

GENERAL PRACTICES FOR USE OF LOCK WIRE, KEY WASHERS, AND COTTER PINS

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1. **PURPOSE:** To establish the requirements of good practices for locking various fasteners and other parts which may require locking in critical applications such as aerospace propulsion systems.
2. **SCOPE:** This standard covers those devices whose primary function is locking, and excludes those devices which have integral locking features incorporated into the item being locked.
  - 2.1 The practices cover the types of locking devices described in the following sections:

Section I	Lock Wire
Section II	Key Washers
Section III	Cotter Pins
  - 2.2 Special applications involving conditions not covered by the basic principles described herein shall be shown on the drawing, and where contradiction occurs between a drawing and this instruction, the drawing shall prevail.

SECTION I LOCK WIRE

I-1. BASIC RULES FOR THE INSTALLATION OF LOCK WIRE:

- I-1.1 Lock wiring is the securing together of two or more parts with a wire which shall be installed in such a manner that any tendency for a part to loosen will be counteracted by an additional tightening of the wire.
- I-1.2 For general purpose lock wiring, use the preferred sizes shown in Table I-1. Use smaller diameter wire where parts are too small to permit a hole diameter to accommodate the preferred sizes, or where space limitations preclude the use of the preferred sizes. The larger sizes are used where stronger wire is required. The proper wire shall be specified on the drawing by part number.
- I-1.3 The lock wire material for use up to 700°F shall be a corrosion-resistant steel such as AMS 5685, and for use up to 1800°F a corrosion and heat-resistant alloy such as AMS 5687 shall be used. Where AMS or other material specifications are used, the specified diameter tolerances in Table I-1 shall supersede those in the material specifications.
- I-1.4 The common method of installing lock wire shall consist of two strands of wire twisted together (so called "Double-Twist" method) where one twist is defined as being produced by twisting the wires through an arc of 180 degrees and is equivalent to half of a complete turn. The single strand method of lock wiring may be used, when so specified, such as in a closely spaced, closed geometrical pattern (triangle, square, rectangle, circle, etc.), or parts in electrical systems, and in places that would make the single strand method more advisable. In such cases the single strand wire shall be limited to the pattern or group of similar parts.
- I-1.5 The maximum span of lock wire between tension points shall be six inches unless otherwise specified.
- I-1.6 Where multiple groups are lock wired by either the double-twist or the single strand method, the maximum number in a series shall be determined by the number of units that can be lock wired by a twenty-four inch length of wire.
- I-1.7 Wire shall be pulled taut while being twisted. The number of twists per inch, as recorded in Table I-1, represents general practice and is given as guidance information only.
- I-1.8 Caution must be exercised during the twisting operation to keep the wire tight without over-stressing. Abrasions caused by commercially available wire twisting pliers shall be acceptable but nicks, kinks, and other mutilations caused by improper tooling and wiring techniques are not acceptable. Gripping surfaces of pliers shall have edges sufficiently rounded to preclude wire damage.
- I-1.9 Lock wire shall not be installed in such a manner as to cause the wire to be subjected to chafing, fatigue through vibration, or additional tension other than the tension imposed on the wire to prevent loosening.
- I-1.10 In all cases wiring must be done through the holes provided. In the event that no wire hole is provided, wiring should be to a convenient neighboring part in a manner so as not to interfere with the function of the parts and in accordance with the basic principles described herein (see Figures I-14, I-19, and I-20).
- I-1.11 Lock wire shall be new upon each application.

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## I-2

- I-1.12 When drawing specifies a lock wiring seal, it shall be applied and crimped to the lock wire as shown in Figure I-12 or I-13. Figure I-12 shows the seal application where all units in a series do not require sealing. Figure I-13 gives examples of sealing required at the end of a series, showing ends of lock wire beyond seal twisted and secured to lock wire between units (Figure I-13a) and to an unused lock wire hole in the last unit (Figure I-13b). When sealing is required for the single strand method, apply and crimp the seal to the twisted wire at the end of the series as represented by Figure I-13a except that twisted wire beyond seal is secured to single strand wire between units.
- I-1.13 Hose and electrical coupling nuts shall be wired in the same manner as tube coupling nuts.
- I-1.14 Various examples of lock wiring are shown in Figures I-1 through I-28. Although every possible combination is not shown, any combination used must adhere to the basic rules outlined in this specification. Figure I-11 shows the single-strand method, while the other figures show the two-strand or double-twist method.

TABLE I-1

Lockwire and lockwire hole data						
Wire dia inches	Tolerance ± inches	700°F AMS 5685 P/N ref only	1800°F AMS 5687 P/N ref only	Twists per inch	⊕ Recommended hole diameter	⊕ Recommended chamfer dia (90°±5 incl)
.016	.001	-----	MS9226-01	11-14	.037-.057#	.070-.090
.020*	.001	-----	MS9226-02	9-12	.037-.057#	.070-.090
.025*	.001	AS100027	MS9226-03	9-12	.060-.080#	.090-.110
.032*	.002	AS100028	MS9226-04	7-10	.060-.080#	.090-.110
.040*	.002	AS100029	MS9226-05	7-10	.060-.080#	.090-.110
.051	.002	AS100030	MS9226-06	5-8	.060-.080#	.090-.110
.063	.002	AS100031	MS9226-07	5-8	.070-.090	.100-.120
.091	.002	-----	MS9226-08	4-7	.100-.120	.140-.160

\* Preferred size.

⊕ Where lock wire is used to secure a castellated nut on a threaded item, selection of locking hole diameter for the item shall be based on cotter pin requirements (see Table III-1).

# Where parts cannot accommodate the recommended hole size, it is permissible to use a smaller hole provided a minimum diametral clearance of .003 is maintained between the wire and the hole.

I-2. DETAIL INSTRUCTIONS FOR THE INSTALLATION OF LOCK WIRE:

- I-2.1 Check the units to be lock wired to make sure that they have been correctly torqued. Under-torquing or over-torquing to obtain proper alignment of the holes is not permitted. If it is impossible to obtain a proper alignment within the specified torque limits, back off the unit and try it again or select another unit.
- I-2.2 In adjacent units, it is desirable that the holes be in approximately the same relationship to each other as shown in Figures I-1 through I-4 for right-hand threads, and the lock wire shall be installed in such a manner that the strand through the hole will have a tendency to pull the unit clockwise. This should be reversed for left-hand threads.
- I-2.3 Insert the lock wire through the first unit and bend around the head of the unit. The direction of wrap and twist of strands shall be such that the loop around the unit comes under the strand protruding from the hole so that the loop will stay down and will not tend to slip up and leave a slack loop (see Figure I-1).
- I-2.4 Twist the strands while taut until the twisted part is just short of a hole in the next unit. The twisted portion should be within one-eighth inch from the hole in either unit.
- I-2.5 Insert the uppermost strand through the hole in the second unit and follow the rules in Para. I-2.3 (see center unit Figure I-1). If there are more than two units in the series, repeat the above procedure.
- I-2.6 After wiring the last unit continue twisting the wires to form a pigtail of three to five twists and cut off the excess wire. Bend the pigtail in toward the part in such a manner as to prevent it from becoming a snag. Short pigtails may be desirable because of vibration.

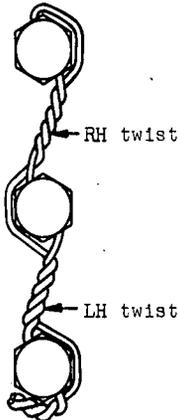


FIGURE I-1

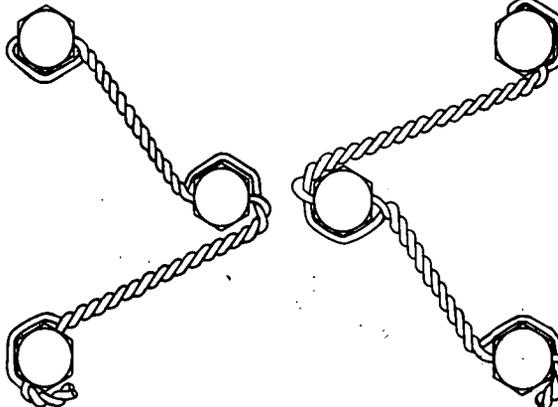


FIGURE I-2

FIGURE I-3



FIGURE I-4



FIGURE I-5



FIGURE I-6



FIGURE I-7

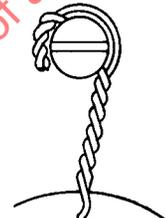


FIGURE I-8

These figures show methods for wiring various standard items. Note: Wire may be wrapped over unit rather than around it in wiring castellated nuts or taper head bolts; also other items may be wrapped over unit where clearance is a problem.

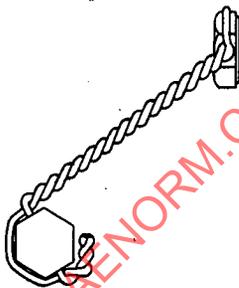


FIGURE I-9



FIGURE I-10

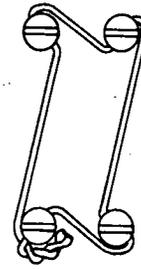


FIGURE I-11

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

When practicable, hollow head plugs shall be wired as shown with the pigtail bent inside the hole to avoid snags and possible injury to personnel.

Correct application of single wire to closely spaced multiple group.

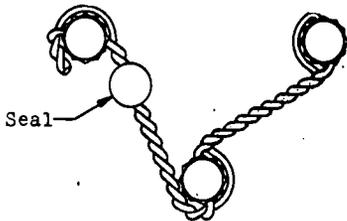


FIGURE I-12

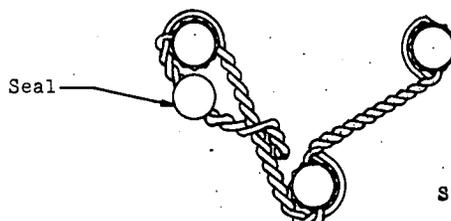


FIGURE I-13a

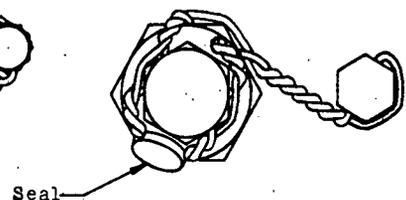


FIGURE I-13b

Methods for attaching seal to protect critical adjustments.

I-4.



FIGURE I-14

Bolt wired to a right angle bracket with the wire wrapped around the bracket.



FIGURE I-15

Figure at left shows correct method for wiring adjustable connecting rod.

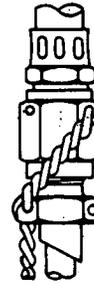


FIGURE I-16

Correct method for wiring the coupling nut on flexible line to the straight connector brazed on rigid tube.

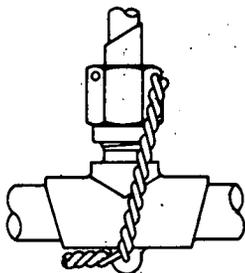


FIGURE I-17

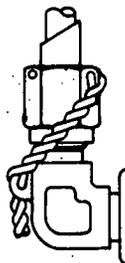


FIGURE I-18

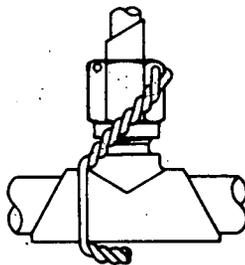


FIGURE I-19

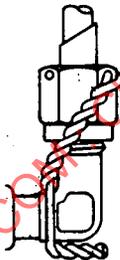
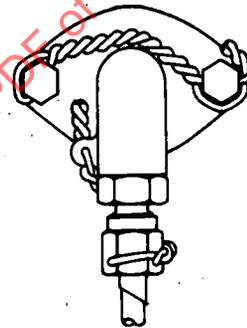


FIGURE I-20

Fittings incorporating wire lugs shall be wired as shown in Figures I-17 & I-18. Where no lock wire lug is provided, wire should be applied as shown in Figures I-19 & I-20 with caution being exercised to insure that wire is wrapped tightly around the fitting.



END VIEW  
(enlarged)

FIGURE I-21

Small coupling nuts or those made of soft material may be wired as shown to lessen possibility of wire breaking or tearing out.

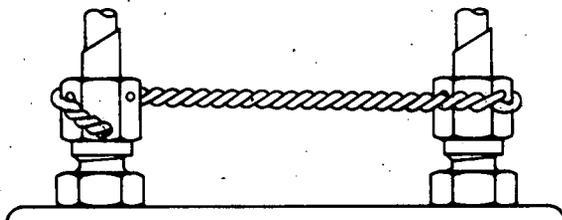


FIGURE I-22

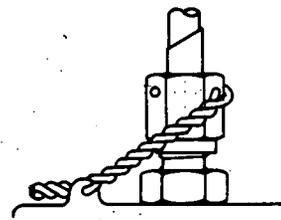


FIGURE I-23

Coupling nuts attached to straight connectors shall be wired as shown when hex is an integral part of the connector.

I-5

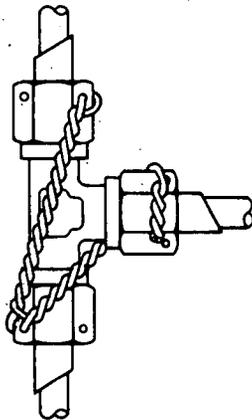


FIGURE I-24

Coupling nuts on a tee shall be wired as shown above so that tension is always in the tightening direction.

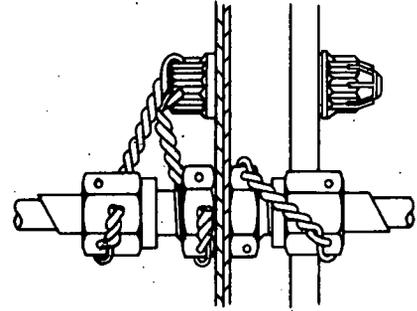


FIGURE I-25

Straight connector  
(bulkhead type)

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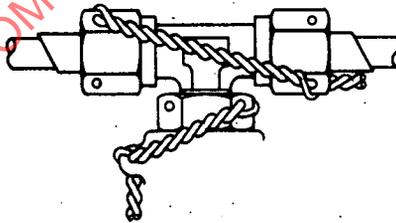


FIGURE I-26

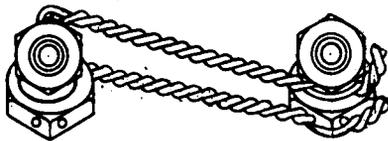


FIGURE I-27

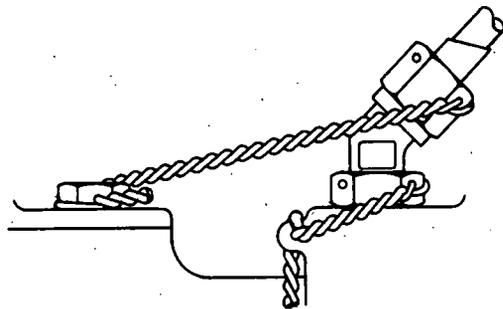


FIGURE I-28

Above figures show the proper method for wiring various standard fittings with check nut wired independently so that it need not be disturbed when removing the coupling nut.

SECTION II KEY WASHERS

II-1. LOCKING WITH KEY WASHERS:

II-1.1 Key washers are used to restrain relative motion between two parts by fitting the keys in keyways in adjacent parts or by bending the keys over parts after application.

II-1.2 Key washers are not reusable and must be replaced with a new key washer after removal.

II-2. LOCKING HEX NUTS WITH KEY WASHERS:

II-2.1 When single hole key washers are used, the key which is bent down against the stationary part shall be positioned as illustrated by Key A in Figure II-1.

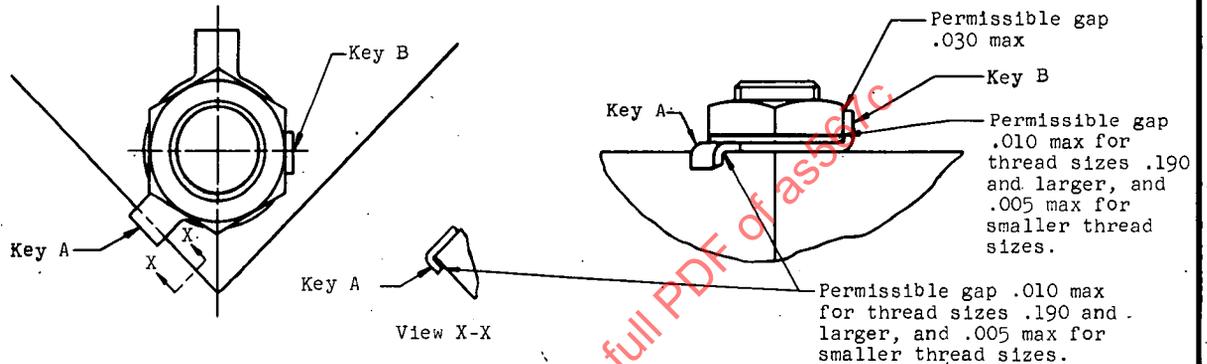


FIGURE II-1

II-2.1.1 Key B shall be bent up across the bottom of only one face of the hex until flat against the face. Figure II-2 shows acceptable and unacceptable bends.

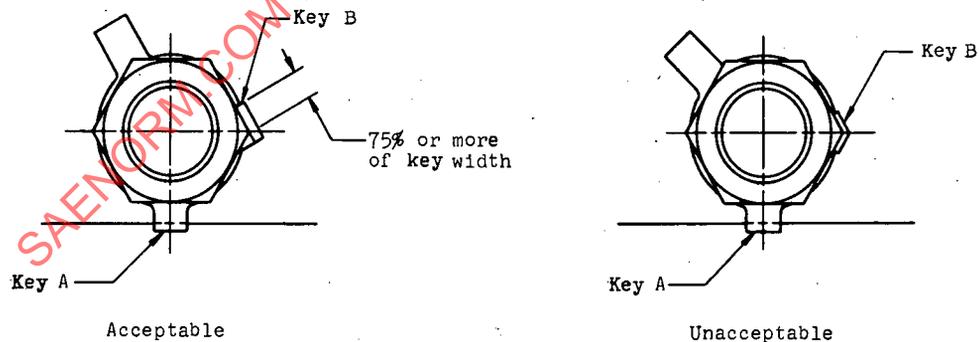


FIGURE II-2

II-2.1.2 The key shall be bent up against the hex face with which its junction line is 75% or more of the key width.

II-2.1.3 In cases of two or more keys, the key most favorably aligned shall be bent as described. It is not mandatory to bend up other keys which may also be aligned.

II-2.1.4 The gap between the hex flat and the bent up key shall not exceed the values given in Figure II-1. Any excess key protruding above the nut shall be bent over to avoid becoming a snag.

## II-2

II-3. DRILLED HOLES FOR WASHER KEYS:

II-3.1 If there is no stationary part against which to retain the key as illustrated in Figure II-1, a hole may be drilled to fulfill this function as shown in Figure II-3.

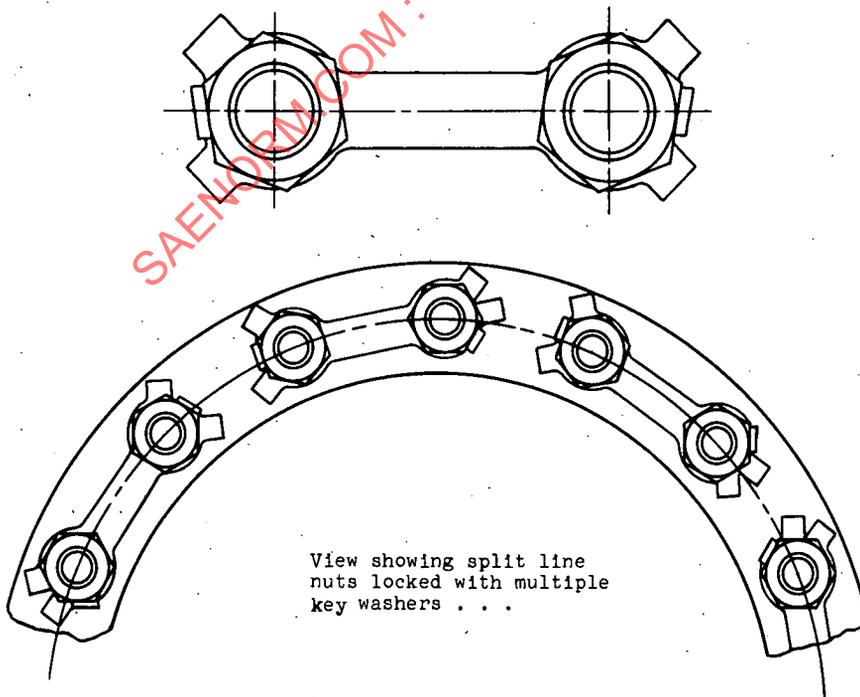
II-3.1.1 Key should not be allowed to move within the hole but should be braced against the side to prevent objectionable movement.



FIGURE II-3

II-4. USE OF MULTIPLE HOLE KEY WASHERS:

II-4.1 When a multiple hole key washer is required, installation shall be as for the single hole key washer except key A provision of paragraph II-2.1 does not apply (see Figure II-4). The rotating parts are involved and a choice of keys is available, the key shall be bent that will utilize centrifugal force to aid in maintaining its bent position.



View showing split line  
nuts locked with multiple  
key washers . . .

FIGURE II-4.

II-3

II-5. ELLIPTICAL KEY WASHERS:

II-5.1 The installation of 180° ellipses shall be accomplished by bending up across one whole face of the hex as shown in Figure II-5.

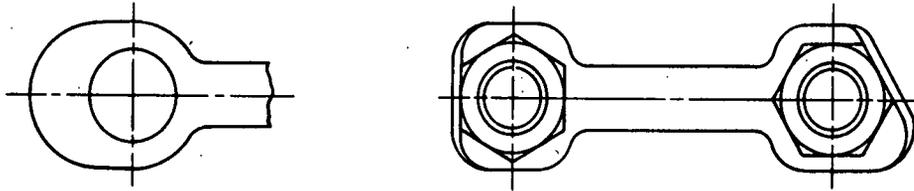


FIGURE II-5

II-6. LOCKING SPANNER NUTS WITH KEY WASHERS:

II-6.1 For the purpose of securing bearings with key washers and spanner nuts, MS172201 through MS172235 key washers and MS172236 through MS172270 spanner nuts may be used for millimeter series bearings. For shaft sizes and dimensions, refer to ARP462. For splined shafts or inch series bearings, MS172271 through MS172320 key washers and MS172321 through MS172370 spanner nuts may be used (see Figure II-6). The key most favorably aligned with the spanner nut slot shall be bent as described in Figures II-6 and II-7. It is not mandatory to bend up other keys which may also be aligned.

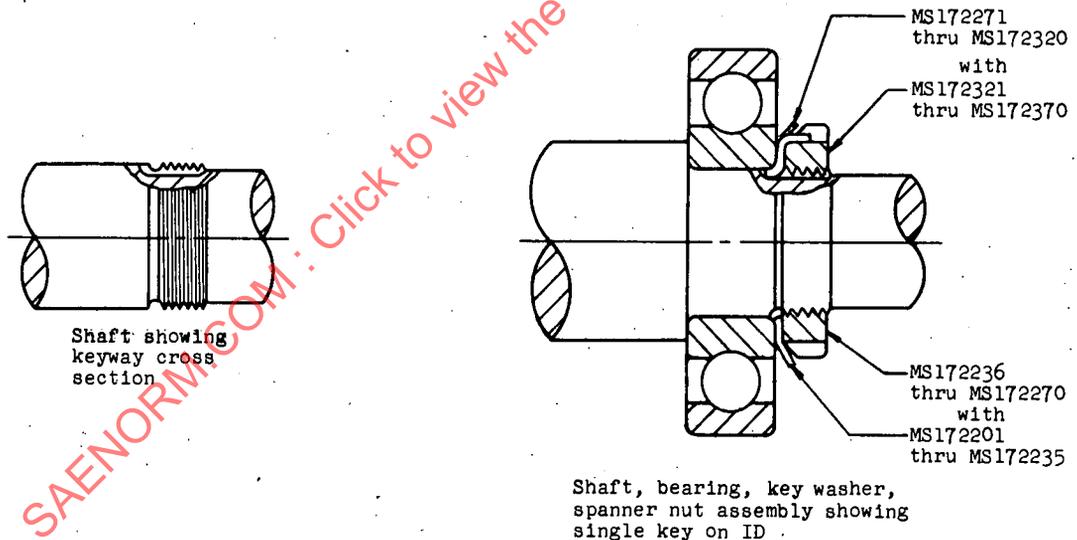


FIGURE II-6

II-6.1.1 When double key washers are used to retain bearings, use double key washers MS9081 and spanner nuts MS172236 through MS172270 (see Figure II-7). For shaft sizes and dimensions, refer to ARP462.

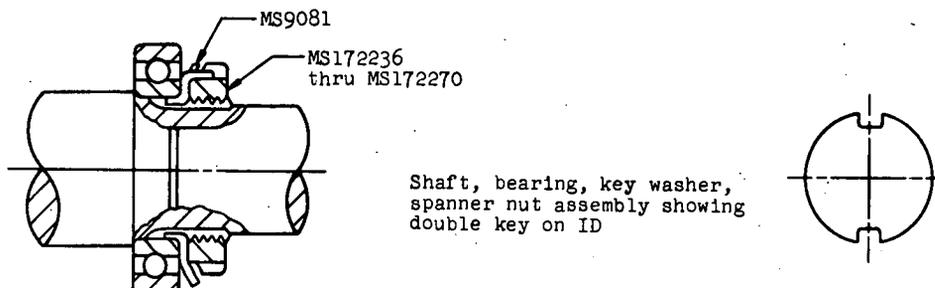


FIGURE II-7

II-4

II-6.1.2 When clearance problems prohibit the use of spanner nuts with slots in the circumference, spanner nuts with the slots in the face may be used. Key washers for use with these spanner nuts are designed with keys on the ID. The keys are long enough to extend through the slot keyway and past the nut. The part of the key extending out of the keyway is bent up into the nut slot (see Figure II-8) thereby creating a locked condition.

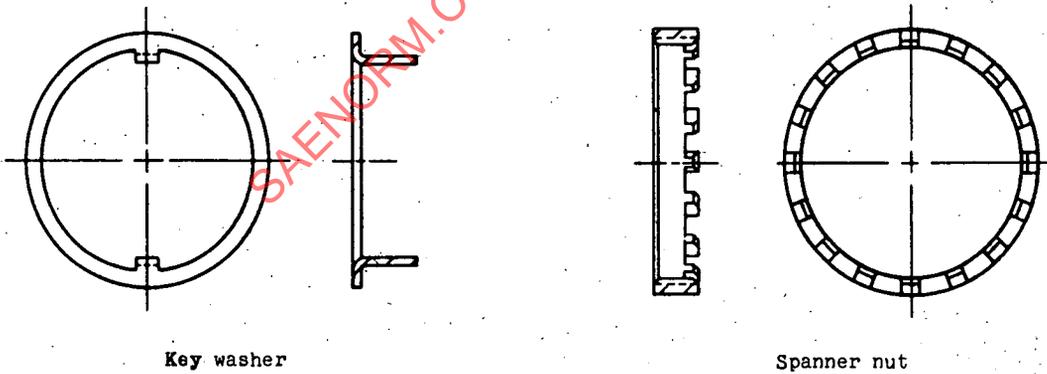
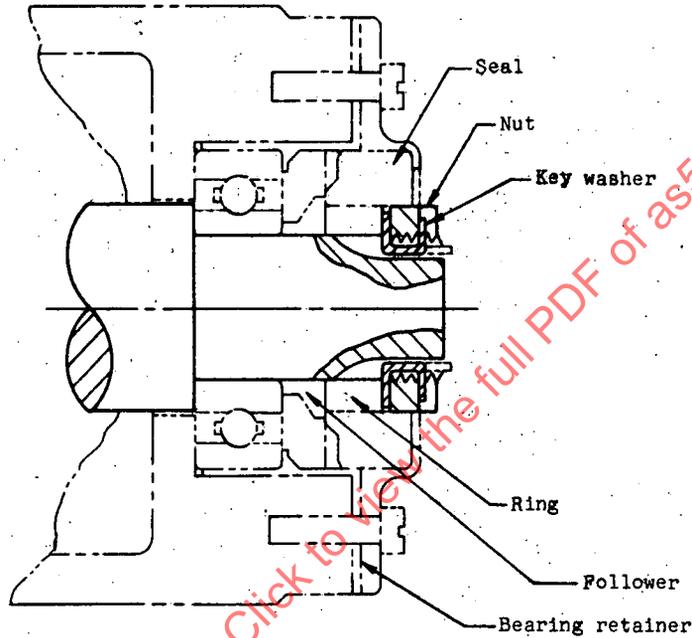


FIGURE II-8