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NAVAL SHIPS TECHNICAL MANUAL

CHAPTER 9090

LOCKING PROCEDURES AND TORQUE WRENCHES FOR THREADED FASTENERS

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NAVAL SHIP SYSTEMS COMMAND, WASHINGTON, D. C. 20360

NAVAL SHIPS TECHNICAL MANUAL

CHAPTER 9090 – LOCKING PROCEDURES AND TORQUE WRENCHES FOR THREADED FASTENERS

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9090.1 GENERAL

The importance of the proper locking of fasteners such as nuts, bolts, screws, plugs, and hose fittings cannot be overemphasized in naval use. Many shipboard machinery casualties now result because a locking device was not installed or was installed incorrectly at time of last assembly. Major consequential damage has occurred many times because of a loose bolt or nut in the system. On land, fasteners are subject to the loosening effects of machinery vibration, and thermal expansion and contraction. Even the normal daily temperature changes make a measurable difference in the clamping forces of nuts and bolts. The heat produced by the machinery increases these differences. At sea, such loosening effects are aggravated by stresses caused by the roll and pitch of the ship. The vibrations transmitted by the less firm foundation of the ship's hull are intensified by the quantities of various types of machinery found on board. Further, shock loads are encountered through operation in heavy seas, from firing of ship's guns and, in combat, from near misses.

9090.2 SCOPE

This chapter covers the use of lock nuts, lock bolts, lock washers, set screws, tablocks, lock pins, safety wiring, staking, the selection of the thread locking coatings and torquing. The selection of the **proper** locking device to be used must be made by the equipment designer and will be found in the parts lists, drawing, and/or equipment manual.

9090.3 TORQUING

Proper torque aids the locking of all types of thread locking fasteners. After tightening, nuts or bolts are held by the static friction of the nut and bolt head against the surface of the items being held together and the friction on the threads of the nut and bolt against each other. This friction is caused by the clamping force created by a slight stretching of the bolt when the nut is tightened. The metal being slightly elastic will pull back towards its original dimensions creating large clamping forces. Excessive tightening will cause the metal to pass its limit of elasticity and cause a permanent stretch. Because of that effect, overtorquing will actually result in lesser frictional forces and more likelihood of the bolt loosening. In addition, the overstretched bolt is weaker and more likely to break from vibration and thermal expansion. Undertorquing also results in low frictional forces and the likelihood of loosening. Since surface undulations, burrs, and poor mating surfaces of the threads can affect the torque materially, all threads should be inspected for cleanliness and burrs before torquing.

Because different metals have their own limits of elasticity, the torque tables at the end of this chapter should only be used for the metal indicated. Further, since variations in pressures on flanges, temperatures of equipment and the material of the bolts or screws make significant differences in the stretching of the bolt, the tables are superseded whenever the equipment manufacturer's technical manual, or other manuals designate specific torques or methods of torquing for a specific application. In all cases of high pressure flanges and hull fittings, the NAVSHIPS drawings should be consulted.

Both the nut and bolt threads should be evenly and lightly coated with a light lubricant or antiseize compound. Antiseize should be used whenever a nut or bolt is installed in a high temperature area.

> **NOTE:** As some antiseize compounds become corrosive under heat (graphite will attack stainless steel, and molybdenum disulfide corrodes silver), always use the antiseize compound recommended in the applicable manuals.

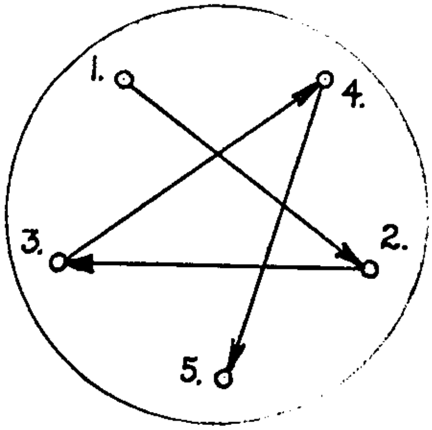
Any fasteners with damaged threads should be discarded. Failure to comply with such pre-torquing requirements will result in an inaccurate torque measurement. When studs or cap screws are to be torqued into blind holes, the holes should be clean and excessive lubricant or antiseize should be removed. Pressures transmitted by excessive lubricants or other materials at the bottom of blind holes can crack metal parts.

All bolts in an assembly should be installed and snugged up before torquing. Final torque to all bolts in any one flange or assembly should always be done by one person. When using a torque wrench or any other method of torque that may be specified (such as measurement of the length of the bolt before and after installation to get a predetermined stretch or snugging up the nut and then turning an added half or three quarter turn) the only method of ensuring an even torque is to allow only one person to do the measurement and final turn.

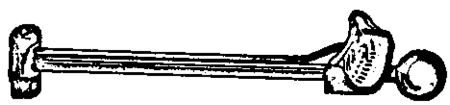
Torque should be applied slowly and evenly until the specified torque is reached. When installing a unit which is circular or has more than one side, the bolts should be cross torqued as shown below. It may be necessary to cross torque two or three times before an even torque is reached, but be sure the maximum torque is not exceeded. Torquing one side first could distort or even crack a flange or casing.

The torque wrench should be calibrated frequently. The flat and round beam types will normally give true readings as long as their pointers indicate zero and the drive heads are tight. Because that type can be kept in calibration they are recommended for shipboard use.

Other type wrenches that indicate by means of a dial indicator, or by releasing or signaling when a preset load is reached are more sensitive to shock and dirt, hence

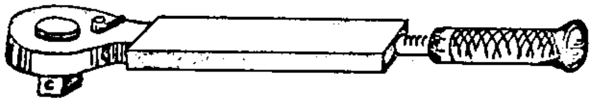


Cross tighten.



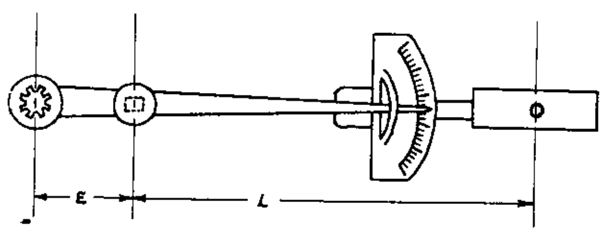
Double round beam.

should be recalibrated whenever possible. A minimum of thirty days between calibrations is recommended. Never check one torque wrench against another.



Toggle.

When using a crows foot or any other extension, calculate the torque to be read by the following equation and drawing.

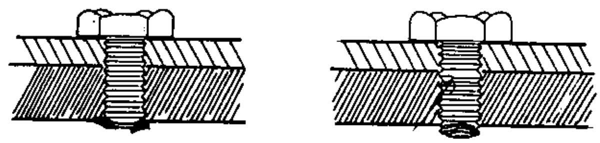


$$R = \frac{L \times T}{L + E}$$

R = Indicated Torque
T = Desired Torque

NOTE: Always inspect for clean lightly oiled threads and clean surfaces before torquing. Discard all hardware with burred threads.

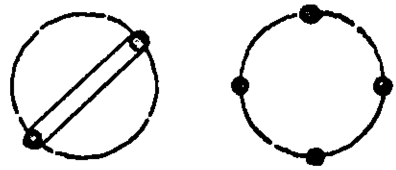
9090.4 STAKING AND PEENING



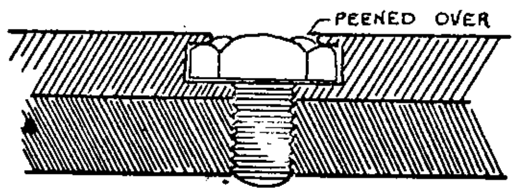
Staked points.

Staking includes the forcing of material from a working surface into the threads or head of a screw or stud, or the forcing of material from the head into the working surface, and deformation of threads by means of a punch. Peening is a means of locking a recessed screw or bolt by forcing some of the material of the working surface over the head preventing it from backing out.

Generally the screw, stud, or bolt should be staked or peened in four points around the circumference. The total staked area should be about one third of the circumference. This allows at least two subsequent removals and reinstallations.



Staked head.



Peened recess.

To force material of the working surface into the fastener or fastener material into the working surface or both, the punch should be placed at approximately a 45° angle in a direction to increase torque if the fastener should turn. The fastener or working surface must be deformed sufficiently to be forced into the other surface in order to prevent the screw from turning.

NOTE: Staking requires careful inspection of the results. The fact that material has been deformed does not necessarily mean that the material has been pushed into the threads. Double check that this has happened.

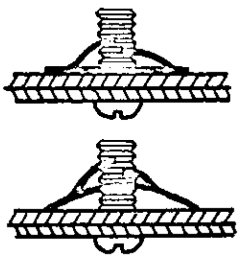
Countersunk screws may be staked by forcing material from the working surface into the drive slots. A good lock is obtainable even though only two points are staked.

Headless set screws may be staked by using a center punch directly in the center of the screw, forcing the end threads outward. This can only be done when the head is flush or below the surface of the surrounding material. The deformation of the threads prevents the screw from backing out. This method can also be used on bolts or capscrews when they are threaded into a flange with the bolt hole completely through and the opposite side (threaded side) reachable.

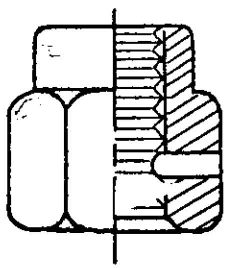
Center staking of set screws and capscrews is especially applicable when the set screw or cap screw is threaded into a brittle material such as cast aluminum. The deformation of the material of the screw is not likely to cause damage, while trying to deform the material of the working surface at the edge of the screw might crack brittle material. Check that the deformation actually occurs, as many types of set screws are case hardened and cannot be deformed sufficiently to lock.

9090.5 LOCKNUTS

Types of locknuts in common use include nylon insert nuts, spring beam nuts, distorted collar and distorted thread nuts, jam nuts and spring nuts (other than the spring beam type).



Spring nut.

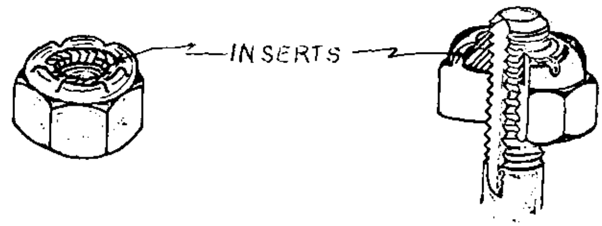


Nylon plug.

Nylon insert nuts deform the nylon insert when they are screwed on. The resilient material is forced to assume the exact shape of the bolt threads. The nylon's elasticity puts pressure on both sides of the bolt thread creating large frictional forces. Nylon plugs which do not extend completely around the circumference tend to force the nut to the side cocking it slightly. This produces frictional forces on one side of the bolt thread. Although both types will lock without seating, applying the proper torque to the nut stretches the bolt creating clamping forces that add to the locking abilities of the nut. For positive torquing, use the torque values listed for self-locking nuts. Torque locknuts to the maximum value given for their size.

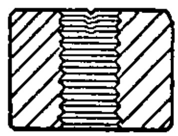
Nylon inserts do not deform the bolt thread hence they are used when frequent removal may be necessary. Before reusing, check the inserts. If worn or torn discard the nut. Install the nut (on clean lightly oiled threads) finger tight. If the nut can be installed to the point where the bolt threads pass the insert without a wrench, discard the nut and use a new one. Nylon inserts should not be used in areas where the temperature may be higher than 250° F. in transient conditions or 180° F. during continuous operation.

Distorted collar, distorted thread, and spring beam locknuts are all called steel self-locking nuts. Distorted collar and distorted thread nuts tend to deform the threads of the bolt. As this deformation may weaken the bolt threads they

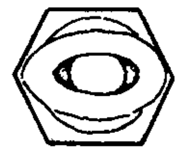


Nylon inserts.

are usually used where frequent removal is unnecessary. Distorted collar nuts either have an oval steel insert or the nut is formed with an elliptical opening. As the nut is threaded on, the bolt forces the nut or collar into a round shape. The elastic steel nut tends to return to the oval shape causing high pressures to be exerted on two sides of the bolt, gripping it. This can also deform the bolt and therefore is not used where frequent removal is required.

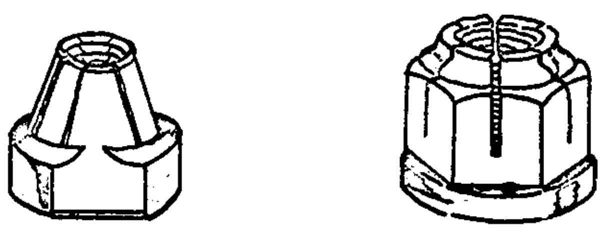


Distorted thread.



Distorted collar.

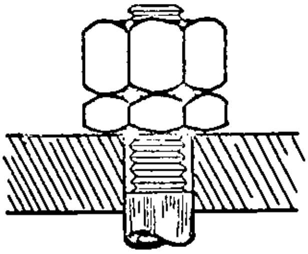
Distorted thread locknuts are made either with depressions on the face of the nut distorting a few threads locally or by a number of deflected threads in the center of the nut. In either one, forcing the threads on the bolt deforms the threads toward the angle of the bolt threads. The bolt threads are also deformed in the direction of the nut threads and high interference frictional forces are created.



Spring beam.

Spring beam lock nuts are formed with a slight taper in the threads toward the upper portion of the nut. Slots are cut in the outer portion forming segments that can be forced outward when the nut is installed. Elastic reaction causes the segments to push inwards gripping the bolt. Like the nylon insert nut, this nut does not deform the bolt threads and can be used on frequently removed items. The nuts should be checked for loss of elasticity of the segments by installing on lightly oiled clean threads. If the nut can be threaded past the deflection segments without a wrench, discard the nut and replace with a new one.

Jam nuts are to be installed with the thinner nut to the working surface and the thicker nut on the outside. The thin nut is deformed by the wider nut and pressed against

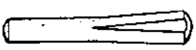


the working surface and threads. If for any reason the thin nut is used alone (if used alone it is not a lock nut), the torque in tbe charts must be reduced in proportion to the active threads. The chart torque is calculated for nuts with usable threads equivalent to the inside diameter of the nut (bolt diameter). The leading and trailing chamfers (non-threaded portion) must be subtracted from the nut depth. The formula used is:

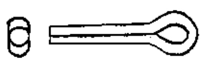
$$\frac{\text{Thin nut thread depth}}{\text{bolt diameter}} \times \text{Chart torque}$$

Spring locknuts lock by means of the side grip on the bolt. When torquing, the spring nut flattens or straightens a spring section. There are many types of spring lock nuts using curved metal springs, bellows, and coil springs. All spin on and off without locking until the pressure against the working surface straightens the spring. These nuts are usually used in special applications. The equipment manuals should be consulted for torque value. If no values are given, use the standard torque tables; for lock nuts adjusting for the thickness of the nut in the case of thin nuts . Always use clean lightly oiled threads. Discard any with damaged threads.

9090.6 LOCKPINS



Split taper.

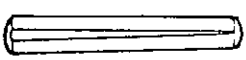


Cotter.

Roll.

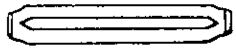
The types of lock pins used on threaded fasteners include tapered pins, straight pins either hollow (roll or coil spring) or solid, key pins and cotter pins.

When alining holes for lock pins, torque the nut to minimum torque; then tighten it until the holes aline or the maximum torque is reached. If the maximum torque is reached before lining up the holes, use another nut or bolt. Exceptions to this tightening rule include locking of bell-cranks, ball-bearings, knuckle joints, and other cases where a loose fit is required to allow for movement and rotation of the part.

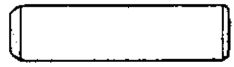


Taper pin.

Tapered interference-fit pins should be selected 0.001 inch to 0.002 inch larger at the largest diameter than the hole. They are driven in until flush.



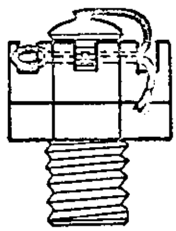
Straight hollow.



Straight solid.

Straight pins are either snug fit or interference fit. Solid pins are usually snug fit. If the pin is longer than the hole both ends are peened. If the ends are flush with the hole they are staked.

Key pins are snug fit. Normally key pins are only used where another unit, nut or collar prevent the pin from coming out.



Cotter pin installation.

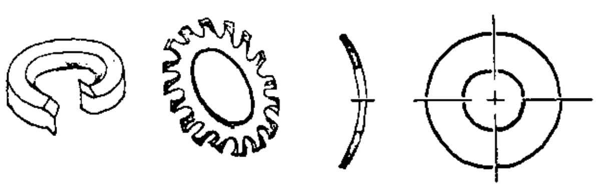
Cotter pins should be snug fit with the head of the cotter pin seated into the castellation of the nut. The head of the pin may be lightly tapped to seat it. One end should be pulled back over the stud or bolt and the other end tapped flat against the nut. Any excess length should be cut from the ends to prevent snagging of clothes or flesh.

> **CAUTION:** When cut, the pieces may snap out cutting and even blinding a person, or dropping into the equipment. Cover the end with a piece of cloth to catch it, so it will neither injure personnel nor fall into the machinery.

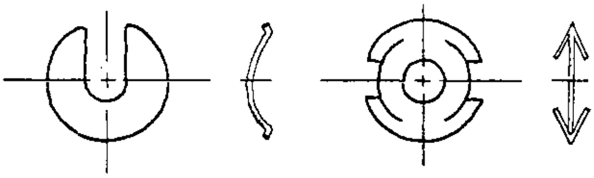
In some areas where snagging is likely, the manuals or drawings will call for the buds to be spread around the sides of the nut. When this is done, the head of the pin cannot fit into the castellation without twisting the ends 90° to bend them around the sides. Since this twisting would weaken the pin the head should be installed across the castellation.

9090.7 LOCK WASHERS

The most common lock washer used is the helical spring (split ring) washer. Other types of spring washers, and toothed lock washers, while fairly common are normally used only in special applications.



The helical spring washer is flattened when the bolt is torqued down. When torqued, it acts as a flat washer contributing normal friction to the locking of the screw or bolt. When the nut and bolt loosen, the spring presses against the nut or bolt and the working surface, maintaining the tension on the bolt, effectively locking it. Because of the helical spring washers' small diameter, it is not usually used on soft materials or with oversized or elongated holes.



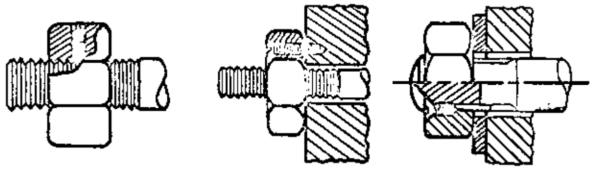
Curved or conical spring washers have almost the same properties as the helical spring washer. They provide a constant tension on the bolt or screw when loosened. The tension produced is usually less than that produced by the helical washer. Like any locking device relying on tension, spring washers may loosen on shock loading. When the bolt stretches more than the spring distortion from the shock loading, the washer serves no further purpose. They should be rechecked where possible when shock is sufficient to suspect loosening. Some spring washers have teeth on the outer edge. These teeth do not aid in locking but prevent side slippage and turning.

Toothed lock washers have teeth that are twisted or bent so that when loosening, cutting edges engage both working surfaces on the nut, bolt, or screw. Some have teeth on the inner diameter for applications where teeth projecting beyond the nut are not desired. The more common type have teeth on the outer diameter. Washers with teeth on both inside and outside diameters are used for soft materials and oversize holes. The teeth are twisted so that as the nut is installed and torqued down, the rim of the washer supports the pressure. Any backing off of the nut or bolt releases tension allowing the teeth to dig into both the working surface and the nut or bolt.

9090.8 MISCELLANY

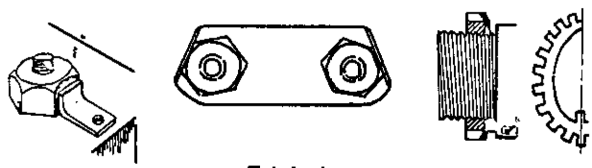
1. Thread locking coatings harden into resins which lock the nut or bolt into place and also seal the threads against fluid leakage. The break-away torque required to remove the nut is higher than the normal torque for installation. On removal, the coating will powder; this must be cleaned before reinstallation. A light, even coating is required. Clean off excessive amounts and torque to the values listed for lock nuts. As some coatings will powder under shock, use the coating specified by applicable manuals and drawings.

2. Set screws lock threads by two means. Installation at right angles to the nut and bolt threads applies pressure to the bolt threads that locks the bolt to create frictional forces and distorts the threads to interfere with the bolts backing out. Set screws themselves are usually locked by a safety wire or staking.



Set screws.

3. Tab locks generally lock by butting a tab against a flat face of the nut or bolt and preventing the tab lock from turning by bending a second tab against a nearby flange, over a nearby edge, into a hole drilled into the working surface or, in the case of the tab lock made to fit under two bolts or nuts, against another nut or bolt. Other methods of locking the tab lock in place are using a screw to lock the tab lock to the working surface and safety wiring. Special tab locks that lock by means of an internal key or flat surface are used on studs with key slots or flat sections cut to take these tab locks.



Tab locks.

Whenever a tab is bent, the bend radius areas should be inspected for cracks. **Tabs are not made for rebending.** Hence unless multiple tabs are provided or the tab lock is prebent and screwed into place, **the tab lock should never be reused.** The nut should be torqued down until a flat face is presented to the tab. Never tab on a corner. If the flat side can not face the tab within the torque limits of the nut use another nut or bolt. Always torque with clean lightly oiled threads.

9090.9 SAFETY WIRING

The purpose of safety wiring is to prevent the nut, bolt, screw, or any other threaded part from backing off. This can only be done by installing the wire so that it will tend to tighten by pulling against the untorquing direction. Lock wire should be taut but not overstressed. Too much tension or tight twisting will cause the wire to break under vibration. The units to be wired should be properly torqued. If the holes do not line up so that the wire will pull tight, do not loosen or overtorque. Install another nut or bolt that will aline the holes within the torque limits or drill a new hole where space allows. Wire as directed in the diagrams shown in this chapter. Cut the excess wire and bend the end toward the nut or part. Projecting ends are a safety hazard.

As various conditions require special wire materials; i.e., stainless steel for high temperature application, brass, or copper for non-magnetic electronic uses and monel for salt water corrosion resistance; use the type wire specified for the job.

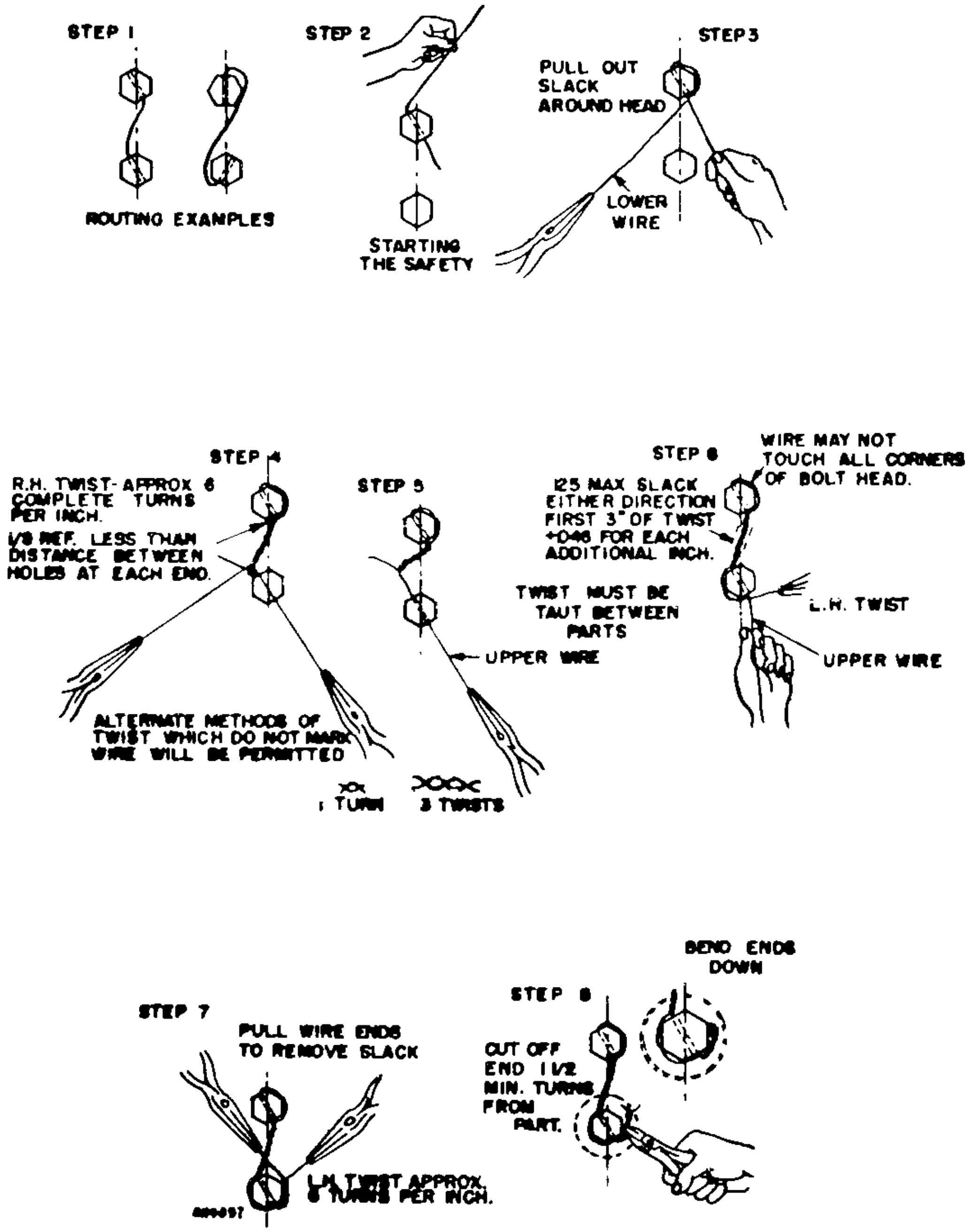
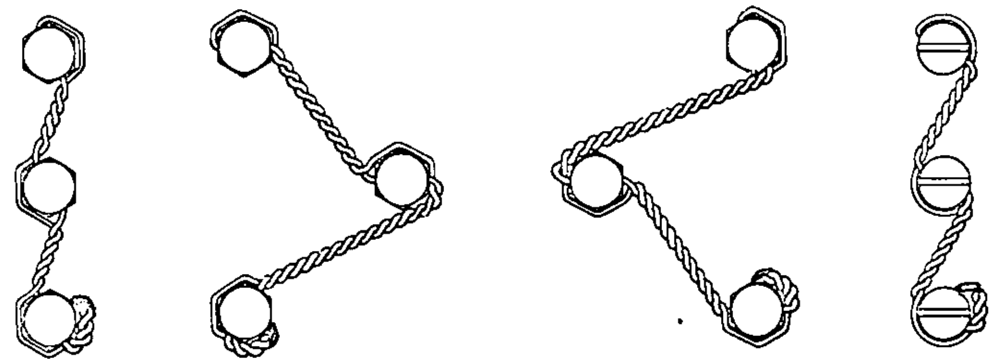
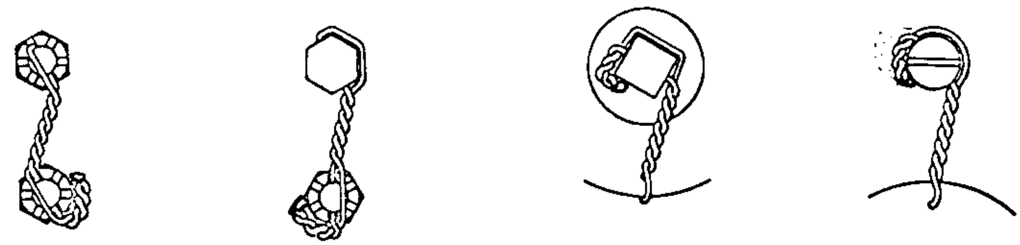


Figure 9090-1. Lockwiring procedure.



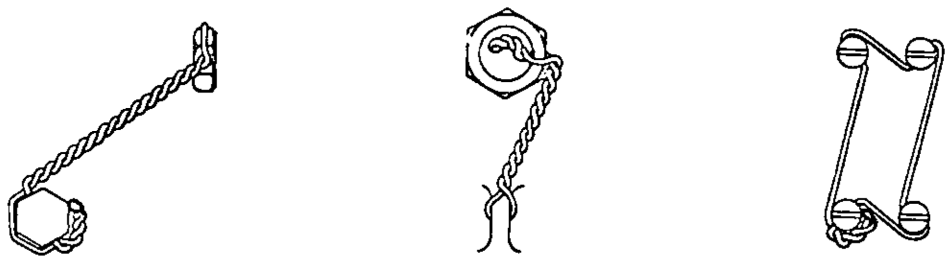
EXAMPLE 1 EXAMPLE 2 EXAMPLE 3 EXAMPLE 4

Examples 1, 2, 3, and 4 apply to all types of bolts, fillister head screws, square head plugs, and other similar parts which are wired so that the loosening tendency of either part is counteracted by tightening of the other part. The direction of twist — from the second to the third unit is counterclockwise to keep the loop in position against the head of the bolt. The wire entering the hole in the third unit will be the lower wire and by making a counterclockwise twist after it leaves the hole, the loop will be secured in place around the head of that bolt.



EXAMPLE 5 EXAMPLE 6 EXAMPLE 7 EXAMPLE 8

Examples 5, 6, 7 & 8 show methods for wiring various standard items. Note: Wire may be wrapped over the unit rather than around it when wiring castellated nuts or on other items when there is a clearance problem.



EXAMPLE 9

Example 9 shows the method for wiring bolts in different planes. Note that wire should always be applied so that tension is in the tightening direction.

EXAMPLE 10

Hollow head plugs shall be wired as shown with the tab bent inside the hole to avoid snags and possible injury to personnel working on the engine.

EXAMPLE 11

Correct application of single wire to closely spaced multiple group.

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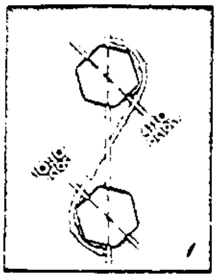
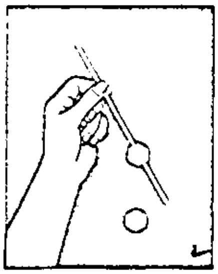
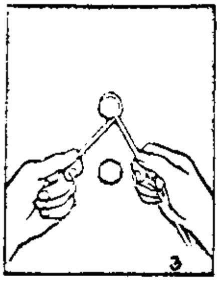
Figure 9090-2. Lockwiring examples.



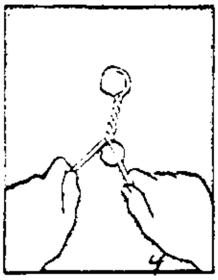
Position the holes



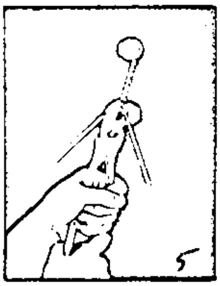
Insert proper gage wire.



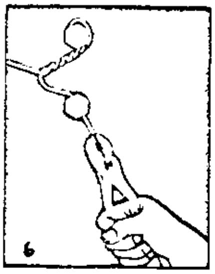
Grasp upper end of the wire and bend it around the head of the bolt; then under the other end of the wire. Be sure wire is tight around head.



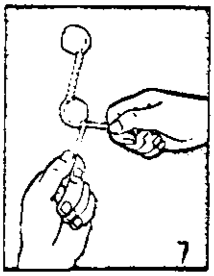
Twist wire until wire is just short of hole in the second bolt.



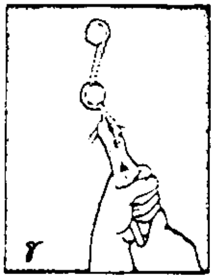
Keeping wire under tension twist in a clockwise direction until the wire is tight. When tightened the wire shall have approximately 8-10 turns per inch.



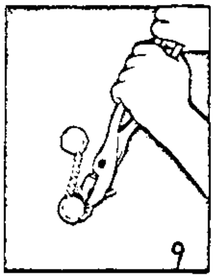
Insert the uppermost wire, which points towards the second bolt, through the hole which lies between the nine and twelve o'clock position. Grasp the end of the wire with a pair of pliers and pull the wire tight.



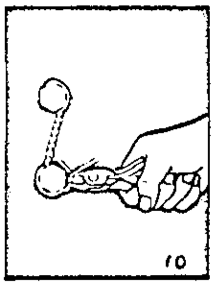
Bring the free end of the wire around the bolt head in a counterclockwise direction and under the end protruding from the bolt hole. Twist the wire in a counterclockwise direction.



Grasp the wire beyond the twisted portion and twist the wire ends counterclockwise until tight.



During the final twisting motion of the pliers, bend the wire down and under the head of the bolt.



Cut off excess wire with diagonal cutters. and bend the cut edge into the nut of part.

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Figure 9090-3. Lockwiring examples.

9090.10 TORQUE WRENCHES

1. **Engineering Principles.** Torque is based on the fundamental law of the lever, that is, force times distance equals a moment, or torque, about a point. Torque is often called a torsional or twisting moment. It is a moment which tends to twist a body about an axis of rotation. If a common end wrench is used to tighten a bolt for example, a force times a distance, a torque, is applied to overcome the resistance of the bolt to turning.

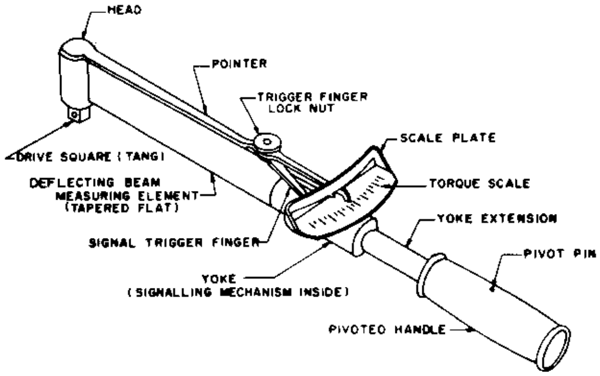

Figure 9090-4. Deflecting beam torque wrench.

A torque wrench (or torque handle) is a gage tool which allows an applied torque to be measured and controlled. The distance of the applied force from the pivot point is held constant and the torque is shown on a scale. Usually a signaling device is included to indicate preset torques.

Torque wrenches are used to apply predetermined tension to screws, studs, bolts, etc. They are used wherever controlled fastening stresses are required in applications such as machinery erection, engine assembly and pressure vessel assembly.

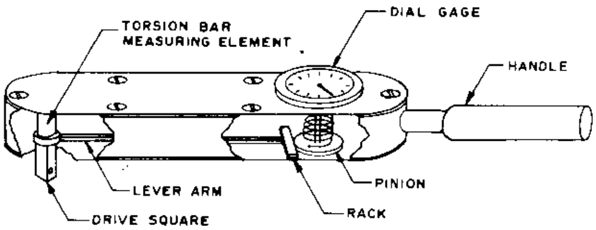

Figure 9090-5. Torsion bar—rigid case type wrench.

Torque wrenches operate basically on one of the following principles or a variation of it:

a. deflection of a beam
b. deflection of a torsion bar
c. compression of a helical spring or springs.

Units of torque most often used are listed below with common conversions:

28.35	gram-inches	=	1 ounce-inch
16	ounce-inches	=	1 pound-inch
12	pound-inches	=	1 pound-foot
1	pound-foot	=	13.82 kilogram-centimeters
100	kilogram-centimeters	=	1 kilogram-meter

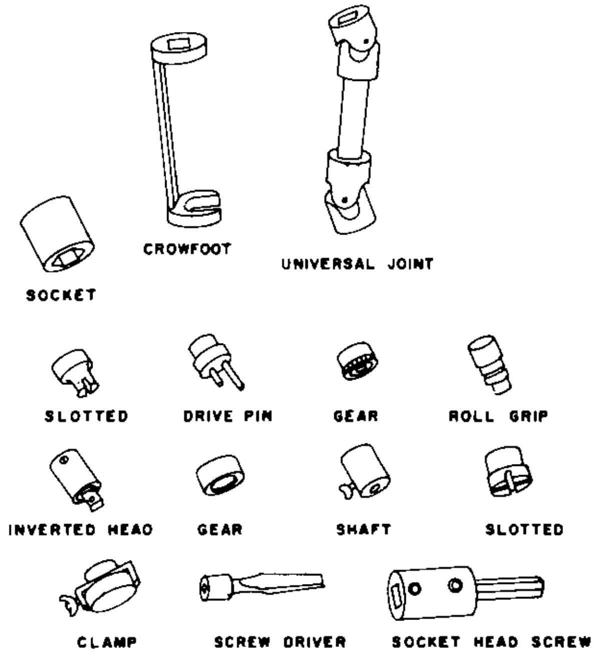

Figure 9090-6. Torque wrench attachments.

2. **Safety.** If possible pull the handle when using a torque wrench. Pushing on the wrench is normally considered dangerous, for, if the work fails or the wrench slips, knuckles will invariably be "skinned."

The average individual can pull with a maximum reasonable force of about 100 pounds. Pulling with forces greater than this may cause loss of balance, falls and injuries should the piece fail or slip. Remember, the larger wrenches are made for two man operation.

3. **Description.** Torque wrenches operating on the deflecting beam principle are probably the simplest and most common type evolved from the three principles listed in 1. above. The parts of a typical wrench of this type are shown in figure 9090-4. The primary component is the beam or measuring element. It is alloy steel and may be round, double round, straight flat or tapered flat. To one end of the beam is attached a head piece containing the drive square (tang) and fixed pointer mounting. A yoke is attached to the other end. Mounted on the yoke is the torque scale handle and, when provided, the signaling mechanism. If a signaling mechanism is included, a trigger finger is installed on the pointer. This can be set to trip the signaling mechanism at any pre-determined torque. The signal consists of an audible click and a sharp feel impulse in the handle. As a force is applied to the handle, the beam deflects with the scale. The pointer remains fixed, hence a torque is indicated on the scale. Another class of deflecting beam type wrench is provided with a dial indicating gage instead of the open pointer and torque scale arrangement.

Rigid case wrenches with indicator dials are another type and may operate on any of the principles, or combination of two, listed in 1. above. The actuating element is enclosed in a rigid frame with a removable access cover. The deflecting beam, used in some rigid case wrenches, is similar to that explained above. Another common actuating element, the

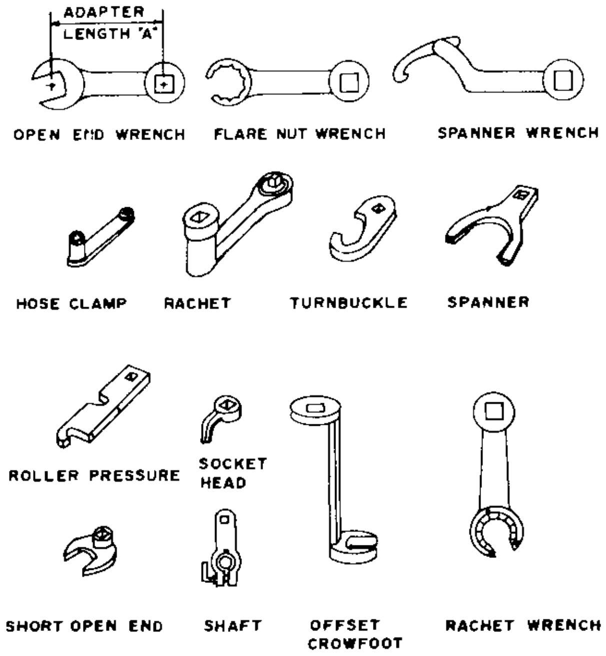

Figure 9090-7. Torque wrench adapters.

deflecting torsion bar, is a piece of steel generally circular in cross section and attached at one end to the frame so that when torque is applied the bar will twist about its longitudinal axis. A lever arm and gear arrangement transmits the torque indication to a dial gage. The drive square is connected directly to the torque bar. A torsion bar rigid case wrench is shown in figure 9090-5. Wrenches operating by compression of a helical steel spring have provisions for presetting the dial to a given torque. Setting the dial compresses the spring which applies force upon an automatic linkage. When the torque applied equals the setting in the dial the linkage overcomes the spring resistance and the wrench automatically releases.

Three other wrench types operate by the compression of a helical spring. These are: a rigid case type using a micrometer setting instead of a dial, a tee handle rigid case type with a ratcheting feature, and a rigid case preset torque type (set and sealed single value). The types, classes and styles of torque wrenches available to the Navy are summarized below.

- Type I -Deflecting beam
  - Class 1–Indicator plate
    - Style A–Direct reading
    - Style B–Direct reading with audible signal
  - Class 2–Indicator dial
    - Style A–Direct reading
    - Style B–Direct reading with audible signal
- Type II–Rigid case with indicator dial
  - Style A–Direct reading
  - Style B–Presetting torque dial, direct reading with audible signal
  - Style C–Direct reading and flash signal
- Type III–Rigid case, micrometer style torque presetting audible indicating
  - Class 1–Plain head
  - Class 2 - Ratchet reversible head
- Type IV–Tee handle, rigid case ratcheting, audible signal
  - Class 1–Torque value set and sealed
  - Class 2–Torque value setting adjustable
- Type V–Rigid case preset torque audible indicating

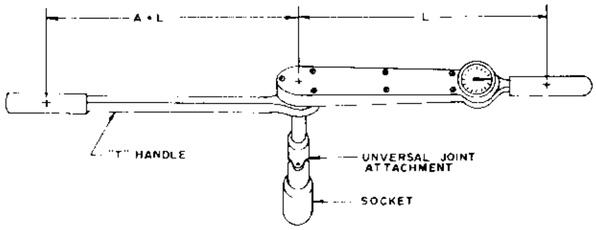

Figure 9090-8. Use of "T" handle with conventional torque wrench.

4. **Range and Accuracy.** Torque wrenches are available in many sizes from small with ranges such as 0 to 32 ounce-inches to large with ranges such as 0 to 2000 pound-feet or 900 to 3000 pound-feet.

Wrench tolerances are listed below for all types except IV.

Percent of Full Scale		Tolerance at room temperature	
From	Up to but not Including		
0	20	within ± 0.07	of the applied torque required, within range of wrench
20	80	within ± 0.04	
80	Full Scale	within ± 0.05	

5. **Accessories.**

a. **Atatchments.** An attachment enables connection of the torque wrench with the work. It may be any shape or form of work engaging member functioning coaxially with and attachable to the drive square of the wrench. It does not affect the scale reading of the wrench. Common and special types of attachments are shown in figure 9090-6.

b. **Adapters.** An adapter is any rigid shape or form of work engaging member extending longitudinally forward from the axis of and attachable to the drive square of the torque wrench. With an adapter it is possible to reach applications that may otberwise be impossible to torque. Since adapters extend the lever length they increase the capacity of the wrench. For example, an adapter equal to the lever length of the wrench will multiply the torque by two. To find the increase in torque at the work end of the adapter use the following formula:

$$T_a = T_w \times \frac{(L + A)}{L}$$

where T_a = torque exerted at the end of the adapter
T_w = wrench scale readings
L = lever length of wrench
A = length of adapter

Examples of adapters, common and special, are shown in figure 9090-7.

c. **"T" Handle.** This is a handle equal to the length of the wrench lever extending in the opposite direction. A universal joint is used between the drive square of the wrench

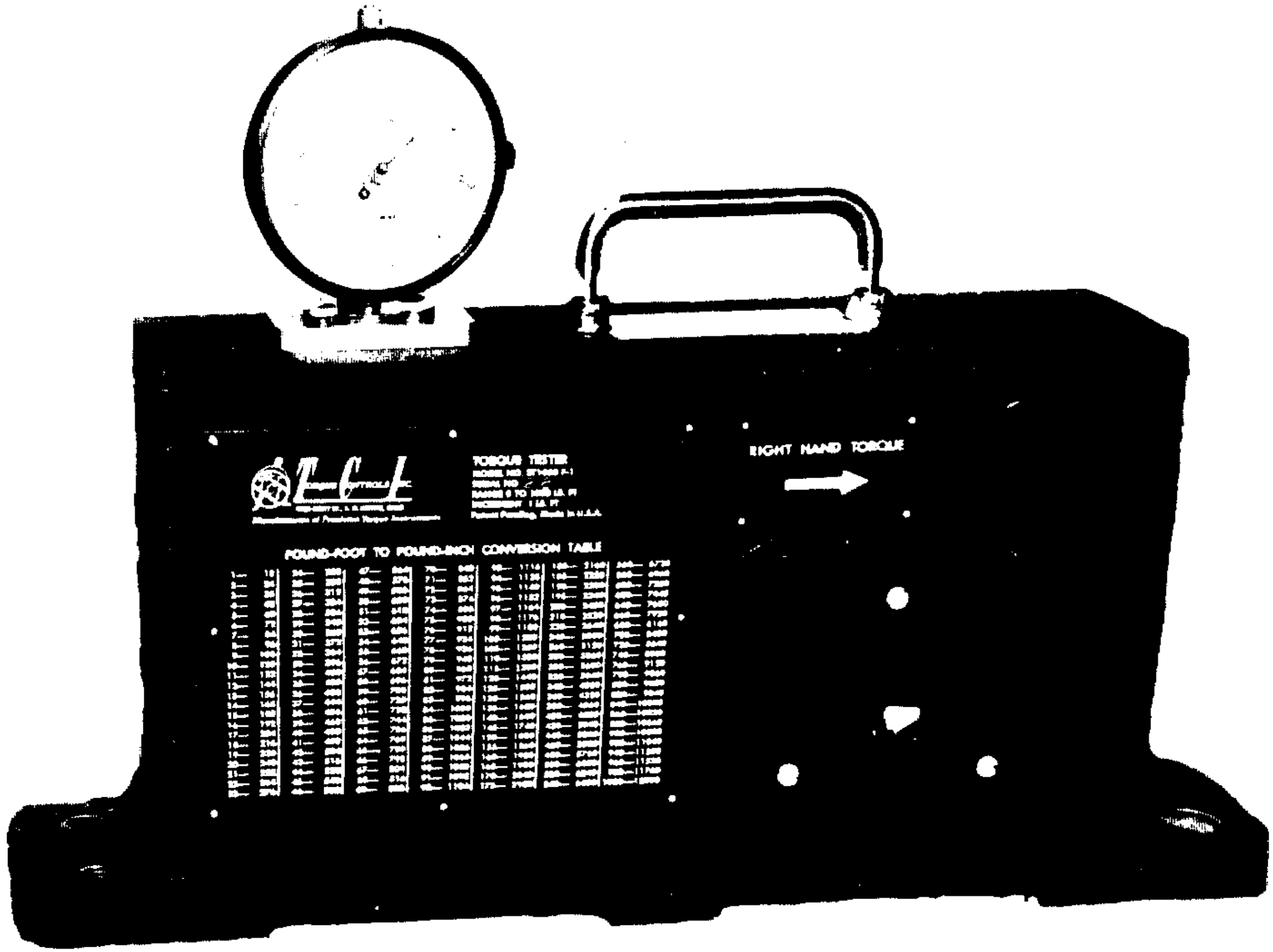

Figure 9090-9. Torque wrench calibrator.

and the adapter. This governs and equalizes the force applied to each of the handles by the operator. See figure 9090-8. Multiply the scale reading by two for the correct torque.

d. **Torque Multipliers.** Generally the maximum range of a one-man torque wrench is about 600 pound-feet. Torque applications beyond this should be made using a torque multiplying device in conjunction with the torque wrench.

e. **Memory Hand.** In some applications it is desirable to have a retained indication of the maximum reading. On the torque scale and dial type wrenches a memory hand may be provided which is deflected by the pointer. It stays at the maximum reading until returned manually.

6. **Using the Torque Wrench.**

a. Many torque wrenches are equipped with a means for fixing the point of force application. A floating or pivoted handle accomplishes this. To use a pivoted handle, grasp it lightly and pull on the handle floating it on the pivot point. This concentrates the pulling force. The fact that the handle end may contact the yoke extension in the process of pulling will not necessarily cause inaccuracies so long as the hand hold position is not deliberately shifted so as to obviously change the concentration of pulling force to a point between the yoke extension and pivot.

b. Pull on the handle in a plane as near as possible to that of the rotation of the wrench.

c. Apply force until the desired torque is indicated on the scale or dial. Wrenches with signaling mechanisms will also give a click and impulse to the hand to indicate when the desired torque has been reached.

d. On open pointer and torque scale wrenches set the sensory trigger finger to trip the trigger when the pointer is exactly on the desired scale value. Tighten its lock nut by hand. The trigger finger is not a reference pointer. Do not attempt to aline it with markings on the scale.

e. Select the proper range and size wrench for each particular application. A good rule of thumb is to select a wrench so that the working range is within the mid two-quarters of the capacity of the wrench.

f. When adapters are used, the best arrangement is to have the axis of the work engaging end intersect the extended centerline of the torque wrench frame.

g. Tabulated torque values for fasteners may be obtained from the various manufacturers of torque wrenches.

7. **Care of Torque Wrenches.**

a. **Measuring Element.** In the deflecting beam type wrench the beam portion is the sensing device. It should not be marked, etched or scratched with part numbers, tool numbers, any other markings.

b. **Pointer—Deflecting Beam Type Wrench.**

(1) Zero Setting—The pointer tip should intersect the zero mark on the scale when the tool lies at rest. Make minor adjustment by bending the pointer tip with pliers. Larger adjustment may be made by springing the entire pointer. Hold the pointer at the head end of the wrench where it is welded to prevent breaking it off.

(2) Floating the Pointer—This is an adjustment to prevent the pointer from riding on the scale plate or contracting the beam. Lock the head end of the wrench in a vise to prevent breaking the pointer out of the head and slide a knife or wedge between the pointer and beam. This will tend to lift the pointer, clearing it.

8. **Torque Wrench Calibration.**

a. **Calibrators.** One type of calibrator conforming to military specifications is shown in figure 9090-9. With the following five sizes all commonly encountered wrenches may be calibrated:

Size	Range	Graduation Values
1	5–100 oz-in.	0.1 oz-in.
2	0–1000 oz-in.	1.0 oz-in.
3	0–4000 oz-in.	4.0 oz-in.
4	0–2000 lb-in.	2.0 lb-in.
5	0–1000 lb-ft.	1.0 lb-ft.

Applied torque is indicated on a dial scale which is equipped with a manually resetable follower hand on reading retainer. These calibrators are accurate to within ± 1 percent of the applied load or one dial graduation, whichever is greater, throughout the range of the scale. Right or left hand torque may be calibrated on the units. Suitable adapters are provided for various sizes of wrench drives.

b. **Loading Devices.** A loading device for applying a load to the torque wrench simulating proper hand application of force should be used with size 3, 4, and 5 calibrators. For these calibrators, both hydraulic and mechanical loaders are available. They are portable so that only one loader is required per set of calibrators.

To simplify proper handle positioning when mounting wrenches for use with a loading device, adjustable adapters are also available.

c. **Calibrating the Wrench.** Insert the square drive of the wrench into a female square coupling on the calibrator. For manual loading pull up slowly on the torque wrench while comparing the readings on the wrench with those of the calibrator gage. When using the hydraulic or mechanical loader, mount the wrench handle and apply the load as directed in the loader instructions.

On signaling type wrenches, when the wrench signals by clicking, flashing or releasing, the torque at this signal is indicated on the calibrator gage. Adjust the wrench signal trigger up or down so that the signal occurs at exactly the desired torque value.

CAUTION: Do not overload the calibrator.

STANDARD THREAD SCREWS
(HEX HEAD, ALL TYPES)
STANDARD THREAD NUTS
(PLAIN, SLOTTED, SELF-LOCKING)

STEEL Thread Size	Torque Plain, Self-Locking Nut Inch-Pounds	Torque Slotted Nut Inch-Pounds
.086-56	-	-
.099-48	-	-
.112-40	-	-
.125-40	-	-
.138-32	-	-
.164-32	-	-
.190-32	60-65	-
.216-24	65-70	-
.250-28	80-85	70-95
.3125-24	125-140	120-165
.375-24	275-300	250-325
.4375-20	425-450	400-475
.500-20	500-600	500-700
.5625-18	825-875	750-1000
.625-18	1125-1200	1000-1400

STANDARD THREAD SCREWS
SLOTTED HEAD—ALL TYPES

STEEL Thread Size	Torque Applied At Slot Inch-Pounds
.086-56	2-3
.099-48	3-4
.112-40	5-6
.125-40	6-7
.138-32	7-9
.164-32	10-12
.190-32	18-20
.216-24	22-25
.250-28	30-35
.3125-24	40-45
.375-24	55-60
.4375-20	80-90
.500-20	100-110
.5625-18	-
.625-18	-

NUTS—FLARED TUBE
STRAIGHT THREAD COUPLING

Tubing OD	Nut Size	Torque Values Inch-Pounds	
		Aluminum Alloy Tubing	Steel Tubing
.125	.3125-24	-	-
.188	.375-24	-	90-100
.250	.4375-20	40-65	135-150
.313	.500-20	60-80	180-200
.375	.5625-18	75-125	270-300
.500	.750-16	150-250	450-500
.625	.875-14	200-350	650-700
.750	1.0625-12	300-500	900-1000
1.000	1.3125-12	500-700	1200-1400
1.250	1.625-12	600-900	-
1.500	1.875-12	600-900	-

FLUID FITTINGS (CONE TYPE)
TORQUE APPLIES WHEN
TIGHTENING NUT

STEEL	Torque Value Inch-Pounds		
Tube Size	Nut Size	Min	Max
.125	.3125-32	40	45
.250	.4375-20	80	85
.375	.625-18	150	175
.500	.750-16	275	300