings.

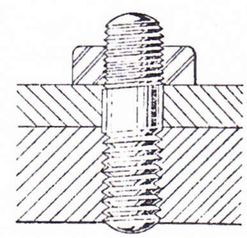

Fig. 2:8 Stud

Nuts

Nuts (Fig. 2:10) are produced in various shapes and designs. Like most other fasteners, they may be made of steel, stainless steel, brass, or

Fig. 2:1 Hexagon Cap Screw

Fig. 2:3 Belleville Screw

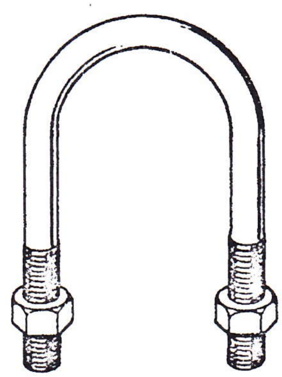

Fig. 2:9 U-Bolt

even plastic. They can be plated with chromium, nickel, zinc, cadmium, lead, and other metals. Some nuts are self-locking; others have a lock washer attached to them.

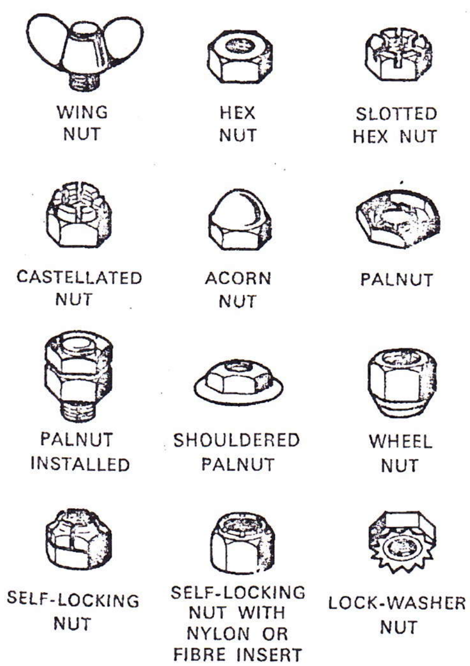

Fig. 2:10 Common Shapes and Designs of Nuts

The *Palnut*, which prevents an ordinary nut from shaking loose, should be brought up to finger tightness against the nut to be locked, and then tightened further by approximately one more flat. Note that each nut illustrated in Fig. 2:10 is positioned so that the underside would face the part to be mounted. Threading the nut on the other way could have serious consequences. If, for example, the cone-shaped part of a wheel nut doesn't reach into the stud hole of the rim, the wheel will eventually come off! It should also be noted that many self-locking nuts do not lock reliably if used more than once.

Speed Nuts (Fig. 2:11a) are for light work and where low cost and space are of primary concern (e.g., automotive trim pieces).

Cage Nuts (Fig. 2:11b) are used in inaccessible areas where the nut cannot be reached (e.g., radiator mounts).

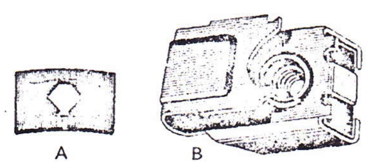

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Fig. 2:11 (a) Speed Nut; (b) Cage Nut.

Sizes of Fasteners

Before you replace a fastener you must be sure of the specifications and measurements that apply to it. If the equipment was manufactured in North America, the size of the fasteners is, in most cases, still measured in inches, although there are already some metric sizes, and eventually the sizes of all parts are expected to be converted to the metric system. Products imported from continental Europe and Asia are based on the metric system. The mixing of the two types of fasteners must obviously be avoided, especially when using screws that fit into threaded castings. If in doubt, and if you do not have a suitable thread gauge (page 24), simply use a nut or bolt of known size and try to fit it by hand to the fastener whose size is in question. In rare cases you may find two threads of the same size that do not match

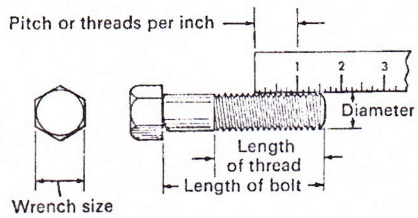


Fig. 2:12 Screw Dimensions

because one has a standard right-hand thread and the other has a left-hand thread. For example, the wheel nuts and studs on the left-hand side of certain models are designed in this way to prevent them from being shaken loose during sudden braking.

The dimensions of a fastener are determined by the method shown in Fig. 2:12. The most common head or wrench sizes can easily be calculated by adding 3/16" to the size of the stem or shank of the fastener. For example, a hexagon bolt with a stem size of 3/8" requires a wrench size of 9/16" (3/8" + 3/16" = 9/16"). This formula can be used in reverse to find the stem size of the fastener, providing the wrench size is known.[4]

The two basic types of thread used on domestic vehicles are the UNF (Unified Fine) and the UNC (Unified Coarse) series.[5] Among other things the type of thread is determined by the "pitch", i.e., the number of threads (or turns) per inch. The UNF series, which has more threads per inch than the UNC series, is stronger, and because of its higher friction factor, is less likely to shake loose. On the other hand, the wider, more deeply cut UNC thread takes a better hold in plastics and in the coarse grain structures of cast metals. It is also more quickly assembled and less likely to seize because of corrosion or high temperatures. The thread sizes of screws, bolts, and studs equal the outer thread diameter as shown in Fig. 2:12. Standard sizes increase in steps of one-sixteenth of an inch, e.g., 1/4", 5/16", 3/8", 7/16", etc. Shank sizes smaller than these are expressed in whole numbers, e.g., 12, 10, 8, 6 (size 12 being larger than 10).

If you wished to obtain a UNF hexagon cap screw 2½" long from the underside of the head to the tip, and with a thread size of 3/8", you would ask for:

1 hexagon cap screw 3/8" × 2½" UNF[6]

Tightening and Loosening Fasteners

You will avoid the worst pitfalls in your work if you observe these simple rules:

1. Standard fasteners are tightened by turning them in a clockwise direction, and loosened by turning them in a counter-clockwise direction (Fig. 2:13).

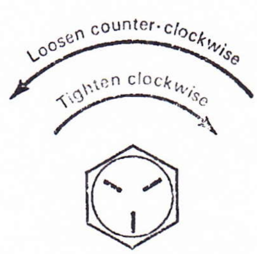
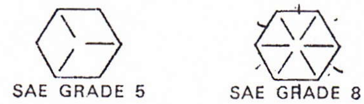


Fig. 2:13 Tightening and Loosening of Standard Right-hand-thread Fasteners

[4]Half-inch bolts have wrench sizes of either 11/16" or 3/4". It should be noted, however, that if the shank size is more than ½", the formula cannot be used.

[5]Some manufacturers use the designation NF (National Fine) or SAE Regular (Society of Automotive Engineers) for the UNF series. The designations NC (National Coarse), or USS (United States Standards), or SAE Coarse are sometimes used for the UNC series. For some special applications an extra-fine thread may be used. It is listed as UNEF, or NEF, or SAE Fine.



[6]In some cases where the fastener has to withstand heavy loads it may be necessary to specify the grade, i.e., its tensile strength. An SAE grade 5 cap screw, identified by three lines on its head, is, for example, not as strong as an SAE grade 8 cap screw of the same size. Threads are also divided into classes: 1A represents a loose fit; 2A meets most automotive requirements; 3A is for precision equipment. The letters 1B, 2B, and 3B are the equivalents for nuts and other internal threads.

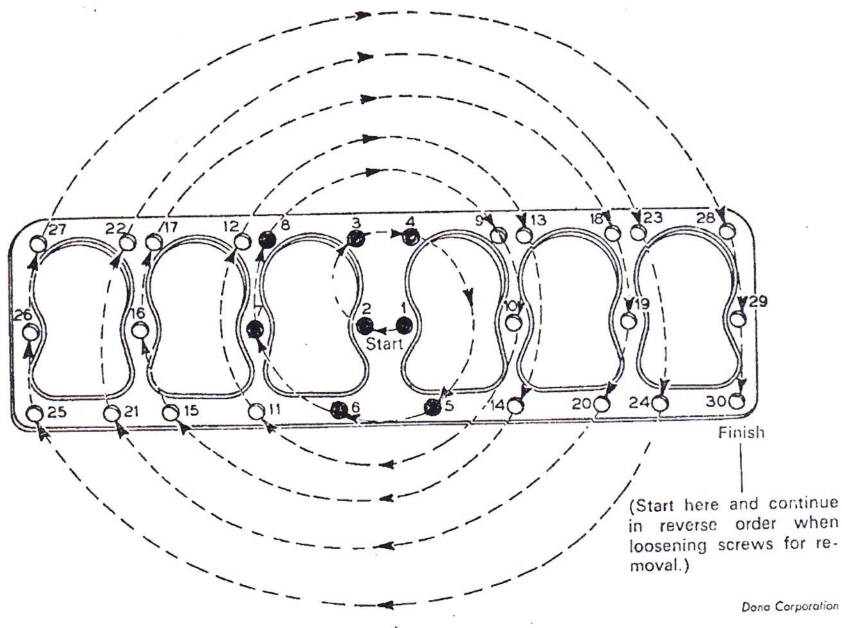


Fig. 2:14 Typical Torque Sequence for Rectangular Parts

2. Non-self-locking fasteners should spin freely until the head touches the part that is being fastened. (A tight thread indicates the wrong size, a dirty or damaged thread, or misaligned parts.)
3. Give all the fasteners on any part several turns before actually tightening any one of them.
4. Refer to the manufacturer's specifications for torque limits and sequence (the degree and order of tightening fasteners).
5. The torque of a fastener is determined by (a) the material of which the part is made; (b) the shape of the part; (c) the intended fit of the part; (d) the size, quality, and condition of the fastener; and (e) the type of gasket material, if a gasket is used.
6. The proper torque sequence for rectangular parts, such as cylinder heads, is illustrated in Fig. 2:14. The proper sequence for circular parts, such as wheels and carburetor and fuel pump covers, is illustrated in Fig. 2:15.

   To remove a rectangular part, reverse the

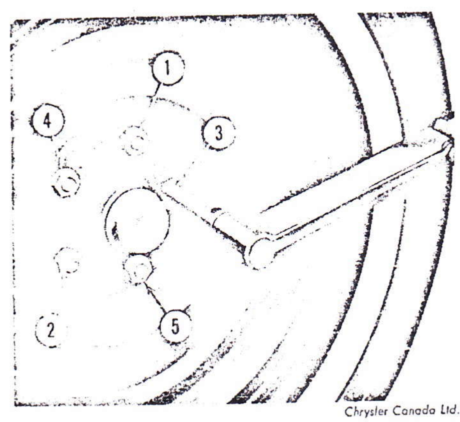


Fig. 2:15 Typical Torque Sequence for Bolt Circles

sequence beginning at one of the corners and working towards the centre. In all cases, but especially where cast metal is employed, torque should be increased gradually in two or three steps. Ignoring these precautions will cause misaligned, distorted, or broken parts. For example, if you start to tighten a cylinder head at the corners, the centre will bulge upwards creating excessive stress in this area. The likely result will be a warped head or a leakage of coolant and gases, or possibly both.

Washers

The most common types of washers are shown in Fig. 2:16. The ordinary flat washer, which comes in a variety of sizes and thicknesses, spreads the contact area of the fastener. This is particularly important when one is working with parts made of softer materials (aluminum, plastic, sheet metal, etc.). The *Lock Washer* may be of many different designs but each one has the same purpose: to lock a nut, bolt, or screw so that it cannot back off. *Thrust Washers* are placed between gears, bearings, and other shaft-mounted parts, to absorb thrust loads, to reduce friction, and to maintain the desired clearance (the distance between two parts). Some washers are made of brass, copper, plastic, nylon, fibre, or rubber, in order to serve as seals and electrical insulators or conductors as well as thrust washers.

Rivets

Two kinds of rivets and their application are shown in Fig. 2:17. The *Tubular Rivet* is used to install clutch- and brake-linings. The *Oval Rivet* has a solid stem and is used to assemble heavy frame or suspension parts. When replacing oval rivets, most mechanics drill out the old rivets and put in high-grade bolts and locking devices. These are safer than improperly secured rivets.

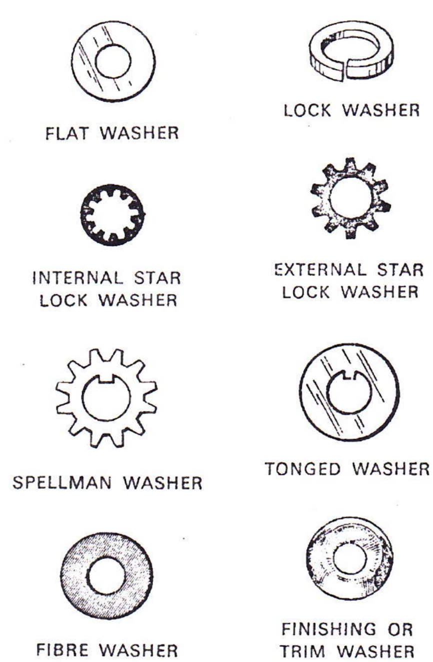


Fig. 2:16 Common Types of Washers

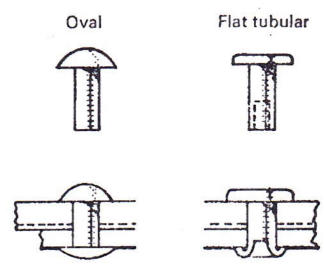


Fig. 2:17 Common Automotive Rivets

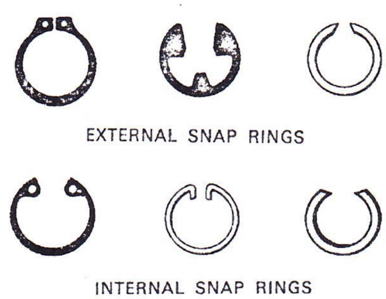


Fig. 2:18 Snap Rings (Lock Rings or Retainer Rings)

Snap Rings

Snap rings, also known as lock rings or retainer rings (Fig. 2:18), are employed to hold parts such as bearings, gears, piston pins, linkage rods, and washers in position. Snap rings may be of the internal, shaft-mounted type, or of the external, bore-mounted type. A groove must be cut in the part for the ring to fit into, as shown in Fig. 2:19. For the method of installation, see Fig. 1:44.

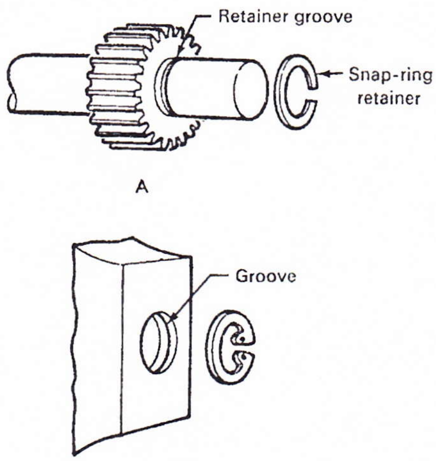


Fig. 2:19 Installation of Snap Rings:
(a) External Shaft-mounted Ring; (b) Internal Bore-mounted Ring.

Cotter Pins

Cotter pins (Fig. 2:20) are used with castellated or slotted nuts as a safety feature on steering and suspension parts; they are also used to secure linkage rods and clevis pins on brake, transmission, and accelerator linkages. In some cases cotter pins maintain critical torque settings or bearing "preloads" on fasteners such

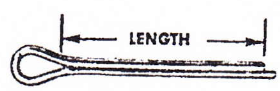


Fig. 2:20 Cotter Pin

as the front-wheel-bearing retainer nut. Fig. 2:21 illustrates the proper installation of a cotter pin. Because of the hazards that might be created, never use a cotter pin more than once.

There are other methods of locking fasteners, including folding sheet metal tabs over the fastener's head (Fig. 2:22). In some cases, soft steel wire (mechanic's wire) is used instead of cotter pins. To lock a screw with wire, the screw must be provided with a small hole in its head (Fig. 2:23).

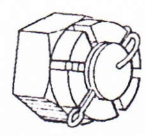


Fig. 2:21 Proper Installation of a Cotter Pin.
(1) Head of cotter is inserted firmly in slot.
(2) Long end of cotter is bent back to centre of bolt, other end bent down flat. (3) Cotter is tight in nut.

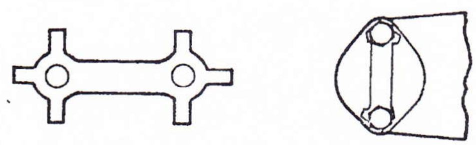


Fig. 2:22 Shim Lock with Folding Tabs

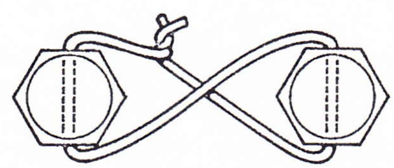


Fig. 2:23 Wire Locking of Fasteners

Keys

To prevent shaft-mounted parts such as timing gears (Fig. 5:24) and pulleys on crankshafts and generators from slipping, keys are installed. The two most common types are the half-moon-shaped "Woodruff" key (Fig. 2:24) and the square key (Fig. 2:25). Another type of key, known as a *Dowel Pin,* is simply an accurately machined steel peg. Dowel pins are

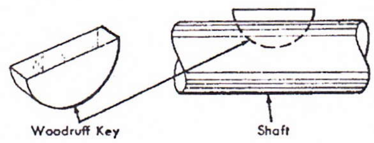


Fig. 2:24 Woodruff Key

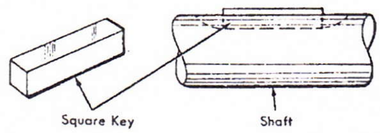


Fig. 2:25 Square Key

pressed into two matching parts that have been provided with corresponding dowel holes. Dowel pins thus ensure a perfectly aligned fit on such parts as some timing gears, transmission housings, and balanced fly-wheel as-

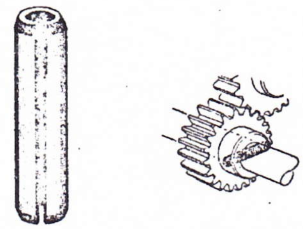


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Fig. 2:26 Slotted Tension Pin

semblies, and between the cylinder block and the head (Figs. 5:22 and 5:26).

The Slotted Tension Pin

This pin (Fig. 2:26) is mostly used to hold gears in position where torque requirements are low (e.g., distributor and oil-pump drive gears).

The purpose of the fasteners shown in Fig. 2:27 is self-evident.

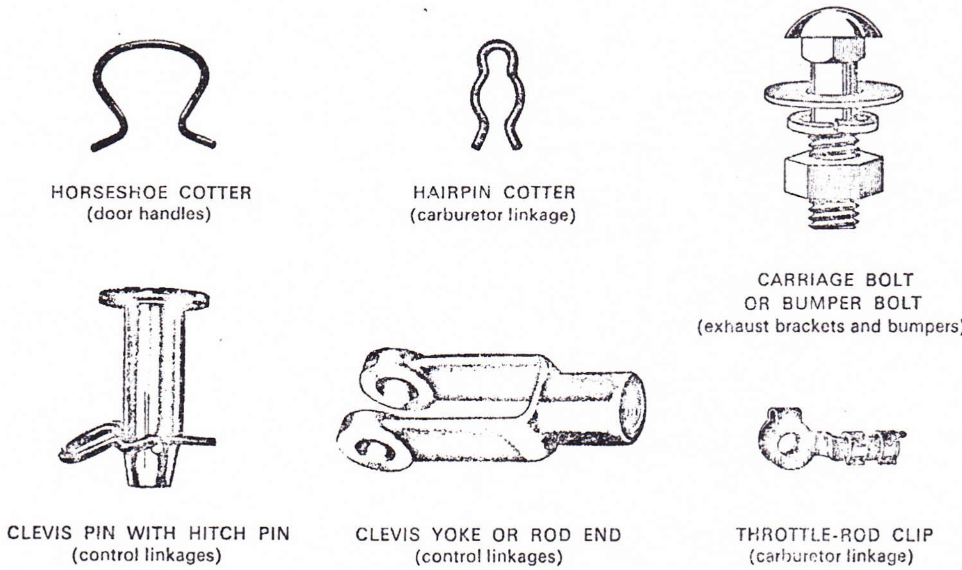

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Fig. 2:27 Miscellaneous Fasteners

Screw Threads and Fasteners

Many precision machined parts are useless until they are assembled into mechanical components. These assemblies require the use of many different types of fasteners. In this unit you will be introduced to different types of fasteners and their proper usage. One of the most fundamental tasks of the machinist is the use of fasteners. Threaded fasteners take on many different shapes and forms, but they all have one thing in common, the use of a thread. Although threads are used for adjustment purposes, measuring tool applications, and the transmission of power, the main use of a thread is as a fastening device.

Thread Terminology

Some of the more commonly used thread terms are:

Angle of Thread- The angle of the thread is the included angle between the sides of the thread (Figure 1). For example the thread angle for Unified Screw Thread forms is 60 degrees.

Major Diameter-Commonly known as the outside diameter (Figure 2). On a straight screw thread, the major diameter is the largest diameter of the thread on the screw or nut.

Minor Diameter-Commonly known as the root diameter (Figure 2). On a straight screw thread, the minor diameter is the smallest diameter of the thread on the screw or nut.

Number of Threads-Refers to the number of threads per inch of length.

Pitch-The distance from a given point on one thread to a corresponding point on the next thread (Figure 1)

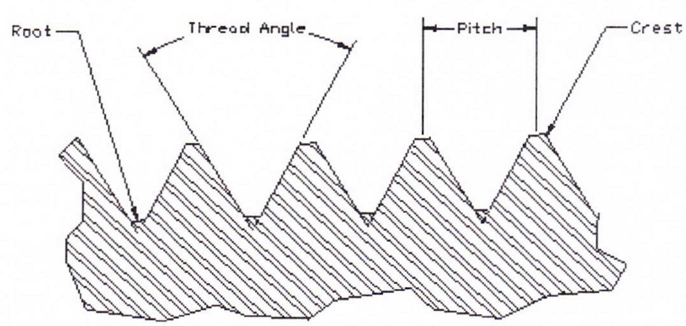


Figure 1. Major parts of a thread.

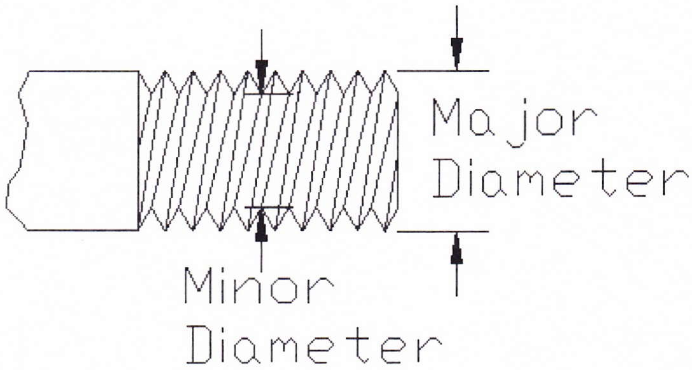


Figure 2. major parts of a thread.

Lead-The distance a screw thread advances in one revolution. The lead and the pitch of a single lead thread are the same. On double lead threads, the lead is twice the pitch. A double lead thread has two start points.

There are a great number of thread forms. In the later units of this course you will examine these in more detail and you will have the opportunity to cut some threads. As far as fasteners are concerned we will concentrate on the unified screw thread form. The unified thread form is an attempt to standardize thread forms in the United States, Canada, and Great Britain. Unified threads are divided into the following series.

- UNC Unified National Coarse
- UNF Unified National Fine
- UNS Unified National Special

Unified coarse and Unified fine refer to the number of threads per inch on fasteners. A specific diameter of bolt or nut will have a specific number of threads per inch of length. For example, a ¼-in. diameter unified national coarse bolt will have 20 threads per inch of length this bolt will be identified by the following specifications:

¼-20-UNC

The ¼ is the Major Diameter and the 20 is the number of threads per inch. A ¼ in diameter bolt with a fine thread would be identified by the following specifications:

¼-28-UNF

The ¼ is the Major Diameter and the 28 is the number of threads per inch.
The Unified Special Series are identified the same way. A ¼ inch diameter UNS bolt may

have 24 or 27 threads per inch.
You may wonder why there would be a need for UNC and UNF series threads. Here are some principles uses of coarse threads and fine thread.

COARSE THREAD SERIES

This series, UNC, is the one most commonly used in the mass production of bolts, screws, nuts and other general fastening applications. It is also used for threading into lower tensile strength materials (bronze, brass, aluminum, and plastics) to obtain the best resistance to stripping of the internal thread. It is also used on quick assembly or disassembly, or if corrosion or slight damage is possible.

FINE THREAD SERIES

This series, UNF, when used on external threads have greater tensile stress area than coarse threads of the same size. The fine series will resist stripping out better than coarse threads in areas where the external and mating internal threads are subjected to loads equal to or greater than the capacity of the screw or bolt. Fine threads are also used were the length of engagement is limited or where wall thickness demands a fine pitch.

UNIFIED SCREW THREADS									
Unified National Coarse (UNC)					Unified National Fine (UNF)				
Size of Screw	Threads per Inch	Major (Outside) Diameter of Thread	Tap Drill Size	Decimal Equivalent of Drill	Size of Screw	Threads per Inch	Major (Outside) Diameter of Thread	Tap Drill Size	Decimal Equivalent of Drill
					0	80	0.060	3/64	0.0469
1	64	0.073	53	0.0595	1	72	0.073	53	0.0595
2	56	0.086	50	0.0700	2	64	0.086	50	0.0700
3	48	0.099	47	0.0785	3	56	0.099	45	0.0820
4	40	0.112	43	0.0890	4	48	0.112	42	0.0935
5	40	0.125	38	0.1015	5	44	0.125	37	0.1040
6	32	0.138	36	0.1065	6	40	0.138	33	0.1130
8	32	0.164	29	0.1360	8	36	0.164	29	0.1360
10	24	0.190	25	0.1495	10	32	0.190	21	0.1590
12	24	0.216	16	0.1770	12	28	0.216	14	0.1820
1/4	20	0.250	7	0.2010	1/4	28	0.250	3	0.2130
5/16	18	0.3125	F	0.2570	5/16	24	0.3125	1	0.2720
3/8	16	0.375	5/16	0.3125	3/8	24	0.375	Q	0.3320
7/16	14	0.4375	U	0.3680	7/16	20	0.4375	25/64	0.3906
1/2	13	0.500	27/64	0.4219	1/2	20	0.500	29/64	0.4531
9/16	12	0.5625	31/64	0.4844	9/16	18	0.5625	33/64	0.5156
5/8	11	0.625	17/32	0.5312	5/8	18	0/625	37/64	0.5781
3/4	10	0.750	21/32	0.6562	3/4	16	0.750	11/16	0.6875
7/8	9	0.875	49/64	0.7656	7/8	14	0.875	13/16	0.8125
1"	8	1.000	7/8	0.875	1"	12	1.000	59/64	0.9219

Figure 3. Unified screw thread chart.

CLASSES OF THREAD FITS

Some thread applications can tolerate loose threads, while others require a tighter fit. An example of this would be the head of an engine. The head of your car or truck engine is held down by a threaded fastener called a stud. A stud is threaded on both ends. One end is threaded into the engine block. The other end uses a nut to tighten down the cylinder head. When the head is removed, you want the stud to remain in the engine block. This end requires a tighter fit than the end of the stud accepting the nut. If the fit on the nut is too tight, the stud will unscrew as the nut is removed.

Unified **thread fits** are classified as lA, 2A, 3A ... or 1B, 2B, 3B .... The A indicates an external thread. The B indicates an internal thread. The numbers indicate the class of fit. The lower the number the looser the fit and vice-versa. Class 2 fits are used on the largest percentage of threaded fasteners. The tighter the fit the closer the tolerance of the sizes of the thread and hence the more expensive to purchase. A typical notation of a unified thread form with fit tolerance would be:

¼-28 UNF 2A

In this particular case the class of fit would be a 2. The symbol A indicates an external thread.

METRIC THREADS

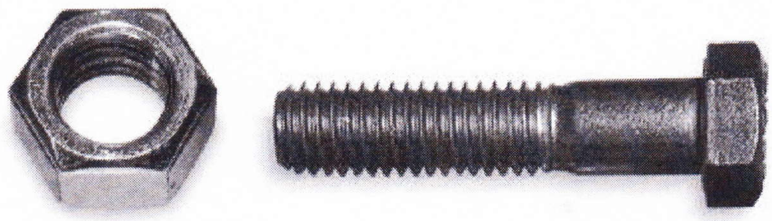
With the importation and exportation of goods, especially in the automotive industry, metric threads have become the prevalent thread type on many kinds of equipment. The metric thread form is similar to the unified thread form in that they are based on 60-degree thread angle. Metric thread series take the following form:

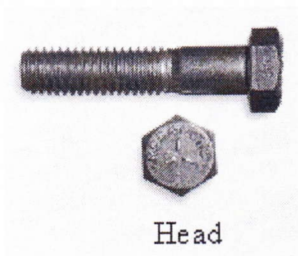
M10 X 1.5-6g

Where M is the major diameter in millimeters and the 1.5 is the pitch (distance from one thread to the next thread) 1.5 millimeters, the 6 is the class of fit and the g symbolizing external thread. This external thread would have a major diameter of 10 millimeters and a pitch of 1.5 millimeters and a "medium" thread fit.

THREAD FASTENER IDENTIFICATION

A general definition of a bolt is " an externally threaded fastener that is inserted through holes in an assembly." A bolt is tightened with a nut. (figure 4) A screw is an externally threaded fastener that is inserted into a threaded hole and is tightened by turning the head (Figure 4).





MACHINE BOLT MACHINE SCREW

Figure 4. A screw is used in a threaded hole while a bolt is used with a nut.

From these general definitions a bolt can become a screw or the reverse can be true. This depends on how they are used. Bolts and screws are the most common of threaded fasteners.

The strength of an assembly in large part depends on the diameter of the bolt or the thread engagement of the screw. Thread engagement is the distance a screw extends into the threaded hole. The minimum thread engagement should be a distance equal to the diameter used; preferably you would like to have 1-1/2 times the screw diameter, for it is easier to remove a broken stud than it is to drill and tap for a larger screw.

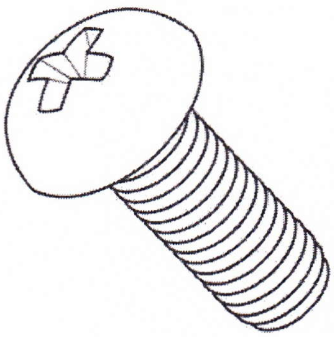
Machine Bolts are made with hexagonal or square heads.

The body diameter, the diameter of the unthreaded portion of the bolt below the head, is typically slightly larger than the nominal or standard size of the bolt. A hole that is to accept a bolt must be drilled slightly larger than the body diameter.

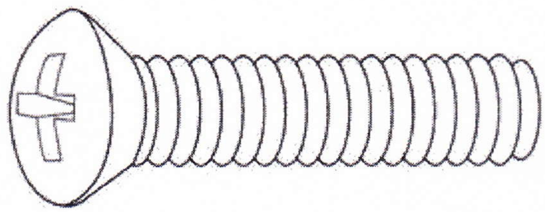
Machine Screws

The machine screw is used for general assembly work. It is manufactured in both fine and coarse thread series and fitted with either a slotted or recessed head.

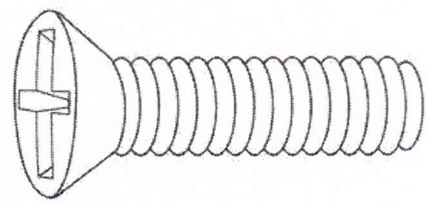
Machine screw sizes vary from No. 0(0.060) to ½ in(0.500) in diameter, and in many different lengths (Figure 5).



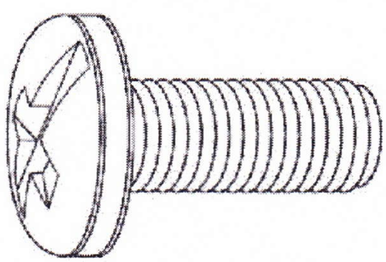
A - Round Head



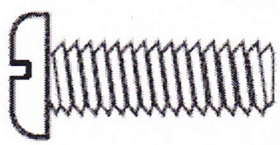
B - Oval Head



C - Flat Head



D - Fillister Head



E - Pan Head

Figure 5. Machine Screws. A-Round Head, B-Oval Head, C-Flat Head, D-Fillister Head, E-Pan Head.

Carriage bolts are used to fasten wood and metal parts together. Carriage bolts have round heads with a square body under the head. The square part of the bolt, when pulled into the wood, keeps it from turning while you tighten the nut (Figure 6).

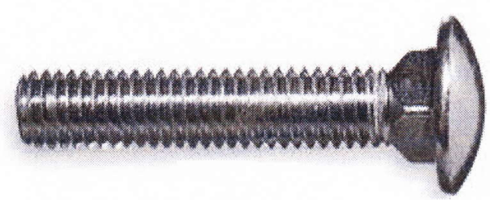


Figure 6. A carriage bolt.

Capscrews are made with a variety of different head shapes and are used where precision bolts or screws are needed. Capcrews are manufactured to close tolerences and have a finished appearance. Capscrews can have flatheads, round heads, fillister heads, socket head, hex heads (Figure 7).

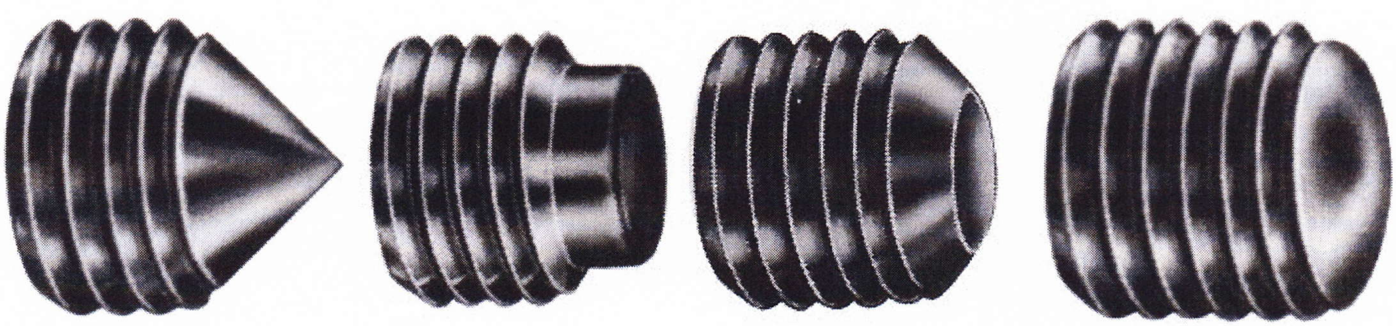
A-Flat Head | B-Round Head | C-Socket Head

Figure 7. Cap Screws.

Figure 8. Knurled point setscrew.

Set Screws are used to lock pulleys, collars, or shafts in place (Figure 8). Socket head set screws usually disappear below the surface of the part to be fastened. Socket head set screws may have hex socket heads or spline socket heads.

Set screws have several different points (Figure 9). The flat head set screws are used where minimal indentation to the part is needed and is used where frequent adjustments are- made. They are also used to provide a jam screw effect when a second set screw is added to prevent vibrating loose. A dog point set screw is used to hold a collar to a shaft. Alignment is always maintained with a dog point set screw because the shaft is drilled with a hole of the same diameter as the dog point. A cup pointed set screw will give a very good slip resistant connection.



Cone **Dog** **Flat** **Oval**

Figure 9. Points of Set Screws

Bolt Grades and Torque Factors

In some instances bolts need to be fastened with just the right amount of pressure, in these instances the manufacture of certain products, will recommend a certain clamping force be applied to a particular fastener. Insufficient torque will usually result in parts working loose and causing a malfunction due to misalignment. Over tightening, on the other hand, can cause stress or warpage which also might disturb alignment on assemblies. The "armstrong" method of tightening fasteners can also cause: broken castings, broken bolts, or stretching of the fastener.

Steel has excellent elasticity; the ability, like a spring to stretch and then snap back to its original shape. Any fastener must reach its limits of stretching in order to exert clamping force. But also like a spring, an over stretched fastener takes on set, loses its elasticity and cannot snap back to its original shape. Proper torquing will prevent this condition.

A popping or snapping sound is sometimes heard during the final tightening of a fastener. This popping sound indicates that the fastener is undergoing set. When a new fastener is being used and the popping occurs, the remedy is to back it off and retighten to the proper torguing specifications. When an old fastener is being used; and you here this popping, take the fastener out clean the bolt and the internal threads out completely. The safer, more economical thing to do is replace the old fastener with a new one.

Cap Screw Grades

Just as critical as proper torquing is the selection of the right grade of fastener for the job. The grades of bolts, or cap screws in the figure are identified by the markings on the heads. The grade indicates the strength of the fastener. Use a manufacturer's chart as a guide for the proper torque of fasteners.

Grade 2 **Grade 5** **Grade 8**

Figure 10. Grades of fasteners.

Nuts

Nuts utilize a hexagonal or square head and are used with bolts with the same shaped head. They are available in different degrees of finish.

REGULAR is un-machined (except for the threads)

REGULAR SEMIFINISHED is machined on the bearing face to provide a straight , flat surface for the washer.

HEAVY SEMIFINISHED the same in finish to the semi-finished; however, the body is thicker for greater strength.

CASTELLATED or **SLOTTED NUTS** have milled slot across the flats so the can be locked in place using a cotter pin or wire.

ACORN NUTS are used when appearance is of the most importance or where projecting threads must be protected.

WING NUTS are used when frequent adjustments or removal is necessary (Figure 11).

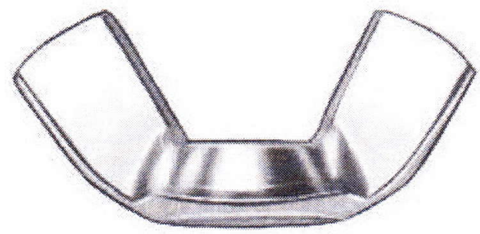


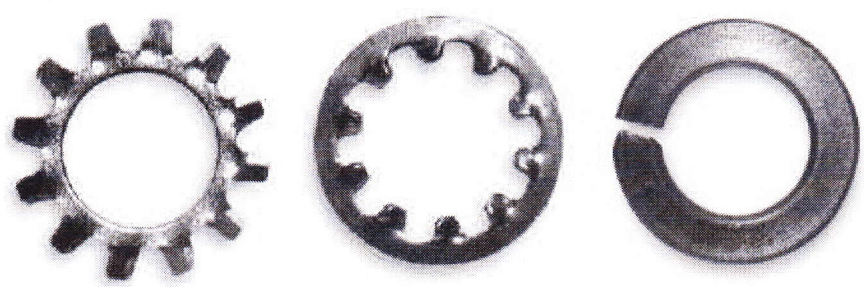
Figure 11. Wing nut

WASHERS

Washers are used to distribute the clamping pressure over a larger area, and prevent marring. They can also be used to provide a larger bearing surface for bolt heads and nuts.

Lock Washers

A lock washer is used to prevent a bolt or nut from loosening under vibration. There are many different types of lock washers, some of the more common lock washers are pictured in figure 12.



A-External **B-Internal** **C-Split**

Figure 12. Lock Washers

Non-threaded Fastening Devices

Non-threaded fasteners make up a large group of fastening devices.

Dowel Pins

Dowel Pins are made of treated alloy steel and are used in assemblies where parts must be accurately positioned and held in absolute relation to one another (Figure 13). They assure perfect alignment and facilitate quicker disassembly and assembly of parts in exact relationships.

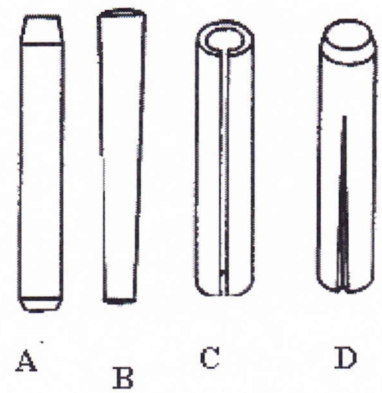


Figure 13. Dowel Pins. A-Straight, B-Tapered, C-Roll, D-Grooved.

Cotter Pins

Cotter pins are fitted into holes that are drilled crosswise in shafts to prevent parts from slipping or turning off (Figure 14).

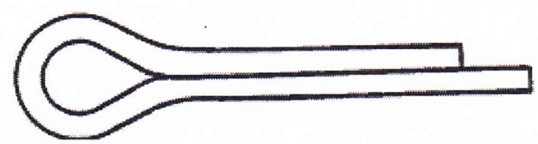


Figure 14. Cotter Pin.

Retaining Rings

Retaining rings are stamped rings, both internal and external, and are used to keep parts from slipping or sliding apart. While most retaining rings need a groove to seal them in position, some types are self locking and do not require the use of a recess.

Figure 15. Various Types of retaining(snap)Rings

Keys

A key is a small piece of metal imbedded partially in the shaft and partially in the hub to prevent rotation of a gear or pulley on a shaft. Here are some different types of keys.

SQUARE KEYS-The width is usually one fourth the shaft diameter. One half of the key is fitted into the shaft and one half is fitted into the hub(Figure 16).

GIB HEAD KEY-Except for the Gib Head, this key is identical to the square key. The gib head provides easy removal(Figure 16).

PRATT & WHITNEY KEY-The ends are rounded and this key is fitted into a slot on the shaft of the same shape (Figure 16).

WOODRUFF KEY-A woodruff key is sem-circular in shape and fits into a keyseat of the same shape. The top of the key fits into a keyway in the mating part (Figure 16).

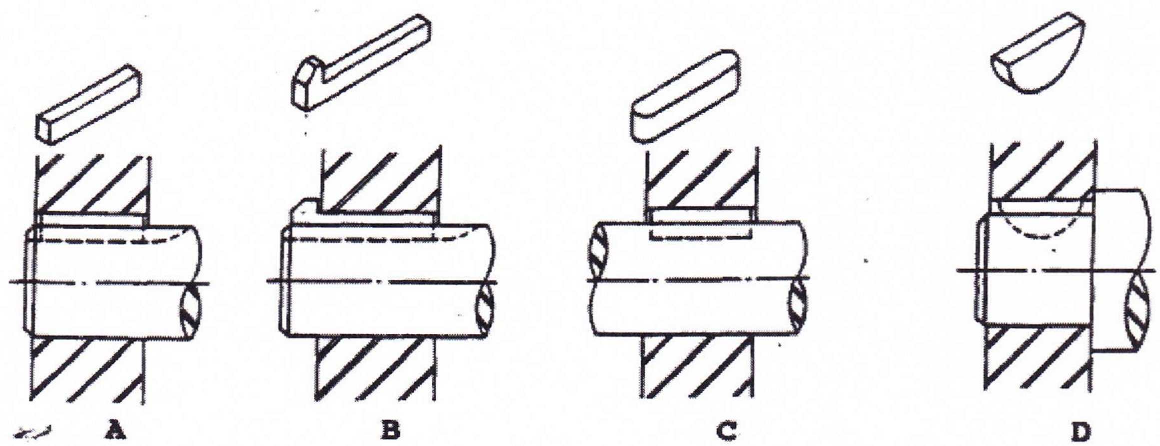


Figure 16. Keys. A-Square, B-Gib head, C-Pratt & Whitney, D-Woodruff.

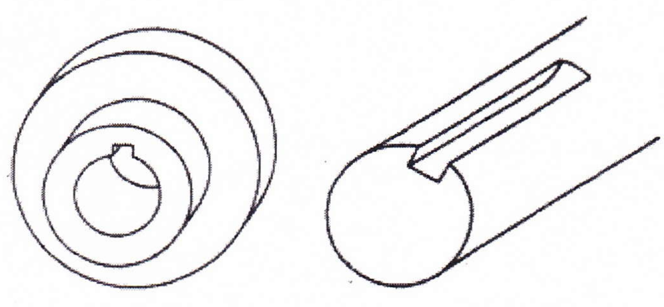


Figure 17. A keyway is broached into the hub of the part. A keyseat is machined in the shaft.