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 @ KVc)	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°

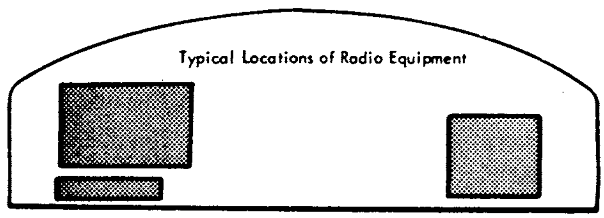
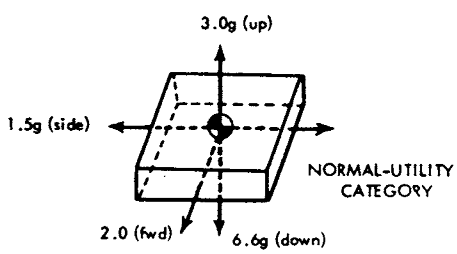


FIGURE 2.1.—Typical radio installations in stationary instrument panels.



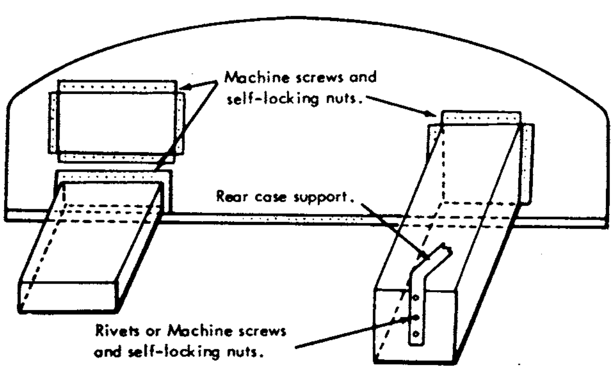


FIGURE 2.2.—Typical panel mount.

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.

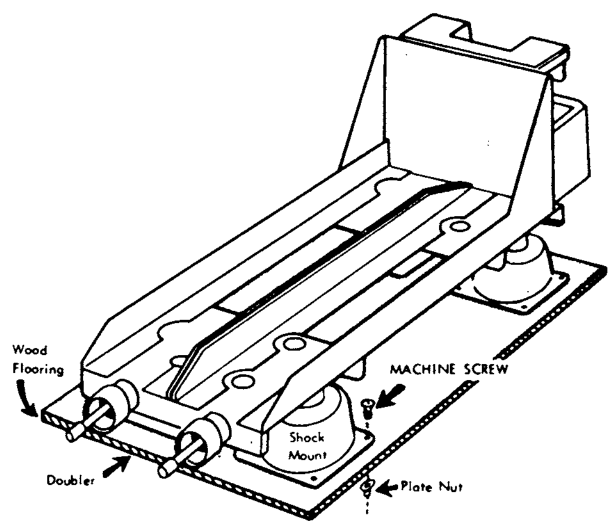


FIGURE 2.3.—Typical shockmounted base.

(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.

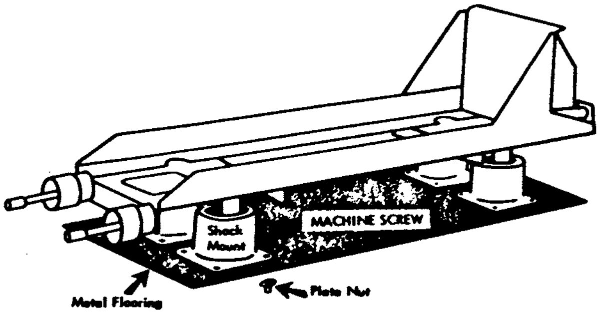


FIGURE 2.4.—Typical shockmounted base.

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.

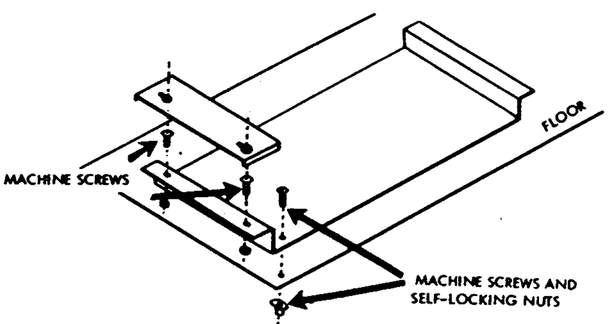


FIGURE 2.5.—Typical rigid baseplate mount.

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.

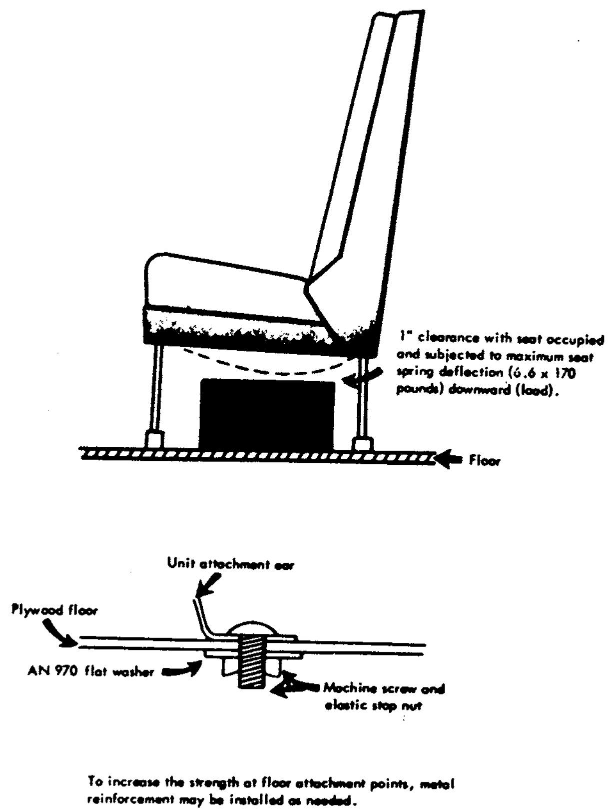


FIGURE 2.6.—Typical underseat installation.

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.

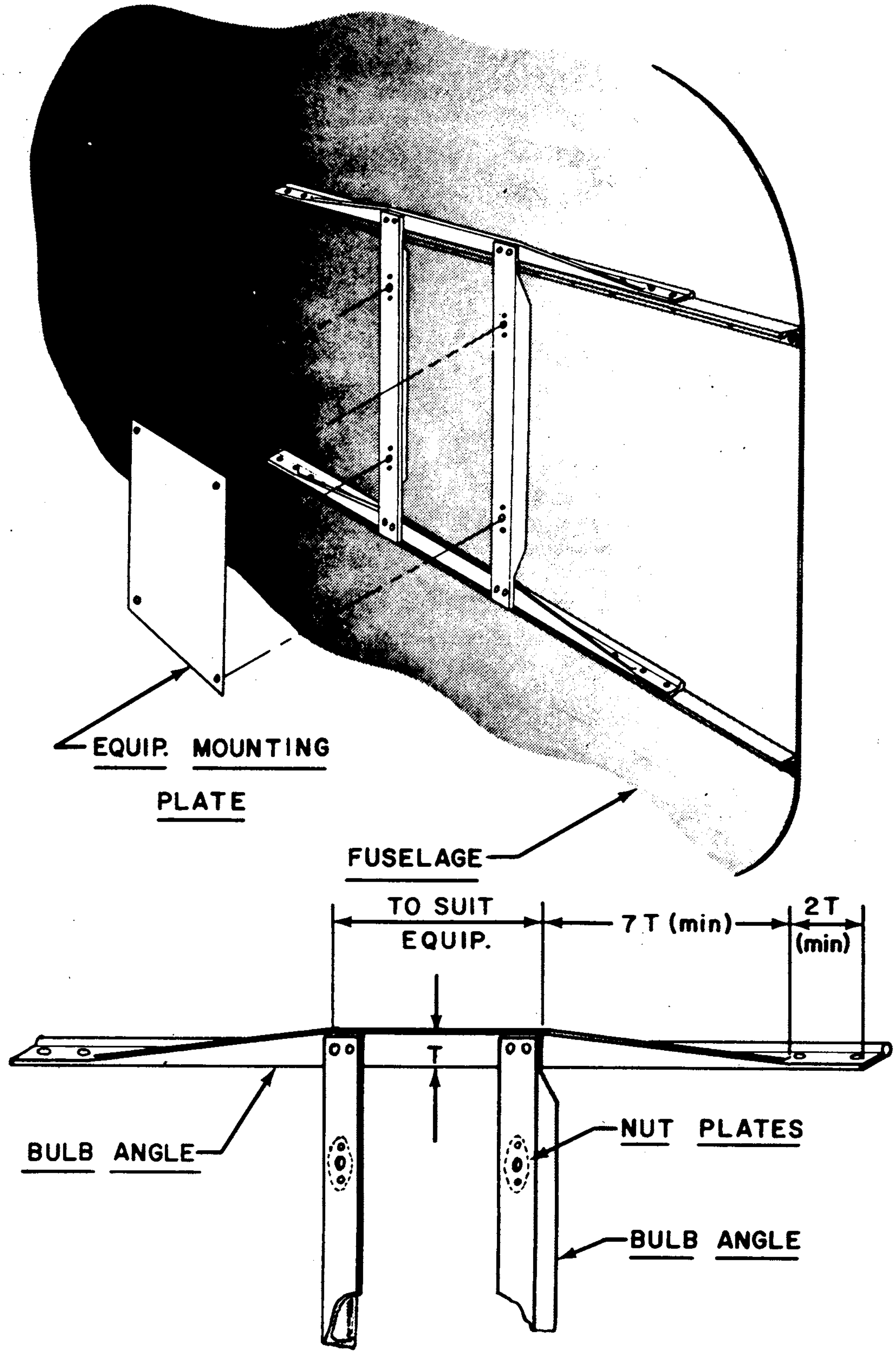
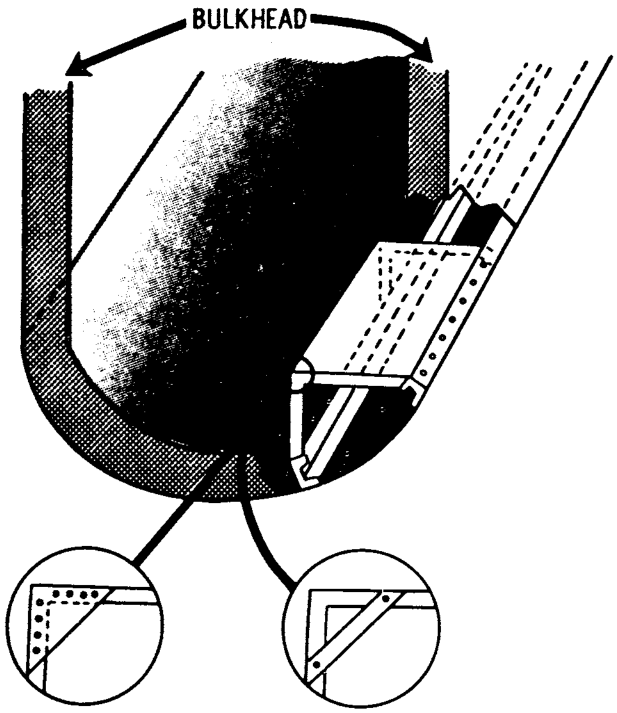


FIGURE 2.7.—Typical remote unit mounting base—vertical or horizontal.



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.

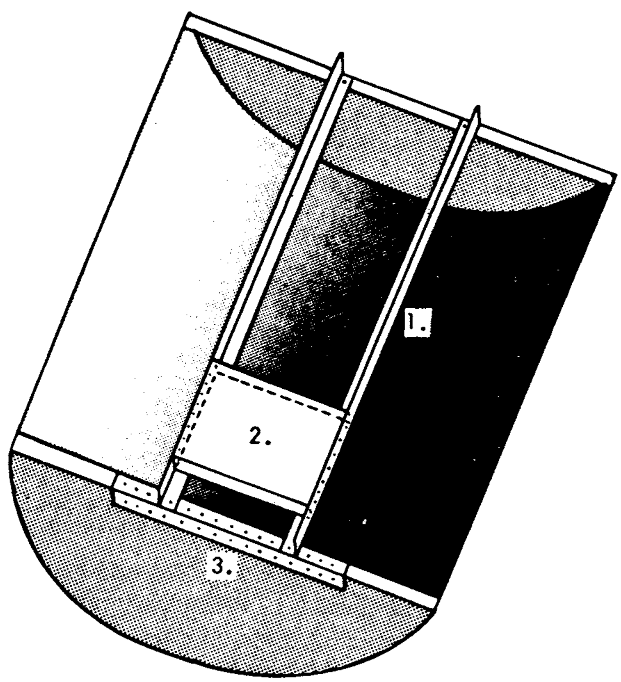
(1) Incorporate a "trip free" resettable type circuit breaker or a fuse in the power supply from the bus. Mount in a manner accessible to a crewmember during flight for circuit breaker resetting or fuse replacement.

(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.

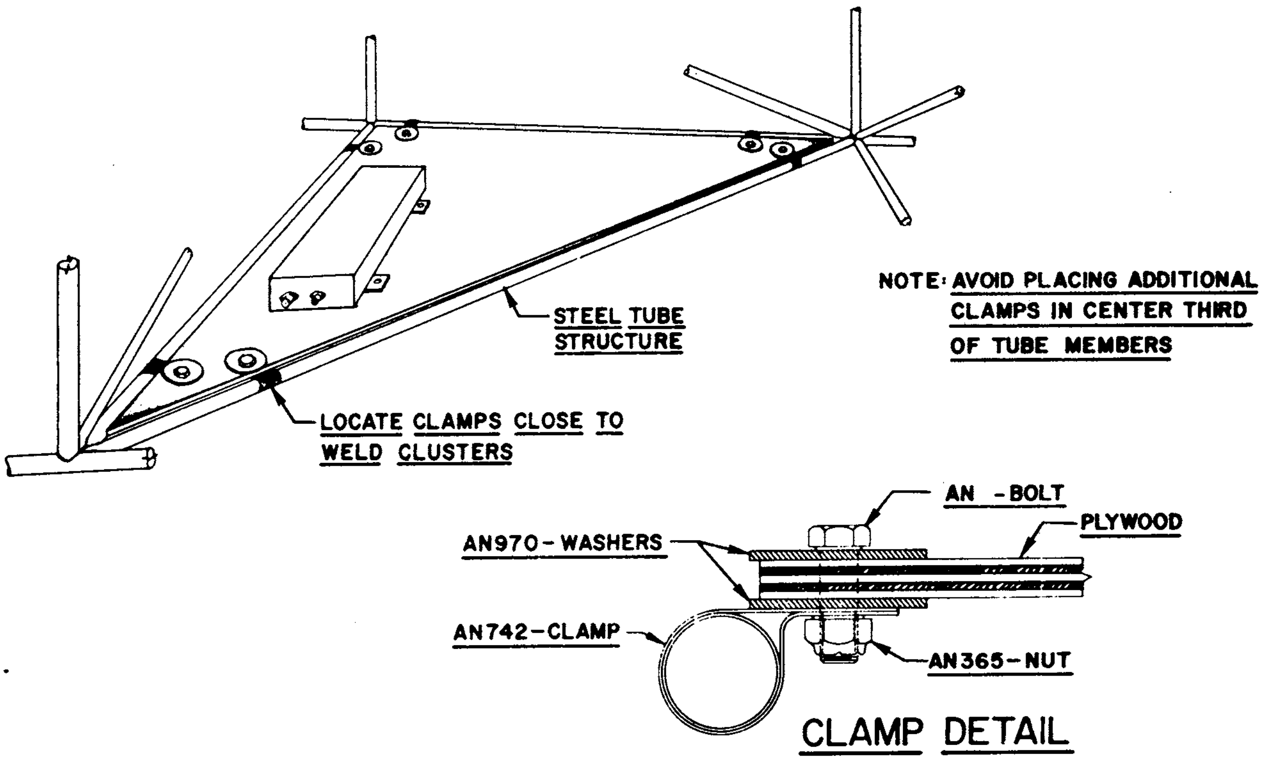


FIGURE 2.10.—Typical attachment of support structure to tubular frame.

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.

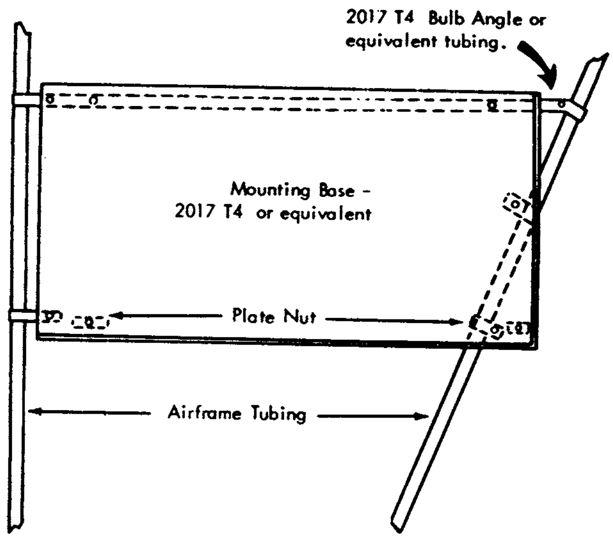


FIGURE 2.11.—Typical mounting plates for remote location of radio units.

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.

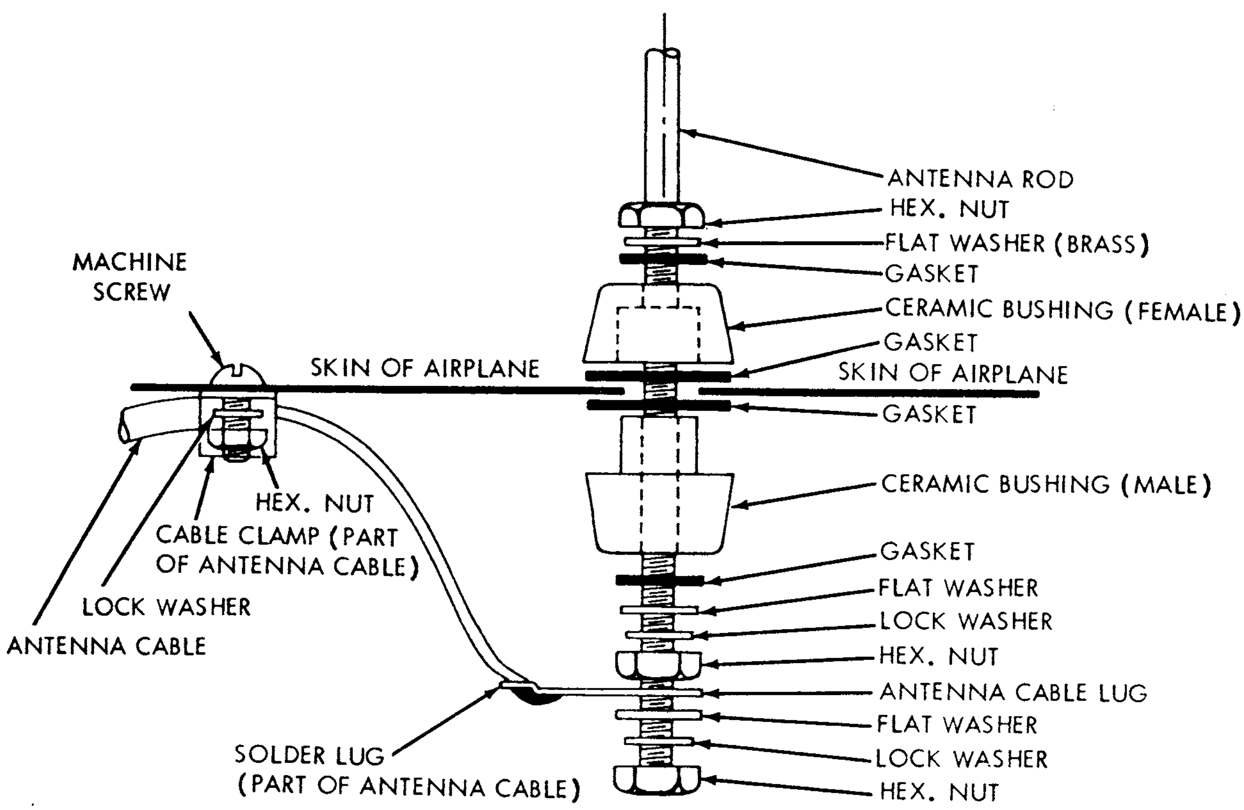
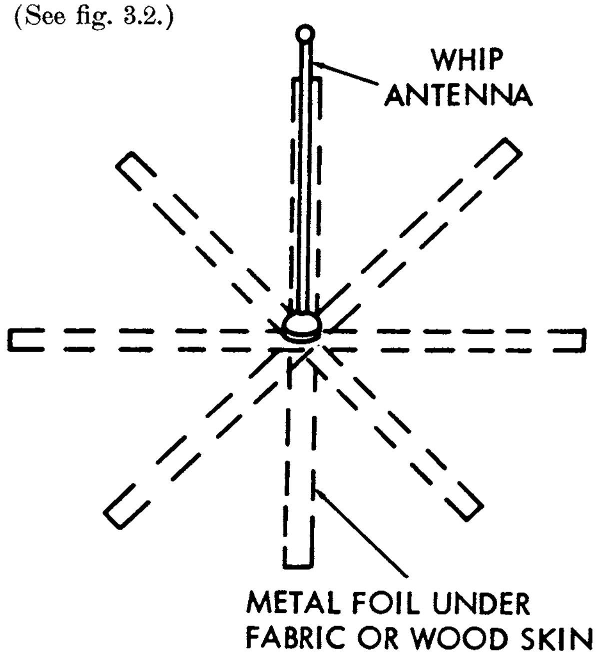


FIGURE 3.1.—Typical whip antenna installation.

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.

$$D = .000327 \times .135 \times (250)^2$$
$$= .000327 \times .135 \times 62{,}500$$
$$= 2.75 \text{ lbs.}$$

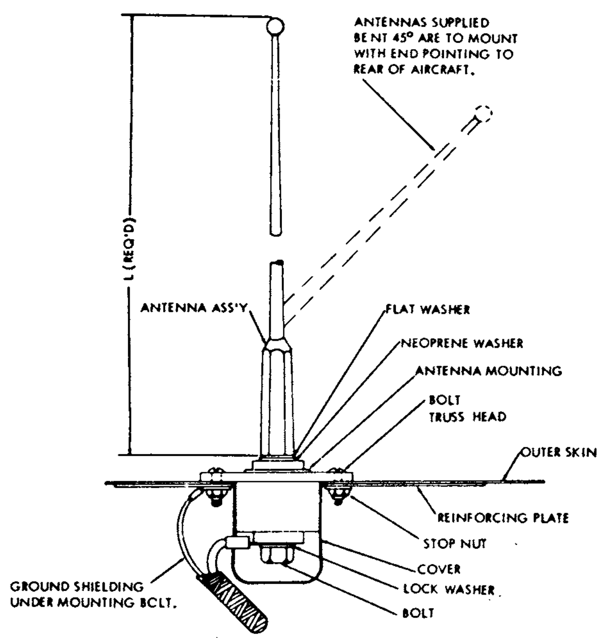


FIGURE 3.3.—Typical shockmounted antenna installation.

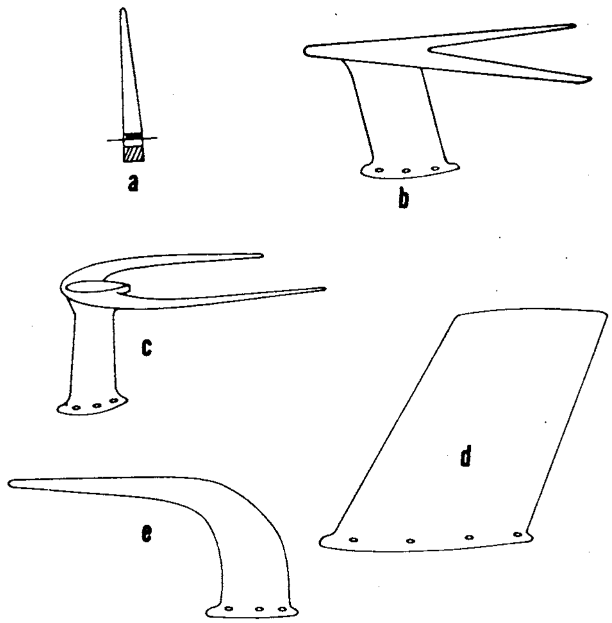


FIGURE 3.4.—Typical rigid antennas.

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.

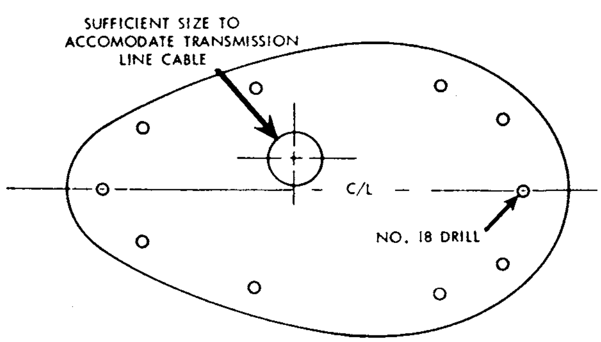


FIGURE 3.5.—Typical antenna mounting template.

(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

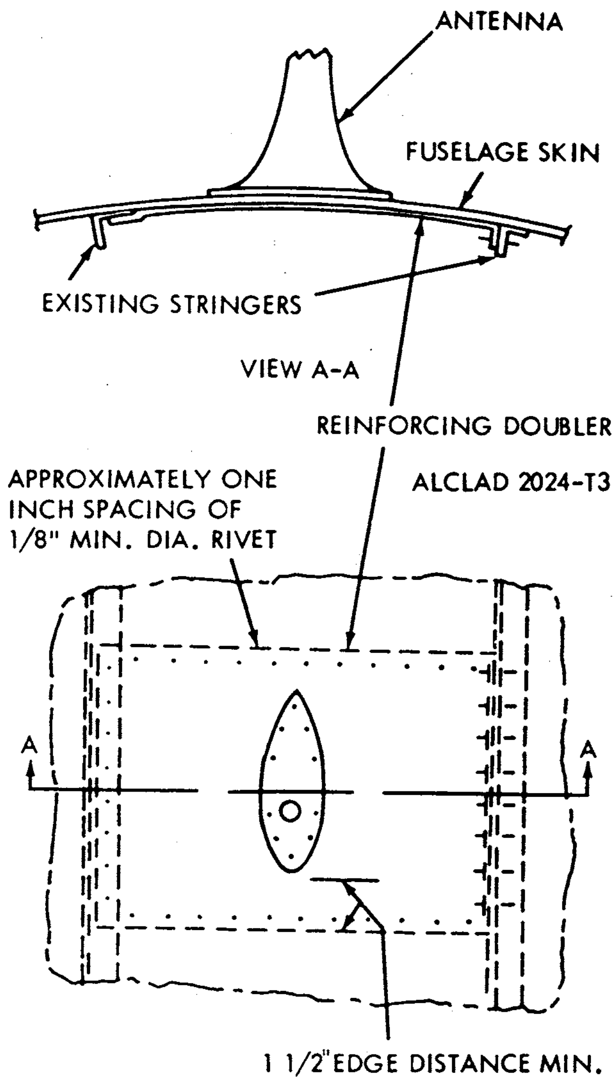


FIGURE 3.6.—Typical antenna installation on a skin panel.

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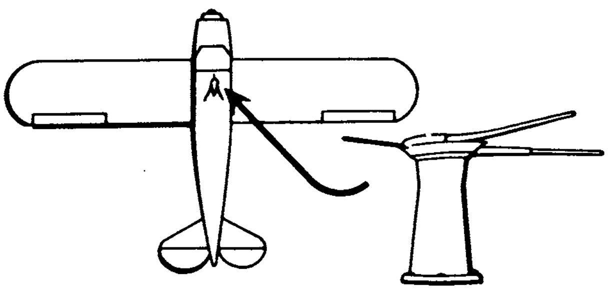


FIGURE 3.7.—Preferred VOR antenna location for maximum signal pickup with minimum ignition interference.

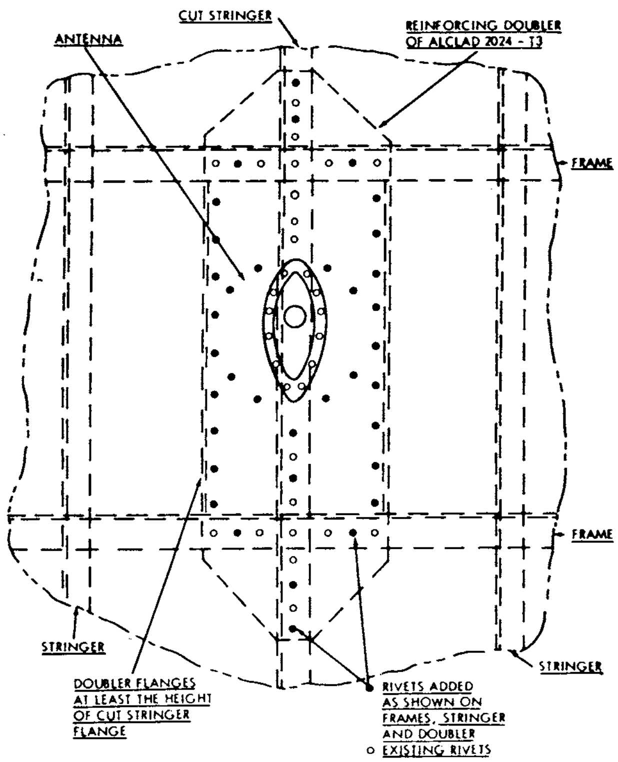


FIGURE 3.8.—Typical antenna installation involving a cut stringer.

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.

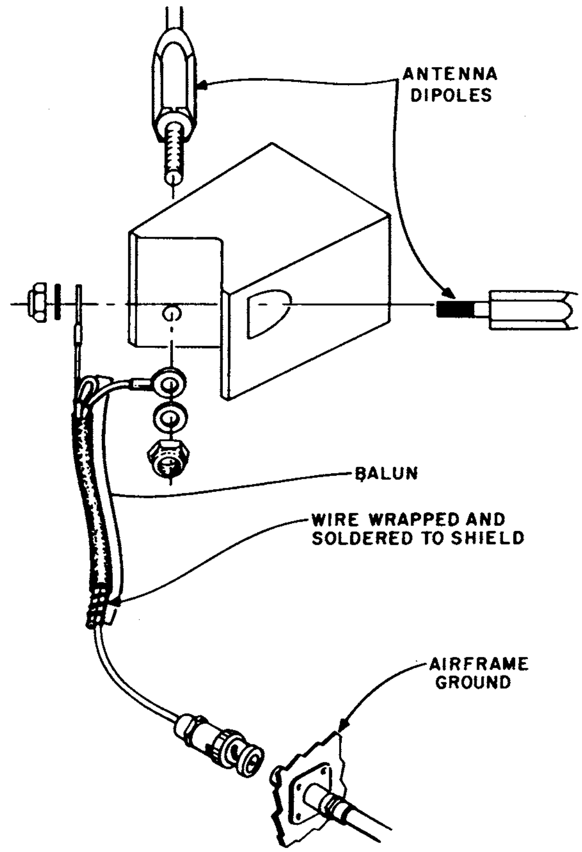


FIGURE 3.9 Typical dipole antenna assembly.

(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.

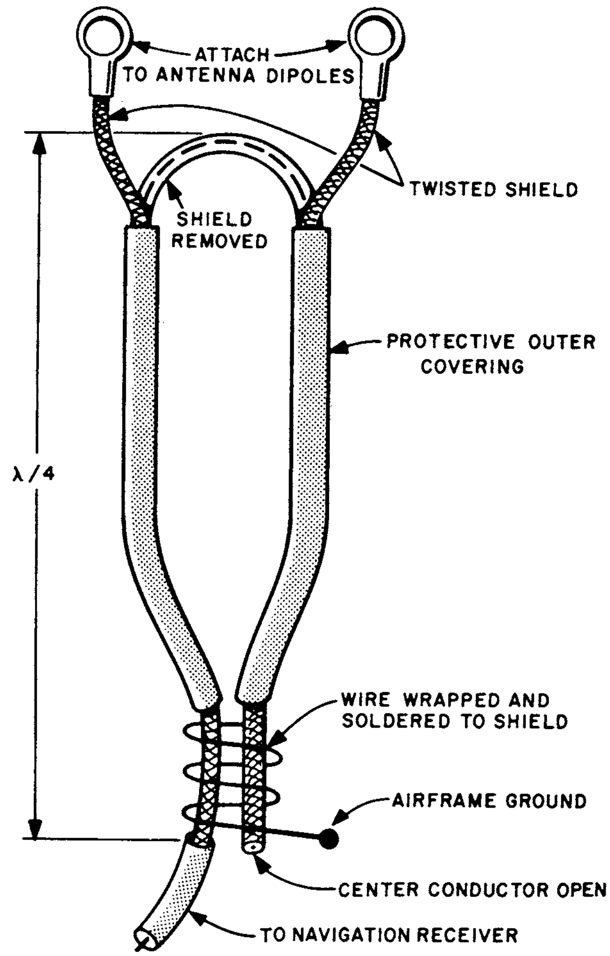


FIGURE 3.10 Typical VOR antenna balun.

(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.

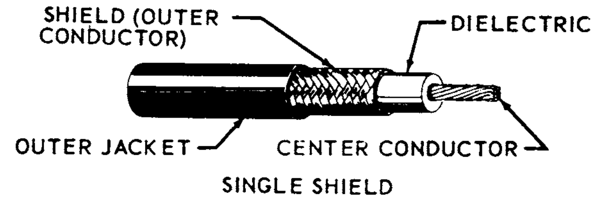


FIGURE 3.11 Coaxial cable preparation.

(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.

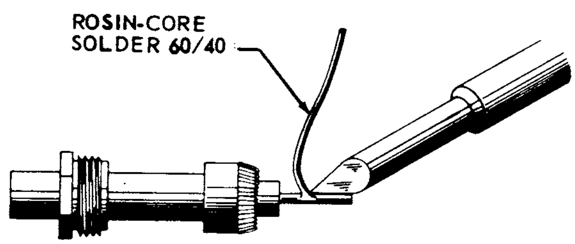


FIGURE 3.12 Coaxial cable tinning center lead.

(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.

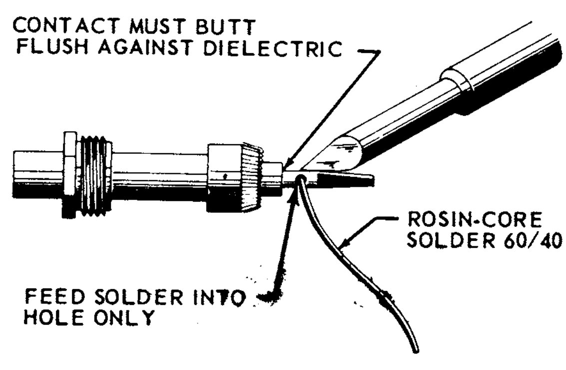


FIGURE 3.13 Coaxial cable soldering center lead.

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

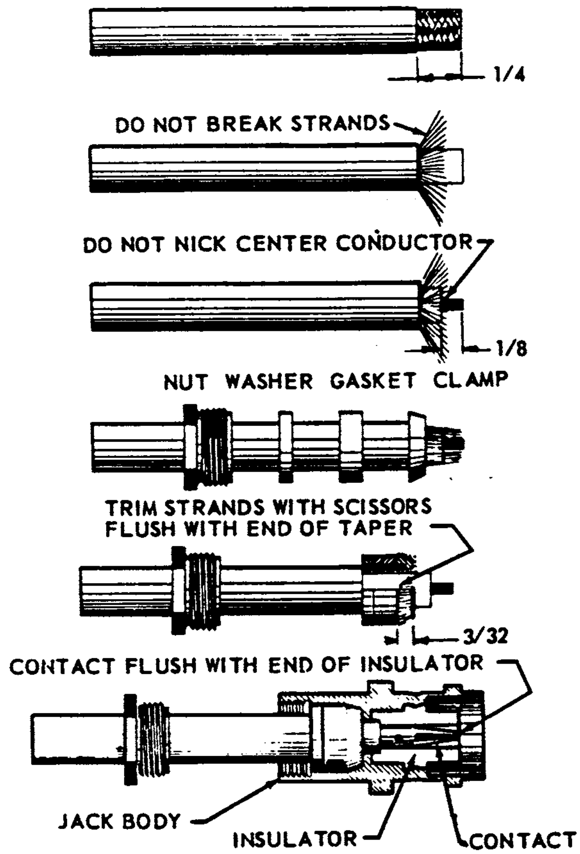
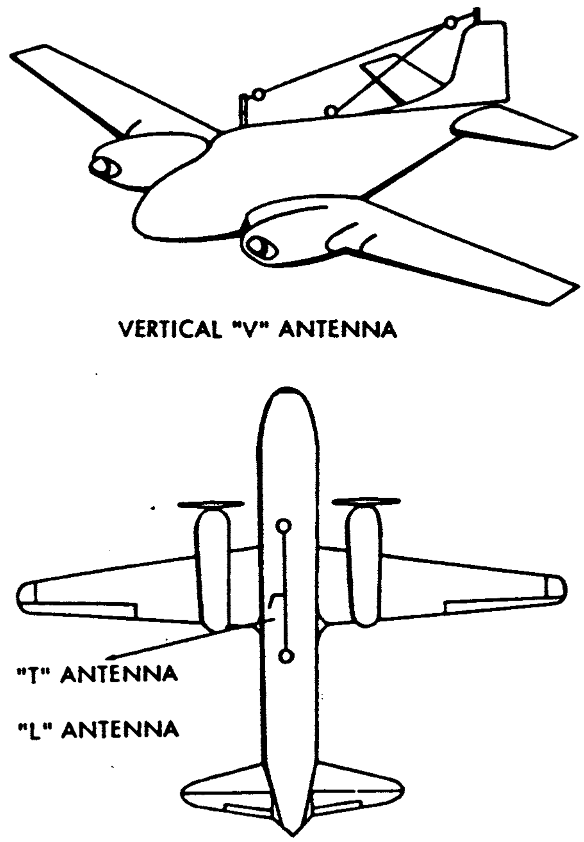


FIGURE 3.14 Coaxial cable install connector body.

(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-



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.

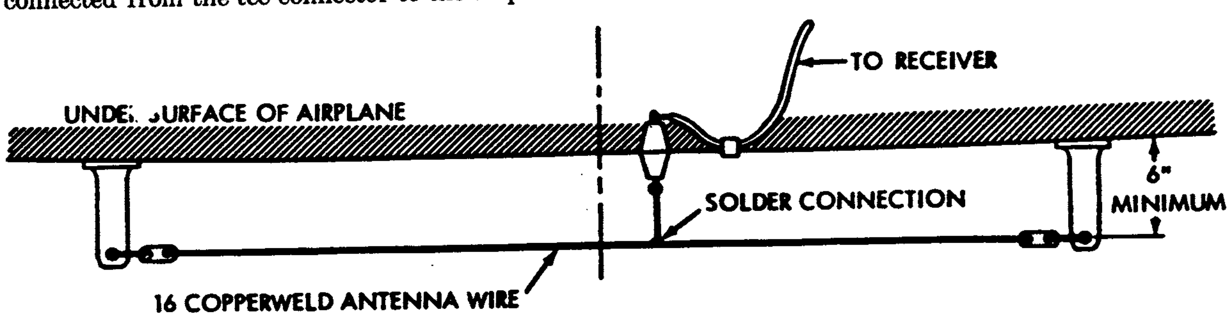


FIGURE 3.16.—Typical marker beacon receiving antenna.

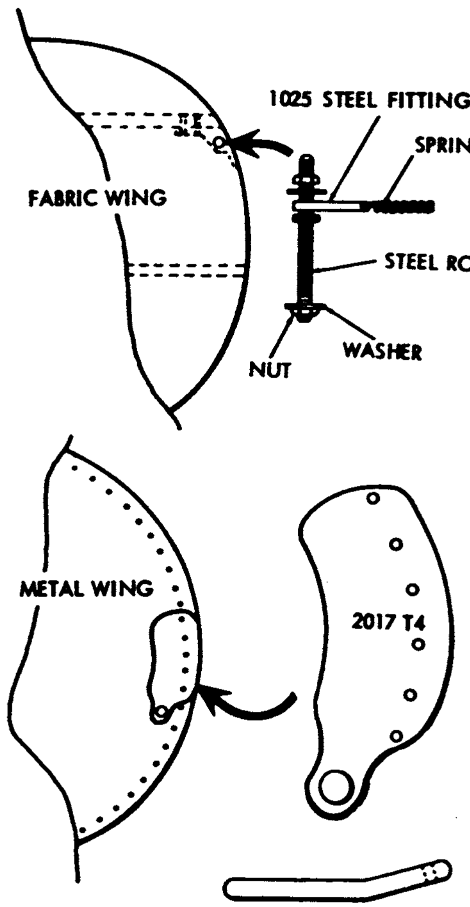


FIGURE 3.17.—Typical wing tip installations.

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.

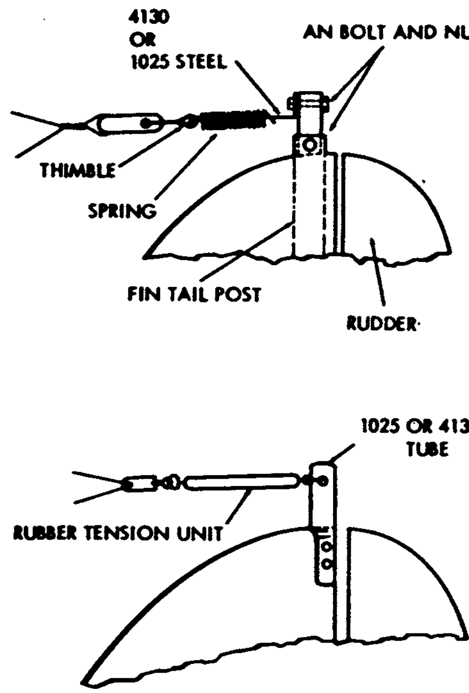


FIGURE 3.18.—Typical fin tip installations.

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-

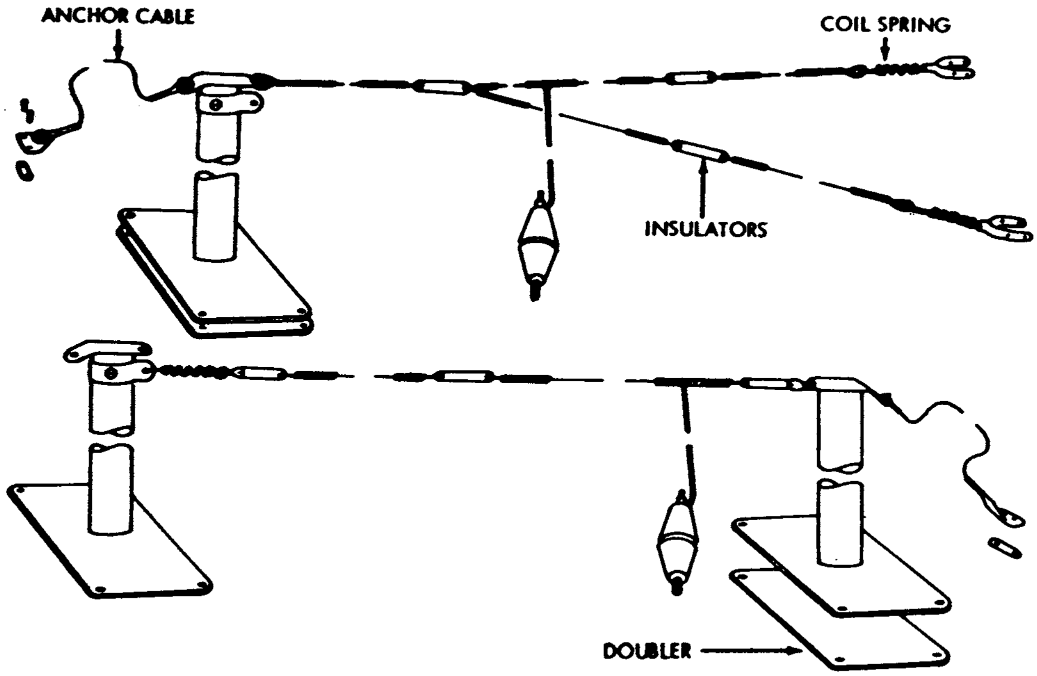


FIGURE 3.19.—Typical wire antenna installations.

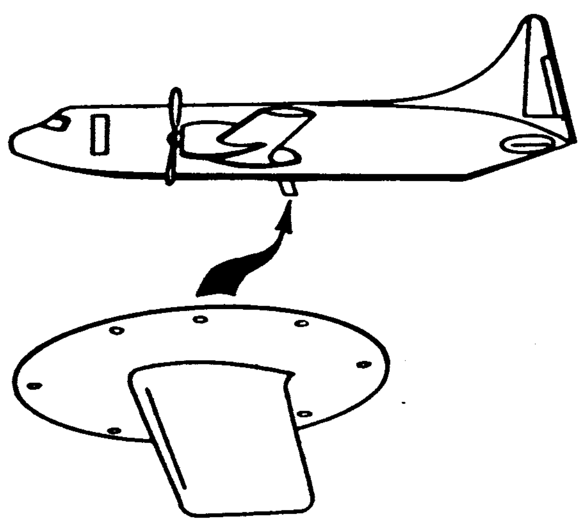


FIGURE 3.20.—Preferred position for distance measuring and/or ATC radar beacon antennas.

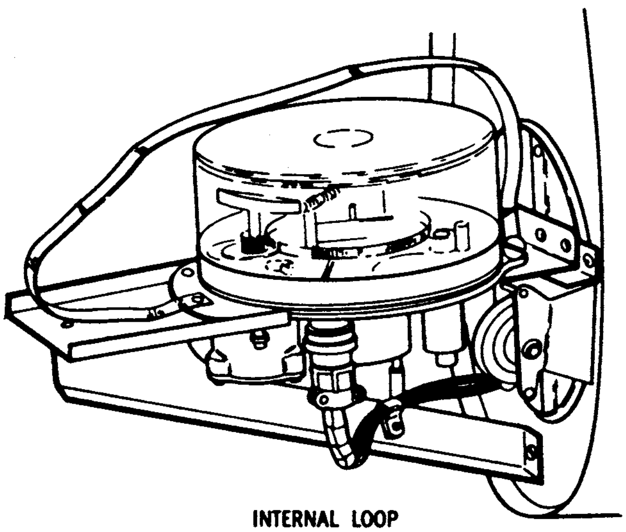
tions from the center of the antenna. Be sure the antenna makes a good, direct electrical connection with the ground plane. Install gaskets, pressurization seals, and/or sealant as required.

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.)

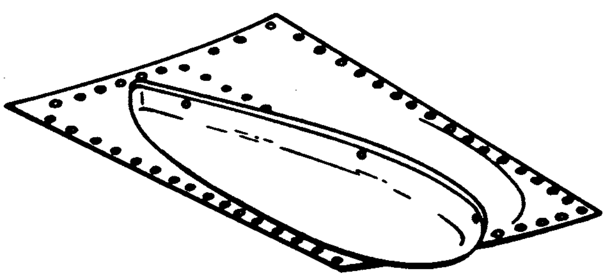
c. *Antenna Cable*. Route the antenna cable in the most direct path practicable. Since losses can be relatively high at these frequencies, follow the equipment manufacturer's recommendations regarding transmission lines and lengths.

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 1/32-inch is obtained. (See fig. 3.22 and 3.23.)

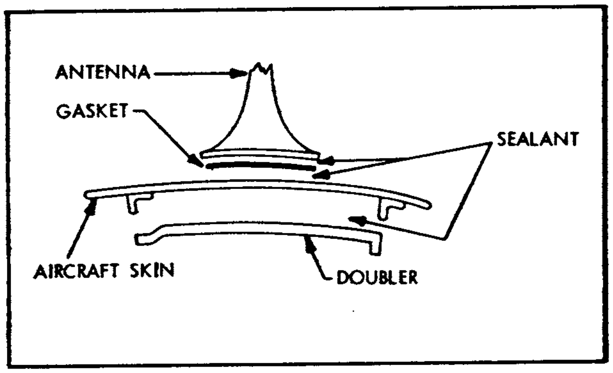


FIGURE 3.22.—Typical antenna installation.

(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.

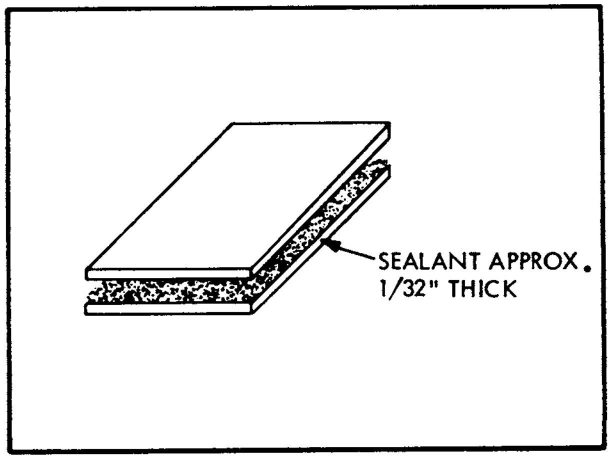


FIGURE 3.23.—Faying surface sealing.

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.

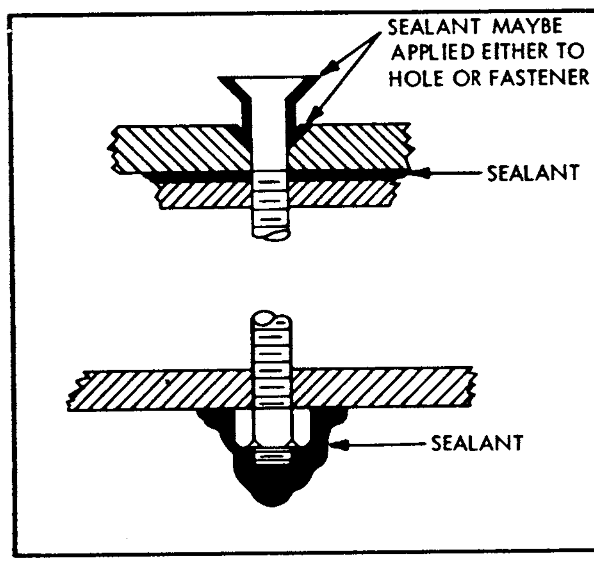


FIGURE 3.24.—Fastener sealing.

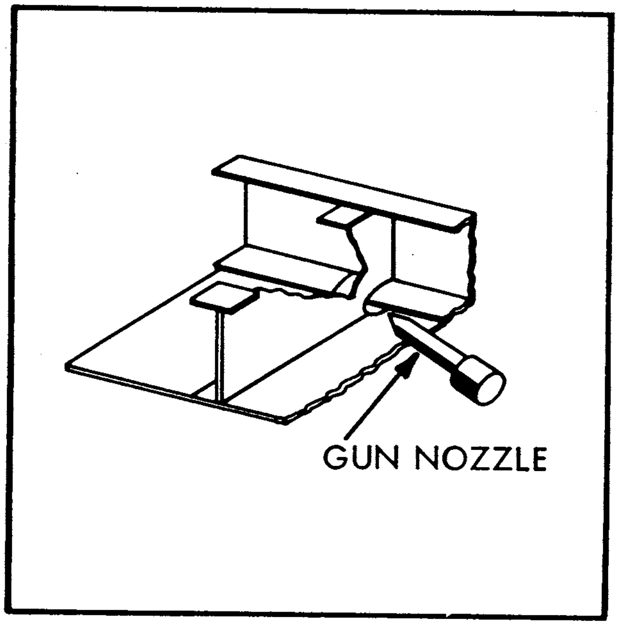


FIGURE 3.25.—Injection sealing.

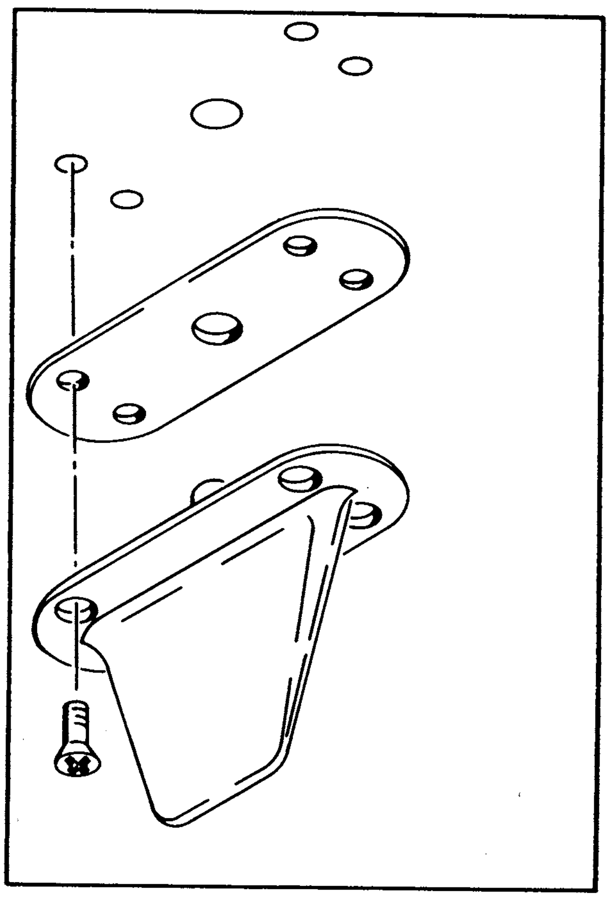


FIGURE 3.26.—Blade antenna installation.

(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.

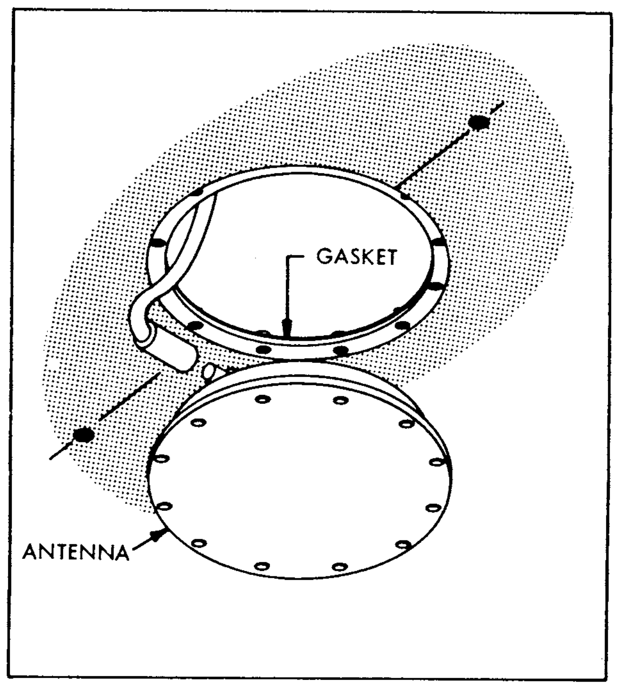


FIGURE 3.27.—ATC flush mounted antenna.

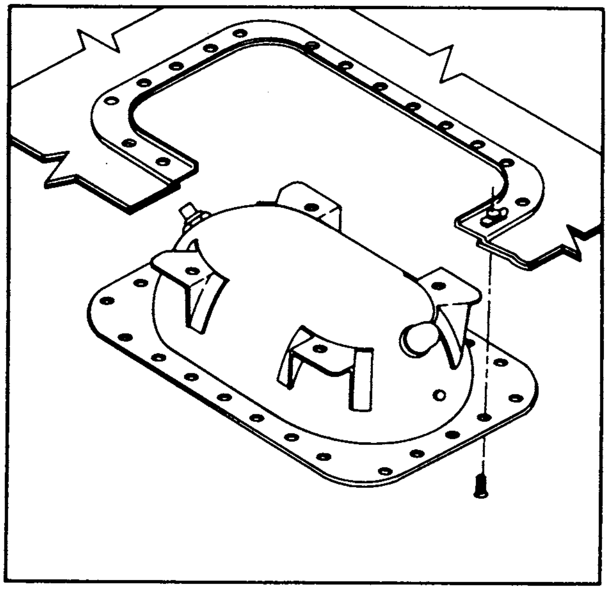


FIGURE 3.28.—Marker beacon flush mounted antenna.

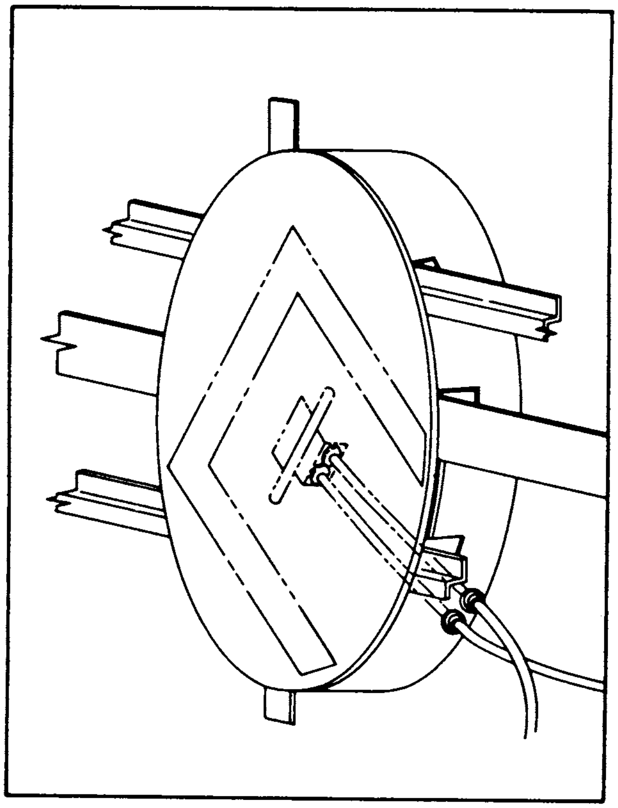


FIGURE 3.29.—VOR flush mounted antenna.

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.)

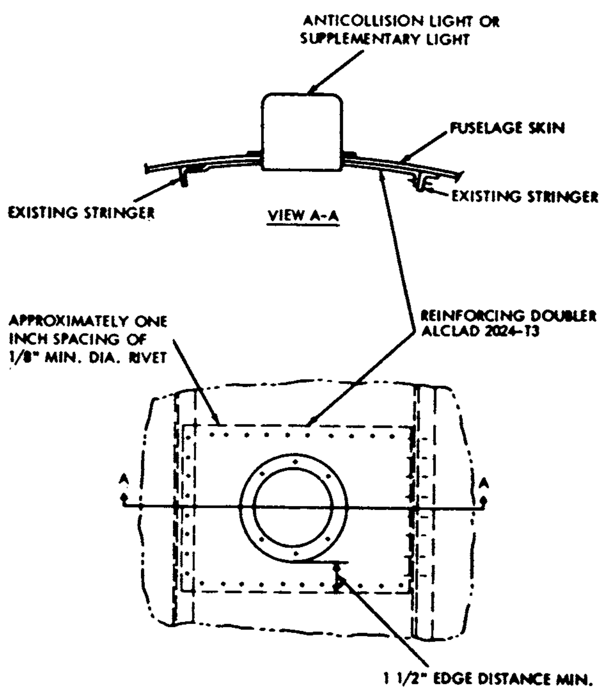


FIGURE 4.1.—Typical anticollision or supplementary light installation in a skin panel (unpressurized).

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.)

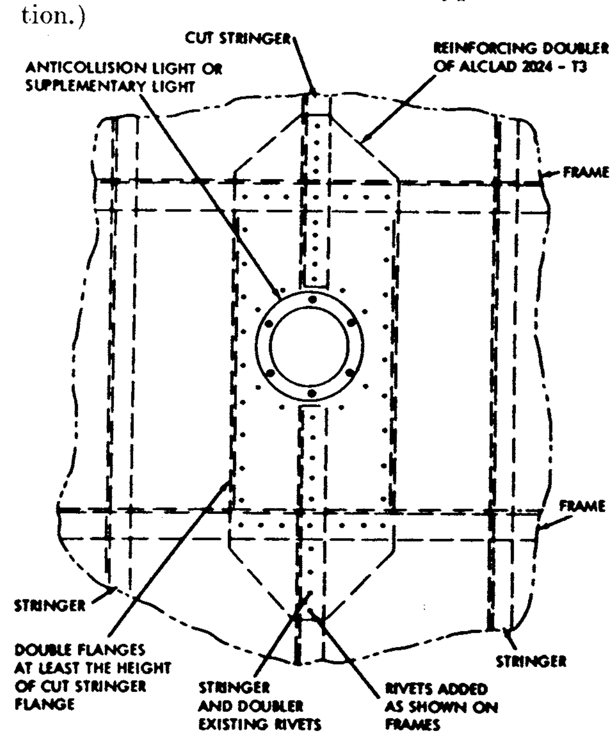


FIGURE 4.2.—Typical anticollision or supplementary light installation involving a cut stringer (unpressurized).

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

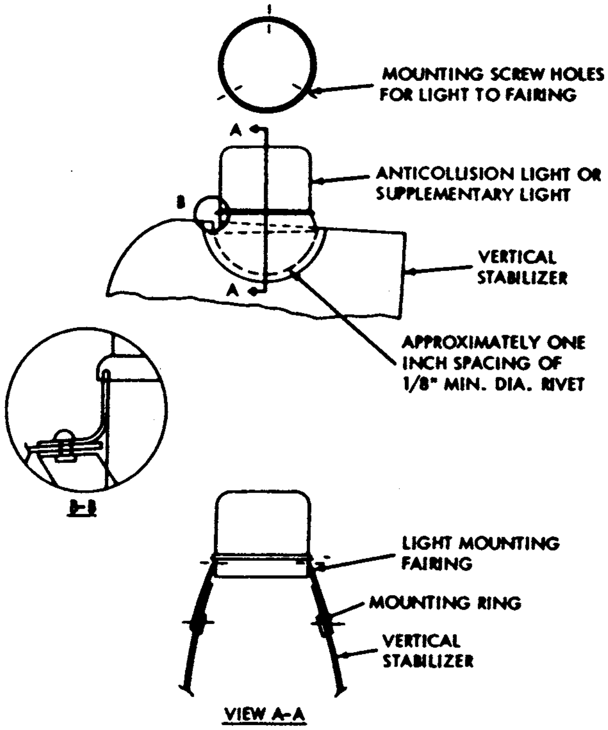


FIGURE 4.3.—Typical anticollision or supplementary light installation in a fin tip.

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.

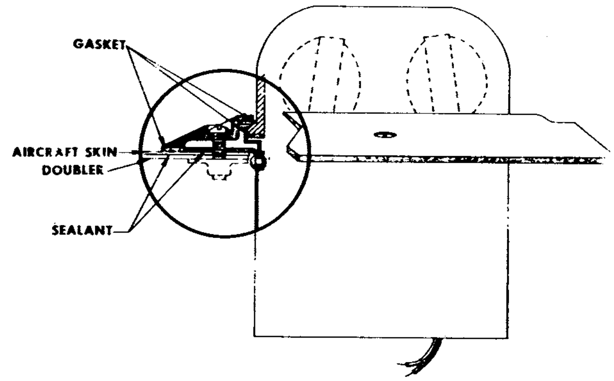


FIGURE 4.4.—Typical rotating type anticollision light installation for pressurized aircraft.

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.

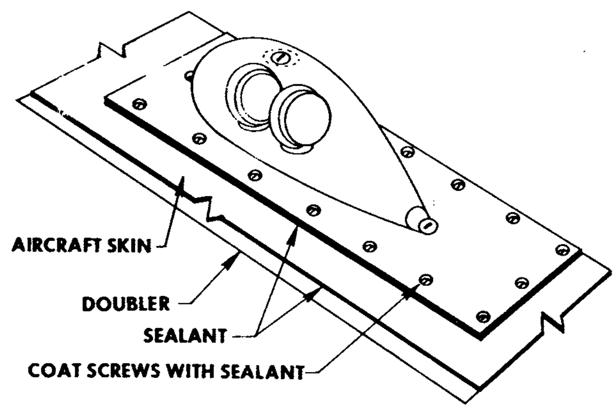


FIGURE 4.5.—Typical oscillating type anticollision light installation for pressurized aircraft.

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.

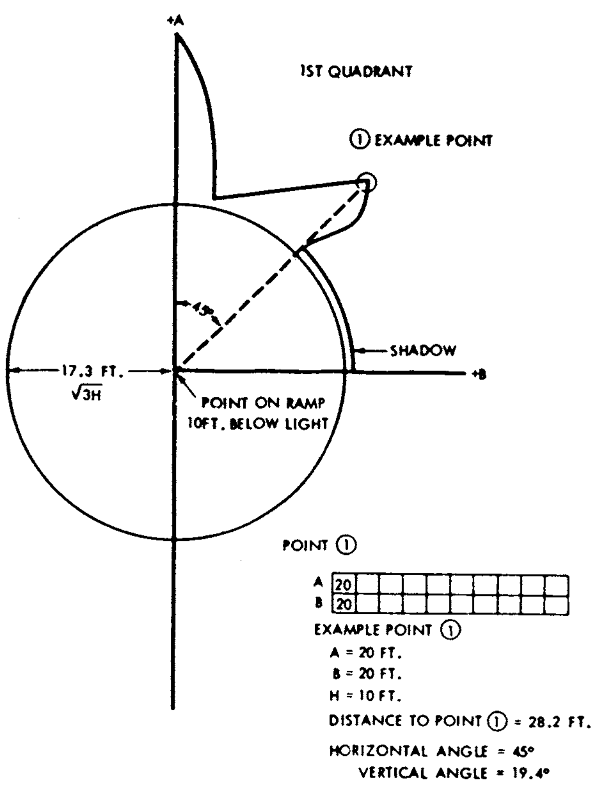


FIGURE 4.6.—Ramp shadow pattern.

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.

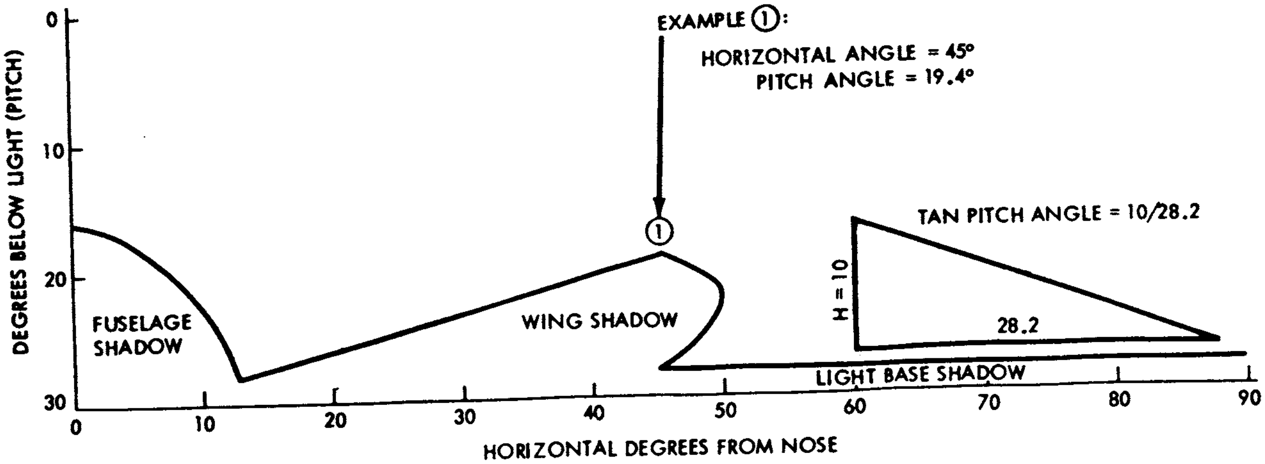


FIGURE 4.7.—Conversion to vertical vs. horizontal degrees.

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

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

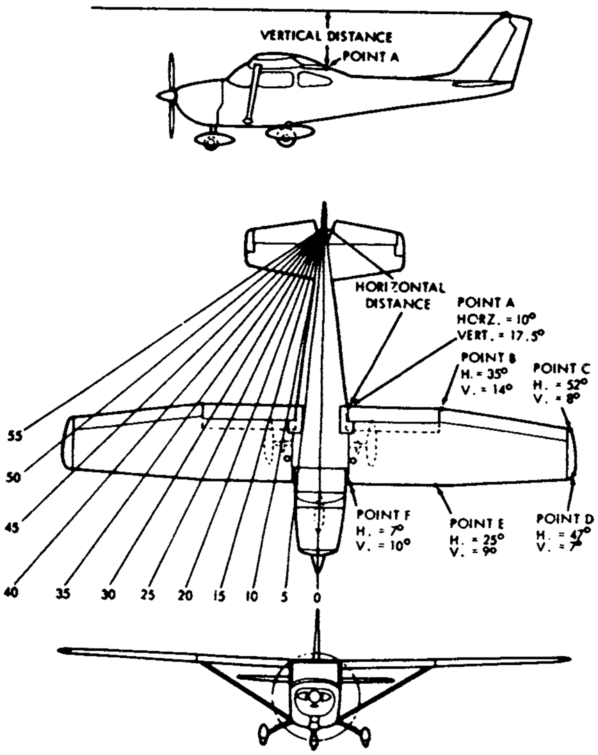


FIGURE 4.9.—Scale drawings.

(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.

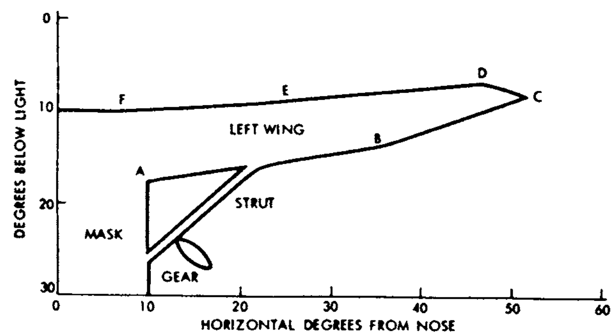


FIGURE 4.10.—Solid angle blockage—1st quadrant.

57.–60. [RESERVED]

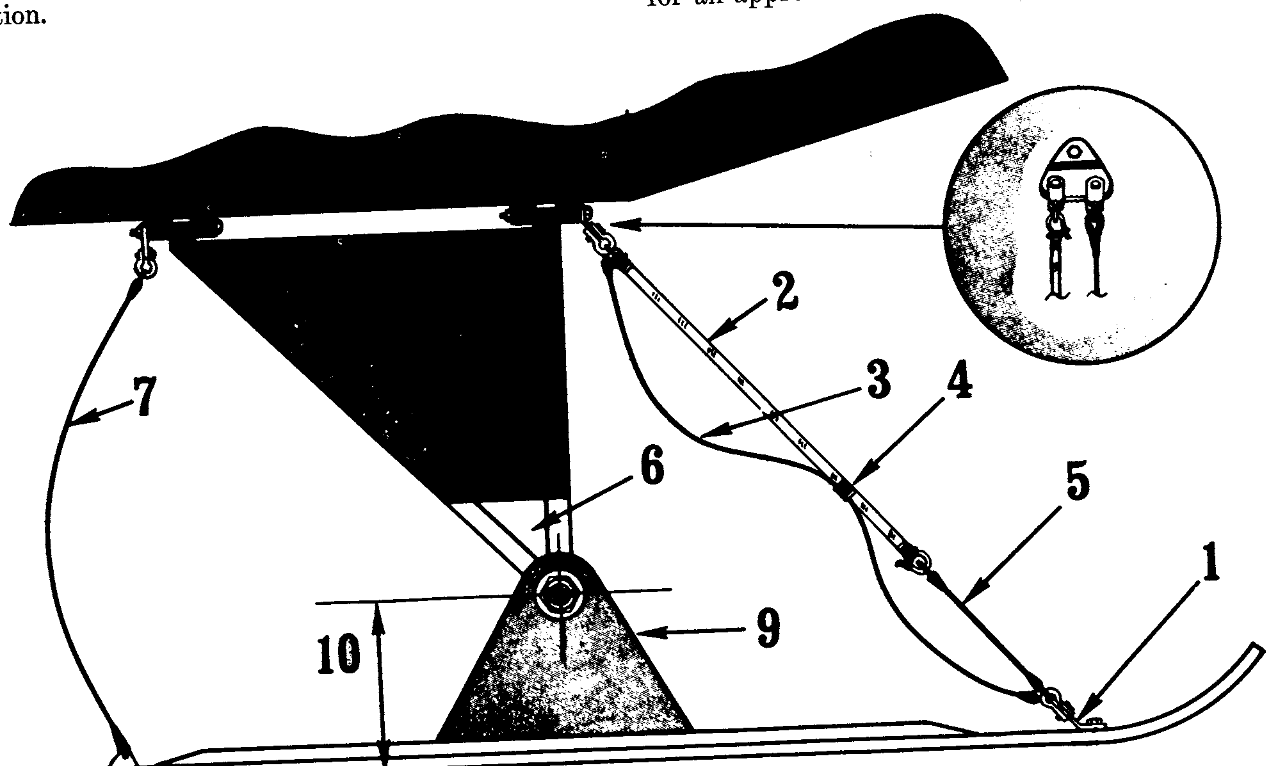
Chapter 5. SKI INSTALLATIONS

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:

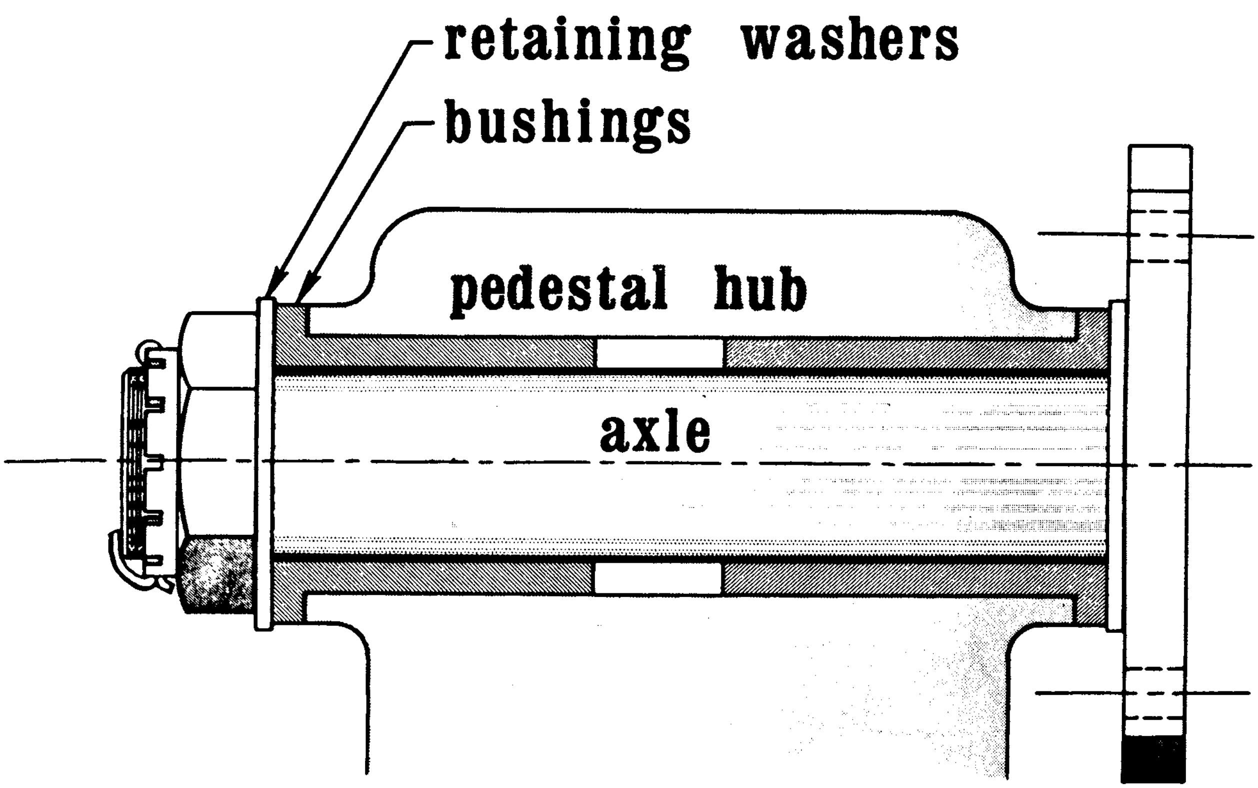


FIGURE 5.2.—Typical hub installation.

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.

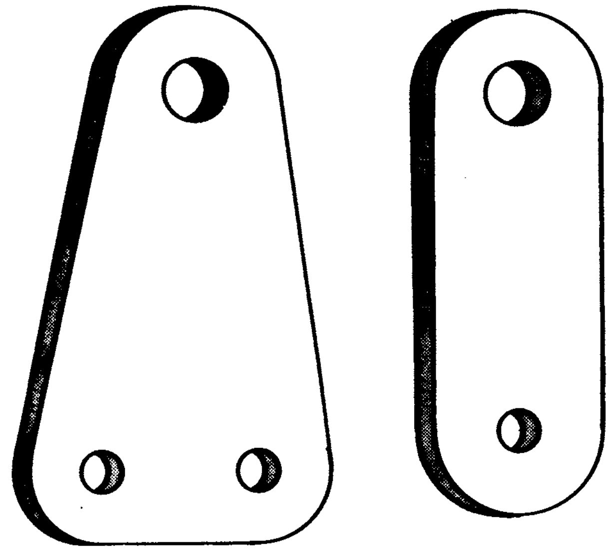


FIGURE 5.3.—Typical fuselage fitting.

(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

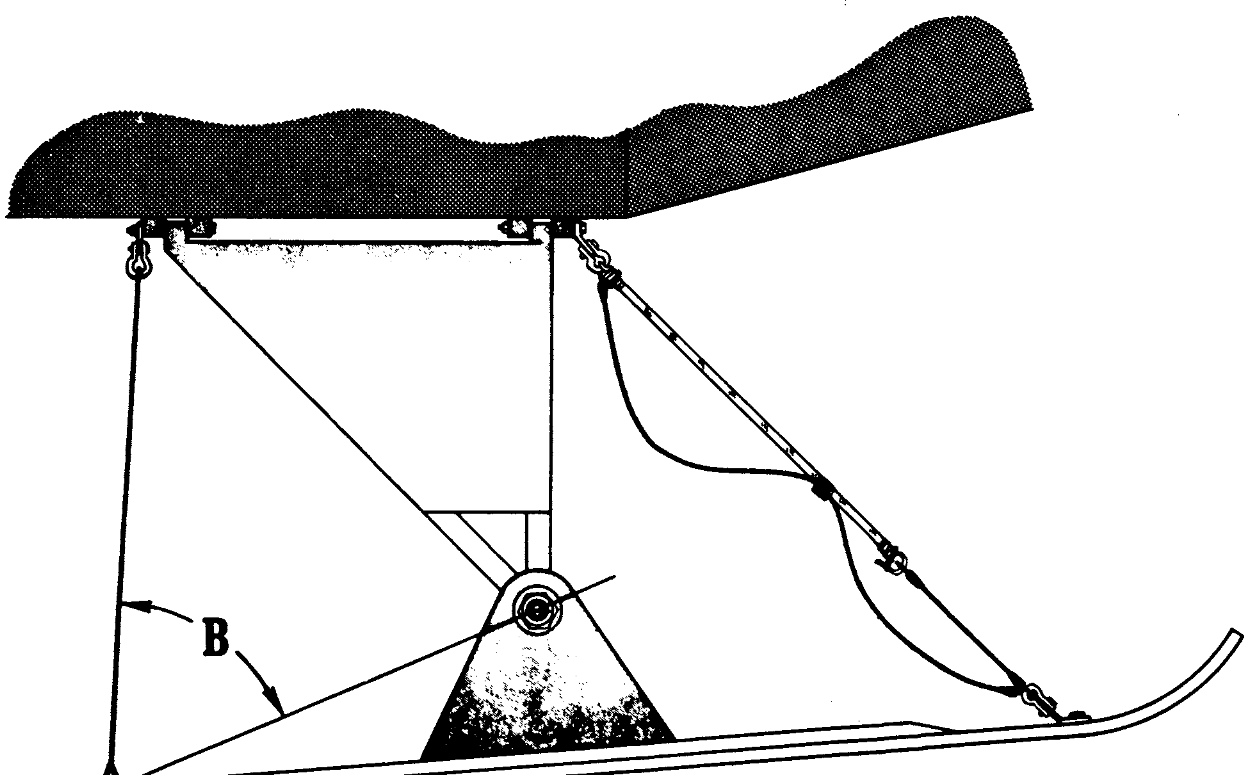


FIGURE 5.4.—Main ski at maximum positive incidence (check cable tight).

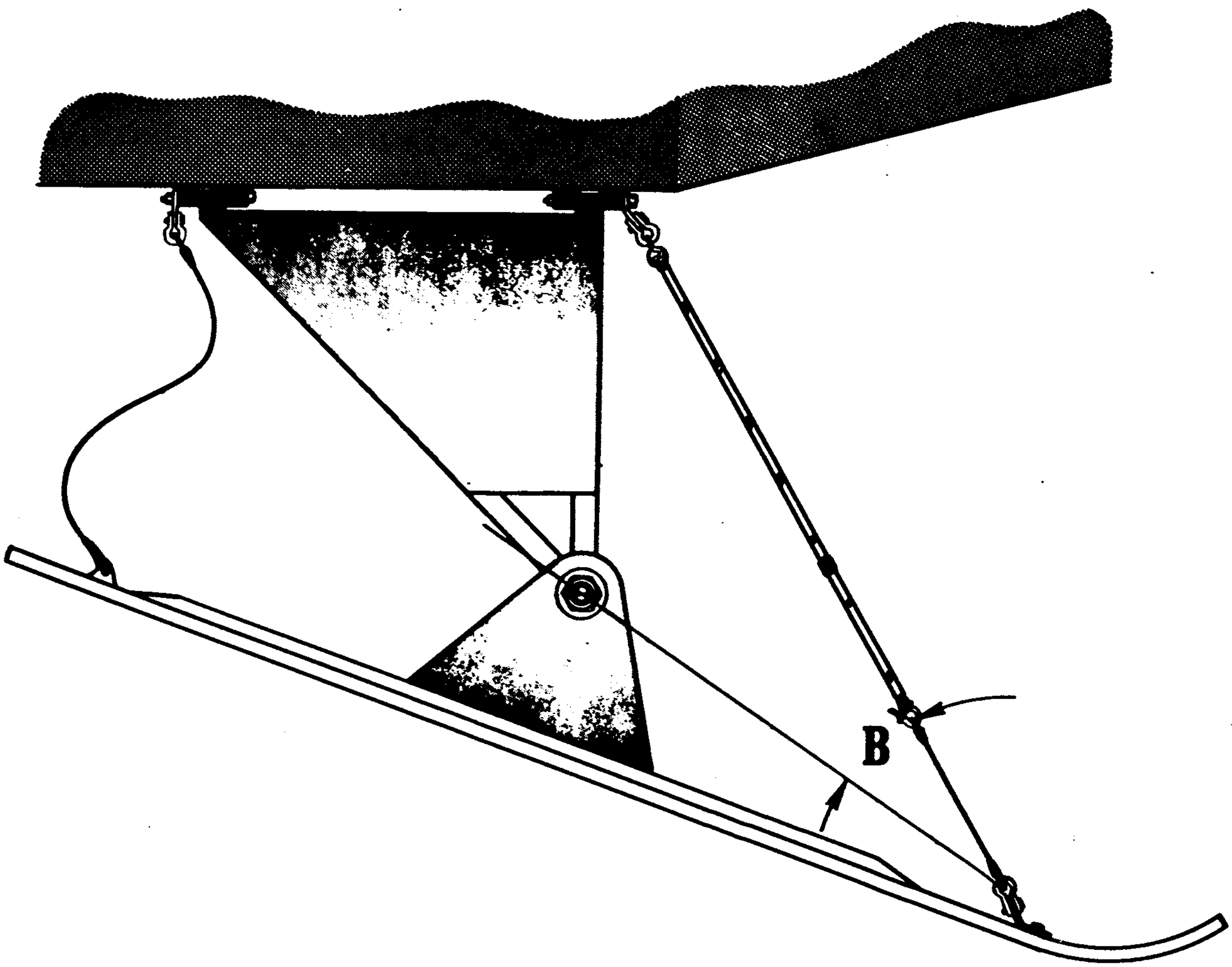


FIGURE 5.5.—Main ski at maximum negative incidence (safety cable tight).

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-

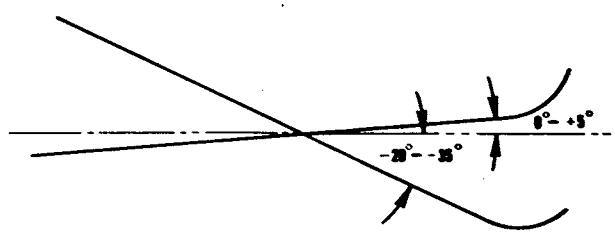


FIGURE 5.6.—Main ski incidence angles.

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 straight-forward 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 straight-forward position during flight.

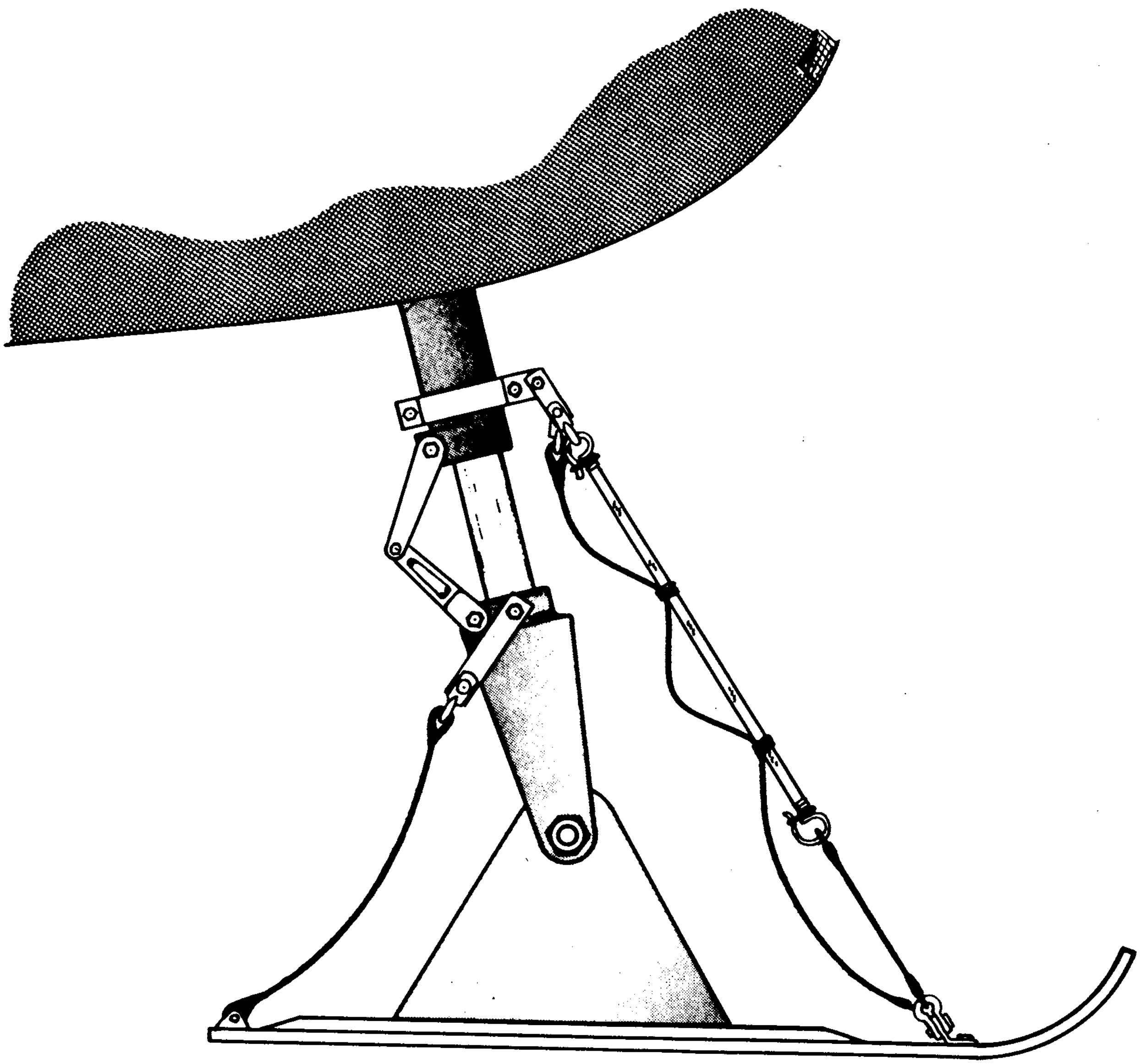


FIGURE 5.7.—Typical nose ski installation.

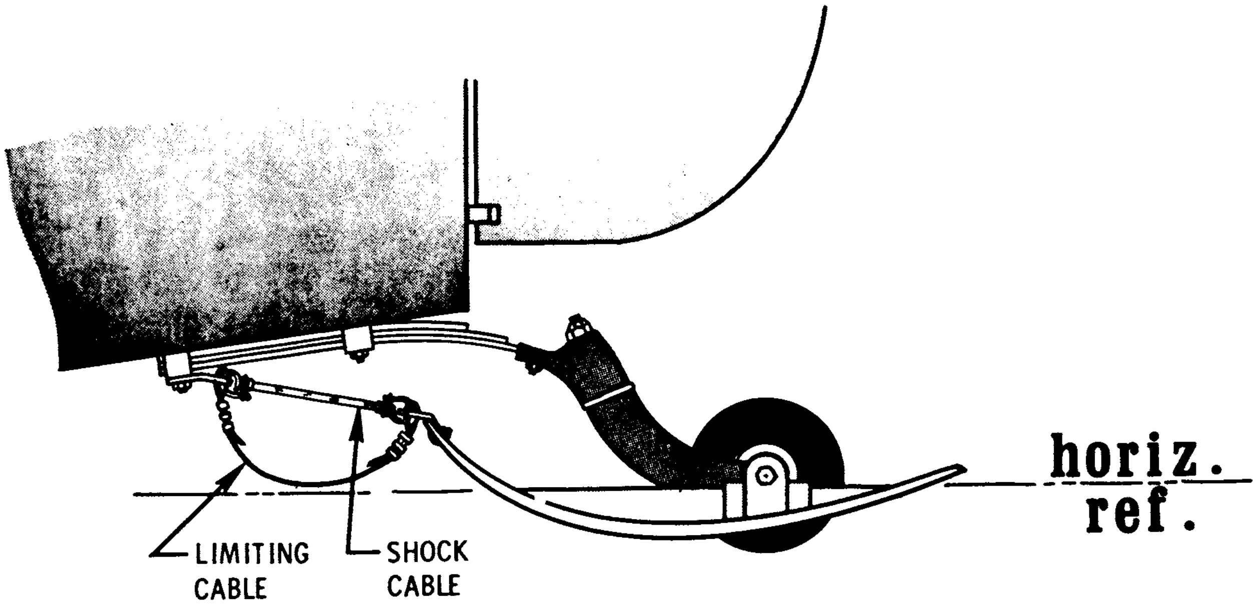


FIGURE 5.8—Typical tail ski installation.

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.

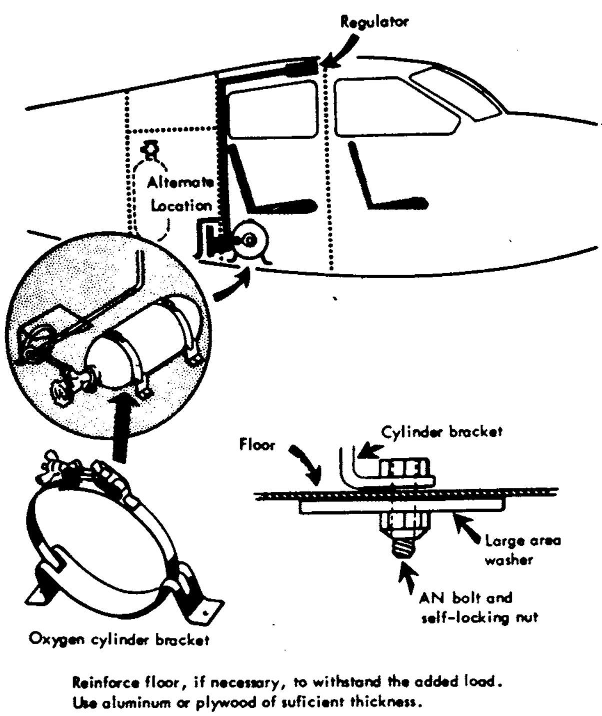


FIGURE 6.2.—Typical floor mounting.

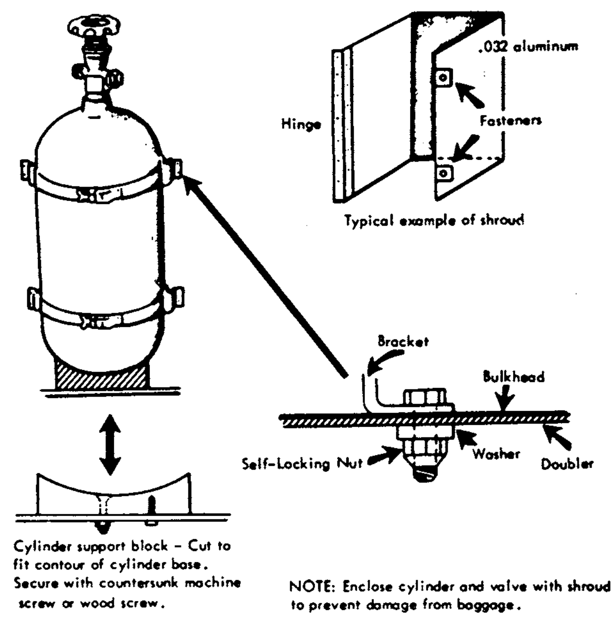


FIGURE 6.3.—Typical baggage compartment mounting.

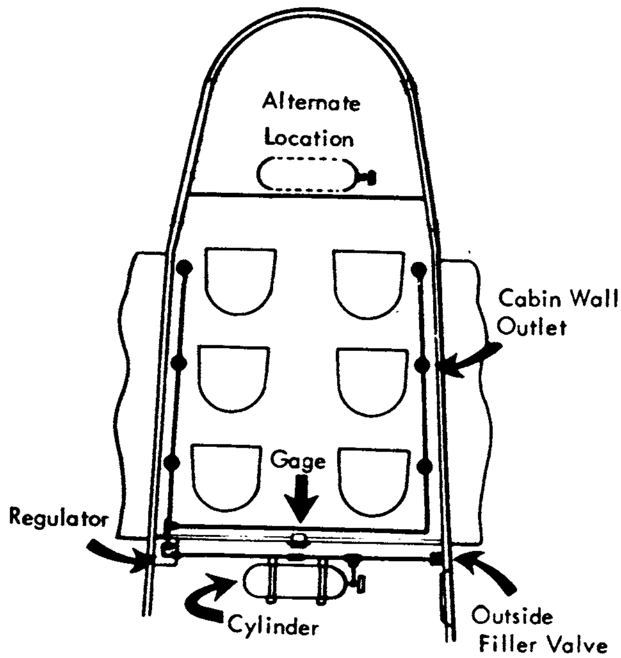


FIGURE 6.4.—Typical oxygen installation in light twin aircraft.

92.–95. [RESERVED]

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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

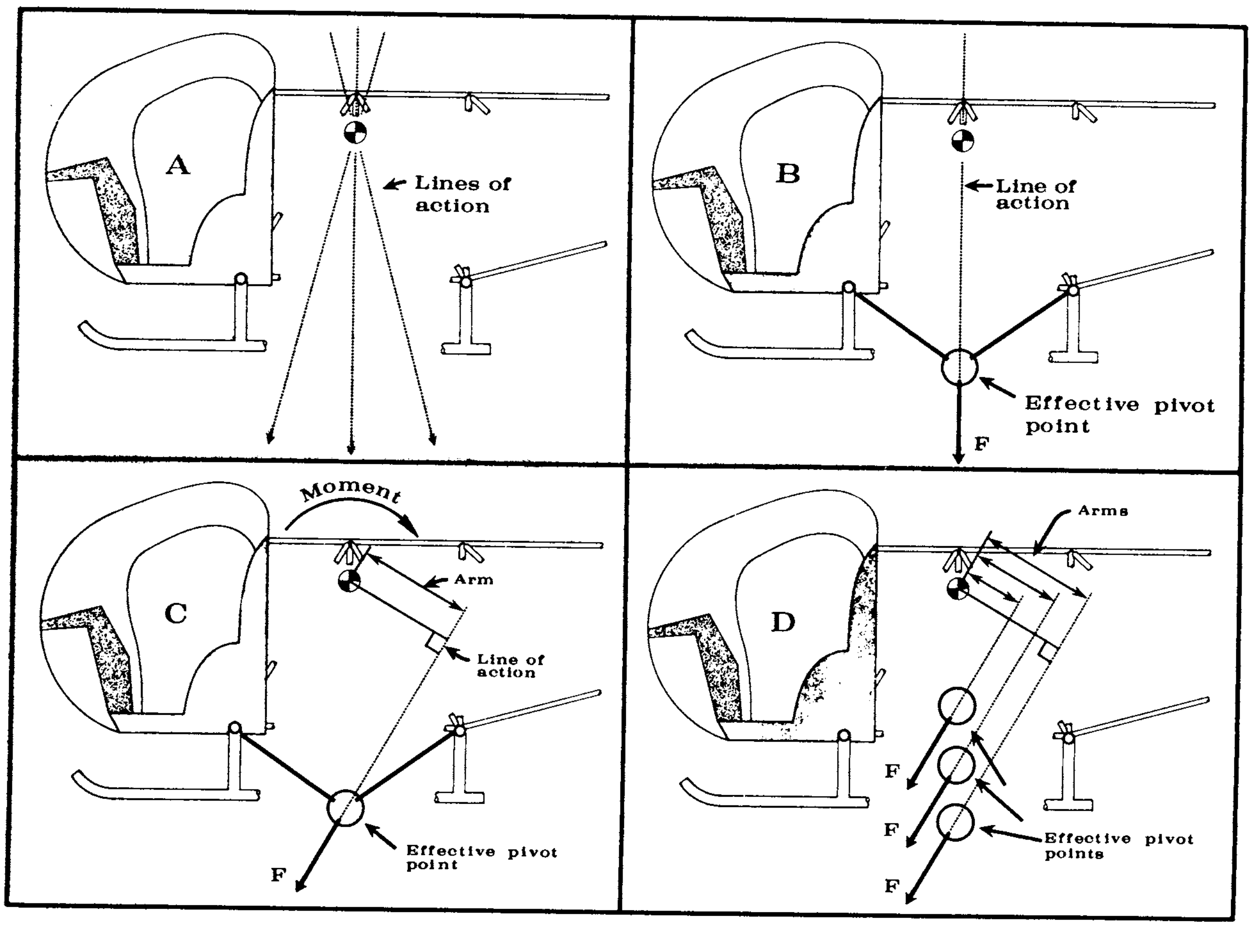

FIGURE 7.1.—Location of cargo release in relation to the rotorcraft's center of gravity.

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. Securé 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.

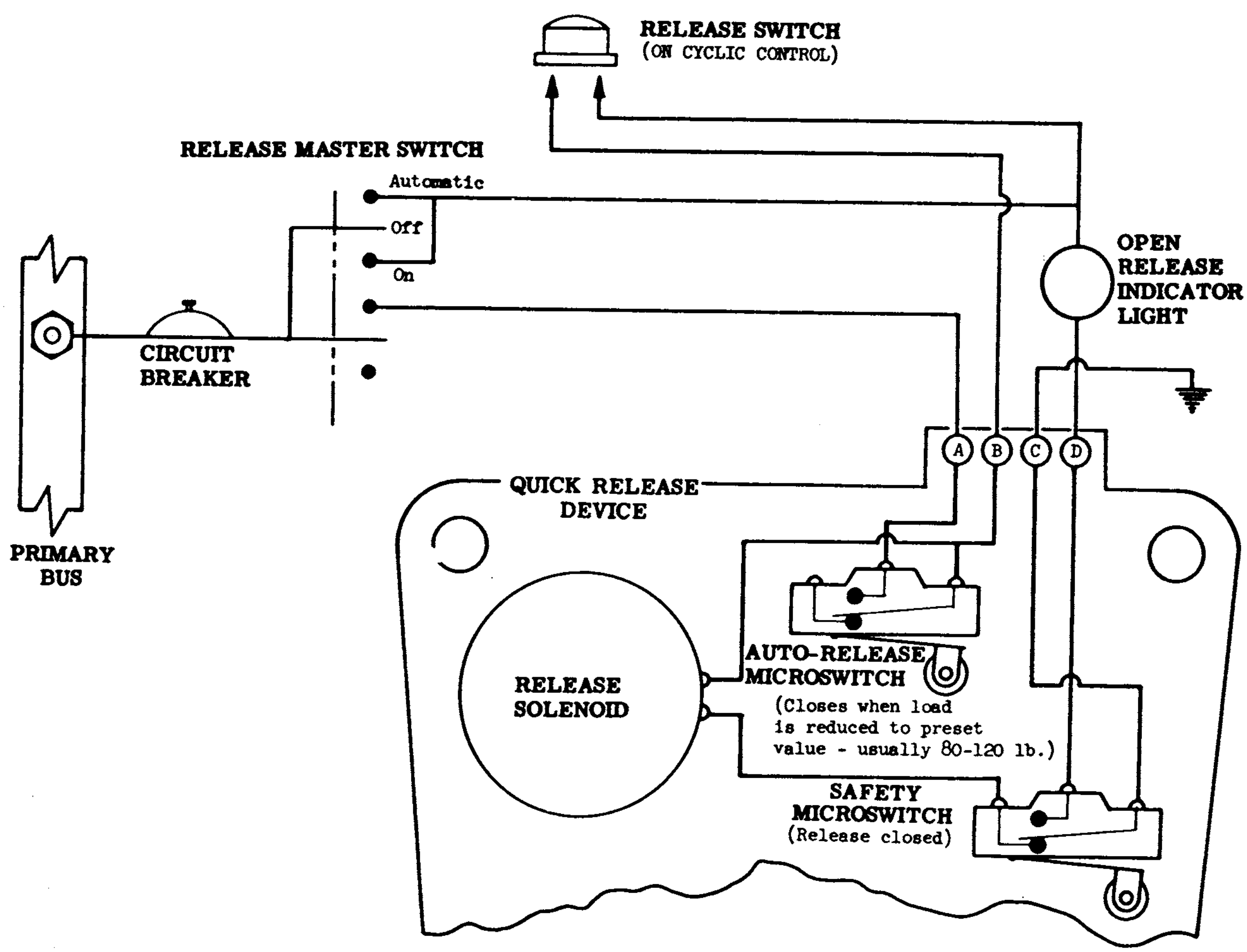

FIGURE 7.3.—Typical cargo sling wiring diagram.

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.

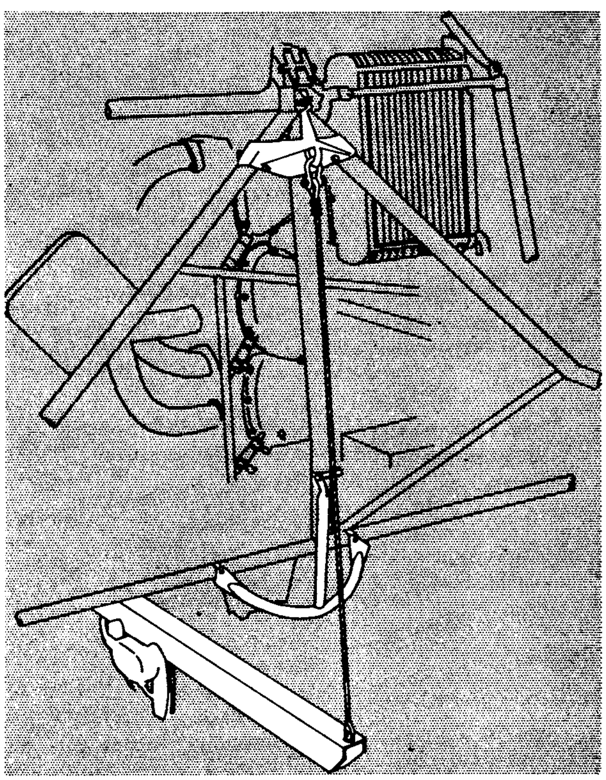

FIGURE 7.4.—Typical cargo sling installation No. 1.

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.

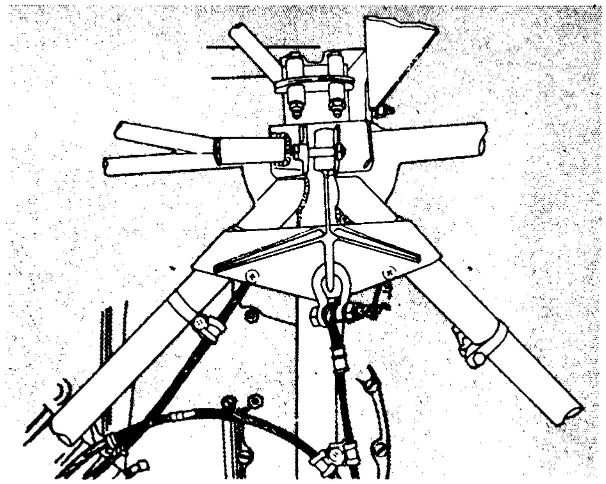

FIGURE 7.5.—Typical cargo sling installation No. 1 (showing fuselage attachment fitting).

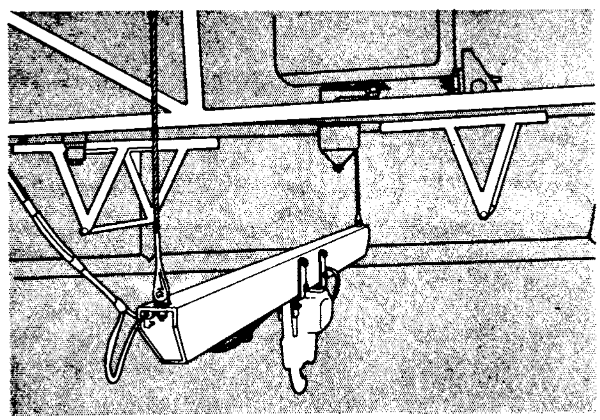

FIGURE 7.6—Typical cargo sling installation No. 1 (showing fore and aft limiting stops).

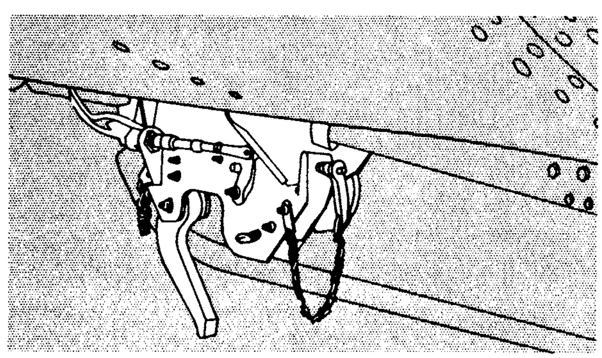

FIGURE 7.7.—Typical cargo sling installation No. 2 (cargo hook attached directly to underside of fuselage).

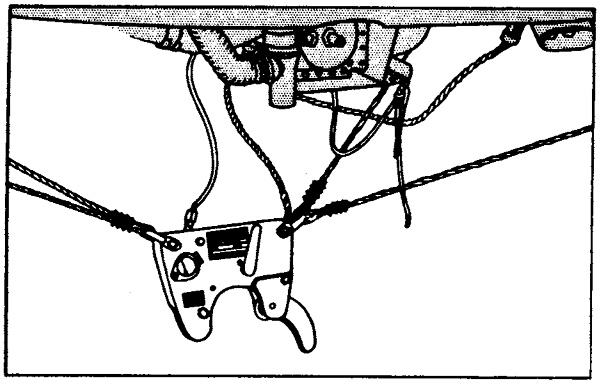

FIGURE 7.8.—Typical cargo sling installation No. 3 (4-leg, cable suspended).

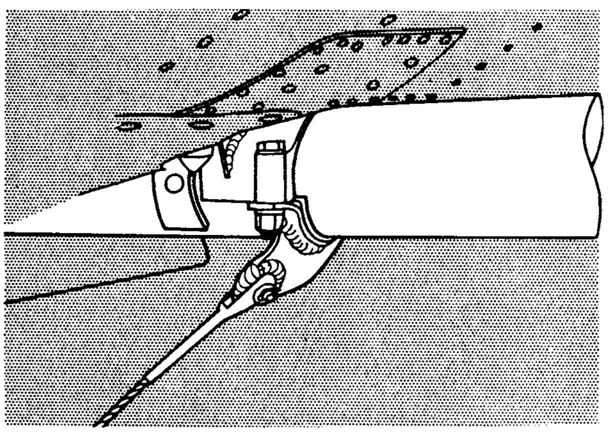

FIGURE 7.9.—Typical cargo sling installation No. 3 (showing cable sling leg attachment to landing gear cross-tube fitting).

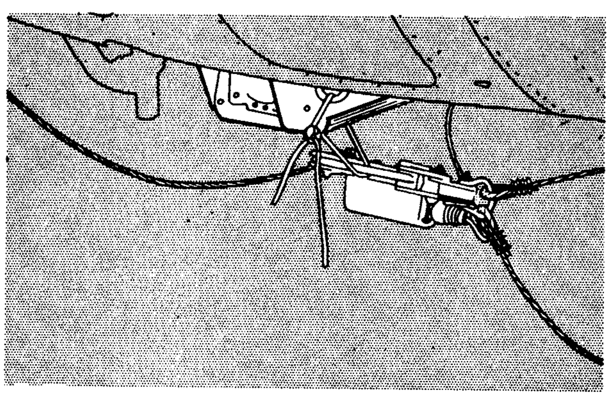

FIGURE 7.10.—Typical cargo sling installation No. 3 (showing cargo sling in stowed position).

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.

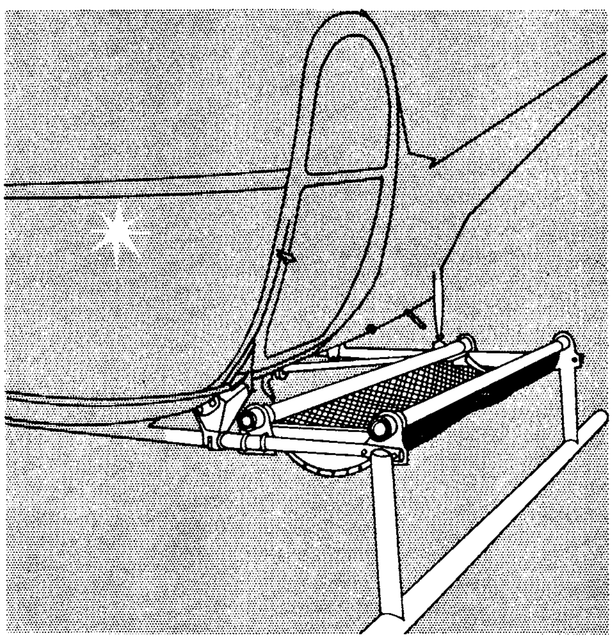

FIGURE 7.11.—Typical cargo rack installation No. 1.

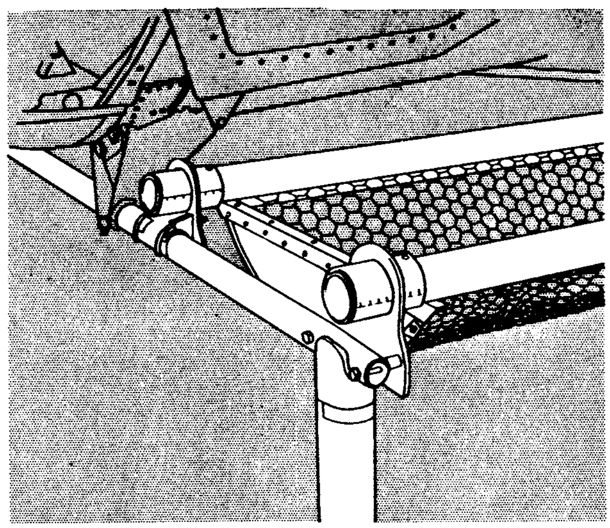

FIGURE 7.12.—Typical cargo rack installation No. 1 (showing attachment detail).

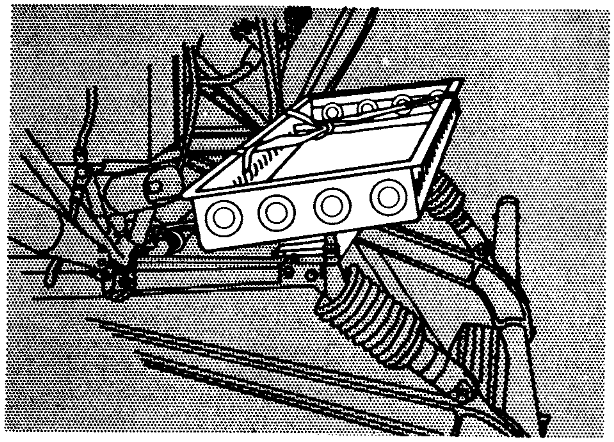

FIGURE 7.13.—Typical cargo rack installation No. 2.

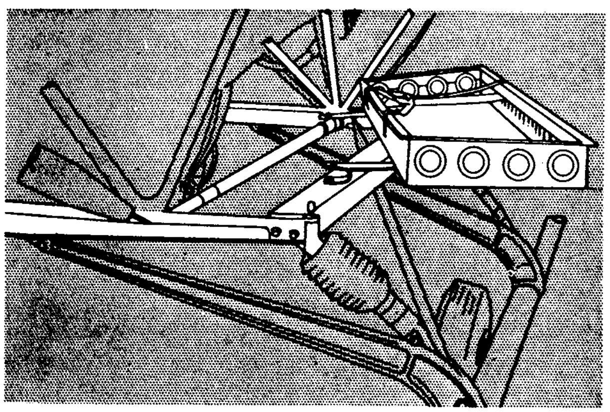

FIGURE 7.14.—Typical cargo rack installation No. 2 (showing rack partially installed).

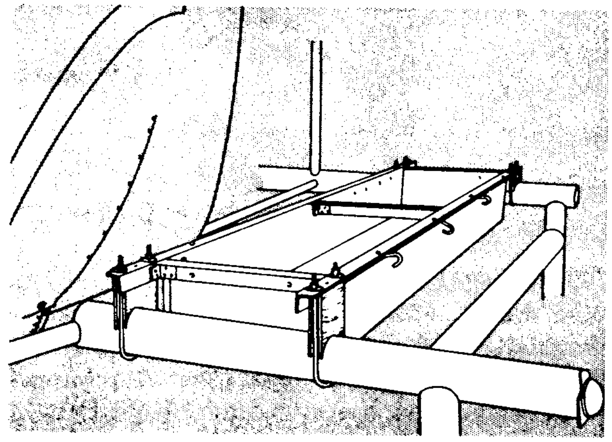

FIGURE 7.15.—Typical cargo rack installation No. 3.

115.–120. [RESERVED]

Chapter 8. GLIDER AND BANNER TOW-HITCH INSTALLATIONS

Section 1. TOWPLANE CONSIDERATIONS

[Deleted] Change 1

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 *

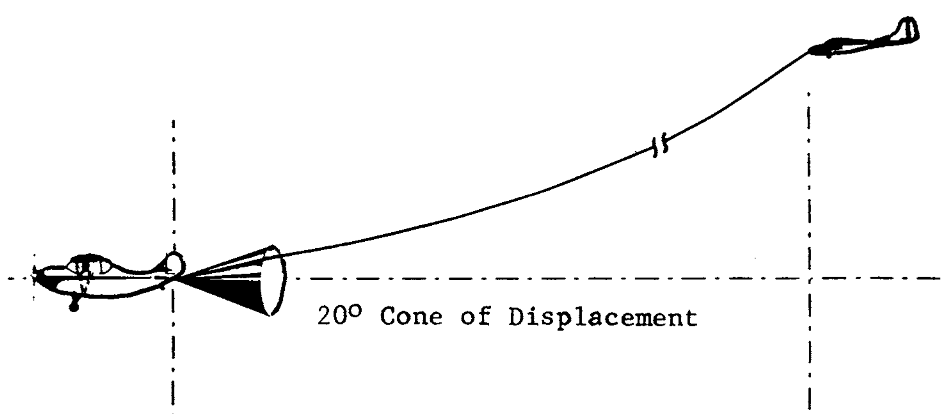

FIGURE 8.1.—Glider tow angle.

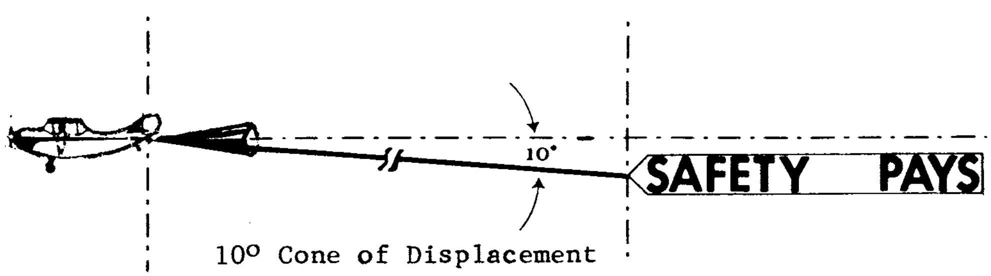

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FIGURE 8.2.—Banner tow angle.

*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)

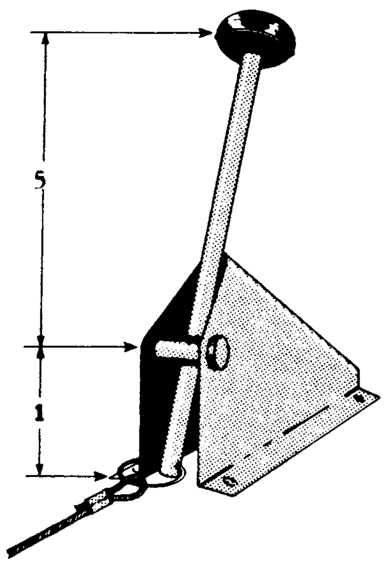

FIGURE 8.3—Typical tow-hitch release handle.

(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 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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(DELETED) -- Change 2

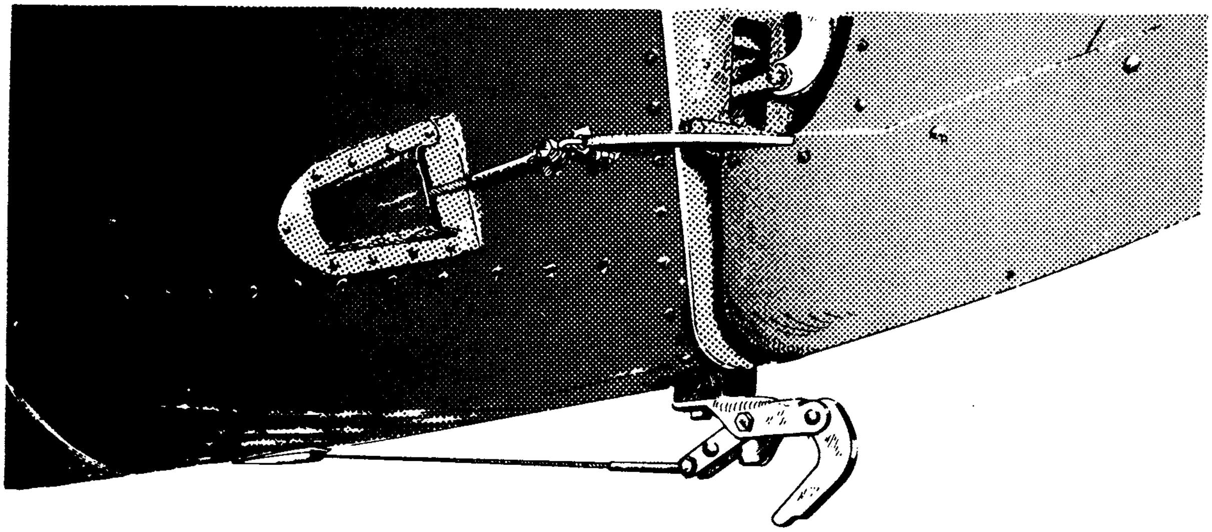

FIGURE 8.6.—Tricycle gear aircraft.

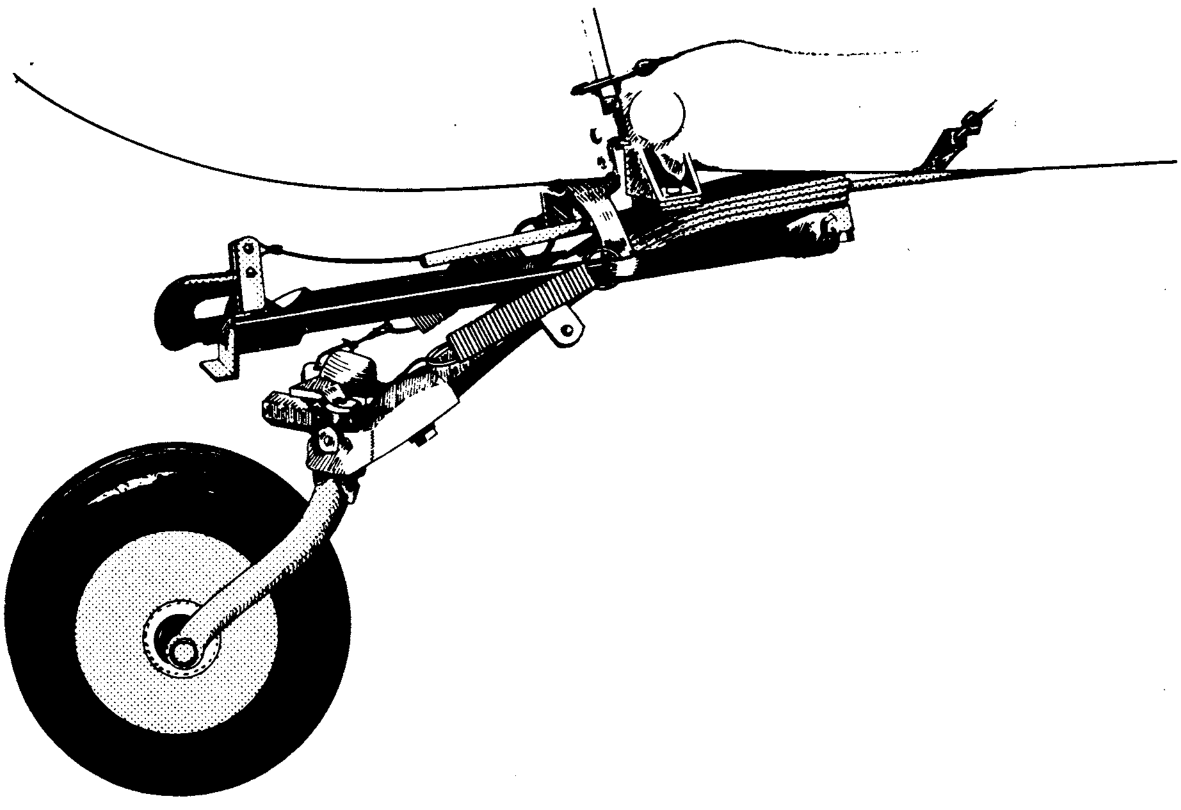

FIGURE 8.7.—Conventional gear aircraft—leaf spring type tailwheel.

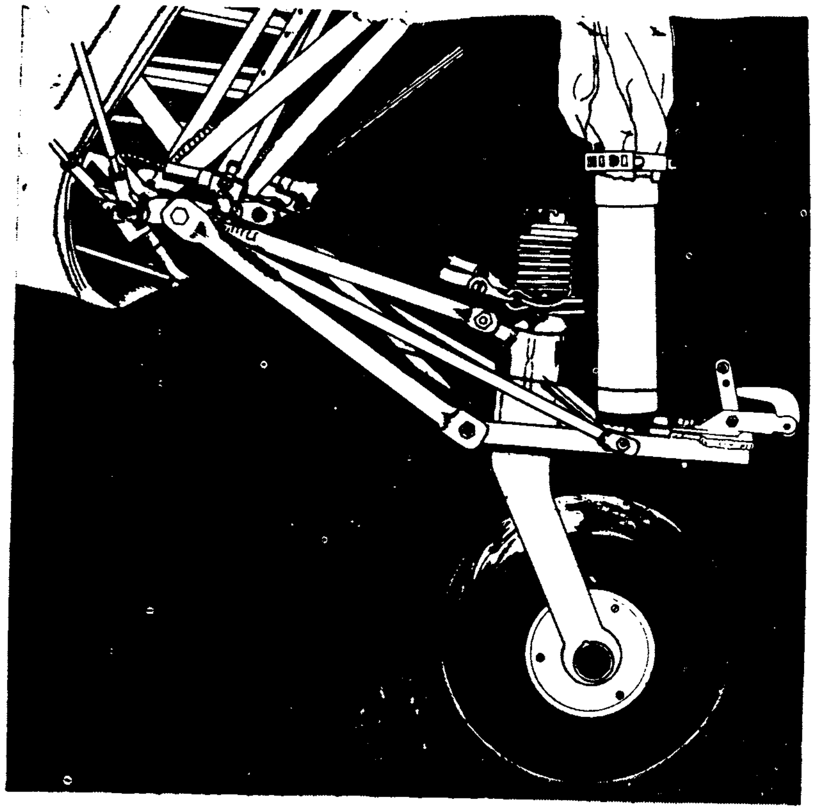

FIGURE 8.8.—Conventional gear aircraft—shock strut type tailwheel.

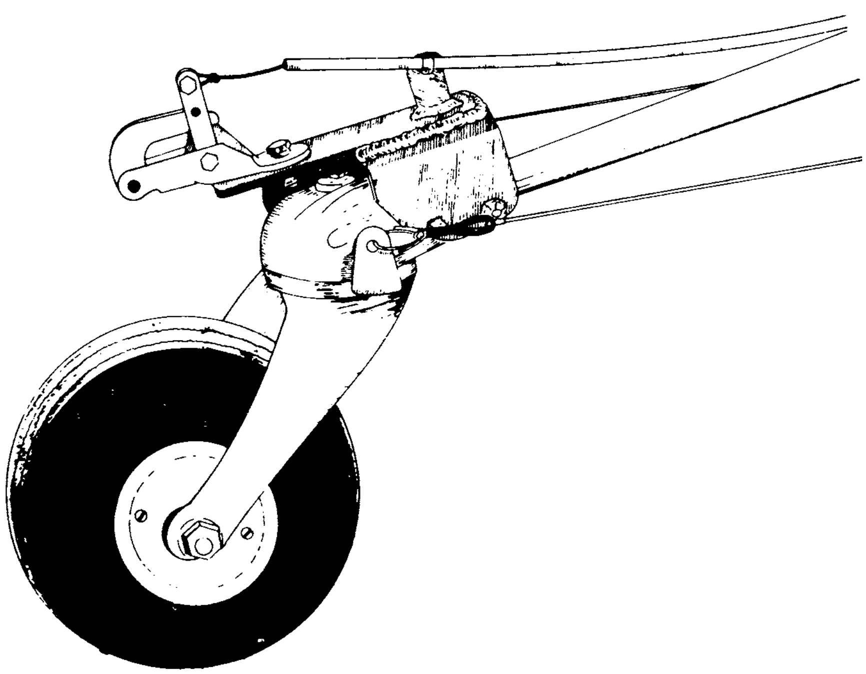

FIGURE 8.9.—Conventional gear aircraft—tubular spring type tailwheel.

134.–145. [RESERVED]