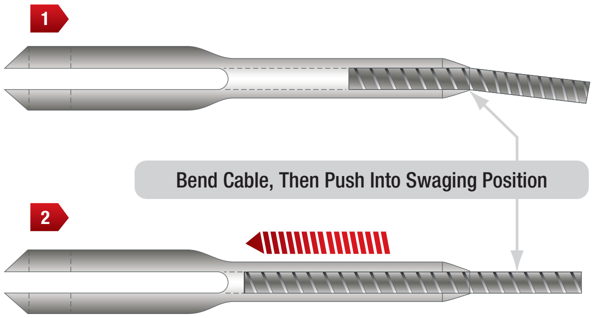

Figure 13-2. Insertion of cable into terminal.

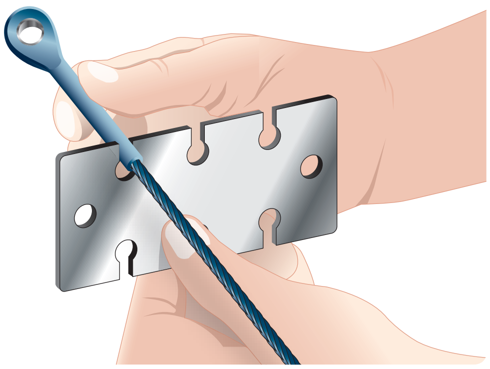

Figure 13-3. Gauging terminal shank dimension after swaging.

SPLICING

Completely severed cables or those badly damaged in a localized area, may be repaired by the use of an eye terminal bolted to a clevis terminal. (***Figure 13-4A***) However, this type of splice can only be used in free lengths of cable which do not pass over pulleys or through fair-leads.

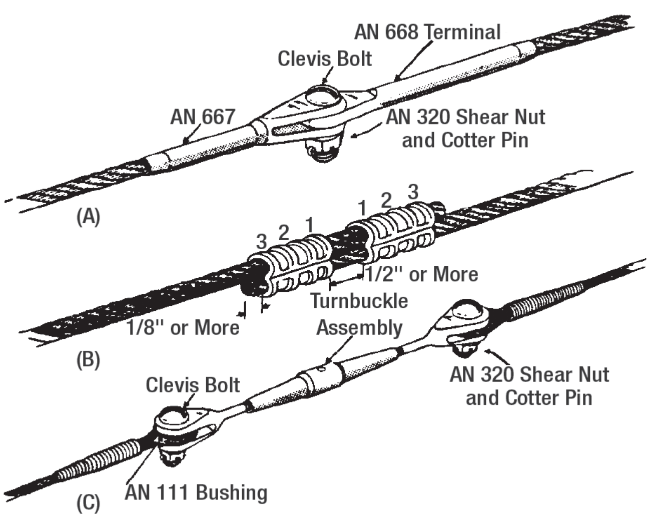

Figure 13-4. Typical cable splices.

SWAGED BALL TERMINALS

On some aircraft cables, swaged ball terminals are used for attaching cables to quadrants and special connections where space is limited. Single shank terminals are generally used at the cable ends, and double shank fittings may be used at either the end or in the center of the cable. Dies are supplied with the swaging machines for attaching these terminals to cables by the method in the following paragraph.

The steel balls and shanks have a hole through the center, and are slipped over the cable and positioned in the desired location. Perform the swaging operation in accordance with the instructions furnished by the manufacturer of the swaging equipment. Check the swaged fitting with a "go no-go" gauge to see that the fitting is properly compressed, and inspect the physical condition of the finished terminal. (***Figure 13-5***)

Cable Slippage In Terminal

Ensure that the cable is properly inserted in the terminal after the swaging operation is completed. Instances have been noted wherein only ¼ inch of the cable was swaged in the terminal.

Observance of the following precautions should minimize this possibility:

- Measure the length of the terminal end of the fitting to determine the proper length of cable to be inserted into the barrel of the fitting.
- Lay off this length at the end of the cable and mark with masking tape. Since the tape will not slip, it will provide a positive marking during the swaging process.
- After swaging, check the tape marker to make certain that the cable did not slip during the swaging operation.
- Remove the tape and paint the junction of the swaged fitting and cable with red paint.
- At all subsequent service inspections of the swaged fitting, check for a gap in the painted section to see if cable slippage has occurred.

NICOPRESS® SWAGED END FITTINGS

The Nicopress® process, a patented process using copper sleeves, is commonly used to create end fittings on control cables. It may be used up to the full rated strength of the cable when the cable is looped around a thimble. (***Figure 13-6***)

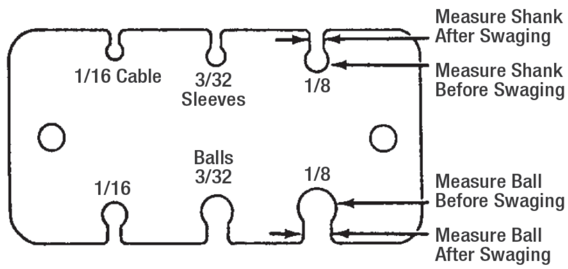

Figure 13-5. Typical terminal gauge.

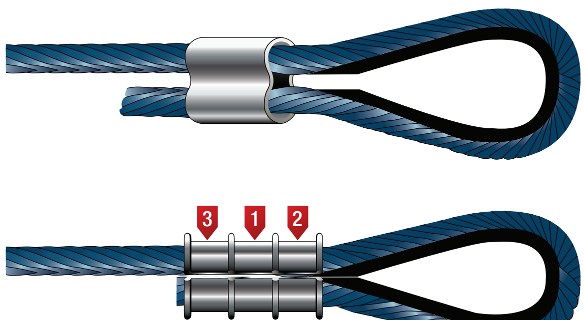

Figure 13-6. Typical Nicopress® thimble-eye splice.

This process may also be used in place of the 5-tuck splice on cables up to and including 3/8 inch diameter. Whenever this process is used for cable splicing, it is imperative that the tools, instructions, and data supplied by Nicopress® be followed exactly to ensure the desired cable function and strength is attained. The use of sleeves that are fabricated of material other than copper requires engineering approval for the specific application. Before undertaking a Nicopress® splice, determine the proper tool and sleeve for the cable to be used. Refer to ***Figure 13-7 and Figure 13-8*** for details on sleeves, tools, and the number of presses required for the various sizes of aircraft cable. The tool must be in good working condition and properly adjusted to ensure a satisfactory splice.

To compress a sleeve, have it well centered in the tool groove with the major axis of the sleeve at right angles to the tool. If the sleeve appears to be out of line after the press is started, open the tool, re-center the sleeve, and complete the press.

Before undertaking a thimble-eye splice, initially position the cable so the end will extend slightly beyond the sleeve, as the sleeve will elongate somewhat when it is compressed. If the cable end is inside the sleeve, the splice may not hold the full strength of the cable. It is desirable that the oval sleeve be placed in close proximity to the thimble points, so that when compressed, the sleeve will contact the thimble as shown in ***Figure 13-6***.

	Copper Oval Sleeve Stock No.						
Cable Size	Plain	Plated*	Manual Tool No.	Sleeve Length Before Compression (approx.) (inches)	Sleeve Length After Compression (approx.) (inches)	Number of Presses	Tested Strength (pounds)
3/64	18-11-B4	28-11-B4	51-B4-887	3/8	7/16	1	340
1/16	18-1-C	28-1-C	51-C-887	3/8	7/16	1	550
3/32	18-2-G	28-2-G	51-G-887	7/16	1/2	1	1 180
1/8	18-3-M	28-3-M	51-M-850	9/16	3/4	3	2 300
5/32	18-4-P	28-4-P	51-P-850	5/8	7/8	3	3 050
3/16	18-6-X	28-6-X	51-X-850	1	1 1/4	4	4 350
7/32	18-8-F2	28-8-F2	51-F2-850	7/8	1 1/16	4	5 790
1/4	18-10-F6	28-10-F6	3-F6-950	1 1/8	1 1/2	3	7 180
5/16	18-13-G9	28-13-G9	3-G9-950	1 1/4	1 5/8	3	11 130
			No. 635 Hydraulic Tool Dies				
3/64	18-23-H5	28-23-H5	Oval H5	1 1/2	1 7/8	1	16 800
1/16	18-24-J8	28-24-J8	Oval J8	1 3/4	2 1/8	2	19 700
3/32	18-25-K8	28-25-K8	Oval K8	1 7/8	2 1/2	2	25 200
1/8	18-27-M1	28-27-M1	Oval M1	2	2 5/8	3	31 025
5/16	18-28-N5	28-28-N5	Oval N5	2 3/8	3 1/8	3	39 200

*Required on stainless cables due to electrolysis caused by different types of metals.

Figure 13-7. Copper oval sleeve data.

Cable Size (inch)	Sleeve No.	Tool No.	Sleeve	Sleeve	Tested Strength (pounds)
	Copper Stop Sleeve Data				
3/64	871-12-B4	51-B4-887	7/32	11/64	280
1/16	871-1-C	51-C-887	7/32	13/64	525
3/32	871-17-J (Yellow)	51-MJ	5/16	21/64	600
1/8	S71-18-J (Red)	51-MJ	5/16	21/64	800
5/32	871-19-M	51-MJ	5/16	27/64	1 200
3/16	871-20-M (Black)	51-MJ	5/16	27/64	1 600
7/32	871-22-M	51-MJ	5/8	7/16	2 300
1/4	871-23-F6	3-F6-950	11/16	21/32	3 500
5/16	871-26-F6	3-F6-950	11/16	21/32	3 800

NOTE: All stop sleeves are plain copper. Certain sizes are colored for identification.

Figure 13-8. Copper stop sleeve data.

The sharp ends of the thimble may be cut off before being used; however, make certain the thimble is firmly secured in the cable loop after the splice has been completed. When using a sleeve requiring three compressions, make the center compression first, the compression next to the thimble second, and the one farthest from the thimble last.

Lap or running splices may also be made with copper oval sleeves. When making such splices, it is usually necessary to use two sleeves to develop the full strength of the cable. The sleeves should be positioned as shown in ***Figure 13-4B***, and the compressions made in the order shown. As in the case of eye splices, it is desirable to have the cable ends extend beyond the sleeves sufficiently to allow for the increased length of the compressed sleeves. Stop sleeves may be used for special cable end and intermediate fittings. They are installed in the same manner as Nicopress oval sleeves.

NOTE: All stop sleeves are plain copper. Certain sizes are colored for identification.

Terminal Gauge. To make a satisfactory copper sleeve installation, it is important that the amount of sleeve pressure be kept uniform. The completed sleeves should be checked periodically with the proper gauge. Hold the gauge so that it contacts the major axis of the sleeve. The compressed portion at the center of the sleeve should enter the gauge opening with very little clearance, as shown in ***Figure 13-9***. If it does not, the tool must be adjusted accordingly.

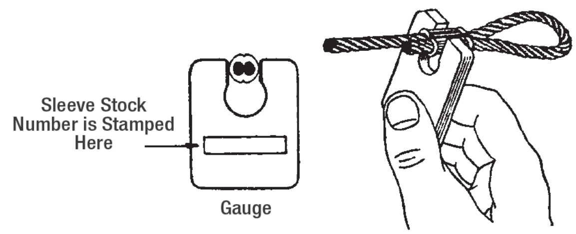

Figure 13-9. Typical terminal gauge.

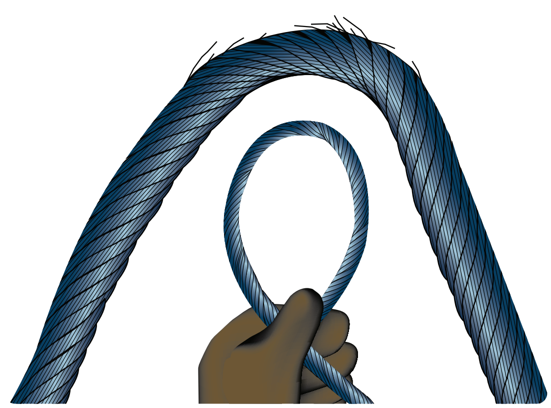

Figure 13-10. Cable inspection technique.

The preceding information regarding copper oval sleeves and stop sleeves is based on tests made with flexible aircraft cable. The sleeves may also be used on wire ropes of other construction, if each specific type of cable is proof-tested initially. Because of variation in rope strengths, grades, construction, and actual diameters, the test is necessary to insure proper selection of materials, the correct pressing procedure, and an adequate margin of safety for the intended use.

INSPECTION AND TESTING OF CABLES

Aircraft cable systems are subject to a variety of environmental conditions and deterioration. Wire or strand breakage is easy to visually recognize. Other kinds of deterioration such as wear, corrosion, and/or distortion are not easily seen; therefore, control cables should be removed periodically for a more detailed inspection. At each annual or 100 hour inspection, all control cables must be inspected for broken wires strands. Any cable assembly that has one broken wire strand located in a critical fatigue area must be replaced. A critical fatigue area is defined as the working length of a cable where the cable runs over, under, or around a pulley, sleeve, or through a fair-lead; or any section where the cable is flexed, rubbed, or worked in any manner; or any point within 1 foot of a swaged-on fitting.

A swaged-on fitting can be an eye, fork, ball, ball and shank, ball and double shank, threaded stud, threaded stud and turnbuckle, compression sleeve, or any hardware used as a termination or end fitting on the cable. These fittings may be attached by various swaging methods such as rotary swaging, roll swaging, hydraulic pressing, and hand swaging tools. (See MIL-T-781.) The pressures exerted on the fittings during the swaging process sometimes pinch the small wires in the cable. This can cause premature failure of the pinched wires, resulting in broken wires.

Close inspection in these critical fatigue areas, must be made by passing a cloth over the area to snag on broken wires. This will clean the cable for a visual inspection, and detect broken wires if the cloth snags on the cable. Also, a very careful visual inspection must be made since a broken wire will not always protrude or stick out, but may lie in the strand and remain in the position of the helix as it was manufactured. Broken wires of this type may show up as a hairline crack in the wire. If a broken wire of this type is suspected, further inspection with a magnifying glass of 7 power or greater is recommended. ***Figure 13-10*** shows a cable with broken wires that was not detected by wiping, but was found during a visual inspection. The damage became readily apparent when the cable was removed and bent as shown.

Kinking of wire cable can be avoided if properly handled and installed. Kinking is caused by the cable taking a spiral shape as the result of unnatural twist. One of the most common causes for this twist is improper unreeling and uncoiling. In a kinked cable, strands and wires are out of position, which creates unequal tension and brings excessive wear at this part of the cable. Even though the kink may be straightened so that the damage appears to be slight, the relative adjustment between the strands has been disturbed so that the cable cannot give maximum service and should be replaced. Inspect cables for a popped core or loose strands. Replace any cable that has a popped core or loose strands regardless of wear or broken wires.

Nylon jacketed cable with any cracks or necking down in the diameter of the jacket shall be replaced. Usable cable life is over when these conditions begin to appear in the nylon jacket.

External wear patterns will extend along the cable equal to the distance the cable moves at that location and may occur on one side of the cable or on its entire circumference. Replace flexible and non-flexible cables when the individual wires in each strand appear to blend together (outer wires worn 40 to 50 percent) as depicted in ***Figure 13-11***. Actual instances of cable wear beyond the recommended replacement point are shown in ***Figure 13-12***.

As wear is taking place on the exterior surface of a cable, the same condition is taking place internally, particularly in the sections of the cable which pass over pulleys and quadrants. This condition (shown in ***Figure 13-13***) is not easily detected unless the strands of the cable are separated. This type of wear is a result of the relative motion between inner wire surfaces. Under certain conditions, the rate of this type of wear can be greater than that occurring on the surface.

Areas especially conducive to cable corrosion are battery compartments, lavatories, wheel wells, etc.; where a concentration of corrosive fumes, vapors, and liquids can accumulate. Carefully examine any cable for corrosion, when it has a broken wire in a section that is not in contact with a wear producing airframe component, such as a pulley, fair-lead, etc. If the surface of the cable is corroded, relieve cable tension and carefully force the cable open by reverse twisting and visually inspect the interior. Corrosion on the interior strands of the cable constitutes failure, and the cable must be replaced. If no internal corrosion is detected, remove loose external

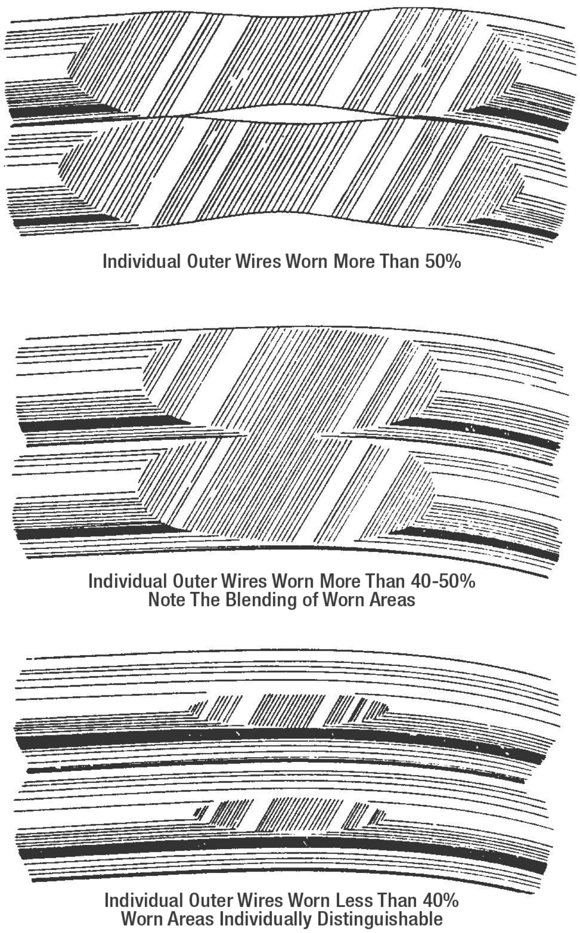

Figure 13-11. Cable wear patterns.

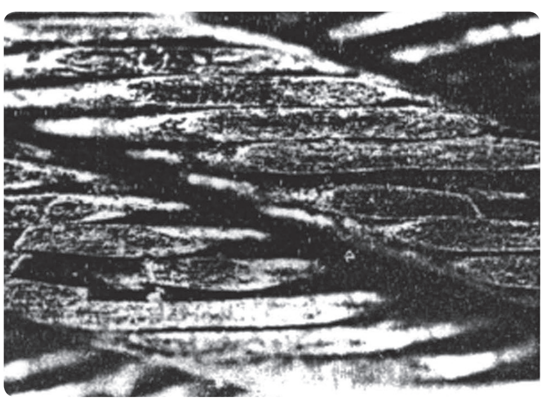

Figure 13-12. Worn cable (replacement necessary).

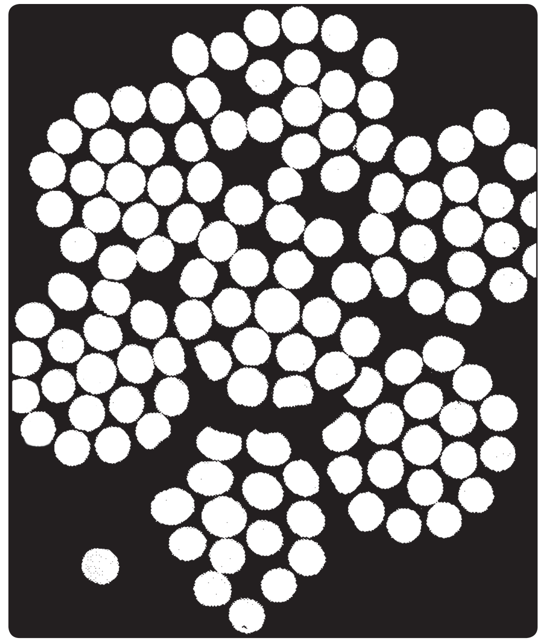

Figure 13-13. Internal end view of cable wear.

rust and corrosion with a clean, dry, coarse weave rag, or fiber brush. Do not use metallic wool or solvents to clean installed cables. Use of metallic wool will embed dissimilar metal particles in the cables and create further corrosion problems.

Solvents will remove internal cable lubricant allowing cable strands to abrade and further corrode. After thorough cleaning, sparingly apply specification MIL-C-16173, grade 4, corrosion-preventive compound to cable. Do not apply the material so thick that it will interfere with the operation of cables at fair-leads, pulleys, or grooved bellcrank areas. Examine cable runs for incorrect routing, fraying, twisting, or wear at fair-leads, pulleys, anti abrasion strips, and guards. Look for interference with adjacent structure, equipment, wiring, plumbing, and other controls. Inspect cable systems for binding, full travel, and security of attaching hardware. Check for slack in the cable system by attempting to move the control column and/or pedals while the gust locks are installed on the control surfaces. With the gust locks removed, actuate the controls and check for friction or hard movement. These are indications that excessive cable tension exists.

NOTE: If the control movement is stiff after maintenance is performed on control surfaces, check for parallel cables twisted around each other, or cables connected in reverse.

Check swaged terminal reference marks for an indication of cable slippage within the fitting. Inspect the fitting assembly for distortion and/or broken strands at the terminal. Ensure that all bearings and swivel fittings (bolted or pinned) pivot freely to prevent binding and subsequent failure. Check turnbuckles for proper thread exposure and broken or missing safety wires/clips.

Inspect pulleys for roughness, sharp edges, and presence of foreign material embedded in the grooves. Examine pulley bearings to ensure proper lubrication, smooth rotation; and freedom from flat spots, dirt, and paint spray. During the inspection, rotate the pulleys, which only turn through a small arc, to provide a new bearing surface for the cable. Maintain pulley alignment to prevent the cable from riding on the flanges and chafing against guards, covers, or adjacent structure. Check all pulley brackets and guards for damage, alignment, and security. Various cable system malfunctions may be detected by analyzing pulley conditions. These include such discrepancies as too much tension, misalignment, pulley bearing problems, and size mismatches between cables and pulleys. Examples of these conditions are shown in ***Figure 13-14***.

Inspect fair-leads for wear, breakage, alignment, cleanliness, and security. Examine cable routing at fair-leads to ensure that deflection angles are no greater than 3° maximum. Determine that all guides and anti-abrasion strips are secure and in good condition. Examine pressure seals for wear and/or material deterioration. Seal guards should be positioned to prevent jamming of a pulley in case pressure seal fails and pieces slide along the cable.

MANUFACTURER WIRE SPLICES

Manufacturers splice cable wires during the mass production of spools of wire. These splices have been mistaken for defects in the cable because individual wire end splices were visible after assembly of a finished cable length. In some instances, the process of twisting outer strands around the core strand may also slightly flatten individual outer wires, particularly in the area of a wire splice. This flattening is the result of die-sizing the cable, and does not affect the strength of the cable. These conditions (as shown in ***Figure 13-15***) are normal, and are not a cause for cable rejection.

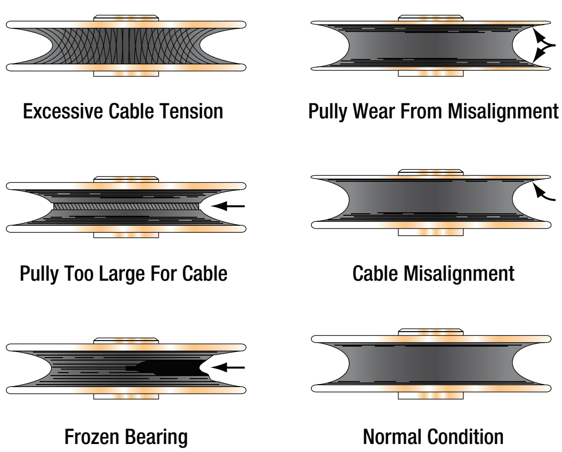

Figure 13-14. Pulley wear patterns.

TESTING CABLE TENSION

For the aircraft to operate as it was designed, the cable tension for the flight controls must be correct. To determine the amount of tension on a cable, a tensiometer is used. When properly maintained, a tensiometer is 98 percent accurate. Cable tension is determined by measuring the amount of force needed to make an offset in the cable between two hardened steel blocks called anvils. A riser or plunger is pressed against the cable to form the offset. Several manufacturers make a variety of tensiometers, each type designed for different kinds of cable, cable sizes, and cable tensions. (***Figure 13-16***)

Carefully adjust control cable tension in accordance with the airframe manufacturer's recommendations. On large aircraft, take the temperature of the immediate area into consideration when using a tension meter. For long cable

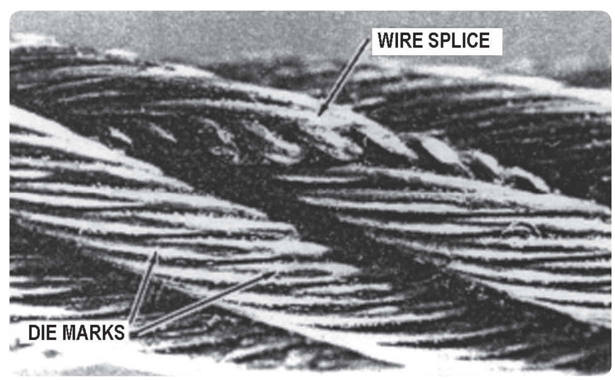

Figure 13-15. Manufacturer's wire splice.

Figure 13-16. Tensiometer.