# Fundamentals
# M7
# MAINTENANCE PRACTICES

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## M7.13
## Control Cables

EASA Part-66
CAT B1

# Training Manual

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# M7 MAINTENANCE PRACTICES

## M7.13 CONTROL CABLES

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# INSPECTION AND TESTING OF CONTROL CABLES

## Inspection of Cables

### General

Handling, checking, adjustment and stretching are relatively easy.

All cables in an aircraft, especially control cables, require careful inspection at regular intervals in order to ensure their satisfactory function and serviceability at all times. The allowable damages of control cables can normally be found in ATA 20 of the particular Aircraft Maintenance Manuals.

### Check of Control Cables and Pulleys

The check of cables is done after cleaning with a dry cloth. Do not use solvents!

**CAUTION:** WEAR GLOVES WHEN YOU TOUCH THE CABLES. BROKEN STRANDS CAN INJURE YOU.

### Check on broken Wires

The very important areas where the wires can break are the lengths of the cable that go through fairleads and around pulleys.

Examine the cables. Ensure that there are no broken wires. To do this:

- Move a cloth along the cable, in two directions.
- If the cloth catches on the cable:
  - Make a visual inspection to find the broken wires.

The permitted limits for the cables with broken wires are:

- For class **7 x 19 cable**, 6 broken wires in a same one–inch (25.4 mm) length of cable with not more than 3 broken wires for each strand.
- For class **7 x 7 cable**, 3 broken wires in a same one–inch (25.4 mm) length of cable with not more than 2 broken wires for each strand.

**CAUTION:** THERE MUST NOT BE BROKEN WIRES IN TWO CONSECUTIVE ONE-INCH (25.4 MM) LENGTH OF CABLE. FOR THE LENGTHS OF CABLES WHICH CAN TOUCH PULLEYS OR GO THROUGH FAIRLEADS AND PRESSURE SEALS, NOT MORE THAN THREE BROKEN WIRES ARE PERMITTED.

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**Figure 1 (A320) Cable Inspection (1)**

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### Inspection of Cables (Cont'd)

#### Check of Wear

Make a visual inspection of the cables, especially the lengths that can touch pulleys, fairleads or pressure seals. Ensure that they are not worn.

- The permitted wear limits in a same one–inch (25.4 mm) length of cable are:
  - For class 7 x 19 cable, a maximum of 6 wires worn to 50% or more of their diameter.
  - For class 7 x 7 cable, a maximum of 3 wires worn to 50% or more of their diameter, if there are no broken wires.

**WARNING:** THE NUMBERS OF PERMISSIBLE WORN WIRES IN A SAME ONE-INCH (25.4 MM) LENGTH OF CABLE IS DECREASED BY ONE WIRE FOR EVERY BROKEN WIRE. A MAXIMUM OF TWO ONE-INCH LENGTHS OF A CABLE WITH WEAR (WITHIN THE LIMITS SPECIFIED ABOVE) IS PERMISSIBLE ON THE TOTAL LENGTH OF THE CABLE (BETWEEN TWO CABLE TERMINALS) ON THE CONDITION THAT THE WEAR IS NOT ON TWO CONSECUTIVE ONE-INCH LENGTHS OF CABLE. IF A WIRE IS WORN TO MORE THAN 60% OF ITS DIAMETER, YOU MUST CALL IT BROKEN WIRE.

#### Internal Cable Wear

In some areas (for example around pulleys and quadrants) the cable can wear internally more than it wears externally.

To find such wear, move the strands apart to examine the cable internally.

#### Corrosion

Corrosion of cables specially occurs in these areas:

- Avionic compartment
- Toilets
- Landing gear bays
- In areas with corrosive atmosphere

If a cable has a broken wire in a length that does not touch airframe components which can make it wear (pulleys, fairleads etc.), carefully examine the cable. Ensure that it has no corrosion.

If necessary, remove the cable. Bend the cable to make sure that the internal strands do not have corrosion.

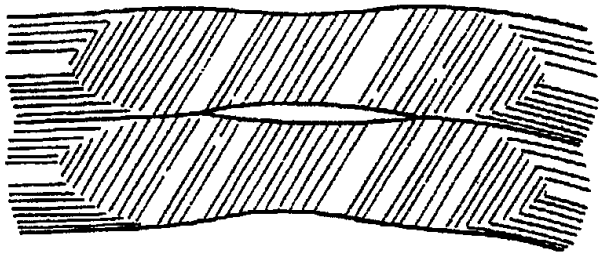
If you find surface corrosion:

- Loosen the cable. Make a full inspection of the inner strands.
- Discard the cable if you find corrosion on the inner strands.
- If you find light surface corrosion, remove it and protect the cable again.

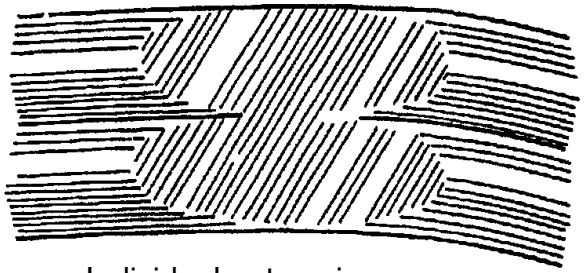
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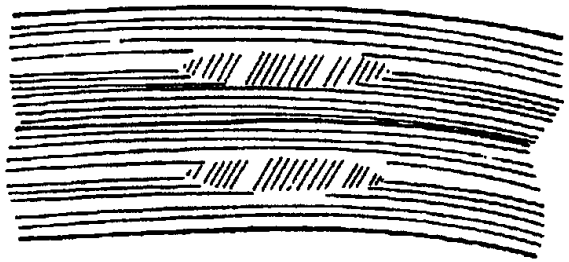




Individual outer wires worn more than 50%



Individual outer wires worn 40–50%
(note blending of worn areas)



Individual outer wires worn less than 40%
(worn areas individually distinguishable)

MAXIMUM WEAR : 50%

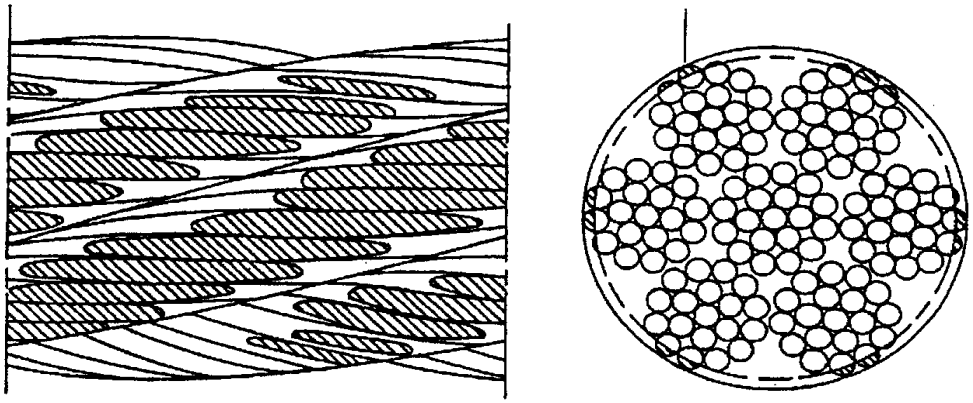


**Figure 2 (A320) Cable Inspection (2)**

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## Inspection of Pulleys

### General

During the check of the entire cable system also the pulleys have to be checked on all possible damages and a proper serviceability.

The pulleys have to be checked on:

- cracked edges and hub
- signs of incorrect wear in the bottom of the groove
- excessive play
- Dirt or debris in the groove.

Examine the pulleys while in operation:

- ensure that the pulleys turn freely and constantly
- ensure that the cable does not skid in the groove.

Ensure that the eccentricity agrees with the values shown in this table:

**Part of the A340 maintenance manual:**

| Pulley, small diameter | Max. eccentricity at top of the groove | Max. eccentricity at bottom of the groove |
|---|---|---|
| Less than or equal to 1.181 in.(30 mm) | 0.011 in.(0.30 mm) | 0.005 in.(0.15 mm) |
| From 30 mm to less than 3.149 in. (80 mm) | 0.015 in.(0.40 mm) | 0.007 in.(0.20 mm) |
| More than or equal to 3.149 in.(80 mm) | 0.019 in.(0.50 mm) | 0.007 in.(0.20 mm) |

### Inspection of Pulley Wobble

Do a wobble check at each turn of the pulley. For pulley with a diameter less than 80 mm (3.1496 in.), the wobble must not be more than 0.25 mm (0.0098 in.).

For pulleys with a diameter of 80 mm (3.1496 in.) or more, the wobble must not be more than 0.30 mm (0.0118 in.).

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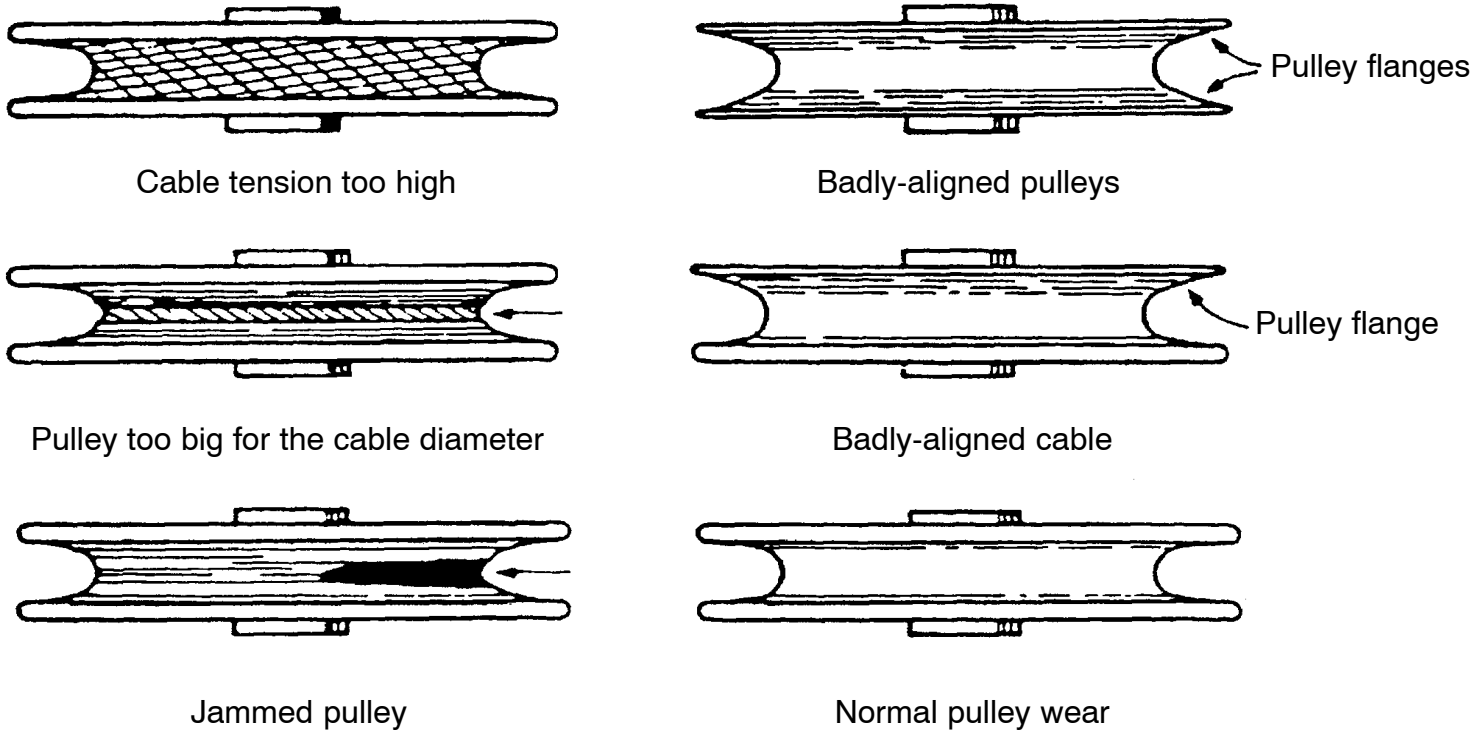



**Figure 3 Pulley Inspection (AMM A320)**

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## Removal/Disconnecting of Control Lines

### Proceeding during Removal/Disconnecting of Control Lines

- Install red warning sign at particular control lever in cockpit.
- Mark the terminal with colored adhesive tape in such a way that the original adjustments can be used as a reference point during reinstallation and readjustment of the system.
- Release turnbuckles slightly for stress relief of the cables.
- Install cable clamp at the cables, which are not removed, in such a way that they are put under a small tension. This small stress on the installed cables prevents unwinding from barrels or the jump off from pulleys.
- If the cable can be sectioned between rigging pin positions the rigging pins have to be installed through particular bus drums or quadrants.
- If needed, remove or loosen pressure seals, pulleys or conducts for removing the cable.

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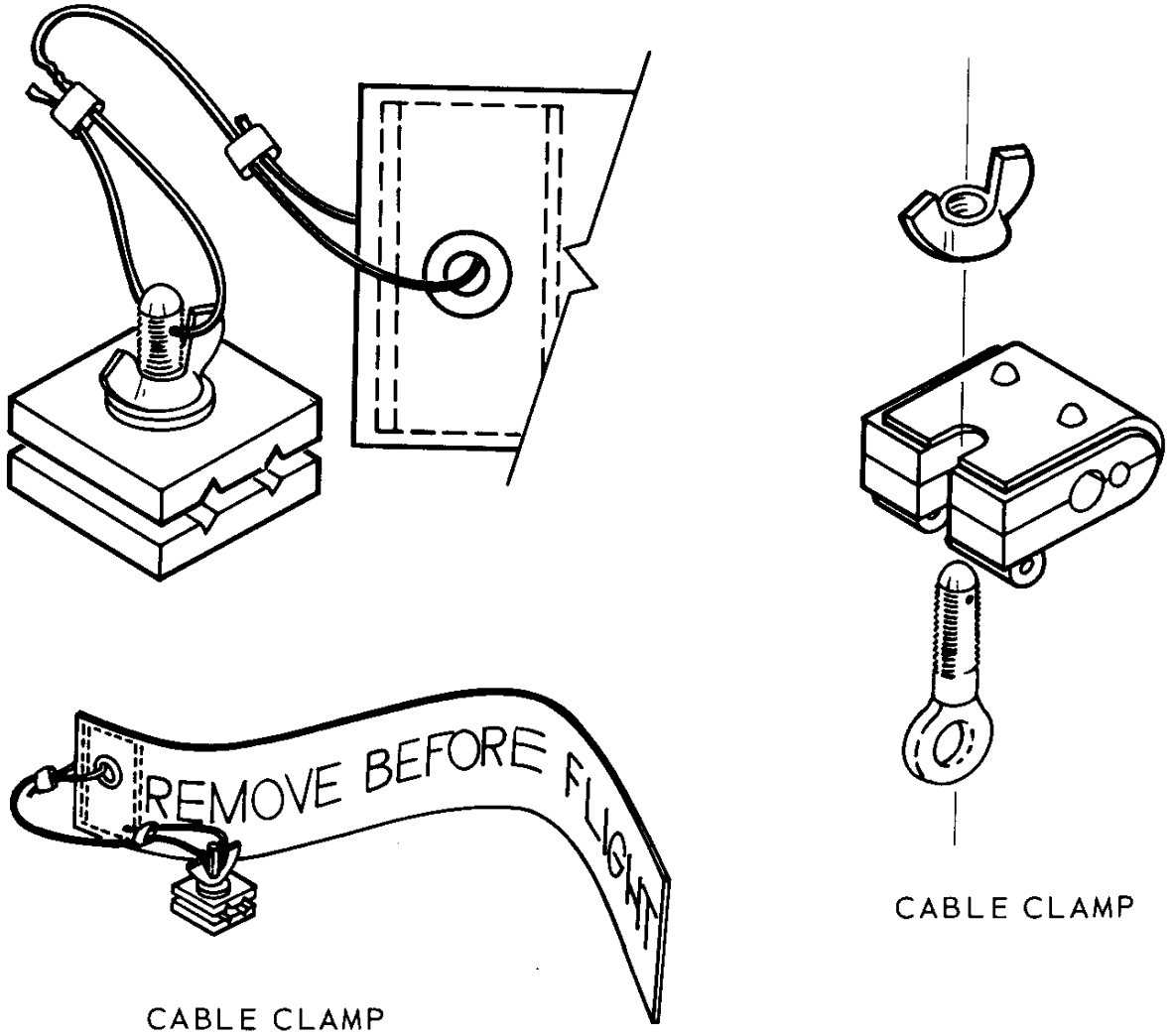



**Figure 4 Cable Clamp**

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## Installation of Manufactured Cable Lines

### General

During installation of a manufactured cable line proceed as follows:

- If necessary, remove all pulleys and pressure seals that may disturb installation.
- If necessary, use old cable lines as guiding for the new lines.
- Reinstall deinstalled or unfastened fairleads, pulleys and pressure seals.
- Prestress the cable lines according to the values given in the AMM and move the system several times.
- Check the cable tension with the tensiometer and tighten the cable according to the AMM.
- Lubricate the cable (Not for cables out of CRES).

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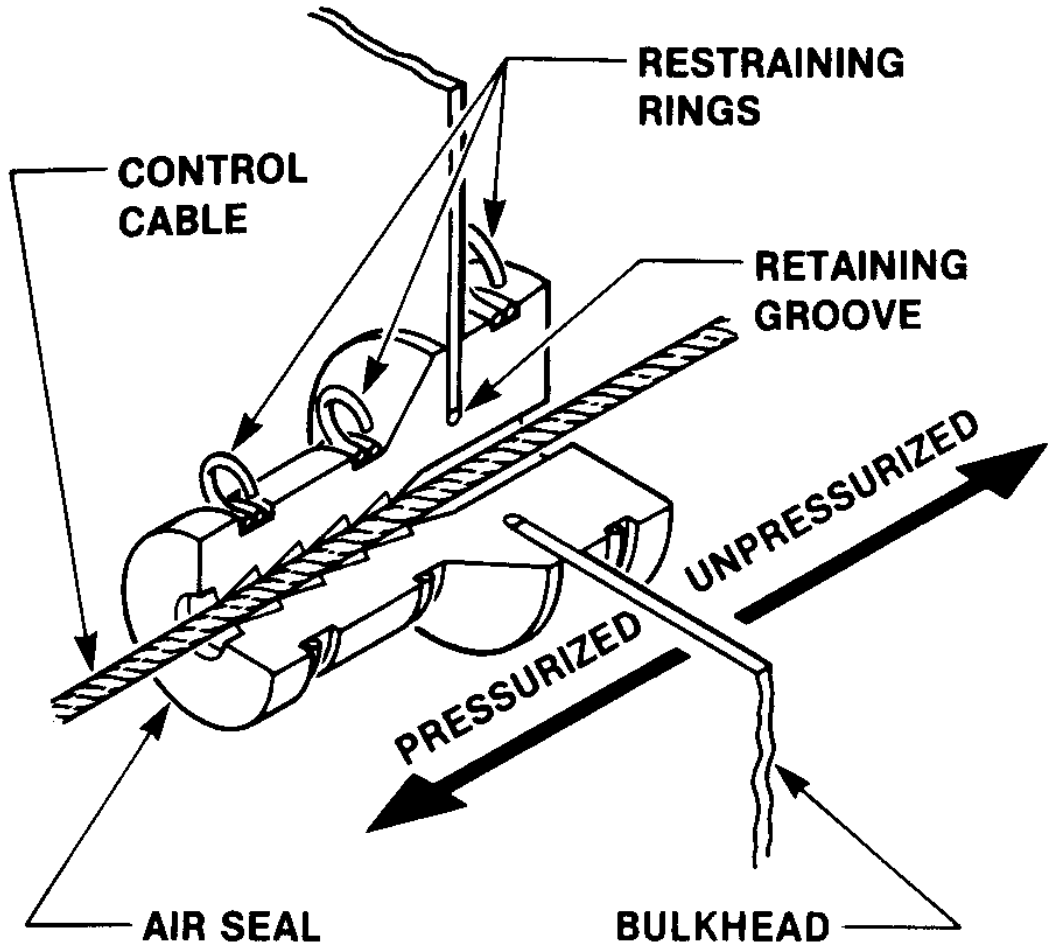



**Figure 5 Air Seal**

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## Installation of half pre-assembled Cable Lines

### General

After procuring a cable that has to be newly installed and is pre-assembled firstly the terminal that has to be rolled on must be chosen according to the AMM (or sample of the old cable line).

The length of cable lines, at which the second terminal is primary installed in the aircraft, has to be chosen with an overlength of 200 mm (8 in.), which is cut away not until the installation of the second terminal. By this it is ensured that the cable end is free of damages.

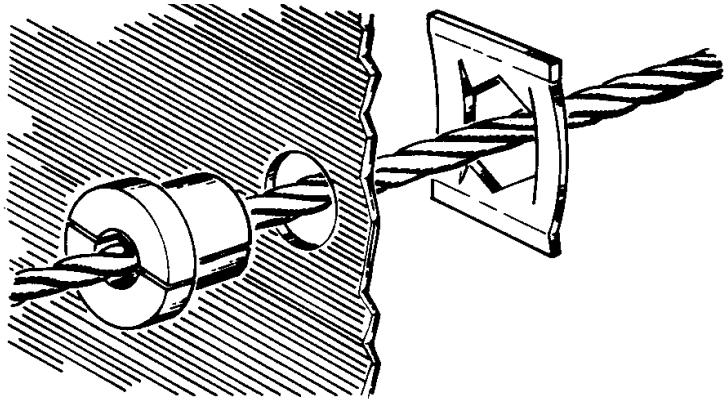
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### Cable Installation Proceeding

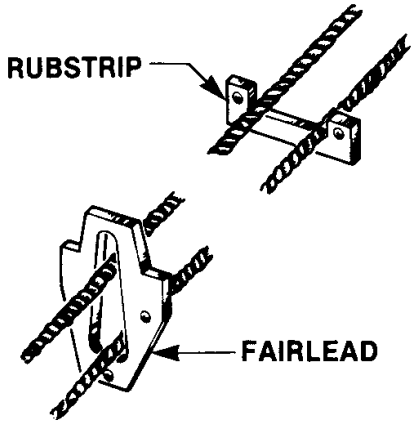
- Wrap tape around the end of the cable to be removed so tight that it can not splice. After that, remove the terminal.
- Connect old and new cable. Use preferably an AL sleeve for this purpose in which both cable ends can be clamped.
  - Choose a sleeve with a preferably small diameter to alleviate pulling the cable through pulleys and fairleads.
- Feed in the new cable and guide the cable with a light tense.
- After feeding in the whole cable, roll on the second terminal and check and adjust according to “Inspection Of Manufactured Cable Lines“ .

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SPLIT FAIRLEAD
(A)




SOLID FAIRLEAD
(B)

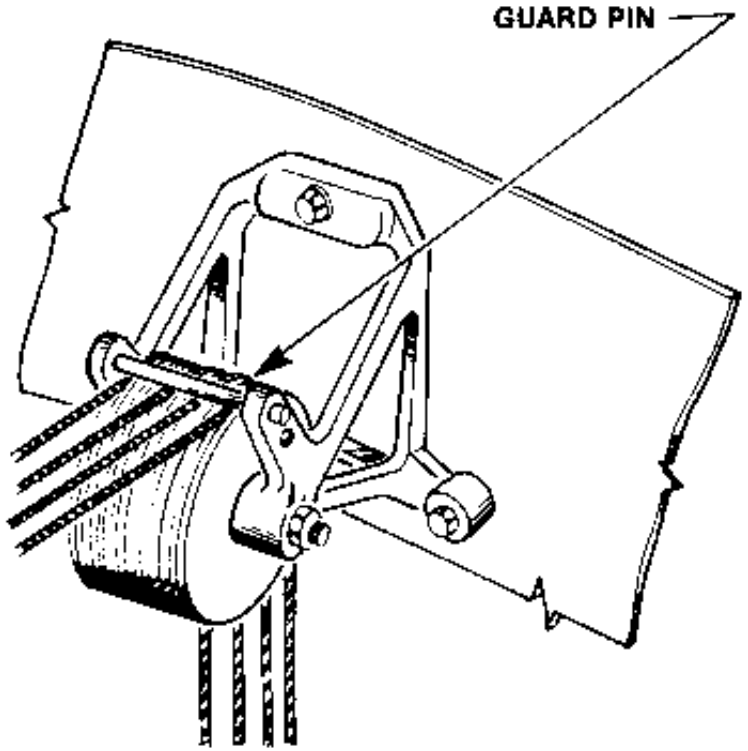



**Figure 6 Fairleads**

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## CABLE TIGHTENING AND MEASURING TENSION

### General

Installed cable lines have to be tightened to a certain tension depending on their location and purpose. Only accurately tightened cable lines ensure a proper transmitting of control commands.

### Pre-Stretching of Cable Lines

A newly-manufactured cable that is delivered by the meter, coiled on a reel, would increase its length under load. This is the reason why it is necessary to preload the cables before they are made into cable lines.

The pre-stretch load equals the test load and can be found in the respective table of the manual. The tension applied has to be done with a steady speed. The load must be applied for 5 minutes.

The cable is only allowed to be preloaded when it is not bent. In the case of cables longer than 30m, the cable may be preloaded over a movable guide pulley.

**NOTE:** Correct tension is essential because loose cables cannot transfer control signals. Loose cables can also lock and thus endanger the airplane and occupants.

Cables with excessive tension are also undesirable in airplanes.

**NOTE:** When the cable tension is adjusted, the ambient temperature is important. In flight, temperatures may vary to a high extent between the ground temperature at the departure airport, the ambient temperatures during flight and the temperature at the destination. Large differences in tensions are created, because the airplane is manufactured from aluminium alloy and the cables are made from steel. The tension values to be adjusted for the individual aircraft types are therefore specified in the respective AMMs.

### Cable Tightening via Turnbuckle

The cable is tightened by turning a turnbuckle. A spring wire clip has to be inserted into the barrel hole of the terminals to prevent the terminals from turning with the cable. The side of the left-hand thread of the turnbuckle is marked by a groove.

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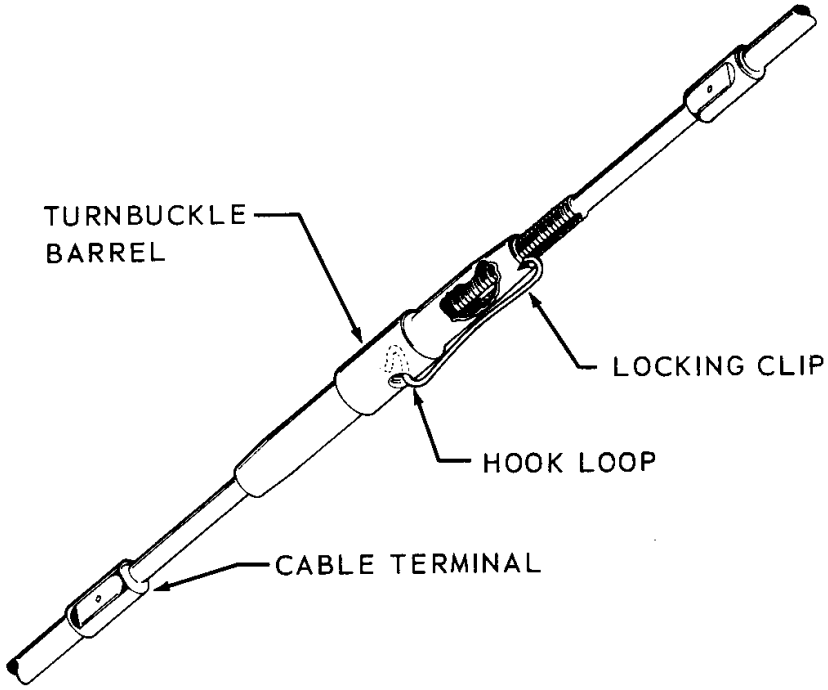



**Figure 7 Turnbuckle**

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## CABLE TENSIOMETER

### General

The cable tension is measured with the tensiometer. The tensiometer is a precision instrument and must be calibrated annually. The entire operation of testing cable tension can be done with one hand. The size of the instrument permits entry through small openings, so that cables in confined areas can be tested and its tension read.

### Build-Up of the Tensiometer

The tensiometer has two scissor hands, a dial with indicator and two riveted steel sectors.

Between these sectors a riser is applied, which is moved up by the scissor hands, tensions the cable and indicates the applied tension on the dial.

**NOTE:** The indicated values are dimensionless and can only be used with a corresponding calibration table. take care that the tensiometer is only used with the right sectors and the right table. Sectors and calibration table are equipped with the serial number of the tensiometer.

Before the tensiometer is used, be sure the correct riser is mounted on the instrument for the size cable to be tested. This information is given on the calibration card in the instrument carrying case. The corresponding riser for every cable diameter is given in the header of the table.

There are five risers, which all have different heights. The height depends on the cable diameter. The smallest riser is used for the largest and the largest for the smallest cables diameter.

But there are also tensiometers with only three different risers. Due to a in-company agreement tensiometers even for the three cable diameters 3/32, 1/8 and 3/16” are only equipped with one riser. Naturally the scale values are different for every cable diameter.

### Procedure

- Move the trigger away from the case as far as possible and place the instrument on the cable with sectors resting against the cable. Tension should not be taken next to a terminal end or turnbuckle, as an inaccurate reading could result.
- Close the trigger with the fingers of the hand in which the instrument is held. Do not twist or pull; this may cause a false reading. Do not let the trigger snap against the case, as this may also give a false reading. The tension should be checked three or four times, moving the instrument slightly along the cable.

If the dial is visible, take the reading and then disengage the instrument by moving the trigger away from the case.

If the dial cannot be seen, the pointer is locked in position by pushing the small brake lever rod at the top left of the case forward. The pointer is unlocked by returning the brake rod to its original position.

**CAUTION:** NEVER LOCK THE BRAKE LEVER ROD UNTIL THE INSTRUMENT IS CLAMPED ON THE CABLE OR A FALSE READING MAY RESULT.

The gauge is not marked in specific units. Convert the dial reading to tension in pounds by referring to the calibration chart attached to the lid of the carrying case.

The indicated dial reading has to be chosen in the corresponding row of the cable diameter. In the same row of the dial reading the tension is listed at the right (kp and/or pounds).

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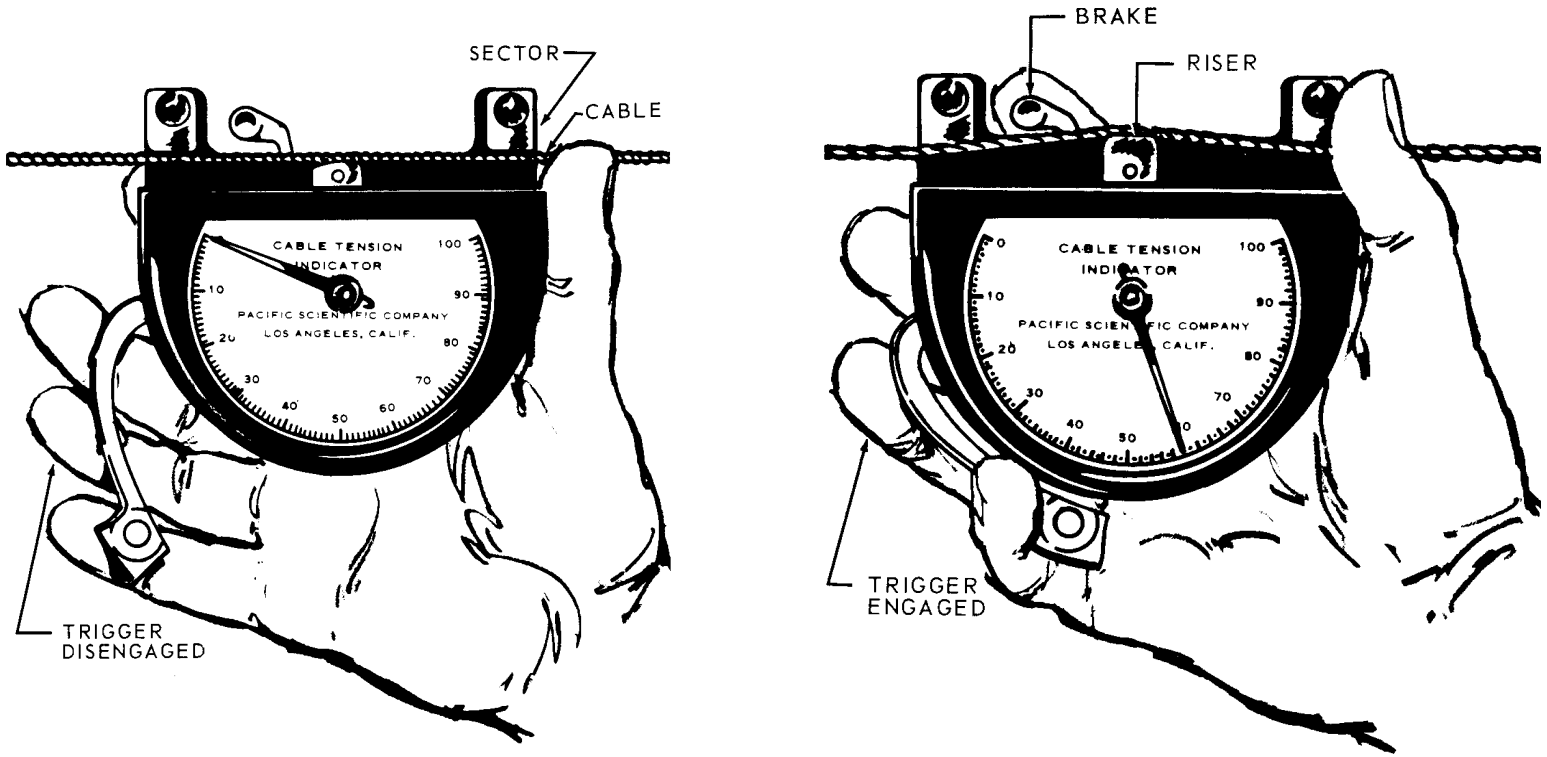



**Figure 8 Cable Tensionmeter Reading**

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## LOCKING OF TURNBUCKLES

### General

the locking of turnbuckles can be done with locking wire or locking clips.

### Locking Turnbuckles with Clips

Locking clips can only be used if terminals and turnbuckle nuts have corresponding grooves for clip insertion.

### Procedure

When locking turnbuckles with clips proceed as follows:

- Turn in the terminal into the turnbuckle and adjust the grooves of terminal and nut in one line
- Insert the straight end of the clip into the groove
- Adjust the remaining end of the clip in such a way that the bent hook points in the direction of the turnbuckle
- Insert the hook with light pressure into the hole in the turnbuckle
- Make sure that the clip is fitted securely and has not been damaged or overbent during installation

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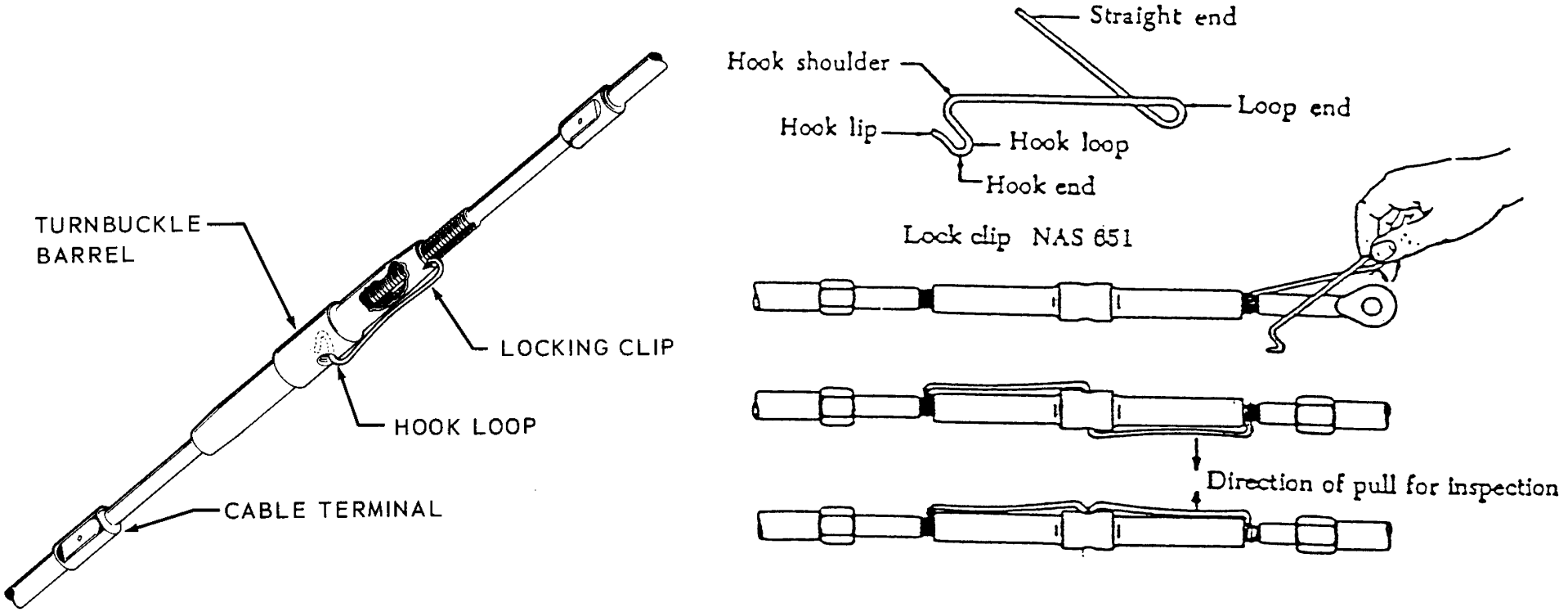



**Figure 9 Locking Turnbuckles with Clips**

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### Locking Turnbuckles with Wire

The specified wire has to be used for wire lockings.

### Procedure

When safetying turnbuckles with wire proceed as follows:

- Guide two wires through the middle hole of the turnbuckle nut.
- Bend the wire ends in a 90 degree direction to the turnbuckle nut.
- Move the wire ends through the hole in the terminal or through the fork of the eye end.
- Bend the wires into the turnbuckle direction. Wind every wire for times around the shaft, whereas the wires are clamped, like it is shown in the figure
- In the terminal only one wire is moved through the hole and this wire is applied around the end of the free wire. Both wires have to be winded around the shaft, like it is shown in the figure.

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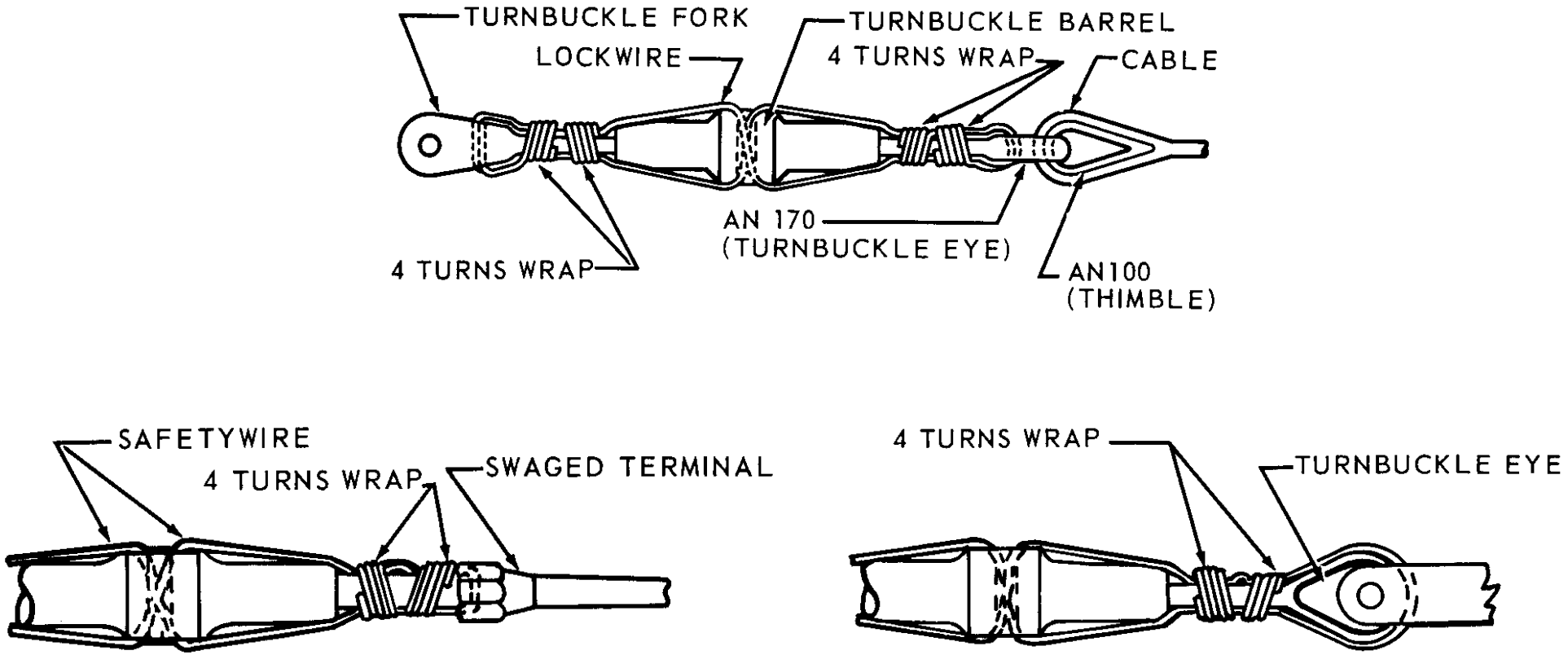



**Figure 10 Locking Turnbuckles with Wire**

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## CABLE IDENTIFICATION

### General

Cables are marked, if possible, by shrinking on plastic sleeves via hot air. The particular part number is printed on the plastic sleeve. The marking of the cable is done in the terminal area.

**CAUTION:** DO NOT APPLY THE HOT AIR STREAM DIRECTLY ON THE CABLE SINCE THIS CAN CAUSE A LOSS OF CABLE LUBRICATION DUE TO THE BLEEDING OUT OF OIL OR GREASE.

If this procedure is not possible due to functional or areal reasons the cables have to be identified with labelled tags.

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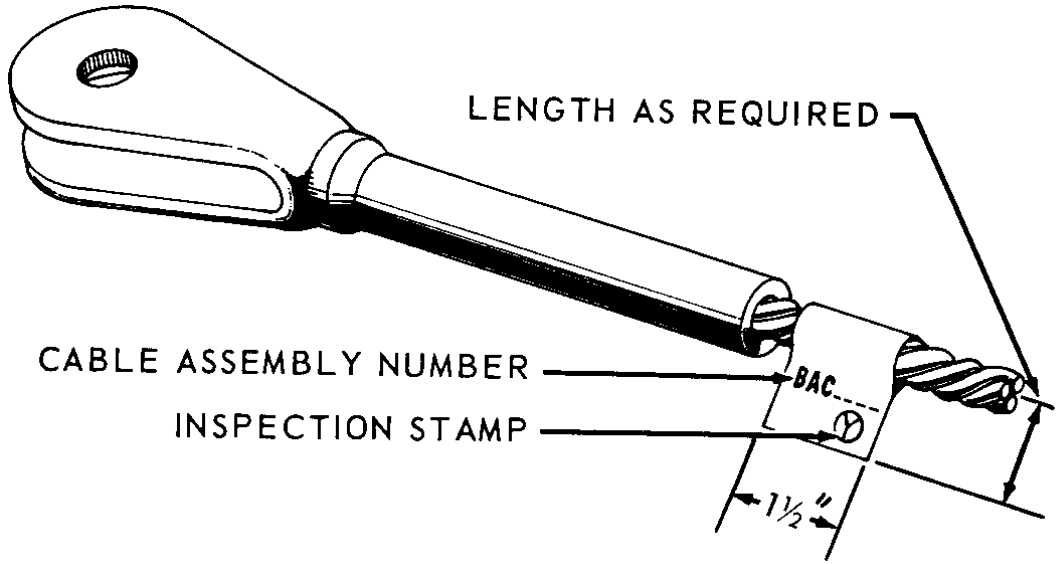



**Figure 11 Cable Identification**

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## CLEANING AND CORROSION PROTECTION OF CABLES

### Cleaning of contaminated Cables

Possible pollution on cable lines must only be removed with a clean and dry cloth.

**CAUTION:** DO NOT USE DEGREASING OR SOLVENT AGENTS IN ANY CASE!

### Corrosion Protection

A corrosion protection has to be applied on high carbon steel.

Examples for materials:

- Rustban 392 (MIL–G–16173 Typ 2)
- Aeroshell Grease 16 (MIL–G–25 760)

Wipe the whole cable with a dry cloth and apply a thin coat of MIL–G–16173 Type 2 . Wipe the cable after that so that only the cable grooves are filled with the protective agent. After becoming touch dry apply a thin grease coat MIL–G–25760. In the wing area and especially at pulleys and other fairings the grease has to be removed so that only a thin layer is existent

If the cable is installed in fuselage or stabilizer, proceed as in the wing area. But a wiping of the whole cable is not necessary.

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# SWAGING OF END FITTINGS

## Rolling on Terminals

### General

Cables in aircraft manufacturing are equipped at their ends with connecting elements so called terminals. Terminals are applied with a special machine (manufacturer or cable shop) or with a hand-held unit.

### Description of Tools

Equipment for rolling on terminals consists of:

- Several sets of rolling discs for different terminals
- Several sets of “Swaging Rolls“ for balls
- A guiding device
- A caliper gauge for terminals
- A caliper gauge for balls
- Allen key for the screws of the rolling disc mountings

Rolling discs for terminals and balls are made for several cable diameters and are marked accordingly.

“LOWER“ is the designation for the rolling disc with two pins and “UPPER“ is the designation for the rolling disk with two holes.

### Procedure

When the expanding machine is placed on the two shanks, the “LOWER“ disc is down (near handle) and the “UPPER“ disc is up.

**CAUTION:** IT IS IMPORTANT TO POSITION THESE DISCS CORRECTLY. TRANSPOSING THEM WILL RESULT IN THE TRANSITION AT THE SLEEVE OF THE TERMINAL BEING SHARP-EDGED, WHICH IS NOT PERMITTED UNDER ANY CIRCUMSTANCES.

After the rolling discs have been installed on the support shaft of the expanding machine, they are mounted with discs and bolts.

The rolling disc with two pins can only be turned counter−clockwise. When the shanks of the machine are moved away from each other, the rolling discs will not turn.

When the shanks are pressed together, the rolling discs move in opposite directions via a pair of gear wheels with a ratchet.

The shanks are opened and closed until the sleeve of the terminal has rounded the circumference of the rolling disc.

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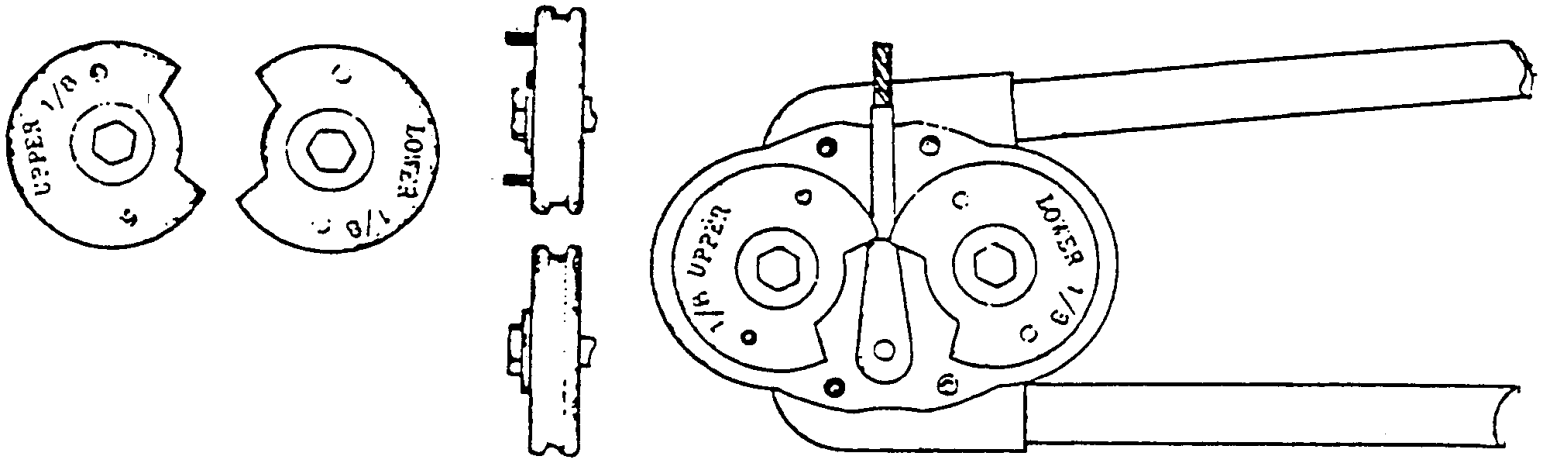



**Figure 12 Hand-Operated Rolling Tool**

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## Rolling of Sleeve Terminals

**Procedure**

Roll on a sleeve terminal as follows:

- Check the sleeve diameter of the terminal using the caliper gauge. The terminal sleeve must fit into the respective test hole of the gauge marked “SLEEVES“. The ball must fit into the test hole marked “BALLS“. The cable diameters are marked on the gauge at the respective holes.
- Select and clean the rolling discs suitable for the respective cable diameter.
- Install the rolling disc with the two pins and the inscription “LOWER“ in the lower support shaft, and the rolling disc with the inscription “UPPER“ and the two holes in the upper support shaft of the expanding machine. Fix both discs with the washers and screws.
- Install the guide.

**ATTENTION:** The cable diameter is indicated at the front of the adapter.

- Move a short part of the cable into the terminal and bend it. The end of the cable will be tight when completely pushed into the terminal.

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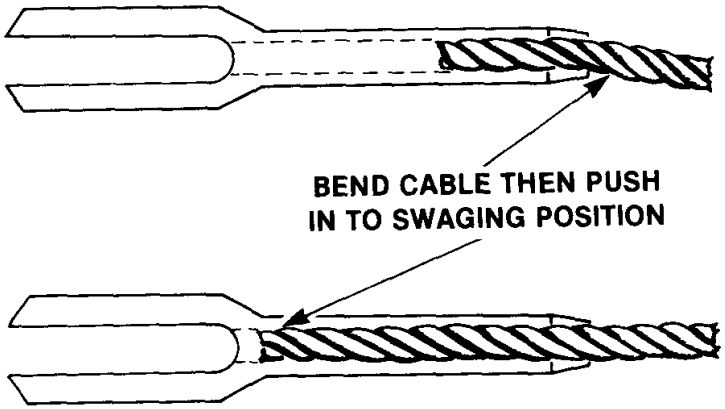



**Figure 13 Inserting Cable in Terminal**

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## ROLLING OF SLEEVE TERMINALS (CONT'D)

- Mark the cable which has been completely inserted into the terminal at the end of the sleeve of the terminal with chalk or tape in order to indicate if the cable slips out.
- Turn the rolling discs into the starting position, using the two pins.
- Press the terminal against the conical guide of the adapter and clamp the cable into the clip at the guiding-device.
- Push the guiding device with the terminal into the starting position for the rolling procedure.
- Turn the rolling discs using the two pins until the terminal is clamped.

**CAUTION:** IT IS NOT PERMITTED TO PERFORM MORE THAN FOUR ROLLING SEQUENCES. EXCESSIVE ROLLING CAUSES BRITTLENESS AND HARDENING OF THE MATERIAL OF THE TERMINAL.

- Perform the rolling procedure quickly.
- After the first operational sequence, a rolling mark will appear on the sleeve of the terminal. Turn the terminal about 90° to compensate for this rolling mark and perform a second operational sequence as described. After the second operational sequence, the terminal sleeve must not show deep impressions.
- Check the diameter of the terminal sleeve with the caliper gauge as described. A slight rolling mark is permitted. The diameter of this rolling mark must not exceed the sleeve diameter by more than 0.010 in. (0,25mm)
- If the diameter of the sleeve terminal has not been tapered sufficiently, a third operation sequence must be carried out. For this you must rotate the terminal through 90°.
- In case a fourth operation sequence is necessary, the terminal must be turned about 90° again.

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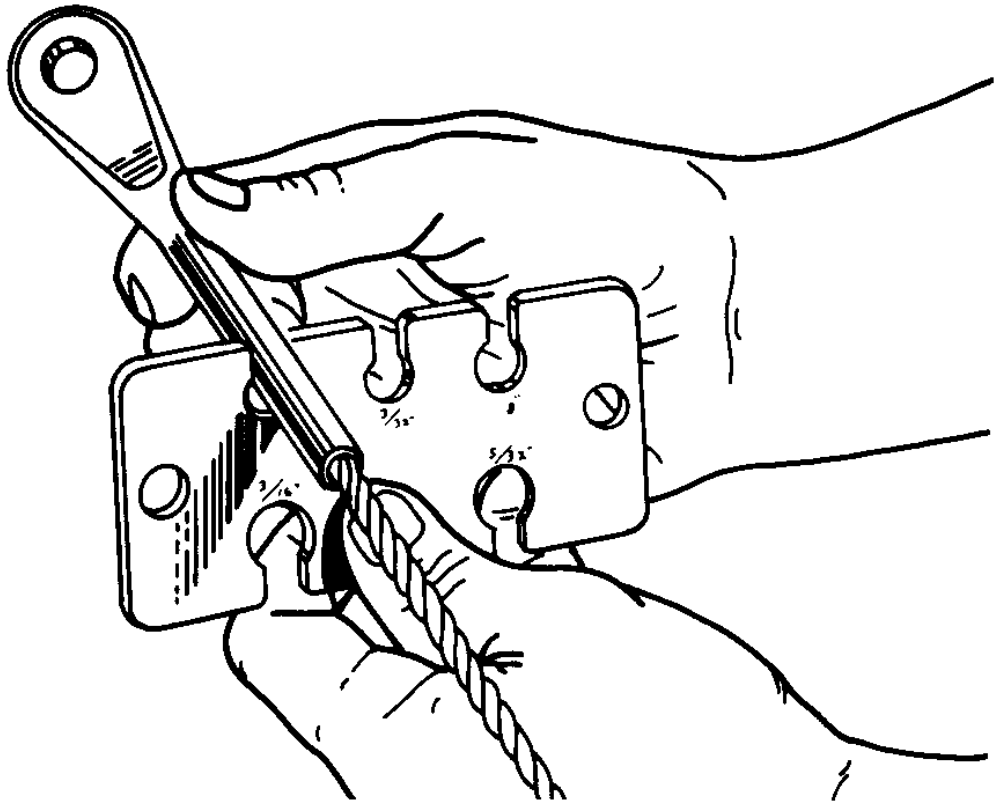


**Figure 14 Gauging Terminal Shank After Swaging**

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## Inspection of Manufactured Cable Lines

### General

Check manufactured cable lines according to the following instructions:

- Check terminals for specified diameters (use caliper gauge of the terminal expanding machine).
- Visual check of the terminals (Use magnifying glass with 6x magnification)
  - There must be no cracks, notches or abrupt changes in cross-section.
- All connections between cable and terminal must be subjected to a test of their tensile strength. In this check, you must evenly apply the respective test pull force (given in a table), observing the specific speed with which the tension may be increased. You must also observe the duration over which the full test pull force is allowed to be applied.

**CAUTION:** IF A SLIPPAGE BETWEEN CABLE AND TERMINAL IS INDICATED DURING THIS TEST (BY MEANS OF MARKS THAT HAVE BEEN APPLIED TO THE CABLE BEFORE THE TEST), THE CONNECTION IS NOT STABLE ENOUGH. THIS CABLE LINE HAS TO BE EITHER DISCARDED OR THE CABLE CAN BE USED FOR SHORTER CABLE LINES AFTER THE TERMINALS HAVE BEEN CUT OFF. IF THE TEST IS PERFORMED WITHOUT SLIPPAGE, THE CONNECTION IS CONSIDERED AS SATISFACTORY.

### Cable Terminal Pull Tester

Rolled-on balls and terminals are checked for sufficient tensile strength by using the Cable Terminal Pull Tester. The Pull Tester consists of

- a vice with steel cheeks with inserted copper cheeks
- and a gauge.

### Procedure

When, for instance, a 1/8“ cable and terminal are checked, you must first select the correct copper cheeks. These must then be inserted into the steel cheeks.

The correct swivel for the terminal must be selected. The cable with the swivel is attached to the test device. The copper cheeks are tightened with two clamping screws to the extent that the cable cannot slacken under the test load.

By turning a hexagon head screw, the cable is tightened with hydraulic power.

The scale of the indicating device shows the load in pounds. The scale has load marks for the respective cable diameter. If not, you must refer to a test table.

Due to a light elongation of the cable the indicator of the gauge will slightly drop. After one or two minutes the pointer has to be returned to the load mark. The full test load should be applied for 5 seconds. Then take off the tension slowly and evenly.

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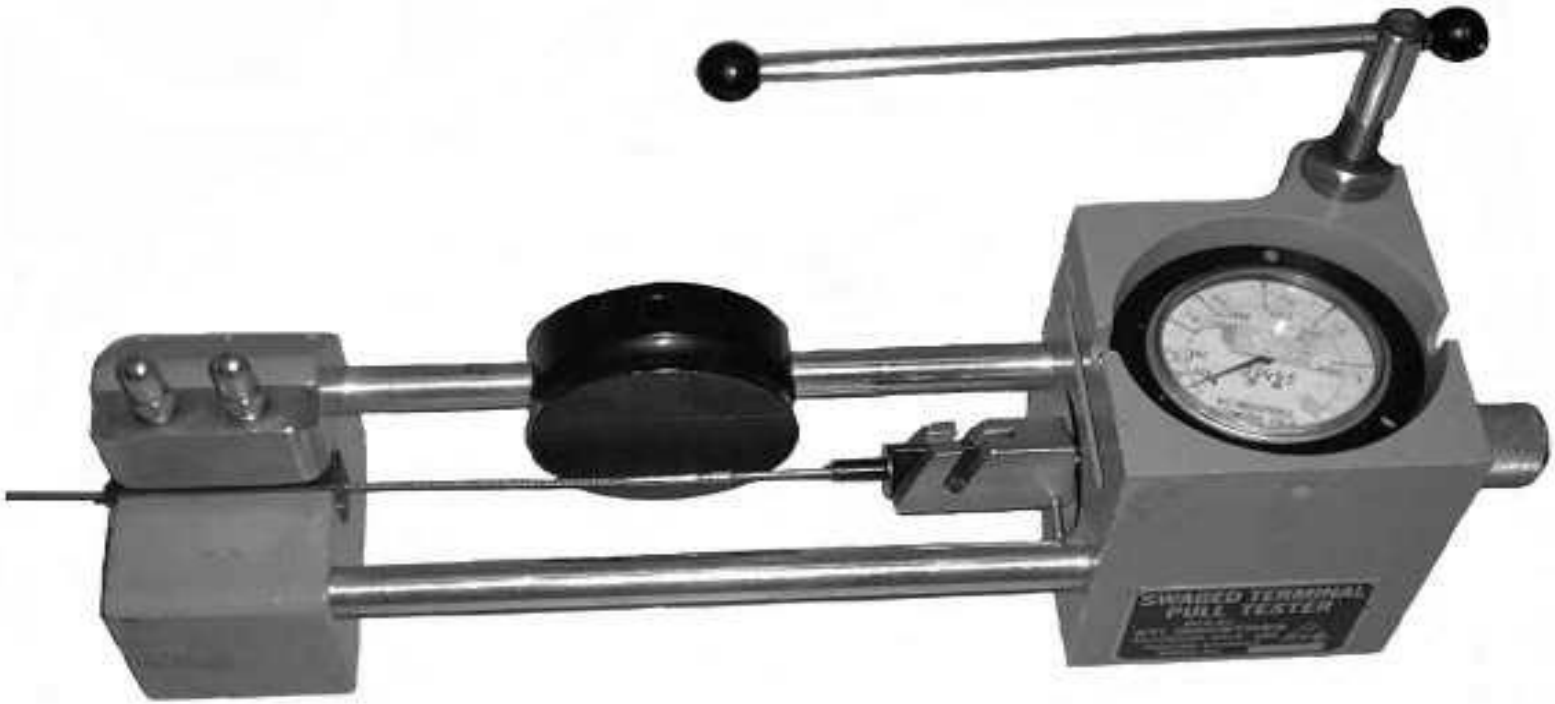



**Figure 15 Cable Terminal Pull Tester**

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# BOWDEN CABLES AND FLEXIBLE CONTROL SYSTEMS

## Teleflex and Bowden Control Systems

### General

**Teleflex** and **bowden control systems** are similar according to their function:

- The cable runs in a protective conduit and is fixed at both ends to it.

This allows it to guide the conduit in curves, which would else not be possible since a tensioned cable runs in a straight line and would so move the conduit in that way.

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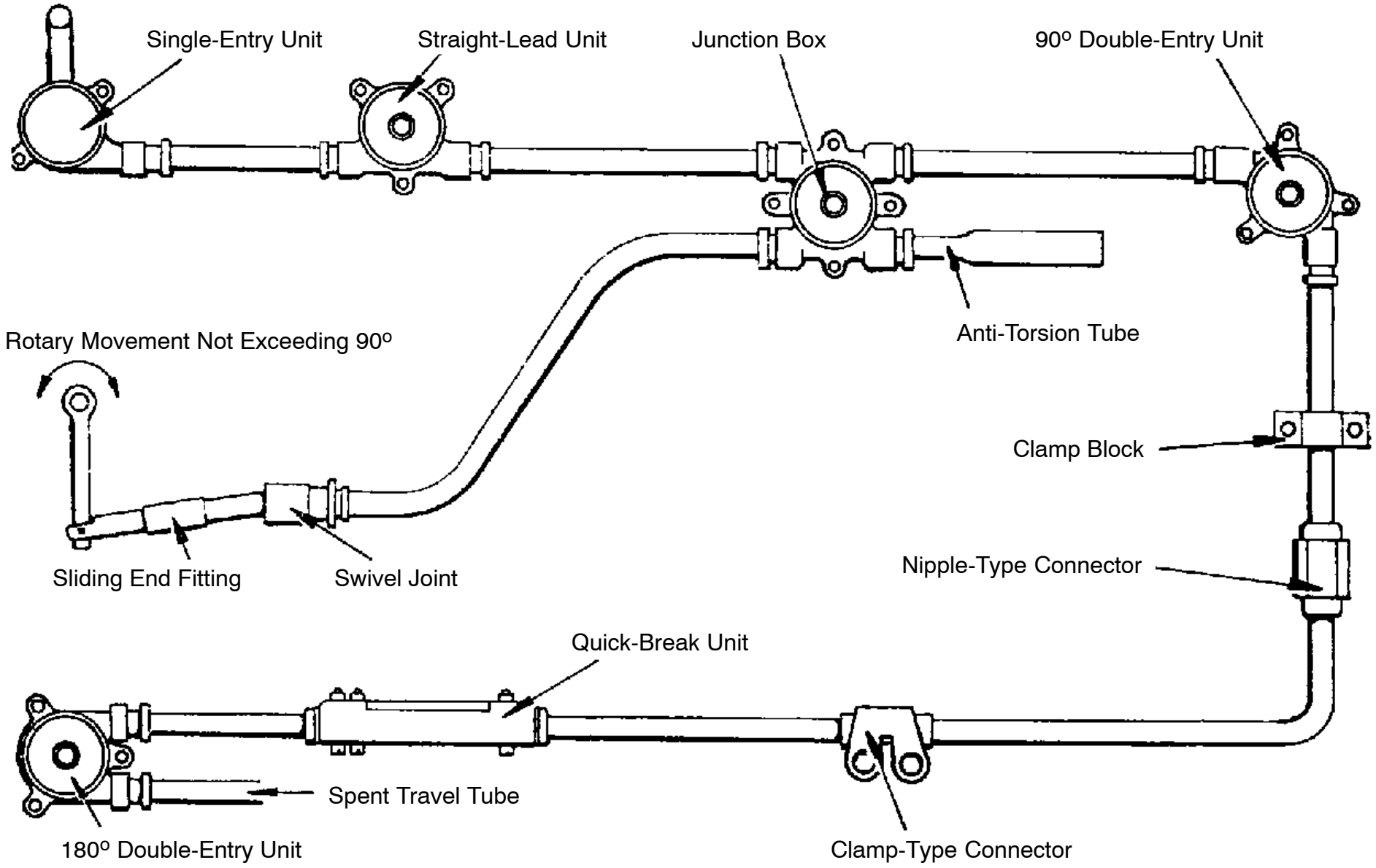



**Figure 16 Teleflex System**

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## Teleflex Controls

### Cables

The cable consists of a tension wire wound either with a continuous left- or right-hand helix winding which engages with the teeth of gear wheels at the transmitting and receiving ends of the control run.

The helix winding may also be used as a thread by which various end fittings can be attached to the cable.

The cable is designed for transmitting both pull and push.

There are two types of cable in use:

- **No 2 Cable**.

  This cable is built up from a high-tensile steel wire which is wound with a compression winding. The latter is wound with a left-hand helix winding which is pitch-spaced by a spacer winding. The cable is 3/16“ diameter.

- **No 380 Cable**

  This cable is built up from a high-tensile steel wire which is wound direct with a right-hand helix winding and spacer winding. In this method of construction there is improved efficiency and a reduction in backlash, particularly when the cable is under compression. The cable is 3/16“ diameter.

**NOTE:** Because of the difference in the lay of the cables (left-hand and right-hand) they are not interchangeable. e.g. a no 2 cable must be used with a no 2 transmitting unit.

### Conduits

The rigid conduits normally used in aircraft are of light alloy, although steel and tungum (Al-Ni-Si-Cu-Zn) conduits are used for special purposes. It may be bent in smooth curves to radii of not less than 3 inches.

Where there is relative movement between conduit and component, flexible conduit may be fitted, but to avoid backlash only the minimum length should be used. Flexible conduit may be bent to a radius of not less than 39 inches.

**NOTE:** Support must be given to bent portions of the conduit, but clamp blocks, spaced 3 ft apart, should be used to secure straight portions to the airframe.

### Sliding End Fittings

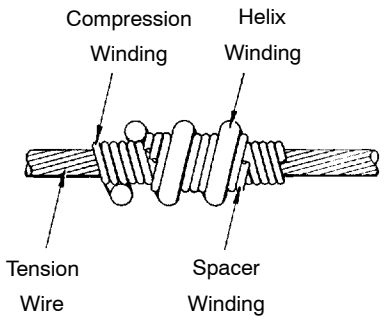
These are used where it is not necessary to convert the pull-push movement of the cable into a rotary movement.

Various types of sliding end fitting are available, each comprising a guide tube terminating in a fork, eye, ball joint or an internal or external threaded fitting.

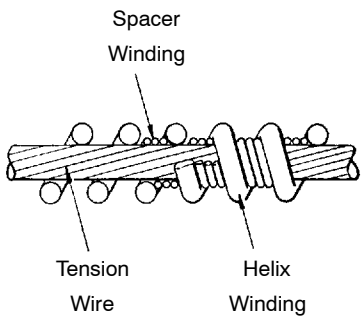
The cable is attached to the end fitting by means of a special collet attachment or by means of a lock spring and plug.

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No 2 Cable




No 380 Cable

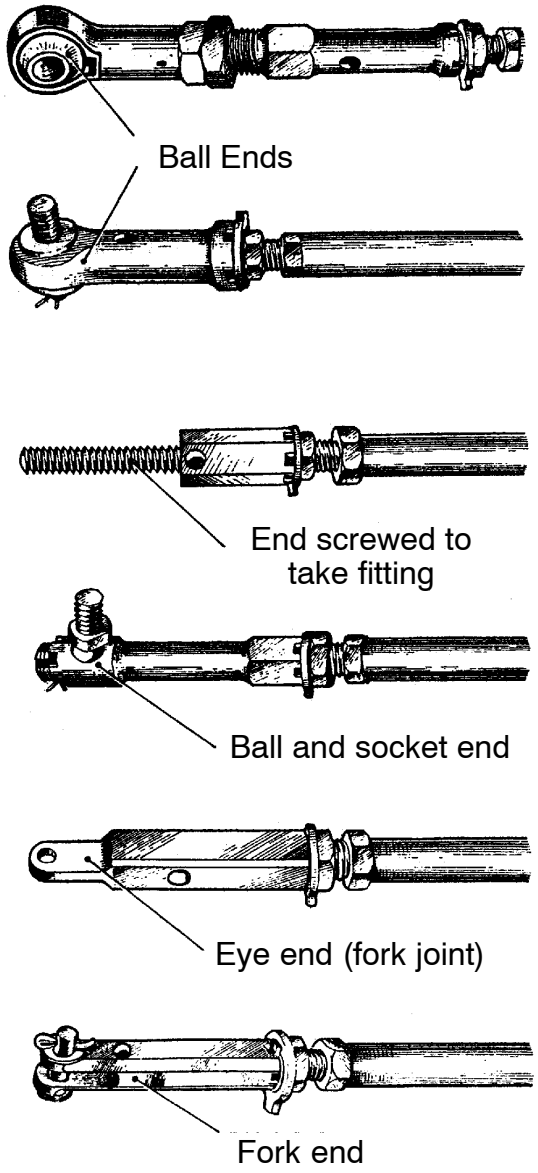



**Figure 17 Types of Teleflex Cable and Typical Sliding End Fittings**

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### End Fittings

The transmitting end of a control is usually fitted with a wheel unit consisting of a hand-operated gear wheel enclosed in a casing.

Alternatively, where the control loading is light and the control run fairly straight, a pull-push operating handle can be used.

At the remote end, the cable operates an appropriate wheel unit or is coupled, by means of a sliding end fitting, direct to the actuating mechanism on the component being controlled.

Swivel joints are also provided to take up the angular movement of an actuating lever at the end of a control run.

### Single-Entry Unit

In this wheel unit the cable enters the unit by means of a conduit connector and is led into a slot in the gear wheel. The rotary travel of the unit is limited to 270° of travel of the gear wheel and a minimum of 40° engagement must be maintained at all times between the gear wheel teeth and the cable.

### Double-Entry Unit

Where greater travel than can be obtained with a single-entry unit is required, a double-entry unit may be used. In this wheel unit the cable enters the unit by means of a conduit connector and, after wrapping round the gear wheel, emerges via another conduit connector at a point 90°, 120° or 180° from the point of entry. The end of the cable that emerges from the unit may be accommodated in a short length of conduit known as a spent travel tube.

### Anti-Torsion Tube

It is sometimes necessary to prevent the control cable from turning in the conduit and so altering the relative adjustment. This is done by installing an oval-sectioned anti-torsion tube in place of a spent travel tube. This tube serves as a guide to an oval ferrule secured to the spent travel end of the cable.

### Straight-Lead Unit

In this unit the cable passes straight through and consequently engages on only a few teeth of the gear wheel. Therefore, these units are not suitable for heavily-loaded controls. It can be interposed in a control run or fitted at the transmitting or receiving ends of a control.

### Junction Box Unit

These are installed where it is necessary to reverse the direction of travel of the control cables, or to branch a run of cable so as to operate two components (eg on both port and starboard sides of the aircraft). In one type the box contains a gear wheel and provision is made for two cables to pass through the box, one on either side of the gear wheel. The gear wheel may be rotated to move both cables, or one cable may operate the gear wheel which in turn operates the other cable.

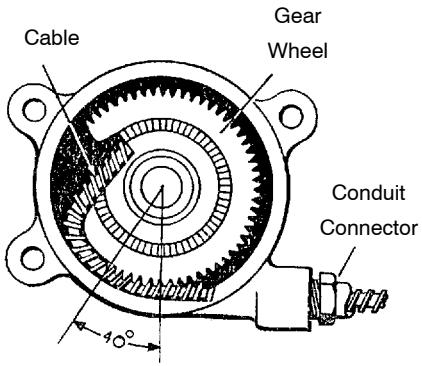
### Swivel Joints

This can be installed where rotary movement of the control lever at the receiving end does not exceed 90°. This type of joint consists of a ball and socket connection inside a housing attached to the end of the rigid conduit. The housing must be rigidly secured to the aircraft structure. The ball is welded to a length of tubing of the same size as the conduit. A suitable sliding end fitting is attached to the end of the control cable so that the guide tube slides freely over the swivel joint tube.

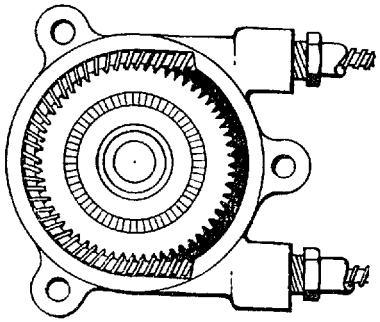
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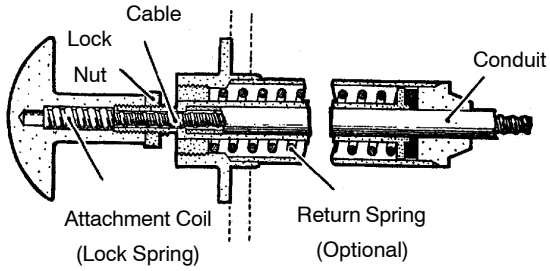




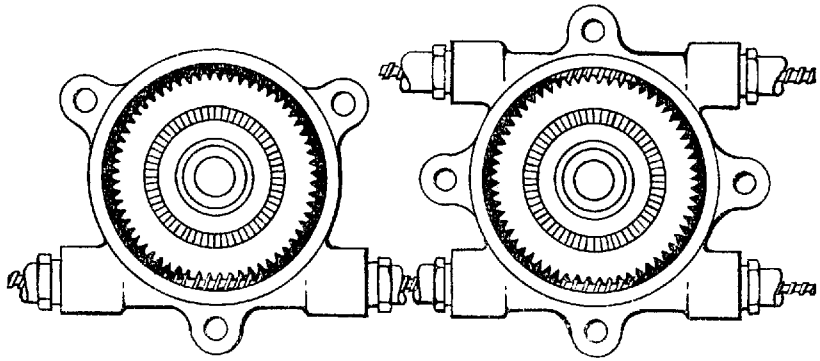

Single-Entry Unit



Double-Entry Unit

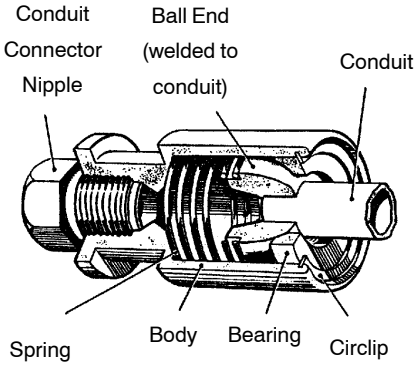



Pull-Push Control Unit



Straight Lead Unit

Junction Box Unit




Swivel Joint

**Figure 18 Teleflex System Components**

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## END FITTINGS (CONT'D)

### Torsion Drive

In certain installations the final linear movement of the control is converted to rotary action by the use of a distributor box coupled, via a torsion drive, to the component to be operated. The torsion drive is similar to a normal flexible drive.

### Distributor Box

This is similar in construction to a receiver unit with a gear wheel attached to the face of the cable gear wheel. The attached gear wheel drives a pinion on a cross shaft which engages with one or two tongue ends of the torsion drive cable. To convert the rotary motion of the torsion drive to the linear movement of a trimming tab, a sprocket-driven screw jack may be used.

To prevent vibration from affecting the setting of a wheel unit control, or to lock the control in any position, a damping device may be fitted. This device consists of a spring-loaded friction plate pressed against the gear wheel.

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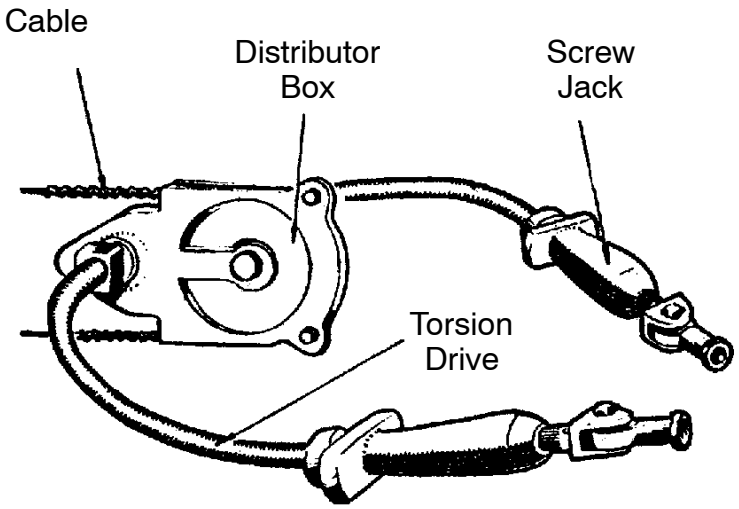



**Figure 19 Teleflex Distributor Box and Torsion Drive**

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### Conduit Connectors

Some conduit connectors are similar in construction to all-metal pipe couplings without an olive. The standard nipple-type connector consists of a screwed nipple that is threaded onto a rigid conduit, before the conduit is flared. The nipple is then screwed into a wheel unit or conduit connector body, thus retaining the conduit secure against a shoulder in the internally-threaded connection hole.

Another type of conduit connector, termed a clamp connector, consists of a split block bored out to house the unflared ends of a conduit. The conduit is gripped by tightening two clamping bolts, and is located by two bifurcated pins.

### Quick-Break Units

Quick-break units of various types are installed in control runs to facilitate removal of components without disturbing the control. The cable joining fittings are similar in all types of quick-break unit and consists of rods machined with interlocking slotted ends attached to the ends of the cables.

### Servicing

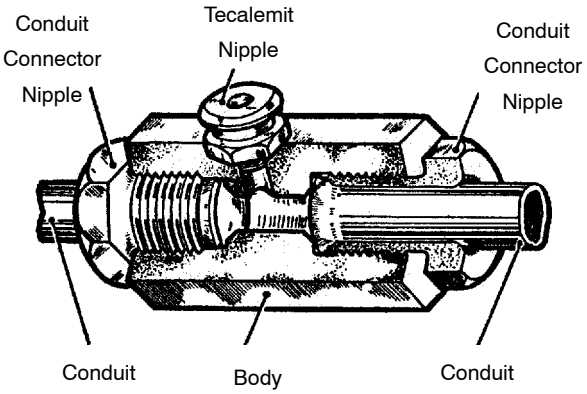
Servicing of the control system consists of checking its operation, examining for wear and damage, renewing defective parts and periodical lubrication.

Stiff control movement may be caused by the following:

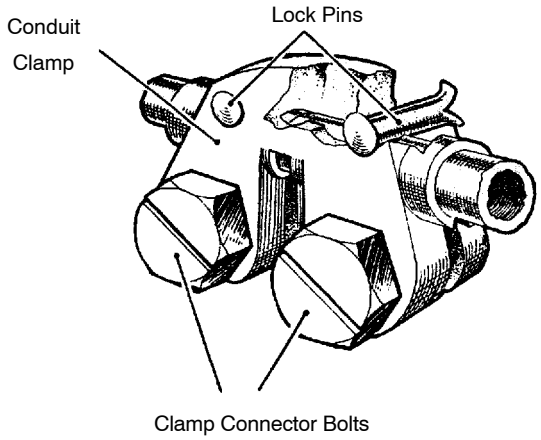
| Probable Cause | Remedy |
|---|---|
| Damaged conduit. | (a) Flexible type<br>renew complete conduit.<br>(b) Rigid type<br>cut out damaged portion and renew. |
| Kinked cable. | Renew cable. |
| Lack of lubricant in conduit. | Dismantle end fittings and remove the cable from the conduit.<br>Smear the cable with high-altitude grease and re-assemble. |
| Bent sliding end fitting. | Remove sliding tube from end of cable and test for freedom.<br>If stiff, fit new parts.<br>Check alignment of swivel joint (if fitted). |
| Fouling between end fitting and airframe due to damage or faulty installation. | Renew damaged parts and reset the assembly. |
| Worn wheel unit gear wheel, allowing cable to override. | Renew wheel unit. |
| Jammed swivel joint. | Dismantle, clean, assemble and test.<br>If unsatisfactory, renew swivel joint. |

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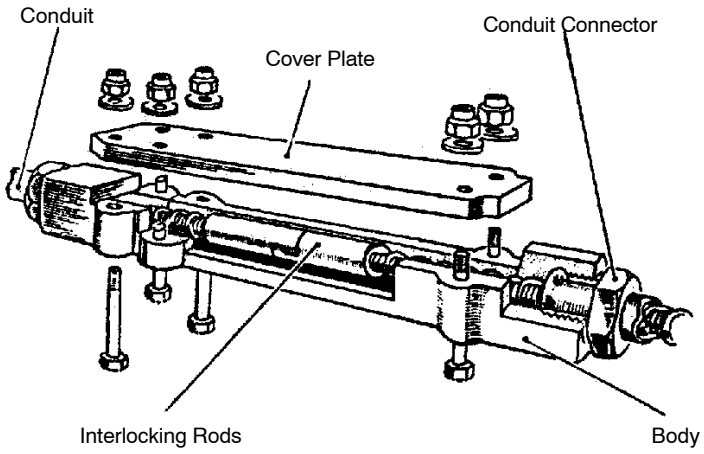
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**Nipple-Type Connector**




**Clamp-Type Connector**




**Typical Quick-Break Unit**

**Figure 20 Teleflex Conduit Connectors**

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## TELEFLEX SYSTEM: INSTALLATION

### Conduit

Rigid conduit must be clean, free from dents and deformations and reasonably straight. When renewing a conduit, never use conduit that has been previously bent for some other part of the system. After fitting the cable in the conduit, it should be possible to work the cable backwards and forwards by hand. If this is not possible, the run of conduit has not been installed properly. Damage to rigid conduit may be repaired by inserting a new length of conduit and making the connection by use of a connector. Bending, if necessary, should be done by use of a bending machine, or by using a special hand bender. Flexible conduit, if damaged, must be completely renewed.

### Conduit Connectors

When tightening a nipple type connector, two spanners should be used to prevent twisting of the conduit. If there is any end play between the conduit and the body of the connector after tightening, dismantle the connection and check the flare on the conduit; flaring of a conduit should be done only with the special flaring tool provided. When fitting a clamp type connector, the ends of the two lengths of conduit must be square and unflared. To fit the connector, remove the locking pins and slacken off the clamping bolts. Slide the two lengths of conduit into the connector and ensure that the ends butt centrally in the transverse slot, then tighten up the clamping bolts. Insert a drill of the correct size through the locking pin holes. Operate the drill which will cut half way through the wall of the conduit. Insert the bifurcated locking pins and open out their legs. The correct size drill is 3/32 inch (2.5mm) in dia for No. 2 and No. 3 conduits.

### Wheel Units

To fit the cable into the single entry unit, tuck it into the slot in the gear wheel and ensure that the cable helix engages with the gear wheel teeth to give a wrap of at least $40^{o}$. On double entry units, the cable should engage with the gear wheel correctly and project through the lead out hole throughout the travel of the control. Ensure that the cable end, when fully extended, does not foul the blanked end of the spent travel tube. All wheel units should be packed with high altitude grease.

### Cable

The cable must be kept clean, free from kinks and well lubricated. If dirty, it may be cleaned in kerosene, wiped dry with a non–fluffy cloth and re lubricated. A cable that has been damaged, strained or over heated, must be renewed. The method of fitting a new cable is as follows:

- Assemble the conduit in position.
- Cut the cable 2 inches (5 cm) in excess of requirements.
- Fit the cable into the unit and engage with the transmitting end fitting.
- Assemble the receiving end fitting and mark the required length of cable.
- Remove the cable from the conduit and cut to length.
- Apply high altitude grease, especially during entering the conduit, during cable installation.
- Connect the cable to the end fittings and check for freedom of movement and range of movement.
- Ensure that all fittings are in safety and correctly locked. Lubricate, as necessary.

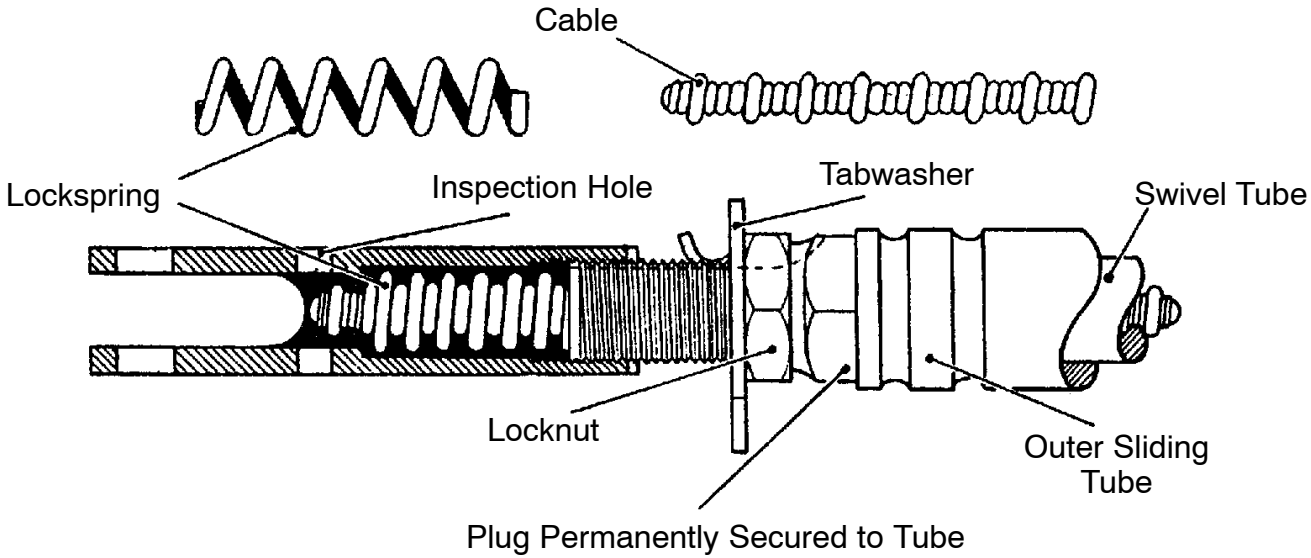
### Sliding End Fitting

To attach the cable to a sliding end fitting, unscrew the hexagon plug, screw the locknut right back and pass the cable through the plug, then proceed as follows:

- Screw the lock spring on to the end of the cable, so that about 3/16 in (two threads) of cable projects through the spring.
- Insert the cable end, with its lock spring, into the bore of the end fitting and screw the plug tight down. During this operation the end fitting must be prevented from rotating.
- Check that the free end of the cable is beyond the inspection hole, but not beyond the fork gap (fork end fittings only). If satisfactory, position the tab washer, tighten the locknut and lock with the tab washer.
- Check the distance from the face of the bore to the sliding tube which should not exceed 0.45 inches (12 mm). This ensures that the lock spring is tightly compressed.

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**Forked-End Type**

**Figure 21 Assembly of Teleflex Sliding End Fitting**

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## Bowden Controls

### Cable

Bowden cables are suitable for transmitting light loads over short distances. a The cable is made of non corrodible steel wire. The return action is provided by a spring.

### Conduit

The conduit consists of a close coil wire, covered with cotton braiding and finished with a black waterproof coating. Caps are fitted on each end of the conduit to prevent the braiding from unravelling. On some installations rigid conduits are used to house the cable over straight runs.

### Cable Nipples

When a control assembly is made up, the ends of the cable are threaded through brass nipples which are soldered or swaged to the cable.

### End Fittings

Various types of end fitting and connector are provided, each installation being designed to meet a specific requirement. Normally, the transmitting end of a control is fitted with a hand lever which engages with the nipple on one end of the cable. At the remote end, the cable passes through an adjustable stop and is connected to the component operating lever. To return the hand lever to the normal position after operation, the system is spring loaded either at the transmitting or receiving end of the control run.

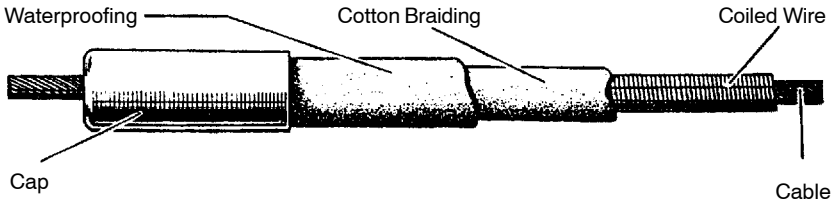
### Hand Lever

A typical hand lever is illustrated. If it is necessary to dismantle an existing control or to fit a new cable, unscrew the adjustment to slacken the cable, then rotate the nipple and slide the nipple and cable sideways to pass the cable through the end fitting slot.

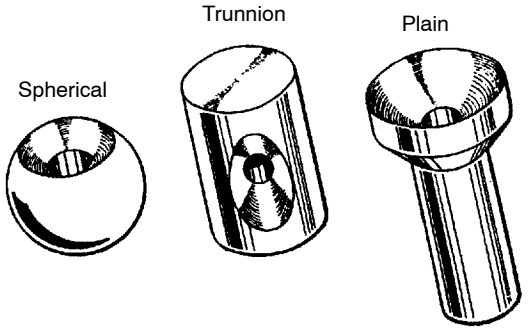
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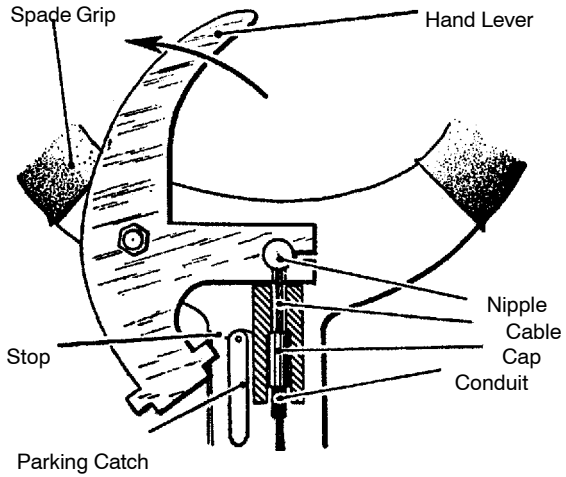





**Cable and Conduit**




**Types of Nipple**




**Typical Hand Lever**

**Figure 22 Bowden Control Components (1)**

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### Adjustment Stop

The remote end of the cable usually passes through a plain stop and is attached to the component by the cable nipple. The plain stops, which may be fitted to both ends of the conduit, consist of hexagon headed screws drilled to allow the cable to pass through. The head of each screw is counterbored to receive the protective cap fitted over the end of the conduit. When the stop is fitted to the remote end of the conduit, it is mounted in a Tee barrel, which must be securely fixed to a rigid member of the airframe. Where it is inconvenient to fit plain stops at the ends of the conduit, a double ended stop may be fitted in the length of the conduit. The stops also enable the length of the conduit to be adjusted, thus altering the tension of the cable.

### Connectors

Two types of connector are used. The cable connector is used for joining two cables only and cannot be employed where a conduit is fitted. It is also used for joining a length of Bowden cable to a cable of a different type, such as may be used for long straight runs. The control connector is used for joining two Bowden controls, as illustrated.

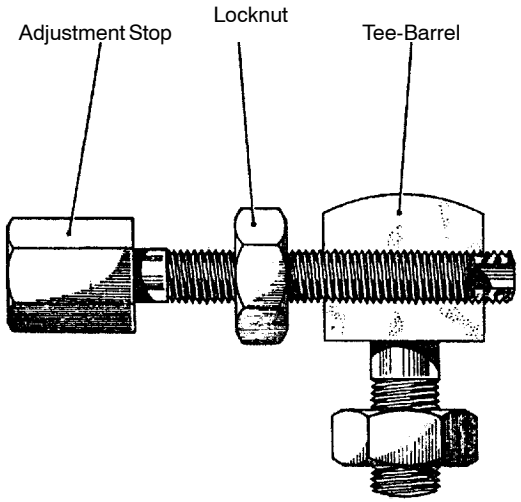
### Junction Box

A junction box is used for connecting a single cable to two others where there are e.g. two components to be operated by a single control.

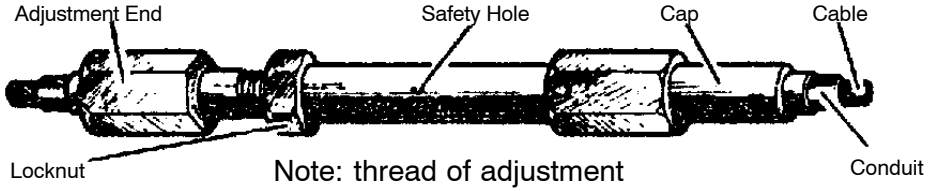
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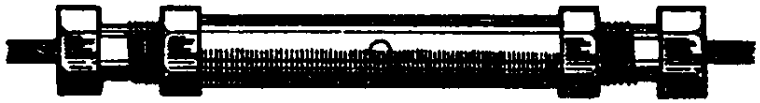



**Adjustable Stop and Tee-Barrel**

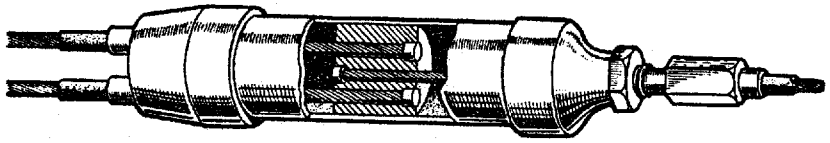



Note: thread of adjustment end must cover safety hole

**Double-Ended Stop**

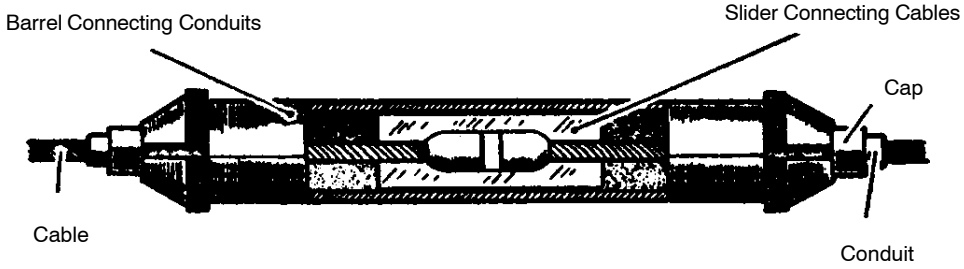


**Cable Connector**



One cable entering operates two cables leaving (for spring-return controls)

**Typical Junction Box**




**Control Connector**

**Figure 23 Bowden Control Components (2)**

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## SERVICING AND INSTALLATION OF COMPONENTS

### Conduit

The conduit must be clean, free from kinks or distortion and not damaged. If damaged, the conduit must be renewed. Any bends in the conduit should be as large as possible. The minimum radius of bend is twelve times the diameter of the conduit. Where the cable is connected to a lever, the alignment should be such that the centre line of the conduit is in a straight line through the mid position of the rise and fall of the arc of travel of the lever. If this adjustment is not made, the cable may rub on the edge of the stop and be worn away. When the conduit has been correctly aligned, the Tee barrel forming the adjustable stop mounting must be securely locked in this position. This is important as, should the Tee barrel swivel, the control will be distorted. The control should be attached to the airframe by pliable clips. For controls longer than 2 ft. (60 cm), the conduit should be supported every 12 in (30 cm). The conduit of a Bowden control should never be in tension.

### Cable

Care must be taken when handling the cable to avoid kinking it, as this will cause the cable to work harshly in the conduit. The cable must be clean, free from fraying or corrosion and lubricated with graphited synthetic grease applied at room temperature (60–70°F, 15 – 20°C) . The grease must be well rubbed into the interstices of the cable.

### Servicing

The control should be inspected periodically as follows:

- Inspect the cable ends for fraying or other damage. Frayed cables must be renewed.
- Inspect the conduit for kinks and signs of wear, especially at bends and at the ends.
- If there is any slackness in the cable, screw out the conduit adjustment stops until the slackness disappears. After adjustment, make sure that all components are still in safety and securely locked.
- Operate the control lever over its full range and ensure that the spring returns the lever freely and smoothly to its stop.
- Check the security and locking of mountings and clips.

### Renewing a Control

When a cable or conduit is to be renewed, the faulty component should be used as a guide to the length required for the new part. The conduit may be cut to the exact length required, but it is advisable to leave the cable rather longer than necessary, because it simplifies the fitting of the cable. The method of fitting a new cable is as follows:

- a nipple to one end of the cable. Lubricate the cable.
- Thread the adjustable stop over the cable and slide on the conduit making sure that the protective caps are fitted at each end. If required, thread on a second adjustment stop.
- Fix the control temporarily in position on the aircraft along the route it is to follow.
- Make sure that the stops are at their minimum length and that the part to be operated is in the normal position, then slide the other nipple on to the cable. Pull the cable taut and, with a lead pencil, mark off the correct position for the nipple.
- the control from the aircraft, cut the cable to length and solder the second nipple in position.
- Fix the control correctly in the aircraft. Adjust the stops until all slack in the cable is taken up and then tighten the locknuts.

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