AIRPLANE SERVICE MANUAL

CARD 1 OF 2

APACHE

PA-23-150

PA-23-160

PIPER AIRCRAFT CORPORATION

PART NUMBER 752-422 REVISED: OCT. 5, 1999

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AEROFICHE REVISION STATUS

Revisions to this service manual 752 422, originally published (on paper only) in 1954, reissued (on paper only) March 15, 1968 and published on microfiche May 28, 1976 are as follows:

Revisions	Publication Date	Aerofiche Card Effectivity
ORIGINAL (Paper only)	1954	None
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COMPLETE REISSUE (Paper only)	March 15, 1968	None
1st (Paper only)	December 21, 1973	None
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4th	February 23, 1983	1 and 2
5th	April 29, 1986	1
6th	September 15, 1998	1 and 2
7th*	October 5, 1999	1 and 2

*** Revisions appear in both cards. Accordingly, discard your existing card set and replace it with these cards dated October 5, 1999.**

A. Consult the latest Piper Customer Service Information Catalog No. 1753-755 (Aerofiche) for current revision dates for this manual.

B. The General Aviation Manufacturers Association (GAMA) has developed specifications for microfiche reproduction of aircraft publications. The information compiled in this Aerofiche Service Manual will be kept current by revisions distributed periodically. These revisions will supersede all previous revisions and will be complete Aerofiche card replacements and shall supersede Aerofiche cards of the same number in the set.

C. Conversion of Aerofiche alpha/numeric grid code numbers:

First number is the Aerofiche card number.
Letter is the horizontal row reference per card
Second number is the vertical column reference per card.

Example: 2J16 = Aerofiche card number two, row J, column 16.

D. To aid in locating information, a complete Preface containing the Section Index Guide, List of Illustrations and List of Tables for all fiche in this set is provided at the beginning of Card 1. Each subsequent aerofiche card contains a partial Preface, displaying only those elements on that card.

IDENTIFYING REVISED MATERIAL

A revision to a page is defined as any change to the text or illustrations that existed previously. Such revisions, additions and deletions are identified by a vertical black line (change bar) along the left-hand margin of the page opposite only the text or illustration that was changed.

Changes in capitalization, spelling, punctuation, indexing, the physical location of the material or complete page additions are not identified by revision lines.

Example.

EFFECTIVITY

This service manual is effective for all PA-23-150 and PA-23-160 airplanes as follows:

Model Name	Model Number	Serial Numbers	Model Years
Apache	PA-23-150	23-1 thru 23-1182	1954 - 1958
	PA-23-160	23-1183 thru 1870	1958 - 1959
Apache G	PA-23-160	23-1871 thru 23-2012	
		23-2044 thru 23-2046	1960 - 1962
Apache H	PA-23-160	23-2013 thru 23-2043	1962

PARTS

This manual generally does not contain hardware callouts for installation. Hardware callouts are only indicated where a special application is required. To confirm the correct hardware used, refer to the PA-23 Apache Parts Catalog P/N 752 421, and FAR 43 for proper utilization.

WARNINGS, CAUTIONS AND NOTES

These are used to highlight or emphasize important information.

— WARNING —

OPERATING PROCEDURES, PRACTICES, ETC., WHICH MAY RESULT IN PERSONAL INJURY OR LOSS OF LIFE IF NOT CAREFULLY FOLLOWED.

— CAUTION —

OPERATING PROCEDURES, PRACTICES, ETC., WHICH IF NOT STRICTLY OBSERVED MAY RESULT IN DAMAGE TO EQUIPMENT.

— Note —

An operating procedure, condition, etc., which is essential to emphasize.

SECTION INDEX GUIDE

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (cont.)

LIST OF ILLUSTRATIONS (cont.)

LIST OF ILLUSTRATIONS (cont.)

LIST OF TABLES

SECTION I

INTRODUCTION

SECTION I

INTRODUCTION

1-1. GENERAL. This manual contains service and maintenance instructions for the Piper Apache PA-23-150 and PA-23-160 designed and manufactured as a versatile aircraft in the personal and business aviation field, by the Piper Aircraft Corporation, Lock Haven, Pennsylvania.

1-2. SCOPE OF MANUAL. Sections II and III comprise the service part of this manual, whereas Sections IV through XIII comprise the maintenance instructions. The service instructions include ground handling, servicing and inspection. The maintenance instructions for each system include troubleshooting, removal and installation of components, and corrective maintenance and testing; each major system of the airplane is covered in a separate section. Only qualified personnel should perform the operations described in this manual.

The description of the airplane included in this section is limited to general information. Section II gives leading particulars and principal dimensions, while each major system is described in its appropriate section of the manual.

1-3. DESCRIPTION. The Apache is a four or five place, twin engine, low wing monoplane of all metal construction with a basic tubular steel fuselage forward section for added strength. The following paragraphs provide descriptions of the major components and systems.

1-4. FUSELAGE. The fuselage, of truss and semi-monocoque type construction, is a combination of four basic units: The nose section, cabin section, tail section and a steel tubular frame, which extends from the tail section, through the cabin section, to the nose wheel.

1-5. WING. The rectangular wing is of all-metal stressed skin, full cantilever, low-wing design, consisting of two wing panels bolted together at the center of the fuselage. The wing tips are removable. The ailerons are cable and push rod controlled and are statically and dynamically balanced. The trailing edge type wing flaps are hydraulically operated.

1-6. EMPENNAGE. The empennage consists of the vertical stabilizer (fin), rudder with trim tab, horizontal stabilizer, and elevator. The control surfaces are dynamically and statically balanced.

1-7. FLIGHT CONTROLS. The flight controls are conventional, consisting of dual control wheels that operate the ailerons and elevator, and dual foot pedals that operate the rudder. The trim for each control is operated by a knob in the cabin ceiling.

1-8. HYDRAULIC SYSTEM. Two separate hydraulic systems are incorporated in the airplane. The main system incorporates a hydraulic Powerpak that operates the landing gear and flaps. The second system operates the airplane's brake system.

1-9. LANDING GEAR. The tricycle landing gear system is hydraulically operated and retractable with doors that partially cover the gear when retracted. The gear struts are air-oil type units.

1-10. ENGINES. The airplane is powered by two Lycoming O-320 Series engines. The engines are four cylinder, air cooled, horizontally opposed units, utilizing direct drive and a wet sump oil system.

1-11. PROPELLERS. Propellers are Hartzell manufactured two blade, full feathering, constant speed units controlled by a governor mounted on each engine.

1-12. FUEL SYSTEM. The fuel system consists of two rubber-type cells located in the wings with a total fuel capacity of 72 U.S. gallons. Incorporated in the system are fuel filters, electric auxiliary fuel pumps, engine-driven pumps and a crossfeed system. Optional auxiliary fuel cells are available, increasing the capacity to 108 U.S. gallons.

1-13. INSTRUMENTS. Provisions for the instrument installation includes panels for engine instruments and advance flight instruments, as well as space for electronics equipment. The panel is shock mounted to minimize vibration to the instruments.

1-14. ELECTRONIC EQUIPMENT. Provision for electronic equipment includes various combinations of radio installations and AutoPilot.

1-15. HEATING AND VENTILATING SYSTEM. Heated air for the cabin and defroster is obtained from a South Wind heater installed in the nose section. In conjunction with the heating system is the ventilating system which is used to cool the cabin and to furnish the heater with outside air.

SECTION II

HANDLING AND SERVICING

SECTION II

HANDLING AND SERVICING

2-1. INTRODUCTION. This section contains routine handling and servicing procedures that are most frequently encountered. Frequent reference to this section will aid the individual by providing information such as the location of various components, ground handling procedures, routine service procedures and lubrication. When any system or component requires service other than the routine procedures as outlined in this section, refer to the appropriate section for that component.

2-2. DIMENSIONS. The principle airplane dimensions are shown in Figures 2-1 and 2-2, and are listed in Table II-I.

2-3. STATION REFERENCE LINES. In order to facilitate the location of various components of the airplane which require maintenance and servicing, a method utilizing fuselage station (sta.), wing station or buttock line (BL), and water line (WL) designations is frequently employed in this manual. (Refer to Figures 2-3 and 2-4.) Fuselage stations, buttock lines, and water lines are reference points measured in inches in a vertical or horizontal direction from a given reference line which indicates station locations of structural members of the airplane. On all PA-23 airplanes, station 0 of the fuselage is located at the foremost point of the nose. The BL station 0 of the wing, horizontal stabilizer and elevator, is the center line of the airplane and WL station 0 of the fuselage, vertical stabilizer and rudder is 12 inches below the bottom edge of the forward left side window.

NOTE

> For weight and balance purposes, refer to the Airplane Flight Manual. The fuselage station reference lines and the datum lines (arm) are not the same. The reference datum line or arm 0 is 6.25 inches forward of fuselage station 0.

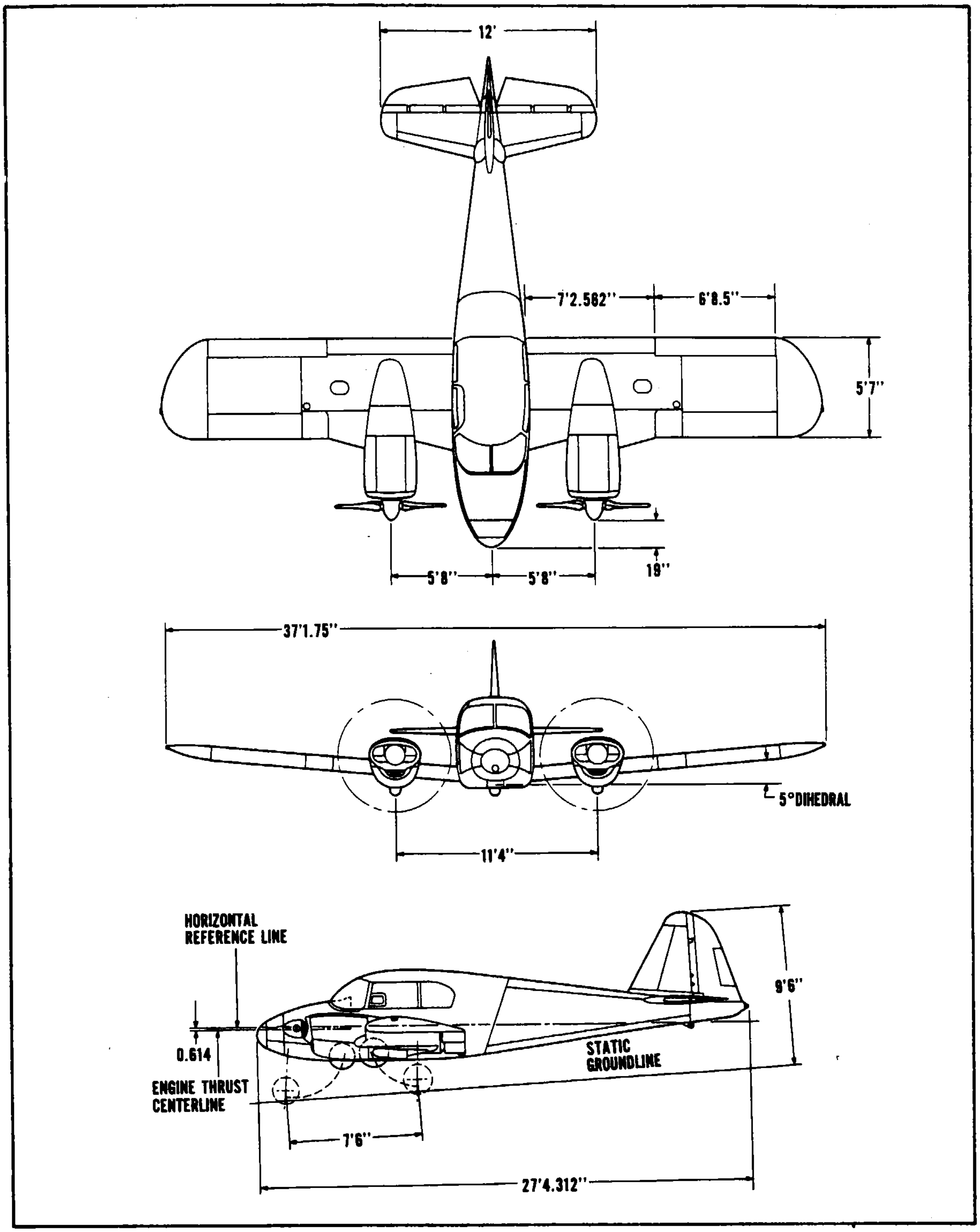


Figure 2-1. Three-View of Apache
PA-23-150, PA-23-160, Serial Nos. 23-1 to 23-1870 incl.

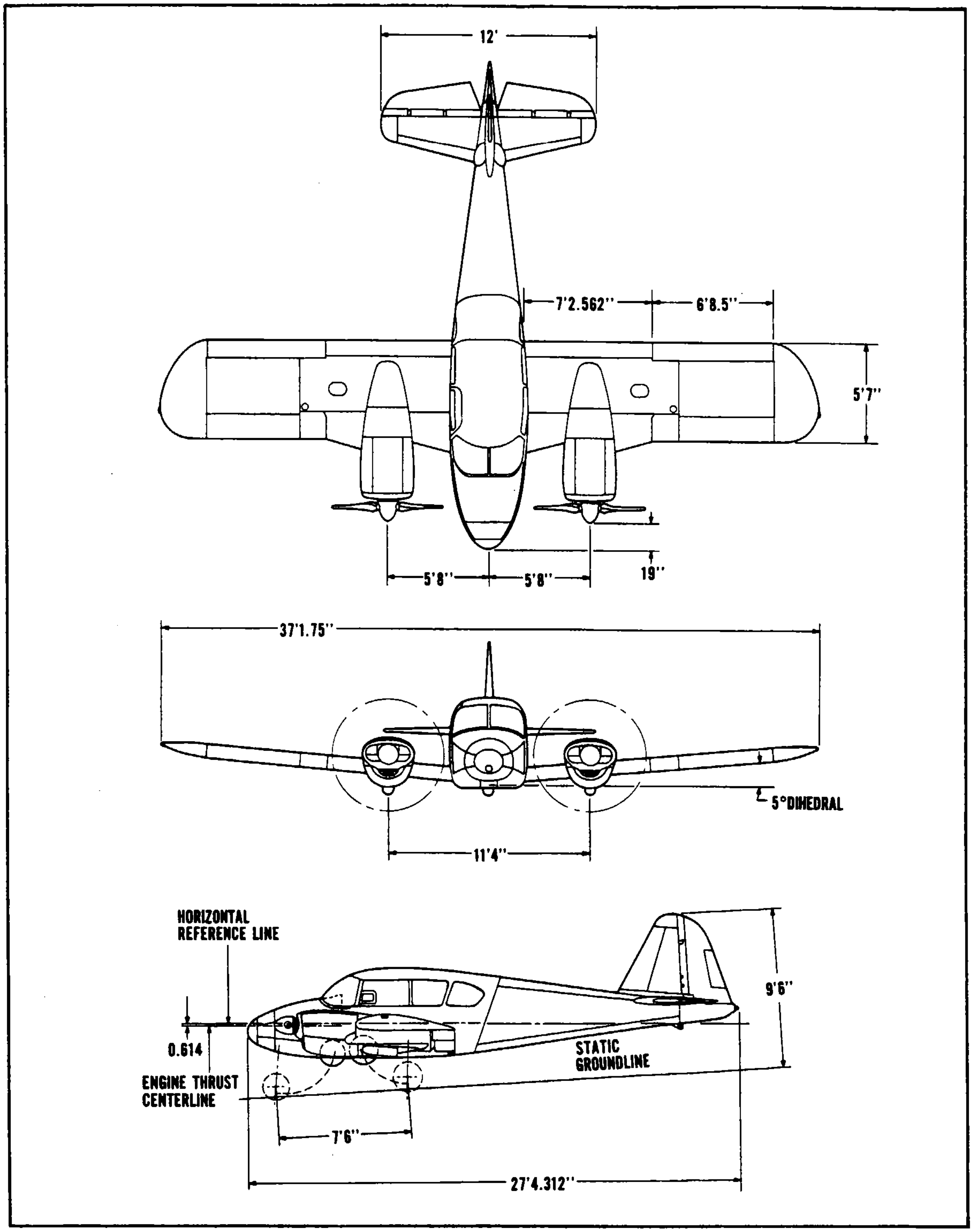


Figure 2-2. Three-View of Apache
PA-23-160, Serial Nos. 23-1871 and up

TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-150)

MODEL	PA-23-150
ENGINE	
Manufacturer	Avco-Lycoming
Model	O-320-A Series
FAA Type Certificate	274
Rate Horsepower	150
Rated Speed:	
Full Throttle	2700 RPM
Performance Cruise (75% Rated)	2450 RPM
Economy Cruise (65% Rated)	2350 RPM
Fuel Consumption Cruise:	
75% Rated Power	10.0 gph
65% Rated Power	8.8 gph
60% Rated Power	8.2 gph
Propeller Drive Ratio	1:1
Propeller Shaft Rotation	Clockwise
Bore	5.125 in.
Stroke	3.875 in.
Displacement	319.8 cu. in.
Compression Ratio	7.00:1
Weight (With Starter and Generator)	272 lbs.
Dimensions:	
Height	23.12 in.
Width	32.24 in.
Length	29.40 in.
Oil, SAE Number	See Table II-III
Oil Sump Capacity	8 qts.
Oil Consumption, Maximum	.012 lb/bhp/hr
Fuel, Aviation Grade, Specified Minimum Octane	80/87[3]
Carburetor, Marvel-Schebler	MA-4SPA
Magnetos, Scintilla:	
Right	SL4N-20
Left	SL4N-21
Magneto Drive, Ratio to Crankshaft	1:1
Magneto Drive, Rotation	Clockwise

[3] WHEN USING FUEL OTHER THAN THE SPECIFIED MINIMUM OCTANE RATING, REFER TO LYCOMING SERVICE LETTER NO. L185A FOR MORE INFORMATION AND RECOMMENDED SERVICE PROCEDURES.

TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-150) (cont.)

MODEL	PA-23-150
ENGINE (cont.)	
Magneto Timing	25° BTC
Magneto Point Clearance	.018 ± .006
Spark Plugs (Shielded):	
AC	SR88
Champion	REM-40E
Spark Plug Gap Setting	.018 to .022 in.
Firing Order	1-3-2-4
Tachometer Drive, Ratio to Crankshaft	0.5:1
Tachometer Drive, Rotation	Clockwise
Starter, Delco-Remy, 12V	1109657
Starter Gear Ratio	2.27:1
Starter Drive, Ratio to Crankshaft	13.556:1
Starter Drive, Rotation	Counterclockwise
Generator, Delco-Remy	1101900 (35 amp)
Voltage Regulator, Delco-Remy	1119145 (35 amp)
Paralleling Relay, Delco-Remy	—
Generator Drive, Ratio to Crankshaft	1.91:1
Generator Drive, Rotation	Clockwise
Vacuum Pump Drive, Ratio to Crankshaft	1.30:1
Vacuum Pump Drive, Rotation	Counterclockwise
Propeller Governor Drive, Ratio to Crankshaft	.866:1
Propeller Governor Drive, Rotation	Counterclockwise
Fuel Pump Drive	Plunger Type

TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-150) (cont.)

MODEL	PA-23-150
PROPELLER	
Manufacturer	Hartzell
Type (2 Blades)	Constant Speed, Full Feathering
Hub Model	HC-82XG-2
Blade Model	7636D
Diameter	76.0 in.
Diameter, Minimum	74.5 in.
Blade Angle, Low Pitch[2]	10.0°
Blade Angle, High Pitch[2]	80.5° (Feathered)
Governor Control	Woodward
Governor Model	210080
FUEL SYSTEM	
Inboard (Main) Fuel Cells	Two
Capacity (Each)	36 U.S. Gal.
Outboard (Auxiliary) Fuel Cells	Two
Capacity (Each)	18 U.S. Gal.
Total Capacity (With Auxiliary Cells)	108 U.S. Gal.
LANDING GEAR	
Type	Hydraulically Retractable
Shock Strut Type	Air-Oil
Fluid Required (Struts, Hydraulic System and Brakes)	MIL-H-5606
Strut Extension (Static Load)	3 in.
Wheel Tread (Width from each tire center)	11 ft., 4 in.
Wheel Base	7 ft., 6 in.
Nose Wheel Turning	15° ± 1° Right, 15° ± 1° Left
Turning Radius:	
Nose Wheel	28.3 ft.
Wing Tip	35.8 ft.

[2] MEASURED AT 30 INCH RADIUS.

TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-150) (cont.)

MODEL	PA-23-150
LANDING GEAR (cont.)	
Wheel, Nose:	
Cleveland	C-3850H or 38501
Wheel, Main:	
Goodrich	G-3-787 or G-3-880
Cleveland	3060 or 3080A
Brake Type:	
Goodrich	G-2-662
Cleveland	3000-500
Tire, Nose	6:00 x 6, 4 ply rating
Tire, Main	7:00 x 6, 6 ply rating
Tire Pressure, Nose	27 lbs.
Tire Pressure, Main	35 lbs.
OVERALL	
Gross Weight	3500 lbs.
Wing Loading	17.2 lbs./sq. ft.
Length	27 ft., 4.3 in.
Width (Span)	37 ft., 1.75 in.
Height (Static Ground Line)	9 ft., 6.0 in.
Height, Propeller Hub, Thrust Line Level	47.37 in.
Clearance, Propeller Tip, Thrust Line Level	9.4 in.
FUSELAGE	
Length (Including Tail Cone Fairing)	27 ft., 1.9 in.
Length (Without Tail Cone Fairing)	24 ft., 3.4 in.
Width (Without Stabilizer)	50.87 in.
Height (Without Vertical Stabilizer)	60.75 in.

TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-150) (cont.)

MODEL	PA-23-150
WINGS	
Airfoil Section at Root	USA 35B Modified
Span (Width)	37 ft., 1.75 in.
Chord	67 in.
Dihedral (Leading Edge)	5 degrees
Incidence (Wing Station 27.0)	0 degrees
Twist	1 degree in 70 in. max. 2 degrees
Wing (Each):	
Distance (End of Spar to Wing Tip)	18 ft., 6.87 in.
Distance (End of Spar to Outboard Rib)	16 ft.
Distance (Leading Edge to Trailing Edge)	37.86 in.
Aileron:	
Length	6 ft., 8.5 in.
Chord	15.43 in.
Flap:	
Length	7 ft., 2.56 in.
Chord	13.88 in.
EMPENNAGE	
Chord, Horizontal Surfaces	54.0 in.
Chord, Vertical Surfaces	71.12 in.
Stabilizer:	
Span (Overall)	12 ft.
Dimension (Leading Edge to Trailing Edge)	30 in.
Incidence	1 degree
Elevator (Each):	
Dimension (Inboard Edge to Tip)	66.69 in.
Chord (Maximum)	23.69 in.
Fin:	
Height (End of Spar to Tip)	58.37 in.
Dimension (Leading Edge to Trailing Edge)	41.31 in.
Rudder:	
Dimension (Bottom Edge to Tip)	60.37 in.
Chord (Maximum)	32.5 in.

TABLE II-1. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-150) (cont.)

MODEL	PA-23-150
AREAS	
Wings (Total Area - Aileron and Flaps)	207.56 sq. ft.
Aileron Area (Each)	16.77 sq. ft.
Flap Area (Each)	16.68 sq. ft.
Elevator Area	16.59 sq. ft.
Horizontal Stabilizer Area	23.60 sq. ft.
Rudder Area	9.0 sq. ft.
Vertical Fin Area	10.58 sq. ft.
CONTROL SURFACES	
Aileron	30° ± 2° Up, 15° ± 2° Down
Elevator	20° ± 2° Up, 15° ± 2° Down
Rudder	30° ± 2° Left, 30° ± 2° Right
Rudder Trim Tab	25° +2° -0° Left, 25° +2° -0° Right
Flaps	50° ± 2° Down
CABLE TENSIONS	
Aileron	35 lbs. ± 20%
Elevator	20 lbs. ± 20%
Rudder	30 lbs. ± 20%
Rudder Trim	10 lbs. ± 20%

TABLE II-IA. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-160)

MODEL	PA-23-160
ENGINE	
Manufacturer	Avco-Lycoming
Model	O-320-B Series
FAA Type Certificate	274
Rate Horsepower	160
Rated Speed:	
Full Throttle	2700 RPM
Performance Cruise (75% Rated)	2450 RPM
Economy Cruise (65% Rated)	2350 RPM
Fuel Consumption Cruise:	
75% Rated Power	10.0 gph
65% Rated Power	8.8 gph
60% Rated Power	8.2 gph
Propeller Drive Ratio	1:1
Propeller Shaft Rotation	Clockwise
Bore	5.125 in.
Stroke	3.875 in.
Displacement	319.8 cu. in.
Compression Ratio	8.5:1
Weight (With Starter and Generator)	278 lbs.
Dimensions:	
Height	23.12 in.
Width	32.24 in.
Length	29.56 in.
Oil, SAE Number	See Table II-III
Oil Sump Capacity	8 qts.
Oil Consumption, Maximum	.012 lb/bhp/hr
Fuel, Aviation Grade, Specified Minimum Octane	91/96
Carburetor, Marvel-Schebler	MA-4SPA
Magnetos, Scintilla:	
Right	SL4N-20
Left	SL4N-21
Magneto Drive, Ratio to Crankshaft	1:1
Magneto Drive, Rotation	Clockwise

TABLE II-1A. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-160) (cont.)

MODEL	PA-23-160
ENGINE (cont.)	
Magneto Timing	25° BTC
Magneto Point Clearance	.018 ± .006
Spark Plugs (Shielded):	
AC	SR88
Champion	REM-40E
Spark Plug Gap Setting	.015 to .018 in. or .018 to .022 in.[1]
Firing Order	1-3-2-4
Tachometer Drive, Ratio to Crankshaft	0.5:1
Tachometer Drive, Rotation	Clockwise
Starter, Delco-Remy, 12V	1109673 or 1109689
Starter Gear Ratio	2.27:1
Starter Drive, Ratio to Crankshaft	13.556:1
Starter Drive, Rotation	Counterclockwise
Generator, Delco-Remy	1101900 (35 amp) 1101915 (50 amp)
Voltage Regulator, Delco-Remy	1119145 (35 amp) 1119246 (50 amp)
Paralleling Relay, Delco-Remy	1116887 (50 amp)
Generator Drive, Ratio to Crankshaft	1.91:1
Generator Drive, Rotation	Clockwise
Vacuum Pump Drive, Ratio to Crankshaft	1.30:1
Vacuum Pump Drive, Rotation	Counterclockwise
Propeller Governor Drive, Ratio to Crankshaft	.866:1
Propeller Governor Drive, Rotation	Counterclockwise
Fuel Pump Drive	Plunger Type

[1] REFER TO LYCOMING SERVICE INSTRUCTIONS NO. 1042.

TABLE II-IA. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-160) (cont.)

MODEL	PA-23-160
PROPELLER	
Manufacturer	Hartzell
Type (2 Blades)	Constant Speed, Full Feathering
Hub Model	HC-82XG, HC-82XL or HC-A2XL
Blade Model	76360-4
Diameter	72.0 in.
Diameter, Minimum	70.0 in.
Blade Angle, Low Pitch[2]	12.0°
Blade Angle, High Pitch[2]	80.0° (Feathered)
Governor Control	Woodward or Hartzell
Governor Model	210080 B-4-1
FUEL SYSTEM	
Inboard (Main) Fuel Cells	Two
Capacity (Each)	36 U.S. Gal.
Outboard (Auxiliary) Fuel Cells	Two
Capacity (Each)	18 U.S. Gal.
Total Capacity (With Auxiliary Cells)	108 U.S. Gal.
LANDING GEAR	
Type	Hydraulically Retractable
Shock Strut Type	Air-Oil
Fluid Required (Struts, Hydraulic System and Brakes)	MIL-H-5606
Strut Extension (Static Load)	3 in.
Wheel Tread (Width from each tire center)	11 ft., 4 in.
Wheel Base	7 ft., 6 in.
Nose Wheel Turning	15° ± 1° Right, 15° ± 1° Left
Turning Radius:	
Nose Wheel	28.3 ft.
Wing Tip	35.8 ft.

[2] MEASURED AT 30 INCH RADIUS.

TABLE II-IA. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-160) (cont.)

MODEL	PA-23-160
LANDING GEAR (cont.)	
Wheel, Nose:	
Cleveland	38501
Wheel, Main:	
Goodrich	—
Cleveland	3080A
Brake Type:	
Goodrich	—
Cleveland	3000-500
Tire, Nose	6:00 x 6, 4 ply rating
Tire, Main	7:00 x 6, 6 ply rating
Tire Pressure, Nose	27 lbs.
Tire Pressure, Main	35 lbs.
OVERALL	
Gross Weight	3800 lbs.
Wing Loading	18.6 lbs./sq. ft.
Length	27 ft., 4.3 in.
Width (Span)	37 ft., 1.75 in.
Height (Static Ground Line)	9 ft., 6.0 in.
Height, Propeller Hub, Thrust Line Level	47.37 in.
Clearance, Propeller Tip, Thrust Line Level	11.4 in.
FUSELAGE	
Length (Including Tail Cone Fairing)	27 ft., 1.9 in.
Length (Without Tail Cone Fairing)	24 ft., 3.4 in.
Width (Without Stabilizer)	50.87 in.
Height (Without Vertical Stabilizer)	60.75 in.

TABLE II-IA. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-160) (cont.)

MODEL	PA-23-160
WINGS	
Airfoil Section at Root	USA 35B Modified
Span (Width)	37 ft., 1.75 in.
Chord	67 in.
Dihedral (Leading Edge)	5 degrees
Incidence (Wing Station 27.0)	0 degrees
Twist	1 degree in 70 in. max. 2 degrees
Wing (Each):	
Distance (End of Spar to Wing Tip)	18 ft., 6.87 in.
Distance (End of Spar to Outboard Rib)	16 ft.
Distance (Leading Edge to Trailing Edge)	37.86 in.
Aileron:	
Length	6 ft., 8.5 in.
Chord	15.43 in.
Flap:	
Length	7 ft., 2.56 in.
Chord	13.88 in.
EMPENNAGE	
Chord, Horizontal Surfaces	54.0 in.
Chord, Vertical Surfaces	71.12 in.
Stabilizer:	
Span (Overall)	12 ft.
Dimension (Leading Edge to Trailing Edge)	30 in.
Incidence	1 degree
Elevator (Each):	
Dimension (Inboard Edge to Tip)	66.69 in.
Chord (Maximum)	23.69 in.
Fin:	
Height (End of Spar to Tip)	58.37 in.
Dimension (Leading Edge to Trailing Edge)	31.31 in.
Rudder:	
Dimension (Bottom Edge to Tip)	60.37 in.
Chord (Maximum)	32.5 in.

TABLE II-IA. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (PA-23-160) (cont.)

MODEL	PA-23-160
AREAS	
Wings (Total Area - Aileron and Flaps)	207.56 sq. ft.
Aileron Area (Each)	16.77 sq. ft.
Flap Area (Each)	16.68 sq. ft.
Elevator Area	16.59 sq. ft.
Horizontal Stabilizer Area	23.60 sq. ft.
Rudder Area	9.0 sq. ft.
Vertical Fin Area	10.58 sq. ft.
CONTROL SURFACES	
Aileron	30° ± 2° Up, 15° ± 2° Down
Elevator	20° ± 2° Up, 15° ± 2° Down
Rudder	30° ± 2° Left, 30° ± 2° Right
Rudder Trim Tab	25° +2° -0° Left, 25° +2° -0° Right
Flaps	50° ± 2° Down
CABLE TENSIONS	
Aileron	35 lbs. ± 20%
Elevator	20 lbs. ± 20%
Rudder	30 lbs. ± 20%
Rudder Trim	10 lbs. ± 20%

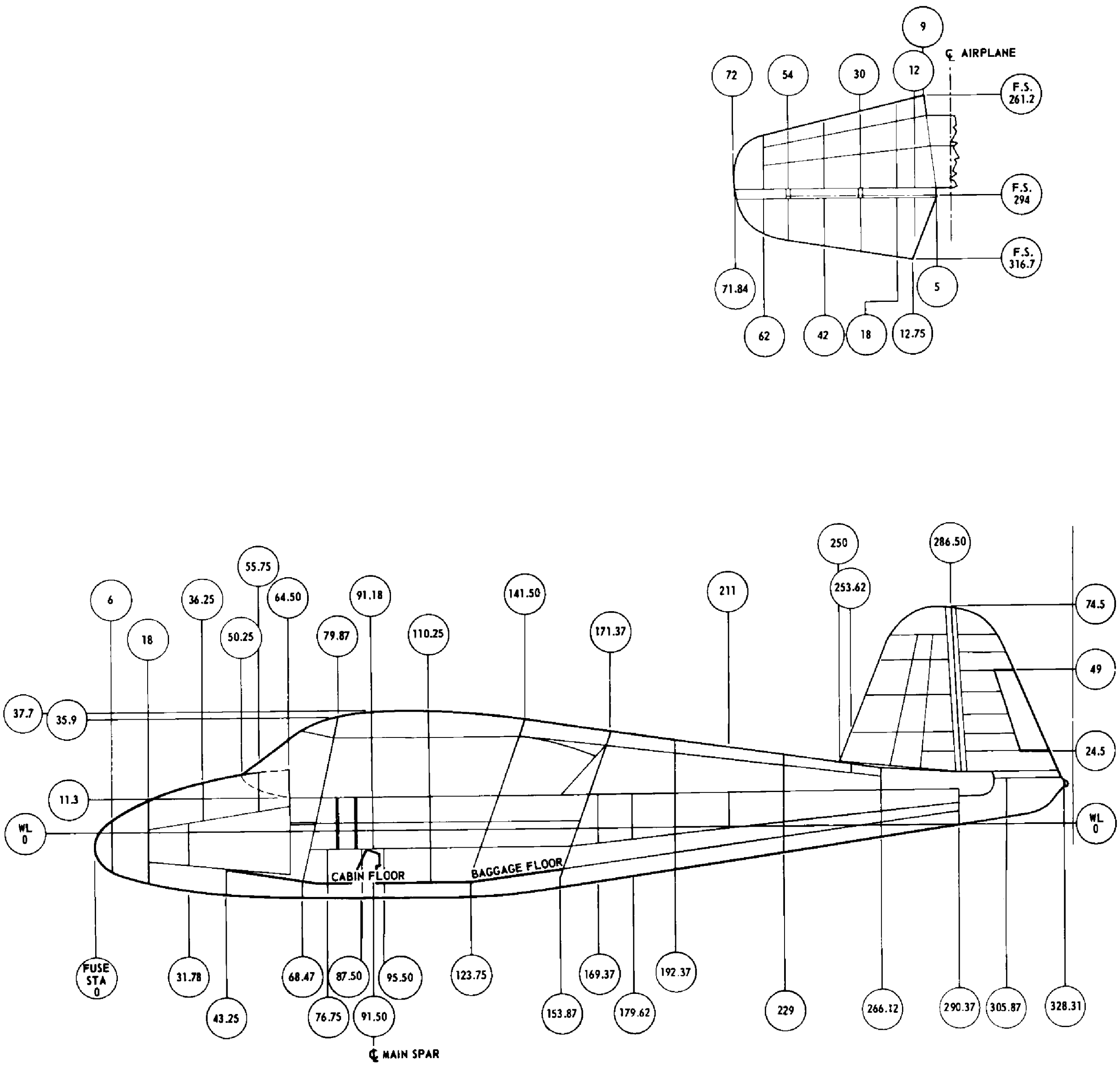


Figure 2-3. Station Reference Lines

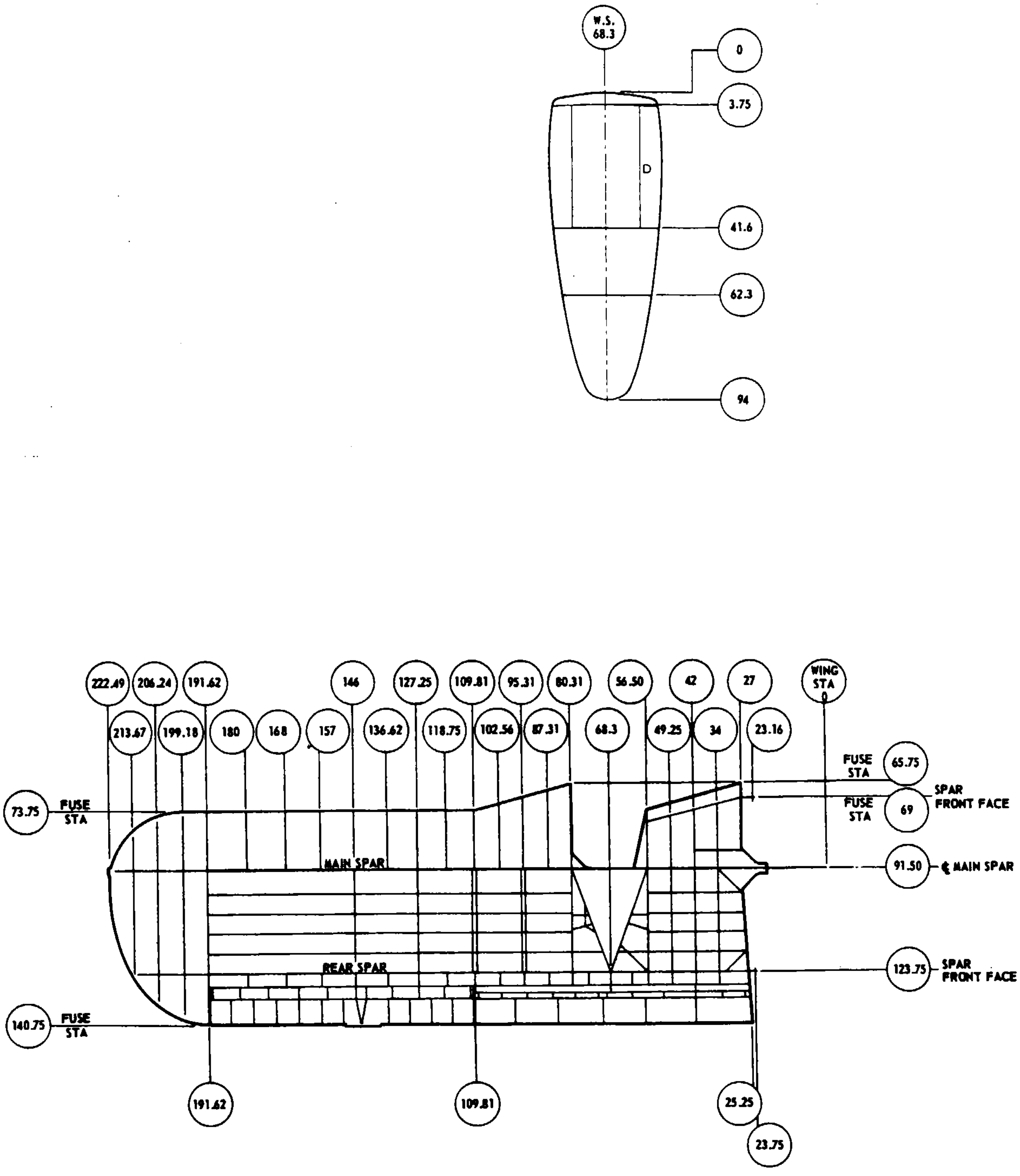


Figure 2-4. Station Reference Lines

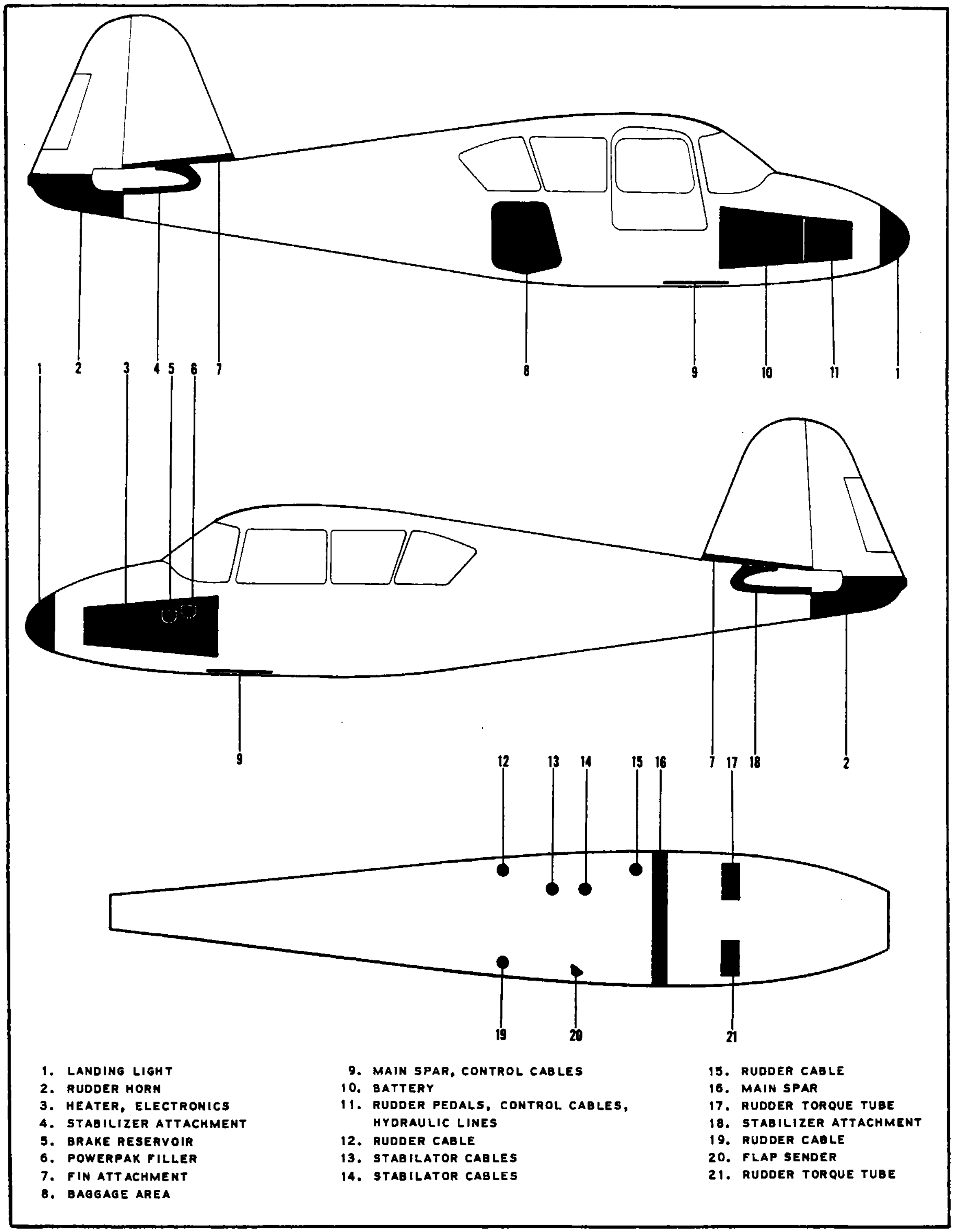
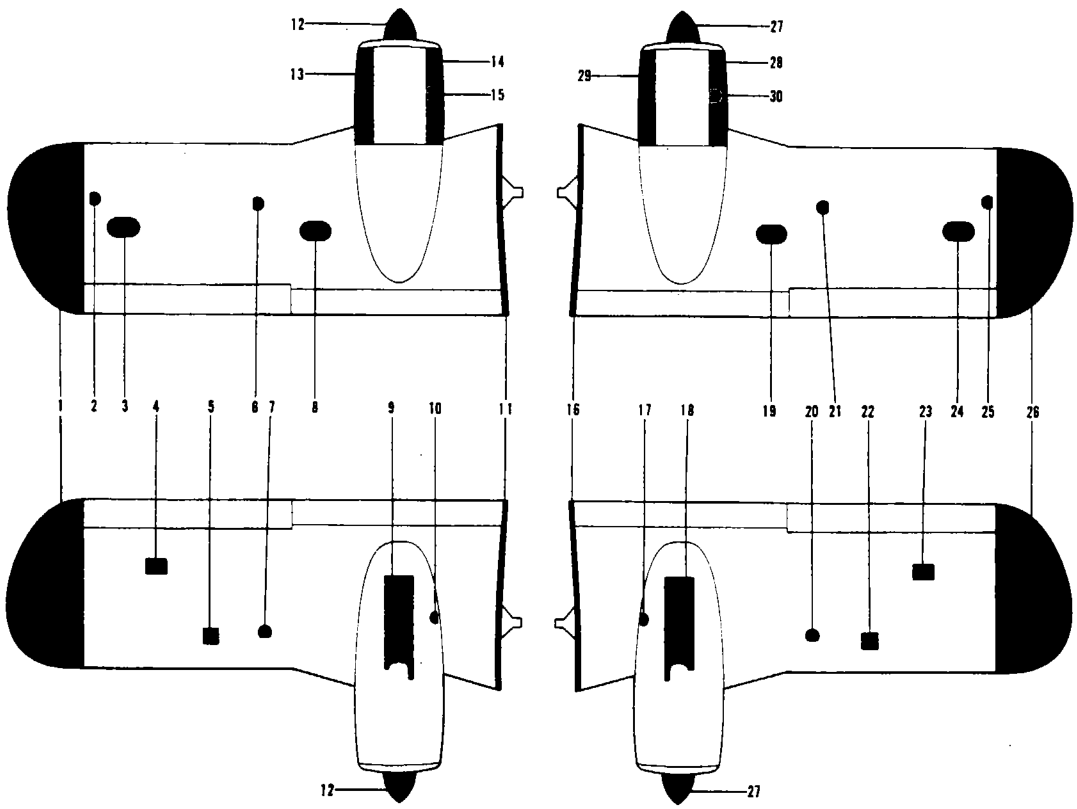


Figure 2-5. Access and Inspection Provisions



1. WING TIP
2. FUEL FILLER
3. FUEL CELL
4. FUEL LINE
5. AILERON BELLCRANK
6. FUEL FILLER
7. AILERON CABLES
8. FUEL CELL, FUEL QUANTITY SENDER
9. LANDING GEAR
10. FUEL FILTER
11. LINE FITTINGS, WIRING, WING ATTACHMENTS, CONTROL CABLES
12. PROPELLER
13. ENGINE AND ACCESSORIES
14. ENGINE AND ACCESSORIES
15. OIL FILLER
16. LINE FITTINGS, WIRING, WING ATTACHMENTS, CONTROL CABLES
17. FUEL FILTER
18. LANDING GEAR
19. FUEL CELL, FUEL QUANTITY SENDER
20. AILERON CABLES
21. FUEL FILLER
22. AILERON BELLCRANK
23. FUEL LINE
24. FUEL CELL
25. FUEL FILLER
26. WING TIP
27. PROPELLER
28. ENGINE
29. ENGINE
30. OIL FILLER

Figure 2-6. Access and Inspection Provisions

2-4. WEIGHT AND BALANCE DATA. When figuring various weight and balance computations, the weight and empty weight center of gravity of the airplane may be found in the Weight and Balance Form of the Airplane Flight Manual.

2-5. SERIAL NUMBER PLATE. The Serial Number Plate on the PA-23 Apache is located on the top of the tail cone, underneath the rudder. Airplane Serial Numbers will be used in this manual where servicing differences occur, and should be used when contacting the factory on Service or Warranty matters.

2-6. ACCESS AND INSPECTION PROVISIONS. The access and inspection provisions for the airplane are shown in Figures 2-5 and 2-6. The component to be serviced or inspected through each opening is assigned an index number to identify it in the illustration. All access plates and panels are secured by either metal fasteners or screws. To enter the aft section of the fuselage, remove the rear baggage compartment upholstery panel by removing the attachment screws.

CAUTION

Before entering the aft section of the fuselage, be sure the airplane is supported at the tail skid.

2-7. TOOLS AND TEST EQUIPMENT. Because of the simplicity and easy accessibility of components, few special tools outside normal shop tools will be required. Tools that are required may be fabricated from dimensions given in the section that pertains to a particular component or are listed in the back of the PA-23 Parts Catalog.

2-8. TORQUE REQUIREMENTS. The importance of correct application cannot be overemphasized. Undertorque can result in unnecessary wear of nuts and bolts as well as the parts they are holding together. When insufficient pressures are applied, uneven loads will be transmitted throughout the assembly which may result in excessive wear or premature failure due to fatigue. Overtorque can be equally damaging because of failure of a bolt or nut from overstressing the thread areas. The following procedures should be followed to assure that the correct torque is applied (refer to Table II-II):

a. Torque (self-locking fasteners) — Add the friction torque from Chart A for sizes 8 through 7/16 to the recommended torque from Chart B to get the final torque. This would be the actual reading on the torque wrench.

b. Torque (castellated and non-self-locking nuts) — Use only the torque given in Chart B. Unless otherwise specified, when castellated nuts are used with a cotter pin on moving joints, do not torque the nut. Turn the nut onto the bolt until proper grip is established and alignment with the cotter pin hole is achieved. Then install the cotter pin.

GENERAL REQUIREMENTS:

a. Calibrate the torque wrench periodically to assure accuracy; recheck frequently.

b. Ascertain that the bolt and nut threads are clean and dry (unless otherwise specified by the manufacturer). If the bolt or nut is specified to be lubricated prior to tightening, the torque range should be reduced 50 percent.

c. Use a bolt length long enough to prevent bearing loads on the threads. The complete chamfer or end radius of the bolt or screw must extend through the nut.

d. Unique torques specified in the text of this manual supersede the torques given in Charts A and B.

e. Refer to the latest revision of Lycoming SSP 1776 for torques on parts used on Lycoming engines.

f. A maximum of two AN960 washers may be added under the bolt heads or nuts to correct for variations in material thickness within the tolerances permitted.

g. Limitations of the use of self-locking nuts, bolts and screws including fasteners with non-metallic inserts are as follows:

1. Fasteners incorporating self-locking devices shall not be reused if they can be run up using only fingers. They may be reused if hand tools are required to run them up, providing there is no obvious damage to the self-locking device prior to installation.

2. Bolts 5/16 inch diameter and over with cotter pin holes may be used with self-locking nuts. Nuts with non-metallic locking devices may be used in this application only if the bolts are free from burrs around the cotter pin hole.

3. Do not use self-locking nuts at joints which subject either the nut or the bolt to rotation.

4. Never tap or rethread self-locking fasteners. Do not use nuts, bolts or screws with damaged threads or rough ends.

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TABLE II-II. RECOMMENDED NUT TORQUES

TABLE A

BOLT SIZE	FRICTION DRAG TORQUE (IN.LBS.)
8*	15
10	18
1/4	30
5/16	60
3/8	80
7/16	100

*APPLICABLE TO COARSE THREADS ONLY.

TABLE B

BOLTS Steel Tension	
AN 3 thru AN 20 AN 42 thru AN 49 AN 73 thru AN 81 AN 173 thru AN 186 MS 20033 thru MS 20046 MS 20073 MS 20074 AN 509 NK9 MS 24694 AN 525 NK525 MS 27039	

NUTS	
Steel Tension	Steel Shear
AN 310 AN 315 AN 363 AN 365 NAS 1021 MS 17825 MS 21045 MS 20365 MS 20500 NAS 679	AN 320 AN 364 NAS 1022 MS 17826 MS 20364

COARSE THREAD SERIES

Nut-bolt size	Torque Limits in-lbs		Torque Limits in-lbs	
	Min.	Max.	Min.	Max.
8 -32	12	15	7	9
10 -24	20	25	12	15
1/4-20	40	50	25	30
5/16-18	80	90	48	55
3/8-16	160	185	95	110
7/16-14	235	255	140	155
1/2-13	400	480	240	290
9/16-12	500	700	300	420
5/8-11	700	900	420	540
3/4-10	1,150	1,600	700	950
7/8- 9	2,200	3,000	1,300	1,800
1 -8	3,700	5,000	2,200	3,000
1-1/8-8	5,500	6,500	3,300	4,000
1-1/4-8	6,500	8,000	4,000	5,000

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TABLE II-II. RECOMMENDED NUT TORQUES (cont.)

	BOLTS Steel Tension		BOLTS Steel Tension		BOLTS Aluminum	
	AN 3 thru AN 20 AN 42 thru AN 49 AN 73 thru AN 81 AN 173 thru AN 186 MS 20033 thru MS 20046 MS 20073 MS 20074 AN 509 NK9 MS 24694 AN 525 NK525 MS 27039		MS 20004 thru MS 20024 NAS 144 thru NAS 158 NAS 333 thru NAS 340 NAS 583 thru NAS 590 NAS 624 thru NAS 644 NAS 1303 thru NAS 1320 NAS 172 NAS 174 NAS 517	Steel shear bolt NAS 464	AN 3DD thru AN 20DD AN 173DD thru AN 186DD AN 509DD AN 525D MS 27039D MS 24694DD	
	NUTS		NUTS		NUTS	
	Steel Tension	Steel Shear	Steel Tension	Steel Shear	Alum. Tension	Alum. Shear
	AN 310 AN 315 AN 363 AN 365 NAS 1021 MS 17825 MS 21045 MS 20365 MS 20500 NAS 679	AN 320 AN 364 NAS 1022 MS 17826 MS 20364	AN 310 AN 315 AN 363 AN 365 MS 17825 MS 20365 MS 21045 NAS 1021 NAS 679 NAS 1291	AN 320 AN 364 NAS 1022 MS 17826 MS 20364	AN 365D AN 310D NAS 1021D	AN 320D AN 364D NAS 1022D

FINE THREAD SERIES

Nut-bolt size	Torque Limits in-lbs		Torque Limits in-lbs		Torque Limits in-lbs		Torque Limits in-lbs		Torque Limits in-lbs		Torque Limits in-lbs	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
8 -36	12	15	7	9					5	10	3	6
10 -32	20	25	12	15	25	30	15	20	10	15	5	10
1/4-28	50	70	30	40	80	100	50	60	30	45	15	30
5/16-24	100	140	60	85	120	145	70	90	40	65	25	40
3/8-24	160	190	95	110	200	250	120	150	75	110	45	70
7/16-20	450	500	270	300	520	630	300	400	180	280	110	170
1/2-20	480	690	290	410	770	950	450	550	280	410	160	260
9/16-18	800	1,000	480	600	1,100	1,300	650	800	380	580	230	360
5/8-18	1,100	1,300	660	780	1,250	1,550	750	950	550	670	270	420
3/4-16	2,300	2,500	1,300	1,500	2,650	3,200	1,600	1,900	950	1,250	560	880
7/8-14	2,500	3,000	1,500	1,800	3,550	4,350	2,100	2,690	1,250	1,900	750	1,200
1 -14	3,700	4,500	2,200	3,300	4,500	5,500	2,700	3,300	1,600	2,400	950	1,500
1-1/8-12	5,000	7,000	3,000	4,200	6,000	7,300	3,600	4,400	2,100	3,200	1,250	2,000
1-1/4-12	9,000	11,000	5,400	6,600	11,000	13,400	6,600	8,000	3,900	5,600	2,300	3,650

NOTE

For more details on torquing, refer to FAA Manual AC43.13-1A.

CAUTION

Do not overtorque fittings.

NOTE

When flared fittings are being installed, ascertain that the male threads are properly lubricated. Torque the fittings in accordance with Table II-III.

TABLE II-III. FLARE FITTING TORQUES

TORQUE — INCH-POUND						
TUBING OD INCHES	ALUMINUM - ALLOY TUBING FLARE - AND 10061 OR AND 10078		STEEL TUBING FLARE AND 10061		HOSE END FITTING AND HOSE ASSEMBLIES	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1/8	— — —	— — —	— — —	— — —	— — —	— — —
3/16	— — —	— — —	90	100	70	100
1/4	40	65	135	150	70	120
5/16	60	80	180	200	85	180
3/8	75	125	270	300	100	250
1/2	150	250	450	500	210	420
5/8	200	350	650	700	300	480
3/4	300	500	900	1000	500	850
1	500	700	1200	1400	700	1150
1-1/4	600	900	— — —	— — —	— — —	— — —
1-1/2	600	900	— — —	— — —	— — —	— — —
1-3/4	— — —	— — —	— — —	— — —	— — —	— — —
2	— — —	— — —	— — —	— — —	— — —	— — —

2-8a. TORQUE WRENCHES. Torque wrenches should be checked daily and calibrated by means of weights and a measured lever arm to make sure that inaccuracies are not present. Checking one torque wrench against another is not sufficient and is not recommended. Some wrenches are quite sensitive as to the way they are supported during a tightening operation. Any instructions furnished by the manufacturer must be followed explicitly.

When it is necessary to use a special extension or adapter wrench together with a torque wrench, a simple mathematical equation must be worked out to arrive at the correct torque reading. Following is the formula to be used (refer to Figure 2-6b):

T =Torque desired at the part.

A = Basic lever length from center of wrench shank to center of handle or stamped on wrench or listed for that model wrench.

B = Length of adapter extension, center of bolt to center of shank.

C = Scale reading needed to obtain desired torque (T).

$$\text{The formula: } C = \frac{A \times T}{A + B}$$

EXAMPLE

A bolt requires 30 foot-pounds and a 3 inch adapter (one-quarter of a foot or .25’) is needed to get at it. You want to know what scale reading it will take on a one-foot lever arm wrench to obtain the 30 foot-pounds at the bolt.

$$C = \frac{1 \times 30}{1 + .25} \text{ or } C = \frac{30}{1.25} = 24 \text{ ft.-lbs.}$$

Remember, the 3 inch adapter must be projecting 3 inches straight along the wrench axis. In general, avoid all complex assemblages or adapters and extensions of flex joints.

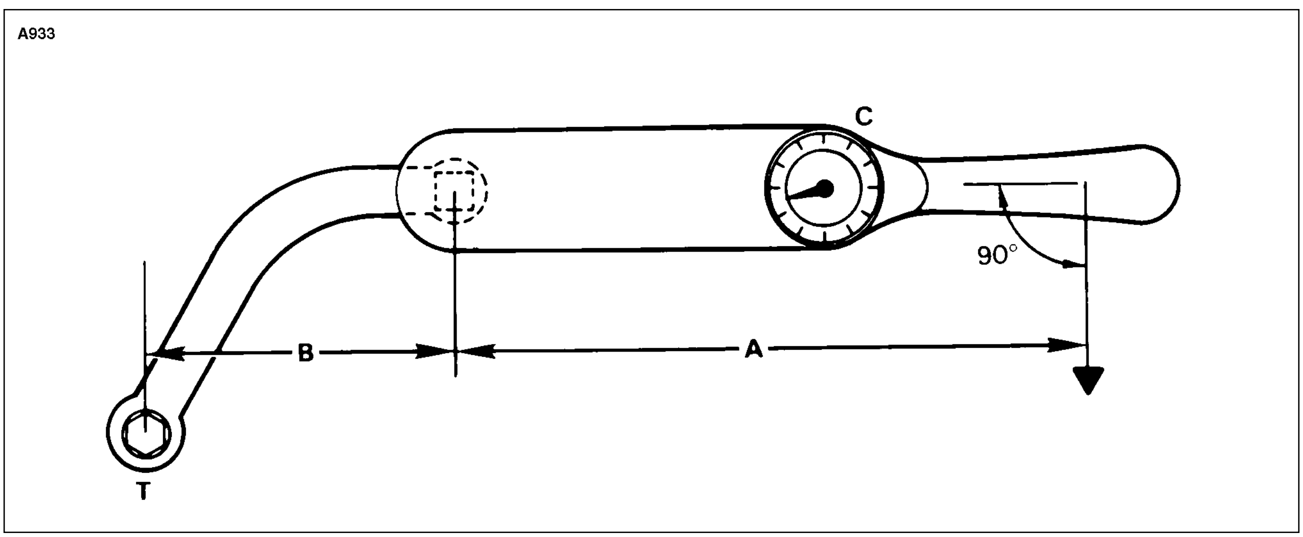


Figure 2-6b. Torque Wrench Formula

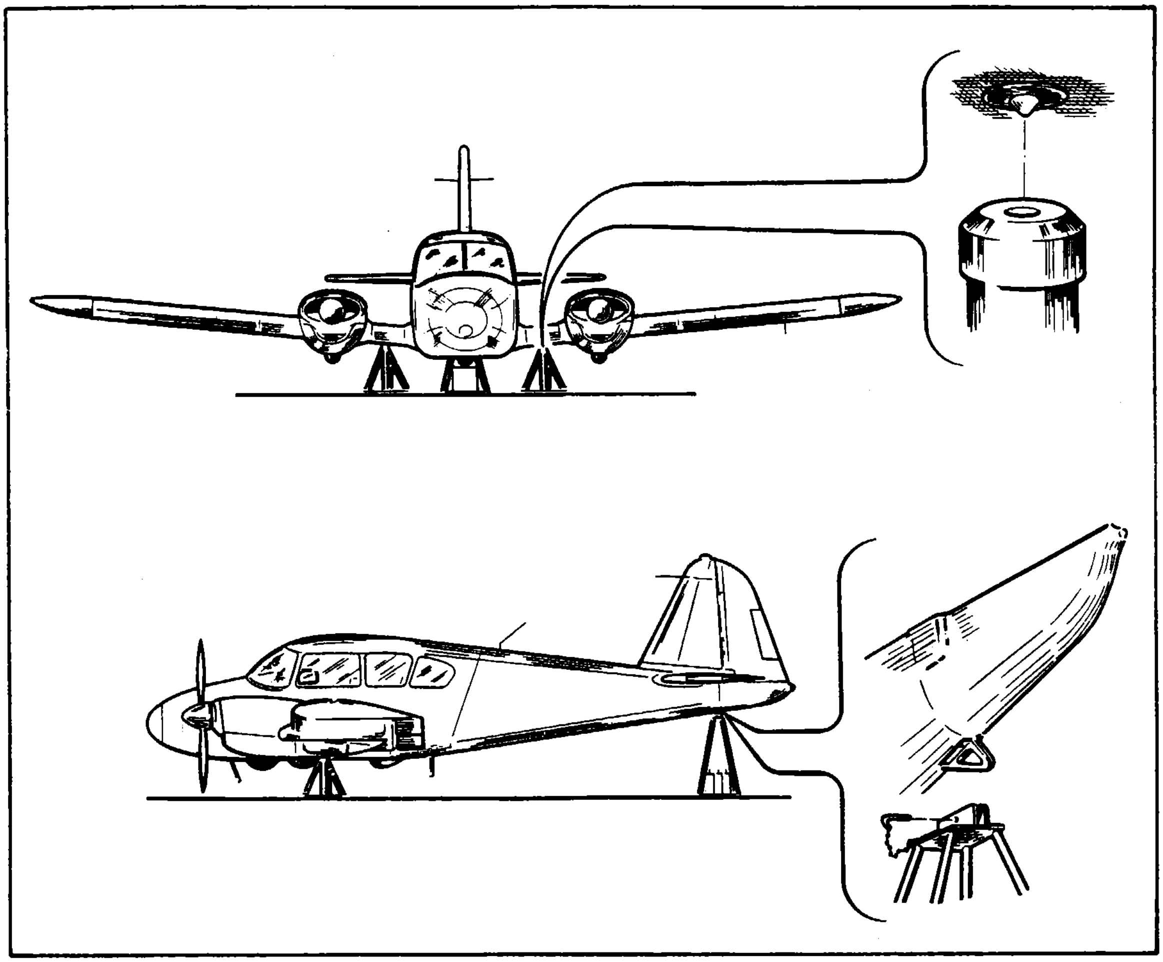


Figure 2-7. Jacking Arrangement

2-9. GROUND HANDLING.

2-10. INTRODUCTION TO GROUND HANDLING. Ground handling covers all essential information governing the handling of the airplane while on the ground. This includes jacking, weighing, leveling, mooring, parking, towing and taxiing. When the airplane is handled in the manner described in the following paragraphs, damage to the airplane and its equipment will be prevented.

2-11. JACKING. The airplane is provided with a jacking pad on each main spar just outboard of the engine nacelle and a support position by making use of the tail skid. (Refer to Figure 2-7.) To jack the airplane, proceed as follows:

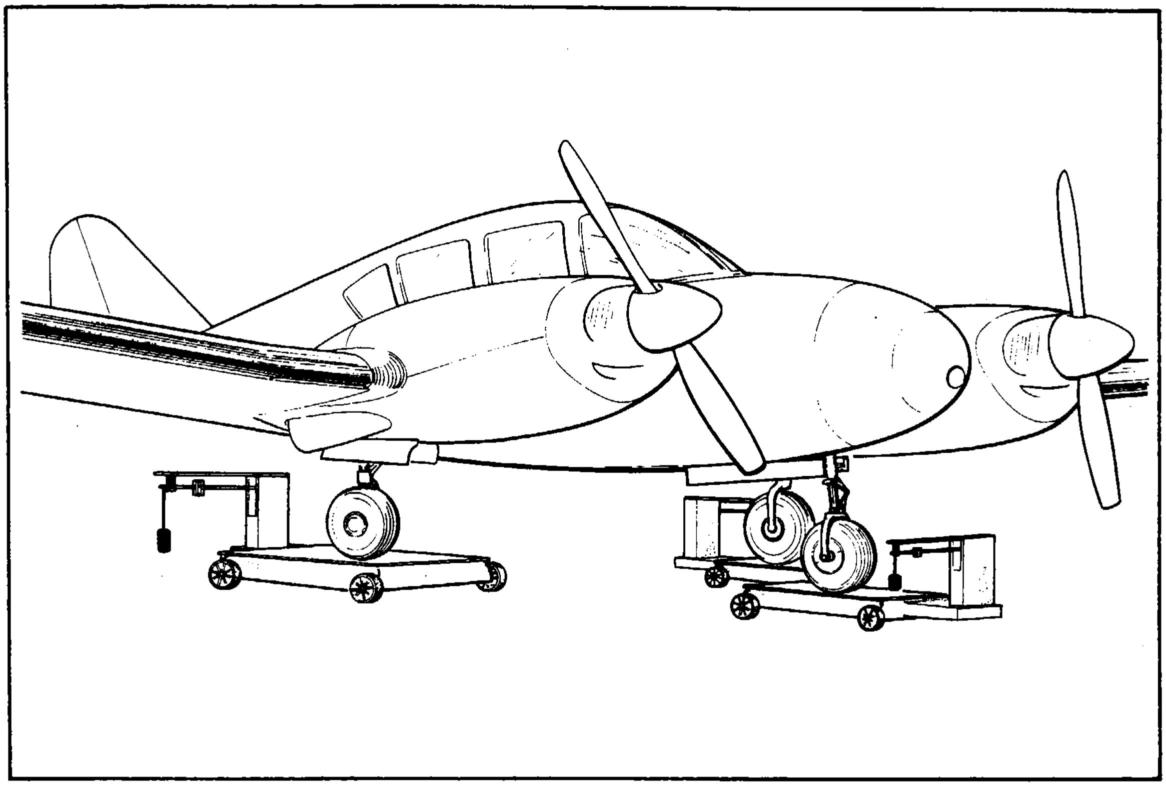


Figure 2-8. Weighing

a. Place the jacks under the jack pads.

b. Attach the tail support to the tail skid. Place approximately 250 pounds of ballast on the support to hold the tail down.

CAUTION

Be sure to apply sufficient tail support ballast; otherwise the airplane will tip forward and fall on the fuselage nose section.

c. Raise the jacks evenly until all three wheels clear the floor.

2-12. WEIGHING. (Refer to Figure 2-8.)

a. Position a scale and ramp in front of each of the three landing gear wheels.

b. Secure the scales from rolling and tow the airplane up on the scales. (Refer to Towing, Paragraph 2-16.)

c. Remove the ramps so as not to interfere with the scales.

d If the airplane is to be weighed for weight and balance computations, level

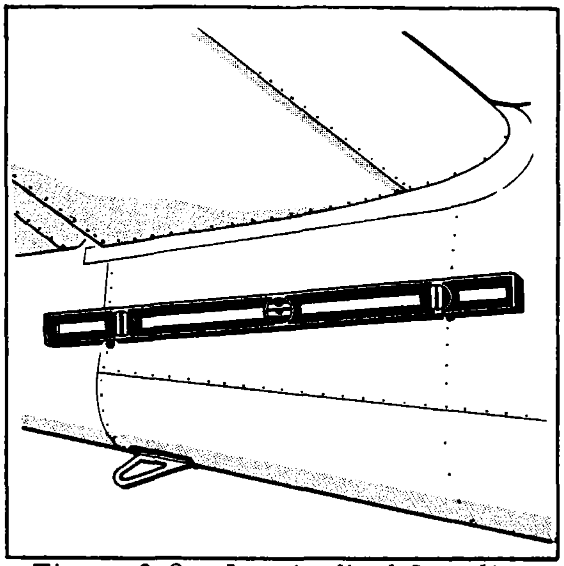


Figure 2-9. Longitudinal Leveling

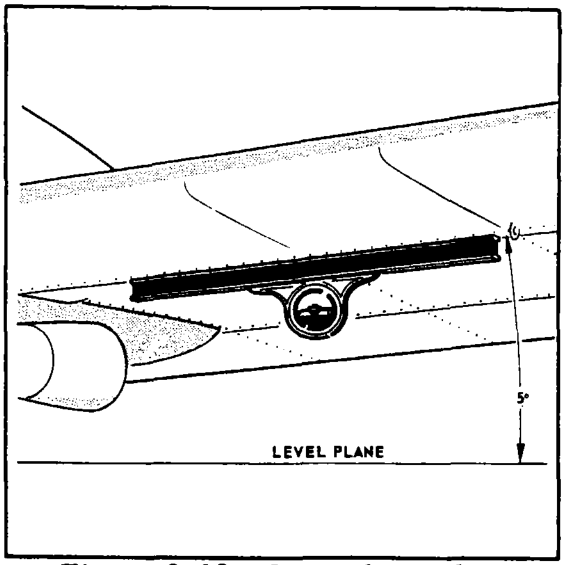


Figure 2-10. Lateral Leveling

the airplane per instructions given in Paragraph 2-13.

e. The aircraft weight is obtained by adding the reading on each of the three scales.

2-13. LEVELING. All configurations of the airplane are provided with a means for longitudinal and lateral leveling. The airplane may be leveled while on jacks; during the weighing procedure while the wheels are on scales; or while the wheels are on the ground. To level the airplane for purposes of weighing or rigging, the following procedures may be used:

a. Level the airplane longitudinally as follows:

1. Partially withdraw the two leveling screws located on the right side of the fuselage beneath the horizontal stabilizer as shown in Figure 2-9.

2. Place a spirit level on the heads of the screws.

3. Level the airplane by inflating or deflating the nose wheel tire or adjusting the jacks until the bubble on the level is centered.

b. Level the airplane laterally as follows:

1. Set a bubble protractor at five degrees and place on a straight edge held along the front spar on the under-surface of the wing as shown in Figure 2-10. Do not place the straight edge on rivet heads.

2. Raise or lower the wing by inflating or deflating the main gear tire or adjusting either jack until the bubble is centered indicating a five degree dihedral of the wing which will level the fuselage.

3. Check the opposite wing with the protractor to ascertain it also has a five degree dihedral.

2-14. MOORING. The airplane is moored to insure its immovability, protection and security under various weather conditions. The following procedure gives the instructions for proper mooring of the airplane.

a. Head the airplane into the wind, if possible.

b. Block the wheels.

c. Insert control surface locks, if available.

d. Secure tie-down ropes to the wing tie-down rings and the tail skid at approximately 45 degree angles to the ground. When using rope constructed of non-synthetic material, leave sufficient slack to avoid damage to the airplane when the ropes contract due to moisture.

CAUTION

Use square or bowline knots. Do not use slip knots.

NOTE

Additional preparations for high winds include using tie-down ropes from the landing gear forks, and securing the rudder.

e. Install pitot tube cover, if available.

2-15. PARKING. When parking the airplane, insure that it is sufficiently protected against adverse weather conditions and presents no danger to other aircraft. When parking the airplane for any length of time or overnight, it is recommended that it be moored as in paragraph 2-14.

a. To park the airplane, head it into the wind, if possible.

b. Set the parking brake by applying toe pressure against the top of the rudder pedals and at the same time pull out on the brake handle. To release the parking brake, apply toe pressure on the pedals and push in on the parking brake handle.

NOTE

Care should be taken when setting brakes that are overheated or during cold weather when accumulated moisture may freeze the brakes.

2-16. TOWING. The airplane may be moved by using the nose wheel steering bar that is stowed in the baggage area or power equipment that will not damage or cause excess strain to the nose gear steering assembly. Towing lugs are incorporated as part of the nose gear fork.

CAUTION

Do not tow airplane with control locks installed.

2-17. TAXIING. Before attempting to taxi the airplane, ground personnel should be checked out by a qualified pilot or other responsible person. Engine starting and shut-down procedures should be covered as well. When it is ascertained that the propeller back blast and taxi areas are clear, apply power to start the taxi roll and perform the following checks:

a. Taxi forward a few feet and apply brakes to determine their effectiveness.

b. Taxi with propeller set in low pitch, high RPM setting.

c. While taxiing, make slight turns to ascertain the effectiveness of steering.

d. Observe wing clearances when taxiing near buildings or other stationary objects. If possible, station a guide outside the airplane to observe.

e. When taxiing on uneven ground, look for holes and ruts.

f. Do not operate the engine at high RPM when running up or taxiing over ground containing loose stones, gravel or any loose material that may cause damage to the propeller blades.

2-18. EXTERNAL POWER RECEPTACLE.

2-19. OPERATION OF EXTERNAL POWER RECEPTACLE. The external power receptacle is located on the underside of the nose section forward of the landing gear. When using external power for starting or operation of any of the airplane's equipment, the master switch must be OFF.

CAUTION

Turn the master switch OFF before inserting or removing plug.

2-20. CLEANING.

2-21. CLEANING ENGINE COMPARTMENT. Before cleaning the engine compartment, place a strip of tape on the magneto vents to prevent any solvent from entering these units.

a. Place a large pan under the engine to catch waste.

b. With the engine cowling removed, spray or brush the engine with solvent or a mixture of solvent and degreaser, as desired. It may be necessary to brush areas that were sprayed where heavy grease and dirt deposits have collected in order to clean them.

CAUTION

Do not spray solvent into the generator, starter and air intakes.

c. Allow the solvent to remain on the engine from five to 10 minutes, then rinse the engine clean with additional solvent and allow to dry.

CAUTION

Do not operate engine until excess solvent has evaporated or otherwise been removed.

d. Remove the protective covers from the magnetos.

e. Lubricate controls, bearing surfaces, etc., per Lubrication Chart.

2-22. CLEANING LANDING GEAR. Before cleaning the landing gear, place a plastic cover or similar material over the wheel and brake assembly.

a. Place a pan under the gear to catch waste.

b. Spray or brush the gear area with solvent or a mixture of solvent and degreaser, as desired. It may be necessary to brush areas that were sprayed where heavy grease and dirt deposits have collected in order to clean them.

c. Allow the solvent to remain on the gear from 5 to 10 minutes, then rinse the gear with additional solvent and allow to dry.

d. Remove the cover from the wheel and remove the catch pan.

e. Lubricate the gear per Lubrication Chart.

2-23. CLEANING EXTERIOR SURFACES. The airplane should be washed with a mild soap and water. Harsh abrasive or alkaline soaps or detergents used on painted or plastic surfaces could make scratches or cause corrosion of metal surfaces. Cover areas where cleaning solution could cause damage. To wash the airplane, the following procedure may be used:

a. Flush away loose dirt with water.
b. Apply cleaning solution with a rag, sponge or soft bristle brush.
c. To remove stubborn oil and grease, use a cloth dampened with naptha.
d. Where exhaust stains exist, allow solution to remain on the surface longer.
e. Any good automotive wax may be used to preserve the painted surfaces. Soft cleaning cloths or a chamois should be used to prevent scratches when cleaning or polishing. A heavier coating of wax on the leading surfaces will reduce the abrasion problems in these areas.

2-24. CLEANING WINDSHIELD AND WINDOWS.

a. Remove dirt, mud, etc., from exterior surface with clean water.
b. Wash with mild soap and warm water or an aircraft plastic cleaner. Use a soft cloth or sponge using a straight rubbing motion. Do not harshly rub surfaces.
c. Remove oil and grease with a cloth moistened with kerosene.

NOTE

Do not use gasoline, alcohol, benezene, carbon tetrachloride, thinner, acetone, or window cleaning sprays.

d. After cleaning plastic surfaces, apply a thin coat of hard polishing wax. Rub lightly with a soft cloth. Do not use a circular motion.
e. A severe scratch or mar in plastic can be removed by using jeweler's rouge to rub out the scratch. Smooth both sides and apply wax.

2-25. CLEANING HEADLINER, SIDE PANELS AND SEATS.

a. Clean headliner, side panels and seats with a stiff bristle brush and vacuum where necessary.
b. Soiled upholstery, except leather, may be cleaned by using an approved air type cleaner or foam upholstery cleaner. Carefully follow the manufacturer's instructions. Avoid soaking or harsh rubbing.

CAUTION

Solvent cleaners require adequate ventilation.

c. Leather material should be cleaned with saddle soap or a mild soap and water.

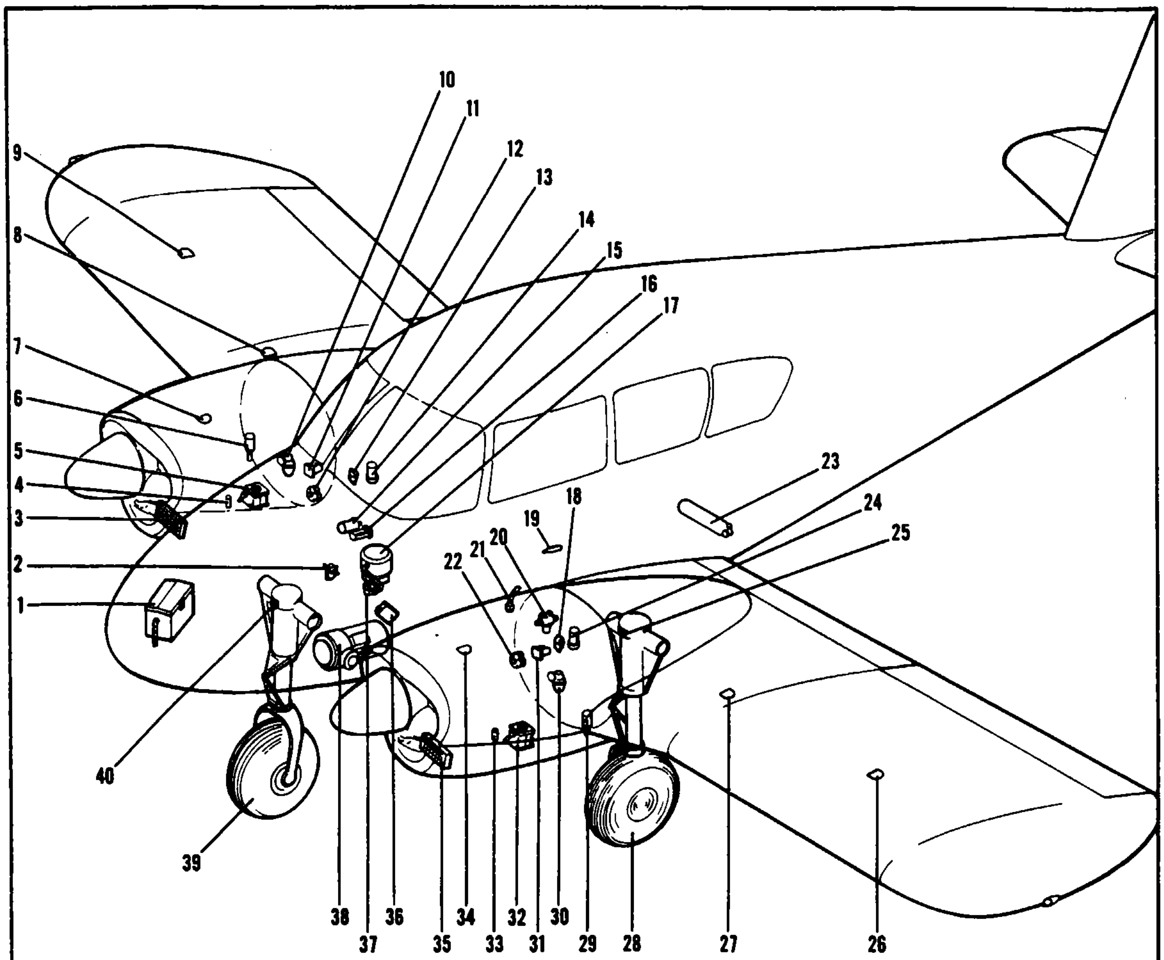
2-26. CLEANING CARPETS. Use a small whisk broom or vacuum to remove dirt. For soiled spots, use a non-inflammable dry-cleaning fluid.

2-27. SERVICING.

2-28. INTRODUCTION TO SERVICING. Servicing the airplane includes the replenishment of fuel, oil, hydraulic fluid, tire pressures, lubrication requirements and other items required to completely service the airplane.

2-29. HYDRAULIC SYSTEM.

2-30. SERVICING HYDRAULIC SYSTEM. The hydraulic system, which consists of the landing gear and flap actuating systems, powerpak and associated lines, should be checked and serviced every 100 hours. The powerpak should be filled with hydraulic fluid, MIL-H-5606 and all hydraulic lines, connections and actuating cylinders checked for damage and leakage. All hydraulic actuating rods should be kept clean of dirt by wiping with a rag soaked in hydraulic fluid. Every precaution must be exercised in handling hydraulic fluid to prevent its contamination. Dirt or other foreign matter in the system may become lodged between the valves and seats of the powerpak and component parts in the various actuating cylinders, thus preventing the system from operating properly. It is recommended that the hydraulic fluid be filtered before using, whether it is new or used fluid. Use a small funnel, a piece of standard commercial filter paper and a container to hold the funnel and filtered oil. Detailed instructions for maintenance of the hydraulic system may be found in Section VI.



1. BATTERY
2. STRAINER, HEATER FUEL
3. FILTER, INDUCTION, RIGHT ENGINE
4. SCREEN, OIL SUCTION, RIGHT ENGINE
5. CARBURETOR, RIGHT ENGINE
6. COLLECTOR TANK, OIL
7. OIL FILLER, RIGHT ENGINE
8. FILLER, INBOARD FUEL CELL, RIGHT
9. FILLER, OUTBOARD FUEL CELL, RIGHT
10. SCREEN, ENGINE DRIVEN FUEL PUMP
11. SCREEN, OIL PRESSURE, RIGHT ENGINE
12. FILTER, VACUUM REGULATOR
13. SCREEN, FUEL DRAIN
14. FILTER, FUEL PUMP, ELECTRIC
15. FILTER, ARTIFICAL HORIZON
16. FILTER, DIRECTIONAL GYRO
17. POWERPAK RESERVOIR
18. SCREEN, FUEL DRAIN
19. CYLINDER, CO_2
20. FILTER, HYDRAULIC, LEFT ONLY
21. DRAIN, CROSSFEED FUEL
22. FILTER, VACUUM REGULATOR
23. CYLINDER, OXYGEN
24. FILTER, FUEL PUMP, ELECTRIC
25. FILLER, OLEO SHOCK STRUT, L AND R
26. FILLER, OUTBOARD FUEL CELL, LEFT
27. FILLER, INBOARD FUEL CELL, LEFT
28. TIRE, L AND R
29. COLLECTOR TANK, OIL
30. SCREEN, ENGINE DRIVEN FUEL PUMP
31. SCREEN, OIL PRESSURE, LEFT ENGINE
32. CARBURETOR, LEFT ENGINE
33. SCREEN, OIL SUCTION, LEFT ENGINE
34. OIL FILLER, LEFT ENGINE
35. FILTER, INDUCTION, LEFT ENGINE
36. RESERVOIR, BRAKE SYSTEM
37. FILLER TUBE, POWERPAK
38. HEATER
39. TIRE, NOSE
40. FILLER, OLEO SHOCK STRUT, NOSE

Figure 2-11. Service Points

2-31. POWERPAK RESERVOIR.

2-32. FILLING POWERPAK RESERVOIR (Gravity).

a. Open the access door or remove the left side panel on the nose to gain access to the hydraulic filler tube. (Refer to Figure 2-5.)

b. Place the airplane on jacks. (Refer to Jacking, Paragraph 2-11.)

c. Remove the cap of filler tube.

d. Place the landing gear selector lever in the "UP" position.

e. Using the hand pump, raise the landing gear. When the landing gear selector lever returns to neutral, place the wing flap selector lever in the "DOWN" position and extend flaps.

f. Add fluid to the system through the filler tube (Refer to Figure 2-11.) until fluid drips from the overflow located in the nose gear wheel well.

NOTE

Remember in step e above, the landing gear is "UP" and the flaps are "DOWN", so overflow fluid will first appear on the nose wheel tire.

g. Swivel the elbow at the cap end of the filler tube until it points down. Hold the loose end of the filler tube down and let the excess fluid drain off.

h. Recap the filler tube and close the access door or install side panel.

i. Operate the landing gear and flaps through their complete cycle, "UP" and "DOWN" at least five times to insure that all air is bled from the system, as indicated by smooth operation of the landing gear and wing flaps.

NOTE

As an added precaution, have a container ready to catch any excessive fluid that wiil be exhausted through the overboard drain in the nose wheel well when recycling landing gear and flaps.

2-33. FILLING POWERPAK RESERVOIR (Pressure).

a. Open the access door or remove the left side panel to gain access to the hydraulic filler tube. (Refer to Figure 2-5.)

b. Place the airplane on jacks. (Refer to Jacking, Paragraph 2-11.)

c. Remove the filler tube cap (Refer to Figure 2-11.) and swivel the elbow down.

d. Disconnect the pressure and suction hydraulic lines from the engine driven hydraulic pump and connect these lines to the auxiliary fluid source.

e. Fill the hydraulic system by turning on the motor of the auxiliary fluid source. Fill until fluid overflows the filler tube.

NOTE

Do not cap the filler tube.

f. Turn off the motor of the auxiliary fluid source and operate both the landing gear and flaps at least twice, using the hand pump.

g. With the landing gear retracted and the flaps down, start the motor of the auxiliary fluid source and refill the system until the fluid overflows the filler tube.

h. Close the line leading from the reservoir of the auxiliary fluid source to its motor. Start the motor and operate the landing gear and the flap system at least five times.

i. With the landing gear retracted and the flaps down, recheck the fluid level.

j. Extend the landing gear and raise the flaps. Disconnect the auxiliary fluid source and re-attach the lines to the engine driven pump.

k. Recap the filler tube and close the access door or install side panel.

2-34. LANDING GEAR SYSTEM.

2-35. SERVICING LANDING GEAR. The landing gear consisting of tires, brakes, oleo strut assembly, drag links, down locks and gear doors, should be visually inspected to determine proper strut extension, possible hydraulic fluid leakage, security and condition of all related components. Minor service is described in the following paragraphs and detailed service and overhaul instructions are listed in Section VII.

2-36. OLEO STRUTS.

2-37. SERVICING OLEO STRUTS. Air-oil shock struts are incorporated in each landing gear oleo assembly to absorb the shock resulting from the impact of the wheels on the runway during landing. To obtain proper oleo action, the nose and main gear oleo struts must have approximately 3.0 inches of piston tube exposed under normal static loads. (Refer to Figure 2-12.) If a strut has less than the

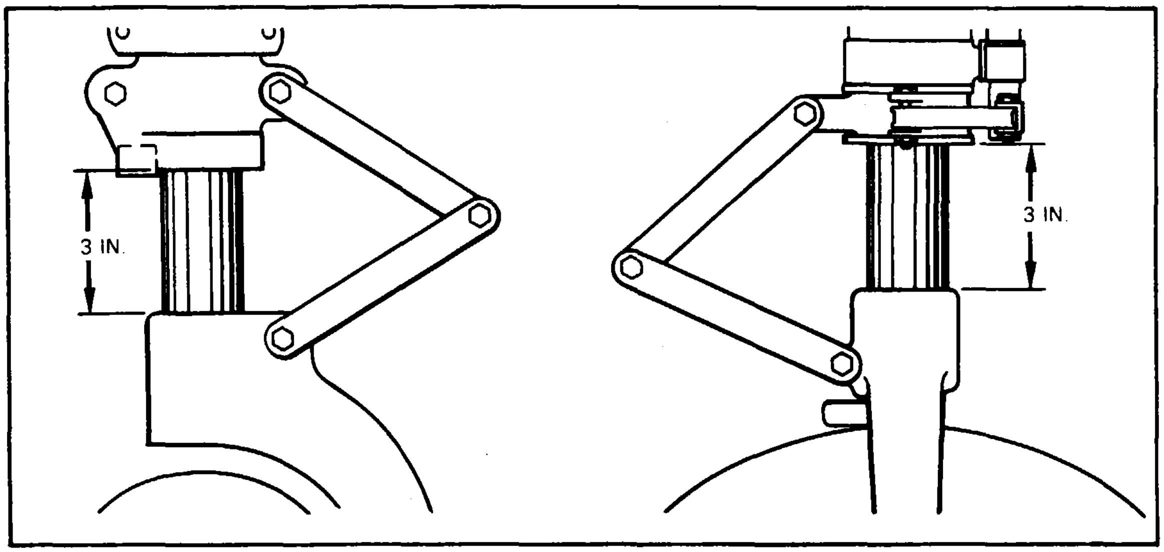


Figure 2-12. Servicing Landing Gear Oleo Struts

required inches exposed, determine whether it needs air or oil by rocking the airplane. If the oleo strut oscillates with short strokes (approximately one inch) and the airplane settles to its normal position within one or two cycles after the rocking force is removed, the oleo strut requires inflating. Check the valve core and filler plug for air leaks, correct if required, and add air as described in paragraph 2-40. If the oleo strut oscillates with long strokes (approximately three inches) and the airplane continues to oscillate after the rocking force is removed, the oleo struts require fluid. Check the oleo for indications of oil leaks, correct if required and add fluid as described in paragraph 2-38.) For repair procedures of the landing gear and/or oleo struts, refer to Section VII.

WARNING

Do not release air by removing the strut valve core or filler plug. Depress the valve core pin until strut pressure has diminished.

NOTE

Struts may be serviced and adjusted per placard on strut.

2-38. ADDING FLUID TO STRUTS. To add fluid to an oleo strut which is partly full, proceed as follows:

a. Place the airplane on jacks. (Refer to Jacking, Paragraph 2-11.)
b. Place a pan under the gear to catch spillage.
c. Release the air in the oleo strut by pressing in on the air valve core pin.
d. Remove the air valve (filler plug). Allow valve core to remain in valve.
e. Extend the strut to two inches from the fully compressed position.
f. At the two-inch extended position, fill the strut through the filler opening with fluid as specified.
g. Slowly compress the strut to the fully compressed position allowing fluid to overflow.
h. With oleo strut in the compressed position, reinstall air valve and safety.
i. Inflate the oleo struts with air to the required extension per instructions in paragraph 2-40.

2-39. FILLING OLEO STRUTS. To fill an oleo strut which has been completely emptied because of repair, leakage, etc., proceed as follows:

a. Place the airplane on jacks. (Refer to Jacking, Paragraph 2-11.)
b. Place a pan under the gear to catch spillage.
c. Remove valve core from air valve.
d. Attach a clear plastic tube to the valve stem and place the other end of the tube in a container of hydraulic fluid as specified.

NOTE

An air-tight connection is necessary between the plastic tube and valve stem. Without such a connection, a small amount of air will be sucked into the oleo strut during each sequence, resulting in an inordinate amount of air bubbles and a prolonged filling operation.

e. Extend the oleo strut by pulling down on the wheel. Fluid will be sucked into the oleo strut. Compress and extend the oleo strut until it is full of fluid, and air bubbles cease to appear in the plastic tube.
f. Compress the oleo strut to within 1/4 inch of full compression, allowing the excess fluid to overflow.
g. With the oleo strut in the near compressed position, reinstall the valve core.
h. Remove the airplane from the jacks.
i. Inflate the oleo struts per instructions given in paragraph 2-40.

2-40. INFLATING OLEO STRUTS. After making certain that an oleo strut has sufficient fluid, as described in paragraph 2-37, attach a strut pump to the air valve and pump up the oleo strut. The oleo struts should be inflated until 3.0 inches of piston is exposed with normal static weight on the gears. Before capping the valve, check for valve core leakage.

2-41. BRAKE SYSTEM.

2-42. SERVICING BRAKE SYSTEM. The brake system incorporates a hydraulic fluid reservoir through which the brake system is periodically serviced. Fluid is drawn from the reservoir by the brake master cylinders to maintain the volume of fluid required for maximum braking efficiency. Spongy brake pedal action is often an indication that the brake fluid reservoir is running low on fluid. Instructions for filling the reservoir are given in paragraph 2-43. When found necessary to accomplish repairs to any of the brake system components, these instructions may be found in Section VII.

2-43. FILLING BRAKE CYLINDER RESERVOIR. The brake cylinder reservoir should be filled to the level marked on reservoir, with the fluid specified in Table II-I. The reservoir, located in the left side of the nose section, shown in Figure 2-11, should be checked at every 100-hour inspection and replenished as necessary.

2-44. DRAINING BRAKE SYSTEM. To drain the brake system, connect a hose to the bleeder fitting on the bottom of the cylinder and place the other end of the line in a suitable container. Open the bleeder and slowly pump the desired brake pedal until fluid ceases to flow. To clean the brake system, flush with denatured alcohol.

2-45. TIRES.

2-46. SERVICING TIRES. The tires should be maintained at the pressure specified in Table II-I. When checking tire pressure, examine the tires for wear, cuts, bruises and slippage.

2-47. POWER PLANT.

2-48. SERVICING POWER PLANT. The power plants should be visually inspected to determine possible fuel and oil leakage, and condition and security of all related components. Additional service information may be found in Section VIII.

2-49. INDUCTION AIR FILTER.

2-50. REMOVAL AND INSTALLATION OF AIR FILTER. The air filter, located inside the lower forward section of each nacelle, may be removed by turning the dzus fasteners which hold it in place and withdrawing it from the nacelle. Install in reverse order of removal.

2-51. SERVICING AIR FILTER. This type of filter must be inspected daily for dirt accumulation and proper oiling. When it is found necessary to clean the filter (daily when operating in dusty conditions), or if filter requires oiling, the following procedure should be accomplished.

a. Thoroughly wash the filter in petroleum solvent. Make certain all dirt is removed from the filter and that the filter is in a serviceable condition.
b. Dry the filter at room temperature, making certain it is thoroughly dry before proceeding with the next step. If the filter is not dry, the solvent will prevent the oil from adhering to the small surfaces of the filter and thereby decrease its efficiency.
c. Immerse the filter in the recommended grade of oil for a period of five minutes.
d. After removal of the filter from the oil, allow to drain thoroughly before installing in the airplane.

2-52. PROPELLER.

2-53. SERVICING PROPELLER. The propeller blades, spinner and visible hub parts should be inspected frequently for damage, cracks and oil leakage. Nicks should be removed from the leading edge of the blades in accordance with applicable FAA regulations. The blades should be checked that they turn freely on the hub pilot tube, by rocking the counterweights back and forth through the slight freedom allowed by the pitch change mechanism. Lubricate the propeller at 100-hour intervals according to the Lubrication Chart, Figure 2-16. Additional service information for the propeller may be found in Section VIII.

2-54. FUEL SYSTEM.

2-55. SERVICING FUEL SYSTEM. At intervals of 50 hours or 90 days, whichever comes first, clean the screens in each strainer bowl located through an access opening on the inboard side of the main wheel wells. Remove and clean the screens in accordance with the instructions outlined in Section IX. Additional service information may also be found in Section IX. Inspection intervals of the various fuel system components may be found in Section III.

2-56. FILLING FUEL CELLS. Observe all required precautions for handling gasoline. Fill the fuel cells to the bottom of the filler neck with the fuel specified in Table II-I. Refer to Figure 2-11 for the location of the access panels for the fuel tanks.

2-57. DRAINING MOISTURE FROM THE SYSTEM. (Refer to Figure 2-13.)

a. Fuel cells should be kept full of fuel during storage and the aircraft refueled as soon as possible after each flight to prevent accumulation of moisture and deterioration of the cells.

b. The fuel system must be drained daily prior to first flight and after refueling to avoid the accumulation of water and/or sediment using the following procedure.

c. The main fuel strainers are located in the inboard sides of the main wheel wells. They are fitted with quick drains and must be drained regularly through their access ports.

d. To drain main (and auxiliary fuel cells, if installed), open the fuel strainer quick drain with the fuel selector set on the main cell. Drain as required to produce one-half (1/2) pint or more of fuel, per cell. After completion of draining the main cell, select the auxiliary fuel cell (if installed) and repeat draining process. Repeat procedure on both left and right wing main (and auxiliary) fuel cells.

NOTE

Selecting individual fuel cells is not required, if Apache Dual Fuel-Drain Kit P/N 765-363 is installed.

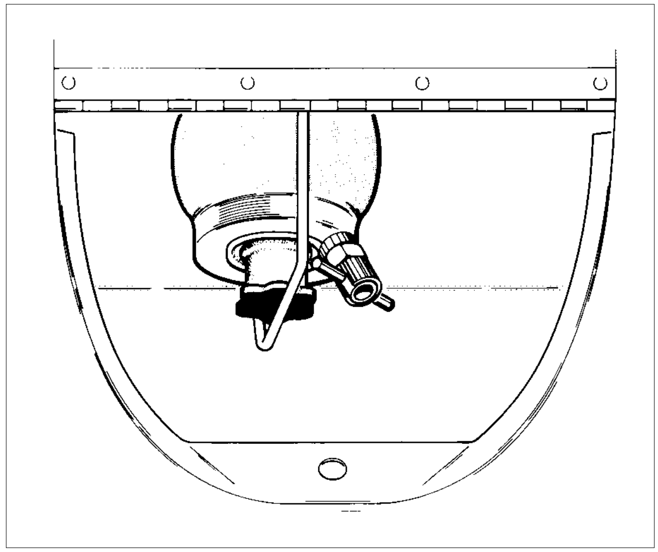


Figure 2-13. Fuel Screen Bowl

e. The crossfeed line drain valve control is mounted on the front face of the fuel control panel. To drain the crossfeed line, open the crossfeed valve and line drain, turn on the righthand electric fuel pump and allow to draln for a minimum of ten (10) seconds. Close crossfeed valve and turn off fuel pump. Open the line drain and turn on the left-hand electric fuel pump and allow to drain for a minimum of ten (10) seconds.

CAUTION

Aircraft must be in normal ground attitude on a level surface for proper draining. Fuel should be collected in a container and examined for water contamination. If water is present, repeat the above procedures until all water is removed. If any fuel cell is draining slower than normal, a complete check of the system should be carried out to determine the cause before flight. Ice formation may cause slow fuel drainage when the aircraft has been exposed to below freezing temperatures. If this is the case, the aircraft should be placed in a warm hangar until normal fuel drainage is attained and all water removed.

NOTE

To minimize water contamination of the fuel during cleaning operations, avoid directing water into the vents, drain tubes, around sealed cover plates and filler cap access openings.

2-58. DRAINING FUEL SYSTEM. Drain the bulk of the fuel from the system by pumping the fuel out of each cell through the filler opening with an electric fuel pump. Complete the draining by opening the cross-feed line drain control. Drain the inboard tanks first, then move the fuel selectors to the auxiliary position, thus allowing the auxiliary cells to drain through the crossfeed line drain. For an alternate draining procedure, open the fuel strainer bowl drain valve, or remove the fuel strainer bowl and allow the fuel to run out by gravity.

NOTE

The fuel strainer bowls are the lowest point in the fuel system.

2-59. OXYGEN SYSTEM.

2-60. SERVICING THE OXYGEN SYSTEM. The oxygen for the breathing system is furnished from a stationary cylinder located under the rear seat. At 1800 psi of pressure the oxygen cylinder has a capacity of 48.3 cubic feet. The cylinder valve is equipped with a hex-capped safety device, should the cylinder become exposed to fire or extreme heat. Do not attempt to remove this device. Keep the cylinder valve closed when plane is on the ground. While in flight, if oxygen is not being used, the “ON-OFF” valve on the console should be closed by turning the control knob clockwise, and the altitude adjusting knob closed by turning it counterclockwise all the way.

No maintenance or service is needed on the console unless damaged by accident. If the gauge pointers do not return to zero when oxygen is turned off and a mask is connected to an outlet, the gauge has been “sprung” by shock or improper operating sequence and should be replaced.

The plastic disposable mask and its components should be kept in its polyfilm envelope, or a suitable container when not in use, so that they will be kept dust free for satisfactory service. Plastic disposable masks may be worn many times by the same person.

2-61. OXYGEN SYSTEM SAFETY PRECAUTIONS. The utmost care must be exercised in servicing, handling and inspection of the oxygen system. Comply with the following precautions:

a. Keep the oxygen regulators, cylinders, gauges, valves, fittings, masks and all other components of the oxygen system free of oil, grease, gasoline and all other readily combustible substances.
b. Do not allow foreign matter to enter the oxygen lines.

WARNING

The presence of foreign matter in the high pressure lines can cause an explosion. When coming in contact with oxygen equipment keep hands, tools and clothing clean - hospital clean.

c. Never attempt to repair or repaint oxygen equipment.
d. Keep fire and heat away from oxygen equipment. Do not smoke while working with or near oxygen equipment and take care not to generate sparks with carelessly handled tools when working on the oxygen system.
e. Never allow electrical equipment to come in contact with the oxygen cylinder.
f. Only a thread compound approved under MIL-T-5542 can be used safely on oxygen systems. Apply only to the first three threads of male fittings to prevent thread seizure.

2-62. FILLING OXYGEN CYLINDER.

a. To refill the oxygen cylinder, remove from the airplane by the following procedure:

1. Raise the rear seat, gaining access to the cylinder.
2. Determine that the cylinder valve is turned OFF.
3. Disconnect the two clamps securing the tank in place.
4. Determine that the flow tube fitting, located at the cabin side panel, is free of dirt, dust, lint or any foreign substance.
5. Disconnect the flow tube fitting and install the cap provided to prevent contamination of the lines.
6. Remove the cylinder and valve assembly from the airplane,

b. Have the cylinder refilled by a reputable, experienced refill station. Specify that it must be filled with "Aviation Breathing Oxygen" as this is specially dried to remove moisture which could cause corrosion and damage in the system, or which could freeze and render the system useless at low temperature.

c. Reinstall the oxygen cylinder by the following procedure:

1. Place the cylinder in the airplane on its mounting brackets.
2. Remove the cap from the flow tube and connect the line at the cabin side panel.

CAUTION

Start the flow tube connection with fingers only to prevent cross threading.

3. Connect the two clamps securing the tank in place and reinstall the rear seat.

2-62a. INSPECTION AND OVERHAUL TIME LIMITS. It is recommended that inspection and overhaul be conducted by an FAA Approved Station; or, the manufacturer, Scott Aviation. The following checks and chart gives recommended inspection and overhaul times for the various parts of the oxygen system.

a. The oxygen cylinder can be identified by the ICC or DOT identification stamped on the cylinder. The standard weight cylinder (ICC or DOT 3AA 1800) must be hydrostatic tested at the end of each 5 year period. The month and year of the last test is stamped on the cylinder beneath the ICC or DOT identification.
b. The outlets should be checked for leakage both in the non-use condition, and for leakage around an inserted connector.
c. The high pressure gauge may be checked for accuracy by comparing its indicated pressure with that of a gauge of known accuracy.
d. Inspection of the regulator may be effected by introducing into an outlet a mask connector to which is attached a 100 psi gauge. With one other outlet flowing through a plugged in mask, the indicated regulator output pressure shall be not less than 45 psig at sea level with 200 psig supply cylinder pressure. It should be noted that the permissible leakage through the 1/16 diameter vent hole in the side of the upper regulator housing is 10 cc/ min. maximum, when the regulator is turned on. There shall be no external leakage anywhere on the regulator when it is turned off. All fittings shall be leak free.

2-63. LUBRICATION

2-64. OIL SYSTEM (Engine). (Refer to latest revisions of Lycoming Service Instruction No. 1014 and Lycoming Service Bulletin No. 480)

2-65. SERVICING OIL SYSTEM. The engine oil level should be checked before each flight and the oil changed as specified in Paragraph 2-70. During oil change, the oil screen(s) should be removed and cleaned and, if installed, the oil filter cartridge replaced. Removal and cleaning of screens may be found in Paragraphs 2-68 and 2-69. Should fuel other than the specified octane rating for the power plant be used, refer to latest revision of Lycoming Service Letter No. L185 for additional information and recommended service procedures. The engine manufacturer does not recommend oils by brand names. Use a quality brand Aviation Grade Oil of the proper season viscosity. For information on the use of detergent oil, refer to Paragraph 2-70 and/or latest revision of Lycoming Service Instruction 1014.

CAUTION

Do not introduce any trade additive to thc basic lubricant unless recommended by the engine manufacturer.

2-66. DRAINING OIL SUMP. To drain the oil sump, provide a suitable container with a minimum capacity of 8 quarts. Remove the left side panel from the engine cowl and open the oil drain valve located on the left underside of the engine by pushing the arms of the drain up and turn counterclockwise. This will hold the drain in the open position. It is recommended the engine be warmed to operating temperature to insure complete draining of the old oil.

2-67. FILLING OIL SUMP. The oil sump should normally be filled with oil to the 8 U. S. quart mark on the engine dip stick. The specified grade of oil may be found if Table II-IIIA or on each engine oil filler access door. To service the engine with oil, open the quick release access door on top of the nacelle and remove the oil filler cap with dip stick.

TABLE II-IIIA. RECOMMENDED LUBRICATING OILS

Air Temperature	MIL-L-6082	MIL-L-22851 (Ashless Dispersant)
All		SAE 15W50 or 20W50
Above 80°F (26.67°C)	SAE 60	SAE 60
Above 60°F (15.55°C)	SAE 50	SAE 40 or SAE 50
30° TO 90°F (-1.11° to 32.22°C)	SAE 40	SAE 40
0° TO 70°F (-17.77° to 21.11°C)	SAE 30	SAE 30, SAE 40, or SAE 20W40
0° TO 90°F (-17.77° to 32.22°C)	SAE 20W50	SAE 20W50 or SAE 15W50
Below 10°F (-12.22°C)	SAE 20	SAE 30 or SAE 20W30

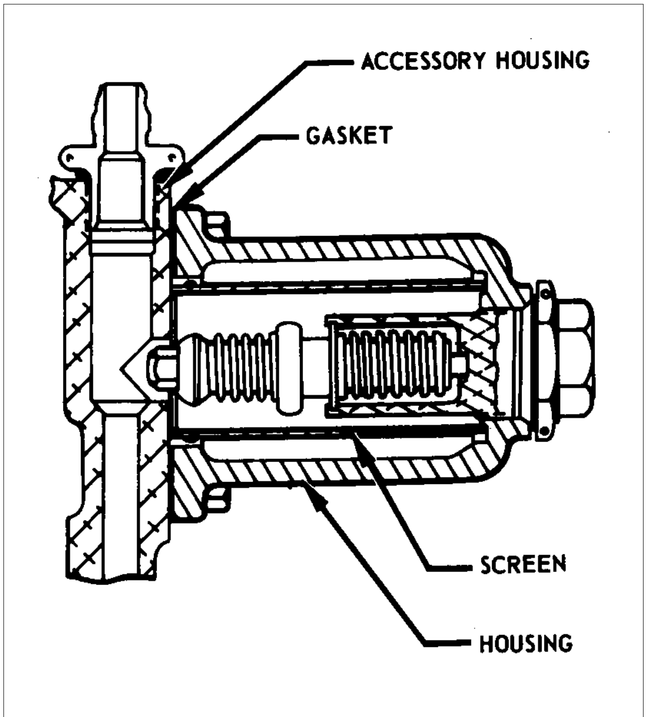


Figure 2-14. Oil Pressure Screen

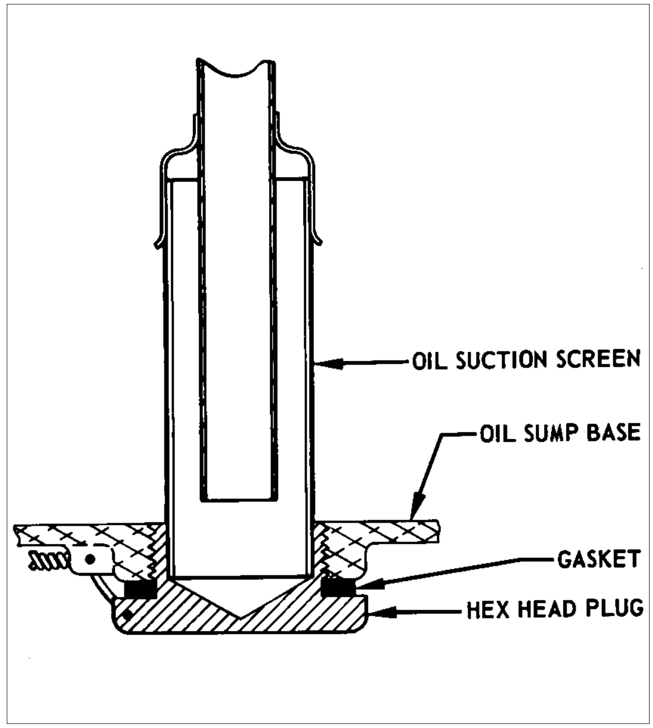


Figure 2-15. Oil Suction Screen

2-68. OIL SCREEN (Pressure). (Refer to Figure 2-14.) The pressure screen, located in a housing on the accessory case of the engine between the magnetos, should be cleaned at each oil change to remove any accumulation of sludge and to examine for metal filings or chips. If metal particles are found in the screen, the engine should be examined for internal damage. The pressure screen is removed by disconnecting the temperature indicator wire and removing the four hex head bolts that secure the screen housing to the accessory case. Clean and inspect the screen. Reinstall by first ascertaining that the screen fits flush with the base of the housing. Install the screen and housing to the accessory case using a new gasket. Torque the attaching bolts 50 to 70 inch pounds.

2-69. OIL SCREEN (Suction). (Refer to Figure 2-15.) The suction screen, located in bottom of the sump forward of the carburetor, should be cleaned at each oil change to remove any accumulation of sludge and to examine for metal filings or chips. If metal particles are found in the screen, the engine should be examined for internal damage. The suction screen is removed from the sump by cutting the safety wire and removing the hex head plug. Clean and inspect the screen and gasket and replace the gasket if over compressed or damaged. To eliminate damage to the oil screen, place it inside the recess in the hex head plug before inserting the assembly into the bottom of the sump. Care must be exercised to enable the screen to enter the oil suction tube inside the sump. (Refer to Figure 2-15.) When certain that the screen is properly seated, tighten the plug. If the plug seems tight, this will indicate that the screen is not properly seated, and must be disassembled and the above procedure repeated. After installation, safety the hex head plug with MS20995-C41 safety wire.

2-69a. **Oil Filter. (Full Flow.)**

a. The oil filter element should be replaced after each 50 hours of engine operation, in airplanes so equipped. This accomplished by removing the lockwire from the bolt head at the end of the filter housing, loosening the bolt, and removing the filter assembly from the adapter.

b. Before discarding the filter element, remove the outer perforated paper cover, and using a sharp knife, cut through the folds of the element at both ends, close to the metal caps. Then, carefully unfold the pleated element and examine the material trapped in the filter for evidence of internal engine damage such as chips or particles from bearings. In new or newly overhauled engines, some small particle of metallic shavings might be found. These are generally of no consequence and should not be confused with particles produced by impacting, abrasion or pressure. Evidence of internal engine damage found in the oil filter justifies further examination to determine the cause.

c. After the element has been replaced, tighten the attaching bolt within 20 to 25 foot-pounds of torque. Lockwire the bolt through the loops on the side of the housing to the drilled head of the thermostatic valve. Be sure the lockwire is replaced at both the attaching bolt head and the thermostatic oil cooler bypass valve.

2-70. **Recommendations for Changing Oil.** (Refer to latest revision of Lycoming Service Bulletin No. 480 and Lycoming Service Instruction No. 1014.)

a. Oil Change Intervals.

(1) For engines relying upon pressure screen filtration alone, change the oil and clean the pressure and suction screens each 25 hours of engine operation or every four months, whichever comes first.

(2) For engines equipped with full-flow oil filters, change the oil and filter each 50 hours of engine operation or every four months, whichever comes first.

b. Ashless Dispersant (Detergent) Oil.

(1) With the exception of turbocharged engines, new or newly overhauled engines should be broken in on straight mineral oil for the first 50 hours of operation, or until oil consumption has stabilized. Lycoming oil additive P/N LW-16702 may be used. Mineral oil must also be used following the replacement of one or more cylinders until the oil consumption has stabilized. Attempting to break-in normally aspirated engines with detergent oil may result in high oil consumption as the additives in some of these oils can retard the break-in of the piston rings and cylinder walls.

(2) All new or newly overhauled turbocharged engines must be broken in and operated only with ashless dispersant (detergent) oil.

(3) In engines that have been operating on straight mineral oil for several hundred hours, a change to ashless dispersant oil should be made with a degree of caution, since the cleaning action of some additive oils will tend to loosen sludge deposits and cause plugged oil passages. When an engine has been operating on straight mineral oil and is known to be in excessively dirty condition, the switch to ashless dispersant oil should be deferred until after the engine is overhauled.

(4) When changing from straight mineral oil to ashless dispersant oil, the following precautionary steps should be taken:

(a) Do not add ashless dispersant oil to straight mineral oil. Drain the straight mineral oil from the engine and fill with ashless dispersant oil.

(b) Do not operate the engine with ashless dispersant oil longer than five hours before the first oil change.

(c) Check all oil screens for evidence of sludge or plugging. Change oil every ten hours if sludge conditions are evident. Resume normal oil drain periods after sludge conditions improve.

2-71. LUBRICATION INSTRUCTIONS. Proper lubrication procedures are of immeasurable value both as a means of prolonging the service life of the airplane and as a means of reducing the frequency of extensive and expensive repairs. The periodic application of recommended lubricants to their relevant bearing surfaces, as detailed in the following paragraphs, together with the observance of cleanliness, will insure the maximum efficiency and utmost service of all moving parts. Lubrication instruction regarding the locations, time intervals, and type of lubricants used may be found in the Lubrication Chart, Figure 2-16. To insure the best possible results from the application of lubricants, the following precautions should be observed:

a. Use recommended lubricants. Where general purpose lubricating oil is specified, but unavailable, clean engine oil may be used as a satisfactory substitute.
b. Check the components to be lubricated for evidence of excessive wear and replace them as necessary.
c. Remove all excess lubricants from components in order to prevent the collection of dirt and sand in abrasive quantities capable of causing excessive wear or damage to bearing surfaces.

2-72. APPLICATION OF OIL. Whenever specific instructions for lubrication of mechanisms requiring lubrication are not available, observe the following precautions:

a. Apply oil sparingly, never more than enough to coat the bearing surfaces.
b. Since the cables are sufficiently coated by the manufacturer, additional protection for the prevention of corrosion is unnecessary.
c. Squeeze the magneto cam follower felts at regular inspection periods. If oil appears on fingers, do not add oil. If the felt is dry, moisten with light oil.

CAUTION

Be careful not to add too much oil, because the excess will be thrown off during operation and will cause pitting and burning of the magneto points.

2-73. APPLICATION OF GREASE. Care must be taken when lubricating bearings and bearing surfaces with a grease gun, to insure that gun is filled with new, clean grease of the grade specified for the particular application before applying lubricant to the grease fittings.

a. Where a reservoir is not provided around a bearing, apply the lubricant sparingly and wipe off any excess.
b. Remove wheel bearings from the wheel hub and clean thoroughly with a suitable solvent. When repacking with grease, be sure the lubricant enters the space between the rollers in the retainer ring. Do not pack the grease into the wheel hub.
c. Use extra care when greasing the Hartzell propeller hub to avoid blowing the clamp gaskets. Remove one grease fitting while applying grease to the other fitting.

2-74. LUBRICATION CHART. Each part of the airplane is to be lubricated as depicted on the Lubrication Chart. The Table shows items to be lubricated, time intervals and type of lubricants to be used.

COMPONENT	LUBRICANT	FREQUENCY
1. RUDDER HINGES AND HORN	MIL-L-7870	100 HRS
2. ELEVATOR HINGES, RIGHT AND LEFT	MIL-L-7870	100 HRS
3. RUDDER AND ELEVATOR, TRIM MECHANISMS	MIL-L-7870	100 HRS
4. ELEVATOR CONTROL	MIL-L-7870	100 HRS
5. BAGGAGE DOOR ANDMAIN DOOR HINGES	MIL-L-7870	100 HRS
6. AILERON AND FLAP HINGES, PULLEY AND BELLCRANK - RIGHT AND LEFT	MIL-L-7870	100 HRS
7. HINGES, MAIN AND NOSE GEAR DOORS	MIL-L-7870	100 HRS
8. MAIN AND NOSE LANDING GEAR GREASE FITTINGS	MIL-G-23827	100 HRS
9. MAIN AND NOSE WHEEL BEARINGS	MIL-G-3545	100 HRS
10. ENGINE OIL SUMP (PRESSURE SCREEN FILTRATION ONLY) 8 QT. CAPACITY (SEE NOTE 2)	MIL-L-6082	25 HRS
10. ENGINE OIL SUMP (FULL FLOW CARTRIDGE FILTRATION) 8 QT. CAPACITY (SEE NOTE 2)	MIL-L-6082	50 HRS
11. INDUCTION AIR FILTER (SEE NOTE 1)	CLEAN	50 HRS
12. TORQUE LINK CONNECTING BOLT, UPPER AND LOWER	MIL-L-7870	100 HRS
13. PROPELLER GREASE FITTINGS, 4 TOTAL (SEE NOTE 4)	MIL-G-23827	100 HRS
14. FRONT SEAT ADJUSTMENT, RIGHT AND LEFT	MIL-G-23827	100 HRS
15. NOSE WHEEL STEERING	MIL-G-23827	100 HRS
16. BRAKE RESERVOIR - MAINTAIN FLUID LEVEL INDICATED ON THE SIDE OF RESERVOIR	MIL-H-5606	100 HRS
17. CONTROL COLUMN AND RUDDER PEDAL ASSEMBLY	MIL-L-7870	100 HRS
18. FILTER (AN6234) HYDRAULIC SYSTEM - REPLACE ELEMENT (LEFT ENGINE ONLY)	REPLACE	100 HRS
19. HYDRAULIC FLUID LEVEL - MAINTAIN LEVEL TO FILLER NOZZLE	MIL-H-5606	100 HRS
20. ELEVATOR AND RUDDER TRIM PULLEYS (SEE CAUTION 4)	MIL-L-7870	100 HRS

CAUTIONS

1. DO NOT USE A HYDRAULIC FLUID WITH A CASTOR OIL OR ESTER BASE.
2. DO NOT OVER-LUBRICATE PEDESTAL CONTROLS.
3. DO NOT APPLY LUBRICANT TO RUBBER PARTS.
4. UNDER NO CIRCUMSTANCES SHOULD THE CABLES FROM THE COCKPIT TO THE REAR OF THE FUSELAGE BE LUBRICATED-AS THIS MAY CAUSE SLIPPAGE.
5. REMOVE ALL EXCESS GREASE FROM GREASE FITTINGS.

NOTES

1. CARBURETOR AIR FILTER WASH FILTER INSUITABLE SOLVENT, SOAK IN OIL AND ALLOW TO DRAIN THOROUGHLY BEFORE INSTALLATION.
2. ENGINE OIL:
   A. SHOULD FUEL OTHER THAN THE SPECIFIED OCTANE RATING FOR THE POWER PLANT BE USED, REFER TO THE LATEST REVISION OF LYCOMING SERVICE LETTER NO. L185 FOR ADDITIONAL INFORMATION AND RECOMMENDED SERVICE PROCEDURES.
   B. SEE PARAGRAPH 2-70 FOR RECOMMENDED OIL CHANGE INTERVALS.
   C. SEE PARAGRAPH 2-70 OR LATEST REVISION OF LYCOMING SERVICE INSTRUCTION NO. 1014 FOR USE OF DETERGENT OIL (MIL-L-22851).
   D. SEE TABLE II-IIIA OR LATEST REVISION OF LYCOMING SERVICE BULLETIN NO. 480 FOR SPECIFIED OIL GRADE AND VISCOSITY.
3. OLEO STRUTS, BRAKE RESERVOIR AND POWER PACK FILL PER PLACARDED INSTRUCTIONS, OR REFER TO SERVICE MANUAL, SECTION II, PARAGRAPHS 2-39, 2-43, AND 2-32 OR 2-33, RESPECTIVELY.
4. PROPELLER REMOVE ONE OF THE TWO GREASE FITTINGS FOR EACH BLADE. APPLY GREASE THROUGH REMAINING FITTING UNTIL FRESH GREASE APPEARS AT HOLE OF REMOVED FITTING.
5. BEARINGS AND BUSHINGS CLEAN EXTERIOR WITH DRY SOLVENT BEFORE RE LUBRICATING (EXCEPT SEALED BEARINGS).

Figure 2-16. Lubrication Chart (Sheet 1 of 2)

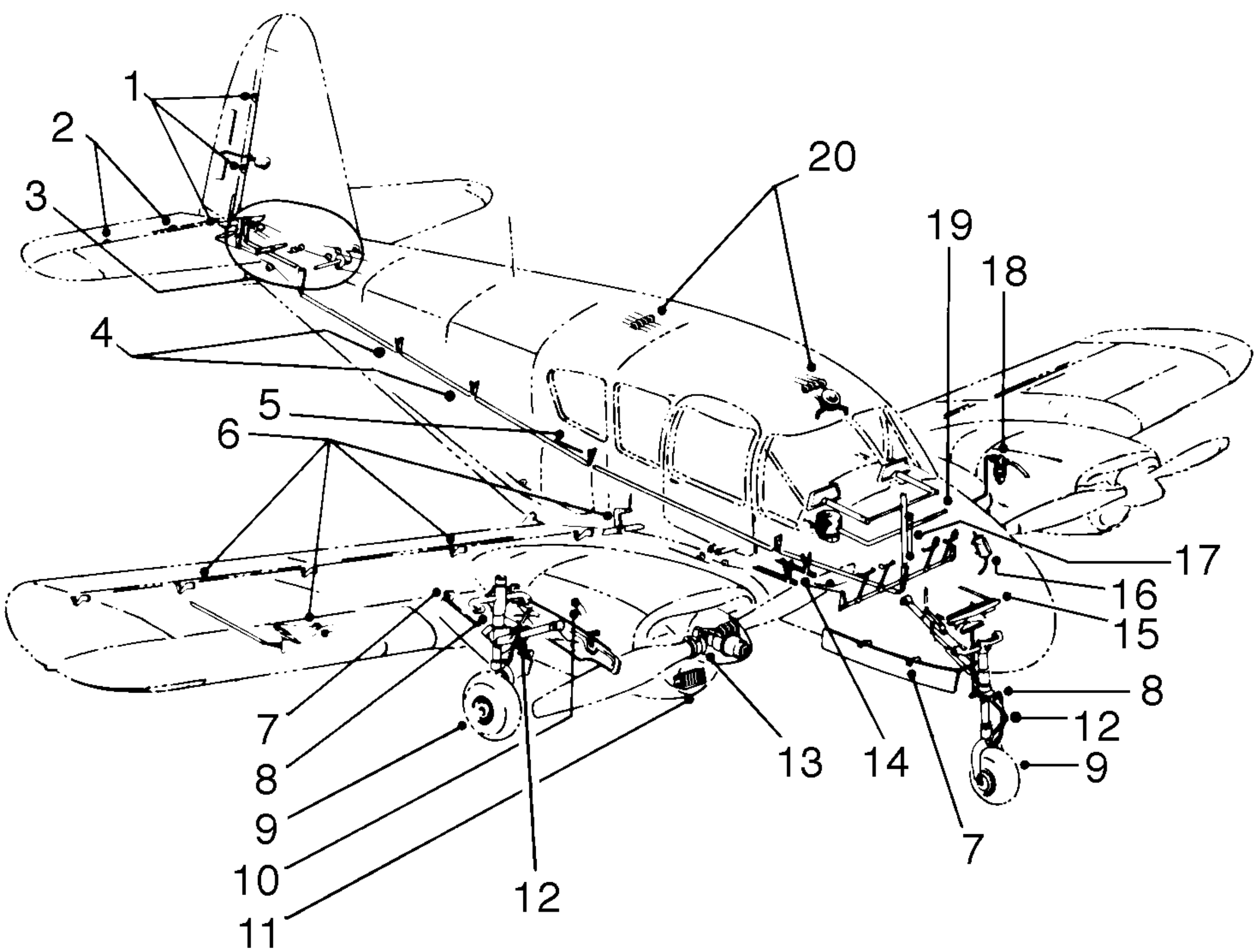


Figure 2-16. Lubrication Chart (Sheet 2 of 2)

2.75 STANDARDS.

TABLE II-IV. THREAD LUBRICANTS

TYPE OF LINE	TYPE OF LUBRICANT
Brakes	MIL-H-5606
Freon	TT-A-580 or MIL-T-5544, Anti-Seize Compound
Fuel	MIL-T-5544, Anti-Seize, Graphite Petrolatum
Landing Gear (Air Valve)	6PB Parker
Oil	MIL-G-6032, Lubricating Grease (Gasoline and Oil Resistant)
Pitot and Static	TT-A-580 (JAN-A-669), Anti-Seize Compound (White Lead Base)

— NOTE —
Lubricate engine fittings only with the fluid contained in the particular lines.

TABLE II-V. MAXIMUM DISTANCE BETWEEN SUPPORTS FOR FLUID TUBING

TUBE OD (IN.)	DISTANCE BETWEEN SUPPORTS (IN.) ALUMINUM ALLOY	STEEL
1/8	9-1/2	11-1/2
3/16	12	14
1/4	13-1/2	16
5/16	15	18
3/8	16-1/2	20
1/2	19	23
5/8	22	25-1/2
3/4	24	27-1/2
1	26-1/2	30

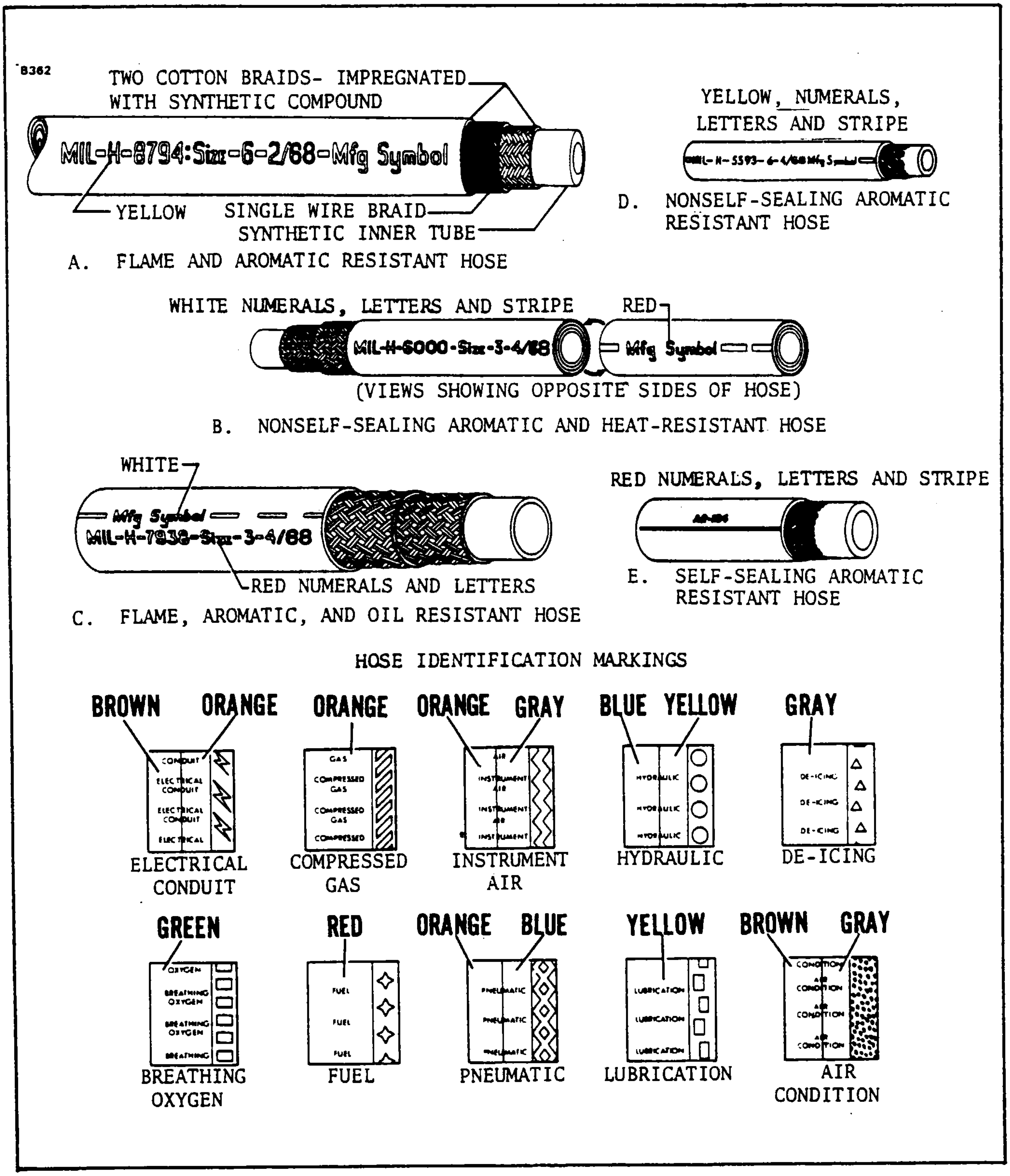


Figure 2-17. Identification of Aircraft Fluid Lines

TABLE II-VI. CONVERSION TABLES

1. These charts contain the various conversion data that may be useful when figuring capacities, lengths, temperatures, and various weights and measures from the English system values to the metric system values or back again.

2. The English system is in use by England and the United States. All other countries use the metric system.

3. Procedure for Converting Inches to Millimeters.

   A. Example: Convert 1.5 inches to millimeters.

      (1) Read down inches column to 1. inches.
      (2) Read across top inch column to 0.5.
      (3) Read down and across to find millimeters (1.5 inches is 38.10 millimeters).

4. Procedure for Converting Fahrenheit (°F) and Celsius (°C) (Centigrade) Temperature. (Refer to Table II-VI.)

   A. Read number in middle column, if in degrees Celsius (°C), read Fahrenheit equivalent in right-hand column. If in degrees Fahrenheit (°F), read Celsius equivalent in left-hand column.

      (1) 70°F = 21.1°C.
      (2) 30°C = 86.0°F.

2-76. IDENTIFICATION OF FLUID LINES. (Refer to Figure 2-17.) Fluid lines in aircraft are often identified by markers made up of color codes, words, and geometric symbols. These markers identify each line's function, content, and primary hazard, as well as the direction of fluid flow.

In most instances, fluid lines are marked with 1-inch tape or decals. Paint is used on lines in engine compartments, where there is the possibility of tapes, decals or tags being drawn into the engine induction system.

In addition to the above-mentioned markings, certain lines may be further identified as to specific function within a system; for example, DRAIN, VENT, PRESSURE or RETURN.

Lines conveying fuel may be marked FLAM; lines containing toxic materials are marked TOXIC in place of FLAM. Lines containing physically dangerous materials, such as oxygen, nitrogen, or freon, are marked PHDAN.

The aircraft and engine manufacturers are responsible for the original installation of identification markers, but the aviation mechanic is responsible for their replacement when it becomes necessary.

Generally, tapes and decals are placed on both ends of a line and at least once in each compartment through which the line runs. In addition, identification markers are placed immediately adjacent to each valve, regulator, filter or other accessory within a line. Where paint or tags are used, location requirements are the same as for tapes and decals.

TABLE II-IV. CONVERSION TABLES (cont)

INCHES TO MILLIMETER

INCHES	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
					MILLIMETER					
0.000		0.0025	0.0050	0.0076	0.0101	0.0127	0.0152	0.0177	0.0203	0.0228
0.001	0.0254	0.0279	0.0304	0.0330	0.0355	0.0381	0.0406	0.0431	0.0457	0.0482
0.002	0.0508	0.0533	0.0558	0.0584	0.0609	0.0635	0.0660	0.0685	0.0711	0.0736
0.003	0.0762	0.0812	0.0838	0.0863	0.0889	0.0914	0.0939	0.0965	0.0965	0.0990
0.004	0.1016	0.1041	0.1066	0.1092	0.1117	0.1143	0.1168	0.1193	0.1219	0.1244
0.005	0.1270	0.1295	0.1320	0.1346	0.1371	0.1397	0.1422	0.1447	0.1447	0.1498
0.006	0.1524	0.1549	0.1574	0.1600	0.1625	0.1651	0.1676	0.1701	0.1727	0.1752
0.007	0.1778	0.1803	0.1828	0.1854	0.1879	0.1905	0.1930	0.1955	0.1981	0.2006
0.008	0.2032	0.2057	0.2082	0.2108	0.2133	0.2159	0.2184	0.2209	0.2235	0.2260
0.009	0.2286	0.2311	0.2336	0.2362	0.2387	0.2413	0.2438	0.2463	0.2489	0.2514

INCHES	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
					MILLIMETER					
0.00		0.025	0.050	0.076	0.101	0.127	0.152	0.177	0.203	0.228
0.01	0.254	0.279	0.304	0.330	0.355	0.381	0.406	0.431	0.457	0.482
0.02	0.508	0.533	0.558	0.584	0.609	0.635	0.660	0.685	0.711	0.736
0.03	0.762	0.787	0.812	0.838	0.863	0.889	0.914	0.939	0.965	0.990
0.04	1.016	1.041	1.066	1.092	1.117	1.143	1.168	1.193	1.219	1.244
0.05	1.270	1.295	1.320	1.346	1.371	1.397	1.422	1.447	1.473	1.498
0.06	1.524	1.549	1.574	1.600	1.625	1.651	1.676	1.701	1.727	1.752
0.07	1.778	1.803	1.828	1.854	1.879	1.905	1.930	1.955	1.981	2.006
0.08	2.032	2.057	2.082	2.108	2.133	2.159	2.184	2.209	2.235	2.260
0.09	2.286	2.311	2.336	2.362	2.387	2.413	2.438	2.463	2.489	2.514

INCHES	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
					MILLIMETER					
0.0		0.254	0.508	0.762	0.016	1.270	1.524	1.778	2.032	2.286
0.1	2.540	2.794	3.048	3.302	3.556	3.810	4.064	4.318	4.572	4.826
0.2	5.080	5.334	5.558	5.842	6.096	6.350	6.604	6.858	7.112	7.366
0.3	7.620	7.874	8.128	8.382	8.636	8.890	9.144	9.398	9.652	9.906
0.4	10.160	10.414	10.668	10.922	11.176	11.430	11.684	11.938	12.192	12.446
0.5	12.700	12.954	13.208	13.462	13.716	13.970	14.224	14.478	14.732	14.986
0.6	15.240	15.494	15.748	16.002	16.256	16.510	16.764	17.018	17.272	17.526
0.7	17.780	18.034	18.288	18.542	18.796	19.050	19.304	19.558	19.812	20.066
0.8	20.320	20.574	20.828	21.082	21.336	21.590	21.844	22.098	22.352	22.606
0.9	22.860	23.114	23.368	23.622	23.876	24.130	24.384	24.638	24.892	25.146

INCHES	0.00	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
					MILLIMETER					
0.		2.54	5.08	7.62	10.16	12.70	15.24	17.78	20.32	22.86
1.	25.40	27.94	30.48	33.02	35.56	38.10	40.64	43.18	45.72	48.26
2.	50.80	53.34	55.88	58.42	60.96	63.50	66.04	68.58	71.12	73.66
3.	76.20	78.74	81.28	83.82	86.36	88.90	91.44	93.98	96.52	99.06
4.	101.60	104.14	106.68	109.22	111.76	114.30	116.84	119.38	121.92	124.46
5.	127.00	129.54	132.08	134.62	137.16	139.70	142.24	144.78	147.32	149.86
6.	152.40	154.94	157.48	160.02	162.56	165.10	167.64	170.18	172.72	175.26
7.	177.80	180.34	182.88	185.42	187.96	190.50	193.04	195.58	198.12	200.66
8.	203.20	205.74	208.28	210.82	213.36	215.90	218.44	220.98	223.52	226.06
9.	228.60	231.14	233.68	236.22	238.76	241.30	243.84	246.38	248.92	251.46

TABLE II-VI. CONVERSION TABLES (cont)

CENTIGRADE—FAHRENHEIT CONVERSION TABLE

Example: To convert 20°C. to Fahrenheit, find 20 in the center column headed (F—C); then read 68.0°F. in the column (F) to the right. To convert 20°F. to Centigrade; find 20 in the center column and read -6.67°C. in the (C) column to the left.

C	F—C	F	C	F—C	F
-56.7	-70	-94.0	104.44	220	428.0
-51.1	-60	-76.0	110.00	230	446.0
-45.6	-50	-58.0	115.56	240	464.0
-40.0	-40	-40.0	121.11	250	482.0
-34.0	-30	-22.0	126.67	260	500.0
-38.9	-20	-4.0	132.22	270	518.0
-23.3	-10	14.0	137.78	280	536.0
-17.8	0	32.0	143.33	290	554.0
-12.22	10	50.0	148.89	300	572.0
-6.67	20	68.0	154.44	310	590.0
-1.11	30	86.0	160.00	320	608.0
4.44	40	104.0	165.56	330	626.0
10.00	50	122.0	171.11	340	644.0
15.56	60	140.0	176.67	350	662.0
21.11	70	158.0	182.22	360	680.0
26.67	80	176.0	187.78	370	698.0
32.22	90	194.0	193.33	380	716.0
27.78	100	212.0	198.89	390	734.0
43.33	110	230.0	204.44	400	752.0
38.89	120	248.0	210.00	410	770.0
54.44	130	266.0	215.56	420	788.0
60.00	140	284.0	221.11	430	806.0
65.56	150	302.0	226.67	440	824.0
71.00	160	320.0	232.22	450	842.0
76.67	170	338.0	257.78	460	860.0
82.22	180	356.0	243.33	470	878.0
87.78	190	374.0	248.89	480	896.0
93.33	200	392.0	254.44	490	914.0
98.89	210	410.0	260.00	500	932.0

TABLE II-VI. CONVERSION TABLES (cont)

MULTIPLY	BY	TO OBTAIN
CENTIMETERS	0.3937 0.03281	IN. FT.
CU. CENTIMETERS	0.001 0.06102 0.0002642	LITERS CU. IN U.S. GAL.
CU. FT.	28.320 1.728 7.481 28.32	CU. CM CU. IN. U.S. GAL. LITERS
CU. IN.	16.39 0.01639 0.004329 0.01732	CU. CM LITERS U.S. GAL. QUARTS
CU. METERS	1000000 35.314 61.023 264.17 999.97	CU. CM CU. FT. CU. IN GAL. LITERS
FEET	0.3048 12.000 304.8 0.3333	METERS MILS MM. YARDS
FT.-LB.	0.1383 0.001285 0.000000376	M-KG BTU KW-HR
FLUID OZ.	8 29.6	DRAM CU. CM
GAL., IMPERIAL	277.4 1.201 4.546	CU. IN. U.S. GAL. LITERS
GAL., U.S. DRY	268.8 0.1556 1.164 4.405	CU. IN. CU. FT. U.S. GAL., LIQ. LITERS
GAL., U.S. LIQ.	231.0 0.1337 3.785 0.8327 128	CU. IN. CU. FT. LITERS IMPERIAL GAL. FLUID OZ.
IN.	2.540 .08333	CM. FT.
JOULES	0.000948 0.7376	FT. FT.-LB.

MULTIPLY	BY	TO OBTAIN
KILOGRAMS	2.205 35.27 1000	LB. OZ. GRAMS
LITERS	1000 61.03 0.03532 0.2642 0.22 1.057	CU. CM. CU. IN. CU. FT. U.S. GAL. IMPERIAL GAL. QUARTS
METERS	39.37 3.281 1000	IN. FT. MM.
METER-KILOGRAM	7.233 9.807	FT.-LB. JOULES
OUNCES, AVDP	0.0625 28.35 437.5	LB., AVDP GRAMS GRAINS
OUNCES, FLUID	29.57 1.805	CU. CM. CU. IN.
LB., AVDP	453.6 7000 16.0	GRAMS GRAINS OUNCES
SQUARE INCH	6.4516	SQ. CM.
POUND PER SQUARE INCH (PSI)	0.0703	KG.-CM SQUARED
STATUTE MILE	1.609 0.8684	KILOMETER NAUTICAL MILE
NAUTICAL MILE	1.151	STATUTE MILE
QUART	.9463	LITER
MILLIMETER	1000	MICRON
MICRON	0.001 0.000039	MILLIMETER INCH
INCH POUNDS	11.521	METER GRAMS
INCH OUNCES	0.72	METER GRAMS
POUNDS	0.453	KILOGRAMS

TABLE II-VII. DECIMAL MILLIMETER EQUIVALENTS OF DRILL SIZES

Decimal/Millimeter Equivalents of Drill Sizes From 1/2" to No. 80

Size	Decimal Equiv.	Millimeter Equiv.	Size	Decimal Equiv.	Millimeter Equiv.	Size	Decimal Equiv.	Millimeter Equiv.	Size	Decimal Equiv.	Millimeter Equiv.
1/2	0.500	12.7000	G	0.261	6.6294	5/32	0.1562	3.9687	51	0.067	1.7018
31/64	0.4843	12.3031	F	0.257	6.5278	23	0.154	3.9116	52	0.0635	1.6129
15/32	0.4687	11.9062	E-1/4	0.250	6.3500	24	0.152	3.8608	1/16	0.0625	1.5875
29/64	0.4531	11.5094	D	0.246	6.2484	25	0.1495	3.7973	53	0.0595	1.5113
7/16	0.4375	11.1125	C	0.242	6.1468	26	0.147	3.7338	54	0.055	1.397
27/64	0.4218	10.7156	B	0.238	6.0452	27	0.144	3.6576	55	0.052	1.3208
Z	0.413	10.4902	15/64	0.2343	5.9531	9/64	0.1406	3.5719	3/64	0.0468	1.1906
13/32	0.4062	10.3187	A	0.234	5.9436	28	0.1405	3.5687	56	0.0465	1.1811
Y	0.404	10.2616	1	0.228	5.7912	29	0.136	3.4544	57	0.043	1.0922
X	0.397	10.0838	2	0.221	5.6134	30	0.01285	3.2639	58	0.042	1.0668
25/64	0.3906	9.9212	7/32	0.2187	5.5562	1/8	0.125	3.1750	59	0.041	1.0414
W	0.386	9.8044	3	0.213	5.4102	31	0.120	3.048	60	0.040	1.016
V	0.377	9.5758	4	0.209	5.3086	32	0.116	2.9464	61	0.039	0.9906
3/8	0.375	9.5250	5	0.2055	5.2197	33	0.113	2.8702	62	0.038	0.9652
U	0.368	9.3472	6	0.204	5.1816	34	0.111	2.8194	63	0.037	0.9398
23/64	0.3593	9.1262	13/64	0.2031	5.1594	35	0.110	2.794	64	0.036	0.9144
T	0.358	9.1281	7	0.201	5.1054	7/64	0.1093	2.7781	65	0.035	0.899
S	0.346	8.7884	8	0.199	5.0546	36	0.1065	2.7051	66	0.033	0.8382
11/32	0.3437	8.7300	9	0.196	4.9784	37	0.104	2.6416	1/32	0.0312	0.7937
R	0.339	8.6106	10	0.1935	4.9149	38	0.1015	2.5781	67	0.032	0.8128
Q	0.332	8.4328	11	0.191	4.8514	39	0.0995	2.5273	68	0.031	0.7874
21/64	0.3281	8.3337	12	0.189	4.8006	40	0.098	2.4892	69	0.029	0.7366
P	0.323	8.2042	3/16	0.1875	4.7625	41	0.096	2.4384	70	0.028	0.7112
O	0.316	8.0264	13	0.185	4.699	3/32	0.0937	2.3812	71	0.026	0.6604
5/16	0.3125	7.9375	14	0.182	4.6228	42	0.0935	2.3749	72	0.025	0.635
N	0.302	7.6708	15	0.180	4.572	43	0.089	2.2606	73	0.024	0.0696
19/64	0.2968	7.5387	16	0.177	4.4958	44	0.086	2.1844	74	0.0229	0.58166
M	0.295	7.4930	17	0.173	4.3942	45	0.082	2.0828	75	0.021	0.5334
L	0.290	7.3660	11/64	0.1718	4.3656	46	0.081	2.0574	76	0.020	0.508
9/32	0.2812	7.1425	18	0.1695	4.3053	47	0.0785	1.9939	77	0.018	0.4572
K	0.281	7.1374	19	0.166	4.2164	5/64	0.0781	1.9844	1/64	0.0156	0.3969
J	0.277	7.0358	20	0.161	4.0894	48	0.076	1.9304	78	0.016	0.4064
I	0.272	6.9088	21	0.159	4.0386	49	0.073	1.8542	79	0.0145	0.3683
H	0.266	6.7564	22	0.157	3.9878	50	0.070	1.778	80	0.0135	0.3429
17/64	0.2656	6.7462									

DRILL SIZES AVAILABLE

Drill may be obtained in regular sizes to a 4 inch diameter, and increase in 64ths of an inch. The regular metric drills vary from 2 to 76mm and increase in 0.5mm variations.

2-77. CHERRYLOCK RIVETS, REMOVAL. (Refer to Figure 2-18.) Should it be necessary to remove an installed cherrylock rivet, the following procedures are recommended:

a. In thick material remove the lock by driving out the rivet stem, using a tapered steel drift pin. (See View 1.)

NOTE

Do not drill completely through the rivet sleeve to remove a rivet as this will tend to enlarge the hole.

b. If the rivets have been installed in thin sheets, driving out the locked stem may damage the sheets. It is recommended that a small center drill be used to provide a guide for a larger drill on top of the rivet stem, and the tapered portion of the stem be drilled away to destroy the lock. (See Views 2 and 3.)

c. Pry the remainder of the locking collar out of the rivet head with the drift pin. (See View 3.)

d. Drill nearly through the head of the rivet, using a drill the same size as the rivet shank. (See View 4.)

e. Break off the rivet head, using a drift pin as a pry. (See View 5.)

f. Drive out the remaining rivet shank with a pin having a diameter equal to the rivet shank. (See View 6.)

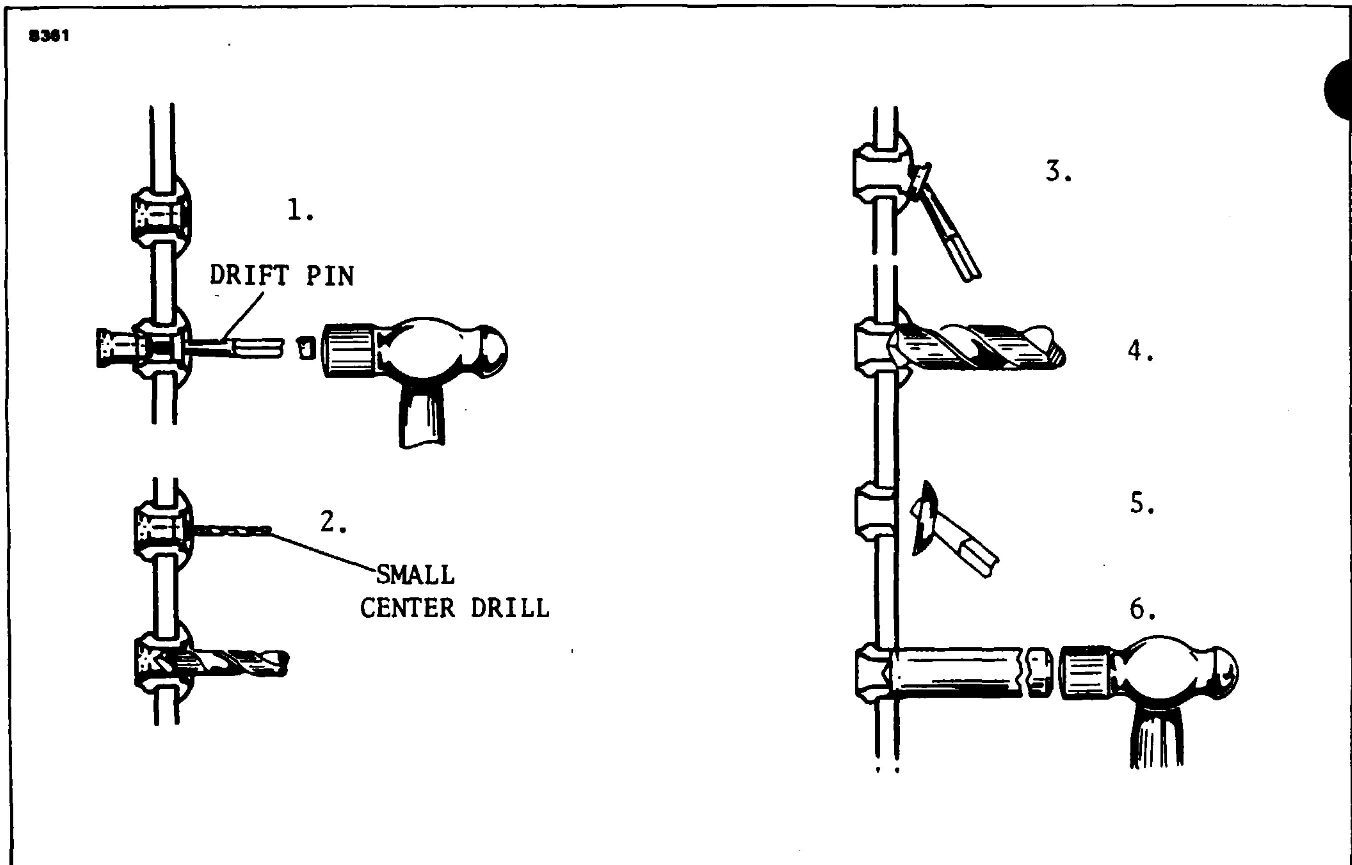


Figure 2-18. Cherrylock Rivet Removal

TABLE II-VIII. HOSE CLAMP TIGHTENING. (INITIAL INSTALLATION)

Types of hose	Types of clamps	
	Worm screw type	All other types
Self sealing	Finger-tight-plus 2 complete turns	Finger-tight-plus 2½ complete turns
All other hose	Finger-tight-plus 1¼ complete turns	Finger-tight-plus 2 complete turns
If clamps do not seal at specified tightening, examine hose connection and replace parts as necessary.		

2-78. FLARELESS TUBE ASSEMBLIES. (Refer to Figure 2-19.) Although the use of flareless tube fittings eliminates all tube flaring, another operation, referred to as presetting, is necessary prior to installation of a new flareless tube assembly which is performed as follows:

a. Cut the tube to the correct length, with the ends perfectly square. Deburr the inside and outside of the tube. Slip the nut, then the sleeve, over the tube (Step 1).

b. Lubricate the threads of the fitting and nut. See Figure 20-5 for proper lubricant to use, depending on the type system the tubing assemblies are to be used on. Place the fitting in the vise (Step 4), and hold the tubing firmly and squarely on the seat in the fitting. (Tube must bottom firmly in the fitting.) Tighten the nut until the cutting edge of the sleeve grips the tube. This point is determined by slowly turning the tube back and forth while tightening the nut. When the tube no longer turns, the nut is ready for final tightening.

c. Final tightening depends upon the tubing. For aluminum alloy tubing up to and including 1/2 inch outside diameter, tighten the nut from one to one and one-sixth turns. For steel tubing and aluminum alloy tubing over 1/2 outside diameter, tighten from one and one-sixth to one and one-half turns.

After presetting the sleeve, disconnect the tubing from the fitting and check the following points (illustrated in Step 3):

a. The tube should extend 3/32 to 1/8 inch beyond the sleeve pilot; otherwise blowoff may occur.

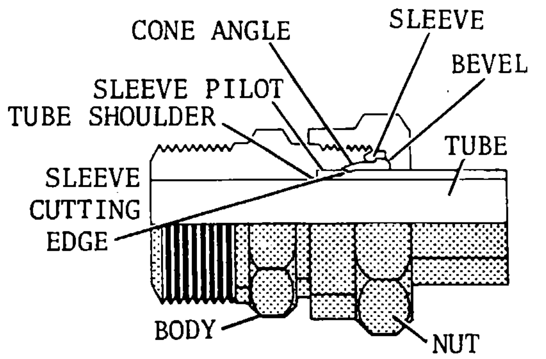
b. The sleeve pilot should contact the tube or have a minimum clearance of 0.005 inch for aluminum alloy tubing or 0.015 inch for steel tubing.

c. A slight collapse of the tube at the sleeve cut is permissible. No movement of the sleeve pilot, except rotation is permissible.

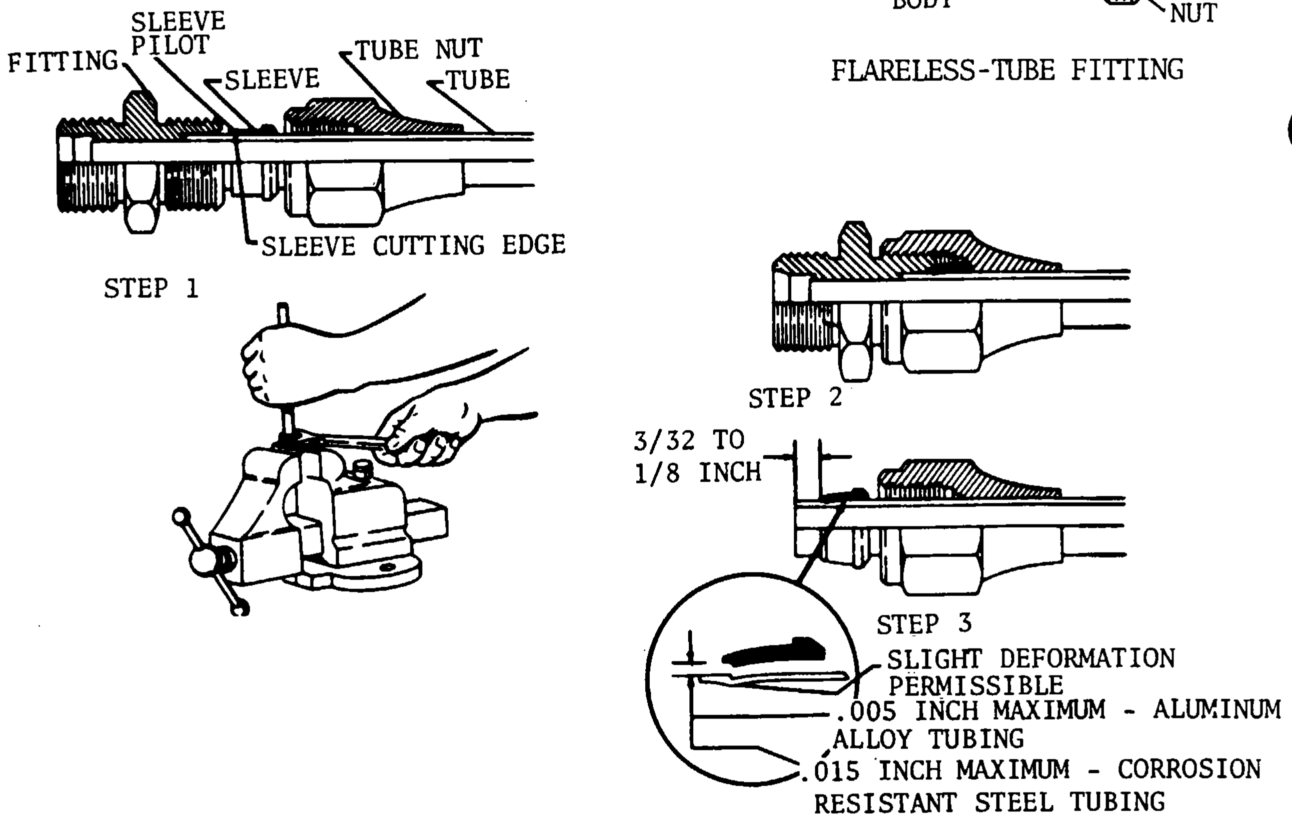
TUBING SYSTEM	LUBRICANT
HYDRAULIC	MIL-H-5606
FUEL	MIL-H-5606
OIL	System Oil
PNEUMATIC	MIL-L-4343
OXYGEN*	MIL-T-5542

*CAUTION-DO NOT USE OIL OR GREASE

TUBING AND HOSE LUBRICANTS



FLARELESS-TUBE FITTING



PRESETTING FLARELESS-TUBE ASSEMBLY

Figure 2-19. Flareless Tube Fittings

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SECTION III

INSPECTION

SECTION III

INSPECTION

3-1. INTRODUCTION. This section provides instructions for conducting inspections. These inspections are described in paragraphs 3-4 and 3-5. Repair or replacement instructions for those components found to be unserviceable at inspection may be found in the section covering the applicable aircraft system.

CAUTION

When working on engines, ground the magneto primary circuit before performing any operation.

3-2. RECOMMENDED LUBRICANTS. Refer to Recommended Lubricants, Section II, for lubrication servicing instructions.

3-3. INSPECTION PERIODS.

3-4. INSPECTION REQUIREMENTS. The required inspection procedures are listed in Table III-I. The inspection procedure is broken down into major groups which are Propeller, Engine, Cabin, Fuselage and Empennage, Wing, Landing Gear, Operational Inspection and General. The first column in each group lists the inspection or procedure to be performed. The second column is divided into four columns indicating the required inspection intervals of 50 hours, 100 hours, 500 hours and 1000 hours. Each inspection or operation is required at each of the inspection intervals as indicated by a circle (O). If an item is not entirely accessible or must be removed, refer to the applicable section of this manual for instructions on how to gain access or remove the item. When performing inspection use forms furnished by the Piper Factory Service Department, available through Piper Dealers or Distributors.

NOTE

In addition to inspection intervals required in Table III-1 a preflight check must be performed as described in Paragraph 3-5.

3-5. PREFLIGHT CHECK. The airplane must be given a thorough preflight and walk-around check. The pilot and/or mechanic must include the preflight check as a normal procedure necessary for the safe operation of the aircraft. Refer to the Pilot's Operating Manual for a listing of items that must be checked.

3-6. OVERLIMITS INSPECTION. If the airplane has been operated so that any of its components have exceeded their maximum operational limits, check with the appropriate manufacturer.

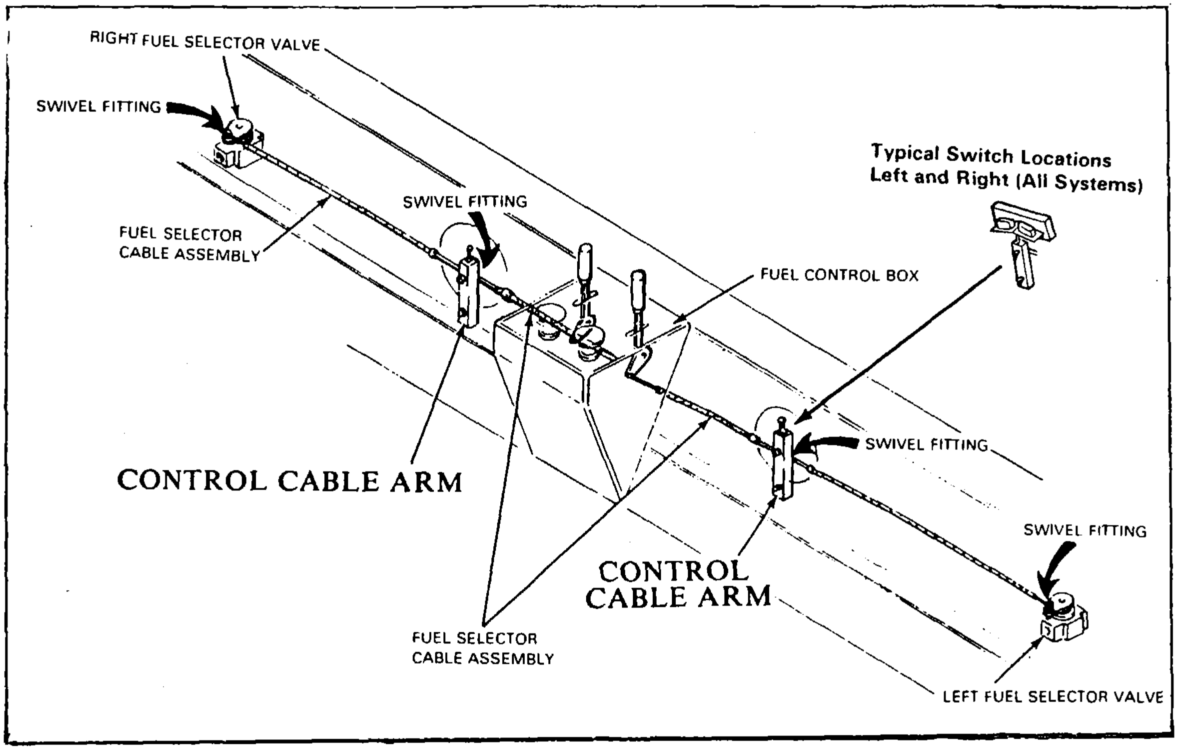

Figure 3-1. Fuel Selector Valve Control Cables

3-7. INSPECTION OF FUEL SELECTOR CONTROL CABLES (Refer to Figure 3-1.) At each 100-hour inspection of the airplane, inspect the fuel selector control cable wires. Conduct the inspection as follows:

a. Remove the access panel covering the main spar from the bottom of the fuselage.
b. Visually check control cable wires at control cable arm swivel fitting for indications of binding, kinks or bends: have someone in cockpit operate fuel controls while mechanic inspects wires at swivel fittings.
c. Replace cable(s) exhibiting any of the above conditions.
d. Check adjustments of selector valve per Section IX.
e. Replace access panel previously removed.

3-8. CONTROL CABLE INSPECTION. Aircraft control cable systems are subject to a variety of environmental conditions and forms of deterioration that, with time, may be easy to recognize as wire/strand breakage or the not-so-readily visible types of wear, corrosion, and/or distortion. The following data may help in detecting the presence of these conditions:

a. Cable Damage.

Critical areas for wire breakage are sections of the cable which pass through fairleads and around pulleys. To inspect each section which passes over a pulley or through a fairlead, remove cable from aircraft to the extent necessary to expose that particular section. Examine cables for broken wires by passing a cloth along length of cable. This will clean the cable for a visual inspection, and detect broken wires, if the cloth snags on cable. When snags are found, closely examine cable to determine full extent of damage.

The absence of snags is not positive evidence that broken wires do not exist. Figure 27-1A shows a cable with broken wires that were not detected by wiping, but were found during a visual inspection. The damage became readily apparent (Figure 27-1B) when the cable was removed and bent using the techniques depicted in Figure 27-1C.

b. External Wear Patterns

Wear will normally extend along cable equal to the distance cable moves at that location. Wear may occur on one side of the cable only or on its entire circumference. Replace flexible and non-flexible cables when individual wires in each strand appear to blend together (outer wires worn 40-50 percent) as depicted in Figure 27-2.

c. Internal Cable Wear

As wear is taking place on the exterior surface of a cable, the same condition is taking place internally, particularly in the sections of the cable which pass over pulleys and quadrants. This condition, shown in Figure 27-3, is not easily detected unless the strands of the cable are separated. Wear of this type is a result of the relative motion between inner wire surfaces. Under certain conditions the rate of this type wear can be greater than that occurring on the surface.

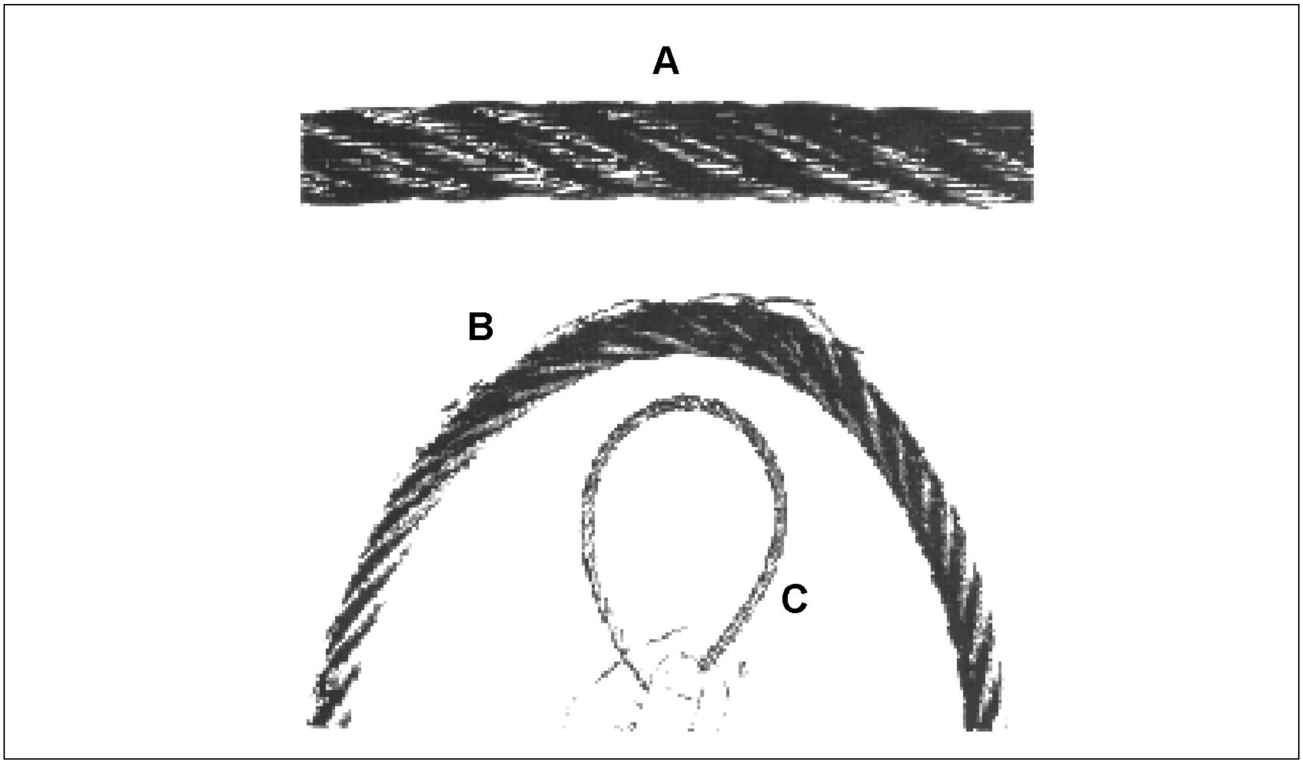

Figure 3-2. Control Cable Inspection Technique

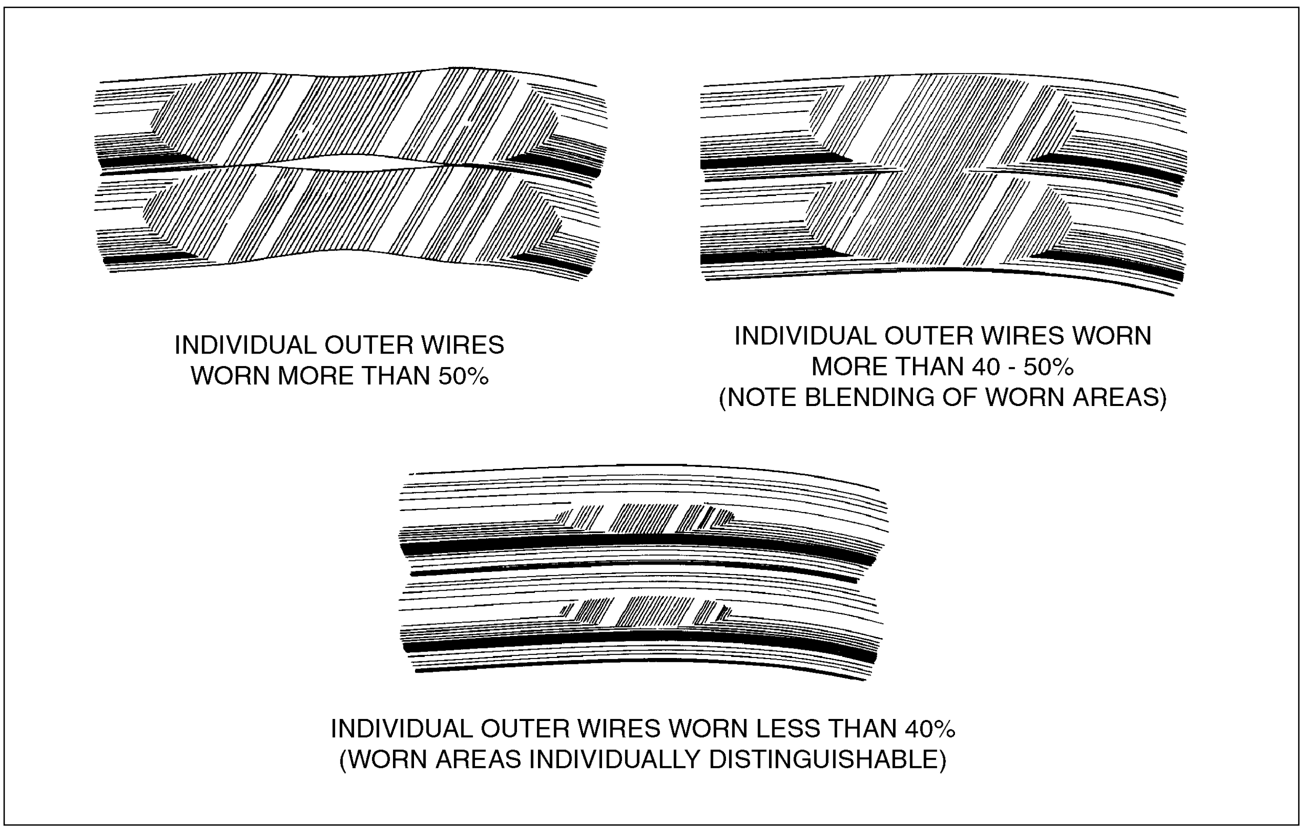

Figure 3-3. External Cable Wear Patterns

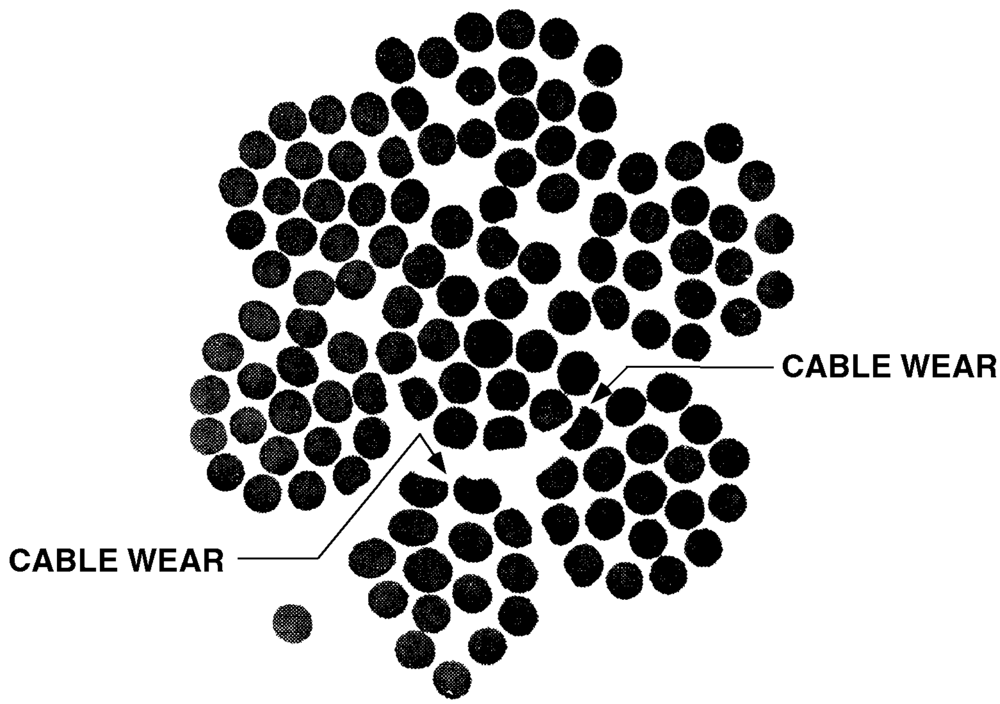

Figure 3-4. Internal Cable Wear

d. Corrosion

Carefully examine any cable for corrosion that has a broken wire in a section not in contact with wear producing airframe components such as pulleys, fairleads, etc. It may be necessary to remove and bend the cable to properly inspect it for internal strand corrosion as this condition is usually not evident on the outer surface of the cable. Replace cable segments if internal strand rust or corrosion is found.

Areas especially conducive to cable corrosion are battery compartments, lavatories, wheel wells, etc., where concentrations of corrosive fumes, vapors, and liquids can accumulate.

— Note —

Check all exposed sections of cable for corrosion after a cleaning and/or metal-brightening operation has been accomplished in that area.

e. Cable Maintenance

Frequent inspections and preservation measures such as rust prevention treatments for bare cable areas will help to extend cable service life. Where cables pass through fairleads, pressure seals, or over pulleys, remove accumulated heavy coatings of corrosion prevention compound. Provide corrosion protection for these cable sections by lubricating with a light coat of graphite grease or general purpose, low-temperature oil.

— CAUTION —

AVOID USE OF VAPOR DEGREASING, STEAM CLEANING, METHYLETHYLKETONE (MEK) OR OTHER SOLVENTS TO REMOVE CORROSION-PREVENTATIVE COMPOUNDS, AS THESE METHODS WILL ALSO REMOVE CABLE INTERNAL LUBRICANT.

f. Cable Fittings

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

g. Pulleys

Inspect pulleys for roughness, sharp edges, and presence of foreign material embedded in the grooves. Examine pulley bearings to assure proper lubrication, smooth rotation, freedom from flat spots, dirt, and paint spray. Periodically rotate pulleys, which turn through a small arc, to provide a new bearing surface for the cable. Maintain pulley alignment to prevent the cable from riding on flanges and chafing against guards, covers, or adjacent structure. Check all pulley brackets and guards for damage, alignment, and security.

h. Pulley Wear Patterns

Various cable system malfunctions may be detected by analyzing pulley conditions. These include such discrepancies as too much tension, misalignment, pulley bearing problems, and size mismatches between cables and pulleys. Examples of these conditions are shown in Figure 27-4.

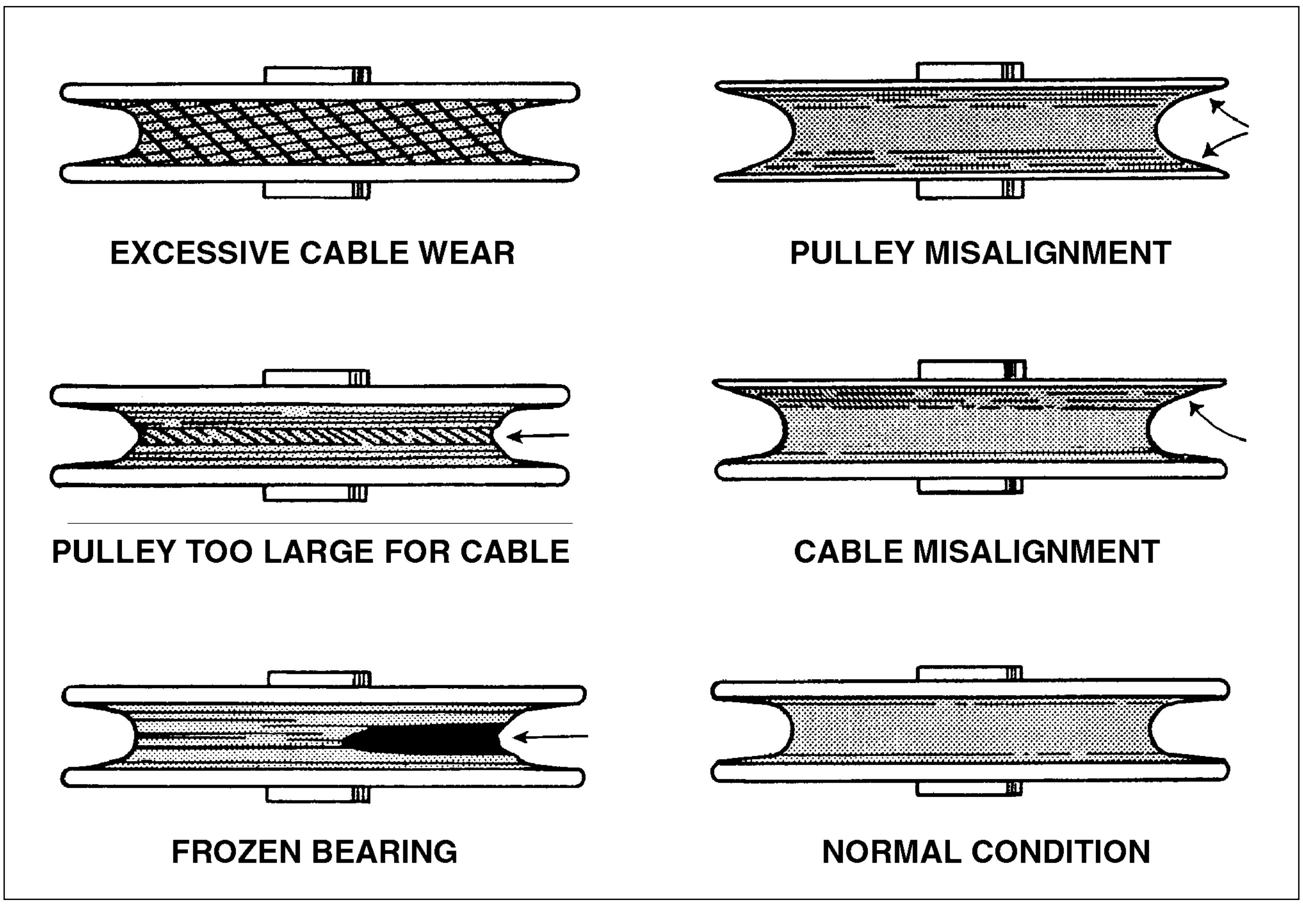

Figure 3-5. Pulley Wear Patterns

TABLE III-I. INSPECTION REPORT

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	L	R	Inspection Time (hrs) 50	100	500	1000
A. PROPELLER GROUP						
1. Inspect spinner and back plate	O	O	O	O	O	O
2. Inspect blades for nicks and cracks	O	O	O	O	O	O
3. Inspect for grease and oil leaks	O	O	O	O	O	O
4. Lubricate propeller per lubrication chart	O	O		O	O	O
5. Inspect spinner mounting brackets	O	O		O	O	O
6. Inspect propeller mounting bolts and safety (Check torque if safety is broken)	O	O		O	O	O
7. Inspect hub parts for cracks and corrosion	O	O		O	O	O
8. Rotate blades and check for tightness in hub pilot tube	O	O		O	O	O
9. Inspect pitch actuating arms and bolts	O	O		O	O	O
10. Remove propellers; remove sludge from propeller and crankshaft	O	O			O	O
11. Overhaul propeller (per latest Hartzell Service Letter No. 61)	O	O	As req'd by Hartzell Svc. Ltr. No. 61.			
B. ENGINE GROUP						
CAUTION: Ground Magneto Primary Circuit before working on engine.						
1. Remove engine cowl	O	O		O	O	O
2. Clean and check cowling for cracks, distortion and loose or missing fasteners	O	O		O	O	O
3. Drain oil sump (See Note 5)	O	O	O	O	O	O
4. Drain oil breather collector tank	O	O	O	O	O	O
5. Clean suction oil strainer at oil change (Inspect strainer for foreign particles)	O	O	O	O	O	O
6. Clean pressure oil strainer (each 25 hours) or change full flow cartridge oil filter (each 50 hours). Inspect strainer or element for foreign particles	O	O	O	O	O	O
7. Inspect oil temperature sender unit for leaks and security	O	O		O	O	O
8. Inspect oil lines and fittings for leaks, security, chafing, dents and cracks (See Note 7)	O	O		O	O	O
9. Clean and check oil radiator cooling fins.	O	O		O	O	O
10. Remove and flush oil radiator	O	O			O	O
11. Fill engine with oil as per Table II-IIIA	O	O	O	O	O	O
12. Clean engine	O	O		O	O	O
13. Replace or clean spark plugs as required (Adjust gap - .015 to .018 or .018 to .022 as per Lycoming Service Instruction No. 1042) (See Note 8)	O	O		O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection			Inspection Time (hrs)			
B. ENGINE GROUP (cont.)	L	R	50	100	500	1000
14. Inspect ignition harnesses and insulators (high tension leakage and continuity)	O	O		O	O	O
15. Inspect magneto main points for clearance (Maintain clearances at .018 ± .006)	O	O		O	O	O
16. Inspect magnetos for oil seal leakage	O	O		O	O	O
17. Inspect breaker felts for proper lubrication	O	O		O	O	O
18. Inspect distributor block for cracks, burned areas or corrosion and height of contact springs	O	O		O	O	O
19. Check magnetos to engine timing	O	O		O	O	O
20. Overhaul or replace magnetos (See Note 6)	O	O				O
21. Remove air cleaner screen and clean (Refer to Section II)	O	O	O	O	O	O
22. Drain carburetor, and remove and clean carburetor inlet screen	O	O	O	O	O	O
23. Inspect condition of carburetor heat door and box	O	O		O	O	O
24. Inspect intake seals for leaks and clamps for tightness	O	O		O	O	O
25. Inspect condition of flexible fuel lines	O	O		O	O	O
26. Replace flexible fuel lines (See Notes 6 and 7)	O	O				O
27. Inspect fuel system for leaks (See Note 7)	O	O		O	O	O
28. Clean screens in electric fuel pumps (plunger type pump)	O	O		O	O	O
29. Inspect fuel pumps for operation (engine driven and electric)	O	O		O	O	O
30. Overhaul or replace fuel pumps (engine driven) (See Note 6)	O	O				O
31. Replace hydraulic filter element (Check filter for contamination)	O			O	O	O
32. Inspect hydraulic pump and gasket for leaks	O			O	O	O
33. Overhaul or replace hydraulic pump (See Note 6)	O					O
34. Inspect vacuum pumps, oil separators and lines	O	O		O	O	O
35. Overhaul or replace vacuum pumps (See Note 6)	O	O				O
36. Inspect throttle, carburetor heat, carburetor mixture and propeller governor controls for travel and operating condition	O	O		O	O	O
37. Inspect exhaust stacks, gaskets and augmentor tubes (Replace gaskets as required)	O	O		O	O	O
38. Inspect breather tube for obstructions and security	O	O		O	O	O
39. Inspect crankcase for cracks, leaks and security of seam bolts	O	O		O	O	O
40. Inspect engine mounts for cracks and loose mounting	O	O		O	O	O
41. Inspect rubber engine mount bushings for deterioration (Replace each 500 hours)	O	O		O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	L	R	Inspection Time (hrs) 50	100	500	1000
B. ENGINE GROUP (cont.)						
42. Inspect all engine baffles	O	O		O	O	O
43. Inspect fire walls for cracks	O	O		O	O	O
44. Inspect fire wall seals for deterioration and leakage	O	O		O	O	O
45. Inspect condition and tension of generator drive belt	O	O		O	O	O
46. Inspect condition of generator and starter	O	O		O	O	O
47. Replace vacuum regulator filter	O	O		O	O	O
48. Lubricate all engine controls (DO NOT lubricate teflon liners of control cables)	O	O		O	O	O
49. Overhaul or replace propeller governor (Refer to latest Hartzell Service Letter No. 61)	O	O	At engine overhaul or each 2000 hours.			
50. Complete overhaul of engine or replace with factory rebuilt (See Note 6)	O	O	As req'd by Lycoming Svc. Instr. No. 1009.			
51. Reinstall engine cowl	O	O		O	O	O
C. CABIN GROUP						
1. Inspect cabin entrance door, baggage compartment door, and windows for damage, operation and security				O	O	O
2. Inspect upholstery for tears				O	O	O
3. Inspect seats, seat belts, securing brackets and bolts (See Note 14)				O	O	O
4. Inspect trim operation				O	O	O
5. Inspect rudder pedals				O	O	O
6. Inspect parking brake				O	O	O
7. Inspect control wheels, column, pulleys and cables (See Note 13)				O	O	O
8. Check landing, navigation, cabin and instrument lights				O	O	O
9. Inspect instruments, lines and attachments				O	O	O
10. Inspect instruments central air filter lines and replace filter				O	O	O
11. Inspect vacuum operated instruments and electric turn and bank (Overhaul or replace as required)				O	O	O
12. Replace filters in gyro horizon and directional gyro					O	O
13. Inspect altimeter (Calibrate altimeter system in accordance with FAR 91.170, if appropriate)				O	O	O
14. Drain crossfeed line			O	O	O	O
15. Inspect operation - crossfeed valve				O	O	O
16. Inspect operation - heater fuel valve, check safety of nut				O	O	O
17. Inspect oxygen outlets for defects and corrosion				O	O	O
18. Inspect oxygen system operation and components				O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	Inspection Time (hrs)			
D. FUSELAGE AND EMPENNAGE GROUP	50	100	500	1000
1. Remove inspection panels and plates (See Note 18)		O	O	O
2. Check fluid in brake reservoir (Fill as required)		O	O	O
3. Inspect battery, box and cables (* at least every 30 days) Flush box as required and fill battery per instructions on box (See Note 15)	O*	O	O	O
4. Inspect heater for fuel or fume leaks		O	O	O
5. Inspect manual heater fuel shutoff valve for fuel leaks and cap nut for safety	O	O	O	O
6. Drain and clean heater gascolator bowl		O	O	O
7. Check recommended time for overhaul of heater per instructions in Section XIII		O	O	O
8. Inspect electronic installations		O	O	O
9. Inspect bulkheads and stringers for damage		O	O	O
10. Inspect fuselage entrance step attachments to fuselage frame, for condition, security, etc. (Refer to latest Piper Service Bulletin No. 672)		O	O	O
11. Inspect loop and loop mount, antenna mount and electric wiring		O	O	O
12. Inspect hydraulic power pack and lines for damage, leaks and proper fluid level (See Note 9).		O	O	O
13. Inspect CO2 system for fluid in lines and safeties on CO2 bottle (Weigh CO2 bottle at 500 hours or at annual inspection, 132 grams unless otherwise noted on bottle)		O	O	O
14. Inspect fuel lines, valves and gauges for damage and operation		O	O	O
15. Inspect fuel selector valve control cables per latest Piper Service Bulletin No. 507		O	O	O
16. Inspect security of all lines		O	O	O
17. Inspect vertical fin and rudder surfaces for damage		O	O	O
18. Inspect rudder and tab hinges, horn and attachments for damage and operation		O	O	O
19. Inspect vertical fin attachments		O	O	O
20. Inspect rudder hinge bolts and bushing, and tab pin for excess wear		O	O	O
21. Inspect rudder trim mechanism		O	O	O
22. Inspect horizontal stabilizer and elevator surfaces for damage		O	O	O
23. Inspect elevator hinges, horn, and attachments for damage and operation		O	O	O
24. Inspect horizontal stabilator attachments		O	O	O
25. Inspect elevator hinge bolts and bushings for excess wear		O	O	O
26. Inspect elevator trim mechanism		O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
D. FUSELAGE AND EMPENNAGE GROUP (cont.)				
27. Inspect aileron, rudder, elevator and trim cables, turnbuckles, guides and pulleys for safeties, damage and operation - set cable tension (See Note 13)		O	O	O
28. Replace rudder hinge bolts			O	O
29. Inspect rotating beacon for security and operation		O	O	O
30. Inspect E.L.T. installation and condition of battery and antenna		O	O	O
31. Lubricate per lubrication chart		O	O	O
32. Inspect flap torque tube, bearing supports, brackets and hydraulic actuator and bellcrank for security, loose rivets, cracks and leaks		O	O	O
33. Inspect fuselage frame for corrosion		O	O	O
34. Reinstall inspection panels and plates		O	O	O
E. WING GROUP (Refer to Note 12.)				
1. Remove inspection plates and fairings		O	O	O
2. Inspect surfaces, skins and tips for damage and loose rivets			O	O
3. Inspect condition of walkway and step			O	O
4. Inspect ailerons and attachments for damage and operation		O	O	O
5. Inspect aileron cables, pulleys and bellcranks for damage and operation - set cable tension (See Note 13)		O	O	O
6. Inspect aileron balance weight for security		O	O	O
7. Inspect flaps and attachments for damage and operation (See Note 10)		O	O	O
8. Replace pins and bolts used as flap and aileron hinges				O
9. Lubricate per lubrication chart		O	O	O
10. Inspect wing attachment bolts and brackets		O	O	O
11. Inspect engine mount attaching structure		O	O	O
12. Inspect fuel tanks and lines for leaks and water (See Note 16)		O	O	O
13. Remove, drain and clean fuel strainer bowl and screen (Drain and clean at least every 90 days) (See Note 17)	O	O	O	O
14. Fuel tanks marked for capacity		O	O	O
15. Fuel tanks marked for minimum octane rating		O	O	O
16. Inspect switches to indicators registering fuel tank quantity		O	O	O
17. Inspect fuel cell vents/drains per latest revision of Piper Service Bulletin No. 340		O	O	O
18. Reinstall inspection plates and fairings		O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	Inspection Time (hrs)			
F. LANDING GEAR GROUP (Refer to Note 12.)	50	100	500	1000
1. Inspect oleo struts for proper extension (Check for proper fluid level as required)	O	O	O	O
2. Inspect nose gear steering control and travel		O	O	O
3. Inspect wheels for alignment		O	O	O
4. Put airplane on jacks		O	O	O
5. Inspect tires for cuts, uneven or excessive wear and slippage		O	O	O
6. Remove wheels, clean, inspect and repack bearings		O	O	O
7. Inspect wheels for cracks, corrosion and broken bolts		O	O	O
8. Check tire pressure (Nose 27 psi - Mains 35 psi)	O	O	O	O
9. Inspect brake lining and disc		O	O	O
10. Inspect brake backing plates, clean and lubricate pins		O	O	O
11. Inspect brake and hydraulic lines		O	O	O
12. Inspect shimmy dampener		O	O	O
13. Inspect gear forks for damage		O	O	O
14. Inspect oleo struts for fluid leaks and scoring		O	O	O
15. Inspect gear struts, attachments, torque links, retraction links and bolts for operation		O	O	O
16. Inspect downlock for operation and adjustment		O	O	O
17. Inspect torque link bolts and bushings (Rebush if necessary)			O	O
18. Inspect drag link bolts (Replace as required)				O
19. Inspect gear doors and attachments		O	O	O
20. Inspect warning horn and light for operation		O	O	O
21. Retract gear - check operation		O	O	O
22. Retract gear - check doors for clearance and operation		O	O	O
23. Inspect anti-retraction system		O	O	O
24. Inspect actuating cylinders for leaking and security		O	O	O
25. Inspect position indicating switches and electrical leads for security		O	O	O
26. Lubricate per lubrication chart		O	O	O
27. Remove airplane from jacks		O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTE

Perform inspection or operation at each of the inspection intervals as indicated by a circle (O).

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
G. OPERATIONAL INSPECTION				
1. Check fuel pump, fuel tank selector and crossfeed operation	O	O	O	O
2. Check fuel quantity and pressure or flow indication	O	O	O	O
3. Check oil pressure and temperature indications	O	O	O	O
4. Check generator output	O	O	O	O
5. Check manifold pressure indication	O	O	O	O
6. Check carburetor heat operation	O	O	O	O
7. Check parking brake operation	O	O	O	O
8. Check vacuum gauge indication	O	O	O	O
9. Check gyros for noise and roughness	O	O	O	O
10. Check cabin heater operation	O	O	O	O
11. Check magneto switch operation	O	O	O	O
12. Check magneto RPM variation	O	O	O	O
13. Check throttle and mixture operation	O	O	O	O
14. Check propeller smoothness	O	O	O	O
15. Check propeller governor action	O	O	O	O
16. Check electronic equipment operation	O	O	O	O
17. Check operation of Autopilot and Automatic Trim (See Note 11)	O	O	O	O
H. GENERAL				
1. Aircraft conforms to FAA Specifications	O	O	O	O
2. All FAA Airworthiness Directives complied with	O	O	O	O
3. All Manufacturers Service Letters and Bulletins complied with	O	O	O	O
4. Check for proper Flight Manual	O	O	O	O
5. Aircraft papers in proper order	O	O	O	O

TABLE III-I. INSPECTION REPORT (cont.)

NOTES:

1. Refer to Piper's Customer Service Information Catalog No. 1753-755 (Aerofiche) for a checklist of current revision dates to Piper Inspection Reports and Manuals. References to Chapter or Section refer to the applicable Chapter/Section in this manual.
2. All inspections or operations are required at each of the inspection intervals as marked by a (O). Both the annual and 100 hour inspections are complete inspections of the airplane, identical in scope, while both the 500 and 1000 hour inspections are extensions of the annual or 100 hour inspection, which require a more detailed examination of the airplane, and overhaul or replacement of some major components.
3. Piper Service Bulletins are of special importance and Piper considers compliance mandatory.
4. Piper Service Letters are product improvements and service hints pertaining to servicing the airplane and should be given careful attention.
5. Refer to latest revisions of Lycoming Service Bulletin No. 480 and Lycoming Service Instruction No. 1014. Lycoming recommends the following oil change intervals: (a) For engines relying upon pressure screen filtration alone, change the oil and clean the pressure and suction screens each 25 hours of engine operation or every four months, whichever comes first: (b) For engines equipped with full-flow (cartridge) oil filters, change the oil and filter each 50 hours of engine operation or every four months, whichever comes first. Should fuel other than the specified octane rating for the power plant be used, refer to Lycoming Service Letter No. L185A for additional information and recommended service procedures.
6. Replace or overhaul as required or at engine overhaul. (For engine overhaul, refer to the latest revision of Lycoming Service Instruction No. 1009.)
7. Replace flexible oil, fuel and hydraulic lines in the engine compartment after 8 years, 1000 hours time-in-service, or at engine overhaul, whichever comes first. Pressure check fluid hoses in the fuselage and wing areas to system pressures after 10 years time-in-service. Visually check for leaks. Hoses in the fuselage and wing areas that pass the pressure check may remain in service and checked again after the next 5 years time-in-service.
8. When using other than the specified 80/87 octane fuel, refer to Lycoming Service Letter No. L185A for more information and recommended service procedures.
9. Comply with Piper Service Bulletin No. 635.
10. Refer to latest Piper Service Bulletin No. 671 and Piper Service Letter No. 853 for Flap Control System Inspection.
11. Refer to Flight Manual Supplement for preflight and flight checks, for intended function in all modes.
12. Refer to Piper Service Bulletin 822.
13. Examine cables for broken strands by wiping the cable with a cloth along the entire length of the cable. Visually inspect the cable thoroughly for damage not detected by the cloth. Replace damaged or frayed cables. Refer to paragraph 3-8 in this section and the latest edition of FAA Advisory Circular 43.13-1A, Paragraph 198.

TABLE III-I. INSPECTION REPORT (cont.)

NOTES (cont.):

14. Verify compliance with latest revision of Piper Service Bulletin No. 980. Inspect seat belt and shoulder harness ends and attachment points for condition and security. Inspect harness web material for condition and wear over its entire length. Particularly look for wear and fraying where harness web passes in and out of adjustable buckle end and shoulder harness inertial reel. If excessively worn, replace. On lap belts, inspect shoulder harness keeper nylon bushing. If excessively worn or missing, replacement of that half of the lap belt is required.
15. Verify compliance with latest revision of Piper Service Bulletin No. 836.
16. Verify compliance with latest revision of Piper Service Bulletin No. 932.
17. Verify compliance with latest revision of Piper Service Bulletin No. 827.
18. For aircraft in normal operation, each 7 years; or, for aircraft in training operations, each 2000 hours time-in-service: remove interior panels and headliner and conduct detailed inspection of aircraft structure (skin, bulkheads, stringers, etc.) for condition and security. Inspection of structure concealed by headliner may be accomplished by alternate means (i.e. - through the use of a borescope) without removing the headliner, providing access is obtained to all concealed areas and borescope provides sufficient detail to adequately accomplish the inspection.

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SECTION IV

STRUCTURES

Revised: 2/13/80

Revised: 2/13/80

SECTION IV

STRUCTURES

4-1. GENERAL.

4-2. The fuselage contains a tubular structure of 4130 chrome molybdenum steel in the cabin area. Figures 4-5 through 4-8 identify the types of skin structure used. No major alterations are recommended without contacting the manufacturer. However, minor repairs such as patching the skin, welding, etc. may be made in accordance with the regulations set forth in FAA Advisory Circular 43.13-1A.

CAUTION

Skin repairs must result in a surface which is as strong as, or stronger than, the original skin. However, flexibility must be retained so that the surrounding areas will not receive extra stress.

4-3. REMOVAL.

4-4. REMOVAL OF WING ASSEMBLY.

NOTE

The major subassemblies of the wing may be removed individually or the wing may be removed as a unit. To remove a wing, a fuselage supporting cradle is required.

4-5. REMOVAL OF WING TIP.

a. Locate the small rectangular plate on top and the larger rectangular inspection plate on the bottom of the front wing spar at the wingskin and tip skin separation. (Refer to Section II.)

b. Remove the No. 8-32 screws holding the plates and remove the plates.

c. Remove the remaining 33 screws holding the tip to the wing.

d. Remove the wire hinge pin holding the wing hinge and tip hinge together. The hinge pin is located under the plate that was previously removed.

The plate serves as a safety for the pin.

e. Pull off the wing tip far enough to disconnect the navigation light wire at the quick-disconnect fitting and then remove the wing tip.

4-6. REMOVAL OF WING FLAPS.

a. Remove wing root rear fairing.
b. Put flap in down position.
c. Disconnect the control rod at the inboard end of the flap.
d. Remove the three hinge bolts.
e. Pull the flap straight back off the wing.

4-7. REMOVAL OF AILERON.

a. Disconnect the aileron control tube at the center aileron hinge.
b. Remove the balance weight from the balance weight arm located at the outboard end of the aileron.
c. Remove the three hinge bolts.
d. Lower the inboard end of the aileron, swing it under the wing and remove the aileron from the wing.

4-8. REMOVAL OF WING.

a. Remove wing root fairing, all wing inspection panels, front fuselage side access panels and the bottom fuselage access panel. (Refer to Section II.)
b. Remove the spinner and propeller. (Refer to Section VIII.)
c. Remove the engine cowl, the top nacelle and the engine. (Refer to Section VIII.)
d. Drain the gas from the wing to be removed. (Refer to Section II.)
e. Drain the brake lines and reservoir. (Refer to Section II.)
f. Set the aircraft on jacks. (Refer to Section II.)
g. Drain the hydraulic system. (Refer to Section II.)
h. Disconnect the fuel shut-off control cable at the fuel shut-off valve. Remove the cable clamp at the rib beside the valve and at the wing butt rib.
i. Disconnect the primer and the fuel crossfeed lines under the fuel control panel.
j. Remove the front and rear seats.
k. Remove the interior trim panel just below the door sill on the right side and remove the lower middle section of the panel on the left side.
l. Remove the screws on the floor at the front and rear of the spar cover, remove seat bracket from spar and remove cover.
m. Disconnect the wing flap from the actuator tube at the inboard end.
n. Disconnect the aileron control cables at the bellcrank, which are accessible through inspection plate on the bottom of the wing about half way out between the engine and the end of the wing. Remove the pulley at the next inboard

inspection hole and at the wing butt. Remove the cap on the micarta rub block in the nacelle space and remove the cables from the wing.

o. Disconnect the vacuum and fuel pressure lines.

p. Disconnect the fuel lines at the wing butt and disconnect the manifold pressure line.

q. Disconnect the airspeed lines.

r. Disconnect the hydraulic lines and the CO_2 lines.

s. Remove the insulating cap from the electric wiring terminal block in the rear section of the fuselage access opening and disconnect the wires.

t. All engine controls (throttle, carburetor heat, propeller governor and mixture) must be removed from the wing. The tachometer shaft is removed last and must be inserted first through the control tube when reassembling due to the large nut on the shaft.

u. Remove the outside wing bolts and arrange a fuselage support. Remove the wing jacks.

v. Remove the center bolts and the rear spar bolt.

w. Remove the wing.

4-9. REMOVAL OF EMPENNAGE.

4-10. REMOVAL OF RUDDER.

a. Remove the tail cone fairing and the two cover fairings.

b. Disconnect the two control cables from the rudder horn.

c. Disconnect the rudder horn from the lower rudder hinge bracket.

d. Disconnect the rudder trim tab control rod.

e. Disconnect the two hinge bolts and remove the rudder.

4-11. REMOVAL OF ELEVATORS.

a. To remove the elevator assembly, first remove the rudder assembly. (Refer to Paragraph 4-10.)

b. Disconnect the elevator trim control rod and the elevator actuating rod from the elevator torque tube assembly.

c. Disconnect the elevator torque tube from the lower elevator hinge bracket.

d. Disconnect the four hinge bolts.

e. Remove both elevators and the elevator torque tube as one unit.

f. To remove one or the other elevator, without having to remove the rudder, tail cone, or fairings, remove the four 3/16-inch bolts fastening the elevator torque control assembly to the elevator butt rib.

g. Remove the two hinge bolts and remove the elevator.

4-12. REMOVAL OF FIN.

a. Remove the tail cone fairing and the rudder. (Refer to Paragraph 4-10.)

b. Remove the fairing around the base of the fin.

c. Disconnect the rudder trim cable drum from the bracket and tape the drum securely so that the cable cannot unwind.

d. Disconnect the antenna wire from the forward insulator at the cabin section. Coil the wire and tape it to the fin itself.

e. Remove the two bolts at the rear attachment bracket.

f. Remove the six bolts at the front attachment plate and remove the fin.

4-13. REMOVAL OF STABILIZER.

a. Remove the tail fairings and the rudder. (Refer to Paragraph 4-10.)

b. Remove the elevators and the elevator torque tube. (Refer to Paragraph 4-11.)

c. Remove the fin. (Refer to Paragraph 4-12.)

d. Remove the fairings at the sides of the stabilizer.

e. Remove the pulleys and the pulley brackets from the elevator center hinge bracket to free the rudder trim cables.

f. Remove the elevator center hinge bracket from the rear spar of the stabilizer.

g. Insert the taped rudder trim cable drum through the holes in the rear and front spars of the stabilizer.

h. Remove the two front attaching bolts and the two rear attaching bolts and remove the stabilizer. Note the number, thickness and location of spacer washers under the spacer blocks at the two rear spar attachment points.

NOTE

If either forward stabilizer attachment fitting is to be removed, note the number and thickness of spacer shims, if installed, between forward and bottom sides of the fitting and the fuselage assembly.

4-14. REMOVAL OF FUSELAGE COMPONENTS.

4-15. The fuselage is primarily a basic structure. Repairs may be accomplished within the limitations described in paragraph 4-2. The removal of minor components is described in paragraphs 4-17 through 4-20.

4-16. Modifications to the fuselage are permissible if they do not involve alterations to the primary structure and if the effect on the center of gravity is taken into consideration. It is recommended that the manufacturer be contacted for information regarding specific alterations proposed.

4-17. FUSELAGE CABIN DOOR REMOVAL.

a. Remove the right windshield moulding.
b. Loosen right front interior side panel to gain access to the hinge pins.
c. Remove a cotter pin from the two hinge pins and remove hinge pins.
d. Remove door from fuselage.

4-18. REPLACEMENT OF DOOR LOCK ASSEMBLY.

a. Remove the rear and bottom plastic mouldings at the door window.

b. Unsnap the spring fasteners holding the inside trim panel forward to the arm rest. It is not necessary to remove the entire panel.

c. Remove the three screws (A), (B) and (F) as indicated in Figure 4-1. Loosen the remaining three screws (C), (D) and (E). Screw F is a longer screw and prevents the clevis pin in the door handle from dropping out of place when the lock is assembled.

d. Remove the two screws (J).

e. Disconnect the coiled spring (K) from the end of the locking rod by pulling the locking rod (G) down between the skin of the door and the frame holding the door lock mechanism. By using care, this part of the frame may be sprung away from the skin to permit sufficient clearance. This point is where the screws were removed in Step (d) above.

NOTE

The rolled flange on the door in this area may be straightened out with a pair of pliers to allow easier access to the mechanism.

f. Remove the clevis pin through the door lock handle by pulling down and removing the handle.

NOTE

Spring (H) is attached to the handle which was held to the door by screw (A). A cutout in the rubber gasket between the frame of the lock and the door permits the spring to slide out from this position.

g. Commencing with Apache serial number 23-250, the door lock frame, part number 18068-00 has been modified. This modification holds the door handle flush with the door and prevents attempts to open the door when the door is locked. Should it be considered desirable to replace the door lock frame for this purpose, or any purpose, the procedure for removing the frame is as follows:

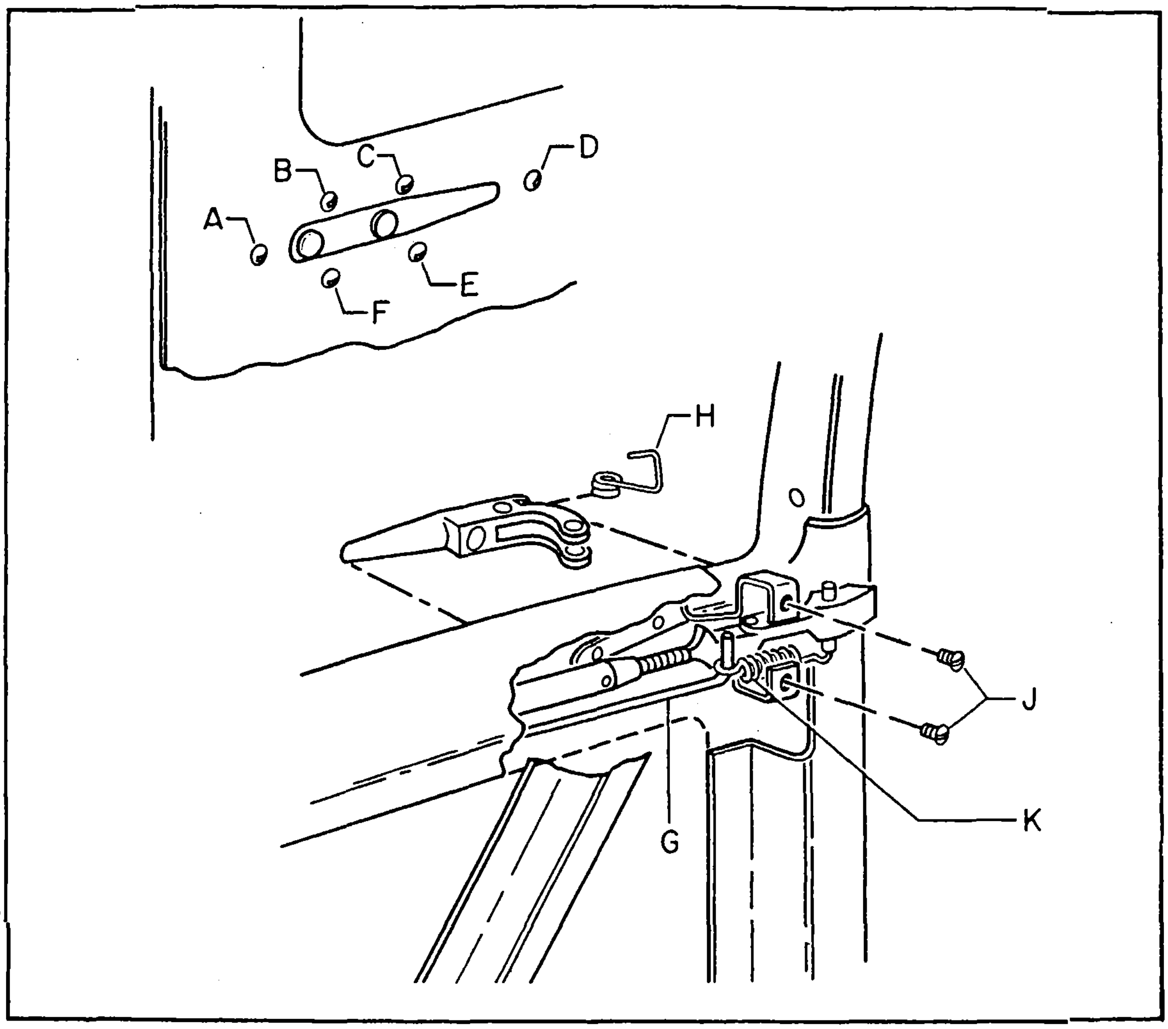


Figure 4-1. Door Lock Installation

(1) Remove screws (C), (D) and (E) from the handle frame. (Refer to Figure 4-1.) Remove the screws from the door latch guide block.

(2) Pull the door latch into the door; this will allow the frame and assembly to drop down. A half turn of the frame will remove the frame from between the inner and outer door shell. The inner shell may be sprung outward to provide clearance.

(3) Position the new frame on the door latch mechanism (a half turn will locate it properly), move it up into place, let the assembly move forward through the block, and install the screws to hold the assembly in position.

h. Position the new handle and lock in the door opening by moving the handle inward beyond the normal position. It will be possible to insert the end of spring (H), which is attached to the handle, into position by sliding the end of the spring through the cutout in the gasket between the frame and the outer skin of the door. The spring will then be in position to be secured in place by the screw marked (A). Install screw (A).

i. Install the clevis pin through the door handle. This clevis pin is inserted from the bottom, head down. Screw (F) is installed to prevent the clevis pin from dropping out.

j. With the locking rod (G) pulled down below the frame of the lock, install the end of the coiled spring and push it up through the hole in the door handle by springing the frame sufficiently. No other means of securing the lock rod is required. The inside door handle at the front of the door may be moved throughout this operation to assist in lining up the mechanism.

k. Install the remaining screws (B) and (J), tighten the others, resnap the trim panel and install the plastic garnish mouldings.

4-19. REPLACEMENT OF LANDING LIGHT.

a. Remove fuselage nose cone fairing.

b. Remove the two self-locking nuts from the lower screws passing through both rear and front brackets (2 and 6, Figure 4-2 for Apache serial numbers 23-1 to 23-1163 inclusive), (2 and 6, Figure 4-3 for Apache serial numbers 23-1164 and up.)

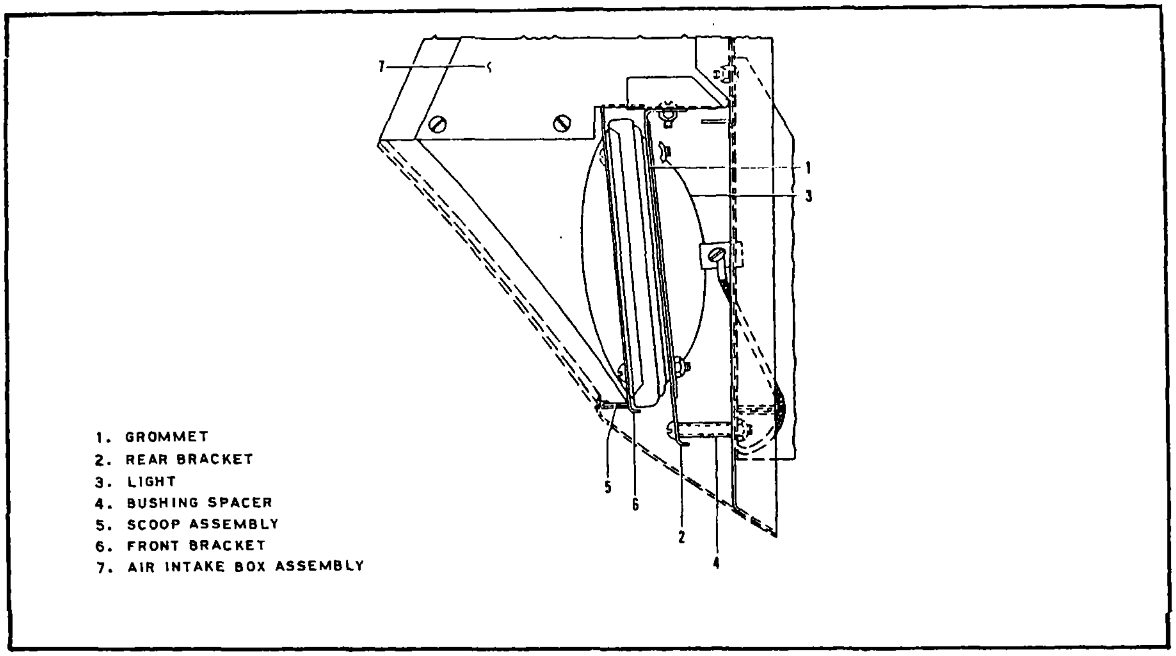


Figure 4-2. Landing Light Installation
Serial Numbers 23-1 to 23-1163

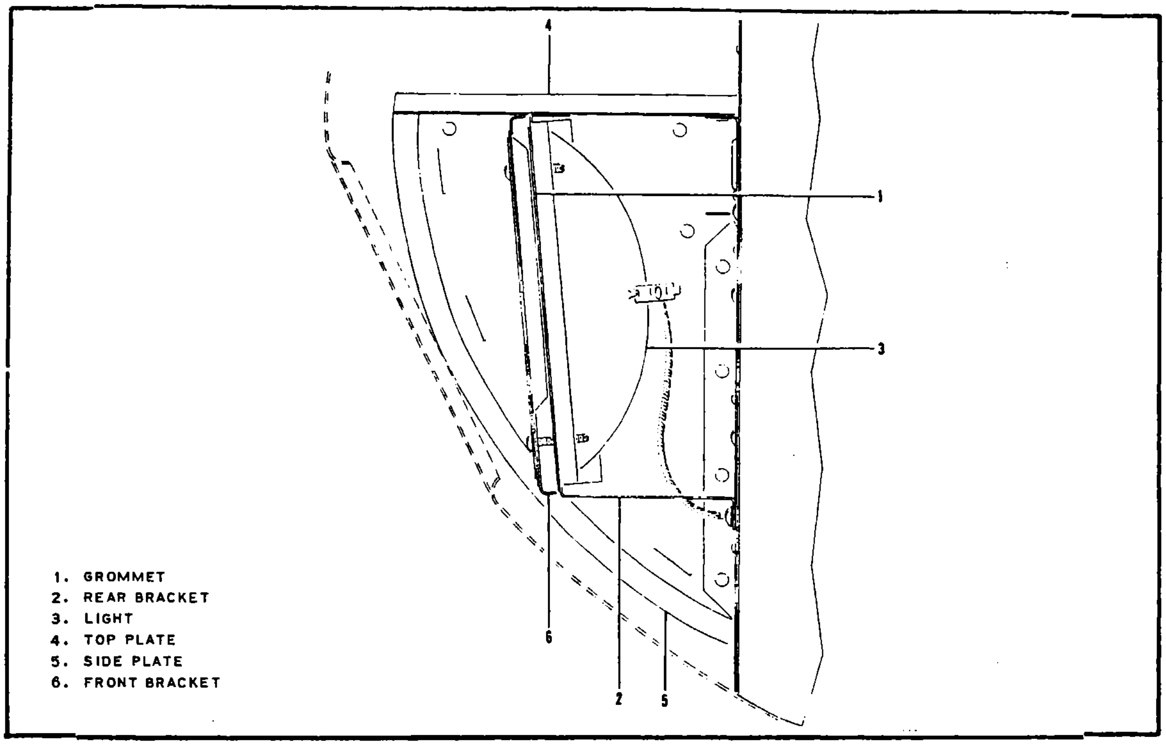


Figure 4-3. Landing Light Installation
Serial Numbers 23-1164 and up

c. Loosen the two self-locking nuts on the upper screws passing through the brackets.

d. Disconnect the electrical leads from the rear of the light (3) and remove the light.

e. Install the replacement light between the brackets, making sure the key on the back of the light is in the rear bracket slot at the left of the bracket.

f. Install the two self-locking nuts on the two lower bracket screws, tighten them and the two upper nuts until the edges of both brackets are parallel. Connect the electrical leads to the rear of the light.

4-20. REMOVAL AND DISASSEMBLY OF LANDING LIGHT HOUSING. Removal and disassembly of the light housing are evident. (Refer to Figure 4-2 for Apache serial numbers 23-1 to 23-1163 inclusive.) (Refer to Figure 4-3 for Apache serial numbers 23-1164 and up.) The only requirements are that the electrical leads to the light are disconnected prior to removal and that the light is not dropped when the front and rear brackets are separated.

4-21. INSTALLATION.

4-22. INSTALLATION OF FUSELAGE COMPONENTS.

4-23. INSTALLATION OF COCKPIT CONTROL LEVER CABLES. If, for any reason, it is necessary to disconnect the six cockpit control lever cables at the top of the pedestal, and if the existing adjustments of these cables are altered or questioned, readjust the cables as follows:

a. Prior to making final adjustments, back off each lock nut to the limit of its travel which is the unthreaded portion of the cable.

b. Connect the mixture and throttle cable clevises to their respective control levers, with the tip of the threaded cable end and the base of the clevis yoke flush, before making the final adjustments as described in Section VIII.

c. Before making the final adjustment to the propeller pitch control cables, as described in Paragraphs 6-12, thread the cable into the clevis until the clevis bears against the nut. This restricts adjustment of the governor at the "FEATHER STOP" position to increases in speed only as far as alterations to speed settings via the control lever end of the cables are concerned. However, this is not true when governor adjustments by means of installed cables are made.

d. Do not install the six control cables in the block, located in front of the pedestal, as three complete pairs. Place the tachometer cables between the right and left mixture cables. As seen from left to right, the cables are positioned within the split block in the following order: the left throttle, right throttle, left propeller pitch, right propeller pitch, left mixture, left tachometer, right tachometer, and finally, the right mixture.

4-24. INSTALLATION OF EMPENNAGE.

4-25. INSTALLATION OF STABILIZER.

a. Install forward stabilizer attachment fittings, if removed. If either fitting has been removed with spacer shims, install the fitting by one of the following procedures:

1. Install an old fitting with the original spacer shims, located between the forward and undersides of the fitting and fuselage assembly. (Spacer shims are used to align the stabilizer laterally and longitudinally.)

2. Install a new fitting with spacer shims, (Forward shims are: .032 P/N 19119-03 and .064 P/N 19119-02. Bottom shims are: .016 P/N 18564-02, .032 P/N 18564-03 and .064 P/N 18564-04.) between the forward and undersides of the fitting, and the fuselage assembly to allow proper alignment of bolt attachment holes. (Maximum allowable total shim thickness is .125 of an inch.)

b. Position the stabilizer (Fin must be installed with stabilizer on airplanes with serial nos. 23-1152 and up.) and align the two mounting holes in the stabilizer rear spar with the two mounting holes in the fuselage. Place a spacer block and a .064 of an inch spacer washer between the stabilizer and the fuselage at each attaching point. Add additional spacer washers (.032 P/N 81102-22) as required to level the stabilizer.

c. Insert the taped rudder trim cable drum through the holes in the front and the rear spars of the stabilizer.

d. Attach the elevator center hinge bracket to the rear spar of the stabilizer.

e. Install the pulleys and pulley brackets on the elevator center hinge bracket with the rudder trim cables attached.

f. Replace the fairing at the sides of the stabilizer.

g. Replace the fin. (Refer to Paragraph 4-26.)

h. Replace the elevators and the elevator torque tube. (Refer to Paragraph 4-27.)

i. Replace the rudder and the tail fairings. (Refer to Paragraph 4-28.)

4-26. INSTALLATION OF FIN.

a. Align the holes in the front attachment plate and the rear bracket with the matching holes in the fuselage and install the six bolts at the front plate and the two bolts at the rear bracket.

b. Connect the antenna wire to the forward insulator at the cabin section.

c. Remove the tape from around the rudder trim cable drum and install the drum in the bracket. Make the proper adjustments to the trim mechanism. (Refer to Section V.)

d. Replace the fairing around the base of the fin.

e. Replace the tail fairings and the rudder. (Refer to Paragraph 4-28.)

4-27. INSTALLATION OF ELEVATORS.

a. Align the four elevator hinge brackets with the four hinges on the rear spar of the stabilizer and install the four bolts.

b. Connect the elevator torque tube to the lower elevator hinge bracket.

c. Connect the elevator trim control rod and the elevator actuating rod to the elevator torque tube assembly.

d. Install the rudder assembly. (Refer to Paragraph 4-28.)

e. If one or the other elevator has been removed, position it at the hinge attaching points and install the two hinge bolts. Fasten the elevator torque control assembly to the elevator butt rib with four 3/16-inch bolts.

4-28. INSTALLATION OF RUDDER.

a. Align the two hinge brackets with the hinges on the fin and install the two hinge bolts.

b. Connect the rudder trim tab control rod.

c. Connect the rudder horn to the rudder lower hinge bracket.

d. Connect the two control cables to the rudder horn.

e. Connect the navigation light wire.

f. Replace the tail fairings.

4-29. INSTALLATION OF WING ASSEMBLY.

4-30. INSTALLATION OF WING.

a. Slide the wing spars into the fuselage and set the wing on the proper supports.

b. Insert the tachometer shaft through the wing control tube and follow with the throttle, carburetor heat, propeller governor and mixture controls.

NOTE

Of the five cables protruding from the left side of the cockpit, two (the throttle and propeller governor cables), are equipped with the same endings. Determine the throttle cable by its shorter length. The same problem occurs at the right side; however, the throttle cable is the longer cable.

c. Place the main spar, attaching the straps with bolts and nuts and attach the rear spar. (Refer to Figure 4-4.)

d. Replace the bolts and bushings at the spar fittings on the outer sides of the fuselage.

e. Place the wing jacks under the wings and remove the supports.

f. Connect the wires at the electrical wiring terminal block located in the rear section of the fuselage access opening.

g. Connect the oil pressure lines.

h. Connect the hydraulic lines.

i. Connect the airspeed lines.

j. Connect the fuel lines at the wing butt and connect the manifold pressure lines.

k Connect the vacuum and fuel pressure lines.

l. Replace the aileron control cables in the rub block on the wheel well; replace the pulley at the wing butt and inspection hole; and connect the cables at the bellcrank, which is accessible through the plate on bottom of the wing midway between the engine and the end of the wing.

m. Connect the flap control rod to the inboard end of the flap.

n. Replace the spar cover.

o. Replace the interior trim panel just below the door sill on the right side and replace the lower middle section of the panel on the left side.

p. Connect the primer and fuel crossfeed lines under the fuel control box.

q. Connect the fuel shut-off control cable at the fuel shut-off valve and re-clamp the cable at the rib beside the valve and at the wing butt rib.

r. Fill the hydraulic system. (Refer to Section II.)

s. Replace the front and rear seats.

t. Fill the brake reservoir and brake system. (Refer to Section II.)

u. Remove the jacks.

v. Fill the fuel tank. (Refer to Section II.)

w. Replace the engines, engine cowling and top nacelle. (Refer to Section VIII.)

x. Replace the spinner and the propeller. (Refer to Section VIII.)

y. Replace the bottom fuselage access panel, the front fuselage side access panels, the wing inspection plates, and the wing root fairings.

4-31. INSTALLATION OF WING FLAPS.

a. Place the flaps in position, align the holes in the flap hinges with the hangers in the wing panel and install the three hinge bolts.

b. Connect the control rod to the flap. (Refer to Section V.)

4-32. INSTALLATION OF AILERONS.

a. Place the ailerons in position, align the holes in the aileron hinges with the hangers in the wing panel and install the three hinge bolts.

b. Attach the balance weight to the balance weight arm at the outboard end of the aileron.

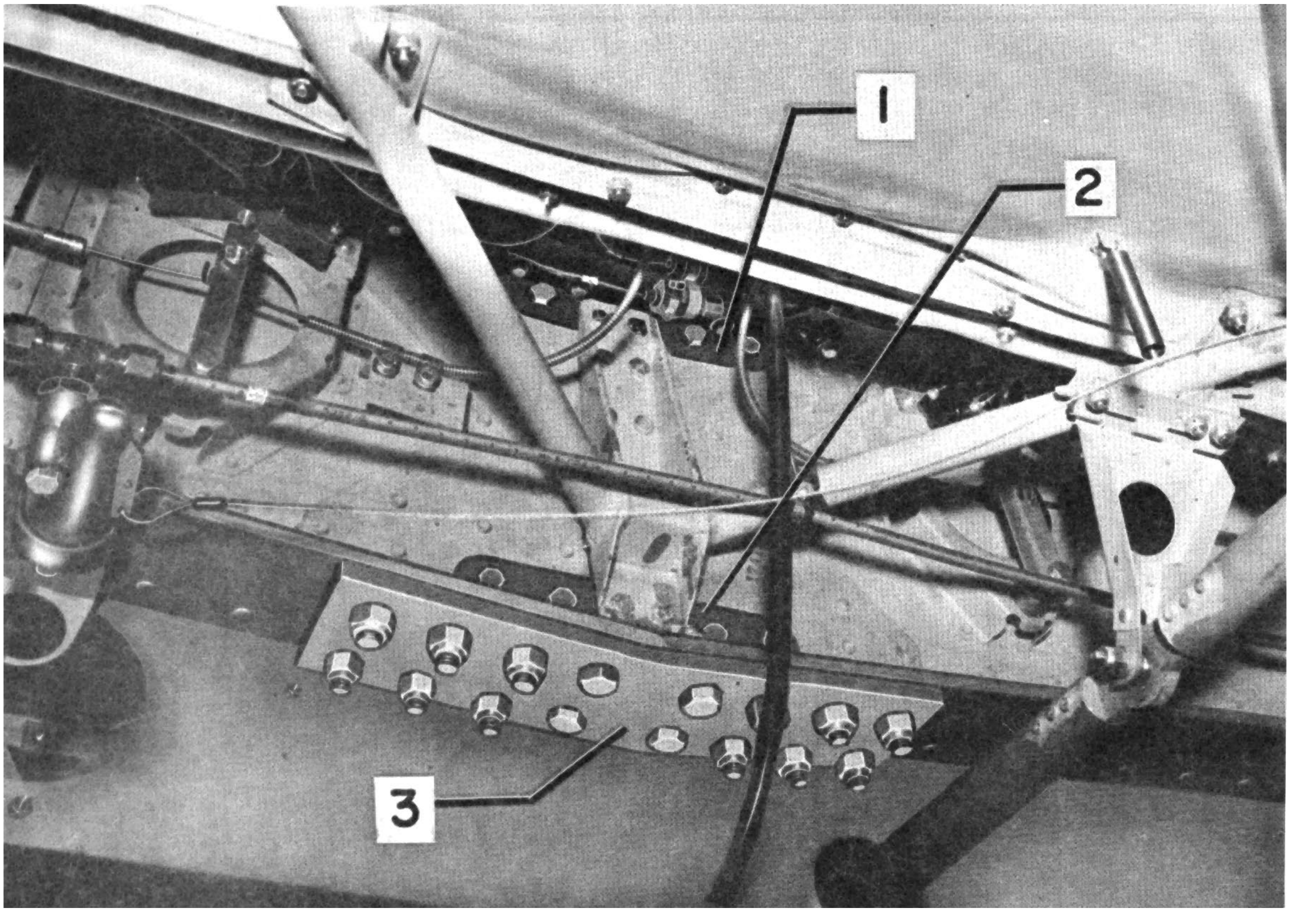
c. Connect the control rod to the aileron.

4-33. INSTALLATION OF WING TIPS.

a. Connect the navigation wire quick-disconnect fitting.

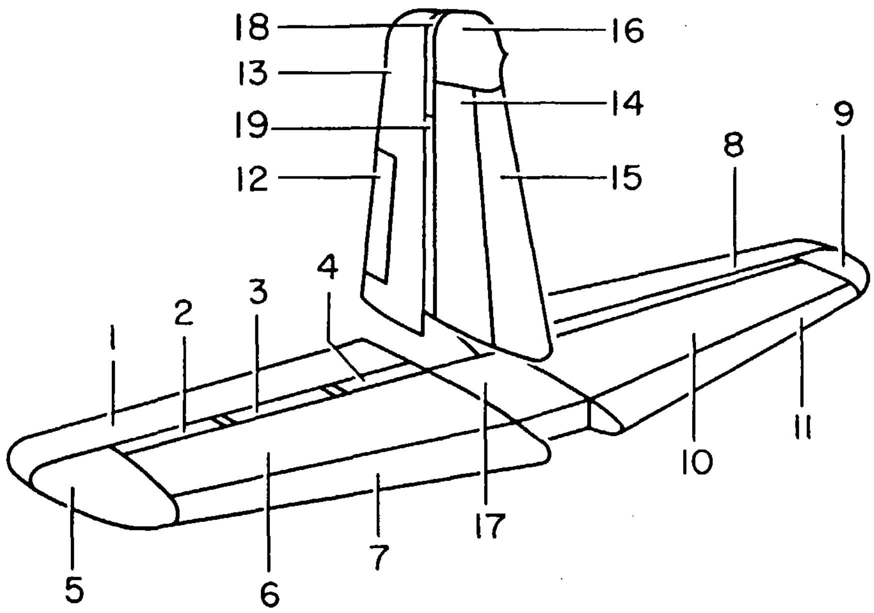
b. Place the wing tip on the mounting strips and replace the hinge pin.

c. Align the holes in the wing tip with the holes in the mounting strips and replace the 33 8-32 screws. Replace the top and bottom rectangular plates over the ends of the hinge pin with 8-32 screws.



1. STRAP
2. STRAP
3. FRONT SPAR MAIN ATTACHING PLATE

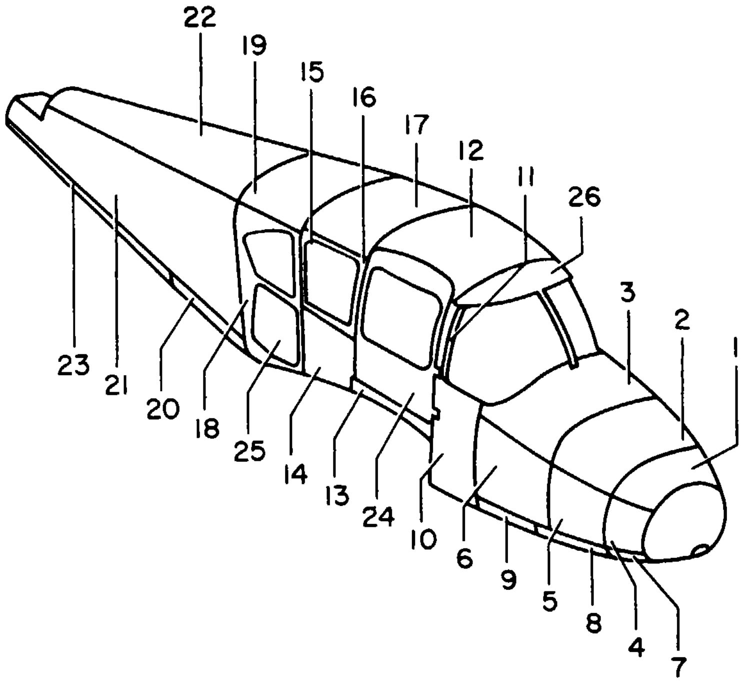
Figure 4-4. Front Spar Attaching Members



NO.	MATERIAL	THICKNESS
1	2024-T3	0.020
2	2024-T3	0.020
3	2024-T3	0.020
4	2024-T3	0.020
5	6061-0	0.025 *
6	2024-T3	0.020
7	2024-T3	0.020
8	2024-T3	0.020
9	6061-0	0.025 *
10	2024-T3	0.020
11	2024-T3	0.020
12	2024-T3	0.020
13	2024-T3	0.016
14	2024-T3	0.020
15	2024-T3	0.020
16	6061-0	0.025 *
17	2024-T3	0.025
18	2024-T3	0.016
19	2024-T3	0.016

* HEAT TREAT TO 6061-T4

Figure 4-5. Empennage Skin Diagram

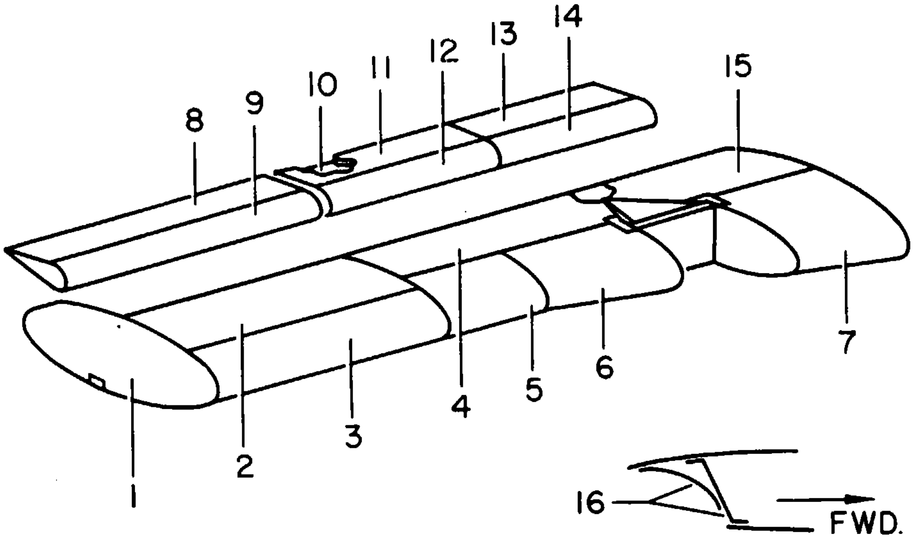


NO.	MATERIAL	THICKNESS
1	2024-0	0.020 *
2	2024-T3	0.020
3	2024-0	0.020 *
4	2024-T3	0.020
5	2024-T3	0.025
6	2024-T3	0.025
7	2024-0	0.020 *
8	2024-0	0.020 *
9	2024-T3	0.020
10	2024-T3	0.020
11	2024-T3	0.020 *
12	2024-0	0.025 *
13	2024-T3	0.020

NO.	MATERIAL	THICKNESS
14	2024-T3	0.020
15	2024-T3	0.020
16	2024-T3	0.020
17	2024-T3	0.025
18	2024-T3	0.020
19	2024-T3	0.025
20	2024-T3	0.025
21	2024-T3	0.032
22	2024-T3	0.025
23	2024-T3	0.025
24	2024-0	0.032 *
25	2024-T3	0.020
26	2024-T3	0.025

* HEAT TREAT TO 2024-T4 AFTER FORMING

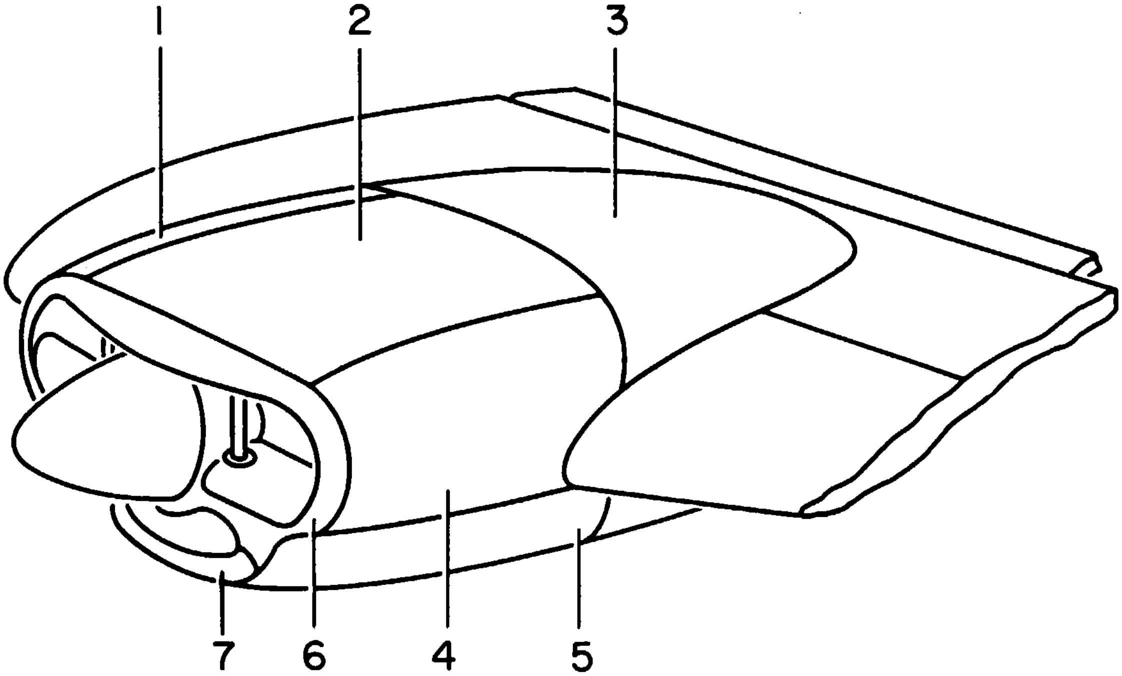
Figure 4-6. Fuselage Skin Diagram



NO.	MATERIAL	THICKNESS
1	6061-0	0.025 *
2	2024T3	0.020
3	2024T3	0.020
4	2024T3	0.025
5	2024T3	0.025
6	2024T3	0.025
7	2024T3	0.032
8	2024T3	0.016
9	2024T3	0.016
10	2024T3	0.020
11	2024T3	0.025
12	2024T3	0.016
13	2024T3	0.025
14	2024T3	0.016
15	2024T3	0.051
16	2024T3	0.016

* HEAT TREAT TO 6061-T4 AFTER FORMING

Figure 4-7. Wing Skin Diagram



NO.	MATERIAL	THICKNESS
1	2024-0	0.032 *
2	2024-0	0.025 *
3	2024-0	0.025 *
4	2024-0	0.032 *
5	2024-0	0.025 *
6	3003-0	0.051
7	2024-0	0.025

* HEAT TREAT TO 2024T4 AFTER FORMING

Figure 4-8. Nacelle Skin Diagram

4-34. STRUCTURAL REPAIRS.

Structural repair methods used must be made in accordance with the regulations set forth in FAA Advisory Circular 43-13-1A. To assist in making repairs and/or replacements, Figure 4-5 identifies the type and thickness of various skin material used.

— WARNING —

No access holes are permitted in any control surfaces. The use of patch plates for repairs of all movable tail surfaces is prohibited. The use of any filler material normally used for repair of minor dents and/or materials used for filling the inside of surfaces is also prohibited on all movable tail surfaces.

Never make a skin replacement or patch plate from material other than the type of the original skin, or of a different thickness than the original skin. The repair must be as strong as the original skin. However, flexibility must be retained so the surrounding areas will not receive extra stress.

4-35. FIBERGLAS REPAIRS.

The repair procedure in this manual will describe the methods for repair of Fiberglas Reinforced Structures. Fiberglas Touch-Up and Surface Repairs such as blisters, open seams, delamination, cavities, small holes and minor damages that have not harmed the fiberglas cloth material. Fiberglas Fracture and Patch Repairs as puncture, breaks and holes that have penetrated through the structure and damaged the fiberglas cloth. A repair kit, part number 756 729 will furnish necessary material for such repairs, and is available through Piper Aircraft Dealers.

— NOTE —

Very carefully follow resin and catalyst mixing instructions furnished with repair kit.

4-36. FIBERGLAS TOUCH-UP AND SURFACE REPAIRS.

1. Remove wax, oil and dirt from around the damaged area with acetone, Methylethylketone or equivalent and remove paint to gel coat.
2. The damaged area may be scraped with a fine blade knife or a power drill with a burr attachment to roughen the bottom and sides of the damaged area. Feather the edge surrounding the scratch or cavity. Do not undercut the edge. (If the scratch or cavity is shallow and penetrates only the surface coat, continue to Step 8.)
3. Pour a small amount of resin into a jar lid or on a piece of cardboard, just enough to fill the area being worked on. Mix an equal amount of milled fiberglas with the resin, using a putty knife or stick. Add catalyst, according to kit instruction, to the resin and mix thoroughly. A hypodermic needle may be used to inject gel into small cavities not requiring fiberglas millings mixed with the gel.
4. Work the mixture of resin, fibers and catalyst into the damaged area, using the sharp point of a putty knife or stick to press it into the bottom of the hole and to puncture any air bubbles which may be present. Fill the scratch or hole above the surrounding undamaged area about 1/16 inch.
5. Lay a piece of cellophane or waxed paper over the repair to cut off air and start the cure of gel mixture.

6. Allow the gel to cure 10 to 15 minutes until it feels rubbery to the touch. Remove the cellophane and trim flush with the surface, using a sharp razor blade or knife. Replace the cellophane and allow to cure completely for 30 minutes to an hour. The patch will shrink slightly below the structure surface as it cures. (If wax paper is used, ascertain wax is removed from surface.)
7. Rough up the bottom and edges of the hole with the electric burr attachment or rough sandpaper. Feather hole into surrounding gel coat, do not undercut.
8. Pour out a small amount of resin, add catalyst and mix thoroughly, using a cutting motion rather than stirring. Use no fibers.
9. Using the tip of a putty knife or fingertips, fill the hole to about 1/16 inch above the surrounding surface with the gel coat mixture.
10. Lay a piece of cellophane over the patch to start the curing process. Repeat Step 6, trimming patch when partially cured.
11. After trimming the patch, immediately place another small amount of gel coat on cut edge of the patch and cover with cellophane. Then, using a squeegee or the back of a razor blade, squeegee level with area surrounding the patch, leave the cellophane on patch for one or two hours or overnight, for complete cure.
12. After repair has cured for 24 hours, sand the patched area using a sanding block with fine wet sandpaper. Finish by priming, again sanding and applying color coat.

4-37. FIBERGLAS FRACTURE AND PATCH REPAIRS.

1. Remove wax, oil and dirt from around damaged area with acetone, methylethylketone or equivalent.
2. Using a key hole saw, electric saber saw, or sharp knife cut away ragged edges. Cut back to sound material.
3. Remove paint three inches back from around damaged area.
4. Working inside the structure, bevel the edges to approximately a 30 degree angle and rough-sand the hole and the area around it, using 80-grit dry paper. Feather back for about two inches all around the hole. This roughens the surface for strong bond with patch.
5. Cover a piece of cardboard or metal with cellophane. Tape it to the outside of the structure covering the hole completely. The cellophane should face toward the inside of the structure. If the repair is on a sharp contour or shaped area, a sheet of aluminum formed to a similar contour may be placed over the area. The aluminum should also be covered with cellophane.
6. Prepare a patch of fiberglas mat and cloth to cover an area two inches larger than the hole.
7. Mix a small amount of resin and catalyst, enough to be used for one step at a time, according to kit instructions.
8. Thoroughly wet mat and cloth with catalyzed resin. Daub resin on mat first, and then on cloth. Mat should be applied against structures surface with cloth on top. Both pieces may be wet out on cellophane and applied as a sandwich. Enough fiberglas cloth and mat reinforcements should be used to at least replace the amount of reinforcements removed in order to maintain the original strength. If damage occurred as a stress crack, an extra layer or two of cloth may be used to strengthen area.
9. Lay patch over hole on inside of structure, cover with cellophane, and squeegee from center to edges to remove all air bubbles and assure adhesion around edge of hole. Air bubbles will show white in the patch and they should all be worked out to the edge. Remove excess resin before it gels on the part. Allow patch to cure completely.
10. Remove cardboard or aluminum sheet from outside of hole and rough-sand the patch and edge of hole. Feather edge of hole about two inches into undamaged area.
11. Mask area around hole with tape and paper to protect surface. Cut a piece of fiberglas mat about one inch larger than the hole and one or more pieces of fiberglas cloth two inches larger than the hole. Brush catalyzed resin over hole, lay mat over hole and wet out with catalyzed resin. Use a daubing action with brush. Then apply additional layer or layers of fiberglas cloth to build up patch to the surface of structure. Wet out each layer thoroughly with resin.

12. With a squeegee or broad knife, work out all air bubbles in the patch. Work from center to edge, pressing patch firmly against the structure. Allow patch to cure for 15 to 20 minutes.

13. As soon as the patch begins to set up, but while still rubbery, take a sharp knife and cut away extra cloth and mat. Cut an outside edge of feathering. Strip cut edges of structure. Do this before cure is complete, to save extra sanding. Allow patch to cure overnight.

14. Using dry 80-grit sandpaper on a power sander or sanding block, smooth patch and blend with surrounding surface. Should air pockets appear while sanding, puncture and fill with catalyzed resin. A hypodermic needle may be used to fill cavities. Let cure and resand.

15. Mix catalyzed resin and work into patch with fingers. Smooth carefully and work into any crevices.

16. Cover with cellophane and squeegee smooth. Allow to cure completely before removing cellophane. Let cure and resand.

17. Brush or spray a coat of catalyzed resin to seal patch. Sand patch, finish by priming, again sanding and applying color coat.

— NOTE —

Brush and hands may be cleaned in solvents such as acetone or methylethylketone. If solvents are not available, a strong solution of detergent and water may be used.

4-38. THERMOPLASTIC REPAIRS.

The following procedure will assist in making field repairs to items made of thermoplastic which are used throughout the airplane. A list of material needed to perform these repairs is given along with suggested suppliers of the material. Common safety precautions should be observed when handling some of the materials and tools used while making these repairs.

1. Surface Preparation:

A. Surface dirt and paint if applied must be removed from the item being repaired. Household cleaners have proven most effective in removing surface dirt.

B. Preliminary cleaning of the damaged area with perchlorethylene or VM&P Naptha will generally insure a good bond between epoxy compounds and thermoplastic.

2. Surface Scratches, Abrasion or Ground-in-Dirt: (Refer to Figure 4-9.)

A. Shallow scratches and abraded surfaces are usually repaired by following directions on containers of conventional automotive buffing and rubbing compounds.

B. If large dirt particles are embedded in thermoplastic parts, they can be removed with a hot air gun capable of supplying heat in the temperature range of 300° to 400° F. Use care not to overheat the material. Hold the nozzle of the gun about 1/4 of an inch away from the surface and apply heat with a circular motion until the area is sufficiently soft to remove the dirt particles.

C. The thermoplastic will return to its original shape upon cooling.

3. Deep Scratches, Shallow Nicks and Small Holes: (Less than 1 inch in diameter.) (Refer to Figure 4-10.)

A. Solvent cements will fit virtually any of these applications. If the area to be repaired is very small, it may be quicker to make a satisfactory cement by dissolving thermoplastic material of the same type being repaired in solvent until the desired paste-like consistency is achieved.

B. This mixture is then applied to the damaged area. Upon solvent evaporation, the hard durable solids remaining can easily be shaped to the desired contour by filing or sanding.

C. Solvent adhesives are not recommended for highly stressed areas, on thin walled parts or for patching holes greater than 1/4 inch in diameter.

TABLE IV-I. LIST OF MATERIALS (THERMOPLASTIC REPAIR)

ITEMS	DESCRIPTIONS	SUPPLIERS
Buffing and Rubbing Compounds	Automotive Type - DuPont #7	DuPont Company Wilmington, Del. 19898
	Ram Chemical #69 x 1	Ram Chemicals Gardena, Cal. 90248
	Mirror Glaze #1	Mirror Bright Polish Co., Inc. Irvin, Cal. 92713
Cleaners	Fantastic Spray Perchlorethylene VM&P Naphtha (Lighter Fluid)	Obtain From Local Suppliers
ABS-Solvent Cements	Solarite #11 Series	Solar Compounds Corp. Linden, N.J. 07036
Solvents	Methylethyl Ketone Methylene Chloride Acetone	Obtain From Local Suppliers
Epoxy Patching Compound	Solarite #400	Solar Compounds Corp. Linden, N.J. 07036
Hot Melt Adhesives Polyamids and Hot Melt Gun	Stick Form 1/2 in. dia. 3 in. long	Sears Roebuck & Co. or Most Hardware Stores
Hot Air Gun	Temp. Range 300° to 400°F	Local Suppliers

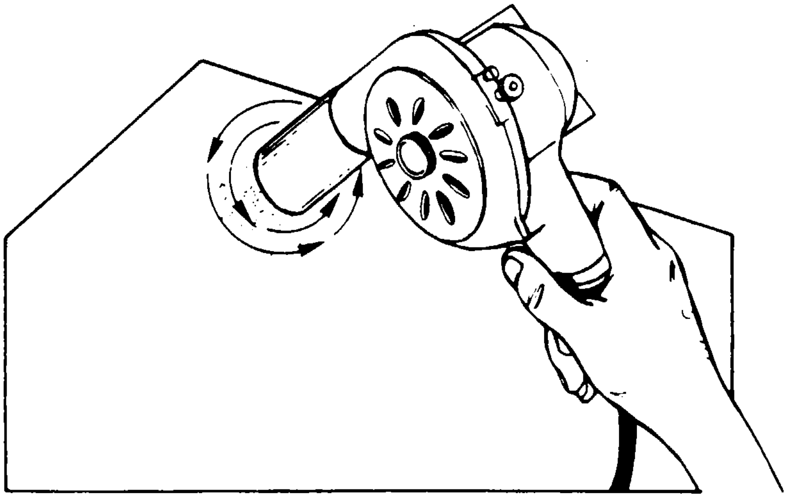


Figure 4-9. Surface Scratches, Abrasions or Ground-in-Dirt

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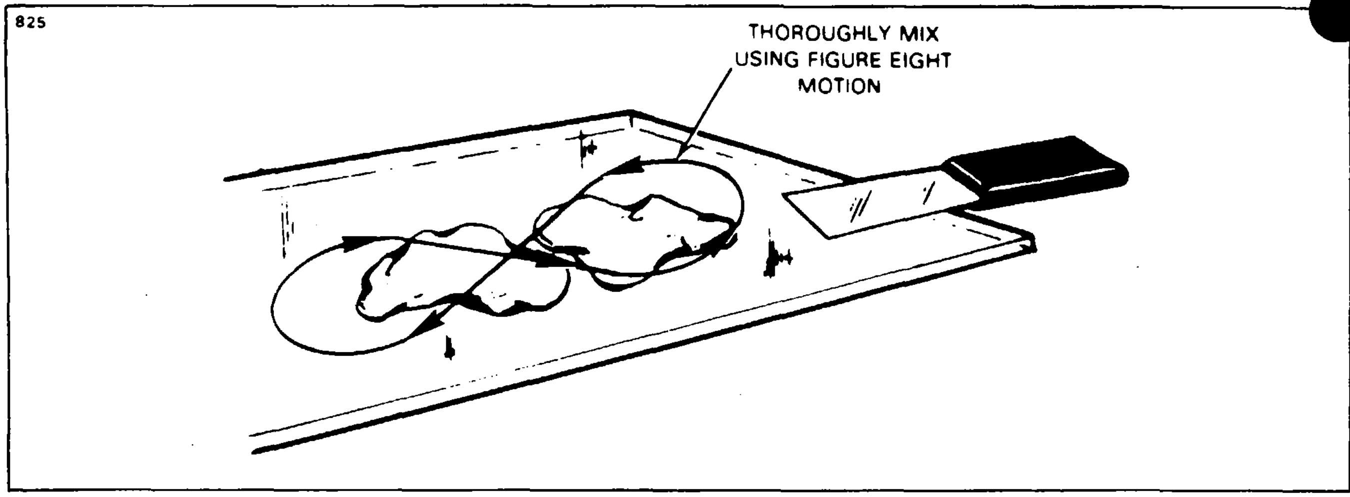


Figure 4-10. Deep Scratches, Shallow Nicks and Small Holes

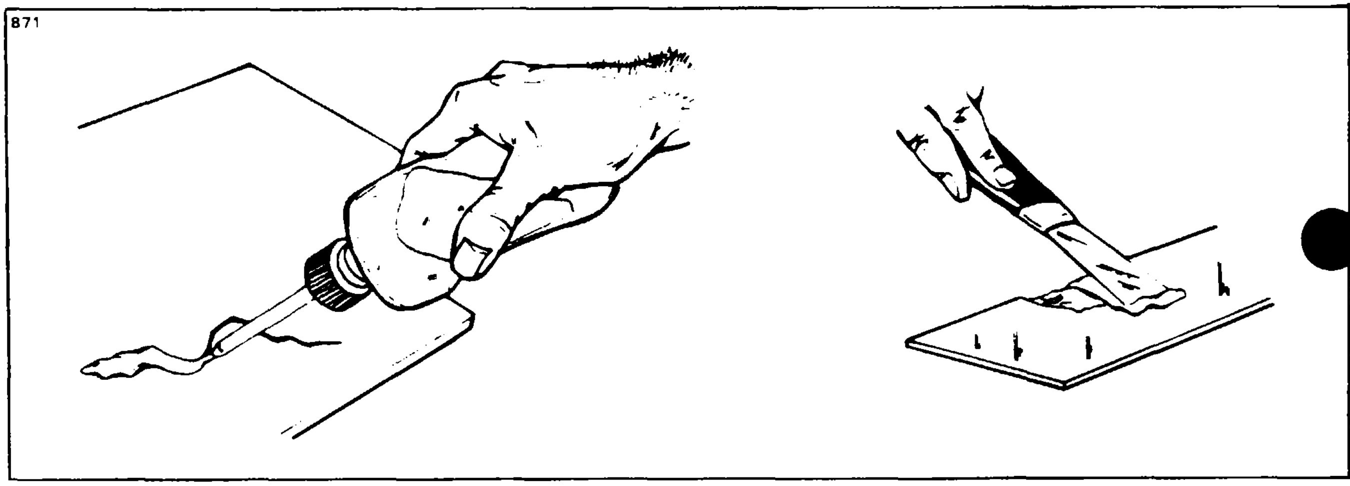


Figure 4-11. Mixing of Epoxy Patching Compound

D. For larger damages an epoxy patching compound is recommended. This type material is a two part, fast curing, easy sanding commercially available compound.

E. Adhesion can be increased by roughing the bonding surface with sandpaper and by utilizing as much surface area for the bond as possible.

F. The patching compound is mixed in equal portions on a hard flat surface using a figure eight motion. The damaged area is cleaned with perchlorethylene or VM&P Naptha prior to applying the compound. (Refer to Figure 4-11.)

G. A mechanical sander can be used after the compound is cured, providing the sander is kept in constant motion to prevent heat buildup.

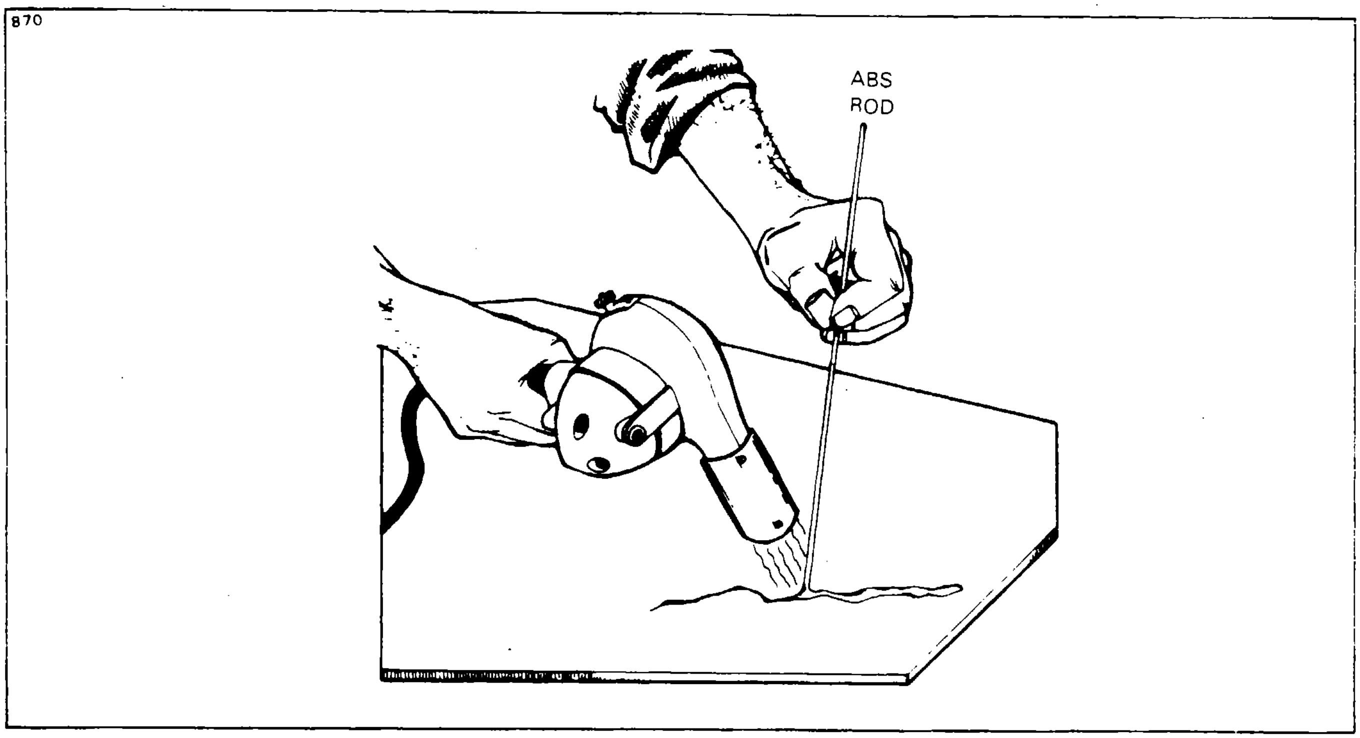


Figure 4-12. Welding Repair Method

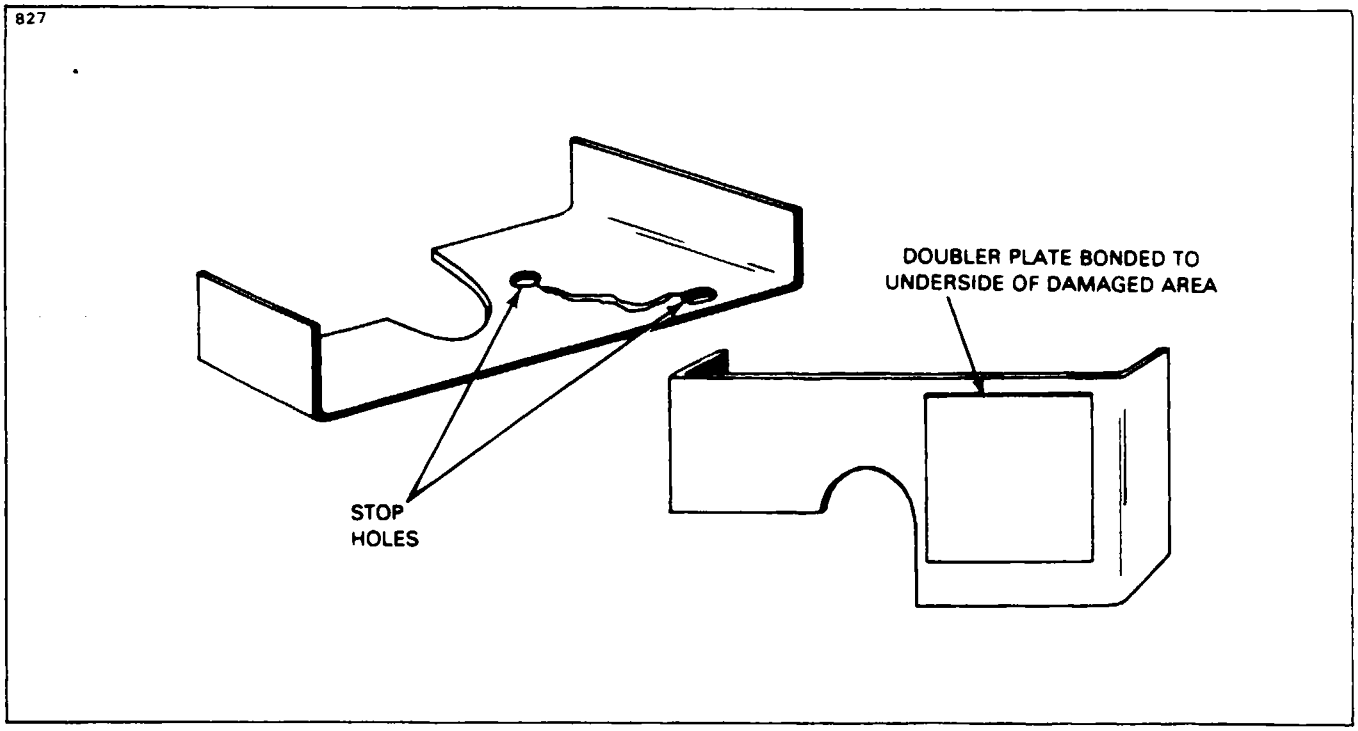


Figure 4-13. Repairing of Cracks

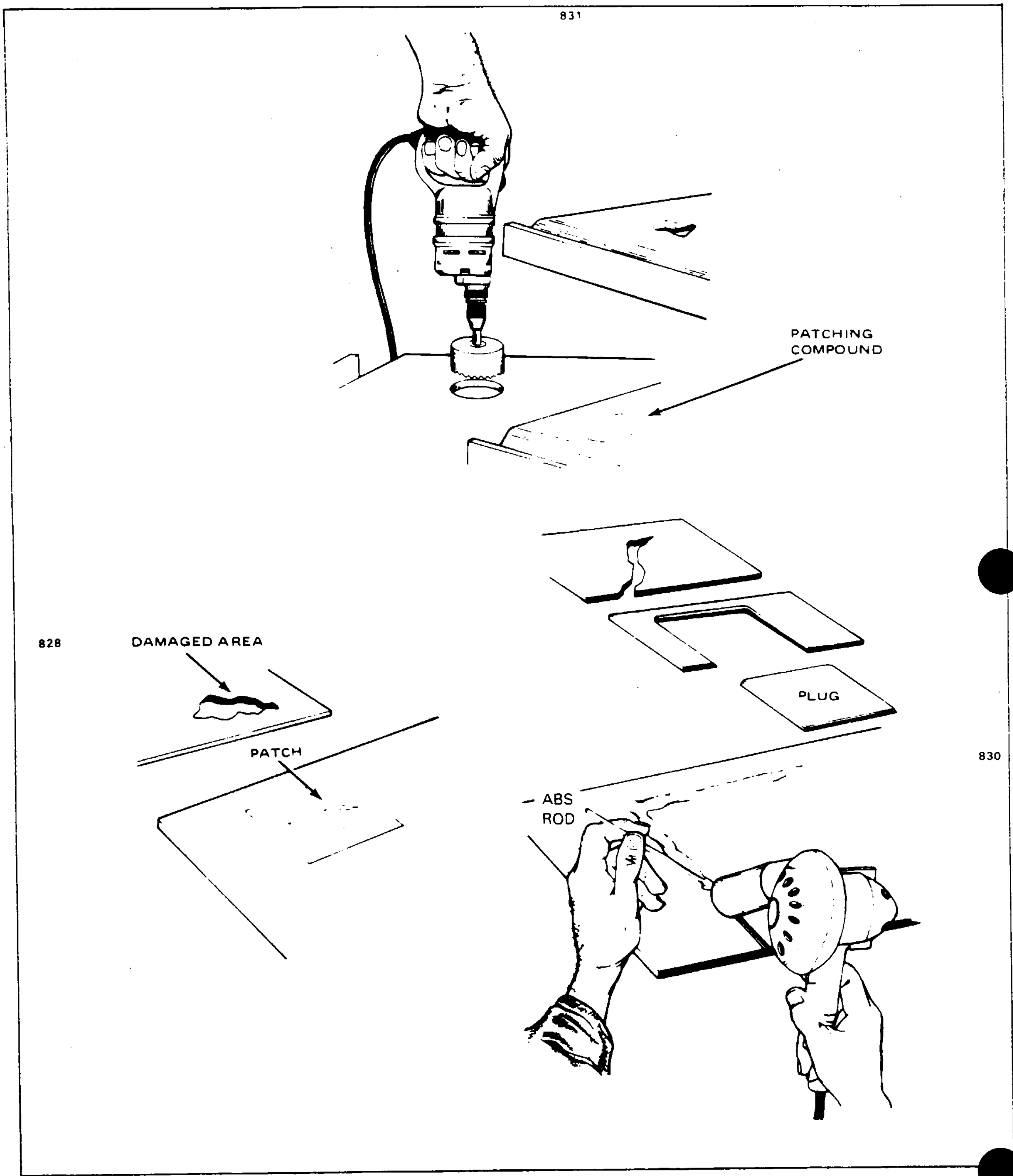


Figure 4-14. Various Repairs

H. For repairs in areas involving little or no shear stress, the hot melt adhesives, polyamids which are supplied in stick form may be used. This type of repair has a low cohesive strength factor.

I. For repairs in areas involving small holes, indentations or cracks in the material where high stress is apparent or thin walled sections are used, the welding method is suggested.

J. This welding method requires a hot air gun and ABS rods. To weld, the gun should be held to direct the flow of hot air into the fusion (repair) zone, heating the damaged area and rod simultaneously. The gun should be moved continuously in a fanning motion to prevent discoloration of the material. Pressure must be maintained on the rod to insure good adhesion. (Refer to Figure 4-12.)

K. After the repair is completed, sanding is allowed to obtain a surface finish of acceptable appearance.

4. Cracks: (Refer to Figure 4-13.)

A. Before repairing a crack in the thermoplastic part, first determine what caused the crack and alleviate that condition to prevent it recurring after the repair is made.

B. Drill small stop holes at each end of the crack.

C. If possible, a double plate should be bonded to the reverse side of the crack to provide extra strength to the part.

D. The crack should be "V" grooved and filled with repair material, such as solvent cement, hot melt adhesive, epoxy patching compound or hot air welded, whichever is preferred.

E. After the repair has cured, it may be sanded to match the surrounding finish.

5. Repairing Major Damage: (Larger than 1 inch in diameter.) (Refer to Figure 4-14.)

A. If possible a patch should be made of the same material and cut slightly larger than the section being repaired.

B. When appearances are important, large holes, cracks, tears, etc., should be repaired by cutting out the damaged area and replacing it with a piece of similar material.

C. When cutting away the damaged area, under cut the perimeter and maintain a smooth edge. The patch and/or plug should also have a smooth edge to insure a good fit.

D. Coat the patch with solvent adhesive and firmly attach it over the damaged area.

E. Let the patch dry for approximately one hour before any additional work is performed.

F. The hole, etc., is then filled with the repair material. A slight overfilling of the repair material is suggested to allow for sanding and finishing after the repair has cured. If patching compound is used the repair should be made in layers, not exceeding a 1/2 inch in thickness at a time, thus allowing the compound to cure and insuring a good solid buildup of successive layers as required.

6. Stress Lines: (Refer to Figure 4-15.)

A. Stress lines produce a whitened appearance in a localized area and generally emanate from the severe bending or impacting of the material. (Refer to Figure 4-16.)

B. To restore the material to its original condition and color, use a hot air gun or similar heating device and carefully apply heat to the affected area. Do not overheat the material.

7. Painting the Repair:

A. An important factor in obtaining a quality paint finish is the proper preparation of the repair and surrounding area before applying any paint.

B. It is recommended that parts be cleaned prior to painting with a commercial cleaner or a solution made from one-fourth cup of detergent mixed with one gallon of water.

C. The paint used for coating thermoplastic can be either lacquers or enamels depending on which is preferred by the repair facility or customer. (See NOTE.)

— NOTE —

It is extremely important that solvent formulations be considered when selecting a paint, because not all lacquers or enamels can be used satisfactorily on thermoplastics. Some solvents used in the paints can significantly affect and degrade the plastic properties.

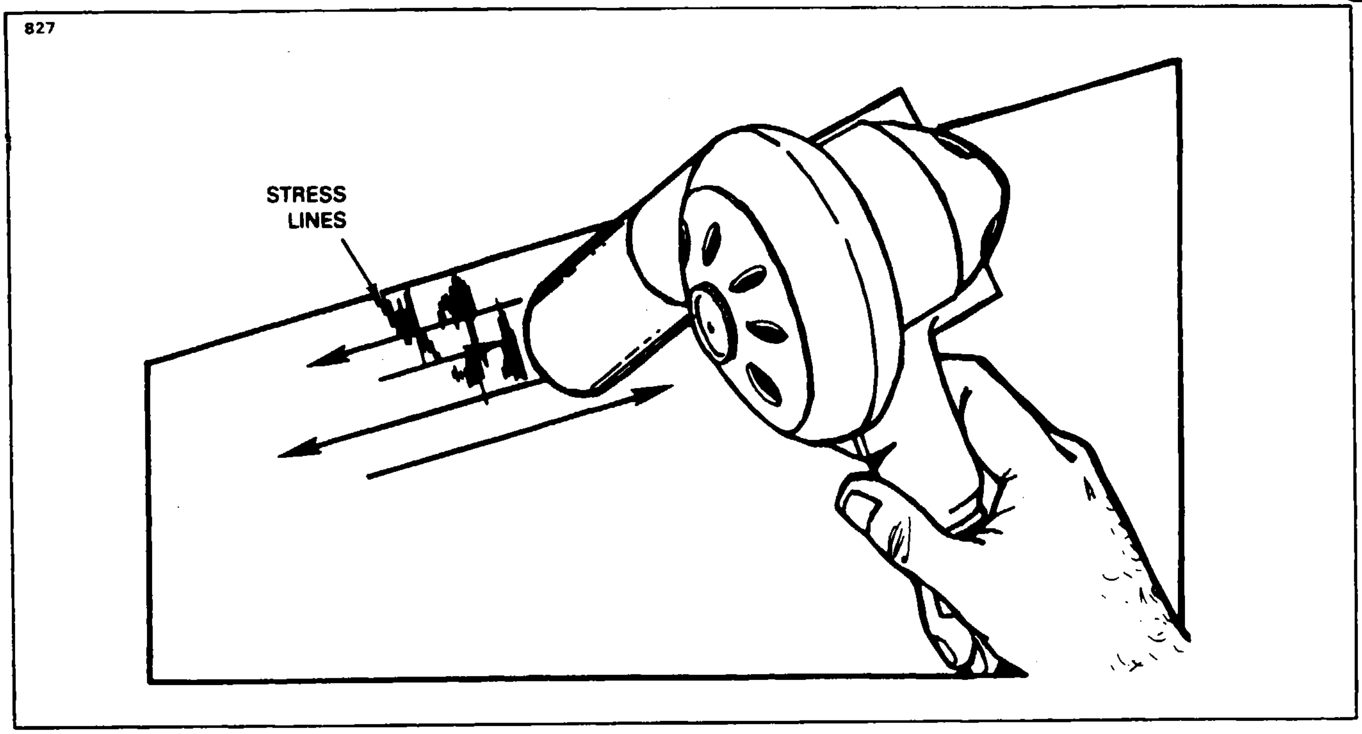


Figure 4-15. Repair of Stress Lines

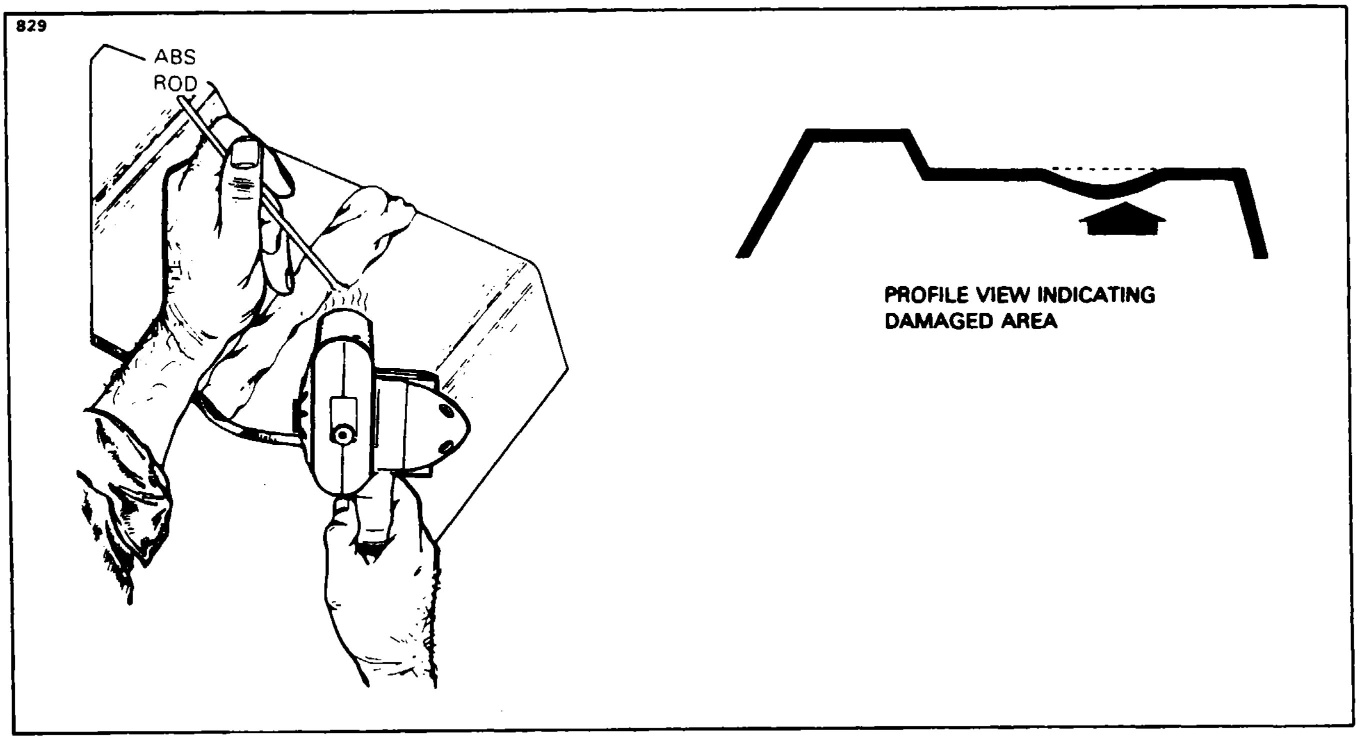


Figure 4-16. Repair of Impacted Damage

D. Another important matter to consider is that hard, brittle coatings that are usually best for abrasion resistance should not be used in areas which incur high stress, flexing or impact. Such coating may crack, thus creating a weak area.

4-39. SAFETY WALK REPAIR.

4-40. SURFACE PREPARATION.

1. Clean all surfaces with a suitable cleaning solvent to remove dirt, grease and oils. Solvents may be applied by dipping, spraying or mopping.
2. Ensure that no moisture remains on the surface by wiping with a clean dry cloth.
3. Outline the area to which the liquid safety walk compound is to be applied and mask adjacent surfaces.

— NOTE —

Newly painted surfaces shall be allowed to dry for 2.5 hours minimum prior to the application of the safety walk.

4-41. PRODUCT LISTING FOR LIQUID SAFETY WALK COMPOUND.

1. Suggested Solvents:
   Safety Solvent per MIL-S-18718
   Sherwin Williams Lacquer Thinner R7KC120
   Glidden Thinner No. 207
2. Safety Walk Material:
   Walkway Compound and Matting Nonslip (included in Piper Part No. 179872)

4-42. APPLICATION OF LIQUID SAFETY WALK COMPOUND.

Liquid safety walk compound shall be applied in an area. free of moisture for a period of 24 hours minimum after application. Do not apply when surface to be coated is below 50°F. Apply liquid safety walk compound as follows:

1. Mix and thin the liquid safety walk compound in accordance with the manufacturer's instructions on the container.
2. Coat the specified surfaces with a smooth. unbroken film of the liquid safety walk compound. A nap type roller or a stiff bristle brush is recommended, using fore and aft strokes.
3. Allow the coating to dry for 15 minutes to one hour before recoating or touch-up; if required after application of.the initial coating.
4. After recoating or touch-up, if done, allow the coating to dry for 15 minutes to one hour before removing masking.

— NOTE —

The coated surface shall not be walked on for six hours minimum after application of final coating.

4-43. SURFACE PREPARATION FOR PRESSURE SENSITIVE SAFETY WALK.

The areas to which the pressure sensitive safety walk is to be installed must be free from all contaminates and no moisture present. If liquid safety walk is installed the area must be prepared as follows:

1. Area must be masked off to protect painted surfaces.
2. Apply suitable stripper MEK Federal Spec. TT-M-261, U.S. Rubber No. 3339 to wingwalk compound. As compound softens remove by using putty knife or other suitable tool.
3. Area must be clean and dry prior to painting.
4. Prime and paint area.

— NOTE —

Newly painted surfaces shall be allowed to dry for 2.5 hours minimum prior to the application of the safety walk.

4-44. APPLICATION OF PRESSURE SENSITIVE SAFETY WALK.

Wipe area with a clean dry cloth to insure that no moisture remains on surface. Do not apply when surface temperature is below 50° F. Apply pressure sensitive safety walk as follows:

1. Peel back the full width of the protective liner approximately 2 inches from the leading edge of the safety walk.
2. Apply the safety walk to the wing area, begin at the leading edge, insure proper alignment and position from wing lap.
3. Remove the remaining protective liner as the safety walk is being applied from front to back of wing area.
4. Roll firmly with a long handled cylindrical brush in both lengthwise directions. Make sure all edges adhere to the wing skin.
5. Install and rivet leading edge retainer.

SECTION V

SURFACE CONTROLS

SECTION V

SURFACE CONTROLS

5-1. GENERAL.

5-1A The Apache is controlled in flight by the use of the three standard primary control surfaces, consisting of the aileron, elevator and rudder. Operation of these controls is through the movement of the control column and rudder pedals. The individual surfaces are connected to their control components by the use of cables and push pull tubes. Provision for directional and longitudinal trim control is provided by an adjustable trim mechanism for the rudder and elevator. The flaps on the Apache are hydraulically operated and can be positioned at any desired setting between 0 and 50 degrees down.

This section pertains to removal, replacement, rigging and adjustments of control surfaces, and their controlling components.

5-2. STANDARD PROCEDURES. The following tips may be helpful where applicable in the individual control system procedures:

a. Turnbuckles must be assembled and adjusted in a manner that each terminal end is screwed an approximately equal distance into the barrel. During adjustment, the terminals must not be turned in a manner which would put a permanent twist in the cable.

b. After adjustment is completed, each turnbuckle must be checked. Not more than three terminal threads shall be visible outside the barrel. Locking clips must be installed and checked for proper installation by trying to remove the clips using fingers only. Locking clips which have been installed and removed must be scrapped and new clips used.

c. Torque all nuts in the flight control surface rigging system in accordance with AC 43.13-1A or to torques specified within this manual text.

d. After completion of adjustment, each jam nut must be tightened securely and inspected.

e. On push rods or rod ends provided with an inspection hole, the screw must be screwed in sufficiently far to pass the hole. This can be determined visually or feel, by inserting a piece of wire into the inspection hole. If no inspection hole is provided, a minimum of .375 of an inch thread engagement must be maintained.

f. All cable rigging tensions given must be corrected to ambient temperature in the area where the tension is being checked.

g. See Figure 5-16 for the proper method of adjusting rod ends to prevent possible damage and binding of bearing surface in rod end, and all pulley guard pins installed.

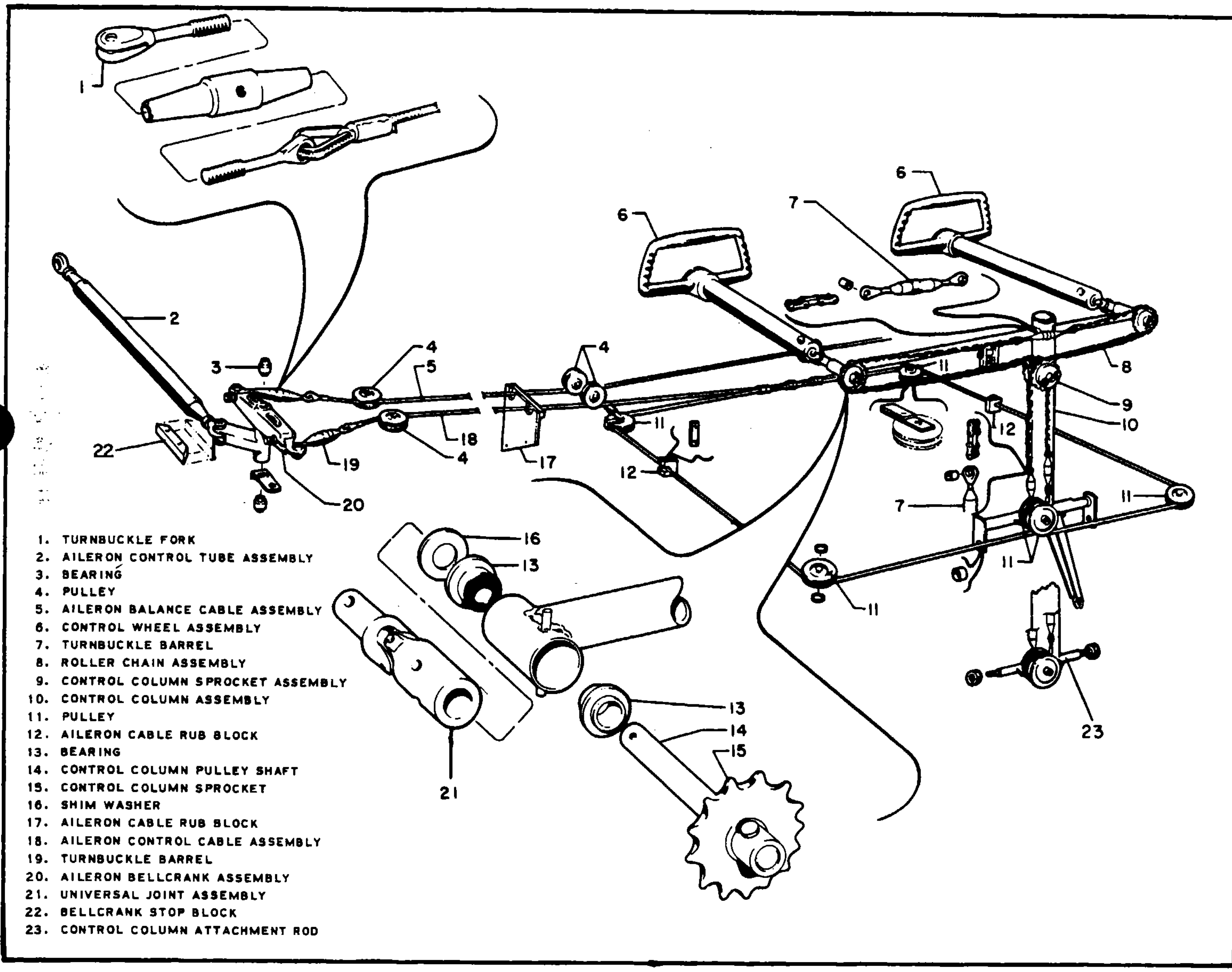


Figure 5-1. Aileron Control Installation

5-3. REMOVAL AND INSTALLATION.

5-4. REMOVAL AND INSTALLATION OF THE AILERON CONTROLS.

a. Lock the ailerons to prevent further motion.

b. Insert a rod in the three turnbuckle barrels (7, Figure 5-1) and rotate the barrels to relieve tension in the roller chain assembly (8).

c. Remove the turnbuckle eyes from the two vertical turnbuckles. Unwrap the chain from the control column sprocket assemblies (9 and 15) and the steering wheel cable from the steering wheel pulleys (11).

d. Insert a rod in the barrel (19) of the turnbuckle which maintains tensions in the bellcrank-connecting aileron control cable assembly (18) and relieve cable tension. Repeat this step for the aileron balance cable assembly (5).

e. Disconnect turnbuckle fork (1) from each end of both bellcranks by removing a cotter pin, nut, washer, and clevis bolt.

f. Disconnect aileron control tube assembly (2) from the aileron bellcrank assembly (20) by removing a cotter pin, shear nut, washer, clevis bolt and washer.

g. Disconnect the control tube from the hinge by removing a self-locking nut, bolt, and two bushings.

h. Free the bellcrank. Remove self-locking nut, washer, bolt, and bearings (3).

i. Remove pulleys by removing self-locking nuts, washers and bolts.

j. Remove the control column left and right sprocket assemblies by removing a bolt and self-locking nut from each.

k. Disconnect universal joint assembly (21) from steering column by removing both self-locking nuts and bolts.

l. Reassemble and install the pulleys, sprockets, universal joints and bellcranks in reverse order of the removal instructions above and refer to Figure 5-1.

m. Rig the aileron. (Refer to paragraph 5-11.)

n. Position the rub blocks so that the control cables are centered in the holes.

5-5. REMOVAL AND INSTALLATION OF THE ELEVATOR CONTROLS.

a. Lower elevators to prevent further movement.

b. Disconnect the elevator control front tube assembly (6, Figure 5-2) from control column assembly (14, Figure 5-2) by removing the cotter pin, nut, washer and bolt.

c. Disconnect elevator control tube brackets (8, Figure 5-2) by removing from each, the self-locking nut and washer from the bolt. Slide the bolt out of the bracket and catch both of the flanged elevator control tube connector spacer bushings (7). Swing bracket up and away.

d. Separate the control front tube (6) and the elevator control center tube assembly (5) by removing the self-locking nut and washer from both bolts. Remove the bolts.

e. Aircraft bearing Serial numbers 23-1 to 23-1870, remove both elevator control tube nylon block assemblies. From each, remove the self-locking nut and the right washer (10) from the upper bolt. Slide out the bolt, freeing right inboard washer, bushings and the elevator control tube nylon block assembly (12). Remove the lower bolt to disassemble the lower nylon block assembly and to free the elevator control tube support links (11). Aircraft bearing serial numbers 23-1871 and up, remove the self-locking nut, washer (15), bushing (7), bolt and bushing (7) to disconnect elevator control center tube assembly.

f. Disconnect the control center tube (5) and the elevator control rear tube assembly (1) from the end of the elevator bellcrank assembly (4) by removing the cotter pin, nut, washer and clevis bolt at each end.

g. Remove the self-locking nut, bolt, bushing (3), bearing (2) and bushing (19) from the bellcrank.

h. Disconnect the elevator torque tube horn from the control rear tube by removing the clevis bolt. Remove the elevator control tube through the rear of the fuselage.

i. Reassemble and install the elevator control push-pull tubes in reverse order of the removal instructions above. (Refer to Figure 5-2.)

j. On aircraft Bearing Serial No. 23-1 to 23-1870, do not install washer (18) inboard of the elevator control tube nylon block support right link (11) on either

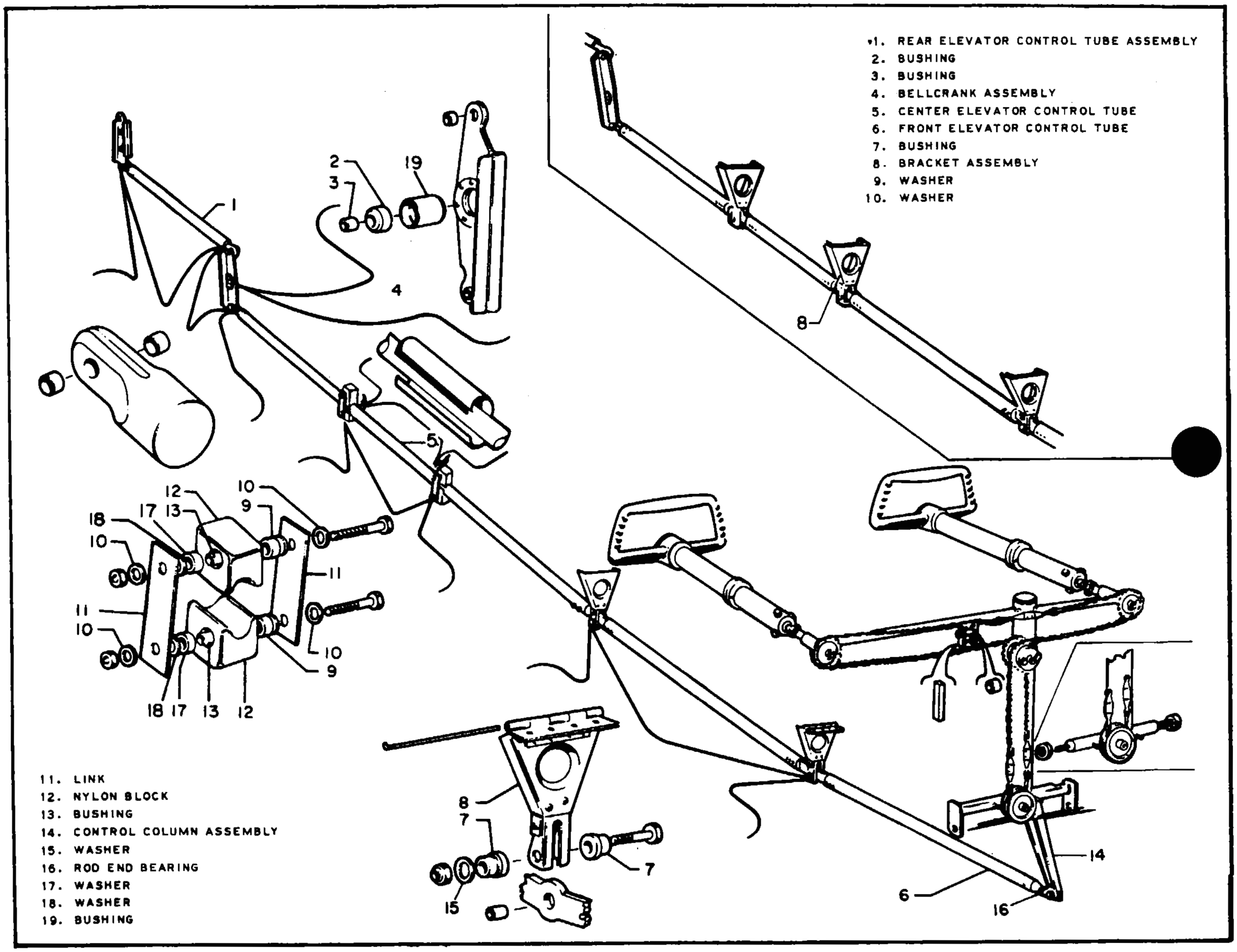


Figure 5-2. Elevator Control Installation

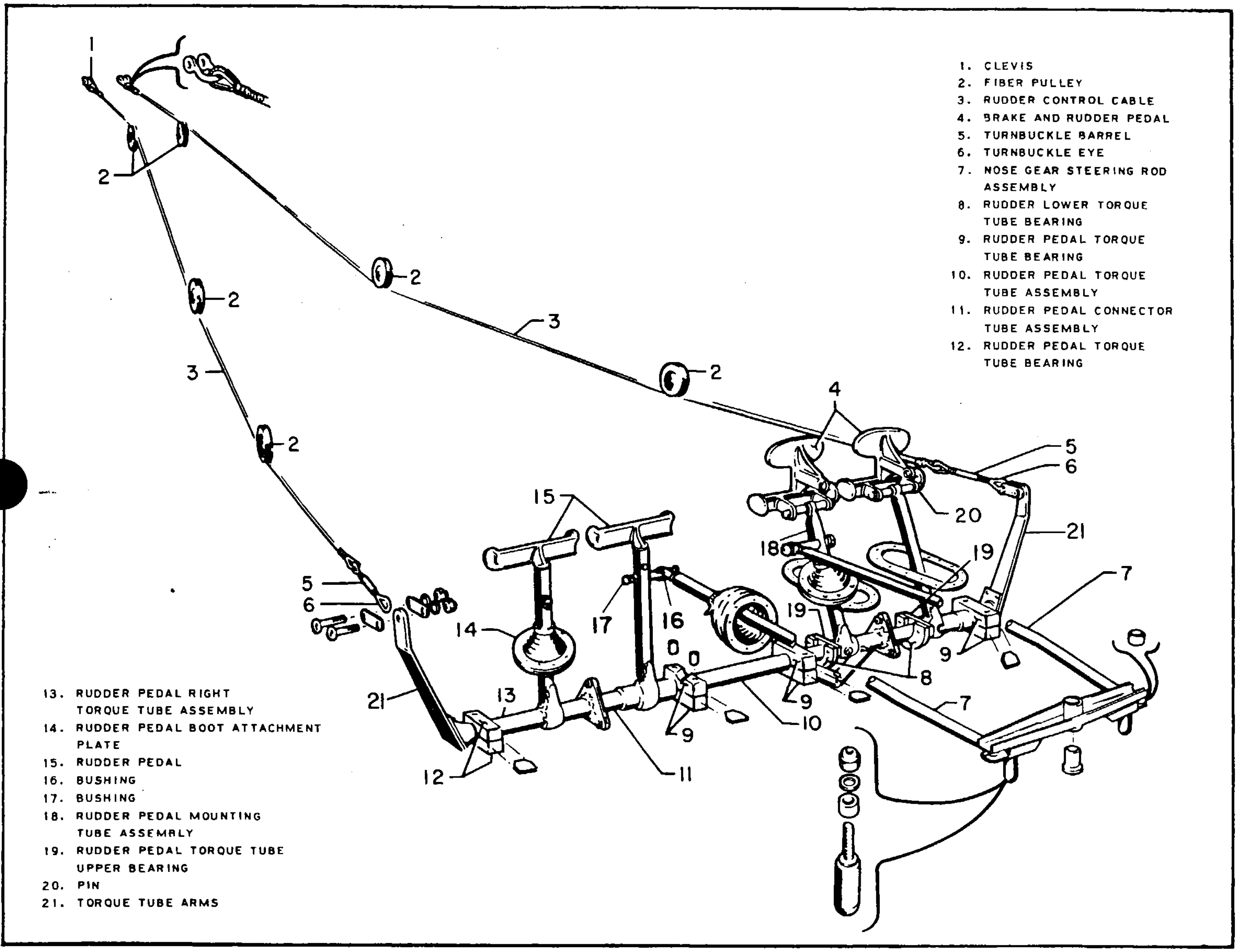


Figure 5-3. Rudder Control Installation

bolt of the rear nylon block assemblies.

k. The elevator control tube brackets are slotted to provide adjustment in nylon block location. Determine the upper and lower limits in vertical travel of the control tube and tighten the block attachment bolts to position the control tube midway between the limits. Obtain the lower limit when the hinge-type elevator control tube bracket hinges are vertical. The upper limit is established by placing the elevator against its stops.

l. A maximum of six threads can be exposed on the rod end bearing (6) that connects the control tube to the control column.

m. Adjust the elevator travel. (Refer to Paragraph 5-15.)

5-6. REMOVAL AND INSTALLATION OF THE RUDDER CONTROLS INSTALLATION.

a. Lock the rudder to prevent further movement.

b. Disconnect both rudder control cables (3, Figure 5-3) from the rudder torque tube horn. Remove the cotter pin, castellated nut, washer and clevis bolt at each end of the horn.

c. Disconnect the cables from the arms (21) of the rudder pedal torque tube assembly (10) by removing the turnbuckle eyes (6) from the turnbuckle barrels (5).

d. Remove a cotter pin, washer, and clevis pin from each brake and rudder pedal (4) freeing the pedal.

e. Remove a self-locking nut, washer, and bolt from the left rudder pedal on the co-pilot side and the right rudder pedal on the pilot side freeing the nose gear steering rod assemblies (7).

f. Remove the self-tapping screws holding the rudder pedal boot attachment plates (14) to the floorboard.

g. Remove the floorboard exposing the torque tube.

h. Remove the self-locking nuts, washers, and bolts holding the rudder pedal torque tube bearings (12) and (9) together.

i. Lift out the rudder pedal torque tube assemblies (10, 13 and 11.)

j. Remove the six fiber pulleys (2) by removing a self-locking nut, washer, and bolt.

k. Reassemble and install all items, except the cables, in reverse order of the removal instructions above. (Refer to Figure 5-3.)

l. Rig the rudder in accordance with the instructions set forth in Paragraph 5-12.

5-7. REMOVAL AND INSTALLATION OF THE TAIL TRIM MECHANISM INSTALLATION. Removal and installation of the tail trim mechanism installation must agree with the configuration of Figure 5-4. Refer to the rigging instructions in Paragraphs 5-13 and 5-16 for the rudder and elevator trim mechanism.

5-8. REMOVAL AND INSTALLATION OF THE TAIL TRIM MECHANISM INDICATOR WIRES. Removal and installation of the indicator wires must agree with the configuration of Figure 5-4. Refer to the rigging instructions of Paragraphs 5-14 and 5-17 for the rudder and elevator trim indicator wires. Use 0.024 inch diameter wire for the indicator wires.

5-9. RIGGING AND ADJUSTMENT.

5-10. GENERAL. Although the fixed flight surfaces on the Apache obviously cannot be adjusted in position for rigging purposes, it may be necessary on occasion to check the position of these surfaces. The movable surfaces have adjustable stops, as well as adjustments on their cables or control rod connections, so that their range of movement can be altered. The positions and travels of the various surfaces are as follows:

a. Wings: 5 degrees dihedral.
b. Elevator: Travel 20 degrees up, 15 degrees down ± 2 degrees.
c. Fin: Should be vertical and in line with center of fuselage.
d. Ailerons: Travel 30 degrees up, 15 degrees down ± 2 degrees.

NOTE

For purposes of changing the lateral trim, a fixed tab is provided on the ailerons which can be adjusted as necessary.

e. Flaps: Travel 50 degrees down.
f. Rudder: Travel 30 degrees left, 30 degrees right, ± 2 degrees.

NOTE

Aircraft must be leveled in accordance with the procedure specified in Section II before rigging and adjusting

5-11. RIGGING AND ADJUSTMENT OF AILERONS.

a. With the control wheel in the neutral position laterally and with the lower surface of the control wheels horizontal, rig cables at turnbuckles so that aileron bellcrank assembly (20, Figure 5-1) is in the neutral position and cable tension is between 28 and 42 pounds on a tensiometer.

NOTE

A fabricated special tool should be inserted to determine aileron bellcrank neutral position (Refer to Figure 5-5.)

b. Adjust aileron control tubes (2, Figure 5-1) so that ailerons are in neutral position.
c. Refer to Paragraph 5-9 for positions and travels of various control surfaces.
d. Obtain specific aileron travel by adjusting aileron stop bolts in the aileron bellcranks. Measure aileron travel by using a bubble protractor.

NOTE

Aileron bellcrank stop screw (2, Figure 5-6) must hit aileron bellcrank stop block before control wheels hit stop.

5-12. RIGGING THE RUDDER.

a. Align the nose wheel so it is in a position to steer straight. Do this either by employing the chalk line method described in Steps "a", "b", and "c" of Paragraph 5-19 or by hanging one plumb bob from the grease fitting at the upper end of the nosewheel drag link and a jig similar to that shown in Figure 5-8. If the jig is fabricated, attach it to the nosewheel and then turn the wheel until the centerline of the jig aligns with the plumb bob.
b. Remove the cotter pins from the ends of both brake pedal pins (Figure 5-3). Slide out both pins (20), but do not remove the brake and rudder pedals (4). Push a 5/16 inch diameter rod, at least 13 inches long, through the hinge pin pivot lugs of the outboard pedal and into the lugs of the adjacent pedal, forcing the rudder pedals to align. This maintains the setting of the plumb bob with the jig centerline, or, if the first method is used, the alignment of the wheel with the chalk line.
c. Attach each cable clevis (1) at the aft ends of the cables to the rudder bellcrank with a bolt, washer, castellated nut and cotter pin.
d. Increase the tension in each cable, evenly, by alternately exposing an equal number of threads at each turnbuckle. Approximately three threads per adjustment are recommended.
e. Locate the sixth rivet from the rear of the rudder and measure the distance to the inboard tip of the trailing edge of the elevator. (Refer to Figure 5-7.) Similarly, measure this distance on the other side of the rudder. Make sure these two distances are equal. While adjusting cable tension, constantly check to see if these distances remain equal to prevent one cable from being tightened more than the other.

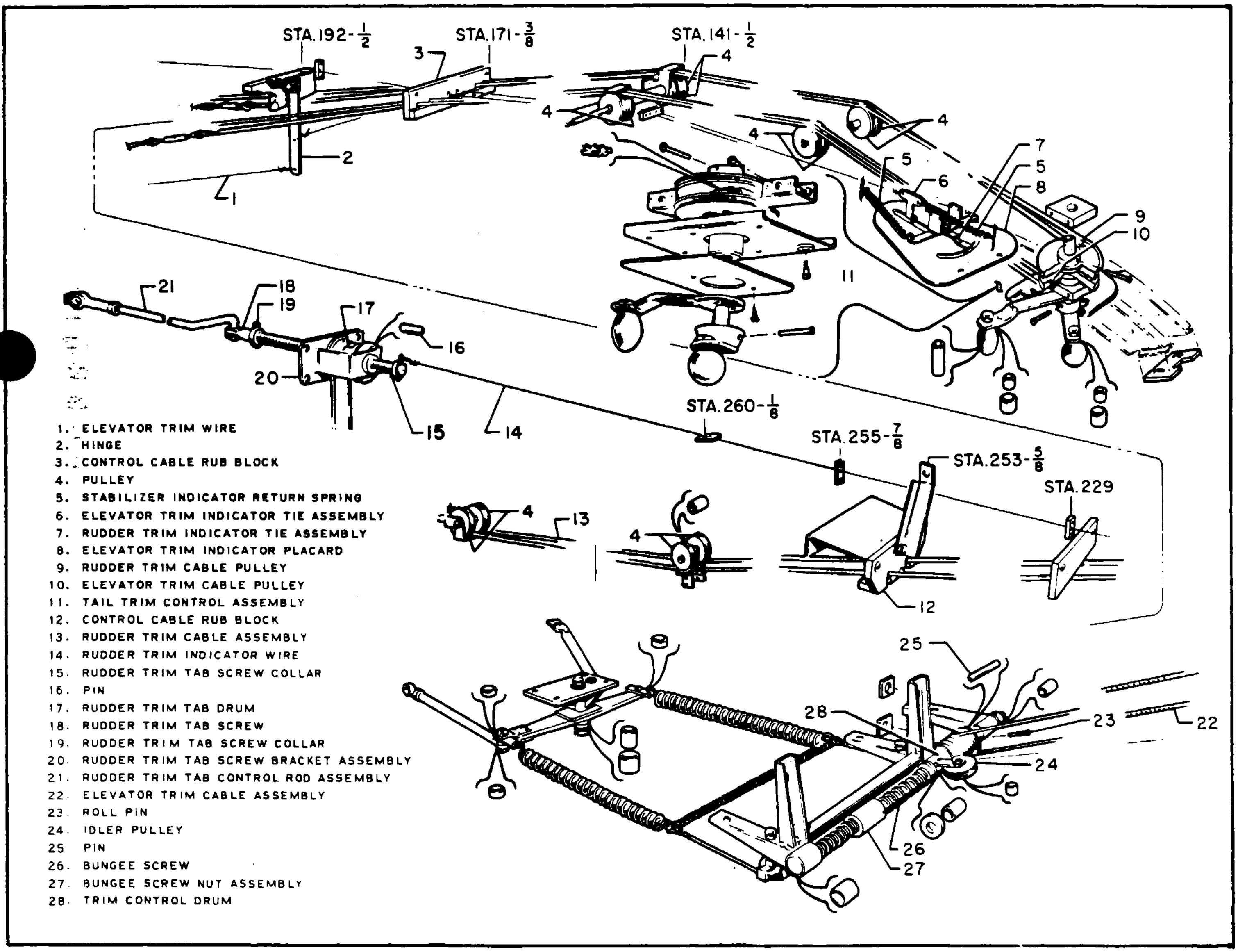


Figure 5-4. Tail Trim Mechanism Installation

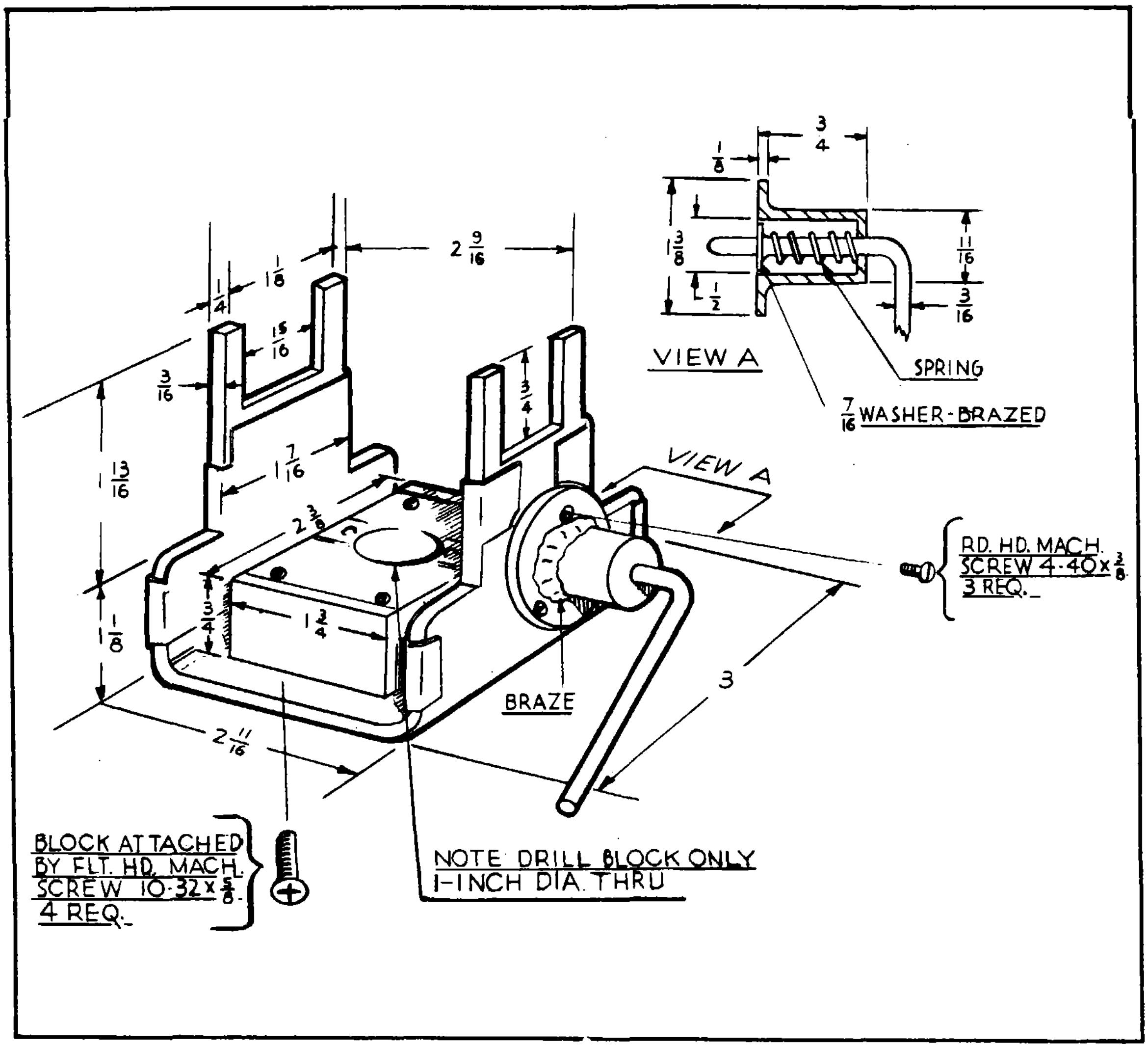


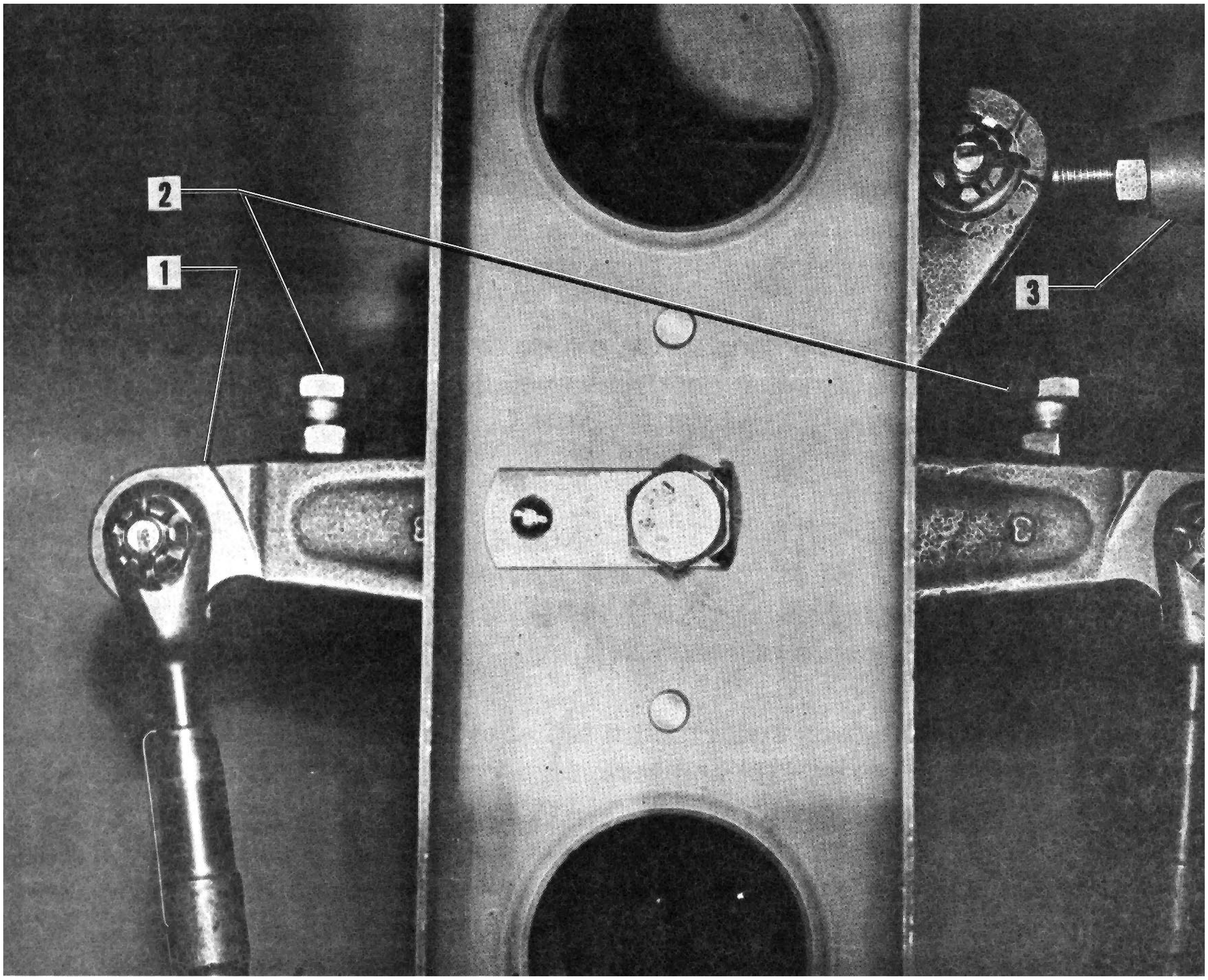
Figure 5-5. Fabricated Aileron Bellcrank Special Tool.

f. Continue the tightening and checking procedure until from 24 to 36 pounds of tension are developed in each cable as determined by a tensiometer.

5-13. RIGGING THE RUDDER TRIM MECHANISM.

a. Thread the rudder trim cable assembly (13, Figure 5-4) through the second slot from the right end of the control cable rub block (3) attached to the top of the bulkhead at Station 171-3/8, just aft of the tubular structure. Pass it over the two inboard right vertical pulleys (4), around the right side of the top pulley and the rudder trim cable pulley (9) at the tail trim control assembly (11). See Figure 7-4 for the rigging configuration.

b. Mark a point 43-1/2 inches forward of the control cable rub block (12). The



1. AILERON BELLCRANK ASSEMBLY
2. AILERON BELLCRANK ADJUSTMENT SCREWS
3. AILERON CONTROL TUBE

Figure 5-6. Aileron Adjustment Points

block is directly behind the half bulkhead and approximately at Station 255-7/8.

c. Connect a turnbuckle and eye to the eye at the end of the cable. Position the turnbuckle at the 43-1/2 inch mark and secure the cable with a C-clamp to the top of the frame at Station 192-1/2 to maintain the turnbuckle location.
d. Thread the cable to the rear of the fuselage until it passes out of the fuselage and under the left pulley at Station 290-3/8.
e. Pull the cable taut and measure 39-1/4 inches up from the center of the jack screw hole, which is located in the fin rear spar. Note this point on the cable.

f. Lay the 39-1/4 inch point of the cable in the slot in the rudder trim tab drum (17), with the free end of the cable directed towards the counterbored-end of the drum. Lock the cable in the slot with the locking pin (16). When installed. the counterbored-end of the drum will be the aft end of the drum. (Refer to Figure 5-11.)

g. Starting from the front of the drum, wrap the length of cable extending from the fuselage around the drum, eight and one-quarter times, winding to the left (counterclockwise when viewed from the rear). This will utilize most of the 39-1/4 inches of cable. (See Detail B, Figure 5-11.)

h. Starting from the rear of the drum, wrap the free end of the cable around the drum nine and one-quarter times, winding to the right (clockwise, when viewed from the rear). (Refer to Detail C, Figure 5-11.)

NOTE

After wrapping the cable around the drum, hold both ends tightly to prevent the cable from unwrapping. (Refer to Figure 5-12.)

i. Position the rear rudder trim tab screw collar (19, Figure 5-4) on the rudder trim tab screw (18) and insert the cotter pin. The wider edge of the collar should be forward.

j. Slip the rudder trim tab screw bracket assembly (20) around the drum. Insert the trim tab screw through the bracket and thread it into the drum. Install the forward rudder trim tab screw collar (15) on the trim tab screw. Insert the cotter pin, temporarily. The wider edge of the collar should be forward. (Refer to Figure 5-12.)

k. Secure the trim tab screw bracket to the fin rear spar with two cap screws passing through the two upper holes.

l. Install the hooked end of the rudder trim tab control rod assembly (21) in the end of the trim tab screw to keep the screw from rotating. If the rod is not available, use a headed rod inserted in the lower rudder lower hinge bracket.

m. Thread the free end of the excess cable under the right pulley, into the fuselage, and to the 43-1/2 inch mark established in Step "b". Slide a Nicropress clamp on the cable.

n. Bend the cable around the unattached eye at the end of the turnbuckle and pass it back through the Nicropress clamp. Do not apply clamp. Remove the C-clamp holding the cable to the top of the bulkhead.

o. Adjust the turnbuckle so that two threads extend from each end of the barrel. Pull the cable taut until the tension is from eight to twelve pounds. Lock the cable with the C-clamp.

p. Push the turnbuckle as far forward as it will go and check to see that the

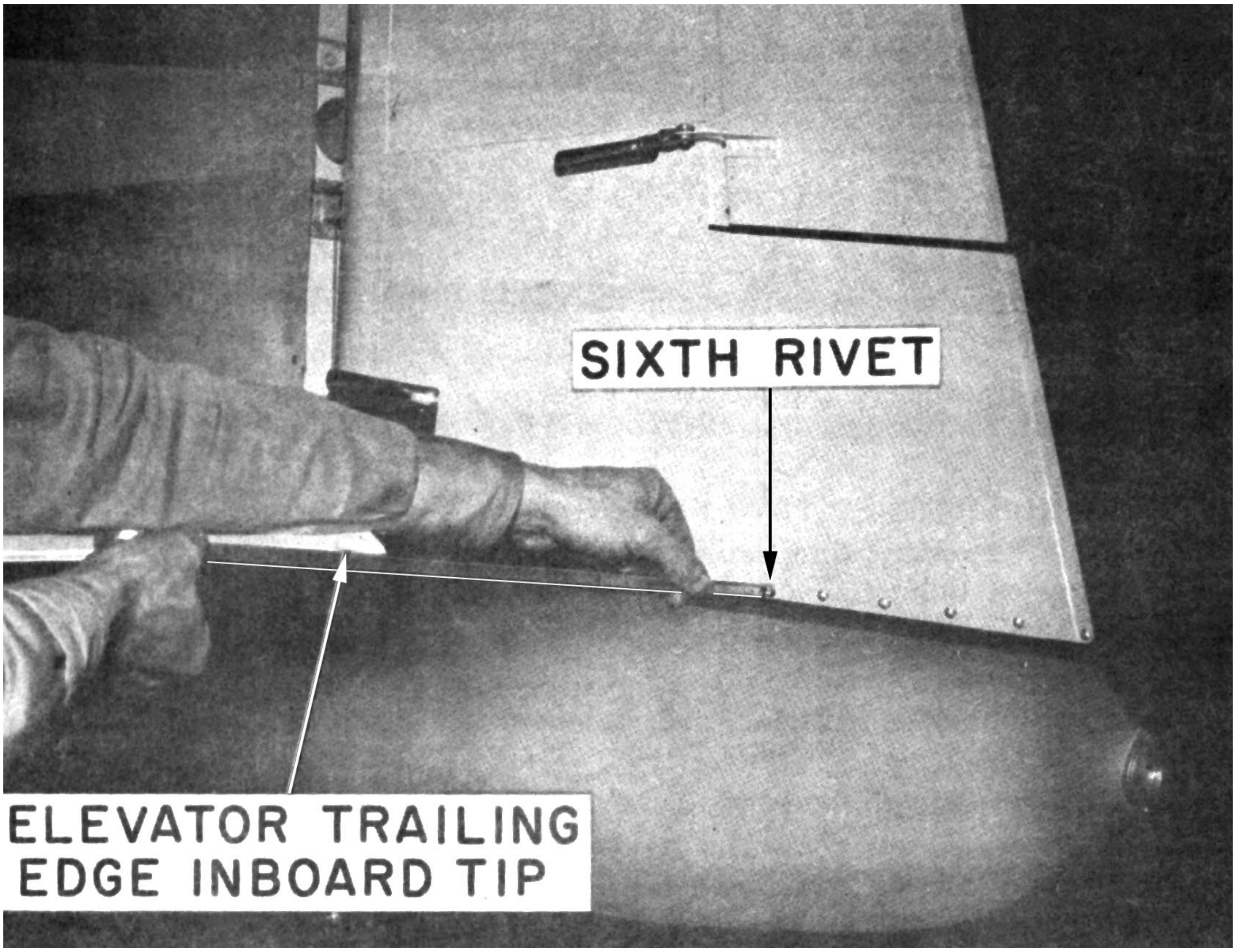


Figure 5-7. Checking Neutral Position of Rudder

turnbuckle does not strike the forward rub block. Move the cable back and check to see that the turnbuckle does not strike the rear rub block.

q. Check the drum when the cable is at its limits to see if there is at least one-half wrap left on the drum. Check to see that the head of the cotter pin in the forward collar is on top when the cable is at its forward limit and that the pin is vertical.
r. Apply the Nicropress, remove the C-clamp, and safety the turnbuckle.
s. Remove the control rod, or headed rod, from the end of the trim tab screw, remove the two cap screws, and remove the bracket from the rear spar. Install cotter pin permanently.
t. Reach into the trim tab screw hole, grasp the indicator wire, and pull the

wire through the head of the forward collar cotter pin. Wrap the end of the wire around the main strand at least five times.

u. Reinstall the trim tab screw bracket with four cap screws. Insert a plain washer between the bracket and the rear spar on each of the two upper cap screws.

NOTE

If the two plain washers are not placed on the two upper cap screws between the bracket and rear spar, the cable will overlap itself when winding on the drum.

v. Reinstall the rudder trim tab control rod assembly.

5-14. RIGGING THE RUDDER TRIM INDICATOR WIRE.

a. Reach into the rudder trim tab screw hole in the fin rear spar, grasp the 0.024-inch diameter indicator wire (14, Figure 5-4) and pull the wire through the head of the cotter pin, which secures the forward rudder trim tab screw collar (15) to the trim tab screw (18).

b. Thread the indicator wire forward, in accordance with the rigging diagram. (Refer to Figure 5-4.)

c. Pass the wire through the head of the cotter pin at the left of the rudder trim indicator tee assembly (7) at the tail trim control assembly (11).

d. Align the trim tab with the rudder.

e. Twist the tee assembly clockwise (looking up) against the tension of the stabilizer indicator return spring (5) until the tee pin is in its most forward position. Maintain this position with the indicator wire by folding it back on the cotter pin, and twisting it around the main strand approximately seven times.

NOTE

It is suggested that the tee pin be placed a little to the left of the forward center position, so that when the procedure of twisting the wire on itself is completed and the tee assembly is released, the spring tension will remove the slack in the twisting strands, permitting the tee assembly to come to rest with the tee pin at the forward center position.

f. Install the tail trim indicator placard (8) at the tail trim control assembly with three screws, two forward and one aft.

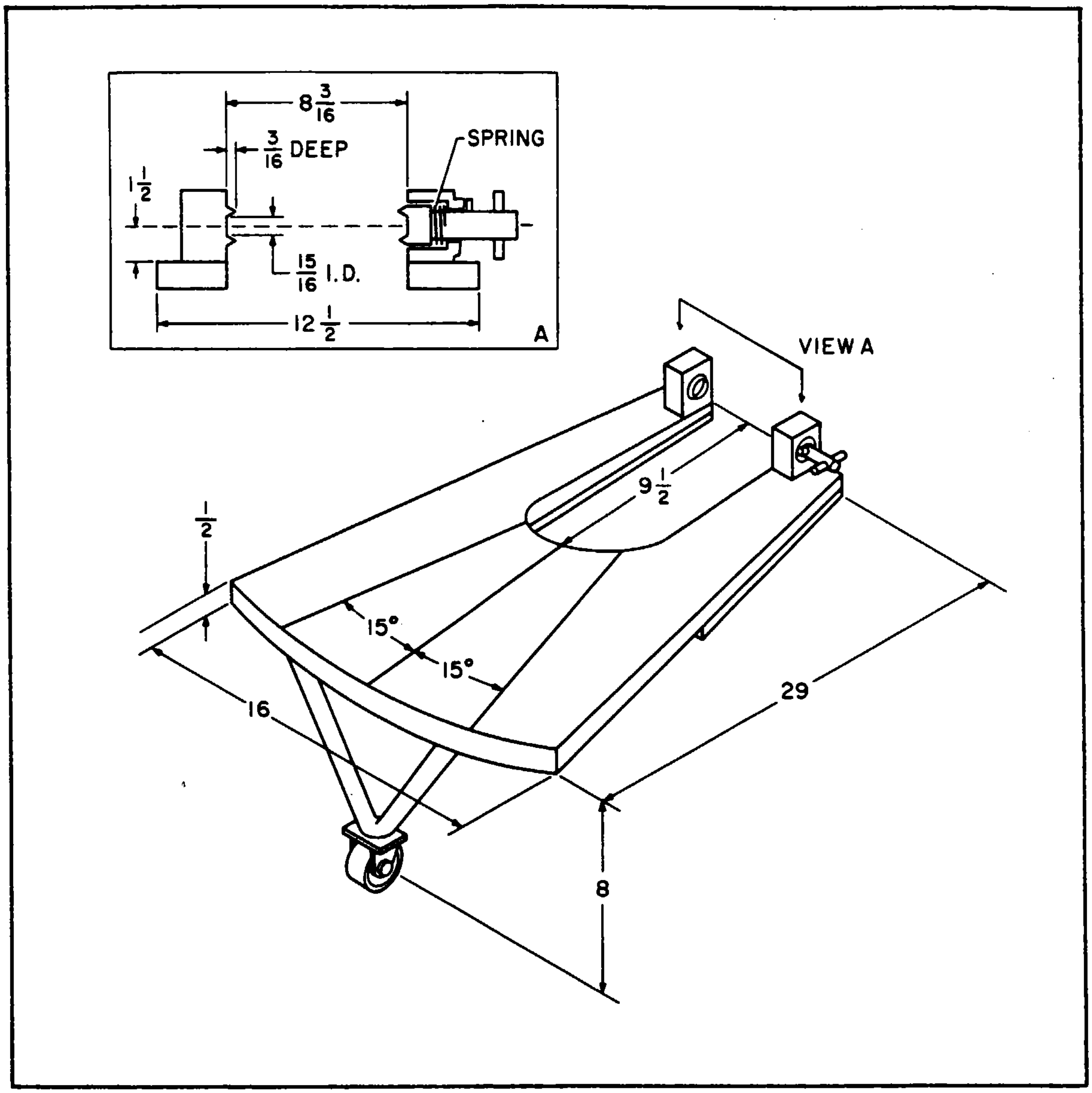


Figure 5-8. Nose Wheel Aligning Jig

5-15. RIGGING AND ADJUSTING THE ELEVATOR.

a. Level the aircraft. (Refer to Section II.)

b. Obtain specified travel of the elevator (20 degrees up, 15 degrees down) by adjustment of the two unbrako socket headscrews located above and below the elevator hinge line. Each are secured in their adjusted position by a lock nut.

c. Set a bubble-type protractor on the upper surface of the elevator and raise the elevator until the protractor reading is 20 degrees. Set the stop. Lower the elevator until a reading of 15 degrees is obtained on the protractor and set the

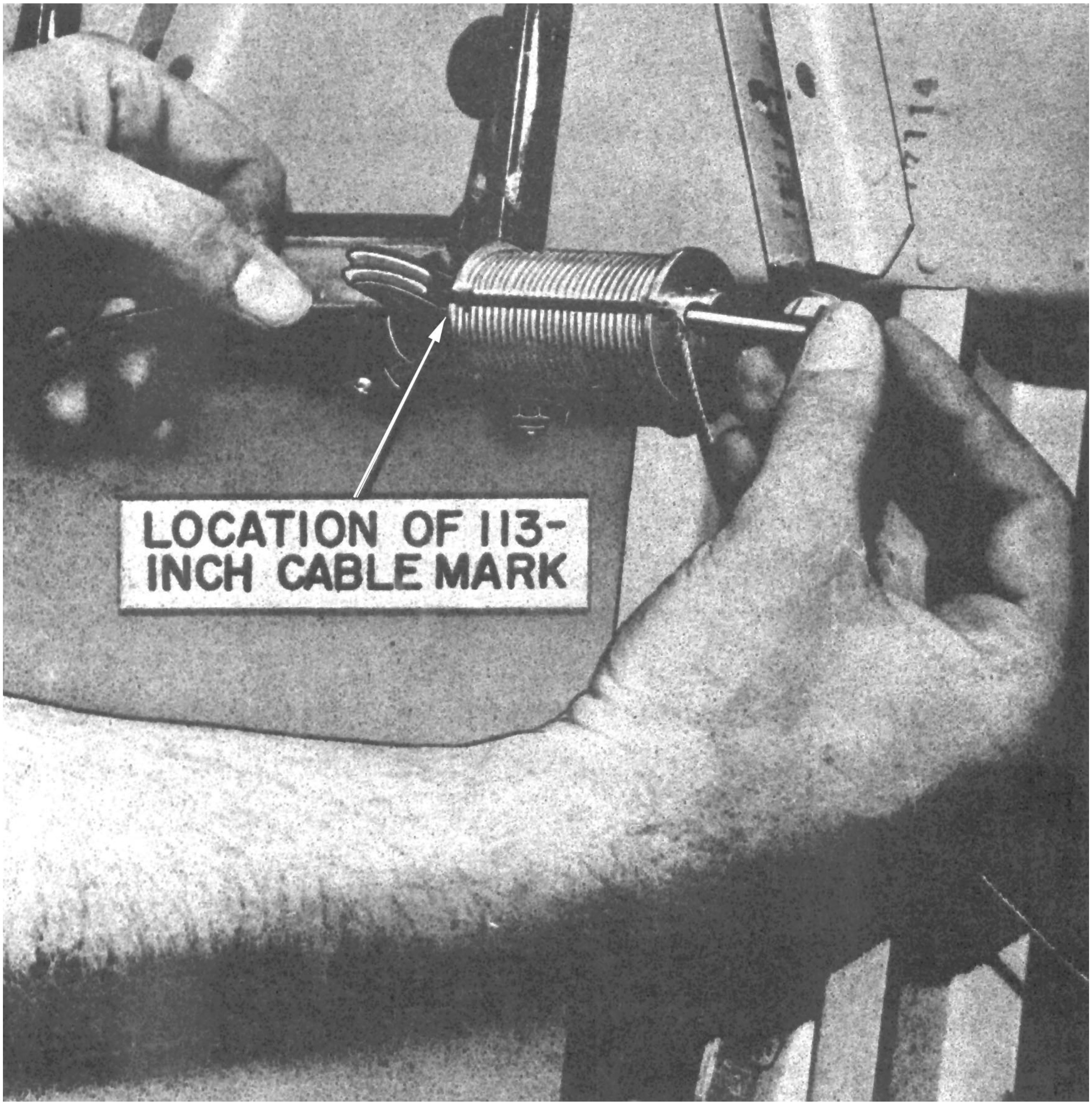


Figure 5-9. Installing Elevator Trim Drum Cable Locking Pin

lower adjusting stop screw.

NOTE

The protractor readings are not in agreement with the numerical limits to elevator movement because of the 5 degrees taper of the upper

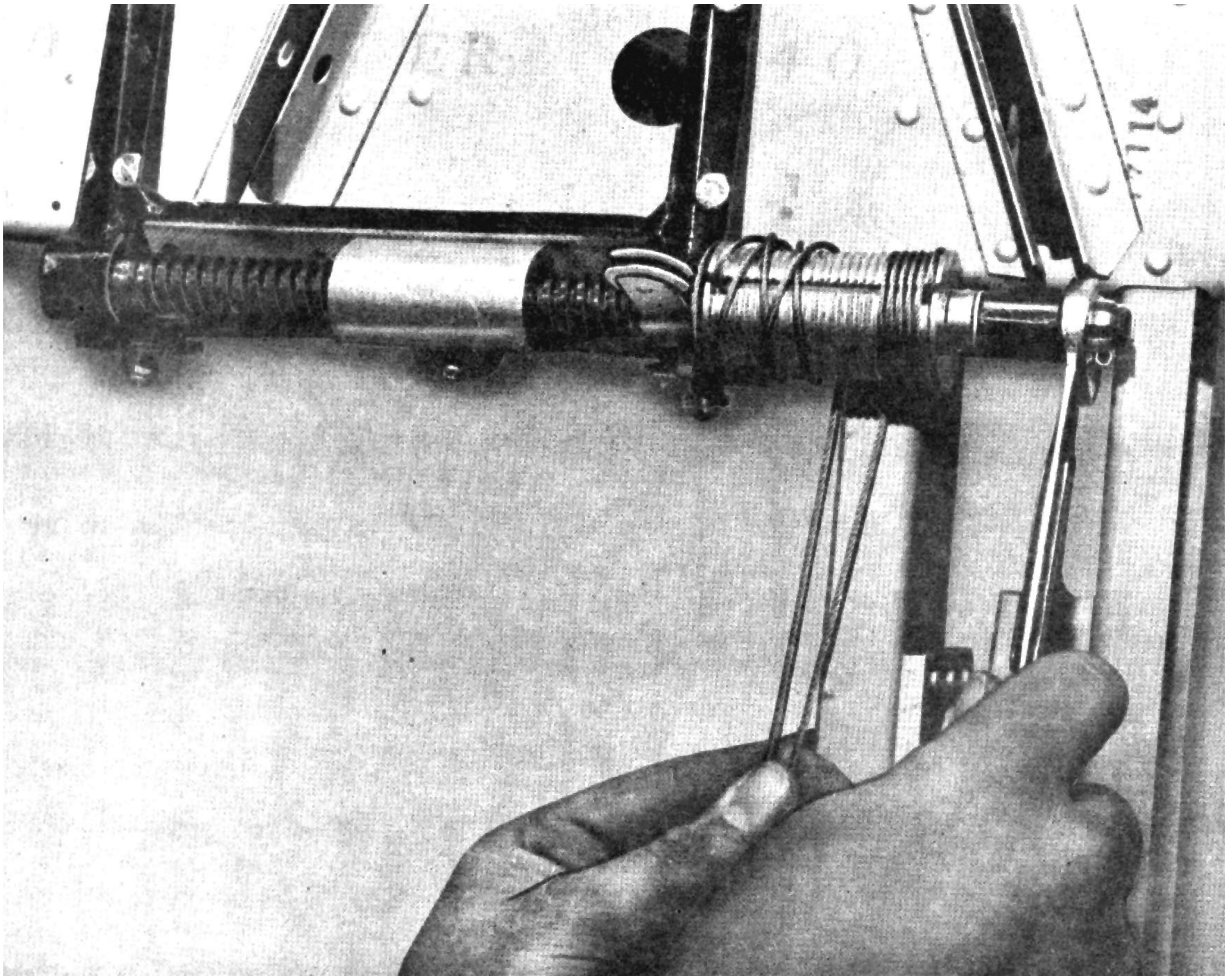


Figure 5-10. Wrapping Elevator Trim Drum Cable

surface of the elevator. Thus, the protractor reading required to give the specified limit when the elevator is raised is five degrees less than the designated value. In the lowered position, 5 degrees are added to the required value.

d. Connect the elevator control front tube assembly (6, Figure 5-2) to the control column assembly (14).
e. Raise the elevator to its full up position. With the elevator held in this position, adjust the rod end bearing (16) to maintain a minimum of 1/8 inch clearance at the rear control column stop.
f. Move the elevator to the down position and check for 1/8 inch clearance at the forward stop.

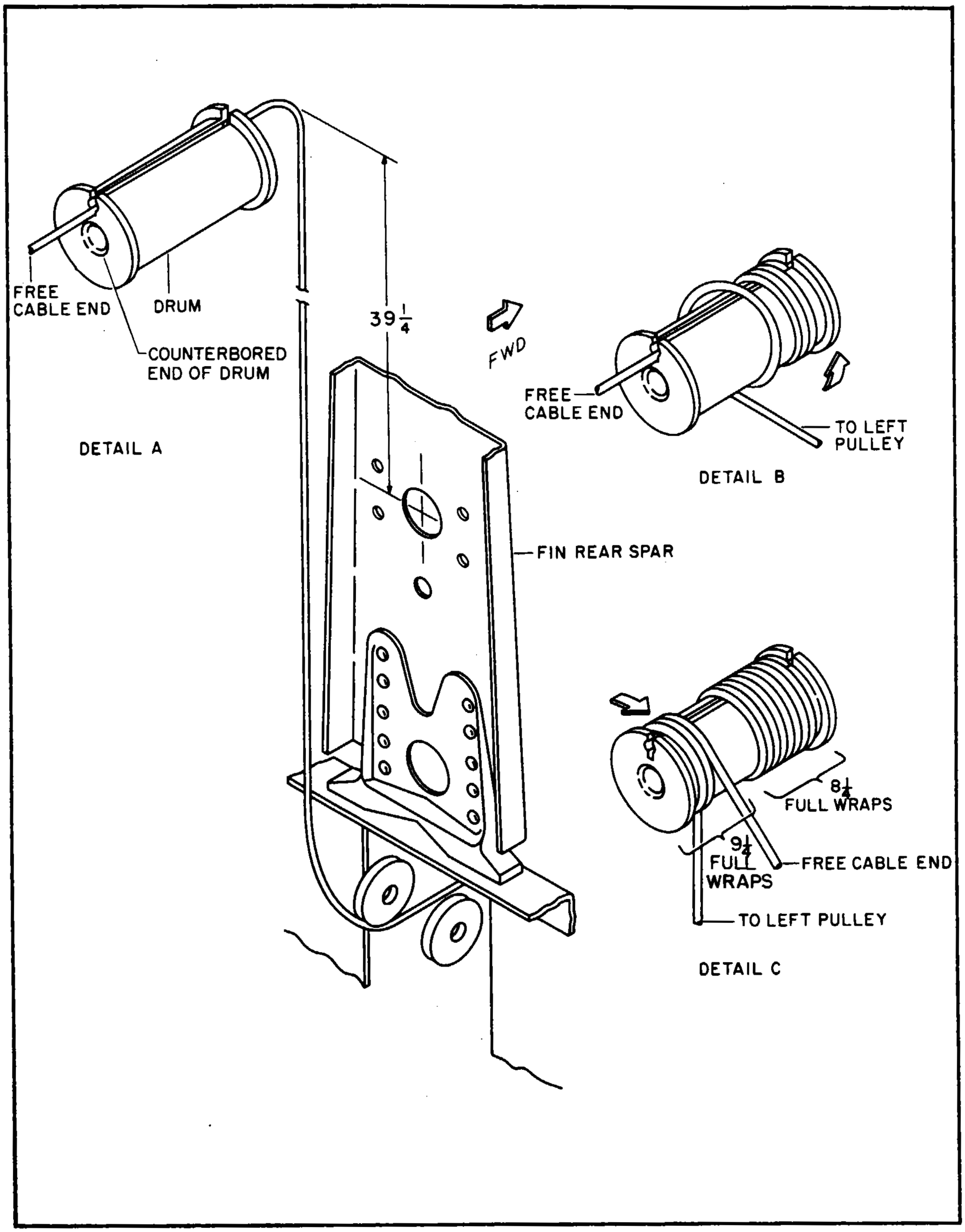


Figure 5-11. Wrapping Rudder Trim Drum Cable

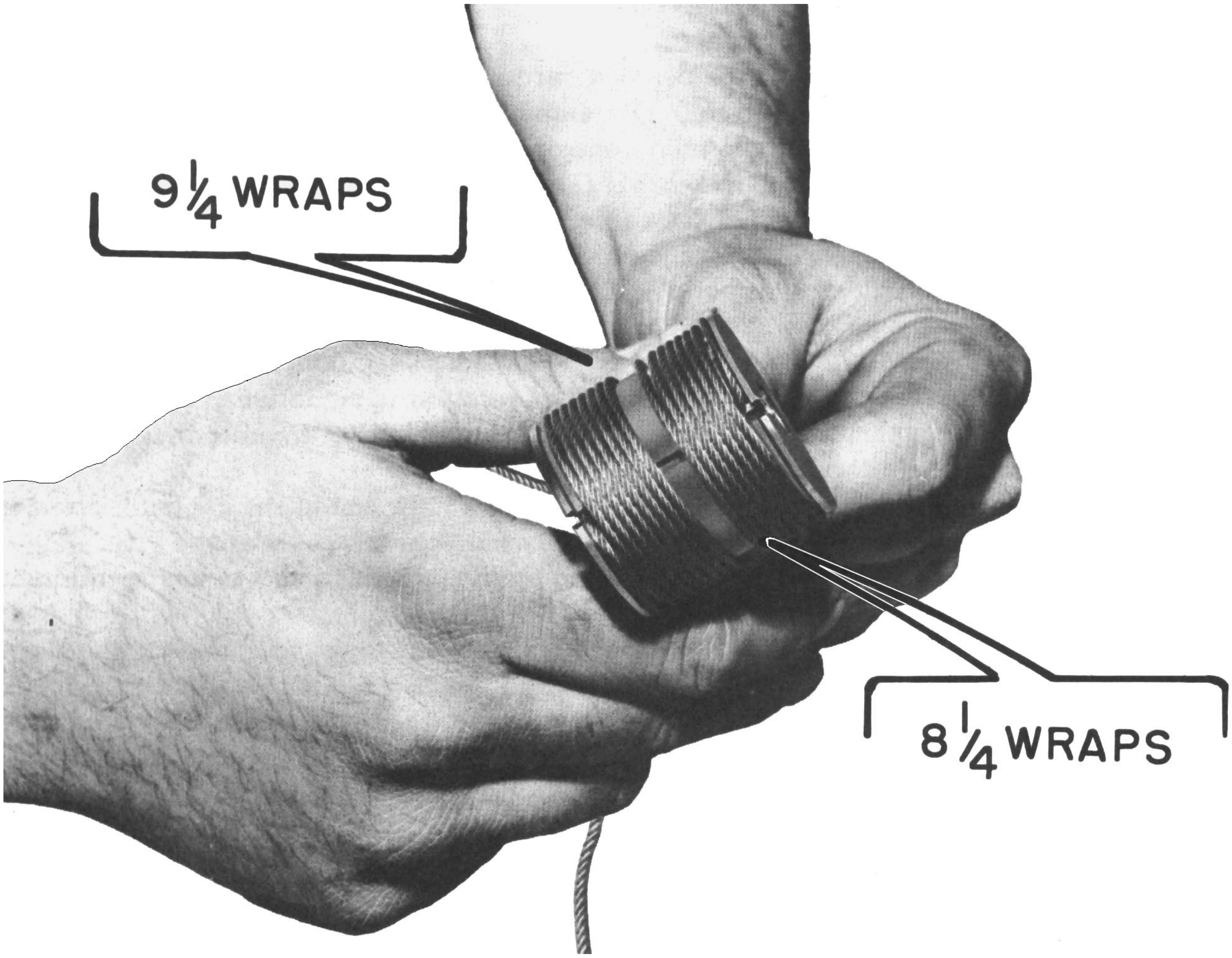


Figure 5-12. Wrapped Rudder Trim Drum Cable

NOTE

A maximum of six threads can be exposed on the rod end bearing that connects the control tube to the control column.

e. Check all bolts and stops for tightness and safetys.

5-16. RIGGING THE ELEVATOR TRIM MECHANISM.

a. Thread the bare end of the elevator trim cable assembly (22, Figure 5-4) completely through the right slot of the control cable rub block (3) at Station

171-3/8, just aft of the tubular structure. Connect a turnbuckle and eye to the eye at the other end of the cable.

b. Pass the cable over the two outboard right vertical pulleys (4) at the top of the cockpit, then around the right side of the lower pulley, the elevator trim cable pulley (10), at the tail trim control assembly (11). Thread the cable back to the rub block at Station 171-3/8. (Refer to Figure 5-4.)

c. Pulling the bare end of the cable taut so that the turnbuckle is drawn against the rub block, measure a distance of 113 inches from the bare end of the cable and mark the cable at that point.

d. Rotate the bungee screw (26) clockwise by means of the nut at the left end of the screw until the floating bungee screw nut assembly (27) bears against the trim control drum (28). The direction of rotation is established by viewing the screw from its nut end. Alter this adjustment slightly, so as to bring the slot in the drum face forward.

e. Place the cable in the drum slot with the bare end of the cable directed to the right and position the mark previously made in the cable at the right side of the cable (Refer to Figure 5-9.) (25) in the drum slot to secure the location of the cable. (Refer to Figure 5-9.)

f. Turn the bungee screw in a counterclockwise direction, moving the floating nut to the right. Continue to do so until the floating nut is at its extreme position. As the floating nut travels away from the drum, the cable from the trim pulley will wind itself around the grooves of the trim control drum. Be sure the first wrap does not bear against the drum flange but that it nests in the first complete groove. (Refer to Figure 5-10.) Clamp the cable to the aircraft frame with a C-clamp to keep the cable from unwinding.

CAUTION

While performing this procedure, the 113-inch length of cable will tend to wrap itself loosely about the drum and possible snap. Therefore, unwind this excess cable as the drum rotates.

g. Manually wrap part of the 113-inch long end of the cable counterclockwise, starting from the right side of the drum. Utilize all of the remaining grooves. This will require about three wraps.

h. Unclamp the cable from the frame and hold the cable securely to keep it from unwrapping. As an aid to prevent unwrapping from the drum, pull the bare end of the cable as far forward as it can go, causing the turnbuckle eye at the other end of the cable to butt against the rub block. Consequently, the cable will be drawn taut.

i. Slip a Nicropress clamp on the bare end of the cable and wrap it around

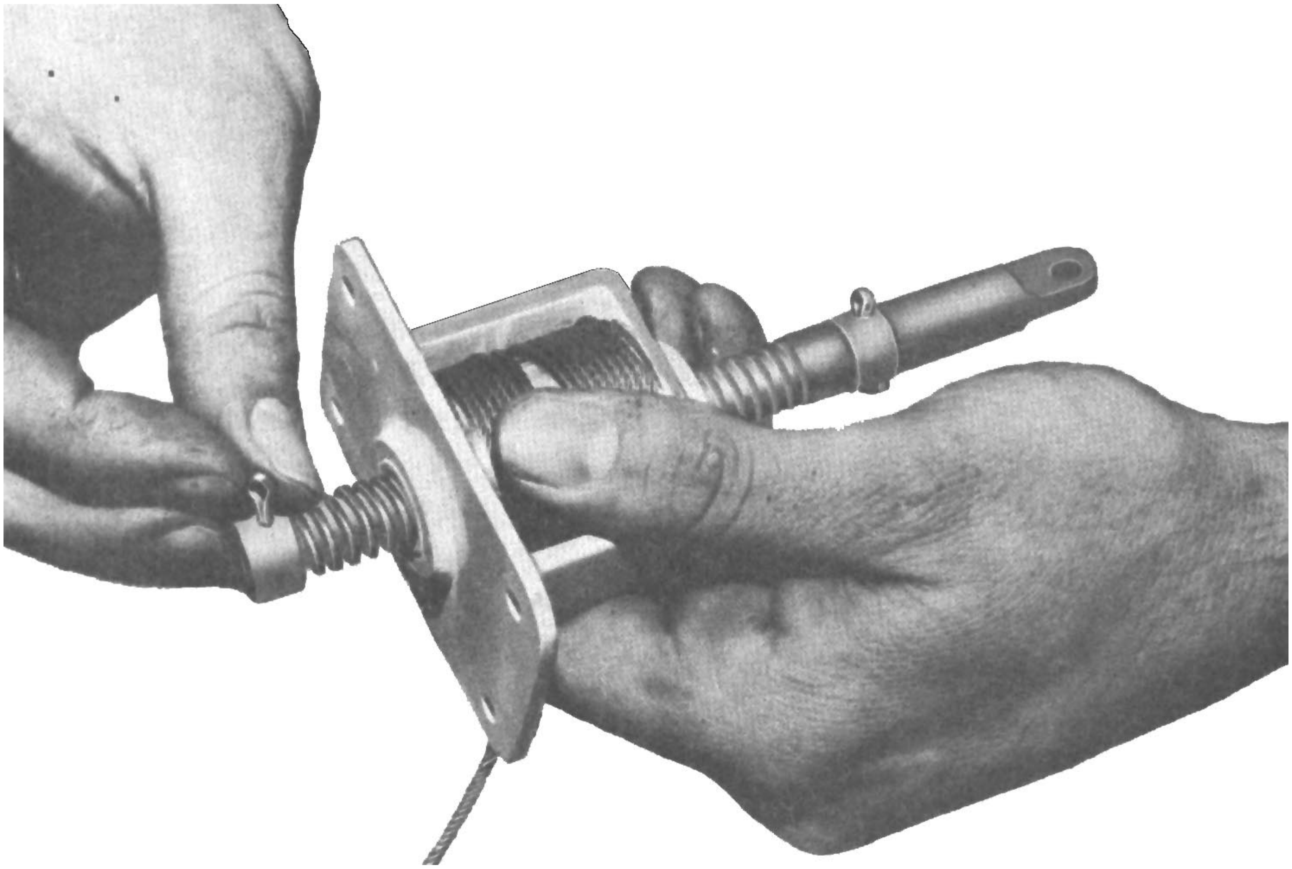


Figure 5-13. Installing the Forward Rudder
Trim Tab Screw Collar Cotter Pin

the free turnbuckle eye; then pass the cable back through the Nicropress clamp. Develop from 16 to 24 pounds of cable tension and secure the free end of the cable with a C-clamp to keep the system tight. Do not apply the Nicropress clamp.

j. Push the turnbuckle as far aft as it will go to make sure that it does not run under the trim control drum. Check to see that there is at least a half wrap remaining on the drum.
k. Run the turnbuckle as far forward as it will go so that it does not strike the rub block at Station 171-3/8.
l. Check the floating nut to see if it is bearing against the support bracket assembly. If it is not, press out the roll pin (23, Figure 5-4) from the drum hub and rotate the bungee screw by means of the nut at its left end until the floating nut is against the support bracket.
m. Reinstall the roll pin. This may necessitate a partial turn of the bungee screw to align the hole in the drum hub and in the screw, but never as much of

an adjustment as that required in the removal of the roll pin, described in step "1" above.

n. Check the tension in the cable to see if it has remained between 16 and 24 pounds with no more than two threads exposed at each end of the turnbuckle barrel. Apply the Nicropress clamp and remove the C-clamp. Safetywire the turnbuckle.

5-17. RIGGING THE ELEVATOR TRIM INDICATOR WIRE.

a. Rotate the trim control drum (28, Figure 5-4) by means of the nut at the left end of the bungee screw (26) until the two groups of elevator trim cable wraps are at the middle of the drum. Under these circumstances, there will be eleven wraps on each side of the drum.

b. Insert 0.024-inch diameter indicator wire (1) into the hole at the left end of the floating bungee screw nut assembly (27), close to its edge. Push the wire through the hole until it protrudes 3-3/4 inches from the front surface of the floating nut. Twist the end of the wire approximately five times around the main strand of the indicator wire.

NOTE

If more than five wraps are made, they will run onto the idler pulley (24) about which the wire is threaded.

c. Carry the indicator wire around the rear of the idler pulley (24), and then draw it forward to the hinge (2) at Station 192-1/2, in accordance with the rigging diagram. (Refer to Figure 5-4)

d. Insert the wire through the head of the cotter pin located at the lower end of the hinge.

e. Holding the hinge vertically, draw the wire taut, fold it back, and twist it around the main strand approximately seven times.

f. Pass a second indicator wire through the end of the elevator trim indicator tee assembly (6), at the tail trim control assembly (11), and twist it around the main strand approximately seven times.

g. Thread the wire aft to the hinge (2), in accordance with the rigging diagram. Pass the wire through the head of the cotter pin located above the pin of step "d".

h. Install the tail trim indicator placard (8), at the tail trim control assemby, with three screws, two forward and one aft.

i. At the hinge, pull the wire aft until the tee pin points to the major cross line indicating that the elevator trim is in the neutral position. Fold the end of the wire forward and twist it around the main strand approximately seven times.

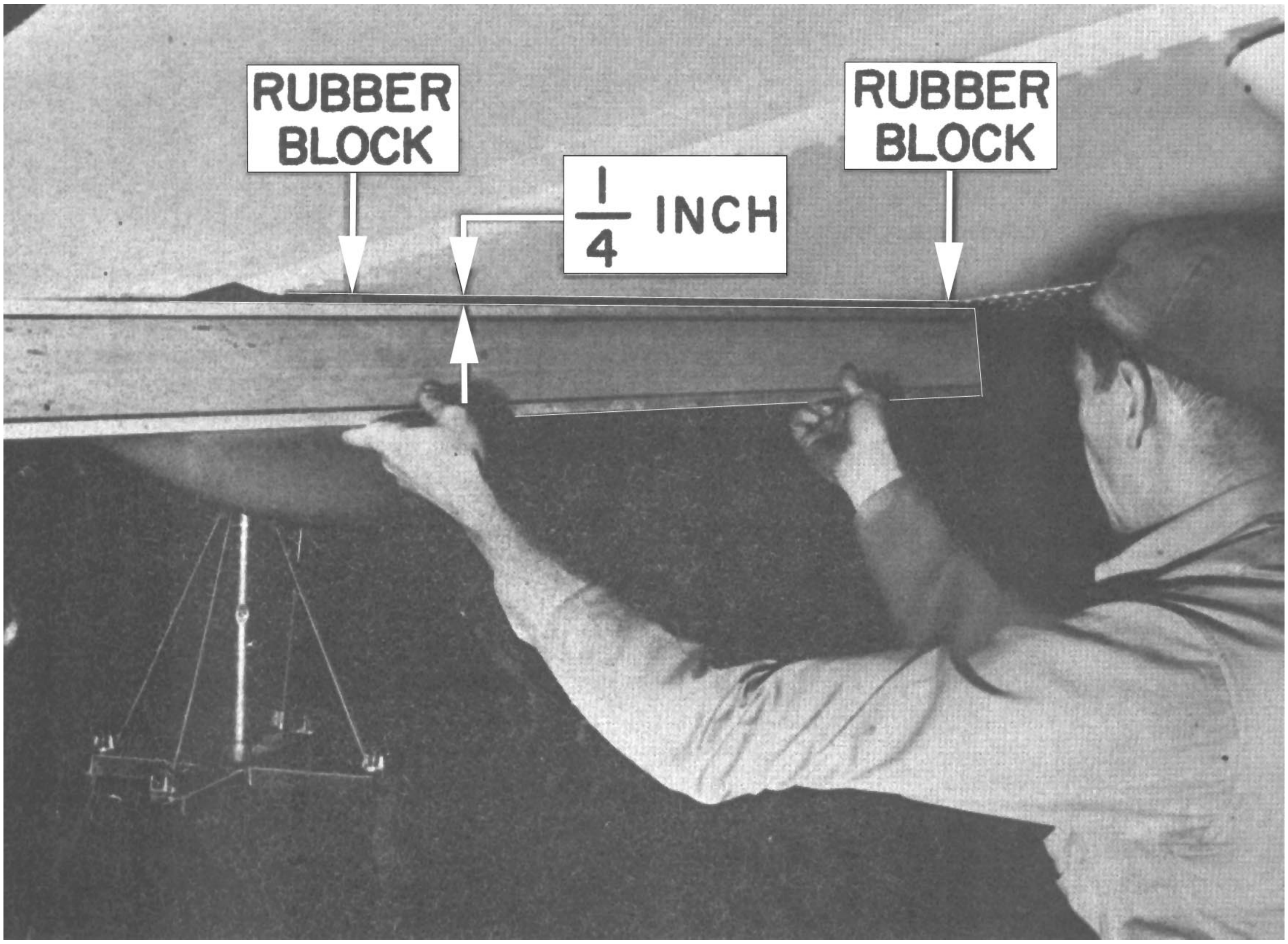


Figure 5 -14. Flap Alignment

5-18. RIGGING AND ADJUSTMENT OF FLAPS.

a. Connect all the flap system linkages together, temporarily.

b. Place the cockpit “FLAPS” control lever in the “DOWN” position. Using the pedestal hand pump, lower the flaps till there is no movement. At this time, the piston rod will be withdrawn into the flap actuating hydraulic cylinder (3, Figure 8-8) as far as the bushing (1), located on it, permits it to go. The locknut, for the tube (2) threaded into the piston rod, and the bottom of the cylinder are the members between which the bushing is compressed.

c. Observe the position of the flap bellcrank assembly (5) with respect to the slot in the flap actuating arm guide block (7). The bellcrank must be at least 1/8 inch from the end of the slot. If it strikes the block, remove the bolt, washer and self-locking nut securing the tube end bearing (4) to the bellcrank and rotate the tube counterclockwise to extend it. Tighten the tube locknut to maintain the

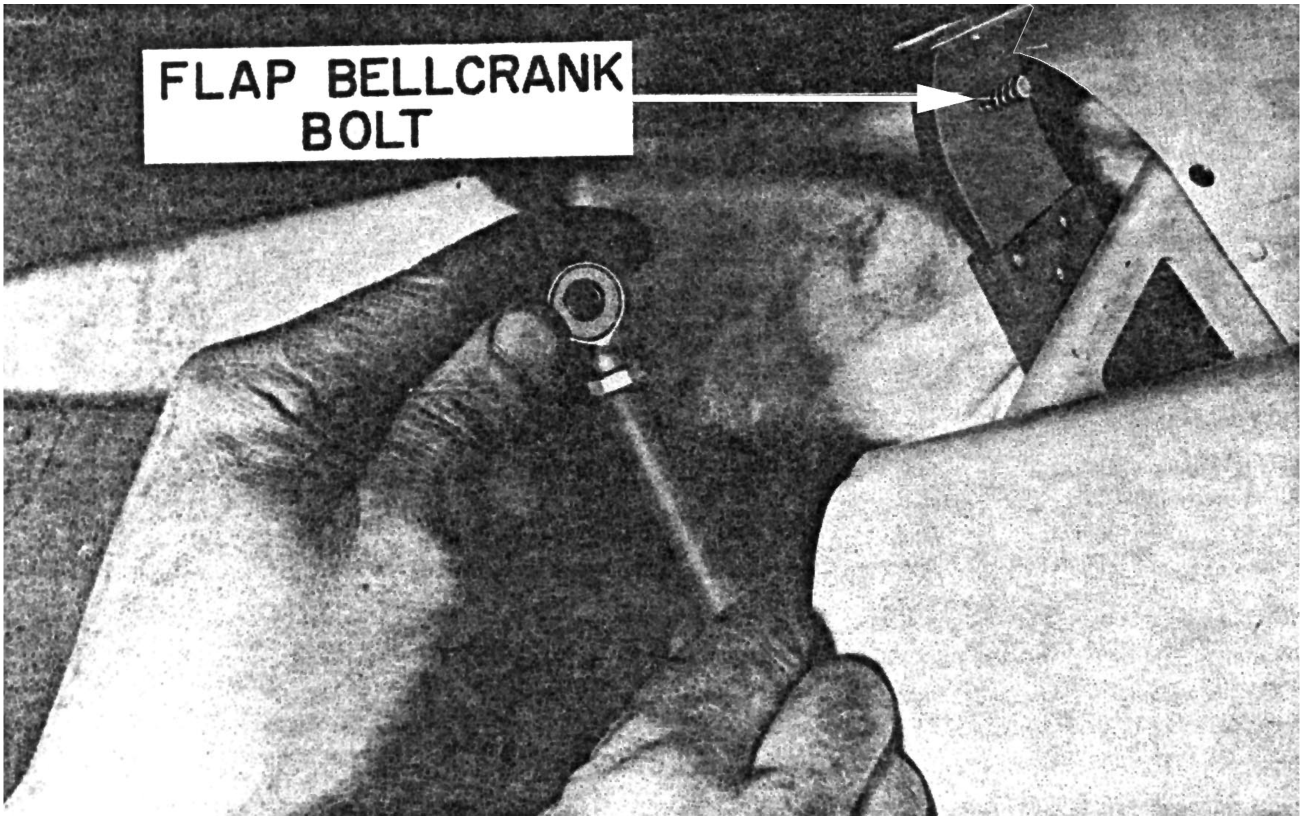


Figure 5-15. Adjusting Flap Control Rod End Bearing

new position of the tube relative to the piston rod. Check to see if end bearing locknut is tight.

d. Connect the tube end bearing to the bellcrank with a bolt, plain washer, and a self-locking nut.
e. Pump the flaps as far up as they will go.
f. Place a straight edge beneath the wing surface and check if the flap is parallel with the bottom of the wing.

NOTE

The bottom of the flap is not flush with the wing. It is 1/4-inch below the wing, therefore, set two hard rubber blocks between the top of the straight edge and the bottom of the wing to check parallelism, (Refer to Figure 5-14.)

g. Rectify a non-parallel condition by lowering the flaps completely via the hand pump. Then disconnect the flap control rod assembly (6) from the bolt in the flap bellcrank. Rotate the control rod end bearing to correct the misalignment. (Refer to Figure 5-15.) Reconnect the control rod to the bellcrank. Raise the flaps until the cockpit control lever returns to neutral and check for parallelism again.

h. If still unsatisfactory, lower the flap and repeat the adjustment. If necessary, also adjust via the control rod end bearing at the flap. To do this, do not separate the end bearing from the flap, but rotate the flap control rod itself. When satisfactory, install a washer between the end bearing and the bellcrank and secure with a castellated nut and a cotter pin.

i. Repeat all of the above procedures on the left flap.

NOTE

Place a plain washer under the castellated nut in addition to the washer located between the control rod end bearing and the bellcrank at the left flap.

j. Move the flap within its limits and note if there is 50 degrees of movement, plus or minus two degrees. Check all locknuts for tightness.

5-19. ADJUSTING THE RUDDER.

a. Align the rudder with the fin (steps "d" and "e," paragraph 5-12) wherein the distance from the inboard corner of the trailing edge of one elevator to the sixth rivet on the bottom of the facing side of the rudder is made equal to that between the opposite elevator and the sixth rivet confronting it.

b. Tie a plumb bob to the nose gear bumper or drag link grease fitting and tie another plumb bob to the tail skid. Using the two bobs as guides, snap a chalk line on the ground. Extend it rearward beyond the empennage.

c. Suspend a plumb bob from the rudder and see if it corresponds with the chalk line. If it does not, remove both of the side access panels from the nose of the aircraft, and adjust the rudder pedal torque tube arm turnbuckle barrels (5, Figure 5-3) to achieve this condition, maintaining the limitation to the maximum number of threads which may be exposed at each turnbuckle and the alignment of the rudder pedals as called for in paragraph 5-11, steps "f" and "h."

d. Swing the rudder 30 degrees from its in line position and set the buttonhead socket screw against the rudder horn. The screws, which serve as stops, are located in both sides of the lower rudder hinge bracket assembly.

e. Repeat step "d," above, in the opposite direction.

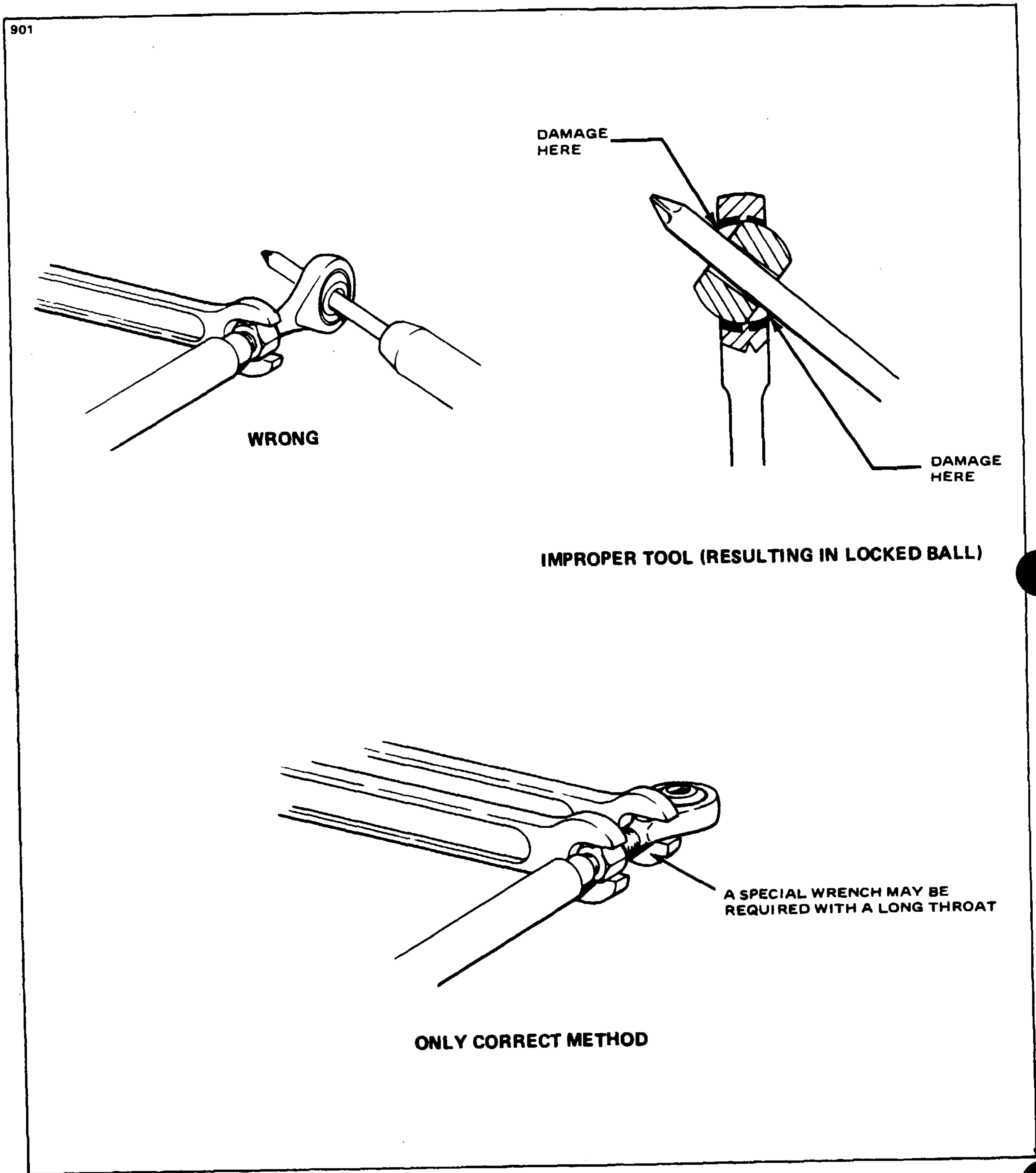


Figure 5-16. Correct Method of Installing Rod End Bearings

SECTION VI

HYDRAULIC SYSTEM

Issued: 3/15/68

Aerofiche
Grid No.

SECTION VI

HYDRAULIC SYSTEM

6-1. GENERAL.

6-2. The hydraulic system covered in this Section consists of the landing gear system and the flap system and the Hydraulic Powerpak which is the control for both. The brake system, although hydraulically operated, is not included in this Section as it has its own hydraulic system independent of the Powerpak. The brake system is covered in Section VII.

6-3. This Section provides instructions for remedying difficulties which may arise in the operation of the hydraulic system. The instructions are organized so that the mechanic can refer to; principles of operation for a basic understanding of the system; troubleshooting for a methodical approach in locating the difficulty; corrective maintenance for removal and repair; installation instructions; adjustments and tests for adjusting and checking the repaired system.

CAUTION

Place the aircraft on jacks prior to starting any investigation of the hydraulic system. (Refer to Jacking, Section II.)

6-4. Refer to Table VI-I for Leading Particulars of the Hydraulic Powerpak.

TABLE VI-I. LEADING PARTICULARS
HYDRAULIC POWERPAK

Operating Pressure	1150 psi
Main-Relief Valve Cracking Pressure	1250-1300 psi
Thermal Relief Valve Cracking Pressure	2000-2050 psi
Powerpak 750P External Valves	2000-2050 psi
Powerpak 750P-1 Serial Nos. 1 to 2023, inc. Internal Valves	2000-2050 psi
Powerpak 750P-1 Serial Nos. 2024 through no. 2033, 2035 and up.	1850-1900 psi
Hydraulic Fluid Required	MIL-H-5606
Reservoir Capacity (full)	4.5 pints (approx.)

TABLE VI-I. LEADING PARTICULARS
HYDRAULIC POWERPAK (con't.)

Reservoir Capacity (emergency)	0.95 pint
Detent Release Pressure	
Landing Gear (R.H.)	1150 psi
Flap	1150 psi
Weight (dry)	8.25 lbs.

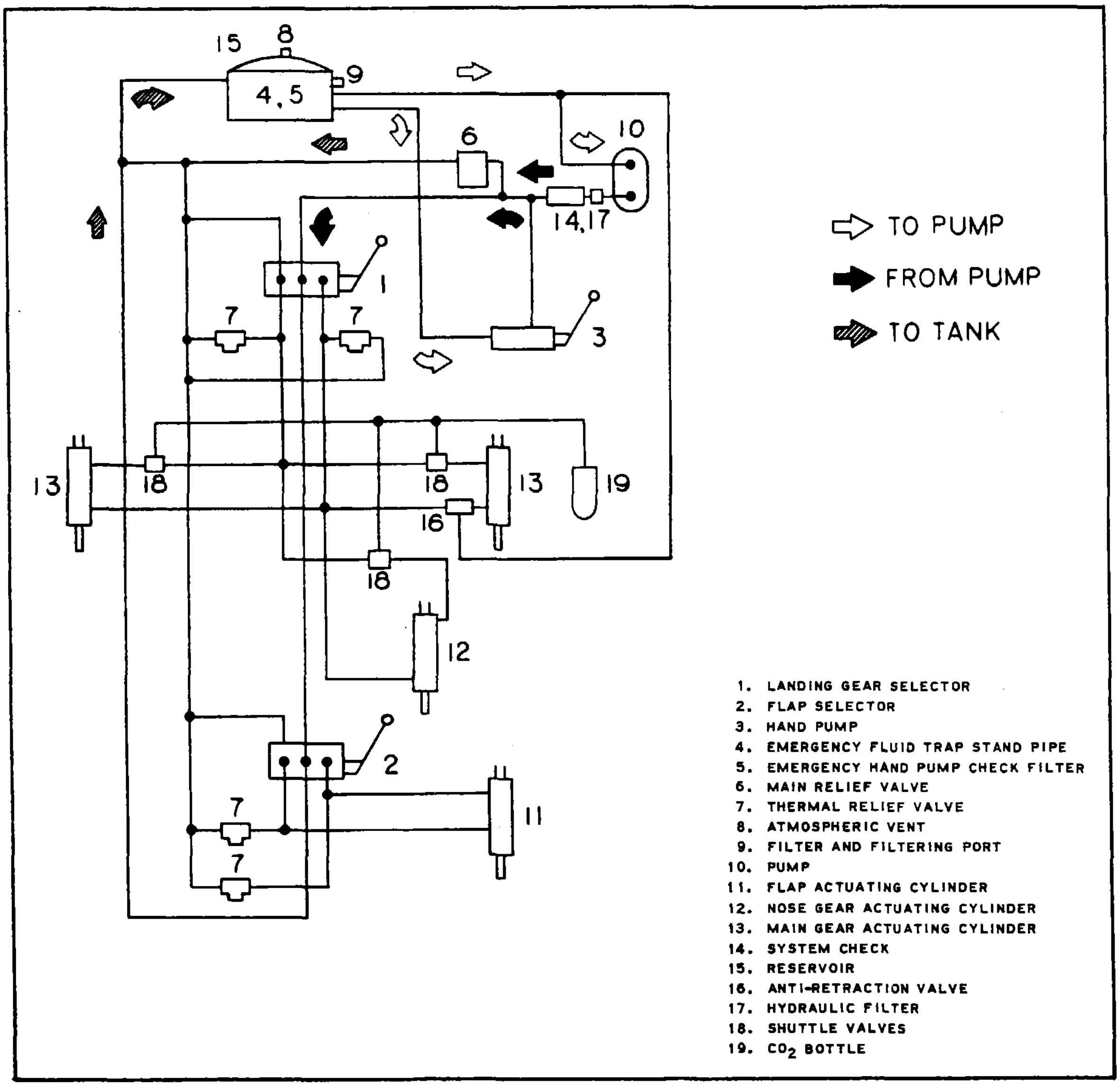


Figure 6-1. Schematic Diagram, Hydraulic System

6-5. PRINCIPLES OF OPERATION.

6-6. GENERAL. The engine driven hydraulic pump draws hydraulic fluid from the Powerpak reservoir (15, Figure 6-1) and pumps it through the pressure port into the landing gear selector pressure chamber. When the two selector valves are in the neutral position, the fluid travels from the landing gear selector valve (1), the wing flap selector valve (2) and back to the reservoir.

6-7. When either selector valve is moved to the "UP" or "DOWN" positions, the fluid travels from that selector valve into the actuating cylinders (11, 12 or 13). As the piston in each actuating cylinder moves in the required direction, the fluid on the other side of the piston is forced back through the selector valve and into the reservoir.

6-8. The main relief valve functions as a safety between the pump and the selector valves, and is set to crack at 1250 to 1300 psi. When the main relief valve opens, the fluid is shunted directly back to the reservoir. On aircraft incorporating Powerpak 750P, three external thermal relief valves are used (25, Figure 6-8) to provide a means of relieving pressure due to thermal expansion. Cracking pressure is set at 2000 to 2050 psi. Powerpak 750P-1, bearing serial numbers 1 to 2023 inclusive, have four internal thermal relief valves with a cracking pressure of 2000 to 2050. The Powerpak with serial numbers 2024 through 2033, 2035 and up, have the cracking pressure set at 1850 to 1900 psi.

6-9. The hand pump (3, Figure 6-1) serves as an emergency pump when the engine-driven pump fails. The system check valve (14) prevents the fluid from backing up through the engine-driven pump into the reservoir. In the event of severe leakage of the hydraulic fluid, the standpipe (137, Figure 6-7) prevents the fluid level from dropping below the emergency quantity required for the operation of the system by means of the hand pump. The engine-driven pump is supplied fluid through the standpipe, so that when the fluid level goes below the top of the standpipe, no fluid will flow. Thus, even though the system may develop a break, and the engine-driven pump continues to operate, devoiding the system of fluid, the standpipe ensures enough fluid in the system for hand pump operation.

6-10. SELECTOR LEVER OPERATION. The operation of the "LANDING GEAR" selector lever and the "FLAP" selector lever is the same. The following description applies to both selector levers unless otherwise noted.

NOTE

Either system may be actuated independently of the other. However, although both selector levers may be moved at the same time, the flap system will not operate until the landing gear system completes its operation.

a. "LANDING GEAR" selector lever "UP". When the selector lever is moved to the "UP" position, it is locked in place by the action of the detent. The detent consists of the ball (79, Figure 6-7), O-ring (78), plunger (77), spring (76), and plug (75). The ball snaps into the groove (A) in the spool (128) and is held in place by the spring (76). Fluid is directed through the cylinder port and into the actuating cylinder as shown in Figures 6-2 and 6-4. The movement of the piston forces the fluid from the actuating cylinder through the selector valve spool and into the reservoir. When the piston "bottoms", or moves as far as possible, fluid pressure starts to build up until it reaches approximately 1150 psi (1150 psi for the flaps). At this time, the pressure forces the plunger (77, Figure 6-7) up, against the spring (76), relieving the spring pressure on the ball (79). The ball pops out of the groove in the spool and the spring (125), which is under compression, forces the spool (and the selector lever) to return to its neutral position.

b. "LANDING GEAR" selector lever "DOWN". When the selector lever is moved to the "DOWN" position, the operation is identical with that described in step "a" above, except that because the selector lever spool (128, Figure 6-7) moves in the opposite direction, the ball (79) snaps into the groove (B). The spring (125) is under compression in this case. Fluid is directed in the opposite direction, as is shown in Figures 6-3 and 6-5.

c. "LANDING GEAR" selector lever "NEUTRAL". When the selector lever is in the neutral position, fluid flows back to the reservoir, as shown in Figure 6-6.

6-11. TROUBLE SHOOTING.

6-12. GENERAL. Malfunctions of the hydraulic system will result in failure of the landing gear or flaps to operate properly. When a trouble arises, the service mechanic should jack up the aircraft (Refer to Section II.) and then proceed to determine the extent of the trouble. Generally, hydraulic system troubles fall into three types: troubles involving the hydraulic supply system, troubles in the landing gear hydraulic system and troubles in the flap hydraulic system. The extent of the trouble can be found by operating the two selector valve levers ("LANDING GEAR" and "FLAPS") on the Powerpak. Table VII lists the troubles which may be encountered and their probable cause, and suggests a remedy for the trouble involved.

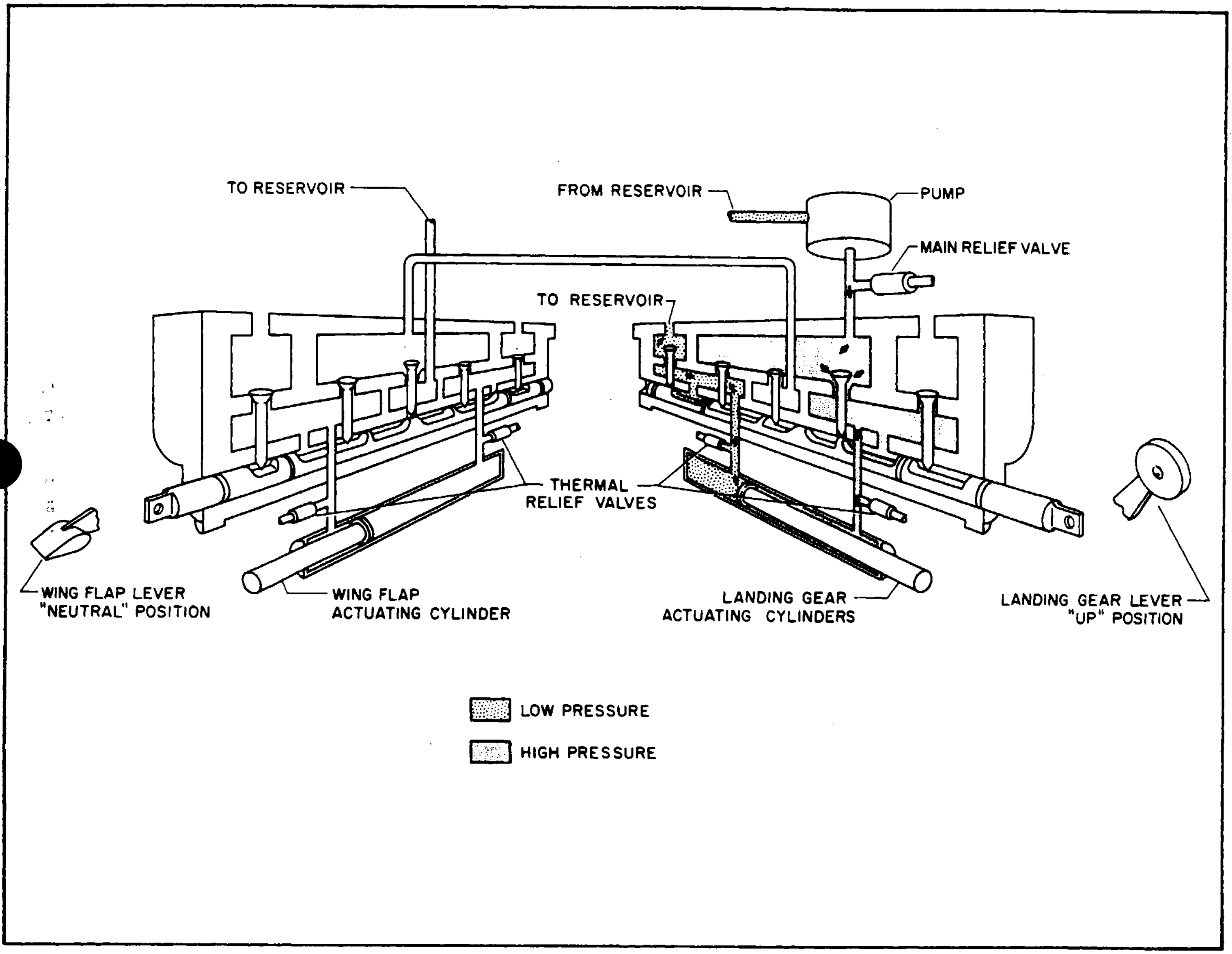


Figure 6-2. Flow Diagram Landing Gear Selector Lever "UP"

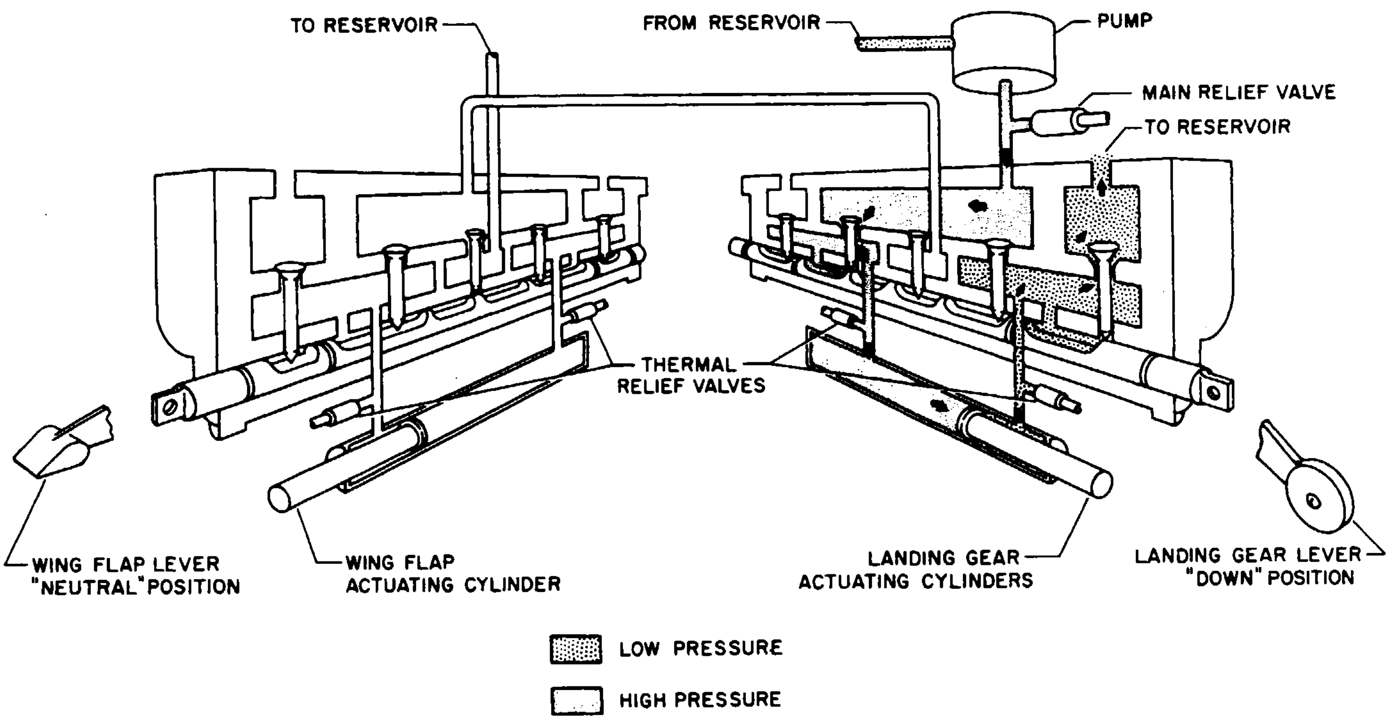


Figure 6-3. Flow Diagram Landing Gear Selector Lever "DOWN"

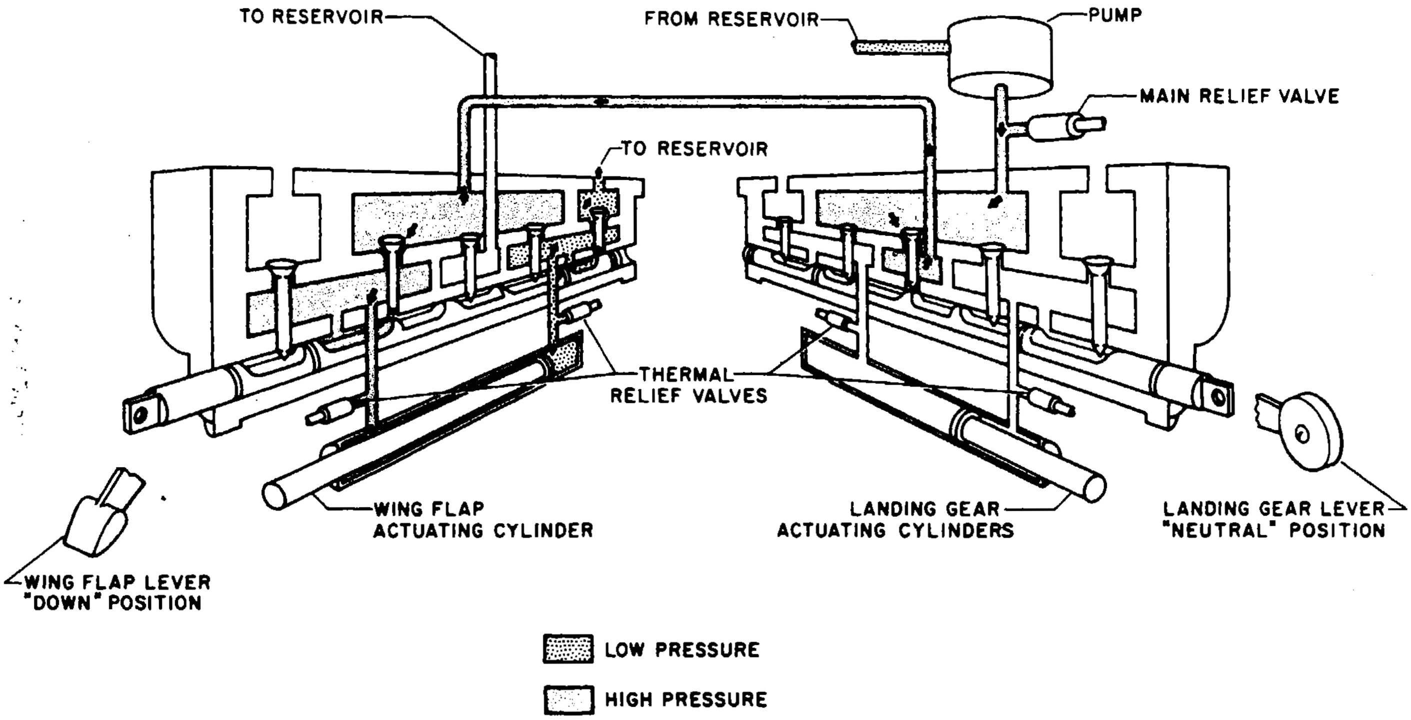


Figure 6-4. Flow Diagram Wing Flap Selector Lever "DOWN"

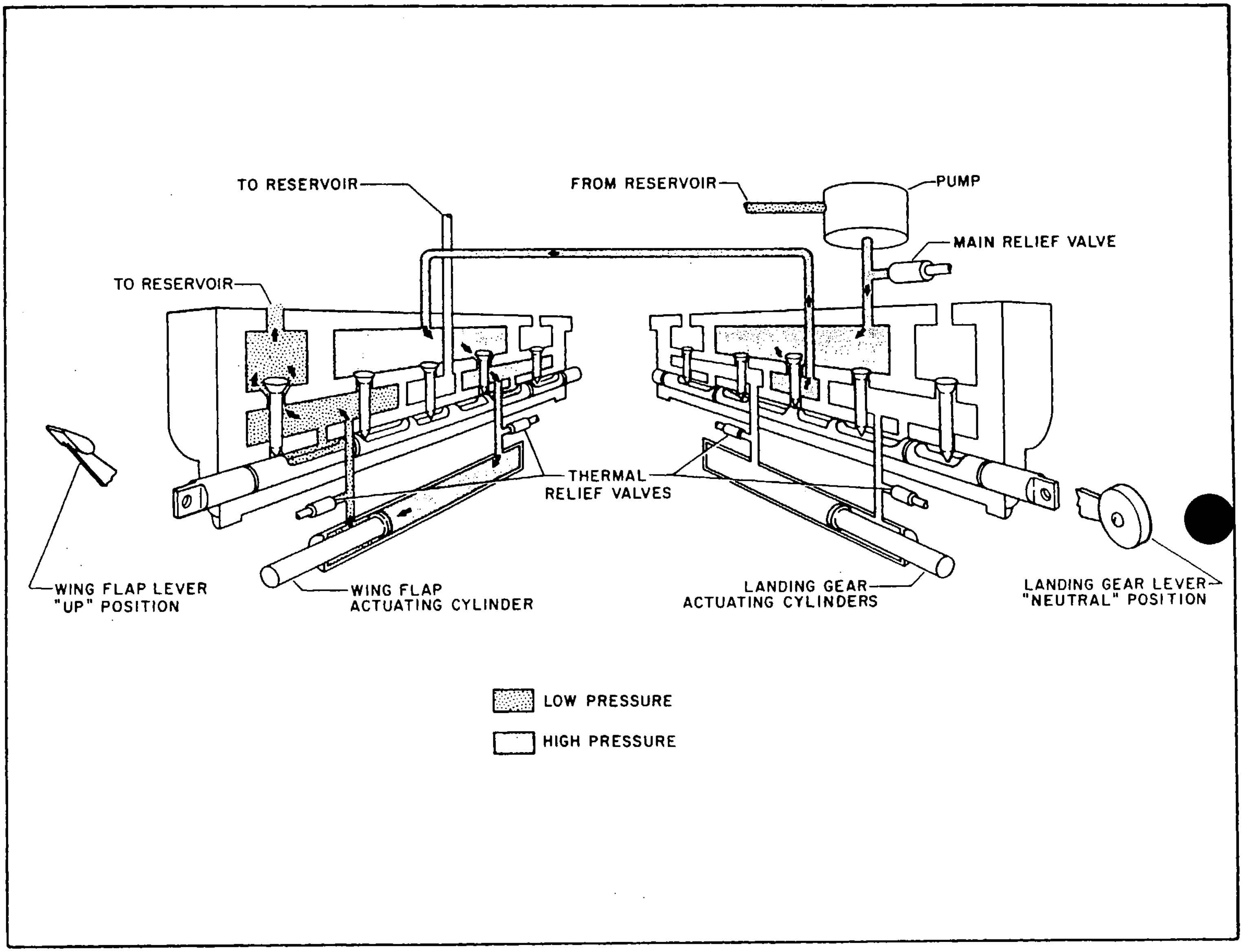


Figure 6-5. Flow Diagram Wing Flap Selector Lever "UP"

TABLE VI-II. HYDRAULIC SYSTEM TROUBLESHOOTING

Trouble	Cause	Remedy
Flap and landing gear systems (both) fail to operate.	Hydraulic fluid reservoir below operating level	Fill Powerpak with hydraulic fluid. (Refer to Section II.)
	Leak or obstruction in hydraulic lines between pump and powerpak.	Check each system with hand pump. If they both work, check lines for damage. Replace damaged line. (Refer to Paragraph 6-20.) If hand pump fails to work refer to "Hydraulic Powerpak failure" under the column heading "Cause".
	Engine hydraulic pump failure	If both systems function using hand pump and lines are not damaged, replace hydraulic pump. (Refer to Section VIII.)'
	Hydraulic Powerpak failure	Refer to Table VI-III.
Landing gear system fails	Leak or damage in hydraulic lines between the three landing gears actuating cylinders and the Powerpak.	Check lines for damage. Replace damaged line. (Refer to Paragraph 6-20.)
	Internal or external leakage in actuating cylinder	Check all three actuating cylinders for damage.

TABLE VI-II. HYDRAULIC SYSTEM TROUBLESHOOTING (con't.)

Trouble	Cause	Remedy
Landing gear system fails to operate. (con't.)		Replace defective cylinder. (Refer to Paragraph 6-21.)
	Hydraulic Powerpak failure	Refer to Table VI-III.
Wing flap system fails to operate	Leak or damage in hydraulic lines between actuating cylinder and Powerpak.	Check lines for damage. Replace damaged line. (Refer to Paragraph 6-20.)
	Internal or external leakage in actuating cylinder.	Check actuating cylinder for damage. Replace if defective
	Hydraulic Powerpak failure	Refer to Table VI-III.
Landing gear system functions improperly	Hydraulic Powerpak failure	Refer to Table VI-III.

6-13. ISOLATING THE CAUSE. When the trouble has been recognized, the first step in troubleshooting is isolating the cause. Hydraulic system troubles are not always traceable to one cause. It is possible that a malfunction may be the result of more than one difficulty within the system. Starting first with the most obvious and most probable reasons for the trouble, the mechanic should check each possibility in turn until, by process of elimination, has isolated the troubles. A thoroughly experienced mechanic does not jump to conclusions. Systematic analysis should replace guesswork, for in the long run it saves time and promotes accuracy. When troubleshooting, it is best never to assure anything. If, for example both the landing gear and flap systems fail to operate, the mechanic should first ask the question: "Is there hydraulic fluid in the Powerpak reservoir?" From there he can proceed down the list of possibilities given in

Table VI-II, making all checks until he has located the source of trouble. If it is found that the Powerpak is at fault, run down the list of possibilities in Table VI-III, Powerpak Troubleshooting, before removing the Powerpak from the aircraft. Paragraph 6-22 describes the removal of the Powerpak.

6-14. CORRECTING THE TROUBLE. The service mechanic should correct the trouble as carefully and efficiently as possible. If the trouble is traceable to an actuating cylinder or hydraulic line, replace the damaged unit. (Refer to Paragraphs 6-20 or 6-21.) If the Powerpak is at fault, remove the Powerpak (Refer to Paragraph 6-22) and disassemble (Refer to Paragraph 6-24). After the trouble is corrected, be sure to check the entire hydraulic system to be sure all components are functioning properly. (Refer to Paragraph 6-47.)

6-15. CORRECTIVE MAINTENANCE.

6-16. GENERAL.

6-17. Paragraphs 6-20 through 6-23 cover removal and installation of the hydraulic system components. Paragraphs 6-25 through 6-36 cover disassembly of the Hydraulic Powerpak.

6-18. Components of the hydraulic system should not be removed unless inspection periods (Refer to Section III) uncovers a damaged component, or if the system is malfunctioning, until troubleshooting, as described in paragraphs 6-12 through 6-14 above, pin points a damaged component.

6-19. REMOVAL AND INSTALLATION.

CAUTION

Release system pressure prior to any removal operation.

6-20. REMOVAL AND INSTALLATION OF HYDRAULIC LINES. Remove a damaged hydraulic line by disconnecting the fittings at each end and by disconnecting where secured to brackets. Provide a small container for draining the line. Refer to Figure 6-8 as an aid in the location of attaching brackets and bends in the lines. Install a new or repaired line in the reverse order. Use any recommended aircraft sealing compound, on all hydraulic system pipe thread fittings. Apply the sealing compound to the male pipe threads.

CAUTION

Do not apply the sealing compound to the first two male pipe threads or to the port of the fitting.

6-21. REMOVAL AND INSTALLATION OF ACTUATING CYLINDERS. The main landing gear actuating cylinders are connected to the engine mounts and the down-locks on the drag links. The nose gear actuating cylinder is connected to the front of the fuselage tubular structure and to the down-lock on the drag link. Access to the main landing gear actuating cylinders is through the top nacelles or the open gear doors. The nose gear actuating cylinders is accessible through the open gear door. The wing flap actuating cylinder is located within the right wall of the cabin, directly forward of the baggage door and is connected to the fuselage tubular structure and the torque tube bellcrank. Remove the interior panel for access. Remove any or all of the four cylinders as follows:

CAUTION

Be sure to place the aircraft on jacks before attempting to remove the landing gear actuating cylinders. (Refer to Section II.)

NOTE

Refer to paragraph 6-39 before removing an actuating cylinder because of external leakage.

a. Release any pressure in the lines by moving the selector levers to "UP" and "DOWN" and then back to neutral.
b. Disconnect the hydraulic lines from the appropriate cylinder. Provide a small container for the lines to drain into.
c. Remove a cotter pin, nut, washer and bolt from each end of the cylinder. The wing flap cylinder is connected to the bellcrank with a self-locking nut instead of the castellated nut and cotter pin.
d. Replace in the reverse order.

CAUTION

Be sure to install each cylinder with its ports pointing down. If installed with the ports pointing up, the cylinder will not clear the tubular structure when the landing gear is retracted.

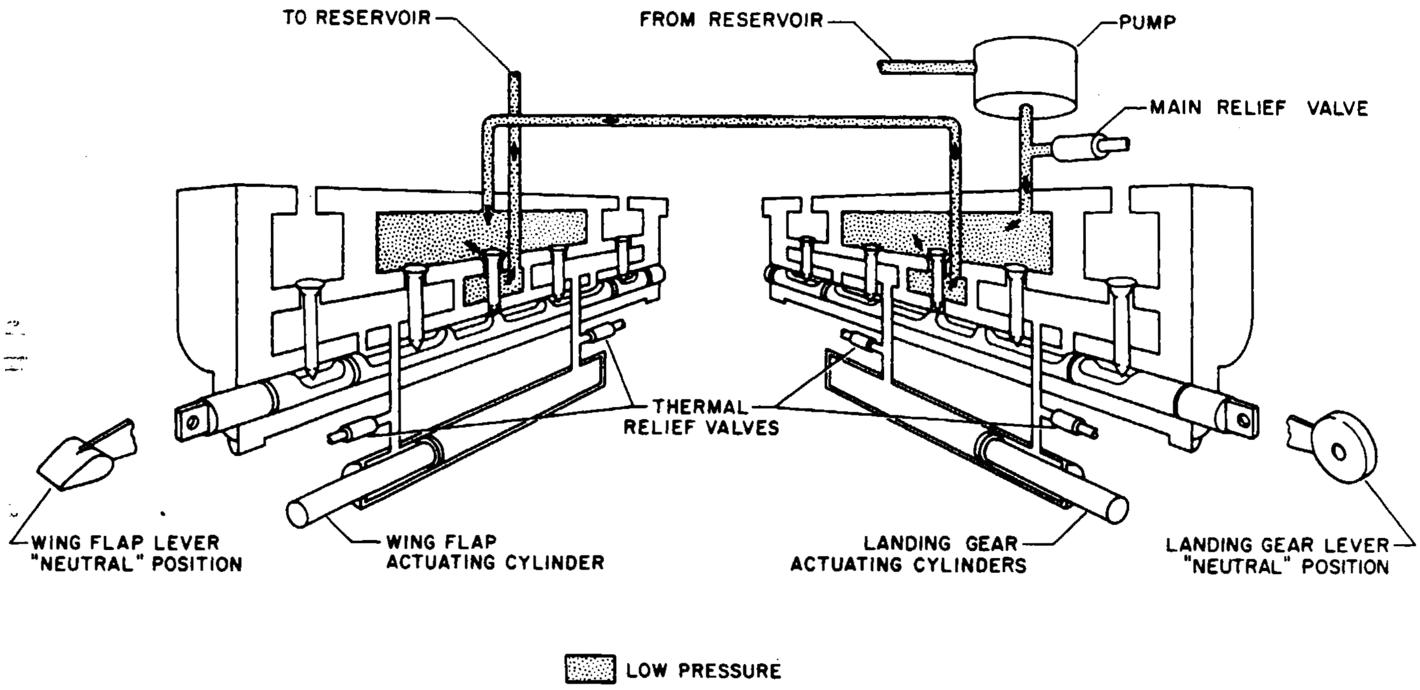


Figure 6-6. Flow Diagram Both Selector Levers Neutral

e. Refer to Section V for wing flap adjustments and to Section VII for down-lock and landing gear limit switch adjustments.

6-22. REMOVAL OF HYDRAULIC POWERPAK. Place the aircraft on jacks (Refer to Section II) and use the following procedure for removing and installing Hydraulic Powerpak:

a. Drain the hydraulic system by disconnecting the hydraulic extension line at the nose gear actuating cyliner, place the end of the line in suitable container, select lever to the "DOWN" position and operate the hand pump until the system is empty.

b. Remove the instrument trim access panel over the top of the instrument panel.

c. Disconnect the overflow vent line from the top of the Powerpak by reaching down through the access hole behind the instrument panel.

d. Remove the flap lever knob and the landing gear lever knob.

e. Remove the eight round-head screws at the sides of the front top panel of the pedestal and remove the carburetor heat control knobs. Remove the panel with the placard attached. Loosen four screws holding pedestal placard tabs.

f. Remove the large black control lock knob from the right side of the pedestal.

g. Remove the six engine control cable clevises from the control cable.

h. Remove the four round-head screws and nuts which attach the engine control lever mounting bracket to the sides of the pedestal.

i. Remove the lowest placard on the pedestal by removing the knobs and nuts from the four heater controls and the six truss-head screws holding the placard onto the pedestal. Swing the placard panel off to the left.

j. Disconnect all hydraulic lines at the Powerpak. Make certain hydraulic fluid does not drain out onto cabin floor.

k. Remove the four bolts attaching the bottom of the Powerpak to the mounting channels.

i. Remove the Powerpak from the pedestal and place on a rigid base preparatory to disassembly.

6-23. INSTALLATION OF HYDRAULIC POWERPAK.

a. Insert the Powerpak into the pedestal.

b. Attach the Powerpak to the channel with four lock-washers and bolts.

c. Connect the seven hydraulic lines to the Powerpak.

d. Install the master switch placard with six truss-head screws. Install the knobs and nuts on the four heater controls.

e. Mount the engine control lever mounting bracket on the pedestal.

f. Reconnect the six engine control cable clevises to the proper controls.

g. Install the large black knob on the right side of the pedestal.
h. Mount the front top panel on the pedestal.
i. Install the carburetor heat control knobs.
j. Install the flap lever knob and the landing gear lever knob (Check flasher light operation.
k. Connect the overflow vent line to the top of the Powerpak.
l. Mount the instrument trim access panel over the rear of the instrument panel.
m. Connect the hydraulic lines at the nose gear actuating cylinder.
n. Re-fill hydraulic system. (Refer to Section II.)
o. Make certain all landing gears are down and locked before removing jacks.

6-24. DISASSEMBLY AND REASSEMBLY OF HYDRAULIC POWERPAK.

6-25. GENERAL. For complete disassembly of the Powerpak, refer to Figure 6-7, and disassemble in the order of the index numbers. The procedures described below are presented in such a manner that investigation and replacement of specific parts as required by Table VI-III, Powerpak Troubleshooting, may be carried out without complete disassembly.

NOTE

Before attempting to disassemble the Powerpak, be sure the special tools and test equipment specified in paragraph 6-26, below, are available. The test equipment is necessary for adjusting spring tensions following reassembly. Refer to paragraph 6-43 for adjustment and test procedures.

6-26. SPECIAL TOOLS AND TEST EQUIPMENT. Refer to Table VI-IV for a list of the special tools and test equipment required for disassembly, reassembly, and testing of the Powerpak.

6-27. DISASSEMBLY AND REASSEMBLY PRECAUTIONS. Be sure to observe the precautions listed below when disassembling the Powerpak. Strict adherance to these precautions ensures a minimum of time and expense for repair of the Powerpak and reduces the chance of damage to poppet and valve seats due to careless mishandling of tools. Damage to poppet or valve seats requires return of Powerpak to the manufacturer for overhaul.

a. Keep the unit free of all foreign matter.
b. For removal and replacement of internal snap rings, use Waldes-Kohinoor, Inc., snap ring pliers, No. 1 and 3 and 3 or equivalent.

TABLE VI-III. POWERPAK TROUBLESHOOTING

Trouble	Cause	Remedy
Flap and landing gear systems (both) fail to operate.	External leakage at base of hand pump handle.	Replace O-rings (57, 59).
	Internal leakage in main relief valve.	Check for damage or foreign matter lodged between ball (35) and seat (34).
		Replace damaged O-ring (33).
	Internal leakage in hand pump and filter	Check for damage or foreign matter lodged between ball (23) and seat (21).
		Replace damaged O-ring (22).
		Replace damaged O-ring (61).
Landing Gear system fails to operate.	External leakage at plugs (115, 121).	Replace damaged O-ring (116, 122).
NOTE Where duplicate parts are used in the two systems, only one part is illustrated and indexed on the exploded view. Be sure to check the part applicable to	Internal leakage in thermal relief valve.	Check for damage or foreign matter lodged between ball (72) and seat (73).
		Replace damaged O-ring (74).
	Internal leakage at detent plunger (77).	Replace damaged O-ring (78).

TABLE VI-III. POWERPAK TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Landing gear system fails to operate (cont.)		
(Note) (cont.)		
the landing gear or flap system. Also, check the parts which are under pressure, first. (Refer to the flow diagrams, Figures 6-2 through 6-6 for illustrations of the parts under pressure for the position of the selector valve when the Powerpak fails.)	Internal leakage in popets (84, 91).	Check for damage or foreign matter lodged between poppets and seats.
		Replace damaged O-rings (83, 90, 93).
		Replace damaged O-rings (81, 88).
	Internal or external leakage at cam spools (128).	Replace damaged O-rings (129).
Flap system fails to operate.	External leakage at plugs (115, 121).	Same as landing gear.
	External leakage at plug (136).	Check plug and threaded hole for damage.
	Internal leakage in thermal relief valve.	Same as for landing gear.
	Internal leakage at detent plunger (77).	Same as for landing gear.
	Internal leakage in poppets (84, 91).	Same as for landing gear.

TABLE VI-III. POWERPAK TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Landing gear fails to retract.	Excessive hydraulic fluid in CO_2 system.	Drain CO_2 lines.
Landing gear drops in flight.	Thermal contraction hydraulic fluid.	"Ground check"
	Leakage in Anti-Retraction Valve.	Replace "O" rings in valve or replace valve
	Leakage in actuating cylinder.	Replace "O" rings in actuating cylinder or replace cylinder.
Hydraulic fluid leaks out of vent after filling reservoir.	Excessive fluid in system due to improper filling technique.	Refer to Section II.

CAUTION

Use extreme care when handling poppet seats, check valves and seats, relief valve seats and bores. Damage to these parts requires returning the Powerpak to the manufacturer for overhaul.

c. Use needle-nose pliers for removal and replacement of all retainer plugs, detent plungers, and poppets.

d. Use a hooked tool to remove check valve, relief valve, and poppet seats.

NOTE

Poppets and seats are matched parts and must be kept together. Damage to either a poppet or a seat requires replacement of the poppet and seat assembly.

e. Prior to removal of cam shafts, relieve the tension on the appropriate spring loaded detent plungers and poppets.
f. Use care when handling O-rings. Coat O-rings and associated parts with hydraulic fluid before reassembly.

6-28. CLEANING. Clean all parts removed with a standard cleaning solution.

6-29. REMOVAL AND INSTALLATION OF HAND PUMP. Removal and disassembly of the complete hand pump consists of removing Items 37 through 66. (Refer to Figure 6-7.) However, if only the piston (60) and associated O-rings (57, 59, 61 and 63) or ball (65) and seat (64) are to be removed, disconnect the link (46) and swing the pump handle (54) up out of the way; then proceed with removal of Items 56 through 66. Reassemble in the reverse order. Be sure to observe the precautions outlined in paragraph 6-27.

CAUTION

The stop gland (58) must be installed on the piston with the outside "O" ring (57) forward.

6-30. REMOVAL AND INSTALLATION OF RESERVOIR, BAFFLE AND PLATES. To remove the reservoir (4, Figure 6-7, baffle (13) and two plates (19), remove Items 1 through 19. Replace in the reverse order.

NOTE

Unless obviously damaged, it is not necessary to remove Items 6 through 11 and Item 19.

6-31. REMOVAL AND INSTALLATION OF STRAINER. Remove the reservoir, baffle and plate. (Refer to Paragraph 6-30.) Then remove the strainer (20, Figure 6-7) and associated parts (21 through 24). Replace in the reverse order. Be sure to observe the precautions outlined in paragraph 6-27.

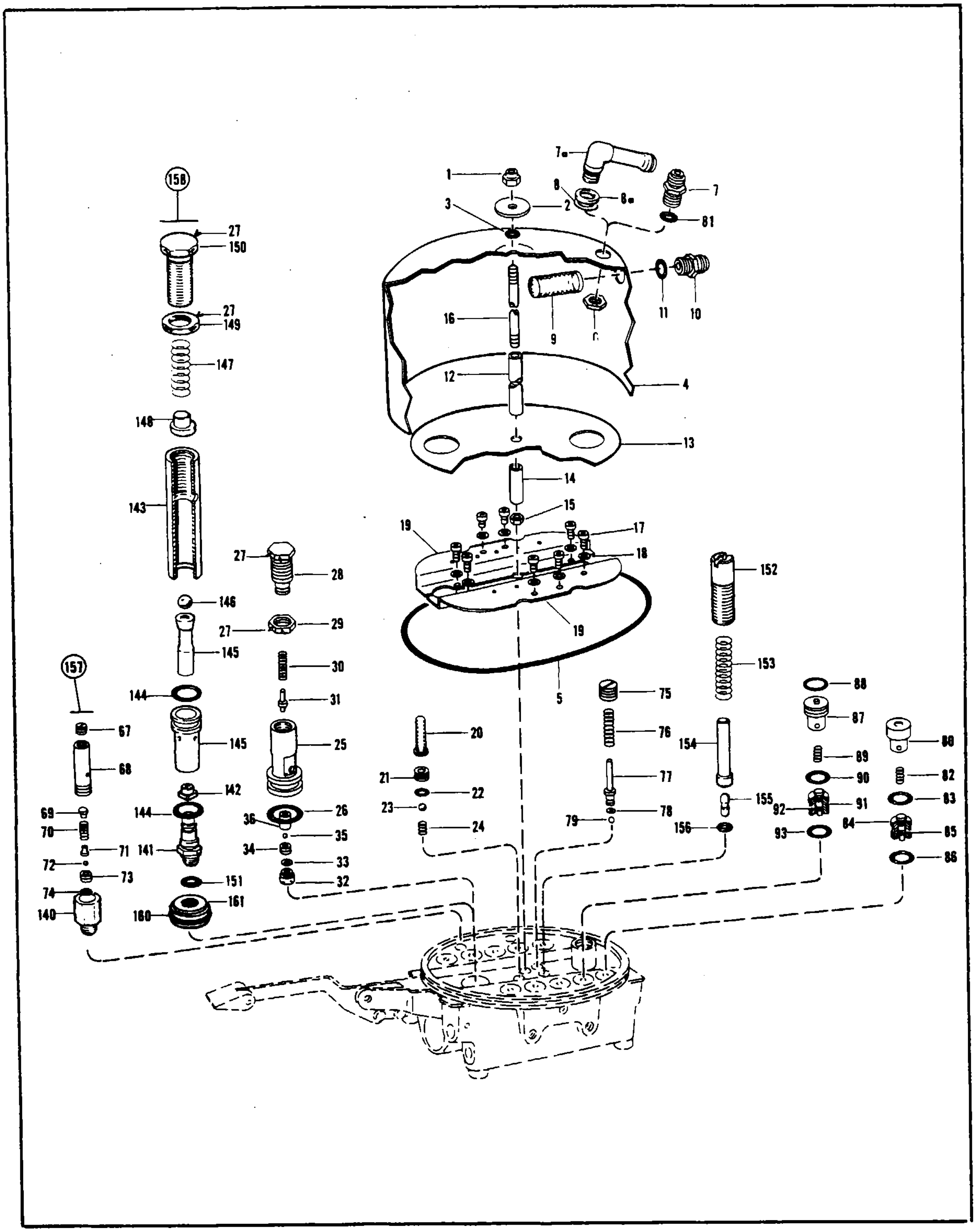


Figure 6-7. Hydraulic Powerpak, Exploded View

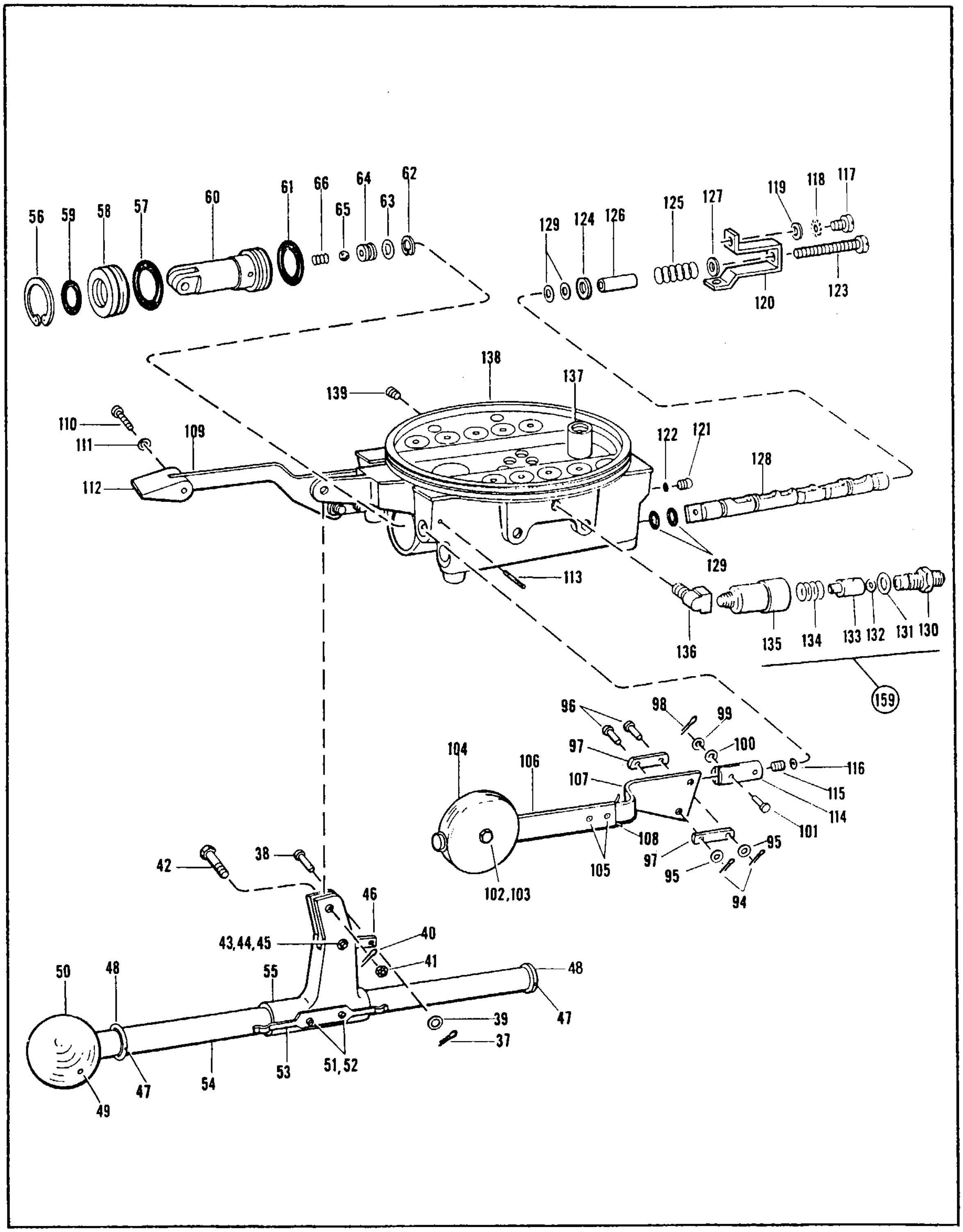


Figure 6-7. Hydraulic Powerpak, Exploded View (cont.)

HYDRAULIC POWERPAK

Electrol No.		Piper No.
750P [1]	. . . .	-
750P-1 [1]	. . . .	31800-00 [1]
-	. . . .	31800-02
-	. . . .	31800-02M

INDEX NUMBER	PART NUMBER	DESCRIPTION	UNITS PER ASSY
1	AN365-428	NUT	1
2	31926-00	WASHER, Reservoir.	1
3	AN6227-5	PACKING, O-ring	1
4	31827-00	RESERVOIR	1
5	AN6230-36	PACKING, O-Ring.	1
6	AN924-6D	NUT	1
7		UNION, Reservoir	1
7a	31927-00	ELBOW, Reservoir	1 [2]
8	Cleveland - 110-9/16	SEAL	1
8a	AN960-916L	WASHER	1
9	31925-00	STRAINER	1
10	AN815-6D	UNION	1
11	AN6290-6	PACKING, O-ring	1
12	31924-00	SPACER, Reservoir	1
13	31944-00	BAFFLE, Reservoir	1
14	31940-00	SPACER, Reservoir	1
15	AN316-4R	NUT	1
16	31939-00	STUD	1
17	1/4-28 NF3	SCREW, Cap socket hd 5/16 in. lg. . . .	8
18	AN936B416	WASHER, Lock.	8
19	31886-02 (L)	PLATE	1
	31886-03 (R)	PLATE	1
20	31912-00	STRAINER	1
21	31937-00	SEAT, Check	1
22	AN6227-6	PACKING, O-ring	1

(1) NOT AVAILABLE FOR SERVICE
(2) USED WITH POWERPAK ASSEMBLY 750P, 750P-1 AND 31800-00.

DESCRIPTION (cont.)

INDEX NUMBER	PART NUMBER		UNITS PER ASSY
23	31804-05	BALL	1
24	31936-00	SPRING, Check	1
25	31951-00	BODY, Relief Valve	1 (2)
26	AN6227-15	PACKING, O-ring	1 (2)
27	MS20995F32	LOCKWIRE	1 (2)
28	31955-00	SCREW	1 (2)
29	31848-00	NUT	1 (2)
30	31957-00	SPRING	1 (2)
31	31952-00	PLUNGER	1 (2)
32	31953-00	PLUG	1 (2)
33	AN6227-4	PACKING, O-ring	1 (2)
34	31954-00	SEAT	1 (2)
35	31814-07	BALL	1 (2)
36	31956-00	RETAINER	1 (2)
37	AN380-2-2	PIN, Cotter	1
38	AN394-19	PIN, Clevis	1
39	AN960PD416	WASHER	1
40	AN380-2-2	PIN, Cotter	1
41	AN320-3	NUT	1
42	AN3-10	BOLT	1
43	AN380-2-2	PIN, Cotter	1
44	AN393-27	PIN, Clevis	1
45	AN960PD10	WASHER	1
46	31922-00	LINK	1
47	52-028-125-1.187	PIN, Roll (ESNA)	2
48	31934-00	STOP	2
49	52-028-125-1.375	PIN, Roll (ESNA)	1
50	31933-00	GRIP	1
51	AN500-6-3	SCREW	2
52	AN935-6L	WASHER, Lock	2
53	31906-00	SPRING	1
54	31825-00	HANDLE	1

(2) USED WITH POWERPAK ASSEMBLY 750P, 750P-1 AND 31800-00.

DESCRIPTION (cont.)

INDEX NUMBER	PART NUMBER		UNITS PER ASSY
55	31829-00	FORK AND BUSHING ASSY	1
56	5000-106	RING, Snap	1
57	AN6227-16	PACKING, O-ring	1
58	31935-00	STOP.	1
59	AN6227-13	PACKING, O-ring	1
60	31938-00	PISTON	1
61	AN6227-15	PACKING, O-ring	1
62	NAS50-43	RING, Snap	1
63	AN6227-6	PACKING, O-ring	1
64	31937-00	SEAT, Check	1
65	31814-05	BALL	1
66	31936-00	SPRING, Check	1
67	31876-00	SCREW ASSY	4
68	31872-00	BODY	4
69	31875-00	RETAINER	4
70	31871-00	SPRING	4
71	31877-00	RETAINER	4
72	31814-02	BALL	4
73	31874-00	SEAT	4
74	AN6227-4	PACKING, O-ring	4
75	31904-00	PLUG	1 (3)
76	31947-00	SPRING	1 (3)
77	31905-00	PLUNGER	1 (3)
78	PRP902-3/4	PACKING, O-ring	1 (3)
79	31814-04	BALL	1 (3)
80	31923-00	RETAINER, Return	4
81	AN6290-6	PACKING, O-ring	1 (2)
82	31856-00	SPRING	4
83	2-15PSI-30-5AN	PACKING, O-ring	4
84	31854-00	POPPET AND SEAT ASSY	4 (4)
85	AN6227-2	PACKING, O-ring	4 (5)
	AN6227-3	PACKING, O-ring	4

(2) USED WITH POWERPAK ASSEMBLY 750P, 750P-1 AND 31800-00.
(3) TWO USED WITH POWERPAK ASSEMBLY 750P, 750P-1 AND 31800-00.
(4) P/N 31854-00 NOT USED WITH 750P.
(5) USED WITH POWERPAK ASSEMBLY 750P ONLY.

DESCRIPTION (cont.)

INDEX NUMBER	PART NUMBER		UNITS PER ASSY
86	2-15PSI-30-5AN	PACKING, O-ring	4
87	31913-00	RETAINER, Pressure	6
88	AN6227-10	PACKING, O-ring	6
89	31856-00	SPRING	6
90	2-15PSI-30-5AN	PACKING, O-ring	6
91	31854-00	POPPET AND SEAT ASSY	6 (4)
92	AN6227-2	PACKING, O-ring	6 (5)
	AN6227-3	PACKING, O-ring	6
93	2-15PSI-30-5AN	PACKING, O-ring	6
94	AN380-2-1	PIN, Cotter	4
95	AN960-PD4L	WASHER	4
96	AN392-11	PIN, Clevis	4
97	31930-00	LINK	4
98	AN380-2-2	PIN, Cotter	2
99	AN960PD10L	WASHER	2
100	AN960PD10	WASHER	2
101	AN393-21	PIN, Clevis	2
102	AN364-832	NUT, Lock	1
103	31908-00	BOLT	1
104	31909-02 (24V)	KNOB, Landing gear	1
	31909-00 (12V)	KNOB, Landing gear	1
105	52-040-187-0312	PIN, Roll (ESNA)	2
106	31910-00	TUBE, Lever	1
107	31931-00	LEVER, Landing gear	1
108	31932-00	TERMINAL BLOCK AND WIRE ASSY	2
109	31928-00	LEVER	1
110	10-32NF3	SCREW, Cap 11/16 in. lg	1

(4) P/N 31854-00 NOT USED WITH 750P.
(5) USED WITH POWERPAK ASSEMBLY 750P ONLY.

INDEX NUMBER	PART NUMBER	DESCRIPTION (cont.)	UNITS PER ASSY
111	AN935-10L	WASHER	1
112	31929-00	KNOB, Wing flap	1
113	52-040-187-0750	PIN, Roll (ESNA)	2
114	31942-00	STUD	2
115	31941-00	PLUG	2
116	PRP902-3/4	PACKING, O-ring	2
117	1/4-28NF3	SCREW, Cap socket hd 5/16 in. lg . . .	2
118	AN936B416	WASHER, Lock.	2
119	AN960-PD416	WASHER	2
120	31943-00	RETAINER	2
121	31941-00	PLUG	2
122	PRP902-3/4	PACKING, O-ring	2
123	31907-00	SCREW	2
124	31902-00	WASHER	2
125	31946-00	SPRING.	2
126	31888-00	SPACER	2
127	31902-00	WASHER	2
128	31887-00 (L)	CAMSHAFT	1
	31887-01 (R)	CAMSHAFT	1
129	AN6227-6	PACKING, O-ring	8
130	31803-00	END FITTING	1
131	MS28778-6	GASKET	1
132	MS28775-011	PACKING	1
133	31861-00	POPPET.	1
134	31799-00	SPRING.	1
135	31801-00	BODY	1
136	W/H3400X2	ELBOW	1
137	31911-00	PIPE, Stand	1
138	31840-02	BODY	1
139	AN932-1	PLUG	1
140	31873-00	HEAD, Thermal Relief Valve	4
141	31948-00	END FITTING	1 (6)

(6) USED WITH POWERPAK ASSEMBLIES 31800-02 ONLY.

DESCRIPTION (cont.)

INDEX NUMBER	PART NUMBER		UNITS PER ASSY
142	31885-00	RETAINER	1[6]
143	31963-00	BODY	1[6]
144	AN6227-7	O-RING.	2[6]
145	31899-00	POPPET ASSY	1[6]
146	31814-03	BALL	1[6]
147	31949-00	SPRING.	1[6]
148	31900-00	GUIDE	1[6]
149	31848-00	NUT	1[6]
150	31962-00	CAP	1[6]
151	AN6290-4	PACKING, O-ring	1[6]
152	31917-00	GEAR DETENT CAP	1[6]
153	31915-00	SPRING.	1[6]
154	31916-00	DETENT SPRING GUIDE	1[6]
155	31914-00	PLUNGER DETENT	1[6]
156	PRP902-3/4	PACKING	1[6]
157	31878-00	THERMAL RELIEF VALVE ASSEMBLY .	4
158	31950-00	POWERPAK RELIEF VALVE ASSEMBLY .	1[6]
159	31862-00	POWERPAK CHECK VALVE ASSEMBLY .	1
160	AN6227-15	PACKING, O-ring	1[7]
161	32278-00	ADAPTER, Relief Valve	1[7]

(6) USED WITH POWERPAK ASSEMBLIES 31800-02 ONLY.
(7) USED WITH POWERPAK ASSEMBLIES 31800-02M ONLY.

PIPER POWER PACK SERVICE LIMITS						
INDEX FIG 6-7 PGS. 6-20 & 6-21	PART NO.	ITEM	MFG. TOL.	NOMINAL	MIN. SERVICE LIMIT	MAX. SERVICE LIMIT
21	31937-00	I.D. Seat-Check	±.005	.171	.1655	.1765
25	31951-00	I.D. Body-Relief Valve	+.002 -.000	.343	.343	.3452
31	31952-00	O.D. Plunger	+.000 -.005	.160	.1545	.160
34	31954-00	I.D. Seat	±.001	.135	.1339	.1361
58	31935-00	I.D. Stop	+.002 -.000	.705	.705	.7072
60	31938-00	O.D. Piston-Shaft	+.000 -.001	.704	.7029	.704
60	31938-00	O.D. Piston-Head	+.000 -.004	.998	.9936	.998
64	31937-00	I.D. Seat-Check	±.005	.171	.1655	.1765
73	31874-00	I.D. Seat	±.001	.100	.0989	.1011
77	31905-00	O.D. Plunger	+.000 -.003	.217	.2137	.217

PIPER POWER PACK SERVICE LIMITS (cont.)

INDEX FIG 6-7 PGS. 6-20 & 6-21	PART NO.	ITEM	MFG. TOL.	NOMINAL	MIN. SERVICE LIMIT	MAX. SERVICE LIMIT
91 & 84	31854-00 [1]	Poppet & Seat Ass'y				
	31853-00	I.D. Seat	+.0005 -.0000	.3125	.3125	.31305
	31852-00	O.D. Poppet	+.0000 -.0003	.3122	.31187	.3122
128	31887-00 (L) 31887-01 (R)	O.D. Spool (Camshaft)	+.0000 -.0005	.4365	.43595	.4365
138	31840-02 31840-03	Body-Bushing Ass'y				
		I.D. Piston Head Bore	+.003 -.000	1.000 1.000	1.000	1.0033
		I.D. Spool Bore	+.002 -.000	.437	.437	.4392
		I.D. Spool Detent Bore	+.003 -.000	.219	.219	.2223

(1) NOT USED WITH POWERPAK ASSEMBLY 750P.

6-32. REMOVAL AND INSTALLATION OF MAIN RELIEF VALVE. Remove the reservoir, baffle and plates. (Refer to Paragraph 6-30.) Then remove the main relief valve by cutting the lock wire (27, Figure 6-7) and removing Items 25 through 36. Replace in the reverse order. Safety with lock wire (27) in accordance with standard procedures. Be sure to observe the precautions outlined in paragraph 6-27.

6-33. REMOVAL AND INSTALLATION OF THERMAL RELIEF VALVES. Remove the reservoir, baffle and plates. (Refer to Paragraph 6-30.) Of the four thermal relief valves, select the one to be removed and remove Items 67 through 74. (Refer to Figure 6-7.) Replace in the reverse order. Be sure to observe the precautions outlined in paragraph 6-27.

6-34. REMOVAL AND INSTALLATION OF DETENTS. Remove the reservoir, baffle and plates. (Refer to Paragraph 6-30.) Of the two detents, select the one to be removed and remove Items 75 through 79. (Refer to Figure 6-7.) Replace in the reverse order. Be sure to observe the precautions outlined in paragraph 6-27.

6-35. REMOVAL AND INSTALLATION OF POPPETS. Remove the reservoir, baffle and plates. (Refer to Paragraph 6-30.) Of the 10 poppets, select the one to be removed and remove Items 80 through 86 or 87 through 93 depending on the type of poppet. (Refer to Figure 6-7.) Replace in the reverse order. Be sure to observe the precautions outlined in paragraph 6-27.

6-36. REMOVAL AND INSTALLATION OF SELECTOR CAMS (SPOOLS). Remove the reservoir, baffle and plates. (Refer to Paragraph 6-30.) Of the two cams (128, Figure 6-7), select the one to be removed and release the spring tension on the five poppets by removing the retainers (80 and 87). Release the spring tension on the appropriate detent. Disconnect the appropriate link (97), and remove Items 117 through 129. Replace in the reverse order. Be sure to observe the precautions outlined in paragraph 6-27.

6-37. REPAIR AND REPLACEMENT PROCEDURES.

6-38. GENERAL. The repair and replacement procedures are limited to minor repair of the actuating cylinders and engine driven pump and replacement of worn or damaged parts in the Hydraulic Powerpak.

6-39. REPAIR AND REPLACEMENT OF ACTUATING CYLINDERS. Actuating cylinders may leak externally at either elbow or at the seal. A coating of oil between the upper and lower elbows indicates leakage of the top elbow, whereas a coating of oil immediately under the bottom elbow only indicates leakage of the bottom elbow. If the bottom of the cylinder is coated with oil, the seal is leaking. Repair the cylinder as follows:

CAUTION

If one or more of the landing gear actuating cylinders are damaged, be sure the aircraft is on jacks before attempting any repairs. This is not necessary if the wing flap cylinder is to be repaired or replaced.

CAUTION

Be sure both selector levers are in the neutral position before disconnecting a hydraulic line from a fitting.

a. If either elbow fitting is leaking, do not remove the actuating cylinder from the aircraft. Remove the appropriate line and take out the fitting. If the leakage is through the threads, apply a suitable sealing compound, to the threads of the fitting and install the fitting. If the fitting is damaged, replace with a new one and reconnect the hydraulic line.

b. If the seal is leaking, remove the actuating cvlinder from the aircraft (Refer to Paragraph 6-21) and disassembly as follows:

(1) Remove the lower hose elbow fitting and the two end plug retaining pins from the cylinder.

(2) Pull out the piston and end plug.

(3) Remove the bearing and locknut from the end of the piston rod and slide the end plug off.

(4) Replace the O-ring on the piston and in the end plug. Apply a coating of hydraulic fluid to both O-rings.

c. Apply a light coating of hydraulic oil to the piston rod and reassemble as follows:

(1) Carefully work the end plug on the piston rod.

CAUTION

Avoid damaging the end plug O-ring.

(2) Insert the piston rod and O-ring into the cylinder and secure with the two end plug retaining pins. Be sure the pins enter the holes in the sides of the end plug. Lock-wire the two pins.

d. Install the actuating cylinder on the aircraft. (Refer to Paragraph 6-21.)

e. Check the repair by placing the appropriate selector lever in the "UP" or "DOWN" position and operating the hand pump until the selector lever returns to neutral.

6-40. REPAIR AND REPLACEMENT OF HYDRAULIC POWERPAK. Repair of the Hydraulic Powerpak consists of replacing damaged or worn parts as required. (Refer to Table VI-III, Powerpak Troubleshooting.) Damage to the housing itself, including valve seats and bores, requires the return of the Powerpak to the manufacturer. For part numbers of items to be replaced, refer to the legend for Figure 6-7.

6-41. ADJUSTMENTS AND TESTS.

6-42. POWERPAK ADJUSTMENTS AND TESTS.

NOTE

There must be no external leakage of the Powerpak during any of the following tests or adjustments. If leakage exists, refer to Table VI-III, Powerpak Troubleshooting.

6-43. INTERNAL LEAKAGE TEST. Using the test equipment specified in Table VI-IV, install the Powerpak securely on a rigid base and connect a pressure line and pressure gauge between the Powerpak and the test hand pump. Also, connect a line between the Powerpak system port and the intake on test hand pump. Make certain the selector levers are in the neutral position and fill the reservoir with filtered hydraulic fluid, Specifications MIL-H-5606. Using the test hand pump; apply 500 psi to each port in turn. There must be no evidence of internal leakage. If internal leakage exists, hydraulic fluid will flow from one of the open ports, and Powerpak must be re-examined for the trouble. Refer to Table VI-III, Powerpak Troubleshooting.

6-44. POWERPAK BLEEDING PROCEDURE. Drain the Powerpak of hydraulic fluid, remove the reservoir, install the open top reservoir and fill with filtered hydraulic fluid. Connect a cylinder, gauge, bleeder and two speed control valves to each pair of cylinder ports (landing gear and wing flaps). Connect the test hand pump between the system port and pressure port of the Powerpak.

TABLE VI-IV. SPECIAL TOOLS AND TEST EQUIPMENT

Part No.	Nomenclature	Manufacturer
Cat. No. 1	Retaining Ring Pliers	Waldes-Kohinoor Inc. 47-16 Austel Place Long Island City 1, N. Y. 11101
Cat. No. 3	Retaining Ring Pliers	Waldes-Kohinoor Inc. 47-16 Austel Place Long Island City 1, N. Y. 11101
525	Hand Pump (3000 psi max)	Hucktrol Inc. Hydraulics 1943 Grand St. Kingston, N. Y. 12401
31870-02	Actuating Cylinder, 2 reqd. (double acting, 1-1/4 in. ID x 8-in. stroke)	Piper Aircraft Corporation Lock Haven, Penna. 17745
540-5	Speed Control Valve, 4 reqd. (adjusted for 300-400 psi back pressure)	Hucktrol Inc. Hydraulics 1943 Grand St. Kingston, N. Y. 12401
	Pressure Gage, 4 reqd. (3000 psi, 2-in. dial)	Standard
	Reservoir, Open Top	

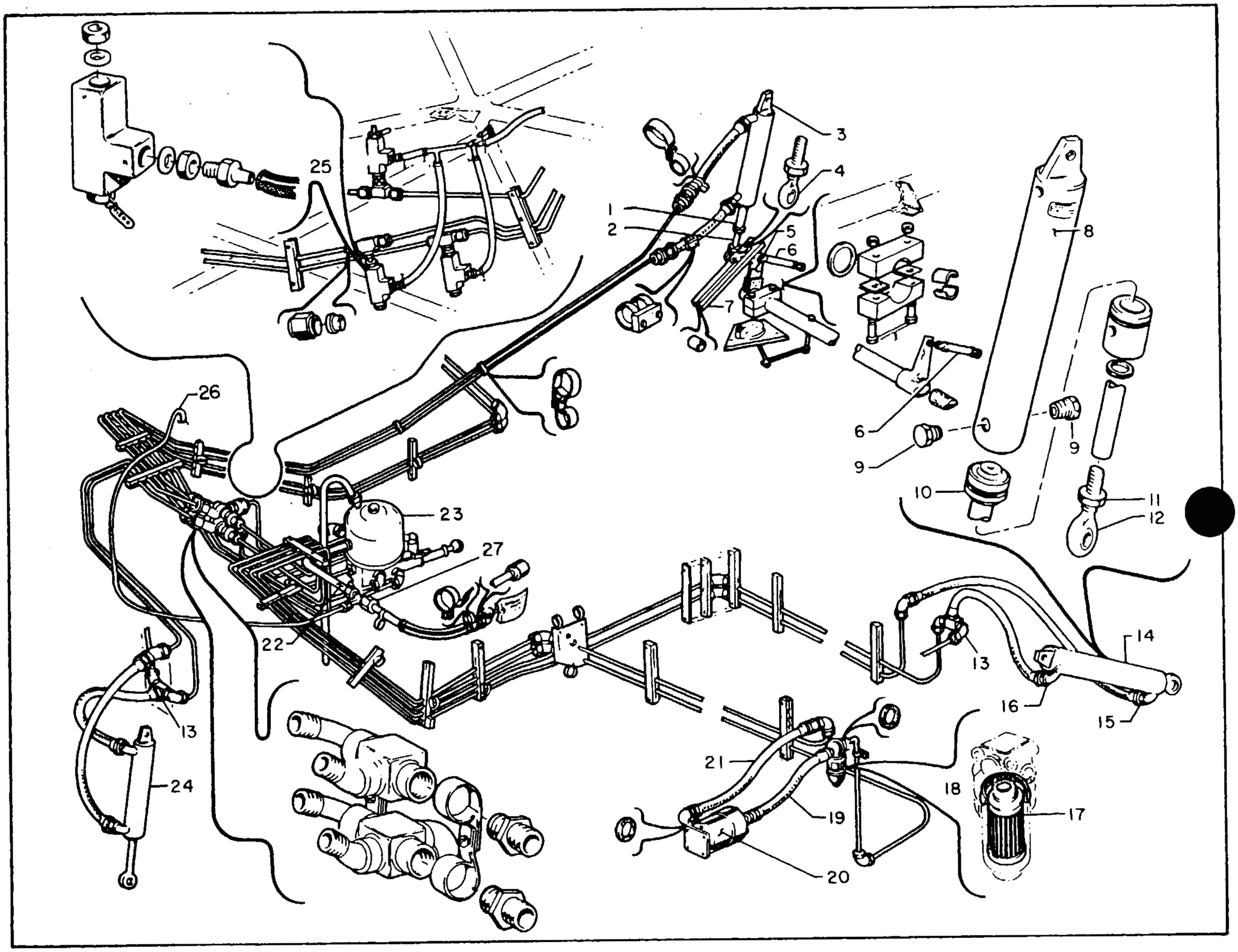


Figure 6-8. Hydraulic System

Legend for Figure 6-8

1. BUSHING
2. TUBE
3. FLAP ACTUATING HYDRAULIC CYLINDER ASSEMBLY
4. END BEARING
5. FLAP BELLCRANK ASSEMBLY
6. FLAP CONTROL ROD ASSEMBLY
7. FLAP ACTUATING ARM GUIDE BLOCK
8. GEAR CYLINDER BODY AND BUSHING ASSEMBLY
9. 1/8-INCH PIPE PLUG
10. O-RING PACKING
11. CHECK NUT
12. END BEARING
13. SHUTTLE VALVE
14. MAIN GEAR ACTUATING HYDRAULIC CYLINDER
15. LOWER ELBOW
16. UPPER ELBOW
17. FILTER ELEMENT
18. OIL FILTER ASSEMBLY
19. FLEXIBLE HOSE ASSEMBLY
20. HYDRAULIC PUMP
21. FLEXIBLE HOSE ASSEMBLY
22. POWERPAK FILLER TUBE ASSEMBLY
23. POWERPAK
24. NOSE GEAR HYDRAULIC ACTUATING CYLINDER
25. THERMAL RELIEF VALVE (USED WITH POWERPAK 750P)
26. THERMAL RELIEF VALVE RETURN LINE (USED WITH POWERPAK 750P)

Connect the gauge between the test hand pump and the pressure port. Proceed as follows:

NOTE

This bleeding procedure, using the open top-reservoir, must be performed prior to adjusting the cracking pressures. (Refer to Paragraph 6-45, below.) The same procedure may be performed at any other time using the Powerpak's reservoir and hand pump.

a. Move the "LANDING GEAR", selector lever to the "DOWN" position and operate the test hand pump until the piston in the test cylinder bottoms (300psi). Open the bleeder in the line under pressure and operate the hand pump until the air is expelled from the system. Cycle four times. Place the "LANDING GEAR" selector lever in the neutral position.

b. Repeat step "a", above, with the wing "FLAPS" lever in the "DOWN" position.

c. Repeat step "a" above, with the "LANDING GEAR" lever in the "UP" position.

d. Repeat step "a", above, with the wing "FLAPS" lever in the "UP" position.

6-45. CRACKING PRESSURE ADJUSTMENTS. With the Powerpak connected and bled as described in Paragraph 8-44, proceed as follows:

a. Hold either selector lever in either the "UP" or "DOWN" position, operate the test hand pump and adjust the main relief valve to crack at 1250-1300 psi. To adjust the main relief valve, loosen the nut (29, Figure 6-7) and turn the screw (28).

b. Move the "LANDING GEAR", selector lever to either the "UP" or "DOWN" position. Operate the test hand pump and adjust the detent spring, by turning the plug (75) to permit lever release to neutral, after the piston bottoms, at 1150 to 1200 psi. The system must maintain approximately 500 psi when the lever is at neutral.

c. Repeat step "b", above, with the wing "FLAPS" selector lever in the "UP" or "DOWN" position. Adjust the detent spring to permit lever release to neutral at 1150 to 1200 psi. The system must maintain approximately 500 psi when the lever is at the neutral position.

d. Cycle steps "b" and "c", above, 10 times each.

e. With either selector lever in both the "UP" and "DOWN" positions, in turn, operate the Powerpak hand pump until the piston bottoms each time.

f. Disconnect the four actuating cylinder lines from the cylinder ports on the Powerpak. Disconnect the test hand pump pressure line from the pressure port on the Powerpak and connect it to a cylinder port. Operate the test hand pump and adjust the thermal relief valve, by turning the screw assembly (67 Figure 6-7). On Powerpak 750P-1 bearing Serial No. 1 to No. 2023 inclusive, the cracking pressure is set at 2000 to 2050 pounds per square inch. If Powerpak 750P-1 with Serial No. 2024 through 2033, 2035 and up is used, set cracking pressure on thermal relief valves at 1850 to 1900 pounds per square inch.

NOTE

When disconnecting hydraulic lines from the Powerpak, have a small container on hand to catch the fluid.

g. Repeat step "f" above, for each thermal relief valve.

h. Drain the Powerpak of hydraulic fluid and disconnect from the test set up. Replace the open top reservoir with the standard closed reservoir and install the Powerpak in the aircraft as described in paragraph 6-23.

6-46. HYDRAULIC SYSTEM TEST.

6-47. FINAL CHECK. After the Powerpak is installed in the aircraft and all lines are connected, fill with hydraulic fluid (Refer to Filling Powerpak Reservoir, Section II) and check the operation of both selector levers.

6-48. EMERGENCY GEAR EXTENSION SYSTEM, CO_2.

6-49. EMERGENCY GEAR EXTENSION SYSTEM. In the event of a hydraulic system failure caused by a line breaking or the Powerpak malfunctioning, the landing gear can be lowered by using the emergency gear extender. The control for the extender is located beneath a small cover plate under the pilots seat. When the control is pulled CO_2 flows from a cylinder under the floorboards through separate lines to the landing gear cylinders and extends the gear.

6-50. SERVICING. Replace the CO_2 bottle whenever it weighs less than 132 grams or one gram less than the weight marked on the bottle.

6-51. RESETTING EMERGENCY GEAR EXTENDER.

CAUTION

After using the emergency gear extender, do not actuate "LANDING GEAR" or "FLAP" until the following procedures have been performed.

a. Place the aircraft on jacks. (Refer to Jacking, Section II.)
b. Loosen the CO_2 lines at the fitting, adjacent to the CO_2 bottle, thus allowing release of the pressure in the hydraulic system.

WARNING

Do not remove CO_2 bottle until the pressure is released.

c. Fill the hydraulic system as described in Filling Powerpak Reservoir, Section II.
d. If repairs are necessary, refer to Troubleshooting and the appropriate paragraph in this section for repair of the hydraulic system.
e. After the hydraulic system has been repaired, filled and checked, reconnect the CO_2 lines and safety the discharge mechanism ring with 0.016 inch soft aluminum safety wire. After arming the cutter head by positioning the cable actuated lever against the cutter head body, install a charged CO_2 bottle and anchor with the set screw.

SECTION VII

LANDING GEAR AND BRAKE SYSTEM

Issued: 3/15/68

SECTION VII

LANDING GEAR AND BRAKE SYSTEM

7-1. GENERAL.

7-2. In a normal landing operation, the main landing gear oleo struts serve as the primary shock-absorbing elements as well as supporting the weight of the aircraft. It is during the braking application that the nose landing gear oleo is called upon to receive its maximum load. This is the result of a portion of the aircraft weight being transferred to the wheel in addition to the load produced by the momentum of the aircraft being translated around the brake-retarded main wheels. The loads are transmitted to, and distributed by, the primary structure of the aircraft. When the oleo struts are properly filled and inflated, they will satisfy the above demands. Refer to Section II for establishing these settings.

7-3. A steerable aircraft on the ground which will also produce minimum component wear is another requirement of the landing gear. These two features are the prime effects of a correctly aligned landing gear.

7-4. The landing gear, above all else, must never fail in its extended position. The devices responsible for the maintenance of this condition are the mechanical downlocks. It is imperative, therefore, that their adjustment is carefully made and that it is frequently checked.

7-5. LANDING GEAR SYSTEM.

7-6. REMOVAL.

7-7. NOSE GEAR REMOVAL.

a. Place the aircraft on jacks. (Refer to Section II.)

b. Remove both of the front fuselage access panels from the sides of the nose and the nose fairing. (Refer to Section II.)

c. Disconnect the nose gear steering rod assembly from the steering bellcrank to free the canvas cover. Remove all of the canvas cover attaching screws and strip off the cover.

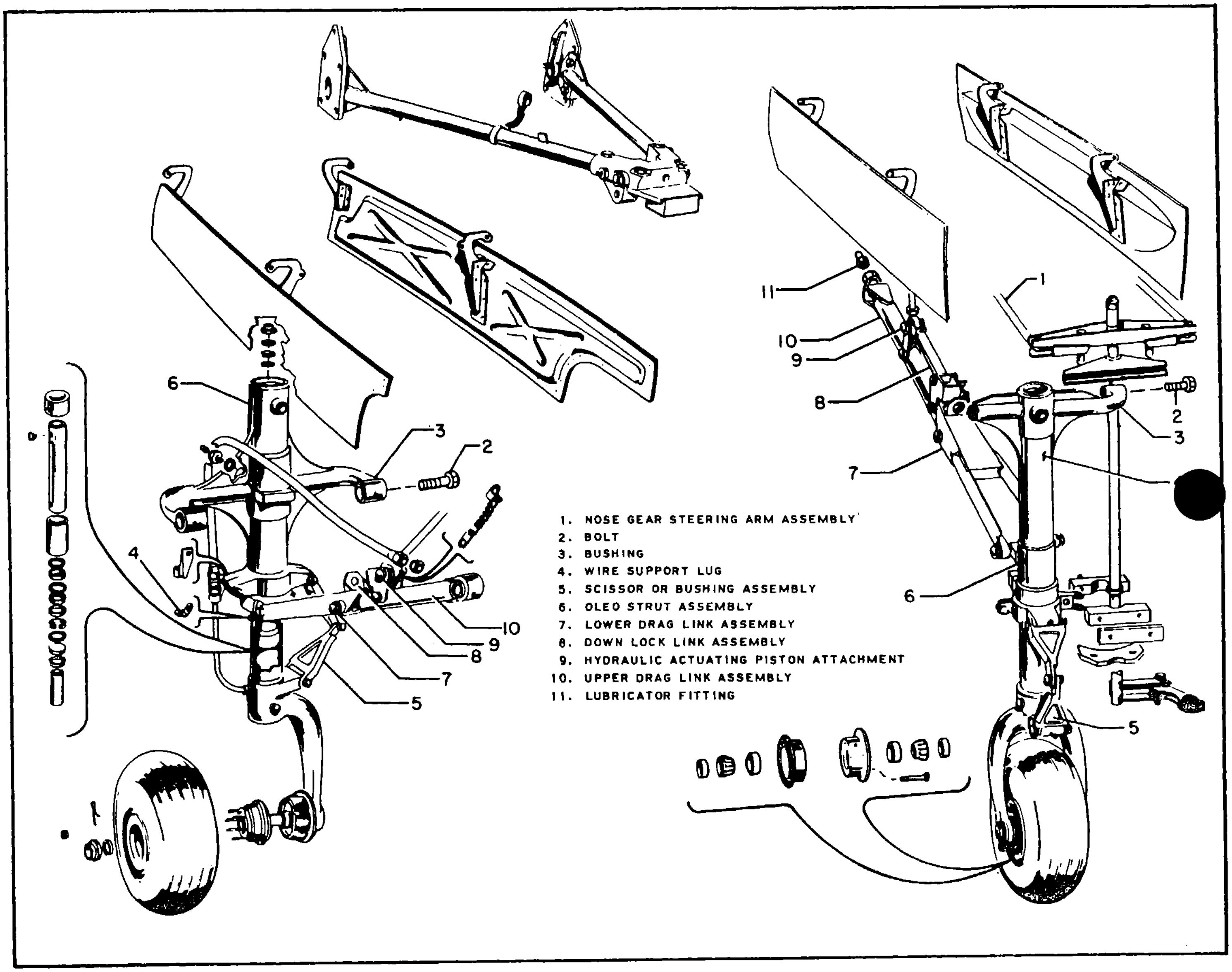


Figure 7-1. Landing Gear Installation
Serial Numbers 23-1 to 23-1837 incl.

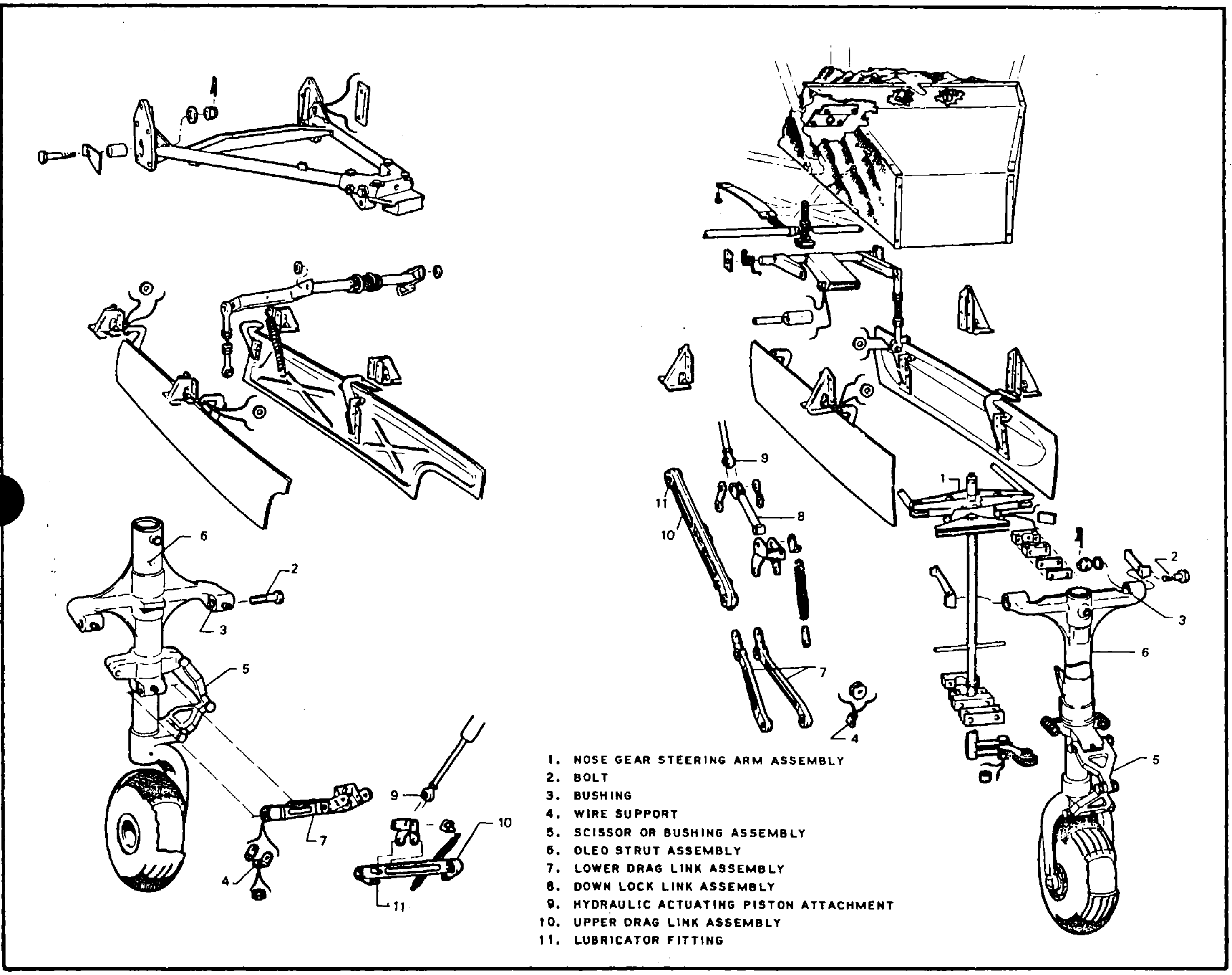


Figure 7-2. Landing Gear Installation
Serial Numbers 23-1838 and up

d. Remove the clamp from around the nose gear oleo strut cylinder, freeing the wire to the nose gear lower drag link assembly switch.
e. Disconnect the drag link assembly from the oleo cylinder.
f. Remove the cotter pin and bolt from each side of the oleo strut, freeing the strut.

NOTE

Do not force the left bolt out completely, as it is difficult to reinstall. Push it out far enough to permit removal of the gear.

g. Disconnect the remaining two electrical leads.
h. Disconnect the two hoses from the hydraulic actuating cylinder.
i. Disconnect the nose gear upper drag link assembly from the tubular structure.
j. Disconnect the actuating cylinder from its pivotal attaching point at the tubular structure.
k. Separate the hydraulic actuating cylinder piston rod from the nose gear down-lock link assembly and remove the entire nose gear assembly.

7-8. MAIN GEAR REMOVAL. Remove the main landing gear installation in a manner similar to that described for the nose gear. Refer to Figure 7-1, Serial Numbers 23-1 to 23-1837 inclusive, or Figure 7-2 for aircraft bearing serial numbers 23-1838 and up for an illustration of the gear and its related parts.

7-9. OLEO STRUT REMOVAL. Remove the oleo strut and disassemble it in accordance with the instructions below.

CAUTION

Discharge air pressure from oleo strut before disassembly.

a. Separate the scissor and bushing assembly (5, Figure 7-1.)
b. Compress and remove the snap ring (16, Figure 7-5).
c. Remove the fork and piston assembly of the oleo strut assembly (6, Figure 7-1) from the body and bushing assembly.
d. Remove the bolt or nut (1, Figure 7-5) from the top of the body and bushing assembly.
e. Remove the washer (2).
f. Compress and then remove the snap ring (7) and the plate (6).
g. Reach into the piston and push out the pins (9).

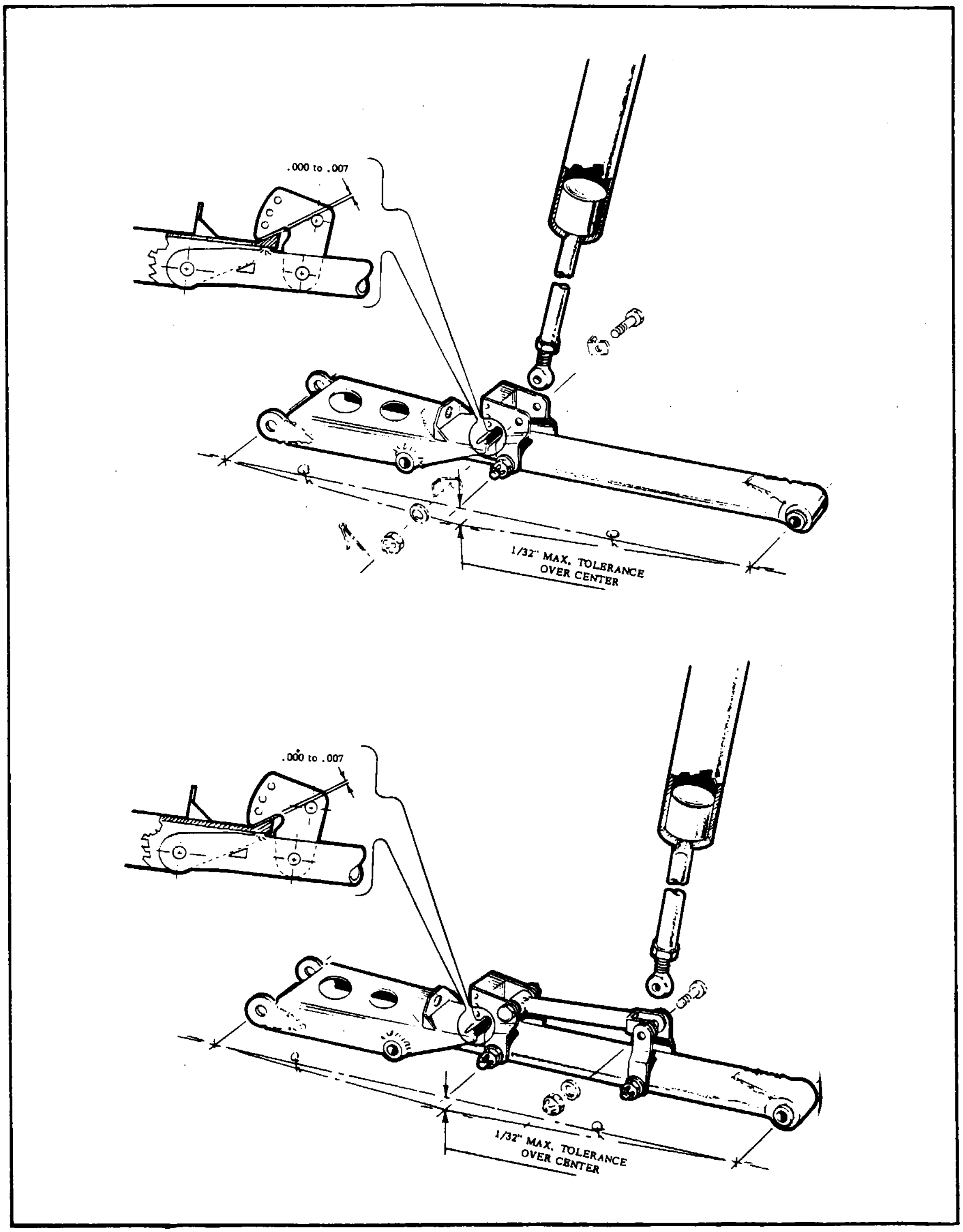


Figure 7-3. Landing Gear Drag Link (Fabricated Type)

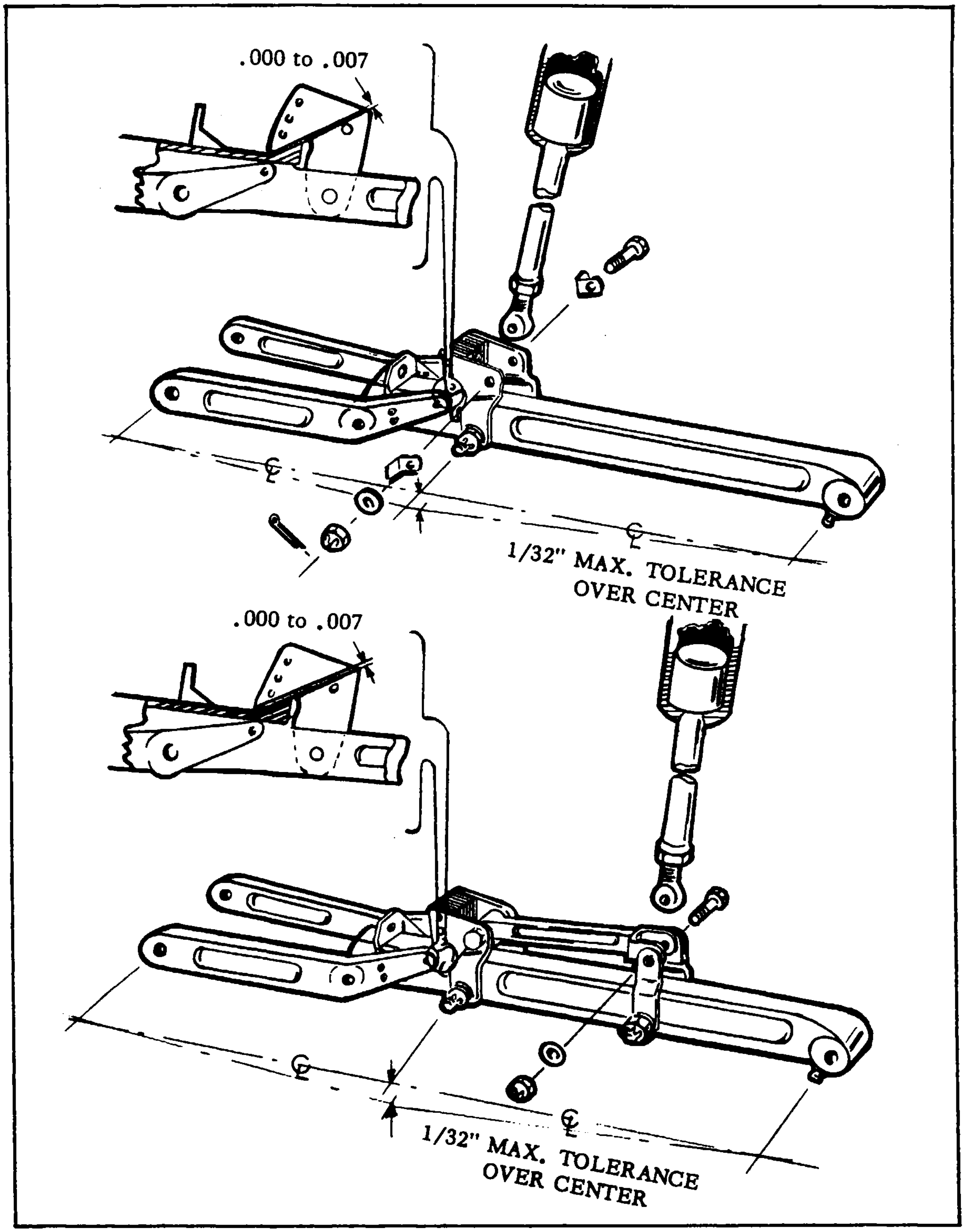


Figure 7-4. Landing Gear Drag Link (Forged Type)

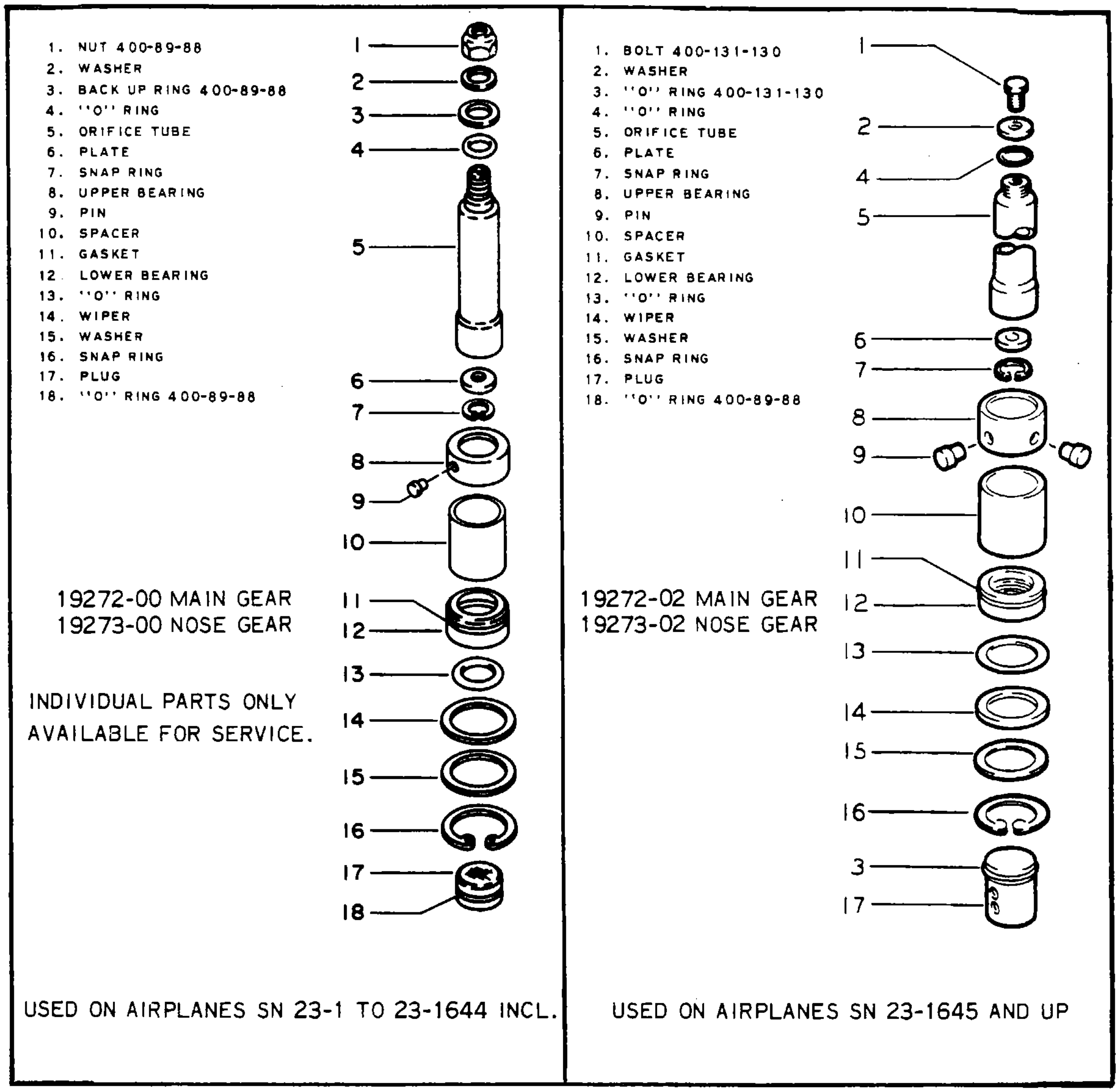


Figure 7-5. Oleo Strut, Exploded View of Internal Parts

h. Slide off the upper bearing (8), the spacer (10), the lower bearing (12) and the washer (15).

i. Remove the wiper (14), the O-ring (13), and the gasket (11).

7-10. INSTALLATION.

7-11. NOSE GEAR INSTALLATION.

a. Position the nose gear oleo strut assembly bushings so that they align with the attaching points at the front of the tubular structure and push the bolts in place. Install a washer and castellated nut on each bolt. Safety both nuts with cotter pins.

b. Connect the actuating cylinder to the tubular structure with a bolt, washer, castellated nut, and a cotter pin.

c. Connect the end of the nose gear upper drag link assembly to the vee formed by the two members of the tubular structure whose forward ends support the oleo strut assembly. Secure the bolt with a washer, castellated nut and cotter pin.

d. Fasten the fork of the nose gear lower drag link assembly to the oleo strut assembly with two clevis bolts, washers, shear nuts and cotter pins. A small right-angle wire support lug with a grommet in its outstanding leg is placed under the head of the left bolt.

e. Connect the upper hydraulic hose from the firewall to the lower connection of the actuating cylinder. Connect the lower hydraulic hose to the upper connection of the cylinder.

f. Clamp the two-wire cable to the oleo strut assembly with two sheet metal hand clamps. Clamp the cable to the tubular structure.

g. Reconnect the two leads from the harness to the two-wire cable.

h. Align the wheel. (Refer to Paragraph 7-14.)

i. Install the canvas cover, passing it over the nose gear steering rod assemblies and clamp it around the bottom of the hydraulic actuating cylinder.

j. Attach the steering rods to the steering bellcrank with bolts, washers and self-locking nuts.

k. Fasten the remainder of the canvas cover to the nose wheel well with truss-head screws.

l. Adjust the bumper block so that the oleo strut assembly compresses the rubber pad approximately 1/16 of an inch.

NOTE

The oleo strut assembly is made to bear against the pad to eliminate up and down bouncing of the strut assembly. The bumper block provides the necessary solid resistance without damaging the gear.

m. Lower the aircraft and remove the jacks.

7-12. MAIN GEAR INSTALLATION. Install the main gear in the same general manner as the nose gear installation. (Refer to Figure 7-1 or Figure 7-2.)

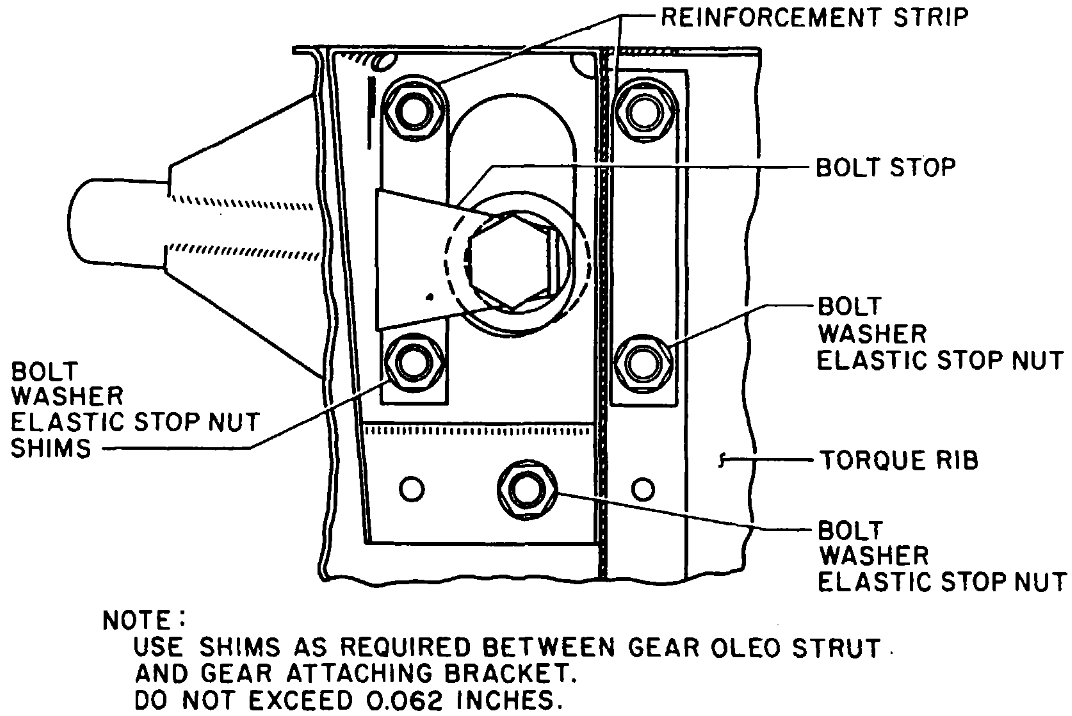


Figure 7-6. Main Gear Attaching Detail

CAUTION

Be sure each attaching bolt is seated properly in the bolt stop inside the torque rib. (Refer to Figure 7-6.)

7-13. OLEO STRUT INSTALLATION.

a. Install the O-ring (3 or 18, Figure 7-5) on the plug (17) and install the plug in the fork and piston assembly of the oleo strut assembly (6, Figure 7-1.)

b. Slide the snap ring (16, Figure 5-3) and washer (15) on the piston.

c. Insert the wiper (14), the O-ring (13) and the gasket (11) in the lower bearing (12). Be careful not to damage these items.

d. Slip the lower bearing on the piston using a twisting motion and a light coat of hydraulic fluid to facilitate installation.

e. Install the spacer (10), the upper bearing (8) and the pins (9).

f. Install the plate (6) and snap ring (7) in the orifice tube (5).

g. Install the O-ring (4), the washer (2) and the nut or bolt (1) on the orifice tube. Tighten bolt or nut.

h. Carefully insert the fork and piston assembly in the body and bushing assembly until the snap ring (16) can be installed in the annular slot at the end of the body and bushing assembly.

7-14. ADJUSTMENTS

7-15. NOSE GEAR ALIGNMENT.

a. Attach a plumb bob to the nose landing gear bumper block or to the lubricator fitting at the end of the nose gear upper drag link assembly.
b. Attach a plumb bob to the tail skid.
c. Using the two plumb bobs as a guide, snap a chal-k line, extending several feet beyond each bob, on the ground.
d. Stand in front of the nose landing gear and orient the tire with the chalk line. Sight along the tire center rib.
e. Adjust both bearings at the ends of each of the nose gear steering rod assemblies to get the four cockpit control pedals aligned. Do not attempt to make the adjustment by means of one bearing but divide the adjustment between

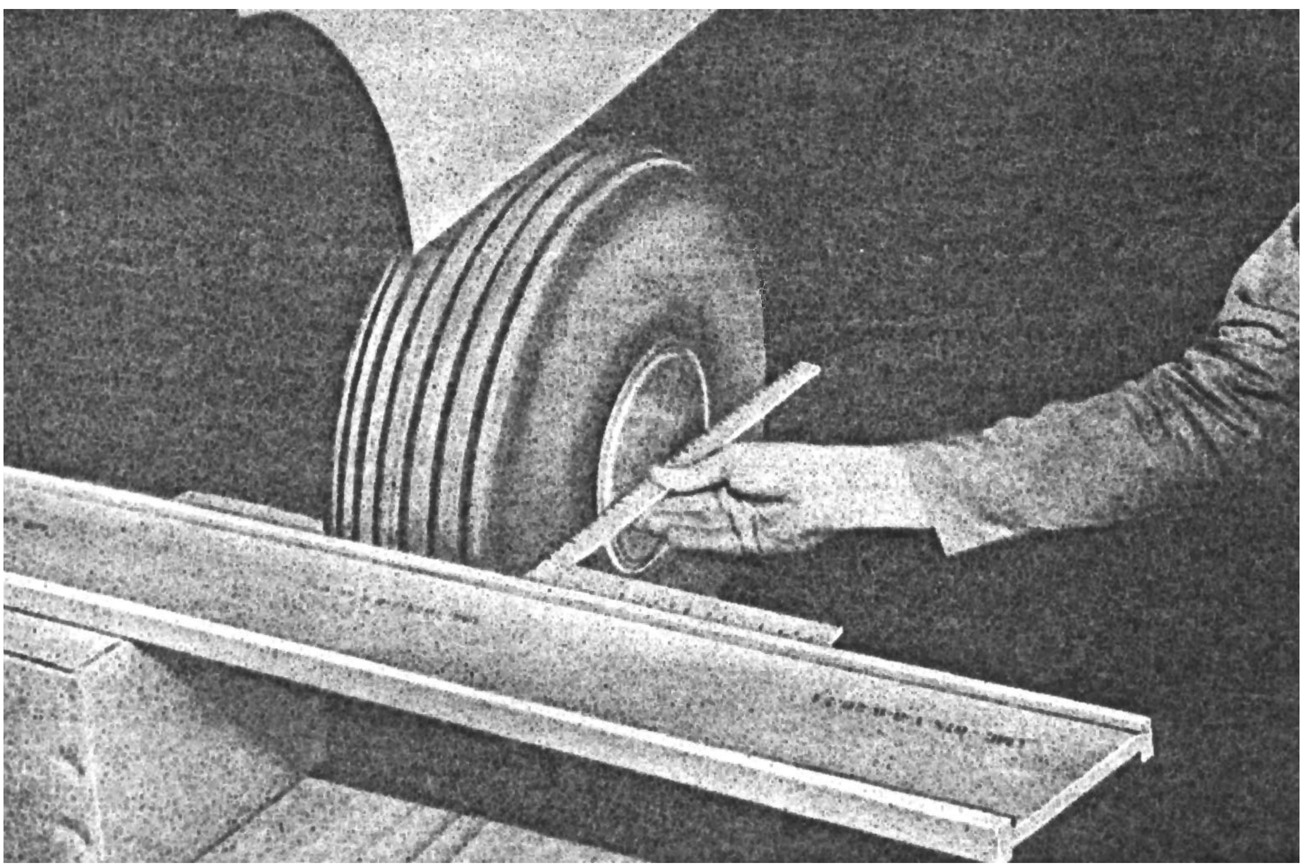


Figure 7-7. Checking Wheel Alignment

the bearings at each end of the steering rod.

NOTE

Make sure no gap exists at the point where the flange plate makes contact with the two pins in the rudder steering arm in order to insure full travel of the nose wheel. Add enough shims to the steering torque rod at these points to accomplish this. Make the adjustment when there is no load at these points.

f. Adjust the shimmy dampener collar by means of its washers to give a good firm fit. If the collar is too tight, the result will be hard steering and, if too loose, nose wheel shimmy will be present. It may be necessary, at times, to try several combinations or thicknesses of washers to get the proper result.

NOTE

The shimmy dampener is the collar to which the top of the scissor and bushing assembly and the lower end of the steering shaft is fastened. This collar is composed of two halves. It has a split friction lining between the collar and gear casting and utilizes washers as space adjustments between the halves of the collar.

CAUTION

Do not lubricate the collar and shoe assembly.

7-16. MAIN LANDING GEAR WHEEL ALIGNMENT.

a. Place a straight edge no less than twelve feet long across the front of both main landing gear wheels. Butt the straight edge against the tire at the hub level. Devise a support, or use a box, to hold the straight edge in this position.

b. Set a square against the straight edge and check to see if its outstanding leg bears on the front and rear sides of the tire. (Refer to Figure 7-7.) If it touches both outboard sides of the tire, the landing gear is correctly aligned. The toe-in for these wheels is O degrees.

NOTE

A carpenter's square, because of its especially long legs, is recommended for this check.

c. If the square contacts the rear side of the tire, leaving a gap between it and the front side of the tire, the wheel is toed-in. If a gap appears at the rear, the wheel is toed-out.

d. Rectify a toed-in condition by removing the cotter pin, castellated nut and bolt at the common pivotal point of the scissor and bushing assembly torque links. On the left landing gear add a spacer between the two links. If this same condition exists on the right landing gear, it will be necessary to remove a spacer between the two links. Reassemble the torque links.

e. Recheck the wheel alignment. If corrected, safety the castellated nut with a cotter pin. If this condition still exists, add or remove washers in the same manner mentioned in the above paragraph.

f. Rectify a toed-out condition on the left landing gear by disconnecting the torque links from each other and remove a spacer between the links. It will be necessary to add a spacer between the links on the right landing gear. Reconnect the links and recheck the alignment.

g. If still further adjustment is required, repeat procedure mentioned in above paragraph.

NOTE

When adding spacers between the torque links, limit the number installed so that the bolt hole is accessible to the cotter pin.

7-17. ADJUSTING MAIN LANDING GEAR DOORS. Comply with the requirements set forth in the following statements in order to achieve a properly functioning movement of the main gear door assemblies.

a. Adjust the main gear cover actuating tube assembly to close the door assemblies without buckling them when the landing gear is retracted.

b. Do not permit the hinge edge of either door assembly to strike the nacelle skin when the gear is extended and the doors are open. If they do, adjust the main gear cover actuating tube assembly to provide no less than 1/16-inch clearance between the edges of the doors and the skin.

NOTE

When the landing gear is extended, ascertain if there is a minimum clearance of 6-7/8 inches between the interior surface of the inboard door and the confronting side of the piston portion of the fork and piston assembly.

c. It is desirable to have a minimum of from 3/16-inch to 1/4-inch clearance between the landing gear and the adjacent cowling.

7-18. ADJUSTING DOWN-LOCKS.

a. Place the aircraft on jacks. (Refer to Paragraph 2-10.)

NOTE

Be certain the nose wheel is clear and free of the ground or floor before actuating gear for any reason.

b. Remove the bolt connecting the actuator cylinder shaft rod end bearing to the down lock latch. (Refer to Figure 7-4 or Figure 7-3.)

c. Double check to make certain that the piston and shaft of the actuating cylinder is in the fully extended position by re-cycling the powerpak manually.

d. Loosen the bearing lock nut at the end of the piston rod. Adjust the end bearing by turning it in the internally threaded end of the piston rod until the attaching bolt passes freely through the gear down-lock link assembly and the bearing. This adjustment should be made with the latch springs detached and manually holding the latch in the closed position. When assured that the bolt is not binding, tighten lock nut and reassemble springs.

NOTE

If the bearing is over-extended, rather than obtaining the free fit for the bolt as described above, excessive pressure may bend or snap the link.

e. Raise and lower the gear by means of the hand pump and check to see if there is any interference encountered by the down-lock latch and the stop. If it operates smoothly and the latch completely seats itself, the adjustment is correct.

7-19. ADJUSTING LANDING GEAR LIMIT SWITCHES. The limits presented below for the extended and retracted conditions of the landing gear limit switches are common to all three landing gears. Adjust the switches by loosening the stamped, sheet metal nut and the switch mounting nut. Then rotate the nut in whichever direction provides the necessary clearance, tighten the mounting nut until it bears against the bracket and tighten the sheet metal nut to secure the switch.

a. Depress the landing gear selector lever and lower the landing gear by means of the hand pump. Place a 1/8-inch wide spacer between the latch and the switch actuator. Adjust the switch so that the actuator is completely depressed. (Refer to Figure 7-8.)

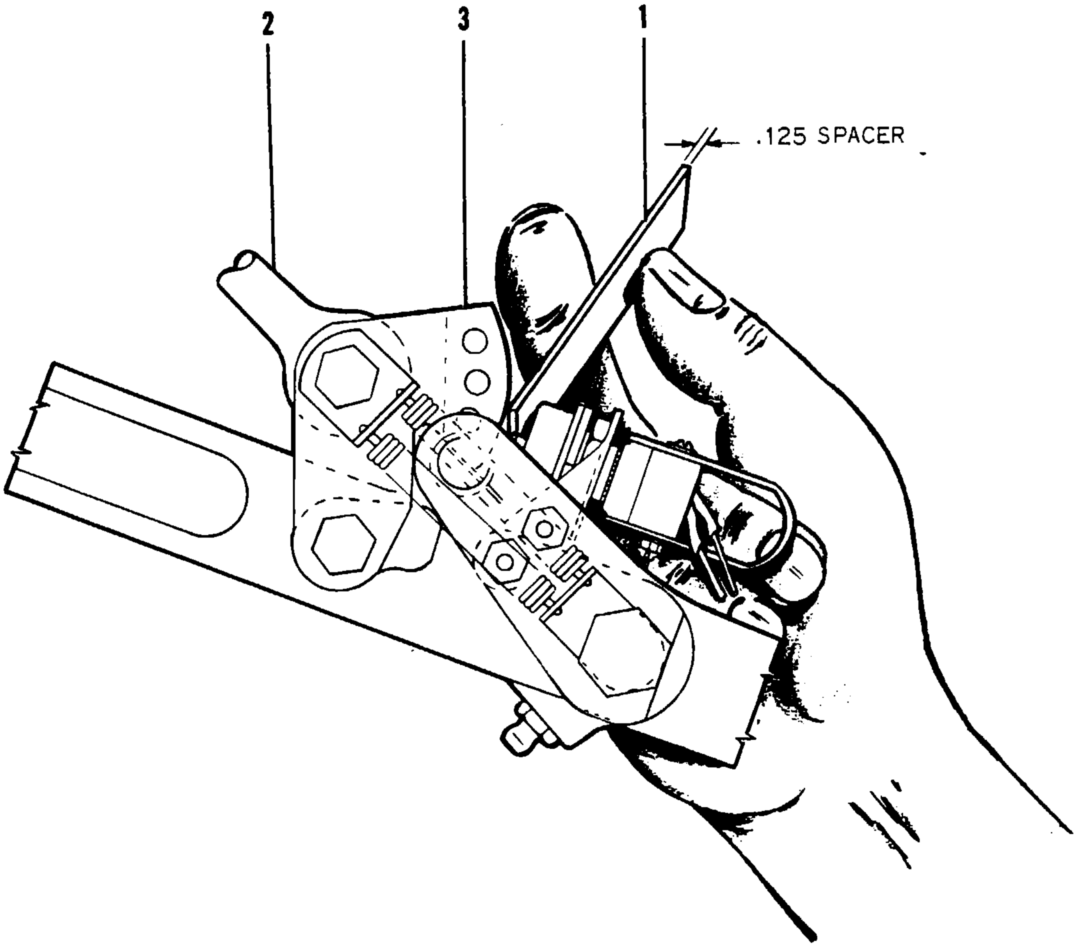


Figure 7-8. Adjusting Landing Gear Limit Switches

b. Remove the nacelle cowling on top of the wing aft of the engine for main landing gear switch adjustments. Remove the canvas cover over the nose wheel well for nose landing gear switch adjustments.

c. Raise the landing gear selector lever and retract the landing gear by means of the hand pump. Place a 1/8-inch spacer between the latch and the switch actuator. Adjust the switch so that the actuator is completely depressed.

d. Install all items removed to facilitate accessibility to the limit switches. Let the aircraft down and remove the jacks.

7-20. ADJUSTING LANDING GEAR ANTI-RETRACTION VALVE. (Refer to Figure 7-9.) The landing gear anti-retraction valve, located on the left main gear strut housing, restricts hydraulic fluid pressure from building up in the retraction system until the landing gear strut is fully extended.

a. Place the airplane on jacks. (Refer to Jacking, Section II.)

b. With the landing gear strut piston in the fully extended position, hold the valve arm in the full down position.

c. Adjust the barrel nut on top of the actuating rod to allow .062 to .093 of an inch as measured at the end of the valve arm.

7-21. BRAKE SYSTEM.

7-22. GOODRICH BRAKE AND WHEEL MAINTENANCE.

NOTE

For efficient operation of the expander tube brake, a few simple rules of maintenance should be followed. Give the same attention to aircraft wheels and brakes as to other aircraft components. Establish and adhere to definite overhaul or inspection periods.

7-23. INSPECTION.

7-24. BRAKE. Make a visual inspection of the brake without removing it from the aircraft.

a. Loosen the adjuster lock nut and back off adjustment cap (turn counter-clockwise) and apply brakes. This will remove pressure trapped in expander tube and allow lining blocks to back off for easier removal.

b. Remove wheel from axle exposing brake.

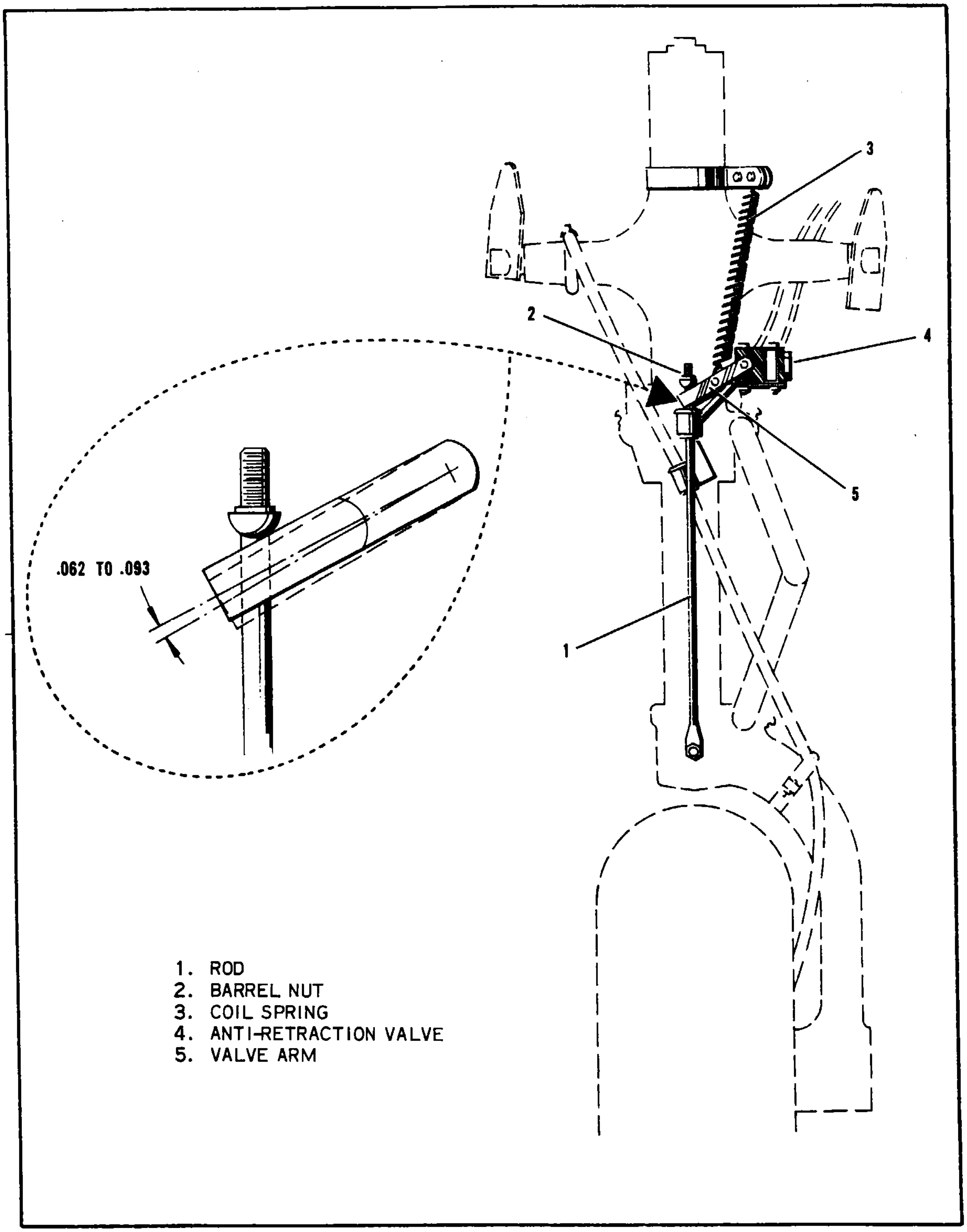


Figure 7-9. Anti-Retraction Valve

CAUTION

Do not apply pressure to brake while wheel (brake drum) is removed.

c. Inspect brake for broken retractor springs (clips). Replace any that are broken.

d. Remove the retractor spring nearest the top of the brake assembly. This will permit removal of the two lining blocks bridged by the removed spring. This may be done by raising the loose end and sliding the lining block from under the retractor spring holding the opposite end in the brake.

e. Measure the thickness of the removed blocks at all four corners, not the retractor spring lip, and take the average. If the measurements average less than 0.220 inch, the brake should be removed for overhaul and rebuilt with new lining.

f. While the two blocks mentioned in (e), above, are out of the assembly, the exposed portion of the expander tube cover should be inspected for indications of excessive heat.

NOTE

The expander tube has an asbestos cover for protection from heat. This is cured in the tube. Discoloration of this asbestos is not to be confused with scorching or hardening of the normal rubber tube cover.

g. If tube appears to be in poor condition, the brake should be removed for overhaul and replacement of the tube.

7-25. WHEEL. Inspect the wheel after removing it as described in Paragraph 7-23.

a. Inspect for tie bolt failure. Replace any found defective.

b. Check the internal diameter of the felt grease seal. Replace the seal if this surface is hard or gritty.

c. Inspect castings for visible signs of cracks or corrosion.

NOTE

If there are indications of cracks, the tire and tube should be removed and the wheel disassembled for a closer inspection of the suspicious area.

d. Replace any castings having visible cracks.

e. Inspect the drum for severe grooving or cracks. Drums should not necessarily be removed from service because of circumferential grooving. Grooves should be permitted until the total width exceeds 3/8 inch before the drum is removed.

7-26. ADJUSTER.

a. Check the brake line and expander tube connections for leaks.

b. Check for rework of adjuster as outlined in B. F. Goodrich Service Bulletin No. 100. If this rework has not been performed, it should be performed at the first opportunity.

c. Inspect the piston face for damage to rubber or for dirt lodged between rubber and machined seat in adjuster body.

d. If brake adjuster does not trap pressure enough to adjust brakes properly, the adjuster spring should be replaced.

NOTE

The above situation may also be corrected by adding a washer into the assembly between the adjuster spring and the bottom of the spring cavity in the piston.

7-27. REASSEMBLY AFTER INSPECTION.

7-28. BLEEDING. If the brake line has been disconnected because of brake or adjuster removal, or if a new brake is installed, bleed the brake and line as prescribed in B. F. Goodrich Service Bulletin No. 101.

7-29. ADJUSTMENT.

a. Reinstall wheel and brake on aircraft.

b. Apply the brakes and release.

c. Check the brake clearance with feeler gage. Clearance should be set between 0.002-0.007 inches.

d. To adjust the shoes out toward the drum and reduce clearance, the adjuster screw should be turned in (clockwise). Apply brake pressure and release. Check clearance.

e. Repeat step (d) above, until the brake adjustment set forth in step (c), above, is attained.

f. When any work is done on the aircraft, the brake cylinders, line and reservoirs should be checked for leaks and the reservoir filled to the proper level.

7-30. CLEVELAND BRAKE AND WHEEL MAINTENANCE.

7-31. INSPECTION AND REPLACMENT OF BRAKE LININGS. Visually inspect brake while installed on airplane. No adjustment of brake clearance is necessary. If, after extended service, the brake linings become excessively worn, replace with new brake linings as follows. (Refer to Figure 7-10.)

NOTE

Linings should be replaced when the thickness of any one segment is 3/32 inch or less.

a. Remove the brake back plates and spacers by removing the bolts from the brake assembly.
b. Remove the nut, the washer, the retraction spring and the sleeve.
c. Move the balance of the brake assembly away from the brake disc far enough to remove the brake pressure plate. (It will not be necessary to disconnect the hydraulic lines.)
d. Remove the used linings by drilling and punching out the old rivets. Install the new brake linings with rivets by using rivet setting kit (part number 754 165) that is available through your nearest Piper distributor or dealer. (This special rivet setting kit should be used as rolling of the rivet is very important to get a tight fit between the rivet and the rivet hole.)

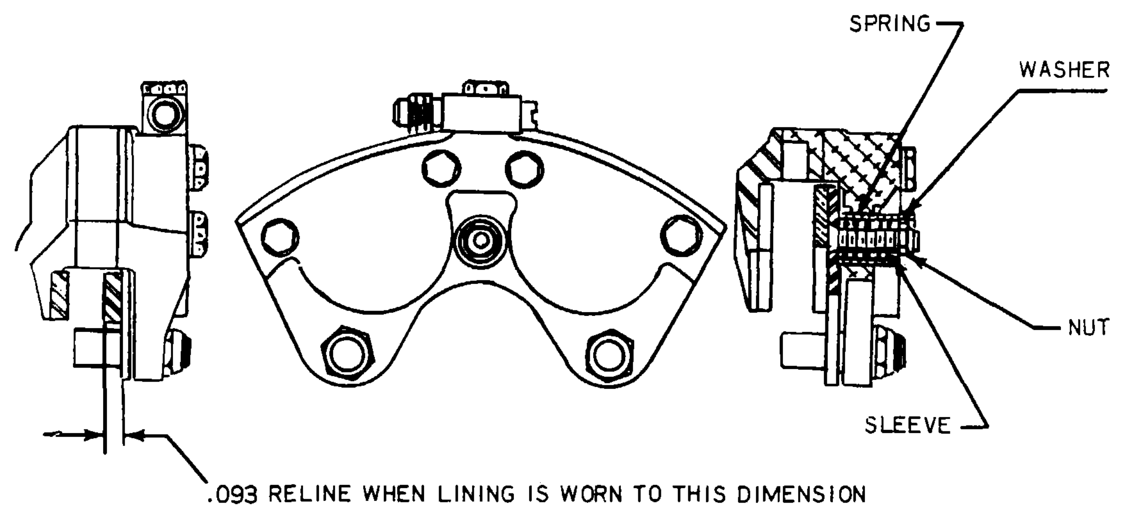


Figure 7-10. Inspection and Replacement of Cleveland Brake Linings

e. Return the automatic adjustment retraction cylinder to its original position by tapping on the inside with a rubber hammer until the end of the cylinder is flush with the brake pistons.

f. Move the balance of the brake assembly away from the brake disc and reinstall the brake pressure plate.

g. After positioning brake assembly on the brake disc, attach the brake back plates and spacers to balance of brake assembly with four bolts.

h. Install the sleeve, the retraction spring, the washer and the nut in brake cylinder on the stud of pressure plate. Turn automatic adjustment nut only to the point of contact with the sleeve. Do not apply torque in excess of that required to overcome the self-locking friction of the nut. After installation no adjustment is necessary.

i. Safety the four bolts on the brake assembly.

NOTES

1. Replacement organic brake linings should be conditioned by performing a minimum of six light pedal effort braking applications from 25-40 MPH, allowing the brakes to partially cool between stops.
2. Replacement metallic brake lining should be conditioned by performing three consecutive hard braking applications from 45 to 50 MPH. Do not allow the brake discs to cool substantially between stops.

7-32. BLEEDING PROCEDURE. If the brake line has been disconnected for any reason, it will be necessary to bleed the brake and line as prescribed below:

a. Place a suitable container at the brake reservoir to collect fluid overflow.

b. Remove brake bleeder screw located at the bottom of the brake bleeder tee.

c. Insert a hose with a bleeder fitting attached into the hole and pressure fill the brake system with MIL-H-5606 fluid.

NOTE

By watching the fluid pass through the plastic hose at the top of the brake reservoir, it can be determined whether any air has entered the system. If air bubbles are evident, filling of the system shall be continued until all of the air is out of the system and a steady flow of fluid is obtained.

d. Remove bleeder hose or device and insert screw.

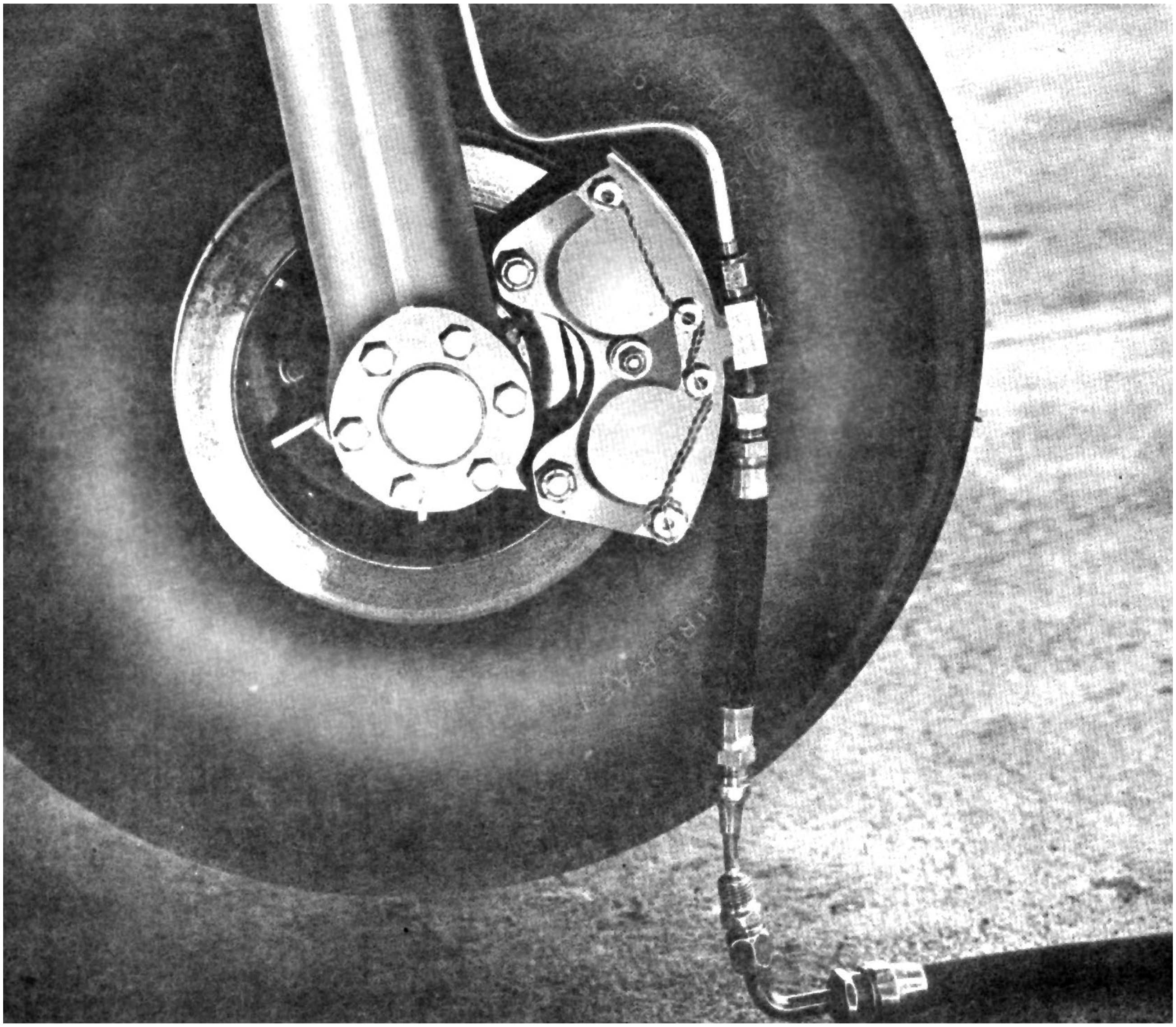


Figure 7-11. Bleeding the Brake

e. Check brakes for proper pedal pressure.
f. This procedure shall be repeated on the other gear.
g. Drain excess fluid from reservoir to fluid level line with a syringe.

7-33. PROCEDURE FOR REPLACING BRAKE DISC ON CLEVELAND WHEEL WHEN DISC IS RIVETED.

a. Remove eight rivets attaching brake disc to inner wheel half by chiseling off the heads and punching out the rivets. (Refer to Figure 5-8, step 1.)
b. Place wheel half assembly into boiling water for five minutes and remove disc from wheel casting by the use of pry bars. (Refer to Figure 5-8, step 2.)
c. Clean casting thoroughly and apply heavy coat of zinc chromate paint in brake disc recess.

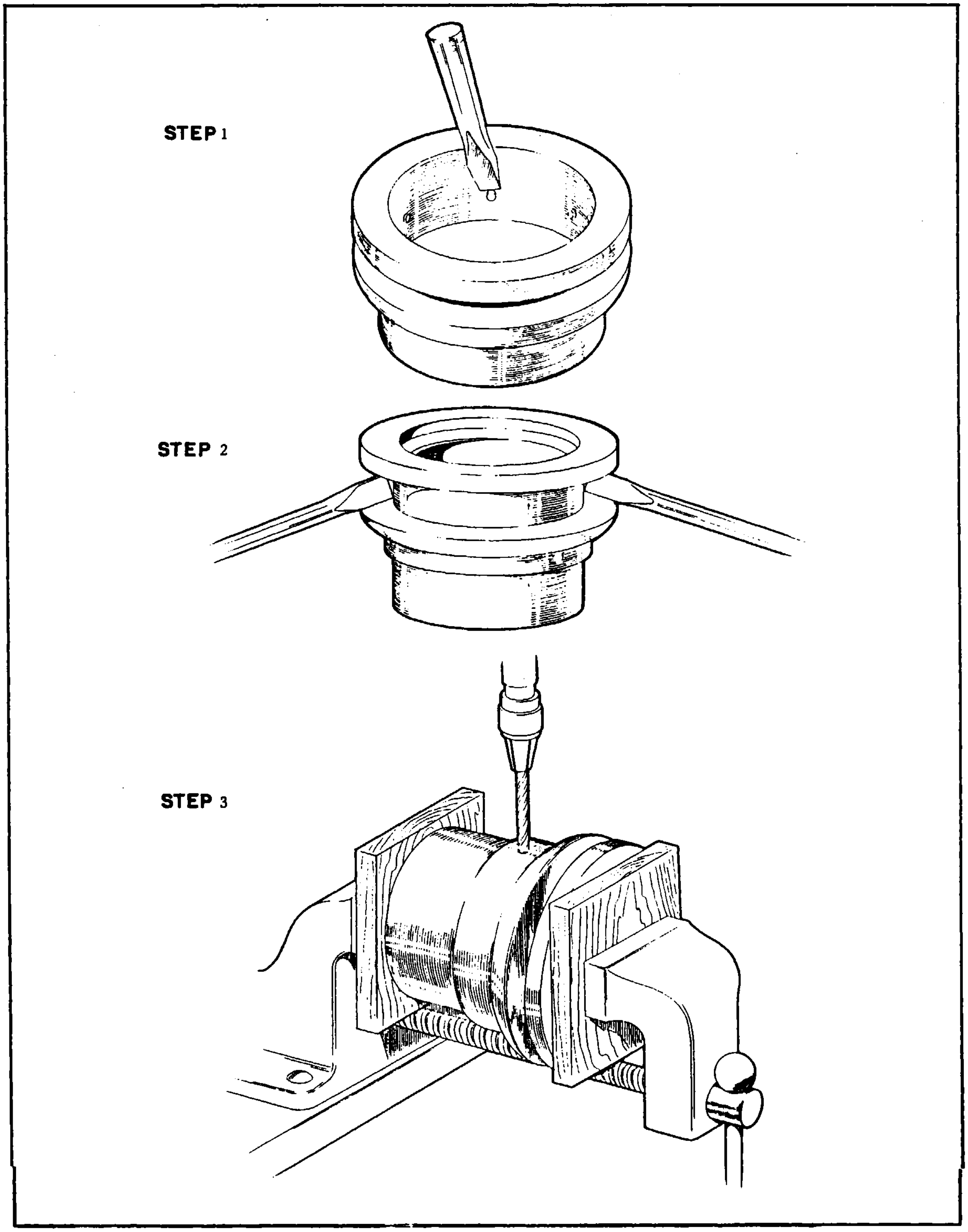


Figure 7-12. Replacing Cleveland Brake Disc When Installed with Rivets

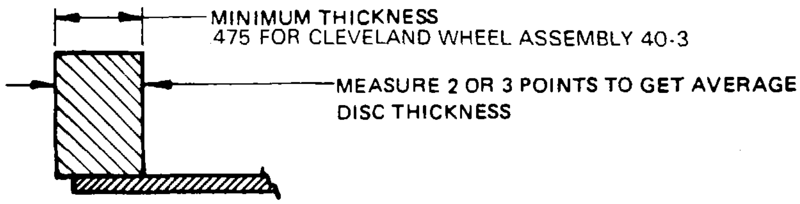


Figure 7-13. Cleveland Brake Disc Minimum Thickness

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d. Place wheel casting into boiling water for a few minutes, remove and insert new replacement brake disc into the expanded wheel. Ascertain that brake disc is properly seated in recess in wheel half.

e. Clamp wheel half and brake disc assembly in vise, as shown in Figure 5-8, step 3, and locate eight (8) 3/16" holes. Drill through disc with an 11/64" drill and then redrill with a 3/16" drill.

f. Rivet wheel half to brake disc with eight (8) AN425-AD6-7 rivets. Set rivets to be certain rivet has properly filled the hole.

g. File rivet heads flush with tire seat and paint.

7-34. ADJUSTING B.F. GOODRICH BRAKES.

a. Place aircraft on jacks. (Refer to Section II.)

b. Loosen the brake valve adjustment cap (1, Figure 7-14) by rotating it counterclockwise.

c. Remove the valve screw (2) at the multiple junction brake valve of the right landing gear.

d. Remove the left side access panel from the nose of the plane. Remove the vent cap from the brake reservoir and add hydraulic fluid MIL-H-5606 until the fluid draining from the valve screw hole is free of bubbles. Reinstall the valve screw.

e. Repeat the procedures described above for the left landing gear. At the completion of the operation, check to see that the fluid in the reservoir is at the indicated level. Install the vent cover on the reservoir.

CAUTION

Make sure the breather opening and tube are not clogged.

f. Instruct an assistant to pump the brake pedals until he feels the pressure building up. Then cease pumping the brakes to release brake pressure.

g. Remove the right valve screw at once and bleed the brake line. Reinstall the valve screw as soon as the fluid clears itself of any air bubbles.

h. Repeat steps "f" and "g", above, at the left brake valve.

i. Turn the brake valve adjustment cap clockwise until it is completely threaded on the valve. Any attempt to rotate the wheel will be ineffectual because the wheel is locked as a result of this procedure.

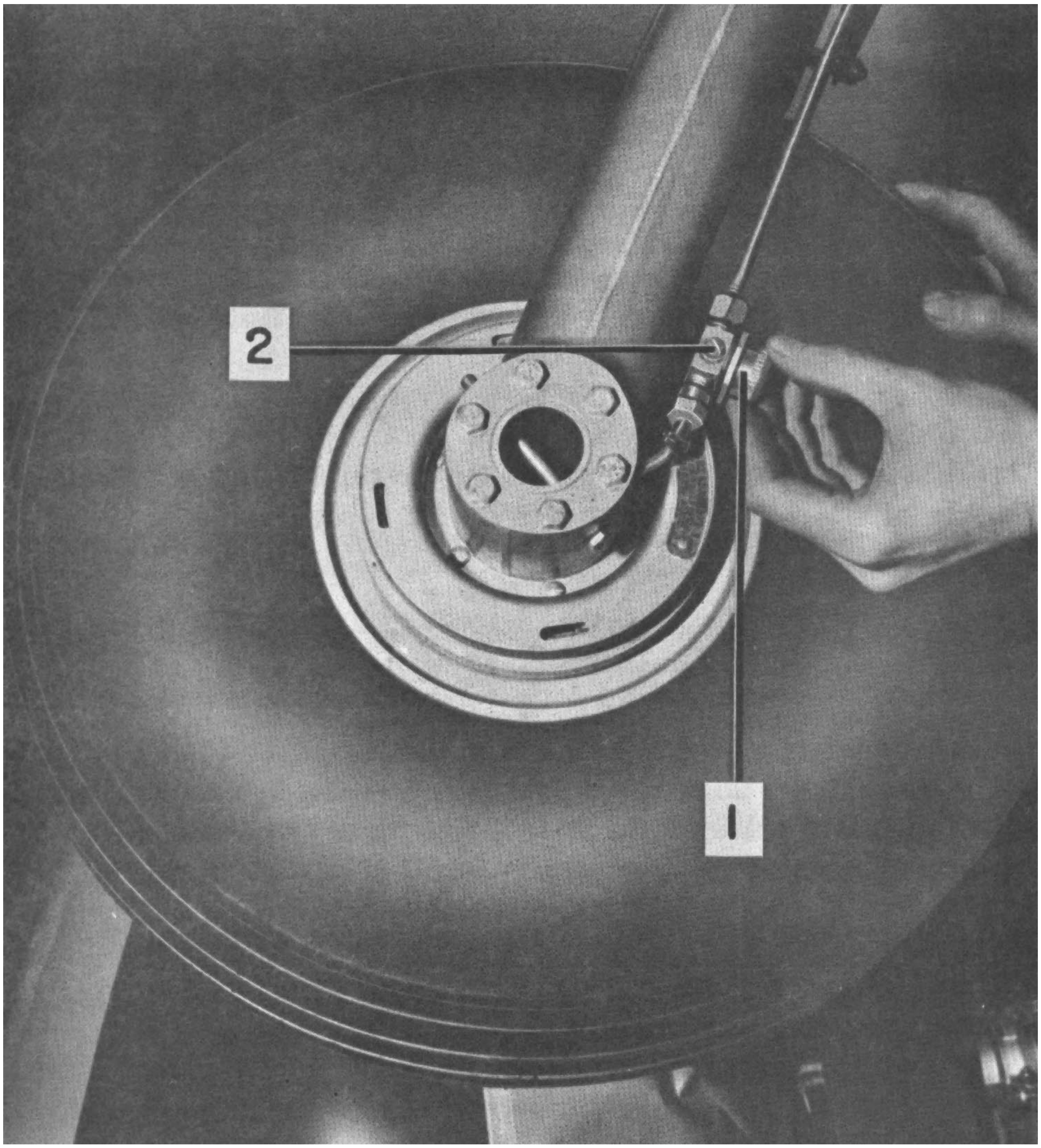
j. Have an assistant pump the brake pedals again, developing system pressure once more. Back off the valve adjustment cap while attempting to turn the wheel manually. (Refer to Figure 7-14.) Leave the valve cap in that position which will permit one revolution of the wheel when it is spun.

k. Repeat steps "i" and "j" on the other wheel. Check both brake valve screws for tightness.

1. Repeat the adjusting procedure several times to insure solid brake operation without undue pedal travel and also to insure proper rotation of wheel.

CAUTION

It is possible to adjust brakes to an extent that will cause overheating and subsequent locking and, in some cases, crack or break the brake springs because of the excessive heat.



1. BRAKE VALVE ADJUSTMENT   2. VALVE SCREW

Figure 7-14. Adjusting the Goodrich Brake

SECTION VIII

POWER PLANT

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SECTION VIII

POWER PLANT

8-1. GENERAL.

8-2. Apache PA-23-150 airplanes are equipped with Lycoming O-320 series engines, each developing 150 H. P. at 2700 RPM and with a compression ratio of 7.00:1. These engines require 80/87 octane fuel. The engines in Apache PA-23-160 airplanes are Lycoming O-320-B series, each developing 160 H.P. at 2700 RPM with a compression ratio of 8.5:1 and requiring 91/96 octane fuel. Early Apaches used Hartzell Model HC-82XG propellers, but in 1959 Hartzell issued Service Bulletin No. 68 requiring the reworking of all existing HC-82XG propellers to the HC-82XL configuration (i.e. - upgrading the propeller mounting bolts to 7/16 inch). Late model Apaches use either the HC-82XL or HC-A2XL Hartzell propellers. For further detailed information on engines and propellers, refer to the manufacturer's applicable publications. Engine troubles peculiar to the Apache are listed in Table VIII-I along with their probable cause and suggested remedies.

8-2A. STANDARD PRACTICES - ENGINE. The following suggestions should be applied wherever they are needed when working on the power plant.

a. To insure proper reinstallation and/or assembly, tag and mark all parts, clips, and brackets as to their location prior to their removal and/or disassembly.
b. During removal of various tubes or engine parts, inspect them for indications of scoring, burning or other undesirable conditions. To facilitate reinstallation, observe the location of each part during removal. Tag any unserviceable part and/or units for investigation and possible repair.
c. Extreme care must be taken to prevent foreign matter from entering the engine, such as lockwire, washers, nuts, dirt, dust, etc. This precaution applies whenever work is done on the engine, either on or off the aircraft. Suitable protective caps, plugs, and covers must be used to protect all openings as they are exposed.

NOTE

Dust caps used to protect open lines must always be installed OVER the tube ends and NOT IN the tube ends. Flow through the lines may be blocked off if lines are inadvertently installed with dust caps in the tube ends.

d. Should any items be dropped into the engine, the assembly process must stop and the item removed, even though this may require considerable time and labor. Insure that all parts are thoroughly clean before assembling.

e. Never reuse any lockwire, lockwashers, tablocks, tabwashers or cotter pins. All lockwire and cotter pins must fit snugly in holes drilled in studs and bolts for locking purposes. Cotter pins should be installed so the head fits into the castellation of the nut, and unless otherwise specified, bend one end of the pin back over the stud or bolt and the other end down flat against the nut. Use only corrosion resistant steel lockwire and/or cotter pins. Bushing plugs shall be lockwired to the assembly base or case. Do not lockwire the plug to the bushing.

f. All gaskets, packings and rubber parts must be replaced with new items of the same type at reassembly. Insure the new nonmetallic parts being installed show no sign of having deteriorated in storage.

g. When installing engine parts which require the use of a hammer to facilitate assembly or installation, use only a plastic or rawhide hammer.

h. Anti-seize lubrication should be applied to all loose-fit spline drives which are external to the engine and have no other means of lubrication. For certain assembly procedures, molybdenum disulfide in either paste or powdered form mixed with engine oil or grease may be used.

CAUTION

Insure that anti-seize compounds are applied in thin even coats, and that excess compound is completely removed to avoid contamination of adjacent parts.

i. Temporary marking methods are those markings which will insure identification during ordinary handling, storage and final assembly of parts.

8-3. REMOVAL.

8-4. PROPELLER REMOVAL.

a. Place "MASTER SWITCH" and magneto switch in the "OFF" position.

b. Place the "LEFT TANK" and "RIGHT TANK" fuel shut-off control valves in the "OFF" position.

c. Place the "MIXTURE" control lever in the "IDLE CUT-OFF" position.

d. Remove 14 screws from the periphery of the spinner and remove spinner.

e. Place the "PROPELLER" control lever in the "FEATHER" position.

f. Slide a feathering paddle on each propeller blade (2, Figure 8-1.) and turn the blades slightly in the direction of decreased feathering to relieve the pressure of the two feathering stops on the feathering stop pins. Push both pins into their brackets and feather propeller blades completely.

g. Remove the bolts, which hold each of the high pitch stop brackets (12) to the propeller hub. Remove both high pitch stop brackets.

CAUTION

Do not use any metal tools to push pins out of the way.

h. Remove the six hex head or ferry head propeller hub mounting bolts, holding the propeller hub to the starter gear.

i. Place a drip pan of approximately one quart capacity under the propeller to catch the oil spillage and remove the propeller.

8-5. ENGINE REMOVAL.

a. Remove the propeller. (Refer to Paragraph 8-4.)

b. Release the quarter-turn cowl fasteners holding each side access panel to the cowling and remove both panels. (Refer to Section II.)

c. Release the four studs at the front of the carburetor air filter assembly and remove the filter.

d. Remove a cap screw from the bottom of both cowl support rods. Using a 7/16-inch open end wrench on the metal boss welded to the support rod for this purpose, unscrew each rod from the captive nut at the top of the cowling.

e. Disconnect the oil cooler intake air hose from the oil cooler assembly leaving it attached to the cowl.

f. Disconnect the flexible hose assemblies from the hydraulic pump at the left engine.

g. Remove the screws at the rear of the top and bottom nacelle cowling assembly and remove the cowling by pulling it forward.

h. Remove the top engine baffle exposing the hoisting hook.

i. Disconnect vacuum lines from vacuum pump.

j. Disconnect primer line at tee connection fitting.

k. Disconnect the mechanical fuel pump inlet line connected to the right side of the pump from the connection at the electric fuel pump.

l. Disconnect the mechanical fuel pump line from T-connection fitting at left side of the pump.

m. Disconnect both generator leads.

n. Disconnect starter lead.

o. If installed, remove the cylinder head temperature thermocouple.

p. Disconnect the oil pressure line from the rear of the engine.

q. Disconnect the manifold pressure line from the left rear cylinder of the

TABLE VIII-I. ENGINE TROUBLESHOOTING

Trouble	Cause	Remedy
Failure of engine to start.	Lack of fuel.	Check fuel system for leaks. Fill fuel tank. Clean dirty lines, strainers, or fuel cocks.
	Underpriming.	Prime with four or five strokes of primer.
	Overpriming.	Turn magneto switches to "off", open throttle, close mixture and rotate engine with starter.
	Incorrect throttle setting.	Open throttle to one-tenth of its range.
	Defective spark plugs.	Clean and adjust or replace spark plug or plugs. Refer to Table I for spark plug gap adjustments.
	Defective ignition wire.	Check with electric tester and replace any defective wires.
	Improper operation of magneto or breaker points.	Check internal timing of magnetos. Clean points.
	Water in carburetor.	Drain carburetor and fuel lines.
	Internal failure.	Check oil sump screen for metal particles. If

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Failure of engine to start. (cont.)	Internal failure. (cont.)	found, complete overhaul of the engine may be indicated.
	Improper switch wiring for left magneto starting.	Reverse magneto switch wires.
	Magnetized impulse coupling - if installed.	Demagnetize impulse couplings.
	Frozen spark plug electrodes.	Replace spark plugs or dry out removed plugs.
	Mixture control in idle cut-off.	Open mixture control.
	Shorted ignition switch.	Check and replace or repair.
Failure of engine to idle.	Incorrect carburetor idle adjustment.	Adjust throttle stop to obtain correct idle.
	Idle mixture.	Adjust mixture. Refer to engine manufacturer's handbook for proper procedure.
	Leak in the induction system.	Tighten all connections in the induction system. Replace any parts that are defective.

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Failure of engine to idle properly (cont.)	Low cylinder compression.	Check cylinder compression.
	Faulty ignition system.	Check entire ignition system.
	Open primer.	Lock primer.
	Improper spark plug setting for altitude.	Check spark plug gap.
	Dirty air filter.	Clean or replace.
Low power and uneven running engine.	Mixture too rich; indicated by sluggish engine operation, red exhaust flames and black smoke.	Check primer. Readjustment of carburetor by authorized personnel indicated.
	Mixture too lean; indicated by overheating or backfiring.	Check fuel lines for dirt or other restrictions. Check fuel supply.
	Leaks in induction system.	Tighten all connections. Replace defective parts.
	Defective spark plugs.	Clean or replace spark plugs.
	Improper grade of fuel.	Fill tank with recommended grade.
	Magneto breaker points not working properly.	Clean points. Check internal timing of magneto.

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Low power and uneven running engine. (cont.)	Defective ignition wire.	Check wire with electric tester. Replace defective wire.
	Defective spark plug terminal connectors.	Replace connectors on spark plug wire.
	Restriction in exhaust system.	Remove restriction.
	Improper ignition timing.	Check magneto for timing and synchronization.
Failure of engine to develop full power.	Throttle lever out of adjustment.	Adjust throttle lever.
	Leak in induction system.	Tighten all connections and replace defective parts.
	Restriction in carburetor air scoop.	Examine air scoop and remove restriction.
	Improper fuel.	Fill tank with recommended fuel.
	Propeller governor out of adjustment.	Adjust governor.
	Faulty ignition.	Tighten all connections. Check system. Check ignition timing.
Rough running engine.	Cracked engine mounts.	Repair or replace engine mount.

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Rough running engine. (cont.)	Unbalanced propeller.	Remove propeller and have it checked for balance.
	Bent propeller blades.	Check propeller for track
	Defective mounting bushings.	Install new mounting bushings.
	Lead deposit on spark plug.	Clean or replace plugs.
	Primer unlocked.	Lock primers.
Low oil pressure.	Insufficient oil.	Check oil supply.
	Dirty oil screens.	Remove and clean oil screens.
	Defective pressure gauge.	Replace gauge.
	Air lock or dirt in relief valve.	Remove and clean oil pressure relief valve.
	Leak in suction line or pressure line.	Check gasket between accessory housing crankcase.
	High oil temperature.	See "High Oil Temperature" in trouble column.
	Stoppage in oil pump intake passage.	Check line for obstruction. Clean suction screen.

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Low oil pressure. (cont.)	Worn or scored bearings.	Overhaul.
High oil temperature.	Insufficient air cooling.	Check air inlet and outlet deformation or obstruction.
	Restriction of air flow to oil cooler.	Check for obstruction.
	Insufficient oil supply.	Fill oil sump to proper level.
	Clogged oil lines or screens.	Remove and clean oil screens.
	Failing or failed bearing.	Examine screens for metal particles and, if found, overhaul engine.
	Defective thermostats.	Replace.
	Defective temperature gauge.	Replace gauge.
	Excessive blow-by.	Usually caused by weak or stuck rings. Overhaul.
	Improper engine operation.	Check entire engine.
	Excessive external dirt on engine.	Clean engine.

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Excessive oil consumption.	Failing or failed bearing.	Check screens for metal particles and, if found, overhaul of engine is indicated.
	Worn or broken piston rings.	Install new rings.
	Incorrect installation of piston rings.	Install new rings.
	External oil leakage.	Check engine carefully for leaking gaskets, "O" rings or sand holes.
	Leakage through engine fuel pump vent.	Replace fuel pump seal.
	Engine breather or vacuum pump breather.	Check engine and overhaul or replace pump.
Inaccurate oil pressure readings.	Cold weather.	In extremely cold weather oil pressure readings up to 100 pounds do not necessarily indicate malfunctioning.
Overpriming.	Cold weather.	Turn magneto switches to "off", open throttle, close mixture and rotate engine with starter.
Inaccurate pressure readings.	Cold weather.	High or low pressure readings due to extre -

TABLE VIII-I. ENGINE TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Inaccurate pressure readings. (cont.)	Cold weather. (cont.)	mely cold weather are not necessarily a malfunction. Small and long oil lines will not transfer pressure readings accurately until engine is quite warm.

engine.

r. Disconnect the oil return line from the rear of the right engine which leads to the oil separator.

s. Remove the bonding strap from the rear of the engine.

t. Disconnect the four control cables from the engine components.

u. Disconnect the tachometer line from the rear of the engine.

v. Disconnect engine oil cooler hoses from the rear of the engine.

w. Remove the bolt from the bottom of the mechanical fuel pump.

x. Remove the vacuum pump if the right engine is to be removed; remove the hydraulic pump if the left engine is to be removed.

y. Disconnect magneto lines. Insert a protective cover over the connection.

z. Disconnect the engine oil temperature lead from oil dome.

aa. Disconnect the engine breather line from the rear of the engine.

ab. Attach a one-half ton (minimum) hoist to the hoisting hook and relieve the tension on the mounts.

ac. Remove the cotter pin, nuts, washers and front rubber mount from each bolt and remove sleeve. Slide bolts out of attaching points. Swing engine free, being careful not to damage any attached parts and remove rear rubber mounts.

8-6. REMOVING THE ENGINE MOUNT.

a. Remove the engine. (Refer to Paragraph 8-5.)

b. Disconnect all fore and aft leads from the firewall.

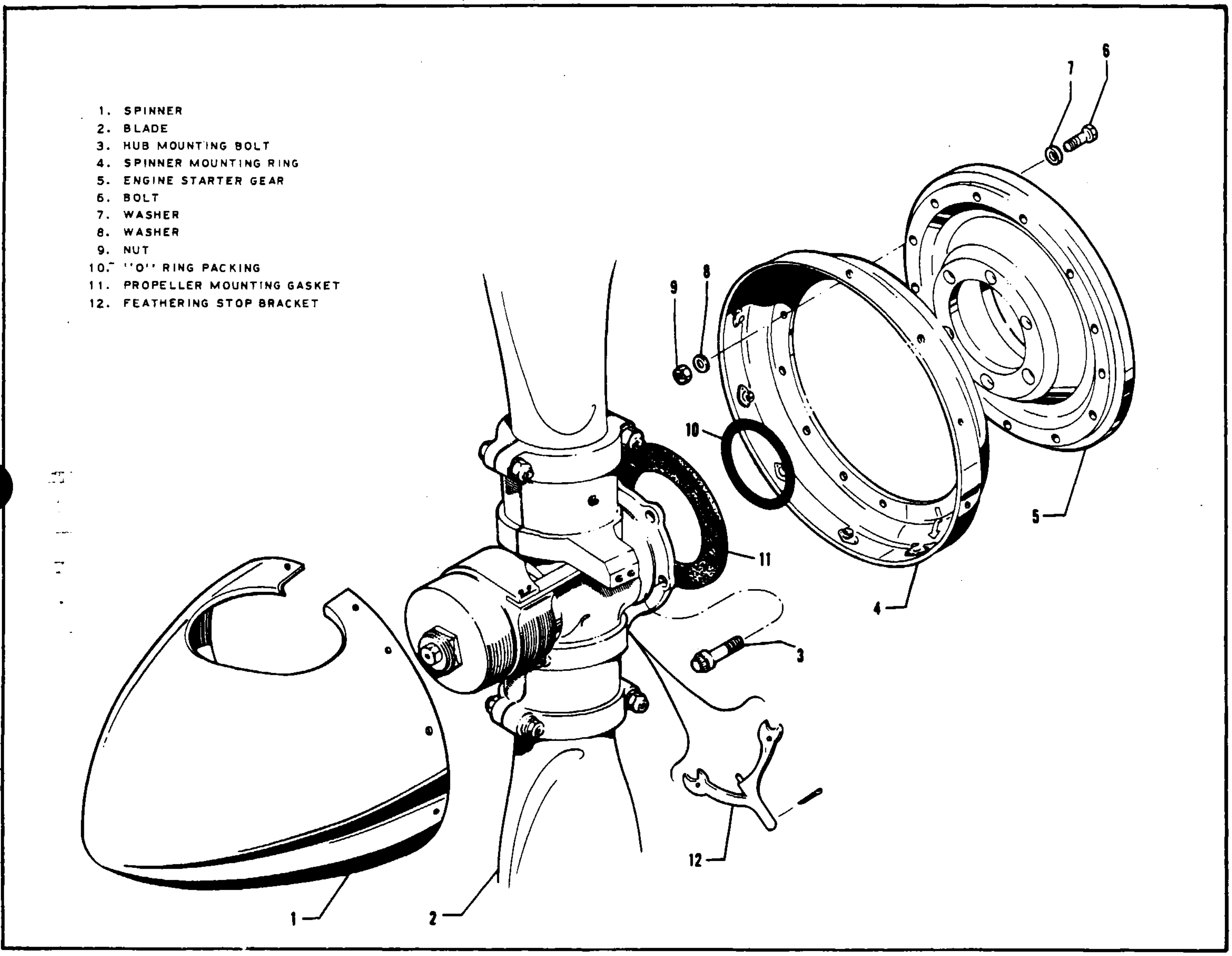
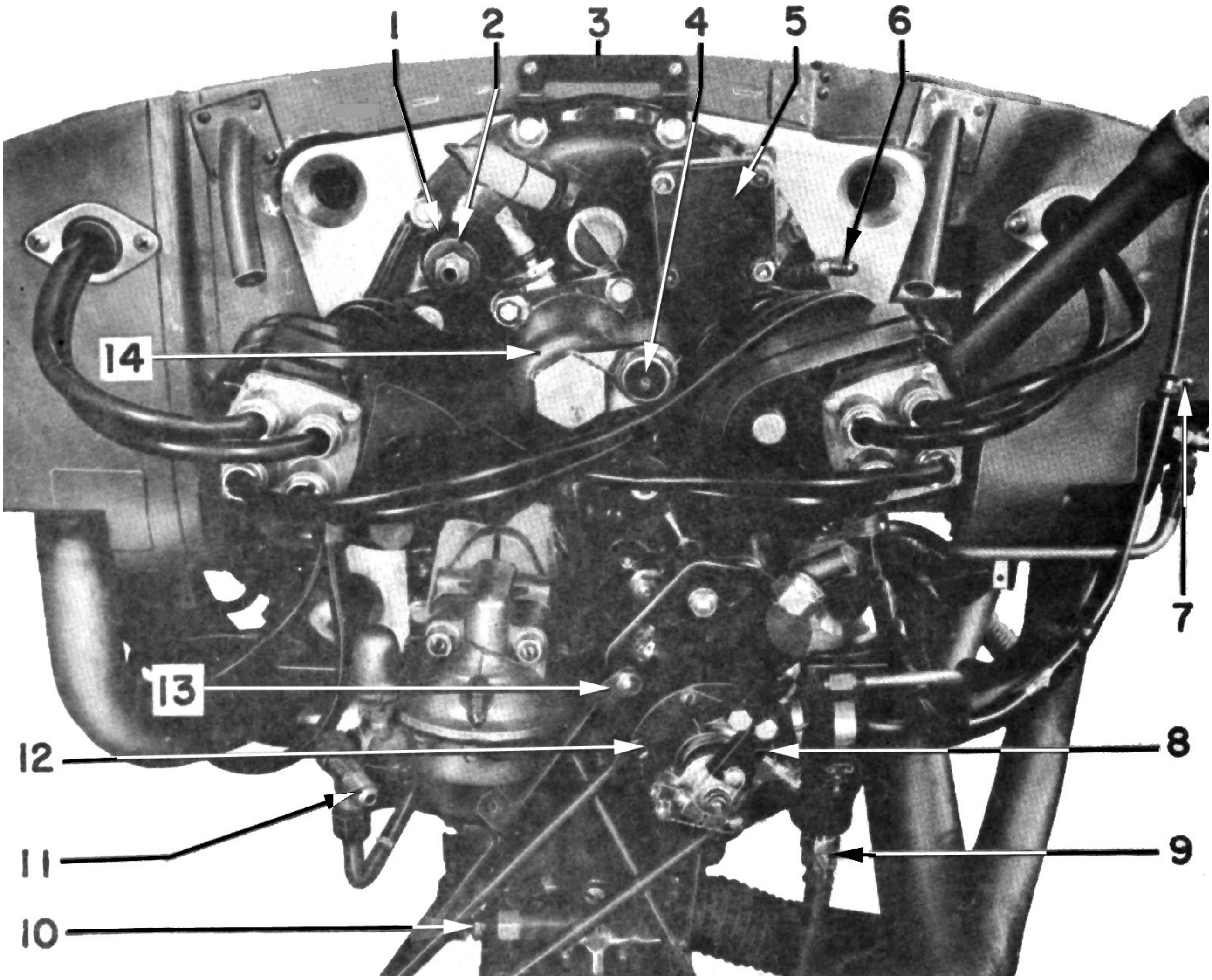


Figure 8-1. Hartzell Propeller



1 1/8 INCH PIPE PLUG	8. ARM ASSEMBLY
2. MALE CONNECTOR	9. OIL DRAIN
3. REAR BAFFLE BRACKET	10. FUEL INLET
4. TEMPERATURE GAUGE	11. TEE FITTING
5. VACUUM PUMP MOUNTING	12. PROPELLER GOVERNOR
6. OIL PRESSURE TAKE-OFF	13. CABLE SUPPORT BRACKET
7. CLAMP	14. OIL SCREEN HOUSING

Figure 8-2. Rear View of Engine Prior to Installation

c. Drill out all peripheral rivets fastening the firewall and the upper plate assembly together. Remove the firewall and the upper plate assembly.
d. Remove the wheel well cover.
e. Remove the bolt at the aft end of the mount.
f. Drive the engine mount attaching bolts out of the mount until they are

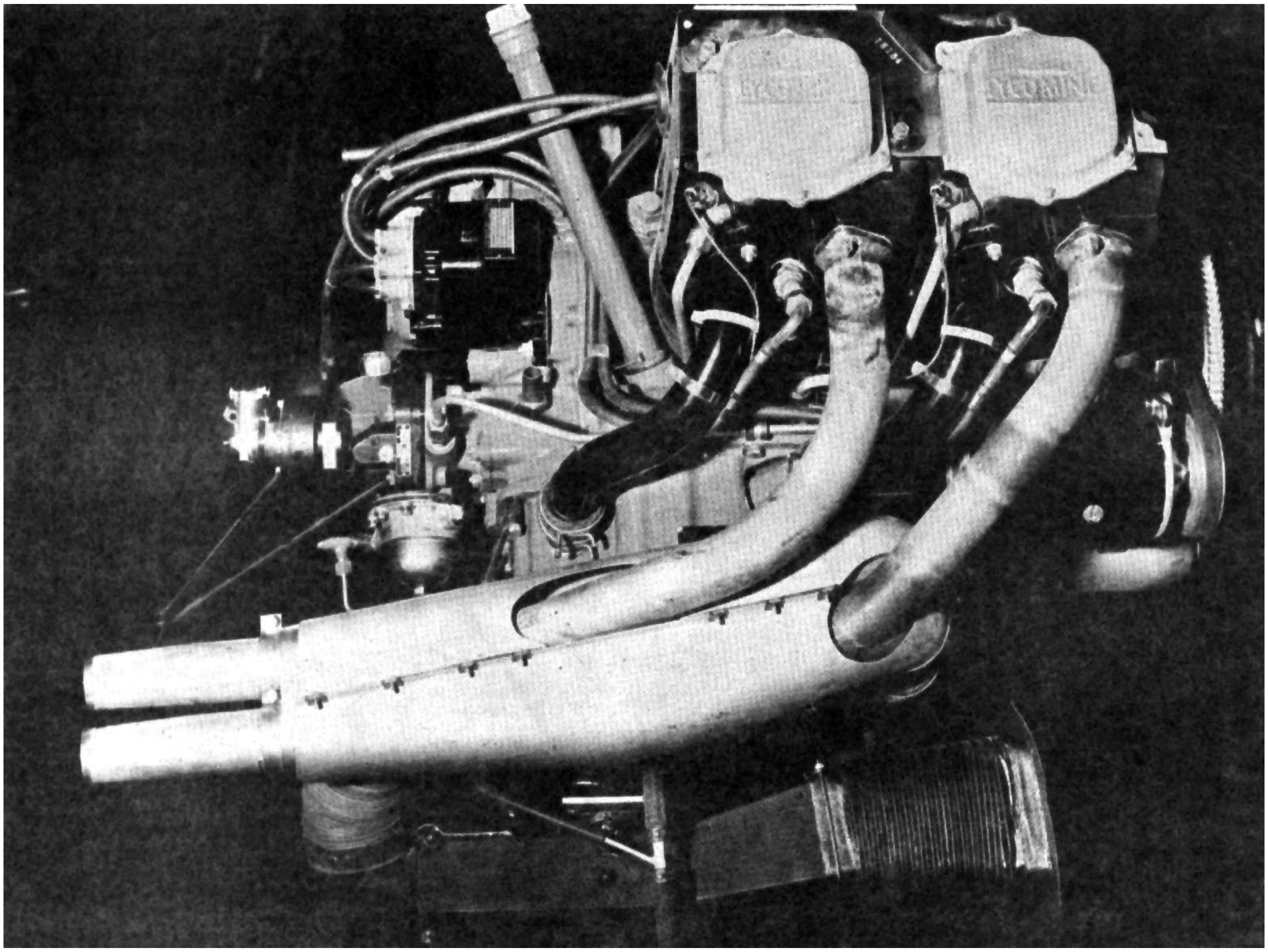


Figure 8-3. Bottom Right View of Engine

flush with the nacelle bulkhead. Remove the engine mount.

8-7. INSTALLATION.

8-8. INSTALLING THE ENGINE MOUNT.

a. Place the engine mount between the nacelle bulkheads and fasten its aft end to the engine mount support by means of a drive-fit bolt, washer, castelated nut and cotter pin.

b. Position the two attaching points of the engine mount with the nacelle attaching points. Reach into the adjacent lightening hole and using a compact mass such as a rivet bucking bar, drive the attaching bolt into the mount. A hammer of sufficient weight to do this will prove unwieldy in the available space. When driving the bolt in, have an assistant visually guide the bolt into the mount. Be sure the lock plate, which keeps the bolt from rotating, is seated properly under the head of the bolt. If completely removed from the nacelle, hold the bolt with a magnet to facilitate aligning it with the bulkhead hole.

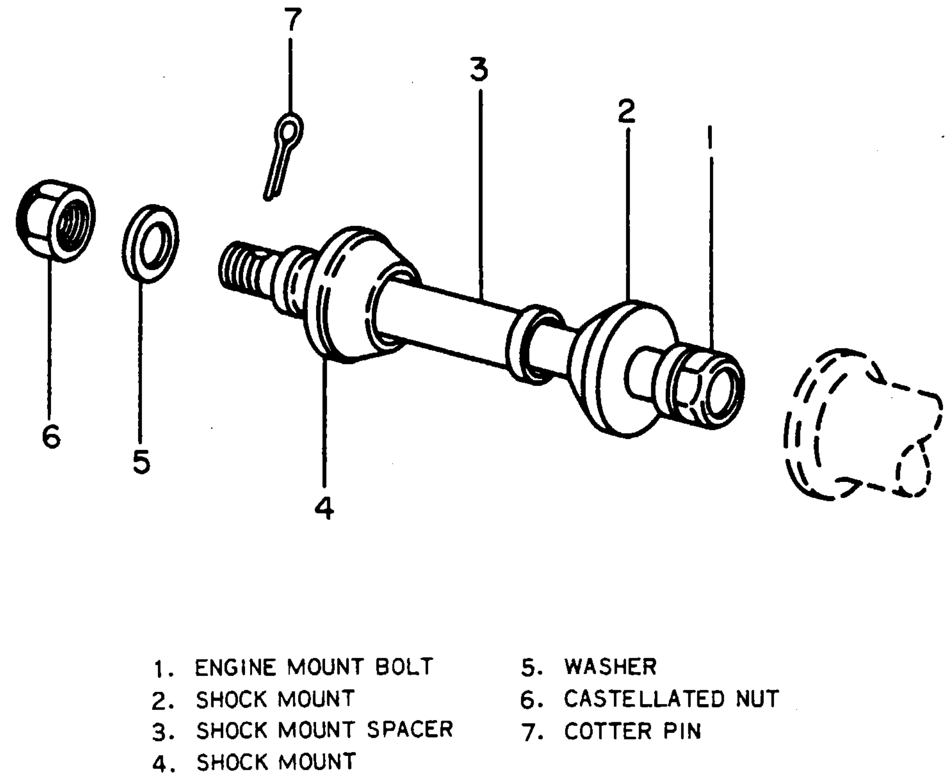


Figure 8-4. Lord Mount, Exploded View

c. Install the wheel cover.

d. Place the firewall in the mount, position the upper plate assembly on the firewall and rivet these two members together.

e. Reconnect all lines to the fittings and terminals on the firewall.

f. Install engine. (Refer to Paragraph 8-9.)

8-9. ENGINE INSTALLATION.

a. Insert engine mounting bolt (1, Figure 8-4) in the engine mount and slide the Lord shock mount (2) onto the bolt so that the pin hole in its flat surface engages the pin protruding from the engine mount at the attachment point.

b. Slide the shock mount spacer (3) onto the bolt, rotating it until it is properly seated within the recess in the conical-surfaced side of the shock mount. Be sure the lobe at the end of the sleeve is positioned correctly in the out-of-round hole in the mount.

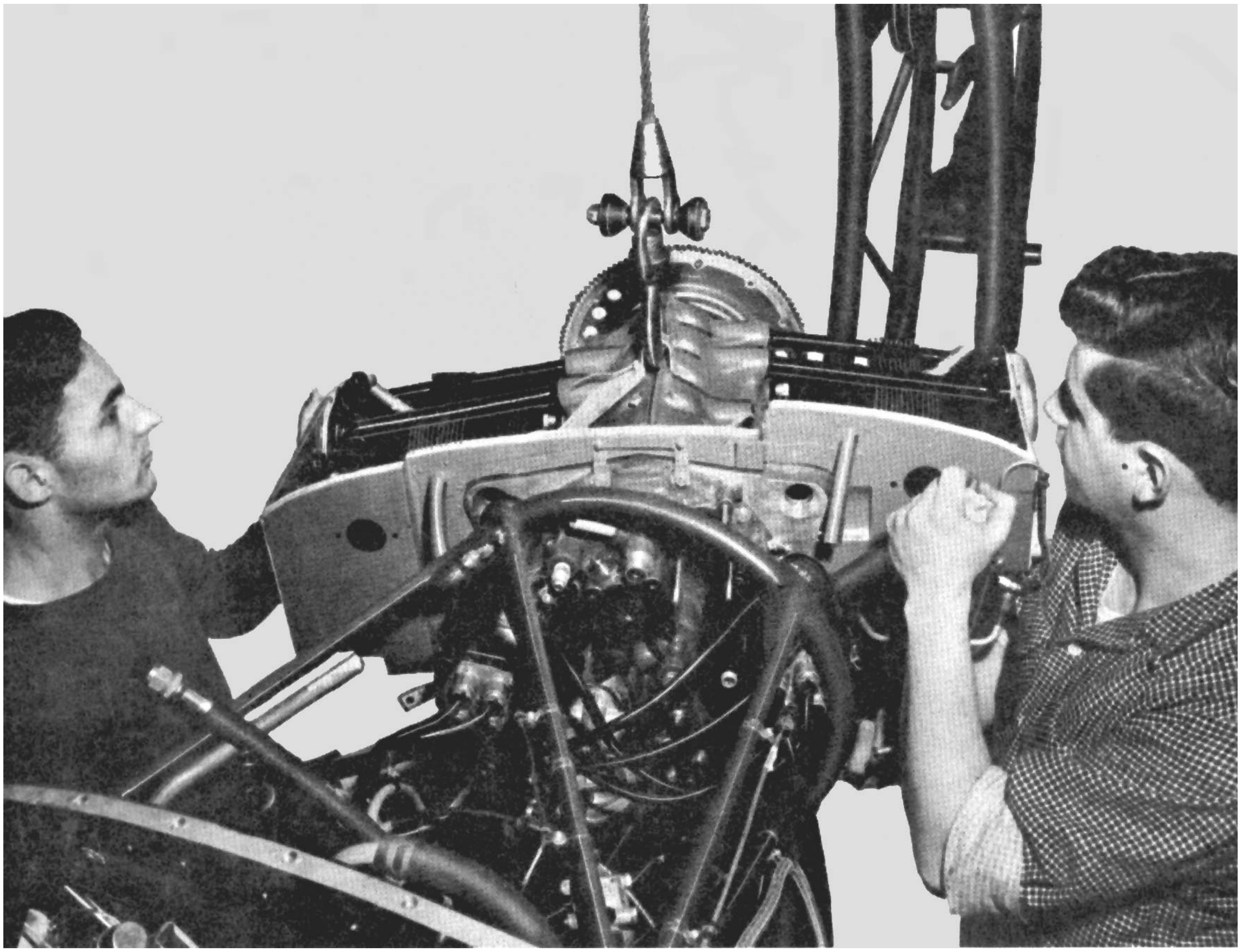


Figure 8-5. Installing the Engine

NOTE

It is possible to force the sleeve into the rubber mount without aligning its eccentric end with the pocket of the mount, thus distorting the Lord mount and consequently defeating the purpose of the suspension.

c. Slide a second Lord shock mount (4) onto the bolt, so that the tapered, truncated conical surfaces of the two mount face each other.
d. Rotate the second, or forward shock mount until the large hole in its flat-surfaced side, corresponding to the out-of-round recess in its conical side, is concentrically visible with the threaded end of the mounting bolt.
e. Push the shock mount aft; its out-of-round opening will slip onto the lobed end of the sleeve, if they are properly aligned.

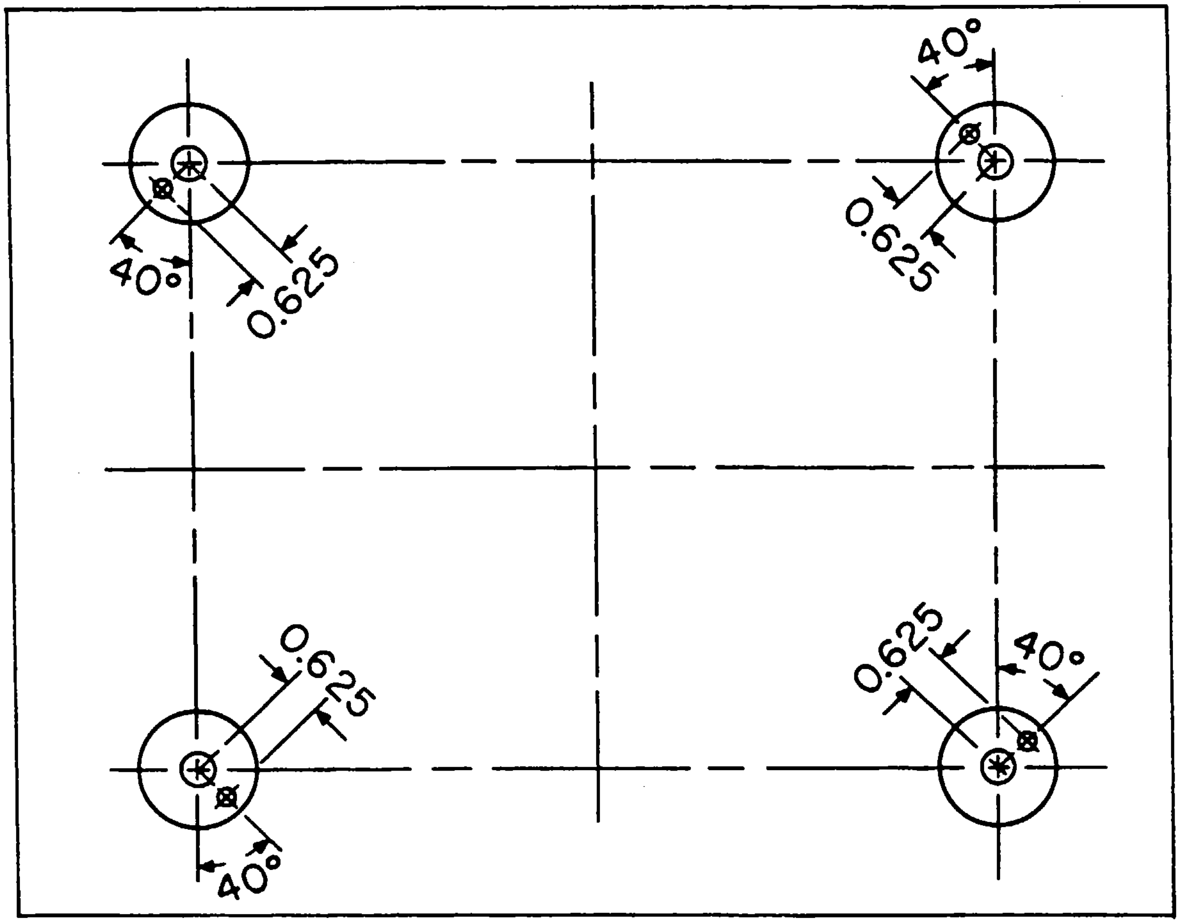


Figure 8-6. Engine Lord Mount Locating Pin Diagram

CAUTION

It is possible to install the front mount on the sleeve with a bind. This will result in an unevenly running engine and perhaps a cracked engine mount.

f. Paint a straight line, parallel to the axis of the mounting bolt, across both shock mounts and the engine mount. Then remove both shock mounts and the engine mount. Then remove both mounts, the sleeve and the bolt.

g. Repeat the procedures described in steps "a" through "f", above, at the remaining three attaching points. The location of the shock mount pin at each of the four attaching points is illustrated in Figure 8-6. Do not mix the newly created assemblies.

NOTE

The pins orient the rubber mounts in the most desirable manner to off-set the torque resulting from engine rotation.

h. Attach a one-half-ton hoist to the hoisting hook and lift the engine. Tilt the rear of the engine downward and set it askew until the magnetos clear the ring of the engine mount. (Refer to Figure 8-5.) Position the mounting lugs of the engine so they align with the engine mount attaching points.

i. Insert an upper mounting bolt into the engine mount until its threaded end extends one or two threads from the mount itself.

NOTE

It is necessary, sometimes, to place a washer under the head of the bolt prior to its insertion in the mount. This is to prevent interference between the nut and the push rod housing of the engine, which may result from adding washers under the nut when completing the installation of a shock mount assembly.

j. Slip a shock mount (2) in between the engine mount and the engine. Taking advantage of the paint marks, rotate the rubber mount until its pin hole is engaged by the engine mount pin.

k. Repeat the procedures described in steps "i" and "j", above, at the three remaining attachment points.

l. Slide the sleeves (3) onto the bolts, being sure in each instance that the lobed end of the sleeve is nested properly in the out-of-round pockets in each rubber mount (2).

m. Install the front engine mounts (4) over the forward end of the sleeve, making sure the paint marks are aligned and the mounts are not binding.

n. Install a washer (5) and castellated nut (6) on each mounting bolt. Tighten the nuts progressively, following a circular sequence. Continue to tighten until an equal amount of torque is obtained on each nut. Install cotter pins (7).

o. Connect the engine breather line to the rear of the engine.

p. Reconnect the engine temperature lead to the rear of the oil pressure dome.

q. Insert the magneto lines.

r. Remove the oil pressure screen housing from the engine to facilitate installation of the vacuum pump stud nut.

s. Install the vacuum pump; on left engine, install the hydraulic pump.

t. Reinstall the oil pressure dome.

u. Install the bolt in the bottom of the mechanical fuel pump.

v. Connect the oil cooler hoses. The hose from the top of the cooler hose is attached to the lower rear of the engine.

NOTE

1. When installing fittings in the oil coolers, care should be used to prevent excessive torque being applied to the cooler. When a rectangular fitting boss is provided, backup wrench should be used, employing a scissor motion, so that no load is transmitted to the cooler. When the oil cooler has a round fitting boss, care should be taken not to permit excessive torque on the fittings.
2. If a pipe thread fitting is used, it should be installed only far enough to seal with sealing compound.
3. Apply Lubon No. 404 to all male pipe thread fittings; do not allow sealant to enter the system.
4. If fitting cannot be positioned correctly using a torque of 10 to 15 foot-pounds, another fitting should be used.
5. When attaching lines to the cooler, a backup wrench should be used.
6. After installation, inspect the cooler for distorted end cups.
7. Run-up engine. After run-up, check for oil leaks.

w. Connect the tachometer line.

x. Reconnect the four control cables making sure there is no binding present.

NOTE

Adjust all controls to provide the same degree of freedom of operation.

y. Attach the propeller pitch control cable, by means of a clamp to the propeller pitch control support bracket (13, Figure 8-2) supported by the governor. Place the "PROPELLER" control levers in the cockpit 1/8-inch from its rearward, or "FEATHER", position. Connect the ball joint or clevis at the end of the cable to the speed adjusting control lever arm assembly (8) with a self locking nut, if ball joint is installed or a castellated nut, and cotter pin if clevis is installed.

CAUTION

Binding of the clevis can break the control arm.

z. Attach the throttle and mixture control cables by means of two cable clamps to the carburetor-supported control cable support bracket.

aa. Place the cockpit "THROTTLE" control lever 1/8-inch from its most rearward position and pull the carburetor throttle arm aft against the idle-adjustment screw. Attach the clevis or ball joint to the throttle arm with a bolt, castellated nut, and cotter pin if clevis is installed or a self-locking nut if ball joint is installed. When properly installed, threads from the end of the eye will be exposed at the yoke of the clevis. The clevis must pivot freely relative to the arm.

CAUTION

If the clevis binds on the arm, the latter will snap.

ab. Push the "THROTTLE" control lever in the cockpit forward and see that it stops no closer than 1/8-inch from the end of the slot.

ac. Place cockpit "MIXTURE" control lever 1/8-inch from its most rearward position, and push the carburetor mixture control arm against the "LEAN" stop.

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Slip the cable wire through the hole in the stud. Then tighten the stud until the wire is crimped by the swivel. If the correct stud is used, the swivel will be free to rotate.

CAUTION

The wire will break if the swivel is not free to turn.

ad. Push the cockpit "MIXTURE" control lever forward and note that it stops no closer than 1/8-inch from the end of the slot.
ae. Secure the carburetor heat control cable to the oil cooler and to the cable support at the carburetor air box. Push the control within 1/8-inch of the panel. Set the butterfly valve arm, located at the carburetor air intake, completely forward, opening the valve. Slide the cable wire through the hole in the shouldered stud. Then tighten the stud until the wire is crimped by the swivel. If the correct stud is used, the swivel will be free.

CAUTION

The wire will break if the swivel is not free to turn.

af. Connect the bonding strap to the outboard side of the engine mount ring.
ag. Connect the oil return line from the oil separator to the rear of the engine.
ah. Install the two clips on the manifold pressure line, secure them to the engine and connect the line to the rear of the No. 3 cylinder.
ai. Connect the oil pressure line to the rear of the engine.
aj. Reconnect the starter lead. Reclamp the lead by means of the special clamps.
ak. At the left engine, connect the heavy generator lead (P9A) to the armature terminal (a), and the light lead (P5C) to the field terminal (F). On dual generator installations, connect the heavy lead (P17A) to the armature terminal (A), and the light lead (P13C) to the field terminal (F).
al. If used, install the cylinder head temperature thermocouple in the bottom cylinder.
am. Reconnect the two fuel lines. The lower line from the middle center connection at the firewall is secured to the Y-connection fitting at the left side of the pump. The upper line is connected to the fuel inlet at the right side of the pump.
an. Connect the primer line to the rear tee connection fitting.
ao. Reconnect the lines to the vacuum pump. The upper line is led to the oil separator and the lower line to the pressure regulator valve.

ap. Reconnect the two hydraulic pump lines to the pump at the left engine. The line from the filter leads to the pressure port of the pump, and the line from the left center of the firewall leads to the inlet port of the pump.

aq. Lay the hoisting hook on its side and attach the top engine baffle to the adjacent baffles with 18 truss-head machine screws.

ar. Slide the complete cowl assembly in position and attach the rear end of the top and bottom sections to the nacelle cowling.

as. Install the air filter.

at. Clamp the generator air ram tube to the rear of the generator.

au. Connect the oil hose to the oil cooler.

av. Thread each cowl tie rod into the captive nut at the top of the cowl assembly until the hole in the bottom of each rod coincides with the hole in the cowl stiffeners. Do not spread or force the cowling to align the rods with the holes in the stiffeners.

aw. Install the two side access panels utilizing the quarter turn cowl fasteners and the nacelle fairings.

ax. Install the propeller. (Refer to Paragraph 8-10.)

6-10. PROPELLER INSTALLATION.

a. Place the "MASTER SWITCH" and magneto switch in the "OFF" position.

b. Place the "LEFT TANK" and "RIGHT TANK" fuel shutoff control lever in the "OFF" position.

c. Place the "MIXTURE" control levers in the "IDLE CUT-OFF" position.

d. Place the "PROPELLER" control levers in the "FEATHER" position.

e. Install the O-ring (10, Figure 8-1) on the crankshaft and the gasket (11) on the propeller mounting bushings.

f. Observe the starter ring gear to make sure it is mounted properly on the engine crankshaft flange. One of the bushings on the crankshaft is stamped with an "O" mark and it must be inserted in the starter ring gear hole likewise identified by an "O" mark.

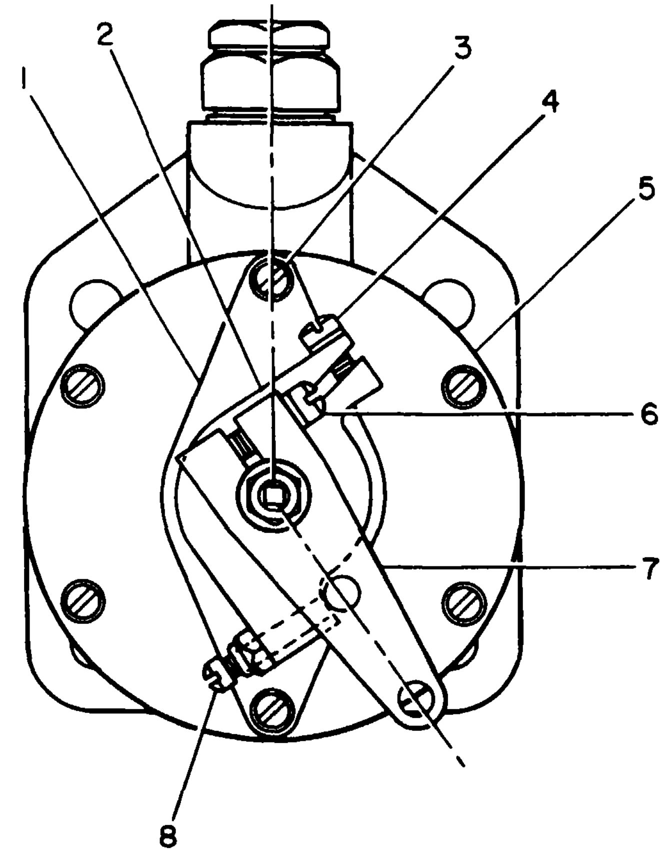
NOTE

The reason for this arrangement is that it is necessary to have the timing marks located in the proper position. The timing marks appear on the gear ring in the form of a punch mark or scribe line which must be lined up with a punch mark or a pin on the starter gear drive housing.

g. With the propeller blades feathered completely, raise the propeller into position with the engine, and slide the propeller onto the propeller mounting bushings.

NOTE

There are two short, diametrically opposed propeller mounting bushings, with which the appropriate holes in the propeller hub flange must coincide.



1. SPRING RETAINER
2. STOP RING
3. SPRING RETAINER FRONT SCREW
4. STOP RING CLAMP SCREW
5. COVER
6. SPEED CONTROL LEVER CLAMP SCREW
7. SPEED CONTROL LEVER
8. HI-RPM FINE ADJUSTMENT SCREW

Figure 8-7. Woodward Propeller Governor Adjustment Points:

h. Install the six hex head or ferry head propeller hub mounting bolts in the propeller hub and tighten them to 40 foot-pounds of torque.

i. Install the high pitch stop brackets (12) so that, when viewed from the front (looking aft), the portion of the bracket on the viewer's right side which houses the stop pin and spring is above the horizontal centerline of the propeller hub. Insert two hex bolts in each bracket and tighten. Safetywire the four or six exposed mounting bolts and the four bracket hex bolts, and the two lock screws.

j. Slide a feathering paddle on each propeller blade (2) and turn the blades in the direction of decreased pitch until the high pitch stop plates clear the stop pins.

k. Install the spinner.

8-11. ADJUSTMENTS.

8-12. ADJUSTING THE WOODWARD PROPELLER GOVERNOR.

a. Remove the nacelle side access panels from both sides.

b. If not already done by the vendor, release the stop ring clamp screw (4, Figure 8-7) and rotate the stop ring (2) about the serrations of the governor cover (5) to align the projection, through which the hi-rpm fine adjustment screw (8) is threaded, with the center line of the spring retainer front screw (3). Position the surface from which the threaded portion of the adjustment screw projects, with the spring retainer front screw. Tighten the clamp screw.

c. Start the engine in accordance with the directions given in Owner's Operating Manual.

d. Push the "PROPELLER" cockpit control lever as far forward as it will go. At this position the governor speed adjusting control lever will be against the hi-rpm fine adjusting screw.

e. Observe engine speed. Adjust the governor speed by means of the fine adjustment screw for 2700 rpm. To do this release the speed control lever clamp screw (4) and move the lever relative to the cover serrations. One serration movement in a clockwise direction produces a decrease in speed of 100 rpm; one serration counter-clockwise increases the speed 100 rpm. One revolution of the hi-rpm fine adjustment screw in a clockwise direction decreases engine speed 25 rpm, counter-clockwise rotation increases engine speed 25 rpm for each revolution of the screw.

f. After setting the engine rpm at 2700, tighten the control lever clamping screw, and run the self-locking nut on the fine adjustment screw against the stop ring projection. Then safetywire the head of the screw to the projection.

g. Pull the "PROPELLER" cockpit control lever aft to the feather stop position. This point is determined when the control lever contacts the spring-loaded stop approximately two-thirds of the way down the pedestal slot.

NOTE

This position is just above the portion of the pedestal placard designated as "FEATHER". It is not the "FEATHER" position.

h. Observe engine speed. Set to 2050 rpm either by threading the clevis at the lever onto the cable, or by turning it in the direction tending to remove the clevis from the cable, depending on whether it it required to decrease or increase engine speed, respectively. It will be necessary, of course, prior to adjusting, to remove the cotter pin, castellated nut, and bolt from the clevis, disconnecting it from the control lever lug, and to release the clevis lock nut.

i. Reconnect cable to control lever, apply clevis lock nut, and recheck engine by moving cockpit control in and out of the appropriate settings.

j. With both cockpit control levers completely forward, thereby assuring that the control lever is against the stop, adjust the clevises at the pedestal to align the two cockpit control levers.

8-13. ADJUSTING CARBURETOR IDLE MIXTURE

a. Following the standard engine starting procedure, operate the engine for at least two minutes at 1200 rpm to ensure proper engine warm-up.

WARNING

When performing engine warm-up indoors, provide a barrier about the engines to protect other persons from possible fatal injuries. There must also be adequate means to ventilate the work area.

b. Draw back on the cockpit "THROTTLE" control lever to obtain a reading of approximately 600 rpm on the tachometer.

c. Turn the idle-mixture screw, located at the rear of the carburetor, clockwise, leaning the fuel-air mixture. Continue to do this until the engine begins to run roughly. It will be noted that at this point, engine speed decreases.

d. Turn the screw counterclockwise until the engine runs smoothly again. Continue to turn the screw in the same direction until the engine runs roughly once more. At this point the fuel-air mixture will be too rich and engine speed will decrease again.

e. Now advance the screw to a position midway between these two, noting that the rpm of the engine will reach a maximum.

8-14. ADJUSTING ENGINE IDLING SPEED.

a. Pull back the cockpit "THROTTLE" control lever until it is completely aft and in the "CLOSE" position. Observe the engine speed on the tachometer.

b. Adjust the idle adjustment screw to obtain from 600 to 650 rpm. Rotate the screw clockwise to increase the speed of the engine; counter-clockwise to decrease speed. The screw is located on the right side of the carburetor.

8-15. ADJUSTING THE HARTZELL PROPELLER GOVERNOR.

a. Remove both side panels of the engine nacelle.

b. Start the engine in accordance with the directions given in the Owner's Flight Manual.

c. Push the "PROPELLER" cockpit control lever as far forward as it will go. At this position the governor speed adjusting control lever will be against the hi-rpm fine adjusting screw.

d. Observe engine speed. Adjust the governor by means of the fine adjustment screw for 2700 rpm. To do this loosen the fine adjustment screw locknut and turn the hi-rpm fine adjustment screw in a clockwise direction to decr engine speed and a counter-clockwise rotation to increase engine speed. One revolution of the fine adjustment screw increases or decreases the propeller speed approximately 15 RPM.

e. After setting the engine rpm at 2700, run the self-locking nut on the fine adjustment screw against the base projection to lock.

f. Pull the "PROPELLER" cockpit control lever aft to the feather stop position. This point is determined when the control lever contacts the spring-loaded stop approximately two-thirds of the way down the pedestal slot.

g. Observe engine speed. Set to 2050 rpm either by threading the fitting at the governor control arm onto the cable, or by turning it in the direction tending to remove the fitting from the cable, depending on whether it is required to decrease or increase engine speed, respectively. It will be necessary, of course, prior to adjusting, to remove the self-locking nut and disconnect it from the governor control arm and to release the fitting lock nut.

h. Reconnect cable to governor control arm, apply fitting lock nut and recheck engine by moving cockpit control in and out of the appropriate settings.

i. With cockpit control levers completely forward, thereby assuring that the governor control arm is against the stop, adjust the clevises at the pedestal to align the two cockpit control levers.

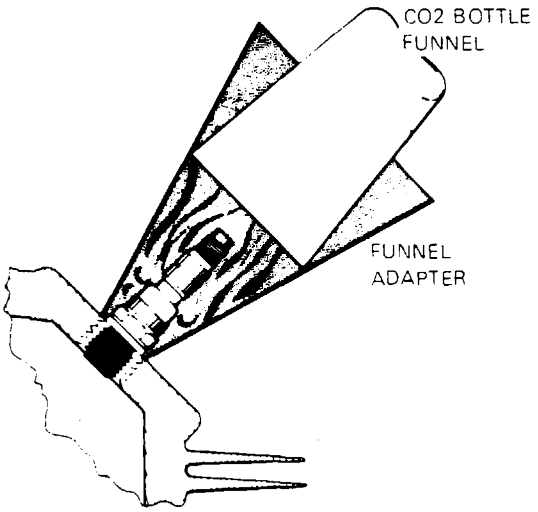


Figure 8-8. Removing Spark Plug Frozen to Bushing

8-16. REMOVAL OF SEIZED SPARK PLUG. Removal of seized spark plugs in the cylinder may be accomplished by application of liquid carbon dioxide by a conical metal funnel adapter with a hole in the apex just large enough to accommodate the funnel of a CO2 bottle. (Refer to Figure 8-8.) When a seized spark plug cannot be removed by normal means, the funnel adapter is placed over and around the spark plug. Place the funnel of the CO2 bottle inside the funnel adapter and release the carbon dioxide to chill and contract the spark plug. Break the spark plug loose with a wrench. A warm cylinder head at the time the carbon dioxide is applied will aid in the removal of an excessively seized plug.

SECTION IX

FUEL SYSTEM

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SECTION IX

FUEL SYSTEM

9-1. GENERAL

9-2. The Apache fuel system installation (Figure 9-1) includes an auxiliary system. Because of this, an auxiliary fuel system illustration (Figure 9-2), and facts pertinent to the system, are presented in this section with the main system data. To secure a complete auxiliary fuel system for an aircraft where such a system does not exist, contact your distributor and request Kit No. 754 058. This item is complete in materials and instructions for obtaining a proper installation. Later manufacture provides drilled attaching points whether the system is incorporated or not. In these instances, some of the installation procedures can obviously be ignored. Troubles peculiar to the Apache fuel system are listed in troubleshooting Table IX-I, along with probable causes and remedies.

NOTE

As originally manufactured, the Apache fuel system required an inconvenient pre-flight fuel draining procedure. Piper Service Bulletin No. 827A requires the installation of the Dual Fuel Drain Kit, P/N 765-363, to simplify the procedure and ease operator workload.

9-3. REMOVAL AND INSTALLATION.

9-4. FUEL SYSTEMS.

9-5. MAIN FUEL SYSTEM. Refer to Figure 9-1 for the layout and relationship of the various fuel system components. Replace a fuel cell in accordance with the instructions of paragraphs 9-10 and 9-17.

9-6. AUXILIARY FUEL SYSTEM. The items comprising the auxiliary fuel system are shown in Figure 9-2. Refer to this illustration as a guide for removal and installation. In addition, refer to paragraph 9-7 for general practices regarding fuel cells.

9-7. FUEL CELLS.

NOTE

Piper Service Bulletin No. 932 requires installation of wedges in the forward and aft inboard corners of PA-23 fuel cells. Verify compliance when servicing fuel cells.

9-8. GENERAL. The purpose of this procedure is to provide a method of handling the bladder type fuel cell, including removal, pre-installation inspection pre-installation of the cell compartment, installation and storage procedures.

9-9. GENERAL REMOVAL INSTRUCTIONS. If it is necessary, for any reason, to remove the cell from the cavity or to deform it inside the cavity, it is suggest-

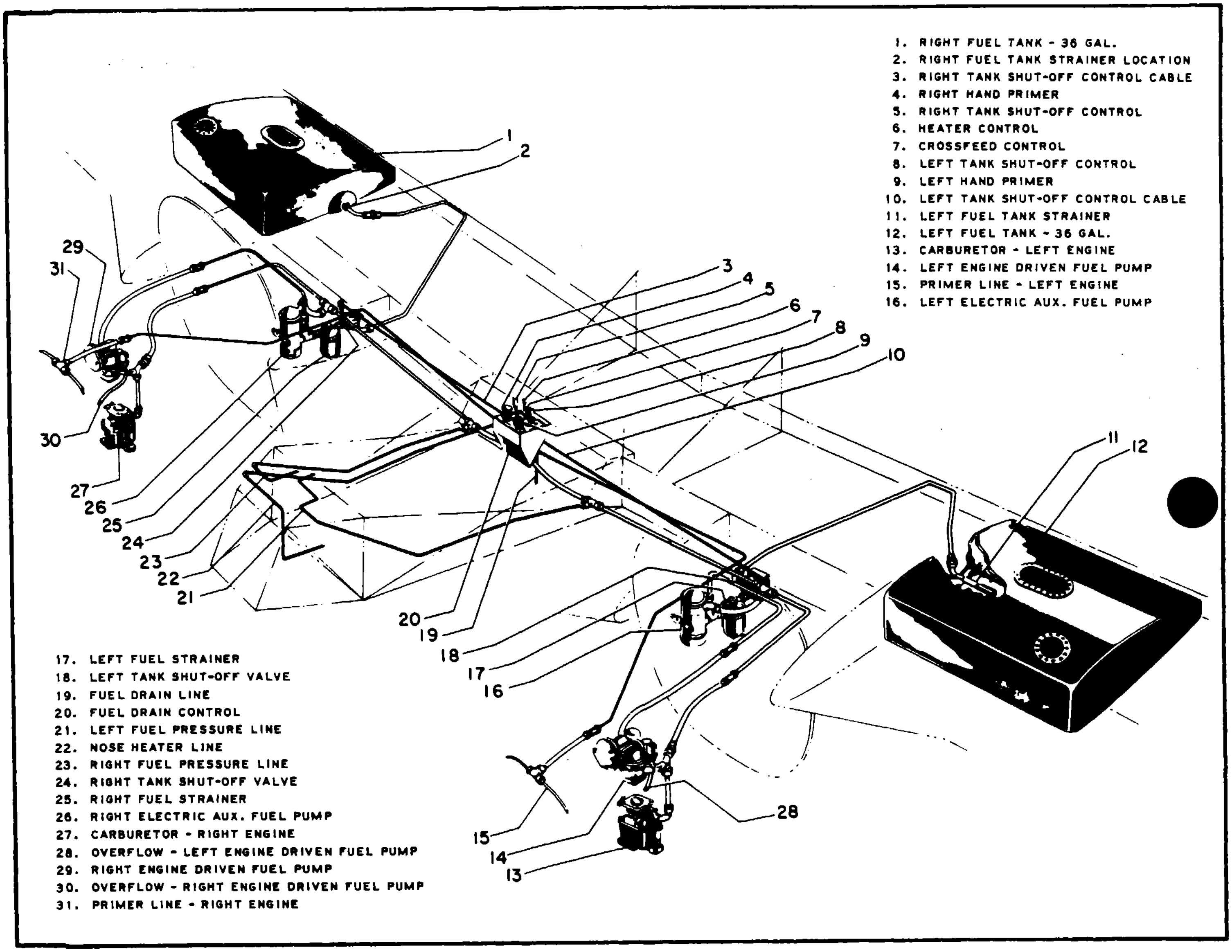


Figure 9-1. Main Fuel System

ed that the cell be drained, and then flushed, sprayed, or rubbed with light engine oil. Do not remove or handle the cell until 24 hours have elapsed after the oil has been applied. Upon removal, disconnect all fittings, hangers, and snap fasteners. Collapse cell to as near the completely collapsed condition as is possible. Be careful when actually removing the cell from its compartment so that the cell does not drag over any sharp edge or projection while it is being removed from the cavity.

9-10. REMOVAL.

a. Drain the fuel cell. (Refer to Section II.)

CAUTION

Be sure crossfeed is off and the proper fuel valve is in the "ON" position.

b. Remove the 16 flat-head screws from the oval cover plate on top of the wing panel and remove the plate.

c. Disconnect the two fuel sender unit wires from unit.

d. Remove the 24 sender unit mounting plate bolts, lockwashers, sender unit plate and two gaskets. On some aircraft, the bolts are either safety-wired or held with self-locking nuts instead of lockwashers.

e. Unlock the winged fastener on the filler neck cover and remove the filler neck plug.

f. Remove the eight filler neck plate bolts, lockwashers, plate and two gaskets. On some aircraft the bolts are either safety-wired or held with self-locking nuts instead of lockwashers.

g. Remove the truss-head screws from the small access plate on the bottom of the wing. Remove the plate and loosen the clamp on the tank outlet neck.

h. Insert arm between fuel cell and the top of the wing and release the seven adjusting tabs located on the outside edges of the cell. These tabs fit into metal clips and can be released by exerting pressure downward with the hand.

i. Insert arm in the big hole at the top of the fuel cell. There are small projections which stick through the tank at each of the attaching brackets. These can be reached from the inside and pushed in an outwardly direction toward the corner of the tank to unseat them from their mounting bracket in the wing. A standard box wrench can be used to slide over the top of the projection onto the nut. This will provide a secure hold.

j. Fold the cell neatly within the cavity and pull gently through the oval opening.

9-11. STORAGE. When synthetic rubber fuel cells are placed in service, the gasoline has a tendency to extract the plasticizer from the inner liner of the cell. This extraction of plasticizer is not detrimental as long as gasoline remains in the fuel cell, inasmuch as the gasoline itself will act as a suitable plasticizer. When the gasoline is drained from the fuel cell, the plasticizing effect of the gasoline is lost and the inner liner of the cell begins to dry out and subsequent cracking or checking will occur. This cracking or checking may penetrate through the inner liner permitting gasoline to diffuse through the walls of the cells after the cell has been refueled. To prevent this failure, a thin coating of light engine oil should be applied to the inner liner of all serviceable fuel cells, which have contained gasoline, when it is evident that the cells will remain without fuel for more than 10 days, whether installed in airplanes or in storage. The oil will act as a temporary plasticizer and will prevent the inner liner from drying out and cracking. If it becomes necessary to return the cell to the contractor or the vendor for testing or repair, do not allow quantities of oil to be puddled in the cell as it will make handling and repair much more difficult. Cells should be repacked as similar to the original factory pack as possible.

a. Do not store the cells under any circumstances near heat or in extremes of humidity.

b. Do not allow the cell to remain longer than absolutely necessary in any strong light.

c. When storing the cells, store in such a manner that their shipping containers are placed level and when necessary to stack more than one high, see that the containers are placed squarely on each other so as to preclude any danger of slipping and the sharp edge of one container perforating another.

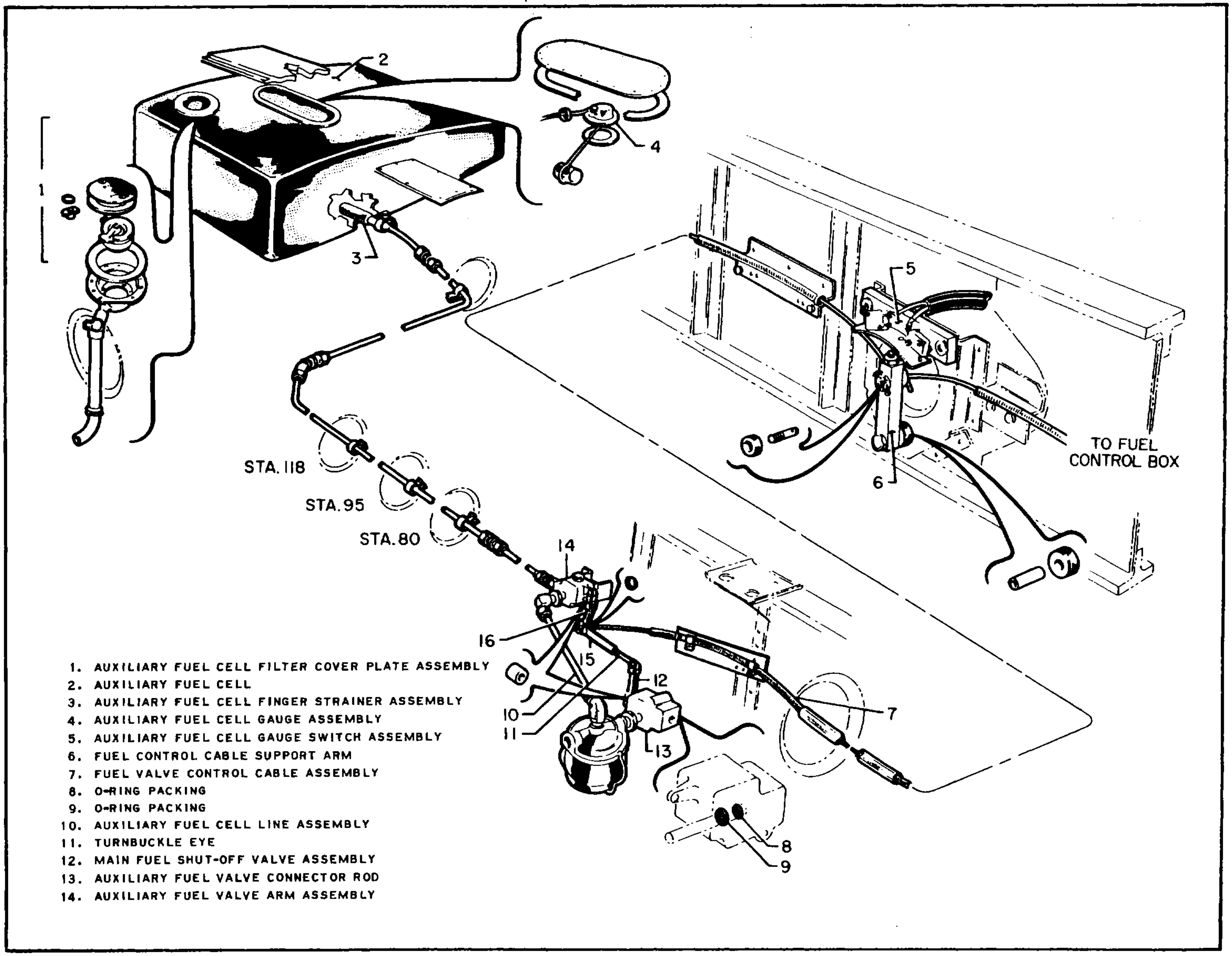
9-12. REPAIR OF FUEL CELL, US-584 CONSTRUCTION.

WARNING

No repairs are to be made on the radius of a cell or in the fitting area of a cell. Cells with such damage are to be returned to the factory for repairs. No damaged areas such as cuts and tears larger than 1 inch are to be repaired in the field.

REFERENCE

USAF Technical Order No. 6J14-1-1.



1. AUXILIARY FUEL CELL FILTER COVER PLATE ASSEMBLY
2. AUXILIARY FUEL CELL
3. AUXILIARY FUEL CELL FINGER STRAINER ASSEMBLY
4. AUXILIARY FUEL CELL GAUGE ASSEMBLY
5. AUXILIARY FUEL CELL GAUGE SWITCH ASSEMBLY
6. FUEL CONTROL CABLE SUPPORT ARM
7. FUEL VALVE CONTROL CABLE ASSEMBLY
8. O-RING PACKING
9. O-RING PACKING
10. AUXILIARY FUEL CELL LINE ASSEMBLY
11. TURNBUCKLE EYE
12. MAIN FUEL SHUT-OFF VALVE ASSEMBLY
13. AUXILIARY FUEL VALVE CONNECTOR ROD
14. AUXILIARY FUEL VALVE ARM ASSEMBLY

Figure 9-2. Auxiliary Fuel System

REPAIRING THE CELL.

a. Outside of Cell.

(1) Use a piece of synthetic rubber coated fabric (U.S. Rubber 5200 outside repair material) Large enough to cover damage at least 2" from cut in any direction. Buff this material lightly and thoroughly with garnet paper and wash with Methyl Ethyl Ketone (U.S. Rubber Co. 339 solution) to remove buffing dust.

(2) Cement buffed side of patch with two coats of U.S. Rubber Co. 3230 cement or Minnesota Mining Co. EC-678. Allow each coat to dry 10-15 minutes.

(3) Buff cell area to be patched lightly and thoroughly with garnet paper and wash with 3339 solution to remove buffing dust.

(4) Cement buffed area with two coats of U.S. Rubber Co. 3230 or Minnesota Mining Co. EC-678 cement. Allow each coat to dry 10-15 minutes.

(5) Freshen cemented area of patch and cemented area of cell with 3339 solution.

(6) While still tacky, apply edge of patch to edge of cemented area on the cell. With a roller or blunt instrument, roll or press the patch to the cemented area and roll or press it down a half-inch to an inch across at a time so as not to trap air between patch and cell. Lay 50 lb. shot bag over patch which is protected by piece of Holland Cloth to prevent sticking. Weight should not be removed for six hours.

(7) Seal coat edge of patch 1/2" with one coat of U.S. Rubber Co. 3230 or Minnesota Mining Co. EC-678 cement and allow the cement to dry thoroughly.

b. Inside of Cell.

(1) After the damaged area has been patched on the outside of the cell and the repair allowed to stand a minimum of six hours, the cell is then ready to have the patch applied on the inside of the cell.

(2) Lightly and thoroughly buff a piece of cured U.S. Rubber 5200/5187 nylon sandwich material large enough to cover damage at least 2" from cut in any direction. Wash buffing dust off patch with Methyl Ethyl Ketone solution (U.S. Rubber 3339).

(3) Cement buffed side of patch with two coats of black rubber cement, U.S. Rubber 3230 or Minnesota Mining Co. EC-678 and allow each coat to dry 10-15 minutes.

(4) Buff cell area to be patched lightly and thoroughly with fine sandpaper (# "0") and then wash off buffing dust with Methyl Ethyl Ketone solution (U.S. Rubber 3339).

(5) Coat buffed area with two coats of black rubber cement, U. S. Rubber 3230 or Minnesota Mining Co. EC-678 and allow each coat to dry 10-15 minutes.

(6) Freshen cemented area of patch and cemented area of cell with Methyl Ethyl Ketone solution (U.S. Rubber 3339).

(7) While still tacky, apply edge of patch to edge of cemented area, centering patch over cut in cell. With a roller or blunt instrument, roll or press the patch to the cemented area on the cell. Hold part of patch off the cemented area and roll or press it down a half-inch to an inch across at a time so as not to trap air between patch and cell. Apply 50 lb. shot bag to repaired area and do not disturb for six hours.

(8) Seal coat patch and 1/2" from edge of patch with two coats of U. S. Rubber 3230 or Minnesota Mining Co. EC-678 cement. Allow the first coat to dry one hour or more. Wipe patch and cemented area lightly with #10 oil, so that when the cell is in its original position the patch area will not stick to other areas of the cell.

c. Scuffed Fabric.

(1) Buff area surrounding scuffed fabric.

(2) Wash buffing dust from area with 3339 solution.

(3) Apply two coats of U.S. Rubber 3230 or Minnesota Mining Co. EC-678 cement to the buffed area, allowing 10 minutes drying time between coats.

9-13. PRE-INSTALLATION INSPECTION AND HANDLING.

a. Store cells at room temperature with no more than normal humidity and in their original shipping container.

b. Remove cells from the shipping container at time of installation.

c. Inspect the cell after removing it from the shipping container for any damage due to crating or removal from crate.

d. In transporting the cell from storage or inspection, do not pick it up by the fittings but carry it or transport it on trucks. Do not drag the cell under any circumstances, nor stack it in any but its original shipping container.

e. Transport cells outside of the installation area in the original shipping container only.

f. Do not handle cells with any sharp pointed tools and be careful that the cell is not placed on any sharp edge or point while it is being transported.

g. Protect all projections, such as fittings of the cell, during handling or transportation.

9-14. PRE-INSTALLATION PREPARATION OF THE CELL COMPARTMENT.

a. Thoroughly clean the cell compartment of all fittings, trimmings, loose washers, bolts or nuts, etc.

b. Round off all sharp edges of the cell compartment.

c. Inspect cell compartments just prior to the installation of the cell.

d. Tap over all sharp edges and rough rivets.

9-15. GENERAL INSTALLATION INSTRUCTIONS.

a. Check to be sure cell is warm enough to flex.

b. Do not use sharp tools such as screwdrivers, or files, for installation purposes.

c. As soon as the cell is in place in its compartment, develop the cell to its full size and connect the hanger fittings. Do not let the cell remain in the folded or collapsed condition any longer than absolutely necessary.

d. After the cell is developed out to its full size, make all connections in accordance with instructions. Be carefullto check all fittings for proper alignment to avoid unnecessary strain.

e. Assemble the sealing or compression surfaces when absolutely dry. Do not use sealing paste.

f. When stop nuts are used, thread the nut on the bolt by hand until it reaches the locking area. Then run the bolt through the lock with a torque wrench. Take a reading after the bolt has run through the lock to determine the friction torque and add this figure to the final torque value. (See placard on fuel cell for proper torque). Finally torque the nuts to this combined torque value.

NOTE

When using castellated nuts, turn nuts on with fingers and apply specified torque with a torque wrench or a torque controlled power tool.

g. After its first application, do not, under any circumstances, retorque the nut without first backing it off completely and performing step "f", above again.

h. Special attention should be given to bolt and stud lengths, to avoid bottoming on the inside of blind tapped holes or dome nuts. Check bolt lengths to avoid riding the nut on the shank or unthreaded area. Either of these conditions produces an error which results in a loss of compression value on the sealing surface of the molded fittings. When fastening or unfastening the snap fasteners, be very careful that a straight push or pull is not exerted, but that the fastener is tilted a little to one side before it is snapped or unsnapped. Remove internal rubber tubing protectors on hanger stud and save them for reuse on cells which may be removed from the airplane. Be careful to avoid damage to hangers and fittings during installation. Refer to paragraph 9-16 for special considerations pertaining to molded nipple fittings.

i. Inspect the cell for final fit within its compartment, making certain that the cell is extended out to the structure and no corners are folded in. Make a final inspection prior to closing the cell to be sure the cell is free from foreign matter such as lint, dust, oil or other installation equipment. If cell is not thoroughly clean, clean it with a lint-free cloth soaked in water, alcohol or kerosene.

CAUTION

Do not use any other solvent.

9-16. MOLDED NIPPLE FITTINGS. The molded nipple fitting is a lightweight fitting developed for ease in installation in certain locations in the airplane. In order to get the best service from this type fitting, it is necessary to exercise certain precautions at the time of installation. The specific precautions other than the general care in handling are as follows:

a. Insert the flow tube into the fitting until the end is flush with the inside edge of the nipple.

b. The hose clamp must be clear of the end of the fitting by 1/4 inch where possible.

c. Locate the hose clamp on the fabric reinforced area of the nipple.

d. Tighten the hose clamp finger-tight. Do this once. Do not retighten unless the hose clamp is loosened completely and allowed to set for 15 minutes before retightening.

e. Do not use sealing paste or gasket compound.

f. Apply a film of liquid detergent soap to the metal flow tubes to facilitate installation and removal.

NOTE

Do not use any other lubricants on fittings of this type.

9-17. INSTALLATION.

a. Fold the new cell compactly and insert through oval opening. Do not cut cell on edges of opening.

b. After unfolding the cell within wing, push outlet neck through hole in bottom of wing, fasten the four slides on bottom of cell and fasten the seven tabs on top of the cell.

c. Replace the two oval gaskets and sender unit mounting plate on oval opening to cell. Insert locating pins, Part Number 18551-00, to line up gaskets and plate with the twenty-four holes in the cell. Pull the pins through the bolt holes in the wing opening and safety temporarily. Place lockwashers under the bolt heads. Turn the 24 bolts in by hand and tighten with a torque wrench and special torque wrench, Part Number 18642-00. (See placard on fuel cell for proper torque.)

d. Connect the sender unit wires and replace oval cover plate and sixteen flat-head screws.

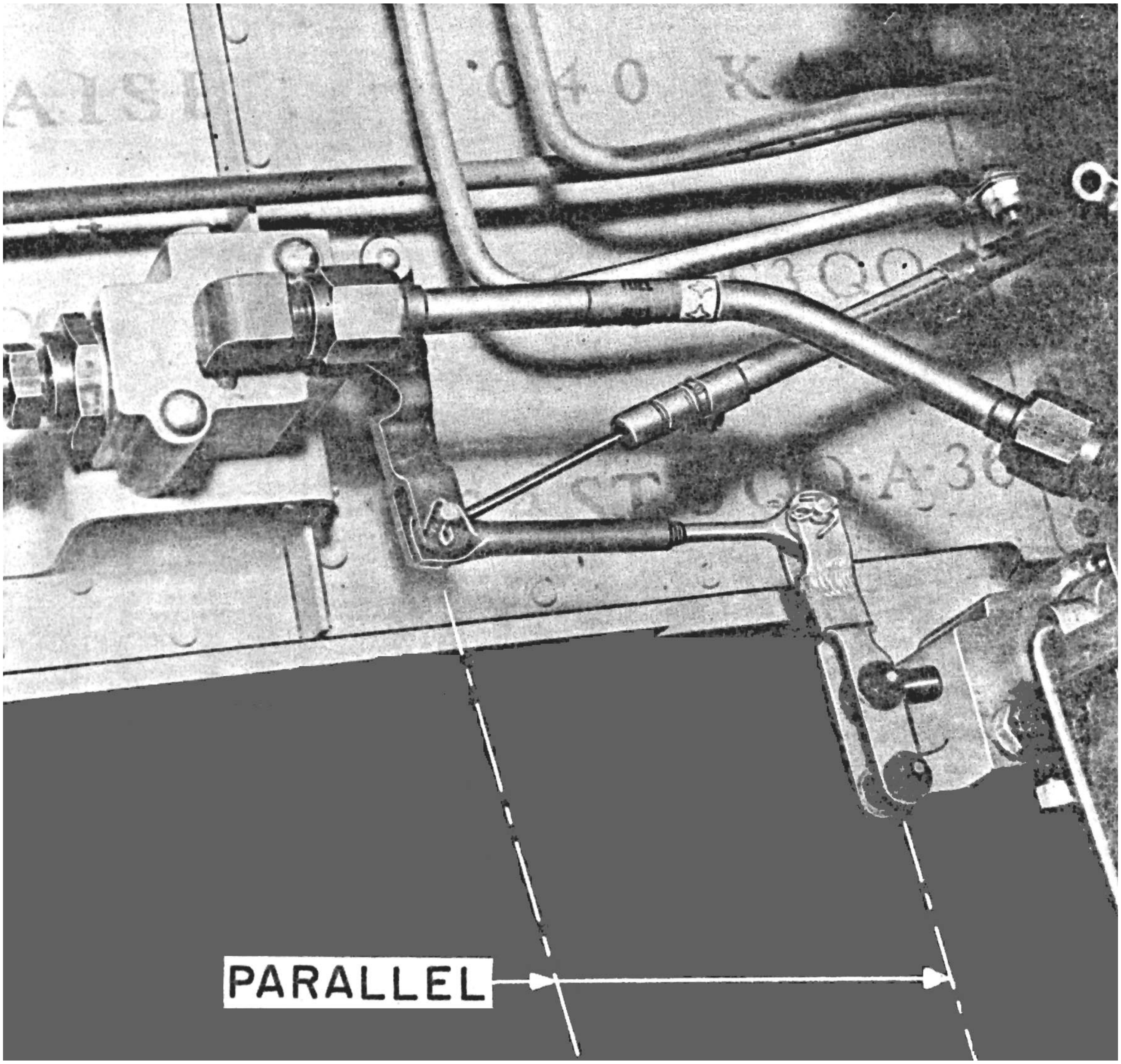


Figure 9-3. Parallel Relation of the Fuel Valve Control and Auxiliary Fuel Valve Arm Assemblies in the “OFF” Position

e. Replace the two round gaskets and filler neck plate on the round covering in the cell. Follow instructions in step “c”, to replace the eight bolts.
f. Tighten the clamp on the cell outlet neck and replace access plate with two screws.
g. Connect the crossfeed fuel lines.
h. Fill the cell to normal capacity of the proper octane fuel.

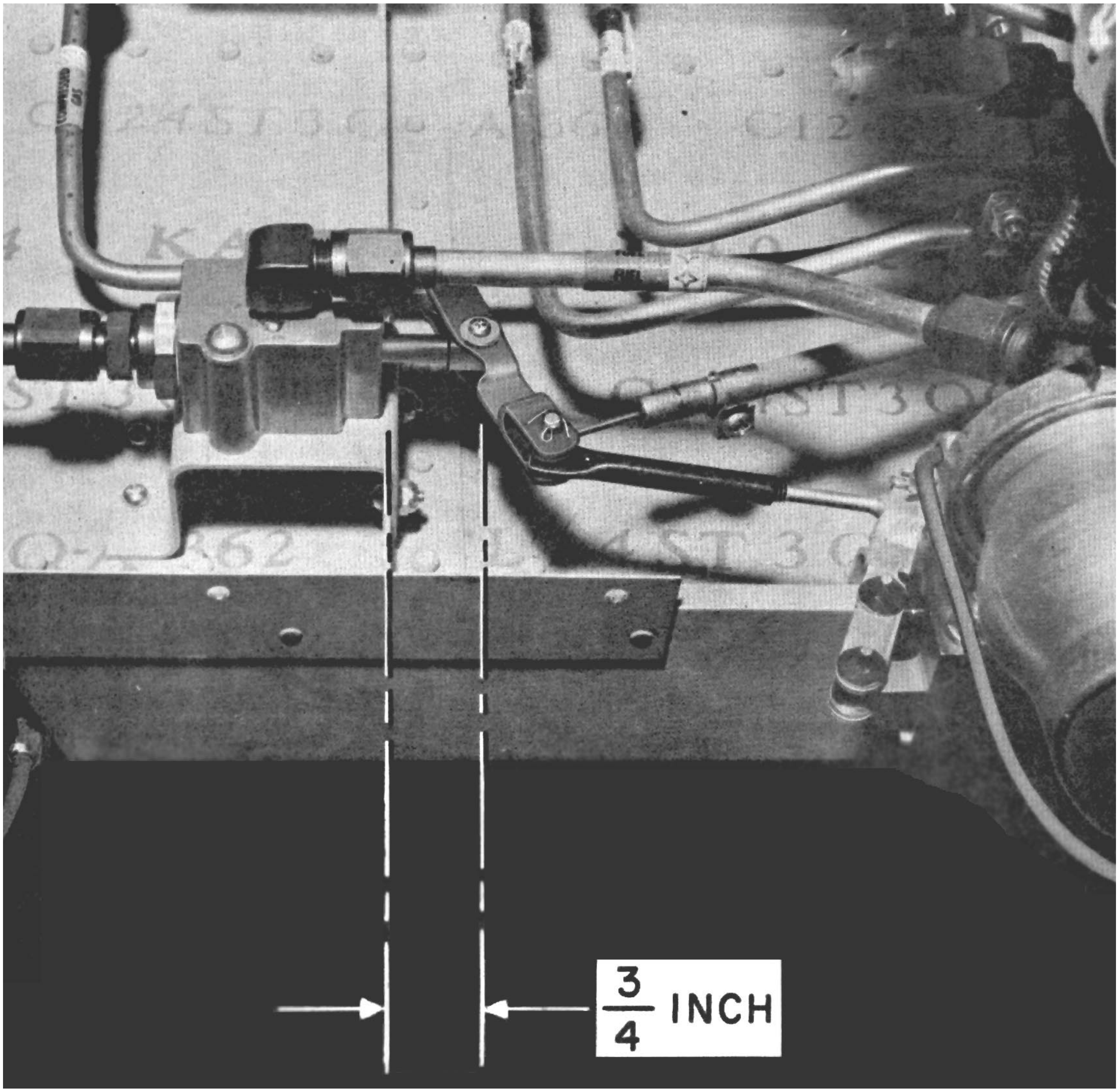


Figure 9-4. Checking Recommended Clearance Between Valve Arm and Valve in the "ON" Position

9-18. ADJUSTING THE FUEL SHUT-OFF VALVES.

a. Place the "LEFT TANK" and "RIGHT TANK" fuel control levers on the fuel control panel box located between the front seats in the "OFF" position.
b. Observe the fuel valve control arm assembly (12, Figure 9-2) and the auxiliary fuel valve arm assembly (16), noting if they are parallel to each other. (Refer to Figure 9-3.)

TABLE IX-I. FUEL SYSTEM TROUBLESHOOTING

Trouble	Cause	Remedy
Fuel gauge fails to indicate on main or auxiliary.	Micro switches not operating.	Check and adjust adjusting screw. (See 5 Figure 9-2.)
	Broken wiring.	Check and repair.
	Gauge not operating.	Replace.
	Float partially or completely filled with fuel.	Remove fuel transmitter unit and replace float.
	Circuit breaker out.	Reset - check.
Fuel gauge indicates full on either auxiliary or main, or both.	Incomplete ground.	Check ground connections at fuel transmitters in wings and at micro switch.
	Defective gauge.	Replace.
No fuel pressure indication on either one or both gauges.	Fuel valves off.	Check valves, turn on.
	No fuel in tank.	Check fuel, fill.
	Defective pump.	Check pumps individually for pressure build up. Check diaphragm and relief valves in engine pump. Check strainer for obstruction in electric pump. Check by-pass valves. Air leak in Intake line.
	Defective gauge	Replace gauge.
Pressure surges or pressure low.	Obstruction in inlet side of pump.	Trace lines and remove obstructions.

TABLE IX-I. FUEL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Pressure surges or pressure low. (cont.)	Faulty by-pass valve.	Replace.
	Faulty diaphragm.	Replace or rebuild pump.
Unidentified leak.	Fuel lines damaged, or improperly installed.	Locate and repair or tighten.
Fuel system locked in either "on" position.	Actuating tab at fuel micro switches interfering with actuating arm.	Check spring tabs and remove side play in arm.
Fuel system open in "off" position.	Fuel valve linkages out of adjustment.	Adjust arms for proper movement. (Refer to paragraph 9-17.)
Fuel valve leaks.	Worn "O" rings.	Replace "O" rings or valve.

NOTE

In addition to being parallel to each other, the arms must also be parallel to the facing surfaces of the bodies of the fuel shut-off valve assemblies (13-14, Figure 9-2).

c. If the arms are not parallel, make the initial adjustment towards correcting this situation by establishing the parallelism of the auxiliary or outboard fuel valve arm assembly and the face of the fuel shut-off valve. To do this, loosen the nut holding the clamp to the support blocks and shift the cable until the arm position is satisfactory. Reclamp the cable.

d. Note the relation of the fuel valve control arm assembly with respect to the properly adjusted auxiliary fuel valve arm assembly. If it is not parallel to the latter, remove the cotter pin, pin, bushing and washer which secure the eye (11, Figure 9-2) to the arm. Turn the eye in whichever direction will make the auxiliary valve arm parallel to the main valve arm. Reconnect the eye to the main arm, placing the head of the pin forward and the washer between the bushing and the forward leg of the main valve arm yoke.

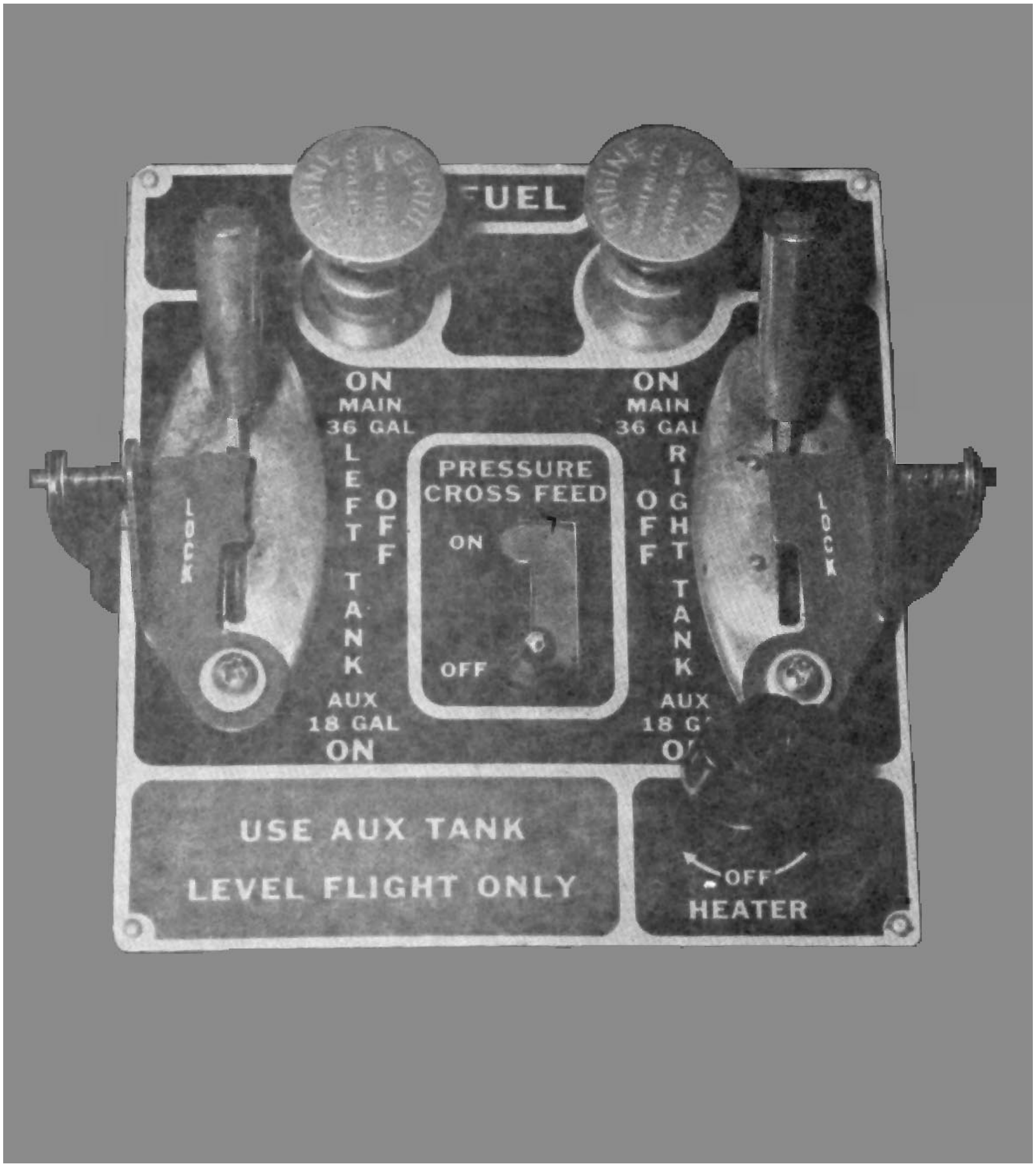


Figure 9-5. Fuel Selector Control Box

e. When either valve is open by virtue of the control being placed in the "ON" position, there must be no less than 3/4 inch between the valve-to-arm attaching rivet and the valve body to obtain complete freedom of travel. (Refer to Figure 9-4.)

9-19. CHECKING THE FUEL SHUT-OFF VALVES.

a. Disconnect the crossfeed fuel line hoses at the engine-driven fuel pump.
b. Fill either the main or auxiliary fuel cells with from 2 to 2-1/2 gallons of

fuel in accordance with the instructions in Section II.

c. Place the fuel control levers of the fuel control panel box in the "OFF" position.

d. Start the electric auxiliary fuel pumps (16 and 26, Figure 9-1) and observe the hoses for indications of fuel. If the valves are functioning properly, there will be no flow.

e. Now fill the other set of tanks and check them in a similar manner, using the electric auxiliary fuel pumps again.

f. When a leak is observed at the conclusion of the checking procedures, adjust the valves. (Refer to Paragraph 9-18.)

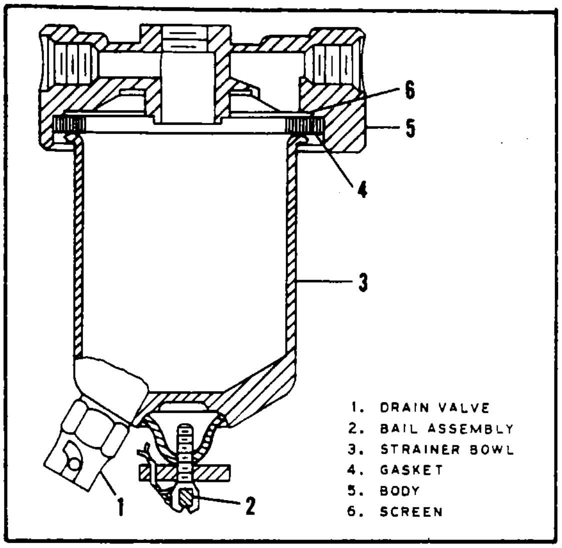


Figure 9-6. Fuel Strainer Bowl

9-20. CLEANING FUEL FILTER BOWL AND SCREEN. (Refer to Figure 9-6.)

The fuel filter bowl with screen, located inside the inboard lower aft section of the nacelle, may be removed and cleaned by the following procedure:

a. Open the access door on the lower inboard side of the nacelle.

b. Cut the safety wire on the fuel bowl, loosen the round nut, move the bail wire to the side and remove the bowl.

c. Remove the gasket and screen from the filter housing.

d. Clean the screen and bowl with acetone or a suitable dry type solvent. If damaged, replace screen.

e. Replace the screen followed by a new gasket.

f. Position the bowl and bail wire, and tighten the round nut.

g. Safety the round nut to the bail wire assembly.

9-21. CLEANING ELECTRIC FUEL PUMP SCREEN. The electric fuel pump screen, located inside the inboard lower aft section of the nacelle just forward of the fuel filter bowl, may be removed and cleaned by the following procedure:

a. Open the access door on the lower inboard side of the nacelle.

b. Cut the safety wire on the bottom of the fuel pump.

c. Remove the base of the fuel pump, removing the screen at the same time.

d. Clean the screen and magnet with acetone or a dry type solvent.

e. Position the screen, gasket and base cover to the pump and turn cover until it snaps into place.

f. Safety the base of the pump to the inlet line.

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AIRPLANE SERVICE MANUAL

CARD 2 OF 2

APACHE

PA-23-150

PA-23-160

PIPER AIRCRAFT CORPORATION

PART NUMBER 752-422 REVISED: OCT. 5, 1999

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AEROFICHE REVISION STATUS

Revisions to this service manual 752-422, originally published (on paper only) in 1954, reissued (on paper only) March 15, 1968 and published on microfiche May 28, 1976 are as follows:

Revisions	Publication Date	Aerofiche Card Effectivity
ORIGINAL (Paper only)	1954	None
COMPLETE REISSUE (Paper only)	October 1960	None
COMPLETE REISSUE (Paper only)	March 15, 1968	None
1st (Paper only)	December 21, 1973	None
2nd	May 28, 1976	1 and 2
3rd	February 13, 1980	1 and 2
4th	February 23, 1983	1 and 2
5th	April 29, 1986	1
6th	September 15, 1998	1 and 2
7th*	October 5, 1999	1 and 2

*** Revisions appear in both cards. Accordingly, discard your existing card set and replace it with these cards dated October 5, 1999.**

A. Consult the latest Piper Customer Service Information Catalog No. 1753-755 (Aerofiche) for current revision dates for this manual.

B. The General Aviation Manufacturers Association (GAMA) has developed specifications for microfiche reproduction of aircraft publications. The information compiled in this Aerofiche Service Manual will be kept current by revisions distributed periodically. These revisions will supersede all previous revisions and will be complete Aerofiche card replacements and shall supersede Aerofiche cards of the same number in the set.

C. Conversion of Aerofiche alpha/numeric grid code numbers:

First number is the Aerofiche card number.
Letter is the horizontal row reference per card
Second number is the vertical column reference per card.

Example: 2J16 = Aerofiche card number two, row J, column 16.

D. To aid in locating information, a complete Preface containing the Section Index Guide, List of Illustrations and List of Tables for all fiche in this set is provided at the beginning of Card 1. Each subsequent aerofiche card contains a partial Preface, displaying only those elements on that card.

IDENTIFYING REVISED MATERIAL

A revision to a page is defined as any change to the text or illustrations that existed previously. Such revisions, additions and deletions are identified by a vertical black line (change bar) along the left-hand margin of the page opposite only the text or illustration that was changed.

Changes in capitalization, spelling, punctuation, indexing, the physical location of the material or complete page additions are not identified by revision lines.

Example.

EFFECTIVITY

This service manual is effective for all PA-23-150 and PA-23-160 airplanes as follows:

Model Name	Model Number	Serial Numbers	Model Years
Apache	PA-23-150	23-1 thru 23-1182	1954 - 1958
	PA-23-160	23-1183 thru 1870	1958 - 1959
Apache G	PA-23-160	23-1871 thru 23-2012	
		23-2044 thru 23-2046	1960 - 1962
Apache H	PA-23-160	23-2013 thru 23-2043	1962

PARTS

This manual generally does not contain hardware callouts for installation. Hardware callouts are only indicated where a special application is required. To confirm the correct hardware used, refer to the PA-23 Apache Parts Catalog P/N 752-421, and FAR 43 for proper utilization.

WARNINGS, CAUTIONS AND NOTES

These are used to highlight or emphasize important information.

— WARNING —

OPERATING PROCEDURES, PRACTICES, ETC., WHICH MAY RESULT IN PERSONAL INJURY OR LOSS OF LIFE IF NOT CAREFULLY FOLLOWED.

— CAUTION —

OPERATING PROCEDURES, PRACTICES, ETC., WHICH IF NOT STRICTLY OBSERVED MAY RESULT IN DAMAGE TO EQUIPMENT.

— Note —

An operating procedure, condition, etc., which is essential to emphasize.

SECTION INDEX GUIDE

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (cont.)

LIST OF TABLES

2A9

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SECTION X

INSTRUMENTS

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SECTION X

INSTRUMENTS

10-1. GENERAL. The instrumentation in the Apache is designed to give a quick and actual indication of the attitude, performance and condition of the airplane. The instrument panel has been arranged to accommodate all the advanced flight instruments on the left side in front of the pilot and the required engine and miscellaneous instruments on the right side. All gyro instruments have been shock mounted to prolong their operation.

The two types of instruments installed in the Apache have been classified in this section as non-electrical and electrical. The first part of this section will pertain to maintenance and troubleshooting of all the instruments and their systems which depend on non-electrical sources for their operation. The remaining portion of this section is directed to maintenance and troubleshooting of all the electrically operated instruments.

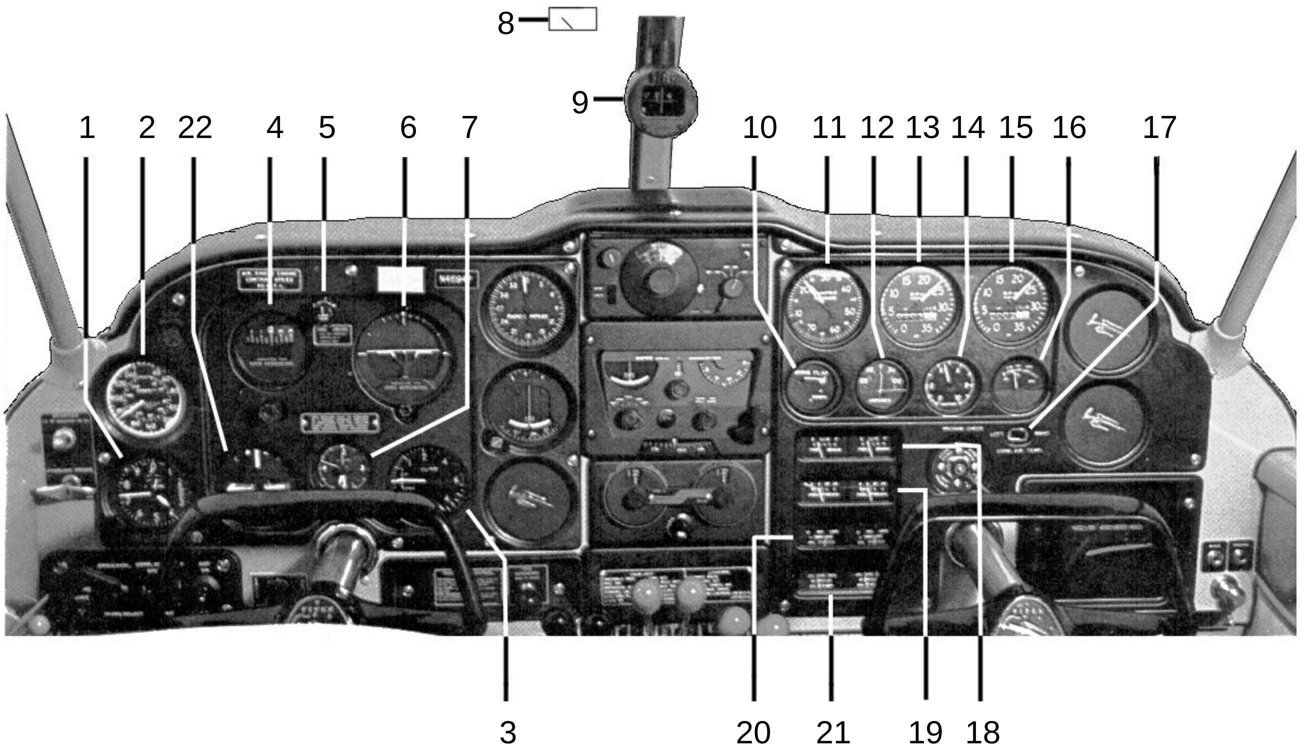
10-2. NON-ELECTRICAL INSTRUMENTS.

10-3. VACUUM SYSTEM.

10-4. GENERAL. The source of vacuum for the gyro instruments is furnished by one or two engine driven pumps, depending on the type vacuum system installed in the airplane. The dual vacuum system is installed as optional equipment on the late model Apache and a kit (754 056) is available for installation of the dual vacuum system on airplanes still incorporating the single system.

The complete dual vacuum system is comprised of two vacuum pumps, two air-oil separators, three regulator valves and the necessary tubing, check valves and connection to make up the system. A manually operated test selector valve is installed in the instrument panel, along with a vacuum gauge, so that an individual check can be made of the vacuum system pressure.

Each vacuum pump exhaust is connected to an air-oil separator mounted adjacent to the pump in the engine compartment. From the bottom of the air-oil separator, a hose returns oil, recovered from the vacuum pump exhaust, to the engine crankcase. Lines from the tops of the air-oil separators are vented overboard through the augmentor tubes. On the late model Apache, these lines are connected to a container mounted on the engine firewall. Draining of this container should be part of the daily pre-flight.



1. ALTIMETER
2. AIRSPEED INDICATOR
3. RATE OF CLIMB INDICATOR
4. DIRECTIONAL GYRO
5. CLOCK
6. AUTO FLIGHT TRIM CONTROL
7. GYRO HORIZON
8. OUTSIDE AIR TEMPERATURE
9. MAGNETIC COMPASS
10. FLAP INDICATOR *
11. MANIFOLD PRESSURE INDICATOR
12. AMMETER *
13. LEFT TACHOMETER
14. VACUUM SUCTION GAUGE
15. RIGHT TACHOMETER
16. CARBURETOR AIR TEMPERATURE INDICATOR *
17. CARBURETOR AIR TEMPERATURE SELECTOR SWITCH
18. FUEL QUANTITY INDICATOR *
19. FUEL PRESSURE INDICATOR
20. OIL PRESSURE INDICATOR
21. OIL TEMPERATURE INDICATOR *
22. TURN AND BANK INDICATOR *

* ELECTRICAL INSTRUMENTS

Figure 10-1. Instrument Panel - Later Models

The vacuum lines are routed from the pumps, through relief valves, mounted on the engine firewalls and continues on through the wings to the fuselage center section. Here the systems are joined and one line continues to the instrument panel. A regulator valve is installed in this line for final adjustment of the complete vacuum system pressure.

10-5. TROUBLESHOOTING

TABLE X-I. VACUUM SYSTEM

Trouble	Cause	Remedy
No vacuum pressure gauge indication at one source.	Pump inoperative. Disconnected. Broken or restricted lines.	Replace pump. Locate trouble and correct.
No vacuum pressure gauge indication at instrument.	Hose from instrument to gauge leaking or restricted.	Check all lines and connections.
No vacuum suction gauge indication at either instrument or source.	Faulty gauge. Malfunctioning relief valve, regulator valve, or vacuum pump.	Check operation of instruments. If operation is normal, replace gauge. If instruments are inoperative, check operation of vacuum pump and relief or regulator valve.
Low vacuum system pressure.	Vacuum relief or regulator valves incorrectly adjusted. Leaking of the system lines or fitting.	Adjust relief or regulator valves in accordance with (Adjustments) of this section. Check all lines and fittings.
Normal pressure indication, but sluggish operation of instruments.	Instruments air filter elements dirty.	Remove and clean or replace.

TABLE X-I. VACUUM SYSTEM (cont.)

Trouble	Cause	Remedy
High system pressure.	Vacuum regulator valve incorrectly adjusted.	Adjust in accordance with (adjustments) of this section.
	Vacuum regulator valve sticking or dirty screen.	Clean and check operation of regulator valve.

10-6. SUCTION GAUGE.

10-7. GENERAL. The suction gauge is mounted in the right side of the instrument panel, just above the test selector valve. This suction gauge is calibrated in inches of mercury and indicates the amount of vacuum created by the engine driven vacuum pumps. The gauge has one connection which is routed to the test selector valve.

10-8. TROUBLESHOOTING. For troubleshooting of this instrument, refer to Table XIV of this section.

10-9. VACUUM TEST SELECTOR VALVE.

10-10. GENERAL. The vacuum test selector valve, located on the right side of the instrument panel, is a four position, manually operated type valve. This valve, incorporated with the vacuum suction gauge, provides a means of checking vacuum pressure at four different locations of the system. Therefore giving a means of localizing trouble in the event a portion of the system is malfunctioning.

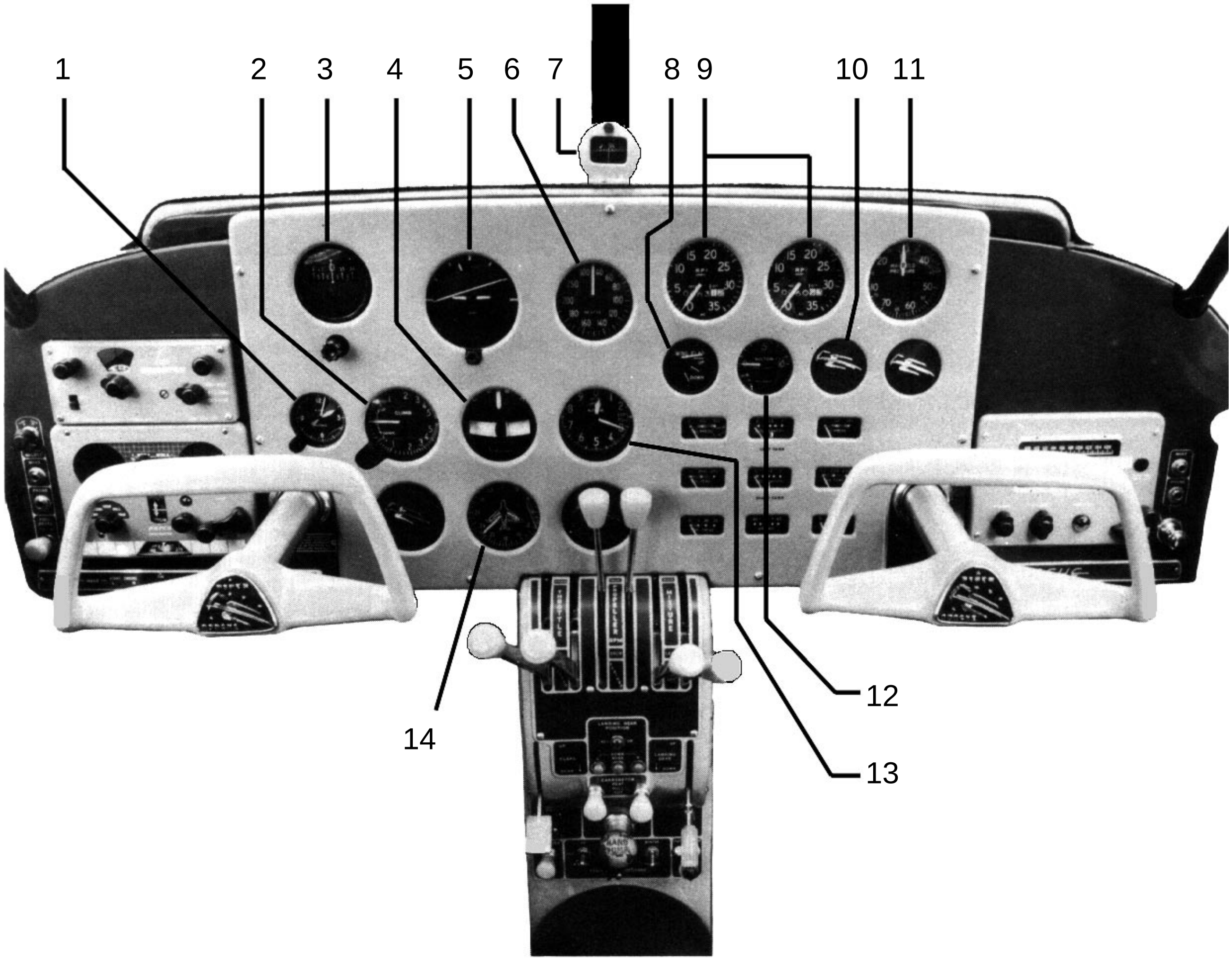
10-11. TROUBLESHOOTING. For troubleshooting of this unit, refer to Table X-I.

10-12. REMOVAL AND REPLACEMENT.

a. To gain access to the test selector valve, remove the instrument access panel and the right instrument face panel.

b. Remove the five lines connected to the valve and note their location for proper installation.

c. Remove the four mounting screws; and remove the valve.



1. CLOCK
2. RATE OF CLIMB INDICATOR
3. DIRECTIONAL GYRO
4. TURN AND BANK INDICATOR *
5. GYRO HORIZON
6. AIRSPEED INDICATOR
7. MAGNETIC COMPASS
8. FLAP INDICATOR *
9. RIGHT AND LEFT TACHOMETER
10. VACUUM TEST SELECTOR VALVE (IF INSTALLED)
11. DUAL MANIFOLD PRESSURE INDICATOR
12. VACUUM SUCTION GAUGE
13. ALTIMETER
14. ADF *

* ELECTRICAL INSTRUMENTS

Figure 10-2. Instrument Panel - Early Models

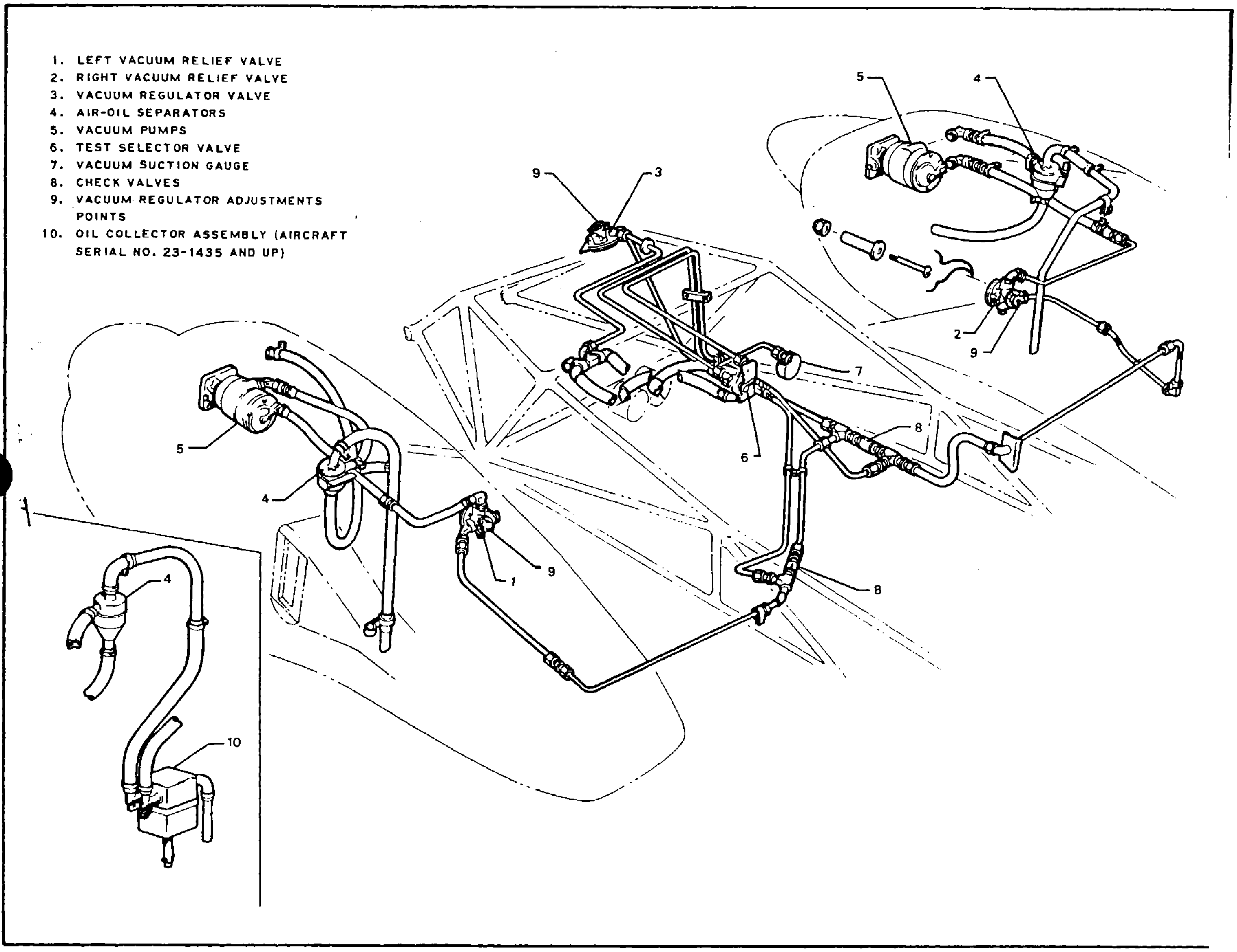


Figure 10-3. Dual Vacuum System.

d. Reinstall the valve in reverse order of removal and replace panels. Check the operation of the system.

10-13. VACUUM RELIEF AND REGULATOR VALVES.

10-14. GENERAL. There are three vacuum valves incorporated in this system; one mounted on the inboard side of each engine firewall, these two relief valves are for the adjustment of the right and left source. Access to these valves is by removal of the inboard nacelle panel on each engine. A third valve is located in the right side of the nose section and is accessible through the battery access panel. The vacuum regulator valve mounted in the nose is for final adjustment of the vacuum system pressure.

10-15. TROUBLESHOOTING. For troubleshooting of the vacuum regulator and relief valves, refer to TABLE X-I.

10-16. ADJUSTMENTS OF VACUUM REGULATOR AND RELIEF VALVES.

a. Remove inboard engine nacelle panels and the battery access panel.

b. Loosen the locking nuts or remove the protective caps from the valves, depending on which type is installed.

NOTE

Do not attempt adjustment of these valves with the engines in operation.

c. Start the engines, after allowing time for warm-up, run the engines at medium R.P.M.

d. With the engines running at medium R.P.M., move the test selector valve to the right source; the suction gauge should indicate between 8.00 and 10.00 inch of mercury. When the selector is moved to the left source, the indication should be the same. If the pressure reading fails to fall within this range, shut down the engines and adjust the relief valves mounted on the engine fire walls by moving the valve adjustment screw clockwise to increase the pressure, and counter-clockwise to decrease the pressure. Start the engines and repeat the check. With the right and left source both indicating the recommended pressure, move the selector to gyro horizon or gyro compass position. The recommended pressure for these positions is 3.5 to 4.5 inch of mercury. To obtain these pressures, shut down the engines and adjust the vacuum regulator valve located in the nose section. Start the engines and repeat the complete system check.

e. After the system pressure has been adjusted to these recommended settings; retighten the locking nuts or replace the protective caps, whichever applies to the type of valve installed. Replace the panels previously removed.

10-17 REMOVAL AND REPLACEMENT.

a. For removal of either relief valve mounted in the engine compartment, remove the right and left engine nacelle panels and the rear nacelle behind the engine firewall. For removal of the regulator valve located in the nose section, remove the battery access panel.

b. To remove the relief valves located in the engine compartments, disconnect the two lines, remove the four mounting screws and remove the valve. The same procedure will apply to the regulator in the nose section.

c. Replace regulator in reverse order given for removal. Check complete vacuum system for proper operation.

10-18. VACUUM PUMPS.

10-19. GENERAL. The vacuum pumps used on the Apache are of the rotary four vane, positive displacement type. These units consist essentially of an aluminum housing containing a tempered sleeve in which an offset rotor, with four moving blades is incorporated. This assembly is driven by means of a coupling mated to the engine driven gear assembly. The pumps are mounted on the accessory section of each engine. Each pump is capable of maintaining system pressure in case of failure of one or the other units.

10-20. TROUBLESHOOTING. For troubleshooting of the pumps, refer to Table X-I of this section.

10-21. REMOVAL AND REPLACEMENT. Either vacuum pump can be removed by the following procedure:

a. Remove side panels and top portions of the engine nacelles.

b. Loosen the two hose clamps and remove the two hoses from the vacuum pump fittings.

NOTE

Note location of hoses for reinstallation.

c. Remove the vacuum pump by removal of the four retaining nuts, lock washer and plain washers.

d. Reinstall pumps in reverse order of removal, noting alignment of spline on the pump drive with the spline on the engine drive assembly.

10-22. DIRECTIONAL GYRO.

10-23. GENERAL. The directional gyro is a flight instrument incorporating an air driven gyro stabilized in the vertical plane. The gyro is rotated at high speed by lowering the pressure in the air tight case and simultaneously allowing atmospheric air pressure to enter the instrument against the gyro buckets. Due to gyroscopic inertia, the spin axis continues to point in the same direction even though the aircraft yaws to the right or left. This relative motion between the gyro and the instrument case is shown on the instrument dial which is similar to a compass card. The dial, when set to agree with the airplane magnetic compass, provides a positive indication free from swing and turning error.

10-24. TROUBLESHOOTING.

TABLE X-II. DIRECTIONAL GYRO INDICATOR

Trouble	Cause	Remedy
Excess drift in either direction.	Excessive vibration with amplitude more than 0.006 inch.	Check shock mounts.
	Insufficient vacuum. If vacuum below 3.75 inch Hg, check for the following:	
	a. Relief valve improperly adjusted.	a. Adjust.
	b. Incorrect gauge reading.	b. Recalibrate.
	c. Pump failure	c. Repair or replace
	d. Vacuum line kinked or leaking.	d. Check and repair Check for collapsed inner wall of hose.

TABLE X-II. DIRECTIONAL GYRO INDICATOR (cont.)

Trouble	Cause	Remedy
Excess drift in either direction. (cont.)	Defective instrument.	Replace instrument.
Dial spins continuously.	Defective mechanism.	Replace.

10-25. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 Of this section.

10-26. GYRO HORIZON.

10-27. GENERAL. The gyro horizon is essentially an air driven gyro scope rotating in a horizontal plane and is operated by the same principal as the directional gyro. Due to the gyroscopic inertia, the spin axis continues to point in the vertical direction, providing a constant visual reference to the altitude of the airplane relative to pitch and roll axis. A bar across the face of the indicator represents the horizon. A miniature adjustable airplane is mounted to the case and aligning the miniature airplane to the horizon bar simulates the alignment of the airplane to the actual horizon. Any deviation simulates the deviation of the airplane from the true horizon. The gyro horizon is marked for different degrees of bank.

10-28. TROUBLESHOOTING.

TABLE X-III. GYRO HORIZON INDICATOR

Trouble	Cause	Remedy
Bar fails to respond.	Insufficient vacuum.	Check pump and tubing.
Bar does not settle.	Excessive vibration.	Check shock mounts. Replace if necessary.
Bar does not settle.	Insufficient vacuum.	Check line and pump. Adjust valve.
	Defective instrument.	Replace.

TABLE X-III. GYRO HORIZON INDICATOR (cont.)

Table	Cause	Remedy
Bar oscillates or shimmies continuously.	Excessive vibration.	Check shock mounts. Replace if necessary.
	Vacuum too high.	Adjust valve.
	Defective mechanism.	Replace instrument.

10-29. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-30. RATE OF CLIMB INDICATOR.

10-31. GENERAL. The rate of climb indicator measures the rate of change in static pressure when the airplane is climbing or descending. By means of a pointer and dial, this instrument will indicate the rate of ascent or descent of the airplane in feet per minute.

10-32. TROUBLESHOOTING.

TABLE X-IV. RATE OF CLIMB INDICATOR

Trouble	Cause	Remedy
Pointer does not set on zero.	Aging of diaphram.	Reset pointer to zero by means of setting screw. Tap instrument while resetting.
Point fails to respond.	Obstruction in static line.	Disconnect all instruments connected to the static line. Check individual instruments for obstruction in lines.
Pointer oscillates.	Leaks in static line.	Disconnect all instruments connected to the static

TABLE X-IV. RATE OF CLIMB INDICATOR (cont.)

Table	Cause	Remedy
Pointer oscillates. (cont.)		line. Check individual instruments for leaks. Reconnect instruments to static line and test installation for leaks.
	Defective mechanism.	Replace instrument.

10-33. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-34. SENSITIVE ALTIMETER.

10-35. GENERAL. The altimeter indicates pressure altitude in feet above sea level. The indicator has three pointers and dial scale. The long pointer is read in hundreds of feet. The middle pointer is read in thousand of feet and the short pointer in ten thousand feet. A field pressure window is located on the right side of the indicator dial and is set by the knob located on the lower left corner of the instrument. The altimeter consists of a sealed diaphragm that is connected to the pointers through a mechanical linkage. The instrument case is vented to the static air system and as static air pressure decreases, the diaphragm expands, causing the pointers to move through the mechanical linkage.

10-36. TROUBLESHOOTING.

TABLE X-V. ALTIMETER

Trouble	Cause	Remedy
Excessive scale error.	Improper calibration adjustment.	Replace instrument.
Excessive pointer oscillation.	Defective mechanism.	Replace instrument.
High reading.	Improper venting.	Eliminate leak instatic pressure system and

TABLE X-V. ALTIMETER (cont.)

Trouble	Cause	Remedy
High reading. (cont.)		check alignment of airspeed tube.
Setting knob is hard to turn.	Wrong lubrication or lack of lubrication.	Replace instrument.
Inner reference marker fails to move when setting knob is rotated.	Out of engagement.	Replace instrument.
Setting knob setscrew loose or missing.	Excessive vibration.	Tighten instrument screw, if loose. Replace instrument, if screw is missing.
Cracked or loose cover glass.	Excessive vibration.	Replace instrument.
Dull or discolored luminous markings.	Age.	Replace instrument.
Barometric scale and reference markers out of synchronism.	Slippage of mating parts.	Replace instrument.
Barometric scale and reference markers out of synchronism with pointers.	Drift in mechanism.	Reset pointers. (Refer to the latest revision of AC 43.13-1.)

10-37. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-38. AIRSPEED INDICATOR.

10-39. GENERAL. The airspeed indicator provides a means of indicating the speed of the airplane passing through the air. The airspeed indication is the differential pressure reading between pitot air pressure and static air pressure.

This instrument has the diaphragm vented to the pitot air source and the case is vented to the static air system. As the airplane increases speed, the pitot air pressure increases, causing the diaphragm to expand. A mechanical linkage picks up this motion and moves the instrument pointer to the indicator speed. The instrument dial is calibrated in knots and miles per hour, and also has the necessary operating range markings for safe operation of the airplane.

10-40. TROUBLESHOOTING.

TABLE X-VI. AIRSPEED TUBES AND INDICATOR

Trouble	Cause	Remedy
Tube does not heat or clear itself of ice with switch "ON". (Heated pitot tubes only.)	Circuit breaker popped.	Reset
Tube does not heat or clear itself of ice with switch "ON". (Heated pitot tubes only.)	Open circuit.	Repair.
	Excessive voltage drop between battery and pitot head.	Check voltage at pitot head.
	Heating element burned out.	Replace pitot head.
Pointers of static instruments do not indicate properly.	Leak in instrument case or in pitot lines.	Check for leak and seal.
Pointer of instrument oscillates.	Leak in instrument case or in pitot lines.	Check for leak and seal.

10-41. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-42. MAGNETIC COMPASS.

10-43. GENERAL. The magnetic compass installed in the Apache is a self-contained instrument and is mounted above the instrument panel on the windshield centerstrip. This instrument has an individual light which is connected to the instrument lighting circuit. The compass correction card is located in the card holder mounted on the instrument panel.

10-44. TROUBLESHOOTING.

TABLE X-VII. MAGNETIC COMPASS

Trouble	Cause	Remedy
Excessive card error.	Compass not properly compensated.	Compensate instrument.
	External magnetic interference.	Locate magnetic interference and eliminate if possible.
Excessive card oscillation.	Improper mounting on instrument panel.	Align instrument.
	Insufficient liquid.	Replace instrument.
Card sluggish.	Weak card magnet.	Replace instrument.
	Excessive pivot friction or broken jewel.	Replace instrument.
	Instrument too heavily compensated.	Remove excess compensation.
Liquid leakage.	Loose bezel screws.	Replace instrument.
	Broken cover glass.	Replace instrument.
	Defective sealing gaskets.	Replace instrument.

TABLE X-VII. MAGNETIC COMPASS (cont.)

Trouble	Cause	Remedy
Discolored luminous markings damping liquid.	Age.	Replace instrument.
Defective light.	Burned out lamp or broken circuit.	Check lamp or continuity of wiring.

10-45. DUAL MANIFOLD PRESSURE GAUGE.

10-46. GENERAL. The dual manifold pressure gauge is a vapor proof, absolute pressure type instrument. Pressure from the intake manifolds of both engines is transmitted to the instrument through lines. Two pointers, one for each engine, indicate the manifold pressure available at each respective engine in inches of mercury.

10-47. TROUBLESHOOTING.

TABLE X-VIII. MANIFOLD PRESSURE INDICATOR

Trouble	Cause	Remedy
Excessive error at existing barometric pressure.	Pointer shifted.	Replace instrument.
Excessive error when engine is running.	Line leaking.	Tighten line connections.
Sluggish or jerky pointer movement.	Improper damping adjustment.	Adjust damping screw.
Broken or loose cover glass.	Vibration or excessive pressure.	Replace glass and reseat case.
Dull or discolored luminous markings.	Age.	Replace instrument.

TABLE X-VIII. MANIFOLD PRESSURE INDICATOR (cont.)

Trouble	Cause	Remedy
Incorrect reading.	Moisture or oil in line.	Disconnect lines and blow out.

10-48. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-49. TACHOMETER INDICATOR.

10-50. GENERAL. The tachometer provides an indication of crankshaft speed in revolutions per minute. Each engine on the Apache has an individual tachometer which is connected to the engine accessory section by a flexible cable. Both tachometers have a recording mechanism mounted in the instrument for recording the time that the engine is in actual operation.

10-51. TROUBLESHOOTING.

TABLE X-IX. TACHOMETER

Trouble	Cause	Remedy
No reading on indicator, either permanent or intermittent.	Broken shaft. Springs weak.	Replace instrument. Replace instrument.
Pointer oscillates excessively.	Rough spot on, or sharp bend in shaft.	Repair or replace.
	Excess friction in instrument.	Replace instrument.

10-52. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-53. ENGINE OIL PRESSURE GAUGE.

10-54. GENERAL. There are two individual oil pressure gauges mounted in a cluster on the right side of the instrument panel. Each gauge is connected to the pressurized engine oil passage of its respective engine.

10-55. TROUBLESHOOTING.

TABLE X-X. ENGINE OIL PRESSURE GAUGE

Trouble	Cause	Remedy
Excessive error at zero.	Pointer loose on shaft. Overpressure or seasoning of bourbon tube.	Replace instrument.
Excessive scale error.	Improper calibration adjustment.	Replace instrument.
Excessive pointer oscillation.	Improper damping or rough engine relief valve.	Disconnect line and drain. Check for leaks. If trouble persists, clean and adjust relief valve.
Sluggish operation or pointer or pressure fails to build up.	Engine relief valve open.	Check and clean.

10-56. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-57. FUEL PRESSURE GAUGE.

10-58. GENERAL. Two fuel pressure gauge instruments are mounted in a cluster on the right side of the instrument panel. Each gauge is connected to the fuel system at the wing root section. Pressure is routed through small lines to the individual gauges which are calibrated in pounds per square inch.

10-59. TROUBLESHOOTING.

TABLE X-XI. FUEL PRESSURE GAUGE

Trouble	Cause	Remedy
Low or no pressure indication.	Defective fuel pump.	Replace.
	Defective electric fuel pump switch.	Replace.
	Defective wiring.	Repair.
	Defective gauge.	Replace.
	Leak in engine pump diaphram.	Repair.
	Leak in pressure line.	Repair.
Needle fluctuation.	Surge dome on pump filled with fuel.	Remove and empty.

10-60. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-61. ELECTRICAL INSTRUMENT.

10-62. TURN AND BANK INDICATOR.

10-63. GENERAL. The turn and bank indicator is an electrical instrument used for making correctly controlled turns. The turn portion of the indicator is an electrically driven gyroscope, while the bank portion is a ball sealed in a curved glass tube filled with damping fluid. The electrical switch for the turn and bank indicator is located on the switch panel under the left instrument panel.

10-64. TROUBLESHOOTING.

TABLE X-XII. TURN AND BANK INDICATOR

Trouble	Cause	Remedy
Pointer fails tc respond.	Foreign matter lodged in instrument.	Replace instrument.
	No electrical circuit.	Check for voltage at instrument.
Incorrect sensitivity.	Misadjustment of sensitivity spring.	Adjust by means of sensitivity spring screw. If this pulls the pointer from zero, replace instrument.
Pointer does not set on zero.	Gimbal and rotor assembly out of balance.	Replace instrument.
	Pointer incorrectly set on its staff.	Replace instrument.
	Sensitivity adjustment pulls pointer off zero.	Replace instrument.
Vibrating pointer.	Gimbal and rotor assembly out of balance.	Replace instrument.
	Pitted or worn pivots or bearings.	Replace instrument.
In low temperature, pointer fails to respond or does so sluggishly and with insufficient deflection.	Oil has become too thick.	Replace instrument.
	Insufficient bearing clearance.	Replace instrument.

TABLE X-XII. TURN AND BANK INDICATOR (cont.)

Trouble	Cause	Remedy
Pointer sluggish in returnin to zero and does not set on zero when stationary.	Oil or dirt between damping pistons and cylinder.	Replace instrument.
	Excessive clearance between rotor and rotor pivots.	Replace instrument.
Ball in inclinometer does not center.	Instrument out of alignment on panel.	Correct alignment.

10-65. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-66. FUEL QUANTITY INDICATOR.

10-67. GENERAL. The two fuel quantity gauges used on the Apache are mounted in a cluster on the right instrument panel. These instruments are calibrated in fractional divisions of one fourth, one half, three fourths and full. A transmitter unit is installed in each fuel cell. This unit contains a resistance strip and a movable control arm. The position of this arm is controlled by a float in the fuel cell and this position is transmitted electrically to the indicator gauge to show the amount of fuel in the cell. If the auxiliary fuel system is installed, the quantity gauges will indicate the amount of fuel in the cell, to which the fuel control levers are positioned. When the fuel control levers are moved to the "OFF" position, the quantity gauges will indicate empty.

10-68. TROUBLESHOOTING.

TABLE X-XIII. FUEL QUANTITY INDICATORS

Trouble	Cause	Remedy
Inaccurate or no indication.	Defective gauge.	Replace.

TABLE X-XIII. FUEL QUANTITY INDICATORS (cont.)

Trouble	Cause	Remedy
Inaccurate or no indication. (cont.)	Defective micro switch.	Replace.
	Defective wiring.	Repair.
	Defective fuel transmitter.	Repair or replace.
Gauge indicates full constantly.	Intermittent or no ground.	Repair.

10-69. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-88 of this section.

10-70. OIL TEMPERATURE INDICATORS.

10-71. GENERAL. The two oil temperature indicators are mounted in the instrument cluster on the right instrument panel. These instruments will provide a temperature indication of the engine oil in degrees Fahrenheit. Each instrument has a separate temperature bulb located in the oil screen assembly, on the engine accessory section.

10-72. TROUBLESHOOTING.

TABLE X-XIV. OIL TEMPERATURE INDICATORS

Trouble	Cause	Remedy
Instrument fails to show any reading.	Broken or damaged capillary. Wiring open.	Check engine unit and wiring to instrument.
Excessive scale error.	Improper calibration adjustment.	Repair or replace.
Pointer fails to move as engine is warmed up.	Broken or damaged capillary or open wiring.	Check engine unit and wiring.

TABLE X-XIV. OIL TEMPERATURE INDICATORS (cont.)

Trouble	Cause	Remedy
Dull or discolored luminous marking.	Age.	Replace instrument.

10-73. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-88 of this section.

10-74. CARBURETOR AIR TEMPERATURE INDICATOR.

10-75. GENERAL. The carburetor air temperatur indicator is mounted in the right instrument panel. A selector switch is incorporated in the system to eliminate the use of two instruments. This instrument is calibrated in degrees Fahrenheit and will provide a means of anticipating carburetor icing conditions. A temperature bulb is located in the carburetor air box of each engine and the air temperature indication is transmitted through wires back to the instrument.

10-76. TROUBLESHOOTING.

TABLE X-XV. CARBURETOR AIR TEMPERATURE INDICATOR

Trouble	Cause	Remedy
No temperature indication.	Broken wire or lead.	Repair.
	Defective instrument.	Replace.

10-77. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-86 of this section.

10-78. AMMETER.

10-79. GENERAL. This instrument measures the amount of current received or the amount of current drain on the battery. On Apaches Serial Numbers 23-1 to 23-1501 inclusive, the ammeter is mounted in the instrument cluster located on the right side of the instrument panel. On later model aircraft, Serial Numbers 23-1502 and up, the instrument is mounted in the right instrument panel.

10-80. TROUBLESHOOTING. Refer to Table XI. (Generator Section)

10-81. REMOVAL AND REPLACEMENT. Refer to Paragraph 10-88 for aircraft bearing Serial Numbers 23-1 to 23-1501 inclusive and Paragraph 10-86 for aircraft with Serial Numbers 23-1502 and up.

10-82. FLAP POSITION INDICATOR.

10-83. GENERAL. The flap position indicator is located on the right instrument panel and indicates the position of the flaps. A transmitting unit for this instrument is located under the right rear floorboard. The transmitter contains a resistance strip and a moveable contact arm which is connected mechanically to the flap actuating torque tube. As the flaps are actuated, their position is transmitted electrically to the flap position indicator.

10-84. TROUBLESHOOTING.

TABLE X-XVI. FLAP POSITION INDICATOR

Trouble	Cause	Remedy
Inaccurate or no indication.	Defective indicator.	Replace.
	Defective wiring.	Repair.
	Defective flap transmitter.	Repair or replace.
Indicator indicates up constantly.	Intermittent or no ground.	Repair

10-85. REMOVAL AND REPLACEMENT. Refer to Paragraph 12-86 of this section.

10-86. REMOVAL AND REPLACEMENT OF FACE MOUNTED INSTRUMENTS.

NOTE

These airplanes were originally equipped with A.C. Sparkplug or Stewart Warner engine gauges and sending unit systems which are no longer available. For replacement engine gauges and sending units, see the current Apache Parts Catalog (P/N 752 421) or Piper Service Spares Letter No. 406.

10-87. GENERAL. Since all instruments are mounted in a similar manner, a description of a typical removal and installation is provided as a guide for the removal and installation of the instruments. Special care should be taken when any operation pertaining to the instruments is performed.

a. Remove the instrument access panel by removing the retaining screws and lifting off the panel.

b. Remove the face panel by removing the screws from around the perimeter of the panel.

c. With the face panel removed, the mounting screws for the individual instruments will be exposed. Remove the connections to the instrument prior to removing the mounting screws of the instrument to be removed.

NOTE

Tag instrument connections for ease of installation.

d. Installation of the instruments will be in the reverse given for removal. After the installation is completed and before replacing the instrument access panel, check all components for security and clearance of the control column.

10-88. INSTALLATION OF AIR-DRIVEN GYRO (PORT FITTINGS). The following procedure applies to those aircraft having the Edo-Aire air-driven gyro installation. The use of teflon tape on fitting threads is recommended.

CAUTION

Permit no oil, grease, pipe compound or any foreign material to enter ports prior to installation of fittings. Make certain all air lines are clean and free of foreign particles and/or residue before connecting lines to gyro.

NOTE

Use of thread lube on fittings or in ports will create a warranty void condition.

a. Carefully lay teflon tape on the threads allowing one thread to be visible from the end of the fitting. Hold in place and wrap in the direction of the threads so tape will remain tight when fitting is installed.

b. Apply sufficient tension while winding to assure that tape forms into thread grooves. One full wrap plus 1/2 inch overlap is sufficient.

c. After wrap is completed, maintain tension and tear tape by pulling in direction of wrap. The resulting ragged end is the key to the tape staying in place.

d. Press the tape well into the threads.

e. Screw fitting into port being careful not to exceed torque requirements as noted on decal on gyro cover.

10-89. REMOVAL AND REPLACEMENT OF CLUSTER MOUNTED INSTRUMENTS.

NOTE

These airplanes were originally equipped with A.C. Sparkplug or Stewart Warner engine gauges and sending unit systems which are no longer available. For replacement engine gauges and sending units, see the current Apache Parts Catalog (P/N 752 421) or Piper Service Spares Letter No. 406.

10-90. GENERAL. A cluster, located on the right side of the instrument panel, contains eight or nine individual instruments. Apache S/N's 23-1 to 23-1501 inclusive have the nine instrument cluster, while Apache S/N's 23-1502 and up have the eight instrument installation. Removal of instruments in either installation can be accomplished by the following procedure:

a. Remove the instrument access panel by removing the retaining screw and lifting off the panel.

b. Remove the face panel by removing the screws from around the perimeter of the panel.

c. With the face panel removed, the clear plastic cover on the cluster assembly will be exposed. Remove this cover by removing the two center mounting screws.

d. Remove the connection to the individual instrument to be removed and remove the instrument from the cluster assembly.

e. Replace instrument in the reverse order of removal. Check all mountings and connections for security.

SECTION XI

ELECTRICAL SYSTEM

SECTION XI

ELECTRICAL SYSTEM

11-1. INTRODUCTION. This section contains instructions for correcting difficulties which may arise in the operation of the electrical system in PA-23-150 and PA-23-160 airplanes. It includes a general description and function of each part of the system along with test and adjustments of the various components. This does not include any electronics installations such as AutoPilot or radios. For AutoPilot Service Information, refer to Section XII of this manual. Radio Service and Repairs may be found in the appropriate radio manufacturers manuals.

11-2. DESCRIPTION. Electrical power is supplied by a 12-volt, direct current, single wire, negative ground electrical system. A 12-volt battery is incorporated in the system to furnish power for starting and a reserve power source in case of generator failure. An external power receptacle can be provided as optional equipment in the fuselage to permit the use of an external power source for cold weather starting. A 35-ampere or 50-ampere generator is supplied with the left engine as standard equipment. An additional 50-ampere generator may be supplied with the right engine as optional equipment.

Standard lighting on the Apache are navigation lights, a landing light, cockpit light and instrument spot lighting. As optional equipment, a rotating beacon can be mounted on top of the vertical fin, individual instrument lights installed and a taxi light installed on the nose landing gear.

11-3. TROUBLESHOOTING. Troubles peculiar to the electrical system are listed in Table XI-I in the back of this section, along with their probable causes and suggested remedies.

WARNING

All checks and adjustments of the generator and/or its components should be made with the engines stopped. Therefore, to complete some checks or adjustments, it will be necessary to remove these units from the airplane and be placed on a test stand.

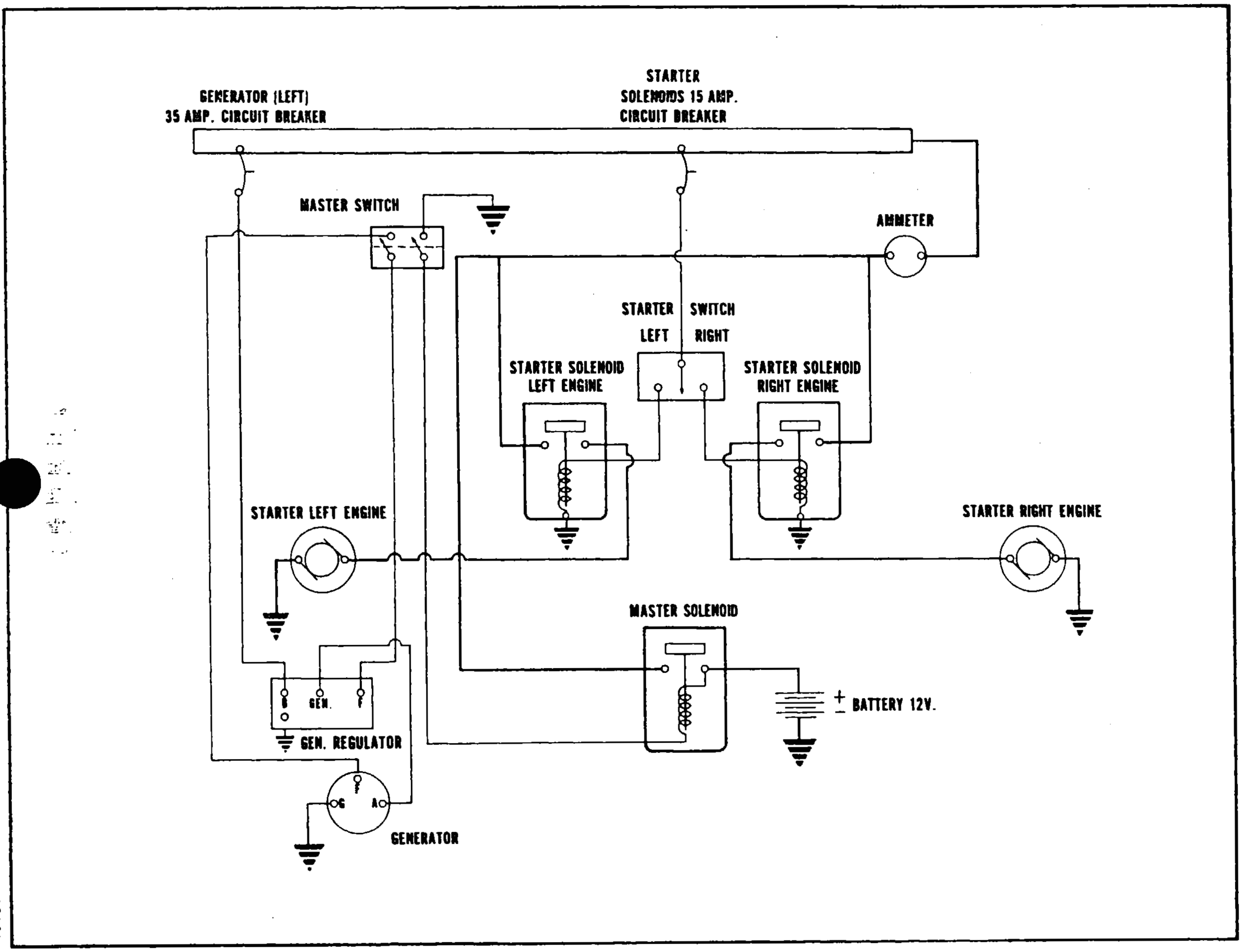


Figure 11-1. Generator Wiring System Schematic (Single)

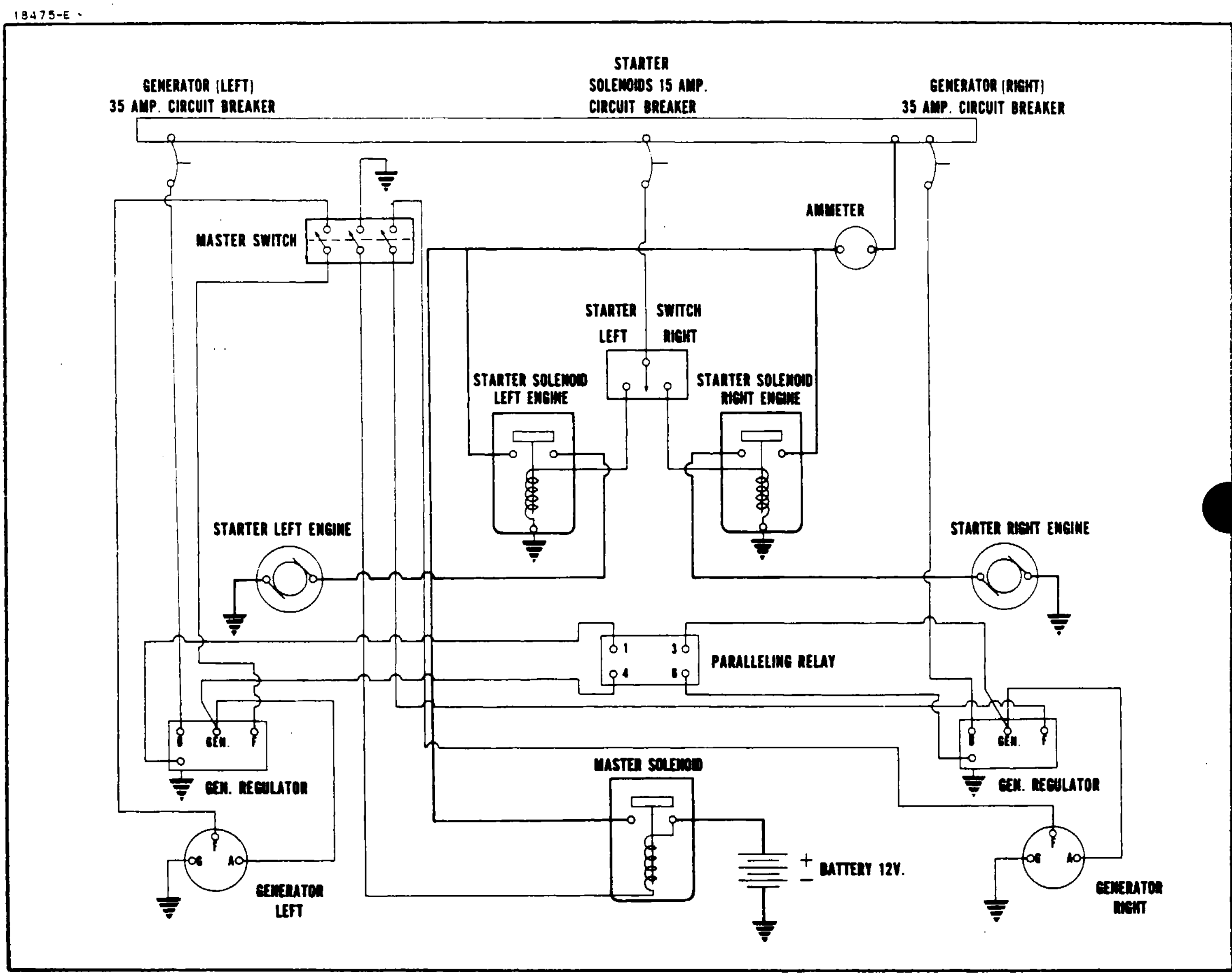


Figure 11-2. Generator Wiring System Schematic (Dual)

11-4. GENERATOR SYSTEM.

11-5. DESCRIPTION OF GENERATOR SYSTEM. The generator is of the two brush, shunt type and is controlled by a regulator operating on the principal of inserting resistance into the generator field circuit to cause a reduction of generator voltage and current output. With each generator is the regulator assembly, composed of a voltage regulator and current regulator, to prevent overloading of the battery and electrical circuits. Also with the regulator is a reverse current cutout to prevent the generator from being motorized by the battery when the generator output drops below the battery voltage. Where dual generators are used, a paralleling relay is used to connect the two generators. The generator is located on the front lower right side of the engine and utilizes a belt drive from the engine crankshaft. The generator voltage regulator is located on the engine firewall. The best assurance of obtaining maximum service from the generator with minimum trouble is to follow a regular inspection and maintenance procedure.

11-6. DESCRIPTION OF GENERATOR PARALLELING SYSTEM. When dual generators are installed, the generators will be identical and the regulators involved are standard three unit regulators with a "paralleling winding" on the voltage regulator unit. These paralleling windings function in such a manner that each generator tends to take an equal portion of the electrical load.

The cut-out relay, current regulator and voltage regulator unit of the regulators function in the same manner as standard regulators. The paralleling coil, located on the voltage regulator unit of each regulator, is connected into the circuit so that it either aids or opposes the voltage regulator shunt winding, depending on the direction of current flow through the coil.

When the operating voltage of one regulator tends to be at a different voltage than that of the other regulator, current will flow through the paralleling coils from the regulator with the higher setting. The paralleling coils are connected so that this current flow lowers the voltage of the regulator with the highest setting. The amount of current which flows through the paralleling coils is the amount required to cause the regulators to operate at the same voltage.

The two-unit paralleling relay acts as a switch to either join or separate the ends of the paralleling coils of the two regulators. Each set of contacts in the external two-unit paralleling relay (Refer to Figure 11-5.) close when the voltage of each respective generator reaches the value for which the relay is adjusted. These contacts close the circuit joining the ends of the paralleling windings on the voltage regulator units. If one generator should fail, the contacts of the paralleling relay unit of that charging system open, breaking the circuit between the paralleling windings. If the other generator and regulator are not defective, they will operate as a normal single generator charging system.

11-7. CHECKING GENERATOR SYSTEM. In analyzing complaints of generator-regulator operation, any of several basic conditions may be found.

a. Fully Charged Battery and Low Charging Rate: This indicates normal generator-regulator operation. Regulator setting may be checked as outlined in paragraph 11-24.

b. Fully Charged Battery and a High Charging Rate: This indicates that the voltage regulator is not reducing the generator output as it should. A high charging rate to a fully charged battery will damage the battery and the accompanying high voltage is very injurious to all electrical units.

This operating condition may result from:

1. Improper voltage regulator setting.
2. Defective voltage regulator unit.
3. Grounded generator field circuit (in either generator, regulator or wiring).
4. Poor ground connection at regulator.
5. High temperature which reduces the resistance of the battery to charge so that it will accept a high charging rate even though the voltage regulator setting is normal.

If the trouble is not due to high temperature, determine the cause of trouble by disconnecting the lead from the regulator "F" terminal with the generator operating at medium speed. If the output remains high, the generator field is grounded either in the generator or in the wiring harness. If the output drops off, the regulator is at fault, and it should be checked for a high voltage setting or grounds.

c. Low Battery and High Charging Rate: This is normal generator-regulator action. Regulator settings may be checked as outlined in paragraph 11-24.

d. Low Battery and Low or No Charging Rate: This condition could be due to:

1. Loose connections, frayed or damaged wires.
2. Defective battery.
3. High circuit resistance.
4. Low regulator setting.
5. Oxidized regulator contact points.
6. Defects within the generator.

If the condition is not caused by loose connections, frayed or damaged wires, proceed as follows to locate cause of trouble.

To determine whether the generator or regulator is at fault, momentarily ground the "F" terminal of the regulator and increase generator speed. If the output does not increase, the generator is probably at fault and it should be checked as outlined in paragraph 11-9. If the generator output increases, the trouble is due to:

1. A low voltage (or current) regulator setting.

2. Oxidized regulator contact points which insert excessive resistance into the generator field circuit so that output remains low.

3. Generator field circuit open within the regulator at the connections or in the regulator wiring.

e. Burned Resistances, Windings or Contacts: These result from open circuit operation or high resistance in the charging circuit. Where burned resistances, windings or contacts are found, always check wiring before installing a new regulator. Otherwise the new regulator may also fail in the same way.

f. Burned Relay Contact Points: This is due to reversed generator polarity. Generator polarity must be corrected as explained in paragraph 11-22 after any checks of the regulator or generator or after disconnecting and reconnecting leads.

11-8. ADJUSTMENTS, TESTS AND MAINTENANCE OF GENERATOR SYSTEM.

The best assurance of obtaining maximum service from generators with minimum trouble is to follow a regular inspection and maintenance procedure. Periodic lubrication where required, inspection of the brushes and commutator and checking of the brush spring tension are essentials in the inspection procedure. In addition, disassembly and thorough overhauling of the generator at periodic intervals are desirable as a safeguard against failures from accummulations of dust and grease and normal wear of parts. This is particularly desirable on installations where maintenance of operating schedules is of special importance. In addition to the generator itself, the external circuits between the generator, regulator and battery must be kept in good condition since defective wiring or loose or corroded connections will prevent normal generator and regulator action. At times it may be found necessary to adjust the voltage regulator or if dual generators are installed, the voltage regulators and paralleling relay. More detailed instructions may be found in the paragraph to follow.

11-9. TEST AND MAINTENANCE OF GENERATOR (Delco-Remy).

11-10. INSPECTION OF GENERATOR.

a. At periodic intervals the generator should be inspected to determine its condition. The frequency with which this should be done will be determined by the type of service in which it is used. High speed operation, excessive dust or dirt, high temperatures and operating the generator at or near full output most of the time are all factors which increase bearing, commutator, and brush wear. Generally speaking, the units should be inspected at approximately 100 hour intervals.

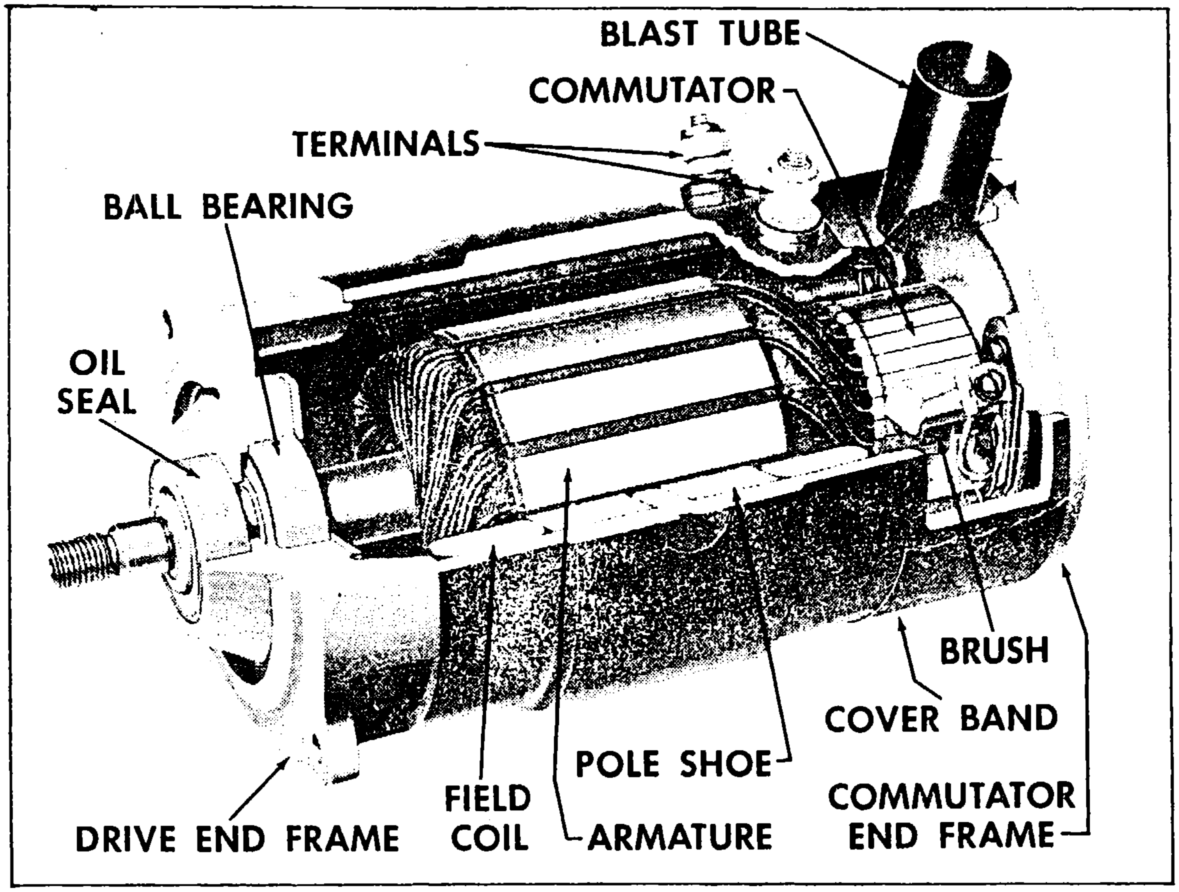


Figure 11-3. Sectional View of Generator

The inspection procedure follows.

b. First inspect the terminals, external connections and wiring, mounting, pulley and belt. Then remove the cover band so that the commutator, brushes and internal connections can be inspected. If the commutator is dirty it may be cleaned with a strip of No. 00 sandpaper. Never use emery cloth to clean the commutator.

c. The sandpaper may be used by holding it against the commutator with a wood stick while the generator is rotated, moving it back and forth across the commutator. Gum and dirt will be sanded off in a few seconds. All dust should be blown from the generator after the commutator has been cleaned. A brush seating stone can also be used to clean the commutator.

d. If the commutator is rough, out of round, or has high mica, the generator must be removed and disassembled so that the armature can be turned down in a lathe and the mica undercut.

e. If the brushes are worn down to less than half their original length, they should be replaced. Compare the old brush with a new one to determine how much it is worn. New brushes should be seated to make sure that they are in good contact with the commutator. A convenient tool for seating brushes is a brush seating or bedding stone. This is a soft abrasive material which, when held against a revolving commutator, disintegrates so that particles are carried under the brushes and wear their contacting faces to the contour of the commutator in a few seconds. All dust should be blown from the generator after the brushes are seated.

f. The brush spring tension must be correct since excessive tension will cause rapid brush and commutator wear, while low tension causes arcing and burning of the brushes and commutator. Brush spring tension can be checked with a spring gauge hooked on the brush arm or brush attaching screw. Correction can be made by bending the brush spring as required. If the brush spring shows evidence of overheating (blued or burned), do not attempt to readjust it, but install a new spring. Overheating will cause a spring to lose its temper.

g. The belt should be checked to make sure that it is in good condition and has correct tension. Low belt tension will permit belt slippage with a resulting rapid belt wear and low or erratic generator output. Excessive belt tension will cause rapid belt and bearing wear. Check the tension of a new belt 25 hours after installation. Proper adjustment is given in paragraph 11-51.

11-11. SHUNT GENERATOR OUTPUT. The maximum output of shunt generators is determined by the current setting of the current regulator with which the shunt generator is used. Checking of this setting is discussed in the applicable regulator bulletin.

11-12. CHECKING DEFECTIVE GENERATORS. If the generator-regulator system does not perform according to specifications (generator does not produce rated output or produces excessive output), and the trouble has been isolated in the generator itself by following the procedure outlined in paragraph 11-6, the generator may be checked further as follows to determine the location of trouble in the generator.

11-13. NO OUTPUT.

a. If the generator will not produce any output, remove the cover band and check the commutator, brushes and internal connections. Sticking brushes, a dirty or gummy commutator (Refer to Paragraph 11-21.) or poor connections may prevent the generator from producing any output. Thrown solder on the cover band indicates that the generator has been overloaded (allowed to produce excessive output) so it has overheated and melted the solder at the commutator riser bars. Solder thrown out often leads to an open circuit and burned commutator

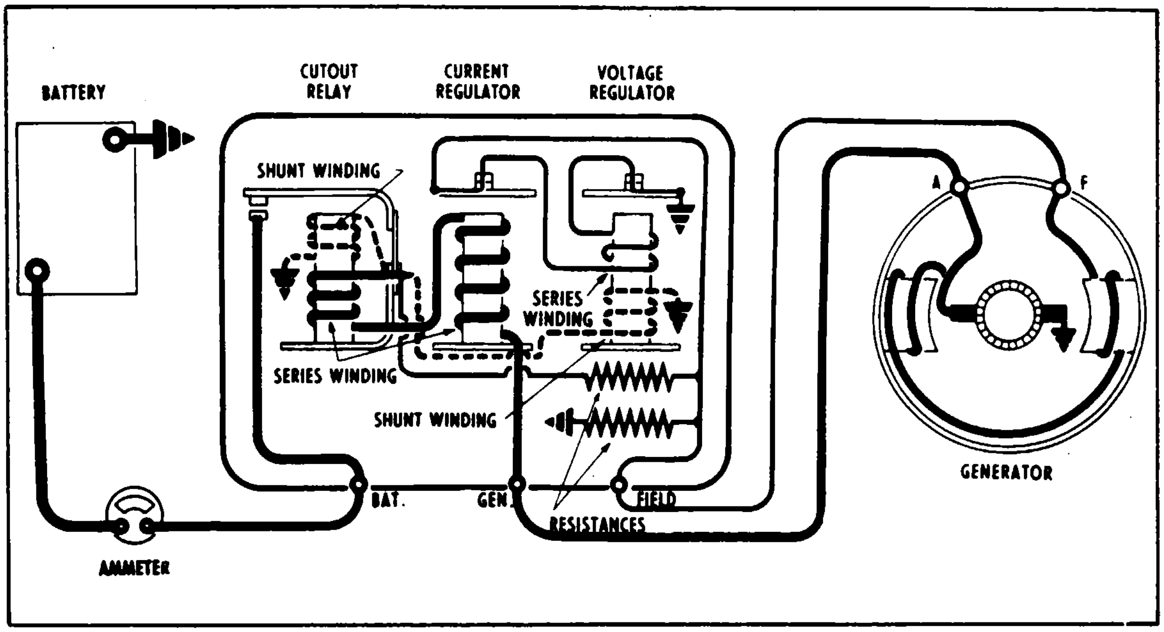


Figure 11-4. Wiring Circuit, Single Regulator

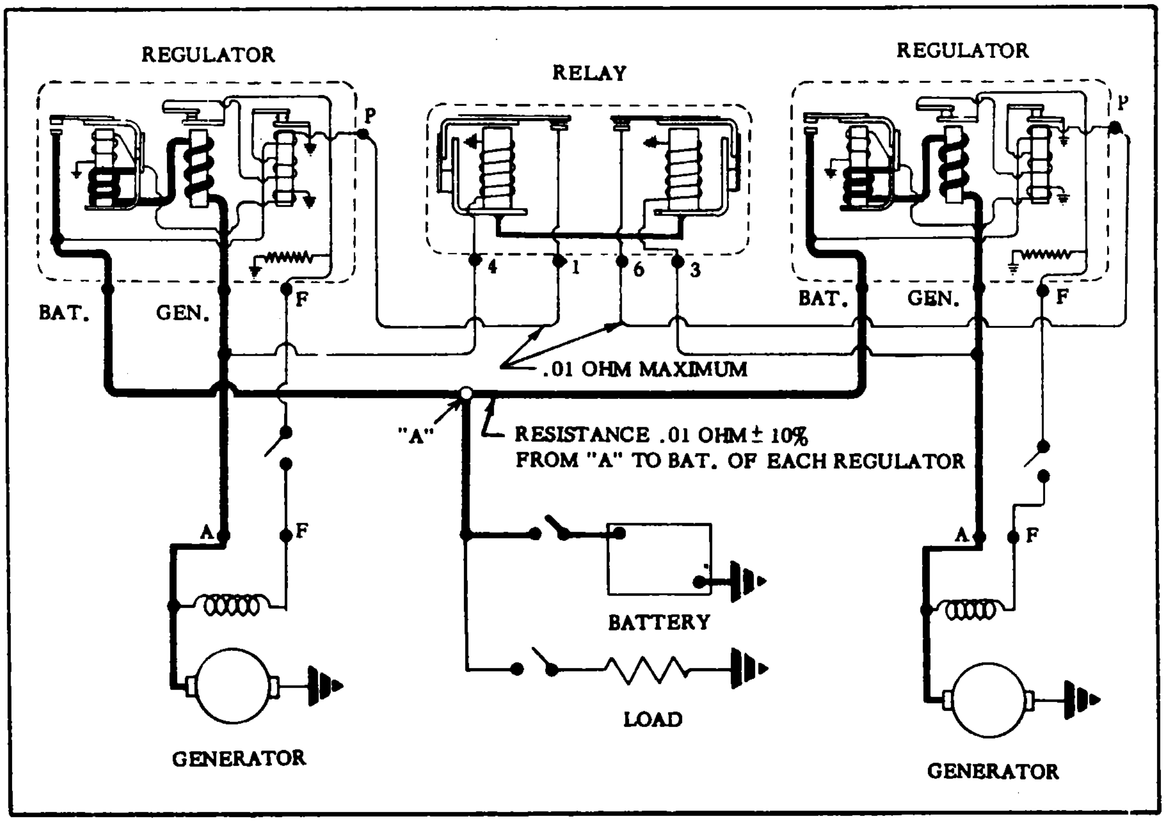


Figure 11-5. Wiring Circuit, Dual Regulators

bars. If the brushes are satisfactorily seated and are making good contact with the commutator, and the cause of trouble is not apparent, use a set of test points and a test lamp as follows to locate the trouble (leads must be disconnected from generator terminals).

b. Raise the grounded brush from the commutator and insulate with a piece of cardboard. Check for grounds with test points from the generator main brush to the generator frame. If the lamp lights, it indicates that the generator is internally grounded. Location of the ground can be found by raising and insulating all brushes from the commutator and checking the brush holders, armature, commutator and field separately. Repair or replace defective parts as required. (Refer to Paragraph 11-19.)

NOTE

If a grounded field is found, check the regulator contact points, since a grounded field may have permitted an excessive field current which will have burned the regulator contact points. Burned regulator points should be cleaned or replaced as required.

c. If the generator is not grounded, check the field for an open circuit with a test lamp. The lamp should light when one test point is placed on the field terminal or grounded field lead and the other is placed on the brush holder to which the field is connected. If it does not light, the circuit is open. If the open is due to a broken lead or bad connection, it can be repaired, but if the open is inside one of the field coils, it must be replaced.

d. If the field is not open, check for a short circuit in the field by connecting a battery of the specified voltage and an ammeter in series with the field circuit. Proceed with care, since a shorted field may draw excessive current which might damage the ammeter. If the field is not within specification, new field coils will be required. (Refer to Paragraph 11-19.)

NOTE

If a shorted field is found, check the regulator contact points, since a shorted field may have permitted excessive field current which would have caused the regulator contact points to burn. Clean or replace points as required.

e. If the trouble has not yet been located, check the armature for open and short circuits. Open circuits in the armature are usually obvious, since the open circuited commutator bars will arc every time they pass under the generator brushes so that they will soon become burned. If the bars are not too badly burned and the open circuit can be repaired, the armature can usually be saved. In addition to repairing the armature, generator output must be brought down to specifications to prevent overloading by readjustment of the regulator.

f. Short circuits in the armature are located by use of a growler. The armature is placed in the growler and slowly rotated (while a thin strip of steel such as a hacksaw blade is held above the armature core). The steel strip will vibrate above the area of the armature core in which short circuited armature coils are located. If the short circuit is obvious, it can often be repaired so that the armature can be saved.

11-14. UNSTEADY OR LOW OUTPUT. If the generator produces a low or unsteady output, the following factors should be considered:

a. A loose drive belt will slip and cause a low or unsteady output.

b. Brushes which stick in their holders, or low brush spring tension will prevent good contact between the brushes and commutator so that output will be low and unsteady. This will also cause arcing and burning of the brushes and commutator.

c. If the commutator is dirty, out of round, or has high mica, generator output is apt to be low and unsteady. The remedy here is to turn the commutator down in a lathe and undercut the mica. Burned commutator bars may indicate an open circuit condition in the armature as already stated above. (Refer to Paragraph 11-13.)

11-15. EXCESSIVE OUTPUT.

a. When a generator produces excessive output on an application, the procedure for determining whether the trouble is in the generator, regulator, or elsewhere is outlined in Paragraph 11-7. If the generator output remains high, even with the "F" terminal lead disconnected, then the trouble is in the generator itself, and it must be further analyzed to locate the source of trouble.

b. In the system which has the generator field circuit grounded externally, accidental internal grounding of the field circuit would prevent normal regulation so that excessive output might be produced by the generator. On this type of unit, an internally grounded field which would cause excessive output may be located by use of test points connected between the "F" terminal and the generator frame. Leads should be disconnected from the "F" terminal and the brush to which the field lead is connected inside the generator should be raised from the commutator before this test is made. If the lamp lights, the field is internally grounded. If the field has become grounded because the insulation on a field lead has worn away, repair can be made by reinsulating the lead. It is also possible to make repair where the ground has occurred at the pole shoes by removing the field coils and reinsulating and reinstalling them. A ground at the "F" terminal stud can be repaired by installing new insulating washers or bushings.

NOTE

If battery temperature is excessive, battery over-charge is apt to occur, even though regulator settings are normal. Under this condition, it is permissible to reduce the voltage regulator setting as explained in the applicable bulletin pertaining to the regulator used on the application.

11-16. NOISY GENERATOR. Noise emanating from a generator may be caused by a loose mounting, drive pulley, or gear; worn or dirty bearings; or improperly seated brushes. Dirty bearings may sometimes be saved by cleaning and relubrication, but worn bearings should be replaced. Brushes can be seated as explained in Paragraph 11-10. If the brush holder is bent, it may be difficult to reseat the brush so that it will function properly without excessive noise. Such a brush holder will require replacement.

11-17. DISASSEMBLY, REPAIR AND REASSEMBLY. Normally, disassembly should proceed only so far as is necessary to make repair or replacement of the defective parts. For example, the field coils should be checked for opens, shorts, or grounds before being removed from the field frame. They should be removed only if they require repair or replacement.

11-18. FIELD COIL REMOVAL. Field coils can be removed from the field frame most easily by use of a pole shoe screw driver. It is also advisable to use a pole shoe spreader, since this prevents distortion of the field frame. The pole shoe screw driver permits easy loosening and removal of the pole shoe screws so that the pole shoes and field coils can be taken out of the field frame. The pole shoe screw driver and spreader should be used on reassembly of the field frame. Careful reassembly is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place.

11-19. INSPECTION AND REPAIR OF PARTS. The armature or field should not be cleaned in any degreasing tank or by use of degreasing compounds, since this might damage insulation so that a short or ground would subsequently develop. Sealed ball bearings do not require cleaning or relubrication. Other generator parts should be cleaned and carefully inspected for wear and other damage. Any defective parts should be repaired or replaced. On reassembly all soldered electrical connections should be made with rosin flux. Acid flux must never be used on electrical connections.

11-20. FIELD COIL SERVICE.

a. The field coils should be checked for grounds, opens or shorts as already explained in Paragraph 11-13.

b. Grounded field coils may sometimes be repaired by removing them so they can be reinsulated. Care must be used to avoid excessive bulkiness when applying new insulation, since this might cause the pole shoe to cut through and cause another ground when the coils are reinstalled.

c. Usually if a field coil is open or shorted internally it will require replacement, since it is difficult to repair such a defect.

d. To remove or replace field coils in the field frame, the use of a pole shoe spreader and screw driver is recommended.

11-21. ARMATURE SERVICE.

a. The armature should be checked for opens, shorts and grounds as explained in following paragraphs. If the armature commutator is worn, dirty, out of round, or has high mica, the armature should be put in a lathe so the commutator can be turned down and the mica undercut. The mica should be undercut .031 of an inch and the slots cleaned out carefully to remove any trace of dirt or copper dust. As a final step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper to remove any slight burrs that might be left as a result of the undercutting procedure.

b. Open circuited armatures can often be saved when the open is obvious and repairable. The most likely place an open will occur is at the commutator riser bars. This usually results from overloading of the generator which causes overheating and melting of the solder. Repair can be effected by resoldering the leads in the riser bars (using rosin flux) and turning down the commutator in a lathe to remove the burned spot and then undercutting the mica as explained in the previous paragraph. In some heavy-duty armatures, the leads are welded into the riser bars and these cannot be repaired by resoldering.

c. Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler, with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short is located. Copper or brush dust in the slots between the commutator bars sometimes causes shorts between bars which can be eliminated by cleaning out the slots. Shorts at cross-overs of the coils at the core end can often be eliminated by bending wires slightly and reinsulating the exposed bare wire.

d. Grounds in the armature are detected by use of a test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure, which is often brought on by overloading and consequent overheating of the generator. Repairs can sometimes be made if grounds are at core ends (where coils come out of slots) by placing insulating strips between core and coil which has grounded.

11-22. POLARIZING GENERATOR. After a generator has been repaired and reinstalled or at any time after a generator has been tested, it must be repolarized to make sure that it has the correct polarity with respect to the battery it is to charge. Failure to repolarize the generator may result in burned relay contact points, a run-down battery and possibly serious damage to the generator itself. The procedure to follow in correcting generator polarity depends upon the generator-regulator wiring circuits; that is, whether the generator field is internally grounded or is grounded through the regulator. (Refer to paragraph 11-33.)

11-23. GENERATOR SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 12-volt generators installed on PA-23 Apache airplanes are as follows:

Generator	1101900	1101915
Delco-Remy, Ref, Service Bulletin	1G-150	1G-150
Brush Spring Tension	24 oz.	24 oz.
Field Current (80° F) Amps Volts	 1.62 - 1.72 12	 1.62 - 1.72 12
Cold Output Amps Volts Approx. RPM	 35 14.0 3100	 50 14.0 3960

COLD OUTPUT: Cold output data applies to generators at 80 degrees F, and with brushes well seated. Variations in temperature and brush seating as well as the condition of the generator may cause deviations of 100 RPM or more from rated speed.
HOT OUTPUT: Hot output is maximum output as controlled by current regulator.

11-24. REGULATOR.

11-25. DESCRIPTION OF REGULATOR. The regulator shown in Figure 11-6 consists of a cutout relay, a voltage regulator and a current regulator unit. The cutout relay closes the generator to battery circuit when the generator voltage is sufficient to charge the battery, and it opens the circuit when the generator slows down or stops. The voltage regulator unit is a voltage-limiting device that prevents the system voltage from exceeding a specified maximum and thus protects the battery and other voltage-sensitive equipment. The current regulator unit is a current-limiting device that limits the generator output so as not to exceed its rated maximum.

11-26. CUTOUT RELAY.

a. The cutout relay (Refer to Figure 11-6.) has two windings, a series winding of a few turns of heavy wire and a shunt winding of many turns of fine wire (shown in dashed lines). The shunt winding is connected across the generator so that generator voltage is impressed upon it at all times. The series winding is connected in series with the charging circuit so that all generator output passes through it. The relay core and windings are assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is centered just above the stationary contact points. When the generator is not operating, the armature contact points are held away from the stationary points by the tension of a flat spring riveted on the side of the armature.

b. When the generator voltage builds up a value great enough to charge the battery, the magnetism induced by the relay windings is sufficient to pull the armature toward the core so that the contact points close. This completes the circuit between the generator and battery. The current which flows from the generator to the battery passes through the series winding in a direction to add to the magnetism holding the armature down and the contact points closed.

c. When the generator slows down or stops, current begins to flow from the battery to the generator.

d. This reverse flow of current through the series winding causes a reversal

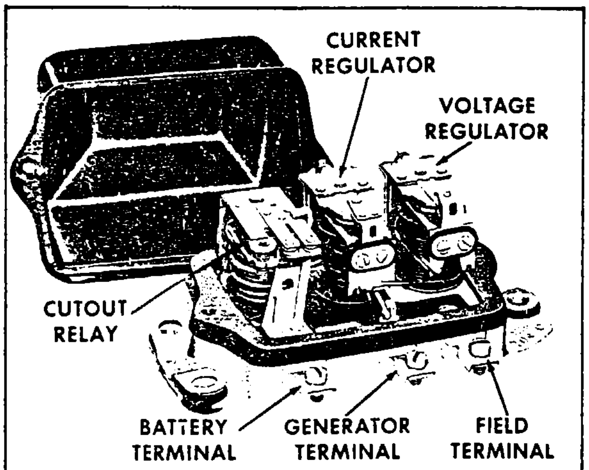


Figure 11-6. Current/Voltage Regulator

of the series winding magnetic field. The magnetic field of the shunt winding does not reverse. Therefore, instead of helping each other, the two windings now oppose so that the resultant magnetic field becomes insufficient to hold the armature down. The flat spring pulls the armature away from the core so that the points separate; this opens the circuit between the generator and battery.

11-27. VOLTAGE REGULATOR.

a. The voltage regulator (Refer to Figure 11-6.) has two windings assembled on a single core, a shunt winding consisting of many turns of fine wire (shown in dashed lines) which is shunted across the generator, and a series winding of a few turns of relatively heavy wire which is connected in series with the generator field circuit when the regulator contact points are closed.

b. The windings and core are assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is just above the end of the core. The armature contains a contact point which is just beneath a stationary contact point. When the voltage regulator is not operating, the tension of a spiral spring holds the armature away from the core so that the points are in contact and the generator field circuit is completed to ground through them.

c. When the generator voltage reaches the value for which the voltage regulator is adjusted, the magnetic field produced by the two windings (shunt and series) overcomes the armature spring tension and pulls the armature down so that the contact points separate. This inserts resistance into the generator field circuit so that the generator field current and voltage are reduced. Reduction of the generator voltage reduces the magnetic field of the regulator shunt winding. Also, opening the regulator points opens the regulator series winding circuit so that its magnetic field collapses completely. The consequence is that the magnetic field is reduced sufficiently to allow the spiral spring to pull the armature away from the core so that the contact points again close. This directly grounds the generator so that generator voltage and output increase. The above cycle of action again takes place and the cycle continues at a rate of 50 to 200 times a second, regulating the voltage to a predetermined value. With the voltage thus limited, the generator supplies varying amounts of current to meet the varying states of battery charge and electrical load.

11-28. CURRENT REGULATOR.

a. The current regulator (Refer to Figure 11-6.) has a series winding of a few turns of heavy wire which carries all generator output. The winding core is assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is just above the core. The armature has a contact point which is just below a stationary contact point. When the current regulator is not operating, the tension of a spiral spring holds the armature away from the core so that the points are in contact. In this position the generator field circuit is completed to ground through the current regulator contact points in series with the voltage regulator contact points.

b. When the load demands are heavy, as for example, when electrical devices are turned on and the battery is in a discharged condition, the voltage may not increase to a value sufficient to cause the voltage regulator to operate. Consequently, generator output will continue to increase until the generator reaches rated maximum current. This is the current value for which the current regulator is set. Therefore, when the generator reaches rated output, this output, flowing through the current regulator winding, creates sufficient magnetism to pull the current regulator armature down and open the contact points. With the points open, resistance is inserted into the generator field circuit so that the generator output is reduced.

c. As soon as the generator output starts to fall off, the magnetic field of the current regulator winding is reduced, the spiral spring tension pulls the armature up, the contact points close and directly connect the generator field to ground. Output increases and the above cycle is repeated. The cycle continues to take place while the current regulator is in operation 50 to 200 times a second, preventing the generator from exceeding its rated maximum. When the electrical load is reduced (electrical devices turned off or battery comes up to charge), then the voltage increases so that the voltage regulator begins to operate and tapers the generator output down. This prevents the current regulator from operating. Either the voltage regulator or the current regulator operates at any one time - the two do not operate at the same time.

11-29. RESISTANCES. The current and voltage regulator circuits use a common resistor which is inserted in the field circuit when either the current or voltage regulator operates. A second resistor* is connected between the regulator field terminal and the cutout relay frame, which places it in parallel with the generator field coils. The sudden reduction in field current occurring when the current or voltage regulator contact points open, is accompanied by a surge of induced voltage in the field coils at the strength of the magnetic field changes. These surges

are partially dissipated by the two resistors, thus preventing excessive arcing at the contact points.
*(The second resistor is not present on all regulators. Many aircraft regulators have this resistor omitted.)

11-30. TEMPERATURE COMPENSATION. Voltage regulators are compensated for temperature by means of a bimetal thermostatic hinge on the armature. This causes the regulator to regulate at a higher voltage when cold which partly compensates for the fact that a higher voltage is required to charge a cold battery. Many current regulators also have a bimetal thermostatic hinge on the armature. This permits a somewhat higher generator output when the unit is cold, but causes the output to drop off as temperature increases.

11-31. REGULATOR POLARITY. Some regulators are designed for use with negative grounded systems, while other regulators are designed for use with positive grounded systems. Using the wrong polarity regulator on an installation will cause the regulator contact points to pit badly and give short life. As a safeguard against installation of the wrong polarity regulator, all regulators of this type have the model number and the polarity clearly stamped on the end of the regulator base. (Refer to Paragraph 11-33, step f.)

11-32. REGULATOR MAINTENANCE.

11-33. MAINTENANCE INSTRUCTIONS.

a. Mechanical checks and adjustments (air gaps, point opening) must be made with battery disconnected and regulator preferably off the aircraft.

CAUTION

The cutout relay contact points must never be closed by hand with the battery connected to the regulator. This would cause a high current to flow through the units which would seriously damage them.

b. Electrical checks and adjustments may be made either on or off the airplane. The regulator must always be operated with the type generator for which it is designed.

c. The regulator must be mounted in the operating position when electrical

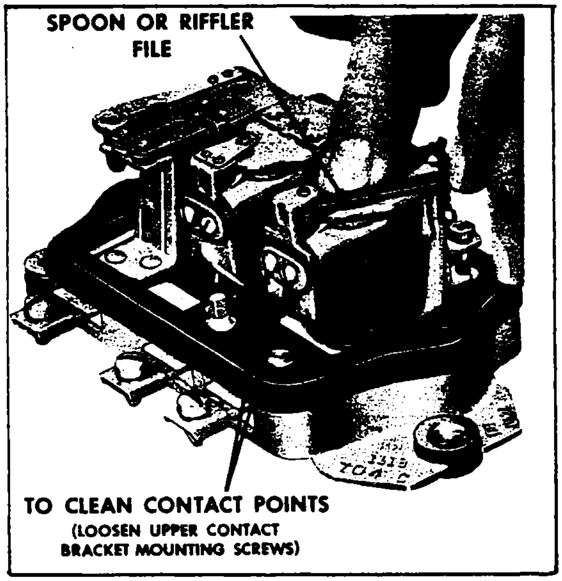


Figure 11-7. Use of Riffler File to Clean Contact Points

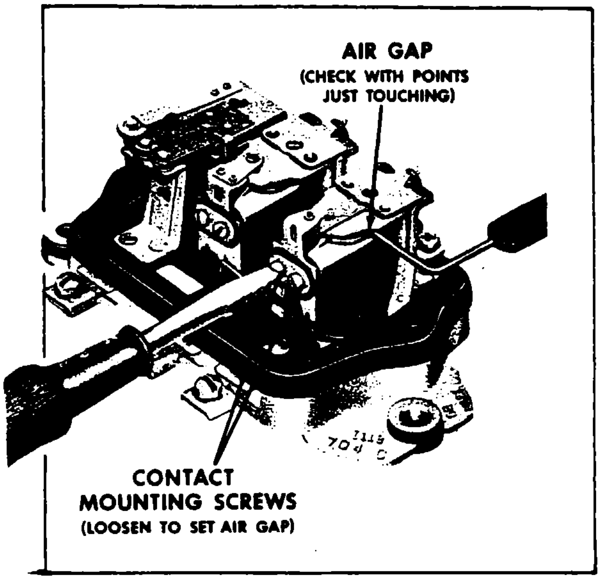


Figure 11-8. Voltage Regulator Air Gap

settings are checked and adjusted and it must be at operating temperature.

d. Specified generator speeds for testing and adjusting.
   1. Voltage Regulator
      (a) Operating speed
   2. Current Regulator
      (a) All generators must be operated at a speed sufficient to produce current in excess of specified setting.
      (b) Voltage of the generator must be kept high enough to insure sufficient current output, but below the operating voltage of the voltage regulator unit.

e. After any tests or adjustments the generator on the airplane must be polarized after leads are connected, but before the engine is started, as follows:

After reconnecting leads, momentarily connect a jumper lead between the "GEN" and "BAT" terminals of the regulator. This allows a momentary surge of current to flow through the generator which correctly polarizes it. Failure to do this may result in severe damage to the equipment since reversed polarity causes vibration, arcing and burning of the relay contact points.

11-34. CLEANING CONTACT POINTS. The contact points of a regulator will not operate indefinitely without some attention. It has been found that a great majority of all regulator trouble can be eliminated by a simple cleaning of the contact points, plus some possible readjustment. The flat points should be cleaned with a spoon or riffler file. On negative grounded regulators which have the

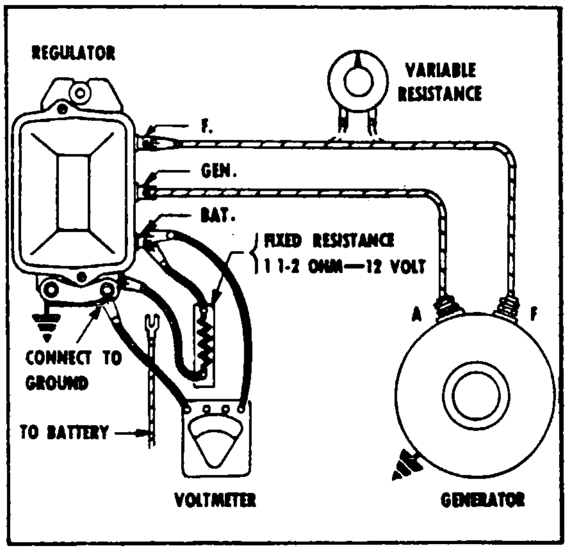


Figure 11-9. Checking Voltage Setting Fixed Resistance Method

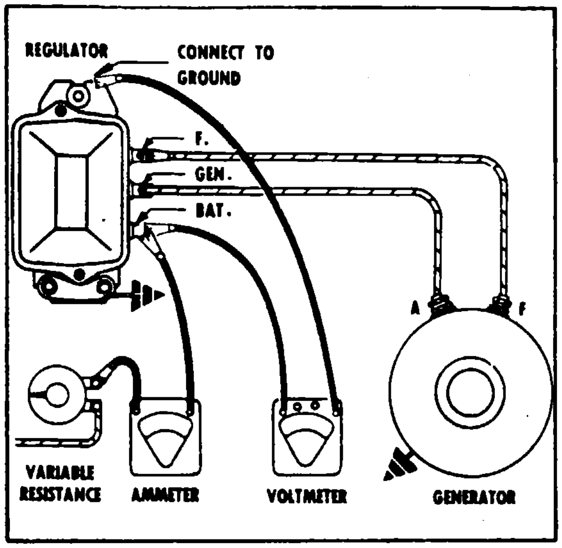


Figure 11-10. Checking Voltage Setting Variable Resistance Method

flat contact point on the regulator armatures, loosen the contact bracket mounting screws so that the bracket can be tilted to one side. A flat file cannot be used successfully to clean the flat contact points since it will not touch the center of the flat point where point wear is most apt to occur. Never use emery cloth or sandpaper to clean the contact points. Remove all the oxides from the contact points but note that it is not necessary to remove any cavity that may have developed.

11-35. REGULATOR CHECKS AND ADJUSTMENTS.

11-36. VOLTAGE REGULATOR. Two checks and adjustments are required on the voltage regulator; air gap and voltage setting.

a. Air Gap: To check air gap, push armature down until the contact points are just touching and then measure air gap. (Refer to Figure 11-8.) Adjust by loosening the contact mounting screws and raising or lowering contact bracket as required. Be sure the points are lined up and tighten screws after adjustment.

b. Voltage Setting: There are two ways to check the voltage setting; the fixed resistance method and the variable resistance method. (Refer to Figures 11-9 and 11-10.)

1. Fixed Resistance Method:

(a) Connect a fixed resistance between the battery terminal and ground as shown in Figure 11-9 after disconnecting the battery lead from the battery terminal of the regulator. The resistance must be 1-1/2 ohms for 12-volt units. It must be capable of carrying 10 amperes without any change of resistance with temperature changes.

(b) Connect a voltmeter from regulator "BAT" terminal to ground.

(c) Place the thermometer within 1/4 inch of regulator cover to measure regulator ambient temperature.

(d) Operate generator at specified speed for 15 minutes with regulator cover in place to bring the voltage regulator to operating temperature.

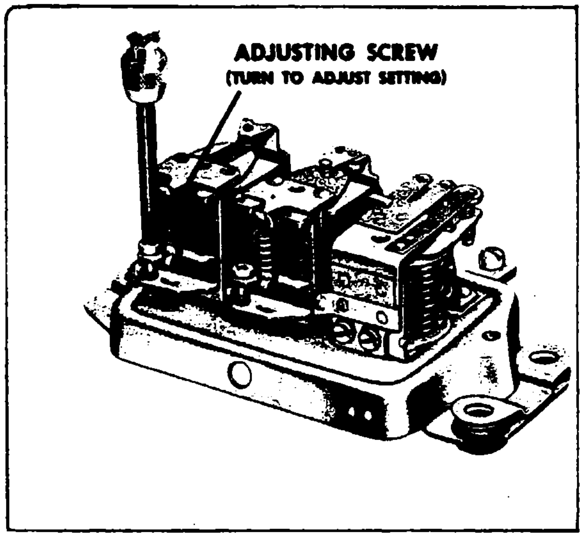


Figure 11-11. Adjusting Voltage Regulator Setting

(e) Cycle the generator:

Method 1: Move voltmeter lead from "BAT" to "GEN" terminal of regulator. Retard generator speed until generator voltage is reduced to 4 volts. Move voltmeter lead back to "BAT" terminal of regulator. Bring generator back to specified speed and note voltage setting.

Method 2: Connect a variable resistance into the field circuit as in Figure 11-9. Turn out all resistance. Operate generator at specified speed. Slowly increase (turn in) resistance until generator voltage is reduced to 4 volts. Turn out all resistance again and note voltage setting (with voltmeter connected as in Figure 11-9). Regulator cover must be in place.

(f) Note the thermometer reading and select the Normal Range of Voltage for this temperature as listed in specifications paragraph 11-44.

(g) Note the voltmeter reading with regulator cover in place.

(h) To adjust voltage setting, turn adjusting screw. (Refer to Figure 11-11.) Turn clockwise to increase setting and counterclockwise to decrease setting.

CAUTION

If adjusting screw is turned down (clockwise) beyond range, spring support may not return when screw is backed off. In such case, turn screw counterclockwise until there is ample clearance between screw head and spring support. Then bend spring support up carefully until it touches the screw head. Final setting of the unit should always be made by increasing spring tension, never by reducing it. If setting is too high, adjust unit below required value and then raise to exact setting by increasing the spring tension. After each adjustment and before taking reading, replace the regulator cover and cycle the generator.

2. Variable Resistance Method:

(a) Connect ammeter and 1/4 ohm variable resistor in series with the battery as shown in Figure 11-9.

NOTE

It is very important that the variable resistance be connected at the "BAT" terminal as shown in Figure 11-9 rather than at the "GEN" terminal even though these terminals are in the same circuit. An examination of the wiring diagram, Figure 11-4, will show that regulation begins at the point where the shunt windings are connected to the series circuit. Any small resistance added to the circuit between the generator and this point will simply be offset by a rise in generator voltage without affecting the output shown at the ammeter.

(b) Connect voltmeter between "BAT" terminal and ground.

(c) Place thermometer within 1/4 inch of regulator cover to measure regulator ambient temperature.

(d) Operate generator at specified speed. Adjust variable resistor until current flow is 8 to 10 amperes. If less current than is required above is flowing, it will be necessary to turn on airplane lights to permit increased generator output. Variable resistance can then be used to decrease current flow to the required amount.

Allow generator to operate at this speed and current flow for 15

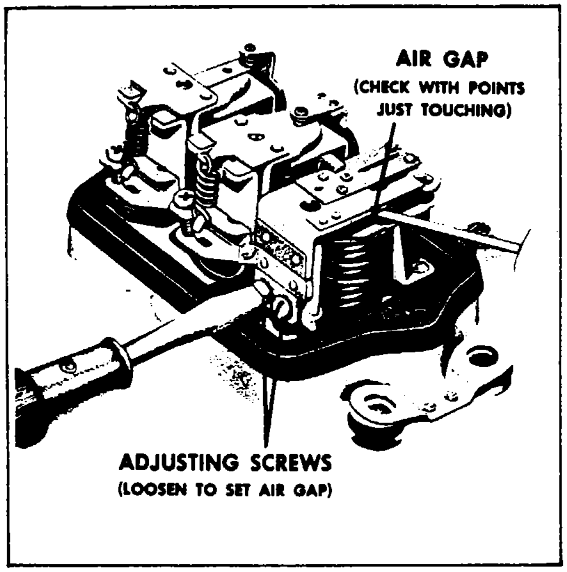


Figure 11-12. Cutout Relay Air Gap Check and Adjustment

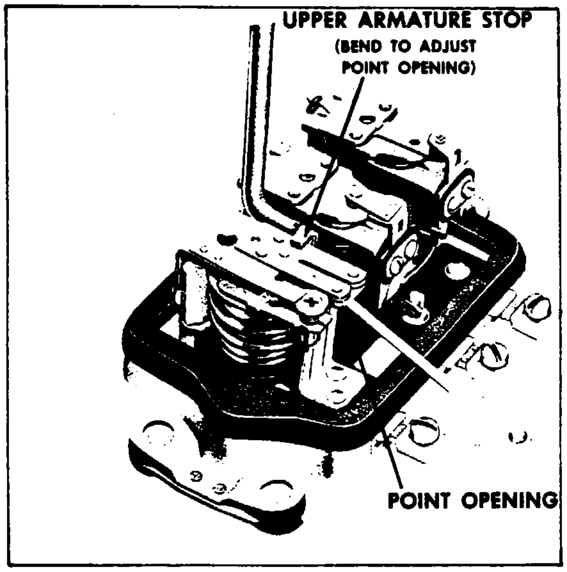


Figure 11-13. Cutout Relay Point Opening Check and Adjustment

minutes with regulator cover in place in order to bring the voltage regulator to operating temperature.

(e) Cycle the generator by either method listed in "Fixed Resistance Method" of "Voltage Setting" procedure.

(f) Note the thermometer reading and select the "Normal Range" of voltage for this temperature as listed in specifications paragraph 11-44.

(g) Note the voltmeter reading with regulator cover in place.

(h) Adjust voltage regulator as required as described in step (h) of "Fixed Resistance Method of "Voltage Setting Procedure." In using the variable resistance method, it is necessary to readjust the variable resistance after each voltage adjustment to assure that 8 to 10 amperes are flowing. Cycle generator after each adjustment before reading voltage regulator setting with cover in place.

11-37. CUTOUT RELAY. The cutout relay requires three checks and adjustments: air gap, point opening and closing voltage. The air gap and point opening adjustments must be made with the battery disconnected.

a. Air Gap: Place fingers on armature directly above core and move armature down until points just close and then measure air gap between armature and center of core. (Refer to Figure 11-12.) On multiple contact point relays, make sure that all points close simultaneously. If they do not, bend spring finger so they do. To adjust air gap, loosen two screws at the back of relay and raise or lower the armature as required. Tighten screws after adjustment.

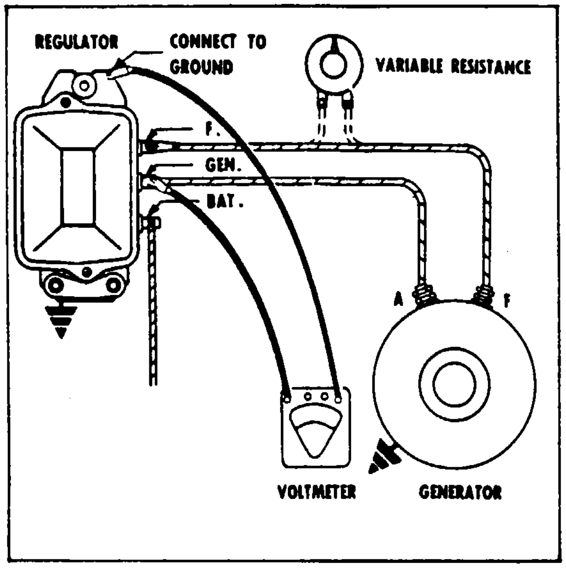


Figure 11-14. Checking Cutout Relay Closing Voltage

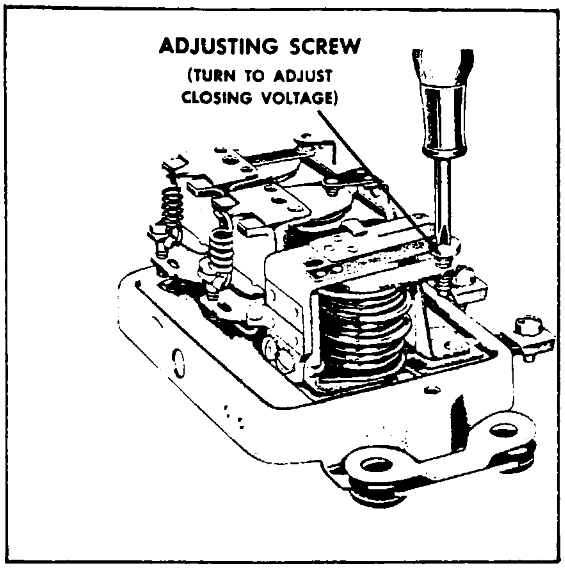


Figure 11-15. Adjustment of Cutout Relay Closing Voltage

b. Point Opening: Check point opening and adjust by bending the upper armature stop. (Refer to Figure 11-13.)

c. Closing Voltage: Connect regulator to proper generator and battery. Connect voltmeter between the regulator "GEN" terminal and ground. (Refer to Figure 11-14.)

Method 1: Slowly increase generator speed and note relay closing voltage. Decrease generator speed and make sure the cutout relay points open.

Method 2: Make connections as in Step c; but, in addition, add a variable resistor connected into the field circuit. (Refer to Figure 9-14.) Use a 25 ohm - 25 watt resistor. Operate generator at medium speed with variable resistance turned all in. Slowly decrease (turn out) the resistance until cutout relay points close. Note closing voltage. With cover in place, slowly increase (turn in) resistance to make sure points open.

d. Adjust closing voltage by turning adjusting screw. (Refer to Figure 11-15.) Turn screw clockwise to increase setting and counterclockwise to decrease setting.

11-38. CURRENT REGULATOR. Two checks and adjustments are required on the current regulator: air gap and current setting.

a. Air Gap: Check and adjust in exactly the same manner as for the voltage regulator.

b. Current Setting: Current regulator setting on current regulators having temperature compensation should be checked by the following method:

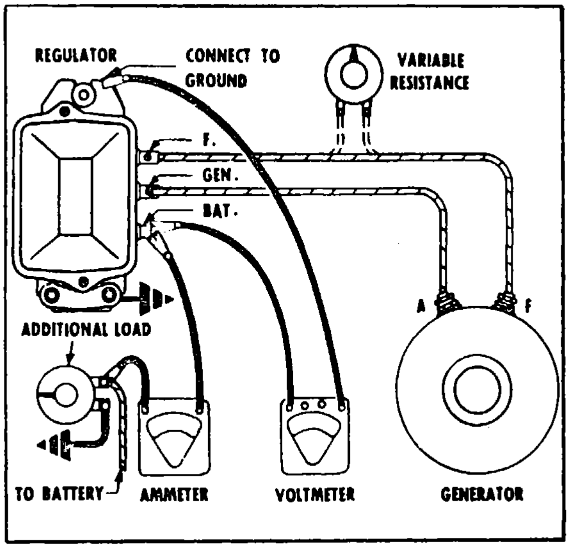


Figure 11-16. Checking Current Regulator, Load Method

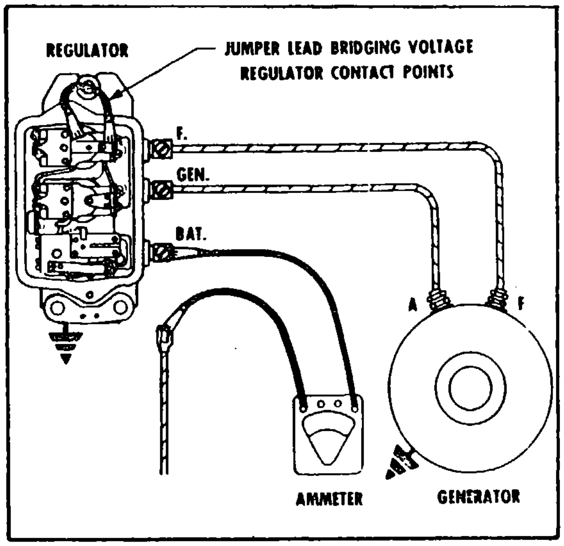


Figure 11-17. Checking Current Regulator, Jumper Lead Method

1. Load Method:
   (a) Connect ammeter into charging circuit as in Figure 11-15.
   (b) Turn on all accessory load (lights, radio, etc.) and connect an additional load across the battery (such as a carbon pile or band of lights) so as to drop the system voltage approximately one volt below the voltage regulator setting.
   (c) Operate generator at specified speed for 15 minutes with cover in place. (This establishes operating temperature; see steps (c) and (d) in paragraph 11-33.) If current regulator is not temperature-compensated, disregard 15 minute warm-up period.
   (d) Cycle generator and note current setting.
   (e) Adjust in same manner as described for voltage regulator. (Refer to Figure 11-11.)
2. Jumper Lead Method: (Use only for current regulators without temperature compensation.)
   (a) Connect ammeter into charging circuit as in Figure 11-17.
   (b) Connect jumper lead across voltage regulator points as in Figure 11-17.
   (c) Turn on all lights and accessories or load battery as in (b) under Load Method:
   (d) Operate generator at specified speed and note current setting.
   (e) Adjust in same manner as described for the voltage regulator. (Refer to Figure 11-11.)

11-39. REPAIRS.

11-40. REGULATOR SPRING REPLACEMENT. If it becomes necessary to replace the spiral spring on either the current or voltage regulator unit, the new spring should first be hooked on the lower spring support and then stretched up until it can be hooked at the upper end. Stretch the spring only by means of a screw driver blade inserted between the turns (or in a similar manner). Do not pry the spring into place as this is likely to bend the spring support. After installing a new spring, readjust the unit setting as already described.

11-41. RADIO BY-PASS CONDENSERS. The installation of radio by-pass condensers on the field terminal of the regulator or generator will cause the regulator contact points to burn and oxidize so that generator output will be reduced and a run down battery will result. If a condenser is found connected to either of these terminals, disconnect the condenser and clean the regulator contact points as previously explained.

11-42. REGULATOR ARMATURE REPLACEMENT. The armature may be replaced by drilling out the two rivets attaching the armature to the regulator frame. Support the frame to avoid bending. Center-punch the rivet heads and drill out with a 3/32 inch drill. Attach the new armature with screws, lockwashers and nuts supplied with the service armature. Assemble screws down so that they will not ground against cover.

11-43. HIGH POINTS ON REGULATOR PERFORMANCE AND CHECKS.

a. The voltage regulator unit limits the voltage of the circuit, thus protecting the battery, lights and other accessories from high voltage.

b. The current regulator unit provides protection to the generator, preventing it from exceeding its maximum rated output.

c. Never set the current regulator above the maximum specified output of the generator.

d Many of the regulators are designed to be used with a positive grounded battery while others are designed to be used with a negative grounded battery only. Never attempt to use the wrong polarity regulator on an application.

e. The majority of reported regulator troubles arise from dirty or oxidized contact points which cause a reduced generator output. Clean the contact points with a spoon or riffler file. Never use emery cloth or sandpaper to clean points.

f. Always make sure that the rubber gasket is in place between the cover and base before replacing the cover. The gasket prevents entrance of moisture, dust and oil vapors which might damage the regulator.

g. The proper testing equipment in the hands of a qualified mechanic is necessary to assure proper and accurate regulator settings. Any attempt on the part of untrained personnel to adjust regulators is apt to lead to serious damage to the electrical equipment and should therefore be discouraged.

h. After any generator or regulator tests or adjustments, the generator must be polarized as explained in paragraph 11-33, step e, in order to avoid damage to the equipment.

i. It is recommended that following replacement or repair of a generator or regulator they be adjusted on a test bench as a matched unit.

11-44. REGULATOR SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 12-volt regulators installed as standard equipment on model PA-23-150 and PA-23-160 airplanes are as follows:

Regulator Model	1119145	1119246 (1)
Delco-Remy, Ref, Service Bulletin	1R-116	1R-116A
Cutout Relay: Air Gap Point Opening Closing Voltage	 .020 in. .020 in. 11.8 - 13.5 volts	 .020 in. .020 in. 11.8 - 13.5 volts
Voltage Regulator Air Gap Voltage Setting	 .075 in. 13.8 - 14.8 volts	 .075 in. 65°F - 14.2-15.7 volts 85°F - 14.4-15.4 volts 105°F - 14.2-15.0 volts
Current Regulator: Air Gap Current Setting	 .075 in. 33 - 37 amps	 .075 in. 48 - 52 amps

(1) Paralleling: With no load on battery terminal, add 5 amp load at P-terminal - voltage regulator to operate 2 to 3 volts lower.

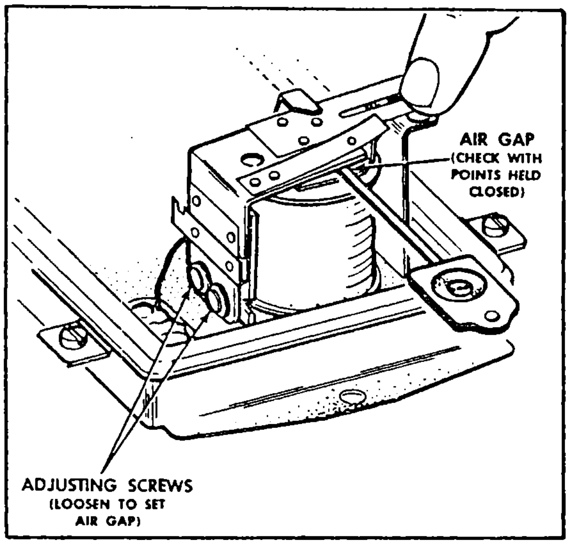


Figure 11-18. Checking and Adjusting Relay Air Gap

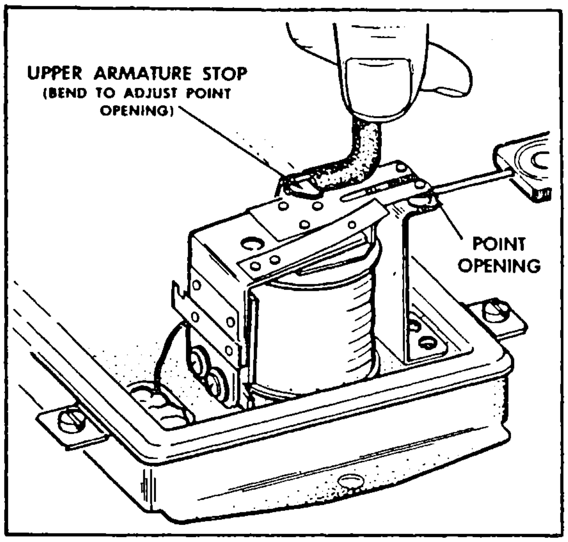


Figure 11-19. Checking and Adjusting Relay Point Opening

11-45. PARALLELING RELAY.

11-46. RELAY CHECKS AND ADJUSTMENTS. The cutout relay requires three checks and adjustments: air gap, point opening and closing voltage. The air gap and point opening adjustments must be made with the battery disconnected. (Refer to specifications given in paragraph 11-50.

11-47. AIR GAP. With the armature pushed down so the points are closed, check the air gap between the armature and core. (Refer to Figure 11-18.) To adjust, loosen the two adjusting screws and raise or lower the armature as required. Be sure the points align and tighten the screws after adjustment.

11-48. POINT OPENING. Check point opening and adjust by bending the upper armature stop as illustrated in Figure 11-19.

11-49. CLOSING VOLTAGE. To check the closing voltage of the cutout relay, connect a voltmeter from the "GEN" terminal of the relay to the relay base or ground as shown in Figure 11-20. Slowly increase the generator speed until the contact points close and read the voltage on the meter. To adjust the closing

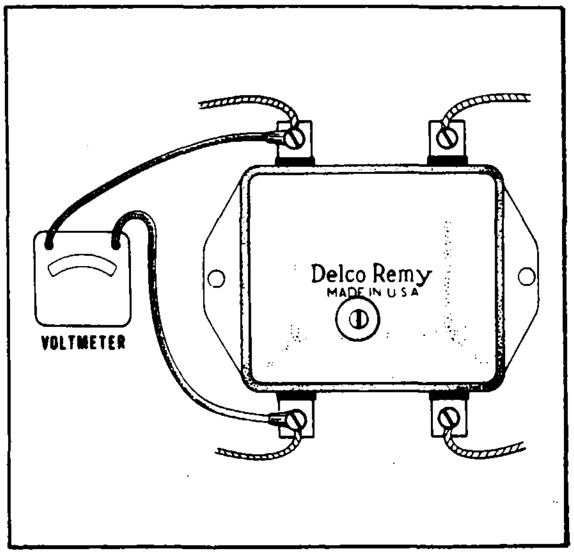


Figure 11-20. Checking Relay Closing Voltage

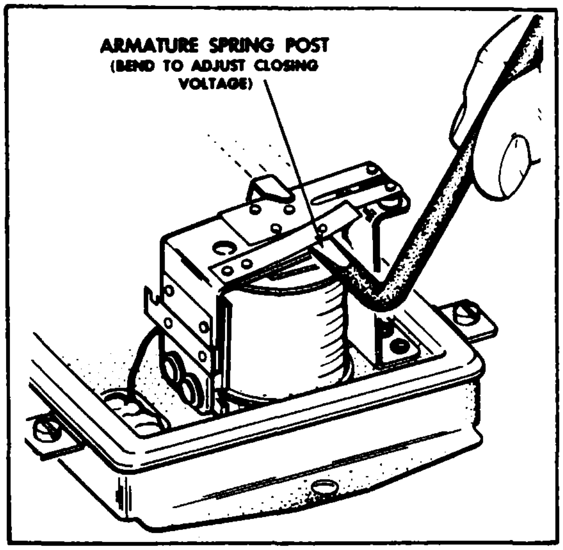


Figure 11-21. Adjusting Relay Closing Voltage

voltage, shut down the engine and bend the armature spring post (Refer to Figure 11-21.) up to increase the closing voltage and bend down to decrease the closing voltage. After each adjustment for both armatures, stop the generator and then slowly increase its speed and check the setting.

11-50. RELAY SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 12-volt relays installed as standard equipment on the model PA-23-150 and PA-23-160 airplanes are as follows:

Relay Model	1116887
Delco-Remy, Ref, Service Bulletin	1R100
Air Gap at Core, Points Closed Point Opening Closing Voltage (Range) Opening Voltage (Range)	.022 ± 10% in. .028 in. 10.5 to 12.3 8 minimum

11-51. CHECKING GENERATOR BELT TENSION. If properly installed, tensioned and checked periodically, the generator drive belt will give very satisfactory service. However, an improperly tensioned belt will wear rapidly and may slip and reduce generator output. Consequently, a belt should be checked for proper tension at the time it is installed, again after 25 hours operation and each 100 hours thereafter.

There are two satisfactory methods of checking generator belt tension; however, the first method described will be found preferable by most maintenance personnel because it is technically simple and requires little time for accomplishment.

a. Torque Method: This method of checking belt tension consists of measuring torque required to slip the belt at the small pulley and is accomplished as follows:

1. Apply a torque indicating wrench to the nut that attaches the pulley to the generator and turn it in a clockwise direction. Observe the torque shown on the wrench at the instant the pulley slips.

2. Check the torque indicated in step 1 with torque specified in the following chart. Adjust belt tension accordingly.

Width of Belt	Condition	Torque indicated at generator pulley
3/8 inch	New	11 to 13 ft. lbs.
3/8 inch	Used	7 to 9 ft. lbs.
1/2 inch	New	13 to 15 ft. lbs.
1/2 inch	Used	9 to 11 ft. lbs.

NOTE

The higher tension specified for a new belt is to compensate for the initial stretch that takes place as soon as it is operated. These higher tension values should not be applied to belts which previously have been used.

b. Deflection Method: Belt tension may be checked by measuring the amount of deflection caused by a predetermined amount of tension. This is accomplished in the following manner:

1. Attach the hook of a small spring-scale to the belt at the approximate mid-point between the rear gear support and the generator.

2. Pull on the scale until a reading of 14 pounds is obtained. (10 pounds for used belts.)

3. Measure the distance the belt has moved with the 10 or 14 pound load applied. The distance (deflection) should be 5/16 inch. If less than 5/16 inch, the belt is too tight.

11-52. CRANKING MOTOR (Delco-Remy).

11-53. OPERATION OF CRANKING MOTOR. When the cranking motor switch is closed, the armature begins to rotate. The drive pinion, being a loose fit on the drive sleeve located on the armature shaft, does not pick up speed as fast as the armature. Therefore, the drive pinion, having internally matched splines with respect to the splined drive sleeve, moves endwise on the shaft and into mesh with the flywheel. As the pinion hits the pinion stop, it begins to rotate with the armature and cranks the engine.

When the engine starts, the flywheel begins to spin the pinion faster than the armature. Again, because of the splined action of the pinion and drive sleeve assembly, the pinion backs out of mesh with the flywheel ring gear protecting the armature from excessive speeds.

Some Bendix drives incorporate a small anti-drift spring between the drive pinion and the pinion stop which prevents the pinion from drifting into mesh when the engine is running. Others use a small anti-drift pin and spring inside the pinion which provides enough friction to keep the pinion from drifting into mesh.

Never operate the motor for more than 30 seconds without pausing for two minutes to allow it to cool.

11-54. CHECKING CRANKING MOTOR. Several checks, both visual and electrical, should be made in a defective cranking circuit to isolate trouble before removing any unit. Many times a component is removed from the airplane only to find it is not defective after reliable tests. Therefore, before removing a unit in a defective cranking system, the following checks should be made:

a. Determine the condition of the battery.

b. Inspect the wiring for frayed insulation or other damage. Replace any wiring that is damaged. Inspect all connections to the cranking motor, solenoid switch, starting switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections and wiring as required. The engine manufacturer specifies allowable voltage drop in the cranking circuit. For this information, refer to the manufacturer's shop manual.

c. Inspect starting and solenoid switches to determine their condition. Connect a jumper lead around any switch or solenoid suspected of being defective. If the system functions properly using this method, repair or replace the bypassed unit.

d. If specified battery voltage can be measured at the motor terminal of the cranking motor, allowing for some voltage drop in the circuit and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

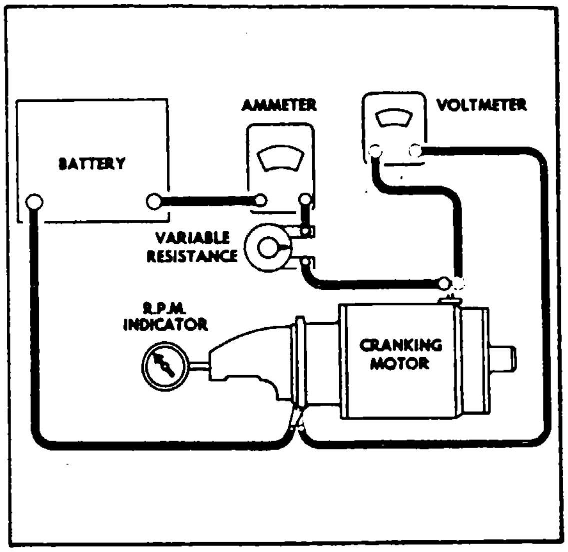


Figure 11-22. No-load Test Hookup

11-55. TEST AND MAINTENANCE OF CRANKING MOTORS.

11-56. INSPECTION. With the cranking motor removed from the engine, the pinion should be checked for freedom of operation by turning it on the screw shaft. The armature should be checked for freedom of operation by turning the pinion. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoe screw will cause the armature to drag and it will not turn freely. If the armature does not turn freely, the motor should be disassembled immediately. However, if the armature does operate freely, the motor should be given electrical tests before disassembly.

11-57. NO LOAD TEST. (Refer to Figure 11-22.) Connect the cranking motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated, from the motor terminal to the motor frame. An RPM indicator is necessary to measure armature speed. Obtain the specified voltage by varying the resistance unit. Then read the current draw and the armature speed and compare these readings with the values listed in paragraph 11-63. Interpret the test results as follows:

a. Rated current draw and no-load speed indicate normal condition of the cranking motor.

b. Low free speed and high current draw indicate:

1. Too much friction - tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.

2. Shorted armature. This can be further checked on a growler after disassembly.

c. Failure to operate with high current draw indicates:

1. A direct ground in the terminal or fields.

2. "Frozen" bearings (this should have been determined by turning the armature by hand).

d. Failure to operate with no current draw indicates:

1. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

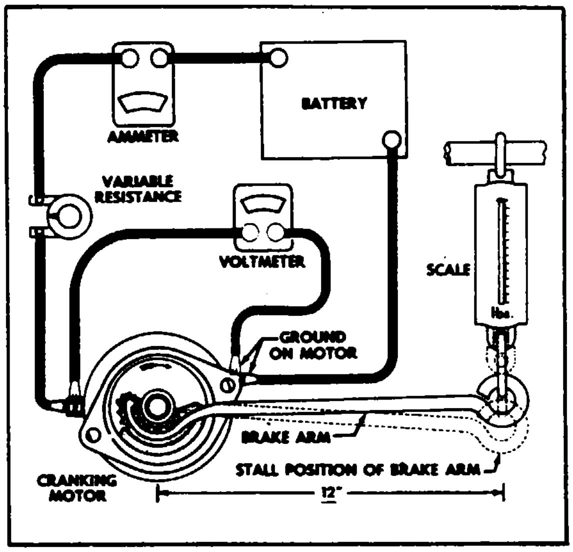


Figure 11-23. Lock-Torque Test Hookup

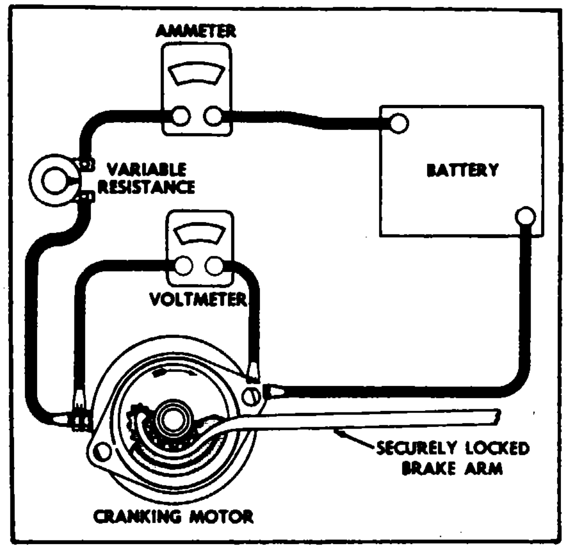


Figure 11-24. Resistance Test Hookup

2. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

3. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

e. Low no-load speed and low current draw indicate high internal resistance due to poor connections, defective leads, dirty commutator and causes listed under step d.

f. High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

11-58. LOCK-TORQUE TEST. (Refer to Figure 11-23.) The lock-torque test requires the equipment illustrated. A variable resistance with a high current capacity should be used. The cranking motor should be securely mounted and a brake arm hooked to the drive pinion. Use extreme caution during this test to make sure the end of the brake arm does not slip off the pinion when current is applied. When specified current is applied, the torque can be computed from the reading on the scale. A one foot brake arm will directly indicate pound-feet. Compare the pound-feet of torque as read on the scale with that listed in paragraph 11-63. If the torque is low, the motor must be disassembled for further tests and repair.

11-59. RESISTANCE TEST. (Refer to Figure 11-24.) This test requires equipment similar to the lock-torque test, with the exception that the pinion is locked securely so it cannot rotate. When the specified voltage is applied, the current should fall in a range as indicated in paragraph 11-63. A high current indicates grounded or shorted conductors, and a low current indicates excessive resistance.

11-60. DISASSEMBLY. If the motor does not perform in accordance with published specifications, it may need to be disassembled for further testing of the components. Normally the cranking motor should be disassembled only so far as is necessary to make repair or replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Following are general instructions for disassembling a typical Bendix drive cranking motor.

a. Remove the cover band, if present, and detach the field coil leads from the brush holders.

b. If gear reduction, remove the drive housing and reduction housing.

c. Remove the bolts attaching the drive housing and commutator end frame to the field frame assembly. Discard the tang lock washers.

d. Separate the commutator end frame, armature assembly, field frame and drive housing.

e. Remove and disassemble the drive from the armature shaft by first identifying the type Bendix drive and then following one of the guides below:

1. Standard Bendix Drive: Remove the head spring screw and slip it off the armature shaft.

2. Folo-Thru-Bendix Drive: Push in the outer anchor plate so the pilot screw or pin can be removed.

NOTE

Some Folo-Thru drives use a rubber cushion in place of a drive spring. To remove from shaft, screw pinion out to drive position, then force pin from shaft through screw sleeve holes.

CAUTION

Do not disassemble this drive, service is by complete replacement.

11-61. COMPONENT INSPECTION AND REPAIR.

a. Brushes and Brush Holders: Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator with proper spring tension (Refer to Paragraph 11-63.) to give good, firm contact. Brush leads and screws should be tight and clean.

b. Armature: The armature should be checked for short circuits, opens and grounds:

1. Short circuits are located by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature. The steel strip will vibrate on the area of the short circuit. Shorts between bars are sometimes produced by brush dust or copper between the bars. Undercutting the insulation will eliminate these shorts.

2. Opens: Inspect the points where the conductors are joined to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not badly burned, resolder the leads in the riser bars and turn the commutator down in a lathe. Then undercut the insulation between the commutator bars .031 of an inch.

3. Grounds in the armature can be detected by the use of a test lamp and prods. If the lamp lights when one test prod is placed on the commutator and the other test prod on the armature core or shaft, the armature is grounded. If the commutator is worn, dirty, out of round, or has high insulation, the commutator should be turned down and undercut as previously described.

c. Field Coils: The field coils should be checked for grounds and opens using a test lamp.

1. Grounds: Disconnect field coil ground connections. Connect one test prod to the field frame and the other to the field connector. If the lamp lights, the field coils are grounded and must be repaired or replaced.

2. Opens: Connect test lamp prods to ends of field coils. If lamp does not light, the field coils are open.

If the field coils need to be removed for repair or replacement, a pole shoe spreader and pole shoe screw driver should be used. Care should be exercised in replacing the field coils to prevent grounding or shorting them as they are tightened into place. Where the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

11-62. ASSEMBLY. To reassemble the motor follow the disassembly procedures in reverse. Install new tang lock washers where removed.

CAUTION

If Folo-Thru drive is manually rotated to locked position, do not attempt to force it in a reverse direction. Proceed to install with pinion meshing with flywheel. When engine starts, the drive will return to the demeshed position.

11-63. CRANKING MOTOR SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 12-volt cranking motors installed as standard equipment on model PA-23-150 and PA-23-160 airplanes are as follows:

Motor Model	1109657	1109673	1109689
Delco-Remy, Ref, Service Bulletin	1M-110	1M-110	1M-110
Minimum Brush Tension	24 oz.	24 oz.	24 oz.
No-Load Test			
Volts	10.6	11.3	11.3
Min. Amps	48	-	-
Max. Amps	80	65	65
Min. RPM	5800	4000	4000
Max. RPM	8200	-	-
Lock Test			
Amps	-	570	570
Torque (ft.- lbs.)	-	27.5	27.5
Approx. Volts	-	6.3	6.3
Resistance Test			
Volts	4.0	-	-
Min. Amps	365	-	-
Max. Amps	420	-	-

11-64. BATTERY.

11-65. SERVICING THE BATTERY. Access to the battery is through the access panel on the right side of the nose. The stainless steel box has a plastic drain tube located on the bottom side near the right rear corner which is normally closed off with a clamp and should be opened occasionally to drain off any accumulation of liquid. The battery should be checked for fluid level, but must not be filled above the baffle plates. A hydrometer check should be performed to determine the percent of charge present in the battery. All connections must be clean and tight.

11-66. REMOVAL OF BATTERY.

a. Remove the access panel from the right side of the nose section.
b. Remove the wing nuts from either side of the box and remove the lid.
c. Disconnect the battery cables.

NOTE

Always remove the ground cable first and install last to prevent accidental short circuiting or arcing.

d. Remove the battery from the box.

11-67. INSTALLATION OF BATTERY.

a. Ascertain that the battery and battery box have been cleaned and are free of acid.
b. Install the battery with the terminals inboard.
c. Connect the battery cables.
d. Install the lid and secure with wing nuts.

11-68. CHARGING BATTERY. If the battery is not up to normal charge, remove the battery and recharge starting with a charging rate of 4 amperes and finishing with 2 amperes.

Hydrometer Reading and Battery Charge Percent	
Hydrometer Readings	Percent of Charge
1280	100
1250	75
1220	50
1190	25
1160	Very little useful capacity
1130 or below	Discharged

11-69. BATTERY BOX CORROSION PREVENTION. The following check against corrosion within the battery box should be performed at least every 30 days.

a. Open the clamp at bottom right rear corner of the battery box and drain off any electrolyte that may have overflowed into the box.

b. Check terminals and connections for corrosion. Corrosion effects may be neutralized by applying a solution of baking soda and water mixed to the consistency of thin cream. Repeat application until all bubbling action has ceased.

CAUTION

Do not allow soda solution to enter battery.

c. Wash battery and box with clean water and dry.

d. Close battery box drain tube clamp.

e. As necessary, paint the battery box with an acid resistant paint.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING

Trouble	Cause	Remedy
	BATTERY 12V	
Battery will not hold charge.	Battery worn out.	Replace battery.
	Charging rate not set right.	Reset.
	Discharge too great to replace.	Reduce use of starter, on ground; use external power wherever possible.
	Standing too long.	Remove and recharge battery if left in unused airplane one week or more.
	Equipment left "ON" accidentally.	Remove and recharge. (See Paragraph 10-12.)
	Impurities in electrolyte.	Replace.
	Short circuit (ground) in wiring.	Check wiring.
	Broken cell partitions.	Replace.
Battery life is short.	Overcharge due to level of electrolyte being below tops of plates.	Maintain electrolyte level.
	Heavy discharge.	Replace.
	Sulfation due to disuse.	Replace.
	Impurities in electrolyte.	Replace battery.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Cracked cell.	Hold down loose.	Replace battery and tighten.
	Frozen battery.	Replace.
Compound on top of battery melts.	Charging rate too high.	Reduce.
Electrolyte runs out of vent plugs.	Too much water added to battery.	Drain and keep at proper level.
Excessive corrosion inside container.	Spillage from overfillings.	Use care in adding water
	Vent lines leaking or clogged.	Repair or clean.
Battery freezes.	Discharged battery.	Replace.
	Water added and battery not charged immediately.	Always recharge battery at least 1/2 hour when adding water in freezing weather.
	Leaking jar.	Replace.
Battery polarity reversed.	Connected backwards on airplane or charger.	Battery should be slowly discharged completely and then charged correctly and tested.
Battery consumes excessive water.	Charging rate too high (if in all cells).	Correct charging rate.
	Cracked jar (one cell only).	Replace battery.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
	GENERATOR	
Generator operating within rated speed range but voltage output low.	If the voltage is low, the generator is operating on residual magnetism.	Check for loose or high resistance connections; clean and tighten.
	Loose or high-resistance electrical connections.	Clean and tighten all electrical connections.
	Brushes excessively worn.	When brush wears down to 1/2 inch, replace with a new one. The new brush must be seated to at least 75% of the contact surface by running the generator without load (with the line switch "OPEN") for at least 15 minutes during the engine warm-up period. CAUTION Do not use abrasives of any description to assist in seating the brushes.
	Brushes binding in the brush boxes.	The brushes should be a free fit without excessive side play in the brush boxes. Binding brushes and the brush boxes should be wiped clean with a cloth moistened in Varsol or undoped gasoline.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range but voltage output low. (cont.)		Replace the brushes as outlined above.
	Brushes not properly seated.	Reseat brushes as outlined above.
	Low brush spring tension.	Brush spring should bear centrally on the top of the brushes, insuring full brush contact with the face of the commutator.
	Dirty commutator.	Clean the commutator with a cloth moistened in Varsol or undoped gasoline.
	Scored or pitted commutator.	Remove and turn commutator down on a lathe.
	Shorted or open armature windings.	Replace armature.
	Improper operations of the voltage regulator.	Adjust regulator.
Generator operating within rated speed range but voltmeter indicates zero.	Loose or high resistance field coil assembly terminals.	Clean and tighten the terminals.
	Wiring not properly connected.	See airplane wiring diagram.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range but voltmeter indicates zero. (cont.)	Grounded field coil assembly.	Replace entire coil assembly.
	Open field coil assembly.	Remove the generator and replace with one known to be in good condition.
Generator operating within rated speed range, but voltage output is erratic.	Unstable operation of the voltage regulator. Same as "Generator operating within rated speed range but voltage output low."	Replace voltage regulator. Use remedy under "Generator operating within rated speed range but voltage output low."
Excessive sparking at generator brushes.	Same as "Generator operating within rated speed range but voltage output low."	Use remedy under "Generator operating within rated speed range but voltage output low."
Generator operating within rated speed range, with line switch closed, but system ammeter indicates low or no output.	None.	Since the voltage regulator holds the generated voltage at an almost constant value, the current output depends entirely upon the condition of the battery and the amount of external load. Therefore, when the battery is fully charged and there is no load on the system, the difference in voltage between the generator and

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range, with line switch closed, but system ammeter indicates low or no output. (cont.)		the battery is so small that little or no current will flow between them.
	Improper operation of the reverse-current relay.	Readjust the relay.
	Generator field demagnetized.	Flash field.
	Burned-out ammeter.	Replace ammeter.
Generator operating within rated speed range but system ammeter reads off scale in the wrong direction.	Generator field magnetized in the wrong direction.	Flash field as explained and check to see that reverse-current relay is operating properly. NOTE Flash the generator field by turning the generator and battery switch to the "ON" position and momentarily connect the "BAT" and "GEN" terminals of the regulator.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
System ammeter shows full charge but battery is discharged.	Generator of improper capacity installed in the system.	Install a generator of larger capacity.
	Battery too small for load requirements.	Install a battery of sufficient capacity.
System ammeter fluctuates excessively when indicating full rated load.	Generating system is overloaded.	Check the system for abnormal loads.
	Improper operation of generator reverse-current relay.	Readjust to operate properly.
Burned-out system ammeter or line fuse.	Discharged battery.	Replace with a fully charged battery.
	Defective wiring.	Replace all defective wiring.

STARTER

Motor fails to operate.	Low battery charge.	Check and recharge if necessary.
	Defective or improper wiring or loose connections.	Refer to wiring diagram and check all wiring.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Motor fails to operate (cont.)	Defective starter solenoid or control switch.	Replace faulty unit.
	Binding, worn, or improperly seated brush, or brushes with excessive side play.	Brushes should be a free fit in the brush boxes without excessive side play. Binding brushes and brush boxes should be wiped clean with a gasoline (undoped) moistened cloth. A new brush should be run in until at least 50% seated; however, if facilities are not available for running in brushes, then the brush should be properly seated by inserting a strip of No. 0000 sand paper between the brush and commutator, with the sanded side next to the brush. Pull sand paper in the direction of rotation, being careful to keep it in the same contour as the commutator. CAUTION Do not use coarse sand paper or emery cloth. After seating, clean thoroughly to remove all sand and metal particles to prevent excessive wear. Keep

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Motor fails to operate (cont.)		motor bearing free from sand or metal particles.
	Dirty commutator.	If commutator is rough or dirty, smooth and polish with No. 0000 sandpaper. If too rough and pitted, remove and turn down. Blow out all particles.
	Shorted, grounded, or open armature.	Remove and replace with an armature known to be in good condition.
	Grounded or open field circuit.	Test and then replace new part.
Motor operates at proper speed but fails to crank engine.	Faulty Bendix drive.	Remove Bendix drive assembly. Clean and check, replace.
Low motor and cranking speed.	Worn, rough, or improperly lubricated motor or starter gearing.	Disassemble, clean, inspect and relubricate, replacing ball bearings, if worn.
	Same electrical causes as listed under "Motor fails to operate."	Same remedies listed for these troubles.
Excessive arcing of motor brushes.	Binding, worn or improperly seated brush or brushes, with excessive side play.	See information above dealing with this trouble.
	Dirty commutator, rough,	Clean as already outlined

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Excessive arcing of motor brushes. (cont.)	pitted or scored.	above.
	Grounded or open field circuit.	Test and replace defective parts.
Excessive wear and arcing of motor brushes.	Rough or scored commutator.	Remove and turn commutator down on a lathe.
	Armature assembly not concentric.	Reface commutator.

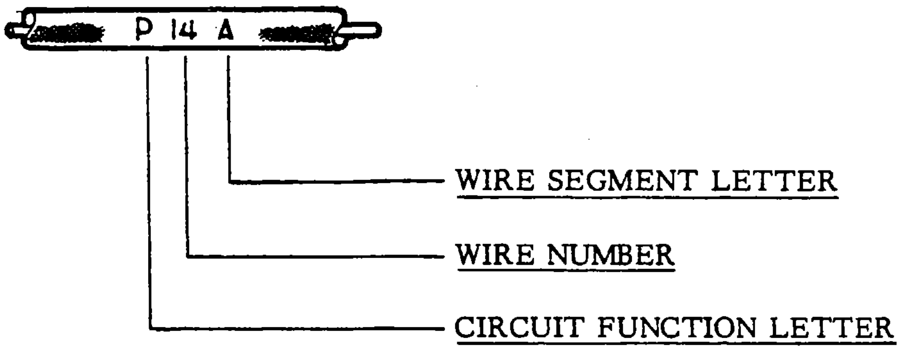
BATTERY-DISCONNECT SOLENOID

Does not operate.	Open circuit.	Repair wiring.
	Dirty contacts on connector plug.	Clean contacts.
	Open-circuited solenoid coil	Replace unit.
	Plunger binding.	Remove and wash plunger and housing thoroughly with carbon tetrachloride. Change spring compression only as a last resort.
Intermittent operation.	Short-circuited coil. Loose electrical connection.	Replace coil. Clean and tighten electrical connections.

TABLE XI-I. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Intermittent operation. (cont.)	Plunger binding.	See remedy pertaining to "Plunger binding" under "Does not operate."
	Badly burned points.	If points cannot be dressed down, replace the unit.

TABLE XI-II. ELECTRICAL WIRE CODING



CIRCUIT FUNCTION LETTER	CIRCUITS
C	CONTROL SURFACE
E	ENGINE INSTRUMENT
F	FLIGHT INSTRUMENT
G	LANDING GEAR
H	HEATER - VENTILATING & DE-ICING
L	LIGHTING
P	POWER
Q	FUEL & OIL
RP	RADIO POWER
RZ	RADIO AUDIO & INTERPHONE
J	IGNITION
RG	RADIO GROUND

2D20

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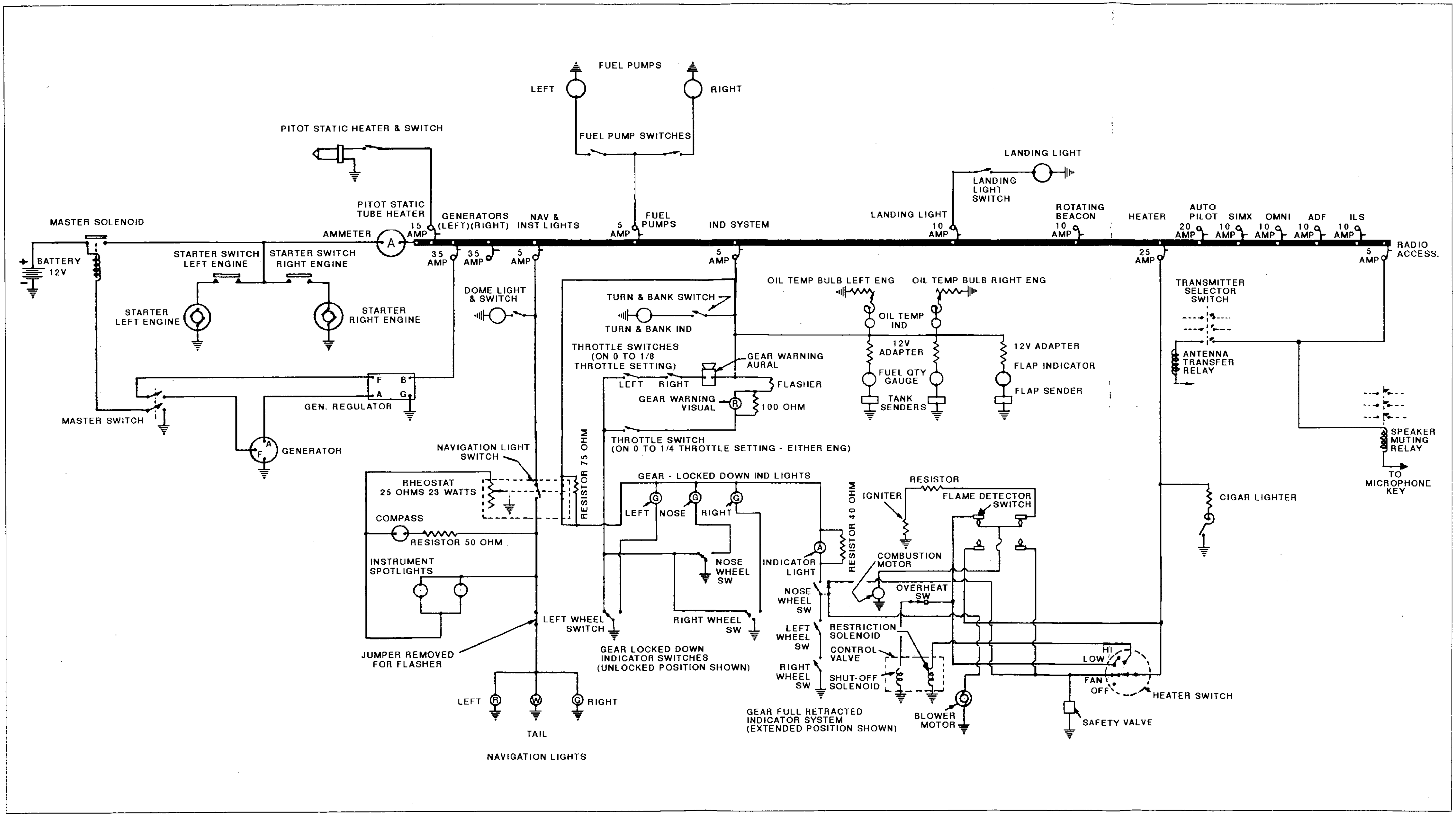


Figure 11-25. Electrical System Schematic - Basic
(S/N's 23-1 thru 23-746)

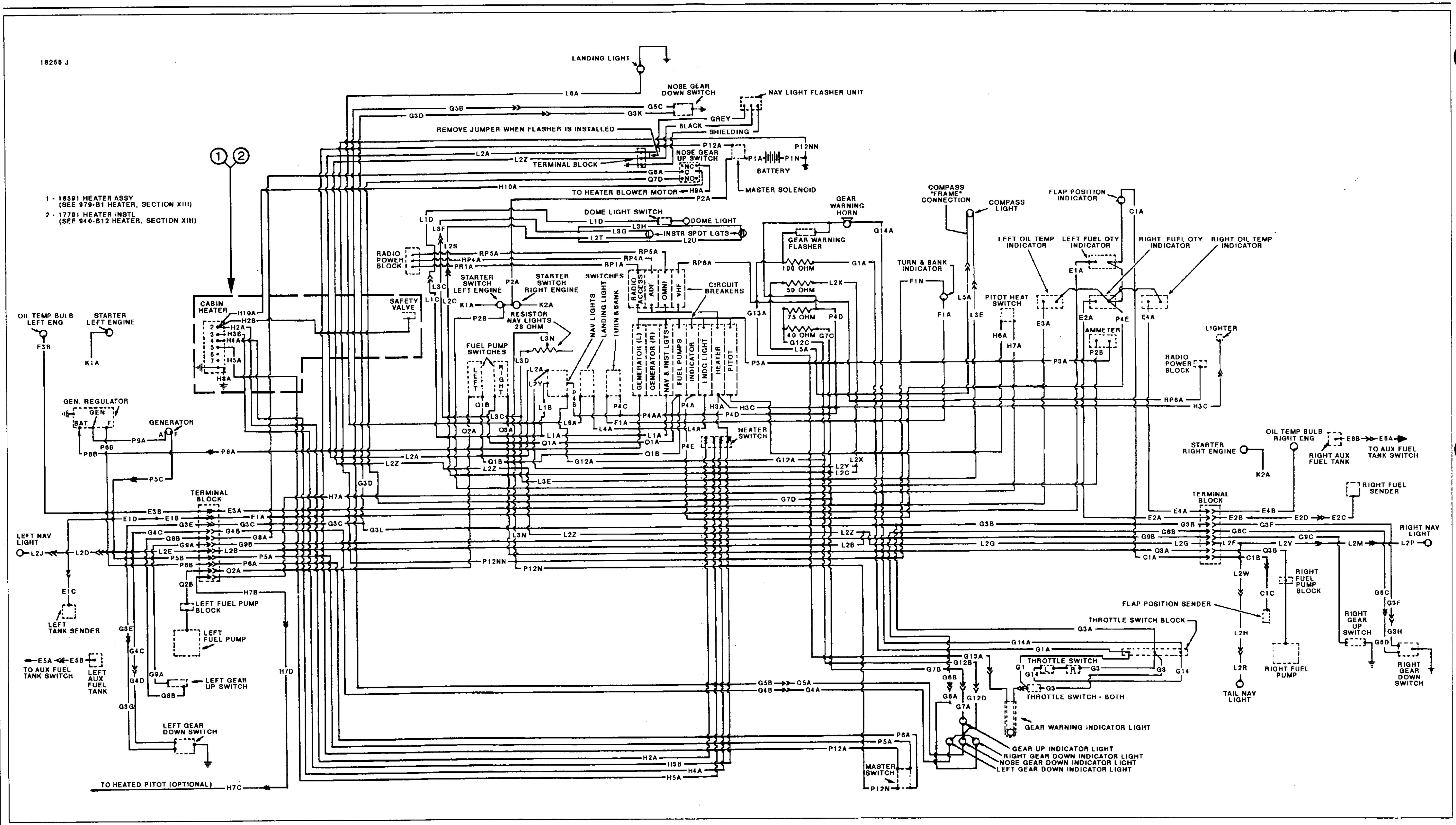


Figure 11-26. Electrical System Schematic - Complete
(S/N's 23-1 thru 23-746)

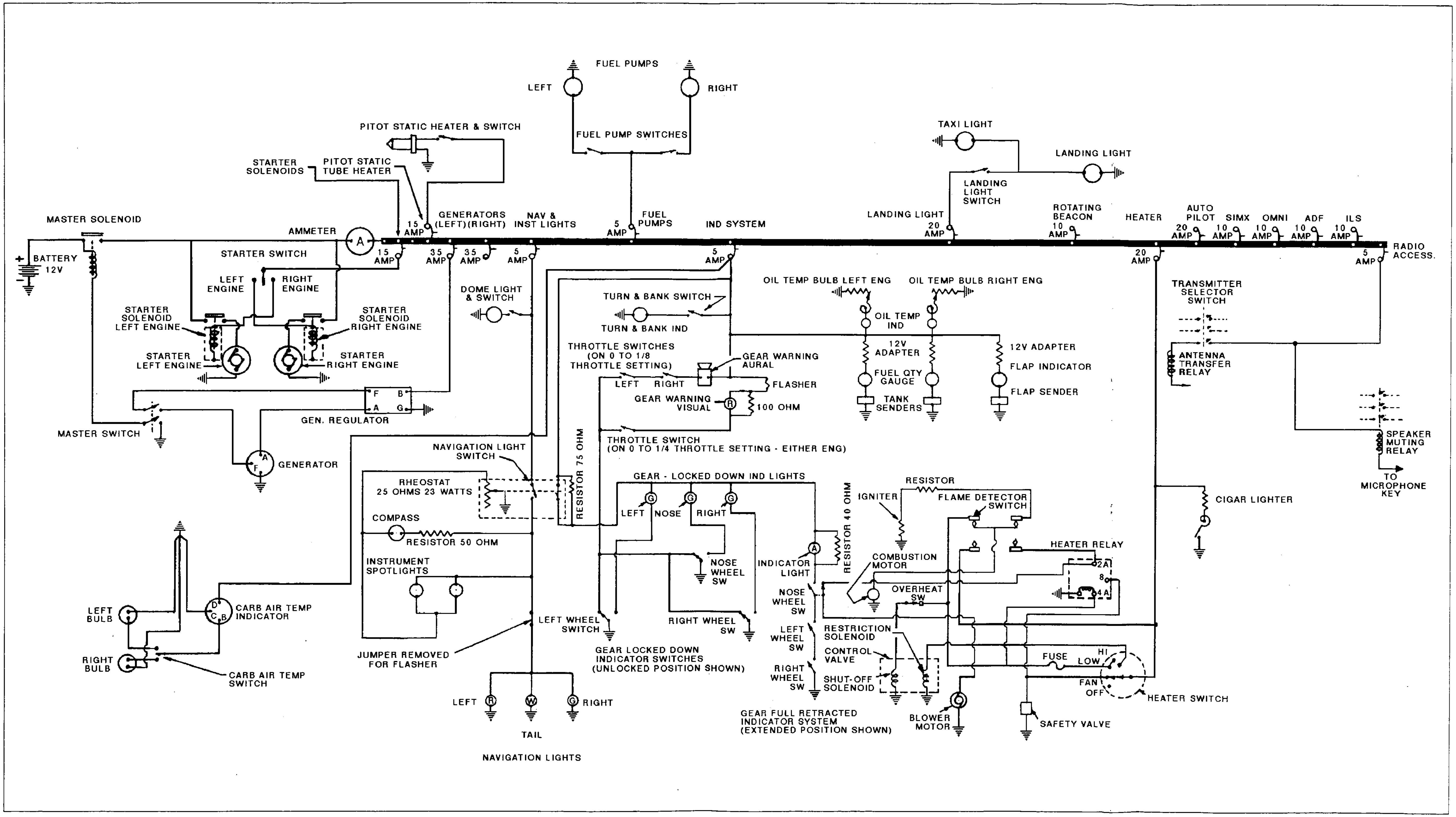


Figure 11-27. Electrical System Schematic - Basic
(S/N's 23-747 thru 23-1683)

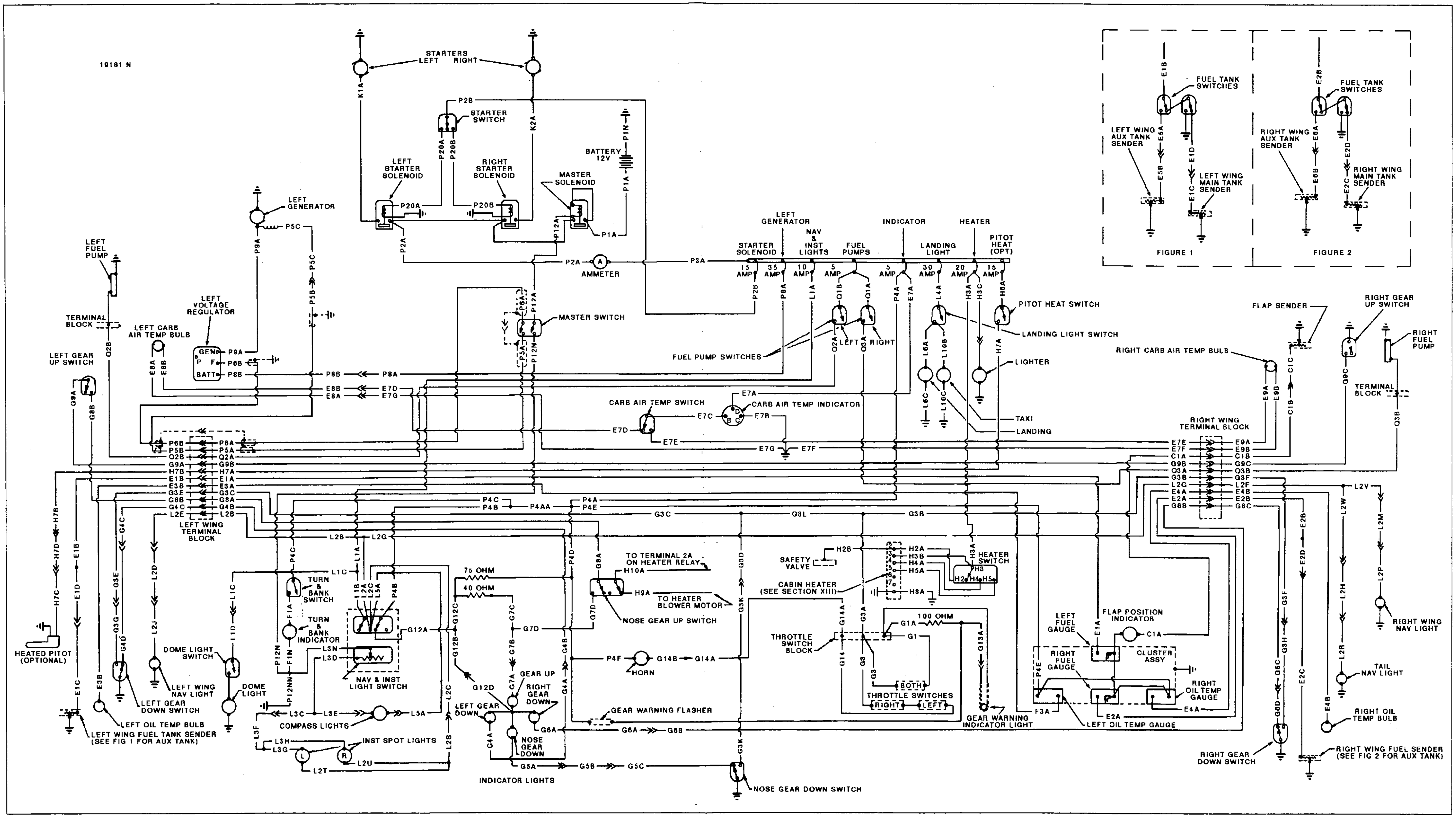


Figure 11-28. Electrical System Schematic - Complete
(S/N's 23-747 thru 23-1683)

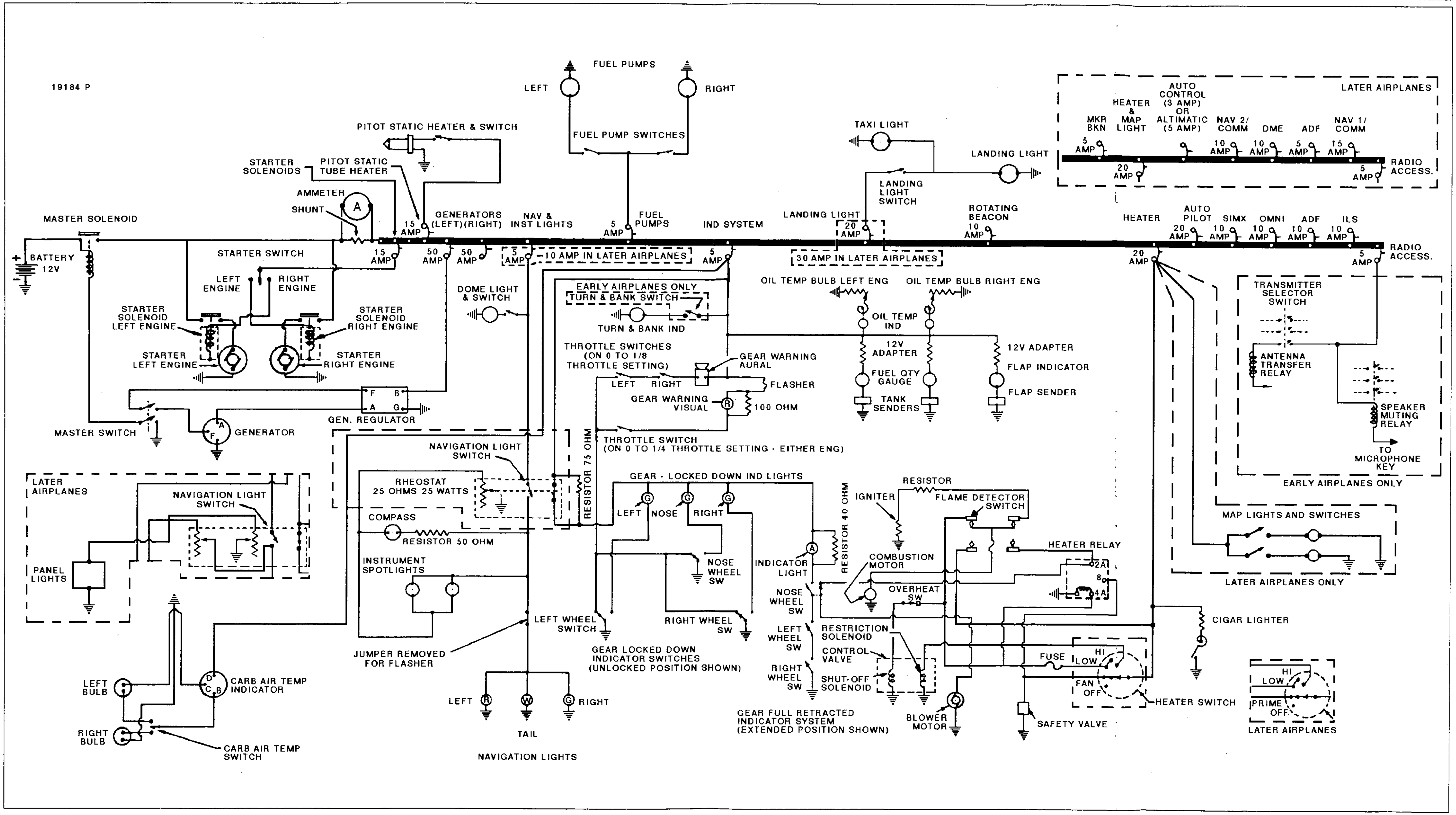


Figure 11-29. Electrical System Schematic - Basic
(S/N's 23-1684 and up)

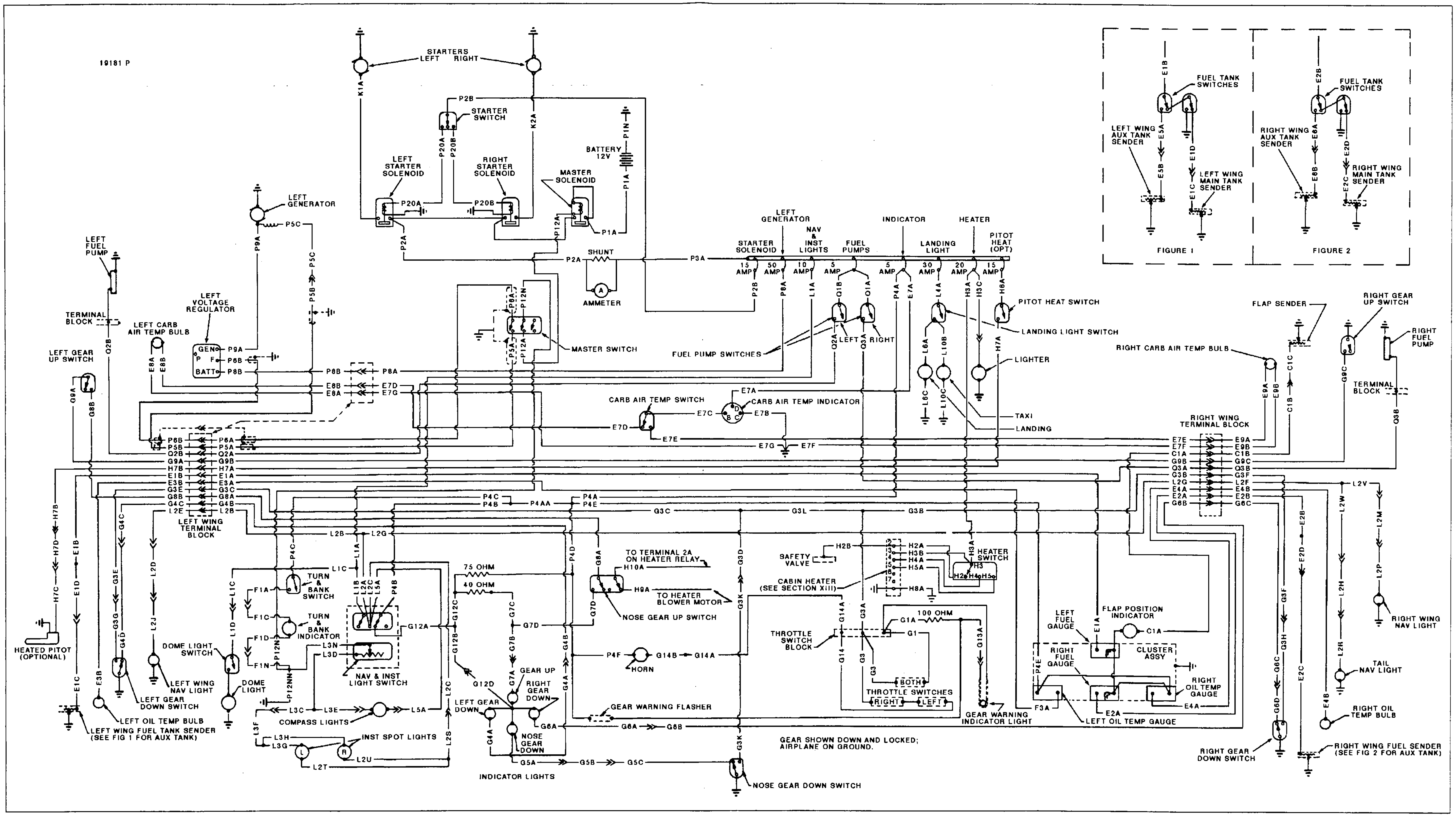


Figure 11-30. Electrical System Schematic - Complete
(S/N's 23-1684 and up - Early Airplanes)

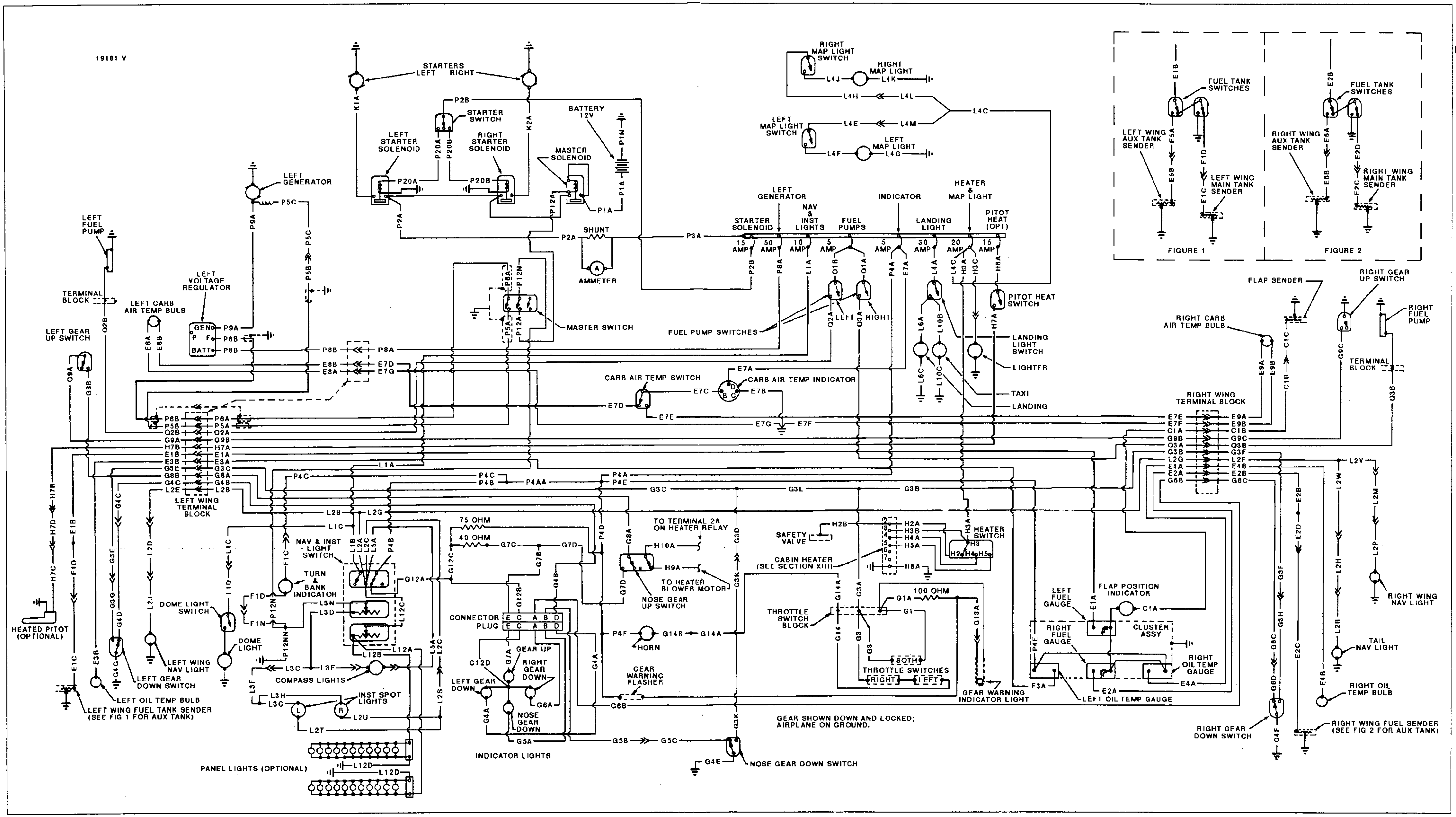


Figure 11-30. Electrical System Schematic - Complete
(S/N's 23-1684 and up - Late Airplanes)

SECTION XII

ELECTRONICS

NOTE

For AutoPilot service and maintenance information, refer to Piper AutoControl Service Manual, Part No. 751 532 and Service Electronics Letter SE-5 or Piper AltiMatic Service Manual, Part No. 753 616 and Service Electronics Letters SE-25 and SE-26.
For radio service and maintenance, refer to the appropriate manufacturer's service manual.

Section XIII

Heating and Ventilating

Aerofiche
Grid No.

Aerofiche Grid No.

Issued: 3/15/68

Aerofiche
Grid No.

SECTION XIII

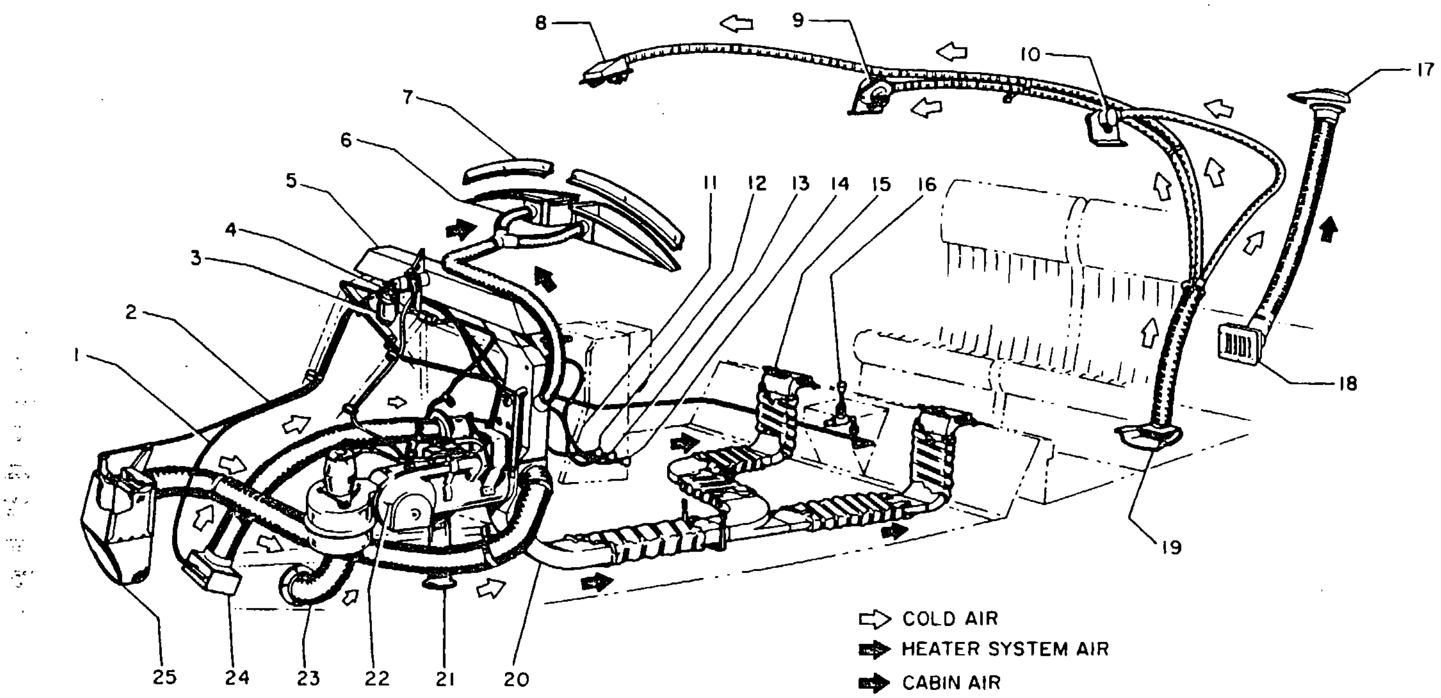
HEATING AND VENTILATING SYSTEM

13-1. INTRODUCTION. This section contains instructions for operation, maintenance and overhaul of the different heating and ventilating systems found in PA-23-150 and PA-23-160 airplanes. In addition, instructions for the inspection and service of the components that contribute to the operation of the heating and ventilating system may be found in this section. Inspection time intervals for these systems may be found in Section III of this manual.

13-2. DESCRIPTION. Several variations of heating and ventilating systems are present in the PA-23 model airplanes. A pictorial description of these systems may be found in Figures 13-1 thru 13-5. The flow of air for heating the interior of the airplanes and windshield defrosting is supplied to the heater by various combinations of air inlets and ducts. Those airplanes with Serial Numbers 23-1 to 23-170 inclusive, intake air is drawn into the heater through an inlet in the nose gear wheel well; Serial Numbers 23-171 to 23-375 inclusive, air is drawn from the cabin through an inlet in the forward cabin bulkhead and those with Serial Numbers 23-376 to 23-746 inclusive, pick up air through the inlet in the cabin and an air intake in the nose section of the airplane. The flow of air through the intake in the nose section of the later system can be regulated by a control in the cockpit. Finally, airplanes with Serial Numbers 23-747 and up, utilize only direct air from the intake in the nose section.

Fresh air ventilating for the forward cabin area is through an inlet in the underside of the nose section, directly forward of the nose gear wheel well doors. The vent is controlled by a knob in the cockpit. In addition, a scoop on the underside of the fuselage of early models or on the upper side of the fuselage of later models, directs air into the cabin through individual vents over each seat. Each vent is individually adjustable for the desired air flow. Located in the aft section of the cabin interior is an exhaust vent.

For a detailed description and operation of the heaters used in the PA-23 airplanes, refer to paragraphs 13-6 and 13-62.



1. CABIN AIR INTAKE BOX CABLE
2. COLD AIR INTAKE BOX CABLE
3. GASOLINE FILTER
4. SAFETY VALVE ASSEMBLY
5. FRONT CABIN HEAT BOX ASSEMBLY
6. DEFROSTER BOX ASSEMBLY
7. DEFROSTER BOX BAFFLE
8. FRONT FRESH AIR VENT
9. RIGHT FRESH AIR VENT
10. LEFT FRESH AIR VENT
11. HEATER AIR INTAKE
12. HEATER AIR CONTROL
13. COLD AIR CONTROL
14. DEFROSTER CONTROL
15. CABIN AIR DEFLECTOR ASSEMBLY
16. HEATER FUEL CONTROL
17. CABIN AIR EXHAUST
18. EXHAUST INTAKE BOX ASSEMBLY
19. CABIN AIR VENT SCOOP
20. REAR CABIN HEAT DUCT
21. HEATER EXHAUST TUBE
22. HEATER
23. HEATER AIR INTAKE HOSE
24. CABIN AIR INTAKE BOX ASSEMBLY
25. COLD AIR INTAKE BOX ASSEMBLY

Figure 13-1. Heating and Ventilating System
PA-23, Serial Nos. 23-1 to 23-170 incl.

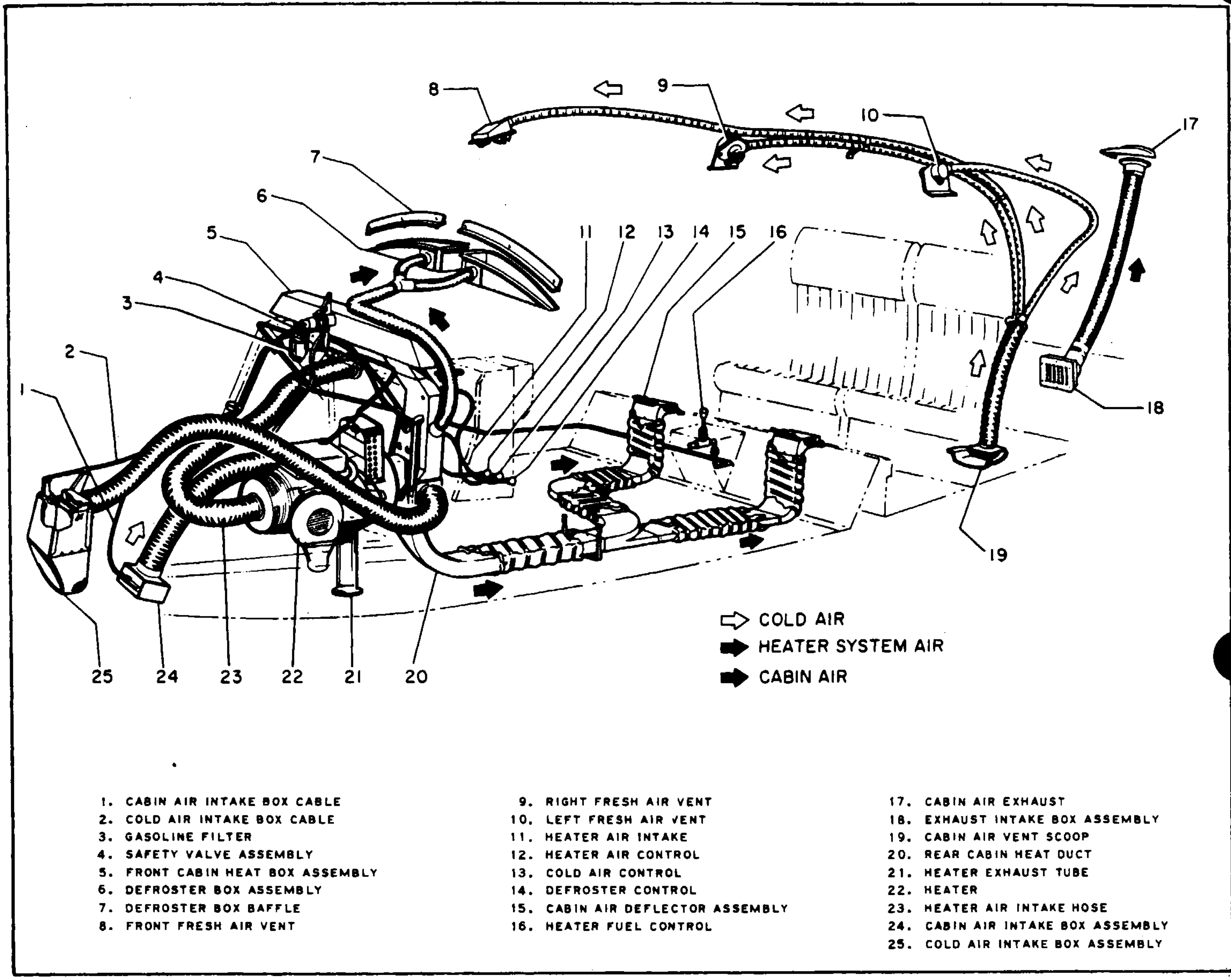
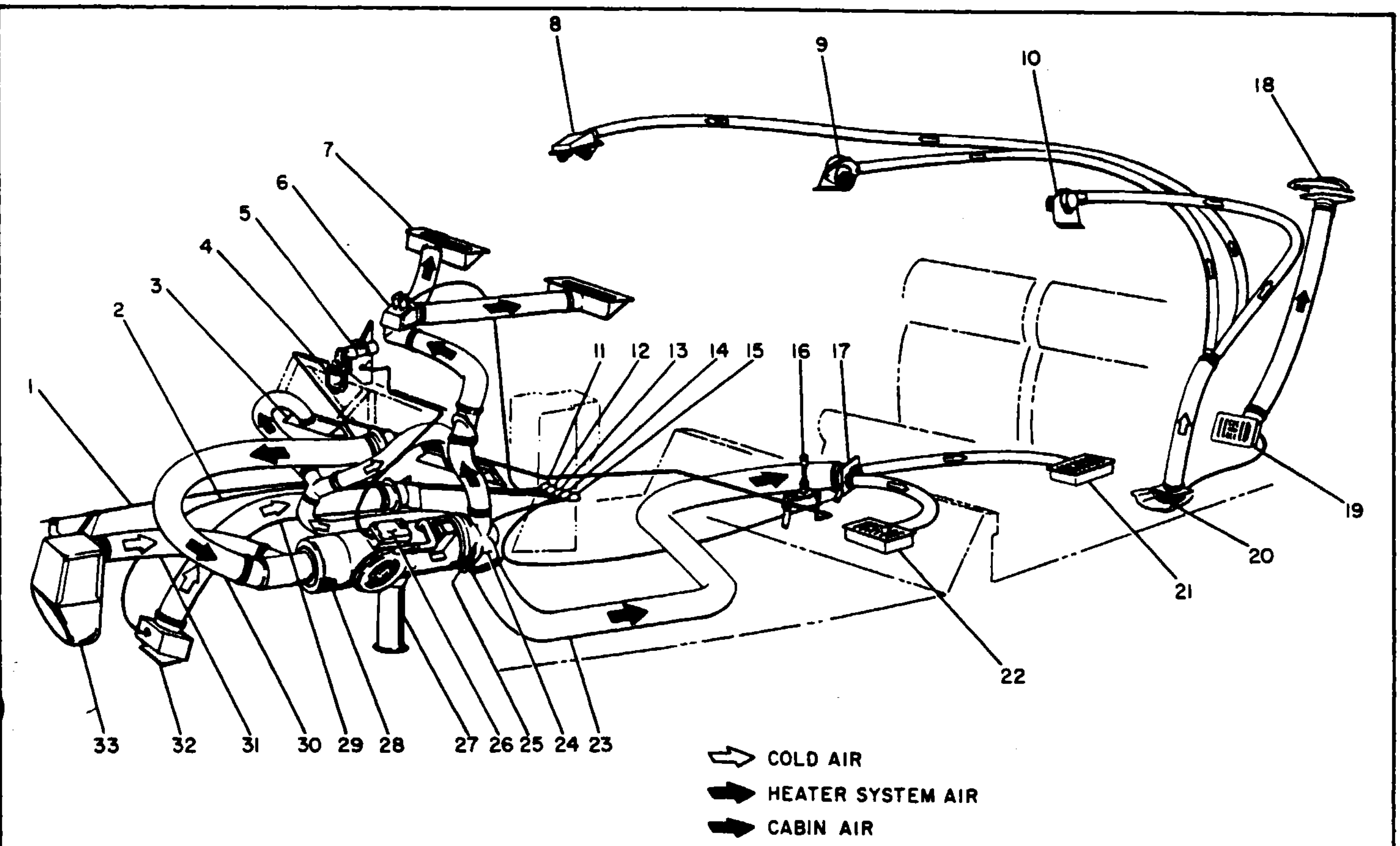
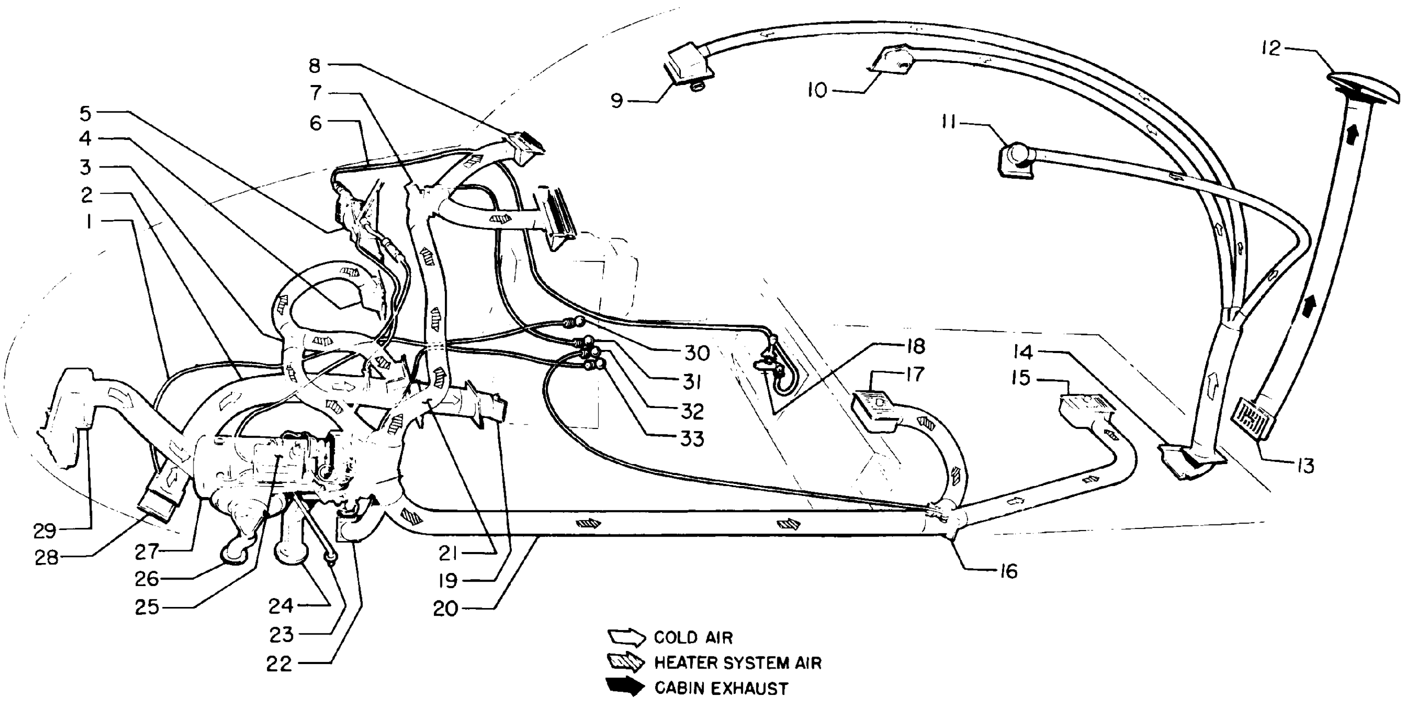


Figure 13-2. Heating and Ventilating System
PA-23, Serial Nos. 23-171 to 23-375 incl.



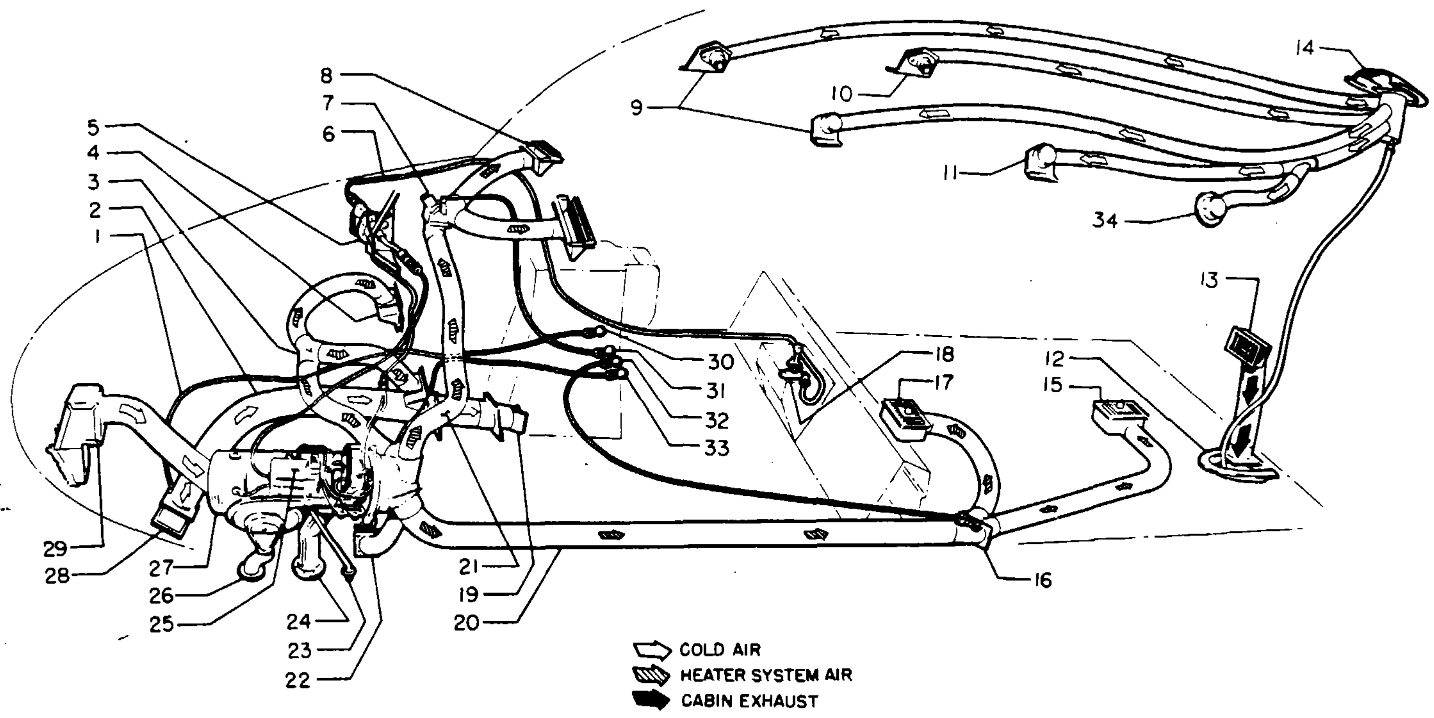
1. COLD AIR INLET BOX CABLE
2. COLD AIR INLET BOX CABLE
3. HEATER SYSTEM AIR INLET
4. HEATER FUEL FILTER
5. HEATER FUEL CONTROL VALVE
6. DEFROSTER CONTROL VALVE
7. DEFROSTER OUTLET
8. FRONT FRESH AIR VENTS
9. RIGHT REAR FRESH AIR VENT
10. LEFT REAR FRESH AIR VENT
11. HEATER SYSTEM COLD AIR CONTROL
12. FRONT SEAT COLD AIR CONTROL
13. DEFROSTER CONTROL
14. CABIN AIR REAR CONTROL
15. CABIN AIR FRONT CONTROL
16. HEATER FUEL SHUT-OFF CONTROL
17. REAR SEAT CONTROL VALVE
18. CABIN AIR EXHAUST OUTLET
19. CABIN AIR EXHAUST BOX
20. CABIN AIR VENT SCOOP
21. REAR CABIN AIR INLET BOX
22. CENTER CABIN AIR INLET BOX
23. REAR SEAT CABIN AIR DUCT
24. AIR DISTRIBUTOR BOX
25. FRONT SEAT CABIN AIR CONTROL VALVE
26. FUEL CONTROL VALVE HOUSING
27. HEATER EXHAUST TUBE
28. HEATER VENTILATING AIR BLOWER
29. COLD AIR FRONT SEAT DUCT
30. RECIRCULATING AIR DUCT
31. CABIN AIR HEATER SYSTEM DUCT
32. COLD AIR INLET BOX
33. COLD AIR INLET BOX

Figure 13-3. Heating and Ventilating System
PA-23, Serial Nos. 23-376 to 23-746 incl.



1. CABLE - COLD AIR INLET CONTROL, FRONT SEAT
2. DUCT - FRESH AIR, FRONT SEAT
3. DUCT - HEATER SYSTEM AIR, FRONT SEAT
4. INLET - HEATER SYSTEM AIR, FRONT SEAT
5. CONTROL VALVE - HEATER FUEL
6. LINE - HEATER FUEL
7. CONTROL VALVE - DEFROSTER
8. INLET - HEATER SYSTEM AIR, DEFROSTER
9. VENTS - FRESH AIR, FRONT SEAT
10. VENT - FRESH AIR, RIGHT REAR
11. VENT - FRESH AIR, LEFT REAR
12. OUTLET - AIR EXHAUST, CABIN
13. BOX - AIR EXHAUST, CABIN
14. SCOOP - FRESH AIR, CABIN
15. INLET - HEATER SYSTEM AIR, REAR CABIN
16. CONTROL VALVE - HEATER SYSTEM, REAR SEATS
17. INLET - HEATER SYSTEM AIR, CENTER CABIN
18. SHUT-OFF VALVE, HEATER FUEL
19. INLET - FRESH AIR, FRONT SEAT
20. DUCT - HEATER SYSTEM AIR, REAR SEATS
21. DUCT - HEATER SYSTEM AIR, DEFROSTER
22. DUCT - HEATER SYSTEM AIR, OVERBOARD DUMP
23. VENT LINE - HEATER FUEL
24. TUBE - HEATER EXHAUST
25. CONTROL VALVE - "HI-LOW", HEATER FUEL
26. TUBE - COMBUSTION AIR INTAKE
27. HEATER
28. SCOOP - FRESH AIR, FRONT SEAT
29. SCOOP - OUTSIDE AIR TO HEATER SYSTEM
30. CONTROL - FRESH AIR, FRONT SEAT
31. CONTROL - HEATER SYSTEM AIR, DEFROSTER
32. CONTROL - HEATER SYSTEM AIR, REAR SEATS
33. CONTROL - HEATER SYSTEM AIR, FRONT SEAT
34. VENT - FRESH AIR, FIFTH SEAT

Figure 13-4. Heating and Ventilating System
PA-23, Serial Nos. 23-747 to 23-1501 incl.



1. CABLE - COLD AIR INLET CONTROL, FRONT SEAT
2. DUCT - FRESH AIR, FRONT SEAT
3. DUCT - HEATER SYSTEM AIR, FRONT SEAT
4. INLET - HEATER SYSTEM AIR, FRONT SEAT
5. CONTROL VALVE - HEATER FUEL
6. LINE - HEATER FUEL
7. CONTROL VALVE - DEFROSTER
8. INLET - HEATER SYSTEM AIR, DEFROSTER
9. VENTS - FRESH AIR, FRONT SEAT
10. VENT - FRESH AIR, RIGHT REAR
11. VENT - FRESH AIR, LEFT REAR
12. OUTLET - AIR EXHAUST, CABIN
13. BOX - AIR EXHAUST, CABIN
14. SCOOP - FRESH AIR, CABIN
15. INLET - HEATER SYSTEM AIR, REAR CABIN
16. CONTROL VALVE - HEATER SYSTEM, REAR SEATS
17. INLET - HEATER SYSTEM AIR, CENTER CABIN
18. SHUT-OFF VALVE, HEATER FUEL
19. INLET - FRESH AIR, FRONT SEAT
20. DUCT - HEATER SYSTEM AIR, REAR SEATS
21. DUCT - HEATER SYSTEM AIR, DEFROSTER
22. DUCT - HEATER SYSTEM AIR, OVERBOARD DUMP
23. VENT LINE - HEATER FUEL
24. TUBE - HEATER EXHAUST
25. CONTROL VALVE - "HI-LOW", HEATER FUEL
26. TUBE - COMBUSTION AIR INTAKE
27. HEATER
28. SCOOP - FRESH AIR, FRONT SEAT
29. SCOOP - OUTSIDE AIR TO HEATER SYSTEM
30. CONTROL - FRESH AIR, FRONT SEAT
31. CONTROL - HEATER SYSTEM AIR, DEFROSTER
32. CONTROL - HEATER SYSTEM AIR, REAR SEATS
33. CONTROL - HEATER SYSTEM AIR, FRONT SEAT
34. VENT - FRESH AIR, FIFTH SEAT

Figure 13-5. Heating and Ventilating System
PA-23, Serial Nos. 23-1502 and up

13-3. TROUBLESHOOTING. Troubles peculiar to the heating and ventilating systems are found throughout this section in table form. Heaters are grouped according to heater model. Further assistance to the electrical function of the heaters may be found in the Electrical Schematics found in Section XI.

13-4. HEATER (South Wind, Model 979-B1).

13-5. HEATER OPERATIONAL INSTRUCTIONS. Operation of the South Wind Heater Model 979-B1, is controlled by an Off-Fan-Low Heat-High Heat Switch located under the left control wheel and a fuel shut-off valve on the fuel system control box located between the two front seats. Knobs at the bottom of the control quadrant control the flow and temperature of the heated air to the cabin.

To turn the heater on, first ascertain that the heater fuel valve (on the fuel control panel) is on, then move the heater switch to High or Low heat. If the heater does not start promptly, return the heater switch to Fan position for 15 seconds to prime the heater; then upon moving the switch to High heat, the heater should start and continue to operate after one and one-half minutes of warm-up.

After the heater switch is turned to the Off position, combustion in the heater stops, but the combustion fan and the circulating air fan continue to operate for about two minutes, while the heater cools slowly and purges itself of hot air and fumes. To obtain best service life from the heater components, it is recommended that the heater switch be turned off about two minutes before stopping the engines and shutting off the master switch. This should normally be done during taxiing after landing.

The heater can be used to warm up the cabin before flight by turning on the master switch, the left electrical fuel pump, and the heater switch. The operation of these units takes about 8 amps, and they should not be used in such a way as to run down the battery, making starting difficult.

13-6. DESCRIPTION AND PRINCIPALS OF OPERATION. The South Wind Model 979-B1 Aircraft Heater, installed as original equipment in airplanes bearing Serial Numbers 23-1 to 23-170 inclusive is designed to produce a maximum of 18,000 BTU of heat per hour. Operating independently of the engine, it may be used to preheat the cabin when the airplane is on the ground. The unit heats "hot" in 60 seconds, providing constant even heat. Cabin temperature is automatically regulated by means of a thermostatic control. The heater produces heat by burning gasoline in an all-welded, sealed stainless steel combustion chamber.

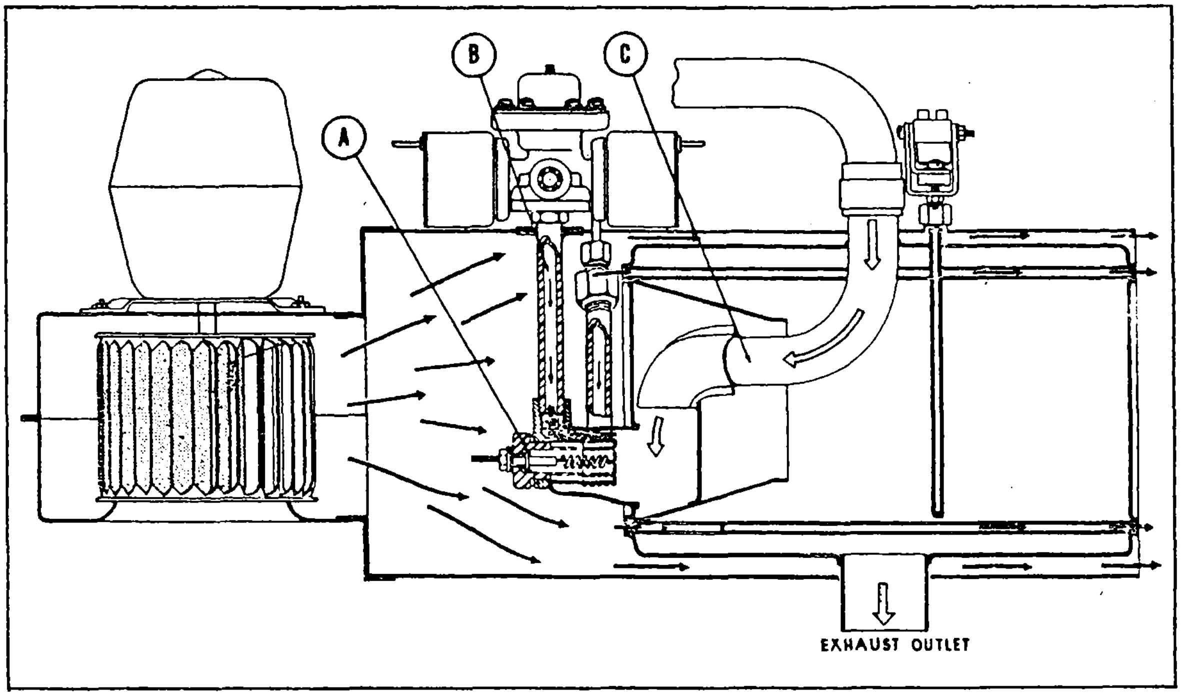


Figure 13-6. South Wind Heater Model 979-B1

With switching on of the heater switch, three things occur simultaneously:

a. Fuel is metered into the heater. (Refer to "B", Figure 13-6.)

b. Air is forced into the heater and mixed with fuel to form a combustible mixture. (Refer to "C".)

c. The electric igniter is energized. (Refer to "A".)

Within 20 seconds the heater ignites. The burning of the combustible mixture creates a large volume of hot gases that flow through the heat exchanger to exhaust. As these gases flow through the heat exchanger, they actuate the flame detector switch which turns off the igniter and starts the ventilating air blower. The blower forces air through the passages of the heat exchanger where it absorbs heat through the walls from the combustion gases. The heated air is then circulated into the cabin of the aircraft.

When the cabin approaches the temperature of the thermostat setting, the thermostat opens the circuit to the restriction solenoid of the heater fuel control valve, causing the fuel flow to be reduced, and the heater goes into low heat operation. If the temperature drops, the valve will again open and the heater will go into high heat operation. By cycling the heater from low to high heat in this manner, the cabin temperature is maintained at the desired heat level as required by the thermostat setting.

When the heater is turned off, the fuel flow is stopped and burning in the heater will stop within a few seconds. However, the ventilating air fan and com-

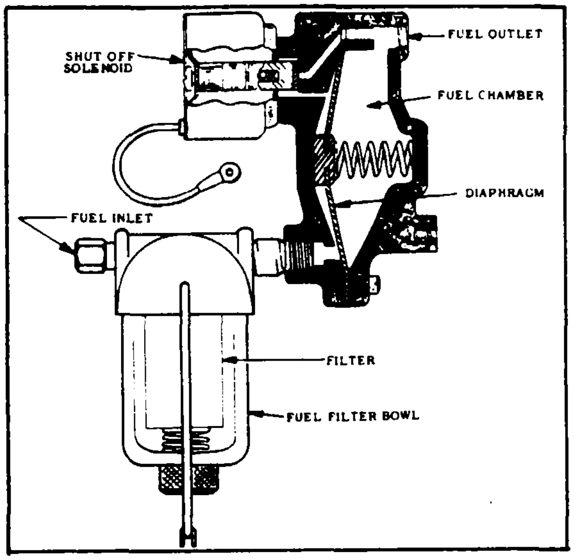


Figure 13-7. Safety Valve

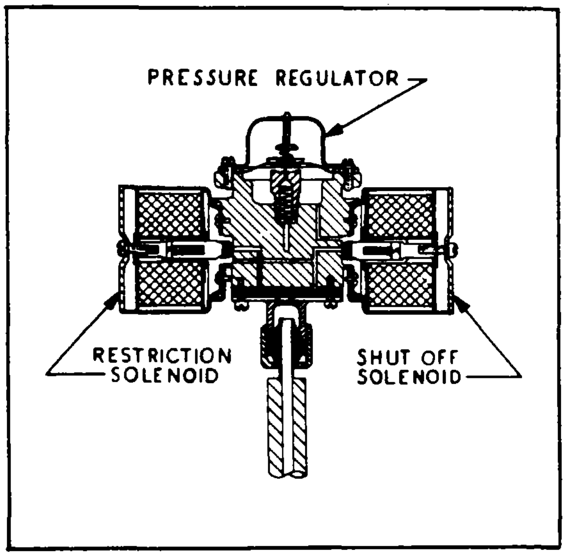


Figure 13-8. Fuel Control Valve

bustion air blower will continue to operate for approximately two minutes to cool and purge the heater.

It becomes apparent from the above explanation that the heater consists of four systems, namely; Fuel System, Combustion Air System, Ventilating Air System and Electrical System. The heater operation will be further explained by taking each of these systems in detail.

The safety valve (Refer to Figure 13-7.) consists of a shut-off solenoid and a casting which houses a large diaphragm and spring. The safety valve provides the initial flow of fuel for ignition. Additional fuel to sustain combustion is permitted to flow only after the shut-off solenoid of the safety valve is energized. Fuel flows from the airplane's fuel pump through the filter to the safety valve diaphragm to exert a pressure and cause the diaphragm to force gasoline contained in the chamber through the outlet port into the heater.

When the flame detector switch closes after combustion, the shut-off solenoid is energized and opens a bypass through which fuel then flows to the heater. Gasoline will continue to flow through this system until the heater is turned off. The fuel chamber behind the diaphragm will refill during heater operation or may be recharged manually by turning the heater switch to Fan for about 30 seconds.

The fuel control valve (Refer to Figure 13-8.) provides the proper amount of fuel for high or low heat operation, depending upon the requirements. The complete valve consists of two solenoid valves and a pressure regulator which maintains constant fuel pressure for heater operation, regardless of the fluctuation of the fuel pump. Both solenoids are energized when the heater is turned on so that maximum heat is obtained. When sufficient heat has been obtained and the thermostat contacts open, the restriction solenoid is de-energized and closes

HEATER SPECIFICATIONS (Model 979-B1)

Electrical Supply	12 volts DC
Current Consumption: Starting Load (Maximum) Operating Load (Maximum)	 12.5 amperes 7.5 amperes
Fuel Pressure Required	1 to 5 pounds
Fuel Consumption: High Heat Low Heat	 1 gallon per 4 hours 1 gallon per 13 hours
Heat Output: High Heat Low Heat	 18,000 BTU per hour 5,500 BTU per hour

closes the restriction valve. This action allows a smaller amount of fuel to be metered into the heater, resulting in a lower heat output. When more heat is required, the thermostat contacts close, energizing the restriction solenoid of the fuel valve, causing the valve to open and allow more fuel to enter the heater. This action results in a greater heat output. The gasoline from the control valve drips down the standpipes, where the fuel saturates the vaporizing pad and is blown into the igniter by the combustion air fan. The High Heat fuel flow standpipe leads directly into the combustion chamber bypassing the orifice plate and delivering a steady flow of fuel to the igniter. The Low Heat fuel flow standpipe leads through a separate outlet from the restriction valve through the orifice plate to the igniter pocket delivering additional fuel.

13-7. COMBUSTION AIR BLOWER. The combustion air blower (Refer to Figure 13-9.) forces air into the combustion chamber, mixing the air with the fuel vapor, forming a highly combustible mixture which is ignited initially by the electric "glow plug" igniter.

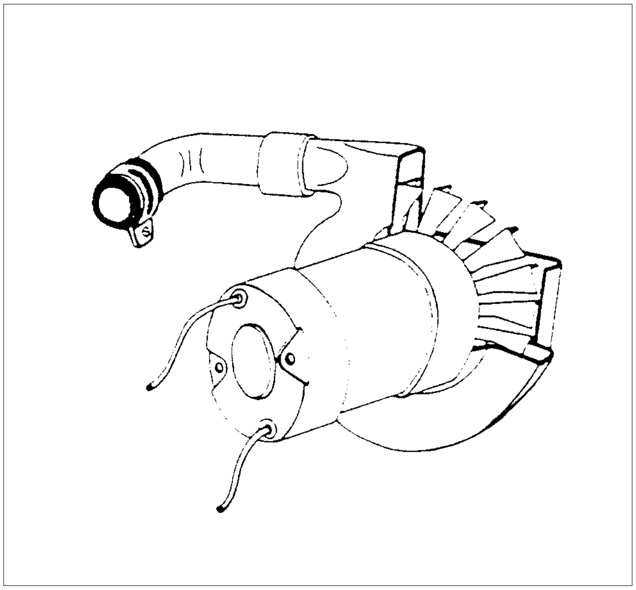


Figure 13-9. Combustion Air Blower

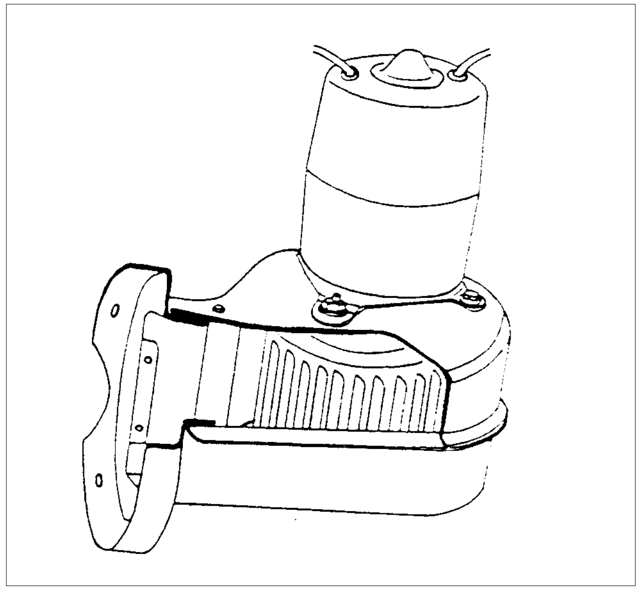


Figure 13-10. Ventilating Air Fan

13-8. HEAT EXCHANGER. The hot gases from the burning in the combustion chamber pass through the central chamber and around the outer chamber to the exhaust tube, where they are expelled. As the hot gases flow through these passages, they dissipate their heat through the stainless steel walls of the heat exchanger.

13-9. VENTILATING AIR FAN. When the ventilating air fan (Refer to Figure 13-10.) is energized, air is forced through the air passages of the heat exchanger. This same air absorbs the heat of the hot combustion gases being dissipated through the walls of the exchanger by the ventilating air fan. The heated air then flows to the outlet.

13-10. HEATER OPERATION (Electrical).

a. When the heater switch is snapped to the heater position, several things occur simultaneously:

1. The igniter is energized. (Refer to “A”, Figure 13-11.)
2. The combustion air motor is energized. (Refer to “B”.)
3. The shut-off solenoid of the fuel control valve is energized, allowing an initial fuel flow from the safety valve to the combustion chamber (Refer to “C”).
4. The restriction solenoid is energized through the thermostat permitting a High Heat fuel flow. (Refer to “D”.)

b. With fuel and air provided and the igniter on, all the requirements for combustion are fulfilled and burning starts within 20 seconds.

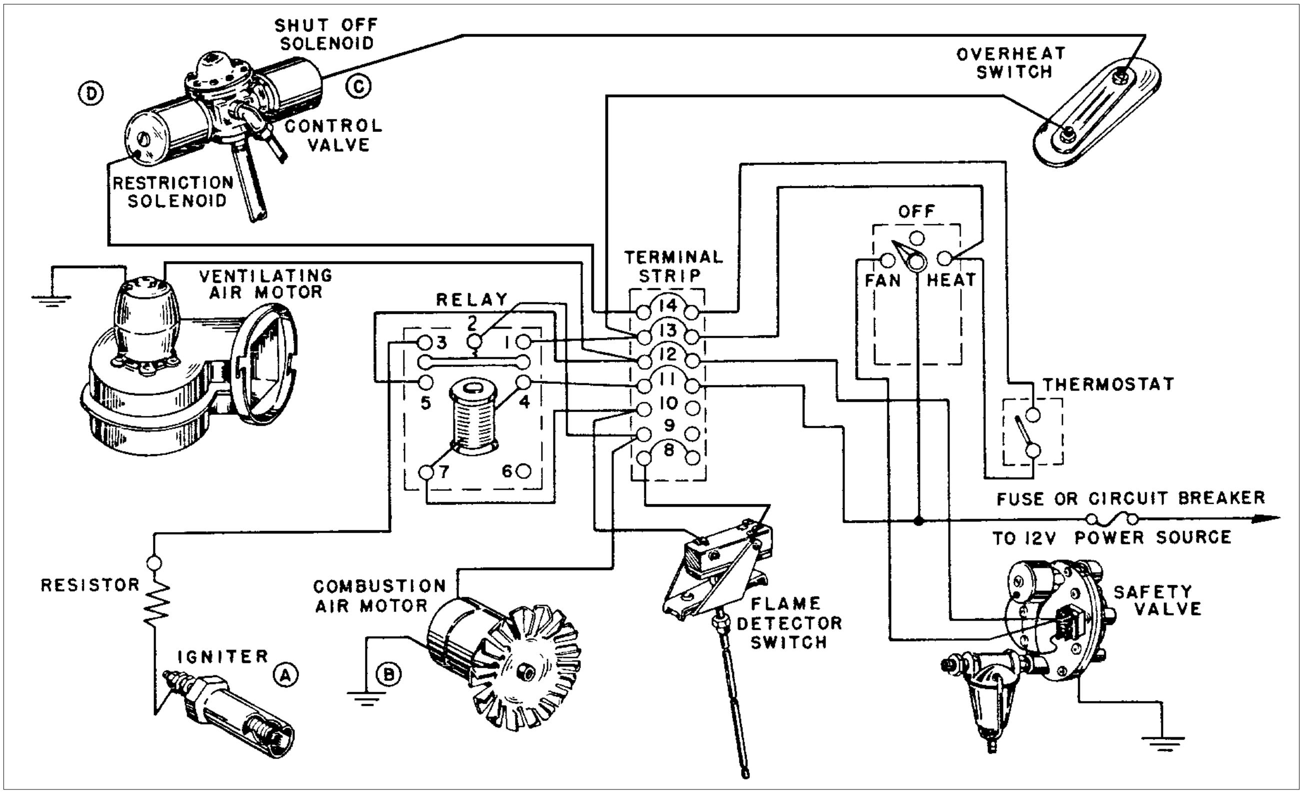


Figure 13-11. Heater Wiring Diagram - Model 979-B1
(Sheet 1 of 2)

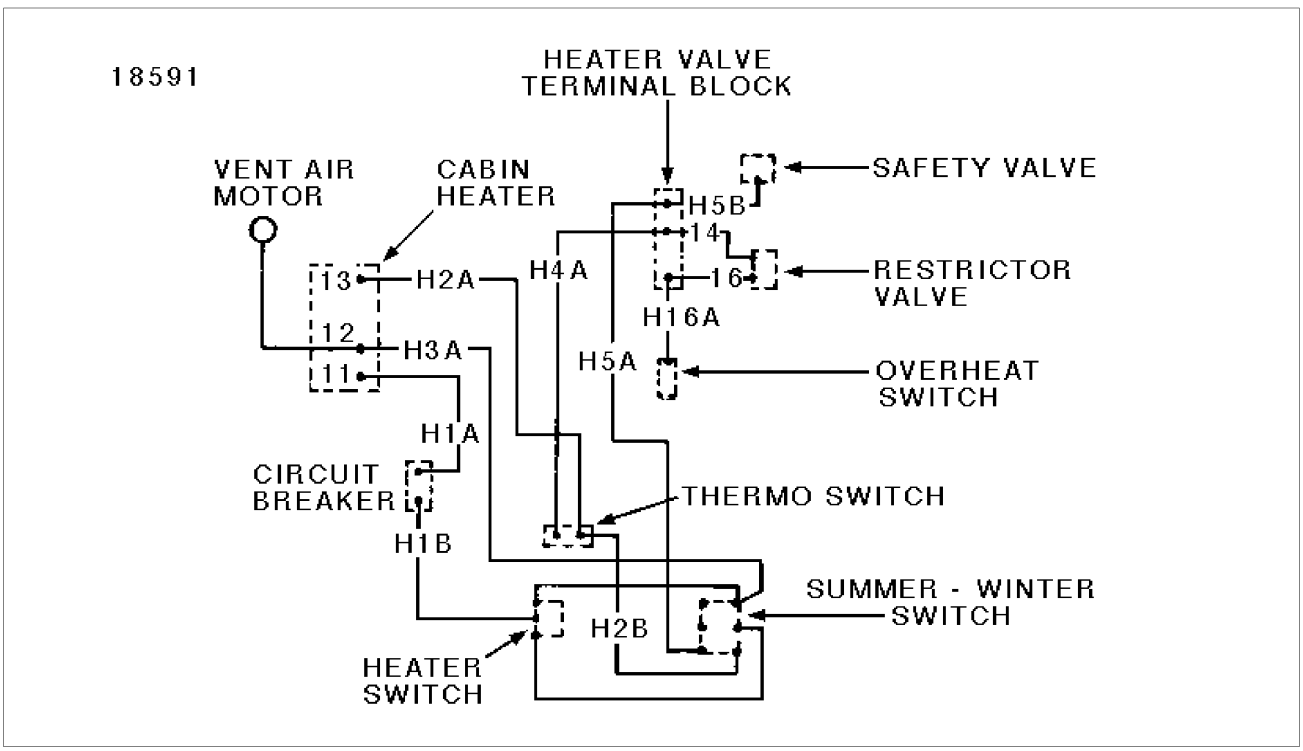


Figure 13-11. Heater Wiring Diagram - Model 979-B1
(Sheet 2 of 2)

13-11. RUNNING.

a. Within 20 seconds after combustion starts, the metal tube of the flame detector switch expands and allows the quartz rod to move downward, causing the micro switch to make contact and energize the relay. When the relay is actuated; the igniter is shut off, the ventilating air fan is energized, and the combustion air fan changes from the starting circuit to the running circuit.

NOTE

The two circuits mentioned above are necessary for the continued operation of the combustion and ventilating blowers during the purging period.

b. With the igniter off and the ventilating air fan in operation, the heater is now in full running operation.

c. The thermostat opens and closes the restriction solenoid of the fuel control valve, causing the heater to burn on High or Low heat, and maintain the desired temperature.

d. Should the heater become too hot, the bimetal blade of the overheat switch will bend and open the circuit to the shut-off solenoid of the fuel control valve, thus stopping the fuel flow to the heater. The overheat switch will remain open until the heater cools.

13-12. PURGING.

a. When the heater switch is snapped OFF, the fuel supply to the heater is shut off. Burning in the heater stops in a few seconds, but the combustion air fan and the ventilating air fan continue to operate to cool and purge the heater. In 2 to 3 minutes, the metal tube of the flame detector switch cools and contracts sufficiently to force the quartz rod up, opening the micro switch and de-energizing the relay. This stops the combustion and ventilating fans and de-energizes the shut-off solenoid of the safety valve.

b. The heater is now completely stopped and can be restarted by snapping the switch to Heat.

13-13. REMOVAL OF HEATER (South Wind, Model 979-B1). The heater, located in the left side of the nose section may be removed as follows:

a. Remove the access panel at the left side of the nose section by removing the panel attachment screws.
b. Turn all of the heater control switches Off.
c. Note hook-up of all electrical leads and disconnect from heater.
d. Disconnect the fuel lines to the heater at the heater.
e. Disconnect the tube to the ventilating air blower at the blower by releasing attachment clamp.
f. Remove the screws that attach heater housing to the heater outlet distribution box.
g. Remove the cap bolts that secure the heater to its mounting brackets.
h. Remove the screws that secure the exhaust tube shroud to the heater.
i. Pull the heater up far enough to relieve the clamp that secures the exhaust tube to the heater housing.
j. Carefully remove the heater.

13-14. INSTALLATION OF HEATER (South Wind, Model 979-B1).

a. Assemble the heater.

b. Position the heater to the heater outlet distribution box.

c. Allow the forward end of the heater to remain raised far enough to connect and secure the exhaust tube to the heater.

d. Position and attach the heater to its mounting brackets with cap bolts.

e. Align holes and install the screws that secure the heater to the distribution box.

f. Align holes and install the screws that secure the exhaust tube shroud to the heater.

g. Attach the ventilating air blower hose to the blower and secure with clamp.

h. Connect the fuel lines to the heater.

i. Connect all electrical leads to the heater. For a schematic of the electrical connections, refer to Electrical System Schematics, Section XI.

j. Check heater operation per paragraphs 13-5 and 13-6.

k. Replace access panel.

13-15. INSPECTION AND TESTING OF HEATER (Model 979-B1).

13-16. PRELIMINARY VISUAL TESTING OF HEATER OPERATION.

a. Overall Test: A complete heater test includes the following:

1. Checking the operation of the heater, in general, using the following charts.

2. Checking the exhaust assembly for restrictions.

3. Checking the heater for proper mounting.

4. Checking the electrical connections at the terminal strip for wiring number code matching and firm connections.

5. With the engine running, inspect the heater fuel lines for leaks.

6. Checking the combustion air blower for output.

7. Checking the ventilating air fan for output.

b. Operational Test:

1. Place the heater switch in the Fan position. The ventilating air fan should start at once.

2. Place the heater switch in the Off position and the ventilating air fan should stop.

3. Place the thermostat knob in the high position. Place the heater switch in the Heat position.

(a) The combustion air fan should start immediately.

(b) Burning should start in the heater within 20 seconds after the heater switch is placed in position.

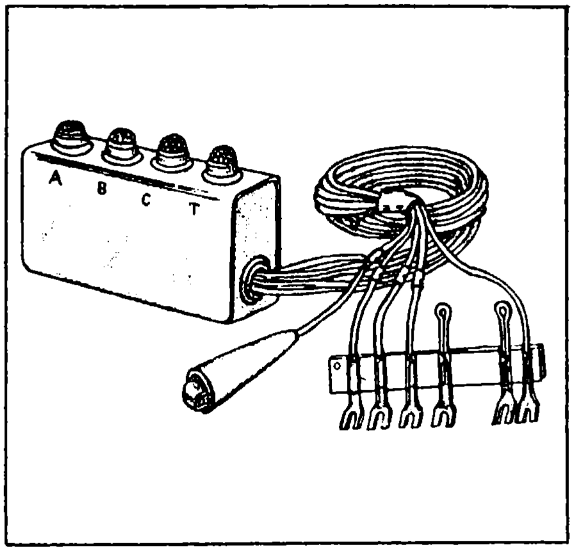


Figure 13-12. Circuit Analyzer

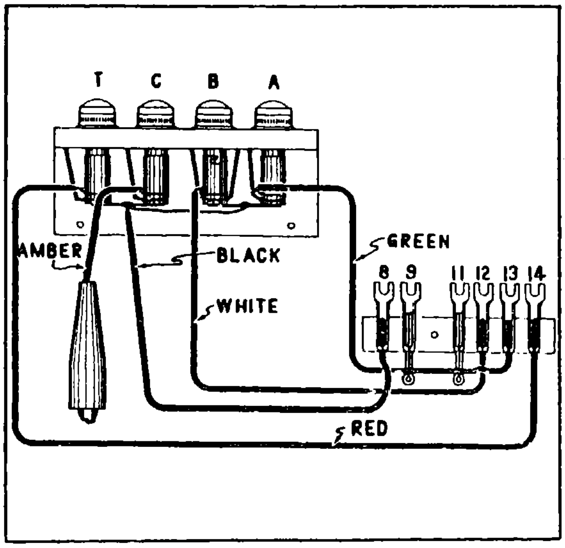


Figure 13-13. Circuit Analyzer Electrical Circuit

(c) The ventilating air fan should start within 60 seconds after the switch is placed in the Heat position. The fan is started automatically by the action of the flame detector switch and relay.

4. Place the thermostat knob in the low position. The heater should now burn on low heat. The burning in the heater decreases in intensity and, therefore, the heater output is reduced.

5. Place the heater switch in the OFF position.

(a) The burning in the heater should cease within 45 seconds.

(b) The combustion air blower and ventilating air fan should continue to run for approximately 2 minutes to cool and purge the heater.

13-17. TEST PROCEDURES.

13-18. CIRCUIT ANALYZER.

a. The model 979 heater Circuit Analyzer, Part Number ST-890264 (Refer to Figure 13-12.), is a multiple test light unit, designed for checking the operation of the electrical circuit of the South Wind Heater Model 979. Using this analyzer, it is possible to check completely the operation of the heater in the airplane without making it necessary to remove the heater except for major repairs. The jewel lights give a constant visual indication of the conditions existing in the heater during a shop test or while in flight.

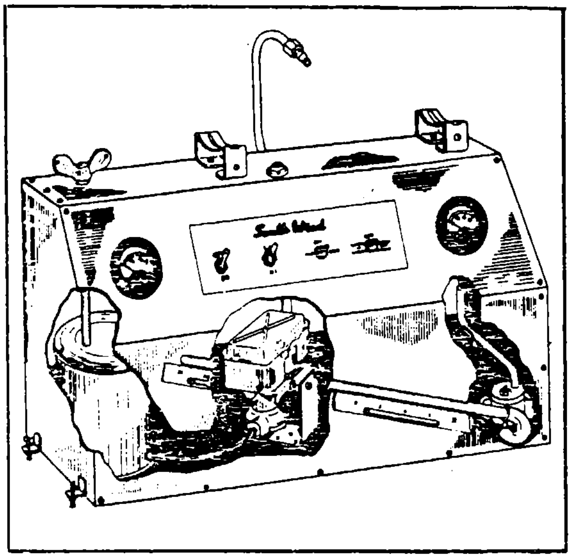


Figure 13-14. Heater Test Stand

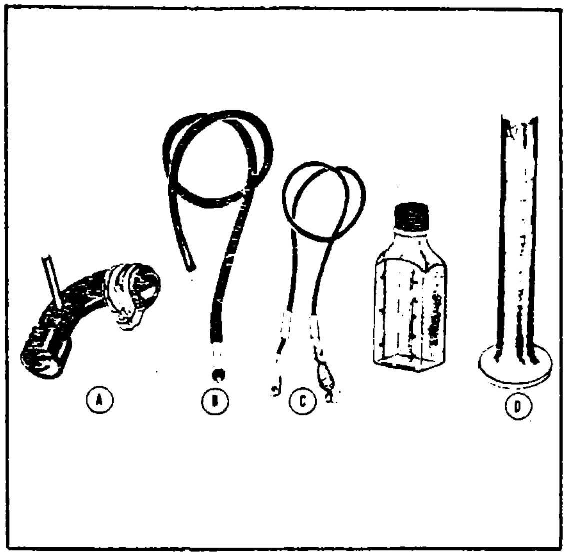


Figure 13-15. Test Stand Accessories

b. The Circuit Analyzer consists of a metal case in which are mounted four 12-volt jewel lights, colored red, amber, white and green. (Refer to Figure 13-13.) Five color-coded test leads lettered A, B, C, T and G extend from the case, one is equipped with an alligator clip and the remaining four are attached to a terminal connecting strip. These test leads are colored to correspond with the colored jewel lights. The black lead, lettered G, provides a common ground.

13-19. TEST STAND.

a. The Model 979 heater test stand equipment consists of a Model 979 heater test stand, South Wind Part Number ST-890301, and a conversion kit, Part Number ST-890249.

b. The test stand (Refer to Figure 13-14.) consists of a cradle for mounting the heater, a fuel tank and an electric fuel pump to supply fuel to the heater. Four switches control operation of the test equipment. A draft gauge measures the fan and blower output.

IMPORTANT

Electrical power for the test stand can be supplied by a 12-volt storage battery, a 12-volt power pack or any 12-volt direct current source.

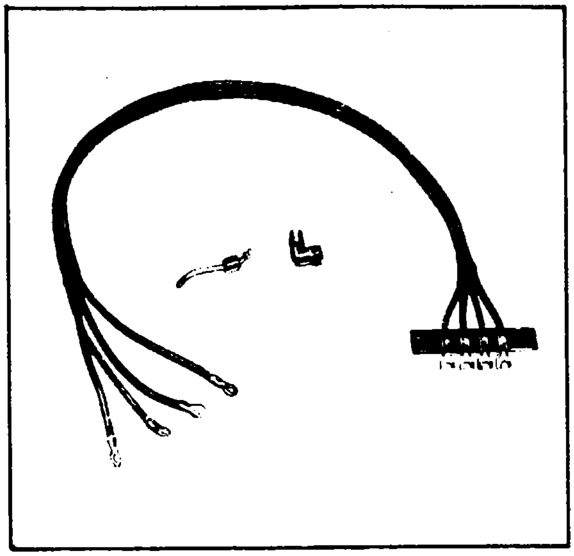


Figure 13-16. Test Stand Conversion Kit

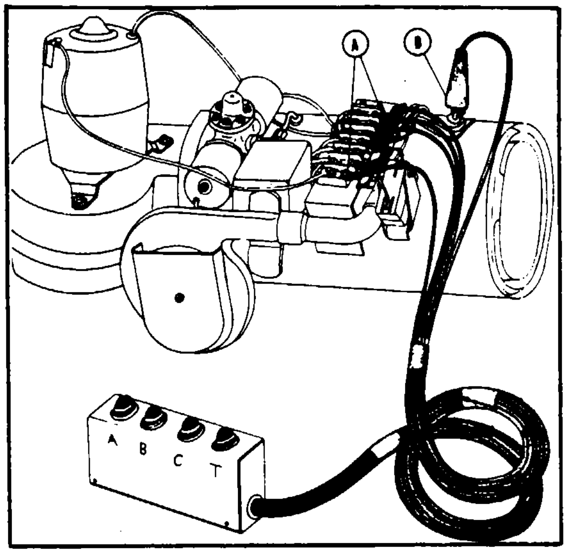


Figure 13-17. Circuit Analyzer Installation

c. The draft gauge, used to measure the output of the ventilating air fan and combustion air blower, consists of a tank or reservoir filled with a special oil, and a glass tube mounted on the panel of the test stand. A moveable scale graduated in inches is mounted on the front of the panel to facilitate measurement of the fluid's movement in the glass tube.

d. The test accessories consist of a test elbow (Refer to "A", Figure 13-15.), tubing adapter, rubber hose ("B", Figure 13-15), test wire ("C"), and a 50 cc glass graduate ("D").

e. The conversion kit, Part Number ST-890249, consists of a connecting strip with four colored coded wires, each terminated with a square terminal (Refer to "B", Figure 13-16.); an adapter fitting ("C"); and, a short length of 1/8 inch copper tubing with a compression nut and collar at one end ("A").

f. When testing a Model 979 heater, the connecting strip is attached to the heater terminal block positions, Nos. 11, 12, 13, and 14. The four square terminals are inserted into the quick disconnects, matching the color coded wires from the test stand.

g. To check the fuel control valve, the valve is removed from the heater. The adapter fitting is screwed on to the extended male fitting in the orifice plate side of the valve. The short length of tubing is connected to the brass elbow on the side of the valve with the compression nut and collar.

13-20. CIRCUIT ANALYZER PROCEDURE.

a. The following test procedure is recommended for checking a newly installed heater or for troubleshooting an installation to be repaired. If operation is satisfactory at each stage of the test, the heater is operating normally. If, however, operation is unsatisfactory at any stage of the testing, consult paragraphs 13-23 through 13-29.

b. The Circuit Analyzer, South Wind Part No. ST-890264, as shipped from the factory, is equipped with 6-volt lamps, Part No. GE47. If the analyzer is to be used on an installation with a 12-volt current source, it will be necessary to unscrew the jewels and replace the lamps, Part No. GE1815.

13-21. CONNECTING ANALYZER.

a. Remove the cover from the Model 979 heater case.

b. Loosen the screws which hold the connecting strip to the heater terminal block. (Refer to Figure 13-17.) Insert the analyzer connecting strip under the terminal screws Nos. 8, 9, 11, 12, 13 and 14 and retighten the screws.

c. Connect the amber lead, terminated by an alligator clip to the bolt terminal of the overheat switch.

13-22. HEATER OPERATION TEST.

a. Turn the thermostat to the High heat position. Turn the heater switch to the Heat position.

1. The red lamp should light.
2. The green lamp should light.
3. The amber lamp should light.
4. The white lamp should light within 20 seconds.

NOTE

The green, amber and white lamps should remain on continuously.

b. Turn the thermostat to the Low heat position. The red lamp should go out immediately. The lamp should go on and off with each flick of the toggle switch.

c. Turn the thermostat to the Low heat position and allow the heater to operate for two minutes.

d. When the red lamp goes out on low heat, turn the control to the high heat position until the lamp lights. Let the switch remain in this position until the lamp goes out again. In this manner, keep turning the switch until the lamp lights at the high heat position. The red lamp at this point should go on and off at the highest heat position.

NOTE

On making a flight test, the red lamp should switch on and off intermittently to indicate proper thermostatic action.

e. Turn the heater switch to the Off position.
   1. Burning should stop completely in 45 seconds.
   2. The ventilating air fan should stop within 1:10 and 2:35 minutes.

NOTE

If the white lamp goes out during the check, it will be necessary to restart the heater.

13-23. FLAME DETECTOR SWITCH TEST.

a. While operating the heater, if the fan stops too soon or too late, the flame detector switch is out of adjustment or may be inoperative.

b. Check the bow spring to see if the tension of the quartz rod is causing the spring to bow up toward the top of the switch.

c. If the spring is not bowed but is in a straight position, it may be assumed that the rod is broken and the switch should be replaced.

d. If the quartz rod is not broken:
   1. Loosen the two switch mounting screws.
   2. Back off the adjusting screw until the switch clicks.
   3. Turn down the adjusting screw until the switch again clicks and then another 3/4 turn.
   4. Retighten the two mounting screws to hold the switch in the proper position.

13-24. FUEL CONTROL VALVE TEST.

a. If the heater goes out on low heat, remove the fuel valve and check the low heat fuel flow. The fuel metered should be 5-6 cc per minute.

b. Check the length of wick from the standpipe, it should be 1/2 inch.

c. Check the heater fuel line for "hot spots" that might cause vapor lock if the above check proves satisfactory.

d. Check and replace the fuel control valve assembly if the heater does not stop burning, giving evidence of an inoperative shut-off valve.

13-25. VENTILATING AIR FAN TEST.

Test 1:

a. With the main switch on, turn the heater switch to the Fan position.

b. Touch the amber test lead to the Fan terminal of the switch. If the amber lamp fails to light, look for:

1. A faulty wire from the ingition switch to the fuse.
2. An open fuse.
3. A faulty wire from the fuse to the heater switch.
4. An inoperative heater switch.

Test 2:

a. With the main switch on, turn the heater switch to the Fan position.

b. Touch the amber test lead to relay terminal #5.

c. If the amber lamp fails to light, look for:

1. A faulty wire from terminal block position No. 12 to the heater switch.
2. A faulty wire from relay terminal #5 to terminal block position No. 12.

Test 3:

a. Check the motor ground wire and the fan connection to relay terminal #5.

b. If these connections are satisfactory, the fan motor must be replaced for it is inoperative.

Test 4:

a. Turn the heater switch to the Off position.

b. Check the intake and outlet ducts for restrictions if the fan runs but the air flow becomes inadequate.

13-26. RED LAMP TEST.

a. Turn the thermostat to the high position.

b. With the motor running and the heater switch in the Heat position, touch the amber test lead to both thermostat terminals, one at a time.

c. If the lamp lights on one but not the other, replace the thermostat. (Thermostat switch must be in the high heat position for this check and the temperature must be below the thermostat setting.)

13-27. GREEN LAMP TEST. Before making any further inspection, check the voltage at terminal block position No. 13 on the terminal strip. A minimum of 11 volts is required for heater operation.

Test 1:

a. With the main switch on and the heater switch in the Heat position, touch the amber test lead to the Heat terminal of the heater switch.

b. If the lamp fails to light, look for an open fuse or an inoperative switch.

Test 2:

a. With the main switch on and the heater switch in the Heat position, touch the amber test lead to the terminal block position No. 13.

b. If the lamp does not light, look for a faulty wire from terminal block position No. 13 to the heater switch.

13-28. AMBER LAMP TEST.

a. With the main switch on the heater switch in the Heat position, touch the amber test lead to the bolt terminal of the overheat switch.

b. If the amber lamp does not light, the overheat switch is inoperative.

c. Replace the complete overheat switch assembly.

13-29. WHITE LAMP TEST.

Test 1:

a. With the main switch on and the heater switch in the Heat position, touch the amber test lead to relay terminal #5.

b. If the lamp lights immediately, it indicates an inoperative relay, or an inoperative or out of adjustment flame detector switch. (Refer to paragraph 13-23.)

Test 2:

a. If the white lamp goes out, restart the heater. If the heater still fails to ignite with the main switch on and the heater switch in the Heat position, touch the amber test lead to relay terminal #2.

b. If the lamp fails to light, there is a broken pigtail in the relay.

NOTE

If the lamp lights at relay terminal #2 but the blower does not operate, check the combustion air motor.

c. Touch the amber test lead to relay terminal #4.

c. If the lamp does not light, there is a faulty wire from relay terminal #4 to heater terminal block position #11, a faulty wire from heater terminal block position #11 to the fuse, or an open fuse.

Test 3:

a. If the heater fails to ignite, turn the heater switch to the Off position.

b. Connect the black test lead to heater terminal block position #11.

c. Touch the amber lead to the bolt terminal of the overheat switch.

d. If the "S" valve does not click, the shut-off solenoid is inoperative.

e. Touch the amber lead to heater terminal block position #14.

f. If the "R" valve does not click the restriction solenoid is inoperative.

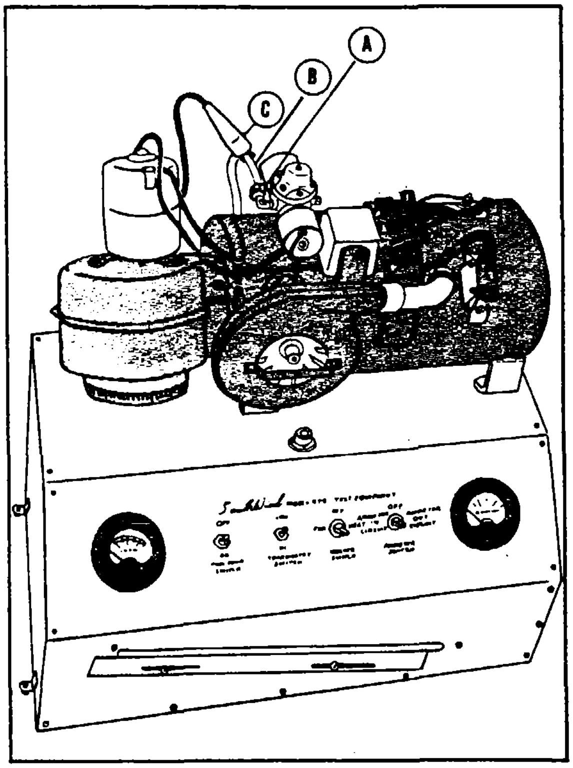


Figure 13-18. Test Stand Installation

g. Touch the amber lead to relay terminal #3.

h. If a spark does not jump, the igniter is defective.

NOTE

If the above noted checks prove satisfactory and the heater still does not ignite, replace the safety valve.

Test 4:

a. If the heater ignites but the fan remains off, disconnect the lead wire from the bolt terminal on the overheat switch. Connect the black alligator clip of the analyzer to ground on the heater.

b. Turn the heater switch to the Heat position and touch the amber test lead to relay terminal #4.

c. If the lamp fails to light, there is a faulty wire between relay terminal #4 and the heater block position 311 or an open fuse.

d. Touch the amber test lead to relay terminal #7.

e. If the relay bridge does not click, the relay is inoperative.

13-30. TEST STAND PROCEDURE.

13-31. CONNECTING HEATER.

a. Place the heater on the cradle of the test stand with the ventilating air fan on the left hand side. (Refer to Figure 13-18.)

b. Using the two double quick-disconnects, connect the four color coded wires from the connecting strips which have been connected to the terminal block positions Nos. 11, 12, 13 and 14. Be sure the color code of the wires matches that of the wires leading into the quick disconnects.

c. Remove the 1/8 inch P. T. compression elbow from the heater fuel control valve and replace the elbow with the 1/8 inch P. T. compression elbow supplied with the test stand. (Refer to "A", Figure 13-18.)

d. Connect the fuel line from the test stand pump to the elbow in the heater fuel control valve "B".

e. Connect the ground lead to the heater fuel control valve with the small alligator clip from the voltmeter ("C").

f. Be sure the fuel pump, heater and ammeter switches on the test stand are in the Off position. Connect the following wires to the source of current, a 6 or 12 volt battery or a South Wind Power Converter, Part No. ST-890090

NOTE

If a 12-volt storage battery is used, check to be sure the voltage is not below 11 volts.

1. The lead wire from the ammeter switch is attached to the positive terminal of the current source.

NOTE

If a Power Converter is used, connect the lead wires for the positive terminal to the plug-in marked fuel pump. For the negative terminal plug the lead into the plug-in marked ground.

2. The lead wire from the fuel pump switch is also attached to the positive terminal of the current source.

3. The lead wire from the voltmeter is attached to the negative terminal of the current source.

13-32. TESTING HEATER OPERATION.

a. Place the ammeter switch in the Ammeter In Circuit position.

b. Place the heater switch in the Fan position. The ammeter should not read more than 11 amperes. The ventilating air fan should start at once.

c. Place the heater switch in the Off position. The ventilating air fan should stop and the ammeter read zero.

d. Place the thermostat switch in the High position.

e. Place the fuel pump switch in the On position.

f. Place the heater switch in the Heat position.

1. The combustion air fan, electric igniter and fuel control valve should operate immediately. The ammeter should read between 13 and 14 amperes. Burning should start within 20 seconds.

2. Sixty seconds after the Heat switch has been turned on the ventilating fan should start. The fan is started automatically by the action of the flame de-

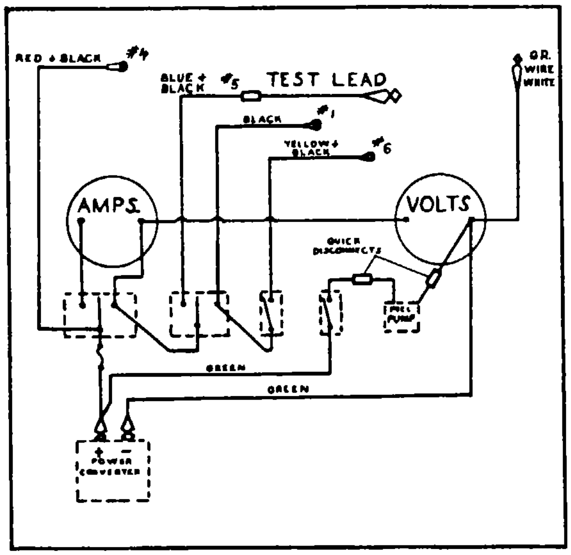


Figure 13-19. Test Stand Electrical Circuit

tector switch and relay. The ammeter now reads between 0 and 1 ampere.

g. Place the thermostat switch in the low position. The burning in the heater will decrease in intensity and reduce the heater BTU output.

h. Place the heater switch and the fuel pump switch in the Off position. Burning in the heater should cease within 45 seconds. The combustion air blower and ventilating air fan should continue to run for approximately two minutes to cool and purge the heater.

NOTE

If the heater does not operate satisfactorily on testing, refer to the Troubleshooting Analysis Chart to diagnose and remedy the trouble.

13-33. ELECTRICAL TESTS.

a. Break the connections from the heater to the test stand at the quick disconnects. Be sure all the switches are off.

b. Connect the twelve-inch test lead provided (Refer to Figure 13-19.) to the test stand black-with-blue-tracer lead with one single quick disconnect.

c. Attach the test stand ground lead to the fuel valve body.

d. Place the ammeter switch in the Ammeter In Circuit position and the heater switch to the Fan position to begin a circuit check.

e. Ventilating Air Fan:

1. Place the black-with-blue-tracer heater terminal lead in the clip of the test lead.

2. The ammeter should read 10 amperes at 12 volts.

f. Restriction Solenoid:

1. Touch the black with yellow tracer heater terminal lead to the clip of the test lead.

2. The solenoid valve marked "R" should click and the ammeter read 1/2 ampere.

g. Shut-Off Solenoid:

1. Disconnect the shut-off solenoid lead wire, No. 16, from the terminal

of the overheat switch and touch the wire lead to the clip of the test lead.

2. The solenoid valve marked "S" should click and the ammeter read 1/2 ampere.

h. Combustion Air Fan:

1. Disconnect the fan wire from terminal block position No. 9 and touch the motor lead to the clip of the test wire.

2. The motor should operate and the ammeter read 3 amperes at 6 volts.

i. Igniter:

1. Touch the black relay terminal lead #3 to the clip of the test wire.

2. The ammeter should read 10 amperes at 12-volts.

j. Overheat Switch:

1. Connect the shut-off solenoid lead No. 16 to the terminal of the overheat switch. Touch the test wire clip to the black relay terminal lead #3.

2. The shut-off solenoid valve should click.

k. Relay:

1. Clip the test wire to the black-with-red-tracer heater lead wire. Touch the test stand ground wire to relay terminal #7.

2. The movement of the relay bridge can be heard.

l. Flame Detector Switch:

1. Connect all wires to the relay and remainder of the unit.

2. Connect the test stand ground wire lead to the heater as well as the two double quick disconnects.

3. Disconnect the wire lead from the terminal of the flame detector switch and connect one lamp of the circuit analyzer between the terminal wire lead and the terminal post of the flame detector switch.

4. Turn the ammeter switch to the In circuit position, the thermostat switch to the High position, the heater switch to the Heat position and the fuel pump switch On.

5. Time the flame detector switch action from the moment the heater switch is snapped to the Heat position. The test lamp must light within 40 seconds.

6. The lamp is out when the switch is open and lights when the contact points of the flame detector switch are closed. While conducting this test the voltmeter should read 5 or 6 volts.

m. Timing Overheat Switch:

1. Connect the heater to the test stand electrical and fuel system. Make sure all the switches are in a neutral position.

2. Disconnect the wire lead from the ventilating air motor at terminal block position No. 12 so as to deactivate the motor.

3. Place the fuel pump switch On, the thermostat switch to the High position, the heater switch to the Heat position and the ammeter switch to the In circuit position.

4. Start timing the action of the overheat switch at the instant ignition oc-

curs. At normal room temperatures, 60° to 70° Fahrenheit, the overheat switch should close the shut-off solenoid valve to stop the fuel flow within 40 to 60 seconds after ignition takes place.

13-34. FUEL CONTROL VALVE TEST.

a. Check the fuel control valve to determine the amount of fuel being metered to the heater unit (15. 8 cc per minute maximum) on high and low heat output. To do so it will be necessary to remove the fuel control valve from the heater. Proceed as follows:

1. Disconnect the shut-off solenoid wire #16 from the bolt terminal of the overheat switch.
2. Disconnect the restriction solenoid wire #14 from terminal block position No. 14.
3. Disconnect the test stand fuel line from the inlet orifice.
4. Disconnect the High heat fuel flow standpipe.
5. Remove the control valve from the 9/16 inch compression collar and nut holding the low heat fuel flow standpipe.

NOTE

Set aside the heater unit being careful not to disconnect the unit from the test stand.

6. Attach the fuel control valve assembly to the test stand fuel line.
7. Attach the conversion adapter fuel line to the high heat fuel flow outlet fitting.

NOTE

Be sure all fittings are secure.

8. With the control panel switches in the OFF position, connect the test wire to the black lead quick-disconnect.
9. Clip the white test stand ground wire to the fuel line.

b. Shut-Off and Restriction Valves:

1. Snap the ammeter switch to the Ammeter In Circuit position and the heater switch to the Heat position.
2. Touch the test wire to the shut-off valve solenoid wire. A distinct click can be heard as the valve opens.
3. Touch the test wire to the restriction valve solenoid wire. A distinct click can be heard as the valve opens.

4. Snap the switches to the Off position.

c. Leak Test:

1. Place the terminals of both solenoid valve wires in the alligator clip of the test wire.

2. Place the glass graduate under the fuel flow standpipe outlet to collect fuel.

3. Snap the fuel pump switch to the On position, the ammeter switch to the Ammeter In Circuit position and the heater switch to the Heat position.

4. Allow fuel to flow through the fuel control valve for a few seconds, then snap the heater switch to the Off position. One or two drops of fuel may fall from the outlets within 15 seconds after the switch has been turned Off.

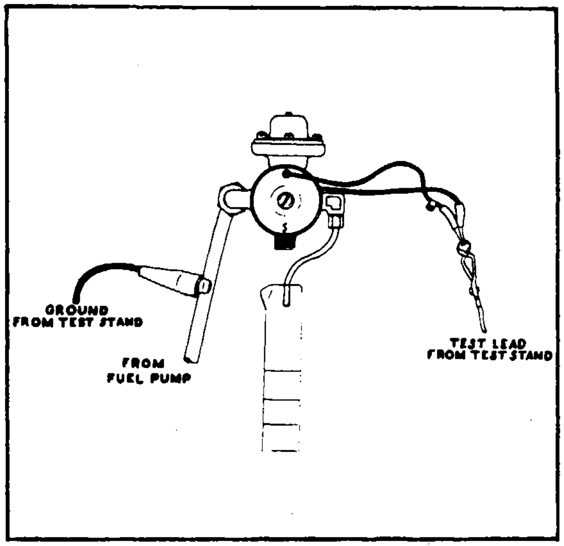


Figure 13-20. High Heat Fuel Flow Check

After the 15 seconds period a drop of fuel may form on the end of the outlets but it will not fall. A two minute check is sufficient. It is advisable, however, that the check be repeated three times.

5. Snap the control panel switches to the Off position.

d. With the fuel valve solenoids connected to the test wire and the fuel control valve grounded, switch the ammeter to the Ammeter In Circuit position, the fuel pump to the On position and the heater switch to the Heat position.

NOTE

> Place a shallow pan under the valve to collect any fuel spillage.

2. After allowing fuel to drip for a few seconds, place the glass graduate under the standpipe openings. (Refer to Figure 13-20.)

3. Switch the fuel pump switch Off and disconnect the fuel valve solenoid wires from the test wire.

4. Read the graduate at eye level. It should contain 14 ± 2 cubic centimeters of fuel.

NOTE

> If the quantity of fuel is not within these limits, replace the valve.

e. Low Heat Fuel Flow:

1. Clip the test wire to the shut-off valve solenoid wire.

NOTE

The shut-off solenoid is identified by the letter "S" stamped on the valve body casting.

2. Switch the fuel pump switch to the On position.

3. After allowing fuel to drip for a few seconds, place the glass graduate under the standpipe outlet and allow fuel to drip into the graduate for a period of four minutes.

4. Snap the fuel pump switch to the Off position and disconnect the fuel valve solenoid wire from the test wire.

5. Read the graduate at eye level. It should contain 16 ± 2 cubic centimeters of fuel.

NOTE

If the quantity of fuel is not within these limits, replace the valve.

6. Snap all the switches to the Off position.

7. Replace the fuel control valve.

13-35. COMBUSTION AIR FAN TEST. Check the combustion air blower to determine if it is supplying the volume of air required for combustion as follows:

a. Remove the elbow connection, the combustion air blower and the heat exchanger after loosening the clamp and hose.

b. Install the elbow furnished with the test stand between the blower and exchanger. (Refer to Figure 13-21.)

c. Connect the outlet tube of the test elbow and the copper tube on the draft gauge reservoir with the rubber hose provided.

d. Level out the draft gauge on top of the test stand. The draft gauge is level when the bubble in the spirit level is exactly in the center of the circle inscribed on the glass cover.

e. Adjust the scale on the panel so that zero marks the beginning of the rise of fluid in the indicator tube.

NOTE

Connect the heater electrical system to that of the test stand.

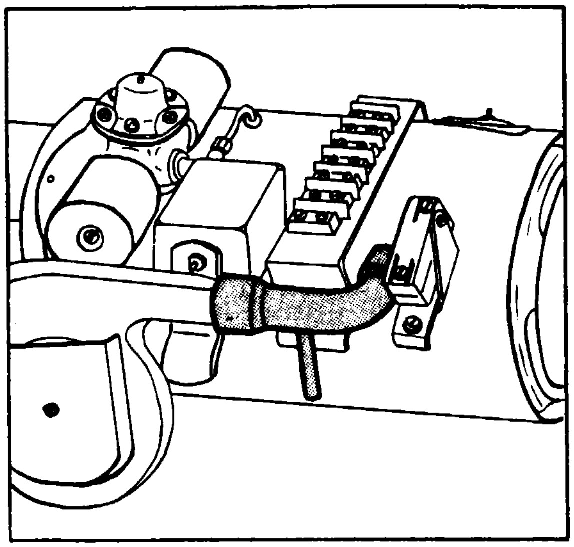


Figure 13-21. Combustion Air Blower Check

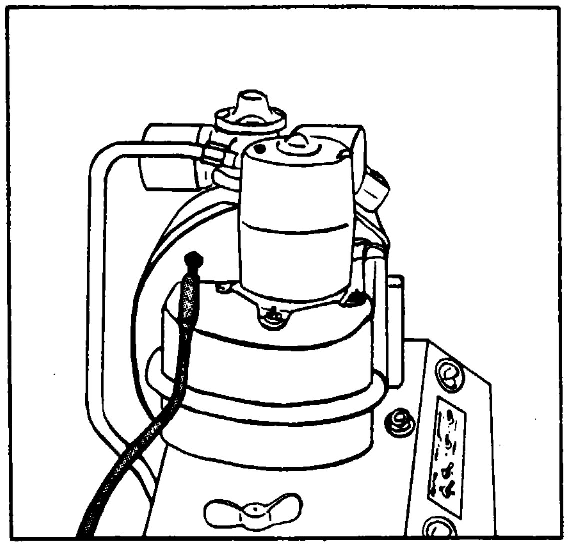


Figure 13-22. Ventilating Air Blower Check

f. Switch the ammeter switch to the ammeter Out of circuit position, the fuel pump switch Off and the heater switch to the Heat position.

g. The draft gauge should read within the limits of the chart below:

Voltmeter	Draft Gauge Reading
11	Max. 5 inches Min. 3-3/4 inches
13	Max. 6-1/2 inches Min. 5 inches
15	Max. 8-1/2 inches Min. 6-1/2 inches

h. A draft gauge reading below the minimum requirements for a given voltage indicates a slow combustion blower motor and is to be replaced. A draft gauge reading above the maximum requirements for a given voltage indicates an exceptionally good blower motor or that there is a restriction in the combustion air passages. Such a restriction will cause slow ignition or smoking of the heater exhaust.

i. Remove the test elbow and replace with the former in preparation for the ventilating air fan test.

13-36. VENTILATING AIR FAN TEST.

a. Check the ventilating air fan to determine if the fan is supplying the volume of air required for proper operation. The fan is to be checked as assembled to the heater unit as follows:

1. Insert the wider outlet end of the two diameter tubing adapter supplied with the test stand into the end of the rubber tubing attached to the reservoir outlet tube. (Refer to Figure 13-22.)

2. Switch the ammeter switch to the ammeter Out of circuit position and the fuel pump switch Off.

3. Insert the smaller diameter outlet end of the two diameter tubing into the ventilating fan assembly adapter "knock-out" hole. If the hole has not been knocked out, it will be necessary to do so for this is the only positioned opening that is to be used for this test.

NOTE

The small rubber washer must be positioned on the end of the adapter tubing to seal the opening during the test.

4. Level out the draft gauge on top of the test stand. The draft gauge is level when the bubble in the spirit level is exactly in the center of the inscribed circle on the glass cover.

5. Switch the heater switch to Fan position.

6. The draft gauge should read within the limits of the chart below:

Voltmeter	Draft Gauge Reading
11	Max. 1-3/4 inches Min. 1-3/4 inches
13	Max. 3-1/2 inches Min. 2-1/2 inches
15	Max. 4-1/2 inches Min. 3-1/4 inches

c. A draft gauge reading below the minimum requirements for a given voltage indicates a slow fan motor and is to be replaced. A draft gauge reading above the maximum requirements for a given voltage indicates an exceptionally good fan motor or that there is a restriction at some point in the air passages of the heat exchanger.

13-37. DISASSEMBLY OF HEATER. (Refer to Figure 13-23.)

13-38. REMOVAL OF FLAME DETECTOR SWITCH.

a. Remove the wire lead from terminal block position No. 8.
b. Remove the wire lead from the terminal block position No. 10.
c. Remove the guard cover from the flame detector switch (74).
d. Unscrew the lock nut under the micro switch bracket and lift out the switch assembly carefully.

13-39. REMOVAL OF VENTILATING AIR BLOWER.

a. Remove the wire lead from terminal block position No. 8.
b. Remove the wire lead from terminal block position No. 12.
c. Remove the three #8 x 1/4 inch RH type Z screws from the ventilating air fan adapter.
d. Remove the complete ventilating air fan assembly (70) from the end of the heater unit.
e. Disassembly of the ventilating air blower is not recommended.

13-40. REMOVING RELAY.

a. Remove the #10-32 hex nut and lockwasher which secure the relay assembly (38) to the heater bracket.
b. Remove the relay from the bracket and allow the relay to hang by the electrical wire connections.
c. The wires attached to the relay are as follows:

Relay Terminal Position		Terminal Block Position
1	to	13
2	to	9
3	to	Igniter
4	to	11
5	to	12
6	(Blank Terminal)	
7	to	10

d. If the relay is to be replaced:
   1. Remove the wire lead from terminal block position No. 11.
   2. Remove the wire lead from terminal block position No. 13.
   3. Remove the wire lead from terminal block position No. 9.

4. Disconnect the wire lead from relay terminal No. 3.
5. Remove the wire lead from terminal block position No. 12.
6. Remove the wire lead from terminal block position No. 10.

e. Replace the wire leads on the relay following the above steps 1 thru 6.

13-41. REMOVAL OF FUEL CONTROL VALVE.

a. Disconnect the shut-off valve solenoid lead wire No. 16 from the overheat switch terminal.

b. Disconnect the restriction valve solenoid lead wire from terminal block position No. 14.

c. Remove the High heat fuel flow line (49) by disconnecting the 3/8 inch fitting to the fuel control valve inlet (21).

d. Remove the fuel control valve casting from the 9/16 inch standpipe (43) fitting by disconnecting same.

NOTE

Do not grasp the solenoid cups when removing the valve.

e. Remove the two #8-32 machine screws (16) holding the standpipe guide plate (25).

f. Remove the Low heat fuel flow standpipe (43) from the outlet above the igniter.

g. Remove the 3/8 inch High heat fuel flow standpipe fitting tubing (49) and grommet (33).

h. Remove the High heat fuel flow standpipe (23) from the outlet (46) beside the igniter well.

13-42. REMOVAL OF OVERHEAT SWITCH.

a. Unscrew the two #6 RH type Z screws (19) from the overheat switch (62).

b. Remove the wire lead No. 16 from the terminal of the overheat switch and the wire lead from terminal block position No. 13.

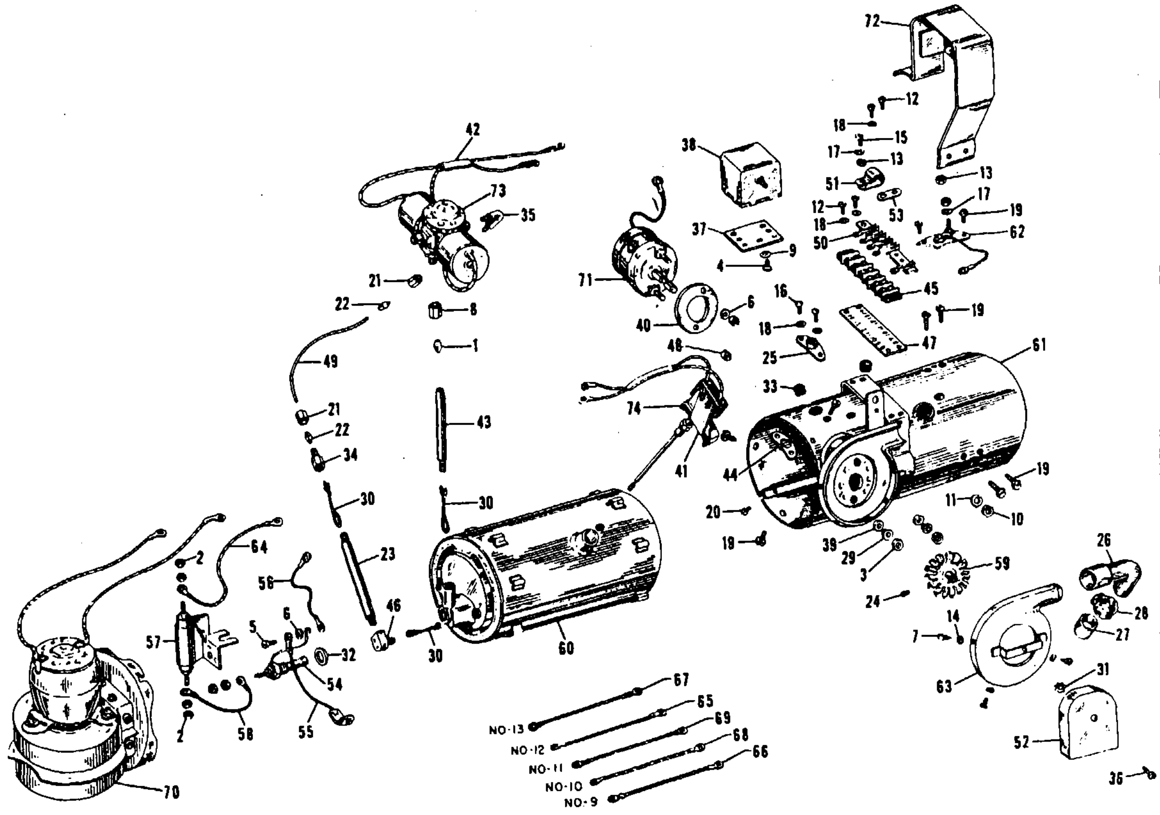
c. Remove the switch.

13-43. REMOVAL OF COMBUSTION AIR BLOWER ELBOW.

a. Loosen the screw holding the hose clamp (28) in place.

b. Slide the clamp (28) and rubber hose (27) away from the connection to free the heat exchanger connection from the blower elbow (26).

c. Remove the air blower elbow from the heater unit housing.



1. COLLAR COMPRESSION
2. NUT, #8-32 HEX
3. NUT, #8-32 HEX
4. SCREW, #6-32 X 5/16 BIND. H.M.
5. SCREW, #8-32 X 1/2 FIL. H.M.
6. WASHER, FLAT
7. SCREW, #4-40 R.H.
8. NUT, UNION HEX (FOR 5/16 TUBING)
9. LOCKWASHER, #6
10. NUT, #10-32 HEX
11. LOCKWASHER, #10
12. SCREW, #8-32 X 5/8 FIL. H.M.
13. NUT, #6-32 HEX
14. WASHER, #4 EXT.
15. SCREW, #6-32 FIL. H.M.
16. SCREW, #8-32 X 5/16 FIL. H.M.
17. LOCKWASHER, #6 INT.
18. LOCKWASHER, #8 INT.
19. SCREW, #8 X 1/4 HEX H. SHEET MET
20. SCREW, #6 X 1/4 HEX H. SHEET MET
21. COUPLING
22. SLEEVE
23. NIPPLE
24. SCREW (CUP POINT), #10-32 X 1/4 ALLEN SET
25. FLANGE, FUEL LINE
26. ELBOW, FUEL AIR
27. HOSE
28. CLAMP, HOSE
29. WASHER
30. CABLE, KNIT
31. LOCKWASHER, #8
32. GASKET, IGNITER
33. GROMMET
34. COUPLING, FEMALE
35. ELBOW, 1/8 PIPE
36. SCREW, #8 X 3/8
37. INSULATOR, RELAY
38. RELAY, 12-V. D.C.
39. WASHER, RUBBER
40. SPACER
41. COUPLING, NUT
42. SLEEVE
43. NIPPLE, 1/8 N.P.T.
44. PLATE, TAPPING
45. STRIP, TERMINAL
46. ELBOW, 1/8 N.P.T. STREET
47. STRIP, DOUBLE MARKER
48. SPACER, CENTERING
49. TUBE, FUEL
50. STRIP, CONNECTING
51. CLAMP, CABLE
52. SHIELD, BLOWER INLET
53. JUMPER, GROUND TERMINAL
54. IGNITER ASSEMBLY
55. WIRE ASSEMBLY, TERMINAL
56. WIRE ASSEMBLY, TERMINAL
57. RESISTOR ASSEMBLY
58. WIRE ASSEMBLY, TERMINAL
59. WHEEL, ASSEMBLY BLOWER
60. EXCHANGER ASSEMBLY, HEAT
61. HOUSING ASSEMBLY
62. SWITCH ASSEMBLY, OVERHEAT
63. HOUSING ASSEMBLY, BRACKET
64. WIRE ASSEMBLY, TERMINAL & IGNITER
65. WIRE ASSEMBLY, TERMINAL
66. WIRE ASSEMBLY, TERMINAL
67. WIRE ASSEMBLY, TERMINAL
68. WIRE ASSEMBLY, TERMINAL
69. WIRE ASSEMBLY, TERMINAL
70. BLOWER ASSEMBLY, VENT, 12-V. D.C.
71. MOTOR ASSEMBLY, 12-V. D.C.
72. GUARD ASSEMBLY, SWITCH
73. VALVE, FUEL CONTROL, 12-V. D.C.
74. SWITCH ASSEMBLY, FLAME DETECTOR

Figure 13-23. Exploded Parts View, Model 979-B1 Heater

13-44. REMOVAL OF COMBUSTION AIR BLOWER WHEEL.

a. Unscrew the three #4-40 RH screws (7) and star washers (14) holding the two halves of the combustion air fan housing.

b. Remove the outer half of the blower housing (63).

c. Loosen the No. 10 Allen set screw (24) which secures the combustion air fan wheel (59) to the motor shaft.

d. Remove the combustion air blower wheel.

13-45. REMOVAL OF IGNITER.

a. Remove the #8 machine screw (5) and washer (6) which secure the igniter ground wire to the igniter housing and remove the parts.

b. Remove the two #8-32 hex nuts securing the lead wire to the igniter terminal post, and the igniter lead as well.

c. Remove the igniter (54) and the gasket (32) from the igniter housing of the heat exchanger.

13-46. REMOVAL OF COMBUSTION AIR BLOWER MOTOR.

a. Complete the steps outlined in paragraph 13-45.

b. Remove the wire lead from terminal block position No. 9.

c. Remove the two #8-32 hex nuts (3), two steel washers (29) and two rubber washers (39) from the fan motor mounting bolts.

d. Remove the fan motor from the heater unit housing.

NOTE

Before replacing the motor exchange the rubber gasket, ground wire and spacers.

13-47. REMOVAL OF HEAT EXCHANGER.

a. Remove the three #8 x 1/4 inch RH type Z screws (19) which hold the heater unit housing in place.

b. Remove the heat exchanger (60) by spreading the heater unit housing open and sliding out the exchanger.

13-48. INSPECTION AND CLEANING OF HEATER.

13-49. FLAME DETECTOR SWITCH.

a. Remove the two screws, nuts, flat-and-star-washers from the bracket holding the micro switch.
b. Remove the adjusting screw, flat washer, bracket and adjusting spring.
c. Inspect the quartz rod for possible damage; replace if necessary.

13-50. VENTILATING AIR FAN.

a. Inspect the condition of the rubber motor mounting grommets.
b. Clean the air fan wheel with a dry type solvent.
c. Inspect the air fan wheel for possible damage to the blades.

13-51. RELAY. The relay is not to be repaired. If found to be inoperative, replace the relay.

13-52. FUEL CONTROL VALVE.

a. Remove the fuel control valve fuel line.
b. Replace the fuel valve inlet screen.
c. Remove the fuel control valve assembly from the standpipe.
d. Remove the three Sems fasteners, bushing and cover assembly and orifice plate from the bottom of the valve.
e. Clean the orifice plate with compressed air.

NOTE

Do not attempt to repair any other part of the fuel control valve. If found inoperative, replace the unit.

f. Remove the fuel flow standpipes and copper tubing.
g. Inspect the condition of the vaporizer wicks in the lower end of each standpipe: replace, if necessary.

13-53. OVERHEAT SWITCH. The overheat switch is not to be repaired. If found to be inoperative, replace the switch.

13-54. COMBUSTION AIR BLOWER.

a. Remove the combustion air blower housing and wheel.

b. Wash the combustion fan wheel in dry type solvent.

c. Inspect the wheel for possible damage to the blades.

d. Remove the combustion air fan motor and inspect the condition of the rubber, motor mounting grommets and gaskets. Replace, if necessary.

13-55. IGNITER. Replace the igniter at each overhaul.

13-56. HEAT EXCHANGER.

a. Remove the heat exchanger from the heater housing.

b. Inspect the heat exchanger for possible damage.

c. To remove combustion residue from within the exchanger:

1. Pour buckshot into the exchanger and shake vigorously.
2. Tap the sides lightly with a rawhide mallet to loosen the remaining residue.
3. Pour out the buckshot and blow out the loosened residue with compressed air.

d. Remove the igniter and clean the combustion residue from within the igniter housing with the igniter housing scraper, Part No. ST-890020.

13-57. HEATER UNIT HOUSING.

a. Inspect the condition of the rubber grommet in the heater unit housing.

b. Clean the inside of the housing with a wire brush and/or dry type solvent.

13-58. REASSEMBLY OF HEATER. To assemble the heater unit, reverse the sequence of paragraph 13-37, Disassembly of Heater. After assembling the unit, test the heater unit with the test prescribed herein.

13-59. SERVICE TOOLS.

a. Fuel Screen Tool: The fuel screen tool, South Wind Part No. ST-890022, (Refer to "A", Figure 13-24.) is to be used in removing and inserting the fuel screen in the control valve inlet. The needle point of the tool is used for the removal of the screen, while the larger end aids in the insertion of the screen in position.

b. Igniter Housing Scraper: The purpose of the igniter housing scraper, Part No. ST-890020, ("B") is to clean the combustion residue from the inside walls of

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TABLE XIII-I. TROUBLESHOOTING ANALYSIS CHART, MODEL 979-B1

REMEDY / PROBABLE CAUSE — ELECTRICAL and WIRING

SWITCH POSITION	TROUBLE	AMPS.	Ignition Switch	Battery	Heater Switch	Heater Ground Wire	Heater Switch Fuse	Battery Wire Fuse	WIRING
REMEDY		Adjust							
REMEDY		Clean							
REMEDY		Repair							
REMEDY		Replace	X	X	X	X	X	X	
FAN	VENTILATING AIR FAN FAILS TO START	0	X	X	X	X	X	X	Ignition Switch to Heater Switch through Strip No. 12 to Relay #5 and Vent Air Fan
FAN	VENTILATING AIR FAN FAILS TO START	over 10							
HEAT	COMBUSTION AIR BLOWER FAILS TO START	0	X	X	X	X	X		Heater Switch through Strip No. 13 to Relay #1
HEAT	COMBUSTION AIR BLOWER FAILS TO START	10							Relay #2 through Strip #9 to Combustion Air Motor
HEAT	COMBUSTION AIR BLOWER FAILS TO START	over 12.5							
HEAT	HEATER FAILS TO IGNITE	3-4							Relay #3 to Igniter
HEAT	HEATER FAILS TO IGNITE	12-13							Relay #1 through Strip No. 13 to Fuel Valve or Heater Switch to Restriction Valve
HEAT	HEATER SLOW TO IGNITE	12-13		X					Heater Switch through Strip No. 14 to Restriction Valve
HEAT	VENTILATING AIR FAN FAILS TO START	0-1			X				Relay #5 through Strip No. 12 to Vent Air Fan
HEAT	VENTILATING AIR FAN FAILS TO START	12-13						X	Relay #4 through Strip No. 11 to Battery. Relay #7 through Strip No. 10 to Flame Detector Switch
HEAT	FAN SLOW TO START	12-13							
HEAT	HEATER OPERATES UNSATISFACTORILY	Won't Cycle "Hi - Lo"							Wires Reversed in Terminal Strip
HEAT	HEATER OPERATES UNSATISFACTORILY	Burning Stops on "Lo" Heat							
HEAT	HEATER OPERATES UNSATISFACTORILY	Heater Cycles "On - Off"							
HEAT	HEATER OPERATES UNSATISFACTORILY	Vent Air Fan Cycles "On - Off"							
HEAT	HEATER OPERATES UNSATISFACTORILY	Low Output							
HEAT	HEATER OPERATES UNSATISFACTORILY	Smoke From Exhaust							
OFF	BLOWERS STOP IN TWO MINUTES	Blowers Don't Stop							
OFF	BLOWERS STOP IN TWO MINUTES	Blowers Slow To Stop							

AIR, FUEL, VENTILATING AIR MOTOR, COMBUSTION AIR MOTOR

TROUBLE / AMPS.	AIR: Ventilating Air Passage Restricted	AIR: Combustion Air Passage Restricted	AIR: Exhaust Restricted	FUEL: Pressure Low	FUEL: No Fuel to Heater	VENTILATING AIR MOTOR: Open Circuit in Microswitch	VENTILATING AIR MOTOR: Short Circuit in Motor	VENTILATING AIR MOTOR: Blower Wheel Binding	VENTILATING AIR MOTOR: Slow Motor	VENTILATING AIR MOTOR: Motor Not Grounded	COMBUSTION AIR MOTOR: Open Circuit in Motor	COMBUSTION AIR MOTOR: Short Circuit in Motor	COMBUSTION AIR MOTOR: Blower Wheel Binding	COMBUSTION AIR MOTOR: Slow Motor	COMBUSTION AIR MOTOR: Motor Not Grounded
REMEDY: Adjust								X		X			X		X
REMEDY: Clean	X	X	X												
REMEDY: Repair					X										
REMEDY: Replace			X			X	X		X		X	X		X	
FAN – Ventilating Air Fan Fails to Start – 0						X				X					
FAN – Ventilating Air Fan Fails to Start – over 10							X	X							
HEAT – Combustion Air Blower Fails to Start – 0															
HEAT – Combustion Air Blower Fails to Start – 10											X				X
HEAT – Combustion Air Blower Fails to Start – over 12.5												X	X		
HEAT – Heater Fails to Ignite – 3-4															
HEAT – Heater Fails to Ignite – 12-13		X	X	X	X									X	
HEAT – Heater Slow to Ignite – 12-13		X	X	X										X	
HEAT – Ventilating Air Fan Fails to Start – 0-1						X				X					
HEAT – Ventilating Air Fan Fails to Start – 12-13							X	X							
HEAT – Fan Slow to Start – 12-13															
HEAT – Heater Operates Unsatisfactorily – Won't Cycle "Hi - Lo"															
HEAT – Heater Operates Unsatisfactorily – Burning Stops on "Lo" Heat			X												
HEAT – Heater Operates Unsatisfactorily – Heater Cycles "On - Off"	X		X	X					X	X					
HEAT – Heater Operates Unsatisfactorily – Vent Air Fan Cycles "On - Off"			X						X						
HEAT – Heater Operates Unsatisfactorily – Low Output	X	X	X	X				X	X					X	
HEAT – Heater Operates Unsatisfactorily – Smoke From Exhaust		X	X										X	X	
OFF – Blowers Stop in Two Minutes – Blowers Don't Stop															
OFF – Blowers Stop in Two Minutes – Blowers Slow To Stop															

RELAY, IGNITER

TROUBLE / AMPS.	RELAY: Contacts Not Made	RELAY: Pigtail Broken	RELAY: Coil Burned Out	RELAY: Contacts Sticking	IGNITER: Shorted	IGNITER: Burned Out	IGNITER: Coated
REMEDY: Adjust	X						
REMEDY: Clean							
REMEDY: Repair							
REMEDY: Replace		X	X	X	X	X	X
FAN – Ventilating Air Fan Fails to Start – 0							
FAN – Ventilating Air Fan Fails to Start – over 10							
HEAT – Combustion Air Blower Fails to Start – 0	#1				X		
HEAT – Combustion Air Blower Fails to Start – 10		X					
HEAT – Combustion Air Blower Fails to Start – over 12.5							
HEAT – Heater Fails to Ignite – 3-4	#3					X	
HEAT – Heater Fails to Ignite – 12-13							X
HEAT – Heater Slow to Ignite – 12-13							X
HEAT – Ventilating Air Fan Fails to Start – 0-1	#4 #5						
HEAT – Ventilating Air Fan Fails to Start – 12-13			X	X			
HEAT – Fan Slow to Start – 12-13							
HEAT – Heater Operates Unsatisfactorily – Won't Cycle "Hi - Lo"							
HEAT – Heater Operates Unsatisfactorily – Burning Stops on "Lo" Heat							
HEAT – Heater Operates Unsatisfactorily – Heater Cycles "On - Off"							
HEAT – Heater Operates Unsatisfactorily – Vent Air Fan Cycles "On - Off"							
HEAT – Heater Operates Unsatisfactorily – Low Output							
HEAT – Heater Operates Unsatisfactorily – Smoke From Exhaust							
OFF – Blowers Stop in Two Minutes – Blowers Don't Stop				X			
OFF – Blowers Stop in Two Minutes – Blowers Slow To Stop				X			

FUEL CONTROL VALVE

TROUBLE / AMPS.	Improper Metering	Inlet Screen Clogged	Orifice Plate Clogged	Shut-Off Valve Stuck Open	Shut-Off Valve Stuck Closed	Restriction Valve Stuck Open	Restriction Valve Stuck Closed	Shut-Off Coil Faulty	Restriction Coil Faulty
REMEDY: Adjust									
REMEDY: Clean		X	X						
REMEDY: Repair									
REMEDY: Replace	X	X		X	X	X	X	X	X
FAN – Ventilating Air Fan Fails to Start – 0									
FAN – Ventilating Air Fan Fails to Start – over 10									
HEAT – Combustion Air Blower Fails to Start – 0									
HEAT – Combustion Air Blower Fails to Start – 10									
HEAT – Combustion Air Blower Fails to Start – over 12.5									
HEAT – Heater Fails to Ignite – 3-4									
HEAT – Heater Fails to Ignite – 12-13	X	X	X		X			X	
HEAT – Heater Slow to Ignite – 12-13	X	X	X				X		X
HEAT – Ventilating Air Fan Fails to Start – 0-1									
HEAT – Ventilating Air Fan Fails to Start – 12-13									
HEAT – Fan Slow to Start – 12-13									
HEAT – Heater Operates Unsatisfactorily – Won't Cycle "Hi - Lo"						X	X		X
HEAT – Heater Operates Unsatisfactorily – Burning Stops on "Lo" Heat	X		X						
HEAT – Heater Operates Unsatisfactorily – Heater Cycles "On - Off"	X	X	X						
HEAT – Heater Operates Unsatisfactorily – Vent Air Fan Cycles "On - Off"									
HEAT – Heater Operates Unsatisfactorily – Low Output	X	X	X				X		X
HEAT – Heater Operates Unsatisfactorily – Smoke From Exhaust	X								
OFF – Blowers Stop in Two Minutes – Blowers Don't Stop					X				
OFF – Blowers Stop in Two Minutes – Blowers Slow To Stop									

THERMOSTAT, OVERHEAT SW., FLAME DET. SWITCH, HEAT EXCH.

TROUBLE / AMPS.	THERMOSTAT: Contacts Sticking	THERMOSTAT: Contacts Open	OVER HEAT SW.: Contacts Open	OVER HEAT SW.: Contacts Stuck Closed	FLAME DET. SWITCH: Switch Not Grounded	FLAME DET. SWITCH: Switch Out of Adjustment	FLAME DET. SWITCH: Spring Bowed Down	FLAME DET. SWITCH: Broken Quartz Rod	HEAT EXCH.: Igniter Housing Coated Inside	HEAT EXCH.: Heat Exchanger Coated Inside
REMEDY: Adjust						X				
REMEDY: Clean									X	X
REMEDY: Repair					X		X			
REMEDY: Replace	X	X	X	X				X		
FAN – Ventilating Air Fan Fails to Start – 0										
FAN – Ventilating Air Fan Fails to Start – over 10										
HEAT – Combustion Air Blower Fails to Start – 0										
HEAT – Combustion Air Blower Fails to Start – 10										
HEAT – Combustion Air Blower Fails to Start – over 12.5										
HEAT – Heater Fails to Ignite – 3-4										
HEAT – Heater Fails to Ignite – 12-13			X			X	X	X		
HEAT – Heater Slow to Ignite – 12-13		X							X	X
HEAT – Ventilating Air Fan Fails to Start – 0-1										
HEAT – Ventilating Air Fan Fails to Start – 12-13					X	X				
HEAT – Fan Slow to Start – 12-13							X			
HEAT – Heater Operates Unsatisfactorily – Won't Cycle "Hi - Lo"	X	X								
HEAT – Heater Operates Unsatisfactorily – Burning Stops on "Lo" Heat										
HEAT – Heater Operates Unsatisfactorily – Heater Cycles "On - Off"					X					
HEAT – Heater Operates Unsatisfactorily – Vent Air Fan Cycles "On - Off"										
HEAT – Heater Operates Unsatisfactorily – Low Output		X								X
HEAT – Heater Operates Unsatisfactorily – Smoke From Exhaust				X						
OFF – Blowers Stop in Two Minutes – Blowers Don't Stop						X	X	X		
OFF – Blowers Stop in Two Minutes – Blowers Slow To Stop						X				

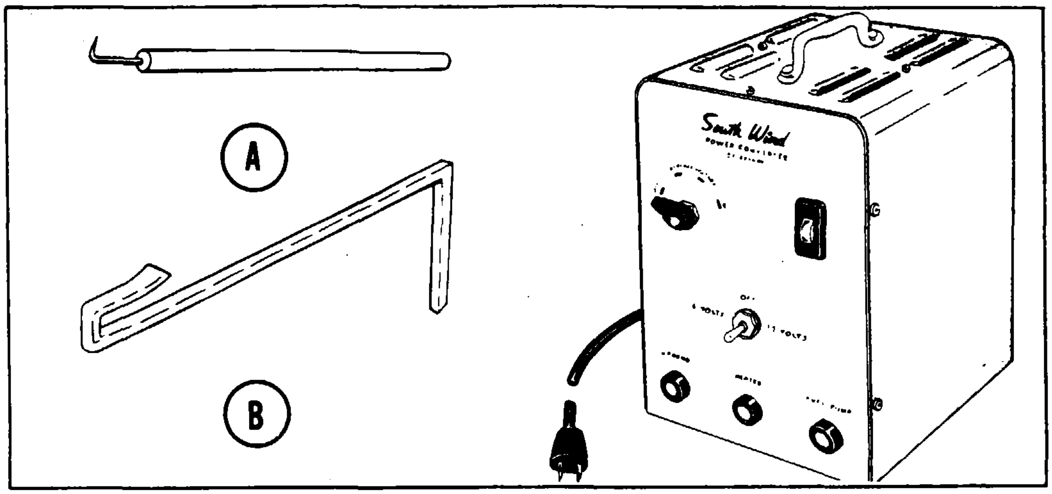


Figure 13-24. Service Tools (South Wind)

the igniter housing.

c. Power Converter: The 6-12 volt Power Converter, Part No. ST-890090, is used to connect the test stand to an ordinary alternating current source. The converter has proven much more efficient than a storage battery as a current source. The converter does not run down as does the battery or need to be removed and replaced.

13-60. HEATER (South Wind Model 940 Series).

13-61. HEATER OPERATING INSTRUCTIONS. The 940 series heaters are controlled by a switch located on the right side of the instrument panel, labeled Fan, Off, Prime, Low and High. To operate the heater, first turn on the fuel control valve located on the fuel selector panel. Move the switch to High or Low heat. If the heater does not start promptly, return the heater switch to Prime position for 15 seconds to prime the heater; then upon moving the switch to High heat, the heater should start and continue to operate after one to one and a half minutes of warm-up. When operating the heater for any length of time on the ground, it is recommended to operate the heater in Low heat position.

The heater uses gasoline from either left fuel tank when the fuel crossfeed is off, and from all tanks when the crossfeed is on.

The push-pull knobs at the bottom of the control pedestal control air flow and temperature. The left control regulates air flowing to the front seat through the heater system and the second knob from the left controls air flowing to the rear seat, the second knob from the right is the defroster control and the right knob controls the supply of cold air through the vent on the forward bulkhead.

After the heater is turned to the Off position, combustion in the heater stops, but the combustion fan and the circulating air fan continues to operate for about two minutes, while the heater cools and purges itself of hot air and fumes. To obtain best service life from the heater components, it is recommended that the heater switch be turned off about two minutes before turning off the master switch.

13-62. DESCRIPTION AND PRINCIPLES OF OPERATION. The South Wind Model 940-B12 heater installed in PA-23 airplanes bearing Serial Numbers 23-171 to 23-1242 inclusive is designed to deliver a maximum of 20, 000 BTU's of heat, and the Model 940-DA12 heater in airplanes with Serial Numbers 23-1243 and up delivers a maximum of 27, 500 BTU's. The basic heater of the 940 Series incorporates an exhaust shroud adapter, fuel control valve enclosure with provisions for a vent and overboard drain, a cycling-type overheat switch and a separate fuel safety valve. In addition on the Model 940-DA12 heater is a thermal fuse and a safety valve shut-off relay.

The principals of operation are basically the same for all models of the 940 Series heaters since the differences between the heaters are confined to safety devices which do not function during normal burning of the heater. Operation of the safety devices follows this description.

The heater produces heat by burning a mixture of gasoline and air in a sealed, all-welded, stainless steel heat exchanger. (Refer to Figure 13-26.) Air for combustion is obtained from a blower on the side of the heater housing and

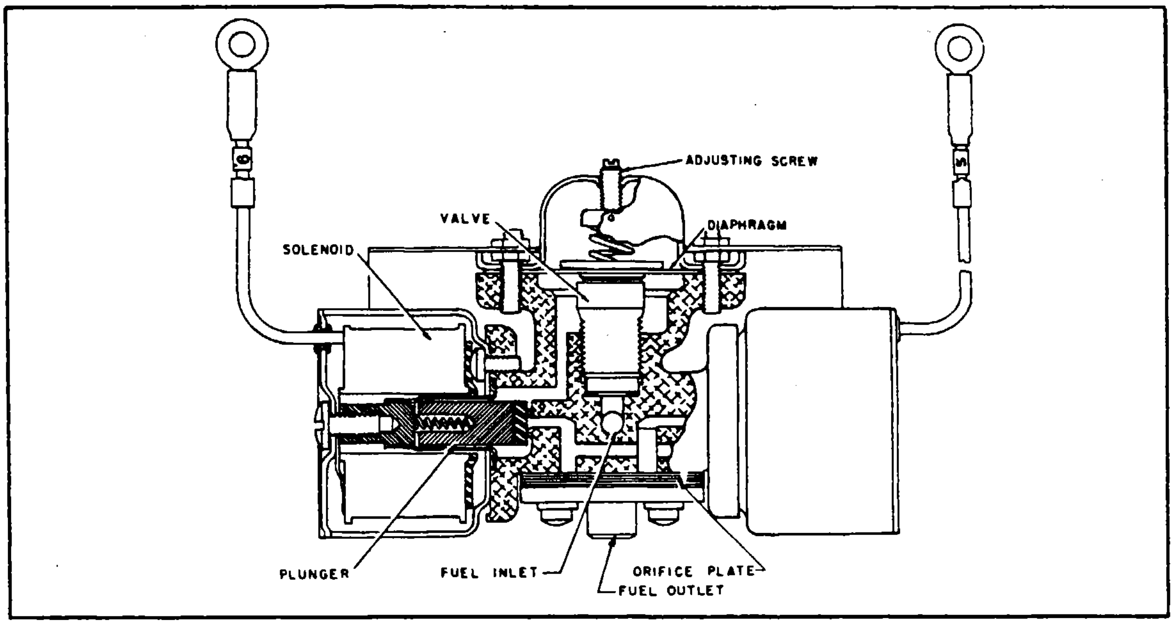


Figure 13-25. Fuel Control Valve (Cutaway View)

is introduced into the heat exchanger through two metal elbows. Gasoline is obtained from the airplane's fuel system and is supplied to the heater through a safety valve and filter which may be mounted at any convenient point near the heater.

Fuel is metered at the heater by the fuel control valve (Refer to Figure 13-25.) which is enclosed in a metal case on top of the heater. The metal case is equipped with fittings for a drain tube at the bottom, and a vent tube at the top. These tubes prevent the possibility of a fire hazard, or release of fumes, in the event that a fuel leak should develop in the valve or fuel line connection.

After being metered by the fuel control valve, the fuel passes through a short steel tube and enters a vertical standpipe. (Refer to Figure 13-26.) The fuel drips down the standpipe and saturates the stainless steel wick in the combustion chamber. The standpipe is surrounded by an electric heating element which is energized during the starting period and serves to preheat the fuel, thus insuring quick starts even at the lowest temperatures.

The fuel is ignited within the heat exchanger by a glow-plug igniter, and the resulting hot gases pass through the wraps of the heat exchanger and out the exhaust tube.

After combustion starts, the igniter and fuel preheater are turned off by the flame detector switch (Refer to Figure 13-28.) which also turns on the ventilating air blower at this time. Since the standpipe is now heated by combustion in the heat exchanger, preheating is no longer required and the preheater is also turned off.

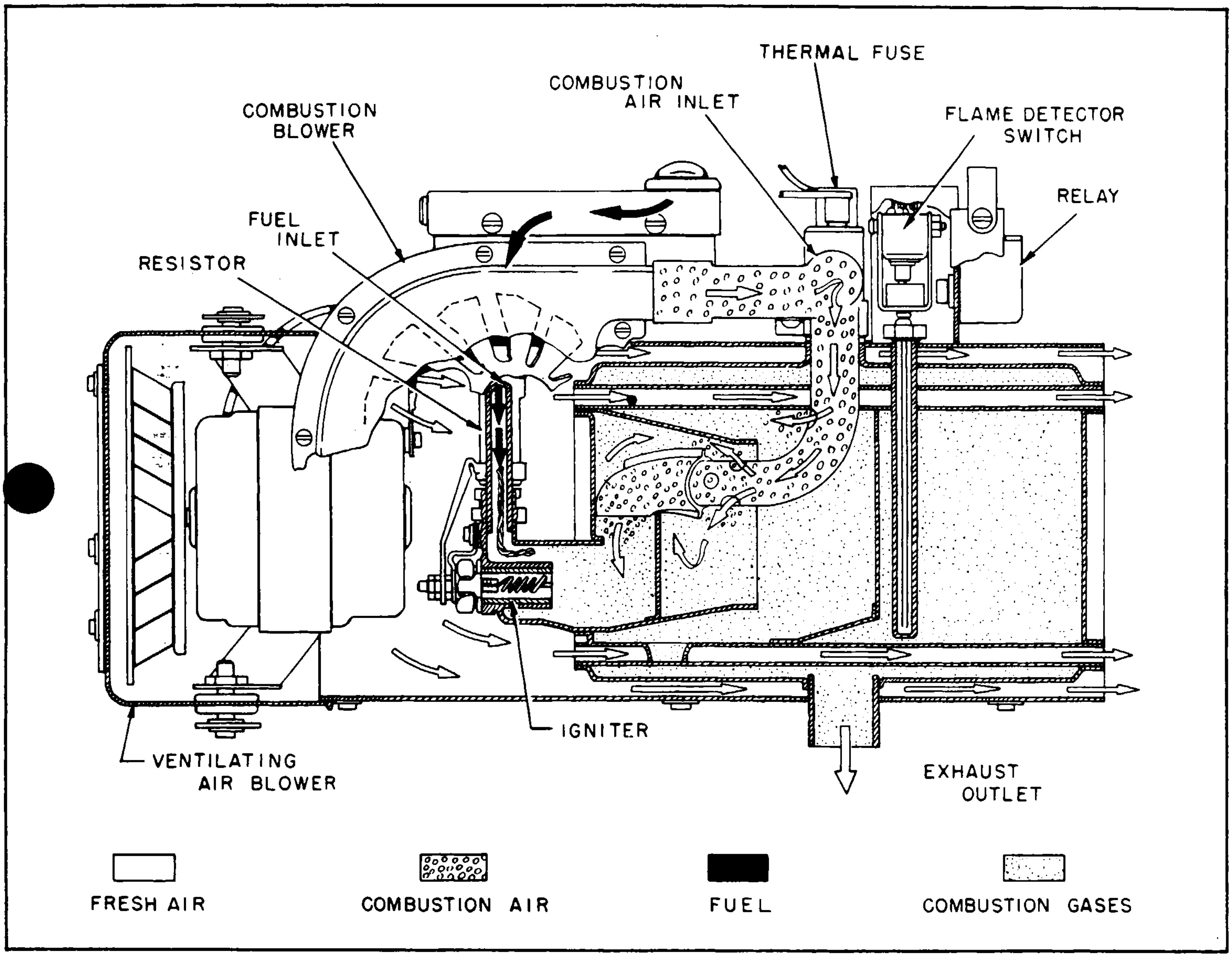


Figure 13-26. Flow System (South Wind Heater)

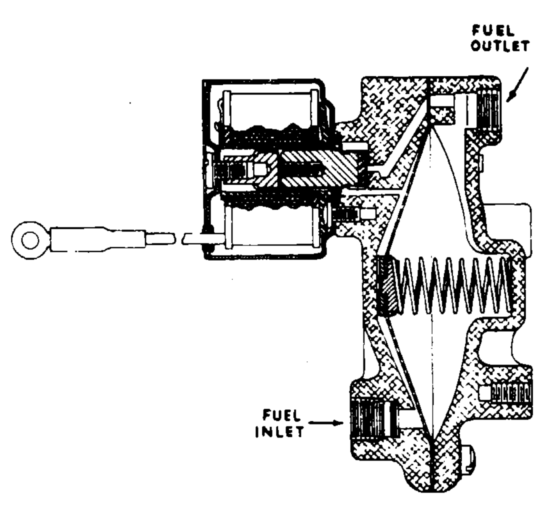


Figure 13-27. Fuel Safety Valve (Cutaway View)

13-63. SAFETY VALVE. The safety valve (Refer to Figure 13-27.) which is supplied with all models of the 940 heater consists of a shut-off solenoid and a casting which houses a large diaphragm and spring. The safety valve provides the initial flow of fuel for ignition. Additional fuel to sustain combustion is permitted to flow only after the shut-off solenoid of the safety valve is energized during a starting cycle. Fuel flows from the fuel source through the filter to the inlet side of the safety diaphragm. Pressure of fuel against the diaphragm forces gasoline, contained in the opposite side of the chamber through the outlet port into the heater.

When the flame detector switch transfers after combustion starts, the shut-off solenoid is energized and opens a bypass through which fuel then flows to the heater. Gasoline will continue to flow through this system until the heater is turned off. The chamber behind the diaphragm will refill during heater operation, as the spring returns the diaphragm to its normal position. This prepares the safety valve for another start. The safety valve may be manually recharged at any time by turning the heater switch to Fan or Prime position for about 30 seconds.

On the model 940-DA, the safety valve also acts as a second safety fuel shut-off valve, since it is energized through the heater relay. In the event of an overheat condition, which causes the thermal fuse or lockout overheat switch to open, the relay will be de-energized and the safety valve solenoid will close at the same time the heater fuel control valve shut-off solenoid closes. This double shut-off is required by Federal Regulations on all new airplane heater installations.

13-64. OVERHEAT SWITCH. Two types of overheat switches are used in the 940 Series heaters. The 940-B and 940-D Series are equipped with bimetal blade cycling-type switches which open at a temperature of 250° F and shut off fuel flow by de-energizing the fuel control valve shut-off solenoid. These switches are designed to protect the heater and airplane by limiting the heater outlet temperature. The cycling-type switch shuts off fuel only, and when the heater cools the switch will close and permit the heater to re-start.

13-65. THERMAL FUSE (Models 940-D and 940-DA). The thermal fuse used on the Models listed above consists of a special combustion air inlet elbow which contains a fusible metal link with electric terminals. The fusible link is connected in series with the hot lead from the heater switch.

An additional requirement of Federal regulations is that airplane heaters be equipped with a device which will prevent operation at any time that combustion air flow is insufficient for safe operation. When applied to the 940 Series heaters, this means that the heater must shut down if combustion air flow is reversed, since the heater will operate safely under any other combustion air flow condition.

The special purpose of the thermal fuse is to shut off the heater if the direction of combustion air flow should be reversed. In such a condition, combustion air would enter through the heater exhaust and flow out through the combustion air inlet. It has been demonstrated that this flow can sustain combustion at a temperature below the overheat switch setting. For this reason, the thermal fuse has been provided at the combustion air inlet. In the event of reverse burning, the hot gases will quickly melt the fusible link and the heater will be completely shut down. The heater cannot be restarted until the fusible link has been replaced after such an occurrence.

NOTE

The reverse burning described above, can only occur under unusual conditions caused by improper installation, or by multiple failure of heater components. The thermal fuse has no effect on the heater during normal operation.

13-66. SYSTEMS. The Model 940 heater consists of four systems: The Fuel System, The Combustion Air System, The Ventilating Air System, and The Electrical System. These systems are more fully described below.

13-67. FUEL SYSTEM. The fuel system consists of the safety valve (which was described under Safety Features), the heater fuel control valve, and the standpipe. These heaters are designed to operate with a fuel pressure between 1 and 15 psi. Less than one pound may not be sufficient to operate the safety valve diaphragm, and more than 15 pounds may damage the pressure regulator in the heater fuel control valve.

13-68. FUEL CONTROL VALVE. The fuel control valve (Refer to Figure 13-25.) provides the proper amount of fuel for high or low heat operation, depending upon position of the thermostat contacts. The complete valve consists of two solenoid valves and a pressure regulator which maintains constant fuel pressure for heater operation, regardless of fluctuations of pressure in the fuel supply. The flow of fuel is regulated by an orifice plate which contains holes of the proper size to meter fuel flow for high and low heat.

When the shut-off solenoid is closed or unenergized, no fuel can enter the standpipe, and the heater is completely shut off. When the shut-off solenoid is energized, fuel flows through the low heat metering orifice and the heater burns on low heat. When both the restriction and shut-off solenoids are energized, fuel flows through both the low heat orifice and the restriction orifice, thereby providing sufficient fuel for high heat operation. After leaving the fuel control valve, the fuel drips down the standpipe where it saturates the stainless steel wick extending into the combustion chamber. (Refer to Figure 13-26.)

13-69. COMBUSTION AIR SYSTEM. The combustion air blower blows air through the metal elbows into the heat exchanger. Inside the heat exchanger the air passes through another duct (Refer to Figure 13-26.) and is blown into the burner cone, where it mixes with the gasoline vapor and the mixture is ignited by the igniter.

The burning gases then swirl around the heat exchanger and exhaust through the outlet tube.

13-70. VENTILATING AIR SYSTEM. The ventilating air blower is mounted on the end of the heater by means of bayonet slots. The blower is a mixed-flow type which discharges axially, due to the design of the housing. It picks up clean air from outside the heater housing and blows it through the slots of the heat exchanger and around the sides, where it absorbs heat which is transmitted through the walls of the heat exchanger by the hot products of combustion. The heated air is then conducted to the space which is being heated.

13-71. ELECTRICAL SYSTEM. The heater electrical system consists of the combustion and ventilating air blower motors, the flame detector switch, the fuel valve solenoids, the fuel preheater and the electric safety devices. Since the differences between heater models are in the number and type of safety devices, the electrical components of the basic Model 940-B Heater are described in the following paragraphs. The differences between this heater and the other models are described in subsequent paragraphs.

13-72. FLAME DETECTOR SWITCH. The purpose of the flame detector switch is to shut off the igniter and fuel preheater as soon as combustion has been established within the heater, and to provide a “purge” cycle after the heater is shut off. This switch consists of a hollow probe upon which is mounted a bracket and micro switch mechanism. The hollow probe contains a quartz rod which has a low rate of expansion when heated. (Refer to Figure 13-30.) The end of the quartz rod actuates the plunger of the micro switch. A leaf spring between the rod and plunger is provided to maintain a pressure through the rod against the end of the tube.

When installed on the heater, the hollow probe extends into the interior of the heat exchanger where it is subject to the heat of combustion. After combustion starts, the heating effect of the flame causes the metal tube to expand. Since the quartz rod does not expand, the lengthening tube relieves the pressure on the micro switch plunger, and the switch contacts transfer. The switch will then remain in this position as long as the tube remains hot, but will automatically return to the starting position when the heat exchanger cools. This purge cycle, after the heater switch is shut off, holds the blowers on until the residual fuel in the burner has been consumed, and the heater is cooled off.

13-73. IGNITER. The igniter is an electric “glow plug” type of heating element which glows red hot when energized. (Refer to Figure 13-26.) To prolong the life of the igniter, it is shut off by the flame detector switch as soon as combustion starts.

13-74. CYCLE OF OPERATION. When the heater switch is turned on, several things occur simultaneously. (Refer to Figure 13-28 or 13-29 according to heater model.)

a. The shut-off solenoid is energized through terminal No. 4 of the terminal strip, the overheat switch, and through the thermal fuse on models so equipped. This permits fuel to drip into the standpipe and saturate the stainless steel wick.

b. The igniter is energized through the flame detector switch which obtains its energy from terminal No. 4 of the terminal strip (or terminal No. 4A of the relay).

c. The fuel preheater heats up, since it is connected in series in the igniter circuit.

d. The combustion air motor is energized through the center connection of the flame detector switch, and the blower starts.

With heated fuel dripping down the standpipe, the igniter glowing red hot, and the combustion air blower in operation, all requirements for combustion are present, and burning soon starts in the heater.

The heat of combustion causes the tube of the flame detector switch assembly to expand and permits the switch contacts to transfer, as previously described.

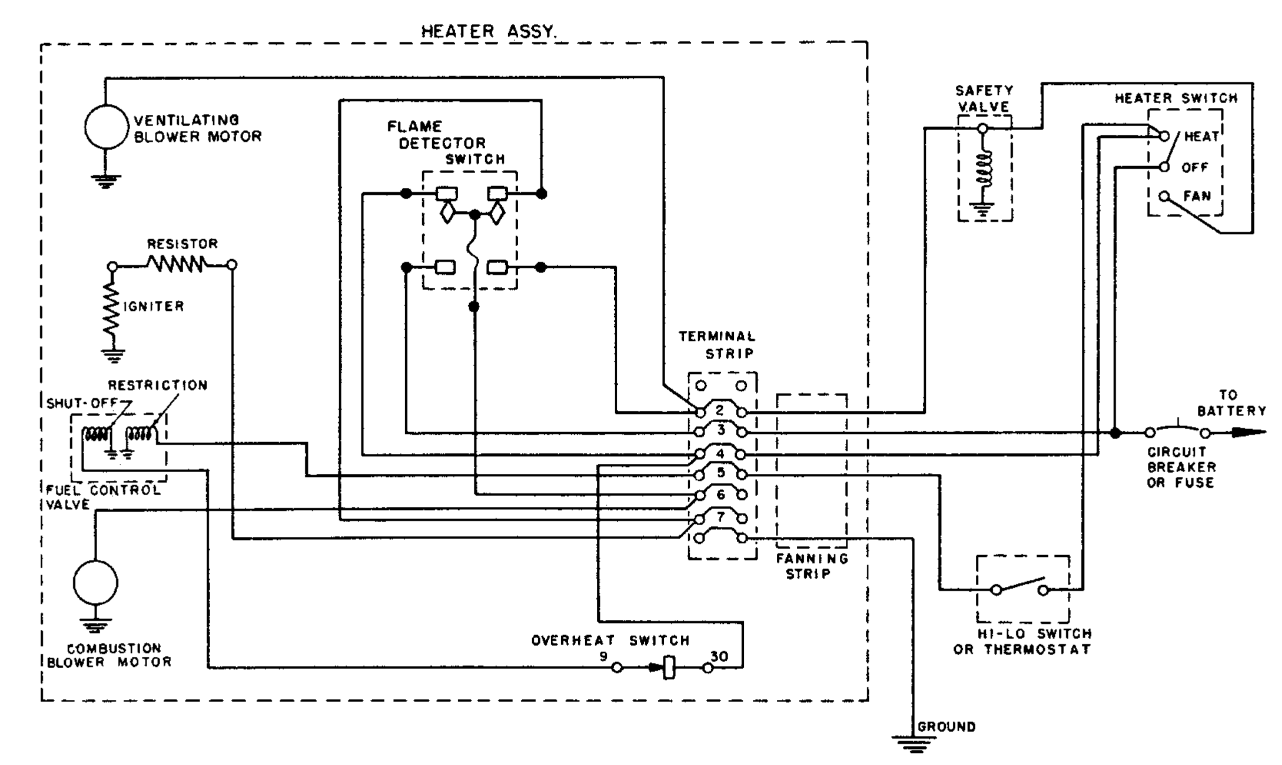


Figure 13-28. Heater Wiring Diagram
(Sheet 1 of 2 - Model 940-B)

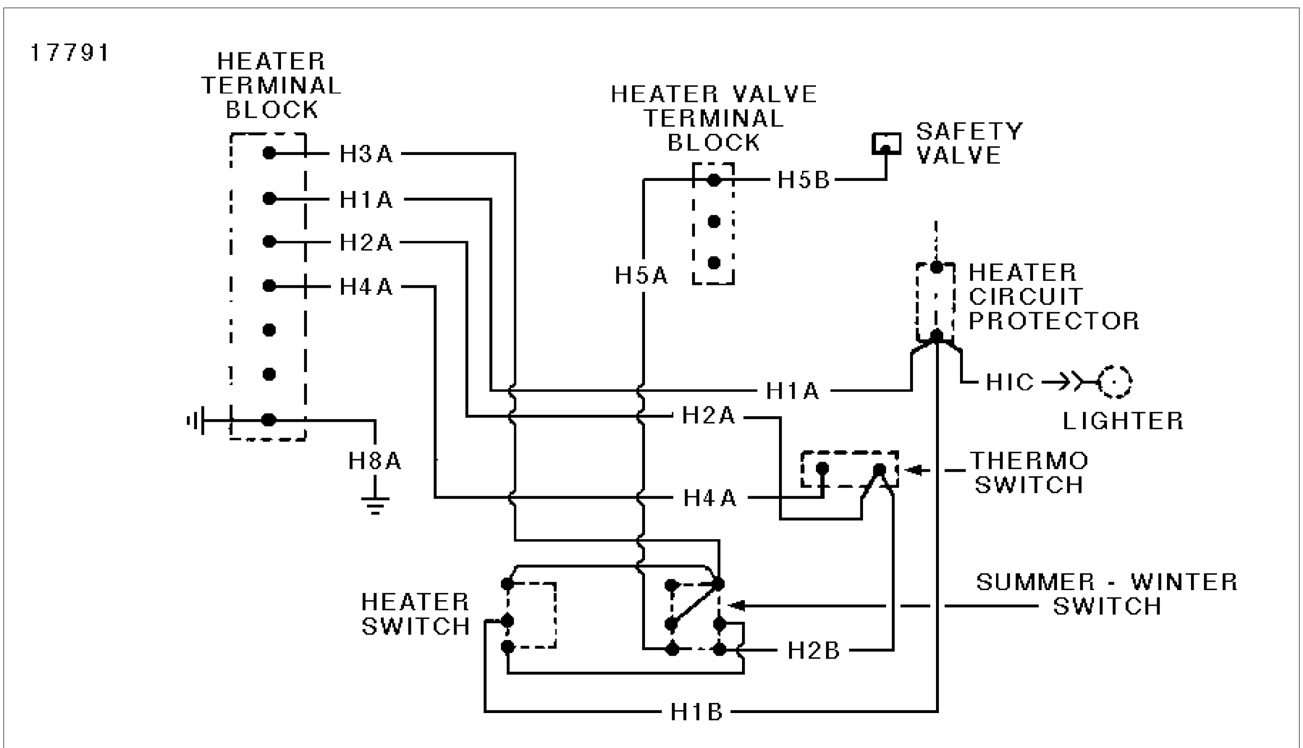


Figure 13-28. Heater Wiring Diagram
(Sheet 2 of 2 - Model 940-B12)

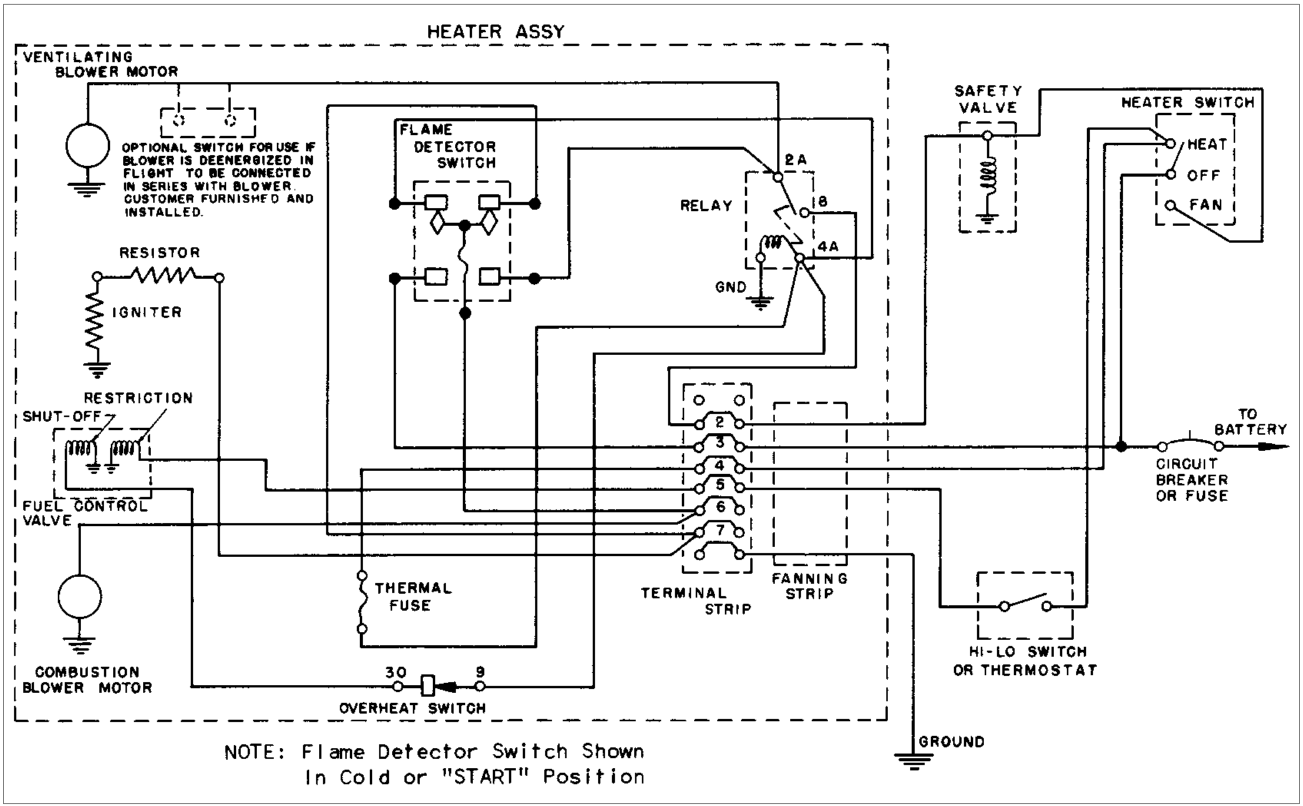


Figure 13-29. Heater Wiring Diagram
(Sheet 1 of 2 - Models 940-D and 940-DA)

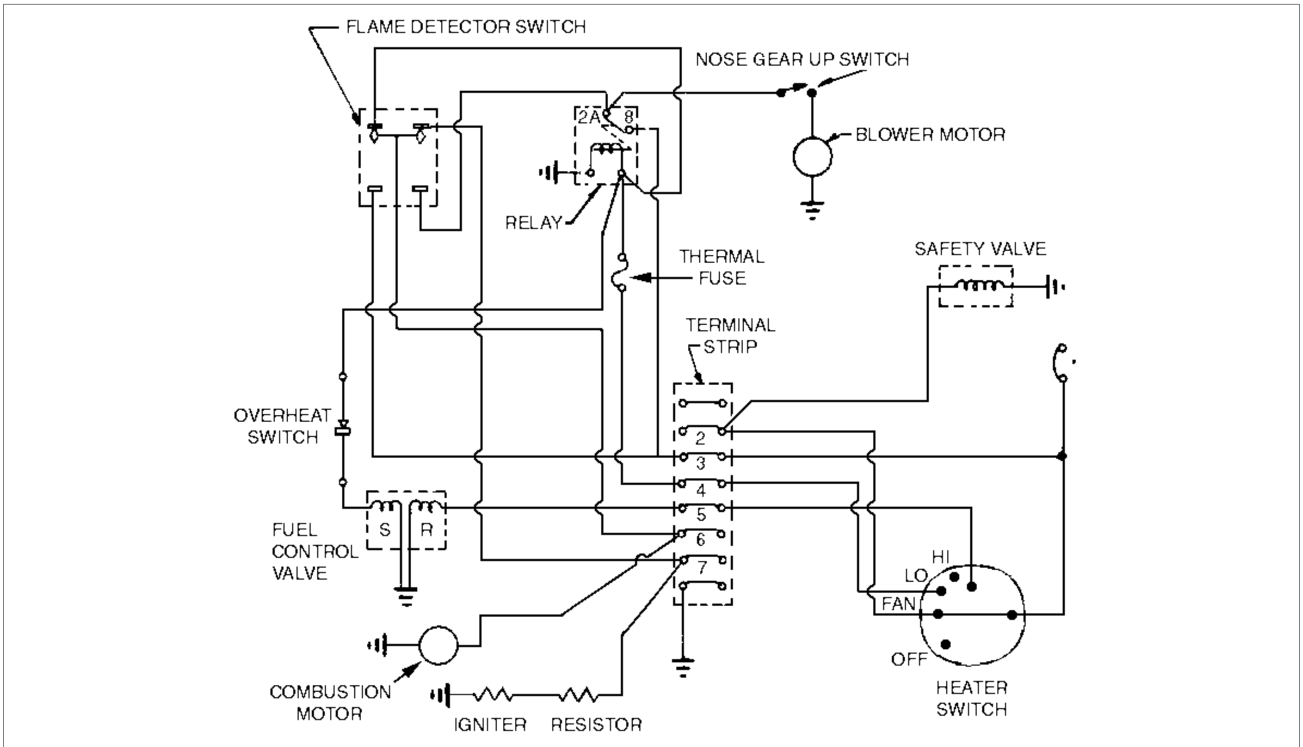


Figure 13-29. Heater Wiring Diagram
(Sheet 2 of 2 - Model 940-D12)

13-75. RUNNING CYCLE. When the flame detector switch transfers, the following events take place:

a. The ventilating air blower motor is energized through terminal No. 2 of the terminal strip (or 2A of the relay) and the flame detector switch and the blower start. The combustion air blower continues to run, since it obtains its energy from the center terminal of the flame detector switch. Electric energy for both blowers is now being supplied from the No. 2 terminal which is connected directly to the battery, and the blowers will continue to run until the flame detector switch cools and returns to its starting position.

b. The igniter and fuel preheater are shut off when the flame detector switch transfers. Since combustion is self-sustaining, they are no longer required. The heater is now in full operation and will continue to burn as long as fuel, air, and electric current are supplied. The temperature of the air may be regulated by opening and closing the restriction solenoid of the fuel control valve by means of a thermostat or HI-LO switch mounted on the right side of the instrument panel.

13-76. PURGING CYCLE. When the heater switch is turned Off, the following sequence of events takes place:

a. The shut-off solenoid of the fuel control valve is de-energized, and fuel flow stops immediately. Burning soon stops due to lack of fuel.

b. The combustion air and ventilating air blowers continue to run since the flame detector switch is still hot and is in its running position. The flow of ventilating and combustion air cools the heat exchanger and purges it of all unburned gas fumes which might remain after burning stops.

c. When the heat exchanger cools, the tube of the flame detector switch contracts and forces the quartz rod up against the micro switch plunger. The switch then transfers to its cold position and the blowers stop. The fuel safety valve solenoid is also de-energized and will not open again until the flame detector switch becomes heated on another starting cycle.

TECHNICAL DATA

Electrical Requirements............12 volts DC

Current Consumption:
- Starting............12 amp
- Running............7 amp

Fuel Pressure ....1 to 15 psi

Fuel Consumption:

940-B
- High Heat............0.26 gph (0.026 lb/min)
- Low Heat............0.08 gph (0.012 lb/min)

940-D
- High Heat............0.37 gph (0.037 lb/min)
- Low Heat............0.12 gph (0.012 lb/min)

940-DA
- High Heat............0.37 gph (0.037 lb/min)
- Low Heat............0.18 gph (0.018 lb/min)

Heat Output:

940-B
- High Heat ....20,000 BTU/HR
- Low Heat ....5,500 BTU/HR

940-D
- High Heat ....27,500 BTU/HR
- Low Heat ....10,000 BTU/HR

940-DA
- High Heat ....27,500 BTU/HR
- Low Heat ....15,000 BTU/HR

Overheat Switch Operating Temperature............250° F

Dimensions ....16-7/8 in. long; 7-3/4 in, wide: 9-1/8 in. high - Weight: 20.5 lbs. (Approx.)

Diameter of Housing ....6-3/16 in. O.D.

Combustion Air Inlet ....1-1/2 in. O.D.

Heater Exhaust 1-1/2 in. O.D.

Exhaust Shroud Flange............2-1/2 in. O.D.

13-77. OVERHEAT SWITCH. The heater is equipped with a cycling type overheat switch to limit duct temperature to a safe maximum level. This switch is connected in series between terminal No. 4 of the terminal strip and the shut-off solenoid of the fuel control valve. When the ventilating air stream exceeds a temperature of approximately 250° F., the bimetal blade of the overheat switch will open the switch contacts and break the solenoid circuit, shutting off fuel to the heater. Burning then stops, but the blowers continue to run. As soon as the heater cools, the overheat switch contacts will close and energize the fuel shut-off solenoid. At this point, fuel flow is re-established in the heater, but the igniter is off and ignition will not occur until the flame detector switch cools and transfers to its starting position. The igniter is then energized and combustion again starts.

If the heater switch remains on, and the cause of overheating is not corrected, this process which is known as "re-cycling", will continue indefinitely. Air temperature, however, will not exceed the temperature of the overheat switch setting.

13-78. ELECTRICAL SYSTEM (Model 940-D and 940-DA). The electrical system of the Model 940-D and 940-DA Heaters has all the components provided on the Model 940-B, plus a thermal fuse in the combustion air inlet elbow and the safety valve relay. (Refer to Figure 13-29.)

The starting cycle for these heaters is similar to the 940-B, except that the safety valve solenoid is energized through the normally open terminal No. 8 of the relay. The relay is energized through the circuit from the heater switch, terminal No. 4, turned on and completes the circuit from terminal 2A to terminal 8, but the safety valve solenoid remains closed because the flame detector switch, in its cold position, does not energize terminal 2A of the relay. Starting of this heater then proceeds in the same manner as described for the Model 940-B, using the reserve fuel supply of the safety valve.

After ignition occurs and the flame detector switch transfers, the safety valve solenoid is energized and burning proceeds the same as in the Model 940-B, and its operation is identical. The Model 940-D Heater will shut off and re-cycle if an overheat condition, due to restriction of ventilating air, should occur since this condition will not normally affect the thermal fuse.

If an unsafe operating condition should occur, due to a lack of combustion air through the heater while it is burning, the hot gases at the combustion air inlet will quickly melt the fusible link of the thermal fuse assembly. This breaks the circuit from the heater switch through terminal No. 4 of the terminal strip, and is equivalent to turning off the heater switch. The heater will then shut down in the normal manner described for the Model 940-B, and cannot be restarted until the thermal fuse has been replaced, since the starting circuit will remain open regardless of heater switch position. In the event of such a shut down, the relay will be de-energized at the moment the overheat condition occurs, and the safety valve and fuel solenoid shut-off valve will both close at the same time without regard to flame detector switch position. The combustion air blower and ventilating air blower will continue to run until the flame detector switch cools and transfers.

13-79. INSPECTION OF HEATER AND HEATER COMPONENTS.

a. Inspect all fuel lines and fittings for fuel stains, indicating leakage, replace lines or tighten fittings as necessary.

b. Check heater for cracks, loose bolts, screws and wiring.

c. Inspect all electrical connections for corrosion, if corrosion is evident, clean all affected components and wipe clean with a slightly oily cloth.

13-80. REMOVAL OF HEATER (South Wind, Model 940 Series). The heater, located in the left side of the nose section may be removed as follows:

a. Remove the access panel at the left side of the nose section by removing attachment screws.

b. Turn all heater control switches off.

c. Disconnect hoses from the rear of the heater air distribution box.

d. Loosen, but do not remove, the four self-locking nuts securing the ventilating air blower assembly to the heater. Twist the blower clockwise and pull it straight off.

e. Disconnect the black wire of the blower motor from the heater terminal strip. The wire designation is No. 2.

f. Loosen the four screws at the side of the fuel control valve housing and lift off the cover.

g. Disconnect all of the leads from the rear of the heater terminal strip. Remove the harness clamp and the starter lead clamp from the flame detector switch guard.

h. Disconnect the dump valve push-pull control cable.

i. Remove the four cap screws located at the bottom left of the fuselage nose and remove the ring from around the exhaust pipe.

j. Pull the heater fuel drain up and out of the grommet in the bottom of the fuselage.

k. Remove the nut and lockwasher from the heater support band clamp, releasing the clamp tension.

l. Remove the cap screws from the upper and lower tubular structure brackets which support the heater. Reach into the front of the heater case and catch the washer and self-locking nut of each screw as they are freed.

m. With an assistant inside the plane using a screw driver to prevent the screws from turning, remove the four self-locking nuts from the left front seat heater system air inlet. Slide the inlet off the screws and push it away from the heater.

NOTE

The inlet is removed to permit heater removal without the heater air box striking nearby components.

n. If only one mechanic is available, an alternate method for step m above is necessary. Remove the five cap screws from the periphery of the heater air distributor box. Slide the box from the rear of the heater case. This procedure eliminates the need to disconnect the hoses and dump box control cable as described in steps c and h above.

o. Carefully remove the heater.

13-81. INSTALLATION OF HEATER. Install the heater in the reverse order of the removal instructions of paragraph 13-80, with the qualifications which follow below.

a. Position the heater between the two tubular structure brackets and secure it with two cap screws, plain washers and self-locking nuts.

NOTE

Do not attempt this step without the aid of an assistant.

b. Install the ventilating air blower on the front of the heater case with a counterclockwise twist and secure it with four self-locking nuts.

c. Apply the heater support band clamp loosely. Adjust the heater position so that the heater distributor air box does not chafe against the tubular structure and the defroster hose does not rub against the left front seat heater system air inlet. Tighten the clamp.

d. Connect the wires to the aft side of the heater terminal strip as indicated in the appropriate Wiring Schematic, Section XI.

e. Connect the black fan motor wire No. 2 to terminal No. 2 at the leading side of the terminal strip.

f. Wrap a two-inch wide strip of black electrical tape around the edge of the ventilating air blower, covering the four self-locking nuts.

g. When a new heater is installed it will be necessary to remove its nameplate. Then move the name plate aft until its two leading attaching holes coincide with the two rear mounting holes in the heater housing. Install two of the original attaching screws in the front of the nameplate. Using the two holes in the rear of the nameplate as guides, drill two holes into the heater housing and install the two remaining self-tapping attaching screws. It will also be necessary to drill two holes in the heater housing to accommodate the screws from the upper and lower tubular structure brackets.

13-82. SERVICE.

13-83. GENERAL. The Model 940 heater is specifically designed to simplify servicing procedures. All controls are easily accessible and the ventilating air blower is attached by means of bayonet slots to facilitate removal and replacement.

All repairs in the field should be confined to replacement of major subassemblies of the heater. It is not recommended that any attempt be made to repair these assemblies without shop facilities. Attempts to repair the ventilating air blower, fuel control valve, safety valve or overheat switches, without complete tools and test equipment, are likely to result in equipment failure or inadequate operation. The following major subassemblies are specially designed to permit unit replacement, and this type of maintenance is recommended for field service personnel:

a. Ventilating Air Blower
b. Flame Detector Switch
c. Fuel Control Valve
d. Igniter
e. Preheater Resistor
f. Overheat Switch
g. Cycling Switch
h. Combustion Air Blower Motor

Instructions for disassembly, repair and reassembly, appear with paragraph 13-99 of this manual. The assemblies need not be removed in the order shown since each unit is designed for separate replacement.

13-84. PERIODIC SERVICE.

a. A complete overhaul of the heater is recommended at 1000 hours of heater operating time and thereafter at 500 hour intervals.

b. The fuel filter must be cleaned at regular intervals.to prevent the condensation of moisture and formation of ice during cold weather.

c. When the fuel filter is cleaned, all fuel connections should be checked for leaks with fuel pressure applied, and all wiring connections for firmness of con-

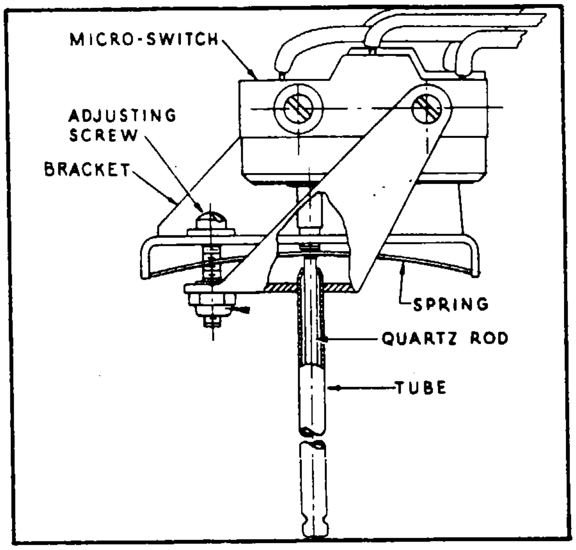


Figure 13-30. Flame Detector Switch (Cutaway View)

nections and condition of insulations.

13-85. ADJUSTING FLAME DETECTOR SWITCH. To adjust the flame detector switch, proceed as follows:

a. Loosen the two locking nuts so that the switch is held firmly but is not locked in position.

b. Back off the adjusting screw (Refer to Figure 13-30.) until the switch clicks.

c. Turn the adjusting screw in slowly until the switch just clicks again.

d. Turn the screw an additional 3/4 turn past the click point.

e. Hold the screws and tighten the switch mounting nuts. Check to make sure the adjusting bracket has not pulled away from the adjusting screw head.

13-86. TROUBLESHOOTING. The Series 940 heaters require a supply of fuel, electric current at the proper voltage, and an unrestricted supply of ventilating and combustion air for proper operation. External failure of any requirement will cause failure or malfunction, even if the heater itself is in perfect condition. For this reason the external causes should always be checked first and repaired, if necessary, before an inoperative heater is removed from the airplane, or disassembled for repair.

13-87. EXTERNAL CAUSES OF TROUBLE.

13-88. ELECTRIC CHECK.

a. Check voltage at the fuse or circuit breaker, through the heater switch and at terminal No. 3 of the heater terminal strip. Terminal No. 3 should be "hot" at any time the airplane's master switch is on. A minimum of 21 volts at these points is required for proper heater operation. Terminal No. 4 should be "hot" when the heater switch and the master switch are on.

b. Turn the heater switch to Fan or Prime position and check voltage through the switch to the hot terminal of the heater safety valve. It is possible for the safety valve to lose its charge of gasoline, in which case the heater will not start until the valve is recharged. A defective heater switch or wiring can, therefore, result in failure to start even if the heater and valve are in good condition.

c. Check wiring through the heater thermostat to terminal No. 5 of the heater. This terminal should be hot at any time the heater switch is turned on and the thermostat is calling for heat. A defective thermostat or wiring can cause the heater to burn on low heat continuously and the output will be insufficient for cold weather service.

13-89. FUEL SUPPLY. Heaters require a supply of fuel under pressure of at least one pound to operate the safety valve and to properly meter fuel to the heater. Check fuel pressure with a pressure gauge and tee fitting at the inlet to the safety valve while the engine fuel pump, auxiliary fuel pump, or other source of fuel pressure is operating. The heater fuel control valve contains a pressure regulator which will reduce fuel pressure to 1 psi for proper metering of fuel through the orifice plate. If fuel pressure at the control valve inlet is less than one pound, the pressure regulator ceases to function and the heater will burn at reduced level of heat output, or may fail to ignite. Any pressure between one and fifteen pounds will provide satisfactory operation.

13-90. COMBUSTION AIR SUPPLY. A reduced or restricted combustion air supply will usually be easy to identify since the heater will produce black smoke at the exhaust outlet and the tube will contain a deposit of soft black carbon. This condition can be caused by an obstruction of any sort in the combustion air inlet pinching off the combustion air tube or an installation defect which prevents the combustion air blower from obtaining a sufficient amount of air. Always check these external causes before changing the combustion air motor. (These same symptoms can be caused by high fuel rate.)

13-91. VENTILATING AIR SUPPLY.

a. The need for ventilating air is apparently less critical than other requirements, since the heater will usually operate at a reduced heat output without any symptoms of malfunctioning when ventilating air flow is impeded. This condition may give the appearance of inadequate heater capacity when the fault is actually an obstruction in the ventilating air stream or a duct system which unduly restricts air flow.

b. Symptoms of inadequate air flow are constant cycling on the cycling switch (or overheat switch) and a relatively high air temperature at the heater outlet. Test for cycling by connecting a test lamp to terminal No. 9 of the overheat switch (or terminal No. 30 of the cycling switch). If the heater cycles constantly, insert a thermometer into the duct about 18 inches from the heater outlet. If the temperature at this point is near 200° F., it can be assumed that ventilating air flow is inadequate and the load on the ventilating air blower must be reduced by removing an obstruction, or reducing the length of the duct system.

13-92. CHECK-OUT PROCEDURE FOR AN INOPERATIVE HEATER. If a heater fails to ignite, first check external causes previously noted, then proceed as directed in the check-out procedure below. This procedure should be followed through in the order presented, since it is designed to isolate the trouble with a minimum of disassembly.

a. On models so equipped, press the reset button of the lockout overheat switch.

b. Turn the heater control switch to Fan or Prime position and wait approximately 30 seconds (for the safety valve to charge), then turn heater switch to On position.

c. The requirements for heater ignition are (1) fuel, (2) a flow of combustion air, and (3) ignition. If the combustion air blower starts when the heater is turned on, the combustion air requirement is satisfied and the thermal fuse and lockout overheat switch are also eliminated as possible sources of trouble, since these components are necessary for blower operation. This leaves only fuel and ignition as causes of failure.

d. If the combustion air blower fails to start, it will be probable that the trouble is in the thermal fuse, lockout overheat switch, flame detector switch or the combustion air blower itself.

e. Since there is more than one possible cause of either condition described above, the heater starting circuit must be checked out in a methodical way to progressively eliminate the different components. The Starting Circuit Check assumes that the blower is inoperative. If the blower operates, the check-out procedure may be started with step (b) below, since the blower circuit will not be in question.

13-93. STARTING CIRCUIT CHECK.

a. On the Model 940-B Heater, a lack of voltage at terminal No. 6 will indicate a defective flame detector switch. If there is voltage at terminal No. 6, of any model heater, and the combustion air blower does not run, remove the heater and return it to the shop for installation of a new combustion air blower motor.

b. If there is voltage at terminal No. 6 and the combustion air blower runs, the trouble is caused by ignition failure or lack of fuel. To differentiate between these possibilities, check voltage at terminal No. 7 of the terminal strip. Loss of voltage at this point will indicate a defective flame detector switch on any model heater.

c. If there is voltage at terminal No. 7, turn off the heater switch and disconnect the igniter wire from terminal No. 7. Connect an ammeter in series between terminal No. 7 and the igniter wire, then turn on the heater switch. The igniter should draw approximately 10 amperes. If there is no current draw, either the igniter or preheat resistor is defective (any model heater). If current draw is normal and there is voltage at terminal 4A of the relay, it can be assumed that the fuel control valve shut-off solenoid is defective.

d. If the igniter current is normal, check voltage at terminal No. 9 of the overheat switch. Loss of voltage at this point indicates a defective overheat switch. If there is voltage at terminal No. 9, the fuel control valve shut-off solenoid is defective and the valve or the solenoid coil must be replaced.

13-94. RUNNING CIRCUIT CHECK. If the heater starts properly, burns for a short time and then goes out, or develops some other type of malfunction, it can be assumed that the starting circuit is operating properly and the difficulty is in the heater control system. The elements which affect heater operation, after starting, are as follows:

a. Starting safety devices
b. Fuel control components
c. The combustion air supply

13-95. STARTING SAFETY DEVICES. Failure of the flame detector switch to transfer will be indicated by failure of the ventilating air blower to start after the heater has burned for a short time. The fuel safety valve will shut off fuel after about two minutes, but the igniter will continue to be energized and may burn out before the condition is detected, since it is not designed for continuous operation.

In all cases where the heater ignites normally and then goes out, it will be necessary to differentiate between the flame detector switch and the safety valve. First, reset the flame detector switch as directed in this section, prime the safety valve, and make another trial start. If the heater goes out again, check wiring from the heater terminal strip to the safety valve and then replace the flame detector switch if no defect is found in the wire. If the valve primes when the heater switch is in Prime position but fails to prime automatically when the heater is burning, the defect will be found in the wiring between the safety valve and terminal strip, or between the terminal strip and relay on heaters so equipped. If the heater burns for less than one minute and then goes out, the safety valve is not holding an adequate charge of fuel and must be replaced.

13-96. FUEL CONTROL COMPONENTS. If the heater ignites and the ventilating air blower starts but heat output is unsatisfactory (too low, too high, or constant cycling), the trouble will be found in the thermostat, the cycling switch, or the fuel control valve. Failure of the restriction solenoid to open will cause low heat output and constant burning, regardless of thermostat setting. Failure of the solenoid to close will cause high heat output and constant cycling. Low heat and constant cycling are caused by a cycling switch or a thermostat out of adjustment. Check these causes and replace the defective component, as required.

13-97. COMBUSTION AIR SUPPLY. Since an excess of combustion air (within limitations of the blower design) does not adversely affect heater operation, the only trouble likely to be encountered with combustion air is an inadequate supply. The symptoms of combustion air restriction are easy to recognize, and have been described under External Causes of Failure in this section. If the air supply is inadequate and the trouble is not caused by restriction, replace the combustion air motor.

NOTE

The combustion air blower must not be subjected to excessive ram air pressures. The blower needs about 1 to 2 inches of water ram air pressure above the pressure in the heater exhaust, but ram air pressures above 3 inches of water are quite liable to cause blower wheel failure.

13-98. TROUBLESHOOTING CHART. The Troubleshooting Chart is a brief summary of the defects and remedies discussed in this Section. This chart at the back of this section may be used as a guide when servicing a heater which fails to perform properly when installed.

13-99. DISASSEMBLY, REPAIR AND REASSEMBLY. An overhaul of the 940 heater consists of a complete disassembly, cleaning, repair, reassembly and test, as described in the following pages. The information is presented in overhaul sequence, but it should be noted that parts are not necessarily removed in the order shown. When making repair or replacements, it is possible to remove most subassemblies without disturbing other parts.

The instructions in the following paragraphs cover all models of the 940 Series heaters. Figure 13-31 is a composite exploded parts view, showing all parts used on all heaters. Not all of these parts are used on any one heater, but the differences and usage of parts are noted in the text. The procedures outlined below are applicable to all models, unless otherwise noted.

The following special service tools are recommended for service and overhaul of the 940 heater.

a. Fuel Valve Screen Tool
b. Igniter Housing Scraper

13-100. DISASSEMBLY. (Refer to Figure 13-31.)

a. Remove the combustion air inlet adapter (1) by removing the sheet-metal screw (2) in its center.

b. Remove the shroud adapter (3) by removing the six screws (4) from the weld nuts in the heater housing.

NOTE

The combustion air inlet adapter and shroud adapter may remain in the airplane when the heater is removed. If attached to the heater they may have other installation parts welded or clamped to them. If such is the case, note positions of such parts before they are removed.

c. Remove the exhaust extension (5), washers (6), "O" ring (7), and gasket (8) from the heater exhaust outlet.

13-101. VENTILATING AIR BLOWER. (Refer to Figure 13-31.)

a. To remove the ventilating air blower (9), disconnect the blower lead from the heater terminal No. 2, or the relay terminal No. 2A, and free the wire.

b. Loosen, but do not remove the four nuts (10) which secure the blower to the heater housing.

c. Turn the blower counterclockwise and pull it straight off of the heater housing.

d. Remove the air inlet louver (11) from the blower assembly by removing the three screws (12).

13-102. FUEL CONTROL VALVE. (Refer to Figure 13-31.)

a. Remove the cover (13) from the fuel control valve housing by loosening the four screws (16). Disconnect valve solenoid leads.

b. Disconnect the short fuel line (17) from the standpipe by loosening the compression nut (18). The ferrule (19) will remain on the fuel line.

Lift the fuel control valve (20) out of the housing and remove the fuel line (17) from the valve by removing the compression nut. Do not attempt to remove the ferrules from the fuel line.

13-103. FLAME DETECTOR SWITCH. (Refer to Figure 13-31.)

a. Disconnect leads of the flame detector switch (40) from the terminal strip, or from terminal strip and relay, according to heater model.

b. On model 940-D, disconnect wires from relay (25) by removing terminal screws (28). Reinstall screws in terminals.

c. Remove the four screws (24) which secure the flame detector switch guard (23) to the heater housing. Remove the guard and relay as an assembly, on heaters so equipped.

d. On heaters equipped with the relay (25), remove the nut (26) and lockwasher (27) to free the relay ground wire and relay assembly.

e. Loosen the compression nut (42) underneath the flame detector switch (40) and back it off until it clears the threads of the heat exchanger bushing.

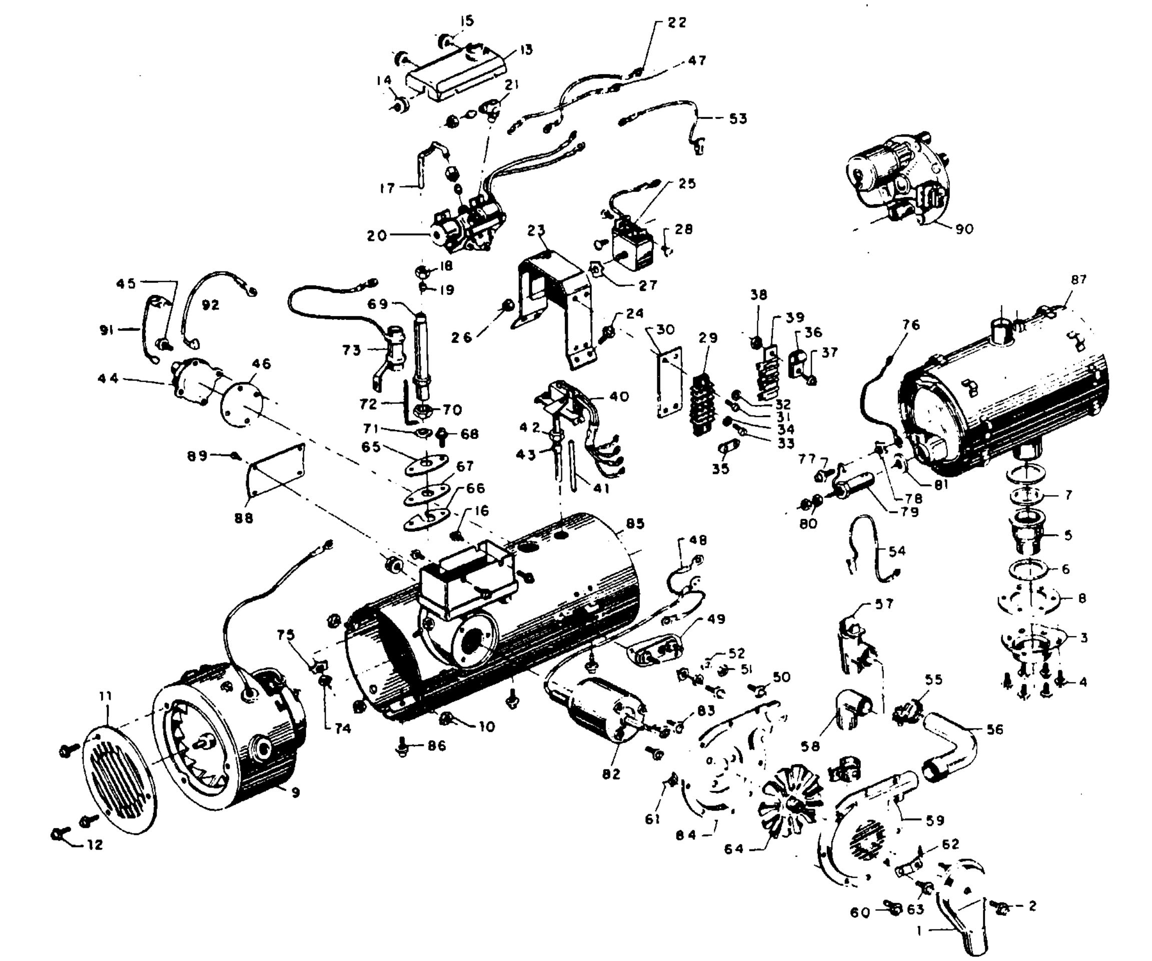
f. Pull the flame detector switch straight out of the heat exchanger, being careful not to bend the tube since it contains a quartz rod (41) which may be broken by rough handling.

13-104. LOCKOUT OVERHEAT SWITCH. (Refer to Figure 13-31.)

a. On models so equipped, disconnect push-on lead of the lockout overheat switch (44) from the thermal fuse (57). Remove the overheat switch by removing the four screws (45). On older model heaters, the leads (91 and 92) are attached to the switch. On later production units, leads are separate.

b. On the 940-D and later production 940-B heater, the lockout overheat switch is not used, but provision for its installation has been made and the heater housing will have a circular cover plate (46) in its place. This cover need not be removed for overhaul.

13-105. CYCLING OVERHEAT SWITCH. (Refer to Figure 13-31.) On all models, remove the cycling overheat switch, or cycling temperature control switch (49) by removing the two attaching screws (50). These switches appear identical on all heaters, but are set at a lower temperature on models which have the lockout overheat switch and have a different part number.



1. AIR INLET ADAPTER
2. SCREW
3. SHROUD ADAPTER
4. SCREW (6 REQ)
5. EXHAUST EXTENSION
6. WASHER (2 REQ)
7. "O" RING
8. GASKET
9. VENTILATING AIR BLOWER
10. NUT (4 REQ)
11. AIR INLET LOUVER
12. SCREW (4 REQ)
13. COVER
14. GROMMET (2 REQ)
15. GROMMET
16. SCREW (4 REQ)
17. FUEL LINE
18. NUT (3 REQ)
19. FERRULE (3 REQ)
20. FUEL CONTROL VALVE
21. ELBOW
22. WIRE ASSEMBLY
23. GUARD
24. SCREW (4 REQ)
25. RELAY
26. NUT
27. LOCKWASHER
28. SCREW (3 REQ)
29. TERMINAL STRIP
30. INSULATOR
31. SCREW (4 REQ)
32. WASHER
33. SCREW (10 REQ)
34. WASHER (4 REQ)
35. JUMPER
36. CLAMP
37. SCREW
38. NUT
39. FANNING STRIP
40. FLAME DETECTOR STRIP
41. QUARTZ ROD
42. NUT
43. FERRULE
44. LOCKOUT OVERHEAT SWITCH
45. SCREW (4 REQ)
46. COVER
47. WIRE ASSEMBLY
48. WIRE ASSEMBLY
49. CYCLING OVERHEAT SWITCH OR LIMIT SWITCH
50. SCREW
51. NUT
52. WASHER
53. WIRE ASSEMBLY
54. WIRE ASSEMBLY
55. CLAMP (2 REQ)
56. ELBOW
57. THERMAL FUSE
58. ELBOW
59. BLOWER COVER
60. SCREW (9 REQ)
61. NUT (9 REQ)
62. BRACKET
63. SCREW (2 REQ)
64. BLOWER WHEEL
65. FLANGE
66. TAPPING PLATE
67. GASKET
68. SCREW (2 REQ)
69. STANDPIPE
70. NUT
71. "O" RING
72. KNIT CABLE
73. PREHEAT RESISTOR
74. NUT
75. LOCKWASHER
76. GROUND STRAP
77. SCREW
78. LOCKWASHER
79. IGNITER
80. NUT
81. GASKET
82. COMBUSTION AIR MOTOR
83. SCREW (3 REQ)
84. BLOWER HOUSING
85. HEATER HOUSING
86. SCREW (3 REQ)
87. HEAT EXCHANGER ASSY
88. NAMEPLATE
89. SCREW (4 REQ)
90. SAFETY VALVE
91. CABLE ASSEMBLY
92. CABLE ASSEMBLY

Figure 13-31. Exploded Parts View, Heater Assembly

13-106. COMBUSTION AIR BLOWER. (Refer to Figure 13-31.)

a. Loosen the two clamps (55) which attach the combustion air elbows (56 and 58), or elbow (56) and thermal fuse (57). Only two of the parts illustrated are used on any one heater. The thermal fuse (57) is used on all models except the 940-B, which has the plain elbow (58). On all models, disassembly is the same. Disconnect wires from the thermal fuse (if used) and then work the two parts off the blower outlet and heat exchanger inlet. Separate parts after removal.

NOTE

On some early models of the 940-B heater, two elbows of the same size were used. If one of these elbows should become damaged, two new elbows (56 and 58) must be used for a replacement, since the old elbow will not mate with the new.

b. Remove the cover (59) of the combustion air blower, by removing the nine screws (60) and speed nuts (61). It is not necessary to remove the bracket (62), or screws (63) unless replacement is required.

c. Loosen the set screw in the hub of the blower wheel (64) and slide the wheel off the motor shaft.

13-107. STANDPIPE AND PREHEATER RESISTOR. (Refer to Figure 13-31.)

a. Remove the two screws (68) from the fuel line flange (65) and tapping plate (66). Remove the two plates and the gasket (67).

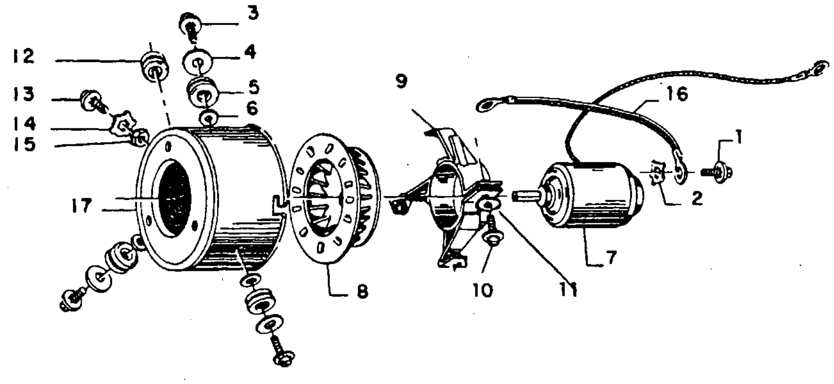
b. Disconnect preheater connector strip from the igniter (70) and loosen the large hex nut (70) on the bottom of the standpipe (69), one or two turns. Remove the standpipe by backing off the smaller hex, which is welded to the pipe. When the threads are clear, the standpipe (69) and preheat resistor (73) can be lifted out through the opening in the heater housing.

c. Remove the preheat resistor (73) from the standpipe and pull out the knit cable (72). Discard the cable and the "O" ring (71). These parts must be replaced at each overhaul.

13-108. IGNITER. (Refer to Figure 13-31.)

a. Remove the nut (74) and lockwasher (75) from the ground stud inside the heater housing, to free the igniter ground strap (76), then remove the screw (77) and lockwasher (78) to free the igniter ground wire.

b. Remove the igniter (79), using a 13/16 inch deep socket, and remove and discard the igniter gasket (81).



1. SCREW	7. MOTOR	12. GROMMET
2. LOCKWASHER	8. BLOWER WHEEL	13. SCREW
3. SCREW (3 REQ)	9. MOTOR MOUNTING BRACKET	14. LOCKWASHER
4. WASHER (3 REQ)		15. NUT
5. GROMMET (3 REQ)	10. SCREW	16. GROUND STRAP
6. WASHER (3 REQ)	11. LOCKWASHER	17. HOUSING

Figure 13-32. Exploded Parts View, Ventilating Air Blower Assembly

13-109. COMBUSTION AIR MOTOR. (Refer to Figure 13-31.)

a. To remove the combustion air motor, it is necessary to first remove the combustion air elbows, the blower housing cover, the blower wheel, the stand-pipe and the preheat resistor.

b. After removing the parts noted above, remove the three mounting screws (83) and remove the motor (82) from inside the housing. This will also free the blower housing (84).

13-110. HEAT EXCHANGER. (Refer to Figure 13-31.) Remove the three screws (86) from the seam of the heat exchanger housing (85) and spread the housing sufficiently to permit the heat exchanger (87) to drop out through the end of the housing.

13-111. VENTILATING AIR BLOWER. (Refer to Figure 13-32.)

a. Remove the screw (1) and lockwasher (2) from the end of the motor (7) to free the motor from the ground strap.

b. Remove the three screws (3), washers (4), grommets (5), and small washers (6) to free the motor mounting bracket (9), then withdraw the motor (7), bracket (9), and blower wheel (8) as an assembly.

c. Loosen the set screw in the hub of the blower wheel (8) and remove the wheel from the motor shaft.

d. Mark the position of the mounting bracket (9) on the motor (7) and remove the bracket by loosening the screw (10).

e. Remove the screw, lockwasher and nut (12, 13 and 14) from the blower housing to free the ground strap (15), then remove the grommet (11) from the housing.

13-112. INSPECTION, CLEANING AND REPAIR.

13-113. HEAT EXCHANGER.

a. Inspect the heat exchanger for possible damage or leaks. Small cracks in the header plate or seams may be repaired by welding, provided the work is done by a welder who is thoroughly experienced in the welding of stainless steel. If the heat exchanger has large cracks, is excessively warped, or has burned through at any point, it must be replaced. When welding cracks, Type 347 weld rod is preferred, although 321 or 310 may be used.

NOTE

Before welding, it is very important to clean all combustion deposits away from the area to be welded, since the lead compounds in the heat exchanger can contaminate the weld to such an extent that a tight weld is almost impossible. Keep all weld beads as small as possible, preferably not over 1/8 inch.

b. Clean combustion residue from inside walls of igniter housing with igniter housing scraper tool.

c. Remove combustion residue from inside heat exchanger by soaking this assembly in a 20% by weight solution of ammonium acetate at a temperature of 180° F., for a period of 5 to 10 hours. Flush out exchanger with water after cleaning, and dry as well as possible with compressed air. This is the preferred method of cleaning. An alternate is to tap the heat exchanger lightly with a rawhide mallet to loosen carbon from the walls. This will loosen most of the residue, which may then be blown out with compressed air.

d. Pressure test heat exchanger by plugging openings and applying 10 psi air pressure to the flame detector switch or standpipe bushing while the unit is submerged in water. Leakage will be indicated by bubbles. No leakage is permitted.

13-114. FUEL CONTROL VALVE. Replace valve if found defective.

13-115. BLOWER ASSEMBLIES.

a. Clean both blower wheels, housings, and the ventilating air blower motor mounting bracket with dry cleaning solvent and blow dry. Wipe off outside of motors with a cloth dampened in solvent, but do not immerse motors.

b. Inspect blower wheels for bent blades and cracks. Pay special attention to the combustion air blower wheel. The slightest evidence of small cracks in, or around, the strain relief cutouts near the hub, is reason to replace this wheel.

13-116. VENTILATING AIR BLOWER MOTOR OVERHAUL. (Refer to Figure 13-33.) An overhaul kit, PAC Part No. 754 306, is available for all ventilating air blower motors of the 940 Series. This kit contains new bearings, brushes, and other parts required for installation. To overhaul the motor, proceed as follows:

a. Remove the two nuts (1) from the end of the motor and pull the end bell (3) off far enough to permit unsoldering of the capacitor lead from the eyelet on the brush holder insulator. Remove the end bell (3).

b. Remove the two nuts (12) from the other end of the motor and pull the two long studs (11) out of the stator (16) without disturbing the two nuts (4) which are threaded part way down to center the studs in the stator.

c. Pull the brush holder (6) out far enough to unsolder stator leads from the eyelets, then remove the brush holder assembly and brushes. If the stator does not have flexible leads to the solder eyelets, cut leads off close to the windings and solder in new leads of flexible stranded wire. This will prevent possible future failure due to vibration.

d. Pull the rotor (13) out of the stator (16). The bearings will remain on the rotor shaft.

e. Remove the load springs (14) from inside the stator (16).

f. Clean the shaft and pull the bearings off the shaft of the rotor (13) with a bearing puller, using anti-seize compound as a lubricant.

g. Clean all parts with a soft bristle brush and blow off with compressed air. Sand commutator of rotor (13) if necessary, or turn down slightly. Do not attempt to repair a badly worn motor. Replace the entire assembly if major repairs are required.

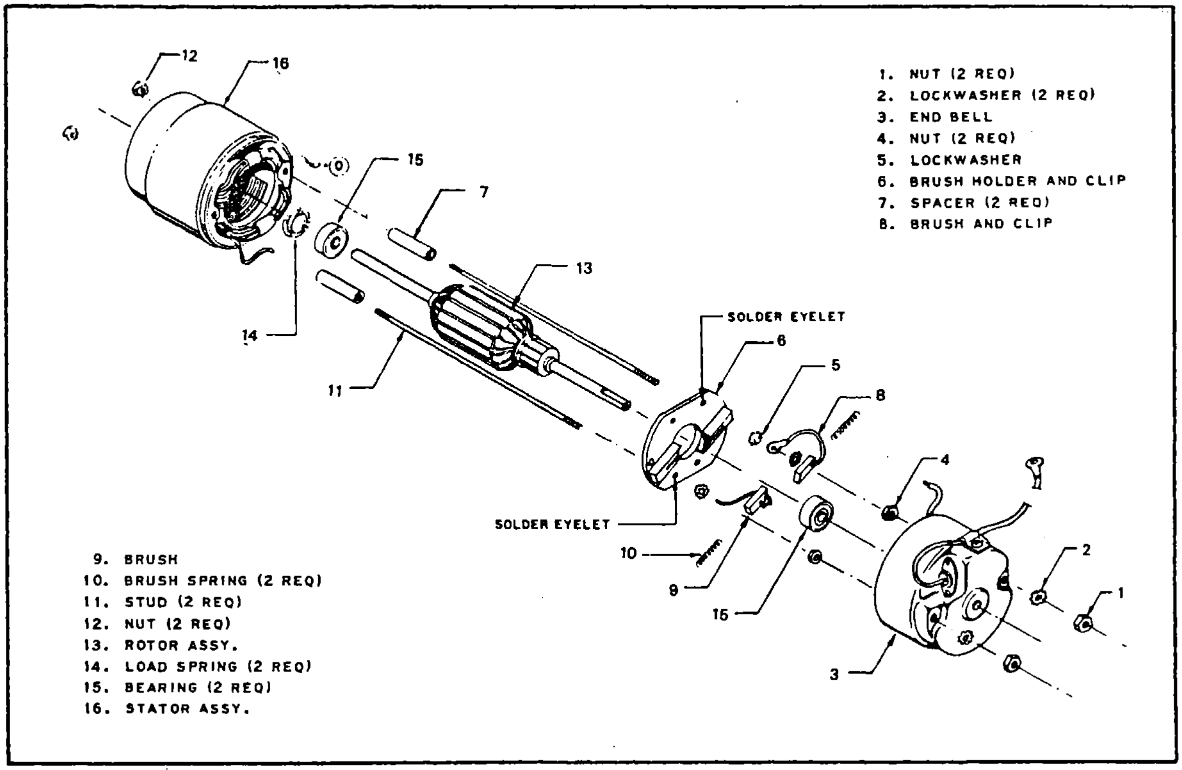


Figure 13-33. Ventilating Air Blower Motor

NOTE

If the commutator is turned, the lathe tool must be ground for copper and must be extremely sharp. Commutator slots must be cleaned after turning to avoid shorts between bars. Sand lightly after turning.

h. Press new bearings on the rotor shaft until they bottom against shoulders on the shaft, using a lubricant.

i. Reassemble the motor parts, using new brushes, brush springs and load springs from the kit. Note that two sets of brushes are provided. Use the new brushes which fit the motor brush holders. The 718855 springs must be used with 1/4 x 3/8 brushes and the 717472 springs with 1/4 x 1/4 brushes. Make sure that stator leads and capacitor lead are securely soldered.

j. No specific test of the motor is required after this repair procedure provided the rotor turns freely and the motor performs satisfactorily after reassembly into the blower assembly. Extensive repairs, that would require performance testing after completion are not recommended.

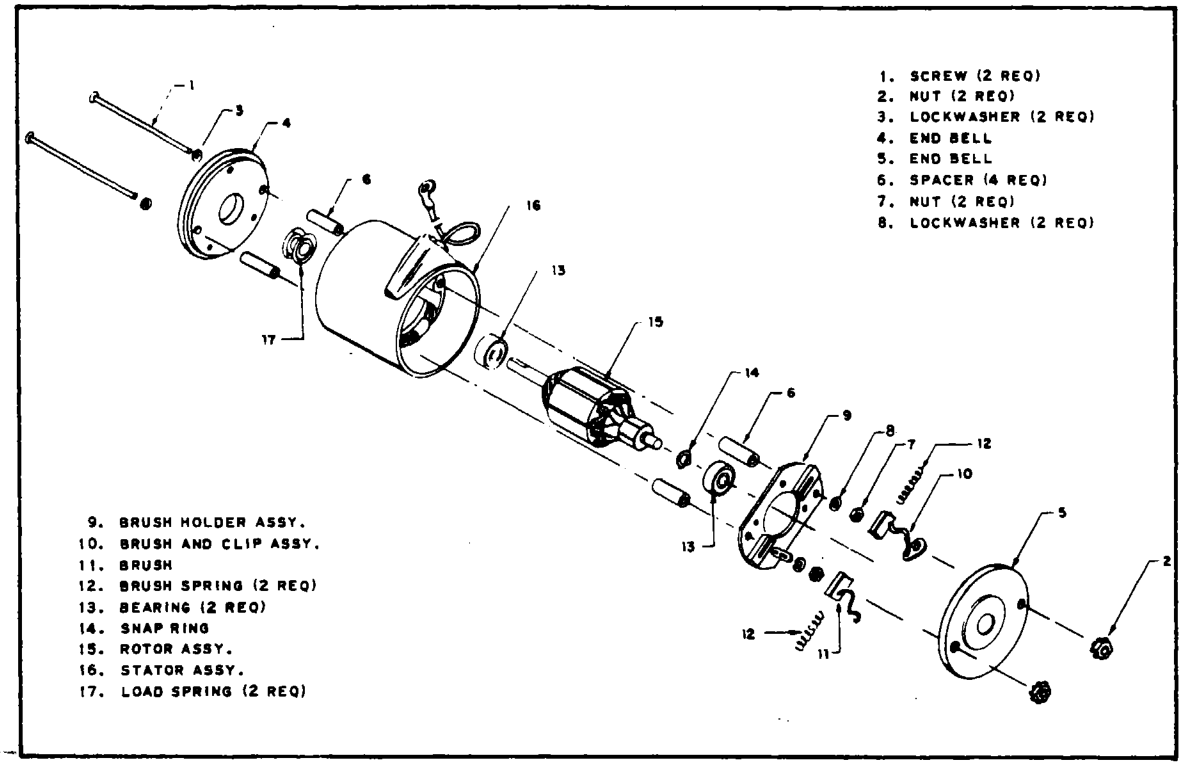


Figure 13-34. Combustion Air Blower Motor

13-117. COMBUSTION AIR BLOWER MOTOR OVERHAUL. (Refer to Figure 13-34.) An overhaul kit, PAC Part No. 754 307, is available for overhaul of the combustion air blower motor on all models of the 940 Series heaters. To overhaul motor, proceed as follows:

a. Remove the two nuts (2) from the end of the motor and remove the end bell (5).

b. Loosen the two small nuts (7) slightly with a 1/4 inch end wrench (or deep socket), then remove long screws (1) with a screw driver while holding nuts (7). This will free the other end bell (4) and spacers (6).

c. Pull the brush holder assembly (9) out far enough to unsolder the stator lead and remove this entire assembly.

d. Pull the rotor (15) out of the stator (16) with bearings on the shaft. Clean the shaft and remove the bearings with a bearing puller, using a lubricant on the shaft.

e. Clean all parts with a soft bristle brush and blow off with compressed air. Sandpaper commutator of rotor (15) or turn down slightly if required.

NOTE

If the commutator is turned, the lathe tool must be ground for copper and must be extremely sharp. Commutator slots must be cleaned after turning to avoid shorts between bars. Sand lightly after turning.

f. Rebuild motor using new bearings (13), brushes (10 and 11), and brush springs (12). When soldering brush pigtails, use long nosed pliers next to the solder joint to prevent solder from "wicking" into the pigtail.

g. No specific test of the motor is required after the above repair procedure provided the shaft turns freely and the motor performs satisfactorily when reinstalled in the heater. More extensive repairs than those described should not be attempted.

13-118. HEATER HOUSING.

a. Clean inside and out with dry cleaning solvent, and inspect housing for roundness and dents. Straighten, or re-shape as necessary.

b. Replace all rubber grommets in the housing.

13-119. FLAME DETECTOR SWITCH. Check bow spring to see if pressure of quartz rod is causing it to bow up toward the top of the switch. If the spring is not bowed, but is in a straight position, the quartz rod is broken and must be replaced.

If such is the case, proceed as follows:

a. Loosen the two switch mounting screws.

b. Remove the adjusting screw.

c. Turn micro switch back on the bracket and remove the bow spring. Inspect condition of the quartz rod.

d. If the quartz rod is broken or chipped on either end, it must be replaced. If it is in good condition, replace it in the tube, turn the switch back into position and reinstall the adjusting screw.

e. Back off the adjusting screw until the switch clicks, indicating that the micro switch has transferred.

f. Turn the adjusting screw slowly in, until the switch just clicks again, to determine point of transfer, then turn the screw exactly 3/4 turn past the transfer point.

g. Hold the screws and tighten micro switch mounting nuts to lock switch securely in place.

13-120. OVERHEAT SWITCH AND CYCLING SWITCH. Visually inspect the overheat switch, or cycling switch, for damage and clean contacts by sliding a strip of clean bond paper between the contacts. Do not use a file or sandpaper, and do not attempt to bend the contact arm. These switches are adjusted at the factory and the adjustment cannot be changed in the field. Replace switch if found defective.

13-121. THERMAL FUSE AND COMBUSTION AIR ELBOWS.

a. Inspect for dents and fit between parts.

b. Clean elbows with dry cleaning solvent and blow out with compressed air.

c. Inspect fusible link of thermal fuse assembly for tightness of the attaching screws and condition of the link. The attaching screws may be tightened if loose, but the entire assembly must be replaced if the link has been damaged or fused. Do not use compressed air to clean the thermal fuse assembly.

13-122. SAFETY VALVE AND FILTER.

a. To clean filter, remove bowl by loosening bail nut and clean inside of bowl. Wash filter element in dry cleaning solvent and blow dry by directing compressed air jet inside the filter. When replacing the bowl, make sure the gasket is in place.

b. Replace the fuel screen in the safety valve and wipe off the outside with a cloth dampened in cleaning solvent. Do not disassemble, or attempt to repair this unit.

c. Replace safety valve if found defective.

13-123. WIRING.

a. Inspect all heater wiring for condition of insulation, and condition of solder connection of the terminals. Repair, or replace, as required.

b. Inspect the terminal strip for damage, and the terminal screws for condition of threads.

13-124. RELAY. Apply a variable voltage between terminal 4A of the relay and the ground wire. Increase and decrease the voltage to determine relay pull-in voltage. The 12 volt relay must pull in at not more than 9 volts. Replace relay if not within limits.

13-125. REASSEMBLY.

13-126. VENTILATING AIR BLOWER. (Refer to Figure 13-32.)

a. Replace the bracket (9) on the motor (7) in its original position and tighten the screw (10). Slip the wheel (8) on the motor shaft but do not tighten the set screw.

b. Install large flat washers (4), new grommets (5), and small washers (6) on each of the three motor mounting bracket screws (3), in order illustrated.

c. Fit the motor and bracket assembly into the housing and start ends of the mounting bracket screws (3) into the weld nuts on the bracket with the washers and grommets on the screws. After screws are started, drop the small washers (6) through the holes in the housing and stuff grommets (5) into the holes. Tighten the screws alternately and evenly to apply a firm pressure to the grommets, and center the motor in the housing. Do not over tighten screws (3), since this will defeat the purpose of the shock-mounting grommets.

d. Reconnect the ground wire (15) to the end of the motor by reinstalling the screw (1) and lockwasher (2).

13-127. HEATER ASSEMBLY. (Refer to Figure 13-31.) Reassembly of the heater is essentially the reverse of disassembly. If the heater is completely disassembled, reassembly will be simplified by following the procedure below, instead of a strict reversal of disassembly.

a. Reinstall the combustion air motor (82) from inside the heater housing (85), place the blower housing (84) on the outside and reinstall the three screws (83). Replace blower wheel (64) on the motor shaft. Adjust wheel for 1/16 inch clearance from housing, and tighten set screw.

b. Replace the blower housing (59) by reinstalling nine screws (60) and speed nuts (61).

c. Reinstall the igniter (79) in the heat exchanger (87), using a new gasket (81), and tighten with a 13/16 inch deep socket. Reinstall the screw (77) to connect the igniter ground wire, attaching one end of the bonding strap (76) with the same screw and lockwasher (78).

d. Adjust the vaporizer cable (72) in the standpipe (69), so that it extends about 1/2 inch from the threaded end. Smooth the end of the cable and twist strands so that loose particles will not break off on threads inside the heat exchanger. Run the nut (70) up on the threads of the standpipe as far as it will go. Place a new "O" ring (71) on the threads at the bottom. Reinstall the standpipe in the heat exchanger by first turning the welded hexagon down tightly into the threads, then turning down the nut (70) against the "O" ring, to obtain a tight seal.

e. Spread the housing and combustion air blower assembly, and fit it over the heat exchanger, with the end of the standpipe projecting through the opening provided. Reinstall the three screws (86) in the seam of the housing. Attach the free end of the igniter ground wire bonding strap (76) to the stud inside the housing, using the nut (74) and lockwasher (75).

g. Fit the tapping plate (66) around the standpipe inside the housing, and place a new gasket (67) and the old flange (65) on the outside. Reinstall the two screws (68) to secure and seal the standpipe.

h. Fit the large combustion air elbow (56) and small elbow (58), or thermal fuse (57) loosely together, using one of the clamps (55). Fit these parts on the combustion air blower outlet and heat exchanger inlet, using the remaining clamp (55). Adjust parts to fit, then tighten both clamps securely.

i. Reinstall the overheat switch, or cycling switch (49), by reinstalling the two screws (50). Do not overtighten screws, since this may distort the switch and affect its calibration. Also, reinstall the lockout overheat switch (44), on models so equipped, by reinstalling the four screws (45).

j. Reinstall the flame detector switch (40) by tightening the nut (42) on the ferrule (43). Tighten nut firmly, but avoid excessive crushing of the flame detector switch tube. If a new flame detector switch is being installed, use a new ferrule (43) and nut (42). These parts should remain on the tube after the first installation, since the ferrule will be firmly pressed onto the tube. This does not affect operation of the switch which may be removed and replaced, as required, so long as it continues to function properly.

k. Reinstall the terminal strip (9) and insulator (30) on the flame detector switch guard (23) by reinstalling the four screws (31). Also, reinstall the relay (25), on models so equipped, by installing the lockwasher on the relay stud inside the guard, then the relay ground wire and the lockwasher nut (26). Tighten nut securely to obtain good electrical contact, then reinstall guard (23) over flame detector switch, using the four screws (24).

l. Connect the short fuel line (17) to the outlet of the fuel control valve (20) and tighten compression nut finger tight. Start the screws (16) into the nuts on the fuel control valve mounting bracket. Fit the fuel control valve into the housing and the fuel line into the standpipe, then tighten the two compression nuts (18) very carefully. Fit new grommets (14 and 15) into the slots in the valve housing, then fit the cover (13) on the housing and tighten the four screws (16) into the fuel control valve mounting bracket.

m Reinstall the air inlet louver plate (11) on the ventilating air blower (9) using screws (12), and reinstall the blower on the heater housing.

n. Install the loose wires (54, 53, 48 and 47), according to the wiring diagram for the heater model, and connect leads of all electric components, using the wiring diagram as a guide. All leads are numbered, with the exception of the two push-on terminals which connect to the thermal fuse. Connect these wires to the nearest terminal. The thermal fuse has no polarity.

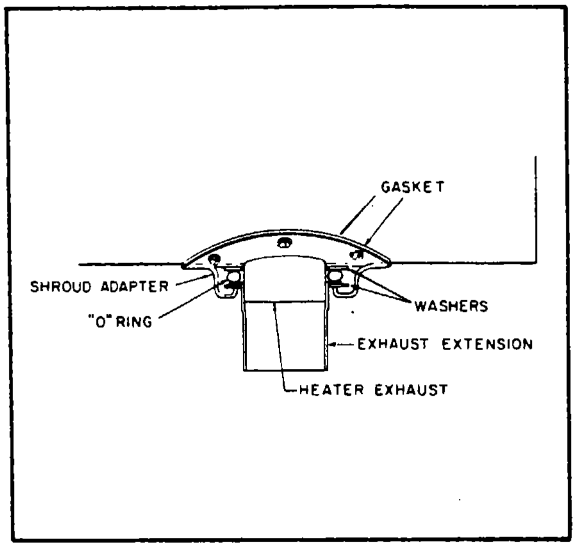


Figure 13-35. Detail of Exhaust Extensions Installation

o. Place flat washers (6), new "O" ring (7), exhaust extension (5), and flat washer (6) on heater exhaust. Fit new gasket (8) around exhaust and install shroud adapter (3) to hold entire assembly by reinstalling six screws (4).

p. Reinstall the air inlet adapter (1) when the heater is reinstalled in the airplane.

13-128. TESTING.

13-129. GENERAL. Any heater that has been overhauled, or subjected to major repair, should be tested before being returned to service. The test should include a "leak test" and "flow test" of the fuel control valve, a "burn test" of the assembled heater, and a test of the overheat switch.

NOTE

The heat exchanger should have been leak tested as directed in paragraph 13-113 prior to reassembly.

13-130. TEST SET-UP. The test set-up should include the following components:

a. A suitable cradle or bracket for mounting the heater with provision to dispose of the exhaust gases.

b. A source of 12 volts DC. This should be a variable source from a transformer and rectifier, so that the voltage can be regulated, and must include a voltmeter and ammeter.

c. A source of fuel at a pressure of 1 to 15 psi. A filter should be included in the fuel supply line. Fuel pressure may be supplied by a gravity system with a head of at least four feet, or by an electric fuel pump.

d. A glass graduate of the type shown in Figure 13-36 is required for testing the fuel control valve, unless a flow meter is available in the fuel supply line.

e. A strobo-type tachometer, although not necessary is desirable to time blower speed.

f. An oven and thermometer, for testing the lockout overheat switch.

13-131. TEST PROCEDURE. The heater test should be conducted in the following order, if possible, since the heater must be cold at the start of the overheat switch test.

13-132. FUEL CONTROL VALVE LEAK TEST. Remove the fuel control valve from the heater, or test the valve separately before reassembly, during the overhaul. Proceed with test as follows:

a. Connect the control valve to the fuel source.

b. Install the short heater fuel line (Figure 13-31, Ref. 17) in the fuel control valve outlet, in its normal position. Support the valve in its normal mounting position (Refer to Figure 13-36.) so that fuel from the fuel line will drip into a glass graduate.

NOTE

The valve must be supported in a normal position so that a line through the mounting screw holes of the bracket will be level. Failure to test the valve in its proper position will affect the fuel rate and may cause rejection of good equipment.

c. Ground the body of the fuel control valve and apply a test voltage to each of the solenoid leads. A distinct click should be heard when the solenoids are energized.

d. Turn on the fuel pressure and energize both solenoids at once. Allow fuel to flow through the valve for a few seconds, then de-energize both solenoids. One or two drops of fuel may fall from the outlet within 15 seconds after the solenoids are closed. After 15 seconds, a drop of fuel may form, but it should not fall. If the valve does not shut off completely, it must be replaced.

13-133. FUEL CONTROL VALVE. Check fuel flow through the valve, as follows, using the test set-up illustrated in Figure 13-36.

a. Energize both solenoids and permit fuel to flow through the valve for a few seconds.

b. Place a glass graduate under the valve outlet and permit fuel to flow for exactly 60 seconds, then shut off both solenoids.

c. Read the graduate at eye level - it should contain the amount of fuel shown in the chart for high heat fuel flow.

d. Repeat the above test with the restriction solenoid de-energized (low heat fuel flow). The graduate should then contain the amount of fuel shown in the table

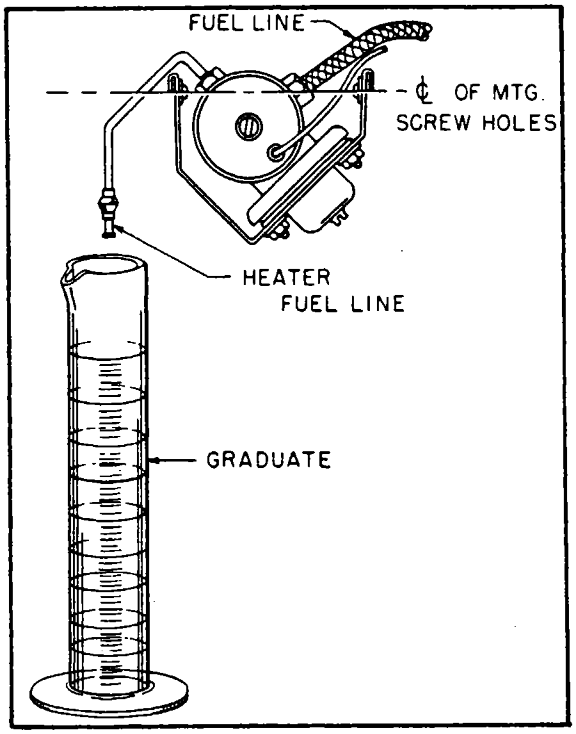


Figure 13-36. Fuel Flow Test Set-Up

for low heat fuel flow.

e. If fuel flow is not within limits, turn adjusting screw clockwise to increase or counterclockwise to decrease fuel flow and retest. Both low and high heat fuel flow must be within limits for proper operation of the heater. Replace or repair the valve if it cannot be brought within limits by adjustment. Reseal the adjusting screw with glyptal cement after test.

13-134. OVERHEAT SWITCH TEST (Models 940-D and 940-DA only).

Install the fuel control valve on the heater and install the heater on the test fixture. Make fuel and electrical connections. Proceed with overheat switch test as follows (Heater should be at room temperature when test is started):

a. Set the HI-LO switch to HI. Preset the voltage control so that voltage, with full starting load, will be 11 volts for the 12 volt heater.

b. Cover the inlet of the ventilating air blower with cardboard or sheet metal, to stop off all flow of ventilating air.

c. Turn on the control switch. Start timing the operation as soon as ignition occurs. When the flame detector switch transfers, reset voltage to 11 volts.

d. Continue timing until the overheat switch opens and shuts off fuel flow (combustion will stop in the heater). This time must be more than 50 seconds, but less than 80 seconds from the moment of ignition. Replace the overheat switch, if not within limits.

FUEL FLOW CHART

Heater Model	Fuel Pressure	High Heat	Low Heat
940-B	1 to 15 psi	16 ± 2 cc (0. 023 to 0. 029 lb/min on flowmeter)	3. 5 to 6 cc (0. 006 to 0. 011 lb/min on flowmeter)
940-D	1 to 15 psi	22 ± 2 cc (0. 034 to 0. 041 lb/min on flowmeter)	7. 0 to 9. 0 cc (0. 010 to 0. 014 lb/min on flowmeter)
940-DA	1 to 15 psi	22 ± 2 cc (0. 034 to 0. 041 lb/min on flowmeter)	12 ± 2 cc (0. 016 to 0. 020 lb/min on flowmeter)

13-135. BURN TEST. Shut the heater off and remove the cover from the ventilating air blower inlet. Allow time for the heater to cool. Proceed with "burn test" as follows:

a. Turn on the heater switch and adjust voltage to 12 volts. Start timing heater action from the moment the switch is turned on.

b. The current draw should not exceed 13 amperes.

c. Ignition should occur within 20 seconds from the moment the switch is turned on.

d. The flame detector switch should close more than 8 seconds, but less than 25 seconds, from the instant the heater ignites.

e. Readjust voltage immediately after the flame detector switch transfers, and allow the heater to run on high heat for at least one minute. If a tachometer is available, the speed of the combustion air motor should be determined with the combustion air adapter removed, and with no restriction on the heater exhaust. The speed should be at least 5000 RPM. In the absence of a suitable light to time the blower, it can be presumed to be operating properly if the heater burns normally and did not have an excessive deposit of carbon in the exhaust tube, or combustion chamber, when cleaned during overhaul. Speed of the ventilating air blower is not critical, since it has no direct effect on combustion.

f. After the heater has burned on high heat for one minute, turn the HI-LO switch to LO. Burning should decrease in intensity and the heat output should be reduced.

g. Turn off the control switch. Burning must stop within 45 seconds, and both blowers should continue to run for more than one minute but less than two min-

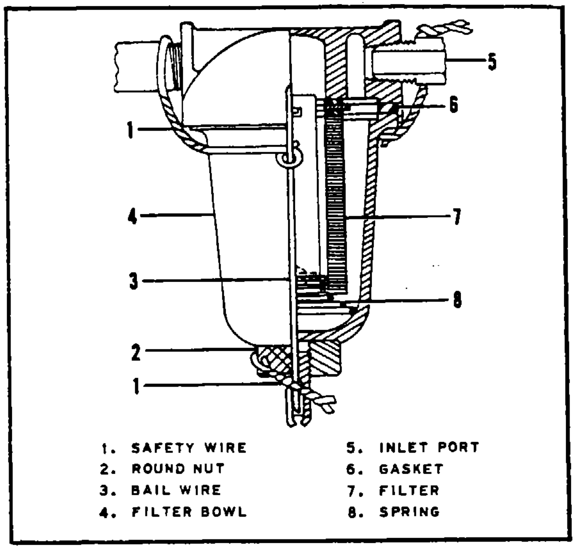


Figure 13-37. Heater Fuel Filter

utes twenty seconds (time from instant the switch is turned off).

13-136. REPLACEMENT OF FUEL FILTER ELEMENT. The fuel filter element located on the aft bulkhead in the fuselage nose section, may be replaced by the following procedure:

a. Remove the access panel from the right side of the nose section.

b. Cut the safety wire on the bottom of the filter.

c. Remove the bowl and filter by unscrewing the round nut at the bottom of the bowl.

d. Clean the bowl and filter with a dry cleaning solvent. Replace the filter element and gasket as necessary.

e. Position the bowl and filter, tighten the round nut and safety with MS20995C32 safety wire.

f. Operate the system and check for fuel leaks.

13-137. REMOVAL OF HEATER FUEL VALVE. The fuel control valve for heater operation, located in the fuel control box between the two front seats, may be removed by the following procedure:

a. Remove the two front seats from the airplane.

b. Remove the attaching screws from around the top and sides of the fuel control box.

NOTE

If the valve is being removed due to leakage and it is determined that the leakage is around the stem, the stem may be replaced without removing the valve body.

c. Lean the box forward and disconnect the outlet fuel line from the valve in the right side of the box.

d. Disconnect the knob and rod from the top of the valve by removing the self-locking nuts and machine screws.

e. Remove the valve by unscrewing it from the attaching fitting.

13-138. INSPECTION AND REPAIR OF HEATER FUEL VALVE. (Refer to Figure 13-38.)

a. Remove the elbow fitting from the valve assembly.

b. The stem assembly (2) may be removed by unscrewing the cap nut (6) with stem handle (3).

c. Inspect the stem, seat body and threads for possible damage.

d. If any part of the stem assembly (2) is damaged or if the cap nut (6) is not drilled for safetying purposes, replace the assembly.

e. Reassemble the unit and tighten the cap nut (6) tight enough to prevent leakage but not to hamper turning the stem handle (3).

f. Safety cap nut (6) with safety wire (1) MS20995-C32. (Refer to Figure 13-38.)

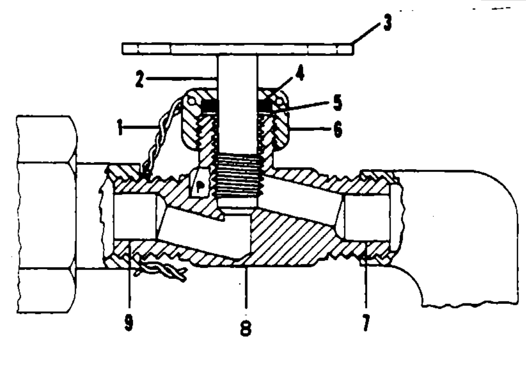


Figure 13-38. Heater Fuel Valve

13-139. INSTALLATION OF HEATER FUEL VALVE.

a. Install the pressure side of the valve to the crossfeed drain line. On late model valves the pressure side is marked with a "P" stamped on the valve body. On early valves that are not stamped the pressure side can be determined by looking into the body ends; with the valve closed the end where no part of the stem or seat is visible is the pressure side.

b. Connect the knob and rod to the stem handle of the valve with machine screws and self locking nuts.

c. Connect the fuel line fitting on the right side of the box to the valve.

d. Operate the left electric fuel pump and check for leakage around the valve stem and connections of the valve body. To determine that the valve seat does not leak when the valve is closed, remove the fuel filter bowl, turn on the electric fuel pump and note if fuel flows from the filter housing inlet port.

e. Position the fuel control box and secure to the spar cover with attaching screws.

f. Install the front seats.

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TABLE XIII-II. TROUBLESHOOTING CHART (HEATER, 940 SERIES)

Trouble	Cause	Remedy
Heater will not start, combustion air blower does not run.	Heater fuel valve not "ON".	Check valve position.
	Defective wiring.	Check wiring and connections.
	Defective combustion air blower.	Replace blower.
	Defective thermal fuse.	Replace fuse.
	Defective lockout overheat switch.	Replace switch.
	Defective overheat switch.	Replace switch.
Blower runs when switch is in HEAT position but heater will not ignite.	No fuel pressure.	Check fuel supply.
	Defective igniter.	Replace igniter.
	Defective fuel control valve.	Replace valve.
	Defective cycling overheat switch.	Replace switch.
	Defective preheat resistor.	Replace resistor.
	Broken quartz rod.	Replace quartz rod.

TABLE XIII-II. TROUBLESHOOTING CHART (HEATER, 940 SERIES) (cont.)

Trouble	Cause	Remedy
Heater ignites but ventilating air blower will not start.	Defective or improperly adjusted flame detector switch.	Replace or reset switch.
	Defective safety valve.	Replace valve.
Heater starts and runs, but goes out later.	Restricted ventilating air flow.	Remove restriction.
	Defective cycling overheat switch.	Replace switch.
	Defective safety valve.	Replace valve.
	Defective relay.	Replace relay.
Heater overheats.	Defective fuel control valve.	Replace valve.
	Restricted ventilating air flow.	Remove restriction.
	Defective cycling overheat switch.	Replace switch.
	Defective cycling switch.	Replace switch.
Heat output low.	Defective fuel control valve.	Replace valve.
	HI-LO switch on LO.	Turn to HI.
	Thermostat out of calibration.	Replace thermostat.

TABLE XIII-II. TROUBLESHOOTING CHART (HEATER, 940 SERIES) (cont.)

Trouble	Cause	Remedy
Heat output low. (cont.)	Cycling switch out of calibration.	Replace switch.
Heater smokes excessively.	Leaking fuel control valve.	Replace valve.
	Slow combustion air motor.	Replace motor.
	Defective installation.	Correct combustion air supply.
Blower will not stop when heater is turned off.	Defective flame detector switch.	Replace or reset switch.
Heater "pops" or "bangs" when starting.	Leaking fuel control valve.	Replace valve.

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