SECTION 3. BOLTS

7-34. GENERAL. "Hardware" is the term used to describe the various types of fasteners and small items used to assemble and repair aircraft structures and components. Only hardware with traceability to an approved manufacturing process or source should be used. This traceability will ensure that the hardware is at least equal to the original or properly-altered condition. Hardware that is not traceable or is improperly altered, may be substandard or counterfeit, since their physical properties cannot be substantiated. Selection and use of fasteners are as varied as the types of aircraft; therefore, care should be taken to ensure fasteners are approved by the Federal Aviation Administration (FAA) for the intended installation, repair, or replacement. Threaded fasteners (bolts/screws) and rivets are the most commonly used fasteners because they are designed to carry shear and/or tensile loads.

7-35. BOLTS. Most bolts used in aircraft structures are either general-purpose, internal-wrenching, or close-tolerance AN, NAS, or MS bolts. In certain cases, fastener manufacturers produce bolts of different dimensions or greater strength than the standard types. *Such bolts are made for a particular application, and it is of extreme importance to use like bolts in replacement.* Design specifications are available in MIL-HDBK-5 or USAF/Navy T.O. 1-1A-8/NAVAIR 01-1A-8. References should be made to military specifications and industry design standards such as NAS, the Society of Automotive Engineers (SAE), and Aerospace Material Standards (AMS). Typical bolt types are shown in table 7-12.

7-36. IDENTIFICATION. Aircraft bolts may be identified by code markings on the bolt heads. These markings generally denote the material of which the bolt is made, whether the bolt is a standard AN-type or a special-purpose bolt, and sometimes include the manufacturer.

a. AN standard steel bolts are marked with either a raised dash or asterisk, corrosion-resistant steel is marked by a single dash, and AN aluminum-alloy bolts are marked with two raised dashes.

b. Special-purpose bolts include high-strength, low-strength, and close-tolerance types. These bolts are normally inspected by magnetic particle inspection methods. Typical markings include "SPEC" (usually heat-treated for strength and durability), and an aircraft manufacturer's part number stamped on the head. Bolts with no markings are low strength. Close-tolerance NAS bolts are marked with either a raised or recessed triangle. The material markings for NAS bolts are the same as for AN bolts, except they may be either raised or recessed. Bolts requiring non-destructive inspection (NDI) by magnetic particle inspection are identified by means of colored lacquer, or head markings of a distinctive type. (See figure 7-1.)

7-37. GRIP LENGTH. In general, bolt grip lengths of a fastener is the thickness of the material the fastener is designed to hold when two or more parts are being assembled. Bolts of slightly greater grip length may be used, provided washers are placed under the nut or bolthead. The maximum combined height of washers that should be used is 1/8 inch. This limits the use of washers necessary to compensate for grip, up to the next standard grip size. Over the years, some fasteners specifications have been changed. For this reason, it is recommended when making repairs to an aircraft, whose original hardware is being replaced, that you must first measure the bolt before ordering, rather than relying on the parts manual for

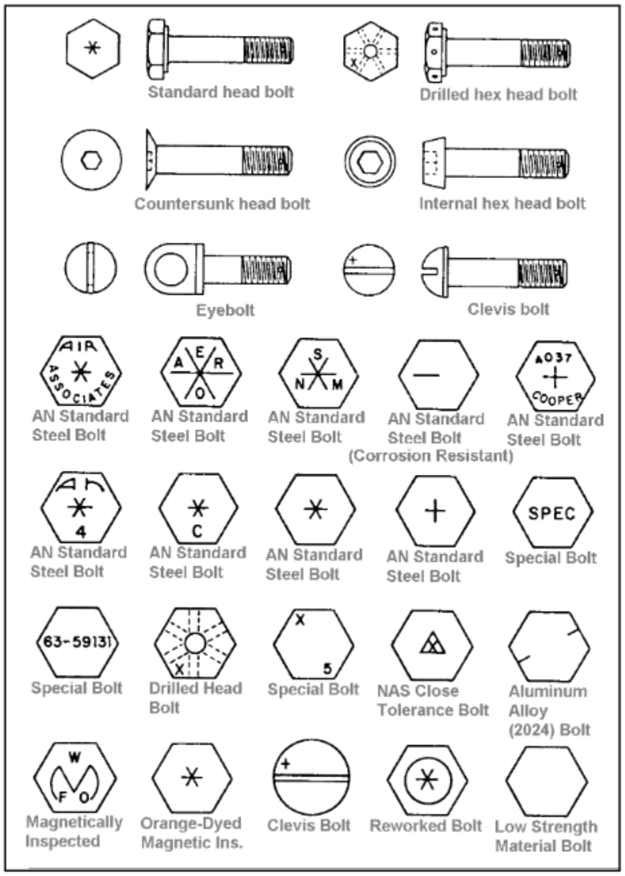

FIGURE 7-1. Typical aircraft bolt markings.

identification. In the case of plate nuts, if proper bolt grip length is not available, add shims under the plate. All bolt installations which involve self-locking or plain nuts should have at least one thread of the bolt protruding through the nut.

7-38. LOCKING OR SAFETYING OF BOLTS. Lock or safety all bolts and/or nuts, except self-locking nuts. Do not reuse cotter pins or safety wire.

7-39. BOLT FIT. Bolt holes, particularly those of primary connecting elements, have close tolerances. Generally, it is permissible to use the first-lettered drill size larger than the nominal bolt diameter, except when the AN hexagon bolts are used in light-drive fit (reamed) applications and where NAS close-tolerance bolts or AN clevis bolts are used. A light-drive fit can be defined as an interference of 0.0006 inch for a 5/8 inch bolt. Bolt holes should be flush to the surface, and free of debris to provide full bearing surface for the bolt head and nut. In the event of over-sized or elongated holes in structural members, reaming or drilling the hole to accept the next larger bolt size may be permissible. Care should be taken to ensure items, such as edge distance, clearance, and structural integrity are maintained. Consult the manufacturer's structural repair manual, the manufacturer's engineering department, or the FAA before drilling or reaming any bolt hole in a critical structural member.

7-40. TORQUES. The importance of correct torque application cannot be overemphasized. Undertorque can result in unnecessary wear of nuts and bolts, as well as the parts they secure. Overtorque can cause failure of a bolt or nut from overstressing the threaded areas. Uneven or additional loads that are applied to the assembly may result in wear or premature failure. The following are a few simple, but important procedures, that should be followed to ensure that correct torque is applied.

NOTE: Be sure that the torque applied is for the size of the bolt shank not the wrench size.

a. Calibrate the torque wrench at least once a year, or immediately after it has been abused or dropped, to ensure continued accuracy.

b. Be sure the bolt and nut threads are clean and dry, unless otherwise specified by the manufacturer.

c. Run the nut down to near contact with the washer or bearing surface and check the friction drag torque required to turn the nut. Whenever possible, apply the torque to the nut and not the bolt. This will reduce rotation of the bolt in the hole and reduce wear.

d. Add the friction drag torque to the desired torque. This is referred to as "final torque," which should register on the indicator or setting for a snap-over type torque wrench.

e. Apply a smooth even pull when applying torque pressure. If chattering or a jerking motion occurs during final torque, back off the nut and retorque.

NOTE: Many applications of bolts in aircraft/engines require stretch checks prior to reuse. This requirement is due primarily to bolt stretching caused by overtorquing.

f. When installing a castle nut, start alignment with the cotter pin hole at the minimum recommended torque plus friction drag torque.

NOTE: Do not exceed the maximum torque plus the friction drag. If the hole and nut castellation do not align, change washer or nut and try again. Exceeding the maximum recommended torque is not recommended.

g. When torque is applied to bolt heads or capscrews, apply the recommended torque plus friction drag torque.

h. If special adapters are used which will change the effective length of the torque wrench, the final torque indication or wrench setting must be adjusted accordingly. Determine the torque wrench indication or setting with adapter installed as shown in figure 7-2.

i. Table 7-1 shows the recommended torque to be used when specific torque is not supplied by the manufacturer. The table includes standard nut and bolt combinations, currently used in aviation maintenance. For further identification of hardware, see chapter 7, section 11.

7-41. STANDARD AIRCRAFT HEX HEAD BOLTS (AN3 THROUGH AN20). These are all-purpose structural bolts used for general applications that require tension or shear loads. Steel bolts smaller than No. 10-32, and aluminum alloy bolts smaller than 1/4 inch diameter, should not be used in primary structures. Do not use aluminum bolts or nuts in applications requiring frequent removal for inspection or maintenance.

7-42. DRILLED HEAD BOLTS (AN73 THROUGH AN81). The AN drilled head bolt is similar to the standard hex bolt, but has a deeper head which is drilled to receive safety wire. The physical differences preventing direct interchangeability are the slightly greater head height, and longer thread length of the AN73 through AN81 series. The AN73 through AN81 drilled head bolts have been superseded by MS20073, for fine thread bolts and MS20074 for coarse thread bolts. AN73, AN74, MS20073, and MS20074 bolts of like thread and grip lengths are universally, functionally, and dimensionally interchangeable.

7-43. ENGINE BOLTS. These are hex head bolts (AN101001 through AN101900), drilled shank hex head bolts (AN101901 through AN102800), drilled hex head (one hole) bolts (AN102801 through AN103700), and drilled hex head (six holes) bolts (AN103701 through AN104600). They are similar to each other except for the holes in the head and shank. Hex head bolts (AN104601 through AN105500), drilled shank hex head bolts (AN105501 through AN106400), drilled hex head (one hole) bolts (AN106401 through AN107300), and drilled hex head (six holes) bolts (AN107301 through AN108200) are similar to the bolts described in paragraph 7-42, except that this series is manufactured from corrosion-resistant steel.

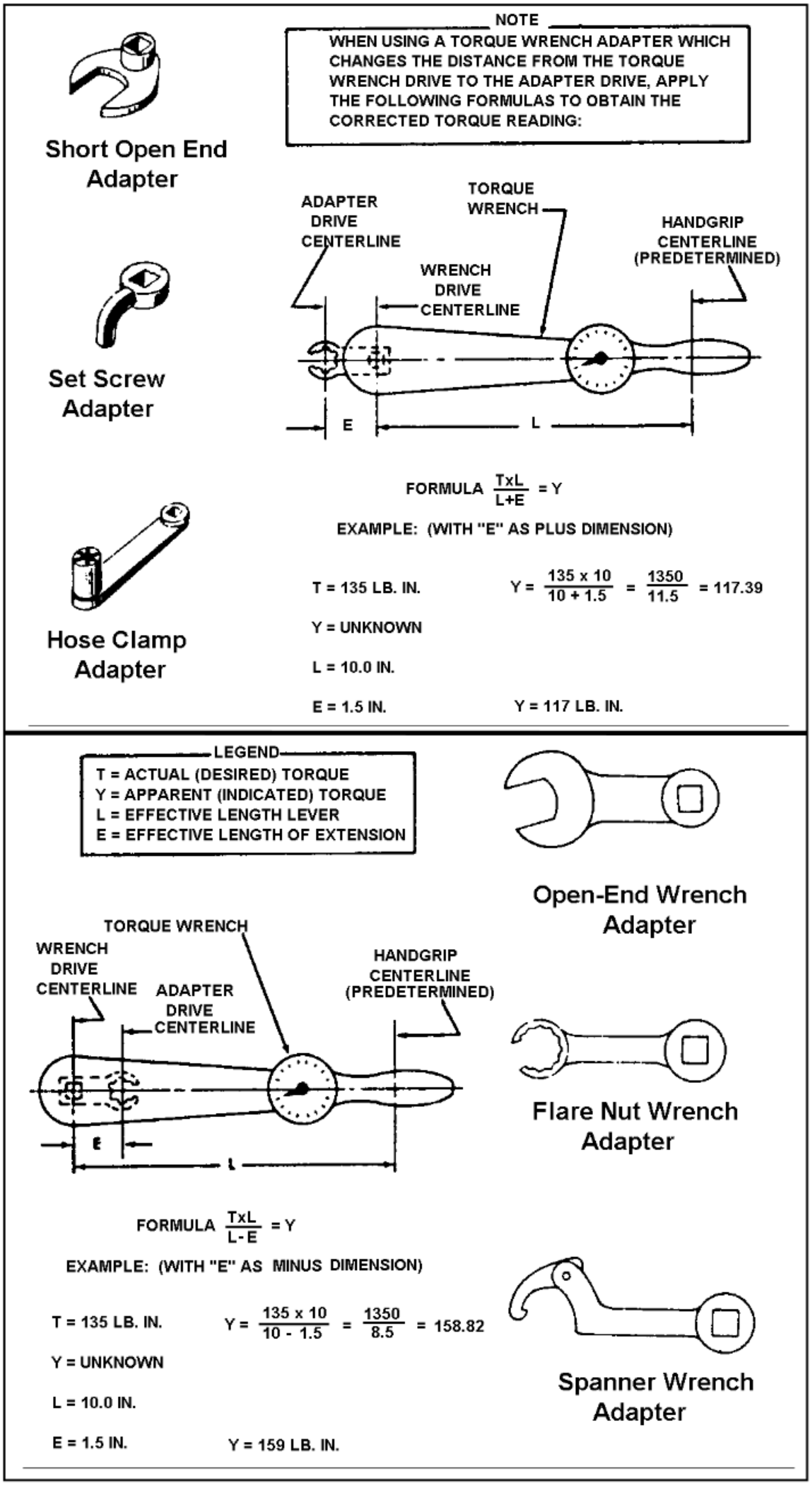

FIGURE 7-2. Torque wrench with various adapters.

TABLE 7-1. Recommended torque values (inch-pounds).

CAUTION THE FOLLOWING TORQUE VALUES ARE DERIVED FROM OIL FREE CADMIUM PLATED THREADS.				
	TORQUE LIMITS RECOMMENDED FOR INSTALLATION (BOLTS LOADED PRIMARILY IN SHEAR)		**MAXIMUM ALLOWABLE TIGHTENING TORQUE LIMITS**	
Thread Size	Tension type nuts MS20365 and AN310 (40,000 psi in bolts)	Shear type nuts MS20364 and AN320 (24,000 psi in bolts)	Nuts MS20365 and AN310 (90,000 psi in bolts)	Nuts MS20364 and AN320 (54,000 psi in bolts)
FINE THREAD SERIES				
8-36	12-15	7-9	20	12
10-32	20-25	12-15	40	25
1/4-28	50-70	30-40	100	60
5/16-24	100-140	60-85	225	140
3/8-24	160-190	95-110	390	240
7/16-20	450-500	270-300	840	500
1/2-20	480-690	290-410	1100	660
9/16-18	800-1000	480-600	1600	960
5/8-18	1100-1300	600-780	2400	1400
3/4-16	2300-2500	1300-1500	5000	3000
7/8-14	2500-3000	1500-1800	7000	4200
1-14	3700-5500	2200-3300*	10,000	6000
1-1/8-12	5000-7000	3000-4200*	15,000	9000
1-1/4-12	9000-11,000	5400-6600*	25,000	15,000
COARSE THREAD SERIES				
8-32	12-15	7-9	20	12
10-24	20-25	12-15	35	21
1/4-20	40-50	25-30	75	45
5/16-18	80-90	48-55	160	100
3/8-16	160-185	95-100	275	170
7/16-14	235-255	140-155	475	280
1/2-13	400-480	240-290	880	520
9/16-12	500-700	300-420	1100	650
5/8-11	700-900	420-540	1500	900
3/4-10	1150-1600	700-950	2500	1500
7/8-9	2200-3000	1300-1800	4600	2700
The above torque values may be used for all cadmium-plated steel nuts of the fine or coarse thread series which have approximately equal number of threads and equal face bearing areas. * Estimated corresponding values.				

7-44. CLOSE-TOLERANCE BOLTS. Close-tolerance, hex head, machine bolts (AN173 through AN186), 100-degree countersunk head, close-tolerance, high-strength bolts (NAS333 through NAS340), hex head, close-tolerance, short thread, titanium alloy bolts (NAS653 through NAS658), 100-degree countersunk flathead, close-tolerance titanium alloy bolts (NAS663 through NAS668), and drilled hex head close-tolerance titanium alloy bolts (NAS673 through NAS678), are used in applications where two parts bolted together are subject to severe load reversals and vibration. Because of the interference fit, this type of bolt may require light tapping with a mallet to set the bolt shank into the bolt hole.

NOTE: Elimination of friction in interference fit applications may sometimes be attained by placing the bolt in a freezer prior to installation. When this procedure is used, the bolt should be allowed to warm up to ambient temperature before torquing.

CAUTION: Caution must be exercised in the use of close-tolerance bolts for all critical applications, such as

landing gear, control systems, and helicopter rotary controls. Do not substitute for close-tolerance fasteners without specific instructions from the aircraft manufacturer or the FAA.

7-45. INTERNAL WRENCHING BOLTS (NAS144 THROUGH NAS158 AND NAS172 THROUGH NAS176). These are high-strength bolts used primarily in tension applications. Use a special heat-treated washer (NAS143C) under the head to prevent the large radius of the shank from contacting only the sharp edge of the hole. Use a special heat-treated washer (NAS143) under the nut.

7-46. INTERNAL WRENCHING BOLTS (MS20004 THROUGH MS20024) AND SIX HOLE, DRILLED SOCKET HEAD BOLTS (AN148551 THROUGH AN149350). These are very similar to the bolts in paragraph 7-45, except these bolts are made from different alloys. The NAS144 through NAS158 and NAS172 through NAS176 are interchangeable with MS20004 through MS20024 in the same thread configuration and grip lengths. The AN148551 through AN149350 have been superseded by MS9088 through MS9094 with the exception of AN149251 through 149350, which has no superseding MS standard.

7-47. TWELVE POINT, EXTERNAL WRENCHING BOLTS, (NAS624 THROUGH NAS644). These bolts are used primarily in high-tensile, high-fatigue strength applications. The twelve point head, heat-resistant machine bolts (MS9033 through MS9039), and drilled twelve point head machine bolts (MS9088 through MS9094), are similar to the (NAS624 through NAS644); but are made from different steel alloys, and their shanks have larger tolerances.

7-48. CLOSE-TOLERANCE SHEAR BOLTS (NAS464). These bolts are designed for use where stresses normally are in shear only. These bolts have a shorter thread than bolts designed for torquing.

7-49. NAS6200 SERIES BOLTS. These are close tolerance bolts and are available in two oversized diameters to fit slightly elongated holes. These bolts can be ordered with an "X" or "Y" after the length, to designate the oversized grip portion of the bolt (i.e., NAS6204-6X for a 1/4 inch bolt with a 1/64 inch larger diameter). The elongated hole may have to be reamed to insure a good fit.

7-50. CLEVIS BOLTS (AN21 THROUGH AN36). These bolts are only used in applications subject to shear stress, and are often used as mechanical pins in control systems.

7-51. EYEBOLTS (AN42 THROUGH AN49). These bolts are used in applications where external tension loads are to be applied. The head of this bolt is specially designed for the attachment of a turnbuckle, a clevis, or a cable shackle. The threaded shank may or may not be drilled for safetying.

7-52.– 7-62. [RESERVED.]

SECTION 4. NUTS

7-63. GENERAL. Aircraft nuts are available in a variety of shapes, sizes, and material strengths. The types of nuts used in aircraft structures include castle nuts, shear nuts, plain nuts, light hex nuts, checknuts, wingnuts, and sheet spring nuts. Many are available in either self-locking or nonself-locking style. Typical nut types are shown in table 7-13. Refer to the aircraft manufacturer's structural repair manual, the manufacturer's engineering department, or the FAA, before replacing any nut with any other type.

7-64. SELF-LOCKING NUTS. These nuts are acceptable for use on certificated aircraft subject to the aircraft manufacturer's recommended practice sheets or specifications. Two types of self-locking nuts are currently in use, the all-metal type, and the fiber or nylon type.

a. DO NOT use self-locking nuts on parts subject to rotation.

b. Self-locking castellated nuts with cotter pins or lockwire may be used in any system.

c. Self-locking nuts should not be used with bolts or screws on turbine engine airplanes in locations where the loose nut, bolt, washer, or screw could fall or be drawn into the engine air intake scoop.

d. Self-locking nuts should not be used with bolts, screws, or studs to attach access panels or doors, or to assemble any parts that are routinely disassembled before, or after each flight. They may be used with anti-friction bearings and control pulleys, provided the inner race of the bearing is secured to the supporting structure by the nut and bolt.

e. Metal locknuts are constructed with either the threads in the locking insert, out-of-round with the load-carrying section, or with a saw-cut insert with a pinched-in thread in the locking section. The locking action of the all-metal nut depends upon the resiliency of the metal when the locking section and load-carrying section are engaged by screw threads. Metal locknuts are primarily used in high temperature areas.

f. Fiber or nylon locknuts are constructed with an unthreaded fiber or nylon locking insert held securely in place. The fiber or nylon insert provides the locking action because it has a smaller diameter than the nut. Fiber or nylon self-locking nuts are not installed in areas where temperatures exceed 250 °F. After the nut has been tightened, make sure the bolt or stud has at least one thread showing past the nut. DO NOT reuse a fiber or nylon locknut, if the nut cannot meet the minimum prevailing torque values. (See table 7-2.)

g. Self-locking nut plates are produced in a variety of forms and materials for riveting or welding to aircraft structures or parts. Certain applications require the installation of self-locking nuts in channel arrangement permitting the attachment of many nuts in a row with only a few rivets.

7-65. NUT IDENTIFICATION FINISHES. Several types of finishes are used on self-locking nuts. The particular type of finish is dependent on the application and temperature requirement. The most commonly used finishes are described briefly as follows.

TABLE 7-2. Minimum prevailing torque values for re-used self-locking nuts.

FINE THREAD SERIES	
THREAD SIZE	MINIMUM PREVAILING TORQUE
7/16 - 20	8 inch-pounds
1/2 - 20	10 inch-pounds
9/16 - 18	13 inch-pounds
5/8 -18	18 inch-pounds
3/4 - 16	27 inch-pounds
7/8 - 14	40 inch-pounds
1 - 14	55 inch-pounds
1-1/8 - 12	73 inch-pounds
1-1/4 - 12	94 inch-pounds
COARSE THREAD SERIES	
THREAD SIZE	MINIMUM PREVAILING TORQUE
7/16 - 14	8 inch-pounds
1/2 - 13	10 inch-pounds
9/16 - 12	14 inch-pounds
5/8 - 11	20 inch-pounds
3/4 - 10	27 inch-pounds
7/8 - 9	40 inch-pounds
1 - 8	51 inch-pounds
1-1/8 - 8	68 inch-pounds
1-1/4 - 8	88 inch-pounds

a. Cadmium-Plating. This is an electrolytically deposited silver-gray plating which provides exceptionally good protection against corrosion, particularly in salty atmosphere, but is not recommended in applications where the temperature exceeds 450 °F. The following additional finishes or refinements to the basic cadmium can be applied.

(1) Chromic Clear Dip. Cadmium surfaces are passivated, and cyanide from the plating solution is neutralized. The protective film formed gives a bright, shiny appearance, and resists staining and finger marks.

(2) Olive Drab Dichromate. Cadmium-plated work is dipped in a solution of chromic acid, nitric acid, acetic acid, and a dye which produces corrosion resistance.

(3) Iridescent Dichromate. Cadmium-plated work is dipped in a solution of sodium dichromate and takes on a surface film of basic chromium chromate which resists corrosion. Finish is yellow to brown in color.

NOTE: Cadmium-plated nuts are restricted for use in temperatures not to exceed 450 °F. When used in temperatures in excess of 450 °F, the cadmium will diffuse into the base material causing it to become very brittle and subject to early failure.

b. Silver plating. Silver plating is applied to locknuts for use at higher temperatures. Important advantages are its resistance to extreme heat (1,400 °F) and its excellent lubricating characteristics. Silver resists galling and seizing of mating parts when subjected to heat or heavy pressure.

c. Anodizing for Aluminum. An inorganic oxide coating is formed on the metal by connecting the metals and anodes in a suitable electrolyte. The coating offers excellent corrosion resistance and can be dyed in a number of colors.

d. Solid Lubricant Coating. Locknuts are also furnished with molybdenum disulfide for lubrication purposes. It provides a clean, dry, permanently-bonded coating to prevent seizing and galling of threads. Molybdenum disulfide is applied to both cadmium and silver-plated parts. Other types of finishes are available, but the finishes described in this chapter are the most widely used.

7-66. CASTLE NUT (AN310). The castle nut is used with drilled shank hex head bolts, clevis bolts, drilled head bolts, or studs that are subjected to tension loads. The nut has slots or castellations cut to accommodate a cotter pin or safety wire as a means of safetying.

7-67. CASTELLATED SHEAR NUT (AN320). The castellated shear nut is designed for use with hardware subjected to shear stress only.

7-68. PLAIN NUT (AN315 AND AN335). The plain nut is capable of withstanding large tension loads; however, it requires an auxiliary locking device, such as a checknut or safety wire. Use of this type on aircraft structures is limited.

7-69. LIGHT HEX NUTS (AN340 AND AN345). These nuts are used in nonstructural applications requiring light tension. Like the AN315 and AN335, they require a locking device to secure them.

7-70. CHECKNUT (AN316). The checknut is used as a locking device for plain nuts, screws, threaded rod ends, and other devices.

7-71. WINGNUTS (AN350). The wingnut is used where the desired torque is obtained by use of the fingers or handtools. Wingnuts are normally drilled to allow safetying with safety wire.

7-72. SHEET SPRING NUTS (AN365). Sheet spring nuts are commonly called speed nuts. They are used with standard and sheet metal self-tapping screws in nonstructural applications. They are used to support line and conduit clamps, access doors, etc. Their use should be limited to applications where they were originally used in assembly of the aircraft.

7-73. 7-84. RESERVED.