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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: ACCEPTABLE METHODS, TECHNIQUES, AND PRACTICES—AIRCRAFT ALTERATIONS

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1. PURPOSE.

This advisory circular contains methods, techniques, and practices acceptable to the Administrator for use in altering civil aircraft.

2. CANCELLATION.

Advisory Circular 43.13-2 dated 1965 is cancelled.

3. REFERENCE.

Part 43 of the Federal Aviation Regulations requires that methods, techniques, and practices acceptable to the Administrator must be used when altering civil aircraft. Methods, techniques, and practices other than those prescribed in this advisory circular may be used provided they are acceptable to the Administrator. FAA Inspectors are prepared to answer questions that may arise in this regard. Persons engaged in alteration of civil aircraft should be familiar with FAR Part 43, and subparts A, D, and E of FAR Part 65, and the applicable airworthiness requirements under which the aircraft was type certificated.

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Chapter 1. STRUCTURAL DATA

1. GENERAL. The minimum airworthiness requirements are those under which the aircraft was type certificated. Addition or removal of equipment involving changes in weight could affect the structural integrity, weight, balance, flight characteristics, or performance of an aircraft.

2. STATIC LOADS. Utilize equipment supporting structure and attachments that are capable of withstanding the additional inertia forces ("g." load factors) imposed by weight of equipment installed. Load factors are defined as follows:

a. Limit Load Factors are the maximum load factors which may be expected during service (the maneuvering, gust, or ground load factors established by the manufacturer for type certification).

b. Ultimate Load Factors are the limit load factors multiplied by a prescribed factor of safety. Certain loads, such as the minimum ultimate inertia forces prescribed for emergency landing conditions, are given directly in terms of ultimate loads.

c. Static Test Load Factors are the ultimate load factors multiplied by prescribed casting, fitting, bearing, and/or other special factors. Where no special factors apply, the static test load factors are equal to the ultimate load factors.

d. Critical Static Test Load Factors are the greater of the maneuvering, gust, ground, and inertia load static test load factors for each direction (up, down, side, fore, and aft).

Static tests using the following load factors are acceptable for equipment installations:

Direction of Force Applied	*Normal-Utility* FAR 23 (CAR 3)	*Acrobatic* FAR 23 (CAR 3)	*Transport* FAR 25 (CAR 4b)	*Rotorcraft* FAR 27, 29 (CAR 6, 7)
Sideward	1.5g	1.5g	1.5g	2.0g
Upward	3.0g	4.5g	* *	1.5g
Forward*	9.0g	9.0g	9.0g	4.0g
Downward	6.6g	9.0g	* *	4.0g

* When equipment mounting is located externally to one side, or forward of occupants, a forward load factor of 2.0g is sufficient.

** Due to differences among various aircraft designs in flight and ground load factors, contact the aircraft manufacturer for the load factors required for a given model and location. In lieu of specific information, the factors used for FAR 23 utility category are acceptable for aircraft with never exceed speed of 250 knots or less and the factors used for FAR 23 acrobatic category for all other transport aircraft.

The following is an example of determining the static test loads for a 7-pound piece of equipment to be installed in a utility category aircraft (FAR Part 23).

Load Factors (From the above table)		*Static Test Loads* (Load factor × 7 pounds)
Sideward	1.5g	10.5 pounds
Upward	3.0g	21.0 pounds
Downward	6.6g	46.2 pounds
Forward	9.0g	63.0 pounds

When an additional load is to be added to structure already supporting previously installed equipment, determine the capability of the structure to support the total load (previous load plus added load).

3. STATIC TESTS.

Caution: The aircraft and/or equipment can be damaged in applying static loads, particularly if careless or improper procedure is used.

It is recommended, whenever practicable, that static testing be conducted on a duplicate installation in a jig or mockup which simulates the related aircraft structure. Static test loads may exceed the yield limits of the assemblies being substantiated and can result in partially sheared fasteners, elongated holes, or other damage which may not be visible unless the structure is disassembled. If the structure is materially weakened during testing, it may fail at a later date. Riveted sheet metal and composite laminate construction methods especially do not lend themselves to easy detection of such damage. To conduct static tests:

a. Determine the weight and center of gravity position of the equipment item.

b. Make actual or simulated installation of attachment in the aircraft or preferably on a jig using the applicable static test load factors.

c. Determine the critical ultimate load factors for the up, down, side, fore, and aft directions. A hypothetical example which follows steps (1) through (4) below is shown in figure 1.1.

(1) Convert the gust, maneuvering, and ground load factors obtained from the manufacturer or FAA engineering to ultimate load factors. Unless otherwise specified in the airworthiness standards applicable to the aircraft, ultimate load factors are limit load factors multiplied by a 1.5 safety factor. (See columns 1, 2, and 3 for items A, B, and C of fig. 1.1.)

(2) Determine the ultimate inertia load forces for the emergency landing conditions as prescribed in the applicable airworthiness standards. (See items D and E, column 3, of fig. 1.1.)

(3) Determine what additional load factors are applicable to the specific seat, litter, berth, or cargo tiedown device installation. The ultimate load factors are then multiplied by these factors to obtain the static test factors. (To simplify this example, only the seat, litter, berth, and safety belt attachment factor of 1.33 was assumed to be applicable. See Item E, column 4, of fig. 1.1.)

(4) Select the highest static test load factors obtained in Steps 1, 2, and/or 3 for each direction (up, down, side, fore, and aft). These factors are the *critical static test load factors* used to compute the static test load. (See column 6 of fig. 1.1.)

d. Apply load at center of gravity position (of equipment item or dummy) by any suitable means that will demonstrate that the attachment and structure are capable of supporting the required loads.

When no damage or permanent deformation occurs after 3 seconds of applied static load, the structure and attachments are acceptable. Should permanent deformation occur after 3 seconds, repair or replace the deformed structure to return it to its normal configuration and strength. Additional load testing is not necessary.

4. MATERIALS. Use materials conforming to an accepted standard such as AN, NAS, TSO, or MIL–SPEC.

5. FABRICATION. When a fabrication process which requires close control is used, employ methods which produce consistently sound structure that is compatible with the aircraft structure.

6. FASTENERS. Use hardware conforming to an accepted standard such as AN, NAS, TSO, or MIL–SPEC. Attach equipment so as to prevent loosening in service due to vibration.

7. PROTECTION AGAINST DETERIORATION. Provide protection against deterioration or loss of strength due to corrosion, abrasion, electrolytic action, or other causes.

8. PROVISIONS FOR INSPECTION. Provide adequate provisions to permit close examination of equipment or adjacent parts of the aircraft that regularly require inspection, adjustment, lubrication, etc.

9. EFFECTS ON WEIGHT AND BALANCE. Assure that the altered aircraft can be operated within the weight and center of gravity ranges listed in the FAA Type Certificate (T.C.) Data Sheet or Aircraft Listing. Determine that the altered aircraft will not exceed maximum gross weight. (If applicable, correct the loading schedule to reflect the current loading procedure.) Consult Advisory Circular 43.13–1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair" for Weight and Balance Computation Procedures.

10. EFFECTS ON SAFE OPERATION. Install equipment in a manner that will not interfere with or adversely affect the safe operation of the aircraft (controls, navigation equipment operation, etc.).

11. CONTROLS AND INDICATORS. Locate and identify equipment controls and indicators so they can be operated and read from the appropriate crewmember position.

12. PLACARDING. Label equipment requiring identification and, if necessary, placard operational instructions. Amend weight and balance information as required.

13.–20. [RESERVED]

Utility Category Aircraft (FAR 23)

TYPE OF LOAD	Direction	LOAD FACTORS					
		1 Limit	2 X Safety	3 = Ultimate	4 X Special	5 Static = Test	6 Critical Static Test
A. Maneuvering	Fwd	(None)					
	Down	6.2g	1.5	9.30g		9.3g	9.3g
	Side	(None)					
	Up	−3.8g	1.5	−5.7g		−5.7g	5.7g
	Aft	1.0g	1.5	1.5g		1.5g	
B. Gust (= 30 FPS @ *K*Vc)	Fwd	(None)					
	Down	6.0g	1.5	9.0g		9.0g	
	Down*	6.4g	1.5	9.6g		9.6g	*9.6g
	Side	1.6g	1.5	2.4g		2.4g	2.4g
*For locations aft of fuselage Sta. 73.85.	Up	−2.8g	1.5	−4.2g		−4.2g	
	Aft	(None)					
C. Ground	Fwd	6.6g	1.5	9.9g		9.9g	9.9g
	Down	4.0g	1.5	6.0g		6.0g	
D. Ultimate Inertia Forces for Emergency Landing Condition (FAR 23.561).	Fwd	Already Prescribed as Ultimate		9.0g			
	Fwd.**	〃	〃	4.5g			**4.5g
	Down	〃	〃	(None)			
	Side	〃	〃	1.5g		1.5g	
	Up	〃	〃	−3.0g		−3.0g	
**For Separate cargo compartments.	Aft	〃	〃	(None)			
E. Ultimate Inertia Forces for Emergency Landing Condition For Seat, Litter, & Berth Attachment to Aircraft Structure (FAR 23.785).	Fwd	〃	〃	9.0g	1.33	12.0g	12.0g
	Down	〃	〃	(None)			
	Side	〃	〃	1.5g	1.33	2.0g	
	Up	〃	〃	−3.0g	1.33	−4.0g	
	Aft	〃	〃	(None)			

*Asterisks denote special load conditions for the situation shown.

Figure 1.1—Hypothetical example of determining static test loads.

Chapter 2. RADIO INSTALLATIONS

21. INSTALLATION. When installing radio equipment, first consider areas or locations designated by the airframe manufacturer and use factory supplied brackets or racks. Follow the aircraft manufacturer's installation instructions. When this information is not available, use locations in the aircraft of known load carrying capabilities. Baggage compartments and cabins or cockpit floors are good mounting platforms providing the floor attachments meet the strength requirements. Another method is to fabricate support racks, brackets, or shelves, and attach them to the aircraft structure to provide a mounting that will withstand the inertia forces stipulated in chapter 1 of this handbook.

a. Determine that the location and installation of radio equipment provides:

(1) Sufficient air circulation to avoid overheating.

(2) Sufficient clearance between high temperature areas of equipment and readily flammable materials.

(3) Protection from potentially hazardous fluids and/or fumes; e.g., water (condensation), fuel, hydraulic fluid, or oxygen units.

(4) Protection against damage from baggage or by seat deflection.

(5) Sufficient clearance to avoid equipment striking adjacent parts of the aircraft or other equipment.

(6) Minimum interference to other installed navigational equipment from the emission of radar/pulse frequencies or from electromagnetic induction.

22. EQUIPMENT MANUFACTURER'S INSTRUCTIONS. Installation instructions provided by the aircraft radio manufacturer are acceptable guidelines when adapted to the aircraft in accordance with data contained in this chapter.

23. INSTRUMENT PANEL MOUNTING. Data in this paragraph is supplemented by chapter 2 of AC 43.13–1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair" and is applicable to the installation of radio units in instrument panels.

a. ***Stationary Instrument Panels—Nonstructural and Structural.*** The stationary instrument panel in some aircraft is primary structure. Prior to making any additional "cutouts" or enlargement of an existing "cutout" determine if the panel is primary structure. If the panel is structural, make additional "cutouts" or the enlargement of existing "cutouts" in accordance with the aircraft manufacturer's instructions, or substantiate the structural integrity of the altered panel in a manner acceptable to the Administrator. Radius all corners and remove all burrs from "cutout" and drilled holes.

b. ***Added Equipment — Stationary Instrument Panel.*** When radio equipment is to be installed in a stationary panel already supporting instruments, glove compartments, etc., determine the capability of the panel to support the total load.

c. ***Case Support.*** To minimize the load on a stationary instrument panel, whenever practicable, install a support between the rear (or side) surface of the radio case and a nearby structural member of the aircraft.

d. ***Added Equipment—Shockmounted Panels.*** When installing radio equipment designed for use in shockmounted panels, total accumulated weight of equipment installed must not exceed the weight carrying capabilities of the shockmounts. Determine that the structure to which the shockmounts are connected is satisfactory for the added weight.

e. ***Existing Factory Fasteners.*** When possible, utilize existing plate nuts and machine screws provided by the aircraft manufacturer for attachment of the radio case or rack. If additional fastening is required, use machine screws and elastic stop nuts (preferably plate nuts).

f. ***Magnetic Direction Indicator.*** As a function of the radio installation, determine if it is necessary to compensate the compass. Install a suitable placard which indicates the compass error with the radio(s) on and off. The receiver(s) should be tuned through the low, middle and higher frequencies to cover all contingencies involving the operation of relays which would cause electromagnetic induction to the magnetic compass. When inverters are installed, determine what effect their operation has on the magnetic compass. Maximum acceptable deviation in level flight is 10° on any heading. The following is an example of a typical compass calibration card.

Typical Compass Calibration Card

FOR	N	30	60	E	120	150
Radio **On.** Steer	4°	35°	63°	93°	123°	154°
Radio **Off.** Steer	358°	27°	58°	88°	118°	148°
FOR	S	210	240	W	300	330
Radio **On.** Steer	183°	214°	224°	274°	304°	337°
Radio **Off.** Steer	178°	208°	238°	268°	293°	327°

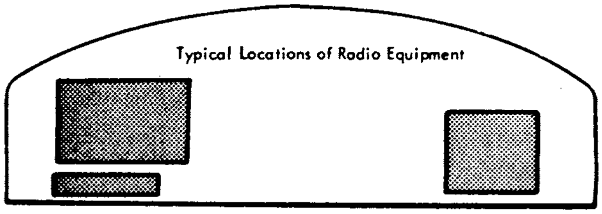
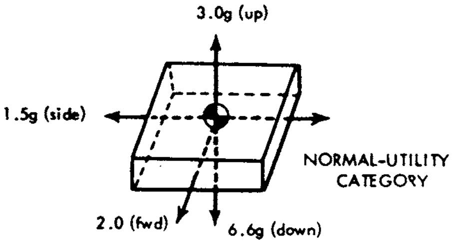


FIGURE 2.1.—Typical radio installations in stationary instrument panels.



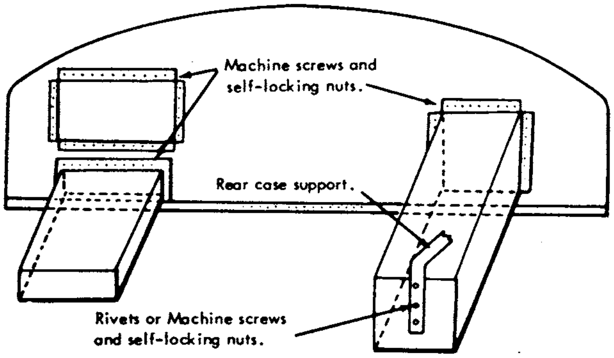


FIGURE 2.2.—Typical panel mount.

24. OTHER MOUNTING AREAS. The following are acceptable methods for installing radio equipment at other than instrument panel locations.

a. *Shockmounted Units.*

(1) *Wood or Composition Flooring.* Secure the shockmounted base assembly (suitable to radio unit) directly to the floor using machine screws. Add a doubler to the bottom of the floor thereby sandwiching the composition floor between each shockmount foot and the doubler. Subsequent removal and reinstallation of the shockmount foot will be facilitated if plate nuts are secured to the doubler. Where practicable, use small retaining screws to keep the doubler in position. Install a ground strap between the radio rack and metal structure of the aircraft.

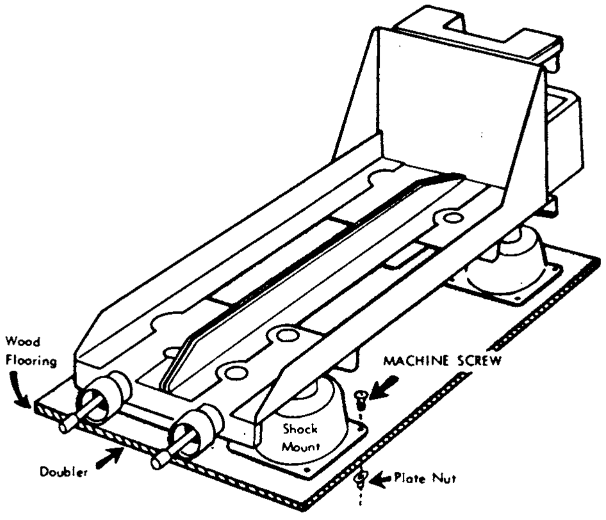


FIGURE 2.3.—Typical shockmounted base.

(2) *Metal Flooring.* Secure the shockmounted base assembly directly to the floor using machine screws, washers, and self-locking nuts. Floor area under and around the radio mounting bases may require installation of doublers or other reinforcement to prevent flexing and cracking. Installation of plate nuts on the floor or doubler will facilitate removal and installation of the shockmounts. Install a ground strap between the shockmount foot and the radio rack.

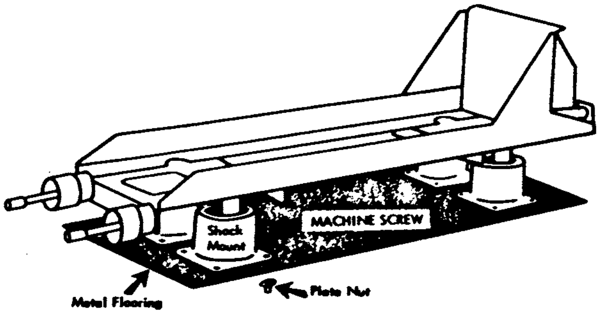


FIGURE 2.4.—Typical shockmounted base.

b. *Rigid-Mounted Unit Base*. Secure radio mounting base plate(s) to floor (wood, composite, or metal) using machine screws as shown in figure 2.5. Use a reinforcing plate or large area washers or equivalent under wood or composite flooring. When mounting base is secured to wood or composite material, install a ground strap between the base and aircraft metal structure.

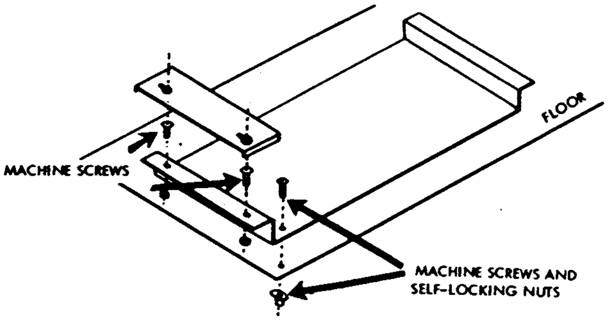


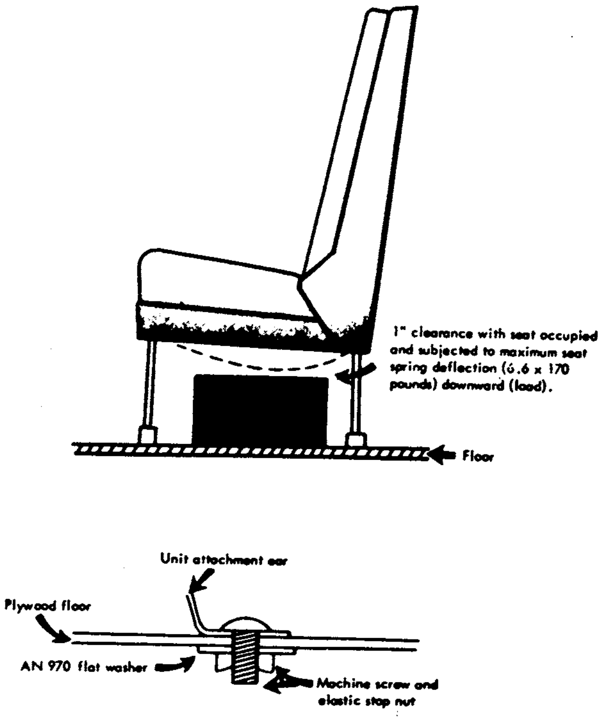
FIGURE 2.5.—Typical rigid baseplate mount.

25. FABRICATION OF SUPPORTING BRACKETS FOR ATTACHMENT TO STRUCTURE OTHER THAN FLOORING.

a. *Typical supporting brackets* usually consist of a shelf or platform upon which the radio unit mounting base assembly can be installed in the same manner as described in applicable paragraph 24.

b. *Fabricate bracket* in accordance with good aircraft design, layout, assembly practices, and workmanship to obtain results compatible with the airframe structure. Generally the thickness of bracket material will depend on the size or area of the platform and load it must sustain in accordance with provisions set forth in chapter 1 of this handbook.

c. *Use a rivet size* and pattern compatible with the aircraft structure to provide the strength needed to assure support of the loads imposed under all flight and landing conditions.



To increase the strength at floor attachment points, metal reinforcement may be installed as needed.

FIGURE 2.6.—Typical underseat installation.

26. SUPPORTING STRUCTURE REINFORCEMENT.

a. *Attach equipment* supporting structure to the aircraft so that its supported load will be transmitted to aircraft structural members. If direct attachment to existing structure (bulkheads, horizontal stringers, etc.) is not feasible, add the necessary stringers, doublers, bulkhead flange reinforcements, etc., to provide adequate support and assure load transfer to primary structure.

b. *Placard*. Fasten on the shelf or bracket a permanent placard (as the example below) stating the design load which the installed structure has been determined to be capable of supporting.

Shelf load not to exceed __________ lbs.

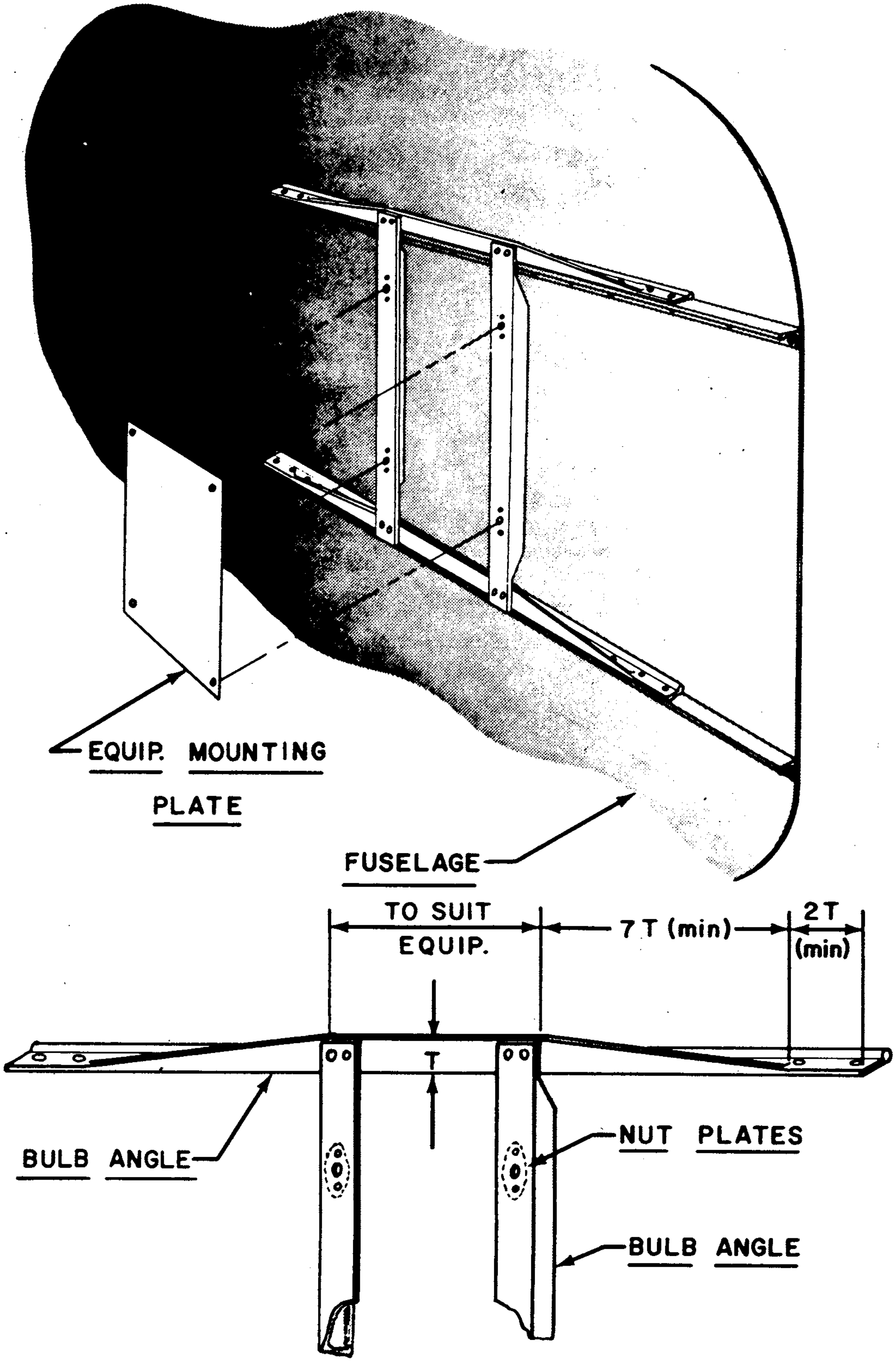
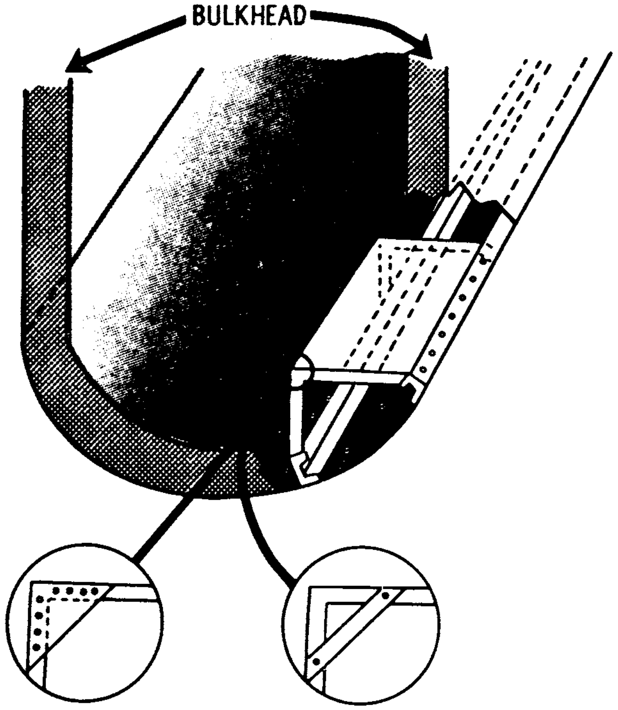


FIGURE 2.7.—Typical remote unit mounting base—vertical or horizontal.



Use standard aircraft practices and procedures for fabrication and attachment of shelf. Reinforce fore and aft corners with gussets or bulb angle.

FIGURE 2.8.—Typical shelf installation.

Fabricate platform using 2017T4(17ST) or equivalent. Apply standard aircraft practices for fabrication and installation.

The equipment manufacturer mounting bases that meet load requirements and can be utilized are acceptable.

27. ELECTRICAL SYSTEMS. The following data in addition to that shown in chapter 11 in AC 43.13–1A is applicable to radio installations.

a. Installation of Wiring.

(1) Use a type and design satisfactory for the purpose intended.

(2) Install in a manner to be suitably protected from fuel, oil, water, other detrimental substances and abrasion damages.

b. Power Sources.

(1) Connect radio electrical systems to the aircraft electrical system at a terminal strip, or use a plug and receptacle connection.

(2) Radio electrical systems must function properly whether connected in combination or independently.

c. Protective Devices.

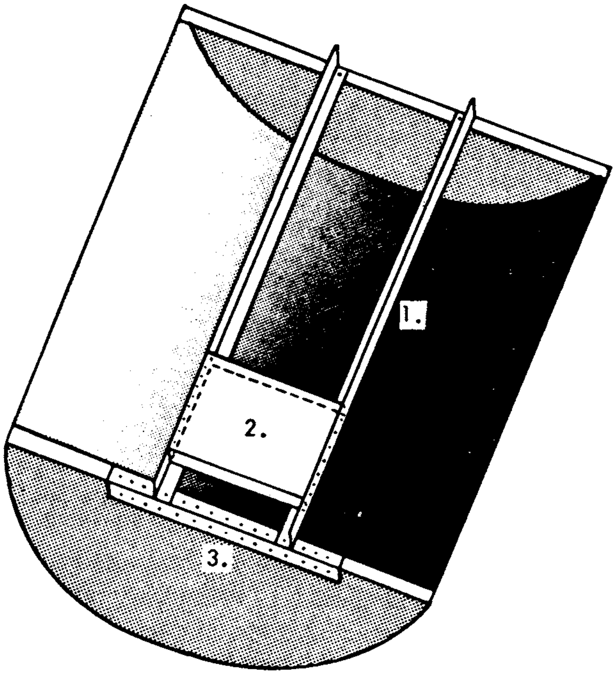
(1) Incorporate a "trip free" resettable type circuit breaker or a fuse in the power supply from the bus. Mount in a manner accessible to a crewmember during flight for circuit breaker resetting or fuse replacement.

(2) Select circuit breakers or fuses that will provide adequate protection against overloading of the radio system circuits.

(3) Connect all leads in such a manner that the master switch of the aircraft will interrupt the circuit when the master switch is opened.

(4) Radio system controls are to provide independent operation of each system installed and are to be clearly placarded to identify their function relative to the unit of equipment they operate.

d. Available Power Supply. To preclude overloading the electric power system of the aircraft when additional equipment is added, make an



1. BULB ANGLE
2. STIFFENING FLANGE OR ANGLE AT ENDS OF PLATFORM
3. REINFORCEMENT ANGLE FOR BULKHEAD

FIGURE 2.9.—Typical rail platform installation—aluminum alloy structure.

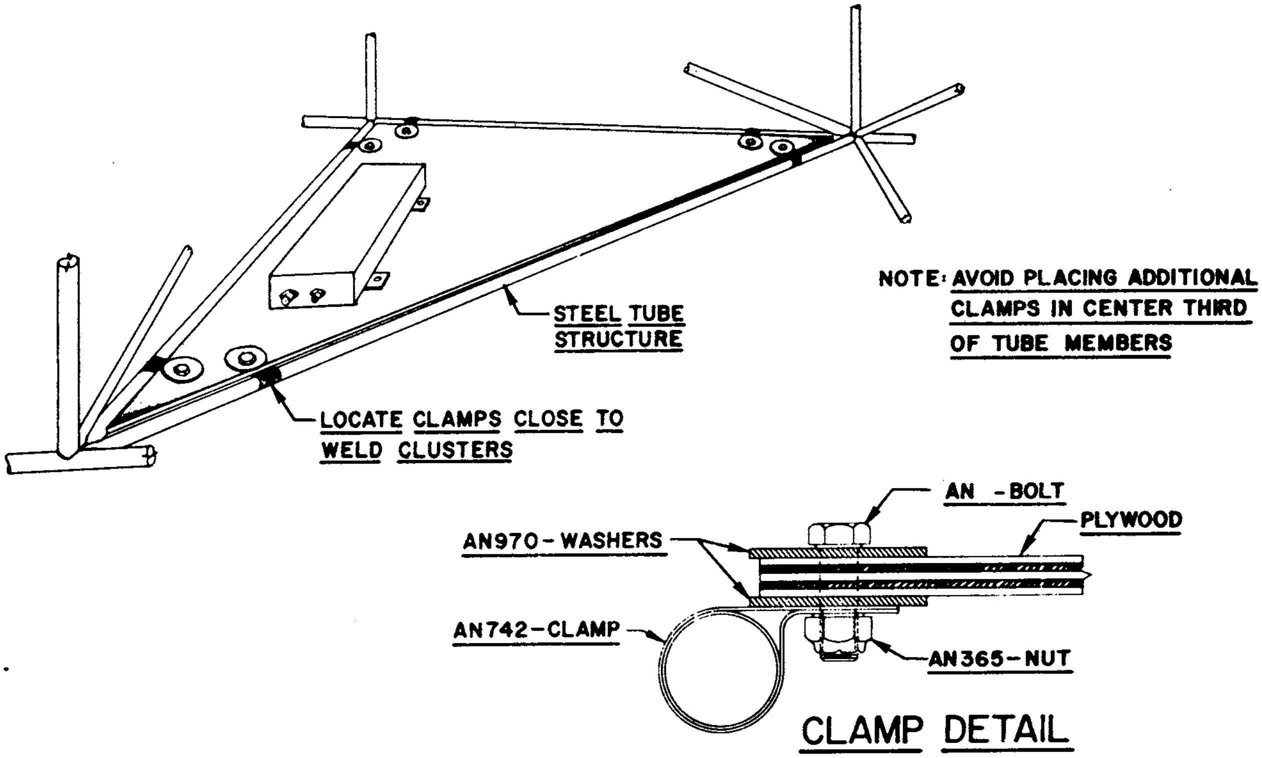


FIGURE 2.10.—Typical attachment of support structure to tubular frame.

electrical load analysis to determine whether the available power is adequate. Radio equipment must operate satisfactorily throughout the voltage range of the aircraft electrical system under taxi, takeoff, slow cruise, normal cruise, and landing operating conditions. If night and instrument flight is contemplated, compute the electrical load analysis for the above flight regimes under the most adverse operating conditions.

e. *Wire Bundle Separation from Flammable Fluid Lines.*

(1) Physically separate radio electric wire bundles from lines or equipment containing oil, fuel, hydraulic fluid, alcohol, or oxygen.

(2) Mount radio electrical wire bundles above flammable fluid lines and securely clamp to structure. (In no case must radio electrical wire bundles be clamped to lines containing flammable fluids.)

f. *Cable Attachment to Shockmounted Units.*

(1) Route and support electrical wire bundles and mechanical cables in a manner that will allow normal motion of equipment without strain or damage to the wire bundles or mechanical cables.

g. *Radio Bonding.* It is advisable to bond radio equipment to the aircraft in order to provide a low impedance ground and to minimize radio interference from static electrical charges. When bonding is used, observe the following:

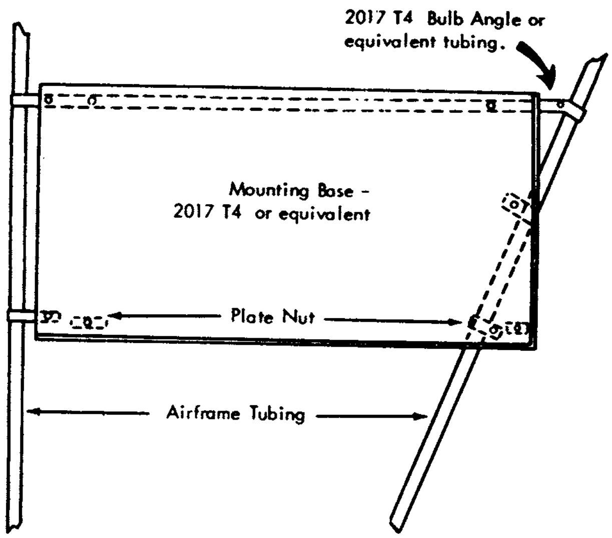
(1) Keep bonding jumpers as short as possible.

(2) Prepare bonded surfaces for best contact (resistance of connections should not exceed .003 ohm).

(3) Avoid use of solder to attach bonding jumpers. Clamps and screws are preferred.

(4) For bonding aluminum alloy, use aluminum alloy or tinned or cadmium-plated copper jumpers. Use brass or bronze jumpers on steel parts.

(5) When contact between dissimilar metals cannot be avoided, put a protective coating over the finished connection to minimize corrosion.



Secure mounting base to airframe tubing with loop-type clamp (AN 742 or equivalent), machine screws, and self-locking nuts.

FIGURE 2.11.—Typical mounting plates for remote location of radio units.

h. *Radio Interference.* Radio interference generated by aircraft components can be eliminated or reduced by exercising proper precautions. The following paragraphs contain two major sources of interference which affect audio reception.

(1) *Ignition system interference* can be minimized with shielding. To be effective, all parts of the ignition system should be shielded in metal in order to eliminate noise resulting from RF radiation.

(a) A metallic braid covering and special end connectors are effective between the magneto and shielded type spark plugs.

(b) Shield the primary lead to the magneto.

(c) Provide a shielded metal cover for the magneto if it is not of a shielded type.

(d) Provide a tight metal-to-metal contact of all connections in the shielding system.

(e) If it is not feasible to shield the engine ignition system, the engine ignition noise may be suppressed by replacing the spark plugs with resistor spark plugs of a type approved for the engine.

(f) If it is found that despite shielding of the ignition wiring and plugs an intolerable noise level is present in the radio system, it may be necessary to provide a filter between the magneto and magneto switch to reduce the noise. This may consist of a single bypass capacitor or a combination of capacitors and choke coils. When this is done, the shielding between the filter and magneto switch can usually be eliminated and the special shielded magneto switch need not be used.

(g) Supporting brackets and wiring details for magneto filters should be in conformance with standard aircraft electrical practice. The reliability of the magneto filter installations should be at least equivalent to that of the remainder of the magneto ground lead installation.

(2) *Inverter interference* is noticeable by a constant noise or hash induced and amplified by the audio circuits of the communication or navigation systems. This noise level can reach such a magnitude that all intelligence of audio reception is lost. Inverter interference can be effectively minimized or eliminated by observing the following precautions during installation:

(a) Locate the inverters in an area separated from other electronic equipment.

(b) Assure that the inverter input and output wires are separated.

(c) Shield the inverter output wires and ground the shields at the inverter end only.

(d) Make sure the inverter case is adequately bonded to the airframe.

i. *Mutual Radio Frequency Interference in DME/ATC Radar Beacon Systems.* Distance measuring equipment (DME) and ATC radar beacon (transponder) systems operate within the same frequency range. Therefore, simultaneous operation of two or more of these systems may result in mutual RF interference. Certain makes of DME and transponder equipment have intersystem suppressor circuitry designed to eliminate mutual interference. When such connections are provided, follow the manufacturer's recommendations for use and wire bundle installation.

28. EMERGENCY LOCATOR TRANSMITTER (ELT) INSTALLATIONS. The ELT unit should be attached to the airframe or other solid structures. Airframe preparation for either vertical or shelf-type mountings is displayed in figures 2.7 and 2.8. The equipment manufacturer mounting bases that meet load requirements and can be utilized are acceptable.

The installation of the ELT antenna should be located as far as practicable from other installed antennas. Methods for securing whip-type antennas to the structure are shown in figures 3.1 and 3.3. Follow the manufacturer's installation procedures when available.

29.–35. [RESERVED]

Chapter 3. ANTENNA INSTALLATIONS

36. PERFORMANCE. For proper performance, it is important that the radio equipment manufacturer's instructions be carefully followed in matching and coupling the antenna to the radio equipment.

a. ***The location of the antenna is of primary importance.*** When selecting a mounting position, consideration should be given but not limited to the following:

(1) Obstruction to signal reception by aircraft or aircraft components.

(2) Ignition noise (RF radiation pickup).

(3) Vibration.

(4) Flutter.

(5) Instrument static source interference.

b. ***Attach antenna mounting*** (masts, base receptacles, and/or supporting brackets) so that the loads imposed (e.g., air, ice, etc.) are transmitted to the aircraft structure.

37. VHF ANTENNA—WHIP.

a. Locate this type antenna so that there is a minimum of structure between it and the ground radio stations. The antenna may be mounted on the top or bottom of the fuselage. It is not advisable to mount the antenna on the cowl forward of the windshield because a lightning strike might possibly blind the pilot.

b. Methods of securing whip antennas to the structure are shown in figures 3.1 and 3.3.

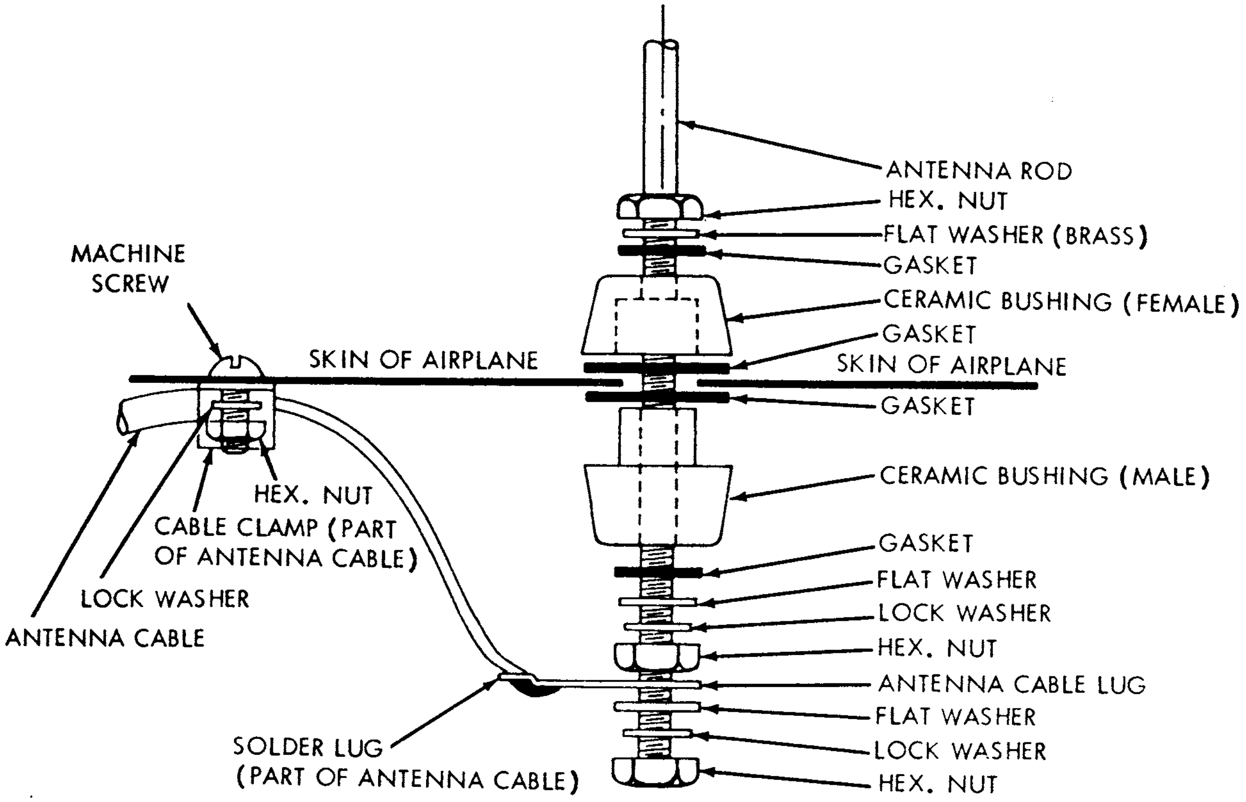
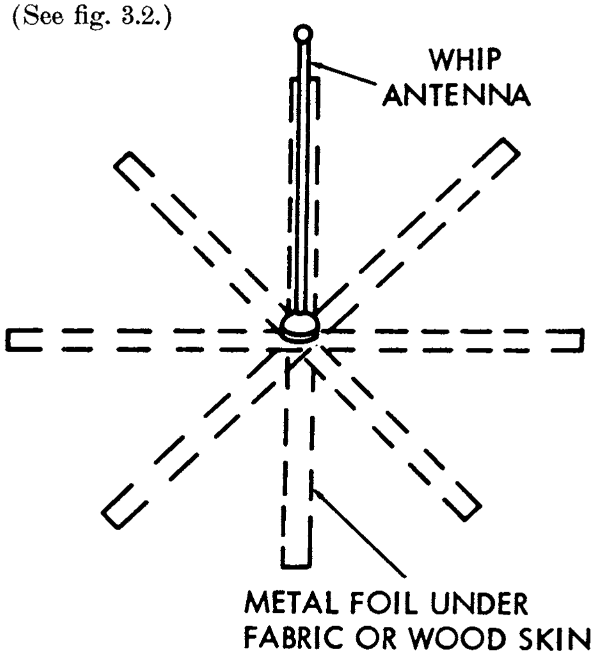


FIGURE 3.1.—Typical whip antenna installation.

c. On fabric-covered aircraft or aircraft with other types of nonmetallic skin, the manufacturer's recommendations should be followed in order to provide the necessary ground plane. An acceptable method of accomplishing this is by providing a number of metal foil strips in a radial position from the antenna base and secured under the fabric or wood skin of the aircraft. (See fig. 3.2.)



NOTE: THE LENGTH OF EACH FOIL RADIAL SHOULD BE AT LEAST EQUAL TO THE ANTENNA LENGTH.

FIGURE 3.2.—Antenna ground plane for nonmetallic aircraft.

38. VHF ANTENNA—RIGID.

a. ***When it is necessary to cover a broader frequency range*** than can be covered by a whip antenna, a blade type should be used because it is resonant over a much broader frequency range. However, a broadband antenna is not as efficient as a small diameter whip antenna and, accordingly, should not be used with relatively low output transmitters (under 5 watts).

(1) The antennas shown in figure 3.4 are normally installed at a point on the fuselage directly above the cabin or baggage compartment.

When a rigid antenna is installed on the vertical stabilizer, evaluate the flutter and vibration characteristics of the installation.

(2) The approximate drag load an antenna is required to withstand can be determined by the following formula:

$$D=.000327\ AV^2$$

(The formula includes a 90 percent reduction factor for streamline shape of antenna.)

Where D is the drag load on the antenna in lbs.,

A is the frontal area of the antenna in sq. ft., and

V is the V_{ne} of the aircraft in m.p.h.

The frontal area of typical antennas are approximately as follows:

Antenna (*Fig. 3.4*)	*Area* (*sq. ft.*)
a	.073
b	.135
c	.135
d	.025
e	.045

Example: Antenna "b" at 250 m.p.h.

$$D=.000327\times.135\times(250)^2$$
$$=.000327\times.135\times62{,}500$$
$$=2.75\text{ lbs.}$$

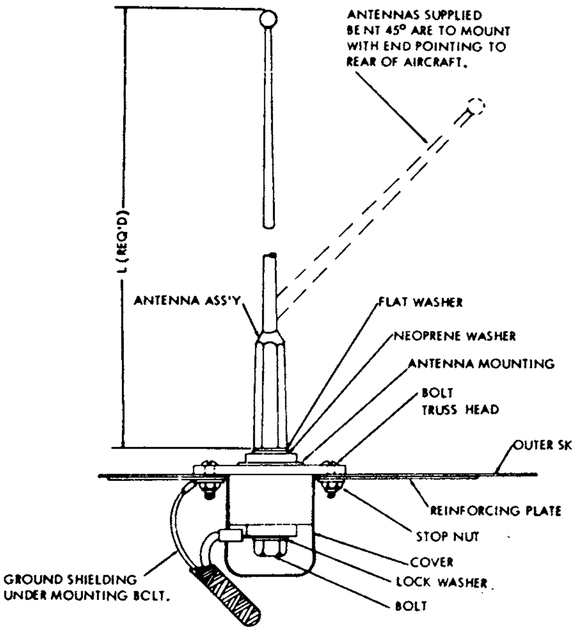


FIGURE 3.3.—Typical shockmounted antenna installation.

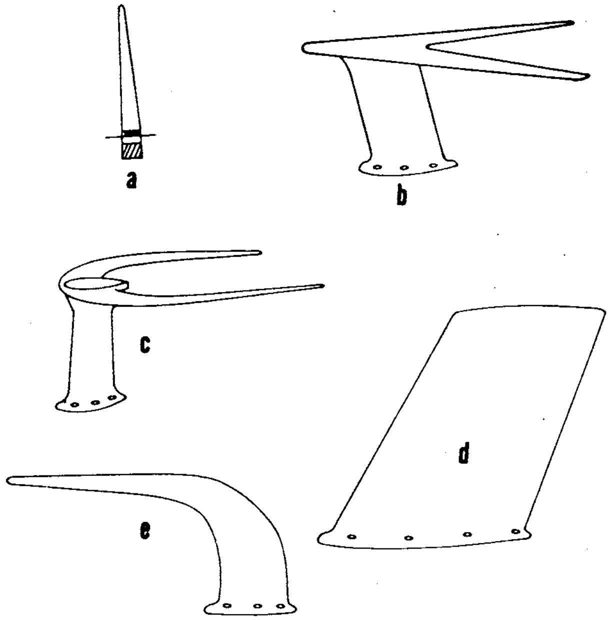


FIGURE 3.4.—Typical rigid antennas.

b. *Installation of Rigid Antennas.*

(1) Place a template similar to figure 3.5 on the fore-and-aft centerline at the desired location. Drill the mounting holes and the correct diameter hole for the transmission line cable in the fuselage skin.

(2) Install a reinforcing doubler of sufficient thickness to reinforce the aircraft skin. The length and width of the plate should approximate that illustrated in figures 3.6 or 3.8.

(3) Install antenna on fuselage, making sure that the mounting bolts are tightened firmly against the reinforcing doubler, and that the mast is drawn tight against the gasket.

When a gasket is not used, seal the crack between the mast and fuselage with a sealer, such as zinc chromate paste or equivalent.

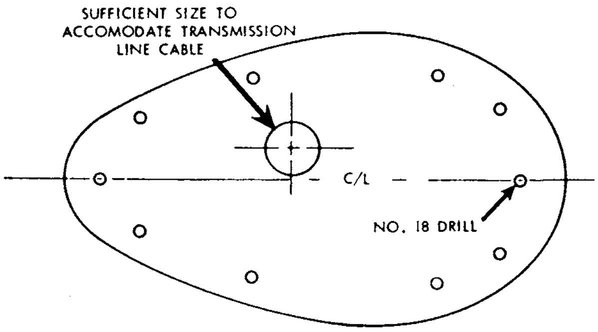


FIGURE 3.5.—Typical antenna mounting template.

(4) Route transmission line cable to the receiver, secure the cable firmly along its entire length at intervals of approximately 2 feet, and take care to prevent fouling of control cables.

39. VHF NAVIGATION RECEIVING ANTENNAS. Locate antennas for omnirange (VOR), and instrument landing system (ILS) localizer receivers at a position on the aircraft where they will have the greatest sensitivity for the desired signals and minimum response to undesired signals such as electrical energy radiated by the engine ignition system. A good location for the VOR localizer receiving antenna on many small

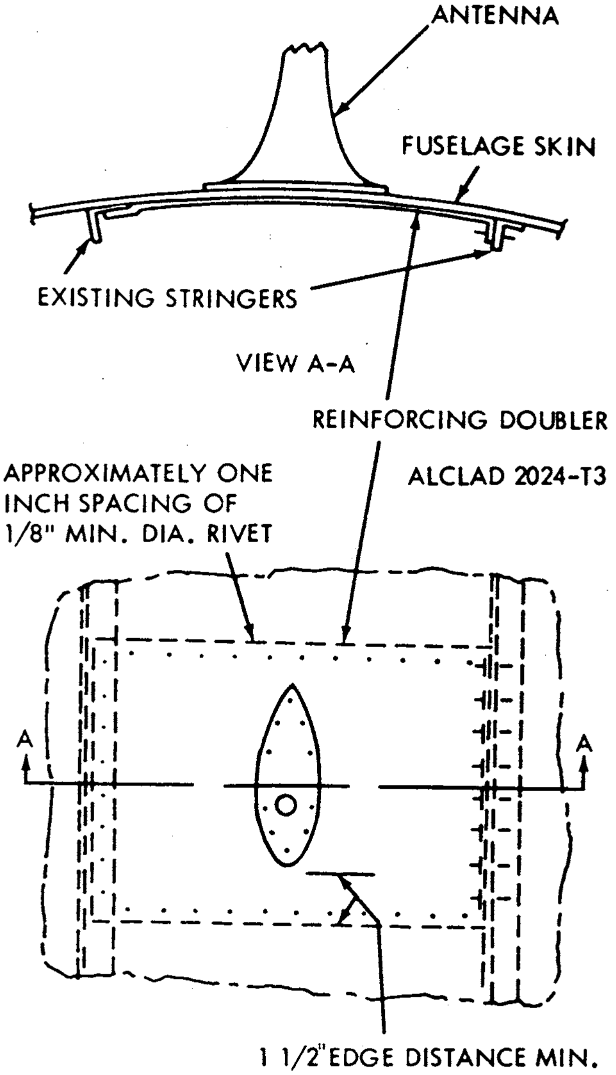


FIGURE 3.6.—Typical antenna installation on a skin panel.

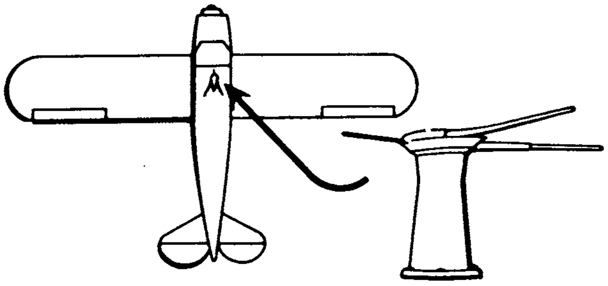


Figure 3.7.—Preferred VOR antenna location for maximum signal pickup with minimum ignition interference.

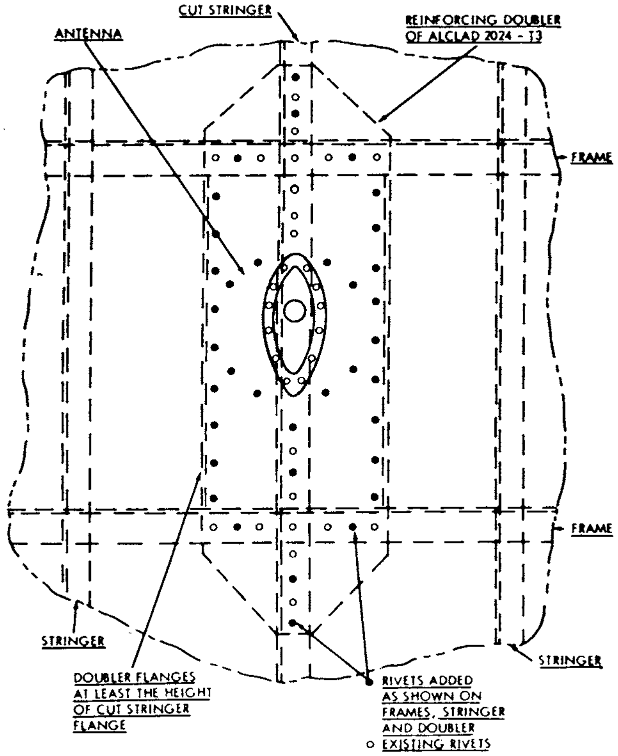


Figure 3.8.—Typical antenna installation involving a cut stringer.

airplanes is over the forward part of the cabin. Mount the rigid V-type antenna so that the apex of the "V" points forward and the plane of the "V" is level in normal flight.

a. VOR Antenna Balun and Transmission Lines. A dual element or balanced antenna system requires a balun or an impedence matching device for maximum signal transfer into an unbalanced coaxial cable. Rigid antennas, as displayed in figure 3.4, incorporate a balun as an integral component of the antenna assembly. Follow the manufacturer's installation procedures and assure that the balun is properly grounded to the airframe. Refer to AC 43.13-1A "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair" chapter 11, for acceptable bonding practices.

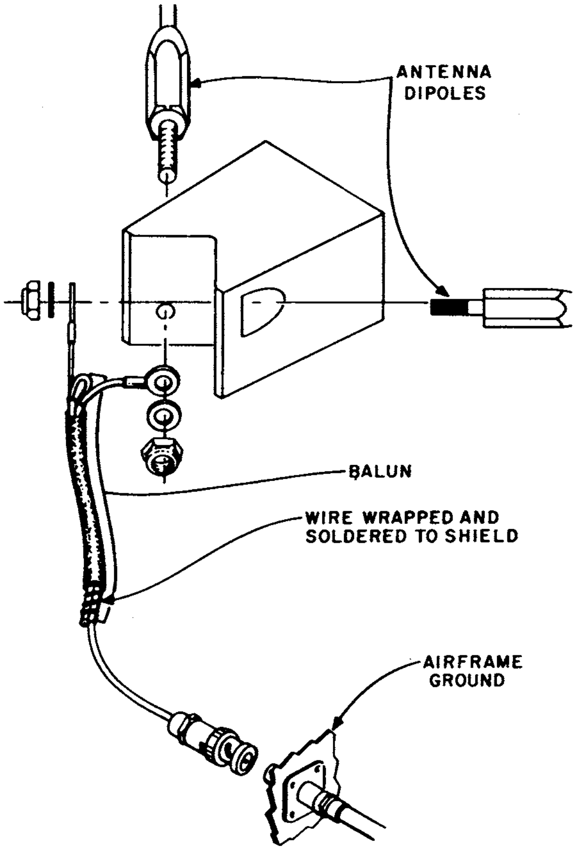


Figure 3.9 Typical dipole antenna assembly.

(2) Figure 3.10 is an illustration of a typical VOR antenna balun. A balun made from a section of the transmission line functions as a tuned circuit or transformer which produces a standing-wave ratio to provide the desired matching impedence. When the antenna is matched to the line, the line measurement in multiples of wave lengths is not critical.

(2) Radio wave velocity is less in a cable than in air; therefore, the wave length in cable will be shorter than in air. Appropriate test equipment must be used for transmission line measurements because the physical and electrical lengths of lines are not always equal.

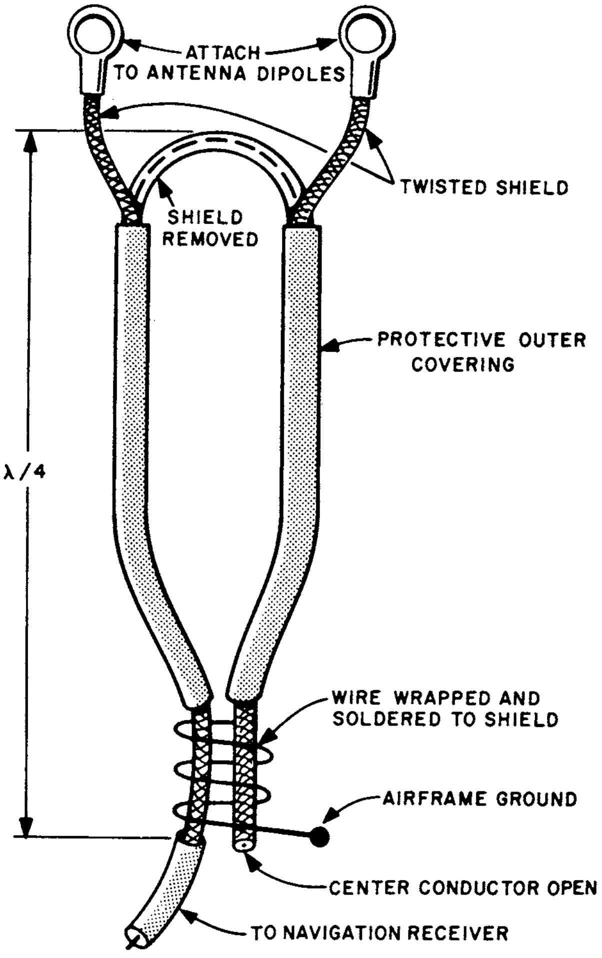


FIGURE 3.10 Typical VOR antenna balun.

(3) The transmission line should be kept as short as possible. Any bends in the cable should have at least a 3-inch radius. Follow the equipment manufacturer's recommendations regarding transmission lines and lengths.

b. Assembly of Coaxial Cable Connectors. Optimum performance of a radio system is dependent upon the coaxial cable connector assembly. Follow the manufacturer's assembly instructions. Assure that the cable is not distorted or flattened when cutting. The electrical characteristics of the cable change when flattened or bent sharply.

(1) To remove the outer jacket, cut with a sharp knife around the circumference, then make a lengthwise slit and peel off the outer jacket. Do not nick, cut or damage the shield.

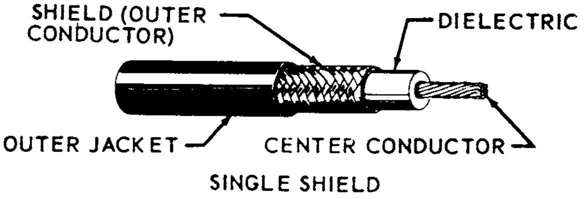


FIGURE 3.11 Coaxial cable preparation.

(2) Comb out the braid and bend back to expose the dielectric. Use a sharp knife to cut the dielectric around the circumference, not quite through to the center conductor. Do not nick or cut the conductor. Remove the dielectric by twisting and pulling.

(3) Solder the contact to the center conductor. Use a clean, well-tinned soldering iron.

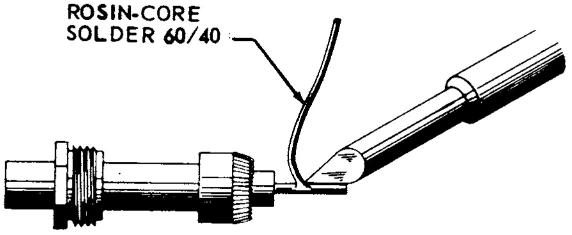


FIGURE 3.12 Coaxial cable tinning center lead.

(4) Do not apply heat too long as this will swell the dielectric and make it difficult to insert into the body of the connector.

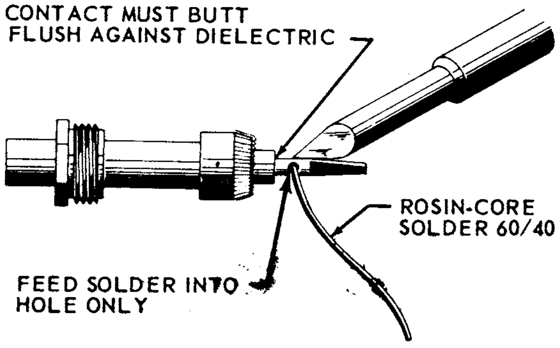


FIGURE 3.13 Coaxial cable soldering center lead.

(5) Install connector body and tighten until secure. Do not overtighten as this will distort the cable.

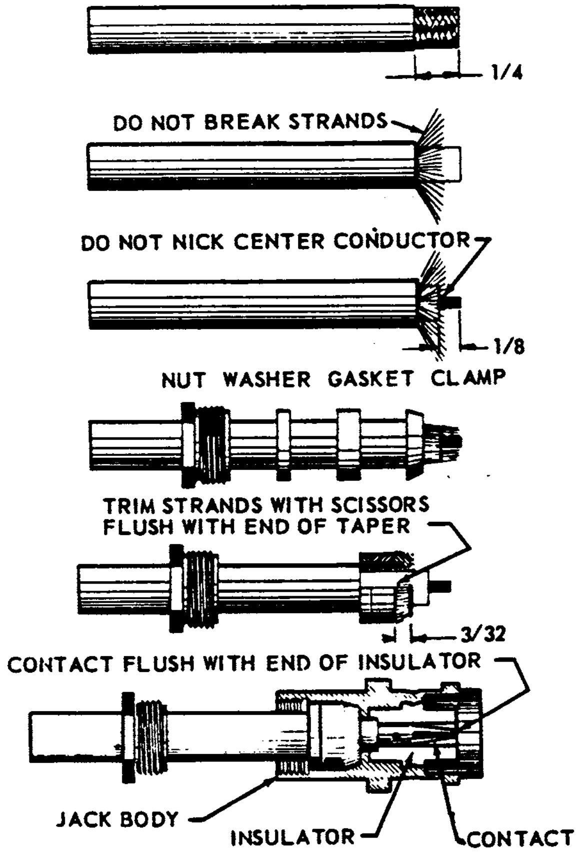
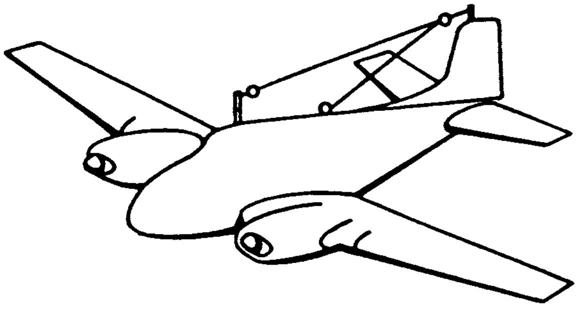


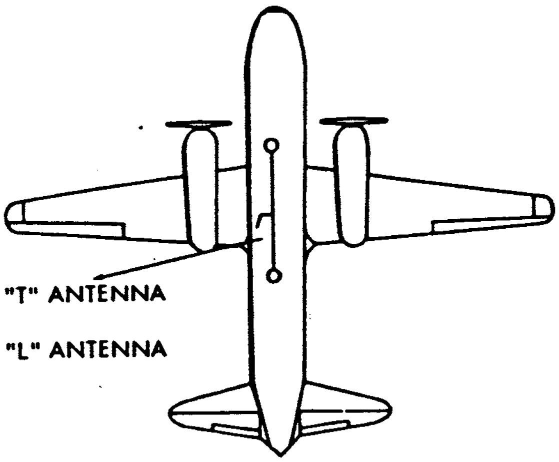
FIGURE 3.14 Coaxial cable install connector body.

(6) Use only the crimping tool recommended by the manufacturer, or an equivalent tool when installing connectors which utilize a crimp-type contact.

c. ***Dual VOR/NAV Receiver Installations.*** Two VOR navigation receivers can be connected to a common VOR antenna. This is accomplished by utilizing a coaxial tee connecter (UG-274 A/U) and matched 0.5 wavelength coaxial cable lengths connected from the tee connector to the respective VOR receivers. Typical cable lengths are from 22 to 35 inches and multiples of these lengths. Another method of coupling two VOR navigation receivers to a common antenna is by utilizing a device called a coupler or diplexer. This de-



VERTICAL "V" ANTENNA



NOTE: AN "L" TYPE ANTENNA IS SIMILAR TO A "T" ANTENNA EXCEPT THAT THE LEAD-IN WIRE IS CONNECTED TO THE END OF THE ANTENNA INSTEAD OF THE CENTER.

FIGURE 3.15.—Typical wire antenna locations.

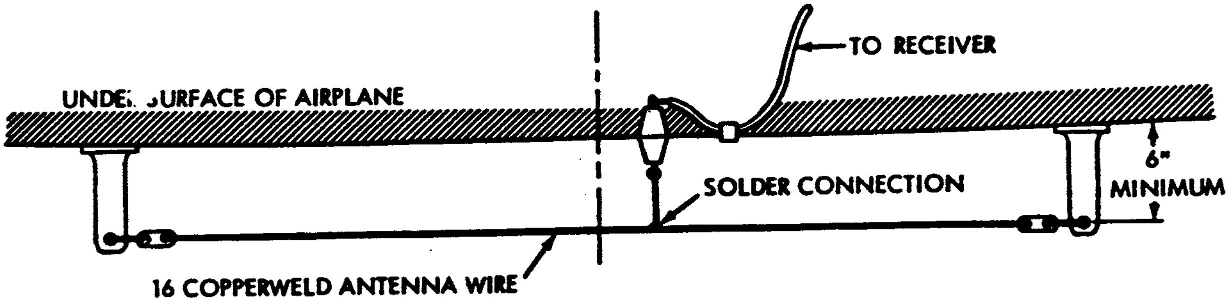


FIGURE 3.16.—Typical marker beacon receiving antenna.

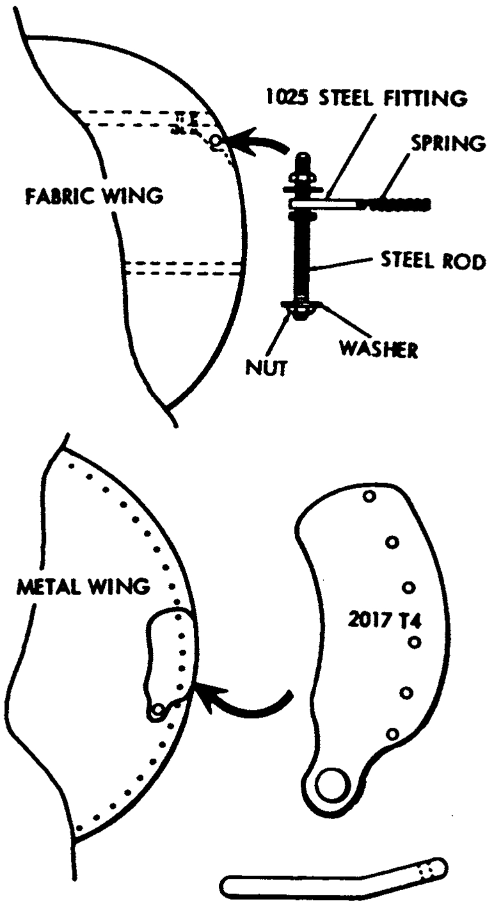


FIGURE 3.17.—Typical wing tip installations.

vice, in addition to impedance matching, also provides isolation between VOR navigation receivers while keeping line insertion losses at a minimum.

40. RANGE RECEIVING ANTENNAS. Mount "T", "L", or "V" antennas on top or bottom of the aircraft with approximately 1-foot clearance from the fuselage and wings. Typical wire antenna installations are shown in figures 3.15 through 3.19.

41. MARKER RECEIVING ANTENNA. The marker receiver operates at a frequency of 75 MHz. In order to keep to a minimum the number of antennas on the aircraft, the marker receiver may utilize the same antenna as the range receiver if that antenna is mounted on the underside of the aircraft. However, both receivers should include provisions to permit simultaneous operation without interference. A whip or other vertical type of antenna should not be used for marker reception since the ground facility transmits from a horizontally polarized antenna.

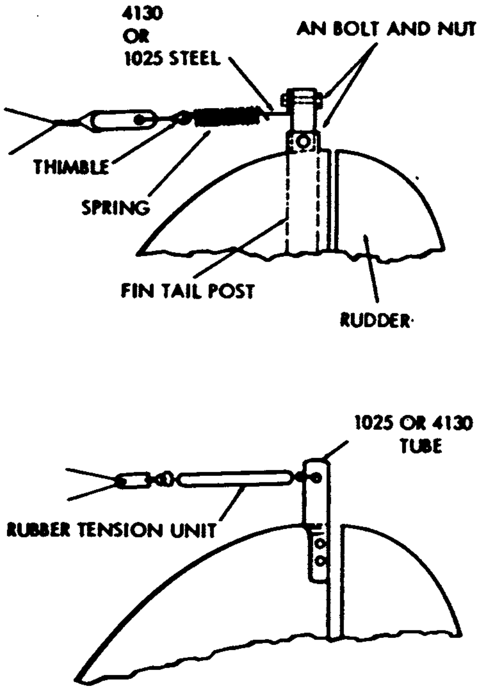


FIGURE 3.18.—Typical fin tip installations.

42. ATC RADAR BEACON (TRANSPONDER) AND DISTANCE MEASURING EQUIPMENT (DME) ANTENNAS. Locate these antennas at an unobstructed location on the underside of the fuselage, preferably at the lowest point of the aircraft when in level flight. To the extent practicable, mount the antenna so that the base is horizontal when the aircraft is in cruise attitude.

a. Installation. Mount the antennas at least 36 inches away from obstructions and as far as possible from other antennas. Tests have shown that the location of the antenna with respect to obstructions is of greater importance than having the antenna installed in a vertical position. However, signal strength and pattern become noticeably affected as the angle of the antenna approaches 45° from the desired vertical position. On fabric-covered aircraft or aircraft with other types of nonmetallic skin, it will be necessary to provide a flat metallic surface or "ground plane" extending at least 12 inches in all direc-

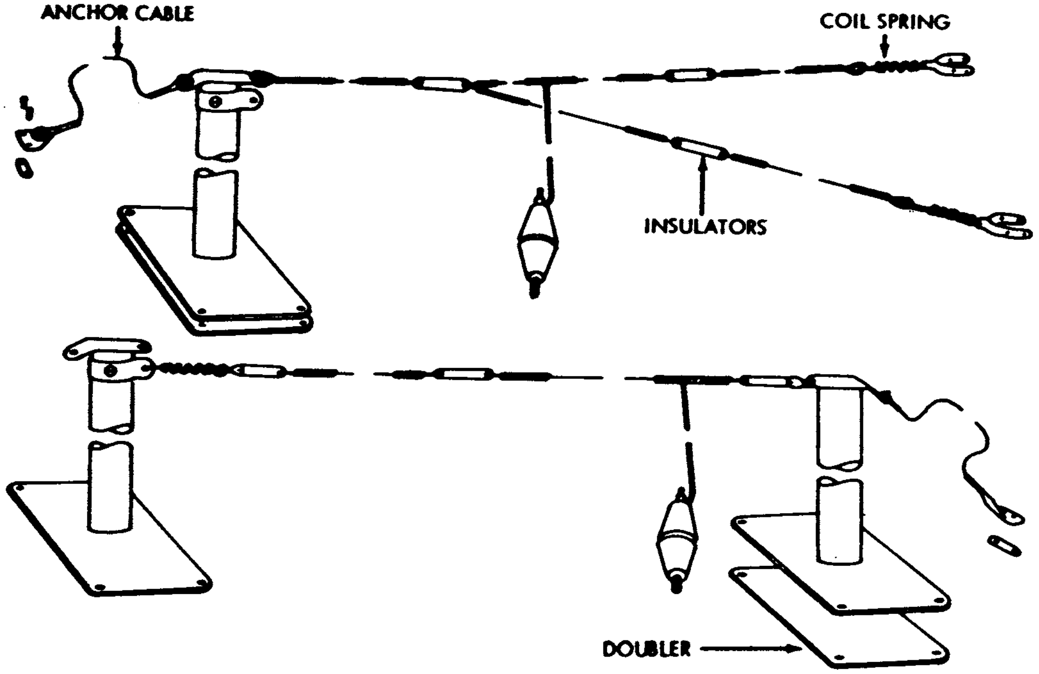


FIGURE 3.19.—Typical wire antenna installations.

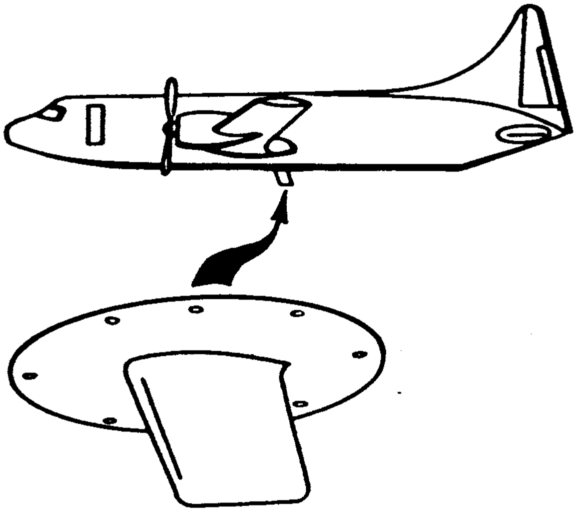


FIGURE 3.20.—Preferred position for distance measuring and/or ATC radar beacon antennas.

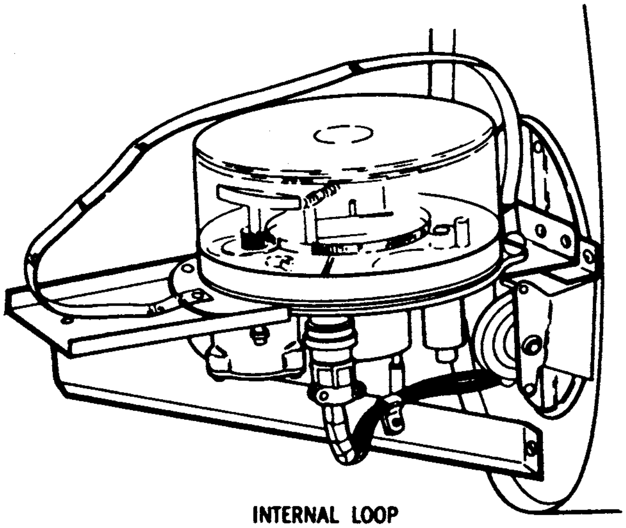
tions from the center of the antenna. Be sure the antenna makes a good, direct electrical connection with the ground plane. Install gaskets, pressurization seals, and/or sealant as required.

b. *Dual System Installations.* When dual ATC radar systems, dual DME systems, or combinations of these systems are installed, determine that the separation between their respective antennas is within the manufacturer's prescribed limits. (See paragraph 27i for mutual interference in DME and ATC radar beacon systems.)

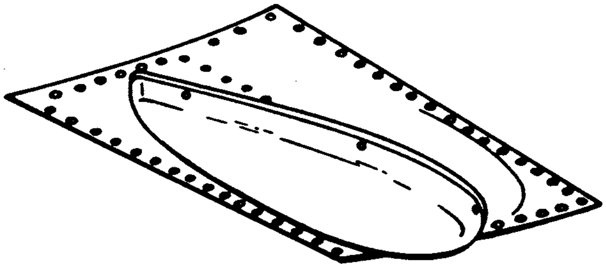
c. *Antenna Cable.* Route the antenna cable in the most direct path practicable. Since losses can be relatively high at these frequencies, follow the equipment manufacturer's recommendations regarding transmission lines and lengths.

43. DIRECTION FINDING ANTENNAS (100 to 1750 KHz). Manual or automatic loop-type antennas are used with direction-finding receivers. The loops are designed for use with a particular receiver. Connecting wires between the loops and receivers are also designed for the specific equipment. Accordingly, only components meeting the specification characteristics of the receiver manufacturer should be used.

a. Loops enclosed in streamlined housings or exposed loops are satisfactory for external mounting on an aircraft. Loops may also be flush mounted on the aircraft when proper attention is given to avoid interference from metallic structure and skin of the aircraft.



INTERNAL LOOP



ENCLOSED LOOP

FIGURE 3.21.—Typical ADF antenna installations.

b. Sense antennas are used to resolve radio bearing ambiguity in direction fiinding systems. The sense and its lead-in must be matched to the input capacitance of the ADF receiver. The sense antenna capacitance is a function of length, spacing between antenna and fuselage, and lead-in capacitance. To achieve this antenna/receiver capacitance match, it is important that the sense antenna be installed in accordance with the ADF manufacturer's recommendations for the particular make and model of aircraft.

c. Installation kits are designed for either top or bottom fuselage mounting of loop and sense antennas, or a combination of these two locations. Particular attention should be paid to the manufacturer's installation instructions for antenna location (top or bottom) and loop output connections, in order to prevent 180° errors in bearing indications.

d. Optimum ADF performance is achieved when the "T", rather than the "L", type of sense antenna is used, (see fig. 3.15). The "T" type has a noise cancelling effect due to the antenna cable being connected in the center of the antenna. The "L" type antenna has directional characteristics and may not produce a definite station passage indication as the "T" type does. A whip antenna of a type and dimension recommended by the equipment manufacturer may be used in place of the "T" or "L" types. Methods of installing a whip antenna are shown in figures 3.1, 3.2, and 3.3.

e. Because the ADF receiver is susceptible to aircraft radiated noise, antenna lead-ins should be routed so that they are kept away from electric power cables, alternators, solid state power supplies, anti-collision lights, pulse transmitting equipment, etc. They may be rounted against airframe members for extra shielding.

f. Loop-ins should be of the recommended type and length. The length of lead-in specified by the manufacturer for a particular installation may be excessive for the physical dimensions between the antenna and receiver. Excessive lead-in should not be trimmed, but should be coiled to take up the extra length. Do not coil excess cable in any area subject to electrical noise.

g. After completing the installation, it is essential that the loop be calibrated. One acceptable means of compliance is contained in AC 43.13–1A, chapter 15, section 6, paragraphs 848 through 853.

44. ANTENNA INSTALLATION ON PRESSURIZED AIRCRAFT. The use of doublers, to reinforce the aircraft skin to support antennas, is previously described in this chapter. The material contained in this paragraph concerns the methods of applying sealant to guard against the passage of air, liquids, and vapors from pressurized structures.

a. Typical Antenna Installation Procedure. When the attaching parts and the antenna are ready for installation, clean all faying surfaces with a cleaning solvent. Clean a larger area than that to which sealant is to be applied. Remove the solvent from the faying surfaces by blasting with dry air and wiping with a clean soft cloth.

(1) Coat the affected area with the primer specified by the sealant manufacturer.

(2) Apply the sealant to one surface, using a spatula or brush, and spread it over the entire faying surface until a uniform thickness of approximately $\frac{1}{32}$-inch is obtained. (See fig. 3.22 and 3.23.)

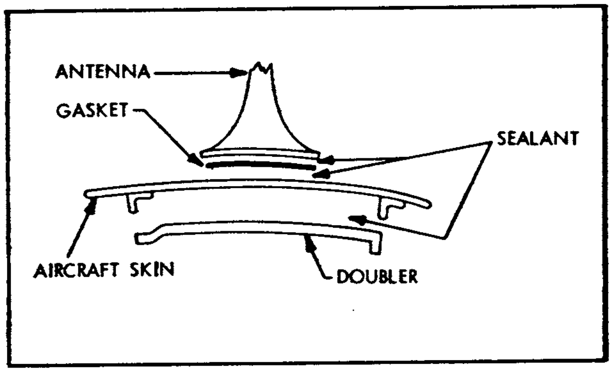


FIGURE 3.22.—Typical antenna installation.

(3) Place the component parts together and install the required fasteners. If permanent fasteners cannot be installed, use temporary fasteners to hold the component parts together until the sealant has cured. Install permanent fasteners with fresh sealant by dipping the fastener in sealant or by filling the fastener hole with sealant. (See fig. 3.24.)

(4) Fill holes and joggles by injecting the sealant into the voids and/or cavities. This method is used where the sealant cannot be applied with a spatula or brush. Figure 3.25.

(5) Allow the sealant to cure, then remove excess sealant from the periphery of the antenna using a nonmetallic scraper.

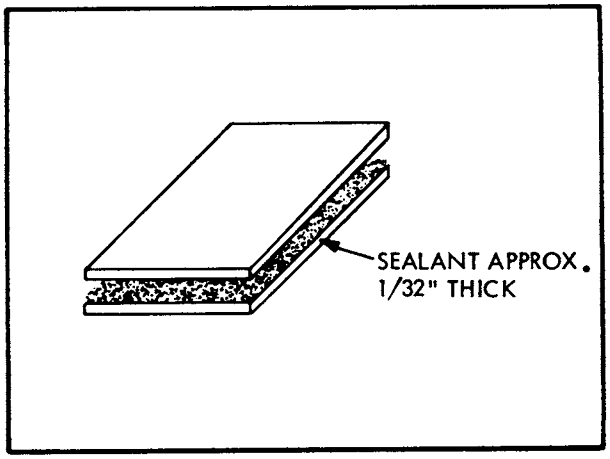


FIGURE 3.23.—Faying surface sealing.

Warning

Sealants may contain toxic and/or flammable components. Avoid inhalation of vapors. Supply adequate ventilation and provide a suitable exhaust system. Wear approved respiratory protection while using these materials in confined areas. Do not allow the sealant to come in contact with the skin or eyes. Insure that no source of ignition is present in the working area.

b. High Speed Aircraft. The sealant methods described should be used to prevent moisture or water from entering the aircraft and the expulsion of air and vapors when the aircraft structure is pressurized.

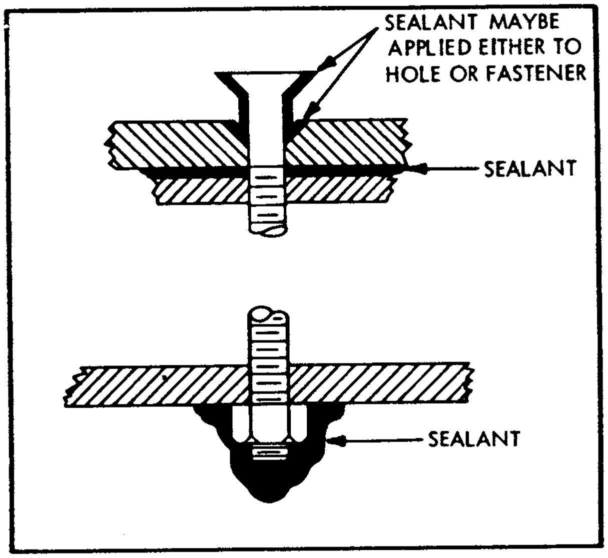


FIGURE 3.24.—Fastener sealing.

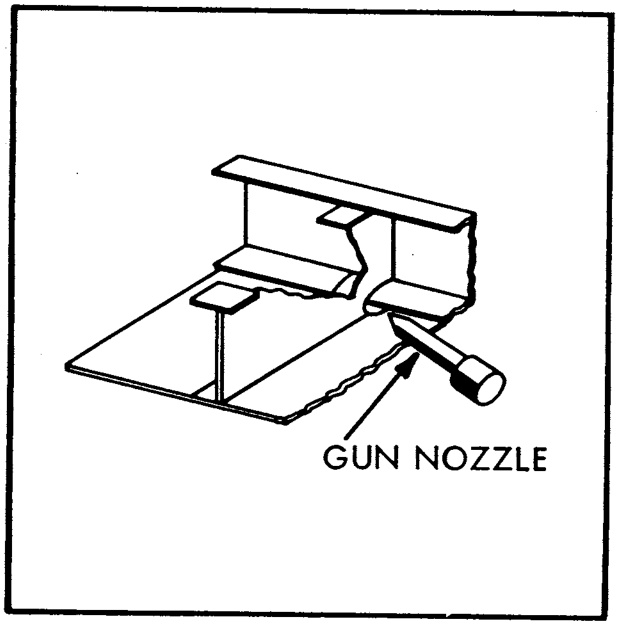


FIGURE 3.25.—Injection sealing.

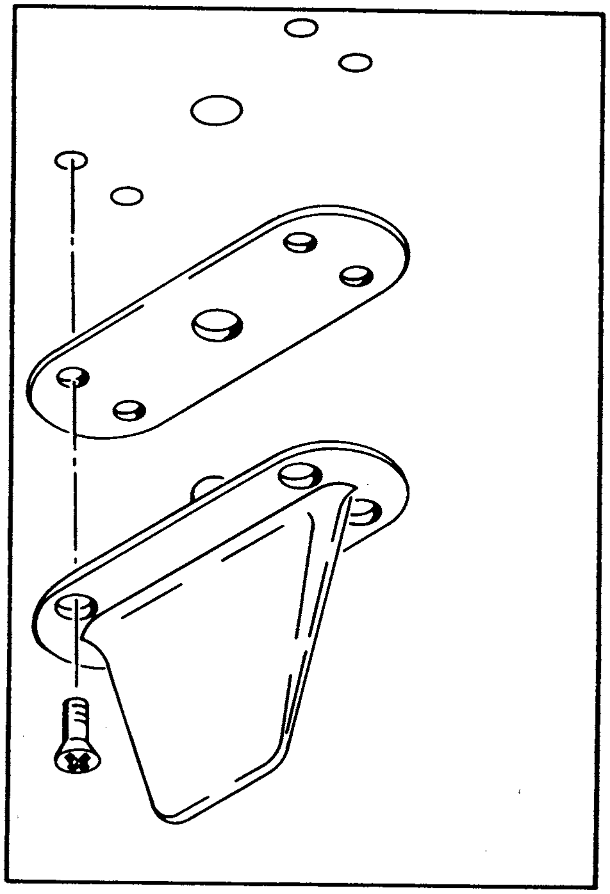


FIGURE 3.26.—Blade antenna installation.

(1) Figure 3.26 displays a blade type antenna mounted on a flat surface using a sealing gasket. This type of installation does not require the application of a sealant.

(2) Figures 3.27 and 3.28 display two types of flush mounted antennas. The antenna unit and fiberglass cover are manufactured as one integral assembly.

(3) Flush mounted antennas installed on a vertical fin are normally part of the primary structure. The radiating elements of the antenna and the fiberglass cover are individual units.

(a) Clean all metal surfaces necessary to insure good electrical bonding contact between the antenna mounting surface and the aircraft structure.

(b) After the fiberglass cover is installed, sealer may be applied to fill the space between the fiberglass cover and skin of the vertical fin. Figure 3.29 displays one-half of a vertical fin antenna installation. An identical installation is required on each side.

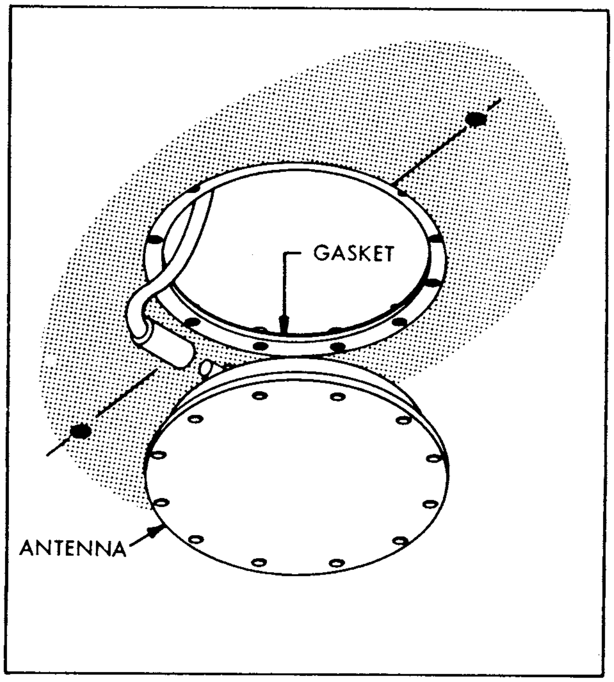


FIGURE 3.27.—ATC flush mounted antenna.

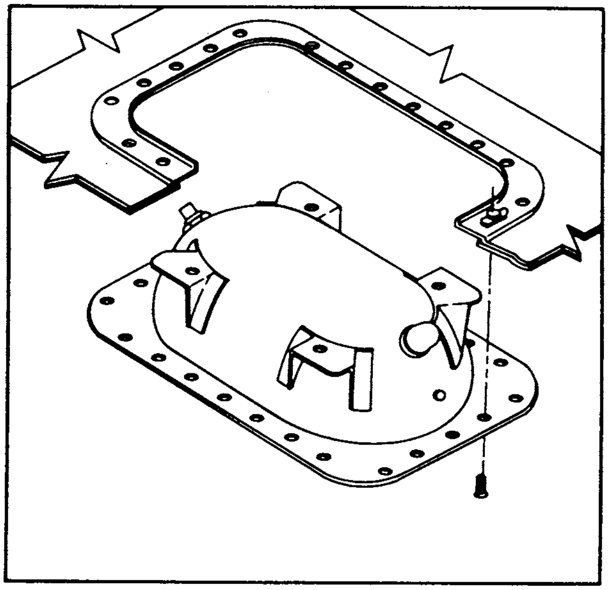


FIGURE 3.28.—Marker beacon flush mounted antenna.

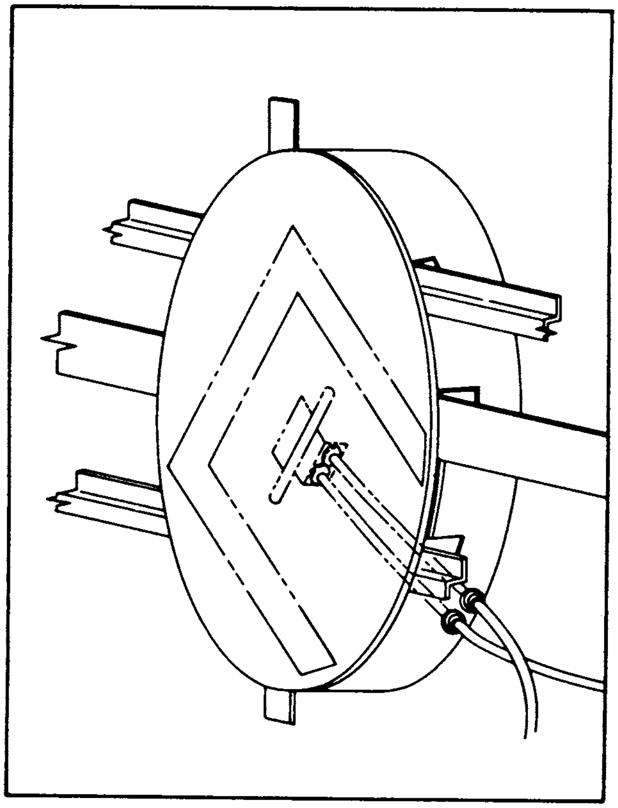


FIGURE 3.29.—VOR flush mounted antenna.

45.–50. [RESERVED]

Chapter 4. ANTICOLLISION AND SUPPLEMENTARY LIGHT INSTALLATIONS

51. ANTICOLLISION AND SUPPLEMENTARY LIGHT SYSTEMS.

a. ***Anticollision Lights.*** The requirements for anticollision lights are included in Federal Aviation Regulations, Parts 23, 25, 27, and 29. Aircraft for which an application for type certificate was made before April 1, 1957, may conform either to the above regulations or to the following standards:

(1) Anticollision lights (when installed) should be installed on top of the fuselage or tail in such a location that the light will not be detrimental to the flight crew's vision and will not detract from the conspicuity of the position lights. If there is no acceptable location on top of the fuselage or tail, a bottom fuselage installation may be used.

(2) The color of the anticollision light shall be aviation red or white in accordance with the specifications of FAR Part 23.

(3) The arrangement of the anticollision light (i.e., number of light sources, beam width, speed of rotation, etc.) should be such as to give an effective flash frequency of not less than 40 and not more than 100 cycles per minute.

b. ***Supplementary lights*** may be installed in addition to position and anticollision lights required by applicable regulations, provided that the required position and anticollision lights are continuously visible and unmistakably recognizable and their conspicuity is not degraded by such supplementary lights.

52. INTERFERENCE.

a. ***Crew Vision.*** Partial masking of the light may be necessary to prevent direct or reflected light rays from any anticollision or supplementary light from interfering with crew vision. Determine that the field of coverage requirements are met. An acceptable method of preventing light reflection from propeller disc, nacelle, or wing surface is an application of nonreflective paint on surfaces which present a reflection problem. Perform a night flight-check to assure that any objectionable light reflection has been eliminated. Enter a notation to that effect in the aircraft records.

b. ***Communication and Navigation.*** Assure that the installation and operation of any anticollision/supplementary light does not interfere with the performance of installed communication or navigation equipment. Capacitor discharge light (strobe) systems may generate radio frequency interference (RFI). This radiated interference can be induced into the audio circuits of communication or navigation systems and is noticeable by audible clicks in the speaker or headphones. The magnitude of the RFI disturbance does not usually disrupt the intelligence of audio reception.

c. ***Precautions.*** RFI can be reduced or eliminated by observing the following precautions during installation of capacitor discharge light systems:

(1) Locate the power supply at least three (3) feet from any antenna, especially antennas for radio systems that operate in the lower frequency bands.

(2) Assure that the lamp unit (flash tube) wires are separated from other aircraft wiring placing particular emphasis on coaxial cables and radio equipment input power wires.

(3) Make sure that the power supply case is adequately bonded to the airframe.

(4) Ground the shield around the interconnecting wires between the lamp unit and power supply at the power supply end only.

53. MARKINGS AND PLACARDS. Identify each switch for an anticollision/supplementary light and indicate its operation. The aircraft should be flight tested under haze, overcast, and visible moisture conditions to ascertain that no interference to pilot vision is produced by operation of these lights. If found unsatisfactory by test, or in the absence of such testing, a placard should be provided to the pilot stating that the appropriate lights be turned off while operating in these conditions.

54. ELECTRICAL INSTALLATION. Install an individual switch for the anticollision light or supplementary light system that is independent of the position light system switch. Data for the installation of wiring, protection device, and generator limitations is contained in chapter 11 of Advisory Circular 43.13–1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair." Assure that the terminal voltage at each light is within the limits as prescribed by the manufacturer.

55. ALTERATION OF STRUCTURE.

a. ***The simplest light installation*** is to secure the light to a reinforced fuselage skin panel. The reinforcement doubler shall be of equivalent thickness, material, and strength as the existing skin. (Install as shown in fig. 4.1.)

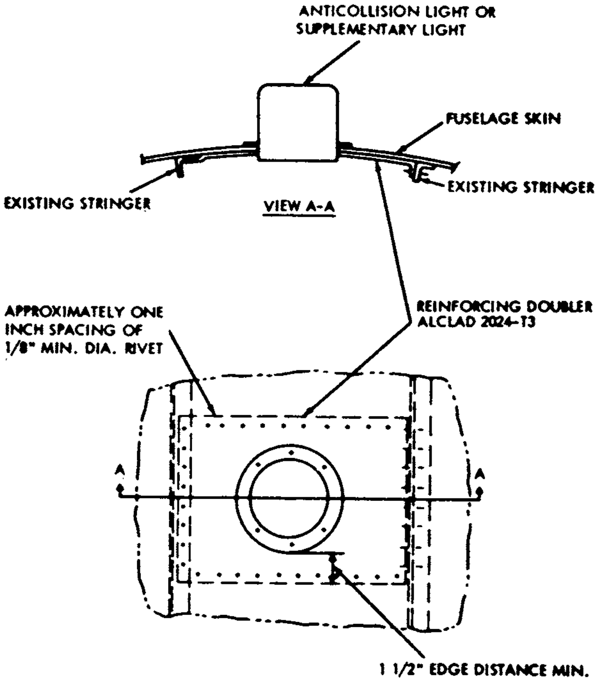


FIGURE 4.1.—Typical anticollision or supplementary light installation in a skin panel (unpressurized).

b. ***When a formed angle stringer is cut and partially removed,*** position the reinforcement doubler between the skin and the frame. Doubler to be equivalent to the stringer in thickness and extend lengthwise beyond the adjacent fuselage frames. The distance between the light and the edge of the doubler is twice the height of the doubler flange. (See fig. 4.2 for typical installation.)

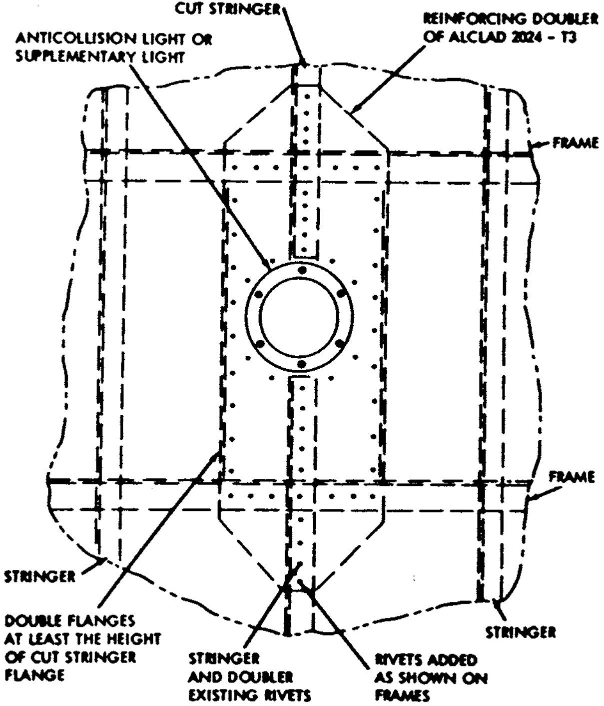
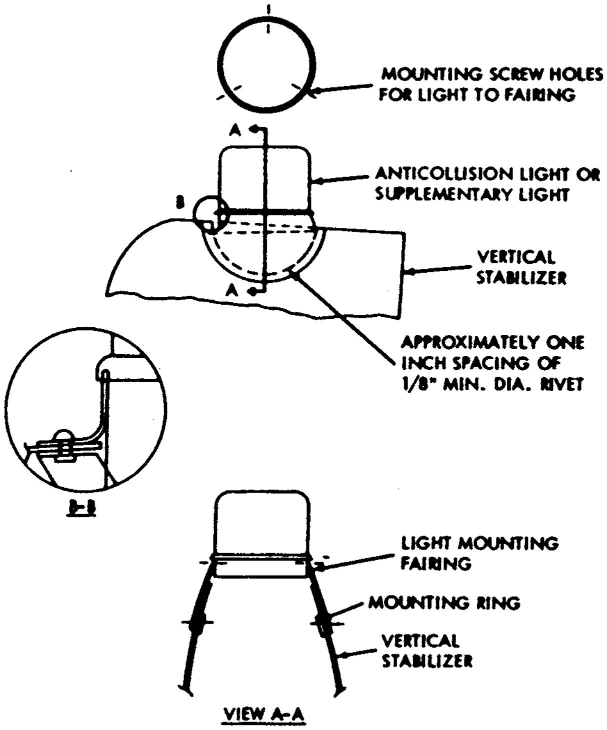


FIGURE 4.2.—Typical anticollision or supplementary light installation involving a cut stringer (unpressurized).

c. ***Engineering evaluation*** is required for installations involving the cutting of complex formed or extruded stiffeners, fuselage frames, or pressurized skin of pressurized aircraft.

d. ***Vertical stabilizer installations*** may be made on aircraft if the stabilizer is large enough in cross section to accommodate the light installation, and aircraft flutter and vibration characteristics are not adversely affected. Locate such an installation near a spar, and add formers as required to stiffen the structure near the light. (A typical installation is shown in fig. 4.3.)

e. ***Rudder installations*** are not recommended because of the possible structural difficulties. However, if such installations are considered, make an engineering evaluation to determine whether the added mass of the light installation



NOTE:
SKIN THICKNESS OF MOUNTING RING AND FAIRING ARE AT LEAST EQUIVALENT

FIGURE 4.3.—Typical anticollision or supplementary light installation in a fin tip.

will adversely affect the flutter and vibration characteristics of the tail surfaces.

f. *Pressurized Aircraft Installation*. Doubler installation to reinforce the aircraft skin previously described in this chapter is adaptable to pressurized structure with the application of sealant. Sealant is used to prevent moisture or water from entering the aircraft and the expulsion of air when the aircraft structure is pressurized.

(1) Sealant procedures for aircraft skin reinforcing doubler and doubler fasteners are contained in paragraph 44, chapter 3 of this manual. The aircraft manufacturer's data may recommend the specific sealant to be used and provide instructions for the application.

(2) Figures 4.4 and 4.5 illustrate two different designs of anticollision light assemblies. The application of sealant is required when either type of light assemblies is installed. Sealant procedures would be identical for installation of a capacitor discharge (strobe) light system.

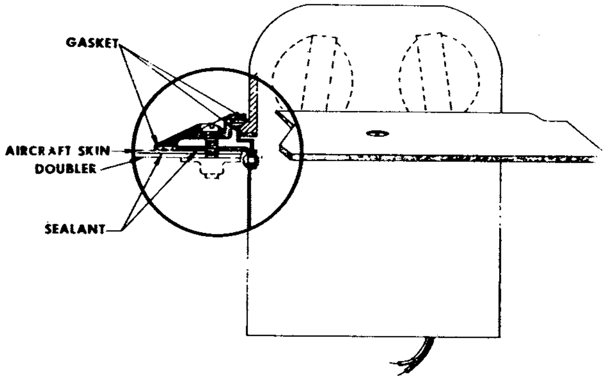


FIGURE 4.4.—Typical rotating type anticollision light installation for pressurized aircraft.

Caution: Sealant and solvents may contain toxic and/or flammable components. Avoid inhalation of vapors and supply adequate ventilation. Wear appropriate respiratory protection while using these materials in confined areas. Avoid contact with the skin and eyes.

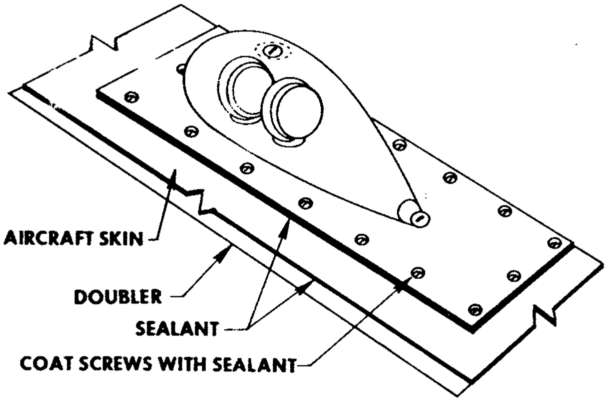


FIGURE 4.5.—Typical oscillating type anticollision light installation for pressurized aircraft.

56. GUIDELINES FOR INSTALLATIONS.

a. *Prior Approval*. Due to the complexity of measurements for intensity, field of coverage, and color, evidence of FAA approval should be obtained from the light manufacturer before installation.

b. *System Performance*.

(1) *Field of Coverage*. Evidence of FAA approval for "field of coverage" should be obtained from the light manufacturer before installation. To insure that the manufacturer's approved field of coverage is applicable to an installation, his mounting tolerance should not be exceeded.

(2) *Obstructed Visibility.* Measure all solid angles of obstruction within the required field of coverage. For multiple light installations, coverage between the mounting levels is not necessary. When a multiple light installation is being evaluated, shadows for each light should be measured independently, and only shadow areas repeated in each independent measurement (overlap) should be counted. Methods for determining the amount of obstructed visibility are given below; however, other methods can give acceptable results.

(a) *Wall Shadows.* This procedure is applicable to installations where shadows from light obstructions appear on a vertical surface such as a hangar wall. Validity is based on two facts: (1) that a vertical surface can approximate a sphere surface if the distance from the light is considerable, and the shadow is reasonably small, and (2) that sphere surface area can be converted to steradians by dividing by the radius squared.

1 Position the aircraft in a darkened hangar so that longitudinal axis is perpendicular to a hangar wall. Level as for weight and balance. To keep measure errors low, the distance from light to wall should be as great as practicable considering hangar size. The distance should not be less than 20 feet.

2 Turn on the lights and measure the area of wall shadows. Sufficient points should be marked and identified so that the shadow pattern can be transferred to graph paper for accurate evaluation. Area can be found by counting squares on the graph or by using a planimeter. Measurements should include areas of transition from shadowed to lighted areas. For top light measurements on multiple light installations, only shadows above the level of the top light should be considered.

3 Compute the solid angle obstruction in steradians, by dividing each shadow area by the square of the distance from the center of the area to the light.

4 Evaluate the results to determine if the system consists of enough lights to illuminate the vital areas around the aircraft, considering the physical configuration and flight characteristics of the aircraft. The field of coverage must extend in each direction within at least 30° above and 30° below the horizontal plane of the aircraft, except that there may be solid angles of obstructed visibility totalling not more than the requirements of paragraph .1401(b) of the applicable airworthiness regulations.

5 For installations where shadows are restricted to directly aft and centered about the longitudinal axis, the following procedures apply:

a Establish a point on the wall which corresponds to a line parallel to the longitudinal axis and through the light associated with the shadow.

b Measure the distance from the light to the point and determine the area representing 0.15 steradians ($A = 0.15d^2$). The distance (d) should be at least 20 feet.

c Draw a circle, with the established point as the center, having an area equal to that found in *b* above.

d If the shadow falls within this circle, its position is acceptable. For multiple light installations, consider only the shadow above light level.

e If the shadow is partially out of the circle, the shape of the 0.15 steradian area may be varied, but the established point should remain at the center of the area (centroid).

(b) *Ramp Shadows.* This procedure is applicable to shadows which appear on a horizontal plane such as a flat level ramp and will be associated with a top mounted light and a 0.5 steradian limit. Area measurements as described in the wall shadow method should not be used. Some error is inherent, because horizontal angles are measured on a plane displaced from the light source. To compensate for these measurement errors, a table (fig. 4.8) is furnished to convert from measured solid angles to true solid angles. A term "square degrees" is used to aid in the discussions of solid angle measurements.

1 If no masking is required, remove the red cover and attach its clamp ring to the light base. If masking is used, obtain a clear cover and install it with a duplicate mask.

2 Center the aircraft on the largest available dark ramp. A minimum of 50 feet radius of clear ramp space will usually be needed. If the installation is symmetrical, clear ramp space will be needed on one side only. Level the aircraft as for weight and balance check. Trim the flaps, rudder, elevator and ailerons. With jacks in place, raise the gear if the measurement results would otherwise be affected.

3 Chalk the following marks on the ramp:

a A reference point directly below the light.

b A circle centered on this reference point having a radius equal to 1.732 times the height of the light above the point. (The circle represents area beyond the minus 30° vertical limit and does not require lighting.)

c A line parallel to the aircraft longitudinal centerline which passes through the reference point.

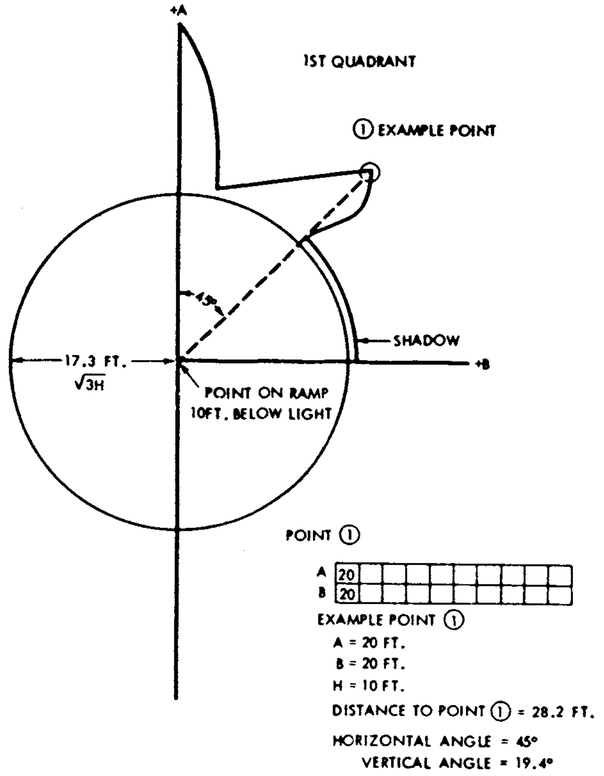


FIGURE 4.6.—Ramp shadow pattern.

d A line perpendicular to the above line, which also passes through the reference point.

4 At night, turn on the anticollision light and chalk all shadow patterns (except jack shadows) which appear outside the circle. If the light rotates so as to cause the shadows to oscillate, lay twine along the outermost edge of the shadow, and chalk along the line.

5 Move the aircraft to facilitate area measurements. Measure, sketch, and chart the ramp marks and other information as shown in Figure 4.6. Measure enough points along the shadow patterns to accurately describe them. Make enough sketches to include all shadows.

6 Convert the above measurements to a graph showing vertical degrees vs. horizontal degrees as shown in Figure 4.7 (first quadrant). The second quadrant will have to be measured also to obtain the total shadow area for one side. If the shadow pattern is symmetrical, no other measurements will be necessary. Use 1 degree for each space on the graph paper and count the square degrees of shadow. A total of 1,642 or less is within limits. A total of 1,872 or more is out of limits, and if possible, should be reduced by adding or moving a light, or by trimming a mask. If the count is between 1,642 and 1,872, proceed as follows: For each 1 degree segment of vertical (pitch), convert the counted square degrees to true square degrees by use of the table of Figure 4.8. If the sum of the true square degrees from all segments exceeds 1,642 (0.5 steradian), the installation is out of limits.

(c) *Scale Drawings.* Accurate scale drawings can be used to measure solid angles of obstruction. Such drawings should have sufficient size and accuracy to give dependable results. In some cases, actual measurements can be combined with small drawings as shown in Figure 4.9. For the 6 points established on the left wing, a string can be used to connect the light successively to each. A protractor can then be used to measure the vertical angle from level. The horizontal angle for each point can be measured on the top view (center). When both horizontal and vertical angles for each point have been determined, they can be plotted on a graph as shown in Figure 4.10. If a symmetrical condition exists, only the first and second quadrants need be measured.

The first quadrant contains approximately 450 square degrees of obstruction. The other wing quadrant will double this to 900 square degrees.

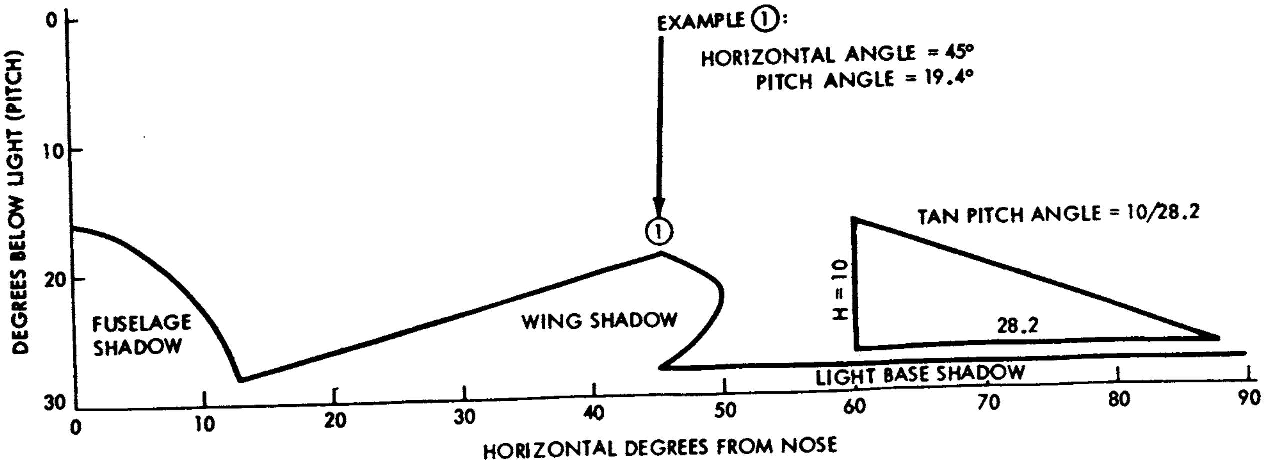


FIGURE 4.7.—Conversion to vertical vs. horizontal degrees.

A measurement of the fin and rudder shadows adds approximately 100 for a total of 1,000 square degrees. Since a maximum of 1,642 square degrees is allowed (0.5 steradians), this installation is well within limits. Due to limitations of the method, results within 10% (0.05 steradians) of the limit are questionable. Many times a mask is required to prevent reflections into the cockpit. In the example of figures 4.9 and 4.10, the installed mask blocks the light for ±10 horizontal degrees and from −10 to −30 vertical degrees. These 400 square degrees were measured at the light.

When larger drawings are used and no actual aircraft measures are made, vertical angles should not be taken directly from the drawing, but should be computed as follows:

1 On the aircraft side view, measure the vertical distance from a point to the light level.

2 On the top view, measure the distance from the point to the light.

3 Compute:

$$\text{Tangent of vertical angle} = \frac{\text{vertical distance}}{\text{horizontal distance}}$$

Pitch Segment (Degrees)	Measured Square Degrees	Correction Factor	True Square Degrees
30-29	90	.87036	78.33
29-28	90	.87882	79.09
28-27	44	.88701	39.03
27-26		.89493	
26-25		.90259	
25-24		.90996	
24-23		.91706	
23-22		.92388	
22-21		.93042	
21-20		.93667	
20-19		.94264	
19-18		.94832	
18-17		.95372	
17-16		.95882	
16-15		.96363	
15-14		.96815	
14-13		.97237	
13-12		.97630	
12-11		.97992	
11-10		.98325	
10-9		.98629	
9-8		.98902	
8-7		.99144	
7-6		.99357	
6-5		.99540	
5-4		.99692	
4-3		.99813	
3-2		.99905	
2-1		.99966	
1-0		.99996	
		TOTAL	

FIGURE 4.8.—Conversion to true square degrees—1st quadrant.

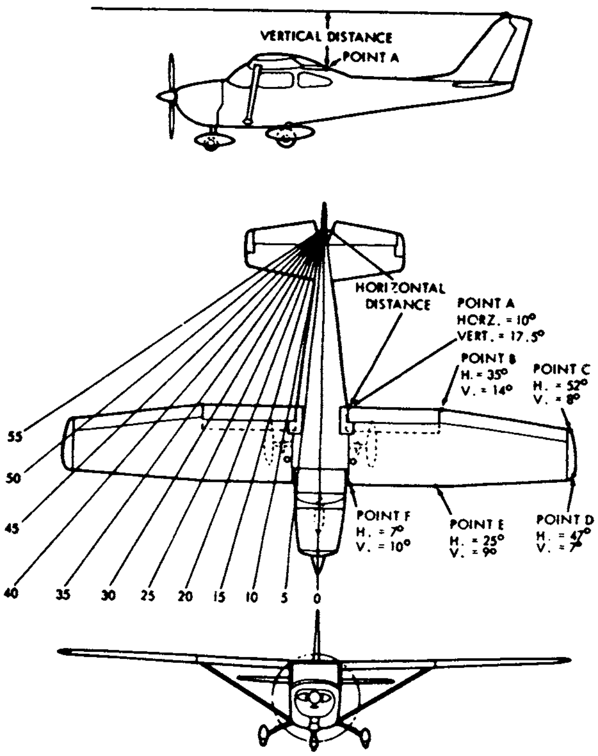


FIGURE 4.9.—Scale drawings.

(d) ***Flashing Characteristic.*** Turn off any flashing supplementary lighting. Observe the flashing of the anticollision light system at a point where each light can be observed independently, and determine that each flashing rate is between 40 and 100 flashes per minute. For multiple light systems, observe at a point where overlap occurs, and determine that the combined flashing rate does not exceed 180 flashes per minute. Flashing outside the required field of coverage is not necessary.

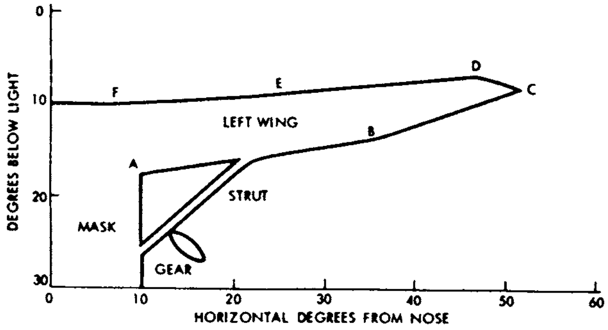


FIGURE 4.10.—Solid angle blockage—1st quadrant.

57.–60. [RESERVED]

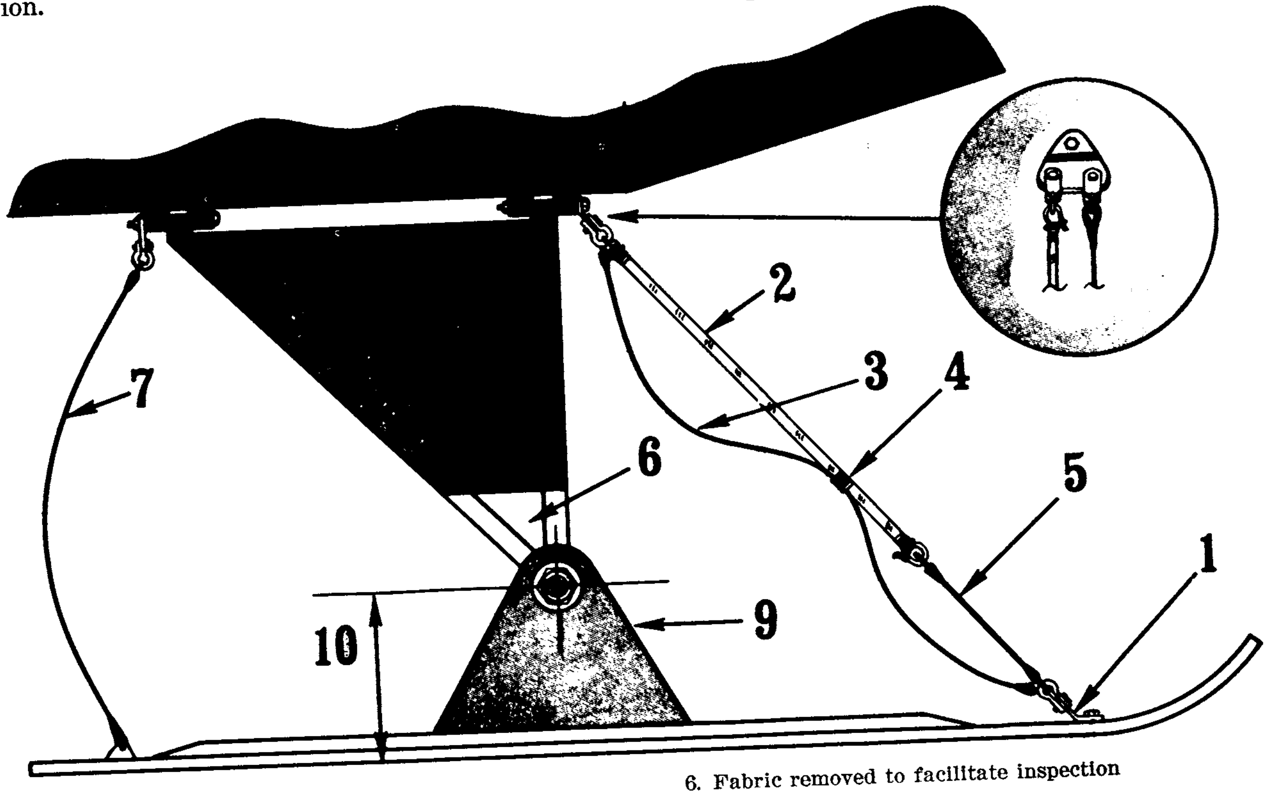
Chapter 5. SKI INSTALLATIONS

Section 1. SELECTION OF SKIS

61. DETERMINING ELIGIBILITY OF AIRCRAFT. Only aircraft approved for operation on skis are eligible for ski installations in accordance with this chapter. Eligibility can be determined by referring to the Aircraft Specifications, Type Certificate Data Sheets, Aircraft Listing, Summary of Supplemental Type Certificates, or by contacting the manufacturer. Also determine the need for the nature of any required alterations to the aircraft to make it eligible for ski operation.

62. IDENTIFICATION OF APPROVED MODEL SKIS. Determining that the skis are an approved model can be done by referring to the identification plate or placard displayed on the skis. A Technical Standard Order (TSO) number; Type Certificate (TC) number; or an aircraft part number, if the skis have been approved as a part of the aircraft, will be shown thereon if the skis are approved models.

63. MAXIMUM LIMIT LOAD RATING. In order for an approved ski to be installed on any given



1. Fitting
2. Shock Cord
3. Safety Cable
4. Tape
5. Crust-cutter Cable
6. Fabric removed to facilitate inspection
7. Check Cable
8. Clevis
9. Ski Pedestal
10. Pedestal Height

FIGURE 5.1.—Typical ski installation.

aircraft, determine that the maximum limit load rating (L) as specified on the ski identification plate or placard is at least equal to the maximum static load (S) times the limit landing load factor (η) previously determined from static drop tests of the airplane by the aircraft manufacturer.

$$L = S \times \eta$$

In lieu of a value η determined from such drop tests, a value of η determined from the following formula may be used:

$\eta = 2.80 + \frac{9000}{W+4000}$ where "W" is the certificated gross weight of the airplane.

Skis approved for airplanes of greater gross weight than the airplane on which they are to be installed may be used provided the geometry of the ski is similar to that of a ski previously approved for the airplane (not more than 10 percent difference in width or length of contact surface). This limitation is to assure that the performance of the airplane will not be adversely affected by oversize skis.

64. LANDING GEAR MOMENT REACTIONS. In order to avoid excessive moment reactions on the landing gear and attachment structure, the ski pedestal height must not exceed 130 percent of the axle centerline height with the wheel and tire installed.

65. [RESERVED]

Section 2. CONVERSION AND INSTALLATION

66. HUB-AXLE CLEARANCE. The pedestal hub should fit the axle to provide a clearance of .005″ minimum to .020″ maximum. Hubs may be bushed to adjust for axle size, using any ferrous or nonferrous metal, hard rubber, or fiber. If rubber or fiber bushings are used, use retaining washers of sufficient size on each side to retain the hub if the bushing should slip or fail. (See fig. 5.2.)

67. CRUST-CUTTER CABLES. Crust-cutter cables are optional. However, when operating in severe crust conditions, it is advisable to have this cable installed to prevent the shock cord from being cut if the nose of the ski breaks through the crust while taxiing.

68. CABLE AND SHOCK CORD ATTACHMENT AND ATTACHMENT FITTINGS. Service reports indicate that failure of the ski itself is not a predominant factor in ski failures. Rigging (improper tension and terminal attachments) and cast-type pedestal material failures are predominant. Usually, failures of the safety cable and shock cord attachment fittings occur at the ski end and not at the fuselage end.

Do not attach tension cords and safety cables at the same point on the fuselage fittings. Provide separate means of attaching cables and shock cords at the forward and aft ends of the skis. Usually, approved skis are supplied with cables, shock cord, and fittings; however, the following specifications may be used for their fabrication and installations:

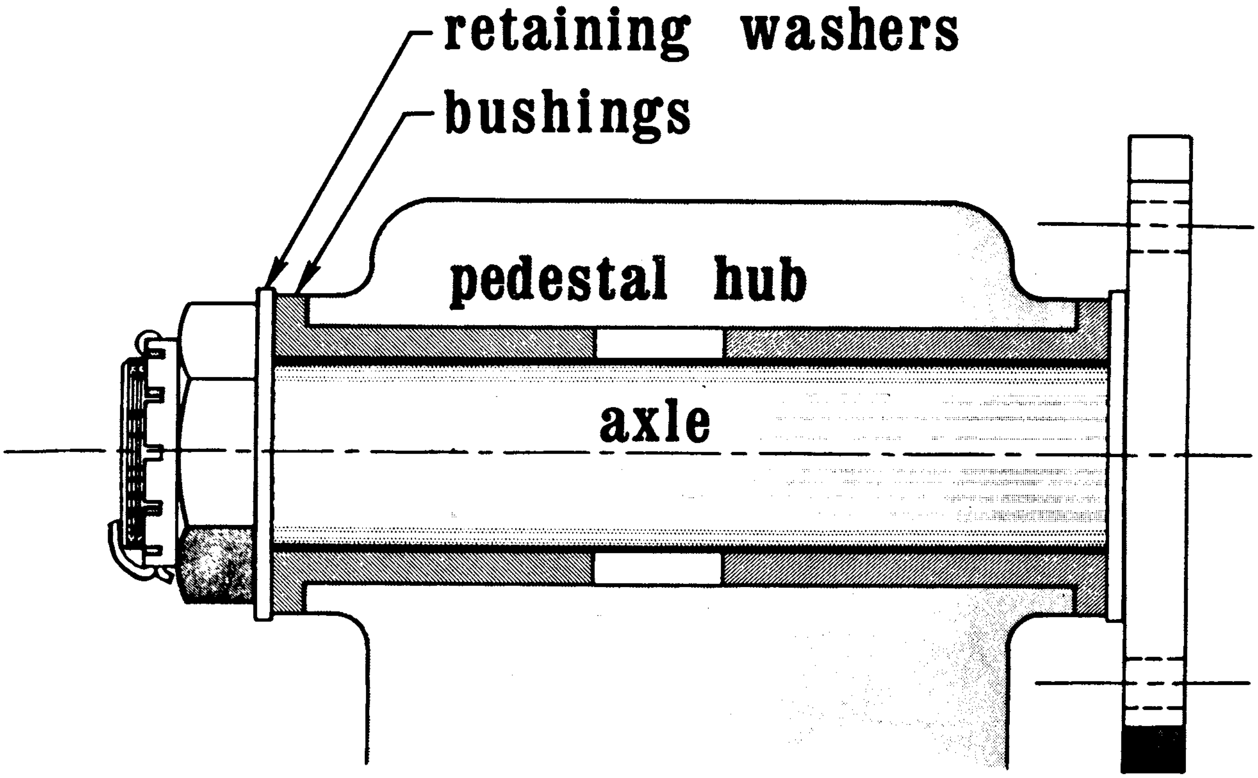


FIGURE 5.2.—Typical hub installation.

Minimum Cable and Shock Cord Sizes

Ski Limit Load Rating	*Single Safety Cable*	*Double Safety Cable*	*Single Crust-Cutting Cable*	*Double Crust-Cutting Cable*	*Single Shock Cord*	*Double Shock Cord*
1500–3000	1/8″	1/8″	1/8″	1/8″	1/2″	1/2″
3000–5000	----	1/8″	----	1/8″	----	1/2″
5000–7000	----	5/32″	5/32″	5/32″	3/4″	3/4″
7000–9000	----	3/16″	----	5/32″	----	3/4″

a. *Cables.* Make the check cable, safety cable, and crust-cutting cable ends by the splice, swage, or nicopress methods; or if adjustable lengths are desired, use cable clamps. Use standard aircraft hardware only. (Hardware used to attach cables must be compatible with cable size.)

b. *Shock cord ends* may be fabricated by any of the following methods:

(1) Make a wrapped splice using a proper size rope thimble and No. 9 cotton cord or .035″ (minimum) safety wire. Attach with clevis or spring steel snap fastener. (*Do not* use cast iron snaps.)

(2) Use approved spring-type shock cord end fasteners.

c. *Fitting Specifications (see figure 5.3) and Installation:*

(1) Fittings fabricated for 1/8-inch cable or 1/2-inch shock cord shall be at least .065″ 1025 steel or its equivalent.

(2) Fittings fabricated for 5/32-inch cable or 3/4-inch shock cord shall be at least .080″ 1025 steel or its equivalent.

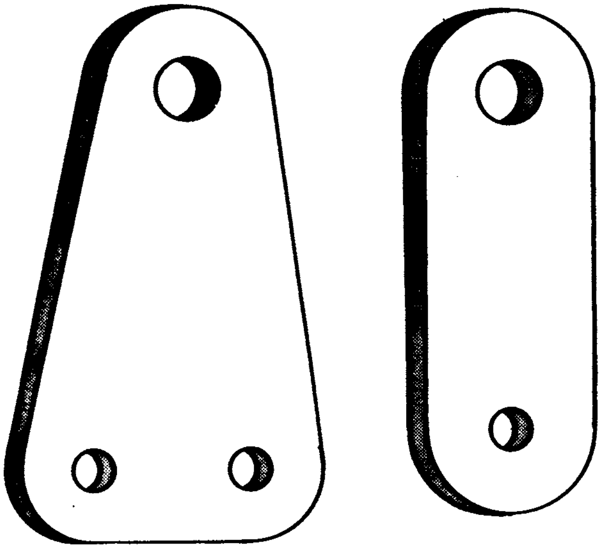


FIGURE 5.3.—Typical fuselage fitting.

(3) An improperly installed fitting may impose excessive eccentric loads on the fitting and attach bolts and result in failure of the fitting or bolts.

69. PROVISIONS FOR INSPECTION. Aircraft using fabric-covered landing gear may have the lower 4 inches of fabric removed to facilitate inspection of the axle attachment area. (See fig. 5.1.)

70. [RESERVED]

Section 3. RIGGING OF SKIS

71. LOCATION OF ATTACH FITTINGS ON FUSELAGE OR LANDING GEAR. Locate fittings so the shock cord and cable angles are not less than 20° when measured in the vertical plane with the shock absorber in the fully extended position (see angle B, figs. 5.4 and 5.5).

NOTE: Do not attach fittings to wing-brace struts, except by special approval (manufacturer or FAA).

72. MAIN SKI INCIDENCE ANGLES. (Aircraft leveled and shock absorbers fully extended.)

a. Adjust length of check cable to provide a zero to 5-degree ski incidence angle (reference figs. 5.4 and 5.6).

b. Adjust length of safety cable to provide −20 to −35-degree ski incidence angle (reference figs. 5.5 and 5.6).

73. TENSION REQUIRED IN MAIN SKI SHOCK CORDS. Apply sufficient shock cord tension to fore end of the skis to prevent flutter at various airspeeds and attitudes. Because of the various angles used in attaching shock cord to the skis, shock cord tension cannot be specified. In most installations the downward force applied at the fore end of the ski, sufficient to cause the check

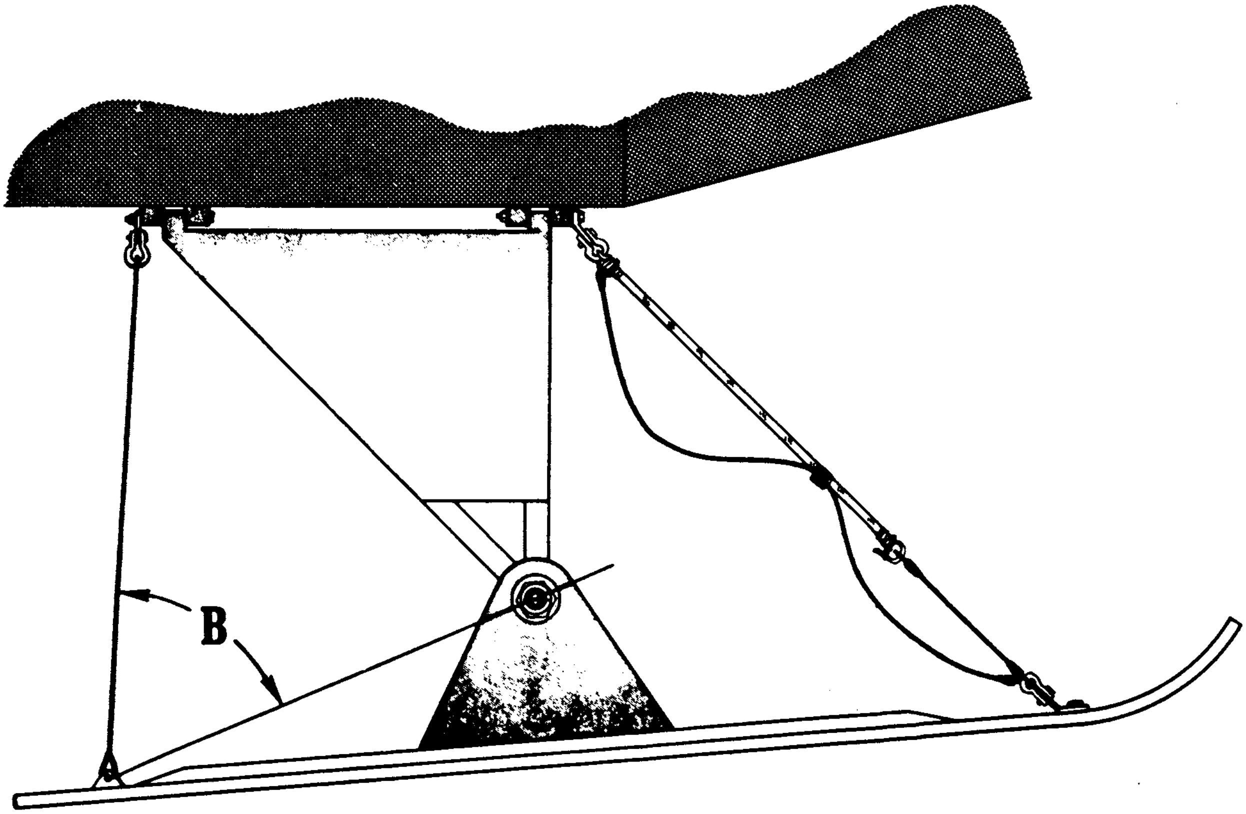


FIGURE 5.4.—Main ski at maximum positive incidence (check cable tight).

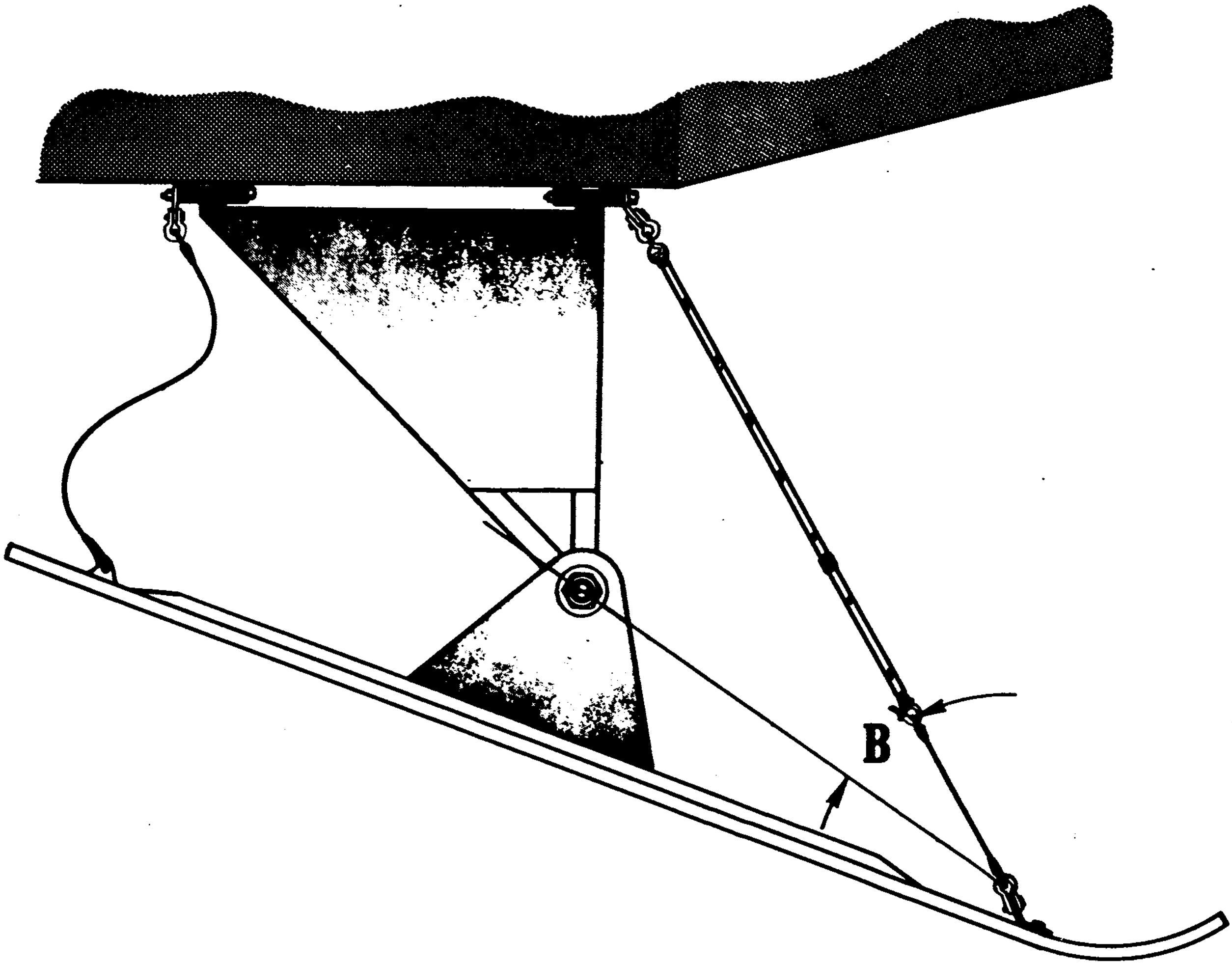


FIGURE 5.5.—Main ski at maximum negative incidence (safety cable tight).

cable to slacken, should be approximately as listed below:

Ski Limit Load Rating	*Downward Force* (pounds)
1500–3000	20–40
3000–5000	40–60
5000–7000	60–120
7000–9000	120–200

74. NOSE SKI INSTALLATION.

The nose ski is installed in the same manner as the main skis (see fig. 5.7) except:

a. Adjust length of safety cable to provide −5- to −15-degree ski incidence.

b. Where it is possible for the nose ski rigging to contact the propeller tips due to vibration, install a ¼-inch shock cord to hold the rigging out of the propeller arc.

75. TAIL SKI INSTALLATION.

a. Use tail skis that have been approved on airplanes of approximately the same weight (within 10 percent) or select as outlined in sec-

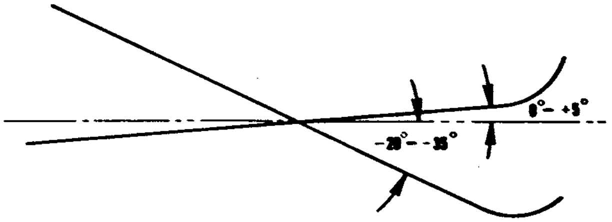


FIGURE 5.6.—Main ski incidence angles.

tion 1. Depending upon the type of ski selected, the tail wheel may or may not have to be removed.

b. Adjust the length of the limiting cable (ref. fig. 5.8) to allow the ski to turn approximately 35 degrees either side of the straightforward position with the weight of the airplane resting on the ski.

c. The shock cord (ref. fig. 5.8) must be of a length that will hold the ski in the straightforward position during flight.

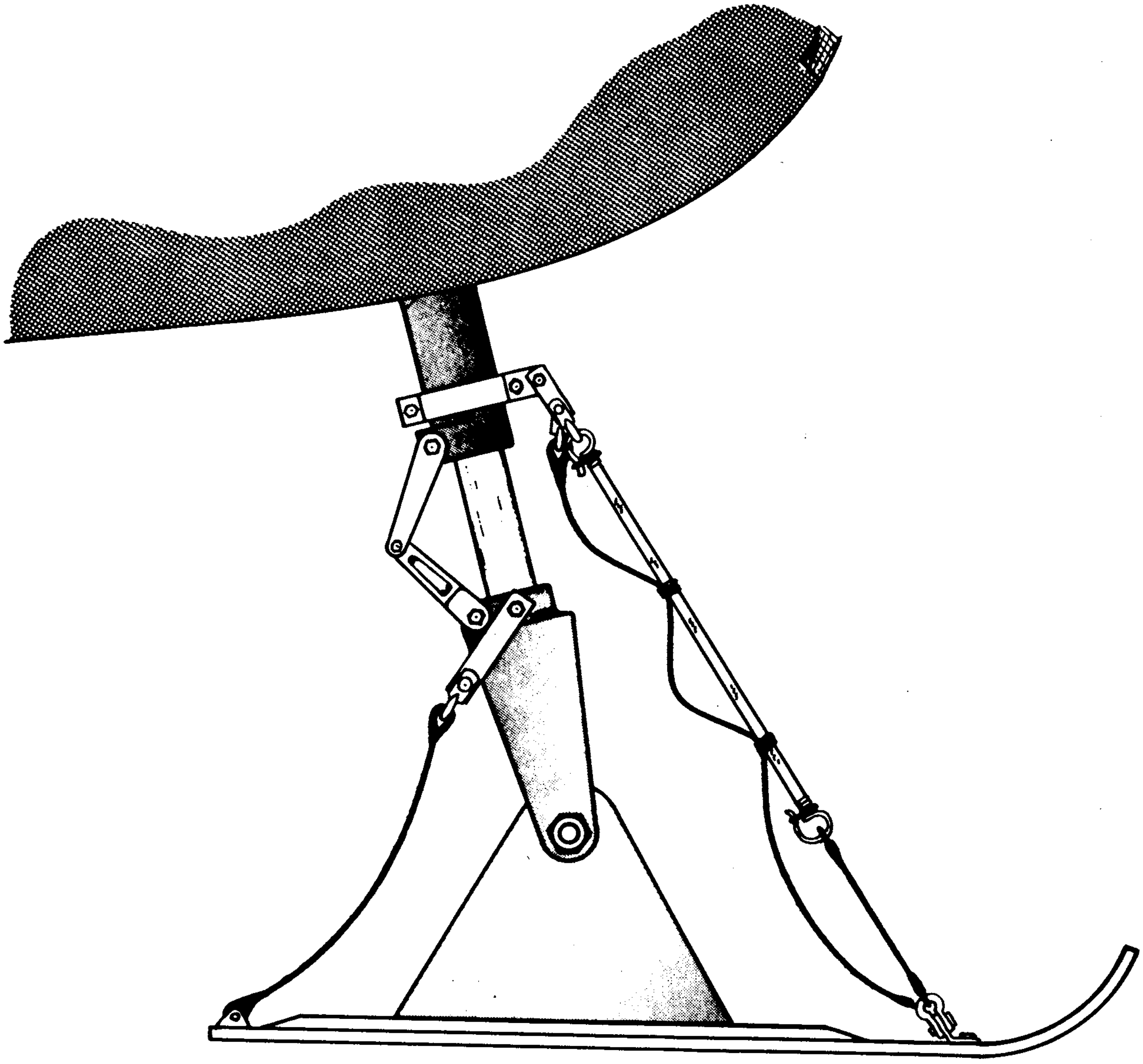


Figure 5.7.—Typical nose ski installation.

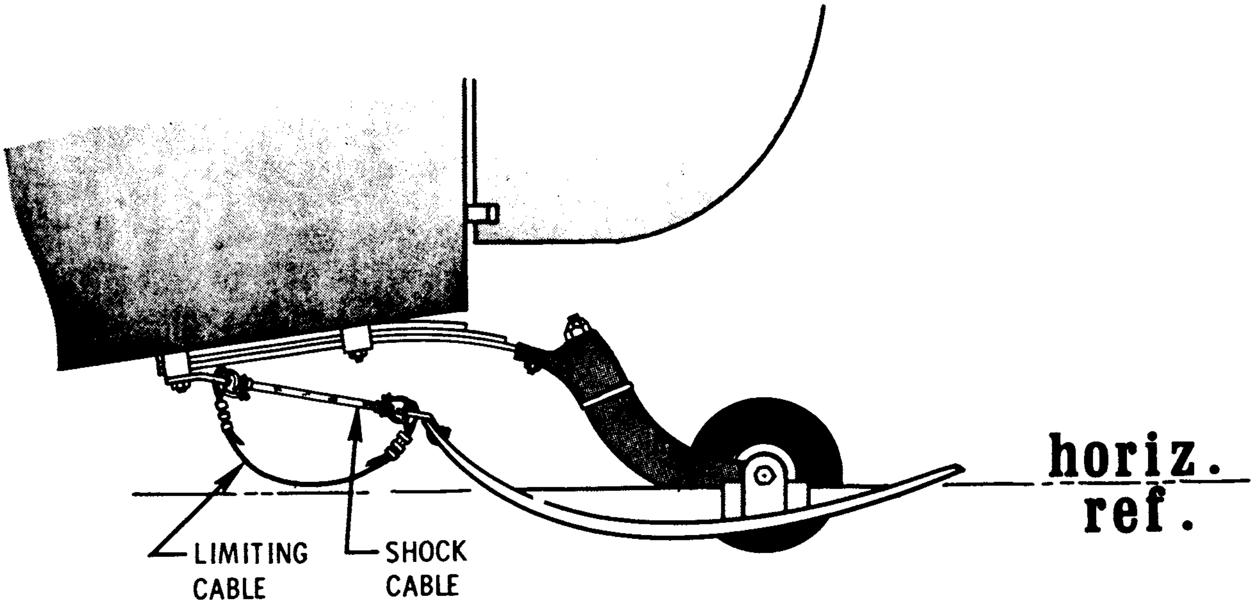


FIGURE 5.8—Typical tail ski installation.

76.–78. [RESERVED]

Section 4. OPERATION

79. PERFORMANCE INFORMATION. The following FAA policies concern performance data and operational check flights for ski installations.

a. For aircraft over 6,000 pounds maximum certificated weight, state the following or similar information in the performance information section of the Airplane Flight Manual and obtain FAA approval.

(1) *Takeoff*. Under the most favorable conditions of smooth packed snow at temperatures approximating 32° F, the skiplane takeoff distance is approximately 10 percent greater than that shown for the landplane.

NOTE: In estimating takeoff distances for other conditions, caution should be exercised as lower temperatures or other snow conditions will usually increase these distances.

(2) *Landing*. Under the most favorable conditions of smooth packed snow at temperatures approximately 32° F, the skiplane landing distance is approximately 20 percent greater than that shown for the landplane.

NOTE: In estimating landing distances for other conditions, caution should be exercised as other temperatures or other snow conditions may either decrease or increase these distances.

(3) *Climb Performance*. In cases where the landing gear is fixed (both landplane and skiplane), where climb requirements are not critical, and the climb reduction is small (30 to 50 feet per minute), the FAA will accept a statement of the approximate reduction in climb performance placed in the performance information section of the Airplane Flight Manual. For larger variations in climb performance, or where the minimum requirements are critical, or where the landing gear of the landplane was retractable, appropriate climb data should be obtained to determine the changes, and new curves, tables, or a note should be incorporated in the Airplane Flight Manual.

b. For aircraft of 6,000 pounds or less maximum certificated weight, make the information in 79a available to the pilot in the form of placards, markings, manuals, or any combination thereof.

80. FLIGHT AND HANDLING OPERATIONAL CHECKS. Accomplish an operational check which includes more than one landing to determine the ground-handling characteristics as well as takeoff and landing characteristics. Take note of ski angles during tail high and tail low landings to avoid having the ski dig in or fail from localized stress. Determine there is sufficient ground control to satisfactorily complete a landing run with a turnoff at slow speed in cases where brakes are not provided. In flight, the ski should ride steady with no unusual drag and produce no unsatisfactory flight characteristics. Enter a notation of these checks in the aircraft records.

81. INTERCHANGING OF SKIS AND WHEELS After the initial installation, removing the skis and reinstalling the wheels or vice versa may be considered a preventive maintenance operation when no weight-and-balance computation is involved.

82.–85. [RESERVED]

Chapter 6. OXYGEN SYSTEM INSTALLATIONS IN NONPRESSURIZED AIRCRAFT

86. SYSTEM REQUIREMENTS. Install oxygen cylinders conforming to Interstate Commerce Commission requirements for gas cylinders which carry the ICC 3A, 3AA, or 3HT designation followed by the service pressure metal-stamped on the cylinder. The 3HT designated cylinders must not be used for portable oxygen equipment.

a. *Tubing.*

(1) In systems having low pressure (400 p.s.i.), use seamless aluminum alloy or equivalent having an outside diameter of 5/16 inch and a wall thickness of .035″. Double flare the ends to attach to fittings.

(2) In high-pressure systems (1800 p.s.i.), use 3/16 inch O.D., .035″ wall thickness, seamless copper alloy tubing meeting Specification WW–T–779a type N, or stainless steel between the filler valve and the pressure-reducing valve. Silver-solder cone nipples to the ends of the tubing to attach the fittings in accordance with Specification MIL–B–7883.

(3) Use 5/16-inch O.D. aluminum alloy tubing after the pressure-reducer (low-pressure side).

(4) Use flexible connections specifically designed for oxygen between all points having relative or differential motion.

b. *Valves.* A slow opening valve is used as a cylinder shutoff valve, or system shutoff valve. Rapid opening and the subsequent sudden and fast discharge of oxygen into the system can cause dangerous heating which could result in fire or explosion of combustibles within the system.

c. *Regulators.* The cylinder or system pressure is reduced to the individual cabin outlets by means of a pressure-reducing regulator which can be manually or automatically controlled.

d. *Types of Regulators.* The four basic types of oxygen systems, classified according to the type of regulator employed, are:

(1) Demand type.
(2) Diluter-demand type.
(3) Pressure-demand type.
(4) Continuous-flow type.

e. *Flow Indicators.*

(1) A pith-ball flow indicator, vane, wheel anemometer, or lateral pressure indicator which fluctuates with changes in flow or any other satisfactory flow indicator may be used in a continuous flow-type system.

(2) An Air Force-Navy flow indicator or equivalent may be used in a diluter-demand type system. Each flow indicator should give positive indication when oxygen flow is occurring.

f. *Relief Valve.*

(1) A relief valve is installed in low-pressure oxygen systems to safely relieve excessive pressure, such as caused by overcharging.

(2) A relief valve is installed in high-pressure oxygen systems to safely relieve excessive pressure, such as caused by heating.

g. *Gauge.* Provide a pressure gauge to show the amount of oxygen in the cylinder.

h. *Masks.* Only masks designed for the particular system should be used.

87. INSTALLATION.

Oxygen systems present a hazard. Therefore, follow the precautions and practices listed below:

a. Remove oil, grease (including lip salves, hair oil, etc.), and dirt from hands, clothing, and tools before working with oxygen equipment.

b. Prior to cutting the upholstery, check the intended route of the system.

Make sure that all system components are kept completely free of oil or grease during installation and locate components so they will not contact or become contaminated by oil or hydraulic lines.

c. Keep open ends of cleaned and dried tubing capped or plugged at all times, except during attachment or detachment of parts. Do *not* use tape, rags, or paper.

d. Clean all lines and fittings which have not been cleaned and sealed by one of the following methods:

(1) A vapor-degreasing method with stabilized trichlorethylene conforming to Specification MIL–T–7003 or carbon tetrachloride. Blow tubing clean and dry with a stream of clean, dried, water-pumped air, or dry nitrogen (water-vapor content of less than 0.005 milligrams per liter of gas at 70° F and 760 millimeters of mercury pressure).

(2) Flush with naptha conforming to Specification TT–N–95; blow clean and dry of all solvent with water-pumped air; flush with anti-icing fluid conforming to Specification MIL–F5566 or anhydrous ethyl alcohol; rinse thoroughly with fresh water; and dry thoroughly with a stream of clean, dried, water-pumped air, or by heating at a temperature of 250° to 300° F for one-half hour.

(3) Flush with hot inhibited alkaline cleaner until free from oil and grease; rinse thoroughly with fresh water; and dry thoroughly with a stream of clean, dried, water-pumped air, or by heating at a temperature of 250° to 300° F for one-half hour.

e. Install lines, fittings, and equipment above and at least 6 inches away from fuel, oil, and hydraulic systems. Use deflector plates where necessary to keep hydraulic fluids away from the lines, fittings, and equipment.

f. Allow at least a 2-inch clearance between the plumbing and any flexible control cable or other flexible moving parts of the aircraft. Provide at least ½-inch clearance between the plumbing and any rigid control tubes or other rigid moving parts of the aircraft.

g. Allow a 6-inch separation between the plumbing and the flight and engine control cables, and electrical lines. When electrical conduit is used, this separation between the plumbing and conduit may be reduced to 2 inches.

h. Route the oxygen system tubing, fittings, and equipment away from hot ducts and equipment. Insulate or provide space between these items to prevent heating the oxygen system.

i. Mount all plumbing in a manner which prevents vibration and chafing. Support 3/16-inch O.D. copper line each 24 inches and 3/16-inch O.D. aluminum each 36 inches with cushioned loop-type line support clamps (AN–742) or equivalent.

j. Locate the oxygen supply valve (control valve) so as to allow its operation by the pilot during flight. The cylinder shutoff valve may be used as the supply control valve, if it is operable from the pilot's seat. Manifold plug-in type outlets, which are incorporated in automatic systems, may be considered as oxygen supply valves since the pilot can control the flow of oxygen by engaging and disengaging the plug-in type oxygen mask.

NOTE: Locate the oxygen shutoff valve on or as close as practicable to the cylinder to prevent loss of oxygen due to leakage in the system.

88. LOCATION AND MOUNTING. Determine the weight factor and c.g. limits for the installation prior to commencing the installation.

a. Mount the cylinder in the baggage compartment or other suitable location in such a position that the shutoff valve is readily accessible. If possible, provide access to this valve from inside the cabin so that it may be turned on in flight in the event that it was not opened prior to takeoff.

b. Fasten the cylinder brackets securely to the aircraft, preferably to a frame member or floorboard using AN bolts with fiber or similar locking nuts. Add sufficient plates, gussets, stringers, cross-bracing, or other reinforcements, where necessary, to provide a mounting that will withstand the inertia forces stipulated in chapter 1 of this handbook.

c. When cylinders are located where they may be damaged by baggage or stored materials, protect them by a suitable guard or covering.

d. Provide at least ½ inch of clear airspace between any cylinder and a firewall or shroud isolating a designated fire zone.

e. Mount the regulator close to the cylinder to avoid long high-pressure lines.

f. Store the masks in such a way that there will be a minimum delay in removing and putting them into use.

89. THREAD COMPOUND. Use antiseize or thread-sealing compound conforming to Specification MIL–T–5542–B, or equivalent.

a. Do not use compound on aluminum alloy flared tube fittings having straight threads. Proper flaring and tightening should be sufficient to make a flared tube connection leakproof.

b. Treat all male-tapered pipe threads with antiseize and sealing compound (MIL–T–5542–B, or tetrafluroethylene tape MIL–T–27730), or equivalent.

c. Apply the compound in accordance with the manufacturer's recommendation. Make sure that the compounds are carefully and sparingly applied only to male threads, coating the first three threads from the end of the fitting. Do not use compound on the coupling sleeves or on the outside of the tube flares.

90. FUNCTIONAL TEST.

Before inspection plates, cover plates, or upholstering are replaced, make a system check including at least the following:

a. Open cylinder valve slowly and observe the pressure gauge.

b. Open supply valve and remove one of the mask tubes and bayonet fittings from one of the masks in the kit. Plug the bayonet into each of the oxygen outlets. A small flow should be noted from each of the outlets. This can be detected by holding the tube to the lips while the bayonet is plugged into an outlet.

c. Check the complete system for leaks. This can be done with a soap solution made only from a mild (castile) soap or by leak-detector solution supplied by the oxygen equipment manufacturer.

d. If leaks are found, close the cylinder shutoff valve and reduce the pressure in the system by plugging a mask tube into one of the outlets or by carefully loosening one of the connections in the system. When the pressure has been reduced to zero, make the necessary repairs. Repeat the procedure in 90c until no leaks are found in the system.

Caution: Never tighten oxygen system fittings with oxygen pressure applied.

e. Test each outlet for leaks at the point where the mask tube plugs in. This can be done by drawing a soap bubble over each of the outlets. Use the solution sparingly to prevent clogging the outlet by soap. Remove all residue to prevent accumulation of dirt.

f. Examine the system to determine that the flow of oxygen through each outlet is at least equal to the minimum required by the pertinent requirements at all altitudes at which the aircraft is to be operated. This can be accomplished by one of the following methods:

(1) In a continuous flow system when the calibration (inlet pressure vs. flow) of the orifices used at the plug-in outlets is known, the pressure in the low-pressure distribution line can be measured at the point which is subject to the greatest pressure drop. Do this with oxygen flowing from all outlets. The pressure thus measured should indicate a flow equal to or greater than the minimum flow required.

(2) In lieu of the above procedure, the flow of oxygen, through the outlet which is subject to the greatest pressure drop, may be measured with all other outlets open. Gas meters, rotometers, or other suitable means may be used to measure flows.

(3) The measurement of oxygen flow in a continuous flow system which uses a manually adjusted regulator can be accomplished at sea level. However, in a continuous flow system which uses an automatic-type regulator, it may be necessary to check the flow at maximum altitude which will be encountered during the normal operation of the aircraft. The manufacturer of the particular continuous-flow regulator used should be able to furnish data on the operating characteristics of the regulator from which it can be determined whether a flight check is necessary.

(4) The checking of the amount of flow through the various outlets in a diluter-demand or straight-demand system is not necessary since the flow characteristics of the particular regulator being used may be obtained from the manufacturer of the regulator. However, in such systems the availability of oxygen to each regulator should be checked by turning the lever of the diluter-demand regulator to the "100 percent oxygen" position and inhaling through the tube via the mask to determine whether the regulator valve and the flow indicator are operating.

g. Provide one of the following acceptable means or equivalent to indicate oxygen flow to each user by:

(1) Listening for audible indication of oxygen flow.

(2) Watching for inflation of the rebreather or reservoir bag.

(3) Installation of a flow indicator.

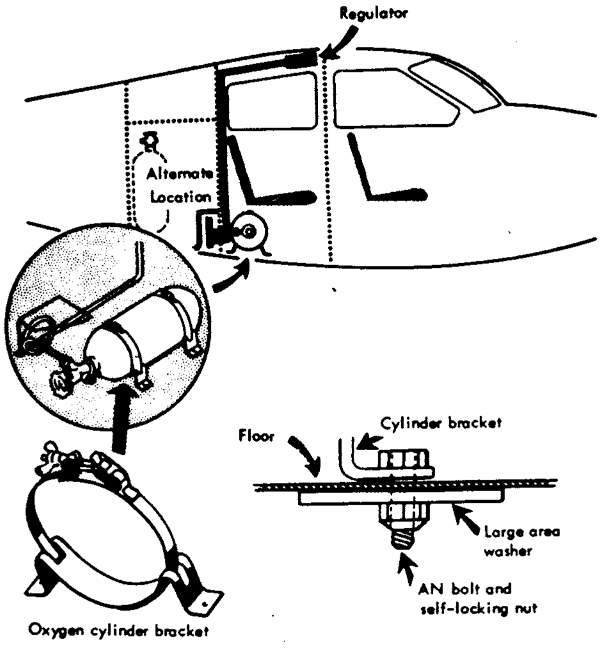
91. OPERATING INSTRUCTIONS. Provide instructions appropriate to the type of system and masks installed for the pilot on placards. Include in these instructions a graph or a table which will show the duration of the oxygen supply for the various cylinder pressures and pressure altitudes.

ACTUAL DURATION IN HOURS AT VARIOUS ALTITUDES

Number of Persons	*8000 Ft.*	*10,000 Ft.*	*12,000 Ft.*	*15,000 Ft.*	*20,000 Ft.*
Pilot only	7.6 hr.	7.1 hr.	6.7 hr.	6.35 hr.	5.83 hr.
Pilot and 1 Passenger	5.07 hr.	4.74 hr.	4.47 hr.	4.24 hr.	3.88 hr.
Pilot and 2 Passengers	3.8 hr.	3.55 hr.	3.36 hr.	3.18 hr.	2.92 hr.
Pilot and 3 Passengers	3.04 hr.	2.84 hr.	2.68 hr.	2.54 hr.	2.34 hr.
Pilot and 4 Passengers	2.53 hr.	2.37 hr.	2.24 hr.	2.12 hr.	1.94 hr.

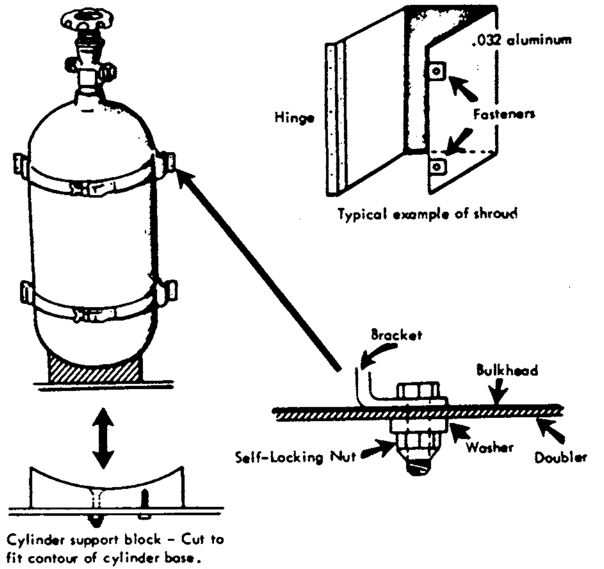
NOTE: The above duration time is based on a fully charged 48 cubic-foot cylinder. For duration using 63 cubic-foot cylinder, multiply any duration by 1.3.

FIGURE 6.1—Typical oxygen duration table.



Reinforce floor, if necessary, to withstand the added load. Use aluminum or plywood of suficient thickness.

FIGURE 6.2.—Typical floor mounting.



Cylinder support block - Cut to fit contour of cylinder base. Secure with countersunk machine screw or wood screw.

NOTE: Enclose cylinder and valve with shroud to prevent damage from baggage.

FIGURE 6.3.—Typical baggage compartment mounting.

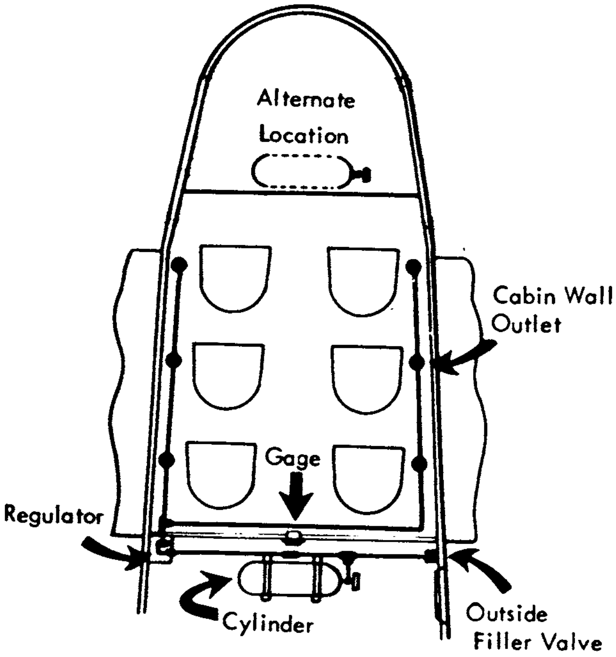


FIGURE 6.4.—Typical oxygen installation in light twin aircraft.

92.–95. [RESERVED]

Chapter 7. ROTORCRAFT EXTERNAL-LOAD DEVICE INSTALLATIONS

Section 1. CARGO SLINGS

96. GENERAL. This section contains structural and design information for the fabrication and installation of a cargo sling used as an external-load attaching means for a Class B rotorcraft-load combination operation under FAR Part 133. As an external-load attaching means, a "cargo sling" includes a quick-release device and the associated cables, fittings, etc., used for the attachment of the cargo sling to the rotorcraft.

97. QUICK-RELEASE DEVICE. Section 133.43(d) of the FARs specifies the requirements for the quick-release device. In addition to commercially manufactured helicopter cargo hooks, some surplus military bomb releases meet the requirements of that section.

98. LOCATION OF CARGO RELEASE IN RELATION TO THE ROTORCRAFT'S C.G. LIMITS.

a. ***An ideal location of the cargo release*** would be one that allows the line of action to pass through the rotorcraft's center of gravity at all times. (See fig. 7.1, illus. A.) However, with

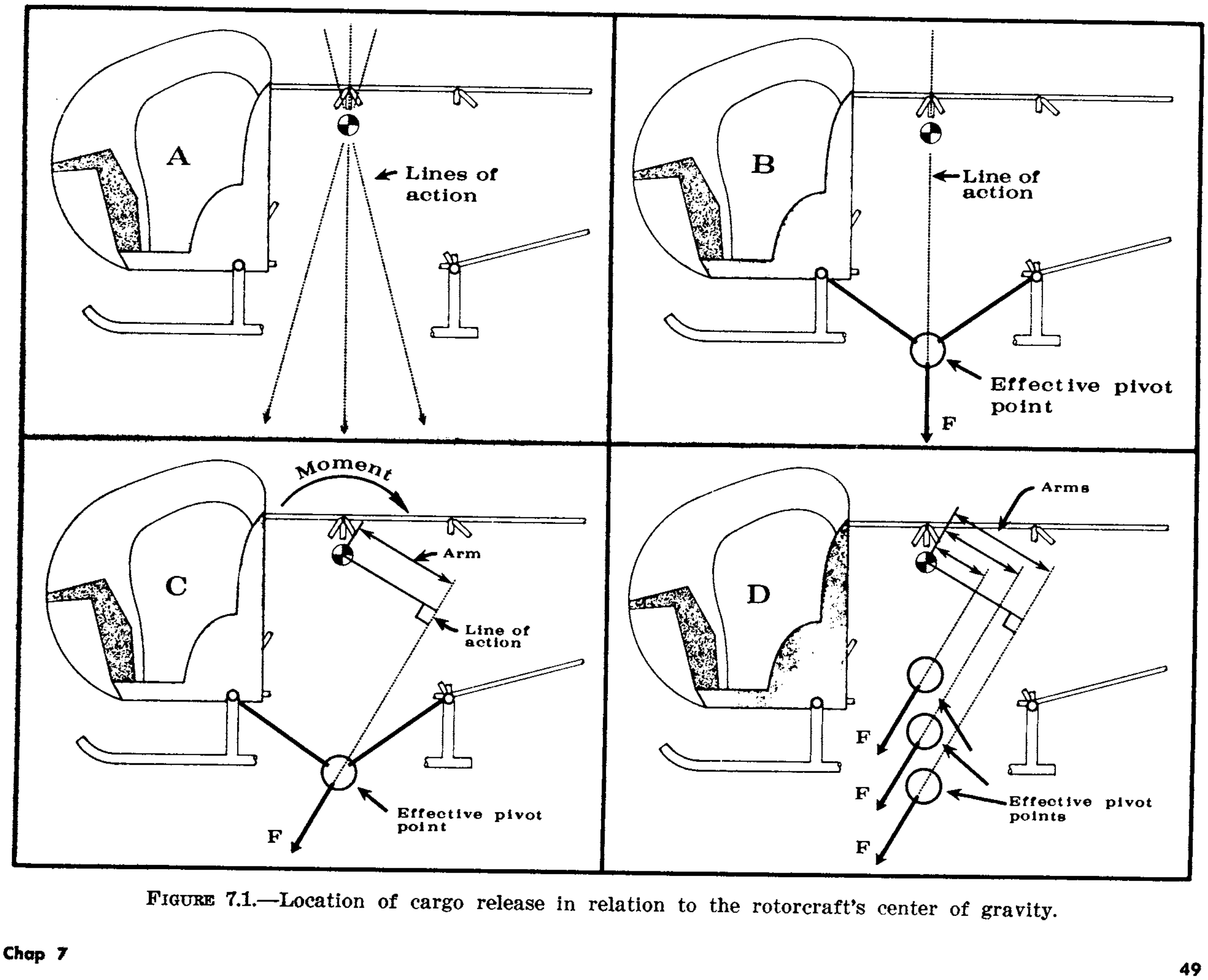


FIGURE 7.1.—Location of cargo release in relation to the rotorcraft's center of gravity.

most cargo sling installations, this ideal situation is realized only when the line of action is vertical or near vertical and through the rotorcraft's c.g. (See fig. 7.1, illus. B.)

b. *Whenever the line of action* does not pass through the rotorcraft's c.g. due to the attachment method used, acceleration forces, or aerodynamic forces, the rotorcraft-load combined center of gravity will shift from the rotorcraft's c.g. position. Depending upon the factors involved, the shift may occur along either or both the longitudinal or lateral axes. The amount of shift is dependent upon the force applied (F) and the length of the arm of the line of action. Their product (F x Arm) yields a moment which can be used to determine the rotorcraft-load combined center of gravity. (See fig. 7. 1, illus. C.) If the rotorcraft-load center of gravity is allowed to shift beyond the rotorcraft's approved center of gravity limits, the rotorcraft may become violently uncontrollable.

c. *Thus, any attachment method or location* which will decrease the length of the arm will reduce the distance that the combined center of gravity will shift for a given load (F) and line of action angle. (See fig. 7.1, illus. D.)

99. MAXIMUM EXTERNAL LOAD. The maximum external load (including the weight of the cargo sling) for which authorization is requested may not exceed the rated capacity of the quick-release device.

100. STATIC TEST. The cargo sling installation must be able to withstand the static load required by FAR 133.43(a). Conduct the test as outlined in Chapter 1 of this advisory circular. If required during the test, supports may be placed at the landing gear to airframe attach fittings to prevent detrimental deformation of the landing gear due to the weight of the aircraft.

101. SLING-LEG ANGLES OF CABLE-SUPPORTED SLINGS. The optimum sling-leg angle (measured from the horizontal) is 45 to 60 degrees. Minimum tension in a sling leg occurs with a sling-leg angle of 90 degrees, and the tension approaches infinity as the angle approaches zero. Thus, larger sling-leg angles are desirable from a standpoint of cable strength requirements. Slings should not be attached in such a manner as to provide sling-leg angles of less than 30 degrees.

102. MINIMUM SLING-LEG CABLE STRENGHT. An analysis which considered the effects of 30-degree sling angles showed that the minimum cable strength design factor required would be 2.5 times the maximum external load for each leg regardless of the number of legs. Although this is the minimum strength required by Part 133, it may be desirable to double this value to allow for deterioration of the sling-leg cables in service. This will result in a cable strength equal to 5 times the maximum external load.

Example: Maximum external load 850 pounds
Minimum required sling-leg cable strength 850 x 2.5 = 2125
Minimum desired sling-leg cable strength 850 x 2.5 x 2 = 4250

A 3/16-inch, nonflexible 19-wire cable (MIL–W–6940) provides a satisfactory cable strength. See figure 4.1, chapter 4, of AC 43.13–1A for a table of breaking strength of steel cable. For convenience, the cable sizes desired for various loads have been calculated and are tabulated in figure 7.2 based on a factor of 5:

Maximum External Load (pounds)	*Aircraft Cable Size For Each Cargo Sling Leg*		
	MIL–C–5693 and MIL–W–6940	*MIL–W–1511*	*MIL–C–5424*
100	1/16	3/32	3/32
200	3/32	1/8	1/8
300	7/64	1/8	1/8
400	1/8	1/8	5/32
500	5/32	5/32	3/16
600	5/32	3/16	3/16
700	3/16	3/16	3/16
800	3/16	3/16	7/32
900	3/16	7/32	7/32
1,000	7/32	7/32	7/32
1,200	7/32	1/4	1/4
1,400	1/4	1/4	9/32
1,600	1/4	9/32	5/16
1,800	5/16	5/16	5/16
2,000	5/16	11/32	3/8

FIGURE 7.2.—Cable Load Table.

103. SLING INSTALLATION. Attach the cargo sling to landing gear members or other structure capable of supporting the loads to be carried. Install the quick-release device in a level attitude with the throat opening facing the direction as indicated on the quick-release device. When cables are used to support the quick-release device, make sure the cables are not twisted or allowed to twist in the direction to unlay the cable.

Some cargo release devices are provided with a fitting to permit installation of a guideline to assist in fully automatic engagement of the load target ring or load bridle. Secure the guideline to the quick-release device with a shear pin of a definite known value which will shear if a load becomes entangled on or over the guideline. Provision should also be made for cable-supported slings to be drawn up against the fuselage into a stowage position to prevent striking or dragging the release on the ground when not in use.

104. INSTALLATION OF RELEASE CONTROLS. See figure 7.3 for typical wiring diagram of the electrical controls.

a. ***Install a cargo release master switch,*** readily accessible to the pilot, to provide a means of deactivating the release circuit. The power for the electrical release circuit should originate at the primary bus. The "auto" position of the release master switch on some cargo release units provides for automatic release when the load contacts the ground and the load on the release is reduced to a preset value.

b. ***Install the cargo release switch*** on one of the pilot's primary controls. It is usually installed on the cyclic stick to allow the pilot to release the load with minimum distraction after maneuvering the load into the release position.

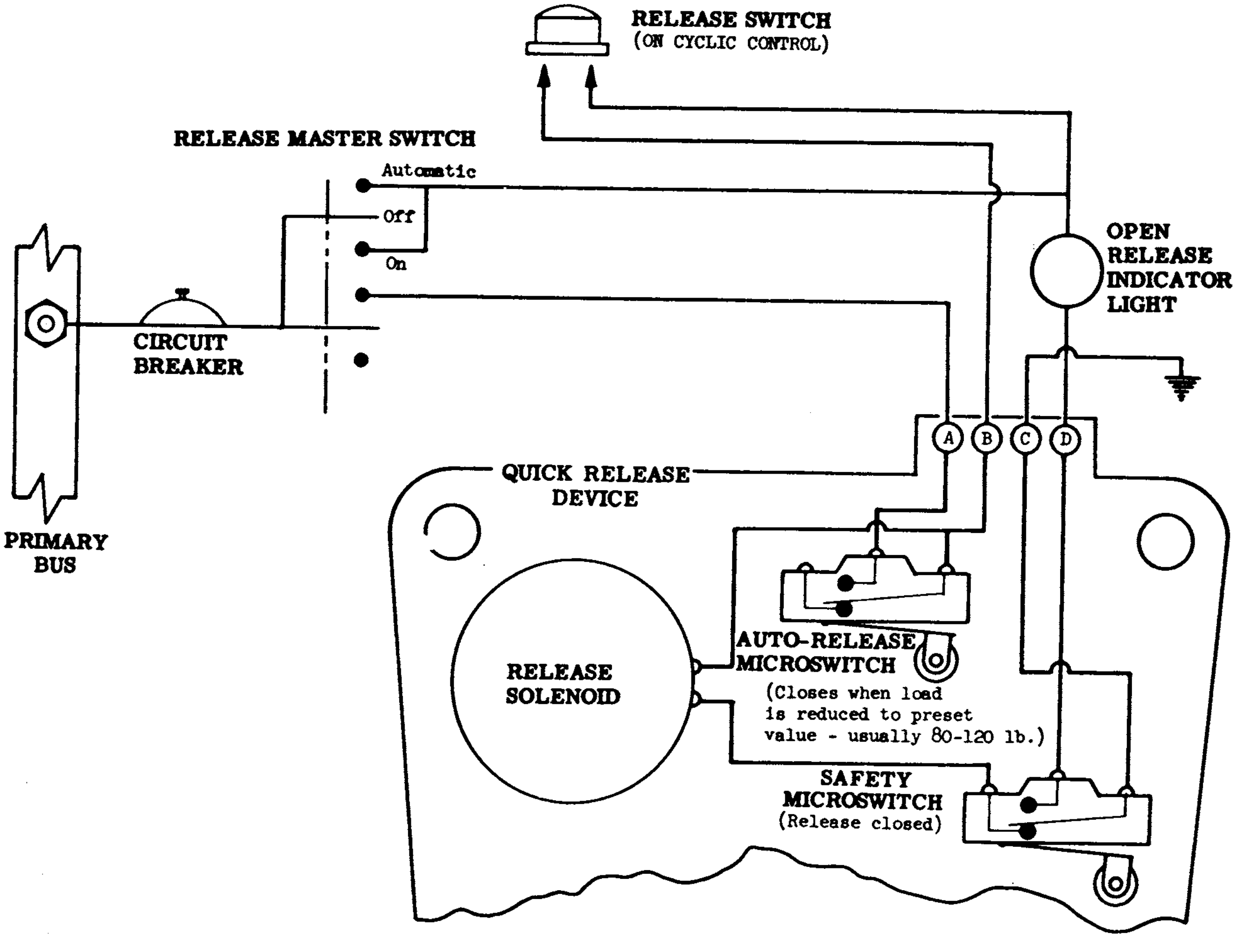


FIGURE 7.3.—Typical cargo sling wiring diagram.

c. *Install the emergency manual release control* in a suitable position that is readily accessible to the pilot or other crewmember. Allow sufficient slack in the control cable to permit complete cargo movement without tripping the cargo release.

d. *The manual ground release handle,* a feature of some cargo release units, permits opening of the cargo release by ground personnel.

e. *Label or placard* all release controls as to function and operation.

105. FUNCTIONAL TEST. Test the release action of each release control of the quick-release device with various loads up to and including the maximum external load. This may be done in a test fixture or while installed on the rotorcraft, if the necessary load can be applied.

If the quick-release device incorporates an automatic release, the unit should not release the load when the master switch is placed in the "automatic" position until the load on the device is reduced to the preset value, usually 80 to 120 pounds.

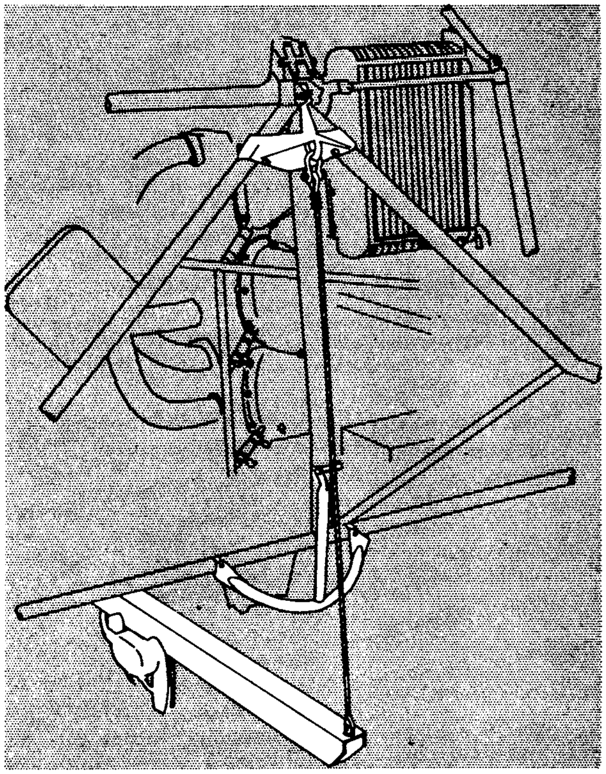


FIGURE 7.4.—Typical cargo sling installation No. 1.

106. SUPPLEMENTAL FLIGHT INFORMATION. The aircraft may not be used in Part 133 external-load operations until a Rotorcraft-Load Combination Flight Manual is prepared in accordance with section 133.47 of that Part.

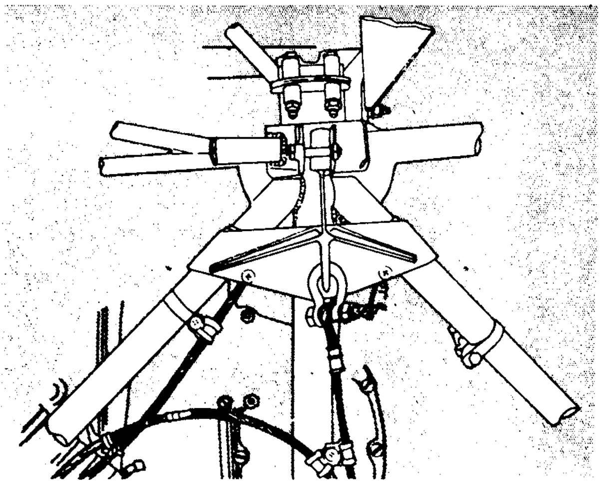


FIGURE 7.5.—Typical cargo sling installation No. 1 (showing fuselage attachment fitting).

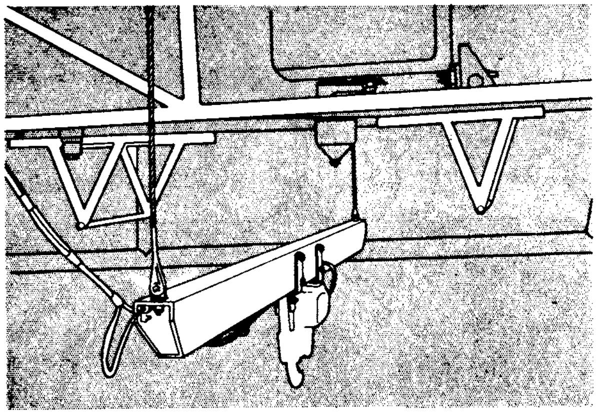


FIGURE 7.6—Typical cargo sling installation No. 1 (showing fore and aft limiting stops).

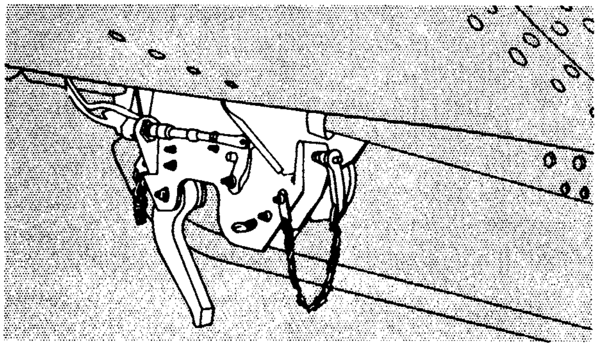


FIGURE 7.7.—Typical cargo sling installation No. 2 (cargo hook attached directly to underside of fuselage).

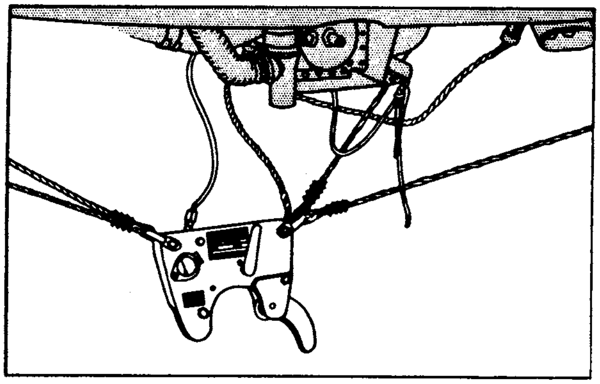


FIGURE 7.8.—Typical cargo sling installation No. 3 (4-leg, cable suspended).

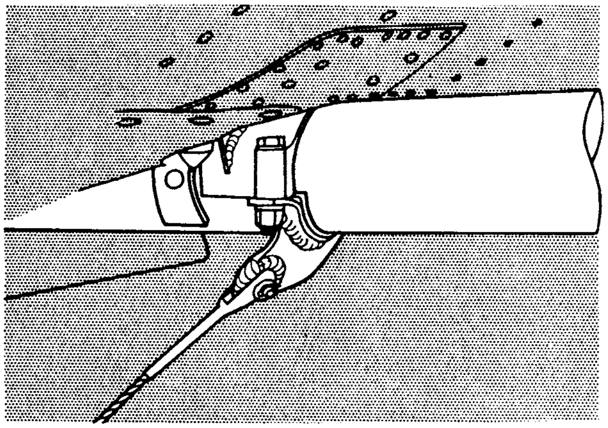


FIGURE 7.9.—Typical cargo sling installation No. 3 (showing cable sling leg attachment to landing gear cross-tube fitting).

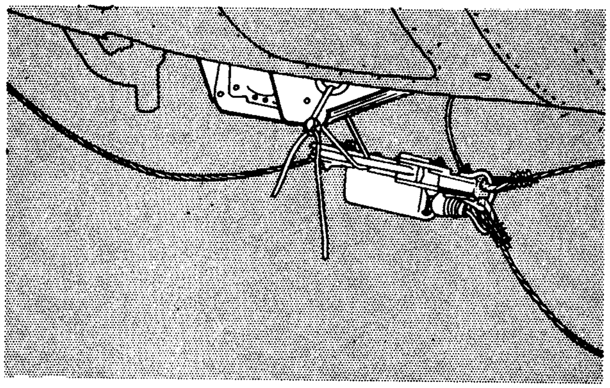


FIGURE 7.10.—Typical cargo sling installation No. 3 (showing cargo sling in stowed position).

107.–110. [RESERVED]

Section 2. CARGO RACKS

111. GENERAL. This section contains structural and design information for the fabrication and installation of a cargo rack used as an external-load attaching means for a Class A rotorcraft-load combination operation under FAR Part 133.

112. FABRICATION OF CARGO RACKS. The type of construction and method of attachment depend upon the material to be used and the configuration of the rotorcraft involved. Illustrations of typical construction and installation methods are shown in fiigures 7.11–7.15.

113. STATIC TEST. The cargo rack installation must be able to withstand the static test load required by FAR 133.43(a). Conduct the test as outlined in chapter 1 of this handbook.

114. SUPPLEMENTAL FLIGHT INFORMATION. The aircraft may not be used in Part 133 external-load operations until a rotorcraft-load combination flight manual is prepared in accordance with section 133.47 of that Part.

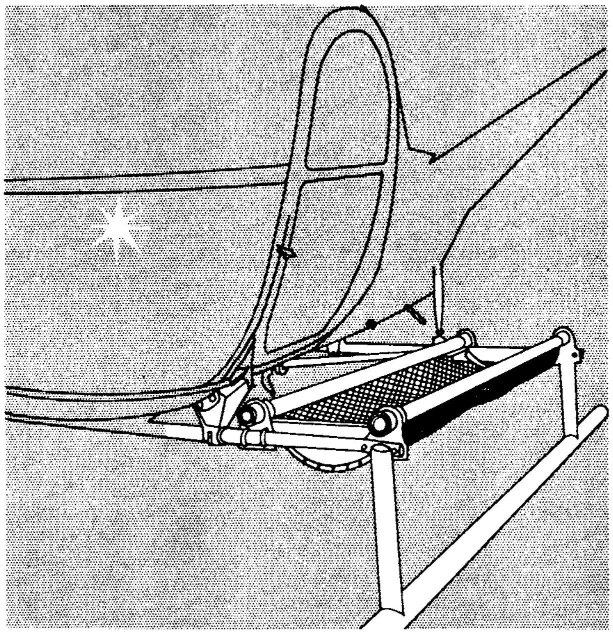


FIGURE 7.11.—Typical cargo rack installation No. 1.

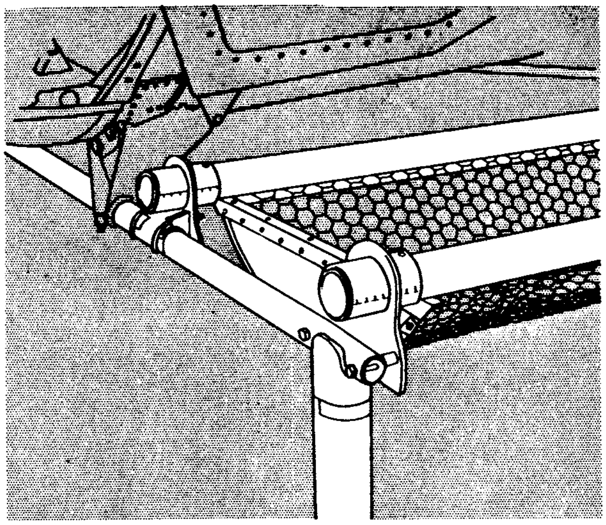


FIGURE 7.12.—Typical cargo rack installation No. 1 (showing attachment detail).

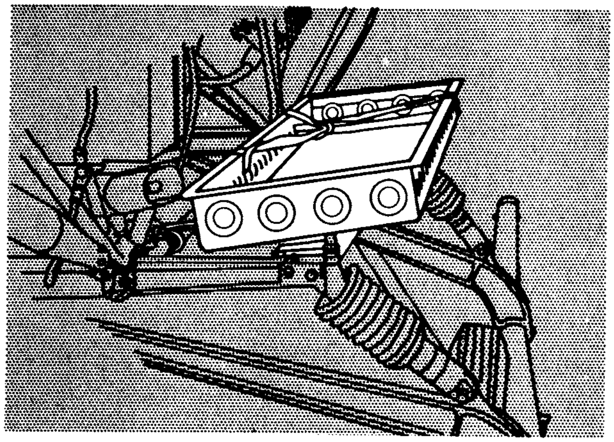


FIGURE 7.13.—Typical cargo rack installation No. 2.

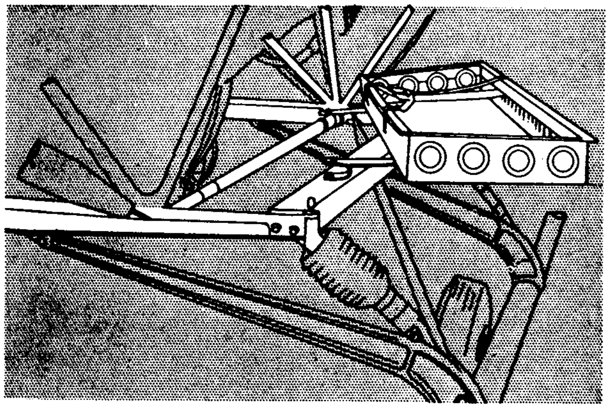


FIGURE 7.14.—Typical cargo rack installation No. 2 (showing rack partially installed).

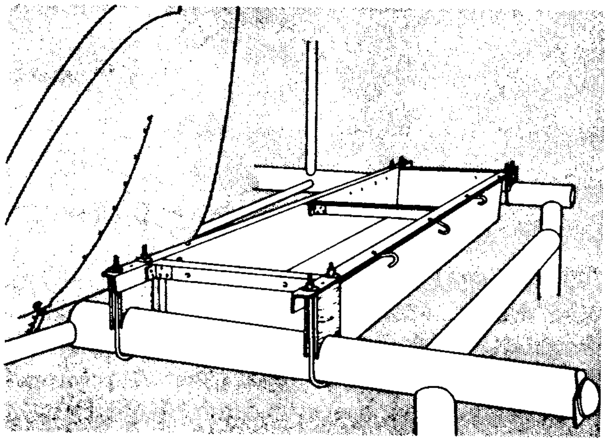


FIGURE 7.15.—Typical cargo rack installation No. 3.

115.–120. [RESERVED]

Chapter 8. GLIDER AND BANNER TOW-HITCH INSTALLATIONS

Section 1. TOWPLANE CONSIDERATIONS

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Section 2. TOW-HITCH INSTALLATIONS

126. STRUCTURAL REQUIREMENTS. The structural integrity of a tow-hitch installation on an aircraft is dependent upon its intended usage. Hitches which meet the glider tow criteria of this chapter are acceptable for banner tow usage. However, because the direction and magnitude of maximum dynamic banner towline loads occur within a more limited rearward cone of displacement than do glider towline loads, hitches which meet the banner tow criteria of this chapter may not be satisfactory for glider towing. Due to the basic aerodynamic difference between the two objects being towed, glider and banner tow-hitch installations are treated separately with regard to loading angles.

* **a.** ***Glider tow hitches.*** Protection for the towplane is provided by requiring use of a towline assembly which will break prior to structural damage occurring to the towplane. The normal tow load of a glider rarely exceeds 80 percent of the weight of the glider. Therefore, the towline assembly design load for a 1,000-pound glider could be estimated at 800 pounds. By multiplying the estimated design load by 1.5 (to provide a safety margin), we arrive at a limit load value of 1,200 pounds. The 1,200-pound limit load value is used in static testing or analysis procedures per paragraph 127 of this handbook to prove the strength of the tow hook installation. When the hook and structure have been proven to withstand *

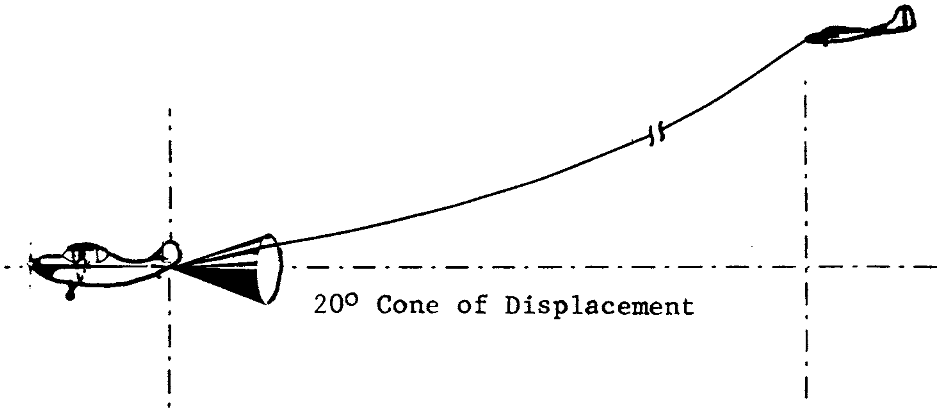
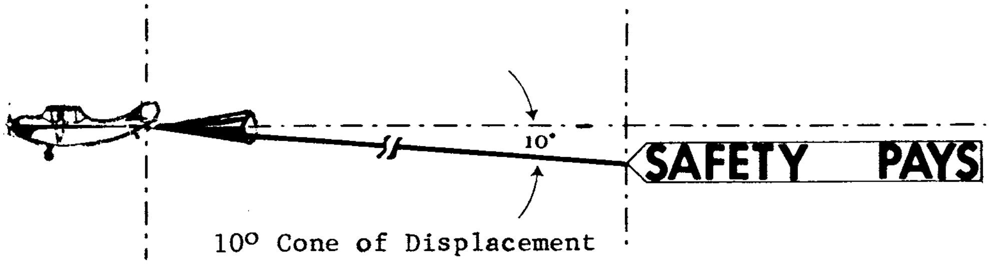


FIGURE 8.1.—Glider tow angle.



*   *

FIGURE 8.2.—Banner tow angle.

*the limit load, then the *maximum* breaking strength of the towline assembly is established at the design load of 800 pounds. Thus, the towline will break well before structural damage will occur to the towplane.

Another approach can be applied if the limit load carrying capabilities of a tow hook and fuselage are known. In this case, the known load value can be divided by 1.5 to arrive at the design load capabilities if the tow hook and fuselage limit loads are known to be 1,800 pounds. By dividing by 1.5 (1800 ÷ 1.5 = 1,200) we arrive at a design load value of 1,200 pounds. Thus, the maximum breaking strength of the towline assembly is established at 1,200 pounds and provides protection for the towplane.

Thus, in considering tow hook installations, one may establish maximum towline breaking strength by:

(1) Dividing the known limit load capabilities of the fuselage and two hook installation by 1.5; or

(2) Knowing the design load needs of the towline assembly and multiplying by 1.5 to arrive at a limit load. Then by analysis or static testing, determine that the hook and fuselage are capable of withstanding that limit load.

b. ***Banner tow hitches.*** Install the hitch to support a limit load equal to at least two times the operating weight of the banner.

127. STRUCTURAL TESTING. Adequacy of the aircraft structure to withstand the required loads can be determined by either static test or structural analysis.

a. ***Static testing.***When using static tests to verify structural strength, subject the tow hitch to the limit load (per paragraph 126 a or b) in a rearward direction within the appropriate cone of displacement per figure 8.2. Testing to be done in accordance with the procedures of Chapter 1, paragraph 3, of this handbook.

b. ***Structural analysis.*** If the local fuselage structure is not substantiated by static test for the proposed tow load, using a method that experience has shown to be reliable, subject the fuselage to engineering analysis to determine that the local structure is adequate. Use a fitting factor of 1.15 or greater in the loads for this analysis.

128. ATTACHMENT POINTS. Tow-hitch mechanisms are characteristically attached to, or at, tiedown points or tailwheel brackets on the airframe where the inherent load-bearing qualities can be adapted to towing loads. Keep the length of the hitch-assembly arm from the airframe attachment point to the tow hook to a minimum as the loads on the attachment bolts are multiplied by increases in the moment arm.

129. ANGLES OF TOW. Tests should be conducted on the system at various tow angles to insure that:

a. There is no interference with the tailwheel or adjacent structure.

b. The towline clears all fixed and movable surfaces at the maximum cone of displacement and full surface travel.

c. The mechanism does not significantly decrease the clearance from the tailwheel to the rudder.

d. The tow hitch does not swivel. Experience has shown swiveling could result in fouling both the release line and towline during operations by the towplane.

e. The opened jaw of the hitch does not strike any portion of the aircraft.

130. PLACARDS. A placard should be installed in a conspicuous place in the cockpit to notify the pilot of the structural design limits of the tow system.

The following are examples of placards to be installed:

a. For glider tow—"Glider towline assembly breaking strength not to exceed ______*______ pounds."

b. For banner tow—"Tow hitch limited to banner maximum weight of ______**______ pounds."

* Value established per paragraph 126 a (1) pr (2).

** Banner hitch limitations are one-half the load applied per paragraph 126 b.

131. WEIGHT AND BALANCE. In most cases, the weight of the tow-hitch assembly will affect the fully loaded aft c.g. location. To assure that the possibility of an adverse effect caused by the installation has not been ignored, enter all pertinent computations in the aircraft weight & balance records. (In accordance with the provisions contained in FAR 43.5(a) (4).)

132. TOW RELEASE MECHANISM.

a. ***Release lever.*** A placard indicating the direction of operation should be installed to allay the possibility of confusion or inadvertant opera-*

* tion, and the design of the release lever should provide the following:

(1) Convenience in operation.

(2) Smooth and positive release operation.

(3) Positioned so as to permit the pilot to exert a straight pull on the release handle.

(4) Sufficient handle travel to allow for normal slack and stretch of the release cable.

(5) A sufficient handle/lever ration to assure adequate release force when the towline is under high loads. (See fig. 8.3)

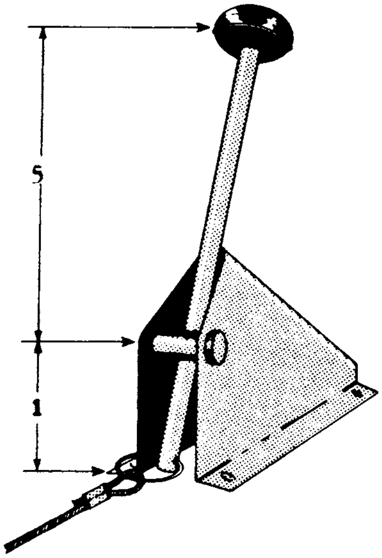


FIGURE 8.3—Typical tow-hitch release handle.

(6) Protection of cables from hazards such as:

(a) Wear and abrasion during normal operation.

(b) Binding where cables pass through fairleads, pulleys, etc.

(c) Accidental release.

(d) Interference by other aircraft components.

(e) Freezing and moisture accumulation when fixed or flexible tubing guides are used.

b. ***Test of the release.*** A test of the release and hook for proper operation through all angles of critical loading should be made using the design load for the glider or banner.

c. ***Release cable.*** Representative size and strength characteristics of steel release cable are as shown in figure 8.4; however, it is recommended that all internally installed release cables be $\frac{1}{16}$-inch or larger.

Diameter inches	*Nonflexible Carbon Steel 1 x 7 and 1 x 19 (MIL-W-6904B)*		*Flexible Carbon Steel 7 x 7 and 7 x 19 (MIL-W-1511A and MIL-C-5424A)*	
	Breaking strength (lbs.)	*Pounds 100 ft.*	*Breaking strength (lbs.)*	*Pounds 100 ft.*
1/32	185	.25	—	—
3/64	375	.55	—	—
1/16	500	.85	480	.75
5/64	800	1.40	—	—
3/32	1,200	2.00	920	1.60

FIGURE 8.4.—Representative steel cable qualities.

133. [Deleted] Change 1.

FIGURE 8.5.— [Deleted] Change 1. *

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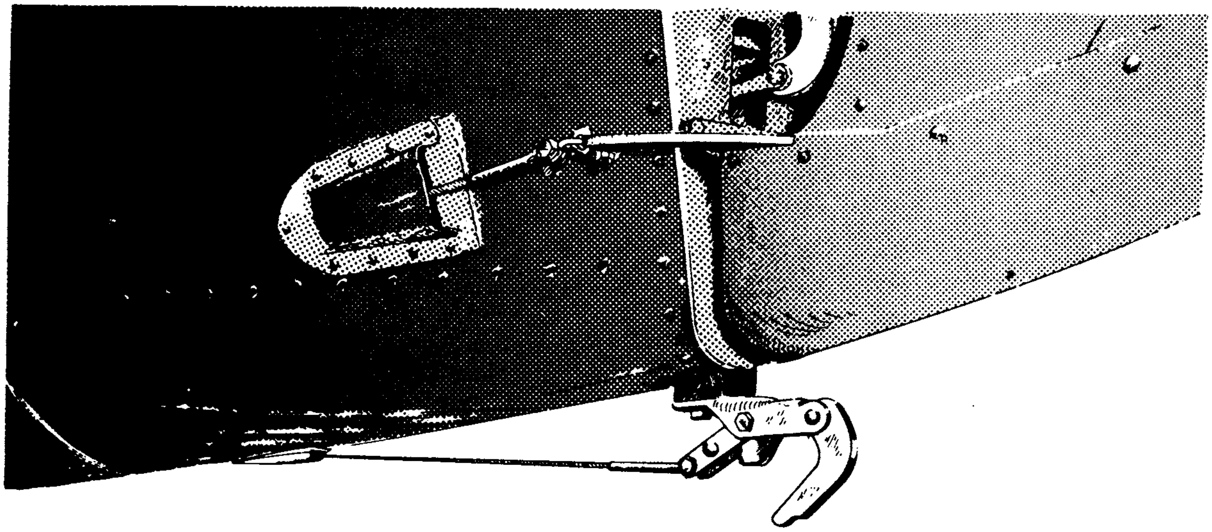


FIGURE 8.6.—Tricycle gear aircraft.

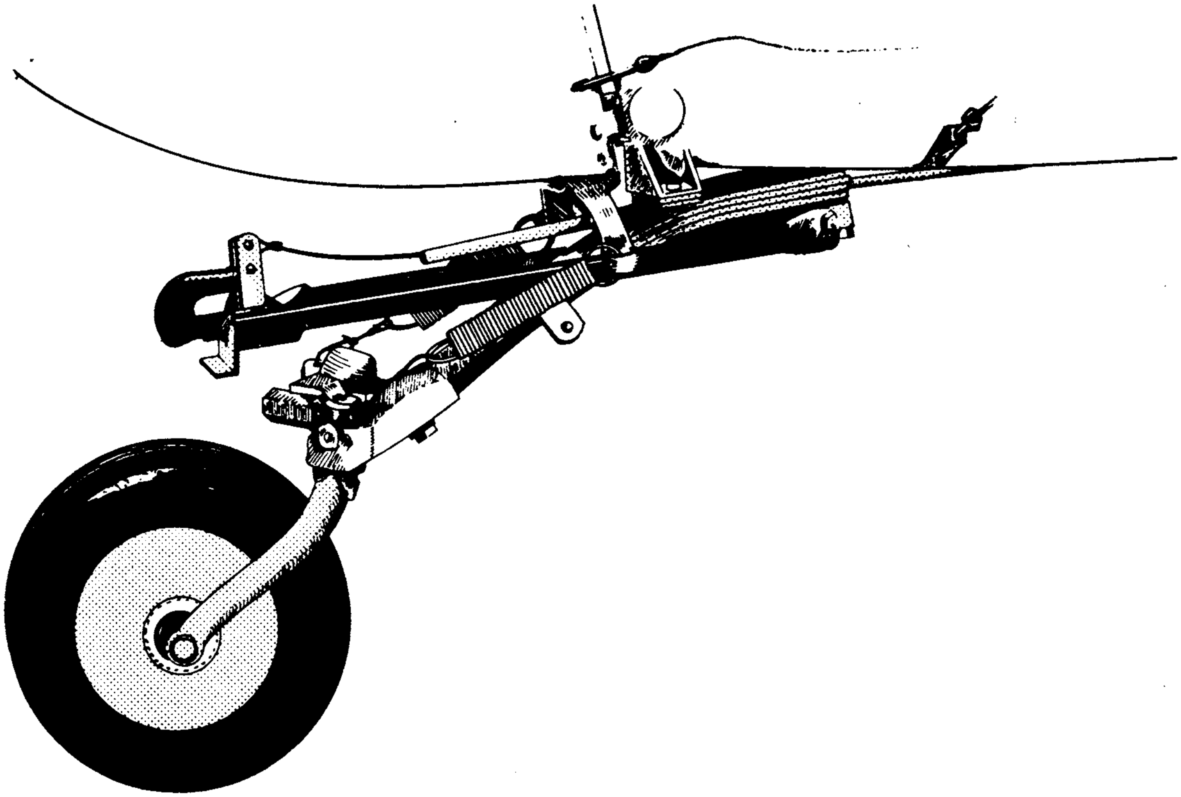


FIGURE 8.7.—Conventional gear aircraft—leaf spring type tailwheel.

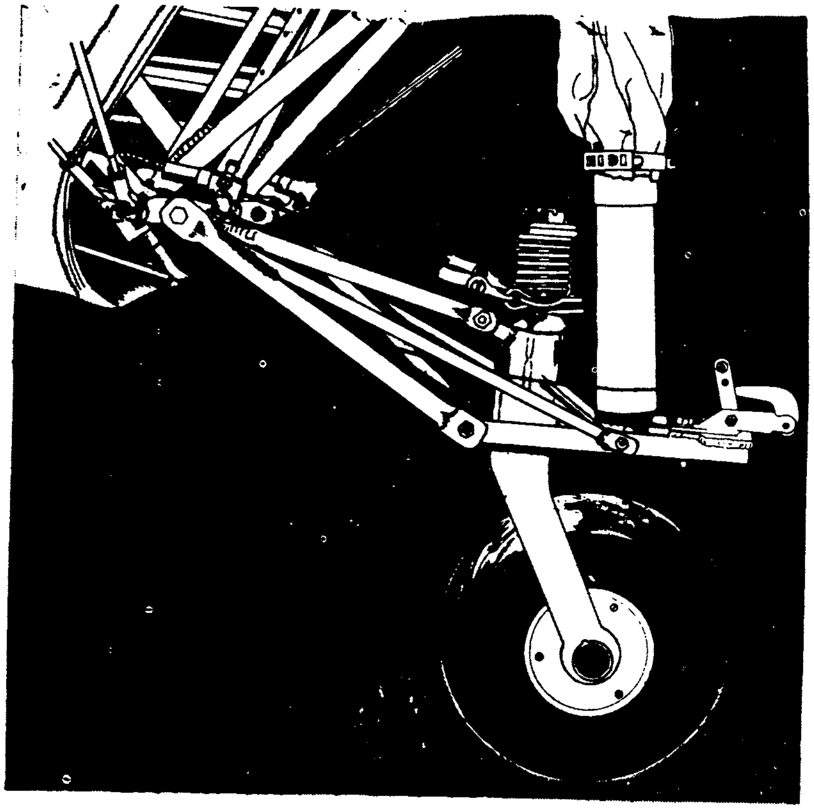


FIGURE 8.8.—Conventional gear aircraft—shock strut type tailwheel.

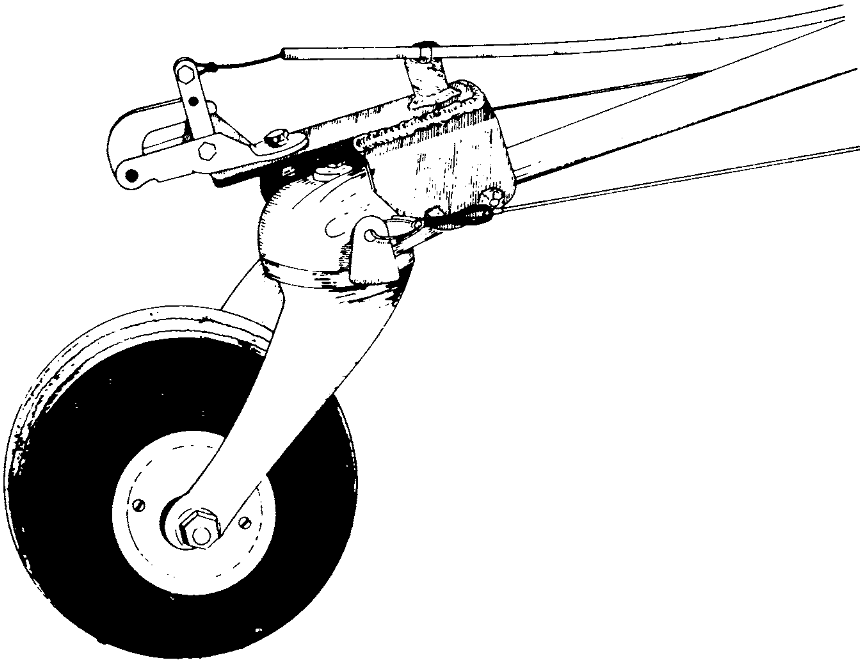


FIGURE 8.9.—Conventional gear aircraft—tubular spring type tailwheel.

134.–145. [RESERVED]

Chapter 9. SHOULDER HARNESS INSTALLATIONS

Section 1. RESTRAINT SYSTEMS

146. GENERAL. The primary objective in shoulder harness design is to prevent incapacitating and/or fatal injuries to personnel involved in a survivable crash condition in which the aircraft cabin structure remained reasonably intact. Any harness configuration which achieves this objective is satisfactory from a safety viewpoint, regardless of the type of harness and mounting position used.

Basic requirements of the aircraft airworthiness rules are designed to provide an aircraft structure to give each occupant a reasonable chance of escaping serious injury in a crash landing. These requirements adequately provide for conditions that can be expected to occur in various types of survivable accidents.

The human body has the inherent capability of withstanding decelerations of 20g's for time periods of up to 200 milliseconds (.2 second) without injury. Experience with aircraft used in agricultural and military operations shows that even in such unusual operations a high rate of survival in crashes is achieved when a restraint system is designed on the order of 20g to 25g deceleration loads.

In view of the foregoing, persons installing a shoulder harness may wish to use a restraint system designed to withstand 20g to 25g loads. In addition, seat belts and seat belt anchorages designed to these load limits may be used.

147. TYPES OF RESTRAINT SYSTEMS. There are two generalized types of shoulder harnesses currently in use. They are the single diagonal type harness and the double over-the-shoulder type harness. The over-the-shoulder harness may utilize either two independent attach points, or join in a "Y" configuration and attach at a single point. (See figs. 9.1 and 9.2) In all cases, however, the original safety belt or a combination harness utilizing a lap belt must be used in the installation.

148. ADVANTAGES OF DIFFERENT HARNESS TYPES. The single diagonal chest strap in combination with a lap belt is the simplest harness system and works effectively for longitudinal decelerations. However, during side decelerations, an occupant in this type harness has a tendency to slip out and away from the chest strap even when it fits snugly. The double over-the-shoulder type harness works well for both longitudinal and side decelerations.

149. MOUNTING CONFIGURATIONS. The type of shoulder restraint configuration acceptable for installation is dependent upon the attachments available in each individual aircraft. Basic harness mounting configurations are:

a. Seat mounted.

b. Airframe mounted.
  (1) Side
  (2) Ceiling
  (3) Floor
  (4) Directly rearward

150. STANDARDS. At the present time, there is a lack of standards for materials acceptable for use in shoulder harnesses. Until such time as a TSO is developed for shoulder harnesses, standards established in TSO–C22f pertaining to the materials and testing of safety belts may be accepted for this purpose.

151. MATERIALS.

a. *Webbing.* Synthetic materials, such as nylon and dacron, may be used for shoulder harness webbing. It is recommended that the webbing of the shoulder harness be the same as that of the lap belt to avoid problems in cleaning, staggered replacement of harness components due to wear or age, etc.

b. *Fittings.* Use hardware that:

(1) Conforms to an acceptable standard such as AN, NAS, TSO, or MIL-SPEC.

(2) Meets the strength required by FAR 23.1413 or 25.1413, as appropriate.

(3) Will not loosen in service due to vibration or rotational loads.

C. *Inertia Reels.* The function of the inertia reel is to lock and restrain the occupant in a crash yet provide the ability for normal movement without restrictions. In addition, automatic rewinding of any slack assures that the harness is always snug, which results in a more comfortable restraint system.

Self-contained inertia reel units may be mounted at readily accessible locations and will generally operate effectively in any attitude. Their use in a body restraint system is satisfactory if mounted in accordance with acceptable methods, techniques, and practices, and will meet static strength requirements equal to those outlined in FAR 23.1413.

Check the reel itself for the following operational hazards:

(1) Inadvertent Lockup. If the inertia mechanism is set at a low "g" setting, unwanted lockup, or binding, of the system may occur. A reel lockup range between .9 and 2.5 "g" is acceptable.

(2) *Improper Webbing Length.* Install adequate webbing on the takeup reel to allow the occupant to reach all necessary switches and controls in the cockpit. Any additional webbing will result in decreasing the reel spring "takeup" tension exerted on the shoulder.

(3) *Incorrect Belt Opening Alignment.* Position the reel so that the belt opening is aligned in the direction of loading. This will prevent the belt from rubbing and fraying due to normal usage.

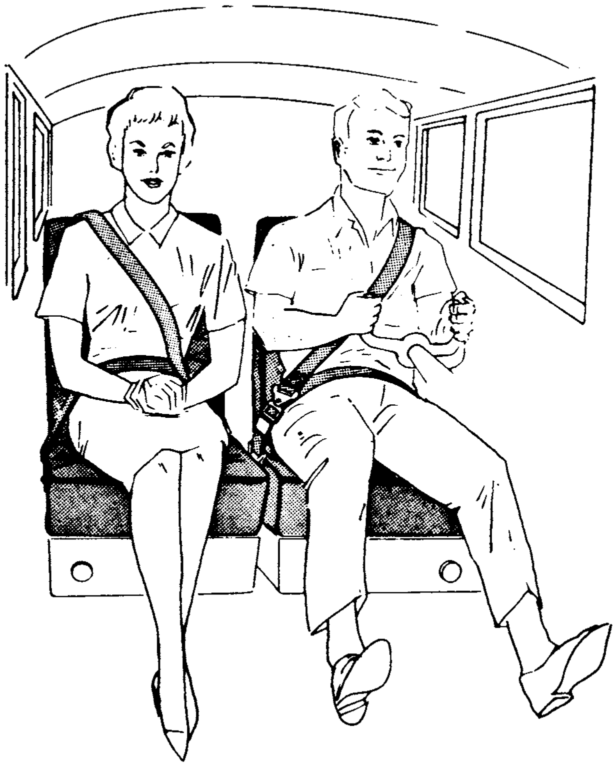


FIGURE 9.1.—Single diagonal type harness.

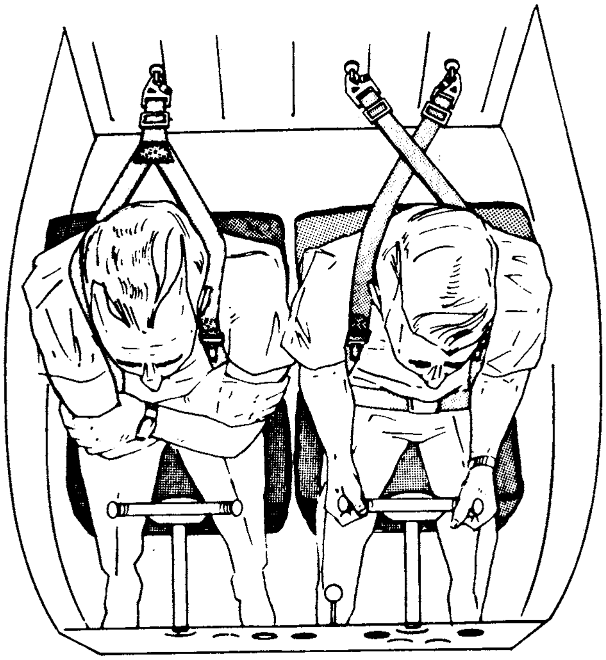


FIGURE 9.2.—Double over-the-shoulder type harness.

152.–155. [RESERVED]

Section 2. EFFECTIVE RESTRAINT ANGLES

156. RELATIONSHIP OF THE HARNESS ASSEMBLY TO THE OCCUPANT. Most restraint systems are designed so that each belt section maintains a certain relationship to the body. The attachment end of a restraint belt must maintain a relative angle and spacing to the head and neck surfaces as it passes over the shoulder and away from the body. This angle must provide sufficient freedom to assure normal body movements of the seated occupant without neck contact or interfering with vision.

157. ATTACHMENT AREAS FOR SHOULDER HARNESS. Effective attachment areas for the various types of shoulder harnesses are defined as angles formed by the attachment ends. Assure that when installing a harness for one seat that in a crash, a passenger to the rear would not sustain head impact injuries on the harness or its attach point.

a. Single Diagonal Type Harness. The optimum rearward attachment area for this type of harness is within an angle of 30 degrees above the horizontal measured from the midpoint on the occupant's shoulder as shown in figures 9.3 and 9.4.

Belt attachments should be located to the rear and outboard of the shoulder. This mounting area is shown in figure 9.5.

(1) Attachment points inboard of this area would permit the harness to impinge on the neck and could result in neck injury during crash impact. In addition, the constant rubbing of the strap on the neck would be uncomfortable and, as a result, act as a distraction to the safe operation of the aircraft. Attachment points forward of this area would reduce the effectiveness of the harness, due to a lack of contact between the harness and the upper torso of the occupant. In addition, a shoulder strap attached forward of

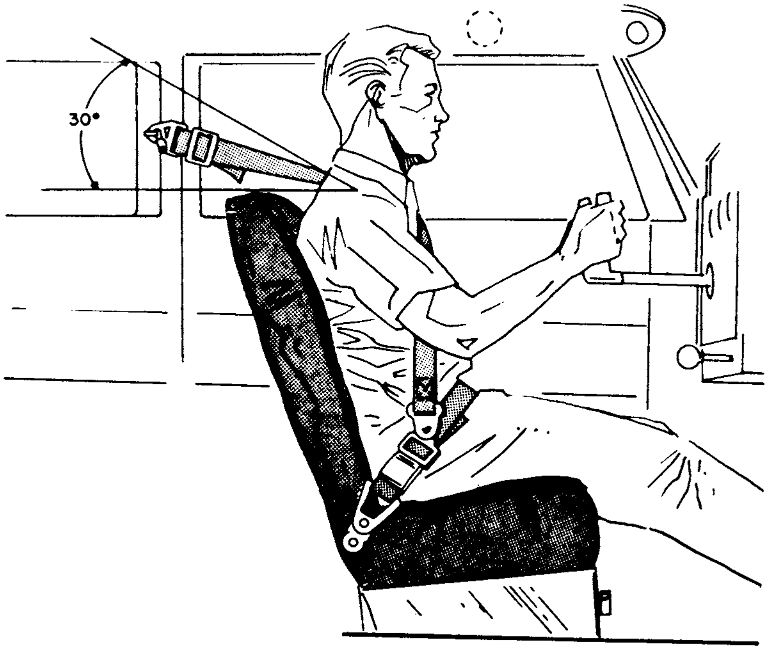


FIGURE 9.3.—Side mounted—single diagonal type harness.

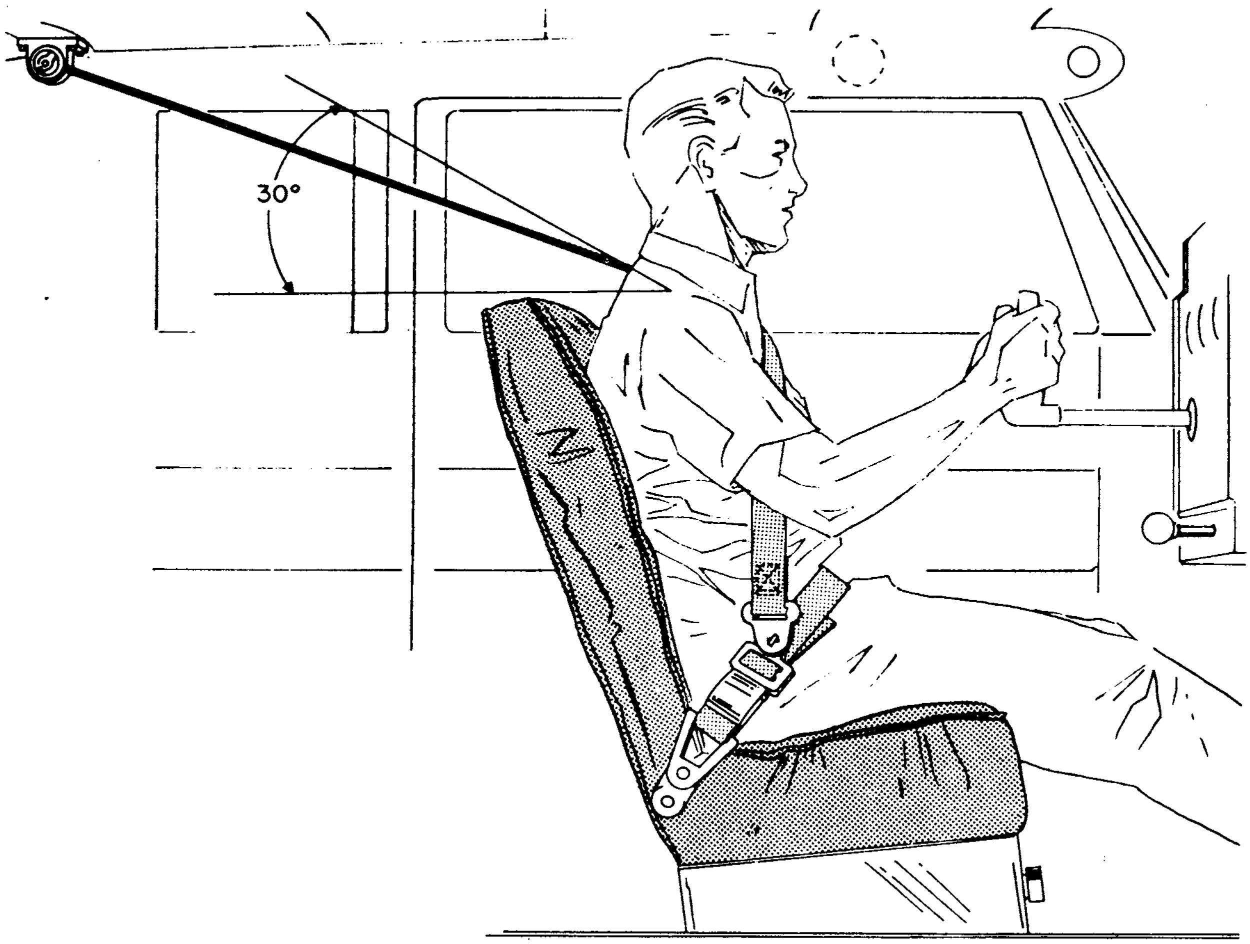


FIGURE 9.4.—Ceiling mounted inertia reel—single diagonal type harness.

the shoulder midpoint could obstruct vision and create a potential safety hazard.

(2) The harness should be kept snug as any decrease in the distance between the occupant's head and the forward cabin structure increases the opportunities for head impact injuries. Also, the chances for twisting out of the harness are significantly increased.

b. *Double Over-the-Shoulder Type Harness.* If this type of harness is intended to be mounted either directly rearward or to the ceiling, mount it within the 30-degree vertical angle as shown in figure 9.6.

Because of the limited number of rearward shoulder harness attachment points in many aircraft, a 5-degree angle below the horizontal is also considered acceptable.

Shoulder harness attach areas as viewed from above are shown in figure 9.7. These mounting areas may be used for either the independent or the "Y" type belts. The outboard limit is established to prevent the belt section from slipping off the shoulder, and the maximum inboard angle is limited to a point which will prevent impingement on the neck surface.

158. AREA AND ANGLE DEVIATIONS. While the areas and angles given in the above paragraphs are intended to assist in the selection of attachment points, they should be considered as the optimum and not be interpreted as being mandatory. Area and/or angle deviations could result in a decrease in the overall efficiency of the restraint system; however, they may be necessary in order to permit a harness installation in an aircraft which otherwise could not be accomplished. It is probable that other compromises may be necessary when adapting a specific restraint system to an aircraft in order to fit a body of average dimensions. These compromises, however, should be permitted only when they are compatible with proper restraint functions.

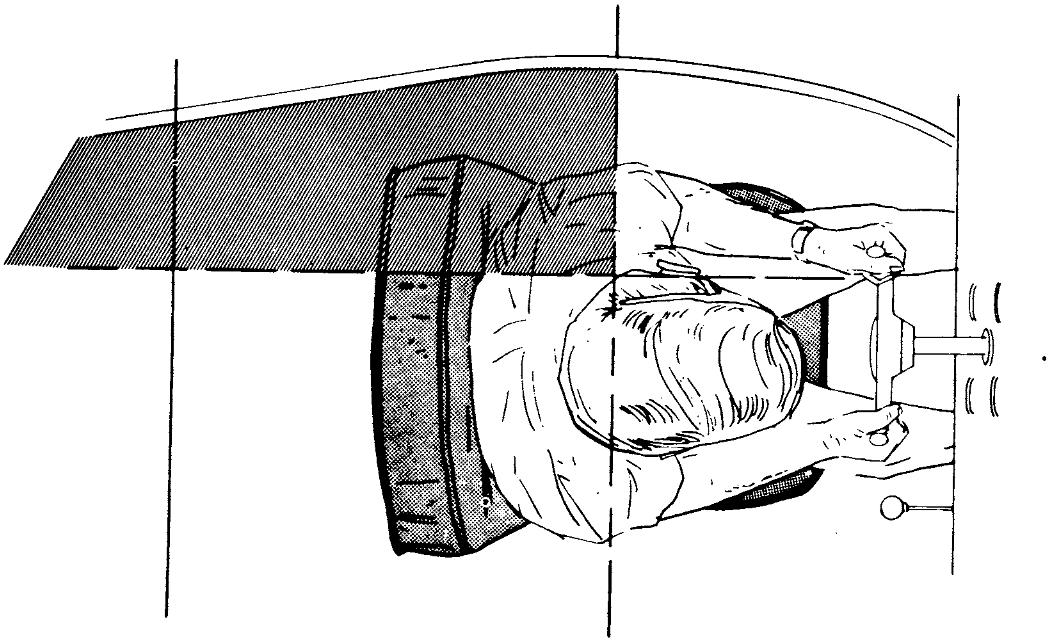


FIGURE 9.5.—Acceptable mounting area—single diagonal type harness.

FIGURE 9.6.—Ceiling mounted inertia reel—double over-the-shoulder type harness.

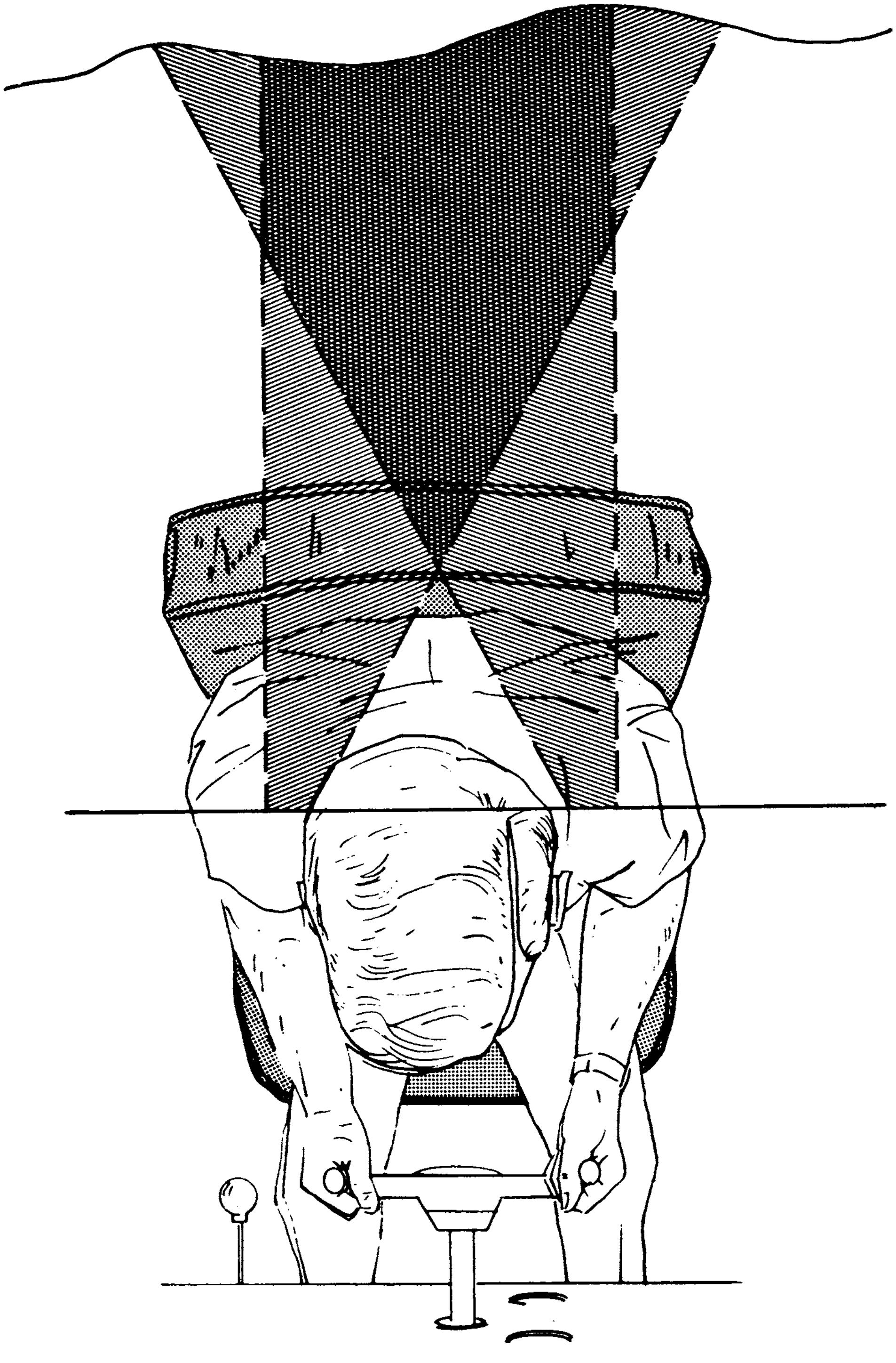


FIGURE 9.7.—Acceptable mounting areas—double over-the-shoulder type harness.

159.-160. [RESERVED]

Section 3. ATTACHMENT METHODS

161. STRUCTURAL ATTACHMENTS. For best results, the restraint system should be anchored to the primary aircraft structure. Design the structural attachment to spread the suddenly applied impact loads over as large an area of the structure as possible. The shoulder harness may be attached to selected secondary members which will deform slowly or collapse at a limited rate. This will assist in dissipating the high impact "g" loads to a level tolerable to the human body. However, the possibility of secondary members collapsing and making it difficult for an occupant to extract himself from the harness should not be overlooked.

162. FLOOR AND SEAT ATTACHMENTS. The double over-the-shoulder type harness shown in figure 9.8 may be used with either floor or seat mounting points, and typical installation methods are illustrated in figures 9.9 and 9.10. Two prerequisites necessary to ensure an effective restraint system are:

a. The seat structure and its anchorages should be capable of withstanding the additional "g" loads imposed by the restrained occupant during an abrupt deceleration. This capability may be determined by static testing in accordance with FAR 23.785, 25.785, 27.785, or 29.785, as appropriate; or, by securing a statement attesting this adequacy from the airframe manufacturer's engineering department.

b. The level of the seat back should at least be equal to the shoulder height of the seated occupant. This will reduce the inherent downward impact loads which would otherwise impart compressive forces on the occupant's torso.

FIGURE 9.8.—Floor mounted inertia reel—double over-the-shoulder type harness.

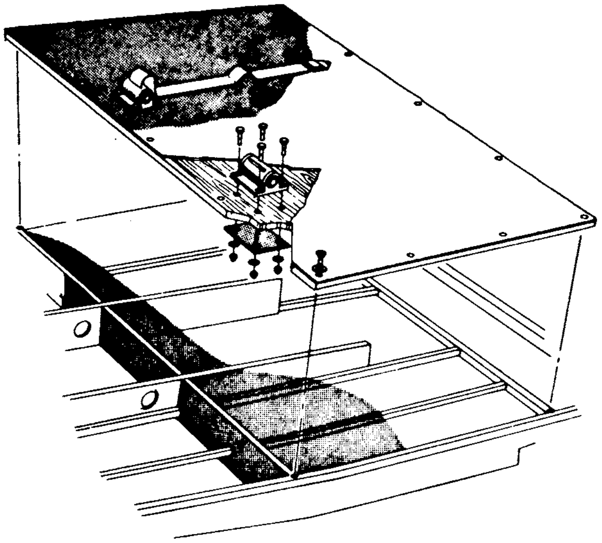


FIGURE 9.9.—Typical floor mounted inertia reel installation.

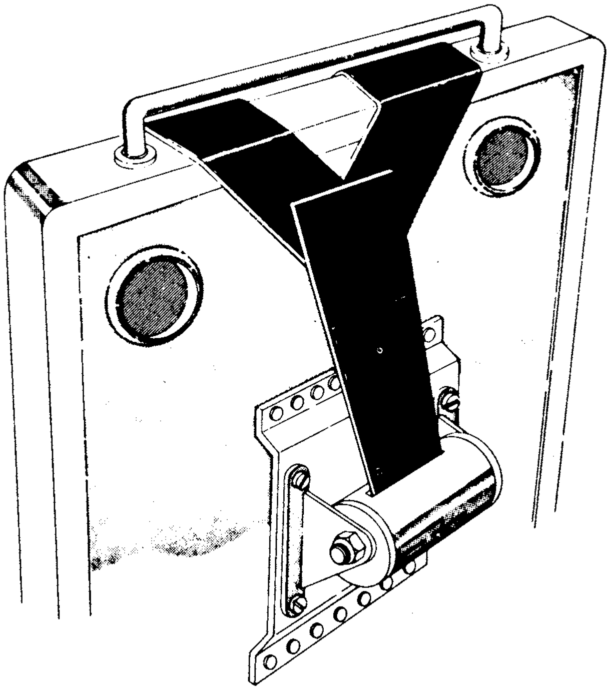


FIGURE 9.10.—Typical seat mounted inertia reel installation.

Seats which utilize a fold-over type of seat back must have some type of locking mechanism so that the seat can support the loads without allowing the occupant to move forward. The lock should be of a type which has a quick release to allow rear seat occupants to rapidly evacuate the aircraft. This type of installation should only be considered if other means of attachment are not available since making a folding seat rigid greatly reduces the protection afforded a passenger to the rear. When a folding seat is provided with a lock, the passenger to the rear should also be provided a shoulder restraint system, or, the back of the forward seat should be provided with sufficient absorptive material to adequately compensate for the added rigidity. Also, the change in load distribution due to the loads being applied to the seat back may require reinforcing the seat and/or belt anchorages to meet airworthiness requirements.

163. AIRFRAME ATTACHMENTS. The method used for the attachment of shoulder harness anchorages is dependent upon the construction features of the aircraft involved.

a. *Monocoque/Semimonocoque Type Constructions.* Illustrations of typical aircraft members and installation methods are shown in figures 9.11 through 9.15.

b. *Tube Type Construction.* Various typical methods of attaching shoulder harness anchorages are shown in figure 9.16. When aircraft cable is used as a component in a shoulder harness anchorages, swage the cable terminals in accordance with the procedures contained in chapter 4 of AC 43.13–1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repairs."

164. STRUCTURAL REPAIR KITS. In many instances, structural repair kits are available from the aircraft manufacturer. While these kits are primarily intended for use in repairing defective or damaged structure, they may also be used as a reinforcement for shoulder harness attach fittings.

165. FLEXIBLE ATTACHMENTS. Various aircraft are designed so that fuselage members and/or skin will flex or "work." This type of structure should not be heavily reinforced for the purpose of attaching shoulder harnesses as this would defeat the design purpose. In cases such as these, use a localized reinforcement, such as shown in figure 9.15, at the attachment point. This will allow the fuselage to flex while still maintaining a collapsible structure to absorb the loads encountered in a crash.

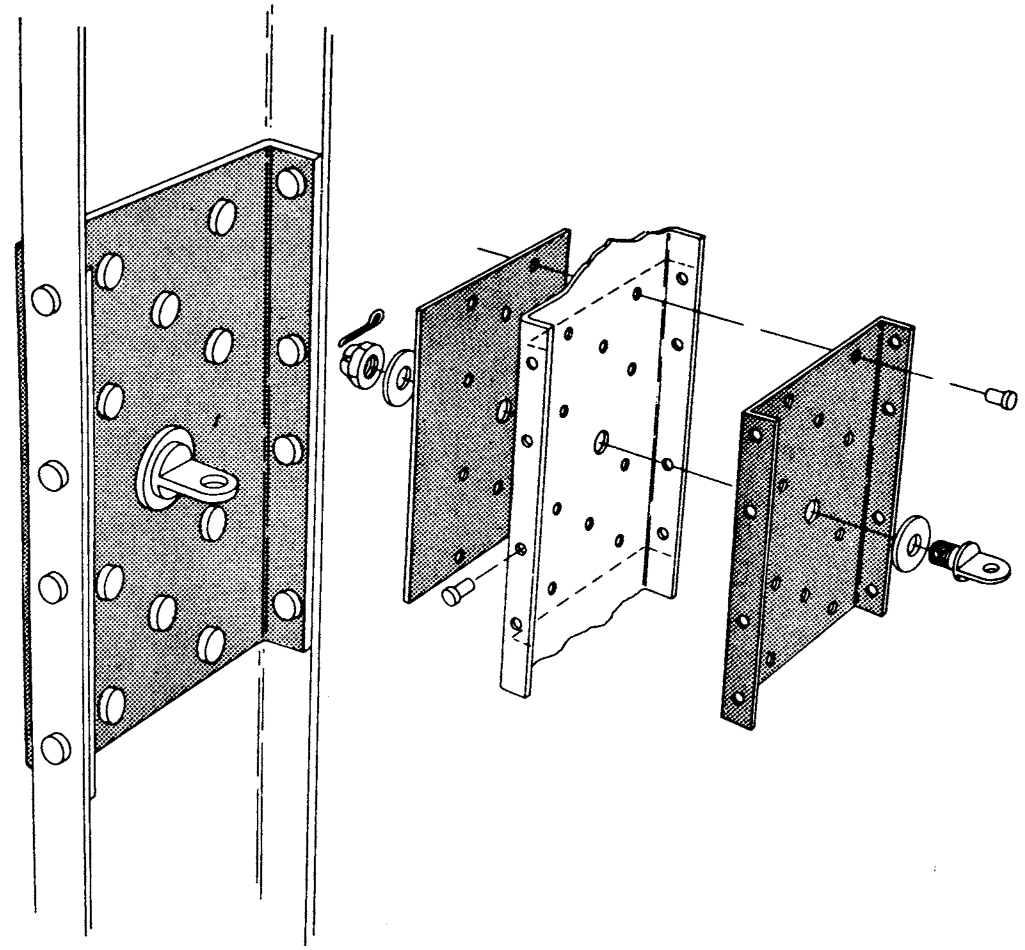


FIGURE 9.11.—Typical bulkhead reinforcement installation.

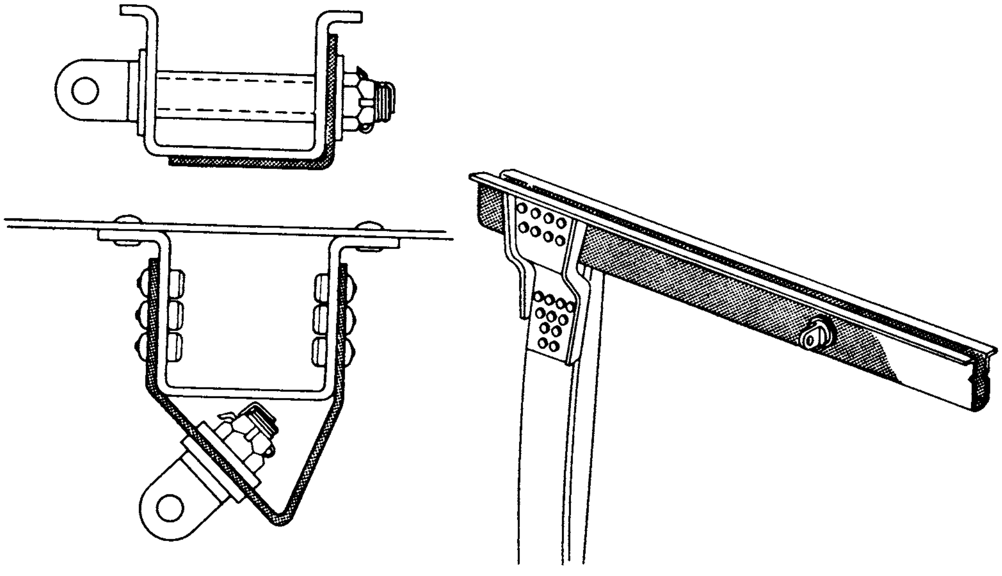


FIGURE 9.12.—Typical wing carry-through member installation.

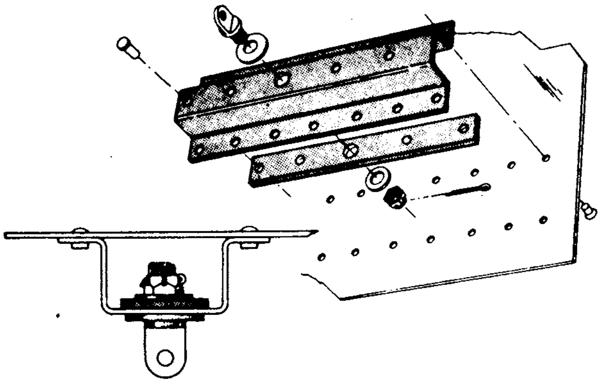


FIGURE 9.13.—Typical hat section reinforcement installation.

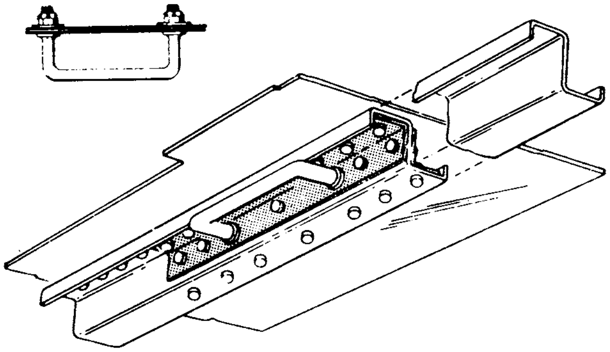


FIGURE 9.14.—Typical stringer section reinforcement installation.

166. SIMPLIFIED INSTALLATION CRITERIA.

To encourage the addition of shoulder restraints to existing aircraft with a minimum of testing and engineering necessary, yet provide a satisfactory restraint, the following general conditions will be acceptable.

a. ***Utilize the original seat belt attachments*** and either the original or a new belt provided with shoulder harness fittings.

b. ***Use webbing approved*** for standard seat belts (TSO–C22f).

c. ***Use hardware approved*** for use on seat belts per TSO–C22f.

d. ***Secure the lower end of the shoulder strap*** to one side of the original seat belt or belt anchorage.

e. ***Use a mount*** for the shoulder restraint independent of the seat such as the aft or ceiling mounts per paragraph 128.

f. ***Test the added mount*** by applying a test load of at least 500 pounds forward at the shoulder point.

167. ENGINEERING APPROVAL.

Installations which involve cutting or drilling of critical fuselage members or skin of pressurized aircraft will usually require engineering evaluation. For this reason it may be desirable to contact the airframe manufacturer to obtain his recommendations.

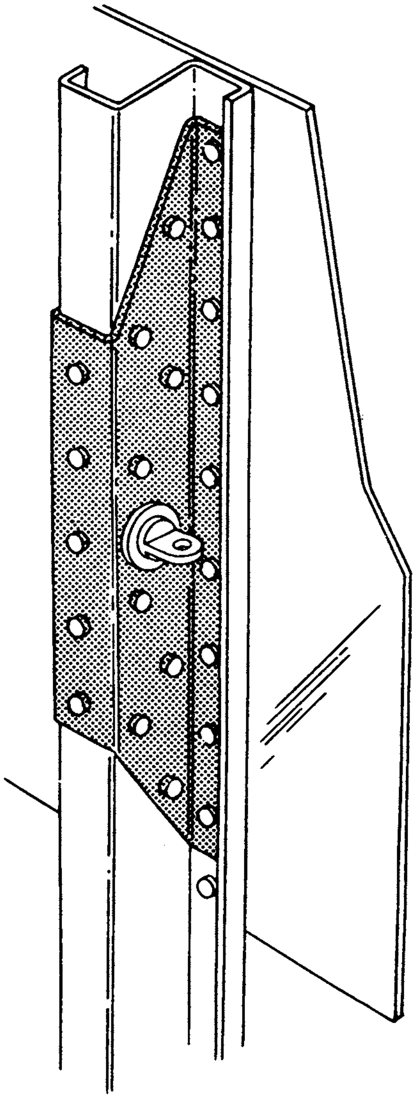


FIGURE 9.15.—Typical stringer section reinforcement installation.

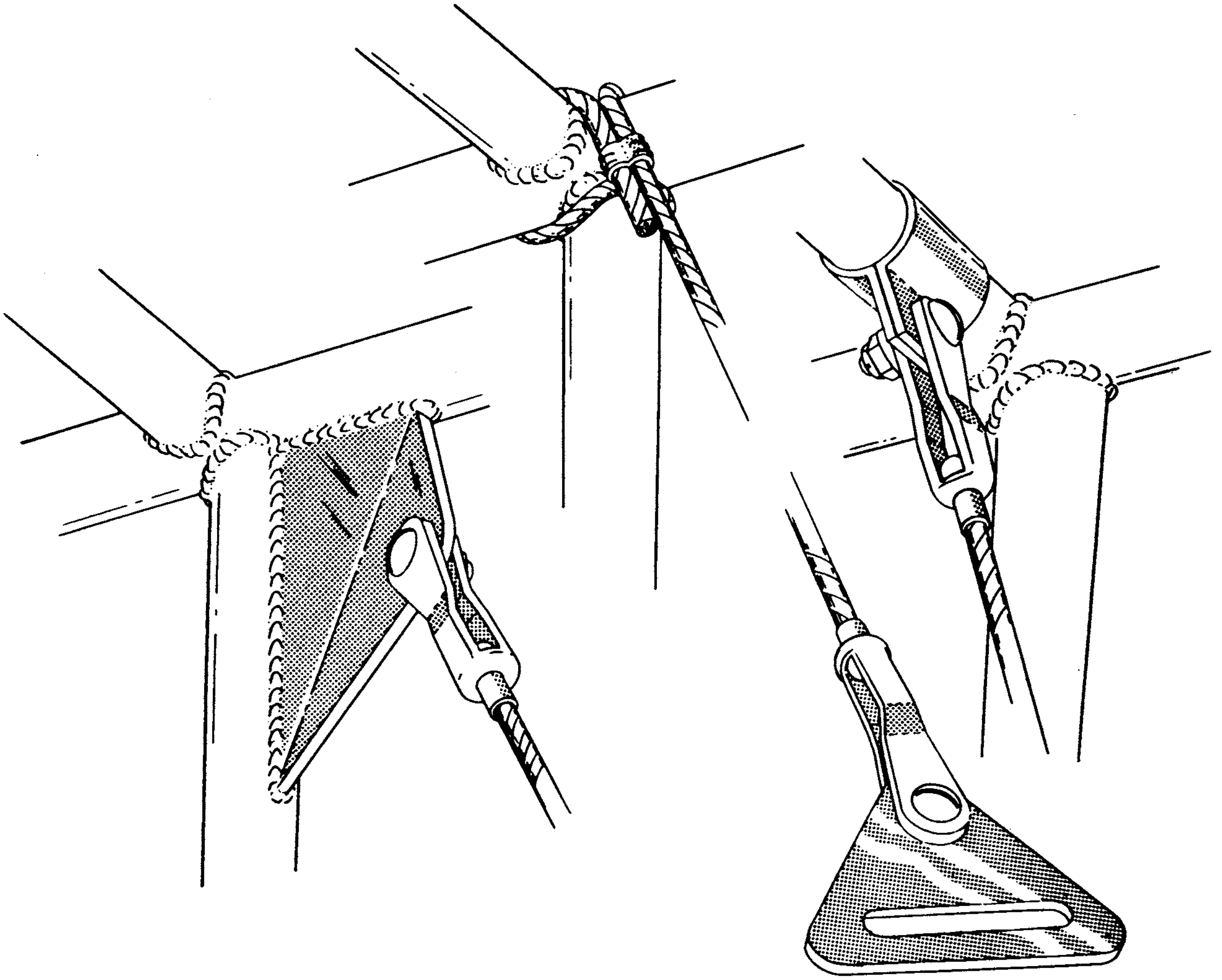


FIGURE 9.16.—Typical attachment to tubular members (adequate chafing protection for tube should be provided. Detail omitted for clarity.)

168.–175. [RESERVED]

Chapter 10. BATTERY INSTALLATIONS

Section 1. GENERAL

176. GENERAL. This section contains structural and design considerations for the fabrication of aircraft battery installations.

177. LOCATION REQUIREMENTS. The battery location and/or its installation should provide:

a. Accessibility for Battery Maintenance and Removal. The electrolyte level of the battery needs frequent checking; therefore, install the battery so that it is readily accessible for this service without the removal of cowling, seats, fairings, etc. Inaccessibility is often the source of neglect of this important piece of equipment. Certain types of batteries cannot be conveniently serviced while installed. Therefore, install and/or locate the battery so that it can be readily removed and reinstalled.

b. Protection from Engine Heat. The installation should protect the battery from extreme engine heat, which would be detrimental to the battery's service life and reliability. Such protection should provide for the temperatures encountered after engine shutdown as well as during engine operation. When locating the battery within the engine compartment, choose a location that will not interfere with the flow of engine-cooling air.

c. Protection from Mechanical Damage. Vibration and other shock loads are a major cause of short battery life. Whenever possible, install the battery in a manner or location that will minimize damage from airframe vibration and prevent accidental damage by passengers or cargo.

d. Passenger Protection. Enclose the battery in a box or other suitable structure to protect

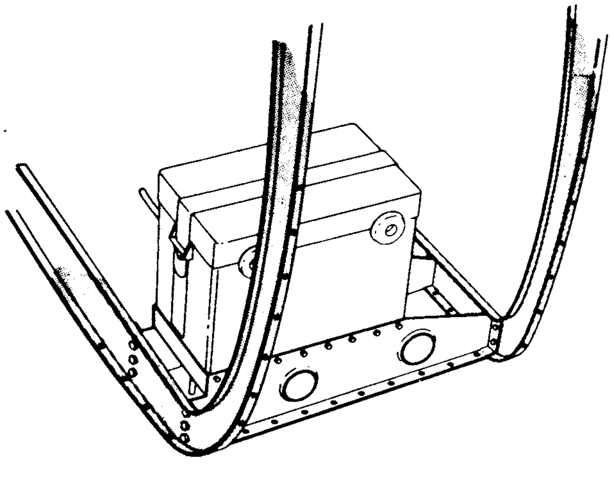


FIGURE 10.1.—Typical battery box installation in aft fuselage area.

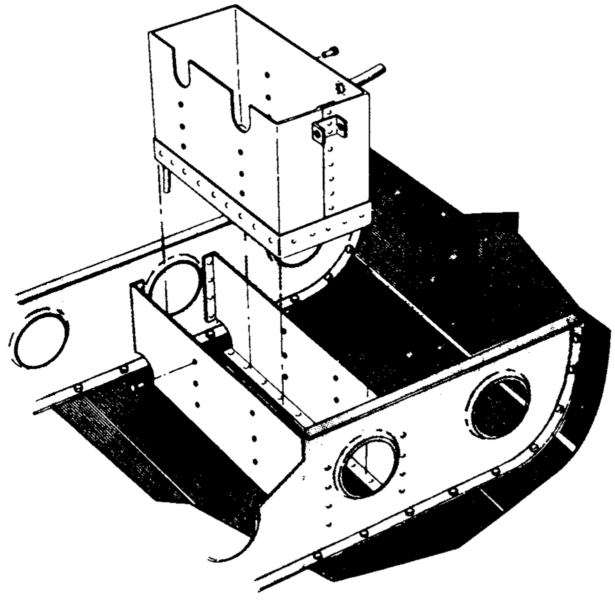


FIGURE 10.2.—Typical battery box installation in aft fuselage area, below cabin floorboards, or may also be adapted for within wing locations (shaded portions indicate original structure).

passengers from any fumes or electrolyte that may be spilled as a result of battery overheating, minor crash, inverted flight, and/or rapid decompression if the battery is located within the aircraft's pressure vessel.

e. ***Airframe Protection***. Protect the airframe structure and fluid lines by applying asphaltic- or rubber-base paint to the areas adjacent to and below the battery or battery box. Apply paralketone, heavy grease, or other comparable protective coating to control cables in the vicinity of the battery or battery box. Damage to adjacent fabric covering and electrical equipment can be minimized by providing a battery sump jar containing a neutralizing agent, properly locating battery drains and vent discharge lines, and adequately venting the battery compartment.

178. DUPLICATION OF THE MANUFACTURER'S INSTALLATION. The availability of readymade parts and attachment fittings may make it desirable to consider the location and type of installation selected and designed by the airframe manufacturer. Appreciable savings in time and work may be realized if previously approved data and/or parts are used.

179. OTHER INSTALLATIONS. If the battery installation has not been previously approved, or if the battery is to be installed or relocated in a manner or location other than provided in previously approved data, perform static tests on the completed installation as outlined in chapter 1 of this handbook. Because of the concentrated mass of the battery, the support structure should also be rigid enough to prevent undue vibration which would lead to early structural failure. Typical illustrations of battery support structure are shown in figures 10.1 thru 10.4.

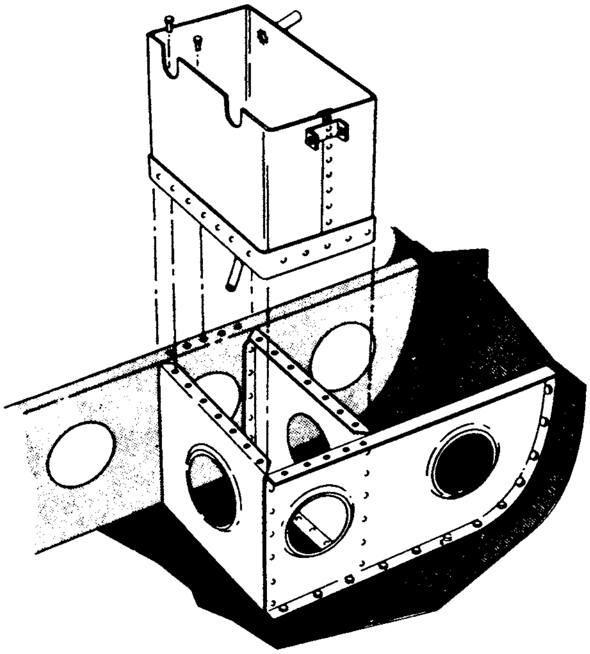


FIGURE 10.3.—Typical battery box installation in aft fuselage area (shaded portions indicate original structure).

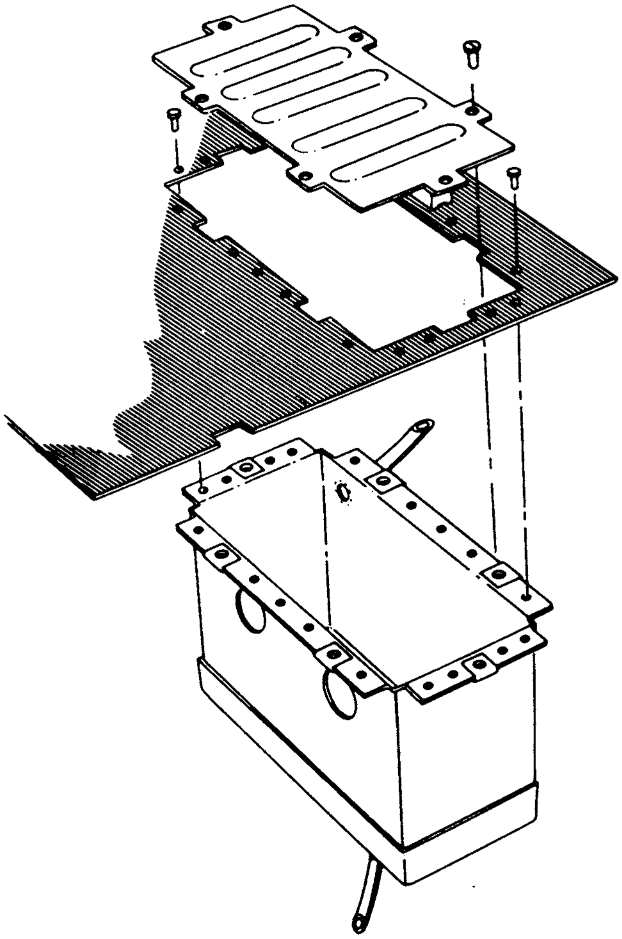


FIGURE 10.4.Typical battery box installation suspended from cabin floorboard section.

180.–185. [RESERVED]

Section 2. INSTALLATION

186. SECURING THE BATTERY. Install the battery box or holddowns in such a manner as to hold the battery securely in place without subjecting it to excessive localized pressure which may distort or crack the battery case. Use rubber or wooden blocks protected with parafin or asphaltic paint as spacers within the battery box, as necessary, to prevent shifting of the battery and possible shorting of the battery terminals or cables. Also, provide adequate clearance between the battery and any bolts and/or rivets which may protrude into the battery box or compartment.

187. VENTING. Provide suitable venting to the battery compartment to prevent the accumulation of the hydrogen gas evolved during operation. For most aircraft batteries, an airflow of 5 cu. ft. per minute is sufficient to purge the battery compartment of explosive concentrations of hydrogen.

a. ***Manifold Type.*** In this type of venting, one or more batteries are connected, via battery or battery box vent nipples, to a hose or tube manifold system as shown in figure 10.5. Fasten such hoses securely to prevent shifting and maintain adequate bend radii to prevent kinking.

(1) ***The upstream side of the system*** is connected to a positive pressure point on the aircraft, and the downstream side is usually discharged overboard to a negative pressure area. It is advisable to install a battery sump jar in the downstream side to neutralize any corrosive vapors that may be discharged.

(2) ***When selecting these pressure points,*** select points that will always provide the proper direction of airflow through the manifold system during all normal operating attitudes. Reversals of flow within the vent system should not be permitted when a battery sump jar is installed, as the neutralizing agent in the jar may contaminate the electrolyte within the battery.

b. ***Free Airflow Type.*** Battery cases or boxes that contain louvers may be installed without an individual vent system, provided:

(1) The compartment in which the battery is installed has sufficient airflow to prevent the accumulation of explosive mixtures of hydrogen;

(2) Noxious fumes are directed away from occupants; and

(3) Suitable precautions are taken to prevent corrosive battery fluids or vapors from damaging surrounding structure, covering, equipment, control cables, wiring, etc.

188. DRAINS. Position battery compartment drains so that they do not allow spillage to come in contact with the aircraft during either ground or flight attitudes. Route the drains so that they have a positive slope without traps. Drains should be at least ½″ in diameter to prevent clogging.

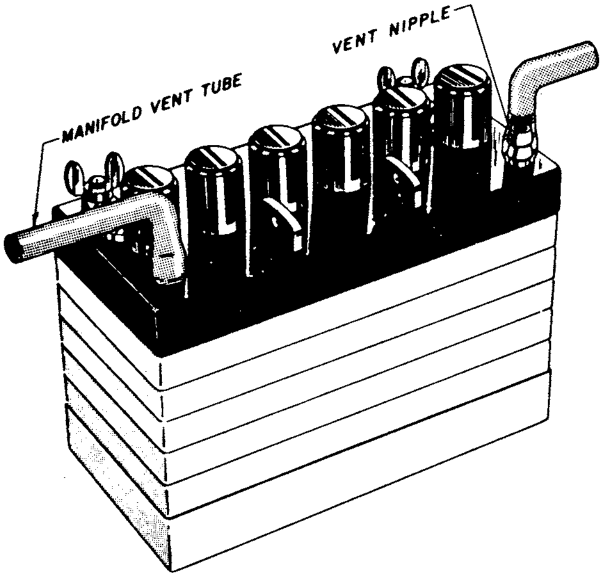


FIGURE 10.5.—Battery with integral vent nipples.

189. ELECTRICAL INSTALLATION.

a. *Cables/Connectors.* Use cables and/or connectors that are adequately rated for the current demand and are properly installed (See AC 43.13–1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair," chapter 11). It may be necessary to contact the battery manufacturer to determine current value of the battery at the 5-minute discharge rate. Cable size can also be selected by using the same gage as used on a previously approved production aircraft with the same battery.

(1) The cables should be of sufficient length to prevent undue strain on the battery connector or terminals.

(2) Clamp and protect cables, including the bus, in a very secure manner. Since these units are not fused, any fault could cause loss of the entire electrical system in addition to a possible fire hazard.

(3) Route cables so that cable or terminals cannot short to the battery case or hold-down frame.

(4) Route cables outside the battery box whenever practicable to prevent corrosion by acid fumes. When internal routing is unavoidable, protect the cable inside the box with acid-proof tubing. Assure that cables will not be inadvertently reversed on the battery terminals either by proper cable lengths and clamps or, if this is not practicable, use conspicuous color coding.

b. *Battery Cutoff.* Install a battery cutoff relay to provide a means of isolating the battery from the aircraft's electrical system. An acceptable battery cutoff circuit is shown in figure 10.6. Mount the relay so that the cable connecting the relay to the battery is as short as feasible, in any case not to exceed two feet, to reduce the possibility of a fire occurring because of a short within this section of cable.

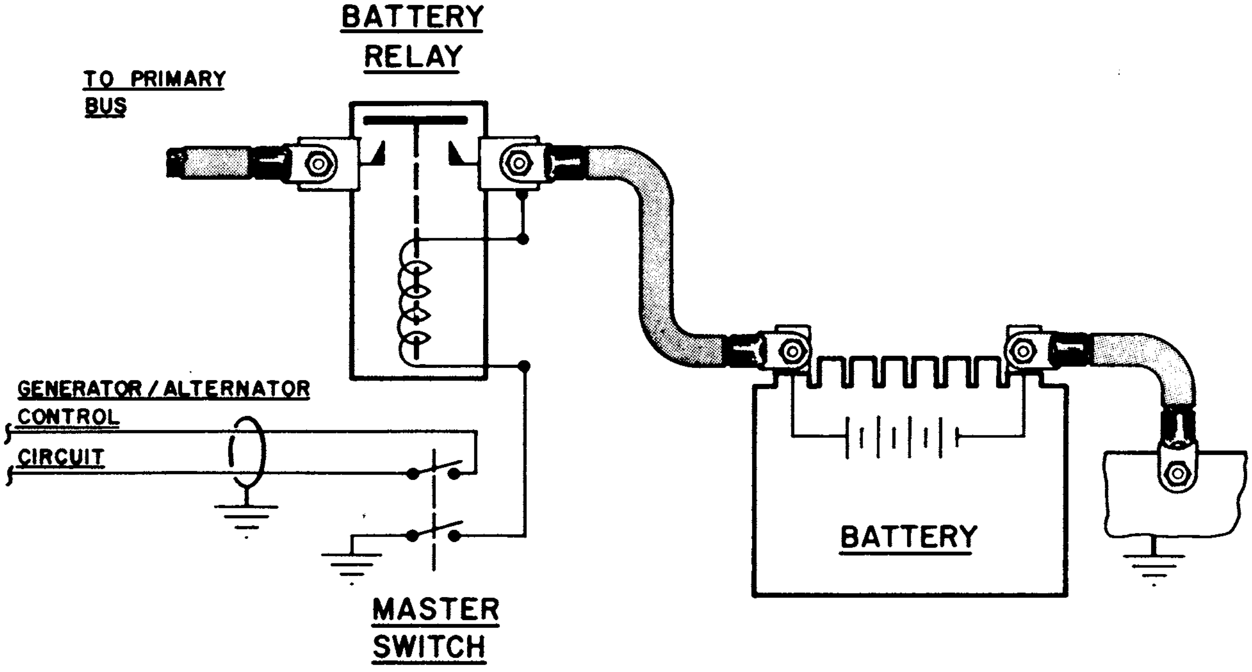


FIGURE 10.6.—Typical battery cutoff and generator alternator control circuit.

190.–195. [RESERVED]

Section 3. REPLACEMENT OF LEAD-ACID BATTERIES WITH NICKEL-CADMIUM BATTERIES

196. GENERAL. Nickel-cadmium batteries fulfill a need for a power source that will provide large amounts of current, fast recharge capability, and a high degree of reliability. The exchange of lead-acid for nickel-cadmium batteries requires careful evaluation of certain areas.

197. ELECTRICAL ANALYSIS. The ampere hour capacity of a nickel-cadmium battery is selected to accommodate the aircraft load requirements. When making this selection, the following items should be considered.

a. ***The low internal resistance*** permits it to recharge very quickly. This high recharge rate can exceed the generator rated capacity and deprive essential circuits of necessary operating current. Total system load (battery recharging plus system loads) must not exceed the pre-established electrical capacity.

b. ***Compare the discharge characteristics curves*** of the batteries to make sure a reduced capacity nickel-cadmium battery is adequate regarding the following:

(1) Ability to provide engine starting or cranking requirements. Turbine engines require an initial surge of approximately 1200 amperes which tapers off within 10 seconds to approximately 800 amperes cranking current. Reciprocating engines require approximately 100 amperes cranking current.

(2) Ability to provide sufficient capacity for low temperature starting. Nickel-cadmium batteries deliver their rated capacity when the ambient temperature range is 70° to 90° F. Increased battery capacity will offset the effects of low-temperature starting.

198. MAINTENANCE CONSIDERATIONS. To provide for ease of inspection and because nickel-cadmium batteries are generally not serviced in the aircraft, it is important that the battery be located where it can easily be inspected, removed, and installed. Some battery cases are designed with viewports on each side of the case for visual monitoring of the cell electrolyte level. If this type of case is to be utilized, consideration should be given to the location of the battery compartment to accommodate this feature.

199. STRUCTURAL REQUIREMENTS. Most lead-acid battery compartments provide adequate structure attachment for the installation of nickel-cadmium batteries. However, cantiliver supported battery boxes/compartments may not be suitable for nickel-cadmium battery installations unless modified to compensate for an increased overhang moment. This may be caused by a change in battery shape and c.g. location even though the replacement battery weighs less than the original lead-acid battery. (See fig. 10.7.) When ever the total installation weight and/or the overhang moment exceed those of the original installation, perform a static test as outlined in chapter 1 of the handbook. If the battery compartment is to be relocated, follow the procedures outlined in Sections 1 and 2 of this chapter.

200. ISOLATION OF BATTERY CASE. Because of the material from which nickel-cadmium battery cases are generally made (stainless or epoxy coated steel), it is desirable to electrically isolate the case from aircraft structure. This will eliminate the potential discharge current produced when spillage or spewage of the electrolyte provides a current path between the cell terminal or connector and exposed metal of the battery case. This isolation is also desirable in that it could prevent a fault within the battery or faulting the generator output to the stucture.

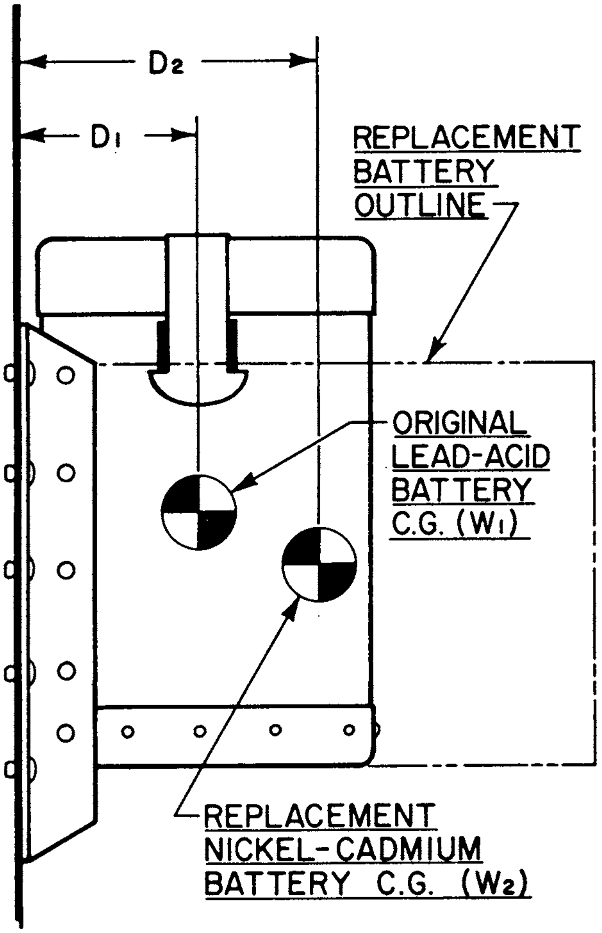


FIGURE 10.7.—Change in cantilever support battery overhang moment.

Example:

Original Overhang Moment with Lead-Acid Battery
$W_1 = 25$ lb.,
$D_1 = 4$ inches
4 inches X 25 lb., = 100 in.-lb.

New Overhang Moment with Replacement Nickel-Cadmium Battery
$W_2 = 19.5$ lb.,
$D_2 = 6$ inches
6 inches X 19.5 lb. = 117 in.-lb.

201. VENTILATION. During the charging process, nickel-cadmium batteries produce hydrogen and oxygen gases. This occurs near the end of the charging cycle when the battery reaches what is called the gassing potential. To avoid a buildup of these gases, and possible accidental ignition, ventilation should be provided to evacuate this gas from the aircraft. There are two types of nickel-cadmium battery cases, one with vent nozzles and the type with viewports.

a. *The vent nozzle type* utilizes vent hoses to evacuate the gas overboard by use of forced air or by venturi effect.

b. *Battery cases with viewports* or louvers must have an air flow sufficient to keep the mixture of air and hydrogen below 4 percent. The gases from this type of case are evacuated into the battery compartment. Regardless of the ventilation system used, the air flow should be a minimum of 5 cubic feet per minute.

202. PREINSTALLATION REQUIREMENTS. Inspect the replacement battery for possible damage incurred during shipment or storage. Give particular attention to signs of spilled liquid within the shipping container, as it may indicate a damaged cell. Follow procedures outlined in Section 2 for battery venting and electrical connections.

a. *Preinstallation battery servicing.* Check at least the following in accordance with the battery manufacturer's instruction:

(1) Remove the shipping plugs (if used) and clean and install the filler cap vent plugs.
(2) Check the tightness of terminal hardware including each cell connector strap to the proper torque values.
(3) Check the polarity of each cell to be sure they are connected in the proper series or sequence.
(4) Charge and check battery voltage and electrolyte level.

b. *Compartments or battery boxes* which have previously housed lead-acid batteries must be washed out, neutralized with ammonia or a baking soda solution, allowed to dry thoroughly, and painted with alkaline-resistant paint. Remove all traces of sulfuric acid and its corrosion products from the battery vent system to prevent contamination of the potassium hydroxide electrolyte and/or possible damage to the cell case material. Replace those parts of the vent system which cannot be thoroughly cleansed (hoses, etc.). When sump jars are incorporated into the vent system, replace the old pad with a new one that has been saturated in a three-percent solution (by weight) of boric acid and water.

203. SECURING THE BATTERY. Follow the procedures outlined in Section 2 of this chapter. Make certain that the holddown bolts are not drawn up so tightly that the battery case/cover becomes distorted. Should the cover become distorted, there is a possibility that the cell terminal hardware may eventually puncture the neoprene cover liner used in many batteries, and short circuit.

Caution: In installations where care has been taken to isolate the battery cases, inadvertent grounding may occur through improper or careless use of safety wire. Use no wood in nickel-cadmium battery boxes as it becomes conductive with time causing a current flow from the battery case to ground. Use only fiberglass or other acceptable material as liners and spacers in the battery box.

204. VOLTAGE AND CURRENT REGULATION. It is essential that the charging voltage and current be checked and, if necessary, the voltage regulator reset to meet the requirements of the nickel-cadmium battery being installed. IMPORTANT——improper charging current or voltage can destroy a battery in a short period of time.

205. WEIGHT AND BALANCE. After installation of the nickel-cadmium battery the weight and balance of the aircraft should be recomputed if:

a. ***The weight*** of the nickel-cadmium battery is different from that of the original lead-acid battery.

b. ***The location*** of the nickel-cadmium battery is different from that of the original lead-acid battery.

Weight and balance procedures for aircraft are contained in chapter 13 of AC 43.13–1A.

206. RESTORATION OF LEAD-ACID BATTERIES. When lead-acid batteries are restored in lieu of nickel-cadmium batteries the procedures contained in sections 1, 2, and 3 of this chapter should be used. Structural requirements are referenced in paragraph 199 and figure 10.7.

Airframe protection is specified in paragraph 177. Follow the procedures outlined in section 2 of this chapter for battery security, battery venting, and battery drains. Assure that all electrical requirements have been accomplished. Place emphasis on aircraft weight and balance. Refer to chapter 13 of AC 43.13–1A.

207.–210. [RESERVED]

Chapter 11. ADDING OR RELOCATING INSTRUMENTS

211. GENERAL. This chapter contains structural and design information to be considered when aircraft alterations involving the addition and relocation of instruments are being made.

212. PREPARATION. First determine what regulation, (CAR 3, 4b, FAR 23, 25, etc.) is the basis for the aircraft type certificate. That regulation establishes the structural and performance requirements to be considered when instruments are to be added or relocated.

a. ***Structure.*** Chapter 1 of this handbook provides information by which structural integrity may be determined. Chapter 2, paragraph 23a through f provides information pertinent to instrument panel installation.

b. ***Location.*** Consult the applicable regulation for the specific requirements for instrument location and arrangement.

(1) In the absence of specific requirements, installation of IFR flight instruments in a "T" arrangement is recommended. Locate the aircraft attitude indicator at top center, airspeed indicator to the left, altimeter to the right and directional indicator directly below, thus forming the letter "T." When a radio altimeter is used, the indicator may be placed on the immediate right of the attitude indicator with the pressure altimeter to the right of the radio altimeter indicator.

213. INSTALLATION. Mount all instruments so they are visible to the crewmember primarily responsible for their use. Mount self-contained gyroscopic instruments so that the sensitive axis is parallel to the aircraft longitudinal axis.

a. ***Structure.*** When making structural changes such as adding holes in the instrument panel to mount instruments, refer to chapter 2, paragraph 23a through f of this handbook. Refer to the aircraft manufacturer's instructions and Advisory Circular 43.13-1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair," chapter 2, section 3, for methods and techniques of retaining structural integrity.

b. ***Plumbing.*** Refer to the manufacturer's instructions for fabrication, routing and installation of instrument system lines. Advisory Circular 43.13-1A provides information regarding the installation and fabrication of aircraft plumbing.

c. ***Vacuum Source.*** Minimum requirements for installation and performance of instrument vacuum systems are covered in the applicable FAR Airworthiness Standards under "Instruments: Installation."

(1) In the absence of specific requirements for vacuum pump installation, refer to FAR Part 25, section 25.1433 for guidance. It is desirable to install a "T" fitting between the pump and relief valve to facilitate ground checking and adjustment of the system.

(2) When a venturi tube power source is used, it should not be taken for granted that a venturi will produce sufficient vacuum to properly operate one or more instruments. Many of the venturi tubes available for aircraft have a flow rate of approximately 2.3 cubic feet per minute at 3.75 inches of mercury (in. Hg) vacuum. Therefore, it is essential that the vacuum load requirements be carefully evaluated.

(3) Vacuum loads may be calculated as follows:

(a) Gyroscopic instruments require optimum value of airflow to produce their rated rotor speed. For instance, a bank and pitch indicator requires approximately 2.30 cubic feet per minute for its operation and a resistance or pressure drop of 4.00 in. Hg. Therefore, operating an instrument requiring 4.00 in. Hg from one venturi would be marginal. Similarly, the directional gyro indicator consumes approximately 1.30 cubic feet per minute and a pressure drop of 4.00 in. Hg. The turn and bank indicator has a flow requirement of 0.50 cubic feet per minute and reaches this flow at a pressure drop of 2.00 in. Hg. The above instruments are listed in Tables 11.1 and 11.3. Optimum values are shown in Table 11.3. It should be noted that the negative pressure air source must not only deliver the optimum value of vacuum to the instruments, but must also have sufficient volume capacity to accommodate the total flow requirements of the various instruments which it serves.

Table 11.1.—Instrument air consumption.

Instrument	*Air consumption at sea level*	
	Differential drop in. Hg suction (Optimum)	*Cubic feet/per minute*
Automatic Pilot System (Types A-2, A-3, & A-3A)		
Directional gyro control unit across mount assembly	5.00	2.15*
Bank & climb gyro control unit across mount assembly	5.00	3.85*
Total	——	6.00*
Automatic Pilot System (Type A-4)		
Directional gyro control unit	5.00	3.50*
Bank & climb gyro control unit	5.00	5.00*
Total	——	8.50*
Bank & pitch indicator	4.00	2.30
Directional gyro indicator	4.00	1.30
Turn & bank indicator	2.00	.50

(*) Note.—Includes air required for operation of pneumatic relays.

(b) To calculate the flow requirements of a simple vacuum system, assume four right-angle elbows and 20 feet of line (½ O.D. x .042) tubing.

1 Assume the flow requirements for:

Turn & bank indicator	.50 CFM
Directional gyro indicator	1.30 CFM
Bank & pitch indicator	2.30 CFM
Total flow required	4.10 CFM

2 The pressure drop for one 90° ½-inch O.D. x .042 elbow is equivalent to 0.62 feet of straight tubing, figure 11.1. Therefore, the pressure drop of four 90° elbows is equivalent to 2.48 feet of tubing.

Table 11.2.—Equivalent straight tube line drops for 90° elbows.

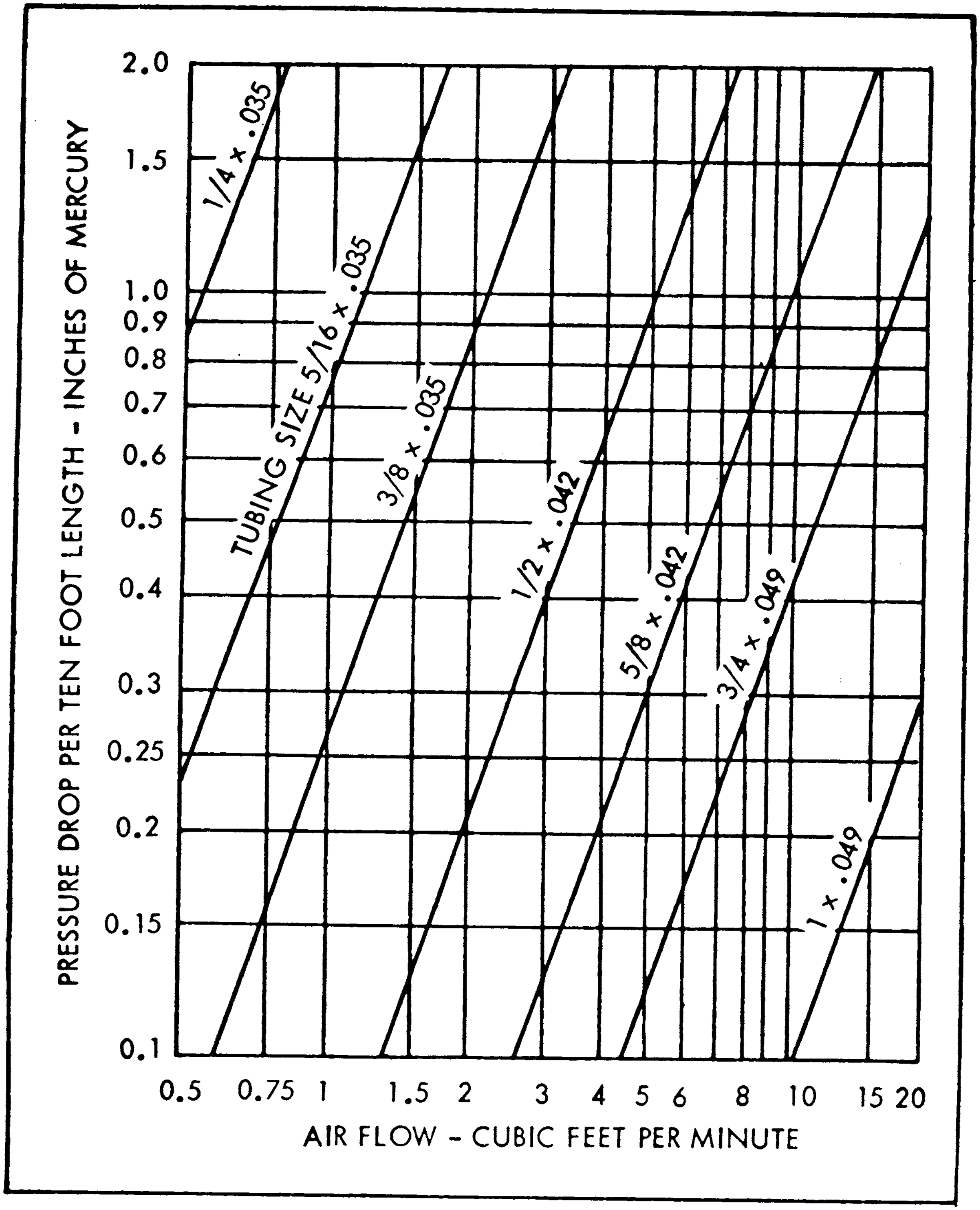
Tubing size		*Pressure drop in a 90° elbow in terms of length of straight tube equivalent to a 90° elbow*
O.D inch	*Wall thickness inch*	*Feet*
¼ ×	.035	0.28
⅜ ×	.035	0.46
½ ×	.042	0.62
⅝ ×	.042	0.81
¾ ×	.049	0.98
1 ×	.049	1.35

3 Determine the pressure drop through 22.48 feet (20 feet + 2.48 equivalent feet) of ½ O.D. × .042 tubing at 4.10 CFM flow. From figure 11.1, pressure drop per each 10-foot length = 0.68 in. Hg. Divide 22.48 feet of tubing by 10 to obtain the number of 10-foot sections, i.e., 22.48 ÷ 10=2.248. Multiply the number of sections by 0.68 in. Hg to obtain the pressure drop through the system. (0.68 × 2.248=1.53 in. Hg)

4 The pump must therefore be capable of producing a minimum pressure differential of

Table 11.3.—Differential pressure across instrument inlet and outlet.

Instrument	*Suction in inches of mercury*		
	Minimum	*Optimum*	*Maximum*
Automatic Pilot System (Types A-2, A-3, & A-3A)			
Directional gyro control unit across mount assembly	4.75	5.00	5.25
Bank & climb gyro control unit across mount assembly	4.75	5.00	5.25
Gauge reading (differential gauge in B & C control unit)	3.75	4.00	4.25
Automatic Pilot System (Type A-4)			
Directional gyro control unit	3.75	5.00	5.00
Bank & climb gyro control unit	3.75	5.00	5.00
Bank & pitch indicator	3.75	4.00	5.00
Directional gyro indicator	3.75	4.00	5.00
Turn & bank indicator	1.80	2.00	2.20



PRESSURE DROP DATA FOR SMOOTH TUBING

FIGURE 11.1

5.53 in. Hg, i.e., 4.00 in. Hg for maximum instrument usage + 1.53 in. Hg (determined) at a flow of 4.10 cubic feet per minute.

d. *Filter.* Filters are used to prevent dust, lint and other foreign matter from entering the instrument and vacuum system. Filters may be located at the instrument intake port or at the manifold intake port when instruments are interconnected. Determine that the capacity of the filter is as great or greater than the capacity of the vacuum system. Assure that there is no pressure drop across the filter media.

e. *Electrical Supply for Instruments.* Guidelines for the installation of instrument electrical wiring and power source are provided in Advisory Circular 43.13–1A, chapter 11, sections 2 and 3, and Chapter 16, section 3.

NOTE: Strict conformance to the shielding specifications supplied by compass manufacturers is recommended in all installations to eliminate any possibility of spurious signals.

f. *Instrument Lighting.* Instrument lighting must be installed in accordance with the regulations that are applicable to the aircraft type certification requirements. If in some instances the reflection of the lights is unsatisfactory, provide a shield or a means for controlling the intensity of illumination.

g. *Magnetic Headings.* Calibrate magnetic instruments with the powerplants operating. After this initial calibration, switch all nav/com and electrical equipment, such as windshield wipers and defrosters, "on" to determine if any electrical system interference affects the instrument calibration. If the calibration is affected, prepare an instrument placard identifying the compass headings with the equipment "on" and also with the equipment "off." Placard in accordance with par. 214f of this chapter.

214. TESTING, MARKING, AND PLACARDING.

a. *Testing the Venturi Tube-Powered Systems.* At normal inflight cruise speed, check the venturi tube-powered system to assure that the required vacuum pressure is being supplied.

b. *Testing the Vacuum Air Pump Powered System.* When the system is powered by vacuum air pumps, check the system while the pumps are operating at their rated r.p.m. and measure the vacum available to the instruments.

c. *Testing of Altimeters and Static Systems.* When checking the operation of an altimeter static system to determine that the system is free of any contaminating materials, be sure to disconnect the plumbing from all air operated instruments before purging the lines with dry air or nitrogen since the pressure necessary for purging may damage any connected instrument. Static system test procedures are provided in FAR 43, Appendix E.

d. *Testing electrical supply (instruments).* Check the voltage at the instrument terminals and determine that it is equal to the manufacturer's recommended values.

e. *Fuel, Oil, and Hydraulic (Instrument Supply).* Measure the fluid pressure at the instrument end of the line to determine whether it is equivalent to that at the pressure source.

f. *Instrument Markings and Placards.* When additional instruments are installed they must be appropriately marked. Refer to the applicable CAR/FAR under "Markings and Placards" for specific instrument marking and placard requirements.

215.–240. [RESERVED]

Chapter 12. LITTER, BERTH, AND CARGO TIEDOWN DEVICE INSTALLATIONS

241. GENERAL. This chapter provides data for making acceptable litter, berth, and cargo tiedown device installations in airplanes and rotorcraft. Prior to proceeding with the alteration, determine the airworthiness standards applicable to the contemplated alteration. Refer to the proper volume of the FAA publication "Type Certificate Data Sheets and Specification" for the certification basis of the aircraft involved. When airworthiness standards pertinent to the airplane involved are not available, current airworthiness standards may be used. For example, FAR 23, 25, 27, or 29, as applicable, may be used in place of CAR 4a, 4b, 6, or 7 or Bulletin 7a.

242. INSTALLATION CONSIDERATIONS.

a. Assure that the altered aircraft can be operated within the weight and center of gravity ranges. Refer to chapter 1, paragraph 9 of this handbook.

b. Determine that there will be free access to all equipment and controls essential to the proper operation of the aircraft, required emergency exits, and emergency equipment.

c. Use only materials that are at least flame-resistant for covering of floors, litters, or berths. Refer to the applicable airworthiness standards for the aircraft involved to determine the required flame-resistant qualities. For aircraft in air taxi or other commercial operations, refer to the applicable operating rule for special requirements regarding fire protection, cargo bins, location of cargo with respect to passengers, cargo compartment, or aisle width.

243. FABRICATION AND INSTALLATION.

a. Litters and berths may be fabricated from tubing, sheet metal, extrusions, canvas, webbing, or other suitable material, using acceptable methods, techniques, and practices. (Ref. Advisory Circular 43.13–1A "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair") Commercially available litters or stretchers may be utilized provided they meet installation and load criteria.

Provide a padded end board, canvas diaphragm, or other means at the forward end of each litter or berth that will withstand the total forward static test load. Safety belts used for litters and berths installed parallel to the aircraft's longitudinal axis are not required to withstand forward loads as these loads are to be taken up by the padded end boards.

Design litters or berths intended for adults for occupants weighing at least 170 lbs. In those instances where litters or berths are for children, design the installation for the maximum intended weight. See paragraph 247 for placarding.

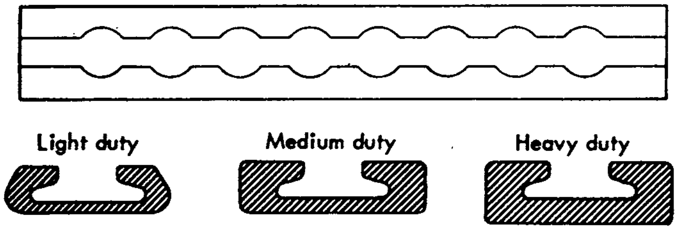
Provide approved seats for any cabin attendants or other passengers that will be carried when litters are installed.

b. Cargo tiedown devices may be assembled from webbing, nets, rope, cables, fittings, or other material which conforms to NAS, TSO, AN, MIL–SPEC, or other acceptable standards. Use snaps, hooks, clamps, buckles, or other acceptable fasteners rather than relying upon knots for securing cargo. Install tensioning devices or other means to provide a method of tightening and adjusting the restraint system to fit the cargoes to be carried.

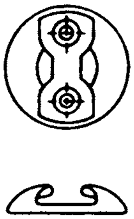
Provide covers or guards where necessary to prevent damage to or jamming of the aircraft's equipment, structure, or control cables.

244. STRUCTURAL ATTACHMENT. Commercially available seat tracks, rails, or other types of anchor plates may be used for structural attachment, provided they conform to an accepted standard (see chapter 1, paragraph 6). This type of hardware permits a ready means of mounting a wide variety of quick-disconnect fittings for litters, berths, and cargo tiedown. Typical examples of such fittings and their attachment are shown in figures 12.1 through 12.5.

EXTRUDED TRACK

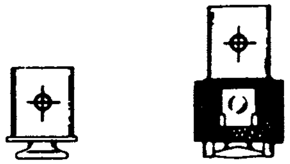


ANCHOR PLATE



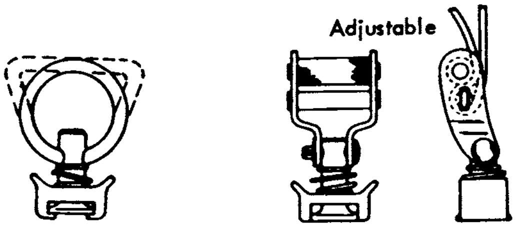
Extruded track and anchor plates are available in several different styles and load capacities and will accommodate a wide variety of quick attachment fittings.

SINGLE PIN TYPE HOLD DOWN FITTINGS



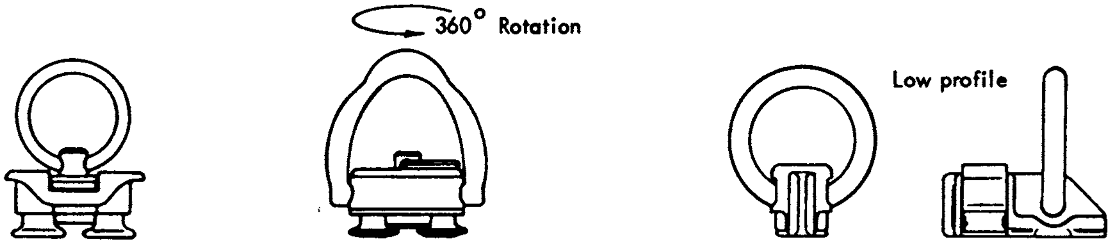
These types of fittings are suitable for litter or berth attachment to the extruded track and anchor plate styles shown above.

SINGLE PIN TYPE CARGO TIE DOWN FITTINGS



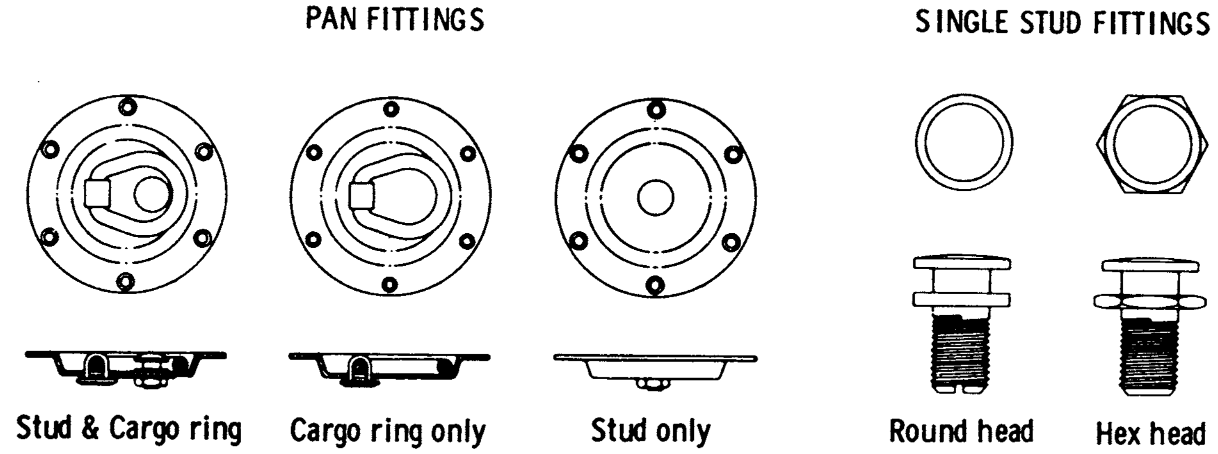
These types of fittings are suitable for cargo tie down attachment to the extruded track and anchor plate styles shown above.

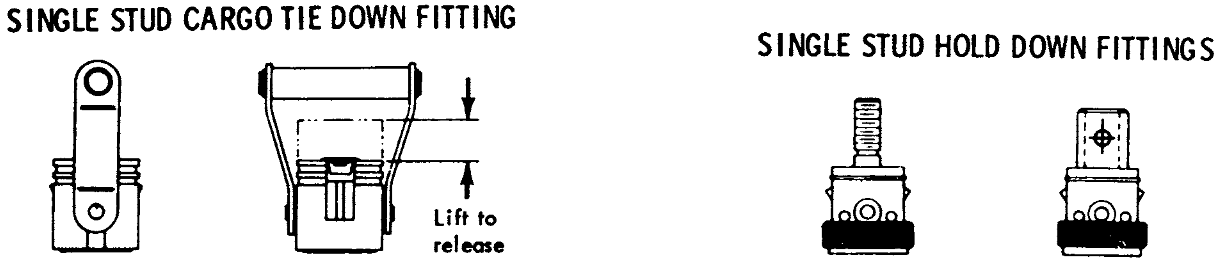
DUAL PIN TYPE CARGO TIE FITTINGS



These types of cargo tie down fittings are of greater capacity than the single pin types and are suitable for use with the extruded track style shown above.

FIGURE 12.1. Extruded track, anchor plates, and associated fittings.





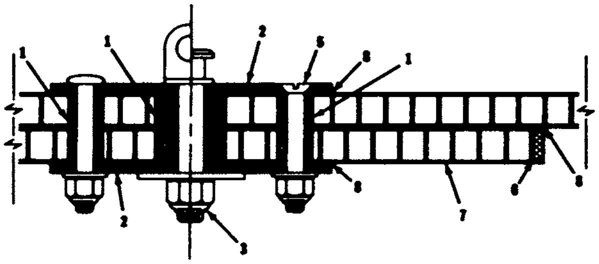
These types of fittings are suitable for cargo tie down attachment to the single stud fittings or stud equipped pan fittings shown above.

These types of fittings are suitable for litter or berth attachment to the single stud fittings or stud equipped pan fittings shown above.

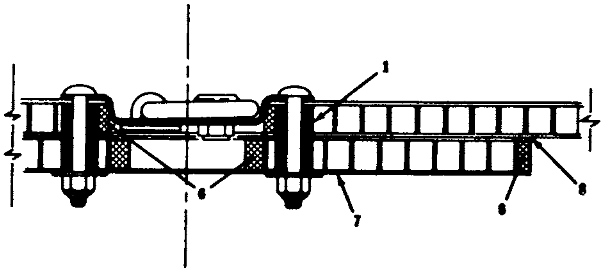
These types of fittings are suitable for litter, berth, and/or cargo tie down attachment directly to the aircraft structure.

FIGURE 12.2. Miscellaneous litter, berth, and cargo tiedown fittings.

A. **Attachment method utilizing a honeycomb doubler.**

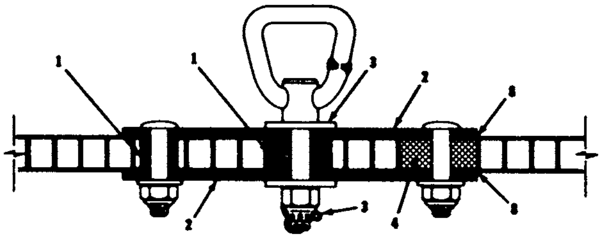


Single Studs or Eye Bolts.



Pan Fittings.

B. Attachment methods utilizing reinforcing plates.



Stud/Rings.

1. Bed all inserts and spacers in a suitable potting compound.
2. Reinforcing plate.
3. Where fitting is subject to rotation, place washers on both sides and use a positive safety means.
4. (Alternate method in lieu of spacers) Undercut honeycomb, inject potting compound, and drill through when set.
5. Countersink if required for clearance or if desired for appearance.
6. Undercut all open edges of honeycomb 1/16" and seal with potting compound.
7. Honeycomb doubler.
8. Use epoxy or other suitable adhesive to attach doubler and reinforcing plates.

FIGURE 12.3. Typical attachment of fittings to honeycomb structures.

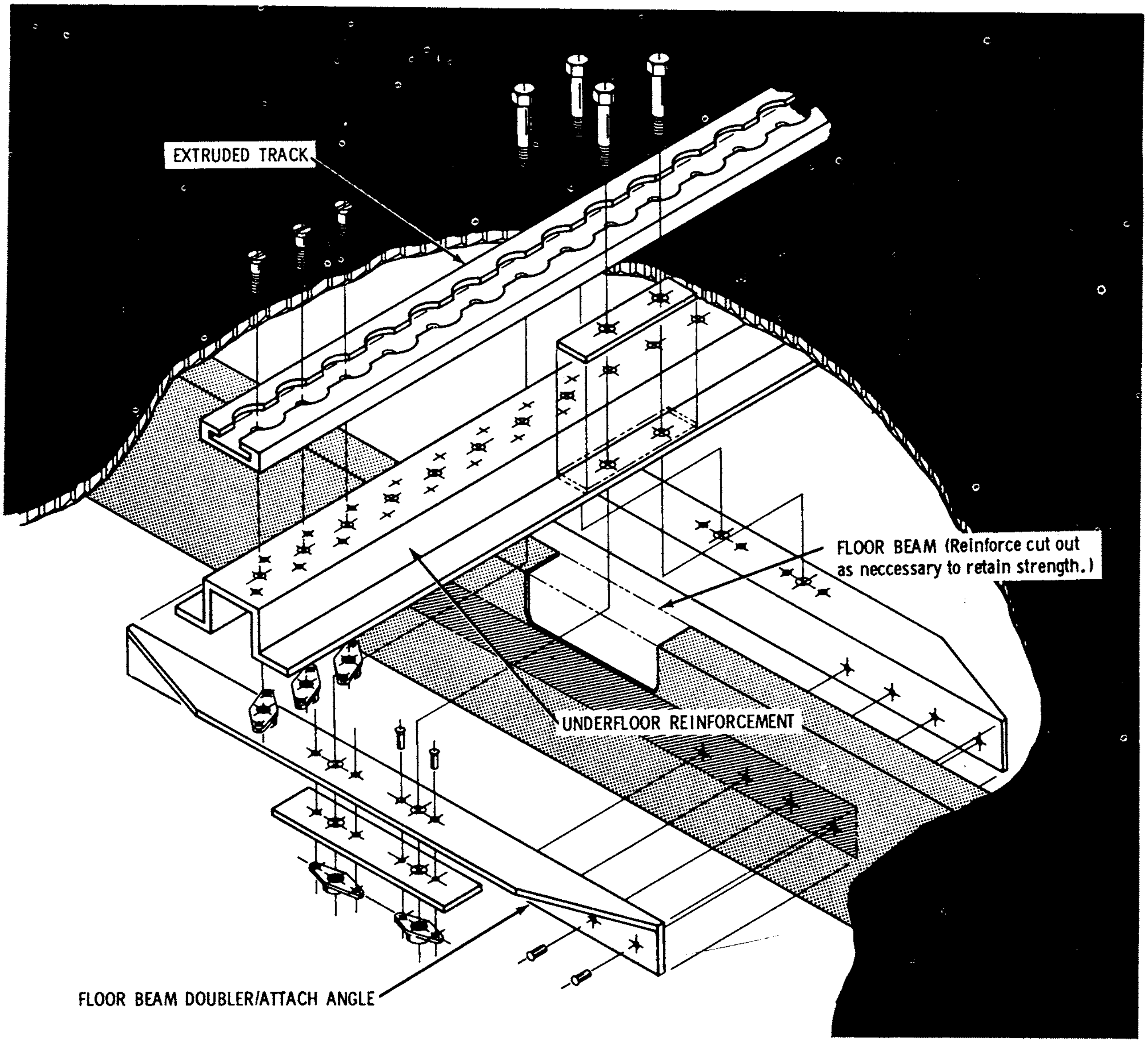
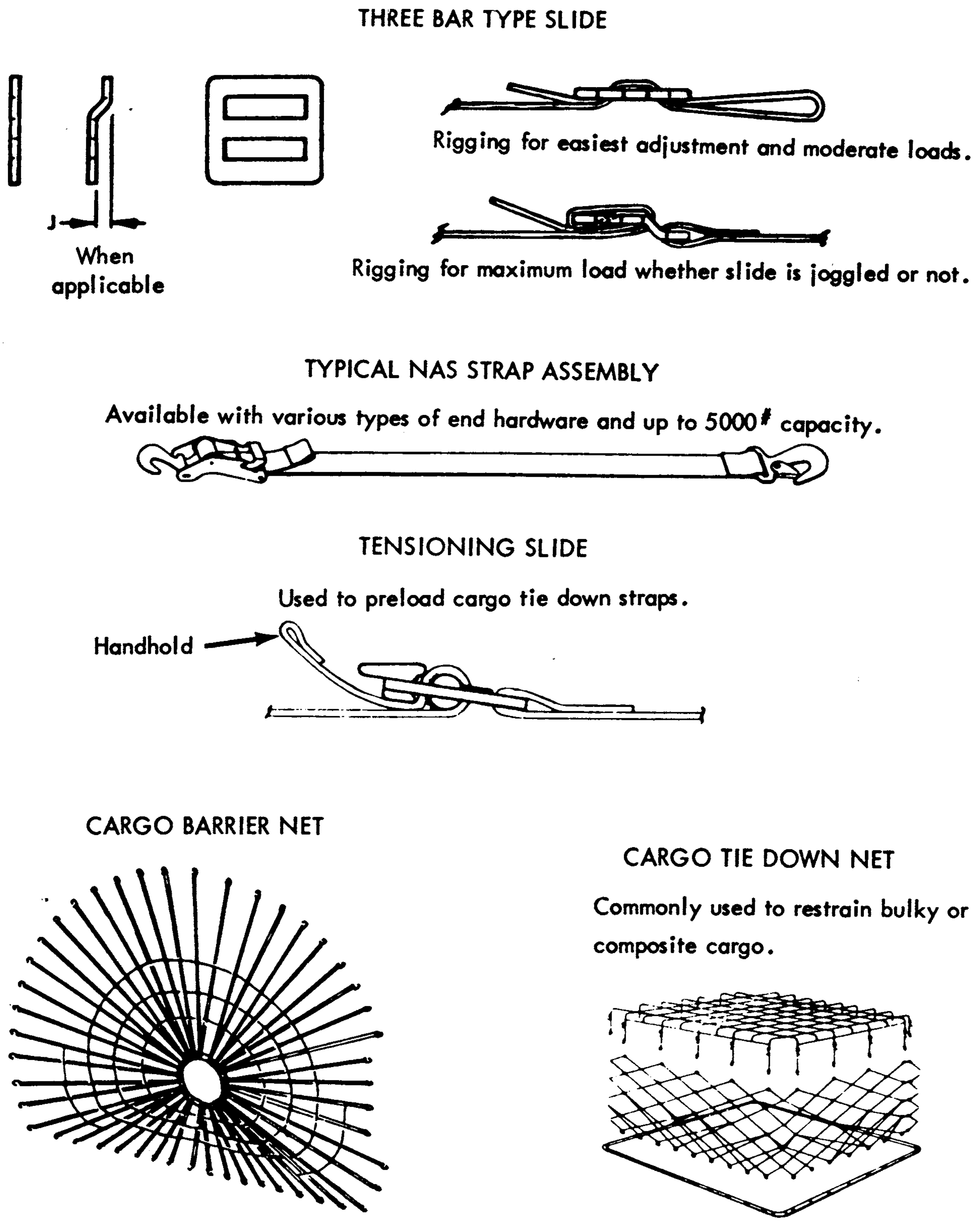


FIGURE 12.4. Installation of underfloor support for extruded track.



THREE BAR TYPE SLIDE

Rigging for easiest adjustment and moderate loads.

Rigging for maximum load whether slide is joggled or not.

TYPICAL NAS STRAP ASSEMBLY

Available with various types of end hardware and up to 5000# capacity.

TENSIONING SLIDE

Used to preload cargo tie down straps.

CARGO BARRIER NET

CARGO TIE DOWN NET

Commonly used to restrain bulky or composite cargo.

FIGURE 12.5. Typical cargo tiedown straps and cargo nets.

When installing these fittings, reinforce the existing floorboards and/or other adjacent structure to obtain the necessary load carrying capacity. Seat tracks installed longitudinally across lateral floor beams generally require full length support for adequate strength and rigidity between beam attach points (see fig. 12.4).

Consider the inherent flexibility of the aircraft structure and install any reinforcement in a manner that will avoid localized stress concentrations in the structural members/areas. Give specific attention to the size, shape, and thickness of the reinforcement, fastener size and pattern, and the effects of any adhesives used.

Fittings used for litter, berth, safety belt, and/or cargo tiedown attachment need not be substantiated by static tests if it can be shown that the fitting's rated minimum breaking strength would not be exceeded by the applicable static test loads. Existing racks, rails, or other points used for attachment may be verified by static tests, analysis, or a written statement by the aircraft manufacturer attesting to its adequacy to withstand the necessary loads.

For litters which are to be readily installed and removed, it may be desirable to utilize existing seat structure, safety belt attach fittings, seat tracks, or other seat attach fittings. When using such attach points, assure by static tests or manufacturer's written statement that they will not be stressed beyond the loads for which they were originally intended.

245. LOAD FACTORS. Use the load factor established by the aircraft manufacturer for type certification as the basis for substantiating the litter or berth and its attachment to the aircraft structure. Cargo tiedown devices installed within passenger compartments are subject to the same load factors as litter or berth installations. Refer to the applicable operating rules for any additional load factor requirements if the aircraft is to be used for air taxi or other commercial operations.

The critical load factors to which the installation is to be substantiated are generally available from the person currently holding the aircraft's Type Certificate (T.C.). When the T.C. holder is no longer active, such data may be obtained from the controlling FAA regional engineering office. The addresses of T.C. holders and FAA controlling regions are given in the FAA publication "Type Certificate Data Sheets and Specifications."

246. STATIC TESTS. It is recommended that static testing be conducted on a duplicate installation in a jig or mockup which simulates the related aircraft structure. Refer to chapter 1, paragraph 3 for static test information.

If the actual installation is used for static testing, inspect both the aircraft and the litter, berth, or cargo tiedown device installation thoroughly before releasing to service. Check all members and fittings for cracks, distortion, wrinkles, or elongated holes. Replace all bolts and threaded fittings that are not inspected by magnetic particle or other acceptable N.D.T. inspection process. Inspect riveted joints for tipped rivet heads and other indications of partially sheared rivets or elongated holes.

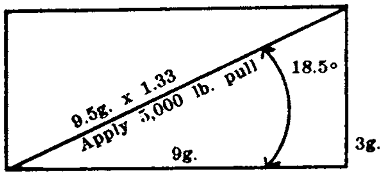
a. For litter and berth installations, compute the up, down, side, fore, and aft static test loads required for substantiation by multiplying the standard passenger weight, 170 lb., by each of the *critical static test load factors*. Refer to chapter 1 of this handbook for computation procedures. (For utility category aircraft use 190 lb., and for litters or berths intended for children use the placarded weight.) Perform tests as necessary to substantiate the complete litter or berth installation for each intended position (forward, aft, or side-facing). When testing for a particular load, install or adjust the litter or berth to the most critical position for that load.

When the safety belt or harness and/or the padded end board is attached to the litter or berth structure, all loads are to be borne by the litter or berth structure and its attachment fittings. Where these are not attached to the litter or berth structure, substantiate the total litter or berth installation for the loads which would be imposed for that safety belt attachment/end board configuration.

b. Cargo Tiedown Installations. All cargo tiedown installations must be tested to the critical ultimate load factor. Refer to chapter 1 of this handbook for computation and testing procedures.

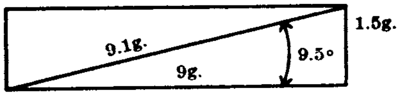
When the cargo compartment is separated from the cockpit by a bulkhead that is capable of withstanding the inertia forces of emergency conditions a forward load factor of 4.5g. may be used. All other applications require the use of a 9g. forward load factor.

Each cargo tiedown fitting installation must be static tested under forward, side, and up load conditions. Individual fittings may be tested by applying a single pull of 12.6g. forward load at an angle of 18.5° up and 9.5° to the left or right, as applicable, of the aircraft longitudinal axis. For example, assuming a 5,000 pound static pull (rating of a typical tiedown fitting) is applied as described and divided by the g. load factor we find the fitting installation will be capable of restraining a 397 pound load under emergency conditions.



$$9.5g. \times 1.33 = 12.6g.$$

$$\frac{5{,}000\text{ lb.}}{12.6g.} = 397\text{ lb.}$$



When a cargo-restraining net or cargo container with multiple attachments is used the static load requirements for each tiedown fitting may be divided equally between the fittings. For example, assume that the maximum cargo load to be carried is 1,800 pounds and 10 tiedown fittings are to be used, the static load requirement for each fitting is approximately 2,155 lbs.

$$\frac{9g. \times 1.33 \times 1{,}800\text{ lbs.}}{10\text{ fittings}} = 2154.6\text{ lbs.}$$

Placard individual tiedowns for the maximum weight to be secured.

247. OPERATING LIMITATIONS, LOADING INSTRUCTIONS, AND PLACARDS. Prepare revisions or supplements to the aircraft's Flight Manual or operating limitations, weight and balance records, and equipment list changes as necessitated by the installation of the litter, berth, or cargo tiedown systems.

> NOTE.—Revisions or supplements to the approved portions of the aircraft's Flight Manual markings, placards, or other operating limitations require FAA engineering approval. Submit the requested changes and supporting data to the local FAA Flight Standards Office for review and processing.

Provide instructions covering the installation and use of the litter or cargo restraint systems. For aircraft which require a Flight Manual, incorporate these instructions as a supplement. On other aircraft, provide a placard which references the appropriate instruction. In the instructions, cover such items as removal and reinstallation of seats or other equipment exchanged for litters or cargo restraint systems, use of cargo nets, barrier nets, number and positioning of tiedown straps, maximum load for each compartment or tiedown area, permissible load per square foot, number of tiedown points allowable per foot of track, and maximum height of the load's center of gravity above the floor.

a. Cargo Area Placards. Install placards or other permanent markings to indicate the maximum allowable cargo load and weight per square foot limitation for each cargo area. Placard seat tracks as to number of tiedown points permissible per foot of track. Attach a permanent lable or other marking on each cargo net, barrier net, and at cargo tiedowns to indicate the maximum cargo weight that the net or attachment will restrain when installed according to the loading instructions.

b. Litter and Berth Placards. Install a placard or other permanent marking on each litter or berth indicating its permissible direction of installation (forward, aft, or side-facing), passenger weight limitation (if less than 170 lbs.), and whether or not the litter or berth may be occupied during takeoffs and landings.

248.–260. [RESERVED]

Chapter. 13. PENETRATION THROUGH PRESSURIZED STRUCTURE

Section 1. ELECTRICAL WIRE BUNDLES AND COAXIAL CABLE FEED THROUGH PRESSURIZED STRUCTURE

261. GENERAL. This section describes typical methods for sealing openings where wires and coaxial cable are installed through pressurized structure.

a. Assure that the strength of the structure is maintained when installations require additional opening.

b. The aircraft manufacturer's data may specify the size and location where additional openings are permitted and the reinforcement required to maintain the design strength of the affected area.

c. The manufacturer's data may also recommend the specific sealant to be used and provide instructions for the application.

> **Caution:** Sealant and solvents may contain toxic and/or flammable components. Avoid inhalation of vapors and supply adequate ventilation. Wear appropriate respiratory protection while using these materials in confined areas. Avoid contact with the skin and eye.

262. CLEANING. Use a cleaning solvent and clean a larger area than required for the fair-lead or connector. Remove solvent by blasting with dry air and wiping with a clean soft cloth.

263. APPLICATION OF SEALANT. Seal electrical wire bundles and connectors where they pass through the opening in the pressurized structure.

a. Separate and coat each wire with sealant over the length which is to pass through the fair-lead, fig. 13.1A. After coating each wire with sealant, pull the wire bundle into position in the fair-lead, fig. 13.1B. Assure that the fair-lead is located on the pressure side of the structure.

b. Apply sealant to the surface of the fair-lead which comes in contact with the pressurized structure. Use a spatula or brush and spread sealant on the entire surface approximately $\frac{1}{32}$-inch in thickness. Attach the fair-lead to the pressurized structure, sealant, sealant should extrude around the mounting flange (see fig. 13.1C).

c. Wrap the fair-lead with at least three turns of masking tape as shown in fig. 13.1D. Puncture the masking tape over the injection hole in the fair-lead assembly and inject sealant with a sealing gun. Apply sealant over each fair-lead fastener as shown in fig. 13.1E.

d. Complete all of the aforementioned steps during the application time of the sealant. Allow sealant to cure, remove masking tape and excess sealant which extruded from the fair-lead mounting flange.

e. Figures 13.2 and 13.3 illustrate a different type fair-lead and wire bundle connector. The procedure for sealant application is the same as previously described.

f. Figure 13.4 illustrates various coaxial connectors frequently used for installation through structure. Fair-leads are not recommended for installation of coaxial cable. Sealant application is the same as previously described.

264.–290. [RESERVED]

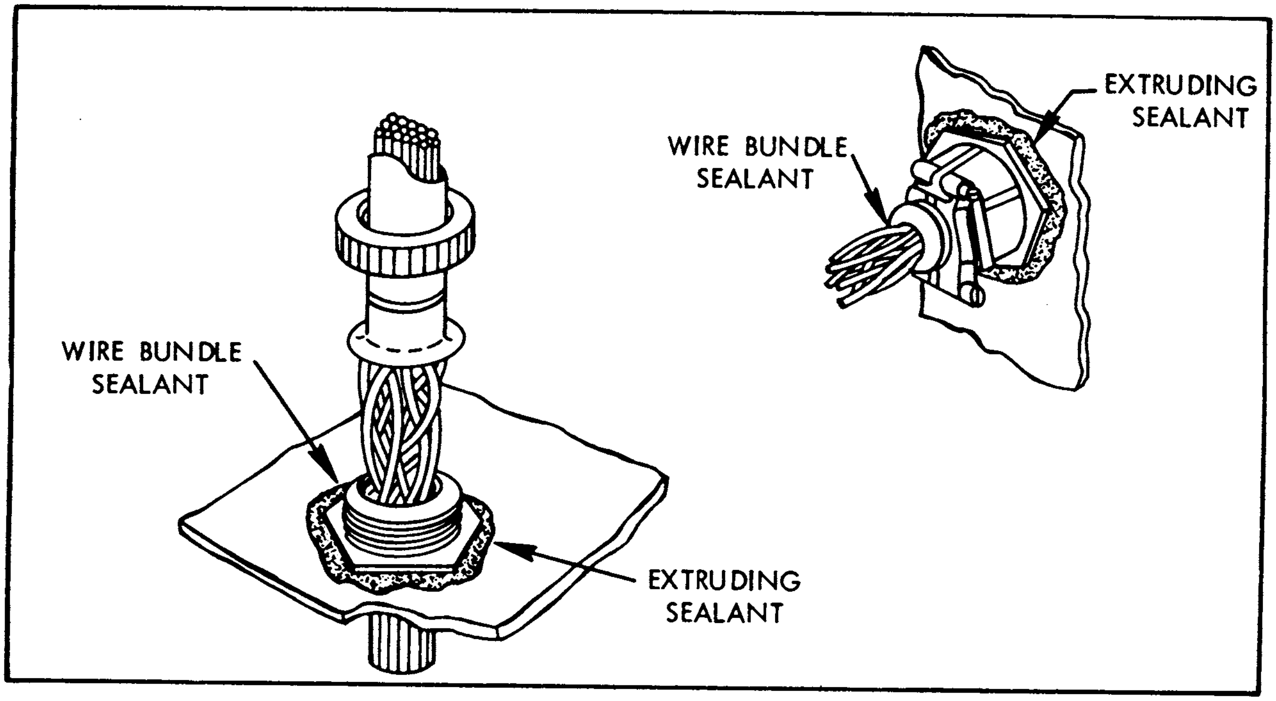


FIGURE 13.2 Fair-lead feed through.

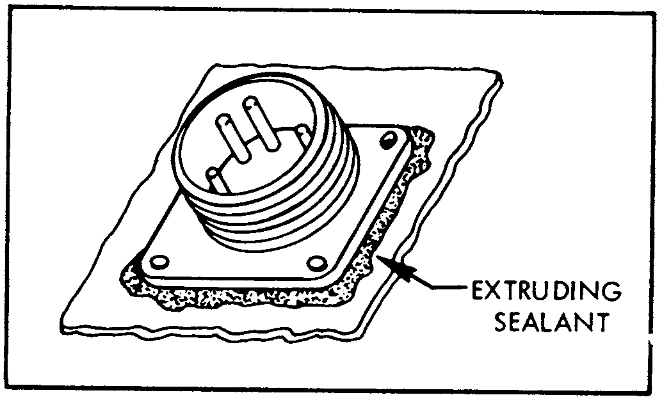


FIGURE 13.3 Typical connector.

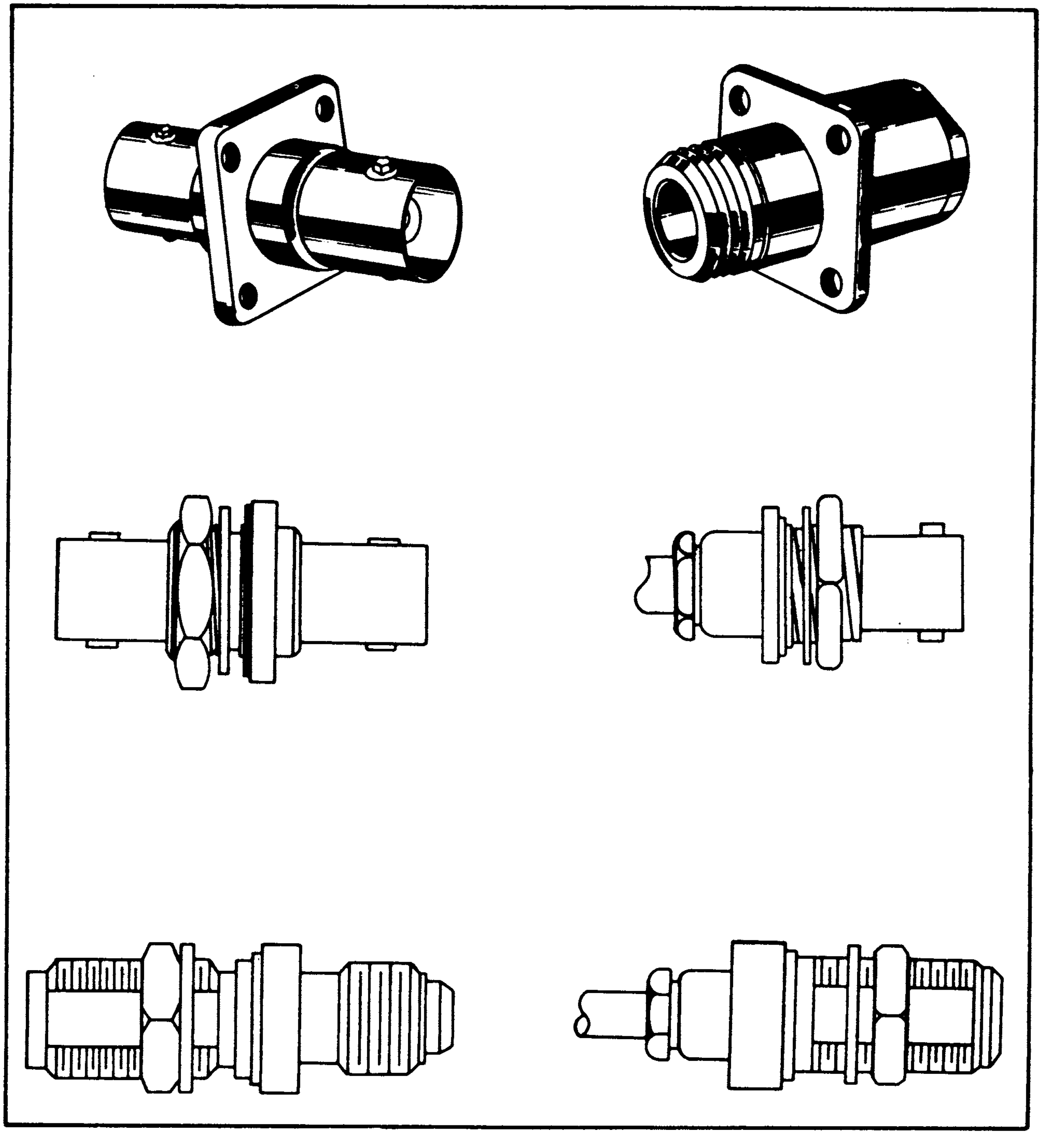


FIGURE 13.4 Coaxial connectors.

Appendix 1

CROSS REFERENCE TABLE OF PARAGRAPH NUMBER CHANGES FROM AC 43.13–2 DATED 1965

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1	1
2	2
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6	6
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10	10
11	11
12	12
13–20 [Reserved]	13–20 [Reserved]
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	29–35 [Reserved]
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45	55
46	56
47–50 [Reserved]	57–60 [Reserved]
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52	62
53	63
54	64
	65 [Reserved]
55	66
56	67
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58	69
	70 [Reserved]
59	71
60	72
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62	74
63	75
	76–78 [Reserved]
64	79
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66	81
67–70 [Reserved]	82–85 [Reserved]
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72	87
73	88
74	89
75	90
76	91
77–80 [Reserved]	92–95 [Reserved]
81	96
82	97
83	98
84	99
85	100
86	101
87	102
88	103
89	104
90	105
91	106
	107–110 [Reserved]
92	111
93	112
94	113
95	114
96–100 [Reserved]	115–120 [Reserved]
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103	123
	124–125 [Reserved]
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Former Paragraph	Revised Paragraph
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	152–155 [Reserved]
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	159–160 [Reserved]
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	168–170 [Reserved]
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166–180 [Reserved]	204
	205
	206
	207–210 [Reserved]
181	211
182	212
183	213
184	214
185–199 [Reserved]	215–240 [Reserved]
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CHANGE 1

DATE 6/1/79

ADVISORY CIRCULAR

CHANGE

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

FAR GUIDANCE MATERIAL

Subject: **ACCEPTABLE METHODS, TECHNIQUES AND PRACTICES—AIRCRAFT ALTERATIONS**—Towline Information

1. **PURPOSE.** This change transmits revised material for Advisory Circular 43.13-2A. Changed material is indicated by asterisks, and the change number and date are carried at the top of each page.

2. **PRINCIPAL CHANGES.** This change deletes operational practices from Chapter 8, section 1, dealing with towplane performance considerations. The change also deletes paragraph 133 dealing with towlines. This information is not pertinent to this publication since it is primarily an operational consideration and not germane to altering of aircraft. The change also clarifies the placarding limits of the towline in terms of the maximum breaking strength of the towrope to be used. The old procedure was to limit the weight of gliders to be towed.

Page Control Chart

Remove Pages	Dated	Insert Pages	Dated
III-VI	Rev. 77	III	6/1/79
		IV-V	Rev. 77
		VI	6/1/79
57-60	Rev. 77	57-60	6/1/79

James M. Vines

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Acting Director
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Initiated by: AFS-830

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U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: ACCEPTABLE METHODS,
TECHNIQUES, AND PRACTICES --
AIRCRAFT ALTERATIONS

Date: 10/30/89
Initiated by: AFS-340

AC No: AC 43.13-2A
Change: 2

1. PURPOSE. This Change corrects an editing error in issuance of "Change 1."

The Change number and date of the changed material are carried at the top of the page. Pages having no changes retain the same heading information.

2. PRINCIPAL CHANGES. Change 1, dated June 1, 1979, deleted paragraph 133. Paragraph 133 continued onto page 61, but this page was inadvertently left out in the page control chart to be removed. Therefore, this change corrects that error.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
61	Rev. 1977	61	10/30/89
62	Rev. 1977	62	Rev. 1977

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