



## ***TWIN COMANCHE***

***Service Manual***

CARD 1 OF 4

- PA-30
- PA-39

# **PIPER AIRCRAFT CORPORATION**

# **WARNING**

The information contained in this manual is periodically revised. Piper Aircraft Corporation urges all users of this manual to keep it current. Contact your nearest Piper Aircraft Corporation distributor to arrange for a subscription to future revisions.

## **NOTE**

Revision service is available in aerofiche format only.

## AEROFICHE EXPLANATION AND REVISION STATUS

The Service Manual information incorporated in this set of Aerofiche cards has been arranged in accordance with the general specifications of Aerofiche adopted by the General Aircraft Manufacturer's Association, (GAMA). 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.

### Conversion of Aerofiche alpha/numeric code numbers:

First number is the Aerofiche card number.

Letter is the horizontal line reference per card.

Second number is the vertical line reference per card.

Example: 2J16 = Aerofiche card number two of given set, Grid location J16.

To aid in locating the various chapters and related service information desired, the following is provided:

1. A complete manual Table of Contents is for all fiche in this set.
2. A complete list of Illustrations is given and follows the Table of Contents.
3. A complete list of Tables is given for all fiche in this set and follows the list of Illustrations.
4. A complete list of paragraph titles and appropriate Grid location numbers is given at the beginning of each Chapter relating to the information within that Chapter.
5. Identification of Revised Material:

Revised text and illustrations are indicated by a black vertical line along the left-hand margin of the frame, opposite revised, added or deleted material. Revision lines indicate only current revisions with changes and additions to or deletions of existing text and illustrations. Changes in capitalization, spelling, punctuation, indexing, the physical location of the material or complete page additions are not identified by revision lines.

6. Revisions to this Service Manual issued are as follows:

Revisions	Date	Aerofiche Card Effectivity
PR740131	January 31, 1974	—
PR760628	June 28, 1976	1, 2 and 3
PR771006	October 6, 1977	1 and 2
PR780426	April 26, 1978	1, 2 and 3
PR790910	September 10, 1979	1 and 2
PR810406	April 6, 1981	1, 2, 3 and 4
PR821028	October 28, 1982	1, 2, 3 and 4

The date on Aerofiche cards should not be earlier than the date noted for the respective card effectivity. Consult the latest card in this series for current Aerofiche card effectivity.

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## **PART I**

### **PA-30**

Part I (Grid 1A15 thru 4F9) contains service information for the PA-30 and PA-39 models. See Part II (Grid 4G1 thru 4I3) for information peculiar to PA-39 model only.

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**1 A14**

## SECTION I

### INTRODUCTION

Paragraph		Aerofiche Grid No.
1-1.	General . . . . .	1A16
1-2.	Scope of Manual . . . . .	1A16
1-3.	Description . . . . .	1A16
1-4.	Fuselage . . . . .	1A16
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1-7.	Flight Controls . . . . .	1A17
1-8.	Landing Gear . . . . .	1A17
1-9.	Brake System . . . . .	1A17
1-10.	Engines and Propellers . . . . .	1A17
1-11.	Fuel System . . . . .	1A18
1-12.	Instruments . . . . .	1A18
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## SECTION I

### INTRODUCTION

**1-1. GENERAL.** This manual contains service and maintenance instructions for the Piper PA-30/39 Twin Comanche, designed and manufactured as a versatile airplane 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 XIV comprise the maintenance instructions. Part II of this manual has service information which is specifically for the PA-39 model only. 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 aircraft 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. For a more detailed description of the airplane, refer to the Owner's Handbook.

**1-3. DESCRIPTION.** The Piper PA-30 Twin Comanche is a four-place (optional 5th and 6th seats are available in Serial Nos. 30-853, 30-902 and up) twin engine, low-wing monoplane of all-metal construction. Paragraphs 1-4 through 1-14 provide descriptions of the major components and systems.

**1-4. FUSELAGE.** The fuselage consists of three basic units: the nose section, the cabin section, and the tail cone section.

**1-5. WING.** The laminar flow wing is of all-metal stressed-skin, full-cantilever 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 wing flaps are electrically operated.

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1-6. **EMPENNAGE.** The empennage consists of the fin, rudder, stabilator and stabilator trim tab. The rudder and stabilator are statically balanced.

1-7. **FLIGHT CONTROLS.** The flight controls are conventional, consisting of a control wheel which operates the ailerons and stabilators, and foot pedals which operate the rudder. Duplicate controls are provided for the copilot.

1-8. **LANDING GEAR.** The landing gear is an electrically operated tricycle gear, consisting of a nose wheel and two main wheels.

1-9. **BRAKE SYSTEM.** The brakes on the PA-30 are hydraulically operated by toe pedals.

1-10. **ENGINES AND PROPELLERS.** The airplane is powered by two Avco-Lycoming four cylinder, direct drive, wet sump, horizontally opposed, fuel injected engines. The propellers are Hartzell full feathering, constant speed units controlled by a governor mounted on each engine. Some propellers are equipped with a backup spring which allows operation of the propeller in case of loss of air from the air cylinder. These propellers are identified by the letter "S" after the hub dash number, such as HC-E2YL-2BS. The "S" propeller should not be intermixed with the other propellers. Each model with its engines and particular propellers are as follows:

Model	Engine	Propeller	H.P.	Octane
PA-30	IO-320-B1A	HC-E2YL-2 HC-E2YL-2B HC-E2YL-2BF HC-E2YL-2BS HC-E2YL-2BSF	160	91/96
PA-30 Turbo	IO-320-C1A	HC-E2YL-2 HC-E2YL-2B HC-E2YL-2BF HC-E2YL-2BS HC-E2YL-2BSF	160	100/130

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**1-11. FUEL SYSTEM.** The fuel system consists of four rubber-type cells located in the wings with a total fuel capacity of 90 U.S. gallons. (Optional 15 U.S. gallon each, tip tanks) two engine-driven fuel pumps, two electric auxiliary fuel pumps and two combination fuel selectors and strainer valves.

**1-12. INSTRUMENTS.** Provisions for the instrument installation includes panels for engine instruments and advance flight instruments. The panel is shock mounted to minimize vibration to the instruments.

**1-13. ELECTRONIC EQUIPMENT.** Provision for electronic equipment includes various combinations of radio installations and AutoPilot.

**1-14. HEATING AND VENTILATING SYSTEM.** Heated air for the cabin and defroster is obtained from a 25,000 BTU gasoline heater installed in the nose section. Fresh air for the cabin interior is obtained from two individual sources; one from the nose section and the other from a scoop located in the speed fairing ahead of the vertical fin.

## SECTION II

### HANDLING AND SERVICING

Paragraph		Aerofiche Grid No.
2-1.	Introduction .....	1A22
2-2.	Dimensions .....	1A22
2-3.	Station Reference Lines .....	1A22
2-4.	Weight and Balance Data .....	1A22
2-5.	Serial Number Plate .....	1B15
2-6.	Access and Inspection Provisions .....	1B15
2-7.	Tools and Test Equipment .....	1B15
2-8.	Torque Requirements .....	1B15
2-8a.	Torque Wrenches .....	1B17
2-9.	Handhold and Walkways .....	1B21
2-10.	Ground Handling .....	1B22
2-11.	Introduction to Ground Handling .....	1B22
2-12.	Jacking .....	1B22
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2-15.	Mooring .....	1C1
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2-19.	Taxiing .....	1C3
2-20.	External Power Receptacle .....	1C4
2-21.	Operation of External Power Receptacle .....	1C4
2-22.	Cleaning .....	1C4
2-23.	Cleaning Engine Compartment .....	1C4
2-24.	Cleaning Landing Gear .....	1C5
2-25.	Cleaning Exterior Surfaces .....	1C5
2-26.	Cleaning Windshield and Windows .....	1C5
2-27.	Cleaning Headliner, Side Panels and Seats .....	1C6
2-28.	Cleaning Carpets .....	1C6
2-29.	Servicing .....	1C6
2-30.	Introduction to Servicing .....	1C6
2-31.	Landing Gear System .....	1C6
2-32.	Servicing Landing Gear .....	1C6

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Paragraph		Aerofiche Grid No.
2-33.	Oleo Struts .....	IC7
2-34.	Servicing Oleo Struts .....	IC7
2-35.	Filling Oleo Struts .....	IC8
2-36.	Inflating Oleo Struts .....	IC9
2-37.	Brake System .....	IC10
2-38.	Servicing Brake System .....	IC10
2-39.	Filling Brake Cylinder Reservoir .....	IC10
2-40.	Draining Brake System .....	IC10
2-41.	Tires .....	IC10
2-42.	Servicing Tires .....	IC10
2-43.	Power Plant .....	IC13
2-44.	Servicing Power Plant .....	IC13
2-45.	Propeller .....	IC13
2-46.	Servicing Propeller .....	IC13
2-47.	Power Plant Induction Air Filter .....	IC13
2-48.	Removal of Air Filter .....	IC13
2-49.	Cleaning Induction Air Filter .....	IC13
2-50.	Cleaning Induction Air Filter, Turbocharged .....	IC14
2-51.	Installation of Induction Air Filter .....	IC14
2-52.	Vacuum System Air Filters .....	IC15
2-53.	Replacement of Central Air Filter .....	IC15
2-54.	Replacement of Instrument Air Filter .....	IC15
2-55.	Replacement of Vacuum Regulator Filters .....	IC15
2-56.	Fuel Systems .....	IC15
2-57.	Servicing Fuel System .....	IC15
2-58.	Filling Fuel Cells .....	IC15
2-59.	Draining Fuel Valves and Lines .....	IC16
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2-61.	Electrical System .....	IC17
2-62.	Servicing Electrical System .....	IC17
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2-64.	Servicing the Oxygen System .....	IC17
2-65.	Oxygen System Safety Precautions .....	IC17
2-66.	Filling Oxygen Cylinder .....	IC18
2-67.	Lubrication .....	IC19
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2-69.	Servicing Oil System .....	IC19
2-70.	Draining Oil Sump .....	IC20

**Paragraph****Aerofiche  
Grid No.**

2-71.	Filling Oil Sump .....	1C20
2-72.	Oil Screen (Suction) .....	1C20
2-73.	Oil Screen (Pressure) .....	1C21
2-74.	Oil Filter (Full Flow) .....	1C21
2-75.	Turbo Oil Filter Cleaning Procedure .....	1C22
2-76.	Recommendations for Changing Oil .....	1C22
2-77.	Lubrication Instructions .....	1C23
2-78.	Application of Oil .....	1C23
2-79.	Application of Grease .....	1C24
2-80.	Lubrication Chart .....	1C24

## 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 procedures outlined in this section, refer to the appropriate section for that component.

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

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, 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 by inches in the vertical or horizontal direction from a given reference line which indicates station locations of structural members of the airplane. Station 0 of the fuselage is located 13.37 inches aft of the foremost point of the nose. Station 0 (BL) of the wing and stabilator is the center line of the airplane; and station 0 (WL) of the fuselage, vertical stabilizer and rudder is 8.25 inches below the bottom edge of the forward left side window. The reference datum line or 0 fuselage station reference line is located 79 inches forward of the wing leading edge.

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.

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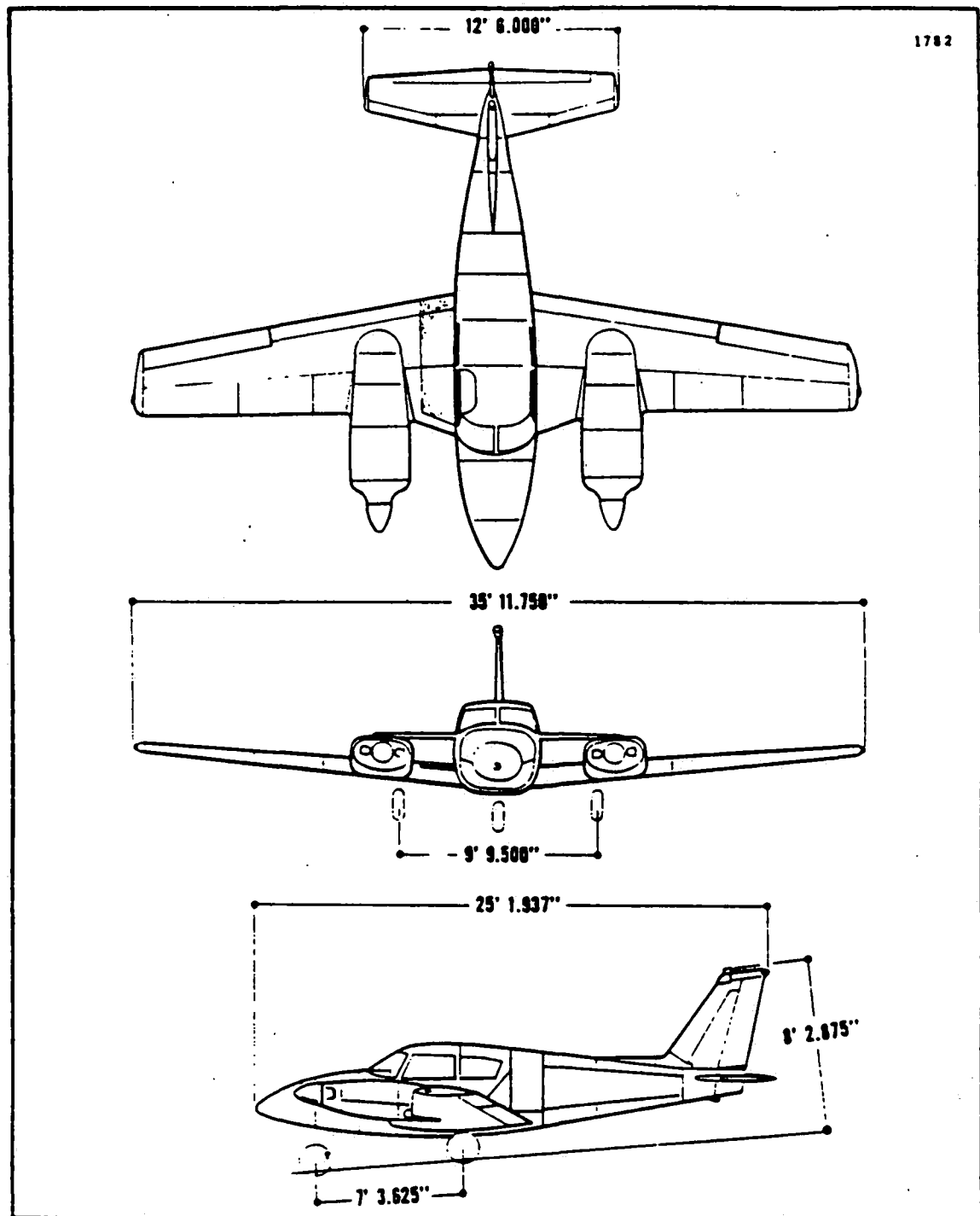


Figure 2-1. Three View of Twin Comanche PA-30  
Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive

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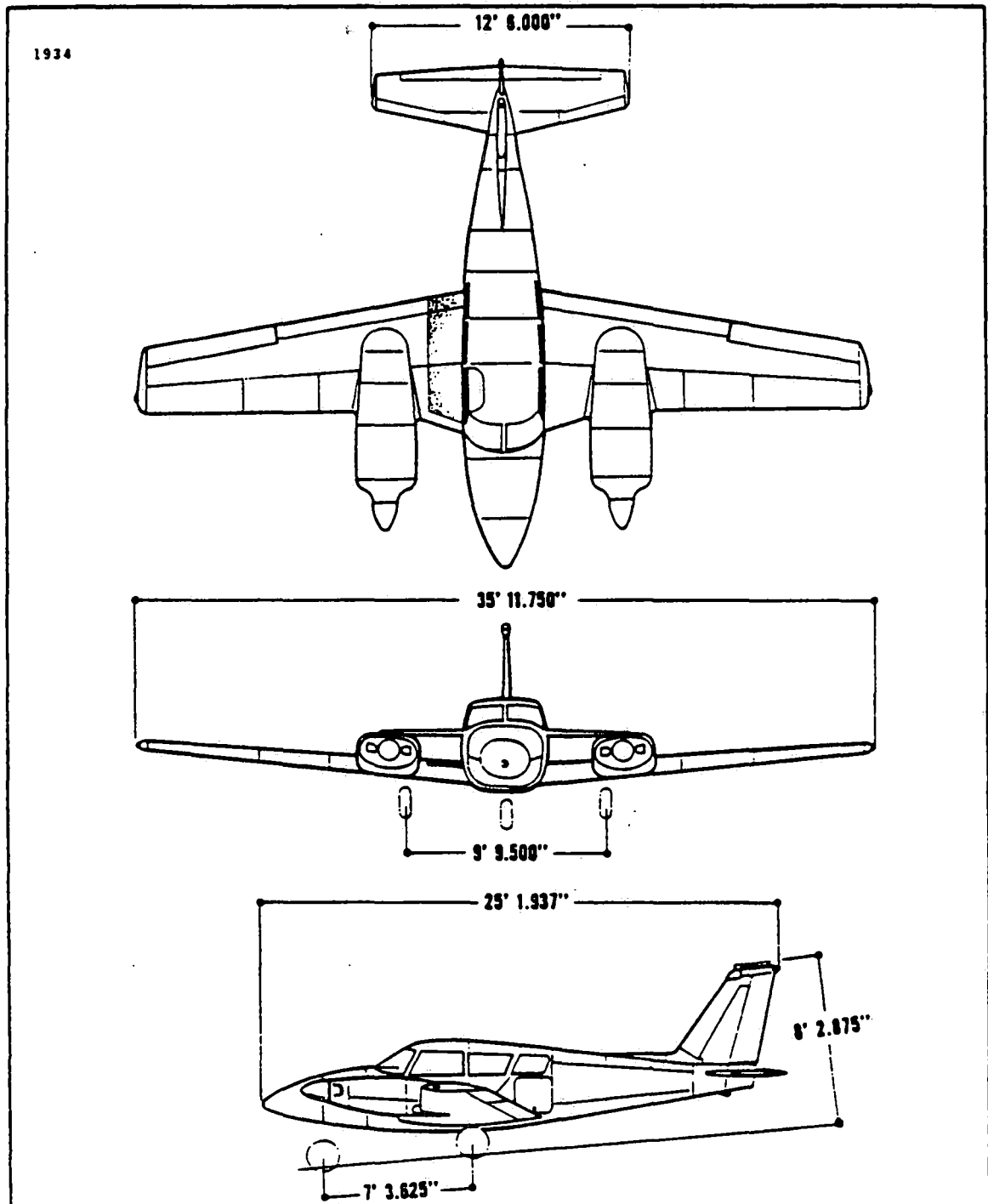


Figure 2-2. Three View of Twin Comanche PA-30  
Serial Nos. 30-853, 30-902 to 30-2000 inclusive

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TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS

MODEL	PA-30
ENGINE	
Manufacturer	Avco-Lycoming
Model	IO-320 B1A
FAA Type Certificate	1E12
Rated Horsepower	160
Rated Horsepower, RPM:	
Full Throttle	160 hp @ 2700 RPM
Performance Cruise (75% rated)	120 hp @ 2450 RPM
Economy Cruise (65% rated)	104 hp @ 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	8.50:1
Weight (With Starter and Generator or Alternator)	287 lbs.
Dimensions:	
Height	19.22 in.
Width	32.24 in.
Length	33.59 in.
Oil, SAE Number	Refer to Table II-III
Oil Sump Capacity	8 quarts
Oil Consumption, Maximum	0.010 lb./bhp/hr.
Fuel, Aviation Grade, Minimum Octane	91/96 octane
Fuel Injector, Bendix	RSA-5AD1
Magneto (2), Scintilla	S4LN-21
Magneto Drive, Ratio to Crankshaft	1:1
Magneto Drive, Rotation	Clockwise
Magneto Timing	25 degrees BTC
Magneto Point Clearance	0.018 + 0.006

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TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS

MODEL	PA-30 Turbo
ENGINE	
Manufacturer	Avco-Lycoming
Model	IO-320 C1A
FAA Type Certificate	1E12
Rated Horsepower	160
Rated Horsepower, RPM:	
Full Throttle	160 hp @ 2700 RPM
Performance Cruise (75% rated)	120 hp @ 2450 RPM
Economy Cruise (65% rated)	104 hp @ 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	8.50:1
Weight (With Starter and Generator or Alternator)	294 lbs.
Dimensions:	
Height	19.22 in.
Width	32.24 in.
Length	33.59 in.
Oil, SAE Number	Refer to Table II-III
Oil Sump Capacity	8 quarts
Oil Consumption, Maximum	0.010 lb./bhp/hr.
Fuel, Aviation Grade, Minimum Octane	100/130 octane
Fuel Injector, Bendix	RSA-5AD1
Magneto (2), Scintilla	S4LN-21
Magneto Drive, Ratio to Crankshaft	1:1
Magneto Drive, Rotation	Clockwise
Magneto Timing	25 degrees BTC
Magneto Point Clearance	0.018 ± 0.006

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

MODEL	PA-30
ENGINE (cont.)	
Spark Plugs (shielded):	
AC	SR-88D
Champion	REM-40E
Spark Plug Gap Setting (in.) <sup>(1)</sup>	0.018 to 0.022 in.
Firing Order	1-3-2-4
Tachometer Drive, Ratio To Crankshaft	0.5:1
Tachometer Drive, Rotation	Clockwise
Starter	
Delco-Remy, 12-volt	Model 1109511
Prestolite, 12-volt	Model MZ4206
Starter Drive, Ratio to Crankshaft	13.55:1
Starter Drive, Rotation	Counterclockwise
Generator, Delco-Remy	12-volt, 50 amp, Model 1101915
Voltage Regulator, Delco-Remy	1119246 (50 amp)
Paralleling Relay, Delco-Remy	1116887 (50 amp)
Alternator, Prestolite	12-volt, ALX 8403
Voltage Regulator, Prestolite	VSF 7203 8A
Over Voltage Control, Prestolite	X17621
Vacuum Pump Drive, Ratio to Crankshaft	1.30:1
Vacuum Pump Drive, Rotation	Counterclockwise
Propeller Governor Drive	AN20010 Type XX
Propeller Governor Ratio	0.866:1
Fuel Pump	AC-GP6440296
PROPELLER	
Manufacturer	Hartzell
Type	Constant Speed Feathering
Hub	HC-E2YL-2B, HC-E2YL-2BF, HC-E2YL-2BS o HC-E2YL-2BSF
Blade (2)	7663-4 or F7663-4
Diameter	72 in.
Diameter, Minimum	70 in.

(1) REFER TO LYCOMING SERVICE INSTRUCTION NO. 1042.

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# PIPER TWIN COMANCHE SERVICE MANUAL

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

MODEL

PA-30 Turbo

ENGINE (cont.)

## Spark Plugs (shielded):

AC	171
Champion	REB-37N
Spark Plug Gap Setting (in.) <sup>(1)</sup>	0.015 to 0.021 in.
Firing Order	1-3-2-4
Tachometer Drive, Ratio To Crankshaft	0.5:1
Tachometer Drive, Rotation	Clockwise
Starter	
Delco-Remy, 12-volt	1109511
Prestolite, 12-volt	MZ4206
Starter Drive, Ratio to Crankshaft	13.55:1
Starter Drive, Rotation	Counterclockwise
Generator, Delco-Remy	12-volt, 50 amp, Model 1101915
Voltage Regulator, Delco-Remy	1119246 (50 amp)
Paralleling Relay, Delco-Remy	1116887 (50 amp)
Alternator, Prestolite	12-volt, ALX 8403
Voltage Regulator, Prestolite	VSF 7203 8A
Over Voltage Control, Prestolite	X17621
Vacuum Pump Drive, Ratio to Crankshaft	1.30:1
Vacuum Pump Drive, Rotation	Counterclockwise
Propeller Governor Drive	AN20010 Type XX
Propeller Governor Ratio	0.866:1
Fuel Pump	Lear-Siegler RG17980

PROPELLER

Manufacturer	Hartzell
Type	Constant Speed Feathering
Hub	HC-E2YL-2B, HC-E2YL-2BF, HC-E2YL-2BS or HC-E2YL-2BSF
Blade (2)	7663-4 or F7663-4
Diameter	72 in.
Diameter, Minimum	70 in.

(1) REFER TO LYCOMING SERVICE INSTRUCTION NO. 1042.

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

MODEL	PA-30
PROPELLER (cont.)	
Blade Angle, Low <sup>(2)</sup>	12.0 ± 0.015 degrees
Blade Angle, High <sup>(2)</sup>	78 degrees
Control Governor	Hartzell
Governor Model	F6-3 or F6
FUEL CELL CAPACITIES	
Inboard (Main) Fuel Cells	Two
Capacity (each)	30 U. S. gallons
Unusable Fuel (each)	3 U. S. gallons
Outboard (Auxiliary) Fuel Cells	Two
Capacity (each)	15 U. S. gallons
Tip Tanks	Two (optional)
Capacity (each)	15 U. S. gallons
LANDING GEAR	
Type	Electrically retractable
Shock Strut Type	Combination Air and Oil
Fluid Required (Struts & Brakes)	MIL-H-5606 (Red)
Strut Extension (Static Load)	2.75 in.
Maximum Air Pressure (Strut)	100 psi
Tread (Width from each tire center)	9 ft. 9.5 in.
Wheel Base	7 ft. 3.625 in.
Nose Wheel Travel	25° Max. 19° Min. right, 25° Max. 19° Min. left
Main Wheel Toe-In	0 degrees
Turning Radius (Min.)	28 ft. 1.5 in.
Wheel, Nose	Cleveland 38501
Wheel, Main	Cleveland 40-34 <sup>(3)</sup> Cleveland 40-90 <sup>(4)</sup>
Brake Type	(Disc) Cleveland 30-23
Tire, Nose	6:00 x 6, 6 ply rated
Tire, Main	6:00 x 6, 6 ply rated
Tire Pressure	42 psi

<sup>(2)</sup> BLADE ANGLE AT 30 IN. RADIUS.

<sup>(3)</sup> SERIAL NOS. 30-2 TO 30-845 INCL.

<sup>(4)</sup> SERIAL NOS. 30-846 AND UP.

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# PIPER TWIN COMANCHE SERVICE MANUAL

TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS (contd)

PA-30

## MODEL

## PROPELLER (contd)

Blade Angle, Low <sup>2</sup>	12.0 + 0.015 degrees
Blade Angle, High <sup>2</sup>	78 degrees
Control Governor	Hartzell
Governor Model	F6-3

## FUEL CELL CAPACITIES

Inboard (Main) Fuel Cells	Two
Capacity (each)	30 U.S. gallons
Unusable Fuel (each)	3 U.S. gallons
Outboard (Auxiliary) Fuel Cells	Two
Capacity (each)	15 U.S. gallons
Tip Tanks	Two
Capacity (each)	15 U.S. gallons

## LANDING GEAR

Type	Electrically retractable
Shock Strut Type	Combination Air and Oil
Fluid Required (Struts & Brakes)	MIL-H-5606 (Red)
Strut Extension (Static Load)	2.75 in.
Maximum Air Pressure (Strut)	100 psi
Tread (Width from each tire center)	9 ft. 9.5 in.
Wheel Base	7 ft. 3.625 in.
Nose Wheel Travel	25‡ Max. 19‡ Min. right, 25‡ Max. 19‡ Min. left
Main Wheel Toe-In	0 degrees
Turning Radius (Min.)	28 ft. 11 in.
Wheel, Nose	Cleveland 38501
Wheel, Main	Cleveland 40-34 <sup>3</sup> Cleveland 40-90 <sup>4</sup>
Brake Type	(Disc) Cleveland 30-23
Tire, Nose	6:00 x 6, 6 ply rated
Tire, Main	6:00 x 6, 6 ply rated
Tire Pressure	42 psi

2 - BLADE ANGLE AT 30 IN. RADIUS.

3 - SERIAL NOS. 30-2 TO 30-845 INCL.

4 - SERIAL NOS. 30-846 AND UP.

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

MODEL	PA-30. PA-30 Turbo
<b>OVERALL</b>	
Gross Weight	3600 lbs., 3725 lbs. <sup>(1)</sup>
Gross Weight Landing	3600 lbs., 3725 lbs. <sup>(1)</sup>
Width (Spa i)	35 ft. 11.75 in.
	36 ft. 9.625 in. <sup>(1)</sup>
Length	25 ft. 1.9375 in.
Height (Static Ground Line)	8 ft. 2.875 in.
Height, Propeller Hub, Thrust Line	
Level	4 ft. 6 in.
Clearance, Propeller Tips, Thrust	
Line Level	11.5 in.
<b>FUSELAGE</b>	
Length (Including Tail Cone Fairing)	23 ft. 0.950 in.
Width (Without Stabilator)	47.875 in.
Height (Without Vertical Fin)	53.875 in.
<b>WINGS</b>	
Span (Width)	35 ft. 11.75 in.
	36 ft. 9.625 in. <sup>(1)</sup>
Chord:	
Station 25 inches	7 ft. 1 in.
Station 62 inches	5 ft. 5 in.
Station 211 inches	3 ft. 3 in.
Dihedral (Leading Edge)	5 degrees
Incidence	2 degrees
Wing Twist	0 degrees
Length of Flap	110.90 in.
Length of Aileron	75.30 in.
<b>EMPENNAGE</b>	
Stabilator Overall Span	12 ft. 6 in.
Fin Setting, Fixed	0 degree centerline

(1) PA-30 TURBO ONLY.

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Revised: 1/31/74

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

I	MODEL	PA-30, PA-30 Turbo
---	-------	--------------------

AREAS

Total Wing Area (Including Aileron and Flaps)	178 sq. ft.
Aileron	14.1 sq. ft.
Flap	20.2 sq. ft.
Stabilator, including trim tab	32.5 sq. ft.
Fin	9.0 sq. ft.
Rudder	5.9 sq. ft.

CONTROL SURFACES TRAVEL

I	REFER TO TABLES V-I AND V-IA.
---	-------------------------------

CONTROL SURFACE CABLE TENSION

I	REFER TO TABLES V-I AND V-IA.
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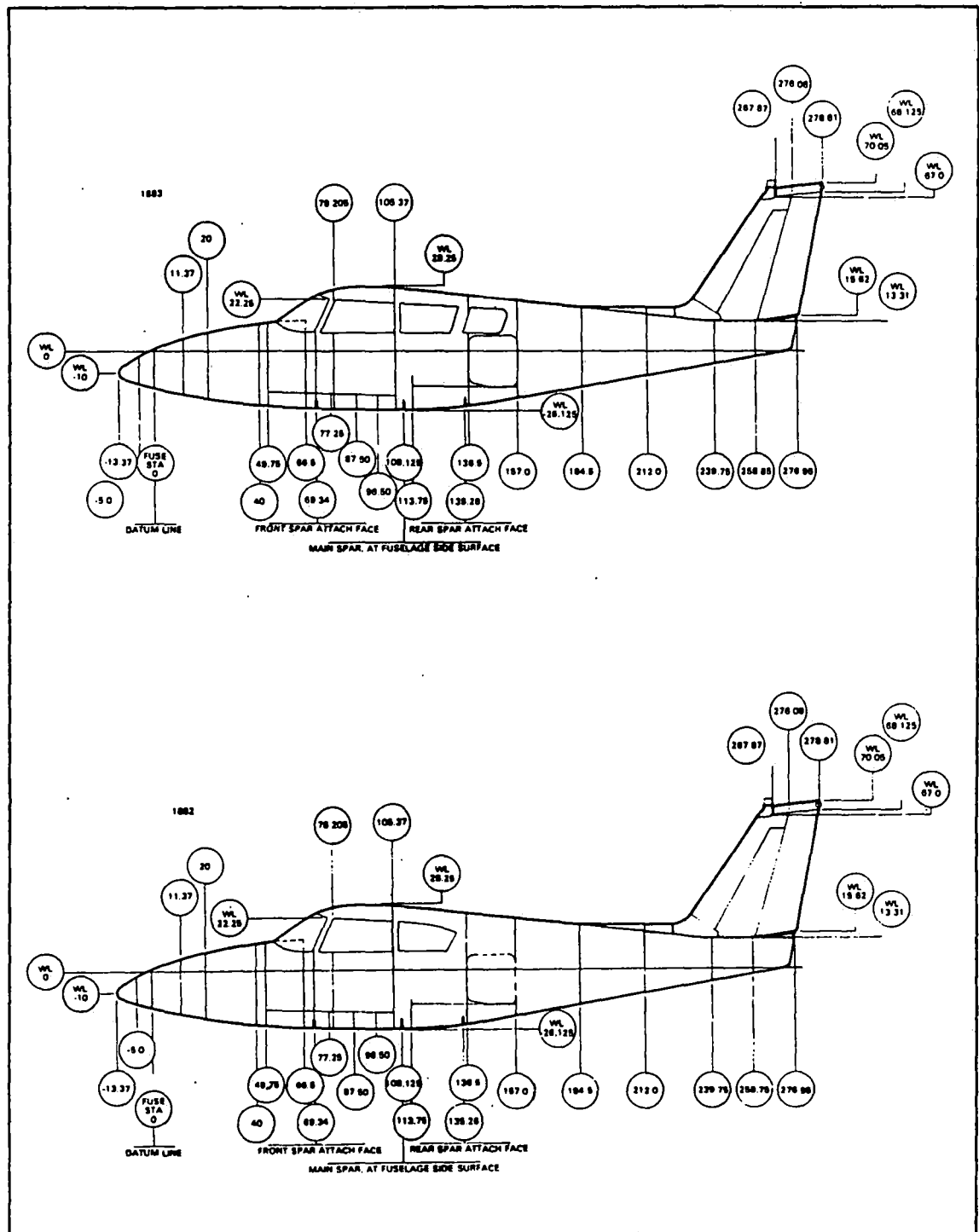


Figure 2-3. Station Reference Lines, Fuselage

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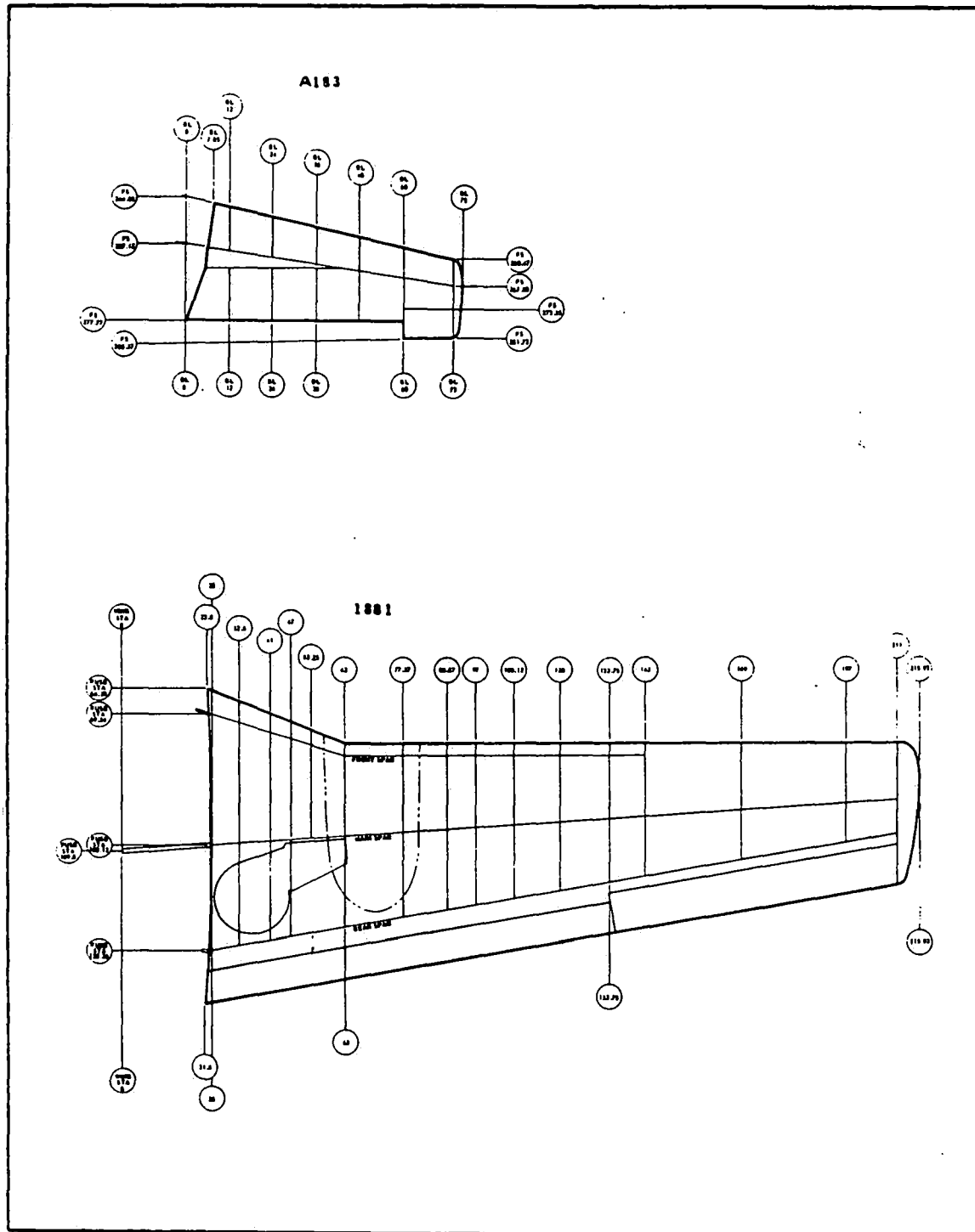
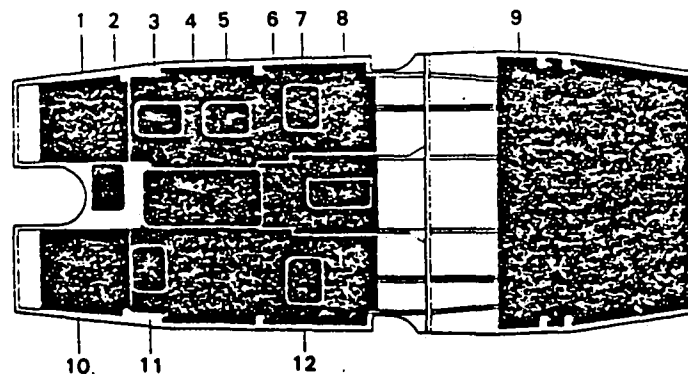


Figure 2-4. Station Reference Lines, Wing and Stabilator

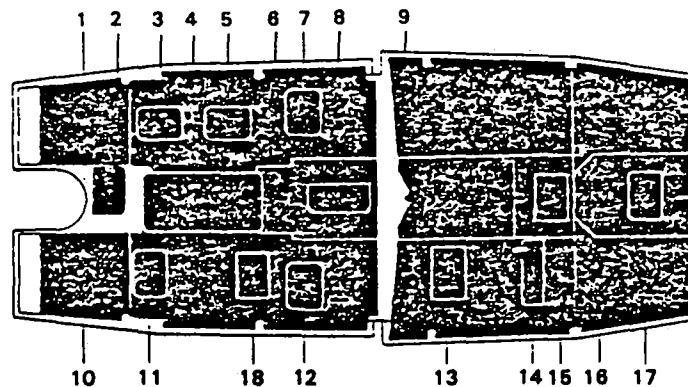
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SERIAL NOS. 30-1 TO 30-852, 30-854 TO 30-901 INCL.



SERIAL NOS. 30-853 AND 30-902 AND UP

- |  |  |
|--|--|
| 1. ELECTRICAL WIRES, OXYGEN CONTROL CABLE  | 11. CONTROL CABLES   |
| 2. FUSE PANEL  | 12. BRAKE LINES, MAIN FUEL CELL OUTLET LINE, CONTROL CABLES  |
| 3. ELECTRICAL WIRES, FUEL LINE RIGHT ENGINE  | 13. CONTROL CABLE PULLEY CLUSTER, BRAKE LINE LEFT GEAR, TRIM SENSOR, MAIN GEAR PUSH-PULL CONTROL CABLE, TIP TANK FUEL LINE |
| 4. LANDING GEAR RETRACTION TRANSMISSION ASSEMBLY                                     | 14. AILERON AND FLAP CONTROL PULLEYS   |
| 5. ELECTRICAL WIRES, FUEL LINE RIGHT ENGINE  | 15. FLAP ACTUATING TRANSMISSION ASSEMBLY, FLAP CONTROL PULLEYS, AUTOPILOT PITCH SERVO                                      |
| 6. FUEL PUMPS, FUEL SELECTOR VALVE CONTROLS  | 16. ELECTRICAL WIRES, FUSELAGE STRINGERS   |
| 7. MAIN FUEL CELL OUTLET LINE, ELECTRICAL WIRES                                      | 17. GYRO AMPLIFIER   |
| 8. FUEL SELECTOR VALVES AND DRAINS   | 18. CONTROL CABLES   |
| 9. MAIN GEAR PUSH-PULL CONTROL CABLES, BRAKE LINE, RIGHT GEAR AND TIP TANK FUEL LINE | 19. CONTROL CABLES AND PULLEYS, FUSELAGE STRINGERS   |
| 10. CONTROL CABLE PULLEY CLUSTER, BRAKE LINES, AUTOPILOT PITCH SERVO                 |  |

Figure 2-5. Access Plates and Panels, Fuselage Interior



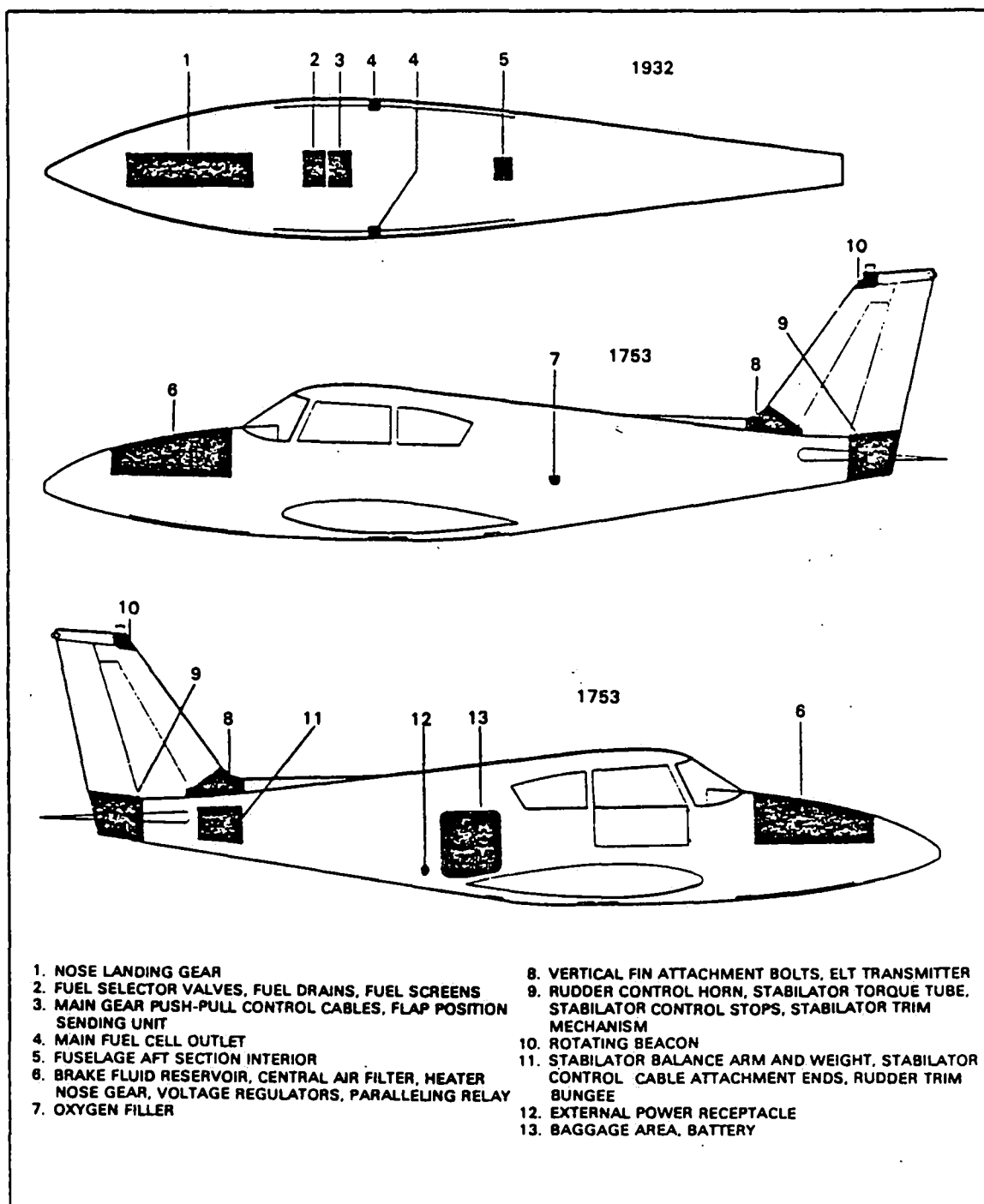


Figure 2-6. Access Plates and Panels, Fuselage  
PA-30, Serial Nos. 30-1 to 30-852 incl. and 30-854 to 30-901 incl.

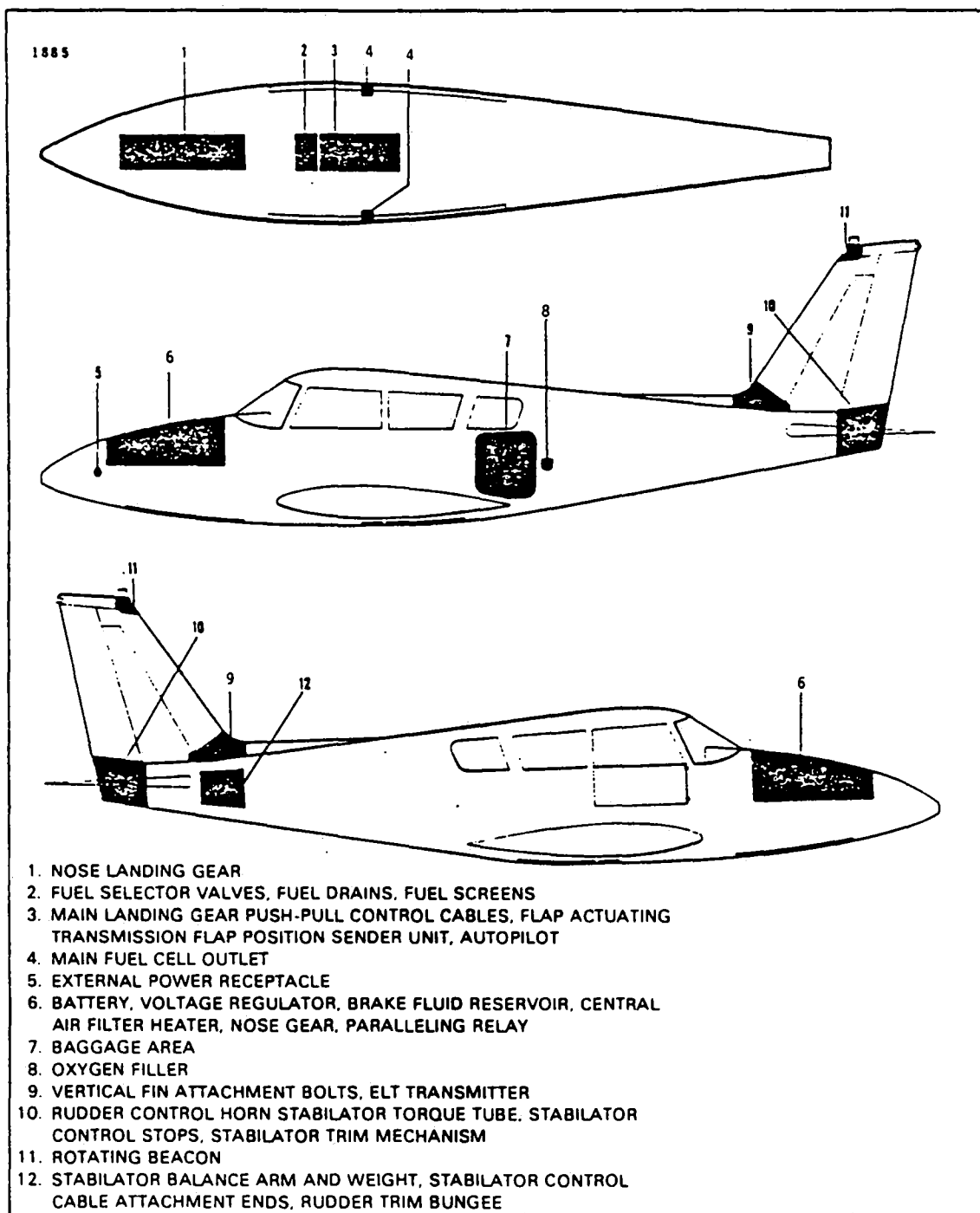


Figure 2-7. Access Plates and Panels, Fuselage  
PA-30, Serial Nos. 30-853, 30-902 to 30-2000 inclusive

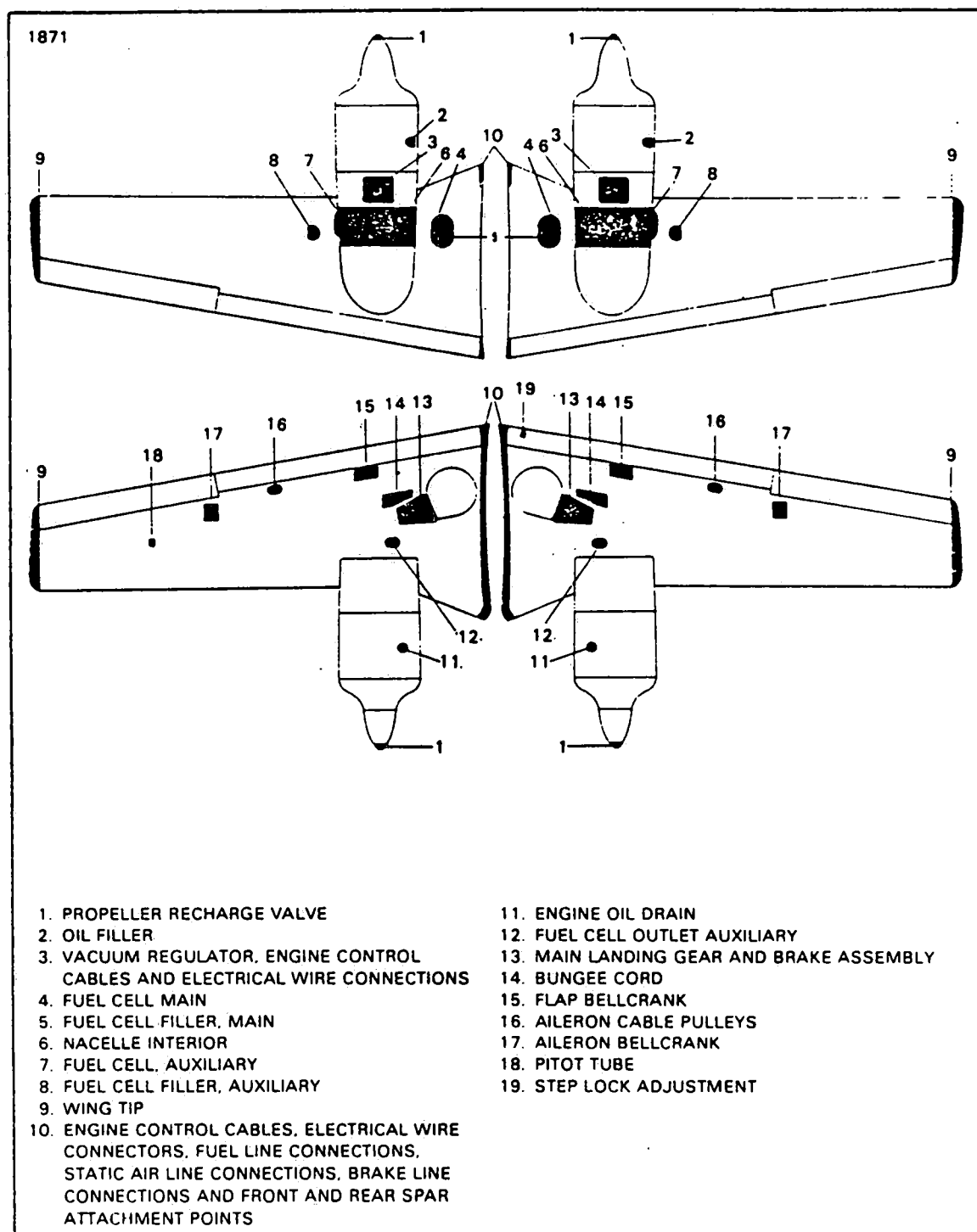


Figure 2-8. Access Plates and Panels, Wings

**2-5. SERIAL NUMBER PLATE.** The serial number plate on the PA-30 can be found at the following locations: On the forward upper portion of the forward cabin bulkhead; inside the fuselage on the left skin opposite the rear fuselage access panel; or on the fuselage adjacent to the left side of the tail skid. Airplane serial numbers will be used in this manual where servicing difference occurs, 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 thru 2-8. 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. The floor panels may be removed by first removing the desired seats, then sliding the carpet edges from under its retainer strips, lifting the edges and removing the carpet attaching screws. Remove the carpet, thus exposing the floor panel attaching screws. To enter the aft section of the fuselage, remove the lower rear baggage compartment upholstery panel by removing the attaching 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 back of the section that pertains to a particular component or are listed in the back of the PA-30 Parts Catalog.

**2-8. TORQUE REQUIREMENTS.** The torque values given in Table II-II are derived from oil-free cadmium-plated threads and are recommended for all airframe installation procedures where torquing is required, unless otherwise noted in sections where other values are stipulated. Engine torque values are found in the latest revision of Avco-Lycoming Service Bulletin No. 268. Propeller torque values are found in Section VIII of this manual. Table II-1a lists the torque values for flared fittings of various sizes and material.

# PIPER TWIN COMANCHE SERVICE MANUAL

## 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-1A.

TABLE II-1A. 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 2-8a.)

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.

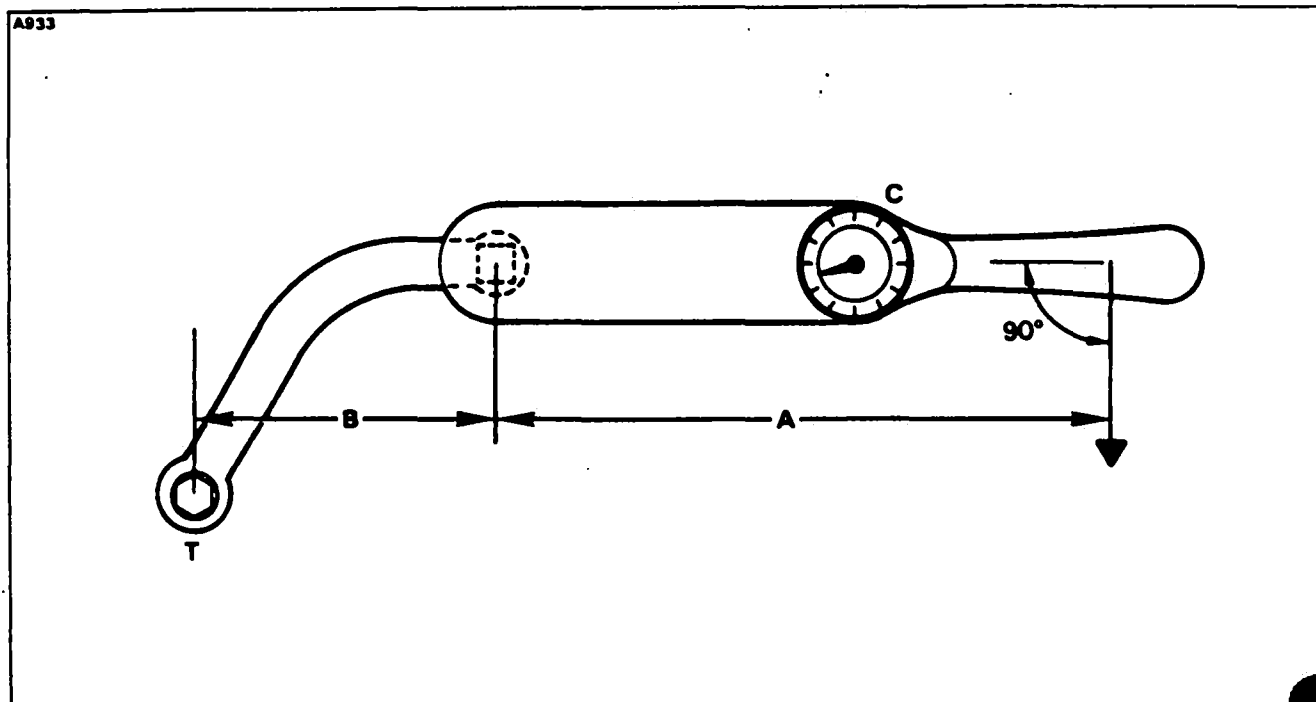


Figure 2-8a. Torque Wrench Formula

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## TABLE II-II. RECOMMENDED NUT TORQUE (INCH-POUNDS)

**TORQUES:** 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:

1. Torque (self-locking fasteners)-Add the friction torque from Table A from sizes 8 through 7/16 to the recommended torque from Table B to get the final torque. This would be the actual reading on the torque wrench.
2. Torque (castellated and non-self-locking nuts)-Use only the torque given in Table 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.
3. Calibrate the torque wrench periodically to assure accuracy; recheck frequently.
4. Ascertain that the bolt and nut threads are clean and dry (unless otherwise specified by the manufacture). If the bolt or nut is specified to be lubricated prior to tightening, the torque range should be reduced 50%.
5. 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.
6. Unique torques specified in the text of this manual supersede the torques given in Tables A and B.
7. Refer to the latest revision of Lycoming SSP1776 for torques on parts used on Lycoming engines.
8. A maximum of two AN980 washers may be added under the bolt heads or nuts to correct for variations in material thickness within the tolerances permitted.
9. Limitations of the use of self-locking nuts, bolts and screws including fasteners with non-metallic inserts are as follows:
  - A. 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.
  - B. 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.
  - C. Do not use self-locking nuts at joints which subject either the nut or the bolt to rotation.
  - D. Never tap or rethread self-locking fasteners. Do not use nuts, bolts or screws with damaged threads or rough ends.

### 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

COARSE THREAD SERIES				
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		
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 TORQUE (INCH POUNDS) (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				AN 3DD thru AN 20DD AN 173DD thru AN 186DD AN 508DD AN 526D 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 17826 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 -38	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	6,500	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	6,800	11,000	13,400	6,600	8,000	3,900	5,600	2,300	3,650



# PIPER TWIN COMANCHE SERVICE MANUAL

## TABLE II-III DECIMAL CONVERSION CHART

4THS	8THS	16THS	32DS	64THS	TO 3 PLACES	TO 2 PLACES	M.M. EQUIV.	4THS	8THS	16THS	32DS	64THS	TO 3 PLACES	TO 2 PLACES	M.M. EQUIV.
			$\frac{1}{32}$	$\frac{1}{64}$	.016	.02	.397				$\frac{17}{32}$	$\frac{33}{64}$	.516	.52	13.097
					.031	.03	.794						.531	.53	13.494
		$\frac{1}{16}$		$\frac{3}{64}$	.047	.05	1.191			$\frac{9}{16}$		$\frac{35}{64}$	.547	.55	13.891
					.062	.06	1.587						.562	.56	14.288
			$\frac{3}{32}$	$\frac{5}{64}$	.078	.08	1.984				$\frac{19}{32}$	$\frac{37}{64}$	.578	.58	14.684
					.094	.09	2.381						.594	.59	15.081
	$\frac{1}{8}$			$\frac{7}{64}$	.109	.11	2.778					$\frac{39}{64}$	.609	.61	15.478
					.125	.12	3.175		$\frac{5}{8}$				.625	.62	15.875
			$\frac{5}{32}$	$\frac{9}{64}$	.141	.14	3.572				$\frac{21}{32}$	$\frac{41}{64}$	.641	.64	16.272
					.156	.16	3.969						.656	.66	16.669
		$\frac{3}{16}$		$\frac{11}{64}$	.172	.17	4.366			$\frac{11}{16}$		$\frac{43}{64}$	.672	.67	17.065
					.188	.19	4.762						.688	.69	17.462
			$\frac{7}{32}$	$\frac{13}{64}$	.203	.20	5.159				$\frac{23}{32}$	$\frac{45}{64}$	.703	.70	17.859
					.219	.22	5.556						.719	.72	18.256
	$\frac{1}{4}$			$\frac{15}{64}$	.234	.23	5.953		$\frac{3}{4}$			$\frac{47}{64}$	.734	.73	18.653
					.250	.25	6.350						.750	.75	19.050
			$\frac{9}{32}$	$\frac{17}{64}$	.266	.27	6.747				$\frac{25}{32}$	$\frac{49}{64}$	.766	.77	19.447
					.281	.28	7.144						.781	.78	19.844
		$\frac{5}{16}$		$\frac{19}{64}$	.297	.30	7.540			$\frac{13}{16}$		$\frac{51}{64}$	.797	.80	20.241
					.312	.31	7.937						.812	.81	20.637
			$\frac{11}{32}$	$\frac{21}{64}$	.328	.33	8.334				$\frac{27}{32}$	$\frac{53}{64}$	.828	.83	21.034
					.344	.34	8.731						.844	.84	21.431
	$\frac{3}{8}$			$\frac{23}{64}$	.359	.36	9.128		$\frac{7}{8}$			$\frac{55}{64}$	.859	.86	21.828
					.375	.38	9.525						.875	.88	22.225
			$\frac{13}{32}$	$\frac{25}{64}$	.391	.39	9.922				$\frac{29}{32}$	$\frac{57}{64}$	.891	.89	22.622
					.406	.41	10.319			$\frac{15}{16}$		$\frac{59}{64}$	.906	.91	23.019
		$\frac{7}{16}$		$\frac{27}{64}$	.422	.42	10.716						.922	.92	23.416
					.438	.44	11.112				$\frac{31}{32}$	$\frac{61}{64}$	.938	.94	23.812
			$\frac{15}{32}$	$\frac{29}{64}$	.453	.45	11.509						.953	.95	24.209
					.469	.47	11.906						.969	.97	24.606
				$\frac{31}{64}$	.484	.48	12.303					$\frac{63}{64}$	.984	.98	25.003
					.500	.50	12.700						1.000	1.00	25.400

HANDLING AND SERVICING

Issued: 12/29/72

2-9. HANDHOLD AND WALKWAYS. A fixed handhold is located on the right side of the fuselage, above the rear window. Walkways of four parts Devco non-skid compound and one part black enamel are painted on the right wing and flap. The lines of rivets on the walkway are covered with non-skid paper strips, secured with sculp-metal compound before the walk is applied.

**CAUTION**

Avoid damage to the wings by stepping only on the walkway.

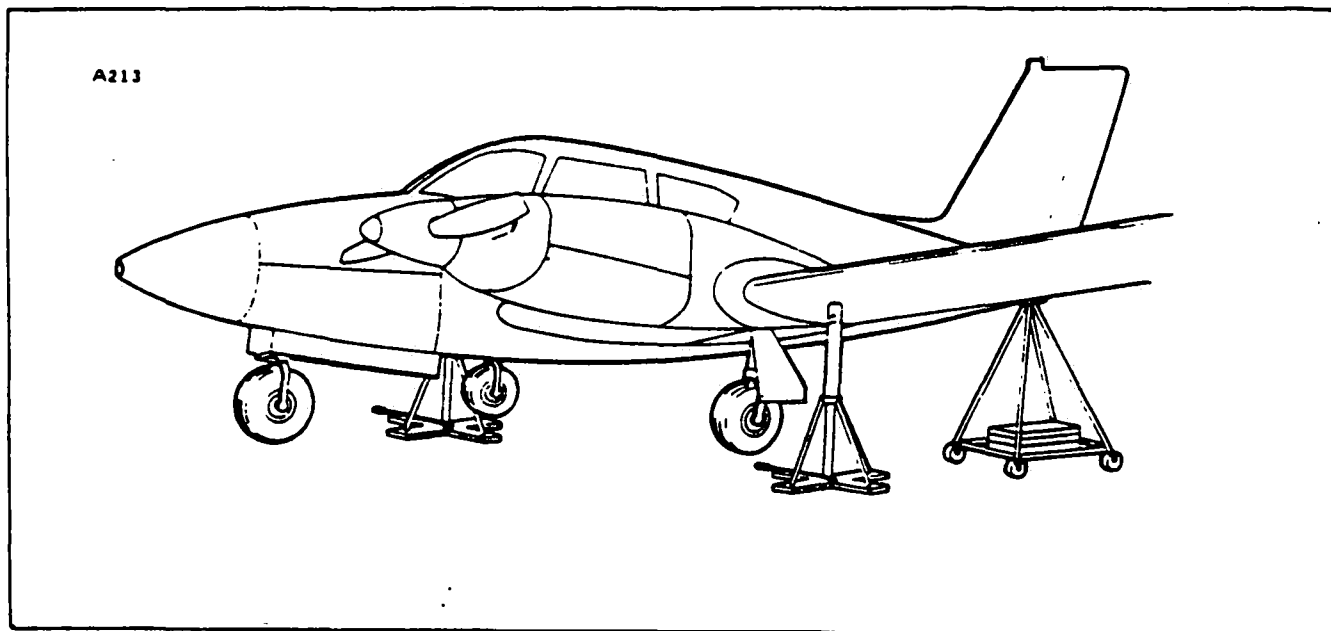


Figure 2-9. Jacking Arrangements

## 2-10. GROUND HANDLING.

**2-11. 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.

**2-12. JACKING.** The airplane is provided with a jack 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 2-9.) To jack the airplane, proceed as follows:

- a. Place the jacks under the jack pads.
- b. Attach the tail support to the tail skid. Place approximately 350 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.

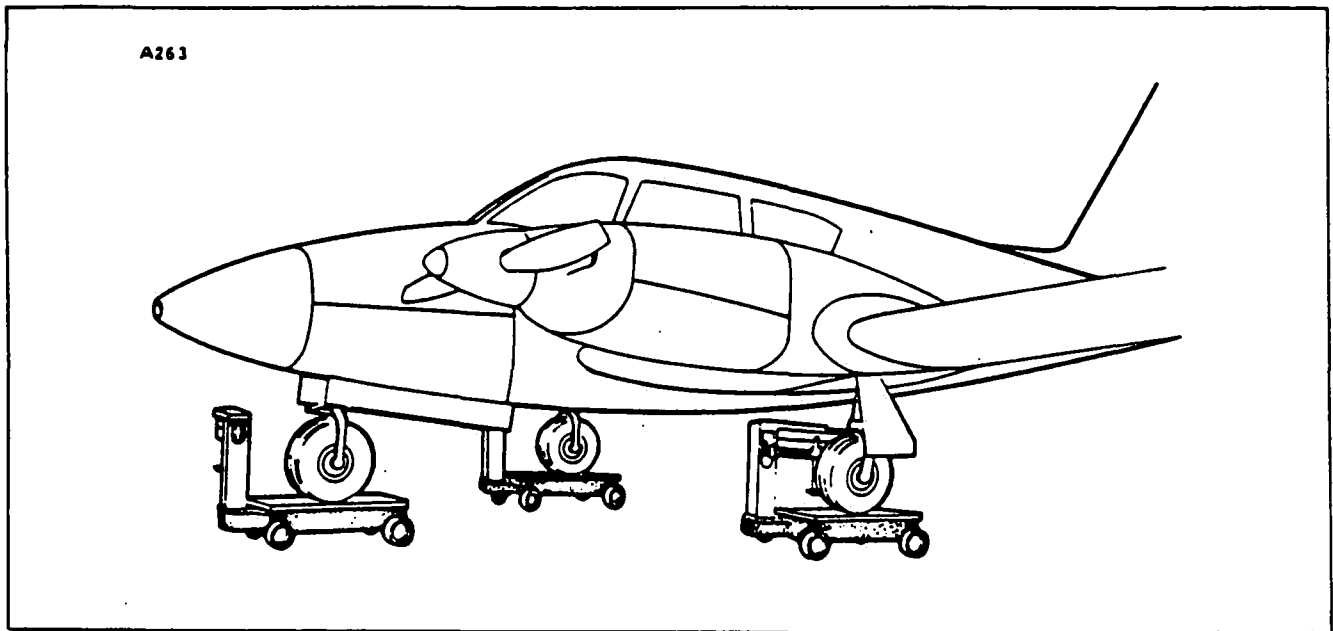


Figure 2-10. Weighing Airplane

**2-13. WEIGHING.** (Refer to Figure 2-10.) The airplane may be weighed by the following procedure:

- a. Position a scale and ramp in front of each of the three wheels.
- b. Secure the scales from rolling forward and tow the airplane up onto the scales using the towing procedure as given in paragraph 2-18.
- c. Remove the ramp so as not to interfere with the scales.
- d. If the airplane is to be weighed for weight and balance computations, level the airplane per instructions given in paragraph 2-14.

**2-14. 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. To longitudinally level the airplane, partially withdraw the two leveling machine screws on the side of the fuselage. On airplanes with Serial Numbers 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, the screws are located over the baggage door. (Refer to Figure 2-11.) On airplanes with Serial Numbers 30-853 and 30-902 to 30-2000 inclusive, there is one screw fore and one aft of the right rear window. (Refer to Figure 2-12.) Place a spirit level on these screw heads and adjust the jacks until the level is centered. Should the airplane be either on scales or on the floor, first block the main gear oleos to full extension; then deflate the nose wheel until the level position is reached.

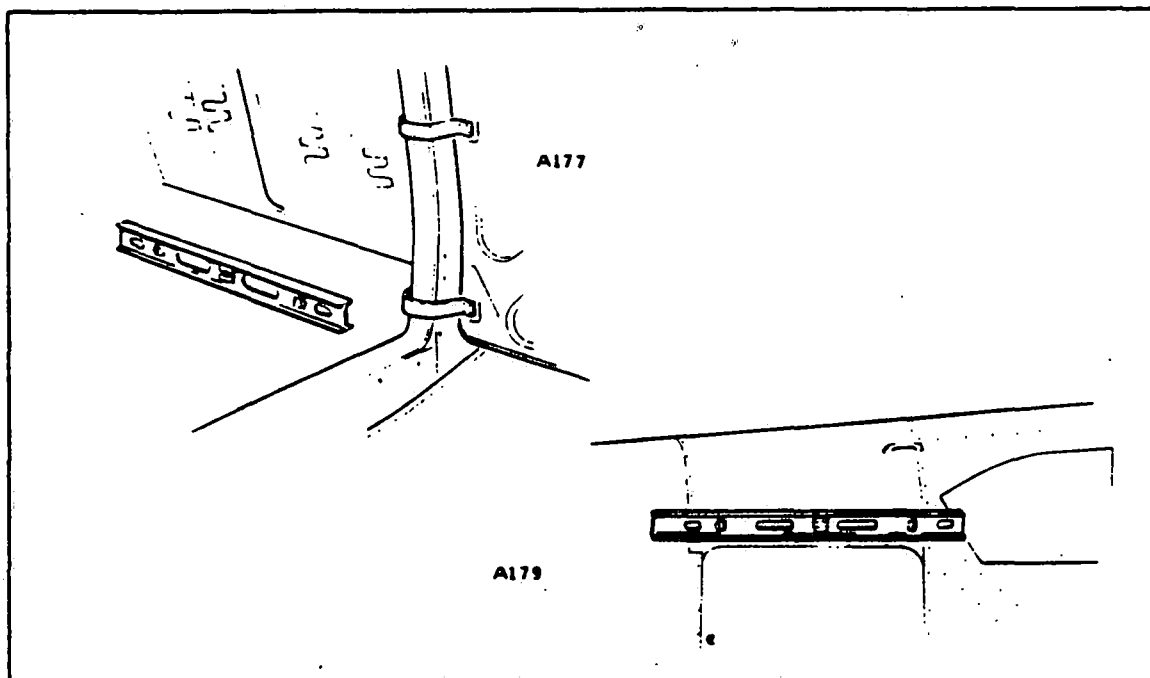


Figure 2-11. Leveling Airplane  
Serial Nos. 30-1 to 30-852 incl; 30-854 to 30-901 incl.

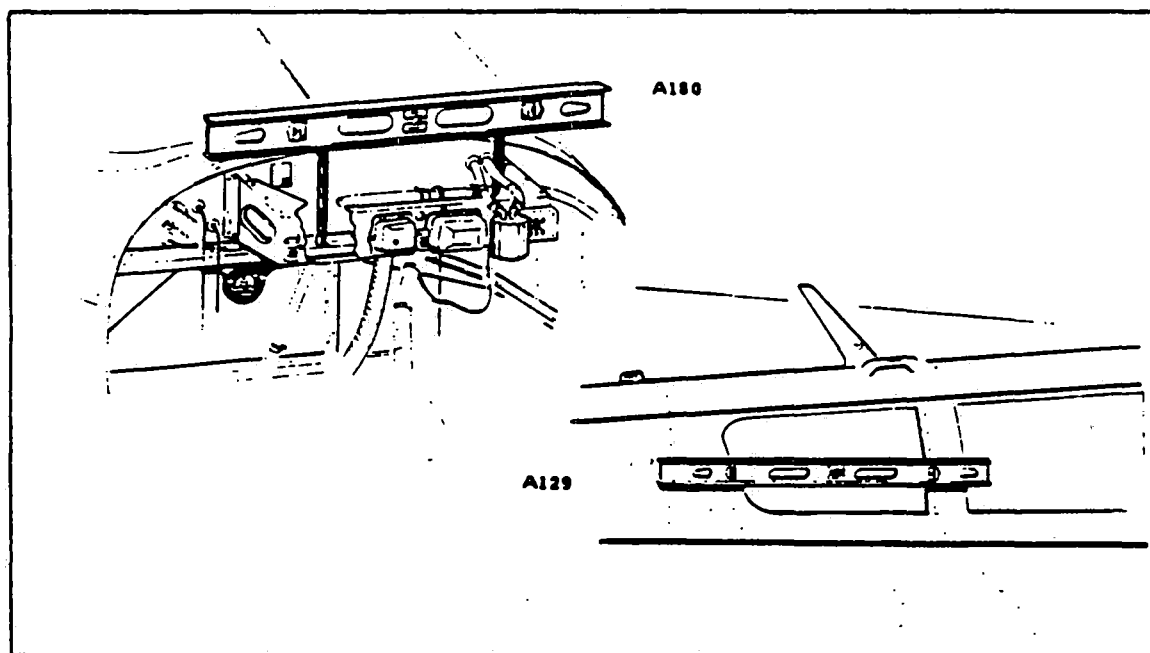


Figure 2-12. Leveling Airplane  
Serial Nos. 30-853, 30-902 to 30-2000 inclusive

b. To laterally level airplanes with Serial Numbers 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, place a level across the floorboard at Station 136.5 over the bulkhead to which the baggage door hinge brackets are attached. (Refer to Figure 2-11.) On airplanes with Serial Numbers 30-853 and 30-902 to 30-2000 inclusive, place a level on or parallel to the hat section channel of the forward cabin bulkhead. (Refer to Figure 2-12.) Should equipment or other obstacles hinder placing the level directly on the channel, use two spacers (rods, etc.) of equal length between the level and channel to bring the level above any obstacles. Raise or lower one wing tip by deflating the appropriate tire on the high side of the airplane or adjust either jack until the bubble of the level is centered.

**2-15. MOORING.** The airplane should be 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. Lock the aileron and stabilator controls using the front seat belt, control wheel lock, or control surface blocks.
- c. Block the wheels.
- d. Secure tie-down ropes to the wing tie-down rings and the tail skid at approximately 45-degree angles to the ground. Leave sufficient slack to avoid damage to the aircraft 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 possible.

2-16. 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 2-15.

- 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 brake 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

To prevent damage to brake drum, care should be taken when setting brakes that are overheated or during cold weather when accumulated moisture may freeze the brake.

2-17. LOCKING AIRPLANE. The cabin and baggage doors are provided with a key lock. The same key can be used to operate both door locks.

2-18. TOWING. The airplane may be moved by using the nose wheel steering bar provided, or power equipment that will not damage or cause excess strain to the nose gear assembly. On airplanes with Serial Numbers 30-1 to 30-852 inclusive, the steering bar is stowed on the underside of the hat shelf in the baggage compartment. On airplanes with Serial Numbers 30-853 and 30-902 to 30-2000 inclusive, it is attached to the forward section of the main spar.

#### CAUTION

When towing with power equipment, do not turn nose gear more than 20-degrees in either direction as this will result in damage to the nose gear and steering mechanism.

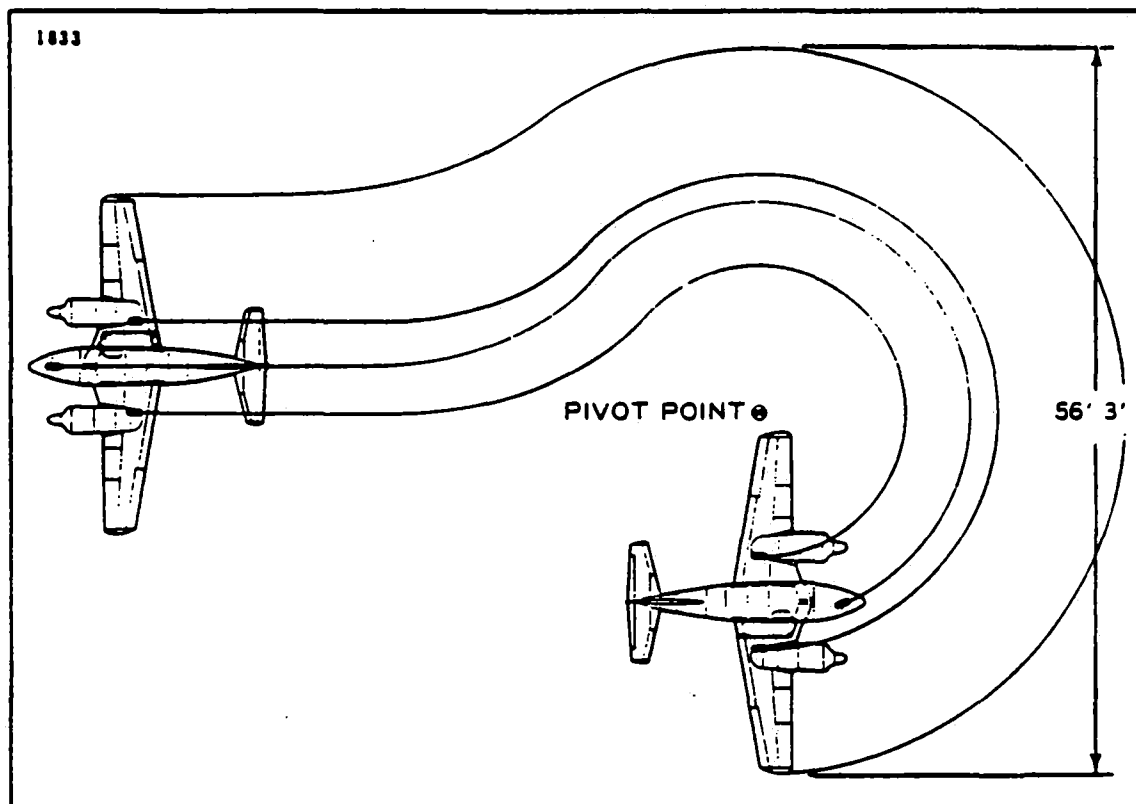


Figure 2-13. Minimum Turning Radius

2-19. 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.



2-20. EXTERNAL POWER RECEPTACLE.

2-21. OPERATION OF EXTERNAL POWER RECEPTACLE. The external power receptacle is located on the right side of the fuselage, just rearward of the baggage door, on airplanes with Serial Nos. 30-2 to 30-852 inclusive and 30-854 to 30-901 inclusive; and on the left side of the nose section of airplanes with Serial Nos. 30-853 and 30-902 to 30-2000 inclusive. When using external power for starting or operation of any of the airplane's equipment, place the master switch in the OFF position before inserting or removing the power plug.

2-22. CLEANING.

2-23. 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 cowl 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 or alternator, starter, or air intakes.

- c. Allow the solvent to remain on the engine from five to ten 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, Figure 2-20.

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**2-24. CLEANING LANDING GEAR.** Before cleaning the landing gear, place a plastic cover or similiar 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 five to ten 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, Figure 2-20.

**2-25. 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:

**NOTE**

When hosing down aircraft avoid directing water in the fuel tank vents, drain tubes or around the sealed cover plates and filler cap access openings.

- 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.

**2-26. CLEANING WINDSHIELD AND WINDOWS.**

- a. Remove dirt, mud, etc., from exterior surface with clean water.
- b. Wash with mild soap and warm water or on 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, cabon tetrachloride, thinner, acetone, or window cleaning sprays.

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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.

f. To improve visibility through windshield and windows during flight through rain, a rain repellent such as REPCON should be applied to the windshield and windows. The surfaces of the windshield and windows treated becomes so smooth that water beads up and readily flows off the surface. Apply this product in accordance with the manufacturer's instructions. (Repco P/N FSCM, made by UNELKO Corporation 727 E. 110th Street Chicago, Ill. 60628.)

### 2-27. 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.

2-28. CLEANING CARPET. Use a small whisk broom or vacuum to remove dirt. For soiled spots, use a non-inflammable dry-cleaning fluid.

### 2-29. SERVICING.

2-30. 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.

### 2-31. LANDING GEAR SYSTEM.

2-32. 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.

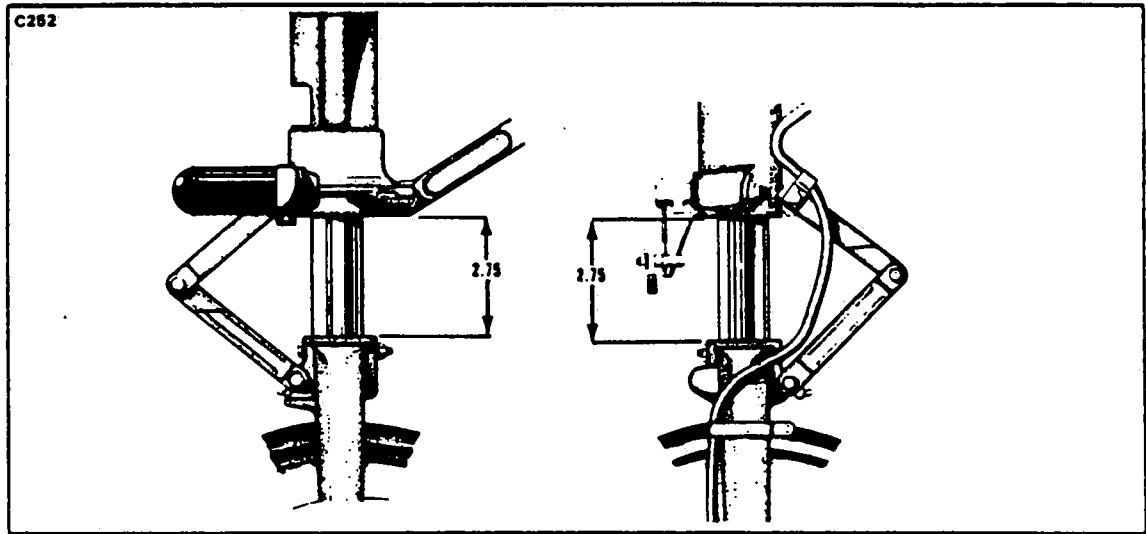


Figure 2-14. Servicing Landing Gear Struts

### 2-33. OLEO STRUTS.

**2-34. SERVICING OLEO STRUTS.** The air-oil type oleo strut should be maintained at proper strut tube exposures for best oleo action. Both the nose and main gear struts must have approximately 2.75 inches of piston tube exposed. (Refer to Figure 2-14.) These measurements are taken with the airplane sitting on level surface under normal static load. (Empty weight of airplane plus full fuel and oil.) If the strut has less tube exposure than prescribed, 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 2-36. 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 2-35. For repair procedures of the landing gear and/or oleo struts, refer to Section VII.

### WARNING

Deflate strut before disassembly.

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2-35. FILLING OLEO STRUTS. To fill the nose or main gear oleo strut with fluid (MIL-H-5606), whether it be only the addition of a small amount or if the unit has been completely emptied and will require a large amount, it should be filled as follows:

**WARNING**

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

**CAUTION**

Dirt and foreign particles form around the filler plugs of the landing gear struts, therefore, before attempting to remove these plugs, the tops of the struts should be cleaned with compressed air and/or with a dry type solvent.

- a. Place the airplane on jacks. (Refer to Jacking, Paragraph 2-12.)
- b. Place a pan under the gear to catch spillage.
- c. At the filler plug, relieve air pressure from the strut housing chamber by removing the cap from the air valve and depressing the valve core.
- d. There are two methods by which the strut chamber may be filled and these are as follows:

**First Method:**

1. Remove the valve core from the filler plug at the top of the nose gear strut housing or at the top inboard side of the main gear housing. Allow the filler plug to remain installed.
2. Attach one end of a clean plastic hose to the valve stem of the filler plug and submerge the other end in a container of hydraulic fluid.

**NOTE**

An air-tight connection is necessary between the plastic tube and the 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.

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3. Fully compress and extend the strut thus drawing fluid from the fluid container and expelling air from the strut chamber. By watching the fluid pass through the plastic hose, it can be determined when the strut is full and no air is present in the chamber.

4. When air bubbles cease to flow through the hose, compress the strut fully and remove the hose from the valve stem.

5. With the strut compressed, remove the filler plug to determine that the fluid level is visible up to the bottom of the filler hole.

6. Reinstall the core in the filler plug and the plug in the strut housing and tighten.

**Second Method:**

1. Remove the filler plug from the top of the nose gear strut housing or at the top inboard side of the main gear housing.

2. Raise the strut piston tube until it is fully compressed.

3. Pour fluid from a clean container through the filler opening until it reaches the bottom of the filler plug hole. (Air pressure type oil container may be helpful.)

4. Install the filler plug finger tight, and extend and compress the strut two or three times to remove air from the housing.

5. Remove the filler plug, raise the strut to full compression and fill with fluid if needed.

6. Reinstall fill plug and tighten.

e. With the airplane raised, retract and extend the gear strut several times to ascertain that the strut actuates freely. The weight of the gear fork and wheel should extend the strut.

f. Clean off overflow of fluid and inflate the strut as described in paragraph 2-36.

g. Check that fluid is not leaking around the strut piston at the bottom of the housing.

**2-36. INFLATING OLEO STRUTS.** After making certain that an oleo strut has sufficient fluid attached, attach the strut pump to the air valve and inflate the oleo strut. The main gear struts should be inflated to provide equal extension with normal static load (empty weight plus full fuel and oil) of a recommended 2.75 inches of piston exposure, although it may be reduced to 2.25 inches at the pilot's discretion. (The nose gear strut may vary from 2.25 to 2.75 inches.) (Refer to Paragraph 2-34.) Rock the airplane several times to ascertain that the gear settles back to the correct strut position. (If a strut pump is not available, the airplane may be raised and line pressure from a high pressure air system used. Lower the airplane and while rocking it, let air from the valve to bring the strut down to the proper extension.) Before capping the valve, check for valve core leakage.

**2-37. BRAKE SYSTEM.**

**2-38. 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 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 or air in the system. Instructions for filling the reservoir are given in paragraph 2-39. When found necessary to accomplish repairs to any of the brake system components, or to bleed the system, these instructions may be found in Section VII.

**2-39. 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 on the left side of the forward cabin bulkhead in the nose section (refer to Figure 2-15 or 2-16), should be checked at every 100-hour inspection and replenished as necessary. No adjustment of the brakes is necessary, though they should be checked periodically per instructions given in Section VII.

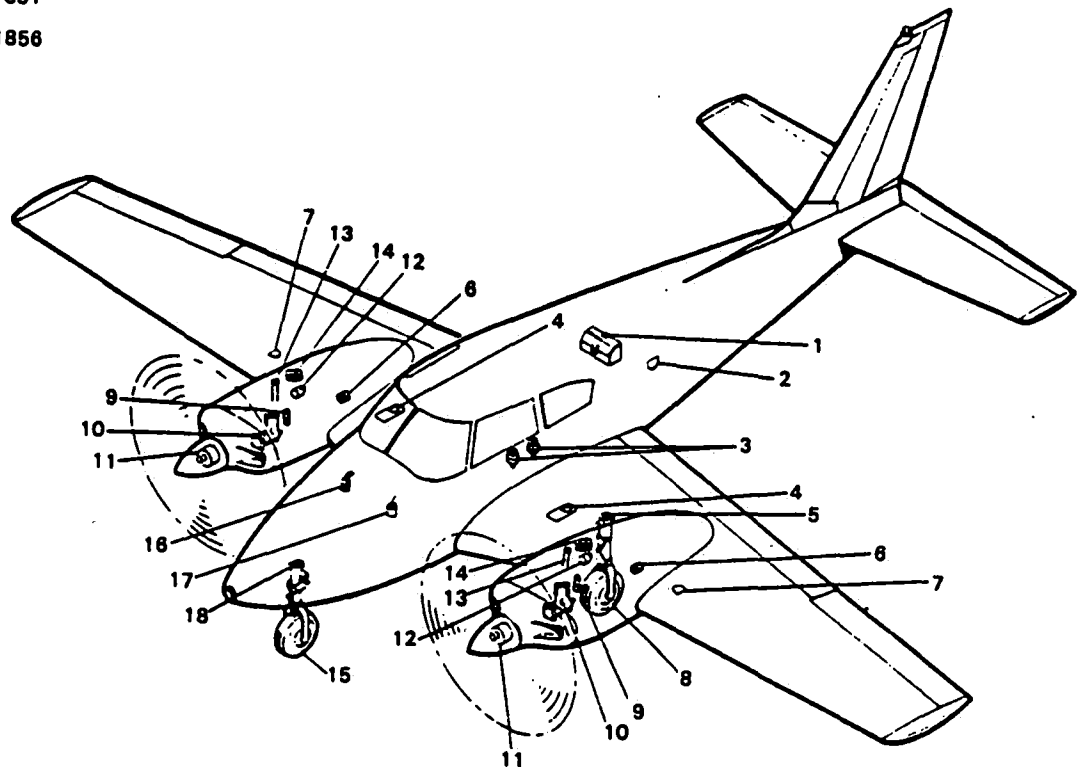
**2-40. DRAINING BRAKE SYSTEM.** To drain the brake system, connect a hose to the bleeder fitting on the bottom of the cylinder and place the other end of the line in a suitable container. Open the bleeder and slowly pump the desired brake pedal until fluid ceases to flow. To clean the brake system, flush with denatured alcohol.

**2-41. TIRES.**

**2-42. SERVICING TIRES.** The tires should be maintained at the pressure specified in Table II-I. When checking tire pressure, examine the tire for wear, cuts, bruises and slippage.

1851

1856



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|--|--------------------------------------|
| 1. BATTERY                               | 10. FUEL INJECTOR                    |
| 2. FILLER OXYGEN                         | 11. AIR VALVE, PROPELLER             |
| 3. FUEL SELECTOR VALVES AND DRAINS       | 12. FILTER, ENGINE OIL               |
| 4. FILLER, MAIN FUEL CELL                | 13. FILLER, ENGINE OIL               |
| 5. FILLER, MAIN OLEO SHOCK STRUT L AND R | 14. FILTER, ENGINE AIR INTAKE        |
| 6. FILTER, VACUUM REGULATOR              | 15. TIRE, NOSE GEAR                  |
| 7. FILLER, AUXILIARY FUEL CELL           | 16. VACUUM SYSTEM CENTRAL AIR FILTER |
| 8. TIRE, MAIN GEAR L AND R               | 17. BRAKE FLUID RESERVOIR            |
| 9. ENGINE OIL SUCTION SCREEN             | 18. FILLER, NOSE OLEO SHOCK STRUT    |

Figure 2-15. Service Points  
Serial Nos. 30-1 to 30-852 incl. and 30-854 to 30-901 incl.



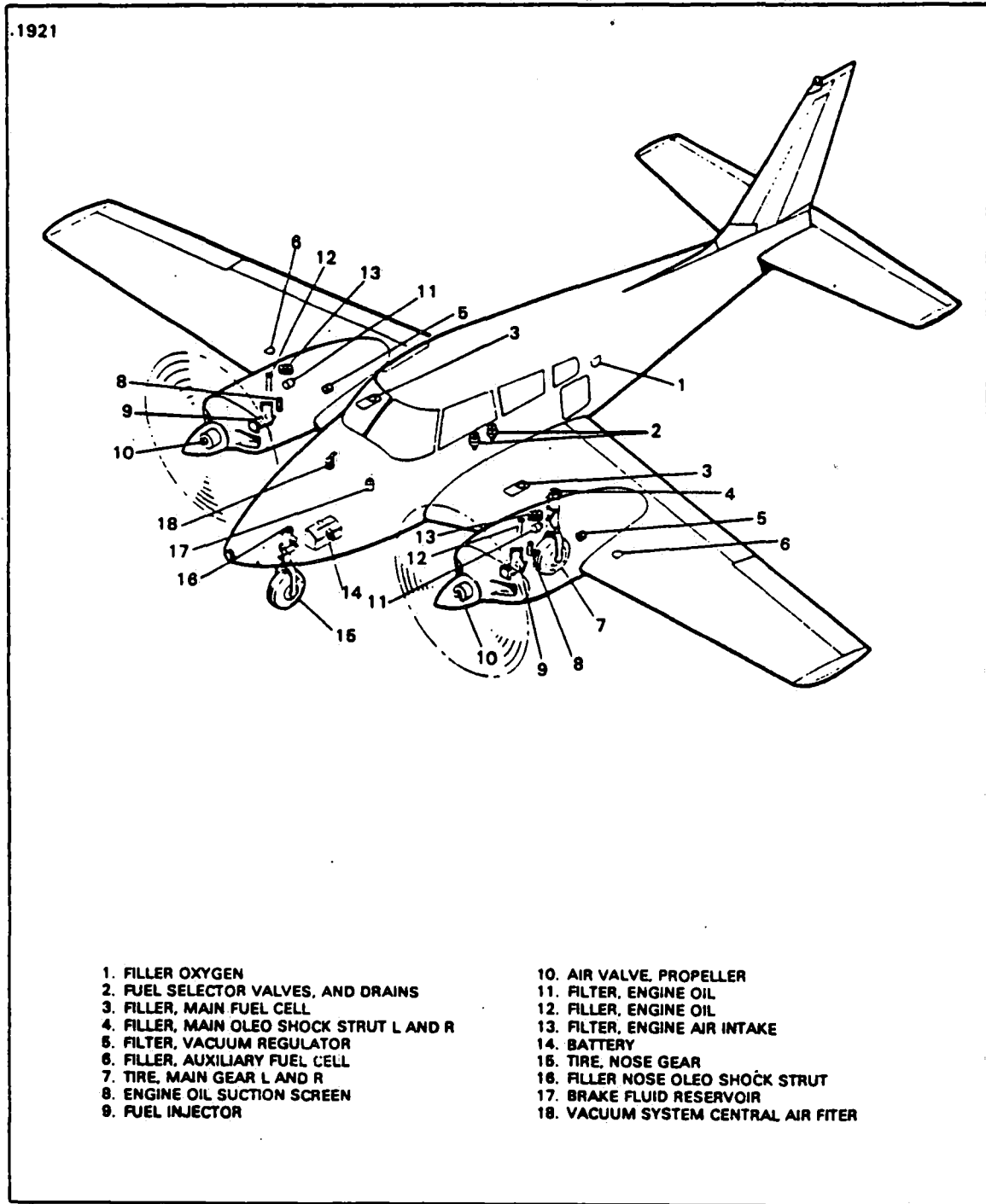


Figure 2-16. Service Points  
Serial Nos. 30-853, 30-902 to 30-2000 inclusive

**2-43. POWER PLANT.**

**2-44. SERVICING POWER PLANT.** Regularly check the engine compartment for oil and fuel leaks, chafing of lines, loose wires and tightness of all parts. For cleaning of the engine compartment, refer to paragraph 2-23. Maintenance instructions for the Power Plant may be found in Sections VIII and VIIIA of this manual and in the appropriate manufacturer's manuals.

**2-45. PROPELLER.**

**2-46. SERVICING PROPELLER.** The propeller blades, spinner and visible hub surfaces should be cleaned and 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 or instructions found in Sections VIII and VIIIA. The face of each blade should be painted when necessary with a flat paint to retard glare. To prevent corrosion, wipe surfaces with a light oil or wax. The blades should be checked that they turn freely on the hub pilot tube by rocking the blades back and forth through the slight freedom allowed by the pitch change mechanism. Lubricate the propeller at 100 hour intervals in accordance with the Lubrication Chart, Figure 2-20. Ascertain propeller is charged to the proper chamber pressure. Additional service information for the propeller may be found in Sections VIII and VIIIA.

**2-47. POWER PLANT INDUCTION AIR FILTER.**

**2-48. REMOVAL OF AIR FILTER.**

- a. Remove the right side access panel from the engine nacelle to gain access to the air filter box.
- b. Turn the three studs and remove the air filter box cover.
- c. Lift the air filter from the filter box.

**2-49. CLEANING INDUCTION AIR FILTER.**

- a. Tap filter gently to remove dirt particles. Do not use compressed air or cleaning solvents.
- b. Inspect filter. If paper element is torn or ruptured or gasket is damaged, the filter should be replaced. The usable life of the filter should be restricted to one year or 500 hours, whichever comes first.

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**2-50. CLEANING INDUCTION AIR FILTER. TURBOCHARGED.**

- a. Clean air filter thoroughly with a dry type solvent or kerosene.
- b. Inspect filter. If element is punctured or ruptured or gasket is damaged, the filter should be replaced.
- c. Allow filter to dry thoroughly then dip in SAE10 weight oil and allow to drain for four hours.
- d. Wipe off excess oil prior to installation.

**2-51. INSTALLATION OF INDUCTION AIR FILTER.**

- a. Place filter in air box and install cover.
- b. Secure cover by turning studs. On turbocharged airplanes, secure air box cover with wing nuts and safety.

**2-52. VACUUM SYSTEM AIR FILTERS.**

**2-53. REPLACEMENT OF CENTRAL AIR FILTER.** Each 100 hours of operation the central air filter, located just forward of the forward cabin bulkhead, should be replaced.

- a. Remove top nose access panel by loosening quarter turn fasteners.
- b. Remove vacuum hoses from filter by removing spring clamps.
- c. Remove nut from stud attaching filter to mounting bracket.
- d. Install new filter in reverse order of removal.

**2-54. REPLACEMENT OF INSTRUMENT AIR FILTER.** Remove the filter assembly and replace during the 500 hour inspection of the airplane.

- a. Remove screws attaching air inlet plate to back of instrument.
- b. Remove snap ring that holds the filter in place and remove filter.
- c. Install new filter in adapter and secure with snap ring.
- d. Install air inlet plate to back of instrument and secure with screws.

**2-55. REPLACEMENT OF VACUUM REGULATOR FILTERS.** Every 100 hours of operation the regulator filters, located aft of the firewall in each engine nacelle, should be replaced.

- a. Remove top access panel from each engine nacelle.
- b. Remove filter from around the regulator and replace with new one.
- c. Install top nacelle access panels and secure with screws.

**2-56. FUEL SYSTEMS.**

**2-57. SERVICING FUEL SYSTEM.** At intervals of 50 hours or 90 days, whichever comes first, clean the screen in each filter bowl located through an access opening in the center bottom of the fuselage. Remove and clean the screens in accordance with instructions outlined in Section IX. Inspection intervals of the various fuel system components may be found in Section III.

Also, check condition of gaskets and seals at all filler openings, and ensure that filler cap rubber is in good condition. Check to see that the filler cap fits snugly in the opening when in the locked position.

**2-58. 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 on the placard located on the underside of the filler cover or in Table II-I. Each main (inboard) fuel cell holds a maximum of 30 U. S. gallons. The auxiliary (outboard) fuel cells have a maximum capacity of 15 U. S. gallons each which give a total of 90 U. S. gallons of fuel with 84 U. S. gallons usable. In addition, as optional equipment are tip tanks with a capacity of 15 U. S. gallons each. In order to obtain maximum capacity when filling fuel cells, the plane should be approximately level.

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### NOTE

Refuel after each flight to keep condensation in fuel tanks at a minimum.

**2-59. DRAINING FUEL VALVES AND LINES.** The fuel filter bowls and lines are drained by opening the access door within the fuselage just aft of the fuel selector console, and pulling up on the red knob in the center of each valve. A transparent plastic tube is attached to each filter bowl and extends through a hole in the bottom of the fuselage. Flow of the fuel is observed by means of the transparent tube. The fuel valves, bowls and lines should be drained regularly to check for water or dirt accumulations.

### NOTE

To ensure removing any water that may be in the fuel lines, drain at least  $\frac{1}{2}$  pint from each tank. Collect the fuel samples in a glass container so the presence of water may be observed.

a. To drain the lines from the main and auxiliary cells, open the drain valve with the selector handle on the main. Completely drain the sediment bowl before moving the selector handle to the auxiliary cell. Repeat the process for the opposite tank.

b. To drain the lines from the tip tanks, move the fuel selector handle to the auxiliary fuel cell position; turn the master switch on; and the electrical selector switch, located on the forward side of the selector panel, to the tip tank position. Open the drain valve to allow the line to drain. Repeat the process for the opposite tank.

### CAUTION

During cold weather operation, if the sediment bowls drain slower than normal, or not at all, it could be an indication of ice at the drain and the aircraft should be hangered to thaw out and drained thoroughly.

**2-60. DRAINING FUEL SYSTEM.** The bulk of the fuel may be drained from the fuel cells and tip tanks by the use of a siphon hose placed in the cell or tank through the filler neck. In addition, the tip tank may be drained by inserting a dowel in the plug at the bottom of the tank and pushing up or by removing the plug itself. The remainder of the fuel may be drained by opening the drain valve in each fuel selector bowl.

**2-61. ELECTRICAL SYSTEM.**

**2-62. SERVICING ELECTRICAL SYSTEM.** Servicing the electrical system involves adding distilled water to the battery to maintain correct electrolyte level, and checking cable connections and for any spilled electrolyte that would lead to corrosion. The security of all electrical connections should be checked as well as the operation of all lights, general condition of the generator or alternator and starter. All electrical wires should be inspected for chafing and bare wires. For detailed information on this system, refer to Section XI of this manual.

**2-63. OXYGEN SYSTEM.**

**2-64. SERVICING THE OXYGEN SYSTEM.** Oxygen for the breathing system is furnished from a stationary cylinder located aft of the baggage area on the left side of the fuselage at station 175.0. At 1800 psi of pressure, the oxygen cylinder has a capacity of 63.7 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 the airplane is on the ground or when in flight and the oxygen system is not being used. To open the oxygen valve, pull out on the control knob located on the instrument panel. To close the valve, push in on the control knob. Refer to Section XIV of this manual for complete service information of this system.

**2-65. 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.

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f. Use Ribbon Dope Thread Sealant (Permacel 412) on male ends of fittings only. Wrap thread in direction of thread spiral, beginning with the second thread on the fitting. Avoid getting any sealant into the lines.

2-66. FILLING OXYGEN CYLINDER. The filler valve for the oxygen system is accessible through a door located on the left side of the fuselage just aft of the rear window.

a. To fill the oxygen cylinder, open the access door; remove the cap from the filler valve and attach the filler hose from the oxygen recharge unit to the filler valve. Ascertain that all fittings are free from oil, grease, dirt, etc.

### NOTE

If the airplane's oxygen cylinder pressure is below 50 psi, the system should be purged as described in Section XIV.

b. To obtain the correct filling pressure for the oxygen system at various ambient temperatures, a table is included for your convenience. The pressures given are not exact, but sufficiently accurate for practical purposes of working pressures between 1800 and 2400 psig cylinders. The cylinder should be allowed to cool to a stabilized temperature after filling before checking against the figures given in Table II-III A.

c. When using a recharge unit consisting of one supply cylinder, slowly open the valve of the supply unit and allow the oxygen to transfer.

d. When using a recharge unit consisting of two or more supply cylinders (cascade storage system), it is recommended that the following procedure be used:

1. Before opening any valves, check the pressure remaining in the airplane's oxygen cylinder. If it is still partly charged, note the pressure indicated on the cylinder gauge. Then open and close each valve on the cascade storage system and determine which cylinder has the lowest pressure. When found, if this cylinder has a pressure lower than the oxygen cylinder in the airplane, do not attempt using it for filling. Use the storage cylinder that has a pressure higher than the airplane's cylinder but lower than the others.

2. Open the valve on only the one storage cylinder with the lowest pressure. When the pressure indicated on the airplane's oxygen gauge and charging gauge has become equal, close the valve of the storage cylinder, then go to the storage cylinder with the next higher pressure and repeat the procedure.

3. If, after using the last storage cylinder, the airplane's oxygen system is still not fully charged, a full storage cylinder should be put in place of a cylinder with the lowest pressure and used in the same manner.

4. A good deal of oxygen will remain in the large cylinders used in the cascade system after filling only one of the cylinders, but such remaining oxygen will be at a pressure something less than the 1800 pounds, which is not sufficient pressure to completely refill another aircraft cylinder, although it will refill several small cylinders.

5. It is not economical, even on a three or four-cylinder cascade system, to begin recharging with oxygen at less than 300 psi pressure in the 300 cubic foot bank of cylinders. So, use 300 cubic foot cylinders down to approximately 300 psi, then return for refilling. In two-cylinder systems, use to approximately 600 psi, then return for filling.

e. When the pressure gauge on the recharge unit or in the airplane reaches 1800 psi, close the pressure regulator valve on the recharge unit. Disconnect the filler hose from the filler valve; replace the protective cap on the filler valve and close the access cover. Check the cylinder pressure according to Table II-III A after the cylinder temperature stabilizes.

TABLE II-III.A. INDICATED OXYGEN PRESSURES  
FOR GIVEN AMBIENT TEMPERATURES

Temperature ° F	Indicated Cylinder Pressure (psig)
110	1980
100	1935
90	1890
80	1845
70	1800
60	1755
50	1710
40	1665

2-67. LUBRICATION.

2-68. OIL SYSTEMS (ENGINE).

2-69. **SERVICING OIL SYSTEM.** The engine oil level should be checked before each flight and changed after each 50 hours of engine operation. During oil change, the oil screen(s) should be removed and cleaned and, when installed, the oil filter cartridge replaced. Intervals between oil changes can be increased as much as 100% on engines equipped with full flow (cartridge type) oil filters provided the element is replaced each 50 hours of operation. Removal and cleaning of screens may be found in paragraphs 2-72 and 2-73. 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 2-76 and/or the latest revision of Lycoming Service Instruction Letter 1014.

**CAUTION**

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

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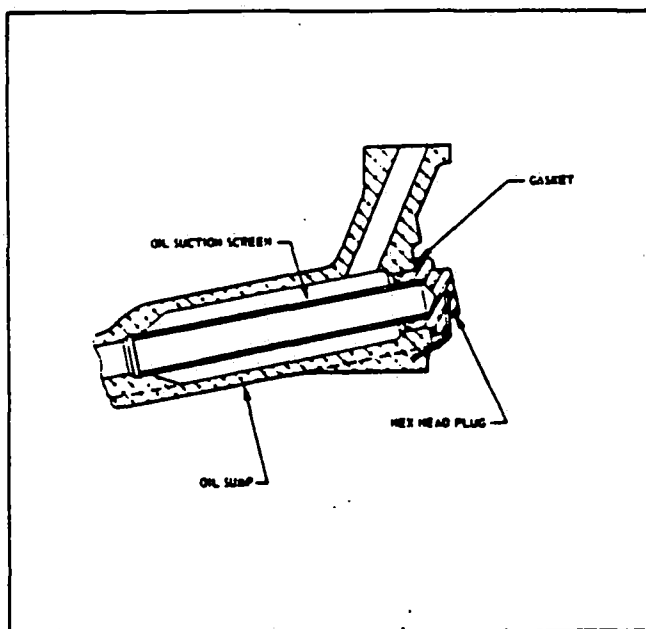


Figure 2-17. Oil Suction Screen

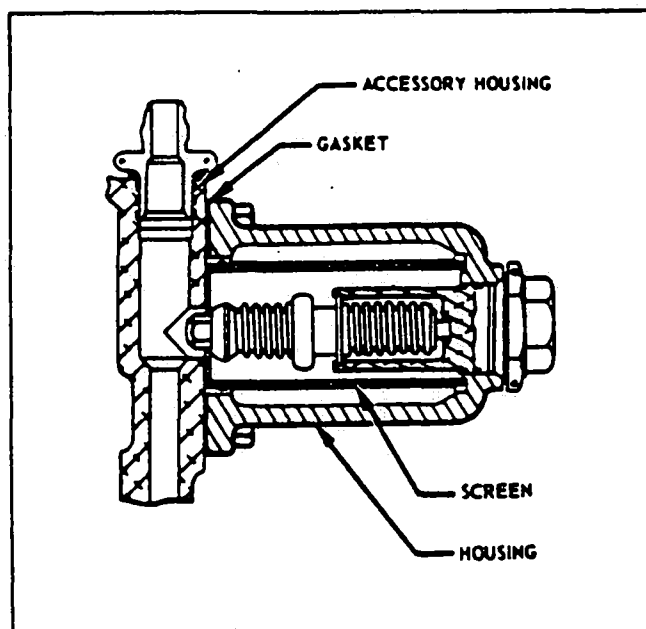


Figure 2-18. Oil Pressure Screen

**2-70. DRAINING OIL SUMP.** To drain oil sump, provide a suitable container with a minimum capacity of 8 quarts.

- a. Remove the oil drain access plate from bottom of the engine cowl.
- b. Remove oil drain plug from bottom of the engine sump. It is recommended the engine be warmed to operating temperature to insure complete draining of the old oil.

**2-71. FILLING OIL SUMP.** The oil sump should normally be filled with oil to the 8 U.S. quart mark on the engine dipstick. The specified grade of oil may be found in Table II-V, the Lubrication Chart, or on each engine oil filler access door. To service the engine with oil, open the quick release access door on the left side of each engine cowling and remove the oil filler cap with dipstick.

**2-72. OIL SCREEN (SUCTION).** The suction screen located in the bottom of the sump to the right of the air induction inlet 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 2-17.) 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.

**2-73. OIL SCREEN (PRESSURE).** 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. (Refer to Figure 2-18.) Install the screen and housing to the accessory case using a new gasket. Torque attaching bolts within 50 to 70 inch-pounds.

**2-74. OIL FILTER. (FULL FLOW.)**

a. The oil filter element should be replaced after each 50 hours of engine operation. This is 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.

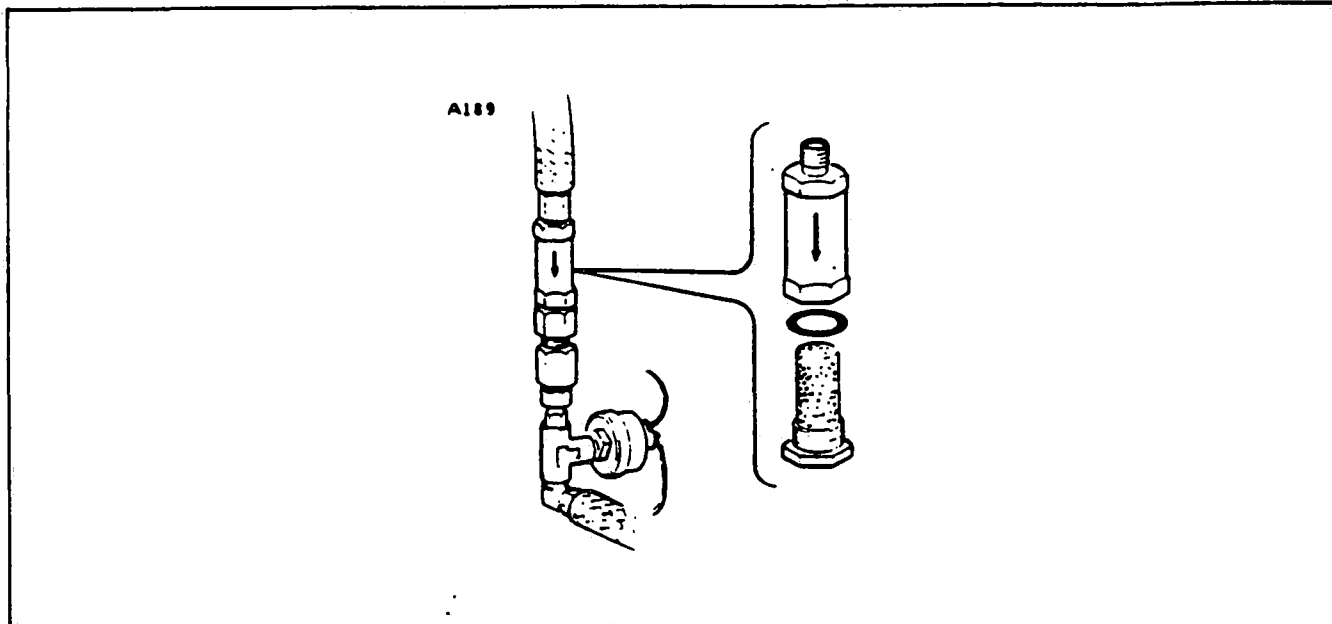


Figure 2-19. Turbo Oil Filter

#### 2-75. TURBO OIL FILTER CLEANING PROCEDURE.

- a. Remove the oil filter, located on the lower right side of the firewall, from line and disassemble unit. (Refer to Figure 2-19.)
- b. Wash parts with solvent and back flush the bronze element. Check condition of "O" ring and replace if necessary. An overnight soaking in carburetor cleaner may be necessary if heavy sludging is evident. (This is usually due to mixing detergent with non-detergent oils.)
- c. Reassemble unit and install filter in the turbo oil system. Clean filter at each oil change.

#### 2-76. RECOMMENDATIONS FOR CHANGING OIL. (Refer to the latest revision of Lycoming Service Instruction No. 1014.)

- a. In engines that have been operating on straight mineral oil for several hundred hours, a change to additive 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 additive or compounded oil should be deferred until after the engine is overhauled.
- b. When changing from straight mineral oil to compounded oil, the following precautionary steps should be taken:
  1. Do not add additive oil to straight mineral oil. Drain the straight mineral oil from the engine and fill with additive oil.
  2. Do not operate the engine longer than five hours before the first oil change.
  3. 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.

2-77. 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 instructions regarding the locations, time intervals, and type of lubricants used may be found in the Lubrication Chart, Figure 2-20. 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.

2-78. 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.

2-79. 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.

2-80. LUBRICATION CHART. Each part of the airplane to be lubricated, as depicted on the Lubrication Chart, is indicated by a frequency symbol which shows the time intervals between lubrications. Application symbols with the frequency symbols show how the lubrication is applied. A parts nomenclature key, referred to by a number adjacent to the frequency symbol, identifies the part to be lubricated. Within the frequency symbol is a code letter which identifies the type of lubricant to be used and a special instructions number which gives instructions for lubricating a particular component.

TABLE II-IV. RECOMMENDED LUBRICATING OILS

Average Grade Oil	Average Ambient Air Temperature	Oil Inlet Temperatures	
		Desired	Maximum
SAE 50	Above 60° F (16° C)	180° F (82° C)	245° F (118° C)
SAE 40	30° F to 90° F (-1° C to 32° C)	180° F (82° C)	245° F (118° C)
SAE 30	0° F to 70° F (-17° C to 20° C)	170° F (77° C)	225° F (107° C)
SAE 20	Below 10° F (12° C)	160° F (71° C)	210° F (99° C)

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TABLE II-IVA. 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)
<p>— NOTE —</p> <p><i>Lubricate engine fittings only with the fluid contained in the particular lines.</i></p>	

### NOTES

1. WHEEL BEARINGS REQUIRE CLEANING AND REPACKING AFTER EXPOSURE TO AN ABNORMAL QUANTITY OF WATER.
2. SEE THE LATEST REVISION OF LYCOMING SERVICE INSTRUCTIONS NO. 10T4 FOR USE OF DETERGENT OIL.
3. MISCELLANEOUS - DURING ROUTINE MAINTENANCE CHECKS, APPLY LUBRICANT TO MISCELLANEOUS LINKAGES.
4. TRANSMISSIONS SHOULD BE DISASSEMBLED, CLEANED, INSPECTED, AND LUBRICATED AT EACH 500 HOUR INTERVAL OR ANNUALLY. ACTUATOR SCREWS SHOULD BE LUBRICATED AT EACH 100 HOUR INTERVAL OR ANNUALLY.

### CAUTIONS

1. DO NOT USE HYDRAULIC FLUID WITH A CASTOR OIL OR ESTER BASE.
2. DO NOT OVER-LUBRICATE COCKPIT CONTROLS.
3. DO NOT APPLY LUBRICANT TO RUBBER PARTS.

### EXAMPLE

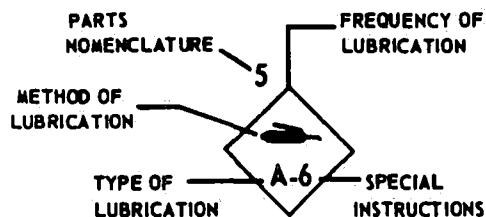


Figure 2-20. Lubrication Chart

## PARTS NOMENCLATURE KEY

1. STABILATOR TRIM TAB AND RUDDER HINGES
2. STABILATOR TRIM PULLEYS
3. FLAP TRANSMISSION
4. FLAP CONTROL ARMS AND CABLE ENDS
5. AIR FILTER, RIGHT AND LEFT
6. COWL FLAP CONTROL LINKAGE, RIGHT AND LEFT
7. ENGINE OIL SUMP, RIGHT AND LEFT
8. BRAKE RESERVOIR
9. PILOT AND PASSENGERS SEAT TRACKS
10. LANDING GEAR RETRACTION MECHANISM
11. LANDING GEAR RETRACTION TRANSMISSION
12. OIL FILTER CARTRIDGE, RIGHT AND LEFT
13. GOVERNOR, THROTTLE AND MIXTURE CABLE ENDS
14. AILERON HINGES, RIGHT AND LEFT
15. FLAP CONTROL ROD ENDS, CABLE ENDS AND BELLCRANK BEARINGS
16. STABILATOR CONTROL CABLE ENDS AND TRIM PULLEYS
17. STABILATOR CONTROL TUBE BEARINGS AND SQUARE TUBE MOUNTING BEARINGS
18. CONTROL WHEEL ROLLERS
19. CONTROL WHEEL CHAIN VERTICAL AND HORIZONTAL
20. LOCK PIN, STEP
21. STEP LOCK PULLEYS AND RELEASE ARM PIVOT BEARING
22. FLAP TRACK
23. FLAP TRACK ROLLERS, STEEL OR NYLON
24. STEERING ROD END BEARINGS, STEERING BELLCRANK PIVOT BEARING,  
STEERING ARM BUSHING, GEAR ALIGNING BUSHING
25. GEAR OLEO STRUT FILLER
26. NOSE GEAR DOOR HINGES, DOOR ACTUATING MECHANISM, NOSE GEAR PUSH-PULL  
ROD END BEARING
27. STRUT HOUSING ATTACHMENT BUSHINGS, DRAG LINK PIVOT AND  
ATTACHMENT BUSHINGS
28. SHIMMY DAMPENER ROD END BEARING AND MOUNT
29. UPPER AND LOWER TORQUE LINK BUSHINGS
30. UPPER AND LOWER TORQUE LINK CONNECTING BOLT
31. WHEEL BEARINGS
32. RUDDER TRIM GUIDE, UNIVERSAL JOINT, TRIM TUBE END BEARING, PUSH-PULL  
TUBE END BEARINGS, BELLCRANK PIVOT BEARING
33. RUDDER TRIM SCREW
34. STABILATOR TRIM MECHANISM
35. RUDDER CONTROL CABLE AND TRIM TUBE END BEARINGS
36. STABILATOR TRIM TAB CONTROL ROD
37. STABILATOR TRIM SCREW
38. RUDDER PEDALS, BRAKE ACTUATING MECHANISM, BRAKE CYLINDER ENDS,  
CONTROL CABLE ENDS AND STEERING ROD ENDS
39. RUDDER PEDAL TORQUE TUBE AND BLOCK BEARINGS
40. STRUT ATTACHMENT BEARING
41. GEAR OLEO STRUT FILLER
42. BUNGEE CORD ROLLERS
43. GEAR DOOR HINGE, RETRACTION ROD END BEARINGS, TORQUE LINK  
CONNECTING BOLT
44. WHEEL BEARINGS
45. UPPER AND LOWER TORQUE LINK BUSHINGS
46. SIDE BRACE MOUNT BEARING
47. SIDE BRACE END BEARING AND PIVOT BEARING
48. RETRACTION CABLE END BEARING AND SIDE BRACE ATTACHMENT BUSHING
49. PROPELLER GREASE FITTINGS, RIGHT AND LEFT
50. AILERON PUSH-PULL ROD END BEARINGS, CONTROL CABLE ATTACHMENT POINTS  
AND BELLCRANK PIVOT BEARINGS

Figure 2-20. Lubrication Chart (cont.)





# PIPER TWIN COMANCHE SERVICE MANUAL

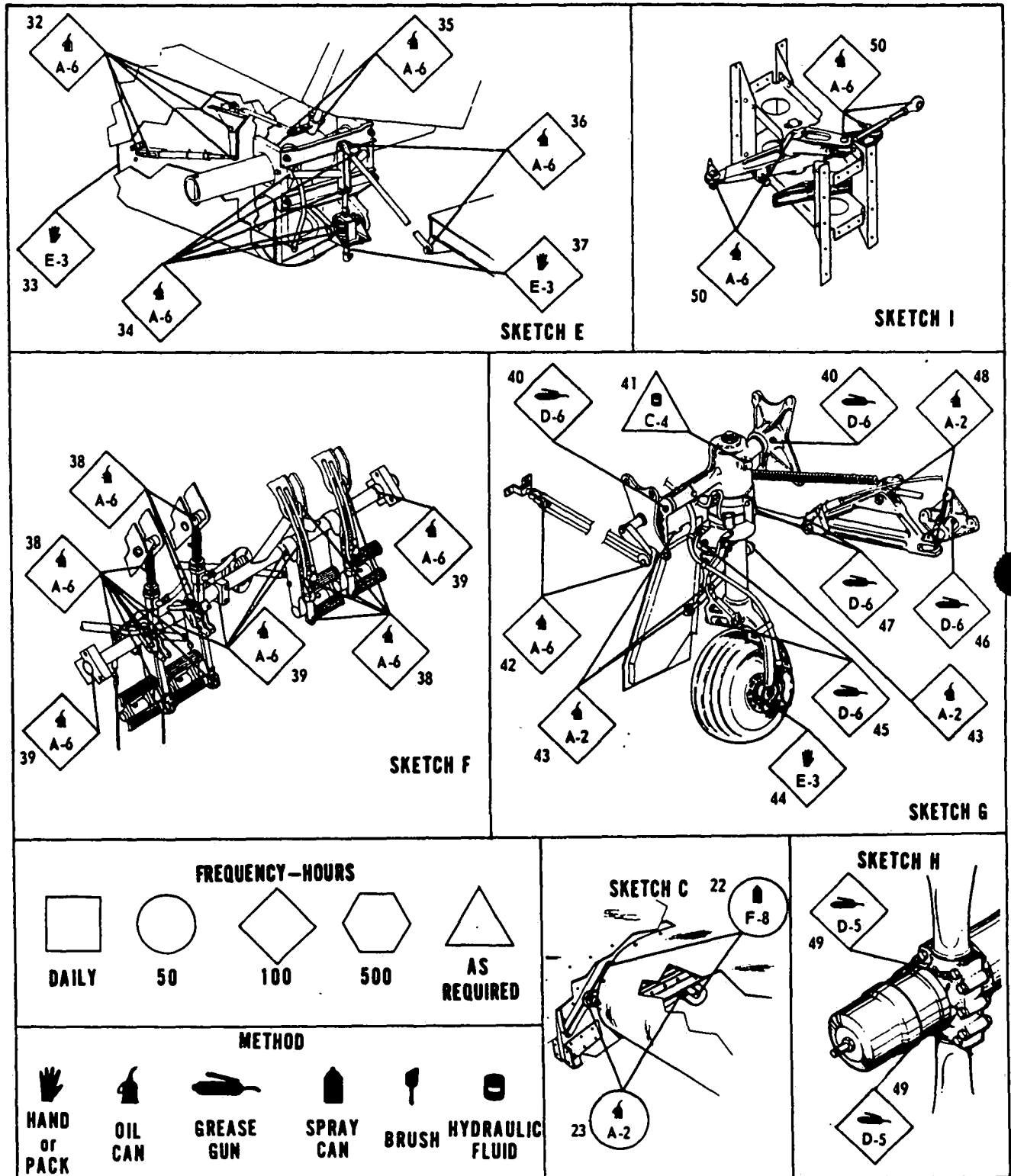


Figure 2-20. Lubrication Chart (cont.)

### TYPE OF LUBRICANTS

IDENTIFICATION LETTER	SPECIFICATION	LUBRICANT
A	MIL-L-7870	LUBRICATING OIL, GENERAL PURPOSE, LOW TEMPERATURE
B	MIL-L-6082	LUBRICATING OIL, AIRCRAFT RECIPRO-CATING ENGINE (PISTON) GRADE AS SPECIFIED SAE 50 ABOVE 60°F AIR TEMP. SAE 40 30° TO 90°F AIR TEMP. SAE 30 0° TO 70°F AIR TEMP. SAE 20 BELOW 10°F AIR TEMP.
C	MIL-H-5606	HYDRAULIC FLUID, PETROLEUM BASE
D	MIL-G-23827	GREASE, AIRCRAFT AND INSTRUMENT, GEAR AND ACTUATOR SCREW
E	MIL-G-3545	GREASE, AIRCRAFT, HIGH TEMPERATURE
F	—	ALL PURPOSE SLIP SPRAY DUPONT NO. 6611

### SPECIAL INSTRUCTIONS

- AIR FILTER** - TO CLEAN FILTER, TAP GENTLY TO REMOVE DIRT PARTICLES. DO NOT BLOW OUT WITH COMPRESSED AIR OR USE SOLVENT. REPLACE FILTER IF PUNCTURED OR DAMAGED.  
TURBOCHARGED ENGINES - CLEAN FILTER IN SOLVENT AND ALLOW TO DRY. DIP IN SAE 10 OIL AND ALLOW TO DRAIN FOUR HOURS.
- BEARINGS AND BUSHINGS** - CLEAN EXTERIOR WITH A DRY TYPE SOLVENT BEFORE RELUBRICATING.
- LANDING GEAR AND FLAP TRANSMISSIONS AND SCREWS**. IDENTIFY TYPE OF TRANSMISSION INSTALLED. DUKES HAS LABEL ON TRANSMISSION HOUSING. DURA HAS PART NO. 1010250 STAMPED ON TRANSMISSION HOUSING. DISASSEMBLE AND CLEAN WITH A QUICK DRYING TYPE SOLVENT. WHEN REASSEMBLING TRANSMISSIONS, FILL DUKES TRANSMISSION WITH DUKES NO. 4 LUBRICANT OR DURA TRANSMISSION WITH MIL-G-7118 OR MIL-G-23827 GREASE. NO SUBSTITUTION IS ALLOWED IN EITHER TRANSMISSION. APPLY A THIN COAT OF MIL-G-7118 OR MIL-G-23827 GREASE ON ACTUATOR SCREWS. SEE NOTE 4.
- OLEO STRUTS AND BRAKE RESERVOIR** - FILL PER INSTRUCTIONS ON UNIT OR CONTAINER, OR REFER TO SERVICE MANUAL, SECTION II.
- PROPELLER** - REMOVE ONE OF THE TWO GREASE FITTINGS FOR EACH BLADE. APPLY GREASE THROUGH FITTING UNTIL FRESH GREASE APPEARS AT HOLE OF REMOVED FITTING.
- LUBRICATION POINTS** - WIPE ALL LUBRICATION POINTS CLEAN OF OLD GREASE, OIL, DIRT, ETC., BEFORE RELUBRICATING.
- LUBRICATING OIL** - INTERVALS BETWEEN OIL CHANGES CAN BE INCREASED AS MUCH AS 100% ON ENGINES EQUIPPED WITH FULL FLOW (CARTRIDGE TYPE) OIL FILTERS PROVIDED THE ELEMENT IS REPLACED EACH 50 HOURS OF OPERATION.
- LUBRICATE FLAP TRACK** WITH DUPONT'S ALL PURPOSE SLIP SPRAY NO. 6611. FLAPS REQUIRE CLEANING AND LUBRICATION AFTER EXPOSURE TO AN ABNORMAL QUANTITY OF WATER. FLAPS WITH NYLON ROLLERS WILL NOT REQUIRE LUBRICATION ON EITHER FLAP TRACKS OR ROLLERS.
- OVERHEAD TRIM PULLEYS** - LUBRICATION MAY BE EXTENDED TO 250 HOURS WHEN DUSTY CONDITIONS ARE AT A MINIMUM.

HANDLING AND SERVICING

Issued: 12/29/72

# PIPER TWIN COMANCHE SERVICE MANUAL

## TABLE II-V. 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	1/18	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	0.1285	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	5.0646	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	2.2806	73	0.024	0.6096
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.

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. (Refer to Table II-VI.)
  - 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 ( $^{\circ}\text{F}$ ) and Celsius ( $^{\circ}\text{C}$ ) (Centigrade) Temperature. (Refer to Table II-VI.)
  - A. Read number in middle column, if in degrees Celsius ( $^{\circ}\text{C}$ ), read Fahrenheit equivalent in right-hand column. If in degrees Fahrenheit ( $^{\circ}\text{F}$ ), read Celsius equivalent in left-hand column.
    - (1)  $70^{\circ}\text{F} = 21.1^{\circ}\text{C}$ .
    - (2)  $30^{\circ}\text{C} = 86.0^{\circ}\text{F}$ .

# PIPER TWIN COMANCHE SERVICE MANUAL

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
37.78	100	212.0	198.89	390	734.0
43.33	110	230.0	204.44	400	752.0
48.89	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
71.11	160	320.0	232.22	450	842.0
76.67	170	338.0	237.78	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

# PIPER TWIN COMANCHE SERVICE MANUAL

## TABLE II-VI. CONVERSION TABLES (cont.)

C328

INCHES TO MILLIMETER									
INCHES — 0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
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
0.002	0.0508	0.0533	0.0558	0.0584	0.0609	0.0635	0.0660	0.0685	0.0711
0.003	0.0762	0.0787	0.0812	0.0838	0.0863	0.0889	0.0914	0.0939	0.0965
0.004	0.1016	0.1041	0.1066	0.1092	0.1117	0.1143	0.1168	0.1193	0.1219
0.005	0.1270	0.1295	0.1320	0.1346	0.1371	0.1397	0.1422	0.1447	0.1473
0.006	0.1524	0.1549	0.1574	0.1600	0.1625	0.1651	0.1676	0.1701	0.1727
0.007	0.1778	0.1803	0.1828	0.1854	0.1879	0.1905	0.1930	0.1955	0.1981
0.008	0.2032	0.2057	0.2082	0.2108	0.2133	0.2159	0.2184	0.2209	0.2235
0.009	0.2286	0.2311	0.2336	0.2362	0.2387	0.2413	0.2438	0.2463	0.2489

INCHES — 0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
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
0.02	0.508	0.533	0.558	0.584	0.609	0.635	0.660	0.685	0.711
0.03	0.762	0.787	0.812	0.838	0.863	0.889	0.914	0.939	0.965
0.04	1.016	1.041	1.066	1.092	1.117	1.143	1.168	1.193	1.219
0.05	1.270	1.295	1.320	1.346	1.371	1.397	1.422	1.447	1.473
0.06	1.524	1.549	1.574	1.600	1.625	1.651	1.676	1.701	1.727
0.07	1.778	1.803	1.828	1.854	1.879	1.905	1.930	1.955	1.981
0.08	2.032	2.057	2.082	2.108	2.133	2.159	2.184	2.209	2.235
0.09	2.286	2.311	2.336	2.362	2.387	2.413	2.438	2.463	2.489

INCHES — 0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
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
0.2	5.080	5.334	5.588	5.842	6.096	6.350	6.604	6.858	7.112
0.3	7.620	7.874	8.128	8.382	8.636	8.890	9.144	9.398	9.652
0.4	10.160	10.414	10.668	10.922	11.176	11.430	11.684	11.938	12.192
0.5	12.700	12.954	13.208	13.462	13.716	13.970	14.224	14.478	14.732
0.6	15.240	15.494	15.748	16.002	16.256	16.510	16.764	17.018	17.272
0.7	17.780	18.034	18.288	18.542	18.796	19.050	19.304	19.558	19.812
0.8	20.320	20.574	20.828	21.082	21.336	21.590	21.844	22.098	22.352
0.9	22.860	23.114	23.368	23.622	23.876	24.130	24.384	24.638	24.892

INCHES — 0.00	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
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
2.	50.80	53.34	55.88	58.42	60.96	63.50	66.04	68.58	71.12
3.	76.20	78.74	81.28	83.82	86.36	88.90	91.44	93.98	96.52
4.	101.60	104.14	106.68	109.22	111.76	114.30	116.84	119.38	121.92
5.	127.00	129.54	132.08	134.62	137.16	139.70	142.24	144.78	147.32
6.	152.40	154.94	157.48	160.02	162.56	165.10	167.64	170.18	172.72
7.	177.80	180.34	182.88	185.42	187.96	190.50	193.04	195.58	198.12
8.	203.20	205.74	208.28	210.82	213.36	215.90	218.44	220.98	223.52
9.	228.60	231.14	233.68	236.22	238.76	241.30	243.84	246.38	248.92

# PIPER TWIN COMANCHE SERVICE MANUAL

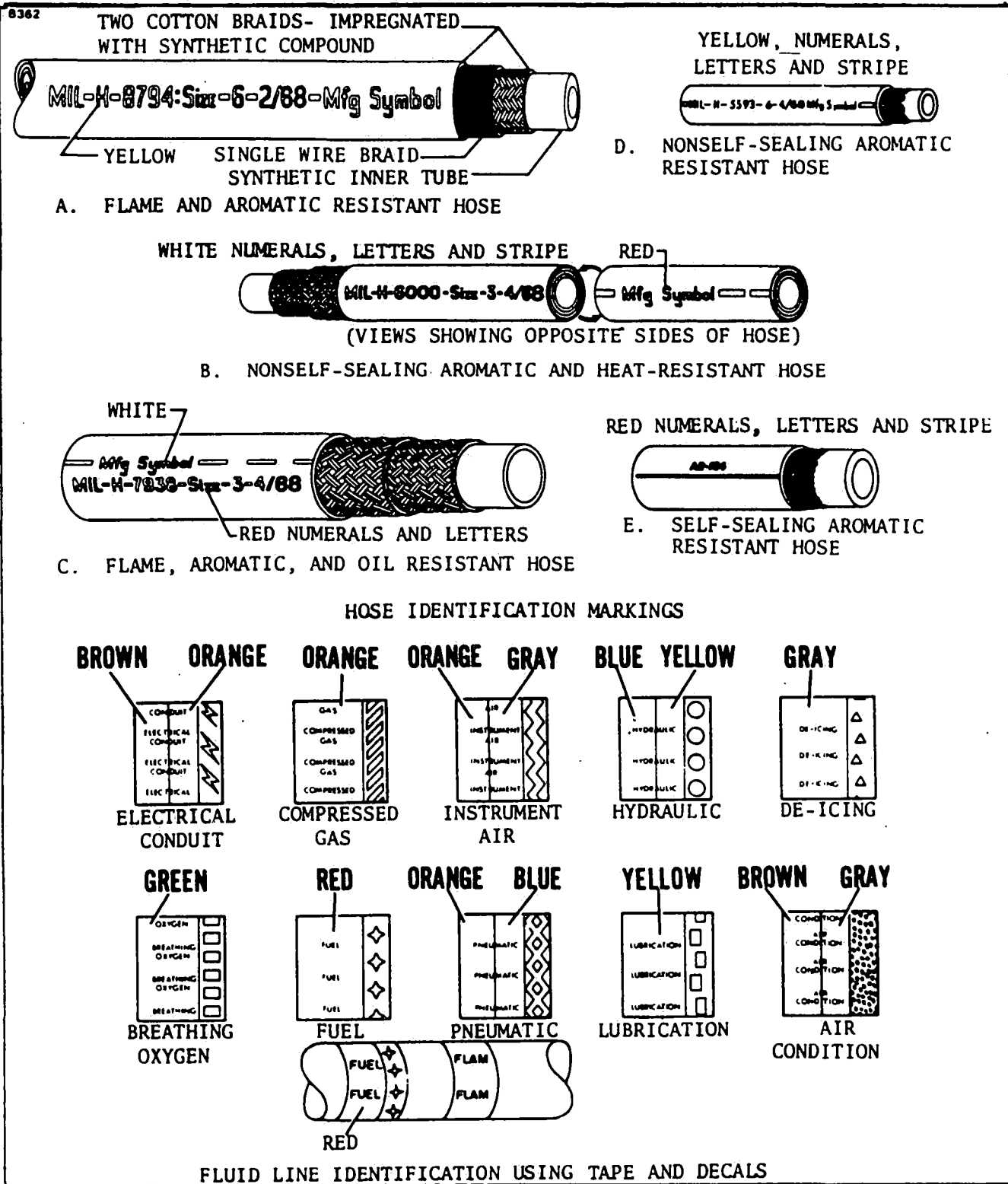
TABLE II-VI. CONVERSION TABLES (cont.)

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	BTU FT.-LB.

MULTIPLY	BY	TO OBTAIN
KILOGRAMS	2.205 35.27 1000	L.B. 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



# PIPER TWIN COMANCHE SERVICE MANUAL



### Figure 2-21. Identification of Aircraft Fluid Lines

8361

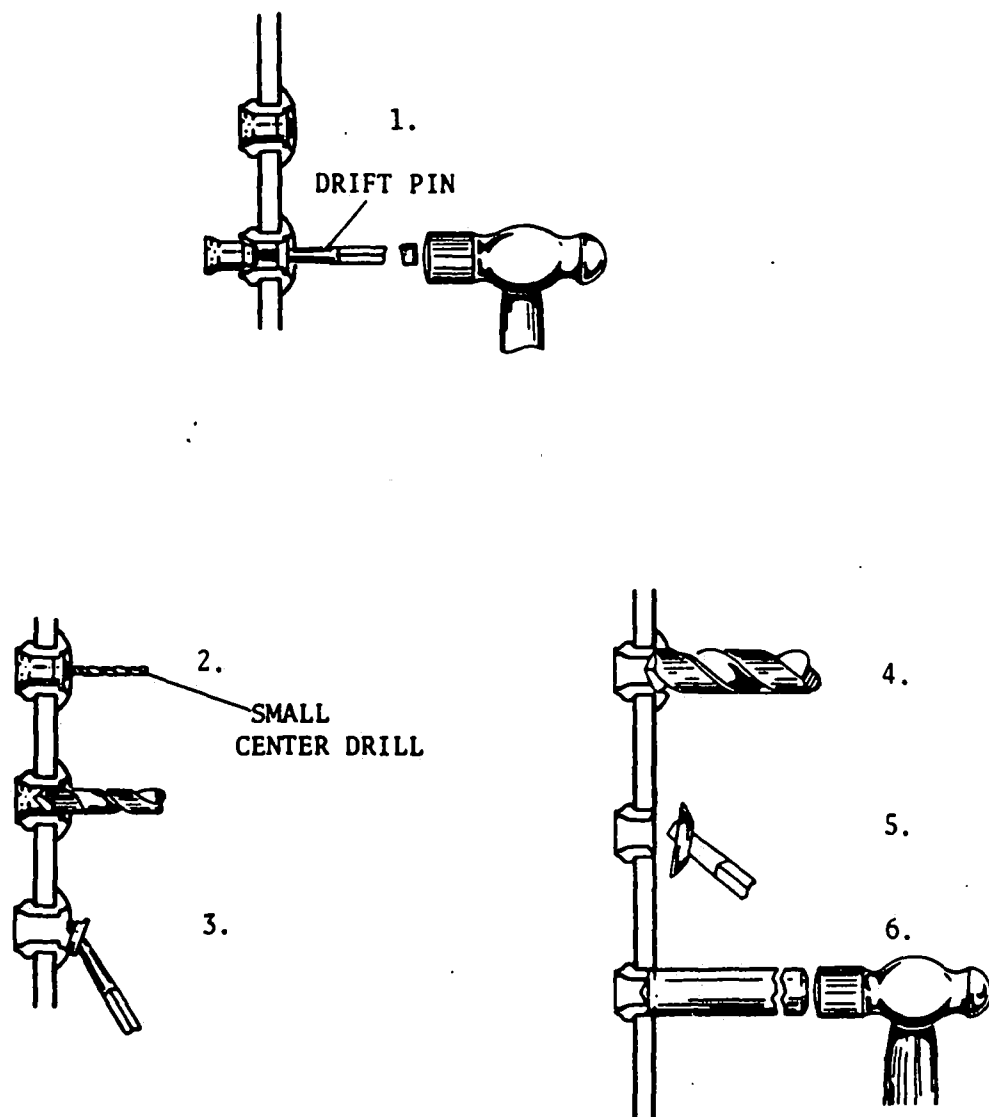


Figure 2-22. Removal of Cherrylock Rivets

# PIPER TWIN COMANCHE SERVICE MANUAL

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

TUBE O.D. (IN.)	DISTANCE BETWEEN SUPPORTS (IN.)	
	ALUMINUM ALLOY	STEEL
1/8	9 1/2	11-12
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

## SECTION III INSPECTION

Paragraph		Aerofiche Grid No.
3-1.	Introduction .....	1D16
3-2.	Recommended Lubricants .....	1D16
3-3.	Inspection Periods .....	1D16
3-4.	Inspection Requirements .....	1D16
3-5.	Preflight Inspection .....	1D17
3-6.	Overlimits Inspection .....	1D18

## 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, Turbocharger, Cabin, Fuselage and Empennage, Wing, Landing Gear, Operational 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.

INSPECTION

Issued: 12/29/72

NOTE

In addition to inspection intervals required in Table III-I 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.

INTENTIONALLY LEFT BLANK

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.

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	Inspection Time (hrs)			
	50	100	500	1000
<b>A. PROPELLER GROUP</b>				
1. Inspect spinner and back of plate for cracks .....	O	O	O	O
2. Inspect blades for nicks and cracks .....	O	O	O	O
3. Check for grease and oil leaks .....	O	O	O	O
4. Lubricate per lubrication chart in Service Manual .....		O	O	O
5. Check spinner mounting brackets for cracks .....		O	O	O
6. Check propeller mounting bolts and safety (Check torque if safety is broken) .....		O	O	O
7. Inspect hub parts for cracks and corrosion .....		O	O	O
8. Check propeller air pressure (Check at least once a month) .....		O	O	O
9. Remove propellers; remove sludge from propeller and crankshaft .....			O	O
10. Overhaul propeller (per latest revision of Hartzell S/L No. 61) .....				
<b>B. ENGINE GROUP</b>				
NOTE: Read Note 8 prior to completing this inspection group.				
CAUTION: Ground Magneto Primary Circuit before working on engine.				
1. Remove engine cowl .....	O	O	O	O
2. Clean and check cowling for cracks, distortion and loose or missing fasteners .....		O	O	O
3. Drain oil sump (See Note 5) .....	O	O	O	O
4. Clean suction oil strainer at oil change (Check strainer for foreign particles) .....	O	O	O	O
5. Clean pressure oil strainer or change full flow (cartridge type) oil filter element (Check strainer or element for foreign particles) .....	O	O	O	O
6. Check oil temperature sender unit for leaks and security .....		O	O	O
7. Check oil lines and fittings for leaks, security, chafing, dents and cracks (See Note 7) .....		O	O	O



# PIPER TWIN COMANCHE SERVICE MANUAL

## TABLE III-I. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>B. ENGINE GROUP (cont.)</b>				
8. Clean and check oil radiator cooling fins .....		O	O	O
9. Remove and flush oil radiator .....			O	O
10. Check rocker box covers for evidence of oil leaks. If found, replace gasket; torque cover screws 50 inchpounds (See Note 9) .....	O	O	O	O
NOTE: Lycoming requires a Valve Inspection be made after every 400 hours of operation. (See Note 8.)				
11. Check wiring to engine and accessories. Replace damaged wires and clamps. Check terminals for security and cleanliness .....		O	O	O
12. Inspect spark plug cable leads and ceramics for corrosion and deposits .....	O	O	O	O
13. Check cylinder compression (Ref: AC43.13-1A) .....		O	O	O
14. Check cylinders for cracked or broken fins .....		O	O	O
15. Fill engine with oil as per lubrication chart .....	O	O	O	O
16. Clean engine .....		O	O	O
17. Check condition of spark plugs (Clean and adjust gap as required, 0.015 to 0.018 or 0.018 to 0.022, as per latest revision of Lycoming Service Instruction No. 1042) .....		O	O	O
NOTE: If fouling of spark plugs has been apparent, rotate bottom plugs to upper plugs.				
18. Check ignition harnesses and insulators (high tension leakage and continuity) .....		O	O	O
19. Check magneto main points for clearance - Maintain clearance at 0.018 ± 0.006 .....		O	O	O
20. Check magneto for oil seal leakage .....		O	O	O
21. Check breaker felts for proper lubrication .....		O	O	O
22. Check distributor block for cracks, burned areas or corrosion and height of contact springs .....		O	O	O
23. Check magnetos to engine timing .....		O	O	O
24. Overhaul or replace magnetos (See Note 6) .....				
25. Remove induction air filter and clean. Replace as required .....	O	O	O	O
26. Remove and clean fuel injector inlet line screen (Clean injector nozzles as required) (Clean with acetone only) .....	O	O	O	O
27. Inspect injector system for signs of fuel dye indicating leaks. NOTE: If dye stains are present, check for loose connections and proper installation of air bleed nozzle shrouds .....	O	O	O	O

# PIPER TWIN COMANCHE SERVICE MANUAL

TABLE III-1. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>B. ENGINE GROUP (cont.)</b>				
28. Inspect alternate air takeoff assembly. Remove air duct hose to check door spring and hinge inside the assembly.....		O	O	O
29. Inspect alternate air inlet valve bracket hinge pinholes for excessive wear. (Refer to the latest revision of Piper Service Bulletin No. 623.) .....		O	O	O
30. Check intake seals for leaks and clamps for tightness .....		O	O	O
31. Inspect condition of flexible fuel lines .....		O	O	O
32. Replace flexible fuel lines .....				O
33. Check fuel system for leaks .....		O	O	O
34. Check fuel pumps for operation (engine driven and electric) .....		O	O	O
35. Overhaul or replace fuel pumps (engine driven and electric) (See Note 6).....				O
36. Check vacuum pumps and lines.....		O	O	O
37. Overhaul or replace vacuum pumps (See Note 6).....				
38. Check throttle, alternate air, mixture and propeller governor controls for travel and operating condition .....		O	O	O
39. Check exhaust stacks and gaskets .....	O	O	O	O
40. Check breather tube for obstructions and security .....		O	O	O
41. Check crankcase for cracks, leaks and security of seam bolts .....		O	O	O
42. Check engine mounts for cracks and loose mounting .....		O	O	O
43. Check rubber engine mount bushings for deterioration (See Note 12).....		O	O	O
44. Check all engine baffles.....		O	O	O
45. Check fire walls for cracks .....		O	O	O
46. Check fire wall seals.....		O	O	O
47. Check condition and tension of generator or alternator drive belt .....		O	O	O
48. Check condition of generator or alternator and starter .....		O	O	O
49. Replace vacuum regulator filter.....		O	O	O
50. Lubricate all controls (DO NOT lubricate teflon liners of control cables) (Refer to Service Manual) .....		O	O	O
51. Overhaul or replace propeller governor. Refer to the latest revision of Hartzell S/L No. 61 .....				
52. Complete overhaul of engine replace with factory rebuilt (See Note 6).....				

Revised: 10/28/82

INSPECT



TABLE III-I: INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>C. TURBOCHARGER GROUP</b>				
1. Inspect all air inlet ducting and compressor discharger ducting for worn spots, loose clamps or leaks . . . . .	O	O	O	O
2. Inspect engine air inlet assembly for cracks, loose clamps and screws . . . . .	O	O	O	O
3. Inspect waste-gate housing, exhaust ducting and exhaust stacks for signs of leaks or cracks . . . . .	O	O	O	O
4. Carefully check all turbo support brackets, struts, etc, for breakage, sagging or wear . . . . .	O	O	O	O
5. Check all oil lines, fuel lines, air lines and fittings for wear, leakage, heat damage or fatigue . . . . .	O	O	O	O
6. Actuate waste-gate control; check spring preload and examine control for any pending sign of breakage . . . . .	O	O	O	O
7. Remove inlet hose to compressor and visually inspect compressor wheel . . . . .		O	O	O
8. Inspect the compressor wheel for nicks, cracks or broken blades . . . . .		O	O	O
9. Check for excess bearing drag or wheel rubbing against housing . . . . .		O	O	O
10. Inspect induction and exhaust components for worn or damaged areas, loose clamps, cracks and leaks . . . . .		O	O	O
11. Check turbine wheel for broken blades or signs of rubbing . . . . .		O	O	O
12. Check turbine heat blanket for condition and security . . . . .		O	O	O
13. Check rigging of exhaust waste gates . . . . .		O	O	O
14. Check rigging of alternate air control . . . . .		O	O	O
15. Run up engine; check instruments for smooth, steady response . . . . .	O	O	O	O
16. Remove all turbocharger components from the engine. Inspect and repair or replace as necessary . . . . .				O
17. Clean turbocharger oil filter per Turbo Oil Filter Cleaning Procedure, Section II, Service Manual at every oil change . . . . .	O	O	O	O
18. Inspect all turbocharger hose assemblies (Refer to Note 15). . . . .		O	O	O
19. Reinstall engine cowl . . . . .	O	O	O	O
<b>D. CABIN GROUP</b>				
1. Remove inspection plates and panels . . . . .		O	O	O
2. Inspect cabin entrance door, baggage compartment door and windows for damage, operation and security . . . . .		O	O	O
3. Check upholstery for tears . . . . .		O	O	O
4. Check seats, seat belts, securing brackets and bolts . . . . .		O	O	O

INSPECTION  
Revised: 4/6/81

# PIPER TWIN COMANCHE SERVICE MANUAL

## TABLE III-I. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>D. CABIN GROUP (cont.)</b>				
5. Check trim operation .....		O	O	O
6. Check rudder pedals, brake pedals and cylinders for operation and leaks .....		O	O	O
7. Check parking brake .....		O	O	O
8. Check control wheels, column, pulleys and cables .....		O	O	O
9. Check landing, navigation, cabin and instrument lights .....		O	O	O
10. Check instruments, lines and attachments .....		O	O	O
11. Check instruments central air filter lines and replace filter .....		O	O	O
12. Check condition of vacuum operated instruments and operation of electric turn and bank (Overhaul or replace as required) .....		O	O	O
13. Replace filters, if installed, in gyro horizon and directional gyro .....			O	O
14. Check altimeter. Calibrate altimeter system in accordance with FAR. 91.170 (if appropriate) .....		O	O	O
15. Check operation of fuel selector valves (See Note 14) .....		O	O	O
16. Check operation of crossfeed valve .....		O	O	O
17. Check operation of heater fuel valves .....		O	O	O
18. Check oxygen outlets for defects and corrosion .....		O	O	O
19. Check oxygen system operation and components .....		O	O	O
20. Reinstall inspection plates and panels .....		O	O	O
<b>E. FUSELAGE AND EMPENNAGE GROUP</b>				
1. Remove inspection plates and panels .....		O	O	O
2. Check fluid in brake reservoir (Fill as required) .....		O	O	O
3. Check battery, box and cables (Check at least every 30 days. Flush box as required and fill battery per instructions in Servicing Battery, Section II, Service Manual) .....	O	O	O	O
4. Check heater for fuel or fume leaks .....		O	O	O
5. Check recommended time for overhaul of heater per Overhaul Instructions, Section XIII, Service Manual .....		O	O	O
6. Check electronic installations (See the latest revision of Piper Service Bulletin No. 553) .....		O	O	O
7. Check bulkheads and stringers for damage .....		O	O	O
8. Check loop and loop mount, antenna mount and electric wiring .....		O	O	O
9. Inspect E.L.T. installation and condition of battery and antenna (See latest revision of Piper S/L 820) .....		O	O	O
10. Remove, drain and clean fuel filter bowl and screen (Drain and clean at least every 90 days) .....	O	O	O	O

INSPECTION  
Revised: 6/4/81

# PIPER TWIN COMANCHE SERVICE MANUAL

## TABLE III-I. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>E. FUSELAGE AND EMPENNAGE GROUP (cont.)</b>				
11. Check fuel lines, valves and gauges for damage and operation .....		O	O	O
12. Check security of all lines .....		O	O	O
13. Check stabilator, fin and rudder surfaces for damage (Refer to latest revision of Piper Service Letter No. 679) .....		O	O	O
14. Inspect fin front spar to fuselage attachment per latest revision of Piper Service Letter No. 777 and Airworthiness Directive No. 76-18-5 .....		O	O	O
15. Inspect stabilator attachment bolts per latest revision of Piper Service Letter No. 667 .....		O	O	O
16. Check stabilator bearings and horns for damage and operation (Refer to latest revision of Piper Service Bulletin No. 464) .....		O	O	O
17. Check rudder hinges, horn and attachments for damage and operation .....		O	O	O
18. Check rudder trim mechanism .....		O	O	O
19. Check stabilator trim mechanism .....		O	O	O
20. Check stabilator free play (Refer to Service Manual, Section IV) .....		O	O	O
21. Check aileron, rudder, stabilator, trim cables and turnbuckles, guides and pulleys for safeties, damage and operation .....		O	O	O
22. Replace rudder hinge bolts .....			O	O
23. Check rotating beacon for wear, etc. ....		O	O	O
24. Lubricate per lubrication chart in Service Manual .....		O	O	O
25. Check security of autopilot bridle cable clamps .....		O	O	O
26. Reinstall inspection plates and panels .....		O	O	O
<b>F. WING GROUP</b>				
1. Remove inspection plates and fairings .....		O	O	O
2. Check wing, aileron and flap surfaces for damage and loose rivets, and condition of wing tips .....		O	O	O
3. Check condition of walkway .....		O	O	O
4. Check aileron attachments and hinges for damage, looseness and operation .....		O	O	O
5. Replace Aileron Outboard Hinge with Aileron Outboard Hinge Bracket Kit No. 760 914 .....				O
6. Check aileron cables, pulleys, bellcranks and control rods for corrosion, damage and operation .....		O	O	O

INSPECTION  
Revised: 6/4/81

TABLE III-I. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>F. WING GROUP (cont.)</b>				
7. Check flap attachments, tracks and rollers for damage, looseness and operation. Clean tracks and rollers . . . . .	O	O	O	O
8. Check flap cables, pulleys, step lock, bellcranks and control rods for corrosion, damage and operation . . . . .		O	O	O
9. Replace bolts used with aileron hinges and flap tracks . . . . .				O
10. Lubricate per lubrication chart in Service Manual . . . . .	O	O	O	O
11. Check wing attachment bolts and brackets . . . . .		O	O	O
12. Check engine mount attaching structure . . . . .		O	O	O
13. Check fuel cells and lines for leaks and water . . . . .		O	O	O
14. Fuel cells marked for capacity . . . . .		O	O	O
15. Fuel cells marked for minimum octane rating . . . . .		O	O	O
16. Check switches to indicators registering fuel cell quantity . . . . .		O	O	O
17. Check fuel cell vents and drain tubes . . . . .	O	O	O	O
18. Check thermos type fuel cap rubber seals for brittleness, deterioration and snug fit of cap in opening . . . . .	O	O	O	O
19. Check for exhaust corrosion in wing panel cavity . . . . .		O	O	O
20. Reinstall inspection plates and fairings . . . . .		O	O	O
<b>G. LANDING GEAR GROUP</b>				
1. Check oleo struts for proper extension (Check for proper fluid level as required) . . . . .	O	O	O	O
2. Check nose gear steering control . . . . .		O	O	O
3. Check wheels for alignment . . . . .		O	O	O
4. Put airplane on jacks . . . . .		O	O	O
5. Check tires for cuts, uneven or excessive wear and slippage . . . . .		O	O	O
6. Remove wheels; clean, check and repack bearings . . . . .		O	O	O
7. Check wheels for cracks, corrosion and broken bolts . . . . .		O	O	O
8. Check tire pressure (42 psi, all) . . . . .	O	O	O	O
9. Check brake lining and disc (1/64 min. lining) . . . . .		O	O	O
10. Check brake backing plates . . . . .		O	O	O
11. Check brake lines . . . . .		O	O	O
12. Check shimmy dampener . . . . .		O	O	O
13. Check gear forks for damage . . . . .		O	O	O
14. Check oleo struts for fluid leaks and scoring . . . . .		O	O	O

# PIPER TWIN COMANCHE SERVICE MANUAL

TABLE III-I. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>G. LANDING GEAR GROUP (cont.)</b>				
15. Check gear struts, attachments, torque links, retraction links and bolts for operation (See Note 11).....		O	O	O
16. Check torque link bolts and bushings (Rebush as required).....			O	O
17. Check drag link bolts (Replace as required).....			O	O
18. Check gear doors and attachments.....		O	O	O
19. Check warning horn and light for operation.....		O	O	O
20. Retract gear - check operation.....		O	O	O
21. Retract gear - check doors for clearance and operation.....		O	O	O
22. Check emergency operation of gear (See the latest revision of Piper Service Letter 782).....		O	O	O
23. Check landing gear motor, transmission and attachments.....		O	O	O
24. Check anti-retraction system.....		O	O	O
25. Check position indicating switches and electrical leads for security.....		O	O	O
26. Replace rubber assist cords (See Note 13).....			O	O
27. Lubricate per lubrication chart in Service Manual.....		O	O	O
28. Remove airplane from jacks.....		O	O	O
<b>H. OPERATIONAL INSPECTION</b>				
1. Check fuel pump and fuel tank selector operation.....	O	O	O	O
2. Check indication of fuel quantity and pressure of flow gauges.....	O	O	O	O
3. Check oil pressure and temperature indications.....	O	O	O	O
4. Check generator or alternator output.....	O	O	O	O
5. Check manifold pressure indications.....	O	O	O	O
6. Check operation of brakes and parking brake.....	O	O	O	O
7. Check operation of vacuum gauge.....	O	O	O	O
8. Check gyros for noise and roughness.....	O	O	O	O
9. Check cabin heat operation.....	O	O	O	O
10. Check magneto switch operation.....	O	O	O	O
11. Check magneto RPM variation.....	O	O	O	O
12. Check throttle and mixture operation.....	O	O	O	O
13. Check engine idle.....	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 controls.....	O	O	O	O



# PIPER TWIN COMANCHE SERVICE MANUAL

TABLE III-I. INSPECTION REPORT

Nature of Inspection	Inspection Time (hrs)			
	50	100	500	1000
<b>H. OPERATIONAL INSPECTION (cont.)</b>				
18. Check operation of flaps .....	O	O	O	O
19. Check operation of Autopilot, including Automatic Pitch Trim, and Manual Trim (See Note 16) .....	O	O	O	O
<b>I. GENERAL</b>				
1. Aircraft conforms to FAA Specifications .....	O	O	O	O
2. All latest FAA Airworthiness Directives complied with .....	O	O	O	O
3. All latest 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

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INSPECTION

## PIPER TWIN COMANCHE SERVICE MANUAL

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TABLE III-I. INSPECTION REPORT (cont.)

**NOTES:**

1. Refer to the last card of the Piper - Parts Price List - Aerofiche for a check list of current revision dates and manuals.
2. All inspections or operations are required at each of the inspection intervals as indicated 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. Inspections must be accomplished by persons authorized by the FAA.
3. Piper Service Bulletins are of special importance and must be complied with promptly.
4. Piper Service Letters are product improvements and service hints pertaining to servicing the airplane and should be given careful attention.
5. Intervals between oil changes can be increased as much as 100% on engines equipped with full flow (cartridge type) oil filters - Provided the element is replaced each 50 hours of operation.
6. Replace or overhaul as required or at engine overhaul. (For engine overhaul, refer to the latest revision of Lycoming Service Instructions No. 1009.)
7. Replace flexible oil lines as required at Engine T.B.O. per the latest revision of Lycoming S B 240.
8. Inspections given for power plant are based on the engine manufacturer's operator's manual. Any changes issued to the engine manufacturer's operator's manual shall supersede or supplement the instructions outlined in this report. Occasionally, service bulletins or service instructions are issued by Avco Lycoming Division that require inspection procedures that are not listed in this manual. Such publications usually are limited to specific models and become obsolete after corrective steps have been accomplished. All such publications are available from Avco Lycoming distributors, or from the factory by subscription. Consult the latest revision of Lycoming Service Letter no. L114 for subscription information. Maintenance facilities should have an up-to-date file of these publications available at all times.
9. Check cylinders for evidence of excessive heat which is indicated by burned paint on the cylinders. This condition is indicative of internal damage to the cylinder and, if found, its cause must be determined and corrected before the aircraft is returned to service.

Heavy discoloration and appearance of seepage at the cylinder head and barrel attachment area is usually due to emission of thread lubricant used during assembly of the barrel at the factory, or by slight gas leakage which stops after the cylinder has been in service for awhile. This condition is neither harmful nor detrimental to engine performance and operation. If it can be proven that leakage exceeds these condition, the cylinder should be replaced.
10. At every 400 hours of engine operation, remove the rocker box covers and check for freedom of valve rockers when valves are closed. Look for evidence of abnormal wear or broken parts in the area of the valve tips, valve keeper, springs and spring seat. If any indications are found, the cylinder and all of its components should be removed (including the piston and connecting rod assembly) and inspected for further damage. Replace any parts that do not conform with limits shown in the latest revision for Lycoming Service Table of Limits No. SSP1776.
11. Refer to the latest revision of Piper Service Letter No. 782 for proper inspection and wear limits.
12. It is recommended that all engine support bushings be changed every 500 hours.
13. Replace rubber assist cords every 500 hours or every three years, whichever ever occurs first.
14. Refer to the latest revision of Piper Service Letter No. 851.
15. Refer to A. D. 81-19-04 and to the latest revision of Rayjay Service Letter No. 28.
16. Refer to Flight Manual Supplement for preflight and flight check, for intended function in all modes.

## SECTION IV STRUCTURES

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# Paragraph

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## SECTION IV

### STRUCTURES

**4-1. INTRODUCTION.** This section explains the removal and installation procedures for the main structural surfaces; for checking and balancing the stabilator and repairing structural surfaces of the PA-30. Information for the rigging and adjustment of these control surfaces, as well as the removal and installation of their controls, may be found in Section V.

#### NOTE

When torquing structural assemblies, standard torque values are to be used as found in Section II or FAA Advisory Circular 43.13-1, unless otherwise stated in this section.

**4-2. DESCRIPTION.** The structures of the PA-30 are of sheet aluminum, completely primed with zinc chromate and covered with acrylic lacquer on the exterior surfaces.

The fuselage is an all-metal semi-monocoque construction comprised of bulkheads, stringers, stiffeners, and longitudinal beams to which the outer skin is riveted. The cross-sectional dimension of the fuselage is 53.875 inches in height, 47.875 inches in width and an overall length of 290.06 inches. Windows include double paned side windows and a two piece windshield. A storm window on the lower left forward section of the left window swings inward and down when the latch at the upper side is released. Cabin access is gained from the right side door. On airplanes with serial numbers 30-2 to 30-852 inclusive and 30-853 to 30-901 inclusive, baggage compartment access is found on the right side of the fuselage at the trailing edge of the wing. On airplanes with serial numbers 30-853, 30-902 and up, the baggage door on the left side of the fuselage may also be used as an emergency exit by holding the inside door knob up while turning the latch clockwise.

Each wing airfoil section is a full cantilever laminar flow type, NACA 642A215, with a maximum thickness of 40% aft of the leading edge. At the point of maximum thickness in the wings, the main spar passes under the seats at fuselage station 108.1. The wing span is 36 feet. With the optional tip tanks, the wing span is 36.8 feet. Installed in each wing are a main and auxiliary fuel cell of the bladder type. The main landing gear retracts into the underside of each wing and is partially enclosed by doors. Attached to each wing are the power plant, aileron and flap. Within the right wing is a step lock to the right flap permitting support for the flap when used as a step. The full length beam type main spar is joined with high strength butt fittings in the center of the fuselage, making in effect a continuous main spar. The main spar is also attached at the side of the fuselage as are the front and rear spars.

The all-metal empennage group is a full cantilever design consisting of a vertical fin, rudder, and stabilator with a trim tab. Both the rudder and stabilator trim are controlled from the cockpit. The stabilator and vertical fin have two channel main spars running full

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length. The stabilator is attached to the fuselage by a torque tube supported by bearing blocks.

#### 4-3. WING GROUP.

##### NOTE

The major sub-assemblies 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.

#### 4-4. WING TIP.

#### 4-5. REMOVAL OF WING TIP.

- a. Remove the screws attaching the wing tip to the wing.
- b. Pull the wing tip far enough off to disconnect the navigation light positive and negative wires at the quick-disconnect fitting.
- c. Remove the wing tip.

#### 4-6. INSTALLATION OF WING TIP.

- a. Connect the positive and negative electrical leads of the navigation light to their respective wire ends in the wing.
- b. Position the wing tip on the wing and start all screws with washers.
- c. With all screws in place, tighten.

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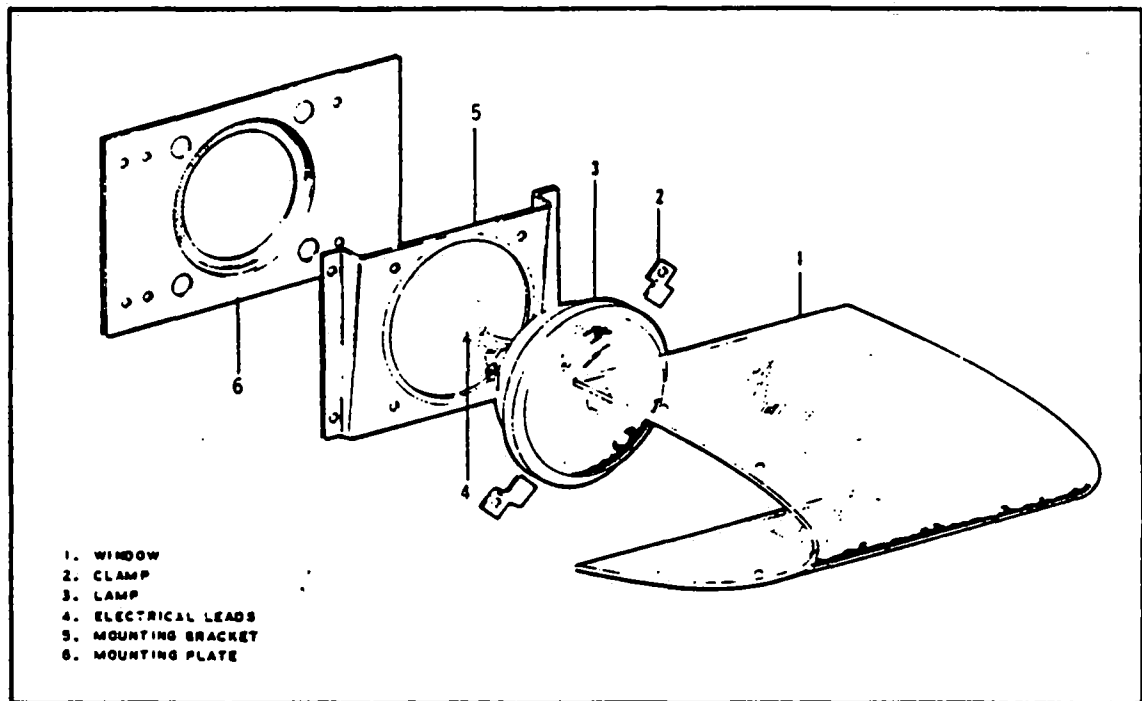


Figure 4-1. Landing Light Installation

#### 4-7. LANDING LIGHT.

##### 4-8. REMOVAL OF LANDING LIGHT. (Refer to Figure 4-1.)

- a. Remove wing tip. (Refer to Paragraph 4-5.)
- b. Remove the sheet metal screws from the landing light window assembly (1).
- c. Remove the machine screws and clamps (2) holding the lamp (3).
- d. Pull the lamp forward and remove the electrical leads (4) from rear of the lamp, then remove the clamp.
- e. To disassemble the landing light housing, remove the screws located in the corners of the housing.
- f. Make sure that the electrical leads to the lamp are disconnected prior to removal and that the lamp is not dropped when the front clamp and rear bracket are separated.

**4-9. INSTALLATION OF LANDING LIGHT. (Refer to Figure 4-1.)**

- a. Install the landing light housing, securing with screws in each corner.
- b. Connect the electrical leads (4) to the back of the lamps (3) and secure the lamp to the mounting brackets (5). Ascertain that the lamp will light.
- c. Install the landing light window (1).
- d. Install the wing tip. (Refer to Paragraph 4-6.)

**4-10. AILERON.**

**4-11. REMOVAL OF AILERON. (Refer to Figure 4-2.)**

- a. Disconnect the aileron control rod at the inboard aileron hinge by lowering the aileron and removing the nut, washers, bushing and bolt. Note position of washers and bushing.
- b. Remove the two hinge bolts; observing the position of the spacer washers.
- c. Pull the aileron straight away from the wing.

**4-12. INSTALLATION OF AILERON. (Refer to Figure 4-2.)**

- a. After placing the aileron in position, install the inboard and outboard hinge bolts. Place the spacer washers to allow for best alignment of hinges.
- b. Move the aileron through its full travel to ascertain that there is no binding.
- c. Connect the aileron control rod at the inboard aileron hinge with the bolt, bushing, washers and nut.

**4-13. FLAP.**

**4-14. REMOVAL OF FLAP. (Refer to Figure 4-2.)**

- a. Remove the access plate to the flap bellcrank located on the rear underside of the wing at approximately the center of the flap. Remove the main gear wheel well splash pan.
- b. Located at the rear inboard portion of the right wing is a combination flap return and step lock. Enter through the wheel well to release spring tension and disengage the step lock. Release the spring tension of the flap, return spring in the left wing by access through the wheel well.
- c. Disconnect the flap control rod and bellcrank return spring at the bellcrank by removing, washer and bolt.



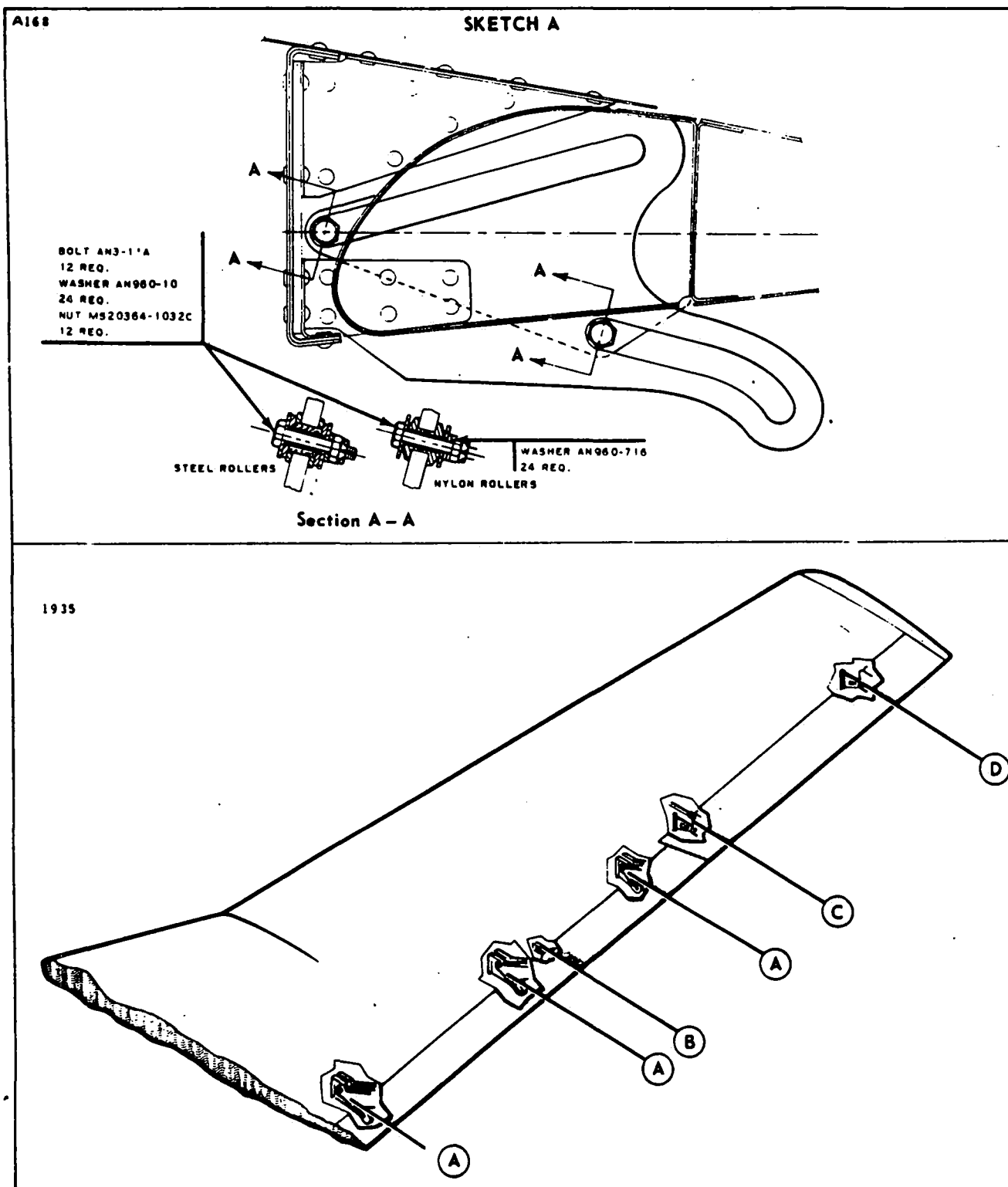


Figure 4-2. Aileron and Flap Installation

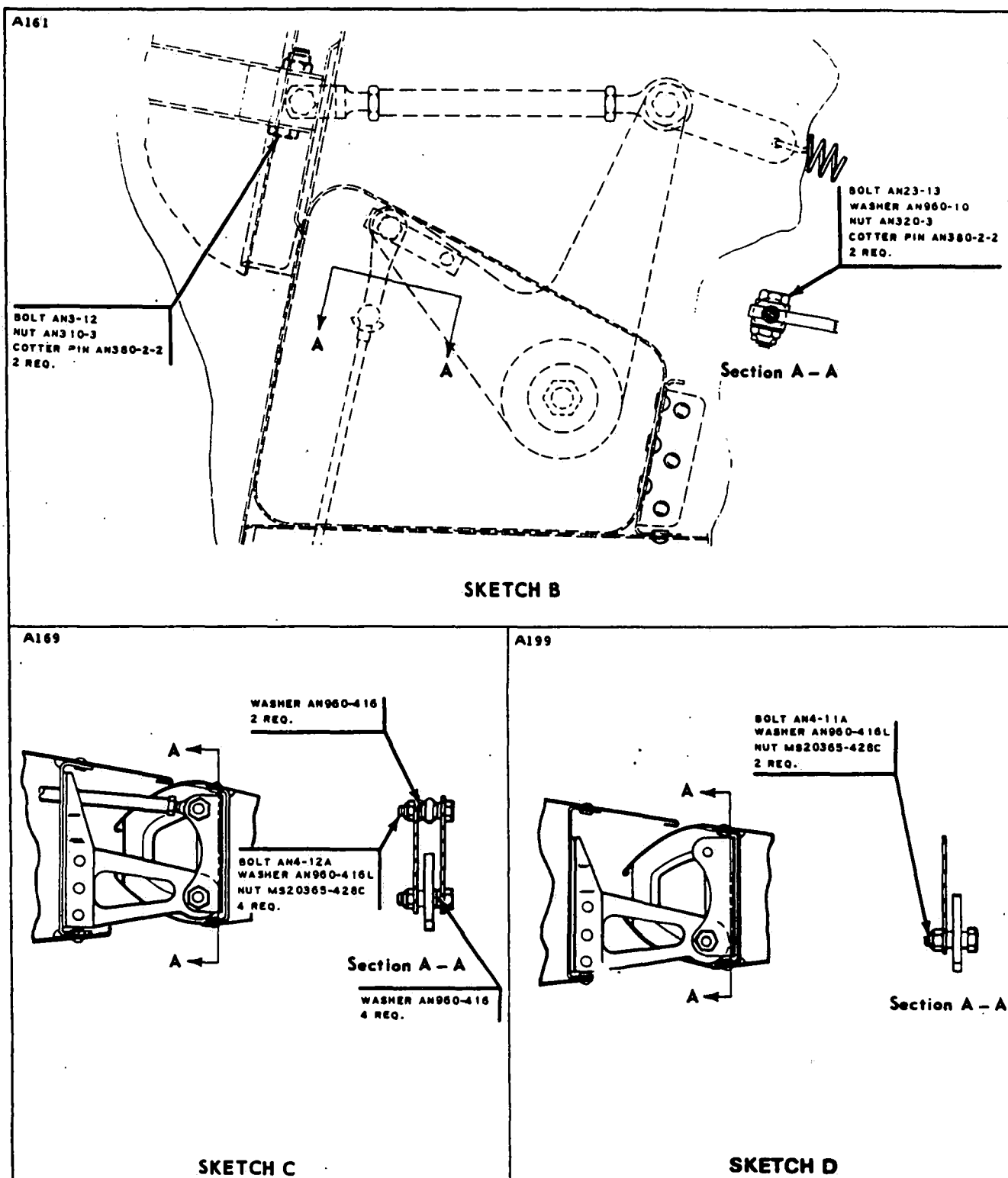


Figure 4-2. Aileron and Flap Installation (cont.)

d. At the right flap, back the adjusting nut off the end of the step lock, return cable located behind an access plate on the inboard underside of the flap. At the left flap, disconnect the flap return cable at the leading edge of the flap on the wing.

e. Remove the top rollers from the flap brackets, allowing the flap to swing forward and permitting access for removal of the lower rollers. Rollers may be removed by taking nut, washer and bolt from the assembly.

f. Remove the flap.

#### 4-15. INSTALLATION OF FLAP. (Refer to Figure 4-2.)

a. Ascertain that the flap control rod is installed on the flap.

b. Position flap in place, lubricate flap roller (Refer to Lubrication Chart, Section II) and install the lower roller assemblies. (Flaps with nylon flap rollers will not require lubrication.)

c. Swing the flap rearward and install the remaining roller assemblies. Move the flap through its full travel to assure that there is no binding.

#### NOTE

When installing flap rollers, position spacer washers to allow no side binding and ascertain that the roller bushings will roll free.

d. At the right flap, insert the flap return step lock cable end through the leading edge of the flap. At the left flap, connect the flap return cable to the leading edge.

e. Connect the flap control rod and bellcrank return spring with nut, washer and bolt.

f. In the right wing, by entering through the wheel well, draw and connect the flap return step lock cable and engage the step lock. In the left wing connect the flap return spring.

g. Check flap rigging and adjustments. (Refer to Rigging of Flap, Section V.)

h. Install access plates and wheel well splash pan.

4-16. WING.

4-17. REMOVAL OF WING. (Refer to Figure 4-3.)

- a. Close the fuel valve and drain the fuel from the wing to be removed. (Refer to Draining the Fuel System, Section II.)
- b. Remove the engine from the wing to be removed. (Refer to Removal of Engine, Section VIII or VIIIA.)
- c. Remove wing butt fairing, wing access plates and bottom fuselage access panel.
- d. Within the fuselage remove the front seats, middle or rear seats and carpets.
- e. Remove the spar cover and floor panels fore and aft of the main spar.
- f. Place the airplane on jacks. (Refer to Jacking, Section II.)

CAUTION

To prevent damage or contamination of fuel, hydraulic and miscellaneous lines, place a protective cover over the line fittings and ends.

NOTE

To facilitate reinstallation of control cables and fuel or hydraulic lines, before removing, mark cable and line ends in some identifying manner and attach a line where applicable to cables before drawing them through the fuselage or wing.

- g. Drain the brake line of the wing to be removed and reservoir. (Refer to Draining Brake System, Section II.)
- h. Disconnect the static air, fuel pressure, fuel supply, heater fuel (right wing), oil pressure, manifold pressure and vacuum lines at the wing butt.
- i. Disconnect brake line at the wing butt.
- j. Disconnect the main and auxiliary fuel lines at the wing butt.
- k. If tip tanks are installed, disconnect fuel lines and remove solenoid valve.
- l. Disconnect electrical leads at the wing butt.
- m. Loosen seal grommets and pull control cables through the firewall.
- n. Loosen seal grommets and pull electrical leads through the firewall.
- o. Pull the engine control cables into the fuselage from the conduit in the wing. The tachometer cable must be removed last and installed first due to the large cap on the end.

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- p. Disconnect electrical leads at bus bar in engine nacelle and pull leads into the fuselage from conduit in the wing.
- q. Disconnect flap control cable at center of fuselage and remove cable pulley.
- r. Disconnect aileron balance cable at aileron bellcrank and aileron primary control cable at clevis in the center of fuselage.
- s. Remove aileron cable pulleys from fuselage to allow cables to be pulled out.
- t. Disconnect main gear push pull cable from torque tube arm and bulkhead.
- u. Remove clamp securing push pull cable to the bottom of the fuselage.
- v. Arrange a suitable fuselage support cradle and support the wing to be removed with trestles.
- w. Remove the front and rear spar bolts from the fittings at the side of the fuselage.
- x. Remove bolts from main spar fittings at the side of the fuselage.
- y. Where the two main spars butt, remove bolts from the top and bottom cap strip plates.
- z. Remove bolts from spar support tube assembly and move it back to clear the spar.
- aa. Remove channel from front of spar by removing attaching bolts.
- ab. Remove remaining bolts from spar web plates.
- ac. Check to insure all disconnections have been made, then pull the wing directly and slowly away from the fuselage.

#### 4-18. INSTALLATION OF WING. (Refer to Figure 4-3.)

- a. Prepare the various lines, control cables, etc. in the fuselage before installation of the wing.
- b. Slide the wing into the fuselage until the main spars butt against each other and support the wing with trestles.
- c. Install bolt that attaches the rear spar to fuselage fitting.
- d. At the side of the fuselage, install fittings and bolts attaching the top and bottom cap strips of the main spar to the fuselage.
- e. Install front spar web plate and aft cap strip straps and install bolts.
- f. Position channel on front of spar web and install bolts.
- g. Insert necessary spacer shims between front spar fitting and fuselage fitting and install bolt.
- h. Position spar support tube assembly and install bolt in aft attaching bracket.
- i. Install cap splice plate and bolts on the bottom capstrip.
- j. Install bolts that attach the support tube assembly to the upper capstrip.
- k. Install cap splice plate and bolts except for four in the center to facilitate torquing of previously installed bolts.
- l. Check rear spar fittings for a maximum permissible gap of 0.010 between mating surfaces (before tightening nut.)

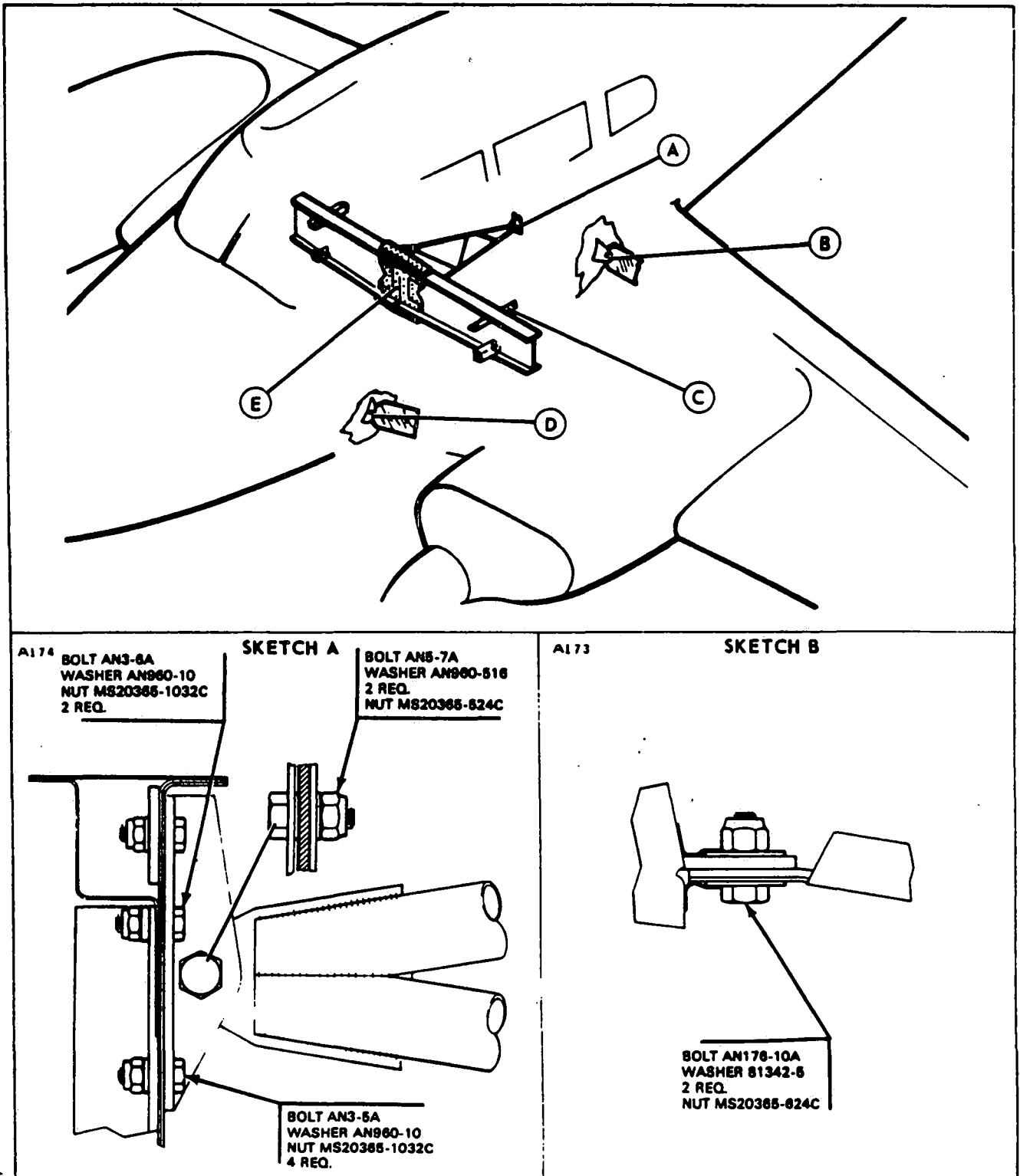


Figure 4-3. Wing Installation

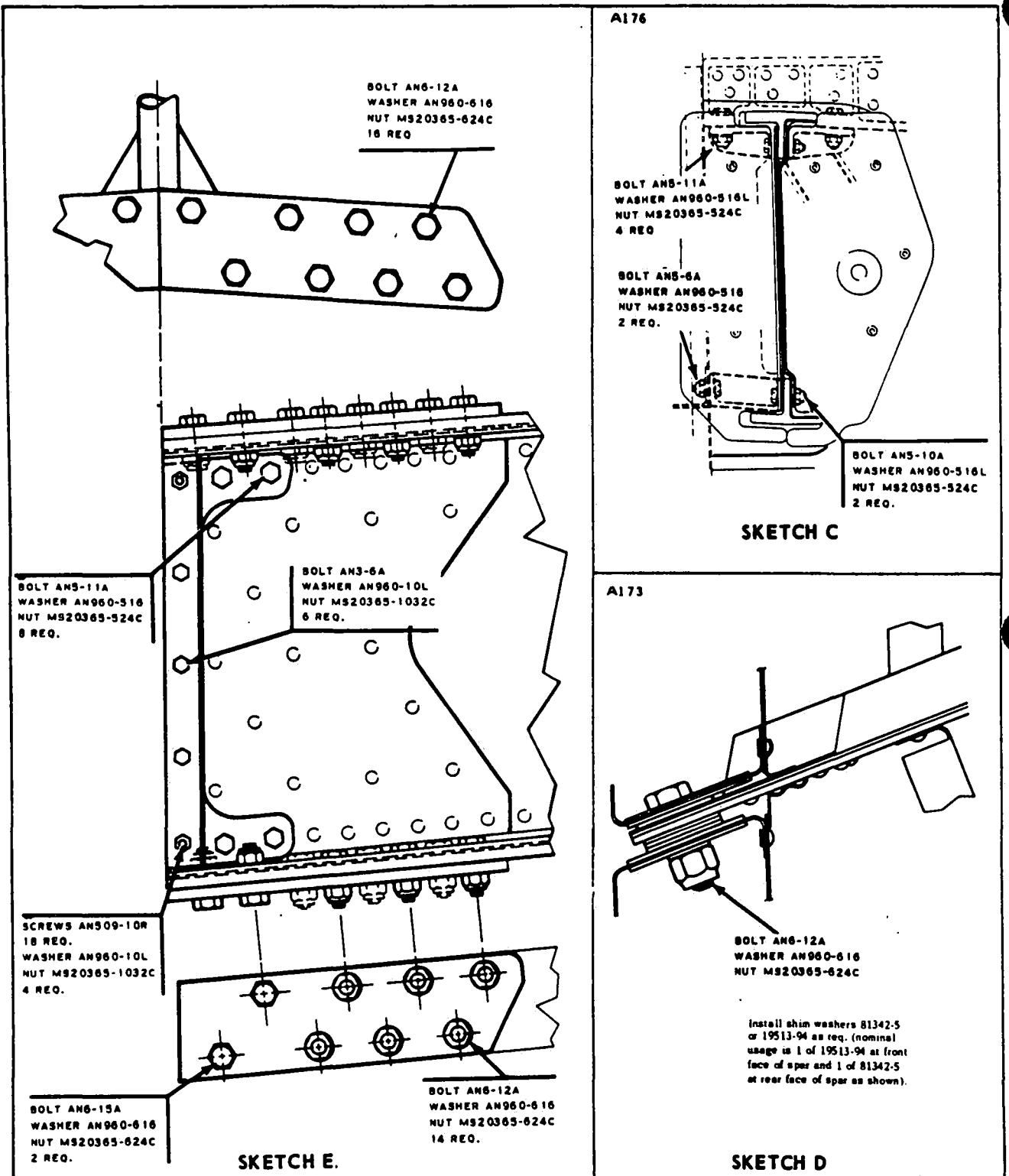


Figure 4-3. Wing Installation (cont.)

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- m. Install washers and nuts on all attaching bolts.
- n. Ascertain that no gap exists between spar splice plates and capstrips.
- o. Torque bolts, securing spar splice plates to capstrip to 160 to 290 inch-pounds or 13 to 24 foot-pounds and all other bolts use standard torque valves.
- p. Install four bolts and seat support on the top capstrip plate and torque bolts to 160 to 290 inch-pounds or 13 to 24 foot - pounds.
- q. Jack airplane and remove trestles.
- r. Connect the main gear push-pull cable to the retraction torque arm and adjust. (Refer to Adjustment of Landing Gear Retraction System, Section VII.)
- s. Route flap control cables into the fuselage, install cable pulleys, and rig system. (Refer to Rigging and Adjustment of Flaps, Section V.)
- t. Route aileron cables, install cable pulleys and rig system. (Refer to Rigging and Adjustment of Aileron Controls, Section V.)
- u. Connect the static air, fuel pressure, fuel supply, heater fuel (right wing), oil pressure, manifold pressure and vacuum lines at the wing butt.
- v. Connect brake line at the wing butt.
- w. Connect the main and auxiliary fuel lines at the wing butt.
- x. If tip tanks are installed, connect fuel lines and install solenoid valve.
- y. Connect electrical leads at the wing butt.
- z. Slide engine control cables through conduit in the wing to the engine nacelle. Due to the large cap on the end, the tachometer cable must be installed first.
- aa. Push control cables through seal grommets in firewall.
- ab. Slide starter, generator or alternator and various electrical leads, etc. through conduit in wing to the engine nacelle.
- ac. Connect short leads to bus bar in engine nacelle and slide remaining leads through seal grommet in firewall.
- ad. Install engine. (Refer to Installation of Engine, Section VIII or VIIIA.)
- ae. Tighten seal grommets around control cables and electrical leads.
- af. Check for fuel leaks and flow.
- ag. Install floor panels, spar cover and carpet.
- ah. Install seat tracks and seats.
- ai. Fill brake fluid reservoir and bleed brakes. (Refer to Bleeding Brakes, Section VII.)
- aj. Install wing butt fairing and access plates.

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4-19. EMPENNAGE.

4-20. STABILATOR.

4-21. REMOVAL OF STABILATOR. (Refer to Figure 4-4.)

- a. Disconnect the stabilator trim control rod by removing nut, washer and bolt.
- b. Disconnect the right and left stabilator from each other at the stabilator rear spar attachment fitting by removing nut, washer and bolt.
- c. Remove bolts attaching the stabilator to the torque tube.
- d. Slide the stabilator from the torque tube.

4-22. INSTALLATION OF STABILATOR. (Refer to Figure 4-4.)

- a. When installing original stabilator on original torque tube, use the following procedure:
  1. Lubricate torque tube and slide stabilator halves in position, aligning the two holes in each stabilator half with holes in torque tube.
  2. Install bolts (ct) through stabilator halves and torque tube.
  3. Install bolt through stabilator rear spar fittings.
  4. Secure bolts with washers and nuts.
  5. Attach the aft end of the stabilator trim control rod to the stabilator trim tab by installing bolt, washer and nut.
  6. Rig stabilator trim tab. (Refer to Rigging and Adjustment of Stabilator Trim, Section V.)
- b. When installing new stabilator on original torque tube, use the following procedure:
  1. Lubricate torque tube and slide stabilator halves in position, aligning the two holes in each stabilator half with holes in torque tube.

NOTE

The bolt holes in the stabilator are smaller than those of the torque tube. Sight through one hole in each stabilator half and align the stabilator fitting hole in the center of the hole in torque tube. Ascertain that all four stabilator bolt holes will align with the rear spar bolt installed.

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2. Ascertain that 0.250 inch clearance is maintained between stabilator skin and fuselage. Trim stabilator skin where necessary.
3. Remove stabilator halves from torque tube and ream one side of one bolt hole in both stabilator halves to 0.3120/0.3130.
4. Install stabilator halves on torque tube; align reamed holes with mating holes in torque tube and install bolt in rear spar fittings.
5. Ream hole all the way through and install bolt (ct).
6. Ream second hole and install bolt (ct).
7. Ream holes in the other half of stabilator in the same manner and install bolts.
8. Secure bolts with washers and nuts and torque.
9. Connect control rod to stabilator trim tab with bolt, washer and nut.
- c. When installing original stabilator on new torque tube, use the following procedure:
  1. Lubricate torque tube and slide stabilator halves in position, aligning one hole in each stabilator half with mating hole in torque tube and inserting locating pin (P/N 25034-00).
  2. Install bolt in stabilator rear spar fittings.
  3. Ream vacant hole in stabilator and torque tube to 0.3120/0.3130 and install bolt (ct).
  4. Remove locating pin and ream second hole to 0.3120/0.3130 and install bolt.
  5. Ream holes in the other half of the stabilator in the same manner and install bolts.
  6. Secure bolts with washers and nuts and torque.
  7. Rig stabilator. (Refer to Rigging and Adjustment of Stabilator Controls, Section V.)
  8. Attach control rod to stabilator trim tab and adjust. (Refer to Rigging and Adjustment of Stabilator Trim, Section V.)

#### 4-23. STABILATOR TRIM TAB.

#### 4-24. REMOVAL OF STABILATOR TRIM TAB. (Refer to Figure 4-4.)

- a. Disconnect the stabilator trim control rod by removing nut, washers and bolt.
- b. Remove the stabilator trim hinge pin by cutting it at the bent portion of one end and pulling it from the hinge. Enlargement of the hinge pin holes may result if the pin is straightened for removal. Replace with a new pin upon installation.

#### 4-25. INSTALLATION OF STABILATOR TRIM TAB.

- a. Align the hinge pin holes of the trim tab with the stabilator and insert new pins. Bend pins at each end down to 90 degrees to secure.
- b. Connect the stabilator trim control rod with bolt, washer and nut.

#### 4-26. RUDDER.

#### 4-27. REMOVAL OF RUDDER. (Refer to Figure 4-4.)

- a. Remove tail cone fairing by removing attaching screws and washers.
- b. Relieve rudder cable tension by rotating the turnbuckle of one cable at the pedal assembly near the forward cabin bulkhead at station 50.0.
- c. Remove cable ends from rudder horn by removing cotter pins, castellated nuts, washers and bolts.
- d. Disconnect taillight wire located at the top of the vertical fin by releasing the quick-disconnect.
- e. Disconnect the trim control rod from the left side of the rudder horn by removing the cotter pin, castellated nut, washer and bolt.
- f. Remove the cotter pin, castellated nut, washer and bolt holding the rudder horn to the aft bulkhead hinge bracket.
- g. On models Serial Nos. 30-1 to 30-2000 incl. that have had Airflow Modification Kit 760 409 or 760 564 installed it is necessary to remove the 21 sheet metal screws that hold the rudder seal to the right side trailing edge skin of the vertical fin.
- h. Disconnect the rudder from the two remaining hinge brackets in the vertical fin by removing castellated nuts, washers and bolts.
- i. Move the rudder to the right or left and upward to separate the hinge brackets.
- j. If desired, separate the rudder horn from the rudder torque tube by removing cotter pins, castellated nuts, washer and bolts (ct). Slide the horn from the torque tube.

#### 4-28. INSTALLATION OF RUDDER. (Refer to Figure 4-4.)

- a. If removed, install the rudder horn into the torque tube of the rudder and secure with bolts (ct), washers and nuts.
- b. Align the two hinge brackets on the rudder with the hinge brackets on the rear spar of the fin and install hinge bolts with washers and nuts. Safety nuts with cotter pins.
- c. Connect the rudder horn to the rudder hinge bracket on the fuselage with bolt, washer and nut. Safety nut with cotter pin.
- d. Connect the two rudder control cables and trim control rod to the rudder horn using clevis bolts, washers and nuts. Safety all nuts with cotter pins.
- e. Connect the navigation lights at the wire quick-disconnect.
- f. Replace the tail cone fairing, and secure with screws and washers.
- g. If installed, reattach the rudder seal of the Air Flow Kit by aligning the seal with the holes in the vertical fin and install the 21 sheet metal screws.

## PIPER TWIN COMANCHE SERVICE MANUAL

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### 4-29. VERTICAL (STABILIZER) FIN.

#### 4-30. REMOVAL OF FIN. (Refer to Figure 4-4.)

- a. Remove the tail fairings and access plate at the right side of the fuselage just forward of the stabilator.
- b. Remove the rudder as described in paragraph 4-27.
- c. Disconnect the antenna wire from the fuselage assembly with the quick-disconnect fitting located at the lower forward position of the fin.
- d. If the quick-disconnect is not installed, remove the antenna from the top of the fin and separate the coaxial cable from the antenna.
- e. Connect a fish line to the cable before removing it from the fin to facilitate installation.
- f. Remove the bolts at the rear attachment bracket of the fin.
- g. Remove the bolts at the front attachment bracket of the fin.
- h. Remove the fin.

#### 4-31. INSTALLATION OF FIN. (Refer to Figure 4-4.)

- a. Position the fin on the top of the fuselage aft section and align the holes in the front attachment plate of the fin with the holes in the front attachment plate on the fuselage. Align the holes in the rear mounting bracket of the fin with the holes in the rear attachment plate on the fuselage. Ascertain that the extruded molding used as a chafing strip is installed along the lower edge of the fin. With a new fin, it may require trimming the lower edge of the fin to allow the molding to fit.
- b. Install the bolts and screws on the forward attachment plate and on the rear mounting bracket of the fin assembly.
- c. Install the receiver antenna in the fin tip if the radio equipment is installed in the airplane.
- d. Connect the receiver coaxial cable to the root of the fin assembly if the receiver antenna is installed on the fin.
- e. Connect the overhead sensing antenna by clamping it to the riveted bracket on the fin assembly and running it to the insulator on the top of the fuselage center section.

#### NOTE

The fin should be vertical and in line with the centerline of the fuselage.

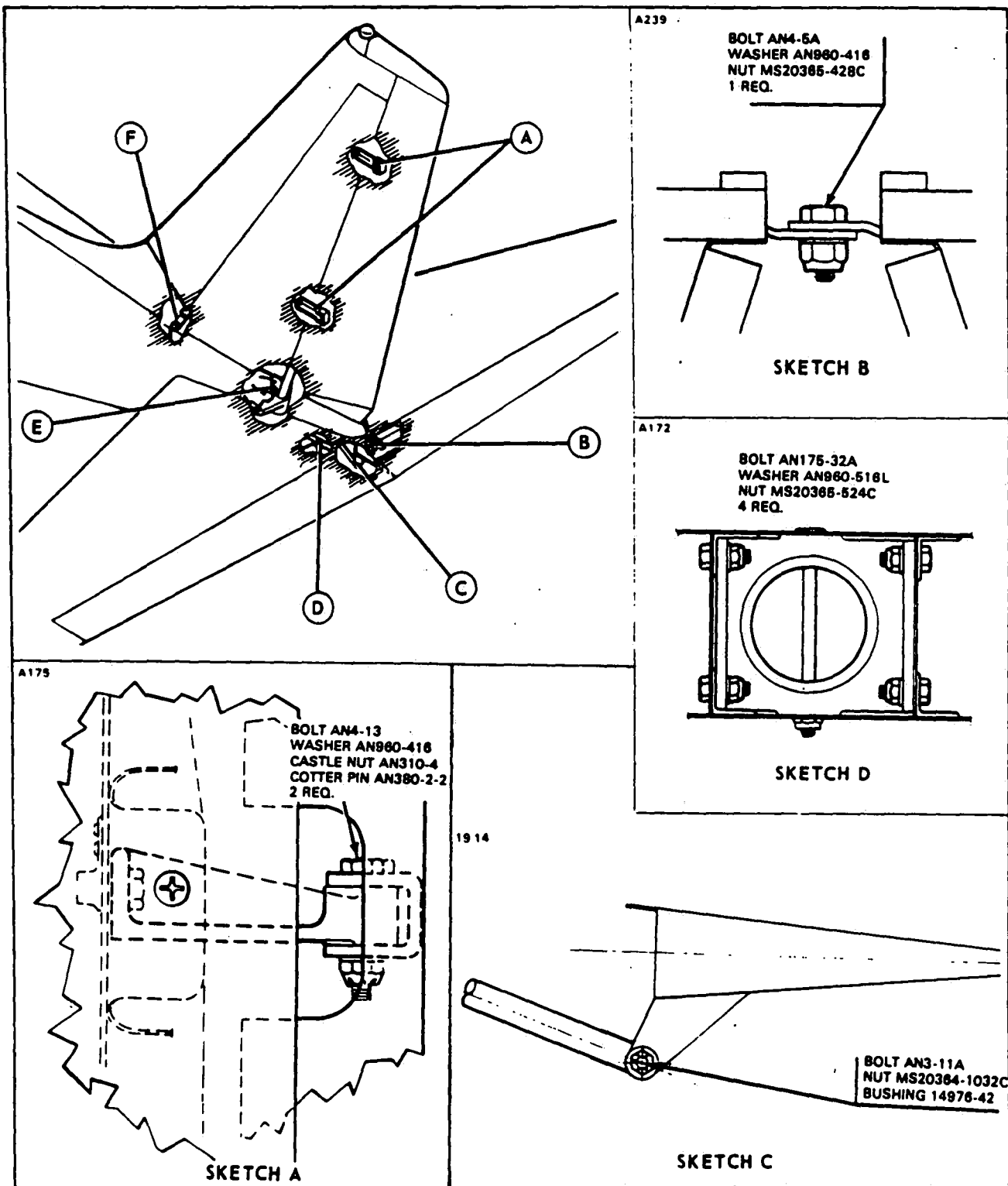


Figure 4-4. Empennage Installation

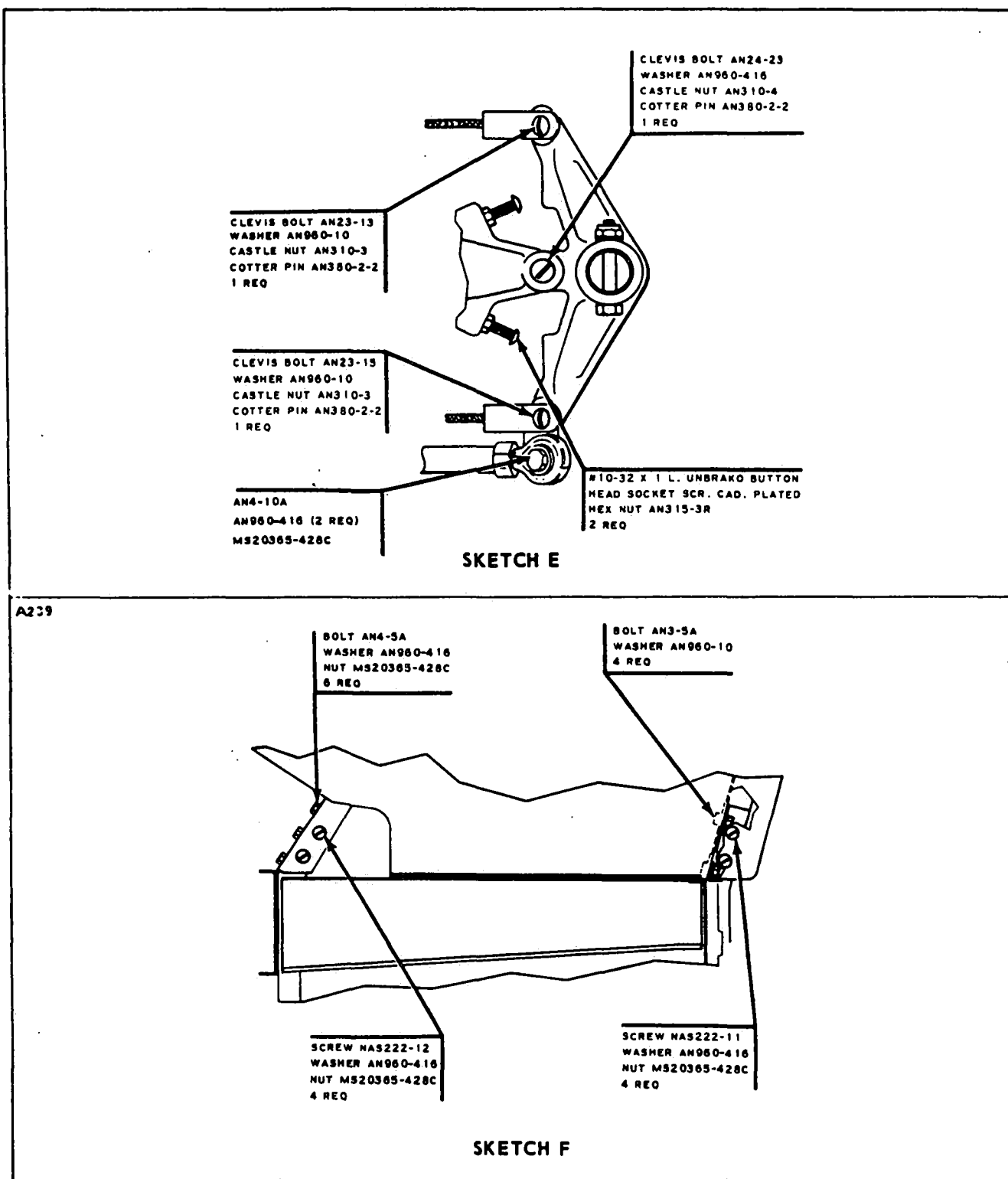


Figure 4-4. Empennage Installation (cont.)

- f. Install the rudder per paragraph 4-28.
- g. Install tail fairings and access plate.

#### 4-32. FUSELAGE ASSEMBLY.

#### 4-33. WINDSHIELD.

4-34. REMOVAL OF WINDSHIELD. The windshield consists of two sections which may be removed as follows:

- a. Remove windshield outside collar fairing by removing attaching screws.
- b. Remove windshield divider strip by removing attaching machine screws and nuts.
- c. Remove left or right upper interior windshield trim panel by removing attaching screws.
- d. Remove left or right interior fairing from windshield post.
- e. Windshield can now be removed by pulling it out from channels.

#### NOTE

A damaged windshield should be saved since it can be used as a pattern for drilling holes in a new windshield.

#### 4-35. INSTALLATION OF WINDSHIELD. (Refer to Figure 4-5.)

- a. Ascertain that new windshield is cut to match windshield removed.
- b. Apply Prestite Tape No. 163 or equivalent over edge of windshield. (Apply two thicknesses on windshield at center post.)
- c. Apply Prestite Tape to back of inner collar and install collar on fuselage.
- d. Install windshield in fuselage and allow 0.125 inch clearance between two sections of windshield at divider post.
- e. Inside the airplane at the top of the windshield install spacer bushings and apply a strip of plastic tape 1.5 inch wide on the windshield and fuselage channel.
- f. Apply PRC 5000 sealing compound or equivalent between fuselage top and side post skins and windshield.
- g. Install screws around the top of the windshield.
- h. Install interior trimstrips, washers and nuts. (Do not tighten nuts.)
- i. Install windshield center strip and screws.
- j. Apply electrical tape and sealer around the bottom of the windshield.
- k. Apply 3M No. 1126 Sealer to back of outside collar.

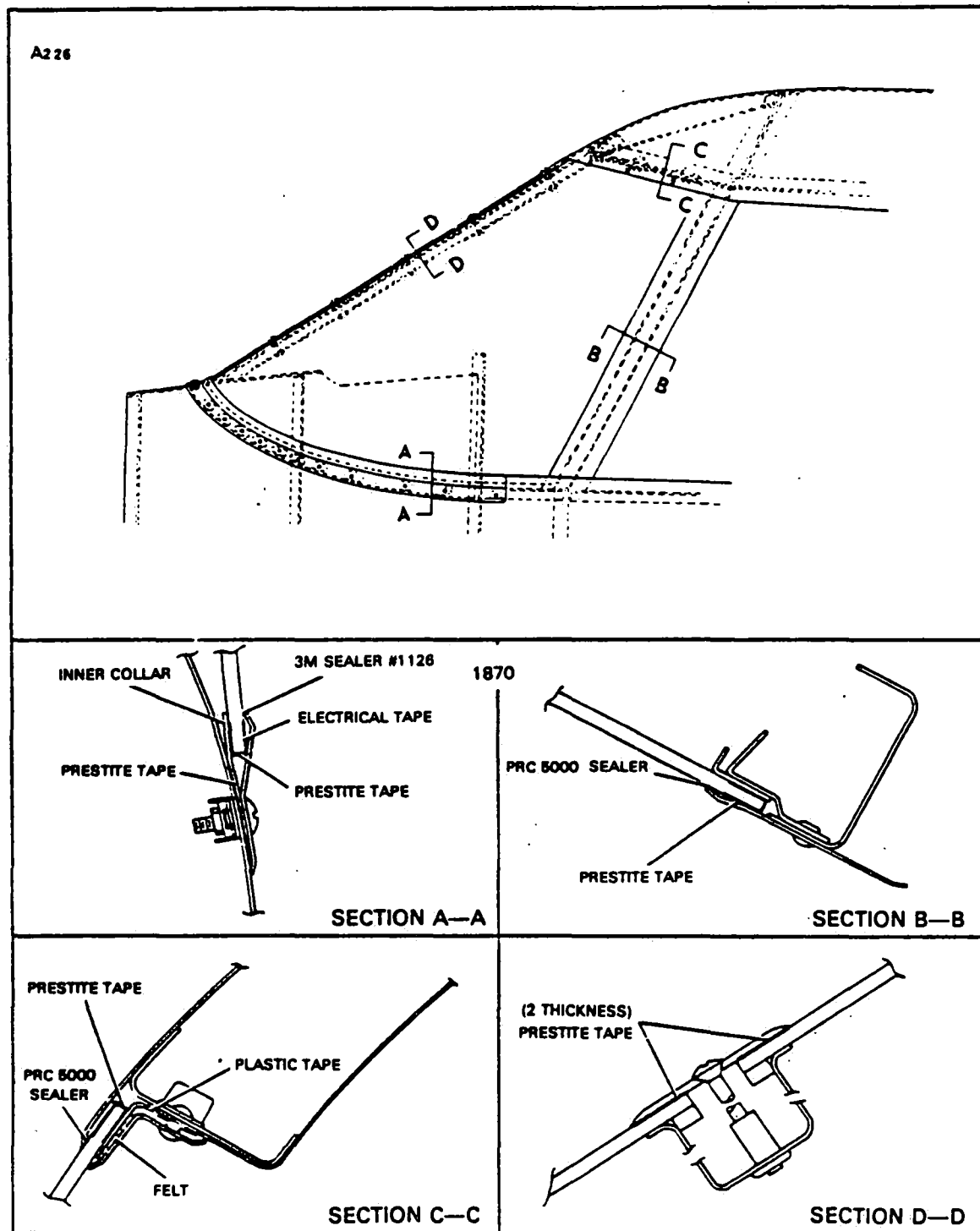


Figure 4-5. Windshield Installation



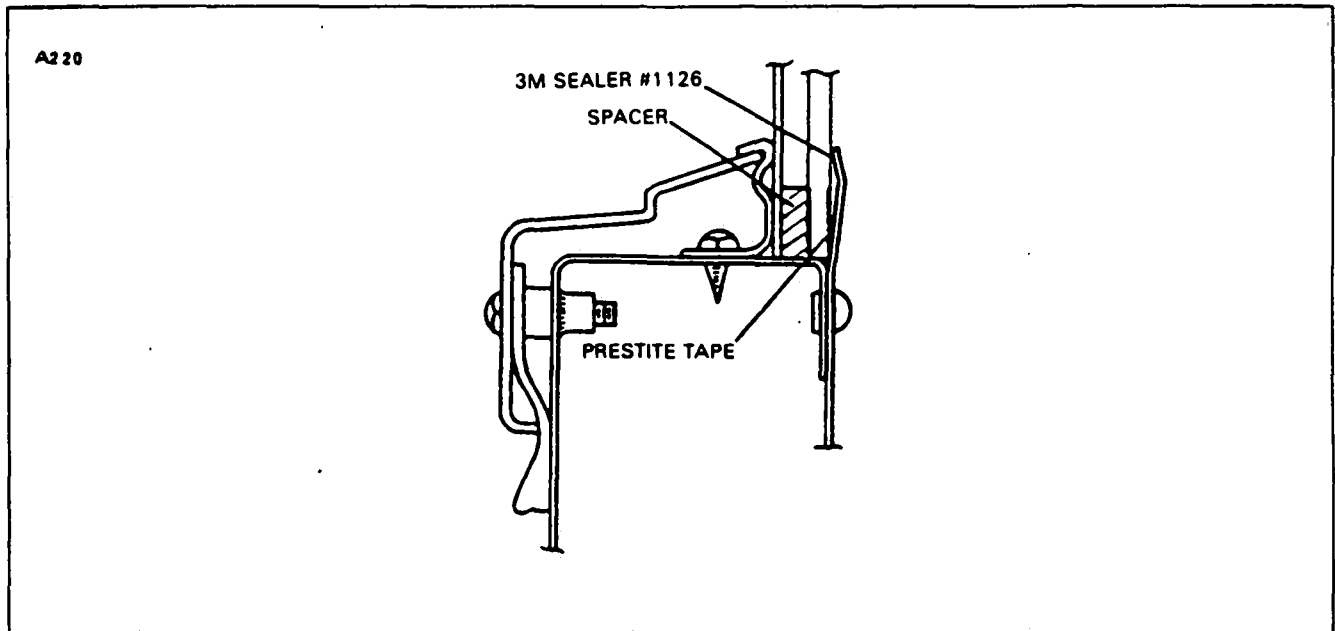


Figure 4-6. Side Window Installation (Typical)

- l. Install outside collar and screws.
- m. Tighten all screws and nuts evenly and check for water seepage.

#### 4-36. WINDOWS (SIDE).

#### 4-37. REMOVAL OF SIDE WINDOWS.

- a. Remove the screws that hold the trim moulding around inside of the window.
- b. Remove the screws that secure the window retainer strip and remove the inner and outer window.
- c. Remove old window sealer trim surfaces.

#### 4-38. INSTALLATION OF SIDE WINDOWS. (Refer to Figure 4-6.)

- a. Ascertain that the new window is cut to same dimensions as old window.
- b. Assemble inner and outer window by cementing rubatex strip to inner window using carbolene neobolene cement C-1. Leave 0.06 to 0.12 gap between ends of rubatex strip to form drain at the lower aft edge of each window assembly. Allow cement to air dry 15 minutes.
- c. Apply Prestite Tape No. 163 or equivalent over edge of outside window where it contacts the fuselage skin and seal with 3M sealer No. 1126.
- d. Install the window assembly and screw inner retainer strip into position.
- e. Place trim molding around inside of window and install screws.

#### 4-39. DOOR.

#### 4-40. REMOVAL OF CABIN DOOR.

- a. Remove the door holder assembly by removing the screw in the door sill.
- b. Remove roll pin from door hinge fitting and drive out the door hinge pin.
- c. Remove the door without letting the serrated bushings drop out.

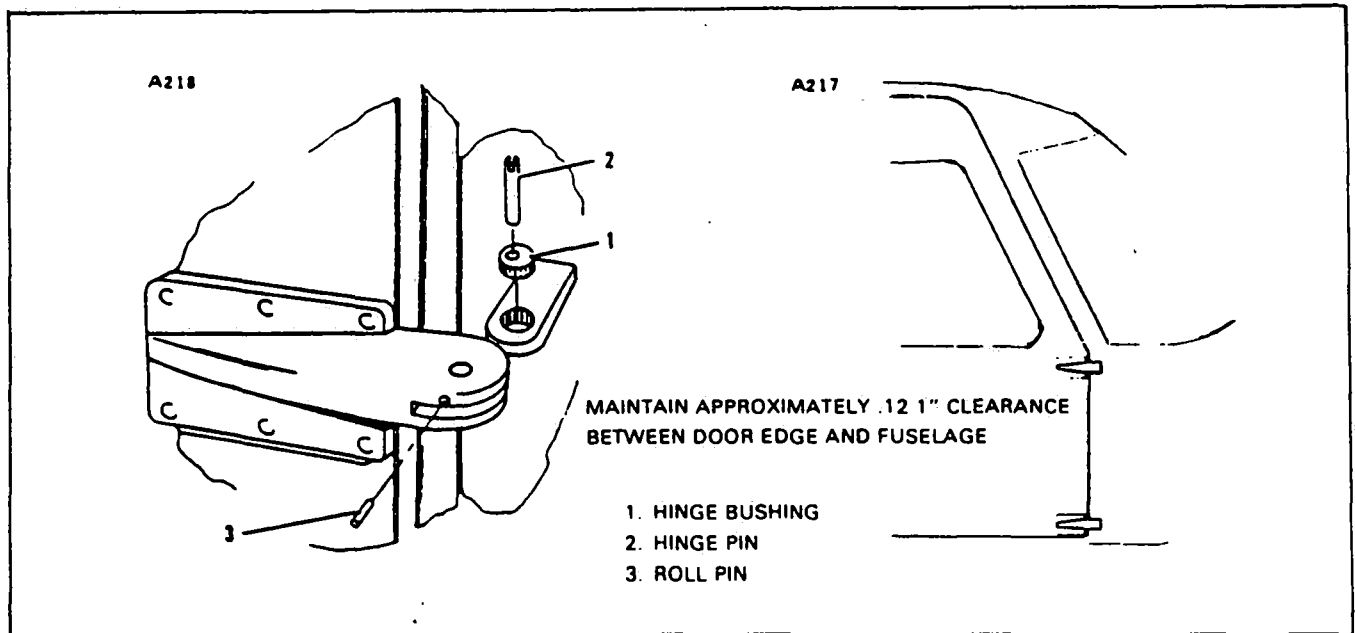


Figure 4-7. Door Installation

**4-41. INSTALLATION AND ADJUSTMENT OF CABIN DOOR.** (Refer to Figure 4-7.) The entrance door is made of formed aluminum assemblies spot welded together. This type of construction gives a ridges assembly, but still retains the flexibility needed for proper fitting of the door. When installing a new door, follow the procedure given below.

- a. Temporarily mount the new door on the fuselage using bolts at the hinge points. As the door will be removed from time to time during fitting, the bolts will make the door easy to remove.
- b. Swing the door closed and check for alignment of the main door latch and the auxiliary latch with their respective latch striker plate. If the door fails to align, remove it and reposition the two serrated door hinge bushings (1). Repeat the above procedure until the door is properly aligned.
- c. Once the door is properly aligned with the door frame, the procedure of trimming and fitting the door can be started. Using a small pair of metal shears and a file, trim the door edges until there is an approximate clearance of 0.125 of an inch between the fuselage skin edge and the door edge.
- d. After the door is fitted, use a short piece of 0.25 inch diameter dowl and a hammer to contour the edges of the door to align with the fuselage skin.
- e. With the door removed, use sandpaper to smooth the rough edges. Replace the door using the required hinge pins (2), staked with roll pins (3). Install the door holding assembly. Apply a light coat of oil to the latch assemblies.

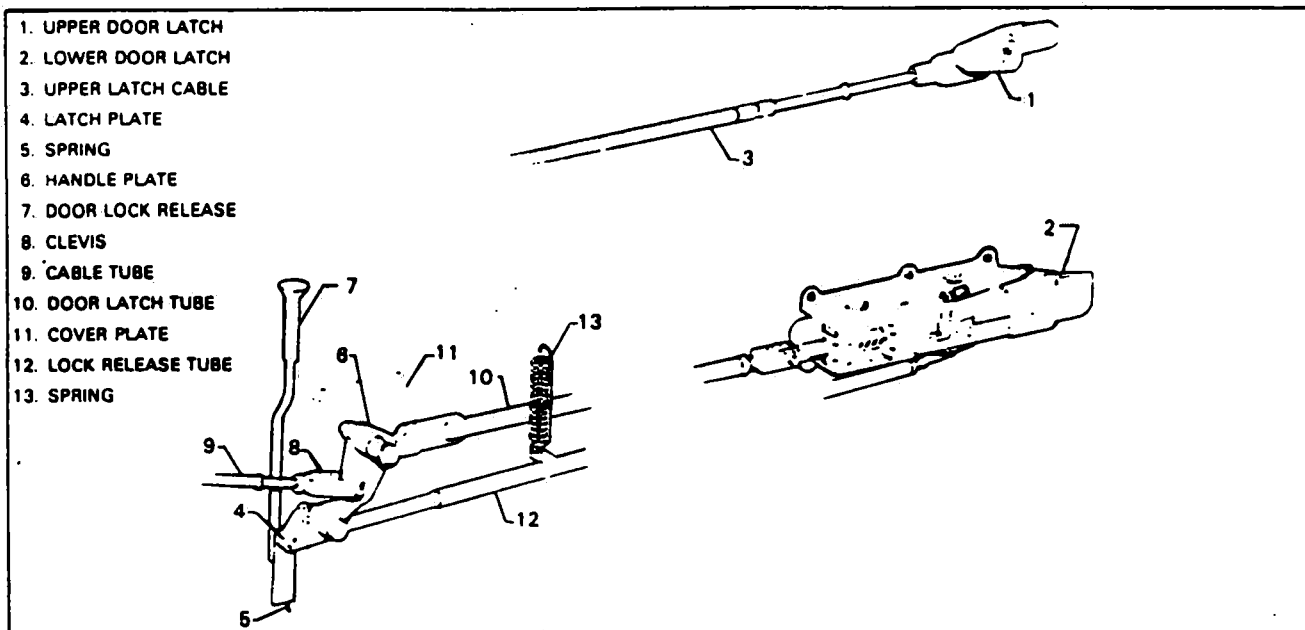


Figure 4-8. Door Locking Mechanism

**4-42. REMOVAL OF DOOR LATCH ASSEMBLY. (Refer to Figure 4-8.)**

- a. Remove door latch assembly by removing door trim upholstery and removing screws attaching latch assembly to door.
- b. Disconnect latch pull rod from inside door handle.
- c. Remove complete latch assembly.

**4-43. INSTALLATION AND ADJUSTMENT OF DOOR LOCKING MECHANISM. (Refer to Figure 4-8.)**

- a. Install the upper (1) and lower (2) latch assemblies with machine screws.
- b. Install latch cable assembly (3) and connect the clevis rod end to the upper latch. Leave approximately three threads of the cable end exposed from the clevis, then tighten the locknut.
- c. Lubricate and install latch plate (4), door lock release (7) and latch spring (5).
- d. Lubricate and install the door handle shaft-plate assembly (6). With the latch plate in locked position, draw the door handle up and to the rear allowing the pawl of the handle plate assembly (6) to catch the latch plate (4).

- e. Align the latch cable clevis end (8) holes with the lower hole of the handle-plate assembly (6). Ascertain that the clevis pin will slip freely through these holes. Remove the pin and take in one turn if adjustment is with a cable that has been previously installed. Take in two turns if adjustment is with a new cable. Install the pin and safety. Check that tube (9) will rotate freely.
- f. Install door latch tube assembly (10) and pin, safety at the handle-plate assembly. Install cover (11) and secure.
- g. Install the latch tube clevis end to the lower latch assembly. Adjust the clevis to allow the inside handle to operate when the outside handle is moved in and out through its three positions. The outside handle should lock flush with its frame.
- h. Install door lock release tube (12) and spring (13). Adjust to allow the forward portion of the outside handle to move out finger width when the rearward portion is depressed.
- i. Check the operation of the latch handle and ascertain that the upper and lower latches (1 and 2) are fully extended when the door handle is in a locked position (full forward). The upper latch (1) is retracted when the lower latch is in closed position (neutral handle position, no force applied) and both latches are retracted when the handle is in open position (full rear).
- j. Ascertain that the flat portion of the door lock release tube (12) is 90 degrees to the flat of the latch plate (4).
- k. Lock all clevis rod ends and safety all pins. Install the door trim.

**4-44. STRUCTURAL REPAIRS.** Structural repair methods used must be made in accordance with recommendations set forth in FAA Advisory Circular 43-13-1. To assist in making repairs and/or replacements, Figure 4-9 identifies the type and thickness of various skin materials used. Never make a skin replacement or patch plate from material other than the type of the original skin or of a different thickness from 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.

It may be necessary to cut access holes to make skin repairs in some areas of the airplane. Refer to Figure 4-10 for typical access holes.

#### WARNING

NO access holes are permitted in any control surface.

Structural repairs must be noted in the airplane logbook, with information as to type of repair. The logbook should be reviewed to determine that previous structural repairs, if any, to the control surfaces do not, where combined, exceed the maximum allowable weight or thickness limits.

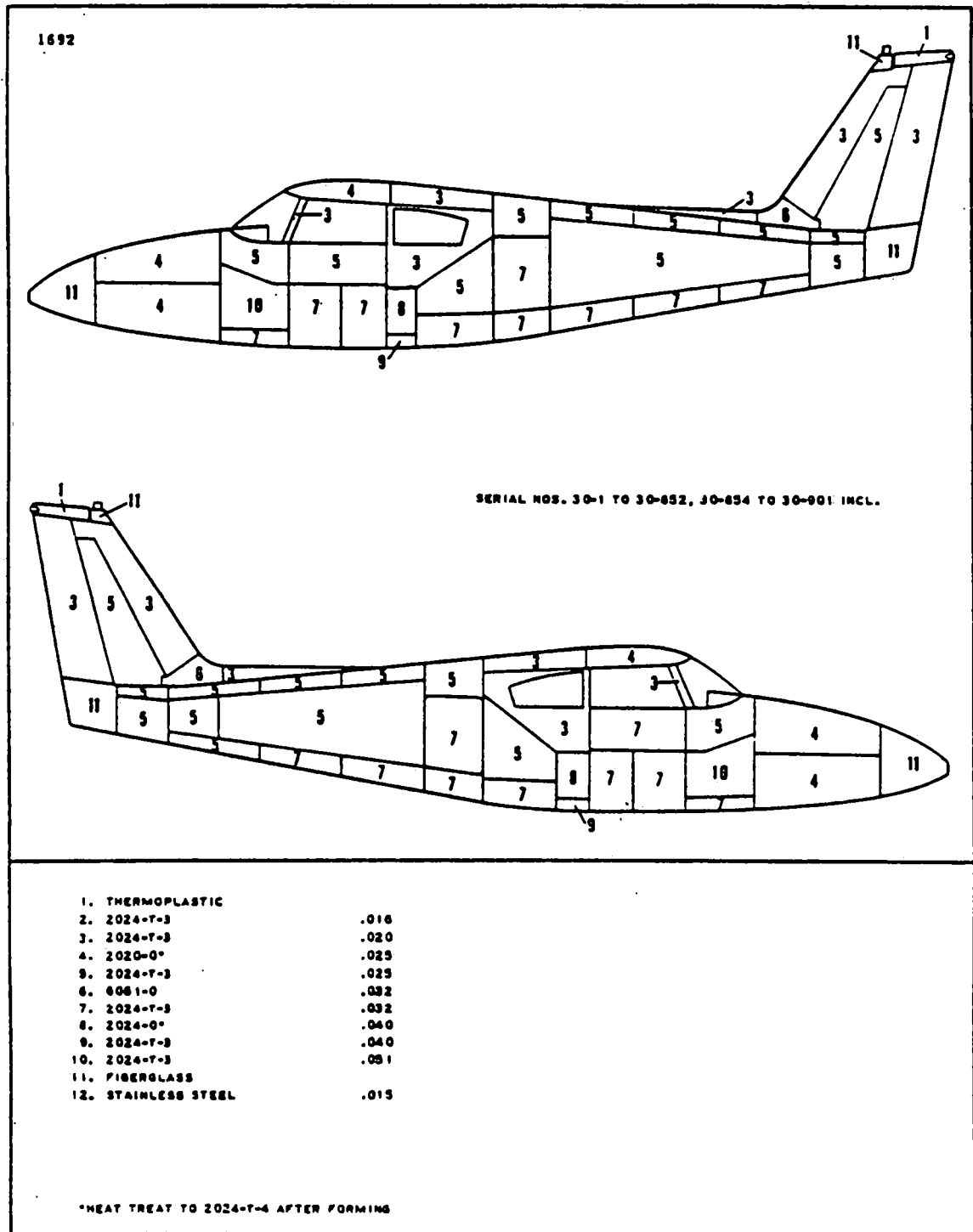
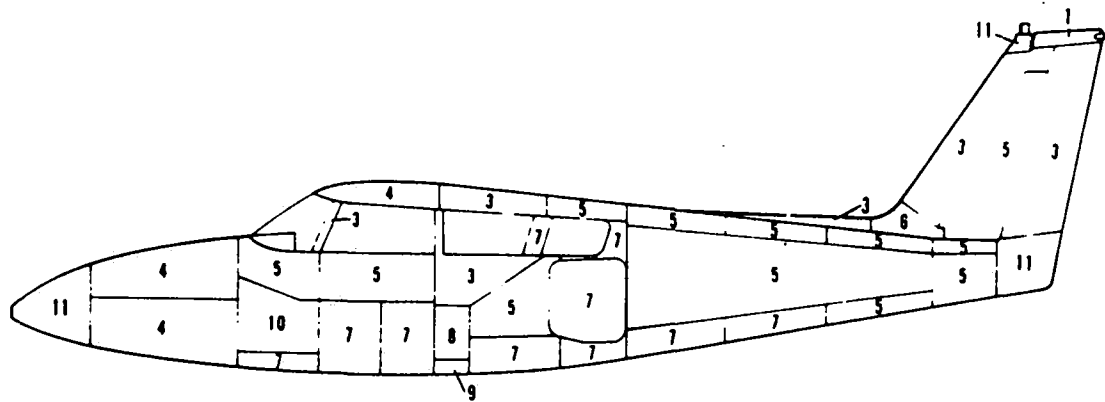


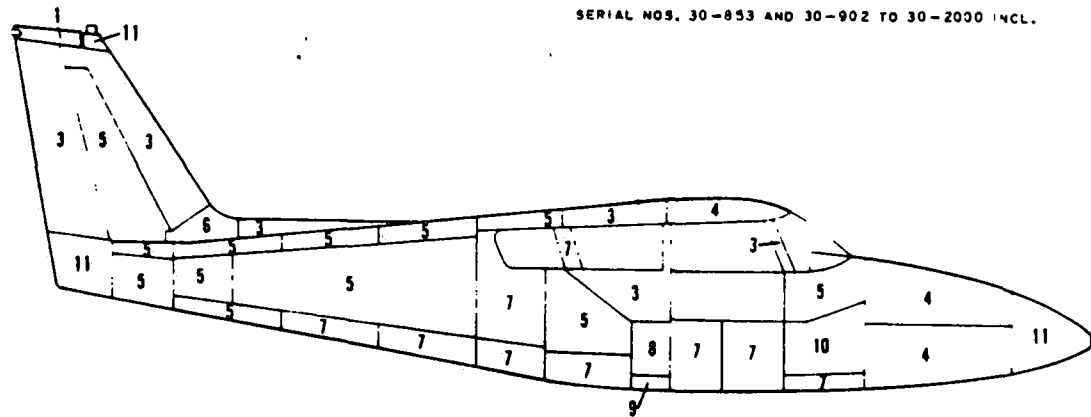
Figure 4-9. Skin Material and Thickness

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SERIAL NOS. 30-853 AND 30-902 TO 30-2000 INCL.



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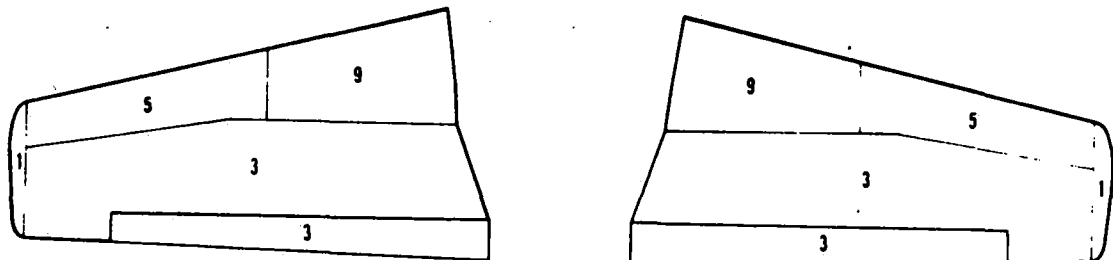


Figure 4-9. Skin Material and Thickness

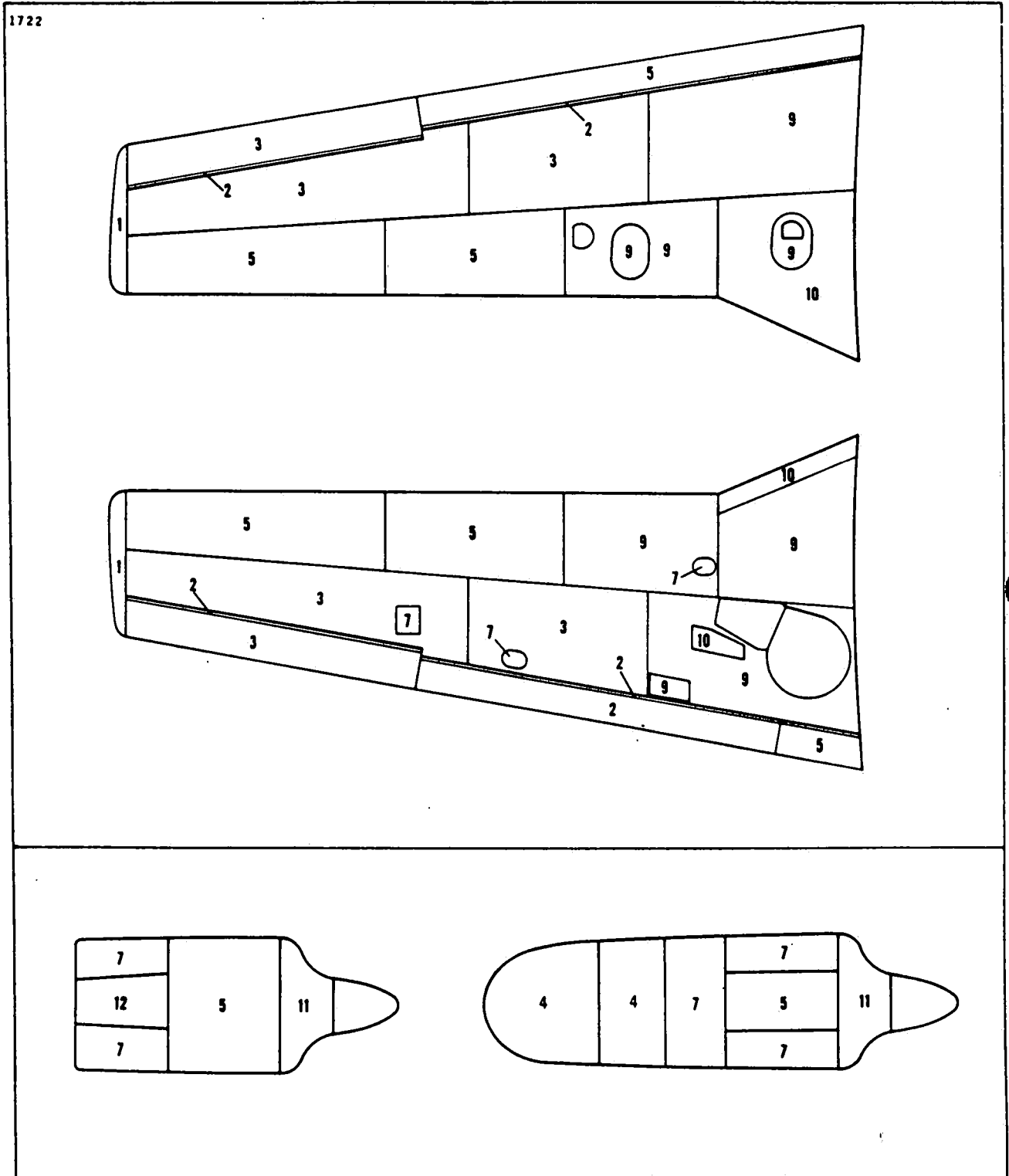


Figure 4-9. Skin Material and Thickness (cont.)

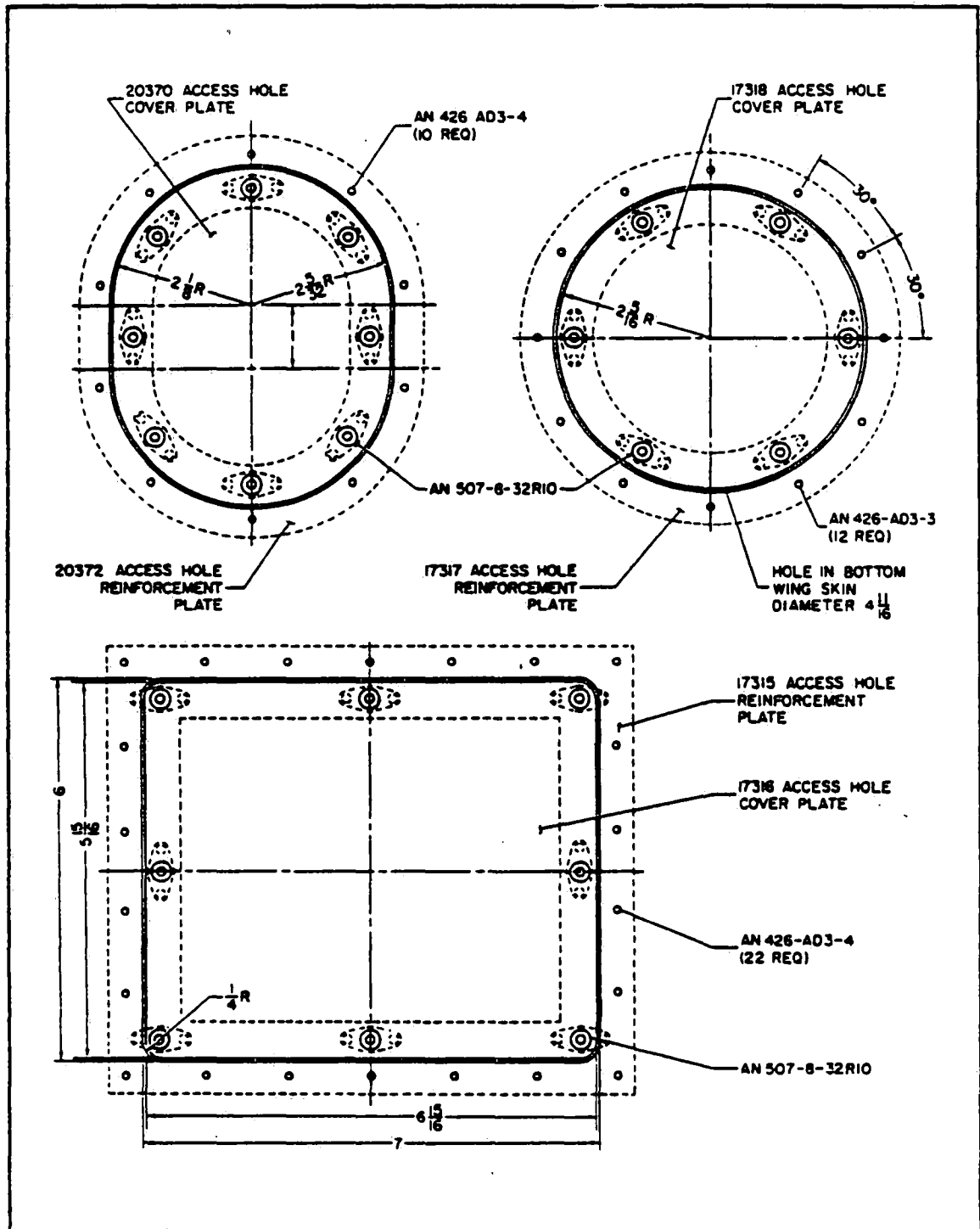


Figure 4-10. Typical Access Holes

STRUCTURES

Issued: 12/29/72



**WARNING**

The use of patch plates for repair of the stabilator, stabilator tab, and rudder shall be limited as described in Paragraphs 4-45 and 4-46. The use of surface filler material normally used for repair of minor dents, stone damage, etc., is prohibited on all movable control surfaces.

**4-45. REPAIR OF STABILATOR AND STABILATOR TAB (HORIZONTAL TAIL SURFACE).** Precautions must be taken when performing any maintenance and/or repairs to the stabilator or stabilator trim tabs. Repairs must be made in a manner that maintains the original configuration, strength, stiffness and weight distribution. Repairs are limited to replacement of complete skin sections, ribs, hinges, spars, etc., and paint.

**WARNING**

During the course of any repair work being accomplished on the stabilator, the complete stabilator trim tab, and trim tab mechanism should be checked for "free play." Refer to Paragraph 4-47 for complete details on checking for free play.

**WARNING**

The structural integrity of the assembly must be maintained. Proper drainage must be maintained to prevent any accumulation of dirt, water or ice.

It is recommended that before a stabilator or tab is repainted, it should be stripped of all old paint. This will prevent the build up of paint with the subsequent effect on the balance of the stabilator. Refer to Paragraph 4-48 or 4-49 for stabilator balancing information.

**NOTE**

The stabilator torque tube, stabilator balance arm, and any part of their mounting structures should be replaced if any damage is detected which could tend to weaken the part, cause loss of stiffness or strength, or which will tend to propagate through continued use.

**STRUCTURES**

Issued: 12/29/72

**4-46. REPAIR OF RUDDER.** Precautions must be taken when performing any maintenance and/or repairs to the rudder. Repairs must be made in a manner that maintains the original configuration, strength, stiffness and weight distribution. Repairs are limited to replacement of complete skin sections, ribs, hinges, spars, etc., and paint.

**4-47. CHECKING AND BALANCING CONTROL SURFACES.**

**4-48. CHECKING STABILATOR CONTROL SURFACES.** The importance of keeping control surfaces in proper balance cannot be overemphasized. The following checks are recommended before balancing to ascertain the amount of "free play" in the stabilator, stabilator trim tab and tab mechanism.

a. **Stabilator:** Check the stabilator for any "free play" at its attachment points by grasping each half near the tip and gently trying to move it up and down, fore and aft, and in and out, on its torque tube. NO play is allowed.

b. **Stabilator Trim Tab:** Set the stabilator trim tab in neutral position. This neutral position is determined with the airplane properly rigged per instructions given in this section of the service manual; the control wheel positioned 7.88 inches from the instrument panel, and the trim indicator at its neutral position. Obtain a straightedge long enough to extend from the ground up to a few inches above the trim tab trailing edge. Place the straightedge next to the trim tab inboard (center) trailing edge, and grasping the tab, gently move it up and down, mark the limits of tab free play on the straightedge. The overall travel (free play) must not exceed .076 of an inch. The use of a dial indicator and fixed stand is recommended, refer to Figure 4-10a.

c. **Stabilator Trim Tab Mechanism:** The complete trim tab mechanism should be checked for free play at the various components such as trim control rod end bearing, trim bellcrank, trim screw, trim drum and trim drum assembly. The bearing located between the stabilator tab horns should fit close enough to eliminate play in the actuator system. However, it should not be so tight that the control rod cannot easily be moved sideways or endwise on the bearing.

Whenever any portion of the stabilator has been repaired and/or repainted (refer to Paragraphs 4-44 and 4-45), it must be rebalanced before the airplane is flown. The following balancing procedure is recommended:

1. Stabilator installation must be complete and ready for flight before balancing.
2. Control cables at balance arm must be disconnected before balancing.

**CAUTION**

It is very important to have the stabilator free to rotate with a minimum of frictional resistance. To insure this requirement, check the bearings, trim tab hinges, and tab control rod end bearings for rust, dirt or worn parts. If any of these conditions exist, repair or replace before balancing.

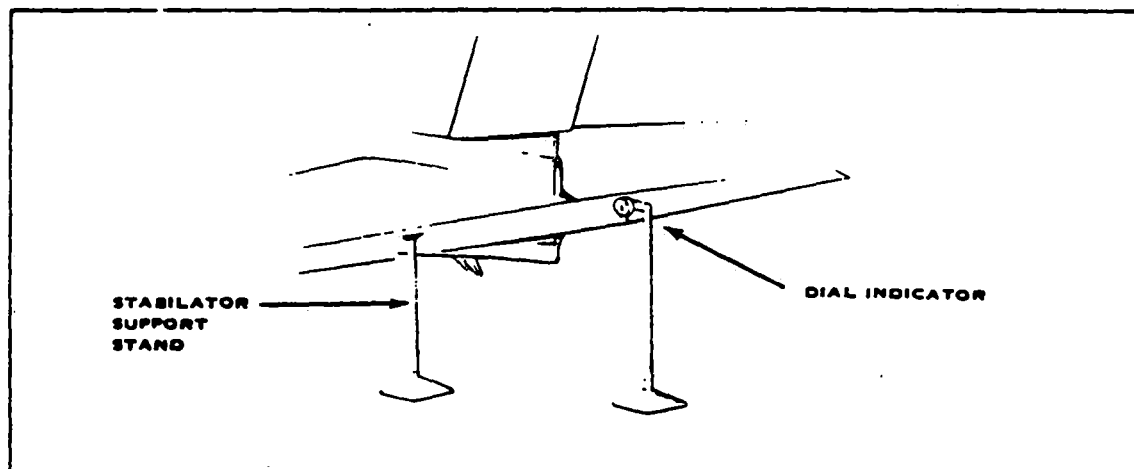


Figure 4-10a. Checking Stabilator Free Play

**NOTE**

There are two different balancing procedures. Check the serial number of the airplane being serviced and use the appropriate procedures.

**4-49. CHECKING AND BALANCING STABILATOR.** (Serial Nos. 30-1 to 30-852 inclusive; 30-854 to 30-901 inclusive; 30-1717; 30-1745 to 30-2000 inclusive.) (Refer to Figure 4-11.)

a. Whenever a stabilator has been repaired and/or repainted, it must be balanced before the airplane is flown.

b. Stabilator installation must be complete before balancing, including tabs and paint. Stabilator control cables (2 and 3) must be disconnected from stabilator balance arm (1) and tab actuator arm must be disconnected from stabilator tab horn during balancing. Hardware used to connect the extension spring cable and stabilator control cables should be removed. Hardware holding balance arm weight in place should be installed. A small piece of tape should be used to hold tabs neutral with stabilator. It is very important to have the stabilator free to rotate with a minimum of frictional resistance.

NOTE

If the bearing resistance is too great, it is necessary to loosen the nuts holding the stabilator torque horn to the stabilator torque tube, and those holding the stabilator to the torque tube as well as the nuts holding the stabilator stop to the torque tube. Measure the bearing resistance again. When this is done, the nuts must be tightened just enough to take the play out of the washers. The bolts holding the stabilator bearing blocks to the fuselage should be loosened and tightened finger tight during balancing. After balancing is completed, stabilator bearing block bolts should be torqued to a value of 135 to 140 inch-pounds. Ascertain that the stabilator is free to rotate with minimum friction.

- c. Master check weight (6) (P/N 23584-00) (weight 1.58 pounds) should be placed on top of balance weight (5) (P/N 23594-00) with the side marked "FRONT" facing forward. (Refer to Figure 4-11.) If this is not enough weight to obtain static balance with the balance arm level, plates (4) (P/N 23179-00) must be added to the forward balance weight attaching bolt until 100% static balance is obtained or until up to two plates more than that required for balance have been added. Generally, it should not be necessary to use more than eight plates. If a total of more than eight plates is necessary to obtain balance, recheck the procedure in steps "b" and "c".
- d. Should it be necessary to obtain a stabilator without a master check weight, a temporary balancing can be accomplished by using the procedure given in "b" above. A sensitive and accurate spring scale can be used to get a balance with  $49 \pm 3$  inch-pounds of torque. Plates should be added (up to eight) until a lifting force between 2.71 and 2.88 pounds will balance the stabilator with the spring scale hooked to the bolt that fastens the two stabilator-connecting tabs (arm of 17 inches). As soon as a master check weight is available, the balance should be checked for accuracy.
- e. After balancing is accomplished, the check weight (or spring scale) should be removed and the plates should be distributed equally on both sides of the stabilator balance tube and the bolt secured.
- f. All stabilator and tab controls should be reconnected.
- g. The stabilator control extension spring link should be adjusted to obtain one and one-quarter inch extension of the spring with the stabilator stops adjusted and the control wheel in the full forward position.
- h. The operation and feel of the stabilator controls should then be checked for proper movement.

4-50. CHECKING AND BALANCING STABILATOR. (Serial Nos. 30-853, 30-902 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive.) (Refer to Figure 4-12.)

- a. Whenever a stabilator has been repaired, it must be balanced before flight.
- b. Stabilator installation must be complete before balancing, including tabs and paint. Stabilator control cables (2 and 3) must be disconnected from the stabilator balance arm (1) and the tab actuator arm must be disconnected from the stabilator tab horn during balancing. Hardware used to connect the extension spring cable (3) and stabilator control cables (2) should be removed. Balance weights (7) (P/N 25780-02) and (6) (P/N 25780-03) must be removed from the balance arm (1). A bolt (AN4-16A) with nut must be installed in place of the bolt (8) (AN4-36A). The aft bolt holding the balance arm weight must remain installed. A small piece of tape should be used to hold tabs neutral with stabilator. It is important to have the stabilator free to rotate with minimum of frictional resistance. Refer to NOTE in Paragraph 4-48 to obtain minimum frictional resistance.

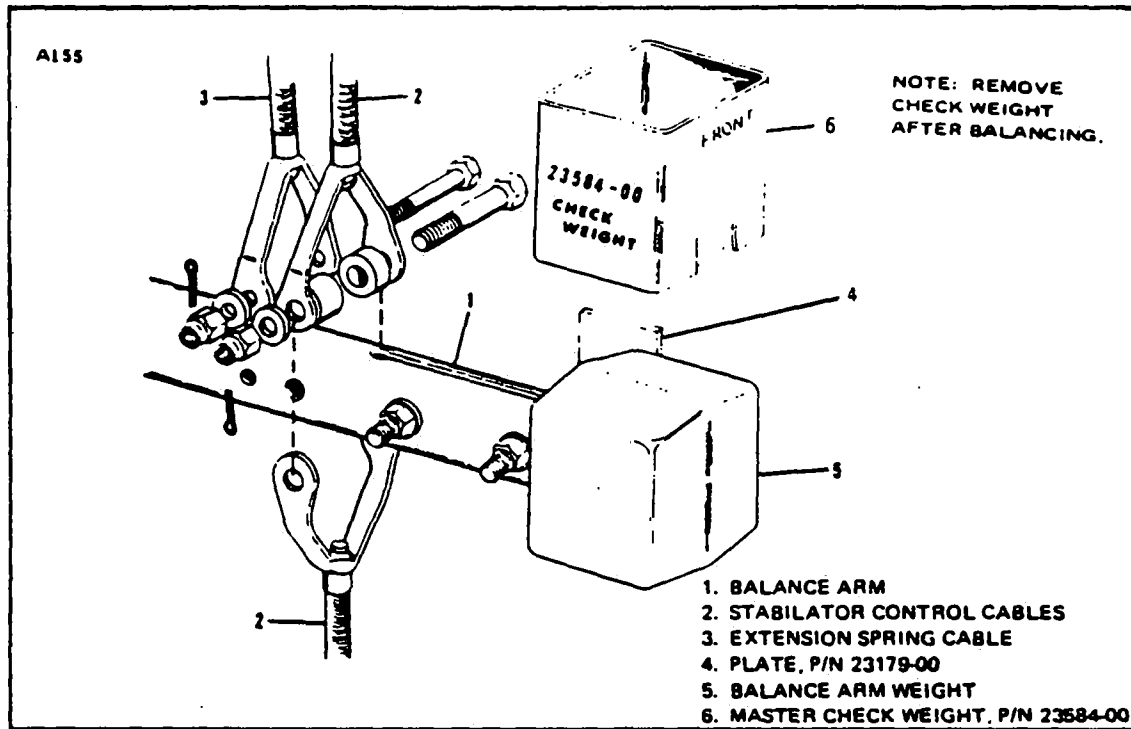


Figure 4-11. Balancing Stabilator, Serial Nos. 30-1 to 30-852 incl.,  
30-854 to 30-901 incl., 30-1717, 30-1745 to 30-2000 incl.

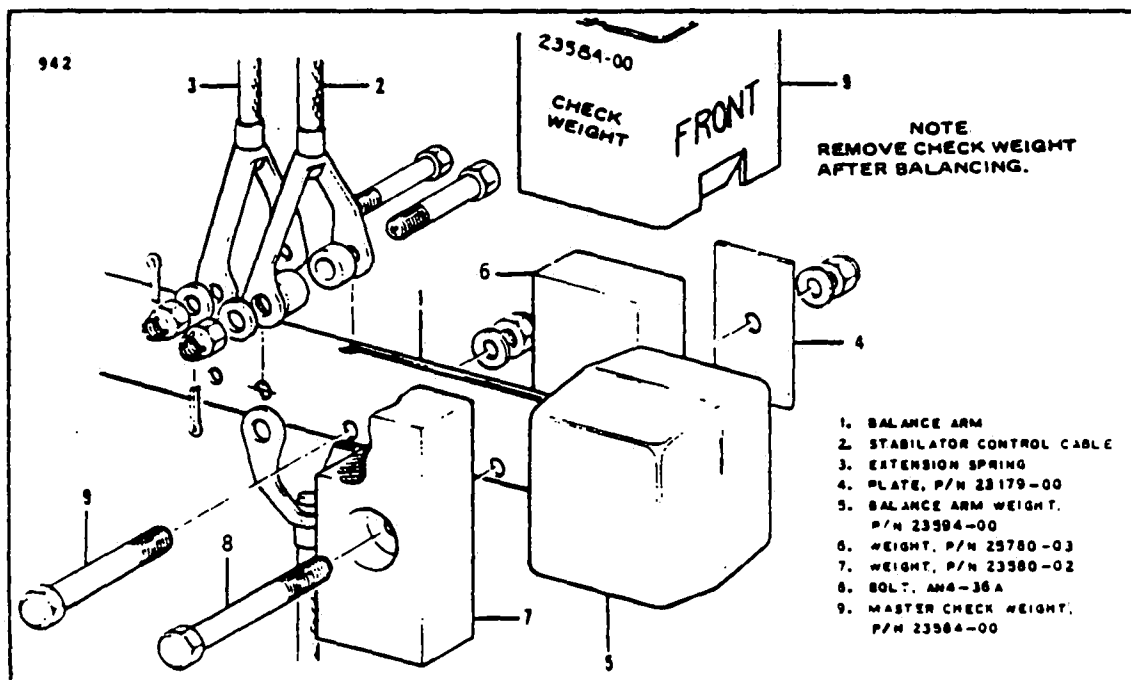


Figure 4-12. Balancing Stabilator  
Serial Nos. 30-853, 30-902 to 30-1716 incl. and 30-1718 to 30-1744 incl.

c. Master check weight (P/N 23584-00) (weight 1.58 pounds) should be placed on top of balance weight (5) (P/N 23594-00) with the side marked "FRONT" facing forward. (Refer to Figure 4-11.) If this is not enough weight to obtain static balance with the balance arm level, plates (4) (P/N 23179-00) must be added to the forward balance weight attachment bolt until 100% static balance is obtained or until up to two plates more than that required for balance have been added. Generally, it should never be necessary to use more than eight plates. If a total of more than eight plates is necessary to obtain balance, recheck the procedure in steps "b" and "c."

d. Should it be necessary to balance a stabilator without a master check weight, a temporary balancing can be accomplished by using the procedure given in "b" above. A sensitive and accurate spring scale can be used to get a balance with 49 + 0 - 3 inch-pounds of torque. Thus, plates should be added (up to eight) until a lifting force of between 2.71 and 2.88 pounds will balance the stabilator with the spring scale being hooked to the bolt which fastens the two stabilator-connecting tabs (arm of 17 inches). As soon as a master check weight is available, the balance should be checked for accuracy.

e. After balancing is accomplished, the check weight should be removed and the front attachment bolt connecting the stabilator balance weight to the stabilator balance arm should be removed and weights (P/N 25780-02 and 25780-03) and bolt (AN4-36A) and stabilator balance weight plates (P/N 23179-00) should be installed at this attachment point. Stabilator balance weight (P/N 25780-02) should be installed on the right side of the stabilator balance arm and stabilator balance weight (P/N 25780-03) and stabilator balance weight plates (P/N 23179-00) shall be installed on the left side of the stabilator balance arm. (Refer to Figure 4-12.)

#### NOTE

Balance weight (7) should be installed so that the counterbore and bolt head face outboard on the right side of the balance arm.

f. All stabilator and tab controls should be reconnected.

g. The stabilator control extension spring link should be adjusted to obtain one and one-quarter inch extension of the spring with the stabilator stops adjusted and the control in the full forward position.

h. The operation and feel of the stabilator controls should then be checked for proper movement.

4-51. **CHECKING AND BALANCING RUDDER.** (Refer to Figure 4-13.) The rudder must be checked to assure it is properly balanced whenever it has been repaired, repainted, or altered in any manner. The balancing requirement of the rudder must be checked with the complete assembly removed from the airplane.

a. Remove the rudder from the airplane, in accordance with instructions given in Paragraph 4-27. The rudder must be complete including rudder control horn, balance weights, tip, etc.

b. Insert bolts in the two end hinges and place the complete rudder assembly on a suitable balance stand, as shown in Figure 4-13.

c. Position an accurately calibrated scale below the trailing edge of the rudder, as shown in Figure 4-13.

d. With the centerline of the rudder level, obtain a reading on the scale. Subtract the weight of any support used between the trailing edge of the rudder and the scale.

e. Measure the distance (in inches) between the point at which the support on the scale contacts the rudder surface and the centerline of the rudder hinge. This is Measurement D on Figure 4-13.

f. Multiply the weight (obtained per paragraph d) by the distance (obtained per paragraph e).

g. The product (moment) should be in accordance with specifications given below:

MODEL	HINGE MOMENT (Trailing edge heavy)
PA-30 and 39	13.5 ± 1.0 inch-pounds
<b>NOTE:</b> Listed Hinge Moment is applicable to complete rudder assembly, painted and with balance weight and rudder tip installed.	

h. Any rudder which does not balance within the given specification must be replaced.

i. Install complete rudder assembly on aircraft in accordance with instructions given in Paragraph 4-28.

#### 4-52. AILERON BALANCING.

##### NOTE

The ailerons are properly balanced as long as the lead weight and steel arm are installed. No further balancing is required. Should repainting be required it will be necessary to remove all the old paint prior to applying the new paint to insure staying within the balance limits.

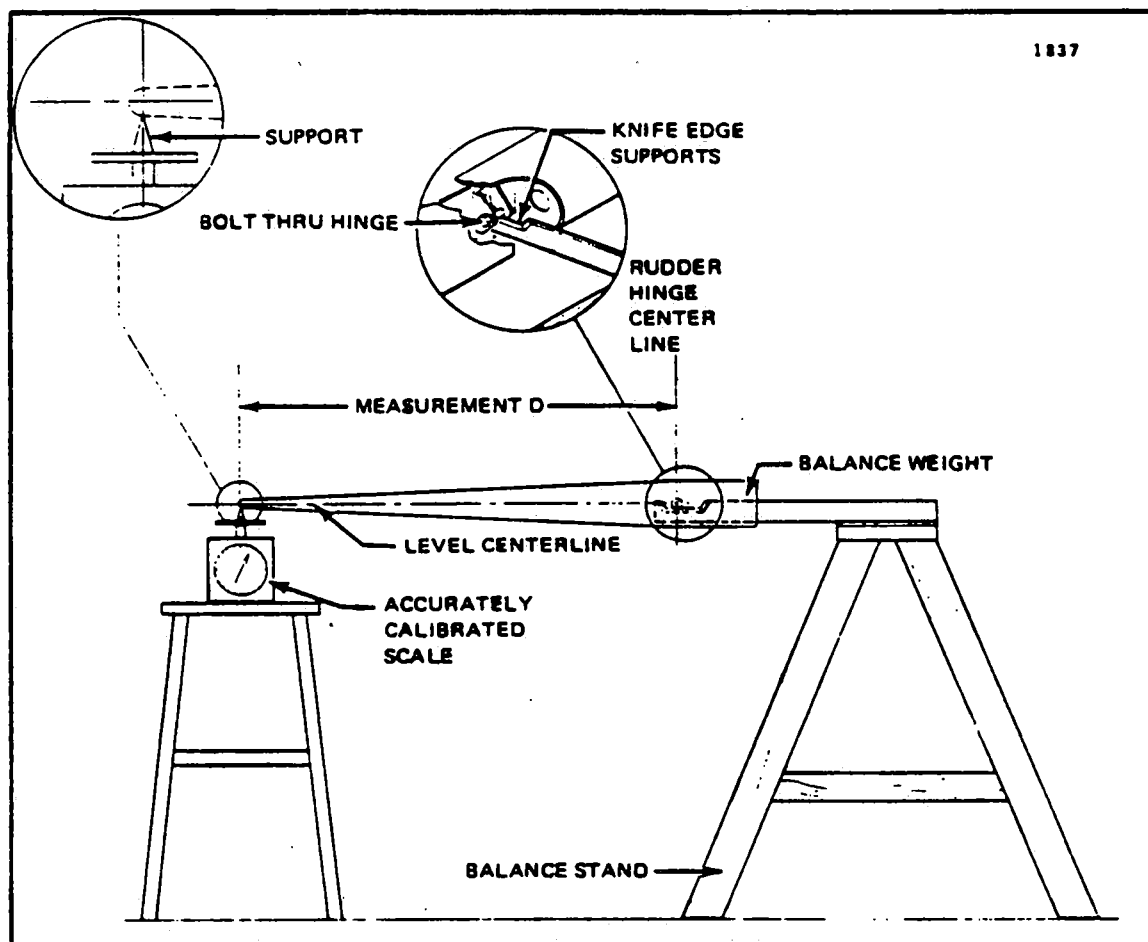


Figure 4-13. Checking and Balancing Rudder

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4-53. FIBERGLASS REPAIRS. The fiberglass procedure in this manual will describe the methods for the repair of fiberglass reinforced structures. Paragraph 4-49 describes Touch-up and Surface Repairs such as blisters, open seams, delaminations, cavities, small holes and minor damages that have not harmed the fiberglass cloth material. Paragraph 4-52 describes Fracture and Patch Repairs of punctures, breaks and holes that have penetrated through the structure and damaged the fiberglass cloth. A repair kit, Part No. 756 729, that will furnish the necessary material for such repairs is available through Piper Aircraft Dealers and Distributors.

NOTE

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

4-54. FIBERGLASS TOUCH-UP AND SURFACE REPAIRS.

a. Remove wax, oil and dirt from around the damaged area with acetone, Methylethylketone or equivalent and remove paint to gel coat.

b. 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 h.)

c. 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 fiberglass 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 fiberglass millings mixed with the gel.

d. 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.

e. Lay a piece of cellophane or waxed paper over the repair to cut off air and start the cure of gel mixture.

f. 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.)

STRUCTURES

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- g. 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.
- h. Pour out a small amount of resin, add catalyst and mix thoroughly using a cutting motion rather than stirring. Use no fibers.
- i. Using the tip of a putty knife or finger tips, fill the hole to about 1/16 inch above the surrounding surface with the gel coat mixture.
- j. Lay a piece of cellophane over the patch to start the curing process. Repeat step f, trimming patch when partially cured.
- k. After trimming the patch, immediately place another small amount of gel coat on one 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 to two hours or overnight for complete cure.
- l. After repair has cured for 24 hours, sand patch area using a sanding block with fine wet sandpaper. Finish by priming, again sanding and applying color coat.

#### 4-55. FIBERGLASS FRACTURE AND PATCH REPAIRS.

- a. Remove the wax, oil and dirt from around the damaged area with acetone, methylethylketone or equivalent.
- b. Using a key hole saw, electric saber saw, or sharp knife, cut away ragged edges. Cut back to sound material.
- c. Remove paint three inches back from around damaged area.
- d. 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.
- e. 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.
- f. Prepare a patch of fiberglass mat and cloth to cover an area two inches larger than the hole.
- g. Mix a small amount of resin and catalyst, enough to be used for one step at a time according to kit instructions.
- h. 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 fiberglass cloth and mat reinforcements should be used to at least replace the amount of reinforcement 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.

STRUCTURES

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i. 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.

j. 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.

k. Mask area around hole with tape and paper to protect surface. Cut a piece of fiberglass mat about one inch larger than the hole and one or more pieces of fiberglass cloth two inches larger than the hole. Brush catalyzed resin over hole, lay mat over hole and wet out with catalyzed resin. Use daubing action with brush. Then, apply additional layer or layers of fiberglass cloth to build up patch to the surface of structure. Wet out each layer thoroughly with resin.

l. 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.

m. 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 on outside edge of feathering. Strip cut edges of structure. Do this before cure is complete to save extra sanding. Allow patch to cure overnight.

n. 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.

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

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

q. 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.

#### STRUCTURES

Issued: 12/29/72

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4-56. 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.

TABLE IV-1. 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 Perchloroethylene 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

a. Surface Preparation:

1. Surface dirt and paint if applied must be removed from the item being repaired. Household cleaners have proven most effective in removing surface dirt.
2. Preliminary cleaning of the damaged area with perchlorethylene or VM&P Naphtha will generally insure a good bond between epoxy compounds and thermoplastic.

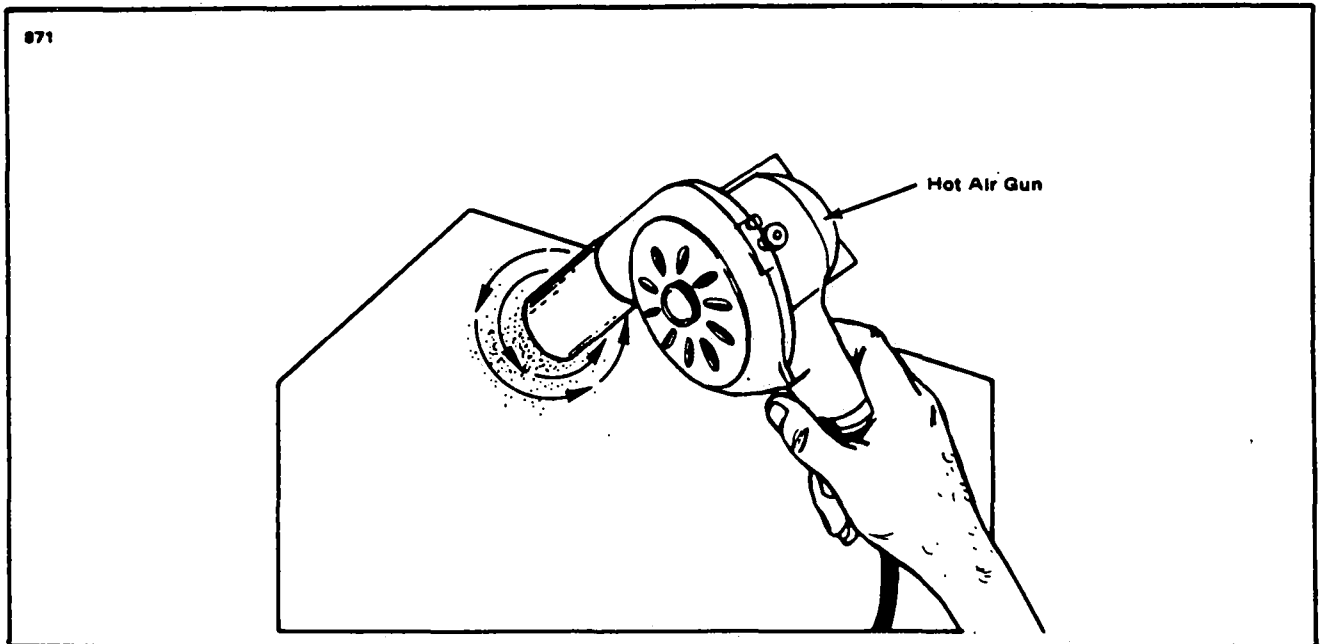


Figure 4-14. Surface Scratches, Abrasions or Ground-in-Dirt

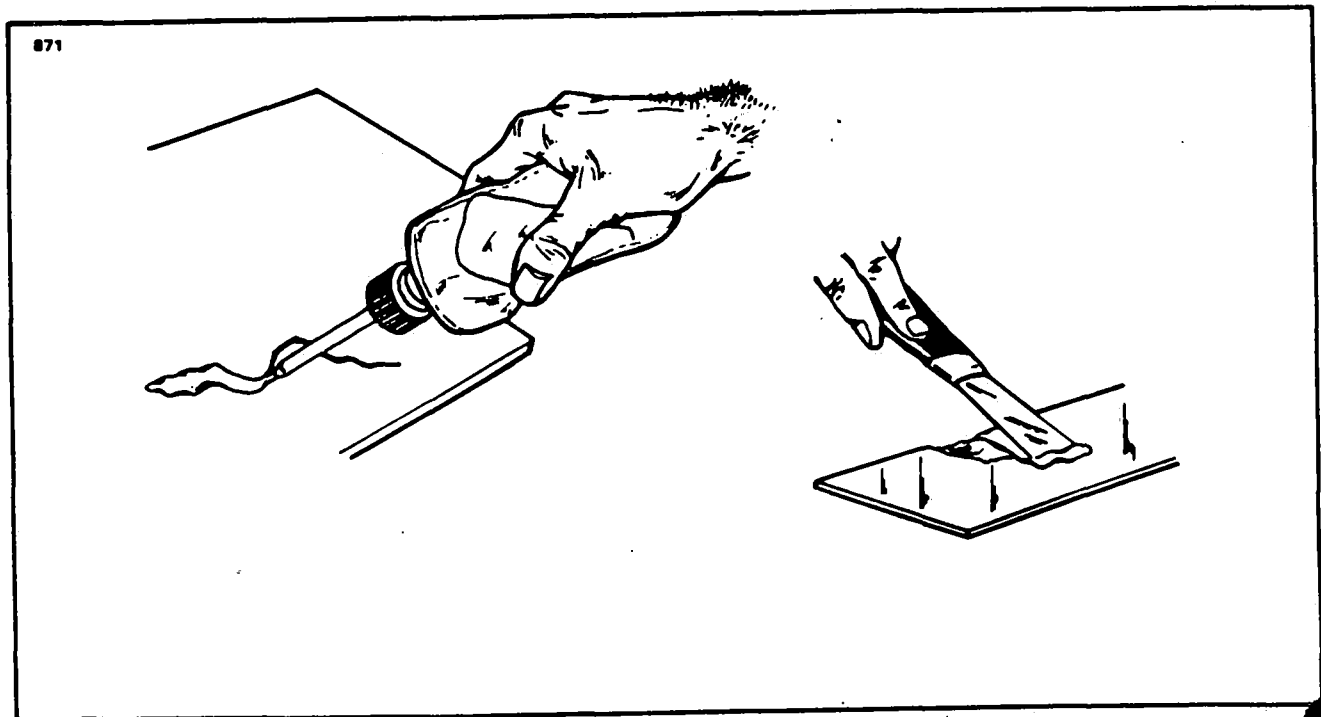


Figure 4-15. Deep Scratches, Shallow Nicks and Small Holes

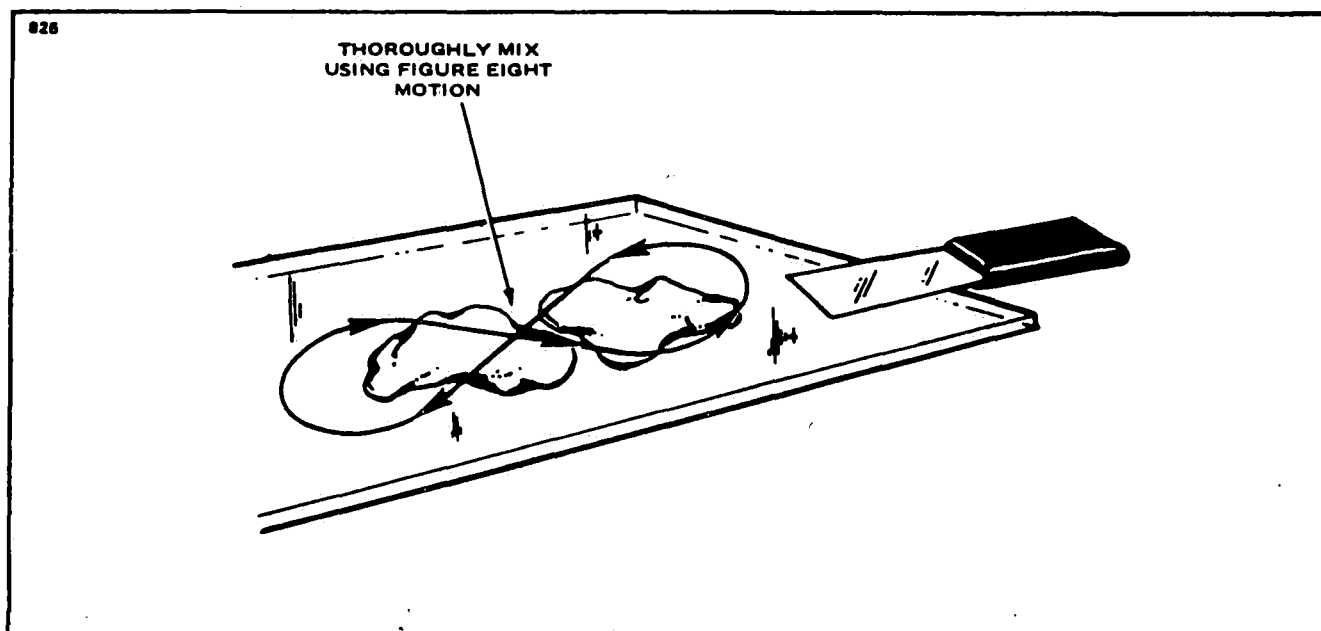


Figure 4-16. Mixing of Epoxy Patching Compound

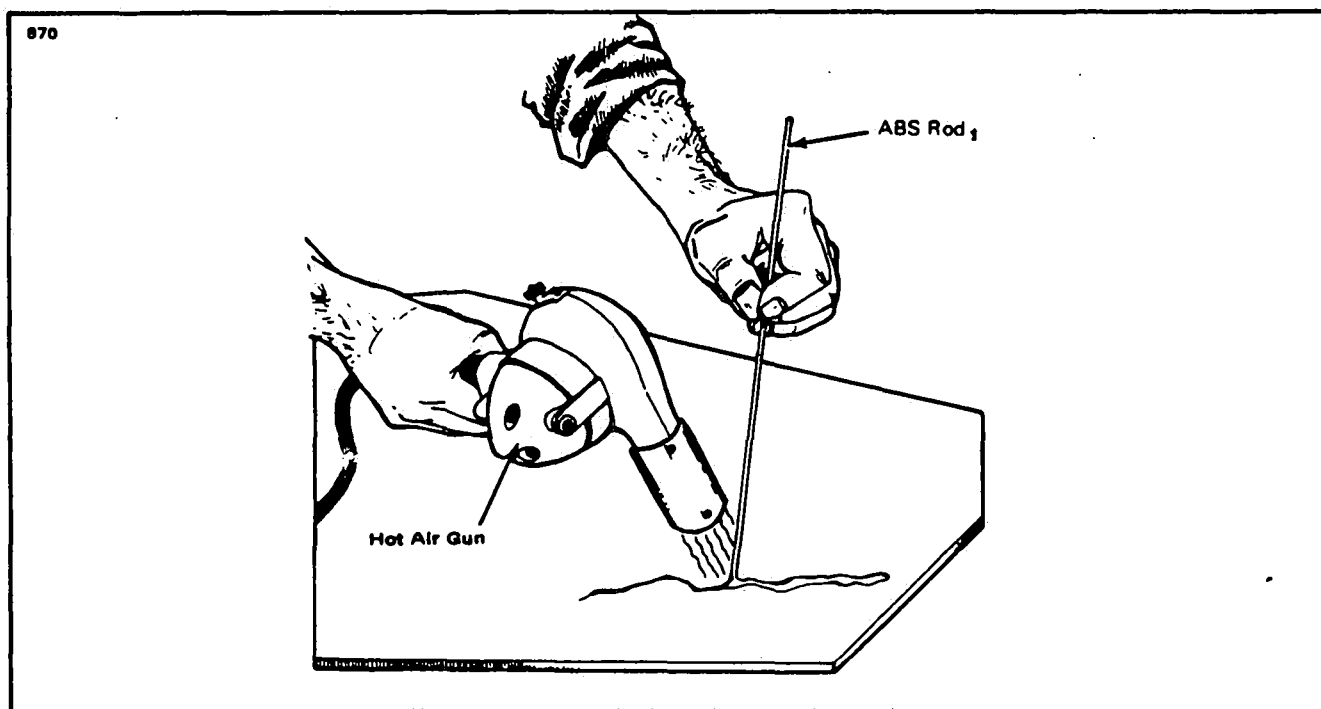


Figure 4-17. Welding Repair Method

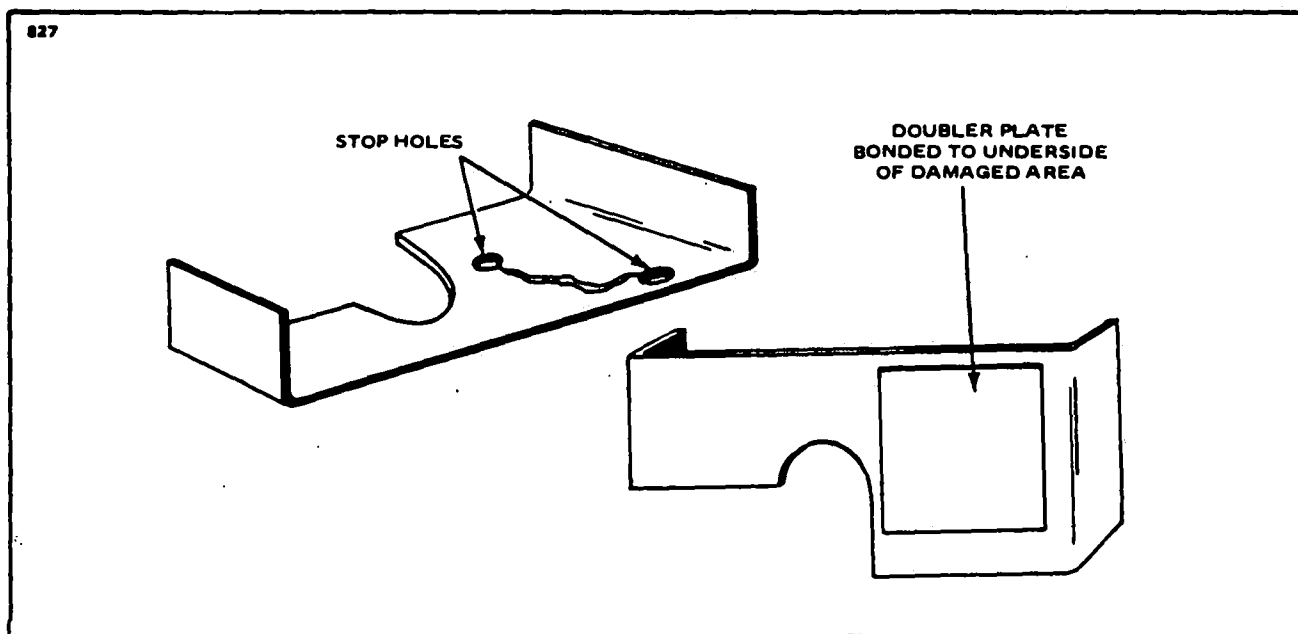


Figure 4-18. Repairing of Cracks

b. Surface Scratches, Abrasion or Ground-in-Dirt: (Refer to Figure 4-14.)

1. Shallow scratches and abraded surfaces are usually repaired by following directions on containers of conventional automotive buffing and rubbing compounds.
2. 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 ¼ 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.
3. The thermoplastic will return to its original shape upon cooling.

c. Deep Scratches, Shallow Nicks and Small Holes: (Less than 1 inch in diameter.) (Refer to Figure 4-15.)

1. 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.
2. 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.
3. Solvent adhesives are not recommended for highly stressed areas, or thin walled parts or for patching holes greater than ¼ inch in diameter.
4. For larger damages an epoxy patching compound is recommended. This type material is a two part, fast curing, easy sanding commercially available compound.
5. Adhesion can be increased by roughing the bonding surface with sandpaper and by utilizing as much surface area for the bond as possible.
6. 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 Naphtha prior to applying the compound. (Refer to Figure 4-16.)
7. A mechanical sander can be used after the compound is cured, providing the sander is kept in constant motion to prevent heat buildup.

## PIPER TWIN COMANCHE SERVICE MANUAL

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8. 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.
9. 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.
10. 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 4-17.)
11. After the repair is completed, sanding is allowed to obtain a surface finish of acceptable appearance.
  - d. Cracks: (Refer to Figure 4-18.)
    1. Before repairing a crack in the thermoplastic part, first determine what caused the crack and alleviate that condition to prevent it from recurring after the repair is made.
    2. Drill small stop holes at each end of the crack.
    3. If possible, a double plate should be bonded to the reverse side of the crack to provide extra strength to the part.
    4. 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.
    5. After the repair has cured, it may be sanded to match the surrounding finish.
  - e. Repairing Major Damage: (Larger than 1 inch in diameter.) (Refer to Figure 4-19.)
    1. If possible a patch should be made of the same material and cut slightly larger than the section being repaired.
    2. 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.
    3. 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.
    4. Coat the patch with solvent adhesive and firmly attach it over the damaged area.
    5. Let the patch dry for approximately one hour before any additional work is performed.
    6. 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.
  - f. Stress Lines: (Refer to Figure 4-20.)
    1. 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 4-21.)
    2. 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.
  - g. Painting the Repair:
    1. An important factor in obtaining a quality paint finish is the proper preparation of the repair and surrounding area before applying any paint.
    2. 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.
    3. 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.



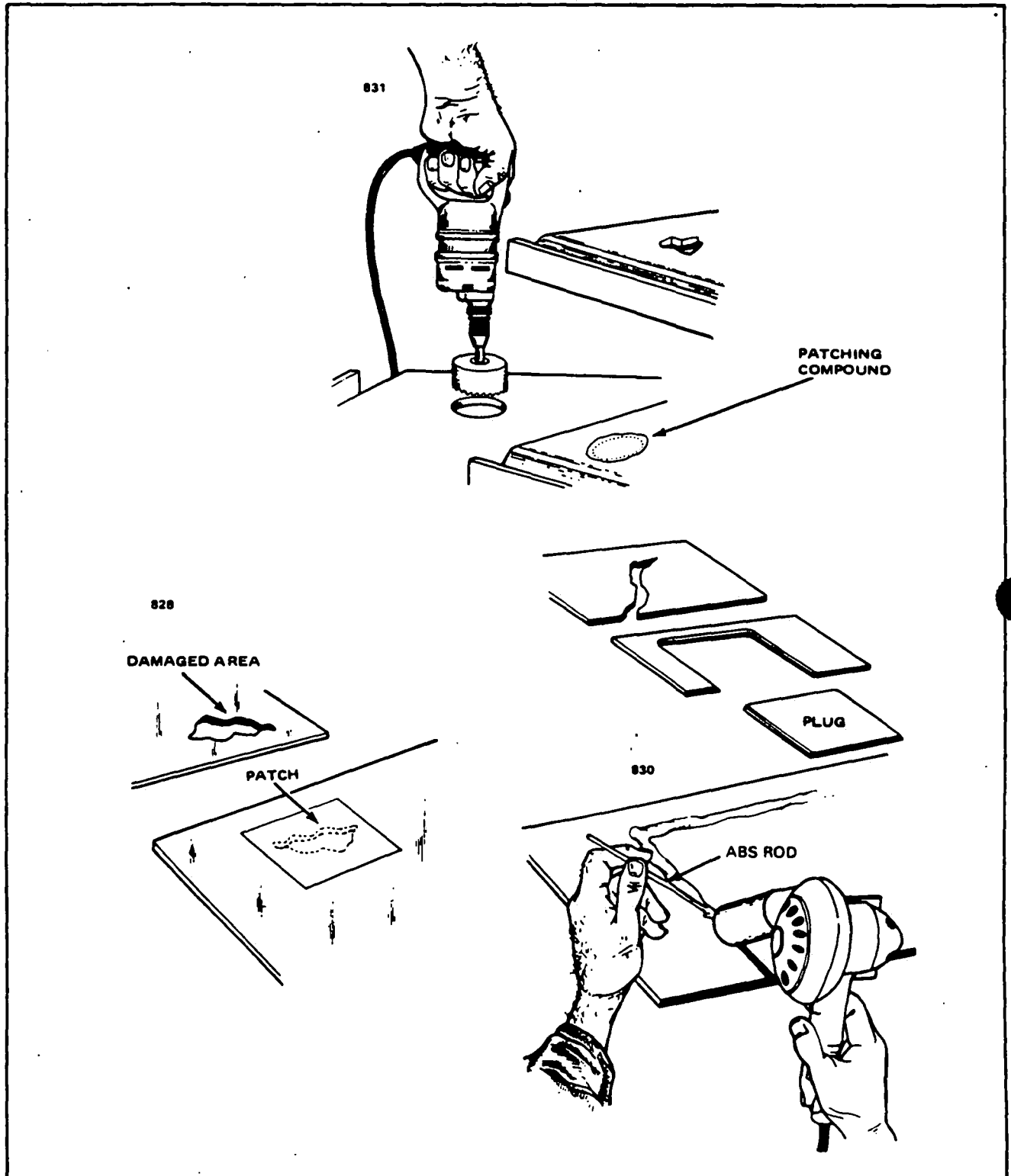


Figure 4-19. Various Repairs

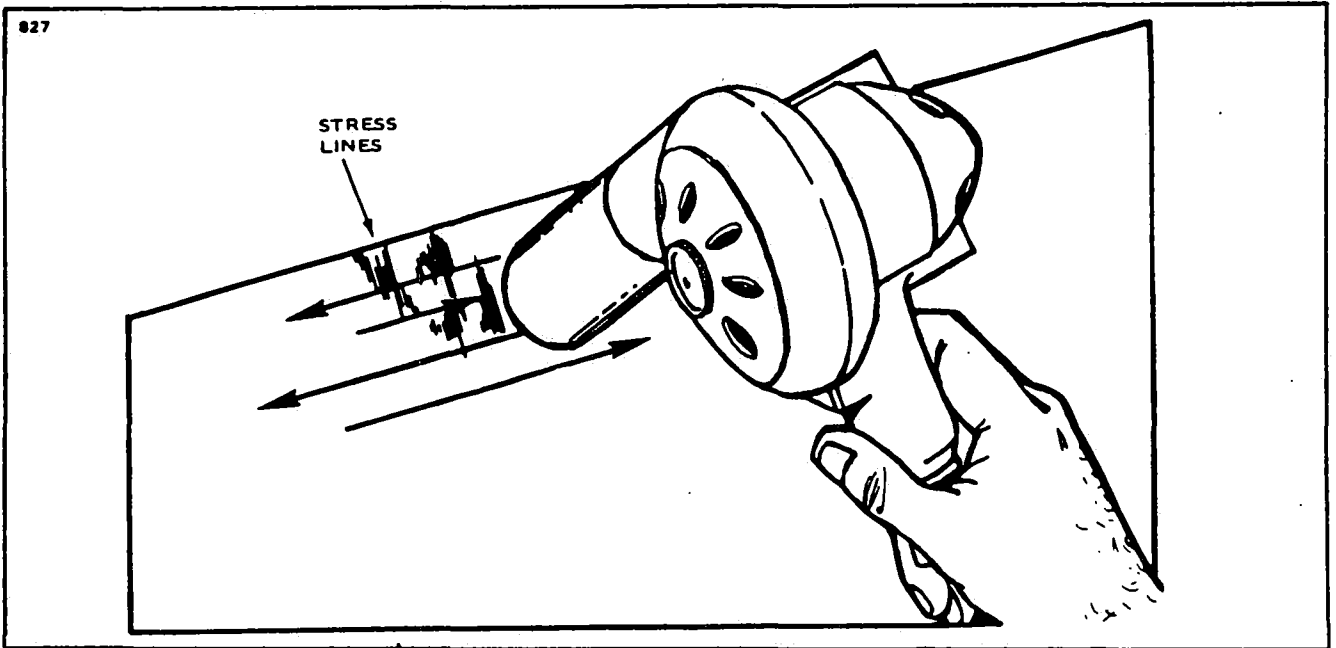


Figure 4-20. Repair of Stress Lines

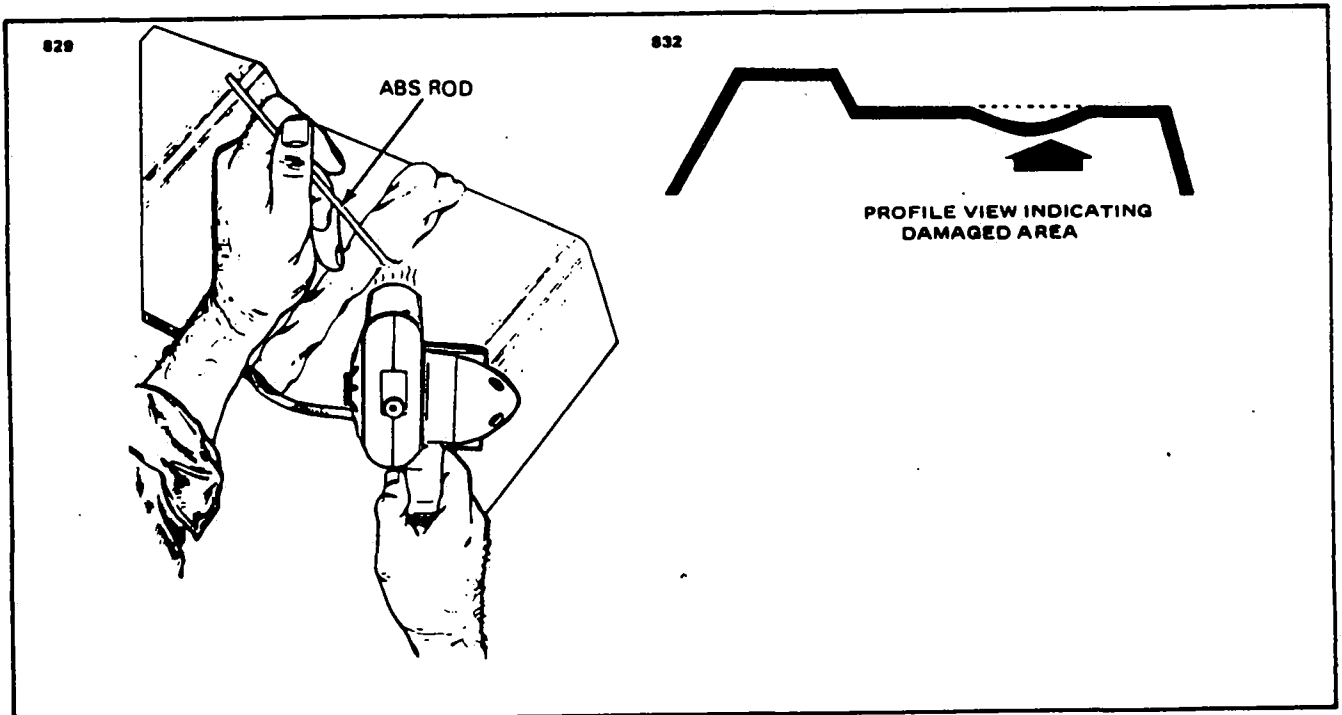


Figure 4-21. Repair of Impacted Damage

4. 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.

4-57. SAFETY WALK REPAIR.

4-58. SURFACE PREPARATION.

- a. Clean all surfaces with a suitable cleaning solvent to remove dirt, grease and oils. Solvents may be applied by dipping, spraying or mopping.
- b. Insure that no moisture remains on the surface by wiping with a clean dry cloth.
- c. 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.

4-59. PRODUCT LISTING FOR LIQUID SAFETY WALK COMPOUND.

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

4-60. 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:

- a. Mix and thin the liquid safety walk compound in accordance with the manufacturer's instructions on the container.
- b. 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.
- c. Allow the coating to dry for 15 minutes to one hour before recoating or touch-up; if required after application of the initial coating.
- d. 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.

**4-61. 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 contaminants and no moisture present. If liquid safety walk is installed the area must be prepared as follows:

- a. Area must be masked off to protect painted surfaces.
- b. 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.
- c. Area must be clean and dry prior to painting.
- d. 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.

**4-62. 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:

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

**4-63. FLOW STRIPS.** For PA-30 Installation. (Refer to the latest revision of Piper Service Letter No. 558.) The flow strips are located on both wing leading edges and secured with AD42ABS pop rivets.

# SECTION V

## SURFACE CONTROLS

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5-2.	Description . . . . .	1G10
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5-7.	Aileron Controls . . . . .	1G20
5-8.	Removal of Aileron Control Cables . . . . .	1G20
5-9.	Installation of Aileron Control Cables . . . . .	1G21
5-10.	Removal of Aileron Bellcrank Assembly . . . . .	1H1
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5-12.	Rigging and Adjustment of Aileron Controls . . . . .	1H2
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SECTION V

SURFACE CONTROLS

**5-1. INTRODUCTION.** This section contains instructions for the removal, installation and rigging and adjustment procedures for the control assemblies of the various structural surfaces. For the removal and installation of the structural surfaces of the airplane, refer to Section IV. The assemblies need not be removed in order of paragraphs since each paragraph describes the individual removal and installation of the component.

**5-2. DESCRIPTION.** The primary flight controls of the PA-30 are of the conventional type operated by dual control wheels and dual sets of rudder pedals. A system of cables, pulleys, bellcranks and push-pull rods transfer the movement of the control wheel and rudder pedals to the ailerons, stabilators and rudder.

The aileron controls consist of two control wheels connected by torque tubes to sprockets on each end of the square tubes. A chain is wrapped around the sprockets to synchronize the control wheels. An additional chain and sprocket is fixed on the left control tube which is coupled to the primary aileron control cable. The cable is routed under the floor along the side of the fuselage to the main spar and out through the wing to the bellcrank in each wing. A one piece balance cable is also connected to the bellcranks. As the control wheels are moved, the control cables move the bellcranks and actuate push-pull rods to move the ailerons.

The stabilator control cables are connected to the control wheel torque tubes. From the connecting points, cables are routed around a series of pulleys under the floor and aft to the tail section of the airplane. The aft end of the cables connect to the stabilator balance arm which in turn is connected to the stabilator torque tube.

When the control wheel is moved forward or aft, the cables move the balance arm up and down turning the torque tube and stabilator.

The rudder is controlled by rudder pedals installed on both the pilot and co-pilot sides. Cables are connected to both sides of the rudder pedal assembly and are routed aft through the bottom of the fuselage to the rudder horn. When one rudder pedal is pushed, the cable pulls the rudder horn turning the rudder.



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TABLE V-I. CONTROL SURFACE TRAVEL AND CABLE TENSION

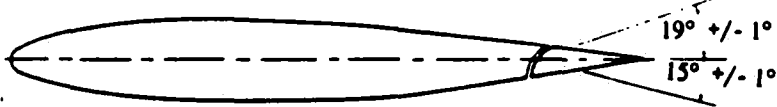
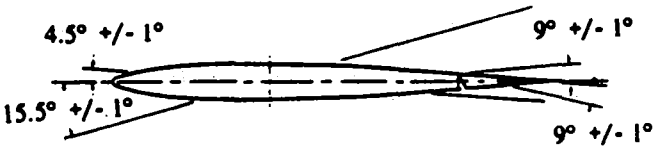
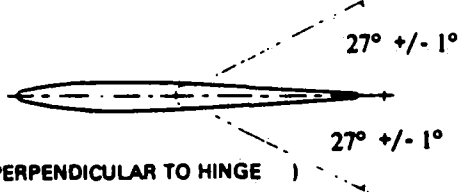
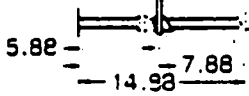
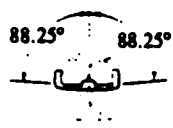
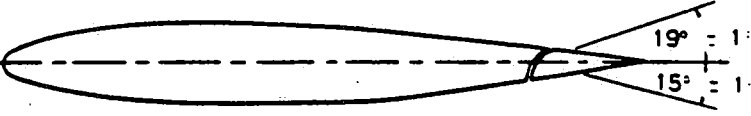
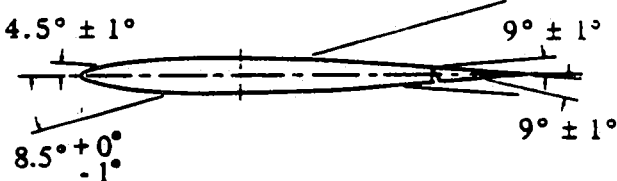
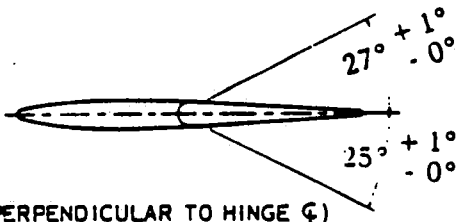
Control Surface Travel Aileron	<p>A209</p> 
Stabilator Stabilator Trim Tab	
Rudder	<p>A237</p>  <p>(MEASURED PERPENDICULAR TO HINGE)</p>
Flaps	27° +/- 1° down
Control Wheel	<p>MEASURED FROM FACE OF INSTRUMENT PANEL</p>   <p>A210</p>
Rudder Pedals	<p>Neutral position 13° aft vertical</p> <p>Neutral to Fwd 3.51 inc.</p> <p>Neutral to Aft 3.18 in. } 6.69 Total</p>
<p>Cable Tension</p> <p>Aileron</p> <p>Stabilator</p> <p>Stabilator Trim Tab</p> <p>Rudder</p> <p>Rudder Trim</p>	<p>NOTE</p> <p>26 lb +/- 20%</p> <p>18 lb +/- 20%</p> <p>12 lb +/- 20%</p> <p>25 lb +/- 40 lbs</p> <p>18 lb +/- 20%</p> <p>10 lb +/- 20%</p> <p>CABLE TENSIONS GIVEN APPLY ONLY TO AIRPLANES WITHOUT AUTOPILOT BRIDLE CABLES ATTACHED. REFER TO APPROPRIATE AUTOPILOT SERVICE MANUAL FOR PROPER CABLE TENSIONS WHEN ATTACHING BRIDLE CABLES.</p>
<p>1. MEASUREMENT TO BE TAKEN AT THE FLEXIBLE PORTION OF THE CONTROL CABLE NEAR THE FORWARD CABIN BULKHEAD.</p> <p>2. ON S/N 30-2 to 1716, 30-1718 to 30-1744 WITHOUT AIRFLOW MODIFICATION KIT INSTALLED.</p> <p>3. ON S/N 30-1717, 30-1745 AND UP (AND ALL PREVIOUS A/C HAVING THE AIRFLOW MODIFICATION KIT INSTALLED, SEE TABLE V-IA.</p>	

TABLE V-IA. CONTROL SURFACE TRAVEL AND CABLE TENSION  
AIR FLOW MODIFICATION KIT INSTALLATION

<p><b>Control Surface Travel</b> <b>Aileron</b></p> <p>Note: In neutral position the angle between the air-plane leveling lugs and the upper surface of the aileron, parallel with and next to the rib rivets, 6 1/2" from the inboard end of the aileron is 12°</p>							
<p><b>Stabilator and Stabilator Trim Tab</b></p>							
<p><b>Rudder</b></p> <p>Note: In neutral position the rudder is rigged 1° right of the rudder - fin C</p>	 <p>(MEASURED PERPENDICULAR TO HINGE C)</p>						
<p><b>Cable Tension</b></p> <p>Aileron</p> <p>Stabilator</p> <p>Stabilator Trim Tab</p> <p>Rudder<sup>(1)</sup></p> <p>Rudder Trim</p>	<p style="text-align: right;">NOTE</p> <table border="0"> <tr> <td>26 lbs ± 20%</td> <td rowspan="5">CABLE TENSIONS GIVEN APPLY ONLY TO AIRPLANES WITHOUT AUTOPILOT BRIDLE CABLES ATTACHED. REFER TO APPROPRIATE AUTOPILOT SERVICE MANUAL FOR PROPER CABLE TENSIONS WHEN ATTACHING BRIDLE CABLES.</td> </tr> <tr> <td>18 lbs ± 20%</td> </tr> <tr> <td>12 lbs ± 20%</td> </tr> <tr> <td>25 lbs. to 40 lbs.</td> </tr> <tr> <td>10 lbs ± 20%</td> </tr> </table> <p>(1) MEASUREMENT TO BE TAKEN AT THE FLEXIBLE PORTION OF THE CONTROL CABLE NEAR THE FORWARD CABIN BULKHEAD.</p>	26 lbs ± 20%	CABLE TENSIONS GIVEN APPLY ONLY TO AIRPLANES WITHOUT AUTOPILOT BRIDLE CABLES ATTACHED. REFER TO APPROPRIATE AUTOPILOT SERVICE MANUAL FOR PROPER CABLE TENSIONS WHEN ATTACHING BRIDLE CABLES.	18 lbs ± 20%	12 lbs ± 20%	25 lbs. to 40 lbs.	10 lbs ± 20%
26 lbs ± 20%	CABLE TENSIONS GIVEN APPLY ONLY TO AIRPLANES WITHOUT AUTOPILOT BRIDLE CABLES ATTACHED. REFER TO APPROPRIATE AUTOPILOT SERVICE MANUAL FOR PROPER CABLE TENSIONS WHEN ATTACHING BRIDLE CABLES.						
18 lbs ± 20%							
12 lbs ± 20%							
25 lbs. to 40 lbs.							
10 lbs ± 20%							

The rudder pedals also turn the nose wheel when in the down and locked position which is covered in Section VII.

Stabilator and rudder trim are operated by knobs and controlled by cables extending through the cabin ceiling and under the floor to the tail section. As the knobs are turned, cable drums are rotated which in turn rotate drums in the tail section. Push-pull rods are connected to actuator screws which are rotated by the cable drums. The push-pull rods are attached to the stabilator trim tab and the rudder horn. When the actuator screws are turned, the push-pull rods move the trim tab and rudder.

**5-2a. TROUBLESHOOTING.** Troubles peculiar to the control system are listed in Table V-II at the back of this section, along with their probable causes and suggested remedies.

**5-3. STANDARD SERVICE PROCEDURES.** The following tips may be helpful in the removal and installation of the various assemblies:

- a. It is recommended, though not always necessary, to level and place the airplane on jacks during rigging and adjustment.
- b. Remove turnbuckle barrels from cable ends before withdrawing cables through structures.
- c. Tie a cord to cable end before drawing cable through structures to facilitate cable reinstallation.
- d. Turnbuckle stations are given at neutral position.
- e. When referring to marking cable ends, etc., before disconnecting, a felt inker may be used.
- f. When turnbuckles have been set to correct cable tension, no more than three threads should be exposed from either end of the turnbuckle barrel.
- g. Cable tensions should be taken with the appropriate surface and trim control in its neutral position.
- h. When installing rod ends refer to Figure 5-1a for proper installation method.

**5-4. CONTROL COLUMN ASSEMBLY.**

**5-5. REMOVAL OF CONTROL COLUMN ASSEMBLY.** (Refer to Figure 5-1.)

- a. To remove either of the control wheels (1 and 10) with tube (2), proceed as follows:
  1. Mark the roller assembly (B) cable attachment fitting (20) and collars fore (21) and aft (22) in reference to their positions around the control wheel tube.
  2. Cut the wire (16) that safeties the cap bolts (17) that secure the roller assembly and collars to the control tube. Remove the cap bolts.
  3. Slide the control tube from the roller assembly, cable attachment fitting and collars and draw the tube from the instrument panel. Note the number of seal washers (18) between the cable fitting and collars.

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- b. The square tube assembly may be removed by the following procedure:
1. Disconnect one turnbuckle (6) of the horizontal control chains (5 and 7) and unwrap chain.
  2. Separate the vertical control chain (13) from the aileron control cables. On airplanes with turnbuckles connecting the vertical chain with the control cables, disconnect one of the connecting turnbuckles and unwrap chain. On airplanes without turnbuckles connecting the vertical chain with the control cables, first relieve chain and cable tension by removing the access plate to either aileron bellcrank at wing station 139.5 loosen the balance cable turnbuckle (forward turnbuckle), then disconnecting the chain from either control cable within the fuselage. Unwrap the chain from the sprocket.
  3. From the horizontal brace between the left and right sprocket brackets (4 and 8), remove three cap bolts and loosen the fourth lowering the brace slightly to allow withdrawal of the sprocket bracket.
  4. Remove bolts and screw holding the sprocket bracket to the bulkhead.
  5. Withdraw the square tube assembly.

### NOTE

If an Autopilot roll servo is installed in the forward end of the square tube shaft forward of the bulkhead, it must be removed from the shaft prior to withdrawing the square tube.

- c. The square tube assembly may be removed from the sprocket assembly by the following procedure:
1. Remove the bulkhead seal, nut and washer (31) from the shaft at the sprocket bracket.
  2. Remove hex nut, washer and bolt (12) from the shaft and sprocket axle (36). Use a Kaynar wrench (P/N W10-3) to remove the nut.
  3. Remove the square tube with shaft from the sprocket assembly taking care that the sprocket and washers do not fall.
- d. If the sprocket assembly housing is not to be removed, the roller assembly may be removed from the square tube at the guide or aft end by the following procedure.
1. Cut the safety wire (16) holding the nylon rub blocks (23) used as guides and remove the blocks. Nylon blocks are secured by attaching screws.
  2. Slide the roller assembly from the square tube.

5-6. INSTALLATION OF CONTROL COLUMN ASSEMBLY. (Refer to Figure 5-1.)

a. When installing the control column assembly, first install the components of the square tube assembly. If the nylon rub blocks (23) have been removed, install and tighten them on their attaching screws and secure in place with safety wire. Washers (25), Part No. 81342-78 may be installed as required under the nylon rub blocks (23) to remove play between the square tube (3) and control tube (2) without restricting control tube movement over square tube.

b. If both the sprocket assembly and roller assembly have been removed, the roller assembly may be replaced over the forward end of the square tube shaft. Adjust with spacer washers and rotate the eccentric bushing (37) to maintain 0.003 of an inch clearance between one roller (15) and the tube (3) with the opposite roller in contact with the tube. Adjust clearance of the other set of rollers.

c. To avoid unnecessary disassembly of control tube when checking end play of the collars (21 and 22) and cable attachment fitting (20), pre-assemble to obtain clearances required between the cable attachment fitting and the fore and aft collars. Pre-assemble as follows:

1. Slide the aft collar (22), cable attachment fitting (20), forward collar (21), and roller assembly onto the control tube (2).

2. Temporarily insert forward collar and roller assembly attaching bolts (17).

3. Move the aft collar until the collars and fitting contact, then withdraw the aft collar until the first of its staggered holes align with the holes in the control tube.

4. Install bolts (17) in aft collar.

5. Check clearances between either collar and cable attachment fitting. Note the required seal washers (18) that will be equal on each side of the cable attachment fitting to maintain a clearance of 0.003 to 0.013 of an inch.

6. Draw line from roller bearing housing across collars and cable attachment fitting to control tube to mark their relative positions.

7. Remove the bolts, roller assembly, collars and cable fitting from the control tube and continue with step d.

d. To install the square tube with sprocket assembly, proceed as follows:

1. Position sprocket (26 or 27) in sprockets (4 or 8) and place washer (38) on square tube shaft (3).

2. Slide square tube shaft into sprocket bracket and sprocket. Attach sprocket with bolt, washer and hex nut (12) using Kaynar wrench (P/N W10-3).

3. On early installations place washer and self-locking nut (31) on sprocket axle (36). On later installations a castle nut and cotter pin (refer to sketch D) are used: Tighten nut (31) or castle nut to allow no end play while permitting the shaft to rotate freely, 180 degrees, from stop to stop. Check the stops to insure a minimum engagement of .062 of an inch between the sprocket stop ins (30) and the aileron stop (29) as shown in Sketch D. Secure the castle nut with a cotter pin. Place the bulkhead seals over the large nut (31) at the forward side of the sprocket bracket.

4. Align holes in sprocket bracket with those in the bulkhead and install bolts and screw securing the sprocket bracket to the bulkhead.

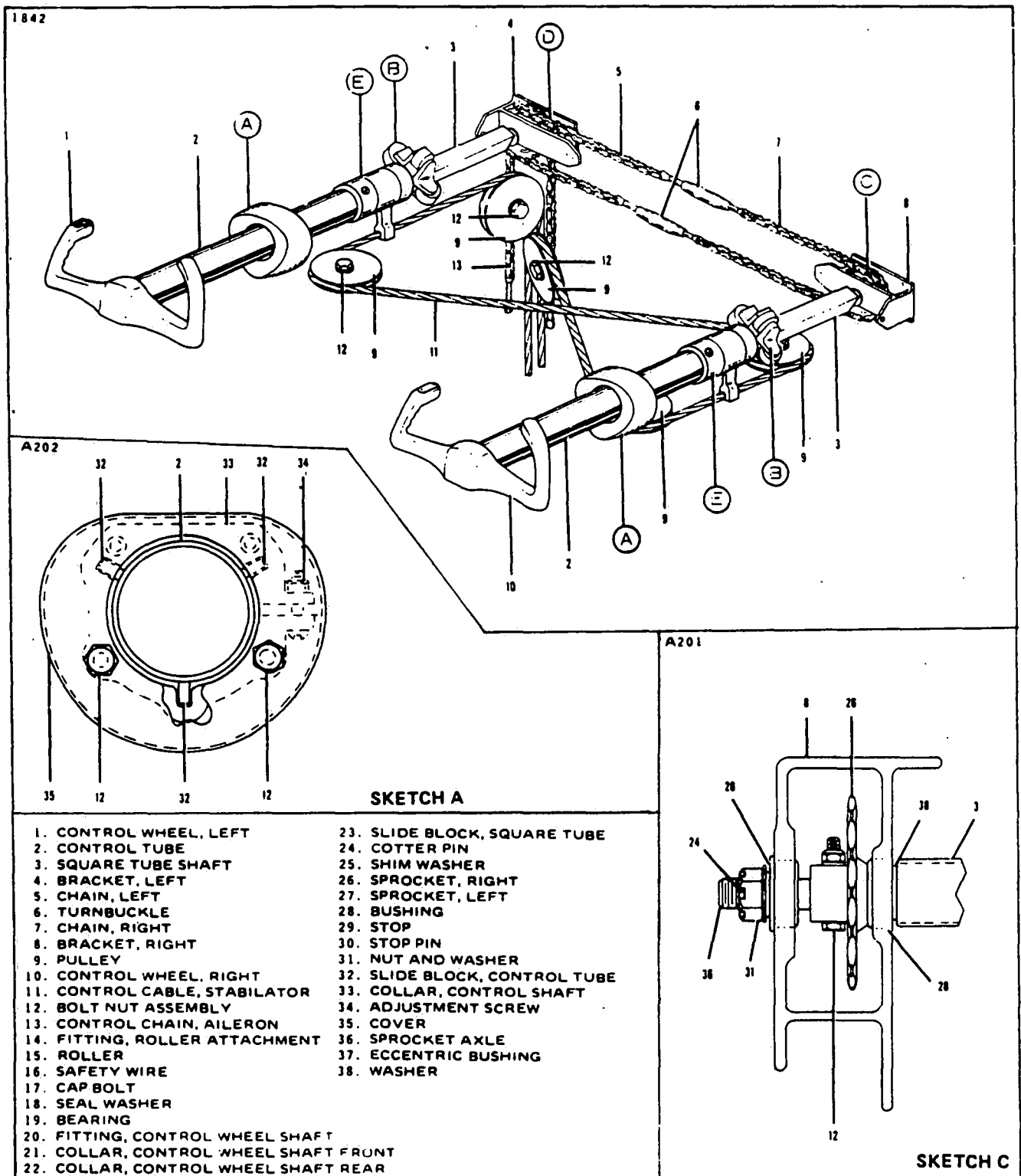


Figure 5-1. Control Column Installation

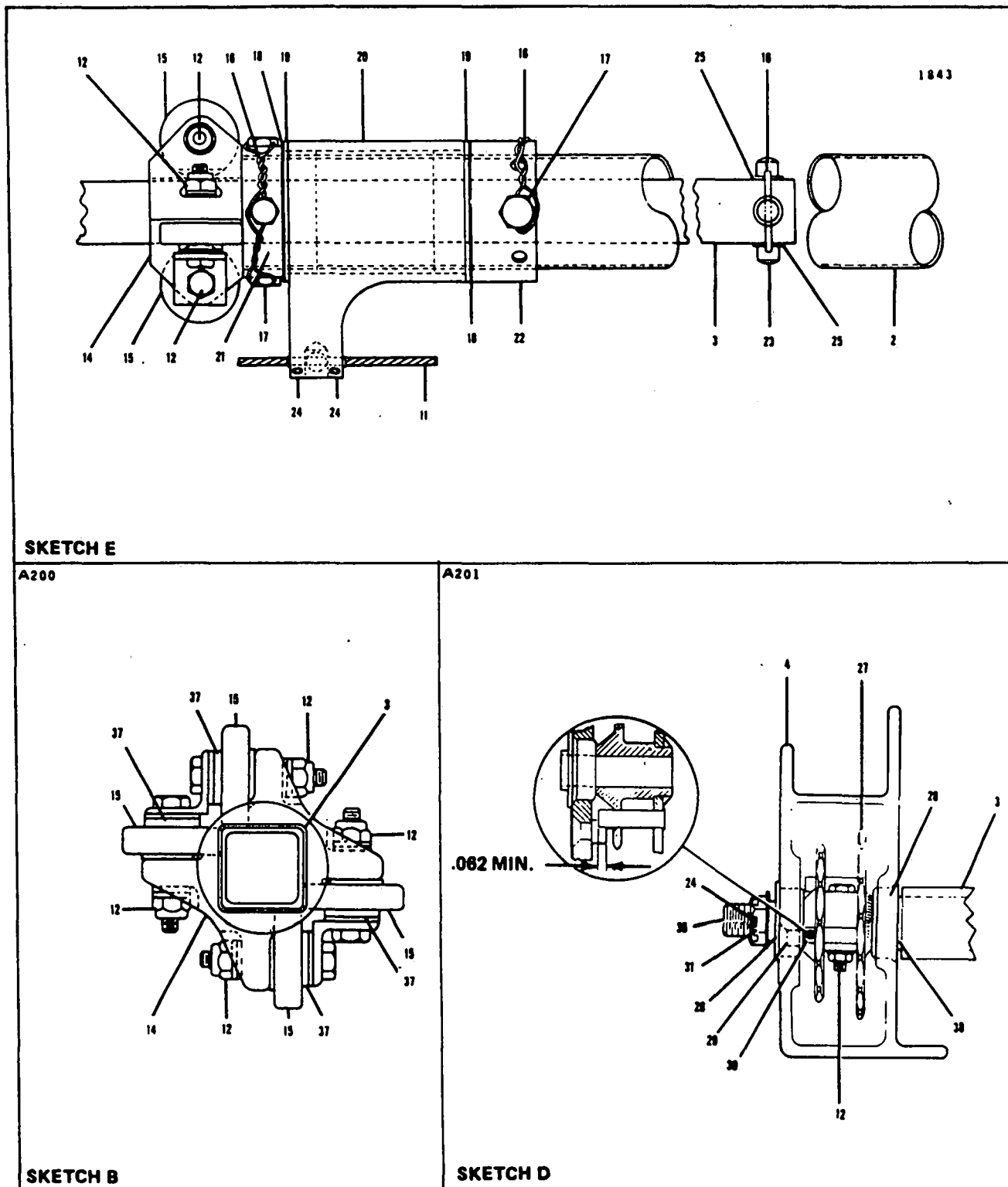


Figure 5-1. Control Column Installation (cont.)

5. Install and tighten cap bolts in horizontal brace.

NOTE

If an AutoPilot roll servo is to be installed on the forward end of the square tube shaft forward of the bulkhead, it may be installed at this time.

- e. To install the control wheel tube (2), proceed as follows:
  1. Lubricate the friction surface of the collars and cable attachment fitting bearings with a light film of grease (MIL-G-3278).
  2. After sliding the control column cover (35) onto the control wheel tube (2), insert the tube through the instrument panel. Slide the control tube into the aft collar (22) and one-half the seal washers (18). Slide the cable attachment fitting (20) with cable arm forward onto the control tube followed by the remaining seal washers (18) and forward collar (21). Insert the end of the control tube over the square tube (3) until the control tube contacts the roller bearing housing.
  3. If the control wheel tube fits easily over the guide blocks (23), align the cable attachment fitting and collars as marked and tighten the cap bolts (17).
  4. Check that there is minimum end play in the bearing tolerance (0.003 to 0.013 of an inch), and that the control tube rotates freely through 180 degrees. Install safety wire (16) in the cap bolts.
  5. In early model airplanes, rotate the lower roller eccentric bushing of the control tube support rollers at the instrument panel to maintain a snug fit between tube and rollers.
  6. On late model airplanes, tighten adjustment screw (34) to obtain a snug fit between tube (2) and slide blocks (32).
  7. Install and tighten screw in control wheel cover (35).
- f. To attach chains to sprocket, use the following procedure:
  1. With the control wheels centered, wrap the horizontal chains (5 and 7) around sprockets (26 and 27). The horizontal turnbuckles (6) should be centered between right and left sprockets. Connect turnbuckles and tighten to allow no slack. Safety turnbuckles.
  2. With the control wheels still centered, wrap the vertical chain (13) around its sprocket. The chain ends should be even with one another. Connect the control chain with the aileron control cables. Set cable tension and check rigging and adjustment as given in paragraph 5-12. Safety turnbuckles.
  3. Check that the control wheel will roll 90 degrees each side of center with no binding.



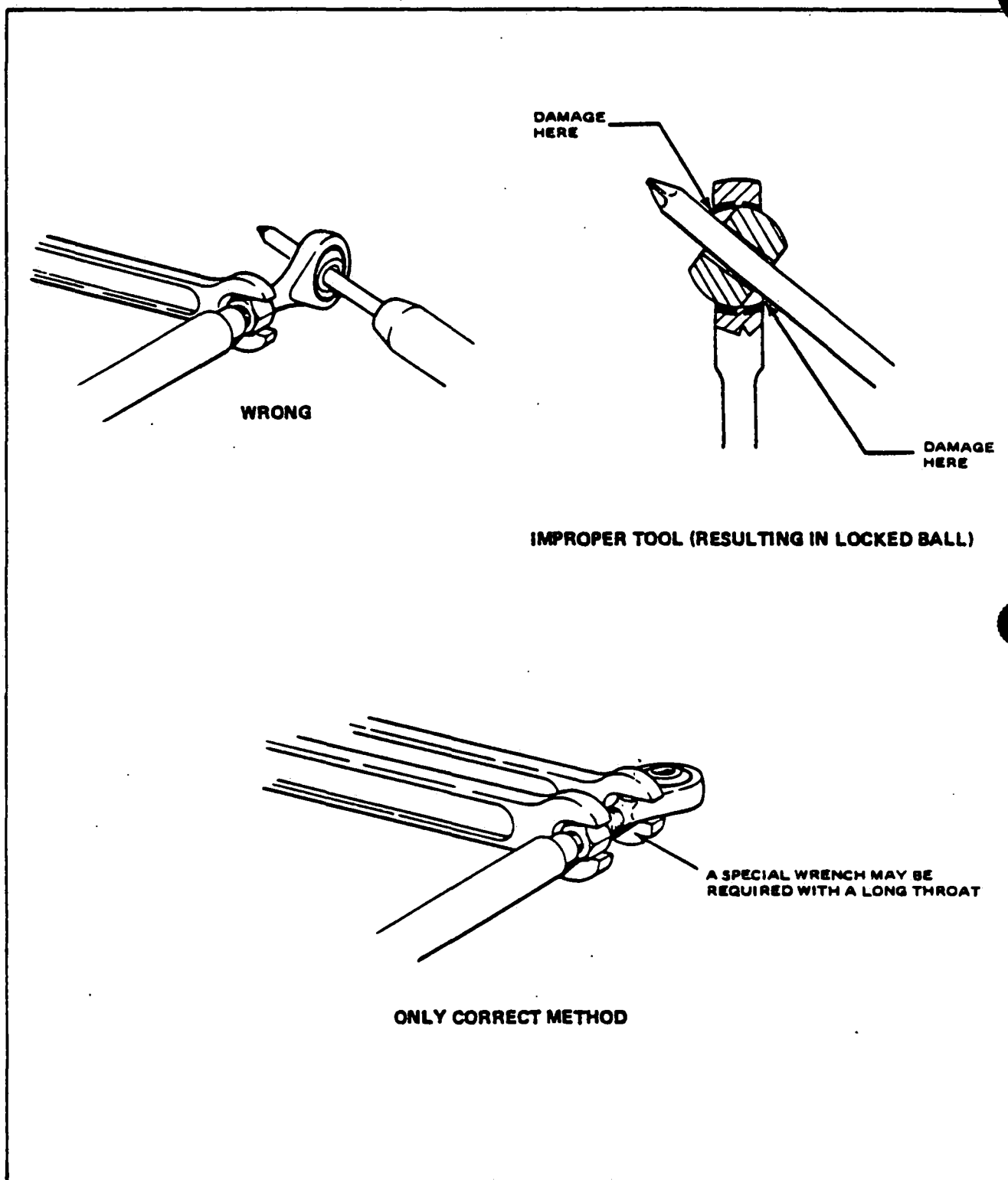


Figure 5-1a. Correct Method of Installing Rod End Bearings

## 5-7. AILERON CONTROLS.

### 5-8. REMOVAL OF AILERON CONTROL CABLES. (Refer to Figure 5-2.)

a. Remove the rear seats, and seat rails, carpet and floor panel from the left side of the fuselage aft of the main spar.

b. To remove the right and/or left primary control cable(s) (6 or 3) within the fuselage from station 50.0 to station 126.5, the following procedure may be used:

1. Remove the front seats and lay back enough floor carpet left of the nose wheel well to enable the removal of the first left floor panel aft of the forward bulkhead.

2. Disconnect the desired cable at the turnbuckle where it connects to the sprocket chain at station 50.0.

3. Remove the cable guard (15) at the pulley cluster just aft of the forward cabin bulkhead, station 50.5, and at the cluster aft of the main spar, station 115.75.

4. Disconnect the cable from the cable leading into the wing at the strap fitting (7) at station 126.5 by removing cotter pin, nut and bolt. On aircraft equipped with rudder-aileron interconnect system, remove the interconnect cable from the large spring, then remove the bolt that connects the two strap fittings.

5. Draw the primary cable back through the fuselage.

c. To remove the right and/or left primary control cable from either wing, the following procedure may be used:

1. Remove the access plates from the aft underside of the wing at stations 72.0, 115.5 and 139.5 and the fairing strip from between the underside of the fuselage and wing.

2. If tension exists in the cable, rotate the turnbuckle barrel on the aft arm of the aileron bellcrank at station 139.5 in the wing to slacken the cable. Then, disconnect the cable from the bellcrank by removing cotter pin, nut, washer and bolt or by disassembling the turnbuckle.

3. Remove the cotter pin cable guard from the cable pulley by reaching through the access hole at wing station 115.5.

### NOTE

The aft end of each bellcrank and the turnbuckle assembly of the primary cable are painted red to facilitate reinstallation.

4. In removing the right control cable (6), remove the pulley located at the aft butt end of the wing by removing the nut, washer and bolt holding the pulley in its bracket.

5. Remove the cable pulley from the forward side of the rear spar support bulkhead at station 135.0. The pulley supporting the left control cable may be removed by removing the nut, washer and bolt that holds the pulley in its mounting bracket. The pulley supporting the right control cable may be removed by first removing the screws securing the mounting bracket to the bottom fuselage skin and rear spar bulkhead, and then removing the nut, washer and bolt that holds the pulley in the bracket.

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6. If not previously disconnected, disconnect the cable from the forward control cable at fuselage station 126.5 by removing the cotter pin, nut and bolt.

7. Draw the cable through the wing. Use caution when drawing the end of the cable through the rub block at wing station 78.0.

d. Removal of the aileron balance cable (40) may be accomplished by the following procedure:

1. Ascertain that the access plates are removed from the aft underside of each wing at stations 72.0, 115.5 and 139.50. Also, the fairing from between the underside of the fuselage and each wing.

2. Remove the floor panel from the right side of the fuselage aft of the main spar.

3. If tension exists in the cable, rotate the turnbuckle barrel on the forward arm of either aileron bellcrank at station 139.5 in the wing to slacken the cable. Then disconnect the cable from each bellcrank by removing cotter pin, nut, washer and clevis bolt or by disassembling the turnbuckle.

4. Remove the cotter pin cable guard from the cable pulley by reaching through the access hole in each wing at station 115.50.

5. Remove the cotter pin cable guards from the left and right pulleys of the balance cable at fuselage station 135.0.

6. If an Autopilot roll servo is attached to the balance cable, remove the slot head screws from the bridle cable clamps at the center of the fuselage. Remove the safety sleeves inboard of each clamp.

7. Draw the cable through the fuselage and each wing. Use caution when drawing the end of the cable through the rub block at wing station 78.0.

#### 5-9. INSTALLATION OF AILERON CONTROL CABLES. (Refer to Figure 5-2.)

a. Installation of the aileron balance cable may be accomplished by the following procedure:

1. Draw the balance cable (4) into each wing from the center of the fuselage.

2. With the cable positioned on both the left and right pulleys in the fuselage at station 135.0 install the cotter pin cable guards.

3. Attach the ends of the cable to the forward end of the bellcrank in each wing by assembling turnbuckles and/or securing with clevis bolt, washer, nut and cotter pin. Do not set cable tension at this time.

#### NOTE

Do not tighten turnbuckle fork ends on bellcrank so tight that the end cannot rotate.

4. By reaching through the access opening in each wing at station 115.5, position the cable around the upper pulley of the cluster and if the primary control cable is installed, install the cotter pin cable guard.

5. If an autopilot roll servo is part of the airplane's equipment, attach the bridle cable to the balance cable with the use of the installation instructions given in Electronics Section.

b. Installation of the left and/or right primary control cables (3 and 6) that lead from the fuselage into the wings may be accomplished by the following procedure:

1. Draw the cable through the wing into the fuselage.
2. Install the cable pulley in the fuselage, forward of the rear spar support bulkhead at station 135.0. For the left pulley, position the cable and pulley and secure with bolt, washer and nut. For the right pulley, position the cable and pulley in the bracket and secure pulley with bolt, washer and nut, and then attach the bracket assembly to the bottom skin of the fuselage and spar support bulkhead using screws. Ascertain that cotter pin cable guards are installed.
3. If the right cable (6) was removed, position the cable and install the pulley in the bracket located on the butt aft end of the wing by using bolt, washer and nut.
4. Through the access hole in the wing at station 115.5 position the cable on the lower pulley of the cluster and install the cotter pin cable guard.

#### CAUTION

When stringing the cables on the front pulley cluster just aft of firewall, be sure to thread cable in the pulley groove and not over top of either the front or bottom cable guards. (Refer to Figure 5-2, View A-A.)

5. Attach the cable to the aft end of the cable bellcrank by assembling turnbuckle and, or securing with clevis bolt, washer, nut and cotter pin.

#### NOTE

Do not tighten turnbuckle fork ends on the bellcrank so tight that the end cannot rotate.

6. If the forward control cables in the fuselage are installed, connect the strap fittings (7) and the rudder-aileron interconnect cable, if installed, at station 126.5 using bolt, nut, cotterpin, and bushing required with the interconnect cable, then slip the loop on the other end of the interconnect cable over the end of the large spring.

c. Installation of the left and/or right primary control cable(s) within the fuselage may be accomplished by the following procedure:

1. From the pulley cluster within the fuselage at station 115.0 draw the primary cable forward through the floor support bulkheads, under the pulley cluster at station 50.0 and up to the vertical sprocket chain.
  2. Connect the cable with turnbuckle to the vertical chain using clevis bolt, bushing, nut and cotter pin.
  3. Connect the fuselage primary cable with the wing primary cable and the rudder-aileron interconnect cable, if installed, with the strap fittings at fuselage station 126.5 using bolt, nut, cotterpin and bushing required with the interconnect cable, then slip the loop at the other end of the interconnect cable over the end of the large spring.
  4. Replace the cable guard (15) at the pulley cluster aft of the rear spar and the two cable guards at the pulley cluster at station 50.0.
- d. Set cable tension per Table V-I, check rigging and adjustment per Paragraph 5-12 and ascertain that all turnbuckles are safetied.

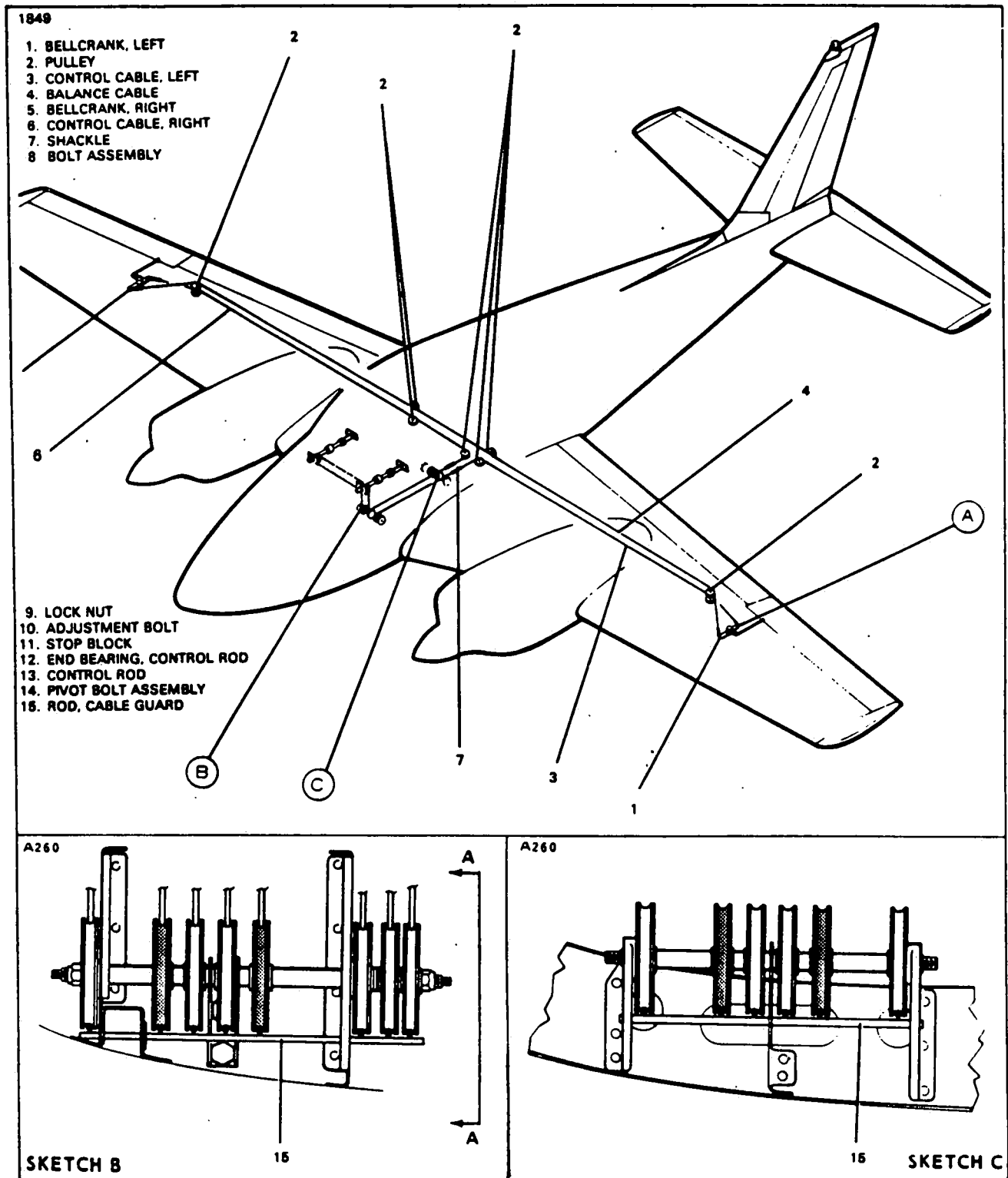


Figure 5-2. Aileron Control Installation

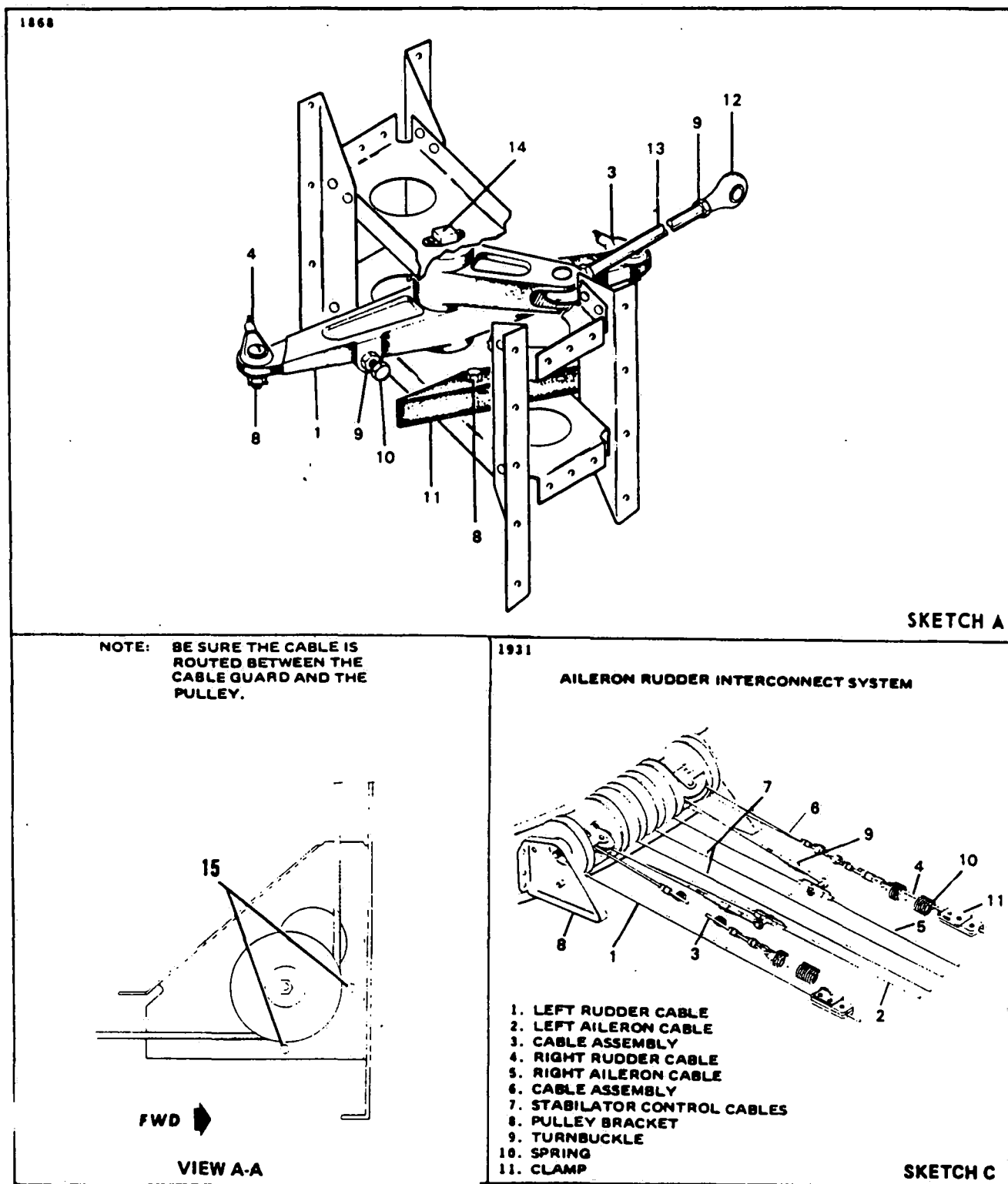


Figure 5-2. Aileron Control Installation (cont.)

**CAUTION**

After setting cable tension on aircraft equipped with rudder-aileron interconnect system, recheck the strap clamp fittings and make sure the aileron cables haven't twisted under tension and wrapped the interconnect cables around them. If this has happened, release tension, disconnect strap clamp fitting, let any twist out of the cable and proceed from Step 3.

1. Insure the interconnect cables are riding in their pulley grooves then adjust the interconnect cable turnbuckles per Paragraph 5-34, j.
- e. Install access plates and panels, carpets, seat tracks and seats.

**5-10. REMOVAL OF AILERON BELLCRANK ASSEMBLY. (Refer to Figure 5-2.)**

- a. Remove the access plate from the aft underside of the wing at station 139.5.
- b. Release cable tension from the control system by rotating one of the turnbuckles attached to the bellcrank (1 or 5).
- c. Disconnect the turnbuckle ends from the forward and aft ends of the bellcrank by removing the cotter pin, nut, washer and clevis bolts.

**NOTE**

The aft end of each bellcrank and turnbuckle assembly of each primary control cable is painted red to facilitate reinstallation.

- d. Disconnect the aileron control rod (13) from the bellcrank by removing cotter pin, nut, washer and clevis bolt.
- e. Remove the pivot bolt (14) that secures the bellcrank and remove bellcrank from wing.
- f. The stop block (11) may be removed by unbolting and removing from wing.

**5-11. INSTALLATION OF AILERON BELLCRANK ASSEMBLY. (Refer to Figure 5-2.)**

- a. Place the bellcrank in its mounting bracket with the adjustable stops (10) toward the outboard end of the wing.
- b. Install the pivot bolt and torque.
- c. Install the aileron control rod (13), secure bolt assembly and safety.

- d. Connect the turnbuckle ends to the bellcrank, secure and safety.

NOTE

The aft end of the bellcrank and the primary cable ends are painted red to help facilitate proper hookup. Do not tighten turnbuckle fork ends on bellcrank so tight that the ends cannot rotate.

- e. Install stop block (11) and torque bolts.
- f. Check aileron controls rigging and adjustment as per Paragraph 5-12.
- g. Install access plate and secure.

5-12. RIGGING AND ADJUSTMENT OF AILERON CONTROLS.

- a. To check and adjust rigging of the aileron controls, use the following procedure:
  1. Ascertain that the control wheels have been properly rigged (Refer to Paragraph 5-6) and place them in neutral position.
  2. Remove aileron bellcrank access plates from the aft underside of the wing at station 139.5.
  3. Check bellcranks for neutral position by aligning bellcrank pivot bolt with rear cable attachment bolt using fabricated checking tool as shown in Figure 5-3. (This tool may be fabricated from dimensions given in Figure 5-17.)
  4. If the bellcranks do not fall in neutral position with control wheels level, adjust cable turnbuckles at bellcranks to position both at neutral. Maintain cable tension specified in Table V-1.
- b. Check and adjust the aileron for neutral position on aircraft without the Airflow Modification Kit installed by the following procedure:
  1. Place a modified straightedge, as shown in Figure 5-4, against the underside of the wing next to and outboard of the row of rivets at station 169 with the aft spacer even with the trailing edge of the aileron. (Do not place tool on rivets.) (This tool may be fabricated from dimensions given in Figure 5-18.)
  2. With the control wheel in neutral and the tool spacers contacting the wing, the trailing edge of the aileron should make contact with the aft spacer.
  3. Should the three points not contact, disconnect control rod and adjust rod end bearing until the three contact points touch the skin surfaces. Check for sufficient thread engagement and tighten jam nut. Connect control rod to aileron and safety.
- c. Check and adjust the aileron for neutral position on PA-30 aircraft (Serial Nos. 30-1 to 30-2000 inclusive) with Airflow Modification Kit 760 409 or 760 564 installed by the following procedure:
  1. Place a bubble protractor on the upper surface of the aileron, parallel with and next to the rib rivets 6 1/2 inches from the inboard edge of the aileron.
  2. With control wheel and aileron bellcrank in neutral position and airplane level, the angle between the airplane leveling lugs and the upper surface of the aileron, should be 12° in neutral position.

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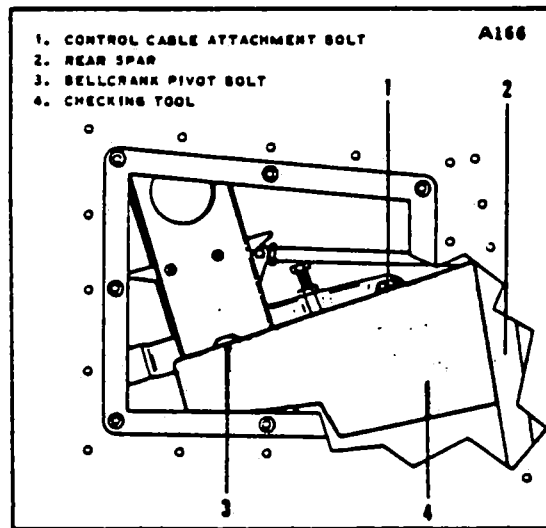


Figure 5-3. Installation of Bellcrank Checking Tool

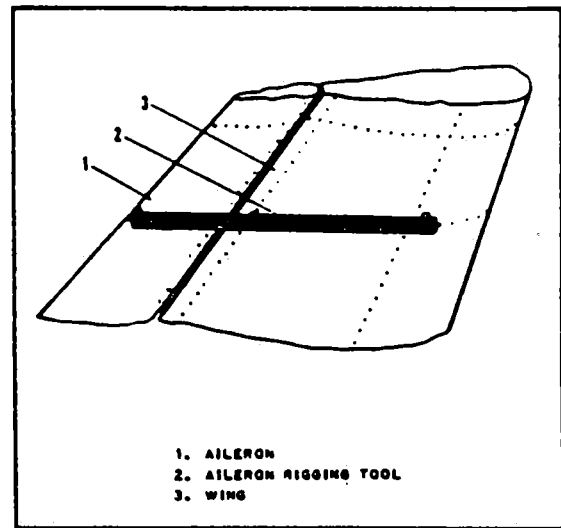


Figure 5-4. Installation of Aileron Rigging Tool

3. Should any adjustment of aileron neutral position be required, disconnect control rods and adjust rod end bearings until aileron neutral position is reached. Check for sufficient thread engagement and tighten jam nut. Connect control rods to ailerons and safety.

d. Place a bubble protractor on the inboard section of the aileron perpendicular to the hinge line and establish neutral or zero on the protractor. Remove the control wheel block and adjust the bellcrank stop bolts to the specific aileron travel from neutral as given in Table V-1 or Table V-1A. Stops on both bellcranks should contact their stops at the same time and before the control wheel contacts the stops.

e. Check that the aileron balance weight does not come in contact with the bottom wing skin.

f. Check control operation, bolts and turnbuckles for safety and install access plates.

### 5-13. AILERON TRIM.

5-14. ADJUSTMENT OF AILERON TRIM. For the purpose of changing lateral trim, a fixed metal tab is installed on the trailing edge of the left aileron or both ailerons. The tabs are adjustable from the ground as necessary.

**5-15. STABILATOR CONTROLS.**

**5-16. REMOVAL OF STABILATOR CONTROL CABLES. (Refer to Figure 5-5.)**

a. To remove the forward control cables that connect the control column assembly with the stabilator cables, the following procedure may be used:

1. Remove the cover plate, fold back the carpet and remove the floor panel at the left side of the wheel well by removing attaching bolts. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the rear seat and carpet and floor panel from the baggage compartment. Remove the access panel to the aft section of the fuselage from the rear wall of the baggage compartment.

In airplanes with Serial Nos. 30-853, 30-902 and up, remove the rear seats and, if installed, family seats. Within the left family seat foot well, remove the floor carpet and forward inspection plate. Models with a one piece baggage area floor panel, remove the complete panel and those with a split floor panel, remove only the left panel. Remove the access door to the aft section of the fuselage from the rear wall of the baggage area.

2. If not previously accomplished, mark the upper set of cable ends to facilitate reinstallation and, with the trailing edge of the horizontal stabilator in the down position, loosen and disconnect both turnbuckle barrels (5) in the aft section of the fuselage at station 172.0.

3. Remove the cotter pin cable guards from the pulley brackets aft of rear baggage area at station 159.0

4. Remove the cotter pin cable guard from double pulley bracket on the aft side of rear spar support bulkhead at station 138.5.

5. Remove the cable guard (9) from the pulley cluster aft of the main spar at station 115.75 by withdrawing cotter pin from one side and removing the guard.

6. Remove the two cable guards (9) from the pulley cluster located beneath the floor panel at the forward bulkhead at station 51.5 by withdrawing cotter pin from one side and removing the guard.

7. Disconnect the cable from the cable attachment fitting on the control wheel column by removing the cotter pins from the fitting arm. (Refer to Figure 5-1.)

8. Remove the stabilator control cable pulleys under each normal control column behind the forward fuselage bulkhead and forward of the instrument panel by removing the pulley bolts and nuts.

9. Draw the cable forward through the fuselage.

b. The following procedure may be used to remove the aft control cables that begin at fuselage station 172.0 and route aft to the balance arm (30) of the stabilator.

1. Remove the access plate from the right rear side of the fuselage just ahead of the stabilator by removing attaching screws.

2. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the back panel access door from the rear wall of the baggage compartment. In airplanes with Serial Nos. 30-853, 30-902 and up, remove the right rear family seat, if installed, and the back panel access door from the baggage area.

3. If not previously accomplished, mark the upper set of cable ends to facilitate reinstallation and, with the trailing edge of the horizontal stabilator in the down position, loosen the turnbuckles (5) at station 172.0.

4. Remove the fork end straps (32) of the cable from the balance arm (30) of the stabilator by removing cotter pin, nut, washer and bolt.

5. Remove pulleys from the top and/or bottom brackets at stations 233.0 and 235.0 respectively by removing nuts, bolts and bushings.

6. Draw the cables aft out of the fuselage.

#### 5-17. INSTALLATION OF STABILATOR CONTROL CABLES. (Refer to Figure 5-5.)

a. To install the aft stabilator control cables that route from the balance arm (30) to fuselage station 172.0, the following procedure may be used:

1. Place the aft cables within the fuselage from the right rear access opening with the turnbuckle end of the cables extended forward.

2. Connect the fork end straps (32) of the upper and lower cables to the balance arm (30) by inserting the bolts from the left side through the washers, straps, bushings and balance arm and installing the nut and cotter pin on the right side of the balance arm.

3. With the cables riding in the pulley grooves, install the upper pulley in its bracket at station 233.0 by inserting the bolt from the right side through the bracket and pulley bushing, and installing the nut. Install the lower pulley at station 235.0 by inserting the bolt from the left side and tightening the nut.

4. If the forward cables are installed, connect the upper and lower aft cable ends to the forward cables using turnbuckles (5).

b. The following procedure may be used to install the forward cables that connect the control column assembly with the aft control cables:

1. Identify the left cable length by measuring approximately 151 inches from the thimble of the unpainted cable end to the swaged ball on the cable.

2. Connect the swaged ball of the 151 inch cable length to the cable attachment fitting by means of cotter pins through the arm of the fitting. (Refer to

Figure 5-1.)

3. With the attached length in the pulley grooves, install the pulleys in their brackets immediately under the left side control column at the forward bulkhead and just forward of the instrument panel.
4. Identify the swagged ball that connects to the right cable attachment fitting approximately 178 inches from the thimble of the painted end.
5. Install the pulleys beneath the right side control column by stringing the cable from the pulley just ahead of the instrument panel and beneath the left control column to the bracket beneath the right control column at the forward bulkhead.
6. With the cable in the groove of the right side forward pulley, install the pulley with bolt and nut.
7. Connect the swagged ball to the right control column cable attachment arm with cotterpins.
8. With the cable in the pulley groove, install the remaining pulley in its bracket beneath the right side control column just forward of the instrument panel.
9. Determine that the cable section from the pulley bracket just forward of the instrument panel beneath the right side control column runs under the opposing cable section midway between the left and right control columns.
10. With the cable in the pulley groove, install the pulley in the lower bracket at the forward bulkhead and beneath the left control column by installing bolt and nut.
11. Draw the cable ends down and under the pulleys at the floor and forward bulkheads and through the pulley grooves aft of the main spar and back panel towards station 172.0.

**CAUTION**

When stringing the cables on the front pulley cluster just aft of the firewall, be sure to thread cable in the pulley groove and not over top of either the front or bottom cable guards. (Refer to Figure 5-5, View A-A.)

12. Connect the forward and aft stabilator cables at station 172.0 with the use of turnbuckles (5).
- c. Set cable tension per Table V-1 and check rigging and adjustment per Paragraph 5-20.
- d. Install floor panels, carpets, seat tracks, seats, access plates and access door.

**5-18. REMOVAL OF STABILATOR TORQUE TUBE ASSEMBLY.** (Refer to Figure 5-5.) Removal of the stabilator torque tube may be accomplished by the following procedures:

- a. Remove the access plate from the right rear side of the fuselage forward of the stabilator.
- b. Remove the top and bottom tail cone fairings.
- c. Disconnect the control cables from the balance arm (30) by removing cotterpins, nuts, washers and bolts connecting the fork end straps (32) at the forward end of the balance arm.

- d. Disconnect the aft end of the control rod (35) from the stabilator trim tab horn at the underside of the stabilator by removing nut, washers and bolt.
- e. Remove nut, washer and bolt from the stabilator rear spar attachment fitting where the two stabilator halves are joined at the airplane centerline.
- f. Disconnect the left and right stabilators from the stabilator torque tube by removing the nuts, washers and four bolts (ct) from the torque tube. Pull each stabilator outward from the torque tube.
- g. Separate the tab control bellcrank (34) from the stabilator bearing blocks (40) by removing cotter pins, bolts, washers and nuts. (It is not necessary to further disassemble this unit.)
- h. Remove the stabilator bearing block reinforcement channels by removing nuts and washers from the bolts of the bearing block.
- i. Remove the bolts from the right stabilator bearing block and the bottom bolt from the left bearing block. The top bolt need not be removed from the left bearing block. Mark top for proper reassembly.
- j. The entire torque tube and counter balance assembly can be removed from the airplane by pulling the stabilator torque tube rearward and rotating the right end of the tube downward to pass the rudder arm.
- k. Remove the components of the torque tube assembly noting the position of parts for proper reassembly and use the following procedure:
  1. Remove the left bearing block (40) by tapping with a soft mallet. Note shims (P/N 80122-84 on inboard side of bearing block).
  2. Remove stop assembly (38) by removing nuts and bolts.
  3. Remove the counter balance arm assembly by removing nut and bolt at the aft end of the balance arm.
  4. Remove the right bearing block assembly noting the shims.
  5. Remove the horn assembly (41) from the tube by removing nuts and bolts.

**5-19. INSTALLATION OF STABILATOR TORQUE TUBE ASSEMBLY. (Refer to Figure 5-5)**  
Installation of the stabilator torque tube may be accomplished by the following procedure:

- a. Install the components of the torque tube by the following steps:
  1. In case an old counter balance horn (41) or stop assembly (38) is to be installed on a new stabilator tube, the holes of the tube must be line reamed for fit by the following procedure:
    - (a) Position the counterbalance horn or stop collar in place on the tube and insert a locating pin into one set of holes for alignment. (Pin, Part No. 25034-00 is required for the horn and pin. Part No. 25034-02 is required for the stop collar.)
    - (b) Line ream the other set of holes from one side of the tube to and through the other side. (Ream horn attachment hole to 0.3120/0.3130 of an inch and collar attachment hole to 0.2465/0.2475 of an inch.)

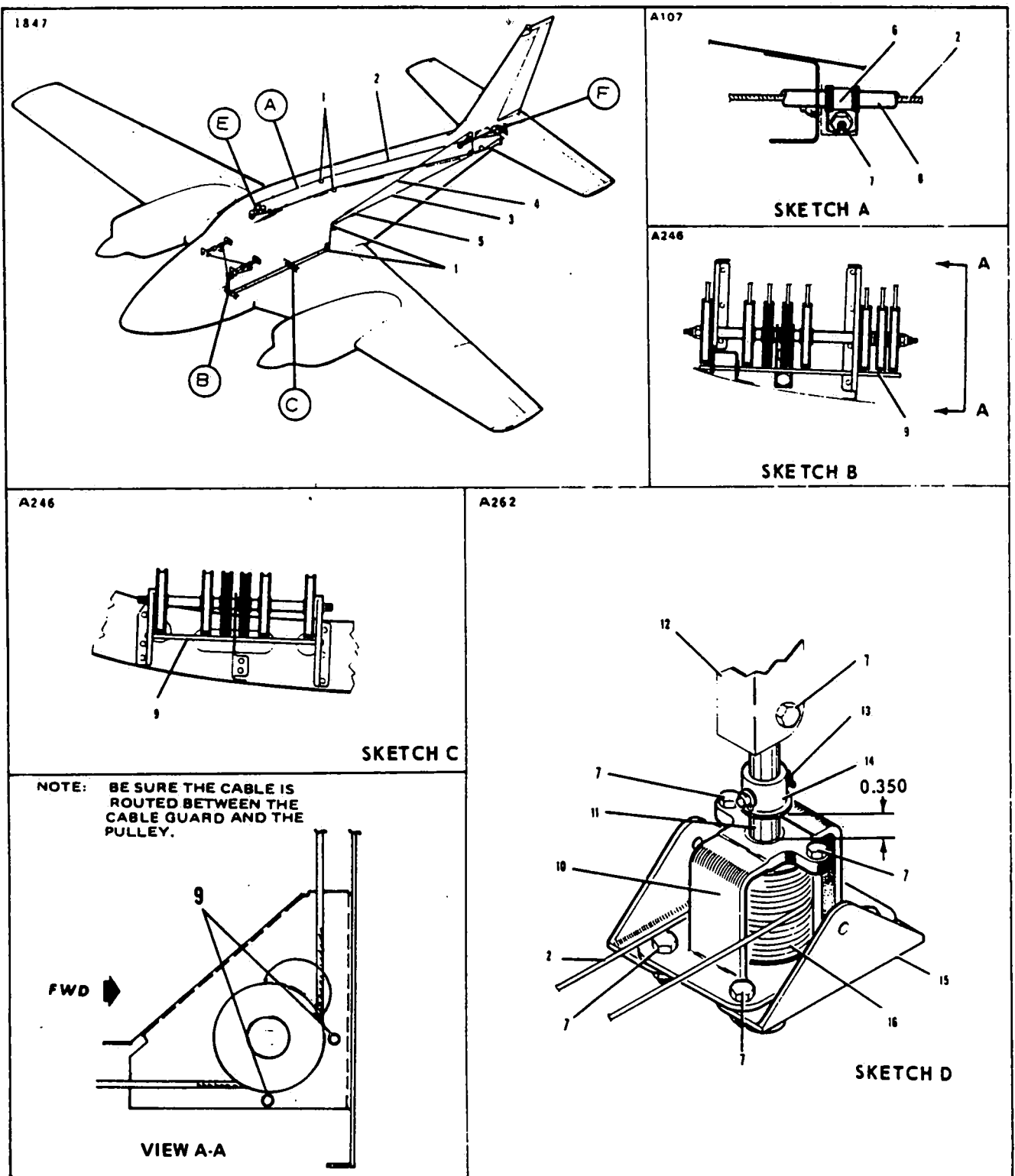


Figure 5-5. Stabilator and Stabilator Trim Controls

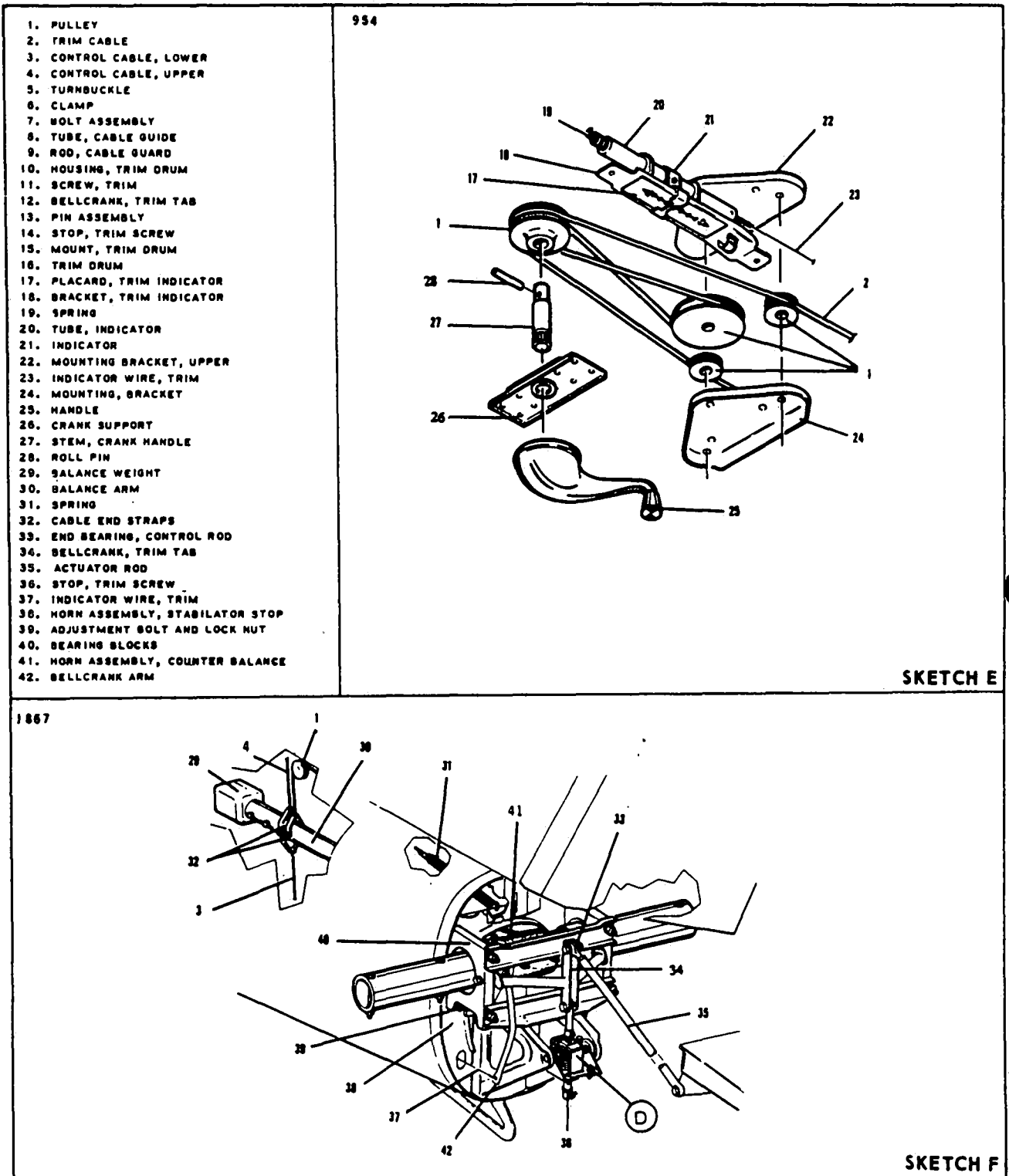


Figure 5-5. Stabilator and Stabilator Trim Controls (cont.)

(c) Insert a bolt in the reamed holes and repeat the process after removing the locating pin.

2. In case a new counter balance horn or stop assembly is to be installed on an old stabilator tube, one side of the holes in the counter balance horn or stop collar must be reamed to 0.3120/0.3130 of an inch for the horn or 0.2465/0.2475 of an inch for the collar before positioning the component on the tube, then use the following procedure:

(a) Insert a locating pin into one set of holes for alignment. (Pin, Part No. 25034-00, is required for the horn and pin, Part No. 25034-02, is required for the stop collar.)

(b) Line ream the far side of the tube by entering from the reamed side.

(c) Insert a bolt through the reamed set of holes, then line ream the remaining far side of the component by entering from the reamed side.

3. In case old components are to be installed on an old tube, no reaming is necessary.

4. Position the balance horn on the center of the torque tube and install bolts (ct) with the heads forward. Install washers and nuts, then torque.

5. Install the stop collar assembly on the left side of the torque tube with the head of the inboard bolt (ct) forward and the head of the outboard bolt aft. Install nuts and washers, then torque.

6. Install the counter balance arm (30) in the horn and secure with bolt (ct) and nut.

7. Install bearing blocks (40) on the torque tube. When installing the bearing blocks it is necessary that there be a dimension of 8.62 inches between the centers of the bearing blocks. Maintain this dimension by placing the necessary shims (P/N 80122-84) equally between each bearing and tube collar. Tap the bearing blocks on the torque tube with a soft mallet maintaining a snug fit between bearing block, shims and collar.

b. With the top bolt of the left bearing block in place, slide the counterbalance arm into the aft end of the fuselage with the left side of the torque tube vertical to pass the rudder arm. Rotate the tube counterclockwise into position. Place the three remaining bolts in the bearing blocks.

c. Install the bearing block reinforcement channels by installing washers and nuts on the bolts of the bearing blocks.

d. Install the bolts, washers and nuts that secure the lower reinforcement channel to the tab drum support bracket.

e. Connect the tab control bellcrank (34) to the stabilator bearing blocks by installing bolts, washers, nuts and cotter pins.

f. Slide the left and right stabilator halves onto the torque tube and secure with bolts (ct), washers and nuts, then torque.

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- g. Install the bolt, washer and nut that joins the two halves at the stabilator rear spar attachment fitting.
- h. Check stabilator balance per Checking and Balancing Stabilator, Section IV.
- i. Connect the aft end of the control rod (35) with the stabilator trim tab horn by installing bolt, washer and nut at the stabilator underside.
- j. Connect the control cable fork end straps (32) with the balance arm (30) by installing bolts, bushings, washers, nuts and cotter pins near the forward end of the balance arm.
- k. Check Stabilator Rigging and Adjustment per Paragraph 5-20.
- l. Install the top and bottom tail cone fairings and access plate on the right rear side of the fuselage forward of the stabilator.

#### 5-20. RIGGING AND ADJUSTMENT OF STABILATOR CONTROLS.

- a. Level the airplane. (Refer to Leveling, Section II.)
- b. To check and set the correct degree of stabilator travel, the following procedure may be used:
  - 1. Check the travel by placing a rigging tool on the upper surface of the stabilator as shown in Figure 5-6. (This tool may be fabricated from dimensions given in Figure 5-19.)
  - 2. Set on a bubble protractor the number of degree up travel as given in Table V-I or Table V-IA and place it on the rigging tool. Raise the trailing edge of the stabilator and determine that when the stabilator contacts its stops, the bubble of the protractor is centered.

#### NOTE

The stabilator should contact both of its stops before the control wheel contacts its stops.

- 3. Set on the protractor the number of degrees down travel as given in Table V-I or Table V-IA and again place it on the rigging tool. Lower the trailing edge of the stabilator and determine that when it contacts its stops, the bubble of the protractor is centered.
- 4. Should the stabilator travel be incorrect in either the up or down position, remove the tail cone fairing by removing the attaching screws and with the use of the stabilator rigging tool and bubble protractor, turn the stops located at the left bearing block of the torque tube in or out (Refer to Figure 5-5) to obtain the correct degree of travel.
- 5. Ascertain that the locknuts of the stop screw are secure and reinstall the tail cone fairing.

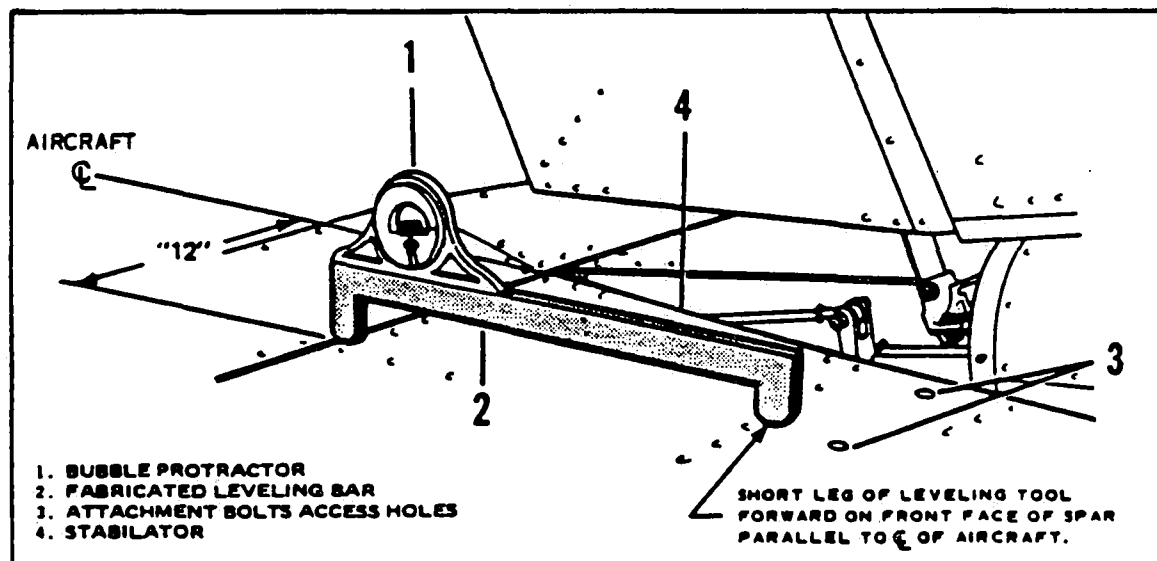


Figure 5-6. Stabilator Rigging Tool

c. To check and set stabilator control tension, and neutral relation of the control wheels with the stabilator, the following procedure may be used:

1. Ascertain that the stabilator balance (Refer to Checking and Balancing Stabilator, Section IV) and travel are correct.
2. Remove the access panel from the rear wall of the baggage compartment or area.
3. Position and maintain the stabilator in a neutral position with the use of the bubble protractor set at zero and placed on the rigging tool.
4. With the stabilator neutral, check that the control wheel is neutral fore and aft, and the control cable tension is correct as required in Table V-I or Table V-IA. Neutral position of the control wheel is 7.88 inches from the metallic surface of the instrument panel as measured along the underside of the control column to the wheel.
5. Should the neutral position of the control wheel and/or cable tension be incorrect, adjust the turnbuckles in the aft section of the fuselage to obtain correct position and tension. With this correct, the turnbuckles should be positioned approximately at station 172.5 to assure turnbuckle clearances.

d. Check and, if required, adjust the stabilator control extension spring located in the extreme aft portion of the fuselage to obtain 1.25 inch extension of the spring with stabilator stops at correct adjustment and control wheel at the full forward position. Access to the spring is gained by removing the access panel located on the right side of the fuselage just forward of the stabilator.

e. Check the full travel of the control wheel with relation to the full travel of the stabilator to determine that the stabilator contacts its stops before the control wheel contacts its stops.

- f. Check safety of turnbuckles and bolts.
- g. Remove the airplane from jacks.
- h. Install access plates and panels.

## 5-21. STABILATOR TRIM CONTROLS.

### 5-22. REMOVAL OF STABILATOR TRIM CABLES AND CONTROL. (FORWARD). (Refer to Figure 5-5.)

- a. Remove the trim crank handle (25) from the overhead light panel by pressing upward on the light panel near the crank stem (27) and removing the clip from the stem.
- b. Remove cabin light panel from cockpit overhead by removing attaching screws.
- c. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the access door from the rear wall of the baggage compartment. In airplanes with Serial Nos. 30-853, 30-902 and up, remove the right rear family seat, if installed, and remove the back panel access door from the baggage area.
- d. Trim cables (2) may be blocked to prevent the unwrapping of cables from the trim drum by removing the lower tail cone fairing and blocking the cables at the trim drum as shown in Figure 5-7.
- e. Disconnect the forward control cable end from the rear control cable by disconnecting the forward turnbuckle in aft area of the fuselage at station 199.0.
- f. To facilitate withdrawal of cable through the tube guides (8) within the cockpit headliner, the following procedure may be used:
  1. If the cable is to be reused, split the neopress sleeve and remove the thimble at one end of the forward cable.
  2. If the cable is not to be reused, it may be cut just forward of the sleeve.

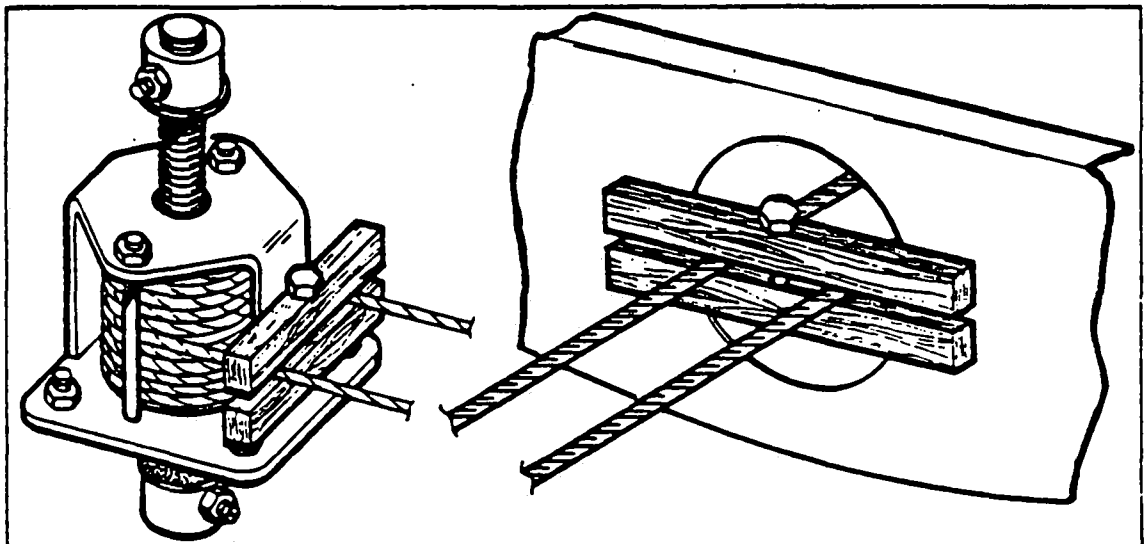


Figure 5-7. Methods of Blocking Trim Cables

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- g. Draw the cable end forward from aft area of the fuselage to and through the trim servo, if installed, around the pulleys at the trim handle and back to the aft area of the fuselage.
- h. The stabilator trim stem (27) and pulley assembly may be removed by the following method:
  - 1. Remove the trim crank (25) lower support (26) from the cabin overhead by removing screws.
  - 2. Remove the stem by removing the roll pin (28) from pulley.
  - 3. Remove the pulley.

### NOTE

The trim screw and pulley assembly should be installed by reversing this procedure prior to installation of stabilator cables.

**5-23. INSTALLATION OF STABILATOR TRIM CONTROLS AND CABLE (FORWARD).** (Refer to Figure 5-5.) One of two procedures may be used for installing the forward cables according to knowledge of cable length. The first procedure should be followed for cables of pre-determined length such as old cables that are to be reused, and new cables measured to the correct length of the old. The second procedure should be used if the old cable is damaged or cut and the replacement is of undetermined length.

- a. For cables of known length, the following procedure should be used:
  - 1. Draw the cable end forward from the pulley located directly aft of the aft wall of the cabin area at station 157.0, through the cable guide tube (8) and around the double pulley and idler pulley of the trim crank (25) at station 87.5. Draw the cable end aft through the guide tube and through the pulley groove at station 157.0 to the aft section of the fuselage.
  - 2. Swage the sleeve to the cable with the thimble and turnbuckle end installed.
  - 3. Connect the forward cable end(s) to the aft cable by connecting the turnbuckles in the aft section of the fuselage at station 199.5.
- b. For cables of undetermined length, the following procedure should be used:
  - 1. Draw the cable end forward from the pulley at station 157.0 through the guide tube (8), around the double pulley and idler pulley at station 87.5 and aft through the guide tube and the pulley at station 157.0 to the aft section of the fuselage.
  - 2. Connect the forward cable end to the corresponding aft cable end by rotating the turnbuckle barrel until threads on each end are showing.

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3. Assemble the eye thimble and sleeve and connect the ends of the aft and forward cables to the barrel with three or four threads.
4. Draw the free cable end until it is tight and clamp the cable so that it will not damage the cable or slip back.
5. Crank the trim a few times to seat the cable on the drum and pulleys.
6. Draw the free end of the cable to approximately the required cable required cable tension.  
(Refer to Table V-I.)
7. Swage the sleeve to the cable and reset the cable tension.
8. Cut off the remaining cable.
- c. If a trim servo is installed, separate the left trim cable at the turnbuckle in the aft section of the fuselage at station 199.0.
  1. Add a cable splice to the forward cable end just separated to compensate for the figure eight wrapping of the trim servo.
  2. Lower the trim servo from its bracket by removing attaching bolts, washers and nuts.
  3. Remove the cable guard bracket from the trim servo drive pulley by removing screws.
  4. Raise the idler pulley above the fixed cable guards on the right side by removing the pulley bolt.
  5. Install the pitch trim servo by passing a portion of the servo up through the cutout in the mounting bracket and attaching the servo with bolts, washers and nuts.
  6. Route trim cable from the forward part of airplane around the top of the drive pulley groove to and around the idler and back to the lower groove of the drive pulley.
  7. Reinstall idler with cable routed around it in a figure eight.
  8. Reinstall cable guard bracket on top of the trim servo by installing screws. Position the bracket within 0.032 of an inch of the pulley.
- d. Connect the forward cable end with aft cable aft the forward turnbuckle.
- e. Install the light panel on the overhead at the trim crank stem with attaching screws.
- f. Install the trim crank handle by placing the handle on the crank stem and pressing upward.
- g. Set cable tension per Table V-I and check rigging and adjustment per paragraph 5-26. Safety all turnbuckles.

**5-24. REMOVAL OF STABILATOR TRIM SCREW AND CABLE ASSEMBLY (AFT). (Refer to Figure 5-5.)**

- a. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the access door from the rear wall of the baggage compartment. In airplanes with Serial Nos. 30-853, 30-902 and up, remove the right rear family seat, if installed, and remove the back panel access door from the baggage area.
- b. Remove the access plate from the right rear side of the fuselage forward of the stabilator by removing the attaching screws.
- c. Remove the tail cone fairings by removing the attaching screws.
- d. Block the aft cables at trim screw assembly to prevent the unwrapping of the cable from the drum. The cables may be blocked as shown in Figure 5-7.
- e. Remove screw cable guards and bushings from the pulley bracket which is attached to the bulkhead aft of the stabilator balance weight at station 239.2 by removing nuts.
- f. Mark one set of cable ends in the aft section of the fuselage at station 199.0 to facilitate installation, then disconnect turnbuckles by rotating their barrels.
- g. Disconnect the trim tab control screw assembly from the tab control bellcrank assembly (34) by removing the cotter pin, castellated nut, washers and bolt from the bellcrank at the upper end of the control screw station 265.6.
- h. Separate the lower bearing block brace from the bracket support assembly by removing four bolts, washers and nuts.
- i. Remove the control cable drum housing (10), trim drum (16), and control screw (11) with stops by removing cotter pins, castellated nuts, and washers from both sides of the bracket support assembly.
- j. Draw the trim drum, bracket drum and cables out of the fuselage from the rear. The support brackets may be pried apart slightly to allow passage of the drum housing with angle (15) and bolts installed.

**5-25. INSTALLATION OF STABILATOR TRIM SCREW AND CABLE ASSEMBLY (AFT). (Refer to Figure 5-5.)**

- a. Place the forward ends of the aft stabilator trim cable within the fuselage and draw them forward.
- b. With the cable evenly wrapped and blocked on the trim drum (16), install the trim screw assembly between its support brackets with washers, bolts, castellated nuts and cotter pins. Only a snug fit is needed. Be sure that the side bolts are inserted in the housing support angles (15) with the threads outward. The support brackets may be pried apart slightly to admit the drum housing support angles with bolts.
- c. Install nuts, washers and bolts connecting the lower bearing block brace to the support brackets.

- d. Connect the turnbuckles to the forward trim cables in the aft section of the fuselage station 199.5 and set cable tension given in Table V-I.
- e. With the cables still evenly wrapped and the turnbuckles parallel, turn the trim screw until 0.350 of an inch is between the upper screw stop (14) and the top of the drum housing (10).
- f. Connect the trim screw (11) with the tab control bellcrank assembly (12) by installing bolt, washers, castellated nut and cotterpin to a snug fit at the upper end of the screw.
- g. Remove the blocks holding the trim tab cables.
- h. With primary tension gained by rotating the turnbuckles, continue rigging and adjustment beginning with step f, paragraph 5-26.
- i. Install cable guard screws with bushings and nuts at the pulleys of station 239.2.
- j. Install tail cone fairings and on the right side of the fuselage forward of the stabilator. Install the access plate with attaching screws.
- k. Install the access door and, if removed, install the right rear family seat to the baggage area.

**5-26. RIGGING AND ADJUSTMENT OF STABILATOR TRIM. (Refer to Figure 5-5.)**

- a. Level the airplane. (Refer to Leveling, Section II.)
- b. Remove tail cone fairing from fuselage by removing the attaching screws.
- c. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the access door from the rear wall of the baggage compartment. In airplanes with Serial Nos. 30-853, 30-902 and up, remove the family seat, if installed, from the right rear of the baggage area, then remove the access door from the back panel.
- d. Determine that the turnbuckles in the aft section of the fuselage at station 199.0 are parallel and that the trim tab cable is evenly wrapped on its drum.
- e. If cable drums are not equally wrapped and the turnbuckles are not together, the drums must be removed and re-wrapped. Refer to paragraph 5-47 for wrapping of the drum.
- f. Measure a space of 0.350 inch between the upper screw stop (14) and the top of the trim drum housing (10). If the required distance is lacking, use the following procedure:
  - 1. Disconnect the trim screw (11) from the bellcrank (12) by removing cotterpin, castellated nut, washers and bolt.
  - 2. With trim cables evenly wrapped and holding the trim drum (16), rotate the trim screw to obtain 0.350 of an inch, then reconnect the trim screw and bellcrank with nut, washers, bolt and cotterpin.

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- g. If the stabilator tab is not aligned with the neutral stabilator, disconnect the stabilator tab actuator rod (35) from the bellcrank (34) by removing cotterpin, castellated nut, washer and bolt.
- h. Loosen jam nut and rotate rod end bearing (33) until the trim tab and stabilator are aligned when the rod end bearing is in place.

### NOTE

The stabilator trim control rod end bearing located at the forward end of the control rod (33) should be checked for freedom of movement during the regular 100 hour inspection by disconnecting the rod at the trim tab and holding the end between your fingers, try to turn the rod from side to side and rotate up and down. If the rod will not turn or is hard to turn, the bearing should be checked more thoroughly by removing the complete assembly (33) from the airplane.

- i. Connect the tab actuator arm to the bellcrank at the rod end bearing with bolt, washers, castellated nut and cotterpin.
- j. With stabilator in neutral position, turn the trim in each direction to screw stops to check tab angle as given in Table V-I and also check minimum number of wraps left on the drum. (Minimum allowable is one and one quarter turns.)

### 5-27. REMOVAL OF TRIM INDICATOR AND WIRE. (Refer to Figure 5-5.)

- a. Remove the lower tail cone fairing by removing attaching screws.
- b. Remove the trim crank handle (25) from the overhead light panel by pressing upward on the panel near the crank stem (27) and removing the clip from the stem.
- c. Remove light panel by removing attaching screws.
- d. Remove bolt and nut holding the indicator assembly to the bulkhead at station 89.0.
- e. Remove screw holding indicator pointer (21) and forward spring (19) to the tube (20).
- f. Slide the tube aft from its placard brackets (18) and aft of station 88.8 then unwrap the indicator wire (23) from the tube or tap out the roll pin.
- g. Disconnect indicator wire from the lower bellcrank arm (42) at station 263.8 by unwrapping and drawing the wire from the fuselage.

### 5-28. INSTALLATION OF TRIM INDICATOR AND WIRE. (Refer to Figure 5-5.)

- a. Draw the indicator wire (23) into the fuselage through the guide tubes to station 88.8.
- b. Secure the forward end of the indicator wire to the aft end of tube (20) by wrapping the wire to the roll pin at the aft end of the indicator tube.
- c. Slide the indicator tube forward into the placard brackets (18) and secure the pointer (21) and forward spring (19) to the tube with a screw.



- d. Install the bolt and nut holding the indicator assembly to the bulkhead at station 89.0.
- e. With the stabilator in neutral, align the stabilator tab and stabilator, then draw the wire until the pointer indicates neutral and wrap the aft end to the bellcrank indicator rod (42).
- f. Install the light panel with attaching screws.
- g. Install the crank handle (25) by first installing the attachment clip on the crank and then pushing the handle onto the stem (27) while pressing upward on the light panel.
- h. Install the lower tail cone fairing by installing the attaching screws.

#### 5-29. RUDDER AND STEERING PEDAL ASSEMBLY.

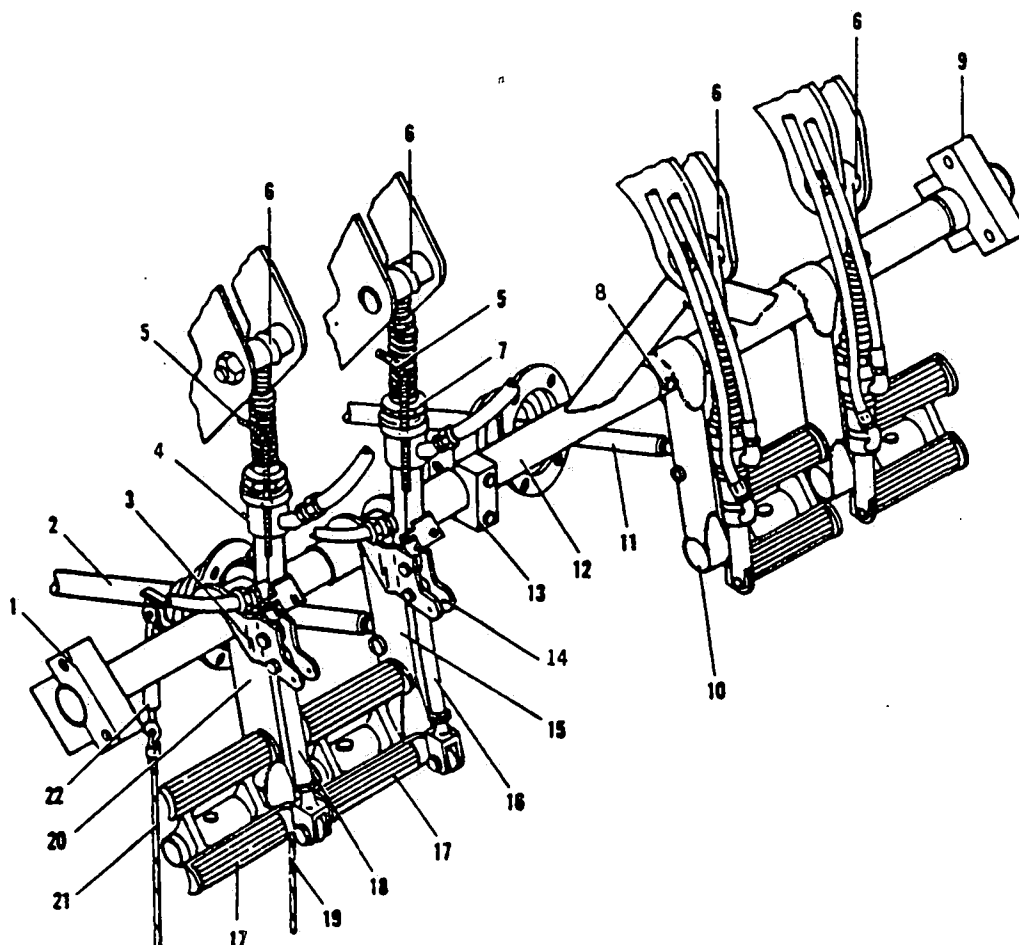
#### 5-30. REMOVAL OF RUDDER AND STEERING PEDAL ASSEMBLY. (Refer to Figure 5-8.)

- a. Disconnect the rudder control cables (21 and 19) from the pedal assembly at station 50.0 by first rotating the barrels of turnbuckles (22), and then disconnecting the fork ends by removing nuts, washers and bolts.
- b. Disconnect the right (11) and left (2) steering rods from the rudder pedal torque arms (15 and 10) by removing attaching screw and nut.
- c. Disconnect the toe brake cylinder assemblies (4 and 7) from the brake idler links (3 and 14) by removing the cotterpin, castellated nut, washer and bolt.
- d. To loosen the two halves of the torque tube (12), remove the two bolts (8) that secure the right inboard pedal (10) to the torque tube.
- e. Disassemble the right (9) and center (13) bearing blocks by removing the lockwires and cap bolts. Note the number of shims between the blocks.
- f. Compress the two halves of the torque tube assembly by sliding them together before removal. The torque tube will then be free of the left bearing block (1).
- g. Take the pedal assembly out from the left side over the wheel well.

#### 5-31. INSTALLATION OF RUDDER AND STEERING PEDAL ASSEMBLY. (Refer to Figure 5-8.)

- a. Lubricate and assemble the torque tube assembly (12) with the right inboard pedal (10) and brake pedals (17), idler links (3 and 14) and connecting rods (16 and 18). Do not bolt the torque tube at the right inboard pedal at this time. Ascertain that there is a measurement of 8.81 inches between the attachment holes of the left toe brake connecting rods (16 and 18) in airplane with Serial Nos. 30-2 to 30-558 inclusive. In airplanes with Serial Nos. 30-559 and up, the adjustment of the toe brake connecting rods should measure 8.56 inches between holes.
- b. Place the pedal assembly into position from the left inside of the fuselage and slide the tube into the left bearing block (1).

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- |   |  |
|---|--|
| 1. BEARING BLOCK, LEFT                          | 13. BEARING BLOCK, CENTER                    |
| 2. STEERING ROD, LEFT                           | 14. IDLER LINK, RIGHT                        |
| 3. IDLER LINK, LEFT                             | 15. RIGHT RUDDER PEDAL TORQUE ARM, LEFT SIDE |
| 4. BRAKE CYLINDER, LEFT                         | 16. CONNECTING ROD, RIGHT                    |
| 5. PARKING BRAKE CONTROL CABLE                  | 17. BRAKE PEDAL                              |
| 6. BRAKE CYLINDER CLEVIS BOLT                   | 18. CONNECTING ROD, LEFT                     |
| 7. BRAKE CYLINDER LEFT                          | 19. RUDDER CONTROL CABLE RIGHT               |
| 8. BOLT ASSEMBLY                                | 20. LEFT RUDDER PEDAL TORQUE ARM LEFT SIDE   |
| 9. BEARING, BLOCK, RIGHT                        | 21. RUDDER CONTROL CABLE, LEFT               |
| 10. RUDDER PEDAL TORQUE ARM, RIGHT SIDE INBOARD | 22. TURNBUCKLE                               |
| 11. STEERING ROD, RIGHT                         |  |
| 12. TORQUE TUBE                                 |  |

Figure 5-8. Rudder Pedal Installation

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c. Install the center (13) and right bearing blocks (9). Use shims (.010, P/N 41371-02; .015, P/N 41371-03; .032, P/N 41371-04) as required between bearing blocks to allow the tube a snug fit yet be free to rotate.

d. Install bolts (8) that secure the right side inboard pedal (10) to the torque tube.

e. Install lockwires in cap bolts of the bearing blocks.

f. Secure the steering rods (2) and (11) to the center set of rudder pedal torque arms (10 and 15) by installing screws and nuts. The heads of the screws should be outboard.

g. Connect the brake cylinder assembly (4 and 7) to the toe brake links (3 and 14) with bolts, washers, castellated nuts and cotter pins.

h. For the left and/or right rudder pedals with toe brakes, check that there is 1.50 inches between the aft surface of the pedal tube (2) and the aft surface of the toe brake pad (3). (Refer to Figure 5-9.) Adjust the clevis bolt (6) at the top of each brake cylinder by removing the cotter pin, nut, washer and bolt and rotating the clevis to the desired adjustment. Reconnect the clevis when adjusted and tighten jam nut.

i. Connect the fork ends of the turnbuckles (22) to the arms of the torque tube assembly with bolts, washers and castellated nuts.

j. Rotate the turnbuckle barrels until required tension is reached as given in Table V-1 and check rudder adjustment as given in Paragraph 5-37. Safety the turnbuckles.

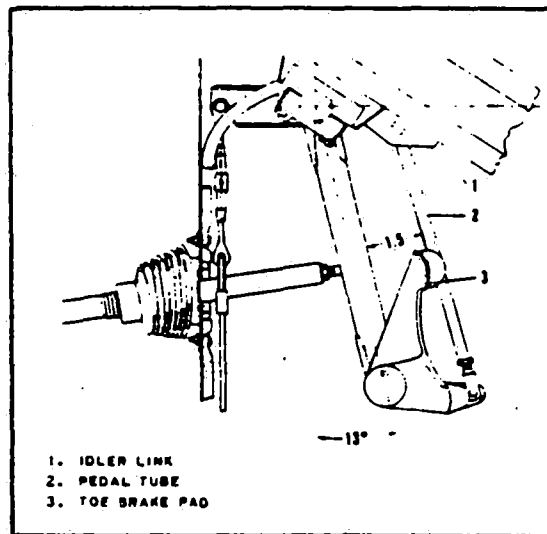


Figure 5-9. Adjustment of Brake Pedal

## 5-32. RUDDER CONTROLS.

**5-33. REMOVAL OF RUDDER CONTROL CABLES.** (Refer to Figure 5-10.) To remove the rudder control cable assembly, use the following procedure:

a. Remove the scuff plate, fold back the carpet, and remove the floor panel at the left side of the wheel well.

b. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the rear seat bottom. Remove carpets and floor panel from the baggage compartment and remove the access door to the aft section of the fuselage from the back panel. In airplanes with Serial Nos. 30-853, 30-902 and up, remove the rear seats and family seats, if installed. Remove the carpets and floor panels aft of the main spar and remove the access door of the back panel.

c. Remove the tail cone fairings by removing the attaching screws.

d. Remove the access panel from the right rear side of the fuselage at station 233.0.

e. Relieve rudder cable tension by rotating one of the two vertical turnbuckles attached to the pedal assembly at the forward cabin bulkhead.

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- f. Remove the cable guards from the pulley clusters at the forward cabin bulkhead at station 52.0 and directly aft of the main spar at station 115.0 by removing the cotterpins and withdrawing the cable guard tubes.
- g. Remove the cotterpin cable guards from the pulley brackets located on the aft side of the wing rear support bulkhead (left cable only) at station 137.0 and at the bulkhead just aft the stabilator balance weight at station 238.0.
- h. On aircraft equipped with the rudder-aileron interconnect system, slip the left and right interconnect cables from the larger springs they are attached to, then remove the clamps that attach the large springs to the rudder cables.
- i. Separate the rudder control cable from the rudder pedal arm by rotating the required vertical turnbuckle barrel attached to the pedal assembly at station 50.0.
- j. Disconnect the cable from the rudder horn (21) by removing the cotterpins, nuts, washer and bolt (20).
- k. Draw the cable aft out of the fuselage.

**5-34. INSTALLATION OF RUDDER CONTROL CABLES. (Refer to Figure 5-10.)**

- a. Draw cable into fuselage from the tail section, over the pulley at the bulkhead just aft of the stabilator balance weight to station 239.0; under the pulley just aft of the baggage area at station 158.0 (the left cable only, over the pulley at station 137.0); under the pulley just aft of the main spar at station 115.0 at the forward cabin bulkhead at station 52.0.

**CAUTION**

When stringing the cables on the front pulley cluster just aft of firewall, be sure the thread cable in the pulley groove and not over top of either the front or bottom cable guards. (Refer to Figure 5-10, View A-A.)

- b. Connect the cable end to the rudder horn (21) at station 260.0 with bolt, washer, castellated nut and cotterpin (20) to a snug fit. Allow the cable end to rotate freely.
- c. Connect the end of the cable to the arm of the pedal assembly at station 50.0 by assembling the turnbuckle.
- d. Install cable guards at stations 52.0 and 115.0 by inserting the guards into bracket holes and securing with cotterpins.
- e. Install cotterpin cable guards at stations 137.0 and 238.0.
- f. Check rudder travel and cables to assure that not binding occurs.
- g. Set cable tension per Table V-1 and rig and adjust the rudder controls per Paragraph 5-37.
- h. Safety the turnbuckles at the forward cable bulkhead.
- i. On aircraft equipped with rudder-aileron interconnect system, attach the large springs (10) to the rudder cables at the swaged balls by means of clamps (11). If the aircraft is equipped with the Airflow Modification Kit, the springs (10) are attached to the rudder cables by means of clamps (10) spaced as shown in Sketch C, then slip the looped ends of the interconnect cables over the other end of the springs (10).

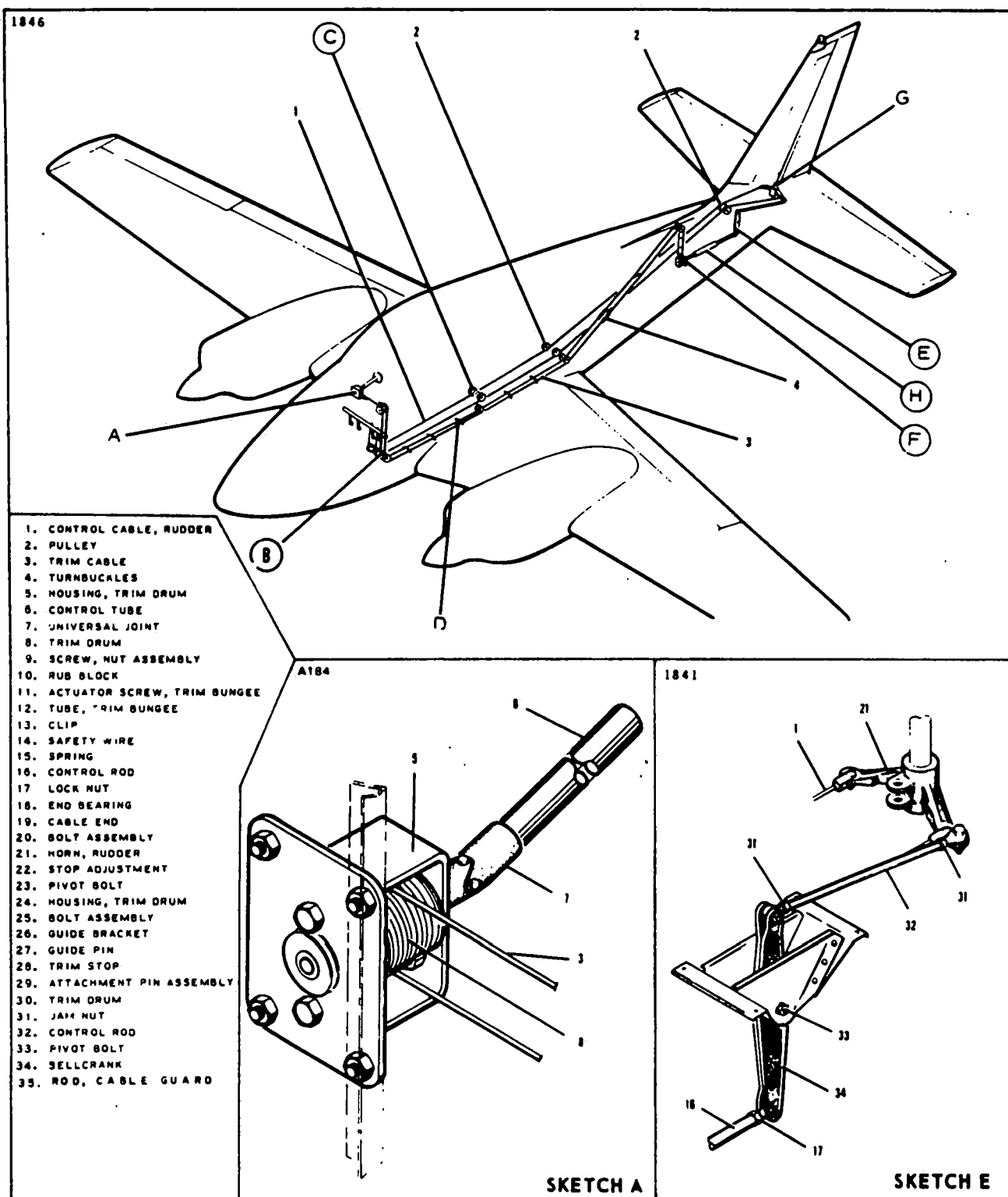


Figure 5-10. Rudder and Rudder Trim Controls

# PIPER TWIN COMANCHE SERVICE MANUAL

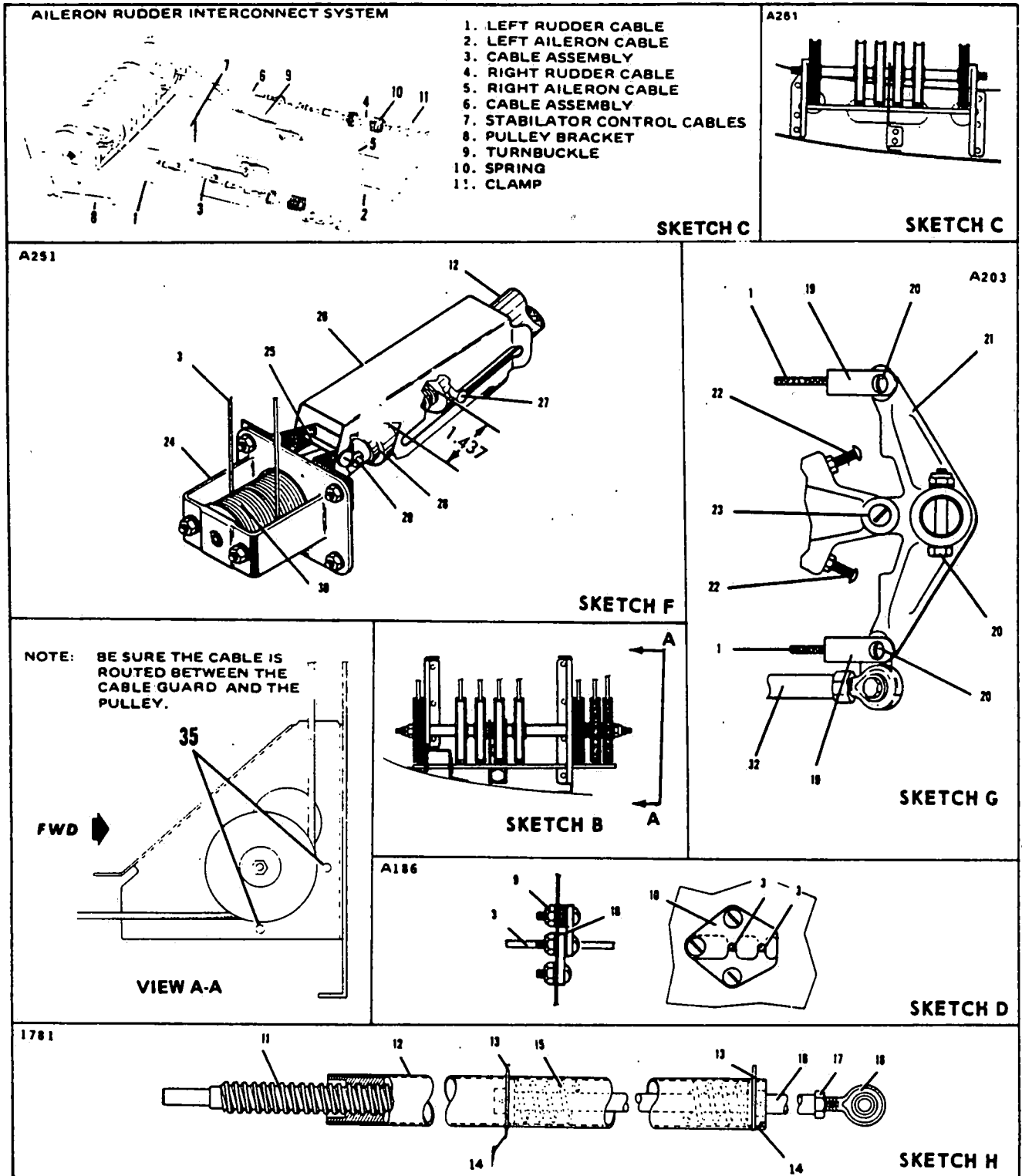


Figure 5-10. Rudder and Rudder Trim Controls (cont.)

j. Insure the interconnect cables are riding in their pulley grooves then adjust the turnbuckle (9) so that the springs (10) have .06 inch extension with rudder and ailerons in neutral position. The length of the left spring may be increased up to .38 inch to allow the aileron controls to spring back approximately equal amounts from right and left stops with the rudder controls held in neutral position.

k. Install the removed floor panels, carpets, scuff plate, access door, access panel, seats and tail cone fairings.

**5-35. REMOVAL OF RUDDER HORN. (Refer to Figure 5-10.)**

- a. Remove tail cone fairings by removing attaching screws and washers.
- b. Relieve rudder cable tension by rotating the turnbuckle of one cable near the forward cabin bulkhead at station 50.0.
- c. Remove cable ends (19) from rudder horn (21) by removing cotter pins, castellated nuts, washers and bolts (20).
- d. Disconnect tail light wire located at the top of the vertical fin by releasing the quick disconnect.
- e. Disconnect the trim control rod (32) from the left side of the rudder horn by removing the cotter pin, castellated nut, washer and bolt.
- f. Remove the cotter pin, castellated nut, washer and bolt (23) holding the rudder horn to the hinge bracket.
- g. Disconnect the rudder from the two remaining hinge brackets in the vertical fin by removing castellated nuts, washers and bolts.
- h. Move the rudder to the right or left and upward to separate the hinge brackets.
- i. Separate the rudder horn from the rudder torque tube assembly by removing nuts, washers and bolts (20). Slide the horn from the torque tube.

**5-36. INSTALLATION OF RUDDER HORN. (Refer to Figure 5-10.)**

- a. Attach the rudder horn (21) to the rudder torque tube with bolts, washers and nuts at the torque tube base.
- b. Align the holes for the hinge bolt in the horn with the hole in the hinge bracket while aligning the bracket holes of the rudder with those in the vertical fin.
- c. Install the bolts, washers and castellated nuts in the three hinge bracket holes.
- d. Connect the tail light on the rudder with the wire in the top of the vertical fin by means of the quick disconnect.
- e. Connect the control cable ends (19) to the rudder horn with bolts, washers, castellated nuts and cotter pins to a snug fit.
- f. Join the rudder trim control rod (32) to its attachment hole on the left side of the rudder horn with bolt, washer, castellated nut and cotter pin.
- g. Set cable tension per Table V-I and check rigging and adjustment of the rudder controls per Paragraph 5-37.
- h. Check the free travel of the rudder and cables, then secure the turnbuckles near the forward cabin bulkhead at station 50.0 with safety clips.

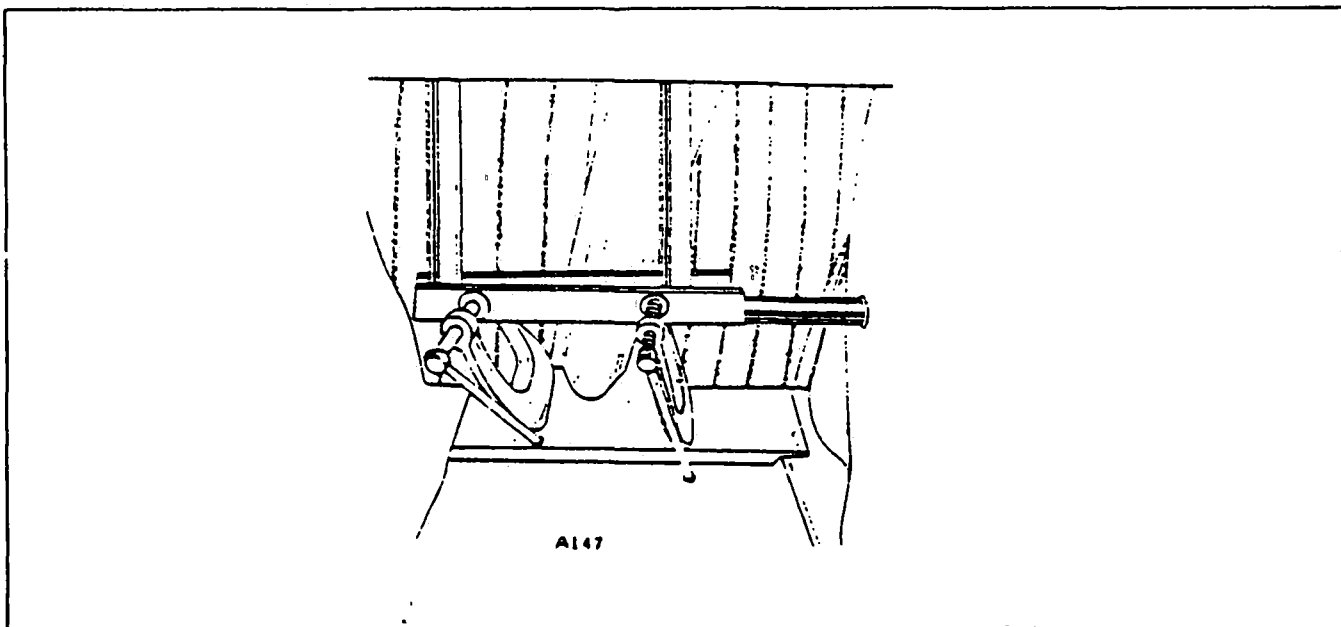


Figure 5-11. Clamping Rudder Pedals In Neutral Position

#### 5-37. RIGGING AND ADJUSTMENT OF RUDDER CONTROLS.

a. Ascertain that the nose gear is properly aligned with the rudder pedals according to Alignment of Nose Landing Gear, Section VII.

b. Check, and if required, adjust rudder for neutral alignment with relation to neutral position of the rudder pedals, and cables for correct tension as required in Table V-I or Table V-IA. The following procedure may be used:

1. Place airplane on jacks (Refer to Jacking, Section II) to clear the nose wheel.
2. Clamp the rudder pedals to align in a lateral position as shown in Figure 5-11.
3. If not previously removed, remove the tail cone fairing by removing attaching screws.
4. Ascertain that rudder trim bungee is in neutral position, (1.437 of exposed rudder trim bungee screw surface as shown in Figure 5-10, Sketch F).

5. Install a small diameter rod on to the bottom of the rudder at the trailing edge. (Refer to Figure 5-12.)

6. Apply masking tape on 90° to airplane centerline, between stabilator halves immediately beneath rod inserted on rudder. On tape, mark the airplane centerline (stabilator trim control rod) and a line 1/4 inch to right of centerline. (Refer to Figure 5-12.)

7. With rudder pedals clamped, check that the rod in the rudder aligns with aircraft centerline and cable tension is correct. (Refer to Table V-I.) On PA-30 aircraft Serial Nos. 30-1 to 30-2000 incl. with Air-flow Modification Kit 760 409 or 760 504, the rudder should be rigged so that with the pedals clamped the rod in the rudder should align with the point 1/4 inch outboard of aircraft centerline as established in Step 6, and cable tension is correct. (Refer to Table VI-IA.) (Cable tension is taken at the flexible portion of the cable at the forward cabin bulkhead, station 50.0.)

8. Should alignment and/or cable tension be incorrect, adjust the turnbuckles which are attached to the rudder pedal assembly to obtain correct alignment and tension.

9. Remove the clamps from the rudder pedals.

c. To check and adjust rudder travel, proceed as follows:



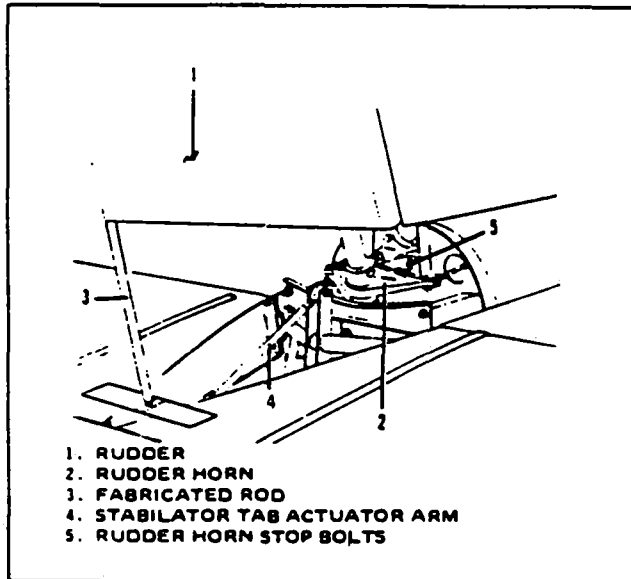


Figure 5-12. Determining Neutral Rudder Position

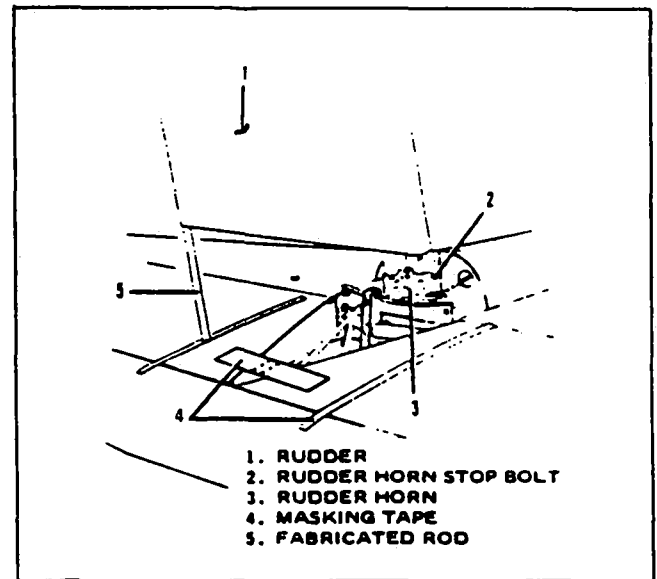


Figure 5-13. Checking Rudder Travel

1. At a distance of 6.52 inches (6.87 inches right and 6.44 inches left on aircraft with Airflow Modification Kit installed) outboard from the centerline of the airplane stabilator trim control rod), make two small dots approximately six inches apart fore and aft, with a pencil, on the top surface of the stabilator, both sides of the rudder and parallel to the airplane's centerline.

2. Run masking tape on each stabilizer surface fore and aft with the edge of the tape placed at the outboard side of the pencil marks.

3. Disconnect the rudder trim system at the lower end of the trim bellcrank at station 251.5.

4. With the small rod attached to the trailing edge of the rudder, swing the rudder in both directions to determine that the pointer intersects the inboard edge of the tapes. (Refer to Figure 5-13.)

5. Should the pointer not intersect the inboard edge of the tape, adjust the rudder stops at the rudder hinge bracket to obtain correct travel.

6. Ascertain rudder trim controls are properly rigged per Paragraph 5-45 and contact control rod to trim bellcrank.

7. From the pilot's seat only, depress each rudder pedal completely and check for full deflection of the rudder to each side.

8. Should the point not intersect the inboard edge of the tape, check for interference at the rudder horn and the nose gear travel stops.

9. If interference is found at the nose gear travel stops, located at the bottom of the strut housing, rework the stops until full deflection of the rudder in both directions is obtained.

NOTE

Maximum allowable nose gear travel is 25 degrees.

10. Check full travel of the nose wheel and rudder to determine that the rudder hits its stops just before the nose wheel hits its stops.

- d. Check safety of turnbuckles and bolts.
- e. Remove pointer rod and install access panels and plates and tail cone fairing.

5-38. RUDDER TRIM CONTROLS.

5-39. REMOVAL OF RUDDER TRIM SCREW AND CABLE ASSEMBLY (FORWARD). (Refer to Figure 5-10.)

a. Remove seats, seat tracks, carpets and floor panels from the left side of the fuselage so that the rub blocks at the bulkheads under the floor panels can be separated. This can be accomplished in the following manner:

1. In airplanes with Serial Nos. 30-2 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the floor panels from the left side of the fuselage between the forward bulkhead and main spar from station 66.5 to 113.8. Within the baggage compartment, remove the carpets and floor panel and from the rear wall remove the access door to the aft section of the fuselage.

2. In airplanes with Serial Nos. 30-853 and 30-902 and up, remove the floor panels from the left side of the fuselage between the forward bulkhead and main spar from station 66.5 to 113.8. Remove the access panels from front and aft corners of foot recess by removing attaching screws. Remove the right family seat, if installed, and remove the access door from the back panel of the baggage area.

b. Remove the top skin assembly from the forward fuselage nose section by removing attaching screws.

c. Remove the access panel from the right rear side of the fuselage at station 233.0.

d. Center the trim indicator to facilitate installation.

e. Block the trim cables (3) at the aft drum assembly, station 226.5 as shown in Figure 5-7 to prevent cables from unwrapping when tension is released at turnbuckles.

f. Disconnect the forward trim cables from the aft cables by rotating the turnbuckles (4) located in the aft section of the fuselage at station 192.0.

g. At the rudder trim control knob below the instrument panel, disconnect the control tube (6) from the universal joint (7) by removing the cotterpin, washer and clevis pin.

h. Remove the cotterpin cable guards from the pulleys that are located in the lower aft area of the fuselage at station 157.5 and forward of the main spar at station 113.8.

i. Separate the rub blocks (10) at stations 136.5, 105.5, 87.5 and 66.5 by removing attaching screws (9).

j. Slide the cable guards from the pulley cluster at the forward cabin bulkhead by removing cotterpins and sliding the guards to the left side of the pulley bracket.

k. Remove the cable retainer plate from its block at the forward cabin bulkhead by removing the attaching screws.

- l. Remove the clamp holding the plastic tubing at the forward cabin bulkhead by removing the attaching screw. (Remove the tubing with the cable.)
- m. Remove the double pulley from the bracket at the forward cabin bulkhead by removing the bolt and washer.
- n. Remove the trim drum (8) and mounting bracket (5) from the forward cabin bulkhead by removing the bolts from the mounting bracket. Remove the nuts and washers forward of the cabin bulkhead by entering through the nose section.
- o. Draw the trim drum, tube and cable from the fuselage cabin.

**5-40. INSTALLATION OF RUDDER TRIM SCREW AND CABLE ASSEMBLY (FORWARD). (Refer to Figure 5-10.)**

- a. Determine that the trim cable assembly is evenly wrapped (centered) on the drum (8) and that the cables are blocked to prevent unwrapping.
- b. Position the trim drum control tube (6) in the universal joint (7) forward of the control knob and below the instrument panel, then align the holes in the trim drum mounting bracket (5) with those in the forward cabin bulkhead and install the bolts (The washers and nuts are installed forward of the bulkhead.)
- c. Install the clevis pin that holds the control tube to the universal joint and secure with a cotterpin.
- d. Draw the ends of the cable through the bulkhead hole at mid-fuselage near the forward bulkhead, then under the pulleys at station 50.0, aft through the bulkhead holes and under the pulleys at the main spar and back panel to the aft section of the fuselage.
- e. With the cable in the tracks of the double pulley, install the pulleys in the bracket at the forward bulkhead by installing the bolt and washer. Be sure the plastic tubing is below and free of pulleys.
- f. With the plastic tubes extending below the cable retainer plate, fasten the upper end of the tubes to forward end of the tubes to the forward cabin wall with clamps and screws.
- g. Install the cable retainer plate on its block at the forward cabin bulkhead by installing attaching screws.
- h. Position the pulley guards in the bracket of the pulley cluster at the forward bulkhead and secure with cotterpins.
- i. Install the rub blocks (10) on the floor support bulkheads at stations 66.5, 87.5, 105.5 and 136.5 by installing the attaching screws (9).
- j. Install cotterpin cable guards in the pulley brackets at stations 113.8 and 157.0.
- k. Attach the forward and aft cables at station 192.0 and gain cable tension as given in Table V-I by rotating the turnbuckle barrels (4). (The turnbuckles should be parallel when the trim tab is in neutral and the cables are evenly wrapped. Rig and adjust per paragraph 5-45.

1. Install top skin assembly of the nose section, the access panel, floor panels, carpets, seat tracks, seats, access door to the aft section of the fuselage.

**5-41. REMOVAL OF RUDDER TRIM SCREW AND CABLE ASSEMBLY (AFT).**  
(Refer to Figure 5-10.)

- a. Block the forward cables at the pulleys just aft of the back baggage compartment or area panel at station 157.5 to prevent unwrapping as shown in Figure 5-7.
- b. Remove the access panel to the aft section of the fuselage by releasing fasteners.
- c. Remove the access plate from the right rear side of the fuselage at station 233.0 by removing the attaching screws.
- d. Block the aft trim drum (30) to prevent unwrapping of the cable.
- e. Separate the aft cable from the forward cables by rotating the turnbuckle barrels (4) in the aft section of the fuselage at station 192.0.
- f. Remove the double pulley from its bracket near the top aft area of the fuselage at station 226.0 by removing nut, washer and bolt.
- g. Detach the guide bracket (26) by removing the nuts, washers and bolts that secure the bracket and trim drum mounting bracket to the bulkhead above the trim drum. Slide the guide bracket aft on the tube assembly.
- h. Free the tube assembly (12) from the aft portion of the universal joint aft of the trim drum by removing the cotter pin, washer and clevis pin (29).
- i. Remove the drum bracket (24) from the bulkhead at station 227.8 by removing the remaining nuts, washers and bolts from the mounting bracket.
- j. Draw the trim drum and cables from the fuselage.

**5-42. INSTALLATION OF RUDDER TRIM SCREW AND CABLE ASSEMBLY (AFT).** (Refer to Figure 5-10.)

- a. With the cables evenly wrapped and blocked, fasten the trim drum (30) and mounting bracket (24) to the bulkhead by installing the bolts, washers, and nuts at the underside of the trim drum.
- b. Secure the control tube (12) to the universal joint of the drum assembly by installing the clevis pin (29), washer and cotter pin.
- c. Secure guide bracket (26) and the upper portion of the trim drum mounting bracket to the bulkhead by installing bolts, washers and nuts.
- d. With the cable in the pulley tracks, install the pulleys in the bracket near the top of the fuselage at station 226.0 by installing bolt, washer and nut.
- e. Connect the aft cables to the forward cables by assembling the turnbuckles (4) at station 292.0.

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- f. Remove cable blocks and gain tension as per Table V-1. Rig and adjust per paragraph 5-45.

**5-43. REMOVAL OF RUDDER TRIM CONTROL TUBE AND BELLCRANK.** (Refer to Figure 5-10.)

- a. Remove the access plate from the right rear side of the fuselage at station 233.0 and remove the tail cone by taking out the attachment screws.
- b. Separate the guide bracket (26) from its bulkhead bracket by removing the cotterpin, nut, washer and screw (25) from the forward part of the bracket at station 228.8.
- c. Separate the tube assembly (12) from the trim drum shaft by removing cotterpin, washer and clevis pin (29) aft of the universal joint.
- d. Disconnect the tube and control rod (16) from the lower end of the bellcrank arm (34) by removing nut, washer and bolt at station 251.50.
- e. Draw the tube assembly out of the fuselage. To disassemble the tube further, use the following steps:
  - 1. Disconnect the aft clip (13) from the tube removing the lockwire (14).
  - 2. Remove clip and pull the control rod (16) with spring (15) from the tube.
  - 3. Remove spring by removing roll pin from bushing.
- f. Separate the bellcrank assembly (34) from its mounting bracket assembly by removing the cotterpin, nut, washer and bolt (33) from station 251.5.
- g. Disconnect the aft control rod (32) from the rudder horn (21) by removing the cotterpin, nut, washer and bolt.
- h. Draw the bellcrank and aft control rod forward, then out through the access hole in the right side of the fuselage.
- i. Disconnect the upper end of the bellcrank from the aft control rod by removing the cotterpin, nut, washer and bolt.

**5-44. INSTALLATION OF RUDDER TRIM CONTROL TUBE AND BELLCRANK.** (Refer to Figure 5-10.)

- a. Assemble the trim bungee tube assembly as follows:
  - 1. Install one bungee spring stop bushing on the bungee rod (16) and secure with roll pin.
  - 2. Slide onto the rod a washer spring (15) and washer compress spring. Install second stop bushing and secure with roll pin.
  - 3. Insert a lock clip (15) into the center most slot of the bungee tube (12) and secure with MS20995-C41 safety wire.
  - 4. Insert the spring assembly into the bungee tube and compress it enough to allow installation of the lock clip. Insert the lock clip into the same side of the tube as the previous clip was and then safety.

5. Install the rod end bearing (18) with jam nut (17) on the bungee rod and adjust to allow a distance of 20.69 inches between the center of the bearing and the end of the tube. Secure end bearing with jam nut.

6. Connect the guide bracket (26) to its bulkhead bracket by installing bolt, washer, castellated nut and cotter pin (25) at the forward part of the bracket. Ascertain that the safety wire (14) that secures the lock clips is at the lower side of the tube.

b. Connect the aft control rod (32) to the upper end of the bellcrank (34) with bolt, washer and nut.

c. Position the bellcrank within the fuselage and secure it to its mounting bracket with bolt, washers and nut.

d. Connect the aft control rod to the rudder horn (21) by installing bolt, washer, nut and cotter pin.

e. Connect the control rod (16) of the bungee assembly to the lower end of the bellcrank by installing bolt, washers and nut. Check rigging and adjustment of the trim system as given in paragraph 5-45.

f. Install tail cone fairing and the right rear side access panel with attaching screws.

#### 5-45. RIGGING AND ADJUSTMENT OF RUDDER TRIM CONTROLS. (Refer to Figure 5-10.)

a. Remove the access panel located on the right side of the fuselage just forward of the stabilator.

b. Place the airplane on jacks and raise enough to allow the nose wheel to clear the floor. (Refer to Jacking, Section II.)

c. If new cables have been installed, operate the trim mechanism from stop to stop several times. This will allow the cables to regain their tightness on the drums.

d. Check cable tension as given in Table V-I.

e. Ascertain that the fore and aft cables are equally wrapped on their drums and the turnbuckles are located opposite each other. If cable drums are not equally wrapped and the turnbuckles are not together, the drums must be removed and re-wrapped. Refer to paragraph 5-47 for wrapping of the drum.

f. With the cables equally wrapped, turnbuckles together and cable tension set as given in Table V-I, the trim indicator at the instrument panel should be in the neutral position. If the indicator is not at neutral, remove the cotter pin and clevis pin securing the universal joint to the trim control. Turn the trim knob until the indicator is at neutral and secure universal joint to trim control with clevis pin and cotter pin.

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g. With the indicator in neutral, measure the distance from the forward end of the trim control tube (12) to the aft surface of the screw stop (28). If the measurement is not 1.437 inch, slide the alignment bracket (26) back by removing attaching nut and bolt (25). Then remove pin (29) securing control tube screw (11) to the universal joint and adjust screw to obtain correct measurement.

h. With measurement obtained, secure the trim screw to the universal joint with clevis pin, washer and cotter pin. Attach the alignment bracket with bolt, washer and nut.

i. Check and, if required, adjust the rod (32) joining the bellcrank (34) to the rudder horn to obtain a measurement of 10.062 inches between the centers of each rod end bearing.

j. Check the rudder for neutral by inserting a small diameter rod into the bottom of the rudder at the trailing edge, and allow its end to extend down to the stabilator trim control rod. Should the rudder not be neutral, disconnect the rod end bearing (18) of bungee assembly from the trim bellcrank and adjust to bring the rudder to neutral. Maintain 0.375 of an inch thread engagement of the rod end bearing in the bungee tube. Remove check rod from rudder.

#### NOTE

If the adjustment cannot be made by adjusting the trim tube rod end bearing only, the adjustment may be divided between both the rudder horn rod and the trim tube end bearing keeping the 0.375 of an inch thread engagement.

k. Check that rod end bearing jam nuts are secure. Install access panel and remove airplane from jacks.

#### 5-46. TRIM DRUM.

5-47. WRAPPING TRIM DRUM. (Refer to Figure 5-14.) All trim drums are wrapped basically by the same procedure and must be removed from the airplane.

a. Mark the end of the drum toward the base of the housing bracket (3) for a reference when later installing and wrapping the cable (1) on the drum.

b. With the drum housing bracket firmly held, remove one of the cable guard bolts (8) from the housing bracket.

c. Remove the drum screw (4) or the drum shaft (9) from the trim screw assembly. The screw is removed by removing the stop (6) located on the end of the screw, opposite the base of the housing bracket. Turn the screw from the drum.

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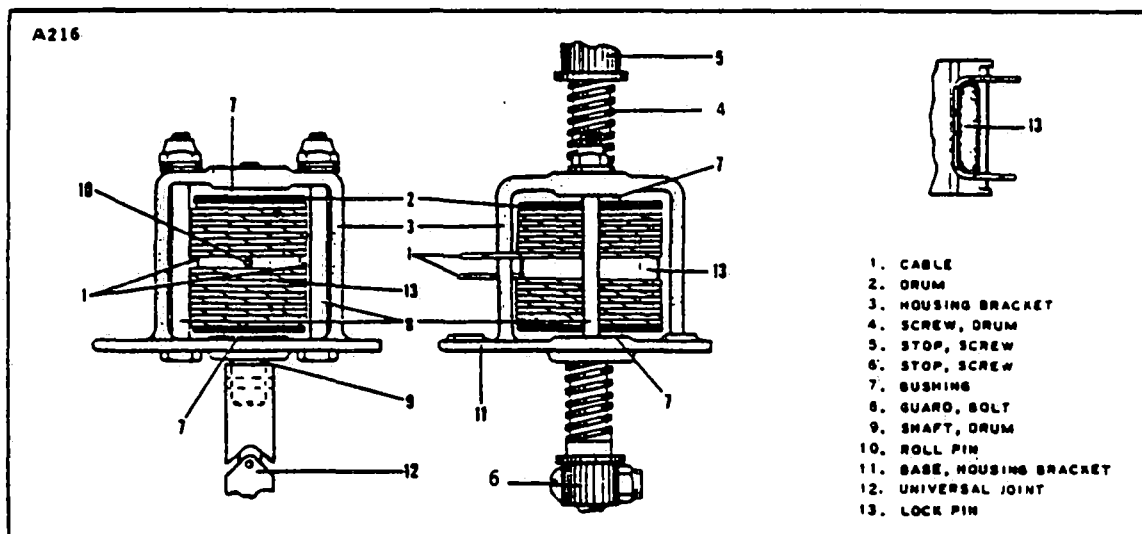


Figure 5-14. Trim Screw Assembly

The shaft is removed by driving the roll pin (10) from the center of the drum. Press the shaft from the drum.

- d. Remove the drum (2) from the housing.
- e. Unwrap the trim cable and remove the cable and lock pin (13) from the drum. (If one end of the cable has been marked to facilitate hook-up of the cable ends, note this location in relation to the drum when installing a new cable on the drum.)
- f. Check the condition of the bushings (7) in the housing for excess wear.
- g. To install and wrap the trim cable, locate the center of the cable, measuring from end to end.
- h. Insert the center of the cable into the cable slot in the drum and install the lock pin.
- i. Hole the drum with the previously marked or base end of the drum down.
- j. Looking down on the drum, wrap up the cable that leads from the base end nine and one-quarter turns in a counterclockwise direction. The cable from the upper end, wrap down in a clockwise direction nine and one-quarter turns.
- k. Insert the drum in the housing bracket, position the drum and route the cables from the assembly as shown in Figure 5-14.
- l. Install the screw and screw stop on the drum shaft and rotate the drum one-quarter turn to allow installation of roll pin.
- m. Block the trim cables in center position to keep them tight and from unwrapping by the method shown in Figure 5-7.
- n. Center the drum between the stops on the screw by rotating the screw.



5-48. WING FLAP CONTROLS.

5-49. REMOVAL OF FLAP TRANSMISSION AND CONTROL ARM ASSEMBLY.  
(Refer to Figure 5-15.)

a. Remove the seats, carpets and floor panels as necessary to expose the center fuselage section between the main and rear spars. If desired, remove the panel from the underside of the fuselage.

b. Removal of the flap transmission assembly may be accomplished by the following procedure:

1. Disconnect the motor electrical leads.

2. Extract the pin (26) at the transmission housing by removing cotter pin (23) and washer (24).

3. Remove the bolt (29) at the forward position of the actuating screw (28) by removing cotter pin and nut (32).

4. Remove attaching screw.

c. The actuating arms may be removed by the following procedure:

1. Disconnect the flap position sender rod (15) by removing the screw from the rod attachment bushing at the actuating arm (17).

2. Disconnect the control cable fork end or turnbuckle (20) end at each actuating arm by removing the cotter pin, castellated nut and bolt (19).

3. Remove the pivot bolt at the top spar support tube (11) by removing the cotter pin, nut, washer and bolt.

4. If not previously removed, separate the actuating screw (28) from the bottom of the actuating arms by removing the bolt, washers and nut.

5. Remove the actuating arms.

d. The spar support assembly may be removed by the following procedure:

1. If not previously disconnected, disconnect the cable fork end or turnbuckle end at each actuating arm by removing the cotter pins, castellated nuts and bolts.

2. Remove the cable pulleys (3) from their brackets by removing the nuts, washers and bolts.

3. Disconnect the electrical lead to the sender unit assembly (16) by removing attaching nut.

4. Remove the support from the recess between the two longitudinal bulkheads by removing the attaching bolts, washers and nuts.

5. With the flap transmission assembly and actuating arms removed, disconnect the support assembly from the main and rear spars by removing nuts, bolts and washers. Note the location of the shim washer on one side of plate between the angles at the rear spar.

6. Remove the spar support assembly from the airplane.

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e. If the spar support assembly is to be removed with the actuating arms and transmission assembly attached, the following procedure may be used:

1. Disconnect the electrical leads to the motor and coil assemblies on the forward right side of the spar support assembly.
2. Disconnect the electrical lead to the flap position sender on the right rear side of the support assembly by removing the attaching nut.
3. Disconnect the cable fork end or turnbuckle end at each actuating arm by removing the cotterpins, castellated nuts and bolts.
4. Remove the cable pulleys from their brackets by removing the nuts, washers and bolts.
5. Remove the support from the recess between the two longitudinal bulkheads by removing the nuts, washers and bolts securing it to the bulkhead.
6. Disconnect the spar support assembly from the main and rear spars by removing the nuts, washers and bolts. Note the location of the shim washer to one side of the plate between the angles at the rear spar.
7. Draw the spar support assembly from its recess in the center fuselage.

#### 5-50. CLEANING, INSPECTION AND REPAIR OF FLAP TRANSMISSION.

- a. Clean the transmission assembly with a suitable solvent.
- b. Inspect the transmission tube for excessive end or side play on the transmission screw.
- c. Ascertain that the transmission tube and screw are not distorted or bent.
- d. Check that the screw bearing is not loose on the transmission screw or within the transmission housing. Excess wear can be determined by holding the transmission and moving the screw up and down.
- e. Check for excess wear within the transmission by turning the screw by hand and noting the end and side play in the transmission drive shaft. End play should not be great enough to cause end pressure on the motor drive shaft.
- f. Should any of these checks show excess wear, corrosion or damage, the transmission or its components should be replaced.
- g. When the transmission assembly is disassembled for any reason, or at 500 hours, it should be repacked with MIL-G-23827 grease.

#### NOTE

Refer to Lubrication Chart, Special Instructions for specific lubrication instructions of flap transmission assembly.

**5-51. INSTALLATION OF FLAP TRANSMISSION AND CONTROL ARM ASSEMBLIES. (Refer to Figure 5-15.)**

a. Installation of the spar support assembly with the flap transmission and control arm assemblies installed may be accomplished by the following procedure:

1. Align the forward end of the spar support (11) with four attachment holes in the main spar and align the aft end in the slot between the attachment angles at the rear spar. Attach the spar support to the main spar with bolts, washers and nuts to determine which side of the slot at the rear spar needs the shim washers. The aft end of the spar support will fall to one side of the slot when fastened at the main spar. Place the shim washer in the slot space and install with bolt, washer and nut.

2. Install the bulkhead support through the center of the spar support assembly by installing the bolts, washers and nuts that secure it to the bulkheads.

3. With cables (2) and (9) in the pulley tracks, install pulleys (3) in the brackets with bolts, washers and nuts.

4. Temporarily connect the cable fork ends or turnbuckle ends (20) at each actuating arm (17 and 18). After rigging and adjustment, permanently secure ends with bolts, washers, castellated nuts and cotter pins. Allow cable ends freedom to rotate.

5. Install the electrical leads to the motor and coil assemblies on the forward right side of the spar support assembly. Refer to Electrical Systems Schematic, Section XI, for wiring hookup details.

6. Connect the electrical lead to the sender unit assembly (16) by installing attaching nut.

7. Rig and adjust per paragraph 5-58.

b. Installation of the spar support assembly with actuating arms and transmission assembly removed may be accomplished by the following procedure:

1. Align the forward end of the spar support with the four attachment holes in the main spar and align the aft end in the slot between the attachment angles at the rear spar. Attach the spar support to the main spar with bolts, washers and nuts to determine which side of the slot at the rear spar needs the shim washer. The aft end of the spar support will fall to one side when fastened at the main spar. Place the shim washer in the slot space and secure with bolt, washer and nut.

2. Install the bulkhead support through the center of the spar support assembly by installing the bolts, washers and nuts that secure it to the bulkheads.

3. With cables in the pulley tracks, install pulleys in brackets with bolts, washers and nuts. Allow ends freedom to rotate.

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c. Installation of the control arm assembly may be accomplished as follows:

1. Attach the actuating arms (17 and 18) to the top of the spar support assembly with bolt, washer and nut.
2. Slide the end of the flap position sender rod (15) into the rod attachment bushing. Allow the screw to remain loose until flap adjustments are made.
3. Secure the actuating arms to the forward end of the transmission screw, if transmission is installed, with adapter (31), bushing (30), bolt (29), washer, nut and cotter pin.
4. With the cables in the pulley tracks, install the pulleys in the brackets with bolts, washers and nuts.
5. Temporarily connect the cable fork or turnbuckle ends (20) to the actuating arms. After adjustment, secure cable ends by installing bolts, washers, castellated nuts and cotter pins. Allow ends freedom to rotate.

d. Installation of the flap transmission assembly may be accomplished as follows:

1. Connect the aft end of the transmission assembly with the attachment bracket of the spar support by installing clevis pin (26), washer (24) and cotter pin (23) just forward of the rear spar.
2. Rotate the actuating screw (28) counterclockwise until the bushing hole in the end of the screw housing aligns with the bottom holes of the actuating arms. Install adapter (31), bushing (30), bolt (29), washers and nut.
3. Connect the motor and coil assembly electrical leads. Refer to Electrical Systems Schematic, Section XI, for wiring hookup details.

#### 5-52. REMOVAL OF FLAP CONTROL CABLES. (Refer to Figure 5-15.)

a. Removal of flap control cables in airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive may be accomplished by the following procedure:

1. Remove the carpets, seat and floor panel from the baggage area.
2. From the underside of the wing remove the wing root fairing, the splash plate from the wheel well and the flap bellcrank access plate from station 72.0.
3. Within the fuselage disconnect the control cables (2) and (9) from the actuating arm (17 and 18) by removing the cotter pin, nut, washer and bolt from the cable fork end (20).
4. Remove the pulley (3) from the bracket on the spar support (11) by removing bolt (19), nut and washer.
5. Separate the flap control cable at the turnbuckle within the fuselage by rotating the turnbuckle barrel. Separate the left cable end from the spring (5) on the fuselage floor.
6. Remove the cotter pin cable guard from the pulley bracket within the wing root just outside the fuselage.

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7. Within the right wheel well only, remove the small pulley (3) from the link assembly on the step lock mechanism by removing nut, washers and bolt.

8. Remove the cotter pin cable guard from the pulley bracket within the wheel well at station 41.0.

9. Disengage the step lock pulley (3) and pull the flap down to gain access to the aft arm of the flap bellcrank (10) at wing station 75.0. (If the flap is to stay down during removal, the return cable (35) may be released within the right wheel well by removing the return spring (4) from its bracket forward of the step lock by removing cotter pin, pin and washer.)

10. Disconnect the cable fork end from the aft arm of the bellcrank at wing station 75.0 by removing cotter pin, castellated nut, washer and bolt.

11. Draw the cable out through the wing.

b. Removal of flap control cables in airplanes with Serial Nos. 30-853, 30-902 and up may be accomplished in the following manner:

1. Remove the seats, seat tracks, carpets and floor panels between the main and rear spars.

2. From the underside of the wing, remove the wing root fairing, the splash plate from the wheel well and flap bellcrank access plate at station 72.0.

3. Within the fuselage, disconnect the control cables (2 and 9) from the actuating arm (17 and 18) at the turnbuckle end (20) by removing cotter pin, nut, washer and bolt.

4. Remove the pulley (3) from the bracket on the spar support (11) and from the bracket near the top of the rear spar by removing nuts, washers and bolts.

5. Remove the cotter pin cable guard from the small pulley bracket within the wing root just outside the fuselage.

6. Within the right wheel well only, remove the small pulley (3) from the link assembly on the step lock mechanism by removing nut and bolt.

7. Remove the cotter pin cable guard from the bracket within the wheel well at station 41.0.

8. Disengage the step lock pulley (3) and pull the flap downward to gain access to the aft arm of the flap bellcrank (10) at wing station 75.0. (If the flap is to stay down during removal, the return cable (35) may be released within the right wheel well by removing the return spring (4) from its bracket forward of the step lock by removing cotter pin, pin and washer.)

9. Remove the cable fork end from the aft arm of the bellcrank at wing station 75.0 by removing cotter pin, castellated nut, washer and bolt.

10. Draw the cable out through the wing.

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5-55. INSTALLATION OF FLAP BELLCRANK. (Refer to Figure 5-15.) Installation of the flap bellcrank may be accomplished by the following procedure:

- a. Determine that the spring link (41) and control rod (40) are installed on the forked arm of the bellcrank (1 or 10) and that the control rod length is set per paragraph 5-58.
- b. Position the bellcrank in its mounting bracket at wing station 72.0 with the forked arm outboard and the remaining arm aft. Secure the bellcrank with pivot bolt.
- c. Install the cable on the aft arm of the bellcrank with bolt, washer and cotter pin (19). Allow the cable freedom to rotate.
- d. With the forward end of the control rod (40) and one end of the link (41) attached to the forward arm of the bellcrank, connect the link with the flap return spring (4) forward of the bellcrank.
- e. Rotate the turnbuckles (20) within the fuselage to draw the bellcrank arm and control rod aft for attachment to the flap.
- f. Pull the flap down to the extended position.
- g. Place the bellcrank in the extended position and guide the control rod through the hole in the trailing edge of the wing.
- h. Attach the flap to the aft end of the control rod with bolt, nut and cotter pin.
- i. Rig and adjust per paragraph 5-58.
- j. Replace access panels, wheel well splash plate, floor panels, carpets, seat tracks and seats.

5-56. REMOVAL OF STEP LOCK ASSEMBLY. (Refer to Figure 5-15.)

- a. From the right wing remove the wheel well splash plate, and the access plate from the underside of the right flap at the inboard end.
- b. Remove the wing root fairing from the under side of the right wing.
- c. Remove the small pulley (3) to the link assembly on the step lock by removing nut, washer and bolt.
- d. Disconnect the flap return spring (4) by removing the cotter pin, pin and washer from the bracket forward of the step lock.
- e. Disconnect the aft end of the flap return cable (35) by removing nut and washer from the cable end within the flap.
- f. Extend the flap manually and remove the nuts and bolts that secure the step lock mounting bracket to the trailing edge and inboard edge of the wing.

**5-57. INSTALLATION OF STEP LOCK ASSEMBLY.** (Refer to Figure 5-15.) Installation of the step lock assembly may be accomplished by the following procedure:

- a. With the flap extended, position the step lock mounting bracket within the right wing and secure it to the inboard and trailing edges by installing the attaching bolts and nuts.
- b. With the cable placed through the holes in the wing trailing edge and through the leading edge of the flap, retract the flap and rotate the adjusting nut with washer a few threads on the aft end of the cable.
- c. Connect the flap return spring to its bracket forward of the step lock by installing pin, washer and cotter pin.
- d. With the step lock engaged, and with the flap control cable in the pulley tracks, install the small pulley on the link assembly of the step lock by installing bolt, washer and nut.
- e. Rig and adjust per paragraph 5-58.
- f. Install flap access plate and wheel well splash plate.

**5-58. RIGGING AND ADJUSTMENT OF FLAPS.** (Refer to Figure 5-15.)

- a. To rig and adjust the flaps, the following procedure may be used:
  1. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the rear seat. In airplanes with Serial Nos. 30-853, 30-902 and up, remove the seats, seat tracks, carpet and floor panels between the main and rear spar.
  2. Remove the flap bellcrank access plates from the underside of each wing at station 72.0, and remove the flap return cable adjustment access plate from the inboard underside of the right flap.
  3. Check and, if required, adjust the fork end (38) of the flap control rod (40) so that one inch is measured from the end of the control rod to the center of the hole in the fork. Then adjust the control rod bearing end (42) to a length of 5.313 from the center of the hole in the rod end bearing to the center of the hole in fork. Secure with jam nuts.
  4. With the flap cables disconnected from the actuating arms (17 and 18), adjust the down limit switch actuating screw (13), located on the actuating arm, so that the screw (28) of the transmission assembly extends to  $14.25 \pm 0.062$ . This measurement is taken from the forward face of the transmission housing to the center line of the attaching bolt (29) at the lower end of the actuating arm. (Refer to Figure 5-15.)
  5. Retract the actuating screw and connect the cable or turnbuckle fork ends to the actuating arms with bolts, washers, nuts and cotter pins. Allow the cable ends freedom to rotate.

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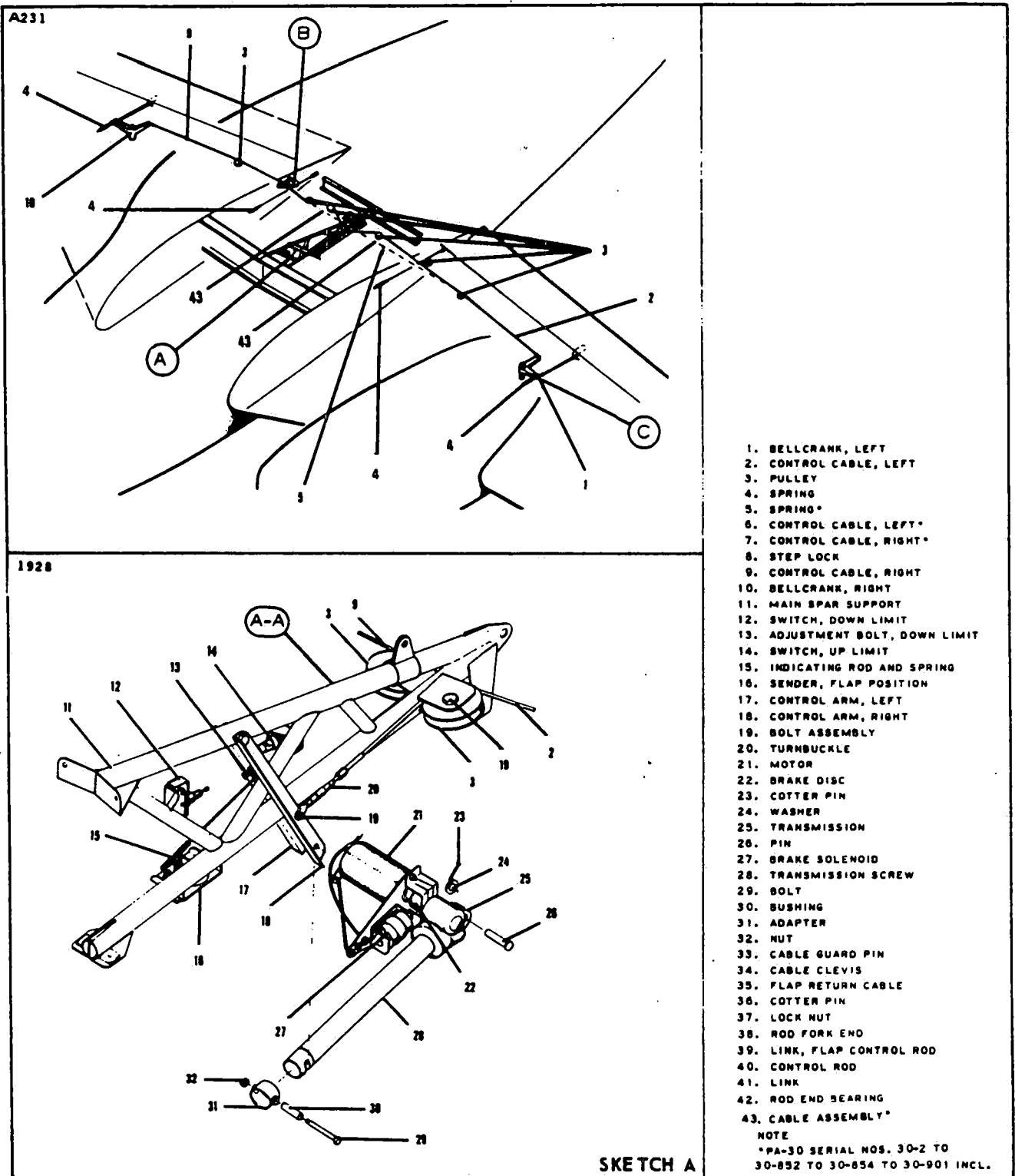


Figure 5-15. Flap Control Installation



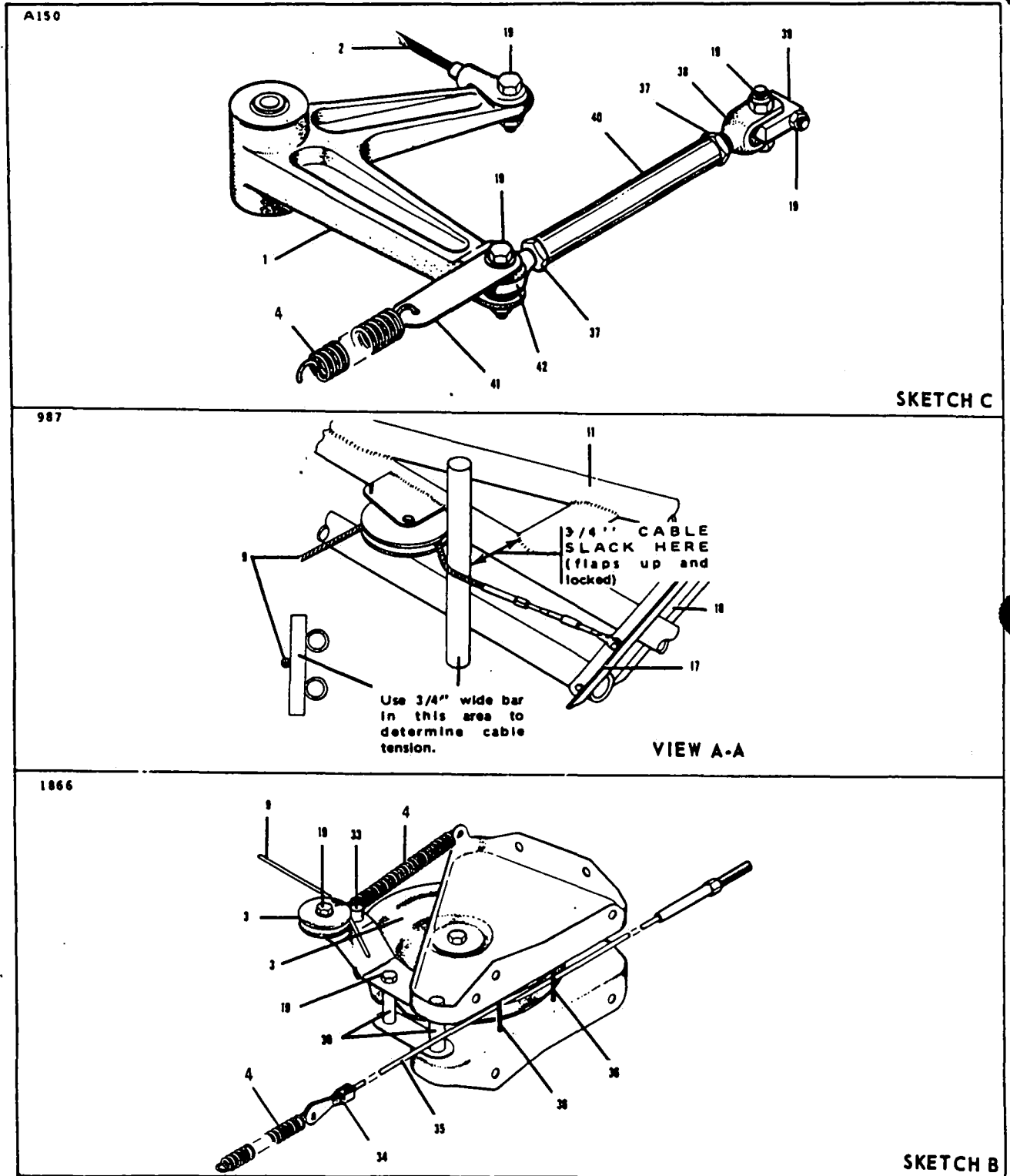


Figure 5-15. Flap Control Installation (cont.)

6. Extend the actuating screw until the down limit switch disengages the electric motor. Adjust the turnbuckles (20) to allow 27 degrees of flap deflection. This adjustment may be accomplished as follows:

(a) Position the flap with roller snug against the upper end of the flap track slot. (With the airplane level, this will allow a flap angle of 13 degrees as read on a bubble protractor placed on the upper side of the flap, outboard of the rivets which are located 23 inches from the flap inboard end.)

#### NOTE

Occasionally flaps are adjusted to compensate for wing heaviness with a stop screw located between the center roller brackets of the flap. If the screw stop prevents the roller from contacting the upper end of the flap track, then rotate the screw clockwise to allow the roller to make contact. The screw should be readjusted for compensating flap deflection after rigging and adjustment is completed.

(b) Place 0 degrees on the bubble protractor, then extend the flap until the down limit switch disengages the electric motor. Adjust the turnbuckles within the fuselage to achieve  $27 \pm 1$  degree of flap deflection. (The angle of the flap with the airplane level should be  $40 \pm 1$  degree.)

(c) Safety the turnbuckles.

7. Adjust the actuating screw of the up limit switch (14) located on the right actuating arm to slacken the cable enough to fully engage the step lock. To accomplish this adjustment, retract the flap fully and adjust the actuating screw to disengage the electric motor when  $3/4 \pm 1/8$  inches slack is gained in the cable at a point 2.5 inches forward of the spar support pulley bracket. (Refer to Figure 5-15.) This slack may be pulled by hand. The left cable will have more slack than the right due to the absence of a step lock. In the fuselage of airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, be sure that the left flap cable tension spring (5) is secured.

8. The step lock cable (35) may be adjusted by turning the adjusting nut at the aft end of the cable (located within the access hole on the inboard, underside of the flap) until approximately  $1/8$  inch vertical play exists in the flap at its trailing edge.

9. To calibrate and adjust the flap position indicator, refer to instructions in paragraph 5-60.

10. Actuate the flap system and check for proper functioning. Check turnbuckles and push-pull rods for safeties.

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11. Reinstall access plates, floor panels, carpets, seat tracks and seats as necessary.

### 5-59. CHECKING FLAP INDICATING SYSTEM.

#### a. Flap position sender check.

1. Remove access plates and panels at flap actuating mechanism.
2. Loosen set screw securing indicating rod to the right control arm.
3. Disconnect electrical lead from sender unit.

4. Connect an ohmmeter to the sender unit, attaching the ohmmeter ground lead to the sender case.

5. Move the indicating rod aft until the sender arm reaches stop "A". (Refer to Figure 5-16.) The ohmmeter should read from 0.00 to 0.50 ohms.

6. Slowly move the indicating rod forward to stop "B" while watching the ohmmeter. The ohmmeter needle should steadily move up the scale without fluctuation, as the indicating rod is moved.

7. With the sender arm against stop "B", the ohmmeter should indicate from 29.6 to 31.3 ohms. If incorrect resistance or fluctuation is found, the sender should be replaced.

8. Check sender ground contact to mounting bracket, it should be free of corrosion.

#### b. Wiring check.

1. Check all ground connections throughout the indicating system for corrosion or loose connections that may cause excessive resistance in the circuit.
2. Check all splices and terminal connections for corrosion and security.
3. Check wiring between connections for excessive resistance due to frayed or broken strands.

#### c. Gauge check.

1. Connect a 14-volt power supply to flap gauge and sender unit. Ascertain the sender is good and has a good ground contact against its mounting bracket.

2. Move sender unit arm up to stop "A" (Refer to Figure 5-16.). the flap indicator gauge needle should point to the up position.

3. Slowly move the sender arm to stop "B", the gauge needle should move steadily without fluctuation and point to the full down position.

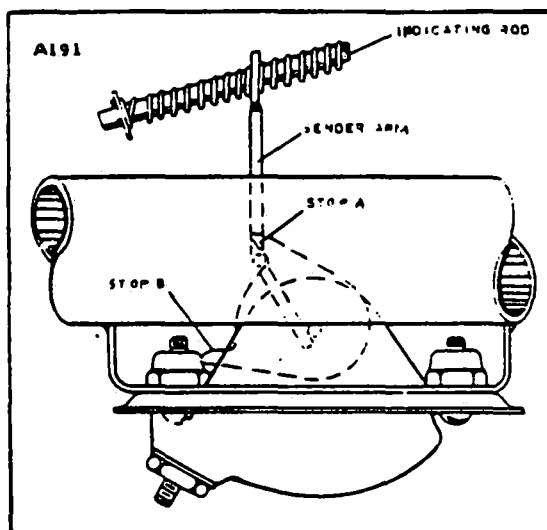


Figure 5-16. Flap Position Sender Unit

5-60. RIGGING AND ADJUSTMENT OF FLAP POSITION SENDER.

- a. Lower the flaps to 15 degrees extension. This positions the indicator on the instrument panel at the bottom of the white arc.
- b. Adjust the position sender rod by means of a set screw at the flap actuating arm so that the indicator hand on the instrument panel is at the bottom of the white arc.
- c. Operate the flap system and check for proper operation.
- d. Check the turnbuckles and push-pull rods for safeties.

NOTE

When determining the deflection angle of the flap, use a bubble protractor. The angle between the aircraft leveling lugs and the flaps when they are full retracted should be 13 degrees, when the flaps are fully extended to 27 degrees the angle should be 40 degrees. Tolerances are  $\pm 1$  degree.

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TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS)

Trouble	Cause	Remedy
<b>AILERON CONTROL SYSTEM</b>		
Lost motion between control wheel and aileron.	<p>Cable tension too low.</p> <p>Linkage loose or worn.</p> <p>Broken pulley.</p> <p>Cables not in place on pulleys.</p>	<p>Adjust cable tension. (Refer to Table V-I.)</p> <p>Check linkage and tighten or replace.</p> <p>Replace pulley.</p> <p>Install cables correctly. Check cable guards.</p>
Resistance to control wheel rotation.	<p>System not lubricated properly.</p> <p>Cable tension too high.</p> <p>Control column horizontal chain improperly adjusted.</p> <p>Pulleys binding or rubbing.</p> <p>Cables not in place on pulleys.</p> <p>Cables crossed or routed incorrectly.</p>	<p>Lubricate system. (Refer to Lubrication Chart, Section II.)</p> <p>Adjust cable tension. (Refer to Table V-I.)</p> <p>Adjust chain. (Refer to paragraph 5-6.)</p> <p>Replace binding pulleys and/or provide clearance between pulleys and brackets.</p> <p>Install cables correctly. Check cable guards.</p> <p>Check routing of control cables.</p>
Control wheels not synchronized.	Incorrect control column rigging.	Rig in accordance with paragraph 5-6.

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Added: 1/31/74

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
AILERON CONTROL SYSTEM (cont.)		
Control wheels not horizontal when ailerons are neutral.	Incorrect rigging of aileron system.	Rig in accordance with paragraph 5-12.
Incorrect aileron travel.	Aileron control rods not adjusted properly.	Adjust in accordance with paragraph 5-12.
	Aileron bellcrank stops not adjusted properly.	Adjust in accordance with paragraph 5-12.
Correct aileron travel cannot be obtained by adjusting bellcrank stops.	Incorrect rigging of aileron cables, control wheel and control rod.	Rig in accordance with paragraph 5-12.
Control wheel stops before control surfaces reach full travel.	Incorrect rigging between control wheel and control cables.	Rig in accordance with paragraph 5-12.
STABILATOR CONTROL SYSTEM		
Lost motion between control wheel and stabilator.	Cable tension too low.	Adjust cable tension per Table V-I.
	Broken pulley.	Replace pulley.
	Cables not in place on pulleys.	Install cables correctly.

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Added: 1/31/74

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TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
<b>STABILATOR CONTROL SYSTEM (cont.)</b>		
Resistance to stabilator control movement.	<p>System not lubricated properly.</p> <p>Control wheel travel resistance too high.</p> <p>Cable tension too high.</p> <p>Pulleys binding or rubbing.</p> <p>Stabilator binding at stabilator bearings.</p> <p>Cables not in place on pulleys.</p> <p>Cables crossed or routed incorrectly.</p>	<p>Lubricate system. (Refer to Lubrication Chart, Section II.)</p> <p>Lubricate and adjust control column per Section V, 5-6.</p> <p>Adjust cable tension per Table V-I.</p> <p>Replace binding pulleys and/or provide clearance between pulleys and brackets.</p> <p>Replace bearings and/or readjust stabilator attachment bolts per Section IV, 4-9b.</p> <p>Install cables correctly.</p> <p>Check routing of control cables.</p>
Incorrect stabilator travel.	Stabilator stop bolts incorrectly adjusted.	Adjust stop screws per paragraph 5-20.
Correct stabilator travel cannot be obtained by adjusting stop bolts.	Stabilator cables incorrectly rigged.	Rig cables in accordance with paragraph 5-20.



TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
<b>STABILATOR TRIM CONTROL SYSTEM</b>		
Lost motion between trim control handle and trim tab.	Cable tension too low.	Adjust in accordance with Table V-I.
	Cables not in place on pulleys.	Install cables according to paragraphs 5-23 and 5-25.
	Broken pulley.	Replace pulley.
	Linkage loose or worn.	Check linkage and tighten or replace.
Trim control handle moves with excessive resistance.	System not lubricated properly.	Lubricate system. (Refer to Lubrication Chart, Section II.)
	Cable tension too high.	Adjust in accordance with Table V-I.
	Pulleys binding or rubbing.	Replace binding pulleys. Provide clearance between pulleys and brackets.
	Cables not in place on pulleys.	Refer to paragraphs 5-23 and 5-25.
	Trim tab hinge binding.	Lubricate hinge. If necessary, replace.
	Cables crossed or routed incorrectly.	Check routing of control cables.

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Added: 1/31/74

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
STABILATOR TRIM CONTROL SYSTEM (cont.)		
Trim indicator fails to indicate correct trim position.	Trim indicator not properly adjusted.  Trim indicator wire broken.	Adjust in accordance with paragraph 5-28.  Replace wire.
Trim indicator fails to indicate any movement.	Trim indicator wire broken.  Broken indicator tension spring.  Forward trim pulley slipping when crank is turned.	Replace wire.  Replace spring.  Check for oil or grease or loose cables and tighten in accordance with Table V-I.
Trim tab fails to reach full travel.	System incorrectly rigged.  Trim drum incorrectly wrapped.	Check and/or adjust rigging per paragraph 5-26.  Check and/or adjust rigging per paragraph 5-26.

SURFACE CONTROLS  
Added: 1/31/74

# PIPER TWIN COMANCHE SERVICE MANUAL

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
RUDDER CONTROL SYSTEM		
Lost motion between rudder pedals and rudder.	Cable tension too low.	Adjust cable tension per Table V-I and paragraph 5-37.
	Broken pulley.	Replace pulley.
	Bolts attaching bellcrank to rudder are loose.	Tighten bellcrank bolts.
Excessive resistance to rudder pedal movement.	System not lubricated properly.	Lubricate system. (Refer to Lubrication Chart, Section II.)
	Rudder pedal torque tube bearing blocks in need of lubrication.	Lubricate torque tube bearing blocks. Consult Lubrication Chart, Section II.
	Cable tension too high.	Adjust cable tension per paragraph 5-37 and Table V-I.
	Pulleys binding or rubbing.	Replace binding pulleys and/or provide clearance between pulleys and brackets.
	Cables not in place on pulleys.	Install cables correctly. Check cable guards.
	Cables crossed or routed incorrectly.	Check routing of control cables.

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
RUDDER CONTROL SYSTEM (cont.)		
Rudder pedals not neutral when rudder is streamlined.	Rudder cables incorrectly rigged.	Rig in accordance with paragraph 5-37.
Incorrect rudder travel.	Rudder bellcrank stop incorrectly adjusted.  Nose wheel contacts stops before rudder.	Rig in accordance with paragraph 5-37.  Rig in accordance with paragraph 5-37.

SURFACE CONTROLS  
Added: 1/31/74

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
<b>FLAP CONTROL SYSTEM</b>		
Flaps fail to extend or retract though flap solenoid actuates. (Motor circuit.)	Master switch off. Defective flap selector switch. Defective flap motor circuit relay. Ground open from flap motor circuit relay. Ground open from flap selector switch. Defective flap motor. Defective circuit wiring.	Turn switch on. Replace selector switch. Replace relay. Check ground connection. Check ground connection. Replace motor. Isolate cause and repair.
Flaps fail to extend or retract. Flap solenoid does not actuate. (Solenoid circuit.)	Master switch off. Flap solenoid circuit breaker open. Defective flap selector switch. Defective up or down limit switch. Defective flap solenoid. Ground open from flap solenoid. Defective circuit wiring.	Turn switch on. Reset circuit breaker. Replace selector switch. Replace defective switch. Replace flap solenoid. Check ground connection. Isolate cause and repair.

SURFACE CONTROLS  
Added: 1/31/74

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
FLAP CONTROL SYSTEM (cont.)		
Flaps have erratic sluggish or retarded operation during extension and retraction.	<p>Transmission needs lubrication.</p> <p>Binding between track and rollers.</p> <p>Slipping or stripped transmission.</p> <p>Loose electrical connection.</p> <p>Dirt, foreign material, paint or damage to flap rollers and tracks.</p> <p>Improper lubricant.</p>	<p>Lubricate the transmission. (Refer to the Lubrication Chart, Section II.)</p> <p>Check for defective parts and replace if necessary.</p> <p>Replace transmission.</p> <p>Check and repair electrical connections.</p> <p>Clean and replace if necessary.</p> <p>Refer to Lubrication Chart, Section II.</p>
No indication of flap position on indicator.	<p>Defective indicator unit.</p> <p>Sender unit not adjusted properly.</p> <p>Defective wiring.</p> <p>Master switch off.</p> <p>Circuit breaker open.</p> <p>Sender unit ground open.</p> <p>Mechanical linkage between walking beam and transmitter, broken or disconnected.</p> <p>Transmitter inoperative.</p>	<p>Replace indicator unit.</p> <p>Adjust sender unit in accordance with paragraph 5-56.</p> <p>Check and repair wiring.</p> <p>Turn switch on.</p> <p>Reset circuit breaker.</p> <p>Check ground connection.</p> <p>Check and repair.</p> <p>Repair.</p>

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
FLAP CONTROL SYSTEM (cont.)		
Flap indicator shows flaps down when they are up.	Incomplete ground.	Check ground connections at transmitter under rear seat.
Flaps fail to retract completely.	Up limit switch incorrectly adjusted.	Adjust flap in accordance with paragraph 5-58.
Flaps do not extend completely.	Down limit switch incorrectly adjusted.	Adjust in accordance with paragraph 5-58.
Flap on one side fails to operate.	Broken control cable.	Repair or replace control cable.
Flaps not synchronized or fail to fit evenly when retracted.	Incorrect rigging.	Rig in accordance with paragraph 5-58.
Sluggish or retarded flap retraction.	Weak retraction springs.	Install Spring No. 83302-54 on the bell-crank links and No. 83302-40 on the return cables.
Flap actuating system fails to shut off when flaps are full up or full down.	The limit switches are out of adjustment.	Reset limit switches. (Refer to paragraph 5-58.)

SURFACE CONTROLS  
Added: 1/31/74

TABLE V-II. TROUBLESHOOTING CHART (SURFACE CONTROLS) (cont.)

Trouble	Cause	Remedy
FLAP CONTROL SYSTEM (cont.)		
Right flap fails to lock when in the retracted position.	<p>Flap actuating cable has insufficient slack.</p> <p>Spring on flap locking mechanism broken.</p>	<p>Rerig up lock cable. (Refer to paragraph 5-58.)</p> <p>Replace spring.</p>

SURFACE CONTROLS  
Added: 1/31/74



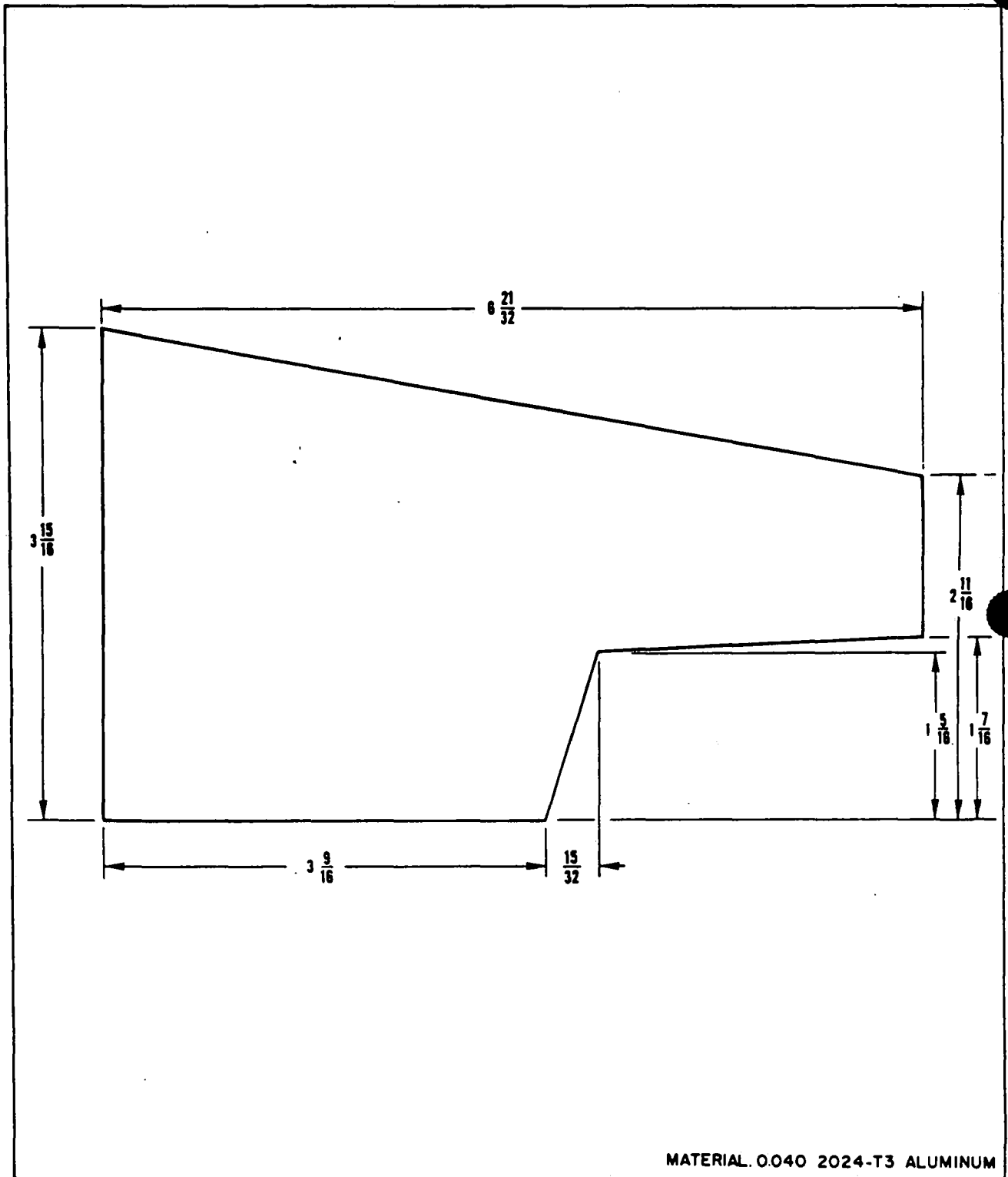
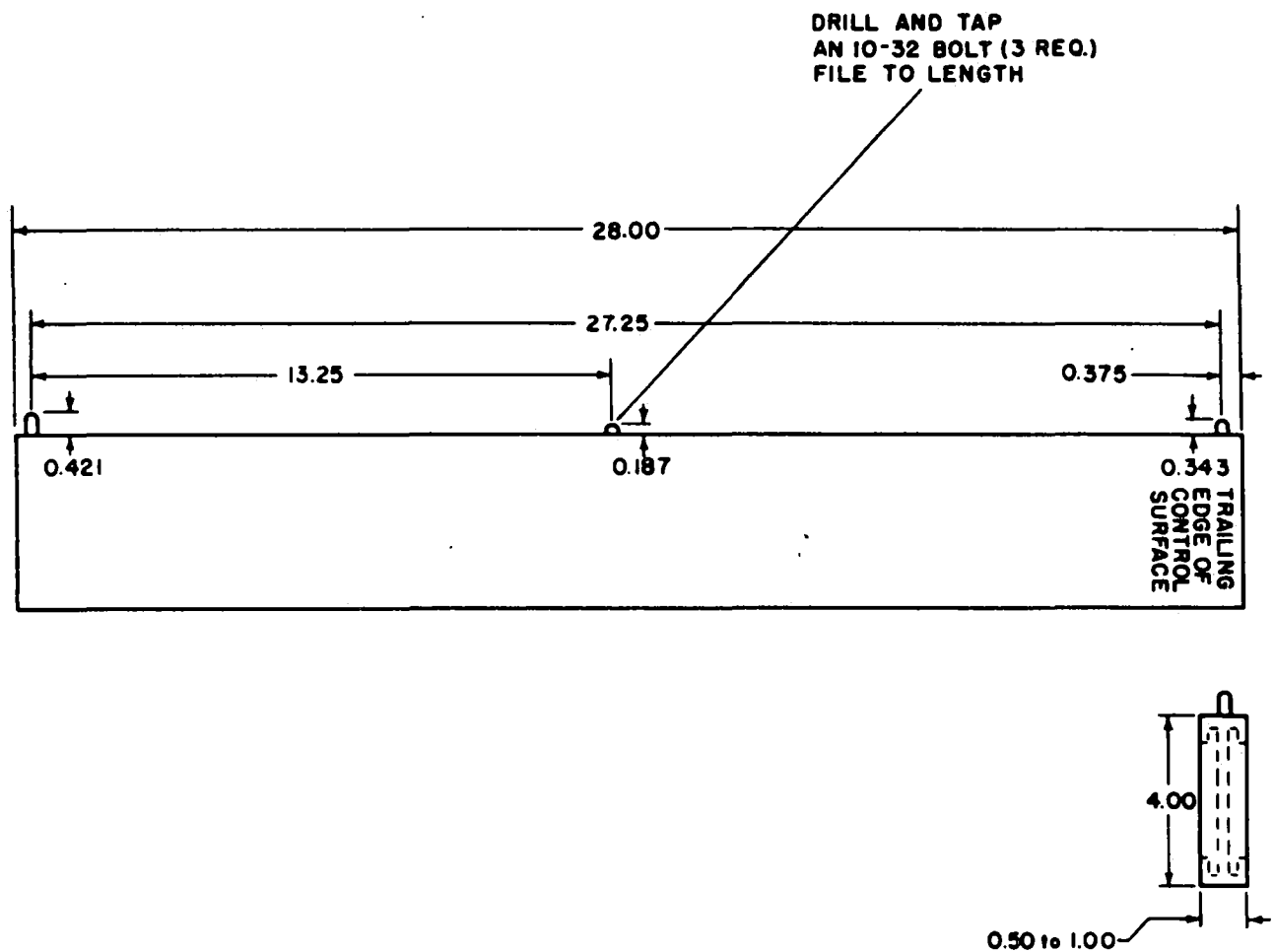


Figure 5-17. Fabricated Aileron Bellcrank Rigging Tool.

A233



MATERIAL: ALUMINUM PLATE  
(SPAR MATERIAL MAY BE USED)

Figure 5-18. Fabricated Aileron Rigging Tool

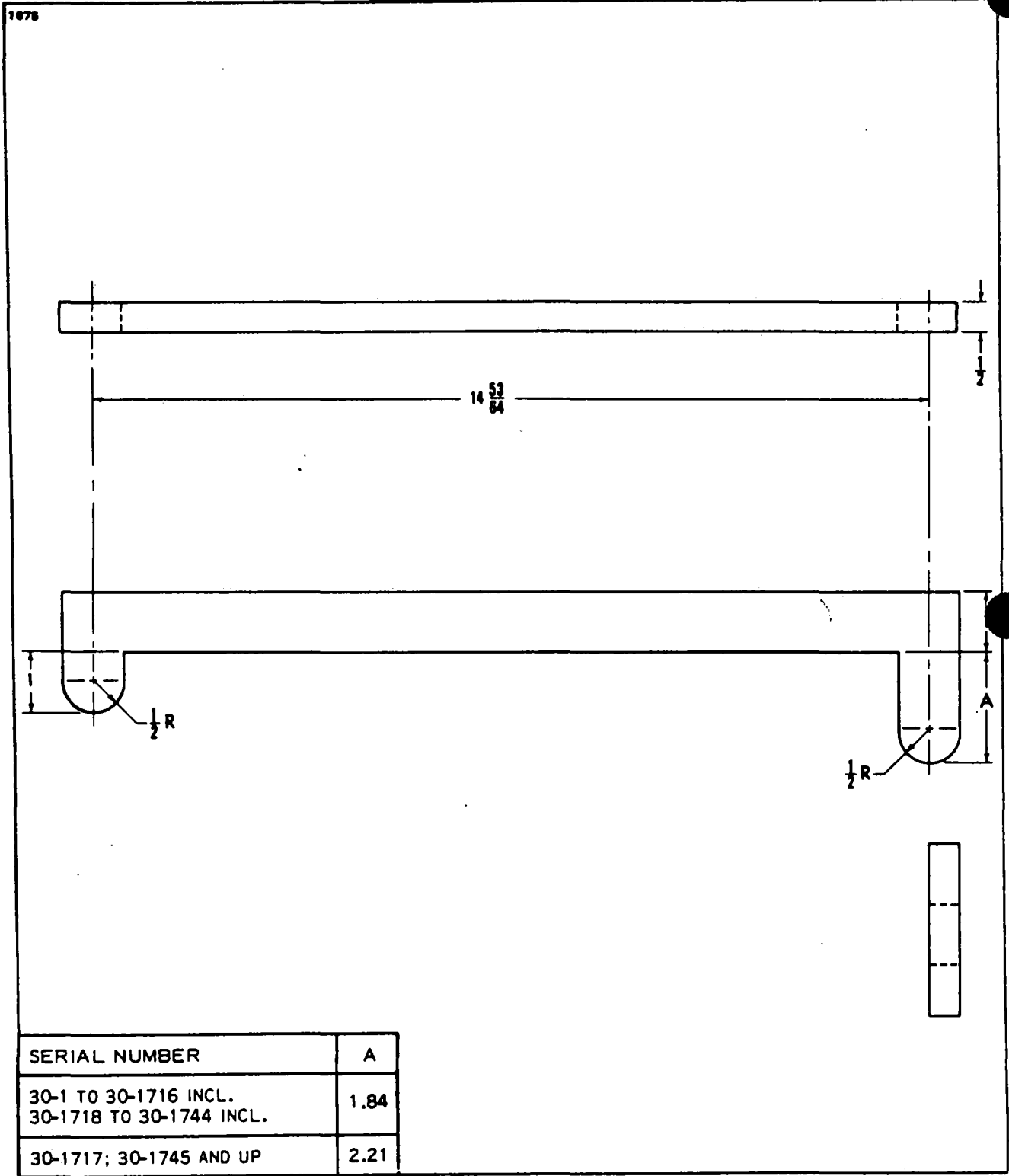


Figure 5-19. Fabricated Stabilator Rigging Tool.

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## **SECTION VI**

### **HYDRAULIC SYSTEM**

#### **NOTE**

The PA-30 has one independent hydraulic system for operation of the wheel brakes which is part of a related system. Removal, inspection and repair, installation and bleeding procedures may be found in Section VII.

**1 J20 THRU 1 L24**

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***TWIN COMANCHE***  
***Service Manual***

CARD 2 OF 4

- PA-30
- PA-39

**PIPER AIRCRAFT CORPORATION**

# **WARNING**

**The information contained in this manual is periodically revised. Piper Aircraft Corporation urges all users of this manual to keep it current. Contact your nearest Piper Aircraft Corporation distributor to arrange for a subscription to future revisions.**

## **NOTE**

**Revision service is available in aerofiche format only.**

## AEROFICHE EXPLANATION AND REVISION STATUS

The Service Manual information incorporated in this set of Aerofiche cards has been arranged in accordance with the general specifications of Aerofiche adopted by the General Aircraft Manufacturer's Association, (GAMA). 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.

### Conversion of Aerofiche alpha/numeric code numbers:

First number is the Aerofiche card number.

Letter is the horizontal line reference per card.

Second number is the vertical line reference per card.

Example: 2J16 = Aerofiche card number two of given set, Grid location J16.

To aid in locating the various chapters and related service information desired, the following is provided:

1. A complete manual Table of Contents is for all fiche in this set.
2. A complete list of Illustrations is given and follows the Table of Contents.
3. A complete list of Tables is given for all fiche in this set and follows the list of Illustrations.
4. A complete list of paragraph titles and appropriate Grid location numbers is given at the beginning of each Chapter relating to the information within that Chapter.
5. Identification of Revised Material:

Revised text and illustrations are indicated by a black vertical line along the left-hand margin of the frame, opposite revised, added or deleted material. Revision lines indicate only current revisions with changes and additions to or deletions of existing text and illustrations. Changes in capitalization, spelling, punctuation, indexing, the physical location of the material or complete page additions are not identified by revision lines.

6. Revisions to this Service Manual issued are as follows:

Revisions	Date	Aerofiche Card Effectivity
PR740131	January 31, 1974	—
PR760628	June 28, 1976	1, 2 and 3
PR771006	October 6, 1977	1 and 2
PR780426	April 26, 1978	1, 2 and 3
PR790910	September 10, 1979	1 and 2
PR810406	April 6, 1981	1, 2, 3 and 4
PR821028	October 28, 1982	1, 2, 3 and 4

The date on Aerofiche cards should not be earlier than the date noted for the respective card effectivity. Consult the latest card in this series for current Aerofiche card effectivity.

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## SECTION VII

### LANDING GEAR AND BRAKE SYSTEM

**7-1. INTRODUCTION.** This section contains instructions for troubleshooting, overhaul, inspection and adjustment of the landing gear, landing gear retraction system, and brake system. Also are adjustment for electrical safety and limit switches.

**7-2. DESCRIPTION.** The PA-30 tricycle landing gear system is an air-oil oleo type unit that is electrically operated, fully retractable with the nose gear retracting aft into the nose section and the main gear retracting inboard into the wing. Gear doors operate by gear movement completely covering the nose gear and partially covering the main gear when retracted.

The retraction mechanism consists of an electric motor and transmission assembly, torque tube assembly, push-pull cables to each main gear and a push-pull tube to the nose gear. Limit switches are installed in the system to cut off the transmission motor when the gear is fully extended or retracted. These switches also operate gear indicator lights in the cabin. To prevent the gear from retracting while the airplane is on the ground, an anti-retraction safety switch located on the left main gear will not allow the gear to retract until weight off the gear has allowed the strut to extend to within three-quarters of an inch of full extension. When the manifold pressure is reduced below 10 to 12 inches and the landing gear is not down and locked, a warning horn will sound. In the cockpit, located between the pilot seats, under the floor panel, is an extension handle used to manually extend the landing gear while in flight should it become necessary. Also, it may be used to extend and retract the gear on the ground while on jacks.

The brakes are hydraulically actuated by individual master cylinders mounted on the left (optional on the right) set of rudder pedals. A reservoir located on the front side of the forward cabin bulkhead supplies hydraulic fluid to each master cylinder. From the cylinders the fluid is routed through lines and hoses to the brake assemblies on each main landing gear. The brakes are self-adjusting, single disc, single housing, double piston assemblies. To operate the brakes, apply toe pressure to the top of the brake pedals. The parking brake may be actuated by applying the brakes and pulling out the parking brake handle. To release the parking brake, depress the brake pedals and push in on the parking brake handle.

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7-3. TROUBLESHOOTING. Troubles peculiar to the landing gear system are listed in Table VII-II at the back of the section, along with their probable causes and suggested remedies. When troubleshooting, check the power supply and ground of the items affected. If no trouble is found, the trouble probably exists inside individual pieces of equipment. The electrical system diagram for the system may be found in Section XI, Electrical System.

#### 7-4. LANDING GEAR SYSTEM.

#### 7-5. NOSE LANDING GEAR.

### WARNING

Deflate strut before disassembly.

7-6. DISASSEMBLY OF NOSE GEAR OLEO. (Refer to Figure 7-1.) The nose gear oleo assembly may be removed and disassembled from the gear oleo housing with the gear removed from or installed on the airplane.

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Place a drip pan under the nose gear to catch spillage.
- c. Remove air and fluid from the oleo strut. Depress the air valve core pin (8) until strut chamber pressure has diminished, remove the filler plug (21) and with a small hose siphon as much hydraulic fluid from the strut as possible.
- d. To remove the complete cylinder and fork assembly from the oleo housing (10), cut the safety wire (6) at the top of the unit, and remove the cap bolts (7) that attach the steering arm (28) and aligner guide bracket (18) to the top of the oleo cylinder (33).
- e. Disconnect the shimmy dampener (13) by removing each cotter pin, nut, washer and bolt (12) that connects the dampener to the oleo cylinder and housing.
- f. Release and remove the snap ring (19) at the top of the housing (10), and pull the complete cylinder (33) and fork assembly (17) from the bottom of the housing. The upper and lower housing bushings (20 and 32) should remain pressed in the housing.
- g. To remove the piston tube (35) and fork (17) from the cylinder (33), first separate the upper and lower torque links (4 and 1) by removing the link connecting bolt assembly (3) and then separate the two links. Note spacer washer (2) between the two links.
- h. Compress the piston tube (35), reach up along the tube and release the snap ring (49) from the annular slot at the bottom of the oleo housing.
- i. Pull the piston tube (35) with component parts from the cylinder.
- j. The piston tube components may be removed by reaching into the tube and pushing out the upper bearing retainer pins (42). Slide from the tube, the upper bearing (43), lower bearing (44) with outer and inner O-rings (46 and 45), wiper strip (47), washer (48) and snap ring (49).

k. To remove the orifice tube (34), remove the large locknut (22) and lockwasher (24) from the top of the cylinder. Pull the tube from the cylinder.

l. The orifice plate (40) is removed from the bottom of the orifice tube by releasing the snap ring (41) that holds the plate in position. Expand and remove the ring (39) from the lower end of the tube.

m. To remove the piston tube plug (37) with O-ring (36) located in the lower end of the piston tube, remove the bolt assembly (15) and insert a rod up through the hole in the body of the fork (17). Push the plug out through the top of the tube.

#### 7-7. CLEANING, INSPECTION AND REPAIR OF NOSE GEAR OLEO.

- a. Clean all parts with a suitable dry type cleaning solvent.
- b. Inspect the landing gear oleo assembly component for the following:
  1. Bearings and bushings for excess wear, corrosion, scratches and overall damage.
  2. Retaining pins for wear and damage.
  3. Lock rings for cracks, burrs, etc.
  4. Cylinder and orifice tube for corrosion, scratches, nicks and excess wear.
  5. Upper and lower cylinder bushings loose or turning in cylinder.
  6. Orifice plate for hole restriction.
  7. Fork tube for corrosion, scratches, nicks, dents and misalignment.
  8. Air valve general condition.
- c. Repair of the oleo is limited to smoothing out minor scratches, nicks and dents and replacement of parts.
- d. Individual replacement of the wiper strip may be accomplished per instructions given in paragraph 7-31.

#### 7-8. ASSEMBLY OF NOSE GEAR OLEO. (Refer to Figure 7-1.)

- a. Ascertain that parts are cleaned and inspected.
- b. To install the piston tube plug (37), first lubricate the tube plug and O-ring (36) with hydraulic fluid (MIL-H-5606), and install the O-ring on the plug. Lubricate the inside wall of the piston tube (35), insert the plug into the top of the tube and push it to the fork end. (Align the bolt holes of the fork (17), tube and plug, and install bolt (CT) (15) with washers (51) and nut (30). (If a new tube (35) is to be installed that has not been drilled, press the tube into the fork piston housing (17) until it bottoms. Using the bolt holes in the fork body as a guide, drill a pilot hole and ream to 0.250/0.252 through each side of the tube wall. Remove burrs from the inside of the tube and flush the tube with a suitable solvent to remove all metal particles.)

- c. If desired, cement a cork in the hole in the bottom of the fork body to prevent dirt from entering between the fork and tube.
- d. To assemble the components of the orifice tube (34), insert the orifice plate (40) into the bottom of the tube and secure with snap ring (41). Lubricate and install the O-ring (38) on the upper end of the tube. Install ring (39) on the lower end of the tube.
- e. Insert the orifice tube (34) up through the bottom of the cylinder (33). With the tube exposed through the top of the cylinder, install the lockwasher (24) and insert roll pin (23) through the lockwasher into the cylinder. Install the tube locknut (22) finger tight at this time.
- f. The fork (17) and tube (35) assembly may be assembled by installing the tube components on the tube. In order, slide onto the tube the snap ring (49), washer (48), lower bearing (44) with outer and inner O-rings (46 and 45) and upper bearing (43). Align the lock pin holes in the upper bearing with the pin holes in the piston tube (35) and install pins (42).
- g. Lubricate the inner wall of the cylinder (33) with hydraulic fluid. Carefully insert the piston tube assembly into the bottom of the cylinder, allowing the orifice tube to guide itself into the piston tube until the snap ring (49) can be installed in the annular slot at the bottom of the cylinder.
- h. At the top of the cylinder (33), tighten the orifice tube locknut (22).
- i. Install wiper strip (47), slide washer (48) into position and secure assembly with snap ring (49).
- j. Ascertain that bushings are installed in the upper and lower torque links (4 and 1) and then install both links. The torque link bolt assemblies should be lubricated and installed with the flat of the bolt head hex adjacent to the milled stop on the wide end of the link. A thin washer (2) is required between contact surfaces of the upper and lower link bushings. Tighten the bolts only tight enough to allow no side play in the link, yet be free enough to rotate. Insure that there is no binding or interference of the torque links when the nose gear is fully compressed. Safety nuts with cotter pins.
- k. Ascertain that the upper and lower oleo housing bushings (20 and 32) are installed. Install the cylinder (33) into the oleo housing (10) and secure with snap ring (19).
- l. At the top of the oleo housing, install on the cylinder the aligner guide bracket (18) and steering arm (28). Install cap bolts (7), tighten to 30 to 35 inch pounds torque and safety with MS20995C40 wire (6).
- m. Install the shimmy dampener (13) using bolts, washer and nuts (12) and safety with cotter pin.
- n. Lubricate the gear assembly. (Refer to Lubrication Chart, Section II.)
- o. Compress and extend the strut several times to ascertain that the strut will operate freely. The weight of the gear wheel and fork should allow the strut to extend.
- p. Service the oleo strut with fluid and air. (Refer to Oleo Struts, Section II.)
- q. Check the nose gear for alignment (Refer to Paragraph 7-13) and gear operation.



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1. TORQUE LINK, LOWER
2. SPACER WASHERS
3. BOLT ASSEMBLY
4. TORQUE LINK, UPPER
5. BOLT ASSEMBLY
6. SAFETY WIRE
7. CAP BOLT
8. AIR VALVE
9. STEERING BUSHING ASSEMBLY
10. OLEO STRUT HOUSING
11. BOLT ASSEMBLY
12. MOUNTING BRACKET ASSEMBLY
13. SHIMMY DAMPENER
14. PISTON TUBE
15. BOLT ASSEMBLY
16. BOLT ASSEMBLY
17. FORK ASSEMBLY
18. ALIGNER GUIDE
19. SNAP RING
20. BUSHING, UPPER
21. FILLER VALVE
22. NUT, ORIFICE TUBE
23. PIN, LOCK
24. WASHER, LOCK
25. BOLT
26. BUSHING, STEERING
27. BUSHING, STEERING
28. STEERING ARM
29. NUT
30. COTTER PIN
31. BUSHING, TRUNNION
32. BUSHING, LOWER
33. OLEO CYLINDER
34. ORIFICE TUBE
35. PISTON TUBE
36. "O" RING, PISTON TUBE PLUG
37. PLUG, PISTON TUBE
38. "O" RING, ORIFICE TUBE
39. RING, ORIFICE TUBE
40. ORIFICE PLATE
41. SNAP RING
42. PIN, BEARING RETAINING
43. BEARING, UPPER PISTON TUBE
44. BEARING, LOWER PISTON TUBE
45. "O" RING
46. "O" RING
47. WIPER STRIP
48. WASHER
49. SNAP RING
50. NUT
51. WASHER

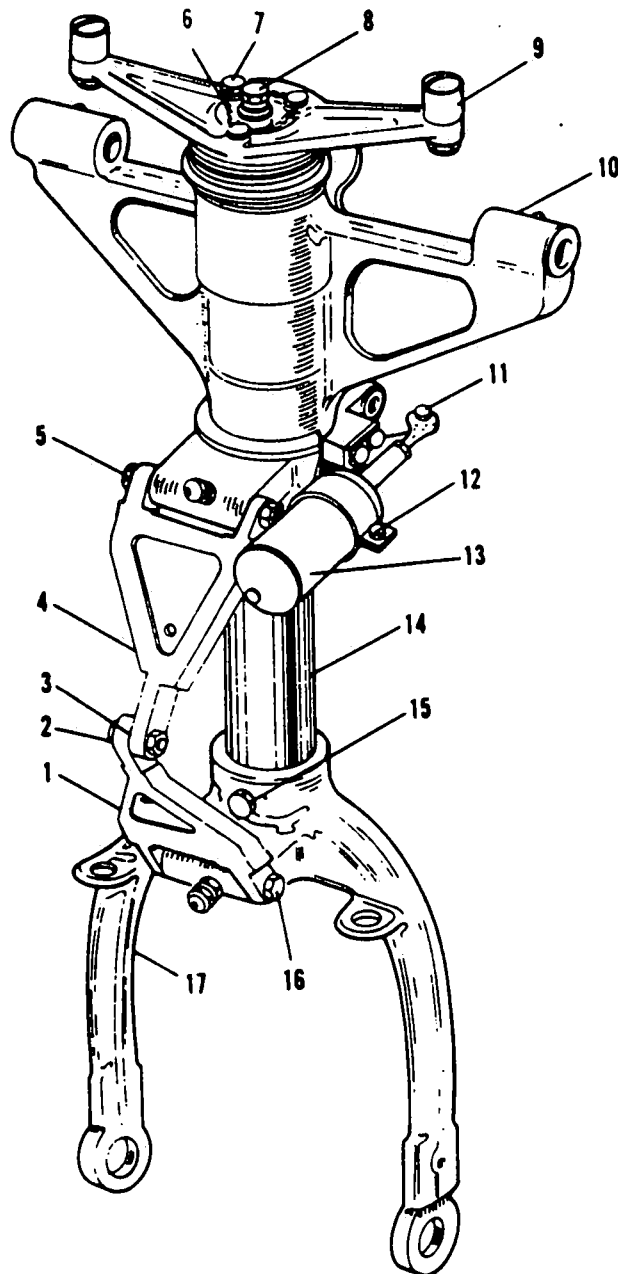


Figure 7-1. Nose Gear Oleo Strut Assembly

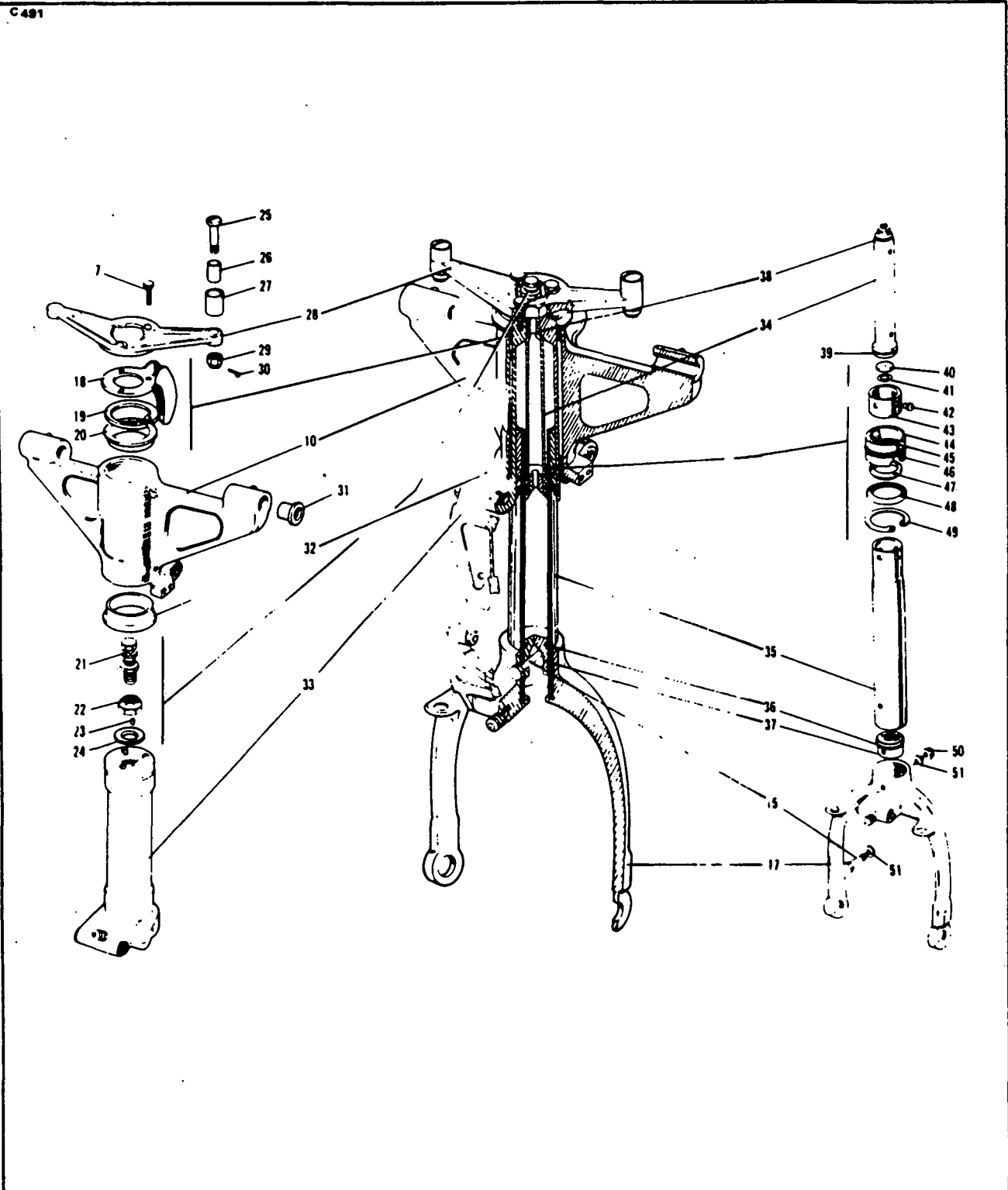


Figure 7-1. Nose Gear Oleo Strut Assembly (cont.)

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**7-9. REMOVAL OF NOSE LANDING GEAR. (Refer to Figure 7-2.)**

- a. Remove nose access panel by loosening the quarter turn fasteners.
- b. Remove the canvas cover from the nose gear mount by releasing snap fasteners.
- c. Place the airplane on jacks. (Refer to Jacking, Section II.)
- d. Remove the down limit switch (29 or 43) from the left drag link (28) by removing switch attaching nut and electrical lead straps. The electrical wires may remain connected.
- e. Disconnect the retraction transmission by pulling up on the release lever.
- f. Retract the landing gear until it hangs in the neutral position, by using the emergency extension lever.
- g. Disconnect the nose gear door actuating rods from their mounting brackets by removing attaching nuts and washers.
- h. Partially retract the landing gear until the nose gear push-pull rod attaching bolt (26) clears the wheel well and then remove bolt.
- i. Partially retract nose gear and remove downlock spring(s) (33) by removing nut(s), washer(s) and bolt(s) securing the spring attachment link(s) to the drag link cross brace (30).
- j. Push up on the nose gear door actuating arms and remove bolts (22) securing the upper left (28) and right (18) drag links to the gear mount. Note spacer washers (21) between drag links and mount.
- k. Remove cotter pins, nuts, washers and bolts (9 and 20) from the strut housing attaching arms and gear mount. Note the number of spacer washers (8 and 19) between the strut attaching arms and the gear mount.
- l. Remove strut assembly and drag links from wheel well.
- m. The steering bellcrank (13) and aligner guide (11) may be removed by removing nuts, washers and bolts securing the steering rods (15 and 16) to the bellcrank; the nut, washer and bolt securing the aligner guide tang to its bracket and the nut, washer, bolt and bushing securing the steering bellcrank to the landing gear mount.

**7-10. CLEANING, INSPECTION AND REPAIR OF NOSE LANDING GEAR.**

- a. Clean all parts with a suitable dry type cleaning solvent.
- b. Inspect the gear components for the following unfavorable conditions:
  1. Bolts, bearing and bushings for excess wear, corrosion and damage.
  2. Strut housing, drag links, torque links, fork assembly and fork tube for cracks, bends or misalignment.
  3. Downlock spring for corrosion and wear, and serviceable limits. (Refer to Table VII-IV.)
  4. Check the general condition of limit switch and its actuator, wiring for fraying, and poor connection or conditions that may lead to failure.

5. Check all polished surfaces for scratches and nicks.
6. Check the drag link assembly, (Refer to Figure 7-2) thru center travel of both the left (18), (35) and right (28), (34) drag links, by placing a straight edge in alignment with the center of the rear and forward drag link attachment points. (See Sketch A of Figure 7-2). Ascertain that when the stop surfaces of the two links touch, the center of the pivot bolt (32) is  $.187 + .062 - .00$  of an inch below the straight edge. This check may be conducted on a surface table using a surface gauge. If the drag links are not within the given tolerances, replace one or both drag links.
  - c. The shimmy dampener requires no service other than routine inspection. In case of damage or malfunction, the dampener should be replaced rather than repaired.
  - d. Repair to the landing gear is limited to reconditioning of parts, such as replacing bearings and bushings, smoothing out minor nicks and scratches, and replacement of parts.

#### 7-11. INSTALLATION OF NOSE LANDING GEAR. (Refer to Figure 7-2.)

##### NOTE

When assembling any units of the landing gear, lubricate bearings, bushings, and friction surfaces with the proper lubricant as described in the Lubrication Chart, Section II.

- a. Install the steering bellcrank and aligner assembly as follows:
  1. Attach the steering bellcrank (13) and aligner assembly (11) with washer and bushings to the nose gear mount with bolt and nut.
  2. Attach the tang of the aligner to the aligner support bracket with bolt, washer and nut.
  3. Connect the steering rods (15 and 16) to the bellcrank with bolts, washers and nuts.
- b. The landing gear oleo housing (5) may be installed as follows:
  1. Position the nose gear to allow the support arms of the housing (5) to align with the support fittings on the tubular mounting structure (17).
  2. Install spacer washers (8 and 19), evenly and as needed to allow no side thrust (a maximum of two washers are allowed on each side), between the support arms and the support fittings; and attach each arm to the fitting with bolts (9 and 20), washers and nuts. Do not safety attaching bolts until after the adjustment of the drag links has been completed.
  3. Extend and retract the gear to determine that the screw head of the aligner roller (11) clears the inside web of the aligner guide (6).

c. The drag links and downlock spring(s) may be installed as follows:

1. Ascertain that the upper (18 and 28) and lower drag links (34 and 35) are assembled, and thru travel of the links is checked according to paragraph 7-10. Allow the drag link cross brace (30) to remain loose until the adjustment of the links is completed.

2. Attach the upper drag links (18 and 28) to the gear mount support, at the forward cabin bulkhead, with bolts (22), washers, nuts and cotter pins. Install spacer washers (21), not to exceed two, between the left drag link (28) and attachment fitting to attain sufficient clearance between clevis (27) and fuselage.

3. Attach the lower drag links (34 and 35) to the strut housing (5) using bolt. Do not secure bolt with washers, nut and cotter pin until after adjustment of drag links.

4. Check adjustment of drag links to determine that they lock as instructed in paragraph 7-12.

5. Secure the drag link cross brace (30) and safety remaining nuts of the attaching bolts. Piper Kit 761 082 should be installed.

6. Connect the downlock spring(s) (33) between the fittings on the gear housing and link cross brace.

d. Install the gear down limit switch (29 or 43) on its mounting bracket on the left drag links and adjust as given in paragraph 7-44.

e. Attach the end bearing of the retraction push-pull rod (25) to the drag link clevis (27) using bolt (26), washer and nut. The head of the bolt (26) with the countersunk portion is to the left or outboard. Also, check adjustment of both the drag link clevis and the push-pull rod as given in paragraph 7-47.

f. Check alignment of the nose landing gear per paragraph 7-13.

g. Connect and adjust the gear door push-pull rods per paragraph 7-17.

#### 7-12. ADJUSTMENT OF NOSE GEAR DRAG LINKS. (Refer to Figure 7-2.)

a. If desired to facilitate adjustment of drag links, remove the top access panel from the nose section by loosening the quarter turn fasteners and the canvas cover from around the nose gear mount.

b. Place the airplane on jacks. (Refer to Jacking, Section II.)

c. Disconnect the retraction push-pull rod (25) at the left drag link (28) by first retracting the gear enough to align the connecting bolt of the push-pull rod and drag link clevis (27) with the one inch hole in the adjacent longitudinal channel and then removing the nut, washer and bolt (26).

d. Remove the downlock spring(s) (33) from between the gear housing (5) and drag link cross brace (30) by removing the nut(s), washer(s) and bolt(s) that secure the spring link(s) to the cross brace.

- e. Loosen drag link cross brace attaching bolts enough to allow the brace freedom to rotate but not separate from either drag link.
- f. Check that there is no excess wear in the bushings and bolts of the drag link assembly.
- g. Ascertain that when the upper and lower drag links are assembled, the thru travel of the links is within the limits given in paragraph 7-10.
- h. Extend and retract the nose gear manually to check that each link assembly locks simultaneously and independently of each other. Should one or both links not lock as required, adjustments may be made as follows:

**NOTE**

Following adjustment to any of the three gears in which the control tubes/rod were disconnected with aircraft on jacks, the transmission disconnected, ascertain that all three gear drag links go over center and lock at the same time independently of each other.

- 1. First, check to determine that the oleo housing is not restricted from swinging far enough forward as a result of the steering arm roller bushing (12) pressing against the steering bellcrank (13), thus preventing one or both links from dropping into the locked position. Should the roller bushing interfere, remove the bushings until after adjustment is completed.
- 2. To check for correct adjustment of forward drag link attachment fittings, proceed as follows:
  - (a) Remove the cotter pin, nut and washer from the bolt attaching the lower drag links (34 and 35) to the strut housing.
  - (b) To determine that the bolt is a slip fit, slide it back and forth through the fittings.
  - (c) Remove the bolt and swing the drag links up and down along the sides of the strut fitting to determine that there is clearance between the drag link fittings and the strut fitting.
  - (d) If there is binding or the drag link fittings will not swing up and align with the strut fitting without forcing them to either side, the entire strut housing (5) must be shimmed to the right or left at the upper strut attaching arms to allow proper alignment of the drag links and strut fitting.
  - (e) If there is excessive clearance which would allow the drag links to be drawn together causing binding when the attaching bolt and nut are tightened, spacer washers (36) should be installed between the drag link and strut fitting. A maximum of two washers are allowed on either side of the strut fitting.
  - (f) With the drag links and strut housing adjusted for proper clearance of the lower drag link attachment fittings, and the attaching bolt is a slip fit, secure the bolt with washer, nut and cotter pin.
  - (g) Extend and retract the nose gear manually to check that each link assembly locks simultaneously and independently of each other.

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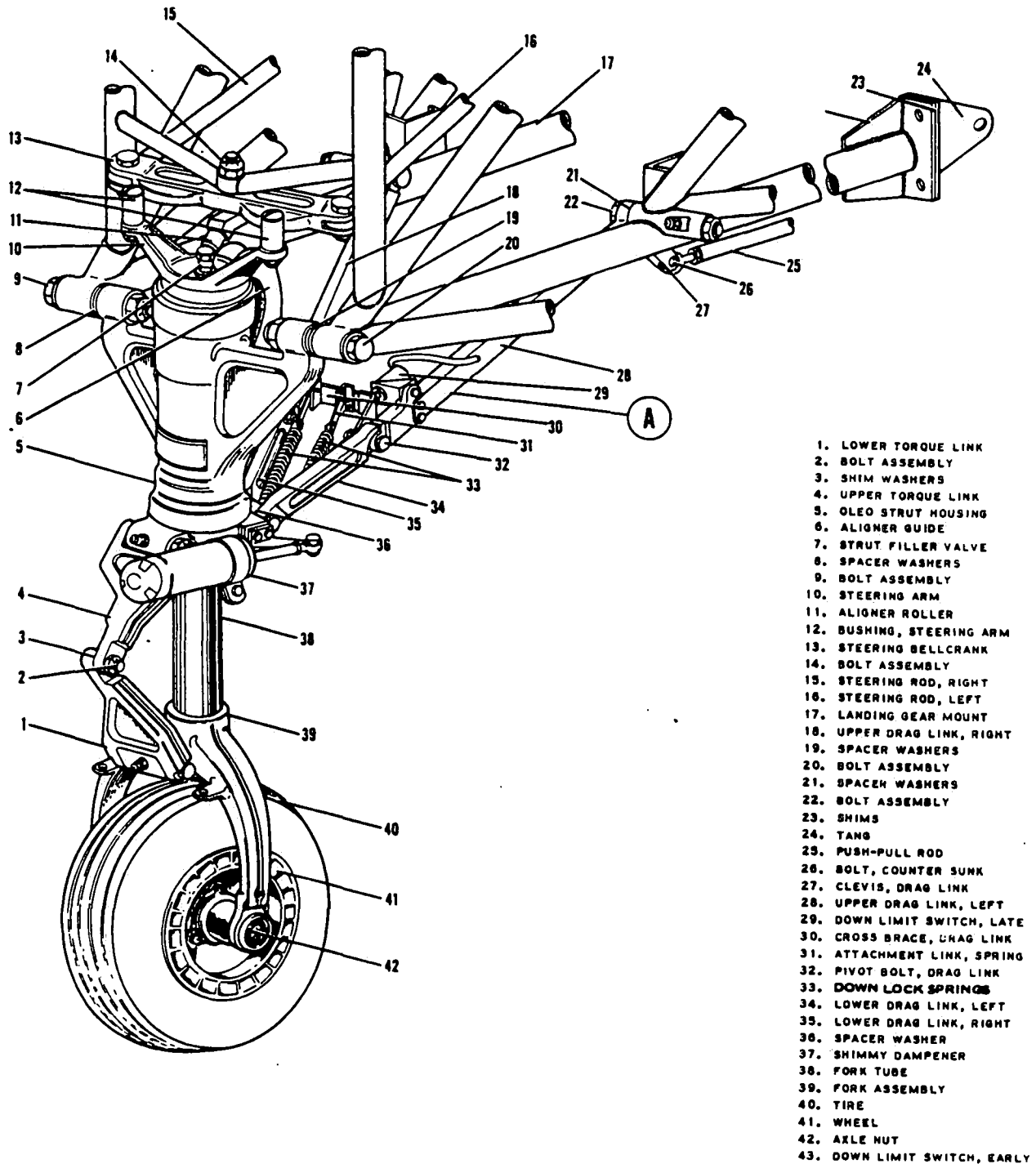


Figure 7-2. Nose Landing Gear Installation

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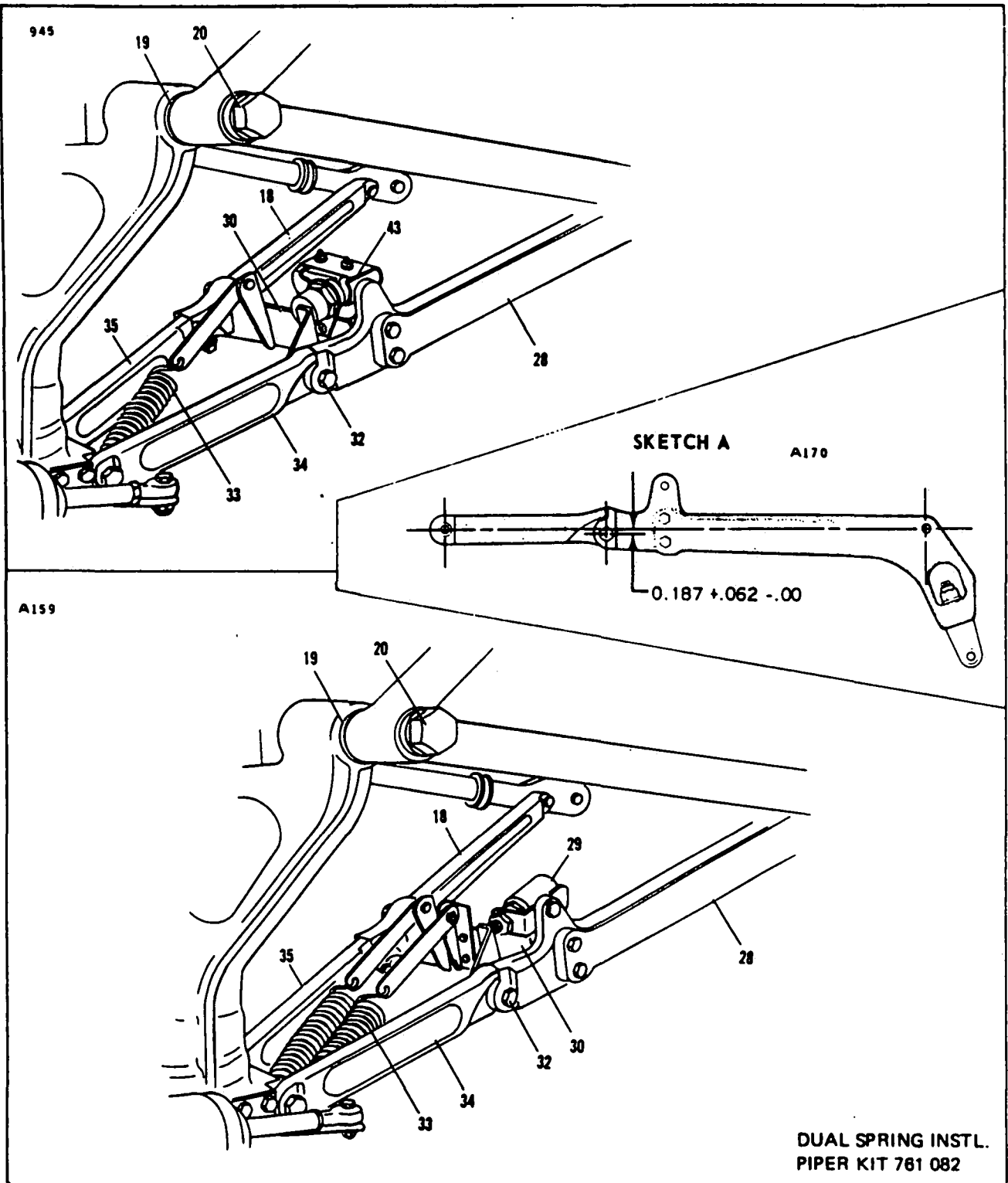


Figure 7-2. Nose Landing Gear Installation (cont.)

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(h) Should further adjustment be necessary, then shims (23) available in 0.016, P/N 21820-02; 0.020, P/N 21820-03 and 0.032, P/N 21820-04 can be installed or removed, as required, between the forward cabin bulkhead and the two center bottom attaching points of the landing gear mount.

NOTE

The maximum amount the landing gear mount can be shimmed is 0.120 of an inch.

(i) Remove or add shims at the forward cabin bulkhead on the same side as the drag link that is binding.

(j) Each time a shim is removed or added, the lower drag link fittings should be checked for adjustment as described in steps "b" thru "e" for this adjustment may change and now be the cause of the binding.

(k) When proper adjustment is attained, the drag links will lock simultaneously and independently of each other when the gear is extended manually and the lower drag link attaching bolt will be a slip fit.

3. When shims are installed or removed between the forward bulkhead and landing gear mount support, the bolt hole in the tang (24) of the mount support may be out of alignment with the hole in the fuselage. When this occurs, drill the holes to the next larger size not exceeding 0.312 of an inch.

4. Secure the lower drag link attaching bolt, cross brace and downlock spring(s) with washers and nuts.

5. Connect and adjust the retraction push-pull rod. (Refer to Paragraph 7-47.)

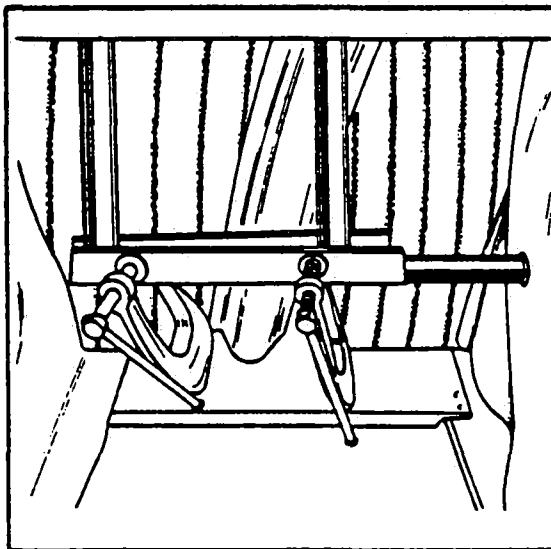


Figure 7-3. Clamping Rudder Pedals in Neutral Position

### 7-13. ALIGNMENT OF NOSE LANDING GEAR.

a. With no load on the nose wheel, make sure no gaps exist at the points where the steering arm bushings contact the steering bellcrank but will allow the bushings to rotate with a slight drag. Install bushings (.625 dia., P/N 14976-23; .687 dia., P/N 14976-21; .812 dia., P/N 14976-102; .750 dia., P/N 14976-13; 1.00 dia., P/N 14175-113) to obtain proper adjustment.

b. Two methods of aligning the nose landing gear are as follows:

#### 1. Chalk Line Method:

(a) Place the airplane on a hard level surface and place on jacks. (Refer to Jacking, Section II.)

(b) Install the plumb bob attachment tool on the nose wheel well frame channel as shown in Figure 7-5 and attach a plumb bob to the tool. (This tool may be fabricated from dimensions given in Figure 7-27.)

(c) Attach a plumb bob to the fuselage one-half inch to the right from center of the tail skid.

(d) Using the plumb bobs as a guide, snap a chalk line extending several feet beyond each bob.

(e) Stand in front of the nose landing gear and orient the tire with the chalk line. Sight along the center rib of the tire. With the rudder pedals clamped in neutral position (Refer to Figure 7-3), adjust the rod ends of each nose gear steering rod to position the cockpit rudder pedals fore and aft. The centered angle of the rudder pedals is 13 degrees aft of the vertical position (Refer to Figure 7-4) with the airplane level. Place a bubble protractor against the pedal steering tube to check this angle. Do not attempt to make the adjustment by

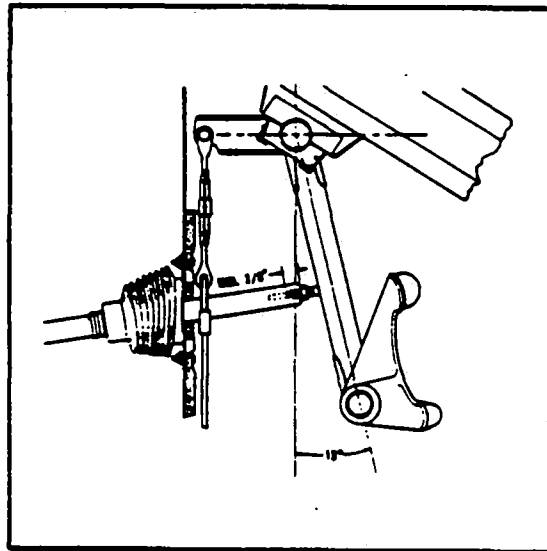


Figure 7-4. Rudder Pedals at Neutral Angle

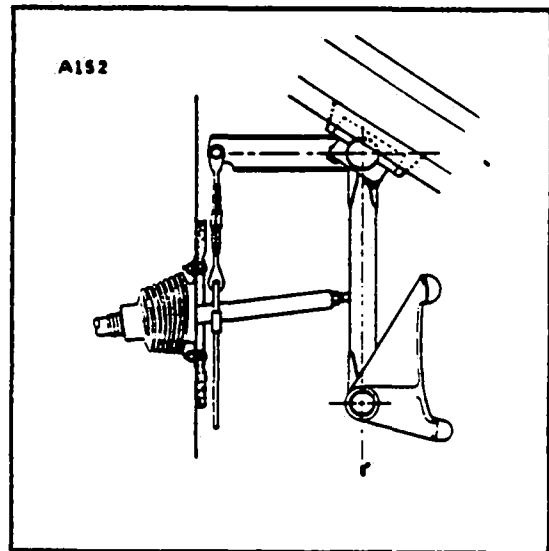


Figure 7-4a. Rudder Pedals at Neutral Position, Serial No. 39-84 and up.

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means of one rod end bearing, but divide the adjustment between the bearings at each end of the steering rod. A three-eighths inch minimum thread engagement must be held. Check by inserting a wire in the check hole of the rod.

(f) Measure 19 degrees on each side of the chalk line, intersecting at the pivot point of the wheel, and check nose landing gear for 19 degrees minimum, 25 degrees maximum right and left travel.

2. Jig Method:

(Fabricate a jig and plumb bob attachment tool conforming to specifications given in Figures 7-27 and 7-28.)

(a) Attach a plumb to the plumb bob attachment tool and install tool on the nose wheel well frame channel as shown in Figure 7-5.

(b) Attach aligning jig to the rear of the nose wheel at the axle as shown in Figure 7-6.

(c) Ascertain that the airplane is laterally level. (Refer to Leveling, Section II.)

(d) Turn the nose wheel until the center line marked on the jig aligns with the plumb bob. With the rudder pedals clamped in neutral position (Refer to Figure 7-3), adjust the rod ends of each nose gear steering rod to position the cockpit rudder pedals fore and aft. The center line of the rudder pedals is 13 degrees aft of the vertical position (Refer to Figure 7-4) with the airplane level. Place a bubble protractor against the pedal steering tube to check this angle. Do not attempt to make adjustments by means of one bearing but divide the adjustment between the rod end bearings at each end of the rod. A three-eighths inch

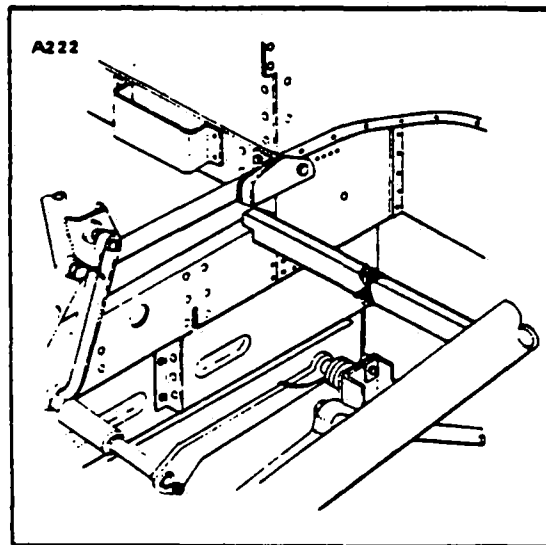


Figure 7-5. Installation of Plumb Bob Attachment Tool

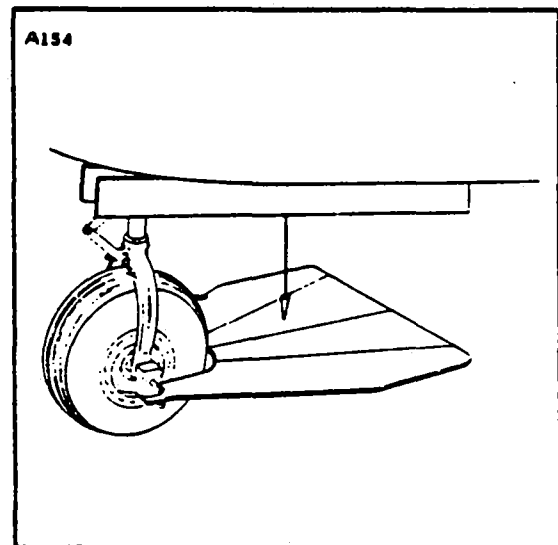


Figure 7-6. Installation of Nose Gear Alignment Jig

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minimum thread engagement must be held.

(e) Check nose gear steering for 25 degrees maximum 19 degrees minimum right and left by turning the jig and wheel to the right and left while observing that the degree marks align with the plumb bob.

**7-14. REMOVAL OF NOSE GEAR DOOR ASSEMBLY. (Refer to Figure 7-7.)**

- a. Remove top nose access panel by loosening the quarter turn fasteners.
- b. Remove bolt, nut and washer attaching each retraction arm torsion spring (9), bushing (10) and spacer (11) (left side only) to its mounting bracket.
- c. Remove the four pivot bolts attaching the door hinges (2) to the fuselage.
- d. Remove the nose door assembly from the wheel well.

**7-15. CLEANING, INSPECTION AND REPAIR OF NOSE GEAR DOOR ASSEMBLY.**

- a. Clean all parts in a suitable dry type solvent.
- b. Inspect doors for cracks or damage and loose, damaged or worn hinges.
- c. Inspect door retraction rods and arms for bends, damage and corrosion.
- d. Check torsion spring and bushing for excess wear and corrosion.
- e. Repairs to the doors may be replacement of hinges and minor skin repair.

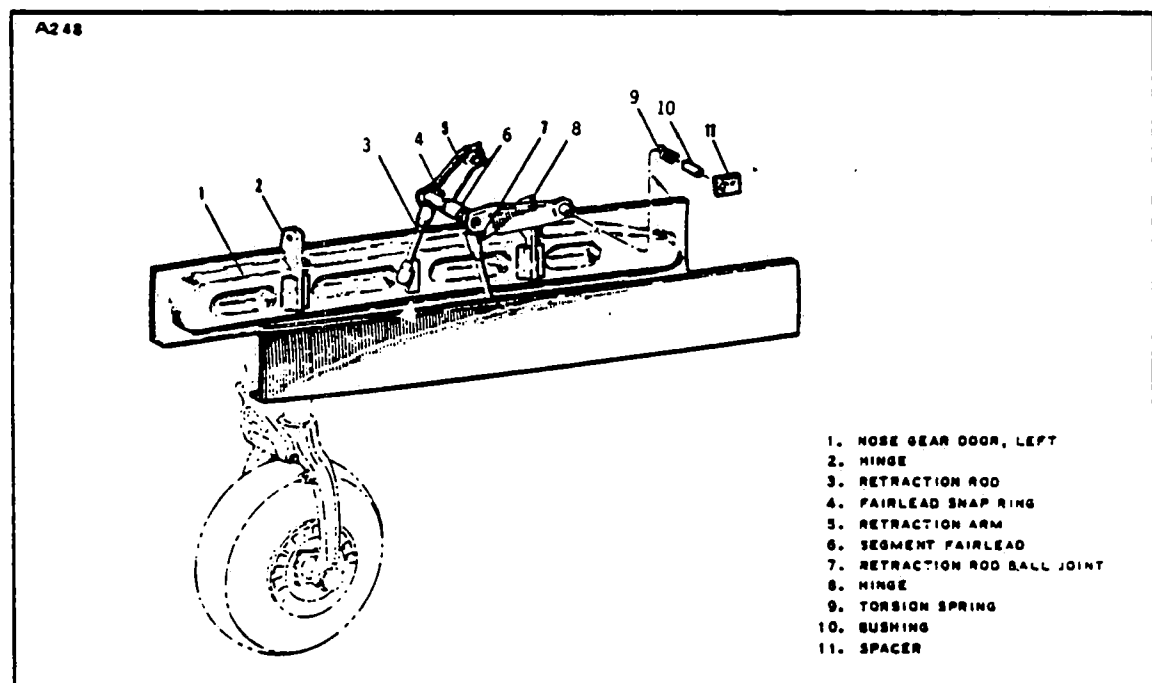


Figure 7-7. Nose Gear Door Installation

**7-16. INSTALLATION OF NOSE GEAR DOOR ASSEMBLY. (Refer to Figure 7-7.)**

- a. Install retraction arms (5) in the wheel well with torsion spring (9), bushing (10) and spacer (11) (left side only) and secure with bolts, washers and nuts.
- b. Align the door hinges (2 and 8) with their brackets and secure with attaching bolts, washers and nuts.
- c. Connect retraction rods (3) to doors (1) and retraction arms (5) and secure with washers and locknuts.

**7-17. ADJUSTMENT OF NOSE GEAR DOOR ASSEMBLY.**

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Adjust one door at a time by lengthening or shortening the retraction push-pull rod.
- c. Adjust each door so it retracts flush with the fuselage and snug against the stops.
- d. Check retraction rod ends for adequate thread engagement for safety and tightness of jam nut.

**7-18. MAIN LANDING GEAR SYSTEM.**

**7-19. DISASSEMBLY OF MAIN GEAR OLEO. (Refer to Figure 7-8.)** The main gear oleo assembly may be removed and disassembled from the gear oleo housing with the gear removed from or installed on the airplane.

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Place a drip pan under the main gear to catch spillage.
- c. Remove the air and fluid from the oleo by depressing the air valve core pin until strut pressure has diminished. Remove the filler plug and with a small hose, siphon as much hydraulic fluid from the strut as possible.
- d. To remove the piston tube (8) assembly from the oleo housing (7), remove the upper (5) and lower (2) torque link connecting bolt assembly (4) and separate the links. Note the number and thickness of spacer washer(s) (3) between the two links.
- e. Compress the piston tube (8), reach up along the tube and release the snap ring (29) from the annular slot at the bottom of the oleo housing.
- f. Pull the piston tube with component parts from the cylinder housing.
- g. The piston tube components may be removed by reaching in the tube and pushing out the upper bearing retainer pins (23). Slide off the upper bearing (22).

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lower bearing (24) with "O" rings (25 and 26), wiper (27), washer (28) and snap ring (29).

h. To remove the orifice tube (19) from the oleo housing, remove the locknut (12) and washer (13) from the top of the housing. Draw the tube with back-up ring (14), "O" ring (15) and ring (16) from the housing.

i. The orifice plate (17) is removed from the bottom of the orifice tube (19) by releasing the snap ring (18) that holds the plate in position. Expand and remove the ring (16) from the lower end of the tube.

j. To remove the piston tube plug (21) with "O" ring (20) located in the lower end of the piston tube (8), remove the bolt assembly (9) and insert a rod up through the hole in the body of the fork (1), pushing the plug out through the top of the tube.

#### 7-20. CLEANING, INSPECTION AND REPAIR OF MAIN GEAR OLEO.

- a. Clean all parts with a suitable dry type cleaning solvent.
- b. Inspect the landing gear oleo assembly component for the following:
  1. Bearings and bushings for excess wear, corrosion, scratches and over-all damage.
  2. Retaining pins for wear and damage.
  3. Lock rings for cracks, burrs, etc.
  4. Cylinder and orifice tube for corrosion, scratches, nicks and excess wear.
  5. Orifice plate for hole restriction.
  6. Fork tube for corrosion, scratches, nicks, dents and misalignment.
  7. Air valve general condition.
- c. Repair of the oleo is limited to smoothing out minor scratches, nicks and dents and replacement of parts.
- d. Individual replacement of wiper strips may be accomplished per instructions given in paragraph 7-31.

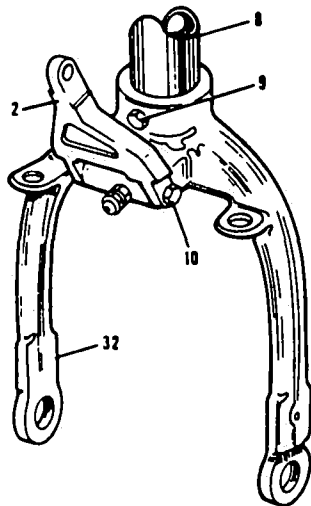
#### -21. ASSEMBLY OF MAIN GEAR OLEO. (Refer to Figure 7-8.)

- a. Ascertain that all parts are cleaned and inspected.
- b. To install the piston tube plug (21), first lubricate the plug "O" ring (20) with hydraulic fluid (MIL-H-5606) and install it on the plug. Lubricate the inside wall of the piston tube (8). Insert the plug into the top of the tube and push it to the fork end. Align the bolt holes of the fork, tube and plug, and install bolt assembly (9). (If a new tube (8) is installed that has not been drilled, press the tube into the fork housing until it bottoms. Using the fork bolt holes as a guide, drill a pilot hole and ream to 0.250/0.252 through each side of the tube wall.



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1. FORK ASSEMBLY
2. TORQUE LINK, LOWER
3. SPACER WASHERS
4. BOLT ASSEMBLY
5. TORQUE LINK, UPPER
6. BOLT ASSEMBLY
7. HOUSING, OLEO STRUT
8. PISTON TUBE
9. BOLT ASSEMBLY
10. BOLT ASSEMBLY
11. AXLE NUT
12. NUT, ORIFICE TUBE
13. WASHER
14. BACK-UP RING, ORIFICE TUBE
15. "O" RING, ORIFICE TUBE
16. RING, ORIFICE TUBE
17. ORIFICE PLATE
18. SNAP RING
19. ORIFICE TUBE
20. "O" RING, PISTON TUBE PLUG
21. PLUG, PISTON TUBE
22. BEARING, UPPER PISTON TUBE
23. PIN, RETAINING
24. BEARING, LOWER PISTON TUBE
25. "O" RING
26. "O" RING
27. WIPER STRIP
28. WASHER
29. SNAP RING
30. NUT
31. WASHER
32. FORK ASSEMBLY, SERIAL NOS. 30-1 TO 30-645 INCL.

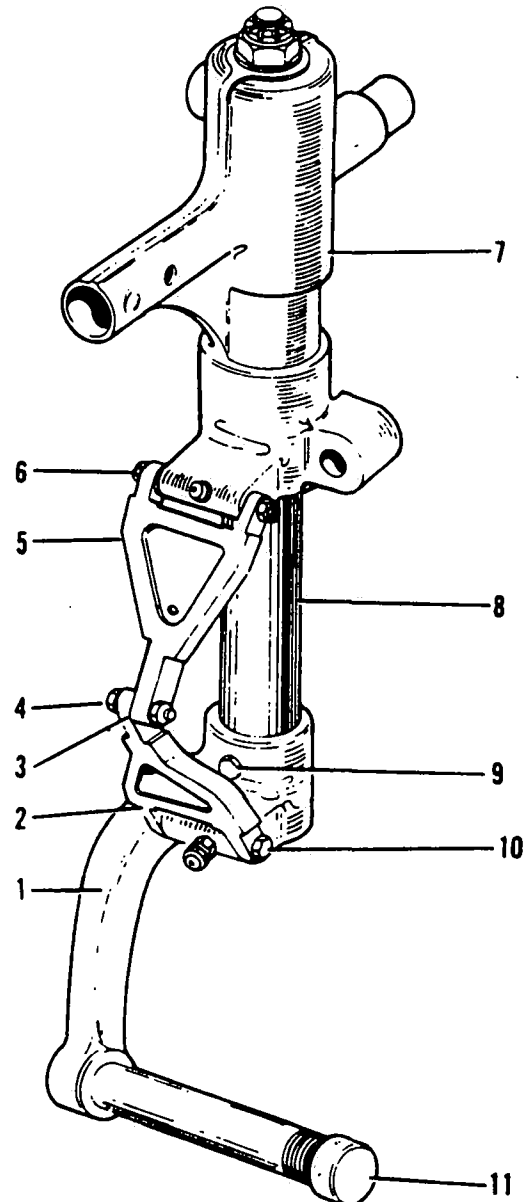


Figure 7-8. Main Gear Oleo Strut Assembly

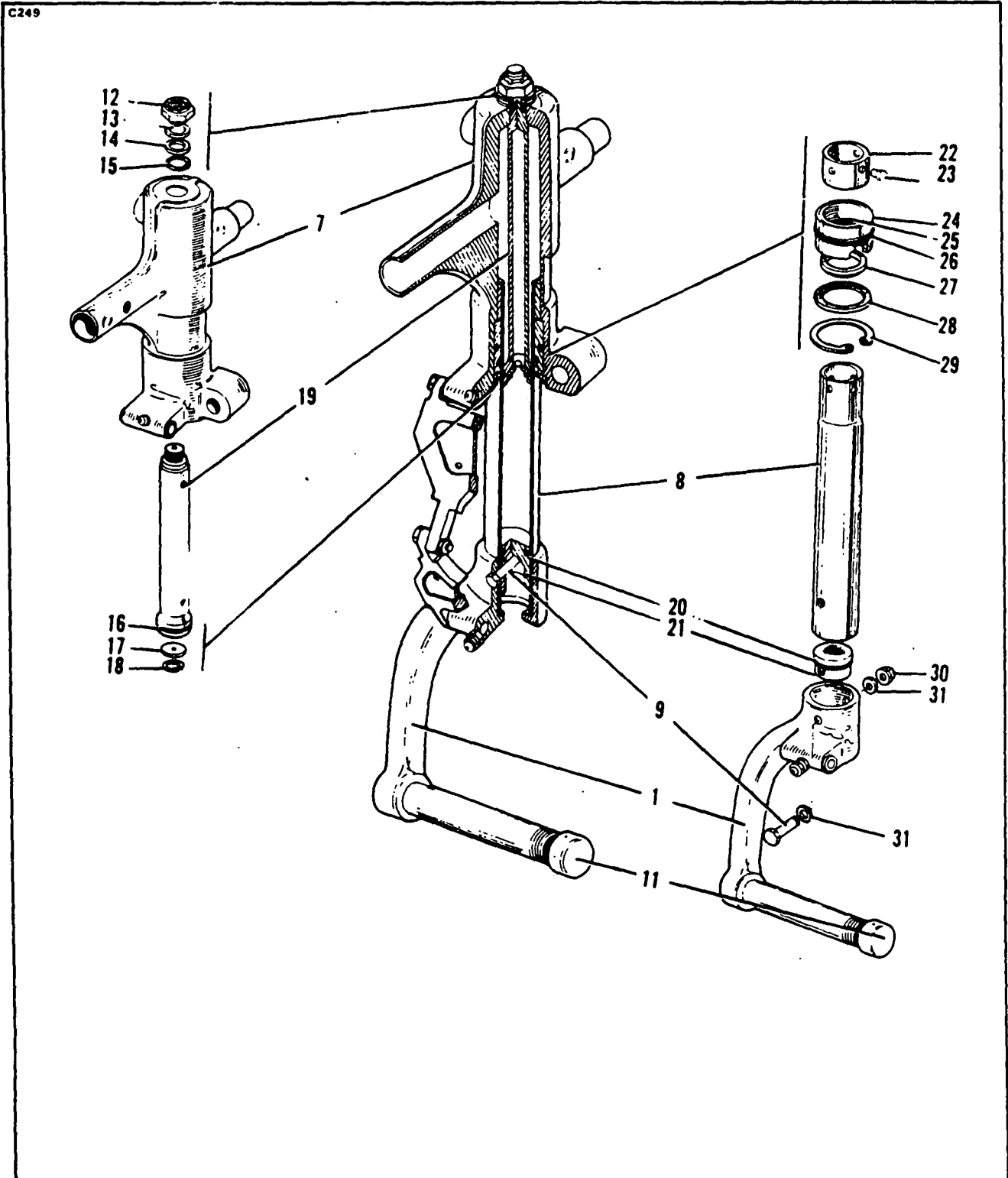


Figure 7-8. Main Gear Oleo Strut Assembly (cont.)

Remove burrs from the inside of the tube and flush the tube with a suitable solvent to remove all metal particles.

c. If desired, cement a cork in the hole in the bottom of the fork body to prevent dirt from entering between the fork and tube.

d. To assemble the components of the orifice tube (19), insert the orifice plate (17) into the bottom of the tube and secure with snap ring (18). Install ring (16) on the lower end of the tube.

e. To install the orifice tube in the oleo housing (7), insert the tube up through the housing. With the end of the tube exposed through the top of the housing, install the "O" ring (15), back-up ring (14), washer (13), and locknut (12). Tighten locknut only finger tight at this time.

f. Assemble the components of the piston tube (8) on the tube by placing, in order, the snap ring (29), washer (28), lower bearing (24) with outer and inner "O" rings (26 and 25) and upper bearing (22). Align the lock pin hole of the upper bearing with the pin holes in the tube and install pins (23).

g. Lubricate the wall of the cylinder oleo housing (7) and piston tube (8), and carefully insert the tube assembly into the housing, guiding the orifice tube (19) into the piston tube until the snap ring (29) can be installed in the annular slot at the lower end of the housing.

h. At the top of the housing, tighten the orifice tube locknut (12). (Should it be an impossibility to tighten the locknut due to the orifice tube rotating with the nut, withdraw the piston tube assembly from the cylinder and, while tightening the nut, secure the orifice tube with the use of a 1-1/2 x 3/16 inch drag link socket held in the slot at its lower end. Check that the orifice tube is centered in the cylinder and then reinstall the piston tube assembly.)

i. Install the wiper strip (27), slide the washer (28) into position and secure the assembly with snap ring (29).

j. Ascertain that the bushings are installed in the upper and lower torque links (5 and 2) and then install links. The torque link bolt assemblies (6 and 10) should be lubricated and installed with the flat of the bolt head hex adjacent to the milled stop of the wide end of the link. (Use the same thickness of spacer washer (3) between the two links as those removed to maintain correct wheel alignment.) Tighten the bolts only tight enough to allow no side play in the links, yet be free enough to rotate. Insure that there is no binding or interference of the torque links when the main gear is fully compressed.

k. Lubricate the gear assembly. (Refer to Lubrication Chart, Section II.)

l. Compress and extend the strut several times to ascertain that the strut will operate freely. The weight of the gear wheel and fork should allow the strut to extend.

- m. Service the oleo strut with fluid and air. (Refer to Oleo Struts, Section II.)
- n. Check the main gear alignment (Refer to Paragraph 7-26) and gear operation.
- o. Remove the airplane from jacks.

#### 7-22. REMOVAL OF MAIN LANDING GEAR. (Refer to Figure 7-9.)

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Disconnect the retraction transmission by pulling up on the release lever.
- c. Retract the landing gear until it hangs in the neutral position, by using the emergency extension lever.
- d. The side brace link assembly may be removed by the following procedure:
  - 1. Disconnect the assist spring. (This may also be accomplished while disconnecting the push-pull cable as described in the next step.)
  - 2. Disconnect the push-pull cable from the upper drag link by removing attaching nut, washer and bolt with swivel assembly (20).
  - 3. Disconnect the gear down limit switch (25) by removing switch attaching nut.
  - 4. Remove the side brace links by removing the pivot bolts (23) at each end.
  - 5. Remove the side brace support bracket (22) from the front spar by removing attaching bolts.
- e. Remove the main gear strut housing with components using the following procedure:
  - 1. Disconnect the gear door retraction rod (29) from the strut housing.
  - 2. Disconnect the brake line (33) and cap it to prevent dripping and contamination.
  - 3. Remove the access panel aft of the rear spar by removing attaching screws.
  - 4. Swing the landing gear enough to allow insertion of a bungee tool, P/N 752 998, between the inboard (4) and outboard (6) bungee pulleys.
  - 5. With tension relieved from the bungee, remove the inboard pulley attaching bolt (3) and remove the bungee assembly by unscrewing the outboard pulley bracket (7) from its fitting.
  - 6. Remove the bolt (9) holding the bungee arm (10) to the rear strut support fitting (11). Cut and remove safety wire (13). Slide studs (14) from rear strut arm.
  - 7. Slide the bungee arm tube out of the rear support fitting freeing the rear strut arm. Note the number and thickness of shims (12) between the rear support fitting and rear strut arm.
  - 8. Remove the gear assembly from the wheel well by removing the attaching bolts holding the front support fitting (18) to the front spar web.
  - 9. Remove the rear support fitting by gaining access to the attaching nuts through the access hole behind the rear spar and remove nuts, washers and bolts.

#### 7-23. CLEANING, INSPECTION AND REPAIR OF MAIN LANDING GEAR.

- a. Clean all parts with a suitable cleaning solvent.
- b. Inspect the gear components for the following unfavorable conditions.
  - 1. Bolts, bearings and bushings for excess wear, corrosion and damage.
  - 2. Gear housing, side brace links, torque links and attachment plates for cracks, bends or misalignment.

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3. Assist spring for corrosion, wear and serviceability. (Refer to Table VII-III.)
  4. Bungee cords for frayed protective covering, brakes and soft areas. Replace cords exhibiting these conditions. (Refer to Table VII-III.)
  5. Wiring for fraying poor connections or conditions which may lead to failure.
  6. Check general condition of limit switch.
  7. Check side brace link through center travel by attaching the upper and lower links, setting them on a surface table, and ascertaining that when the stop surfaces of the two links touch, linkage is not more than 0.125 of an inch  $+.06/-.00$  through center. Should the distance exceed the required through center travel and bolt and bushings are tight, replace one or both links. (Refer to Figure 7-8A.)
  8. Check side brace links and rod end bearing for wear and pitch diameter tolerances in accordance with paragraph 7-23A.
- c. Repair of landing gear is limited to reconditioning of parts such as replacing bearings and bushings, smoothing out minor nicks and scratches, repainting of areas where paint has chipped or peeled and replacement of parts.

### 7-23A. INSPECTION OF MAIN GEAR SIDE BRACE LINKS AND ROD END BEARINGS. (Refer to Figure 7-8c.)

To determine the serviceability of these parts requires the inspection of the threads for wear. This is accomplished by determining the pitch diameter of the threads.

- a. The following information is the suggested method for checking the link:
  1. It will be necessary to obtain a special O-Vee gauge (refer to table included in Figure 7-8c for the specific size gauge to order). This gauge can be purchased from the O-Vee Gauge Company, P.O. Box 43271, Los Angeles 43, California, and a micrometer (see sample order below).
  2. The advantage of using the O-Vee gauge is in its simple three steps, see Figure 7-8c.
  3. There is also the three wire method of checking the thread pitch diameter. For more information on this method see Screw Thread Standard H-28 Handbook put out by the U.S. Department of Commerce, or any good machinist handbook.
  4. If the link is worn less than the tolerances given in the table with Figure 7-8c, it must be replaced.

Sample Order = O-Vee Catalog No. 6803 1/2-20 NF 3 Pitch Dia.  
.4675/.4550

Sample Order = O-Vee Catalog No. 6803 5/8-18 NF 3 Pitch Dia.  
.5889/.5764

### NOTE

When using the O-Vee gauge method to check pitch diameter, use the tolerances given on the O-Vee gauge tab.

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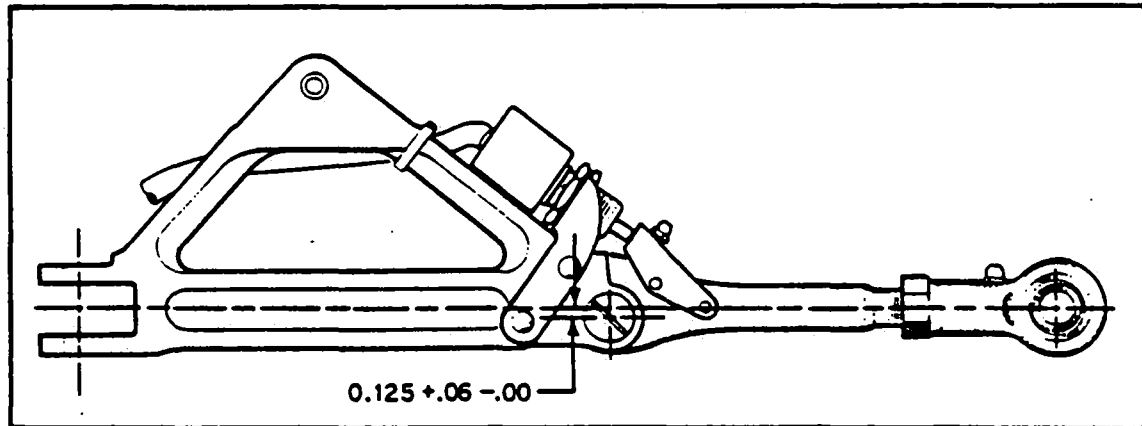


Figure 7-8a. Main Gear Side Brace Link Travel

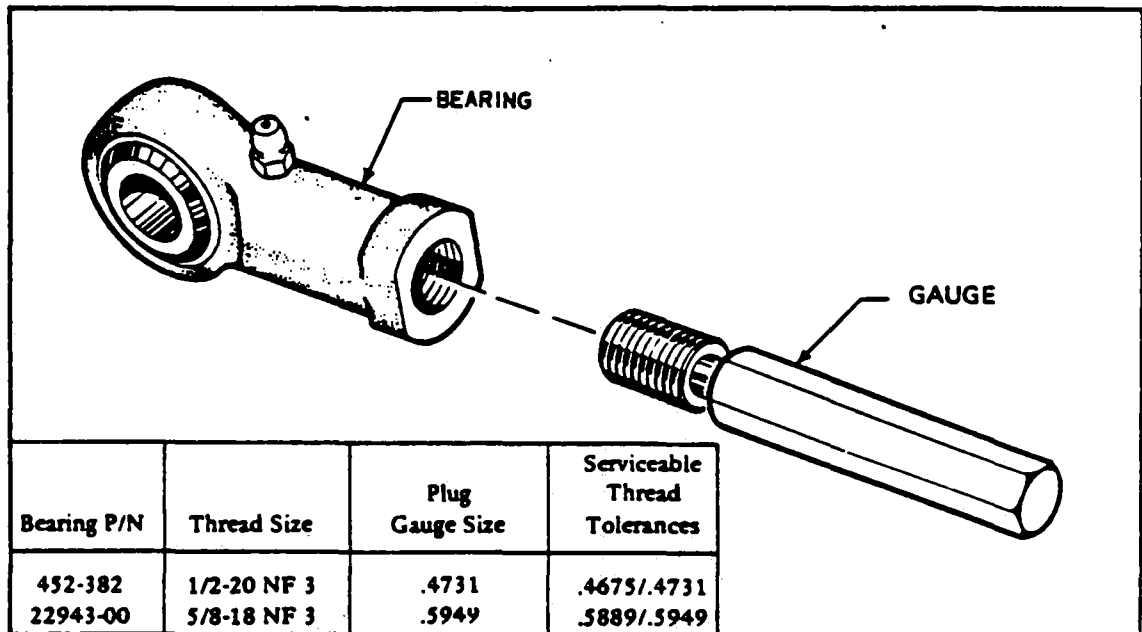


Figure 7-8b. Main Gear Side Brace Bearing Tolerance

b. The following information is the suggested method for checking the bearing threads:

1. This check requires the use of a NO-GO thread plug gauge (refer to table included in Figure 7-8b for the specific size gauge to use. This gauge can be purchased from any good tool supplier.

2. If the NO-GO gauge can be screwed into the bearing, this would indicate that the bearing is worn larger than the tolerances given in the table with Figure 7-8b, and must be replaced.

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Link P/N	Thread Size	O-Vee Gauge	Serviceable Thread Tolerances
20768-00	1/2-20 NF 3	1/2-20	.4675/.4550
20768-01	1/2-20 NF 3	1/2-20	.4675/.4550
24911-00	1/2-20 NF 3	1/2-20	.4675/.4550
22577-00	5/8-18 NF 3	5/8-18	.5889/.5764
25046-00	5/8-18 NF 3	5/8-18	.5889/.5764

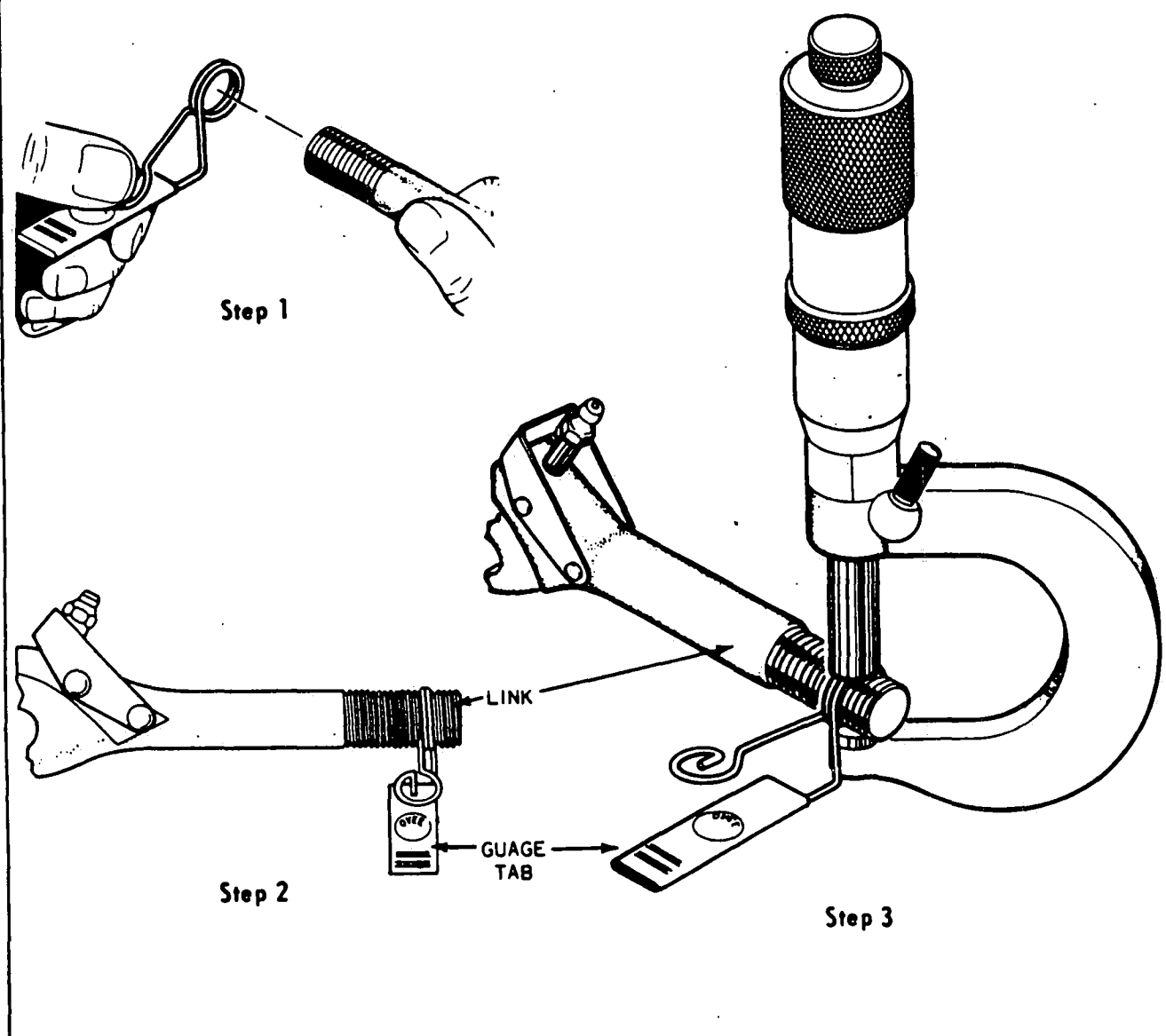


Figure 7-8c. Main Gear Side Brace Link Tolerance



**NOTE**

The NO-GO gauge should not fit a serviceable bearing.

**7-24. INSTALLATION OF MAIN LANDING GEAR. (Refer to Figure 7-9.)**

**NOTE**

When assembling components of the landing gear, lubricate bearings, bushings and friction surfaces with proper lubricant as described in Section II.

- a. Insert a gear support bearing (43 and 48) in each support fitting (11 and 18) and secure with snap rings (45).
- b. The gear housing may be installed in the wheel well of the wing by the following procedure:
  1. Place a spacer washer (17), 0.035, P/N 19513-10, or original number of washers and then the forward support fitting (18) on the forward support arm of the strut housing.
  2. Slide the barrel nut (47) into the forward strut arm and insert the attaching bolt (49) with washer through the fitting into the arm.
  3. Tighten bolt and check support fitting for freedom of rotation.
  4. Secure the aft support fitting (11) to the rear spar web with attaching bolts, washers and nuts.
  5. Position main landing gear strut assembly in the wheel well and attach the front support fitting to the main spar web with attaching bolts and washers.
  6. Using the access hole behind the rear spar, insert the bungee tube (10) with washer (44) (0.125, P/N 14843-20) through the rear support fitting and into the rear strut arm using enough shim washers (12) between the rear support fitting and the strut arm to diminish end play of the strut housing. (Shim washers are available in sizes 0.035, P/N 19513-10; 0.062, P/N 14843-93; and 0.125, P/N 14843-20.)
  7. Position the side brace support bracket (22) on the main spar web and secure with bolts and washers.
- c. Assemble the upper and lower drag links (24 and 27) with pivot bolt (26).
- d. Adjust the lower drag link to a dimension of 6.125 inches from center of the middle pivot bolt to center of the rod end bearing. (Refer to Figure 7-10.)
- e. Install the landing gear door retraction arm on the strut housing and secure with bolt, washers and nut.
- f. Attach the upper drag link to the support bracket with clevis bolt, washer, nut and cotter pin and the lower link to the strut housing with bolt, washers at each side of bearing and nut.
- g. Check for clearance between drag link middle pivot bolt head (26) and the main gear capstrip, and binding of the lower drag link and bearing by retracting and extending the gear by hand. If clearance is less than 0.062 of an inch between pivot bolt head and spar capstrip, additional shims (17) must be added between the strut arm and front support bracket.
- h. Install studs (14) in rear strut arm and safety with minimum 0.041 (Spec. MS20995C41) wire (13).

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- i. Install barrel nut (46) in rear strut arm and insert bolt (9) with washer through

### NOTE

It is suggested that new assist spring (19) be installed if new bungee cords (5) are installed, to insure proper operation of the system.

bungee tube and tighten.

- j. Check gear strut arm support bearings for freedom of rotation by retracting and extending the gear by hand.

- k. Install attaching bolt and bungee cord in roller bracket (7).

- l. Install roller (6) in bracket and secure with pin, washer and cotter pin.

- m. Install inboard pulley (4) and bungee cord assembly on bungee tool (P/N 752 998).

- n. Secure the outboard bungee cord bracket to its fitting aft of the rear spar.

- o. Place the main gear in the up position and secure the inboard bungee pulley to the bungee arm (10) with washers and bolt.

- p. Extend the gear and remove bungee tool.

- q. Connect the retraction push-pull cable (21) to the upper drag link with attaching bolt and adjust. (Refer to paragraph 7-46 for adjustment of push-pull control cables.)

- r. Install the assist spring (19) between the strut housing and upper drag link.

- s. Extend and retract the main gear manually to check that each link assembly locks simultaneously and independently of each other.

### NOTE

Following adjustment to any of the three gears in which the control tubes/rod were disconnected with the aircraft on jacks, the transmission disconnected, ascertain that all three gear drag links go over center and lock at the same time independently of each other.

- t. Install main landing gear down limit switch (25) and adjust. (Refer to paragraph 7-44 for adjustment of landing gear down limit switches.)

- u. Install landing gear safety switch (28) (left gear only) and adjust. (Refer to paragraph 7-43 for adjustment of safety switch.)

- v. Connect the brake line.

- w. Connect the landing gear door retraction rod to the bracket on the main gear strut housing.

### NOTE

Bungee access cover panel to be sealed with 1/8 inch bead of black 3M sealer <sup>TM</sup>1126, applied to access opening flange.

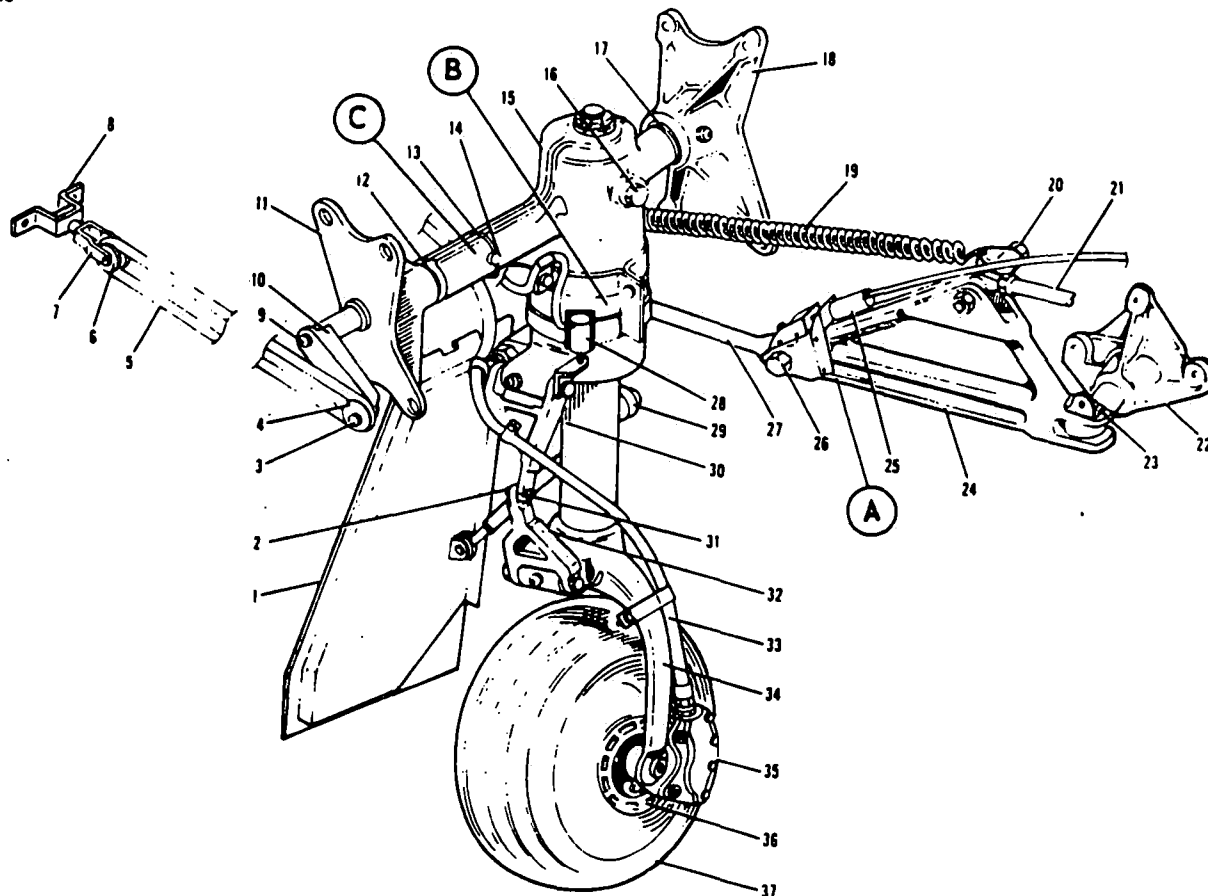
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- |                                  |                             |
|----------------------------------|-----------------------------|
| 1. MAIN GEAR DOOR                | 29. DOOR RETRACTION ROD     |
| 2. BOLT ASSEMBLY                 | 30. UPPER TORQUE LINK       |
| 3. ATTACHMENT BOLT               | 31. SHIM WASHERS            |
| 4. BUNGEE PULLEY                 | 32. LOWER TORQUE LINK       |
| 5. BUNGEE CORD                   | 33. BRAKE LINE              |
| 6. BUNGEE PULLEY                 | 34. FORK ASSEMBLY           |
| 7. BRACKET                       | 35. BRAKE CYLINDER ASSEMBLY |
| 8. FITTING                       | 36. WHEEL                   |
| 9. ATTACHMENT BOLT               | 37. TIRE                    |
| 10. BUNGEE ARM                   | 38. SWITCH ACTUATOR ROD     |
| 11. STRUT SUPPORT FITTING, REAR  | 39. SAFETY SWITCH, EARLY    |
| 12. SHIMS                        | 40. JAM NUT                 |
| 13. SAFETY WIRE                  | 41. ACTUATOR ARM            |
| 14. STUD                         | 42. DOWN LOCK SWITCH, EARLY |
| 15. STRUT HOUSING                | 43. SUPPORT BEARING, REAR   |
| 16. STRUT FILLER VALVE           | 44. SHIM                    |
| 17. SHIMS                        | 45. SNAP RINGS              |
| 18. STRUT SUPPORT FITTING, FRONT | 46. BARREL NUT              |
| 19. ASSIST SPRING                | 47. BARREL NUT              |
| 20. BOLT ASSEMBLY                | 48. SUPPORT BEARING, FRONT  |
| 21. PUSH-PULL CABLE              | 49. ATTACHMENT BOLT         |
| 22. SIDE BRACE SUPPORT BRACKET   |                             |
| 23. PIVOT BOLT                   |                             |
| 24. UPPER DRAG LINK              |                             |
| 25. DOWN LIMIT SWITCH, LATE      |                             |
| 26. PIVOT BOLT                   |                             |
| 27. LOWER DRAG LINK              |                             |
| 28. SAFETY SWITCH, LATE          |                             |

Figure 7-9. Main Landing Gear Installation (Left)

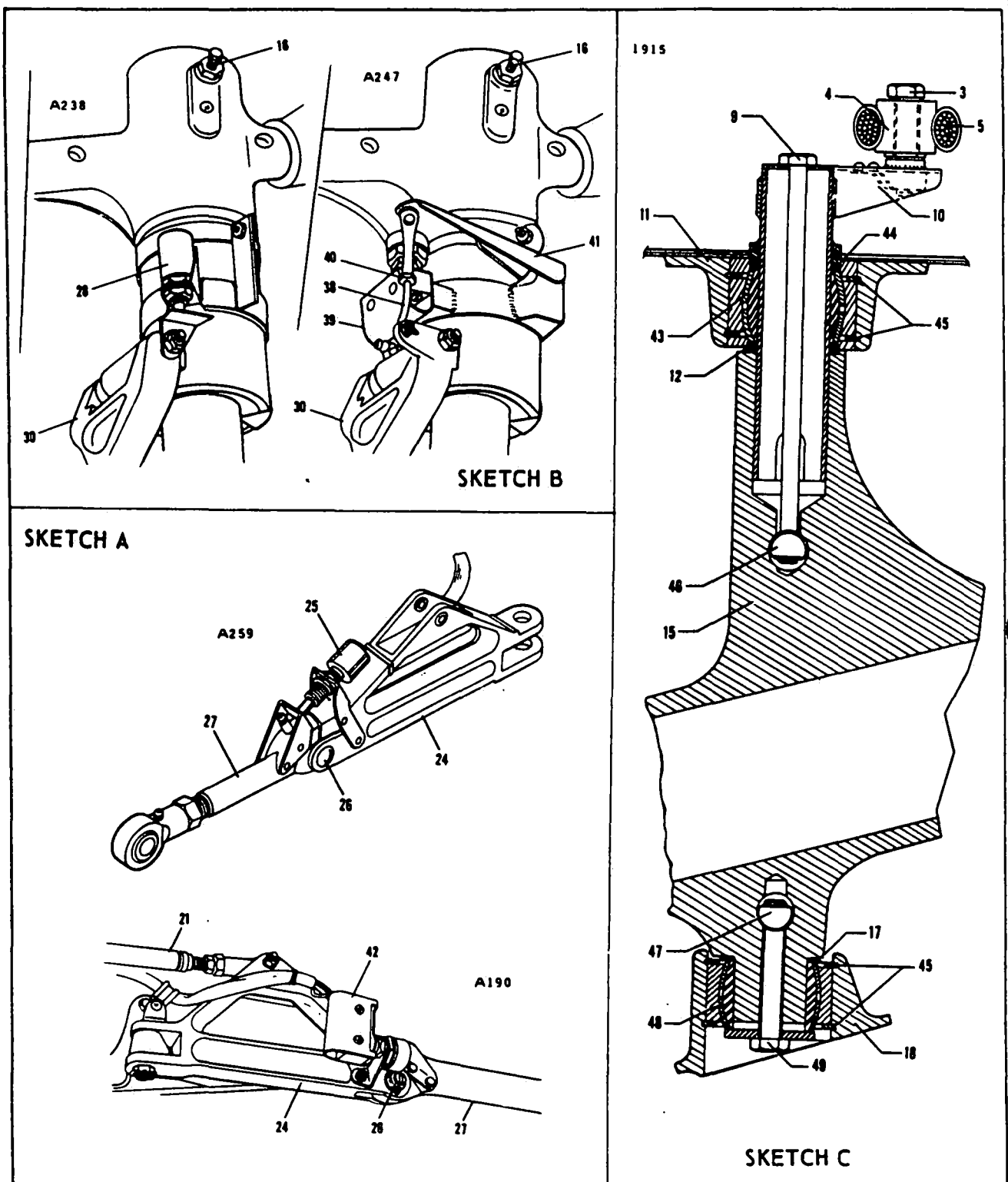


Figure 7-9. Main Landing Gear Installation (Left) (cont.)

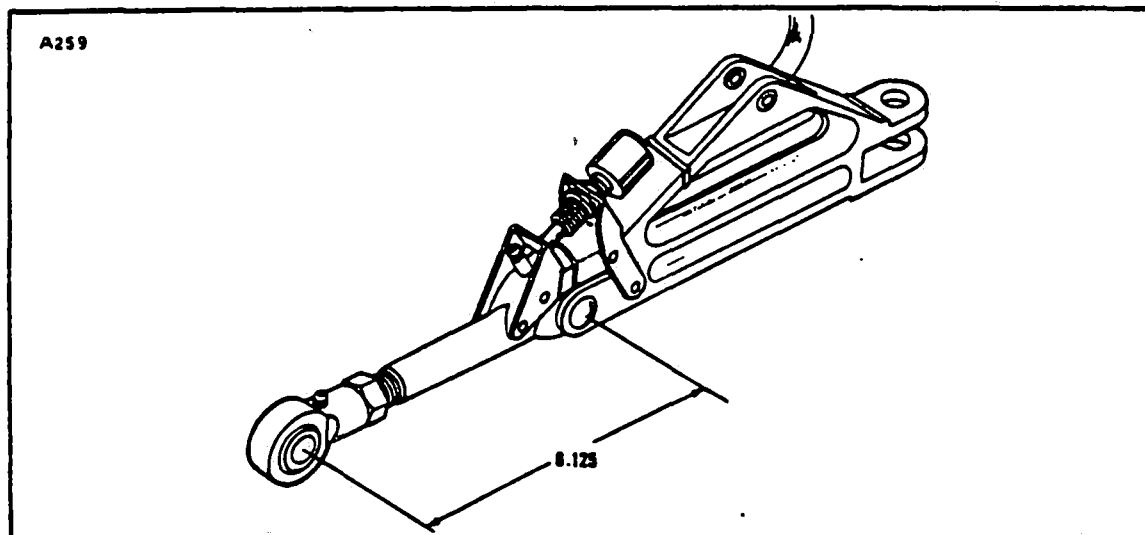


Figure 7-10. Adjustment of Main Landing Gear Drag Link

7-25. ADJUSTMENT OF MAIN GEAR SIDE BRACE LINKS. (Refer to Figure 7-10.) Disconnect the side brace link from the main gear strut housing, and adjust to maintain a distance of 6.125 inches between the center of the pivot bolt which attaches the upper drag link to the lower drag link and the center of the rod end bearing.

NOTE

Do not check adjustment using head of rod end bolt installed in strut as bolt sets at an angle to the center line of the lower drag link.

7-26. ALIGNMENT OF MAIN LANDING GEAR.

- 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 of the landing gear wheels. 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 main landing gear tire. (Refer to Figure 7-11.) If it touches both outboard sides of the tire, the landing gear is correctly aligned. The toe-in for the main landing gear wheels is 0 degrees.

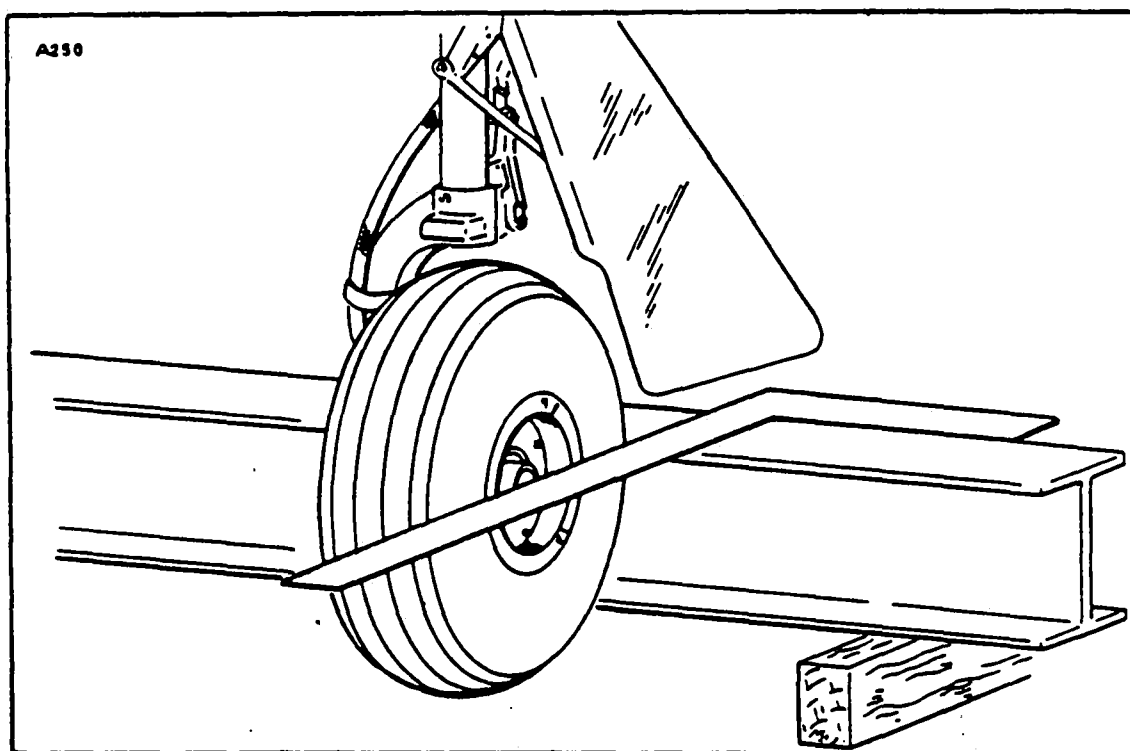


Figure 7-11. Aligning Main Gear

NOTE

A carpenter's square, because of its especially long legs, is recommended for checking main landing gear wheel alignment.

c. If the square contacts the rear side of the tire leaving a gap between it and the front side of the tire, the tire is toed-in. If a gap appears at the rear, the wheel is toed-out.

d. To rectify toe-in or toe-out conditions, remove bolt connecting upper and lower torque links and remove or add spacers to move the wheel in desired direction.

e. Recheck the wheel alignment. If the wheel alignment is correct, safety the castellated nut with a cotter pin. If the misalignment still exists, separate the torque links and add another spacer to the torque links. Limit the number of spacers installed to allow for installation of the cotter pin in the bolt.

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### 7-27. REMOVAL OF MAIN LANDING GEAR DOOR ASSEMBLY.

- a. Disconnect the retraction rod at the oleo strut by removing the attaching nut, washer and bolt.
- b. Remove the gear door by removing the screws attaching it to the bottom of the wing.

### 7-28. CLEANING, INSPECTION AND REPAIR.

- a. Clean all parts with a suitable solvent.
- b. Inspect retraction rod for corrosion at the end bearings.
- c. Inspect doors for cracks, dents, worn hinges and loose brackets.
- d. Repairs are limited to replacement of parts and minor skin repair.

### 7-29. INSTALLATION OF MAIN LANDING GEAR DOOR ASSEMBLY.

- a. Position the gear door in place and secure with attaching screws. Maintain equal clearance between door and wing panel.
- b. Connect the retraction rod to the oleo strut with attaching bolt, washer and nut.

### 7-30. ADJUSTMENT OF MAIN LANDING GEAR DOORS.

- a. Ascertain that there is an all around even clearance between the door and wing panel when the door is in the retracted position.
- b. Adjust by loosening the door hinge screws in the wing panel, repositioning the door and retightening the screws.
- c. The gear door actuating rods should be adjusted so that a nine pound weight suspended at the center line of the inboard edge of the door in the retracted position will create a 0.125 of an inch deflection from the wing contour at the inboard edge of the door.

### 7-31. REPLACEMENT OF WIPER STRIP ON LANDING GEAR STRUTS.

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Jack the airplane only high enough to take weight off the gear.
- c. Release the air pressure from the strut by depressing the valve core pin until the pressure has diminished.
- d. Using snap ring pliers, disengage the snap ring from the annular slot in the oleo housing and allow it to lay at the lower end of the piston tube along with the wiper strip retainer washer.

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e. Remove the old wiper strip from the housing, and clean and inspect the housing to determine that no pieces remain in it.

f. Wipe the piston tube and check it for any abrasions which may damage the new wiper. Polish the tube to remove any abrasions found.

g. A new wiper strip should be cut straight across, and a little longer than needed, to circle the piston tube.

h. Insert the new wiper strip up into the oleo housing with the tapered edge down. Slide the retainer washer and snap ring up the piston tube and insert them into the oleo housing. Using snap ring pliers to compress the snap ring, install it into the annular slot in the oleo housing.

i. Inflate the oleo strut in accordance with instructions given in Oleo Struts, Section II, and remove the airplane from the jacks.

## 7-32. LANDING GEAR RETRACTION SYSTEM.

7-33. PRINCIPAL OF OPERATION. The landing gear is a tricycle type, fully retractable through an electrically operated retraction mechanism. The retraction mechanism consists of an electric motor and transmission assembly, torque tube assembly, push-pull cables for each main gear and a push-pull tube to the nose gear. Limit switches are installed in the system to shut off the motor when the gear is fully extended or retracted. These switches also operate gear indicator lights on the instrument panel.

The landing gear selector switch is placed in the up position activating the retraction motor which operates the transmission. The retraction transmission pushes the torque arms forward which pull the main landing gear cables and pushes the nose gear retraction tube forward, retracting the landing gear. When the gear is fully retracted, the gear up limit switch stops the motor and the amber gear up indicator light on the instrument panel lights. The landing gear selector switch is then placed in the down position, operating the motor and retraction transmission. The transmission pulls the torque arms back which pushes on the main gear cables and pulls on the nose gear tube extending the landing gear. When the gear is fully extended, the gear down switches stop the motor and the green gear down and locked indicator light on the instrument panel lights.

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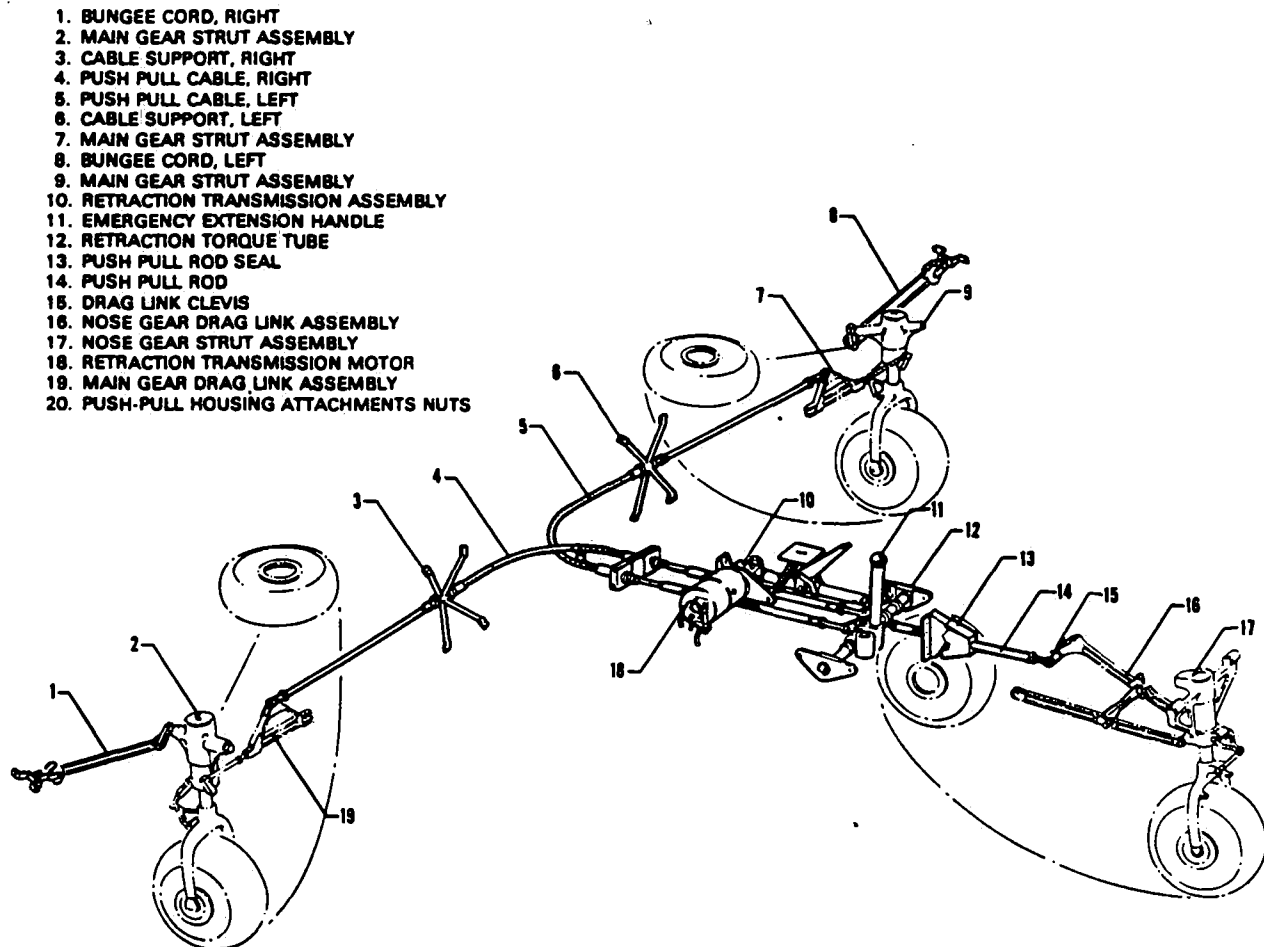


Figure 7-12. Landing Gear Retraction System

**7-34. REMOVAL OF RETRACTION TRANSMISSION ASSEMBLY.** (Refer to Figure 7-14.)

- a. Remove the gear retraction transmission assembly by using the following procedure:
  1. Place the airplane on jacks. (Refer to Jacking, Section II.)
  2. Open the retraction transmission access door located between the two front seats.
  3. Disconnect transmission motor electrical leads by sliding back the protective covering and uncoupling the quick disconnect terminals.
  4. Place the emergency retraction release handle (18) in the full up position.
  5. Disconnect the transmission retraction spring located on the left side of the transmission housing.
  6. Remove the cotter pin, washer and pin (12) attaching the transmission housing to the mounting bracket.
  7. Remove the transmission assembly from the well.

**7-35. CLEANING, INSPECTION AND REPAIR OF GEAR RETRACTION TRANSMISSION.** (Refer to Figure 7-13.)

- a. Remove the six screws attaching the transmission cover (7) to transmission housing and remove the cover noting the position of the mounting lug.
- b. Wipe the old grease from the transmission housing and from the actuator screw (4) and screw nut (3).
- c. Check the gear release arm (1) and ascertain that it will snap lock in place and will require a load of 6 to 12 pounds applied at the end of the arm to release. Adjust by spreading or compressing the arm sides at the round head rivets to obtain proper fit. Once the arm is released, ascertain that there is no binding through its travel.
- d. Inspect the transmission screw and tube nut (2) for end and side play and ascertain that they are not distorted or bent.
- e. Check that the screw bearing (9) is not loose on the transmission screw or within the transmission housing. A loose bearing can be determined by holding the transmission and moving the screw up and down. This check can also be made when the transmission is installed in the airplane, with the landing gear partially retracted, by applying a load to the emergency extension handle and noting play.
- f. Check for wear within the transmission by turning the transmission screw (4) by hand and noting end play in the transmission drive shaft (24). End play usually indicates a worn thrust bearing or a loose connection between the thrust bearing and drive shaft. If end play is in excess of 0.015 of an inch, the transmission should be replaced.

g. The coupling (10) between the transmission and motor may become worn to a point where the metal inserts in the coupling protrudes from the rubber, thus causing chatter. This chatter may be eliminated by grinding the metal inserts until they are 0.010 to 0.015 of an inch below the surface of the rubber. This grinding operation may be repeated until the coupling reaches a minimum diameter of one inch and then should be replaced.

h. Adjust the motor brake (20) (early type) by adjusting the nut on the brake support rod (22) until the brake disc (18) clears the highest point on the retraction transmission coupling. Hold the brake disc firmly against the brake solenoid while making this adjustment.

i. The only adjustment required for the later type motor is to align the brake solenoid unit with the transmission coupling which is accomplished by adjusting the nut on the brake support rod.

j. Fill the transmission housing with grease per special instruction found on Lubrication Chart in Section II of this Service Manual.

#### 7-36. INSTALLATION OF RETRACTION TRANSMISSION ASSEMBLY. (Refer to Figure 7-14.)

a. Ascertain that the transmission is properly lubricated and position it in the transmission well.

b. Align the transmission mounting lug (27) with the hole in the mounting bracket (28) and secure with pin (12), washer and cotter pin.

c. Attach the retraction spring (22 or 23) to the transmission and adjust the cotter pin between the spring and floorboard to maintain enough tension on the spring to hold the transmission away from the retraction torque tube during emergency gear extension.

d. Lubricate the torque arm through bolt (13) and hook the transmission tube (19) over the bolt.

e. Place the emergency release handle (18) in the down and locked position, locking the transmission release tube around the through bolt.

f. Connect the electrical leads and slide the protective covering over the terminals and tie at both ends.

g. Check for proper operation and adjust. (Refer to Paragraph 7-44.)

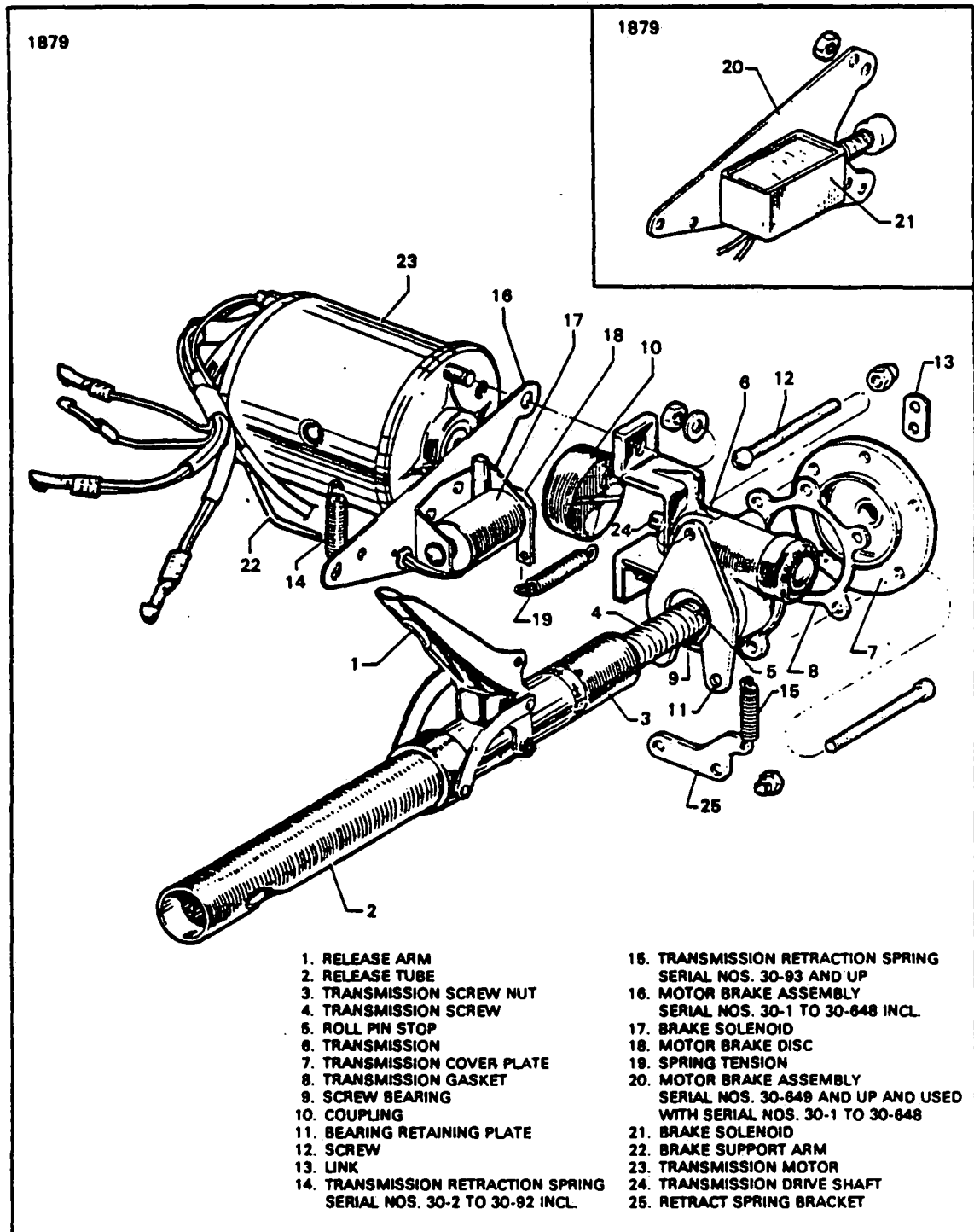


Figure 7-13. Landing Gear Retraction Transmission Assembly

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**7-37. REMOVAL OF NOSE LANDING GEAR PUSH-PULL CONTROL ROD. (Refer to Figure 7-14.)**

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Open the retraction transmission door located between the two front seats and disconnect the transmission by pulling up on the release lever.
- c. Retract the landing gear until it hangs in the neutral position, by using the emergency extension lever.
- d. Disconnect the push-pull rod (11) from the underside of the left torque arm (9) by removing the cotter pin, washer and pin.
- e. Disconnect the forward end of the rod at the left drag link located in the nose gear wheel well by removing nut, washer and bolt. Retract the gear enough to allow removal of the attaching bolt through provided hole in the nose section channel.
- f. Remove the rod by removing end bearing and pulling it through seal and nose gear wheel well.

**7-38. REMOVAL OF MAIN LANDING GEAR PUSH-PULL CONTROL CABLES. (Refer to Figure 7-14.)**

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Open the retraction transmission door and disconnect the transmission by pulling up on the release lever.
- c. Retract the landing gear until it hangs in the neutral position, by using the emergency extension lever.
- d. Remove fuel selector console and carpet attaching screws, roll carpet back off the center access panel and remove panel.
- e. Remove the rear seats and carpet attaching screws on airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive.
- f. Roll the carpet back and remove floor panel aft of the main spar.
- g. On airplanes with Serial Nos. 30-853 and 30-902 and up, remove access panel on bottom of fuselage.
- h. Disconnect the retraction cables (7 and 8) from the torque arms (9 and 10) by removing attaching cotter pins, washers and pins.
- i. Remove castle nuts (3 and 4) from cables at the bulkhead aft of the retraction transmission.
- j. Remove clamps securing cables to bottom of the fuselage.
- k. Enter through the wheel well and disconnect cable ends from upper main gear drag links by removing attaching nut, washers and bolts.
- l. Disconnect cables from the support brackets (36) by removing nuts (34) and washers.

m. Remove the end bearings from the cables at the drag links by backing off the jam nuts and unscrewing the end bearing.

n. Slide the cable support nut (34) and washer off the cable and remove the cable by sliding it through the support bracket and out through the access holes in the floor.

#### 7-39. CLEANING, INSPECTION AND REPAIR OF RETRACTION PUSH-PULL CONTROLS.

a. Clean all parts with a suitable cleaning solvent.

b. The push-pull rod should be inspected for the following unfavorable conditions.

1. Bends in the rod and treaded portion of the end bearings.
2. Dents in the rod.
3. Cracks around the end bearings.
4. Corrosion and excess wear.

c. The main gear push-pull cables should be inspected for the following unfavorable conditions.

1. Freedom of movement through the housing.
2. Corrosion of cable and housing.
3. Excess wear of cable and housing.
4. Bends and cracks of cable ends.

d. Repair of the push-pull controls is limited to replacement of parts.

#### 7-40. INSTALLATION OF NOSE LANDING GEAR PUSH-PULL CONTROL ROD. Install the nose gear push-pull rod using the following procedure:

a. With the rod end bearing removed from the aft end of the push-pull rod, place the rod in the nose wheel well and slide it through the seal assembly.

b. Attach the rod end bearing to the aft end of the rod and check both end bearings for proper thread engagement by sighting or inserting a piece of safety wire through the safety hole.

c. Secure the aft end of the rod to the underside of the left torque arm at the retraction transmission with attaching pin, washer and cotter pin.

d. Because of adjustment later, temporarily attach the front rod end to the left drag link clevis by inserting the countersunk bolt through the clevis from the left allowing sufficient clearance between drag link clevis and fuselage.

e. Adjust push-pull rod per paragraph 7-47.

7-41. INSTALLATION OF MAIN LANDING GEAR PUSH-PULL CONTROL CABLE. (Refer to Figure 7-14.) Install the main landing gear push-pull control cables using the following procedure:

- a. Check cables for freedom of movement through housing prior to installation.
- b. Remove the end bearing from the main gear end of the cable.
- c. Install castellated nut on main gear end of the cable and insert through the access hole in the floor and through the cable support bracket (36).
- d. Install washers and castle nuts and attach the left gear cable (2) to the right torque arm (10) at the transmission with pin, washer and cotter pin.
- e. Install washers and castle nuts and place the right gear cable (1) over top the left gear cable and attach it to the left torque arm (9) at the transmission with pin, washer and cotter pin.
- f. Adjust the cables at the bulkhead aft of the transmission so when the castle nut (3) is tight, three threads are exposed forward of the nut on the cable (1) from the right gear. One thread should show at the castellated nut (4) on the left gear cable (2).
- g. Place the adjusting washer (35) and nut (34) on the cable at the drag link end and install jam nut and end bearing.
- h. Attach the cables to the drag links with bolts, washers and nuts.
- i. Tighten adjusting nut at the support bracket.
- j. Clamp the cables to bottom of the fuselage and spar to prevent chafing.

NOTE

Install conduit with minimum number of bends. Avoid bends with radius less than eight inches.

- k. Adjust the cables. (Refer to Paragraph 7-46.)
- l. Operate the landing gear to check for freedom of movement.

NOTE

When checking the landing gear for operation on jacks, disconnect the retraction transmission and nose gear down lock springs. Following adjustment to any of the three gears in which the control tubes/rod were disconnected with aircraft on jacks, the transmission disconnected, ascertain that all three gear drag links go over center and lock at the same time independently of each other.

- m. When all checks and adjustments are completed, safety all the castellated nuts as shown in Figure 7-14 Sketch B, with MS20995-C41 safety wire.
- n. Install floor panels and attach with screws.
- o. Position the carpet and secure with screws.
- p. Install fuel selector console.
- q. Install the seats.



**7-42. ADJUSTMENT OF LANDING GEAR RETRACTION SYSTEM.**

a. After changing or adjusting any assembly of the gear or retraction system, an adjustment of its following component should be made.

Example: Replacing or adjusting drag link, recheck push-pull cable or rod adjustment.

Example: Shimming left nose gear drag link clevis, recheck push-pull rod.

**NOTE**

When adjusting the complete landing gear system, follow the adjusting procedure, in sequence, as outlined in paragraphs 7-43 through 7-49. Always jack the airplane before attempting any adjustment.

**7-43. ADJUSTMENT OF LANDING GEAR SAFETY SWITCH.**

a. The landing gear safety switch located on the left main gear is adjusted so the switch is actuated in the last 0.75 of an inch of gear extension.

b. The switch with the boot seal and adjusting rod (Refer to Figure 7-9, Sketch B) is adjusted by placing the gear in full down position and the strut fully extended. Screw the actuator arm (41) down until the switch clicks on, then screw down an additional 0.187 of an inch and secure with jam nut (40).

c. The round switch used on aircraft without the adjusting rod and arm is adjusted by compressing the strut until 5.5 inches is obtained between the top of the gear fork (34) and bottom of the gear housing (15), then adjust the switch down until it contacts the striker plate. Secure the switch and safety.

d. Ascertain that either switch will actuate in the last 0.75 of an inch of oleo extension.

**7-44. ADJUSTMENT OF THE GEAR DOWN LIMIT SWITCH.**

a. Before attempting any adjustment of the down limit switch, ascertain that the nose and main gear drag link assemblies are properly adjusted. Refer to Paragraphs 7-12 and 7-25.

b. Each main gear down limit switch attached to the side brace drag link assembly is adjusted by moving the switch toward or away from the striker plate. When the landing gear is down and locked, the limit switch should have broken contact.

c. The nose gear down limit switch located at the left drag link is adjusted by moving it toward or away from the striker plate. When the gear is down and locked, the switch should have broken contact.

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- d. Check operation of the down limit switches by the following procedure:
  1. Open landing gear retraction motor circuit breaker.
  2. Turn on the master switch.
  3. Disconnect the retraction transmission by pulling up on the release lever and manually retracting the landing gear using the emergency extension lever.
  4. At the point where the green light goes out, apply rearward pressure on the nose gear and inward pressure on the main gear. The gear should not unlock.

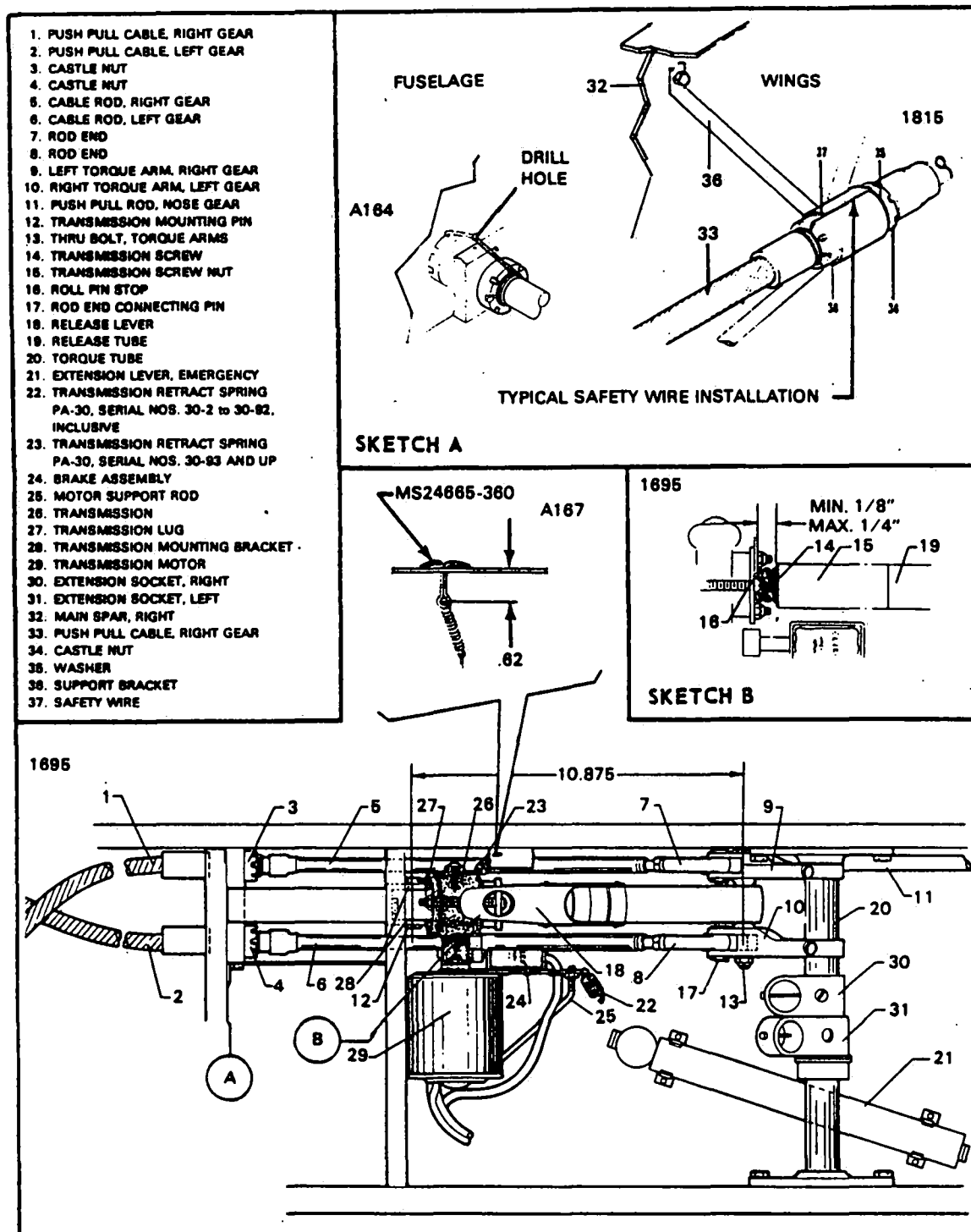
7-45. ADJUSTMENT OF GEAR RETRACTION TRANSMISSION ASSEMBLY. (Refer to Figure 7-14.) Adjust the retraction transmission by using the following procedure:

- a. Release the retraction transmission by pulling up on the emergency release lever.
- b. Adjust the push-pull cables so the cable (1) from the right gear has three threads exposed forward of the castellated nut and the cable (2) from the left gear has one thread exposed forward of the castellated nut. (A spanner wrench may be fabricated to tighten the castellated nuts, see Figure 7-29.)

### NOTE

The main gear push-pull cables cross each other aft of the retraction transmission.

- c. Turn the transmission release tube (19) on actuator screw to maintain a distance of 10.875 inches between the center of the transmission mounting pin (12) and center of the thru bolt (13) connecting the lower portion of the torque arms. This adjustment should allow approximately a (minimum of 0.125 inch) measured along the actuator screw (14) between the roll pin stop (16) and the screw nut (15).
- d. The cable rods (5 and 6) should be moved to approximately 1/8 inch of being full aft.
- e. Adjust the push-pull rod ends (7 and 8) to allow their connecting pins (17) to push freely through the torque arm clevises (9 and 10) and rod end bearings.
- f. Check that the threads of the push-pull rods extend past the check holes in the rod end fittings. Secure the rod end fitting jam nuts and safety all pins.
- g. Safety wire all castle nuts as shown in Figure 7-14 Sketch A.



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**7-46. ADJUSTMENT OF MAIN GEAR PUSH-PULL CABLES.**

- a. With the transmission assembly adjusted (Refer to Paragraph 7-45) and the gear down and locked, adjust the push-pull cable rod end so the bearing hole aligns with the hole in the drag link.
- b. Extend the rod end fitting one-half turn on an old cable and one complete turn on a new cable. This will provide the necessary preload to absorb backlash or play in the cable. Also, it will produce a small amount of constant pressure, through the cable, against the gear drag link when the gear is down and locked.
- c. Be sure the threads of the push-pull cable extend past the check hole in the rod end fitting. Tighten the jam nut against the rod end fitting and install assist spring.

**7-47. ADJUSTMENT OF NOSE GEAR PUSH-PULL ROD.**

- a. Attach the retraction rod clevis to the left nose gear drag link. Shims are installed between the clevis and drag link for correct retraction of the nose gear into the wheel well. Clevis shims, P/N 23115-00, are 0.032 of an inch only and a maximum of three may be installed.
- b. With the main and nose gear down and locked, adjust the push-pull rod end fitting until the hole in the rod end bearing aligns with the hole in the clevis, then turn the rod end in one complete turn. For proper clearance of the clevis, install the clevis bolt with the countersunk portion at the left or outboard side.

**NOTE**

With the gear in the full retracted position, check for interference at the push-pull rod and clevis. The locknut at the rod end bearing may bind with the clevis and cause failure at the threaded portion of the end bearing. The rod end threads should be carefully examined for cracks. When checking the landing gear for operation on jacks, disconnect the retraction transmission and nose gear down lock springs. Following adjustment to any of the three gears in which the control tubes/rod were disconnected with aircraft on jacks, the transmission disconnected, ascertain that all three gear drag links go over center and lock at the same time independently of each other.

- c. Check nose gear door adjustment. (Refer to Paragraph 7-17.)

**7-48. ADJUSTMENT OF GEAR UP SWITCH. (Refer to Figure 7-15.)** Adjust the gear up switch using the following procedure:

- a. Retract the gear and check to insure that both main gear assemblies enter the wheel well approximately the same distance and that the nose gear enters far enough.
- b. If the gear does not retract far enough, move the switch (3) up in its bracket and run the check again. On the late model airplanes a set screw (2) is located

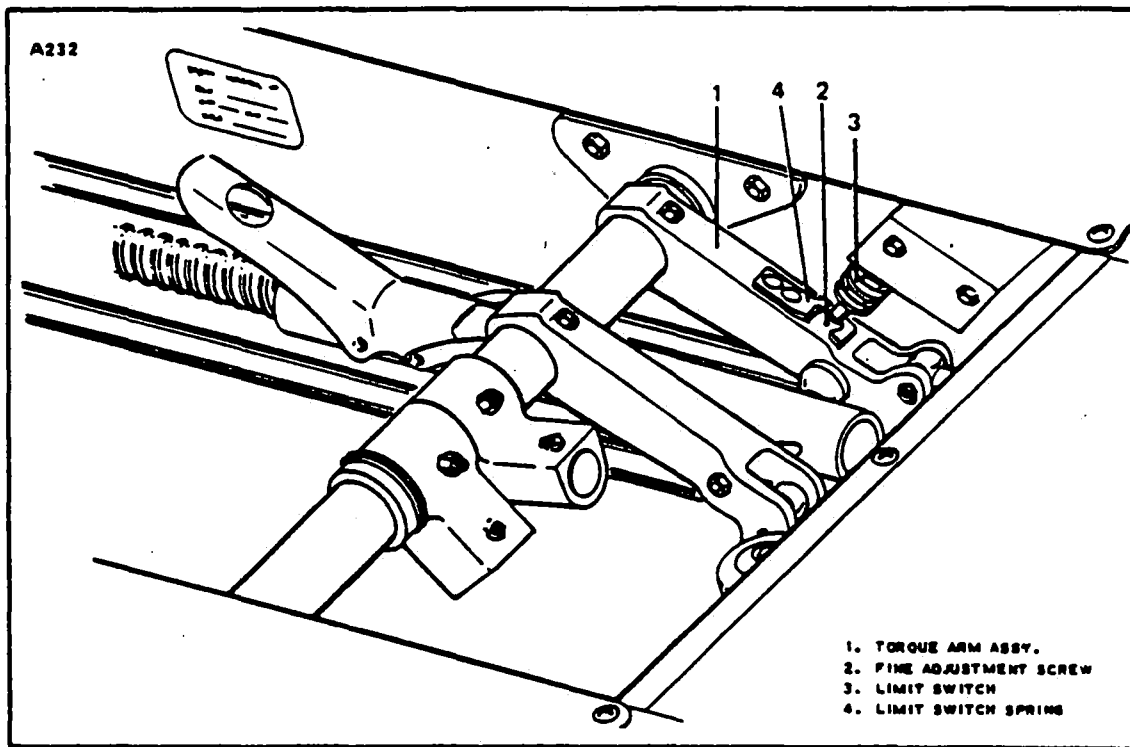


Figure 7-15. Landing Gear Up Limit Switch

in the left torque arm (1) for fine adjustment purposes.

c. If the gear retracts too far before the motor shuts off, the switch must be moved down in its bracket.

d. To determine a proper fit of the main gear, retract the landing gear. The main gear should be pulled snugly against the rubber stop blocks located in the wheel well, and the nose gear should retract far enough.

e. Should it be found necessary to adjust the nose gear, remove or add shims at the drag link clevis, then readjust the push-pull rod.

f. Check nose gear and main gear door adjustment. (Refer to Paragraphs 7-17 and 7-30.)

7-49. CHECKING LANDING GEAR RETRACTION LOAD. (Refer to Figure 7-16.) After the landing gear has been lubricated and properly adjusted as described in the preceding paragraphs, check retraction load by using the following procedure:

a. Place the airplane on jacks. (Refer to Jacking, Section II.)

b. With the gear fully extended, disconnect the retraction transmission assembly by pulling up on the emergency release lever.

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- c. Partially retract the gear until it hangs in the neutral position by using the emergency extension lever.
- d. Install adapter tool (P/N 26347-00) in the left socket of the retraction torque tube.
- e. Ascertain that the shoulder of the adapter is completely seated on the torque tube socket.
- f. Open the gear motor circuit breaker to prevent motor from running during gear check.
- g. Partially retract landing gear using adapter and install torque wrench on adapter, aligning the center line of the torque wrench with the center line of the retraction torque tube.
- h. Turn on the master switch and slowly pull aft on the torque wrench completely retracting the gear.
- i. Observe torque reading when the amber gear up indicator light initially comes on. The torque reading should not exceed limits given in Table VII-I.

TABLE VII-I. TORQUE FOR EFFECTIVE WRENCH LENGTH	
EFFECTIVE WRENCH LENGTH (INCHES)	MAXIMUM TORQUE (FOOT POUNDS)
18	111
16	106
14	100
12	93
10	84

- j. If torque exceeds the limits specified, check for the following:
  - 1. Insufficient lubrication, possible binding, improper adjustment and damaged parts of the retraction system.
  - 2. Check the up limit switch for proper adjustment. It may not actuate soon enough causing the main gear to be pulled too hard against the rubber stop blocks, exerting excessive load on the system. The main gear should fit snugly against the rubber stop blocks in the wheel well.

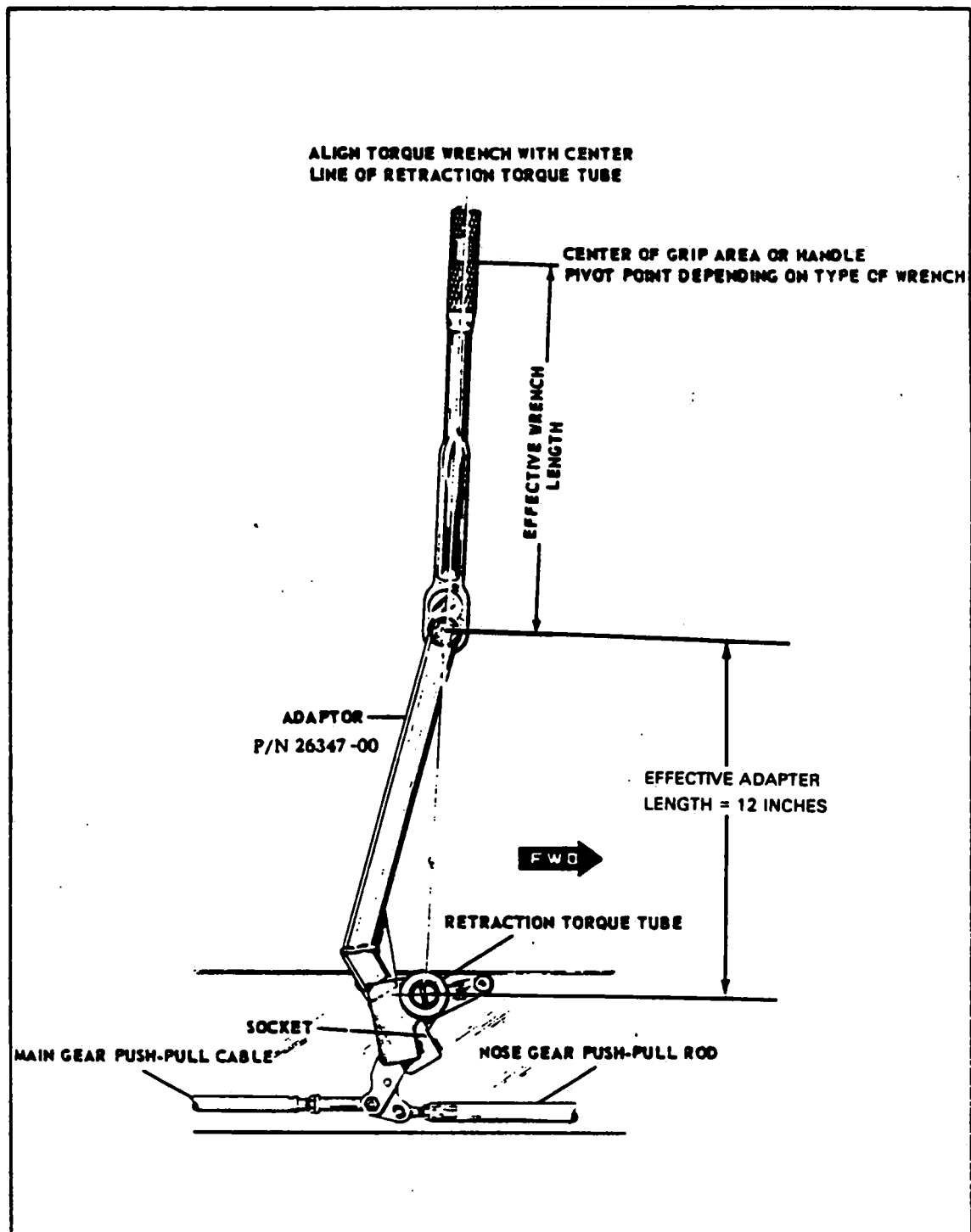


Figure 7-16. Torque Wrench and Adapter Installation

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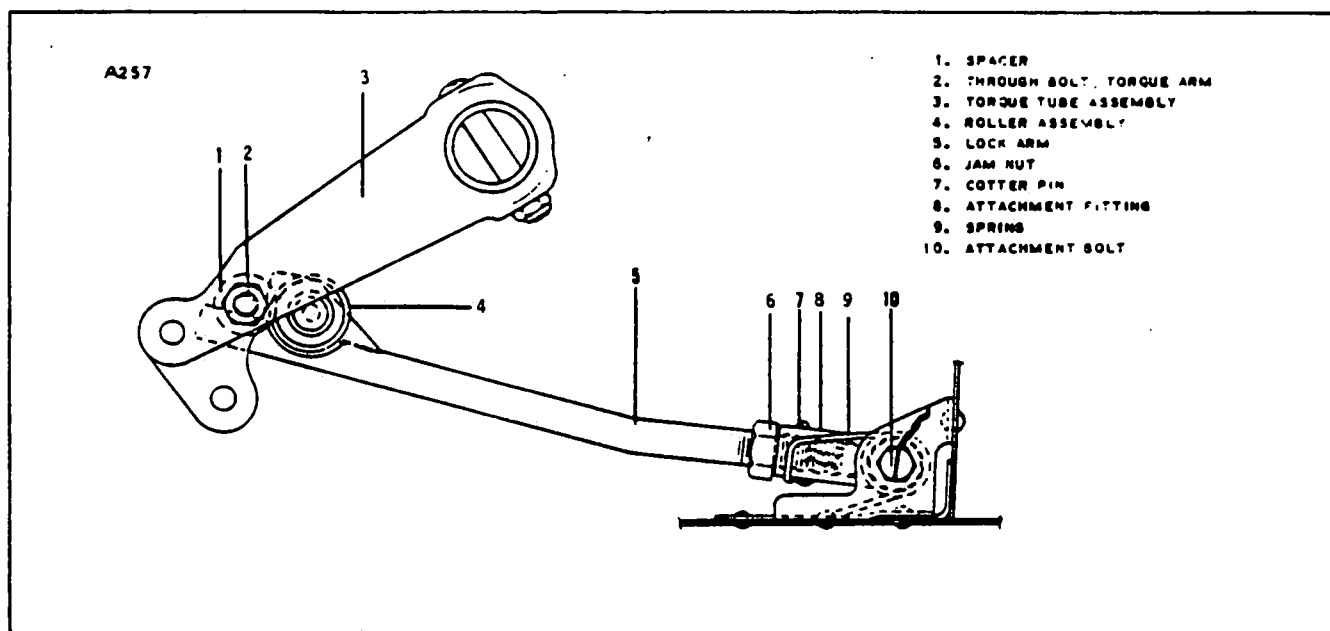


Figure 7-17. Landing Gear Down Lock Installation

**7-50. ADJUSTMENT OF LANDING GEAR DOWN SAFETY LOCK.** The purpose of the gear down safety lock is to provide an additional means to retain the gear retraction torque tube assembly in the down position with the gear transmission disengaged (emergency extension condition). Landing forces are absorbed by the over center mechanism held in position by springs at each gear and not intended to be transferred to the push-pull rod and cables.

- a. Ascertain that the landing gear is properly adjusted.
- b. Adjust the gear down safety lock by the following procedure:
  1. Place the airplane on jacks. (Refer to Jacking, Section II.)
  2. Disconnect the retraction transmission by pulling up on the emergency release lever.
  3. The down safety lock should be adjusted as close to the spacer (1) on the torque arm thru bolt (2) as possible, yet freely engage when the gear is fully extended.
  4. To adjust the lock, remove cotter pin (7), loosen jam nut (6) and turn lock arm (4) in the desired direction.
  5. If one-half turn is needed for correct adjustment, remove bolt (10) attaching lock fitting (8) to the bulkhead bracket and turn fitting in the desired direction.
  6. Install fitting and spring (9) in the bulkhead bracket and secure with bolt.
  7. Tighten jam nut, install cotter pin and safety wire attachment bolt head.
- c. Check the gear down safety lock by using the following procedure:
  1. Install the emergency gear extension lever in the torque tube socket, making sure it is properly seated and fully extended.
  2. Attach an accurate spring scale (0 to 100 pound range) to the bottom of the extension lever knob.
  3. Pull out on the gear motor circuit breaker and turn on master switch.



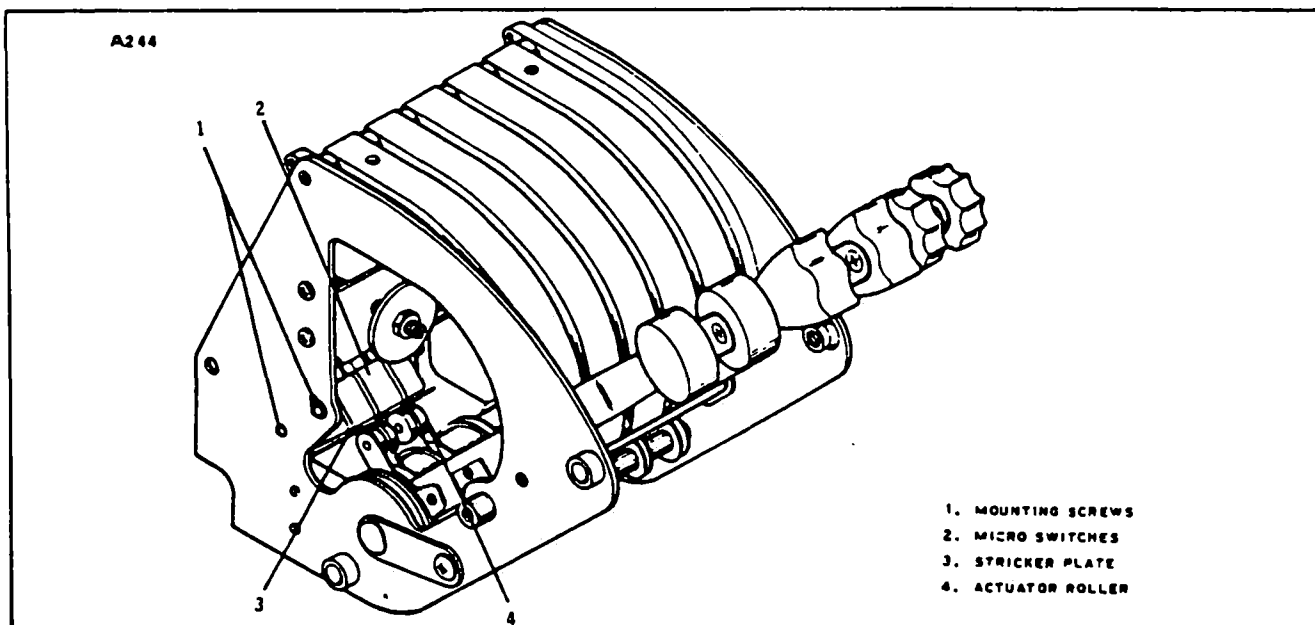


Figure 7-18. Landing Gear Warning Switch Installation

4. Disengage the down safety lock and measure force on the extension lever by pulling horizontally aft on the spring scales until the gear downlock light goes out.
5. Engage the down safety lock and make the same force measurement with the addition of 35 pounds to the first measurement.
6. The gear downlock light should remain "ON".
7. If the gear downlock light goes out, check adjustment of the landing gear retraction system.

#### 7-51. LANDING GEAR WARNING SWITCH.

#### 7-52. REMOVAL OF LANDING GEAR WARNING SWITCH.

- a. Remove the left side panel from the throttle quadrant by loosening the snap fasteners or removing attaching screws.
- b. Remove screws, nuts and washers attaching switch bracket to quadrant.
- c. Disconnect the electrical wires from the switches and remove the switches and bracket.

#### 7-53. INSTALLATION OF GEAR WARNING SWITCHES.

- a. Connect the electrical leads to the micro switches.
- b. Place the switches in their bracket and secure with assembly to the throttle quadrant with screws, washer and nuts.
- c. Adjust warning switches per paragraph 7-54.
- d. Place the side panel on quadrant and snap into place or secure with screws.

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**7-54. ADJUSTMENT OF GEAR WARNING SWITCH.** The following is the procedure for adjusting the gear warning horn micro switches.

- a. Start and run up the engines with the propeller set for high RPM. Retard the throttle until 12 inches of manifold pressure is indicated.
- b. Mark the throttles in some manner so they can be returned to the proper setting indicated during the run-up after the engines have been shut down.
- c. Place the airplane on jacks (Refer to Jacking, Section II) and retract the landing gear.
- d. Position the throttle at the location which gave the proper manifold pressure indication.
- e. With the battery master switch ON, loosen the mounting screws (1) (Refer to Figure 7-18) on the micro switch mounting bracket and move the switches up or down until the gear warning horn starts to operate.
- f. Tighten the mounting screws to secure the switches.
- g. With the gear warning horn operating, lower the gear to insure that the horn ceases to operate when the gear is down and locked.
- h. Remove the airplane from the jacks.
- i. Flight test the airplane to insure proper operation of the gear warning system with the gear up and power reduced below 12 inches of manifold pressure.
- j. Reduce power on one engine and insure amber light flashes.
- k. If horn fails to operate at the required setting, mark the throttles at the proper manifold pressure and repeat the adjusting procedure.

### 7-55. WHEELS.

**7-56. REMOVAL AND DISASSEMBLY OF NOSE WHEEL.** (Refer to Figure 7-19.)

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. To remove the nose wheel, remove the axle tie rod nut, tie rod and axle plugs. Insert a 1.437 inch diameter tube into the fork and tap out the axle from the wheel assembly.
- c. Flex the fork enough to remove the wheel spacers and to allow the wheel to clear the fork assembly.
- d. The wheel may be disassembled by deflating the tire and removing the screws (8) securing the grease seal retainers (5).
- e. Remove the retainer and bearing cones (4).
- f. Remove the bolts (12) securing the wheel halves and separate them.
- g. The bearing cups (3) should be removed only for replacement and may be removed by tapping evenly from the inside of the wheel.

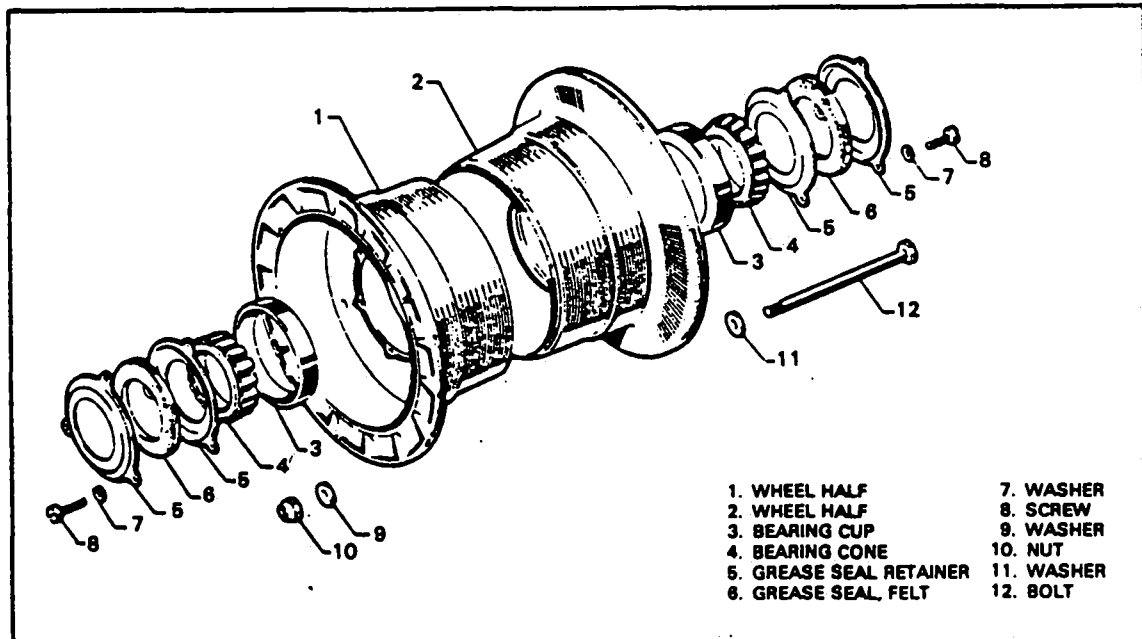


Figure 7-19. Nose Wheel Assembly

**7-57. INSPECTION OF NOSE WHEEL ASSEMBLY.**

- a. Visually check all parts for cracks, distortion, defects and excess wear.
- b. Check tie bolts for looseness or failure.
- c. Check internal diameter of felt grease seals. Replace the felt grease seal if surface is hard or gritty.
- d. Check tire for cuts, internal bruises and deterioration.
- e. Check bearing cones and cups for wear and pitting and relubricate.
- f. Replace any wheel casting having visible cracks.

**7-58. ASSEMBLY AND INSTALLATION OF NOSE WHEEL.**

- a. Ascertain that the bearing cup (3) in each wheel half is properly installed. Install the tire and join the two wheel halves. Install the through bolts (12) with the nuts (10) to the wheel valve stem side, torque to the specification given on the wheel and inflate the tire.
- b. Lubricate and install bearing cones (4).
- c. Install grease seals (6) and retainers (5) and secure with screws (8).
- d. Flex the fork enough to allow for the installation of the wheel and spacer tubes. Insert the axle tube, fork caps and tie bolt. Adjust the tie bolt nut to allow the wheel to turn free yet not fit loose on the axle.

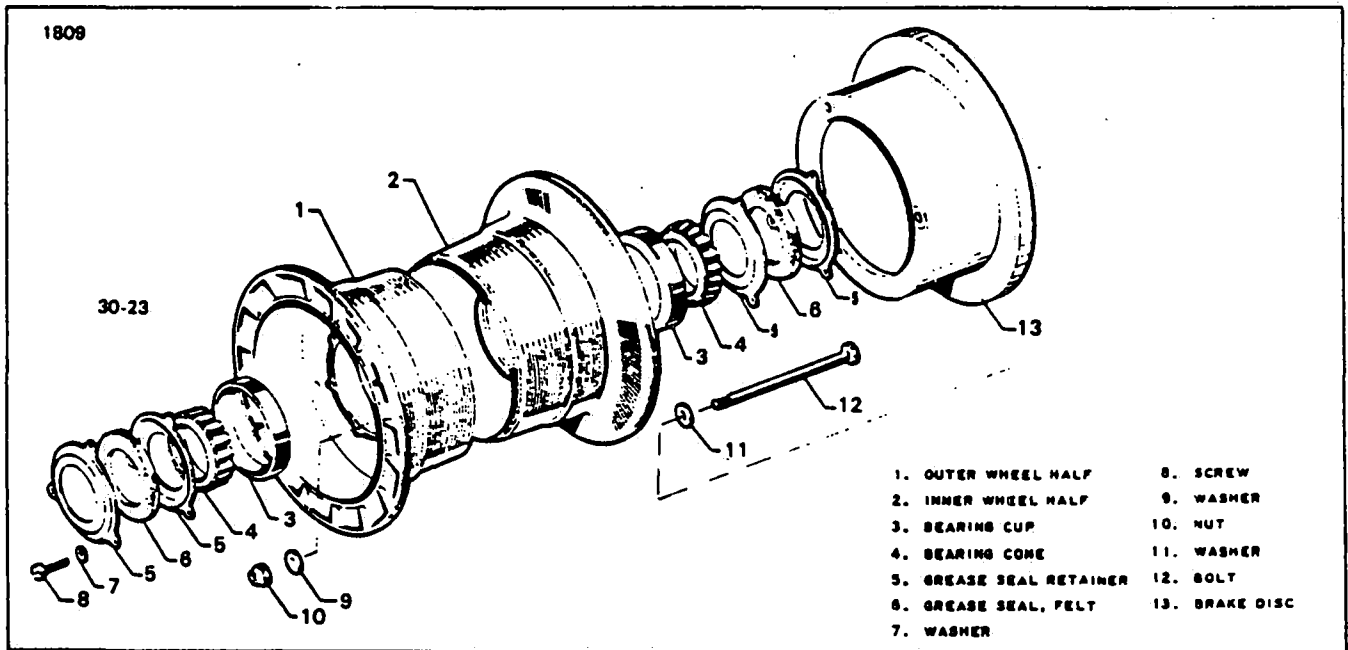


Figure 7-20. Main Wheel Assembly, Serial Nos. 30-2 to 30-845 Incl.

#### 7-59. REMOVAL AND DISASSEMBLY OF MAIN WHEEL.

- a. Place the airplane on jacks. (Refer to Jacking, Section II.)
- b. Remove the four bolts joining brake cylinder and lining back plate assembly and remove the brake assembly.
- c. On airplanes with Serial Nos. 30-2 to 30-845 inclusive, remove and disassemble the wheel as follows (Refer to Figure 7-20.):
  1. Remove the axle tie rod nut, tie rod and axle plugs.
  2. Insert a 1.875 inch diameter tube into the fork and tap out the axle from the wheel assembly.
  3. Insert a prying tool between the side of the fork assembly and wheel and apply enough pressure on the fork to allow the wheel to clear the fork assembly.
  4. The wheel may be disassembled by using the following procedure:
    - (a) Deflate the tire and remove the grease seal retainer (5) by removing the attaching screw (8).
    - (b) Remove the bearing cones (4).
    - (c) Remove the bolts (12) securing the wheel halves together.
    - (d) The bearing cups (3) should be removed only for replacement and may be removed by tapping evenly from the inside.

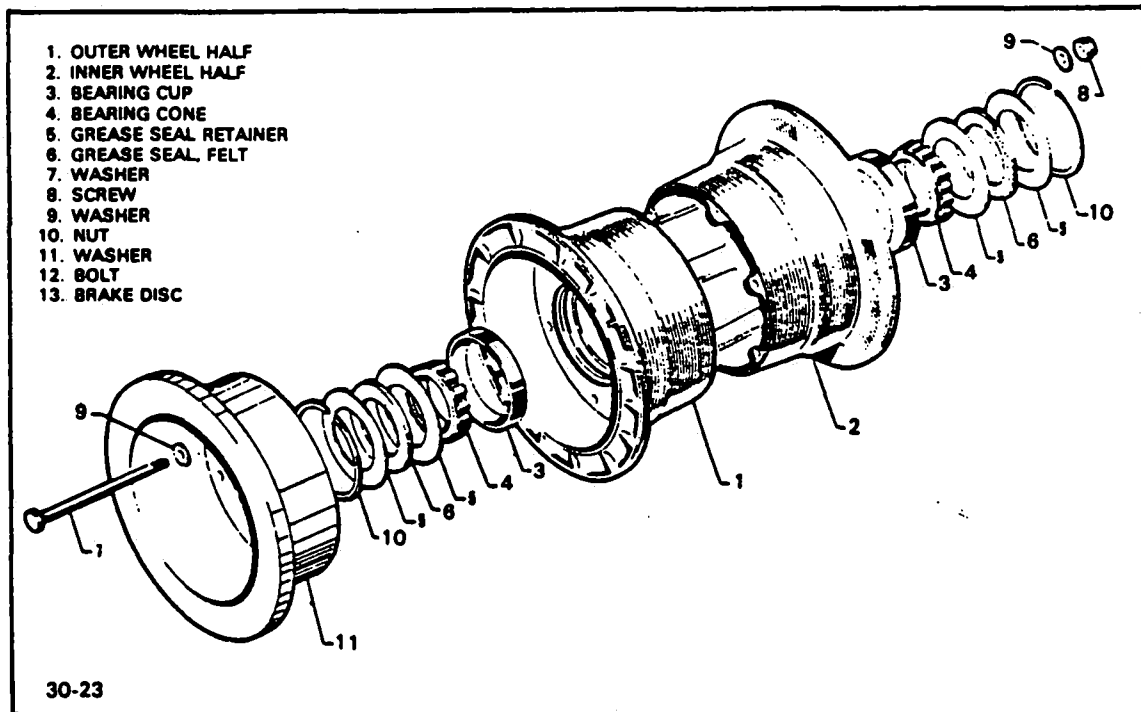


Figure 7-21. Main Wheel Assembly, Serial Nos. 30-846 to 30-2000 incl.

d. On airplanes with Serial Nos. 30-846 to 30-2000 inclusive, remove and disassemble the wheel as follows (Refer to Figure 7-21):

1. Remove the axle dust cover by removing attaching screws.
2. Remove the cotter pin and axle nut and slide the wheel off the axle.
3. The wheel may be disassembled by deflating the tire and removing the snap rings (10) securing the grease seals (6) and seal retainers (5).
4. Remove the bearing cones (4) and remove the bolts (7) securing the wheel halves.
5. The bearing cups (3) should be removed only for replacement and may be removed by tapping evenly from the inside of the wheel.

#### 7-60. INSPECTION OF WHEEL ASSEMBLY.

- a. Visually check all parts for cracks, distortion, defects and excess wear.
- b. Check tie bolts for looseness or failure.
- c. Check internal diameter of felt grease seals. Replace the felt grease seals if surface is hard or gritty.
- d. Check tire for cuts, internal bruises and deterioration.
- e. Check bearing cones and cups for wear and pitting and relubricate.
- f. Replace any wheel casting having visible cracks.

**7-61. ASSEMBLY AND INSTALLATION OF MAIN WHEEL.**

- a. Ascertain that the bearing cup (3) in each wheel half is properly installed.
- b. Install tire and join the two wheel halves.
- c. Insert through bolts (12) with bolt heads on the brake disc side and torque to specifications given on the wheel and inflate tire.
- d. Lubricate the bearing cones (4) and install bearings, grease seals (6) and retainers (5). Secure retainers with screws or snap rings.
- e. On airplanes with Serial Nos. 30-2 to 30-845 inclusive, install the wheel as follows:
  1. The wheel may be installed by flexing the fork enough to allow for installation of wheel and spacer tubes.
  2. Insert the axle tube, fork caps and tie bolt.
  3. Adjust tie bolt nut to allow the wheel to turn freely yet not fit loose on the axle.
- f. On airplanes with Serial Nos. 30-846 to 30-2000 inclusive, install the wheel as follows:
  1. Slide the wheel on the axle.
  2. Tighten the axle nut to allow the wheel to turn freely yet not fit loose on the axle.
  3. Safety the axle nut and install dust cover.
- g. Install the brake assembly by positioning the brake lining back plates between the wheel and brake disc and the brake cylinder on the torque plate. Insert the spacer block and shim between the back plates and cylinder, and install the four bolts to secure the assembly. If the brake line was disconnected, reconnect the line and bleed the brakes. (Refer to Paragraph 7-72.)

**7-62. BRAKE SYSTEM.**

**7-63. REMOVAL AND DISASSEMBLY OF WHEEL BRAKE ASSEMBLY. (Refer to Figure 7-22.)**

- a. To remove the brake assembly, disconnect the brake line from the brake cylinder and cap it to prevent contamination.
- b. Remove the four cap bolts (1) that join the brake cylinder housing (3) and lining back plate assemblies (12). Remove the back plates from between the brake disc and wheel.
- c. Slide the brake cylinder housing from the torque plate (13).
- d. Slide the pressure plate (7) and lining (8) off the anchor bolts (14) of the cylinder housing (3).
- e. The pistons (5) may be removed by injecting low air pressure in the cylinder fluid inlet and forcing them from the housings.
- f. The lining (8 and 11) can be removed by prying it from the pressure plate (7) and back plates (12).

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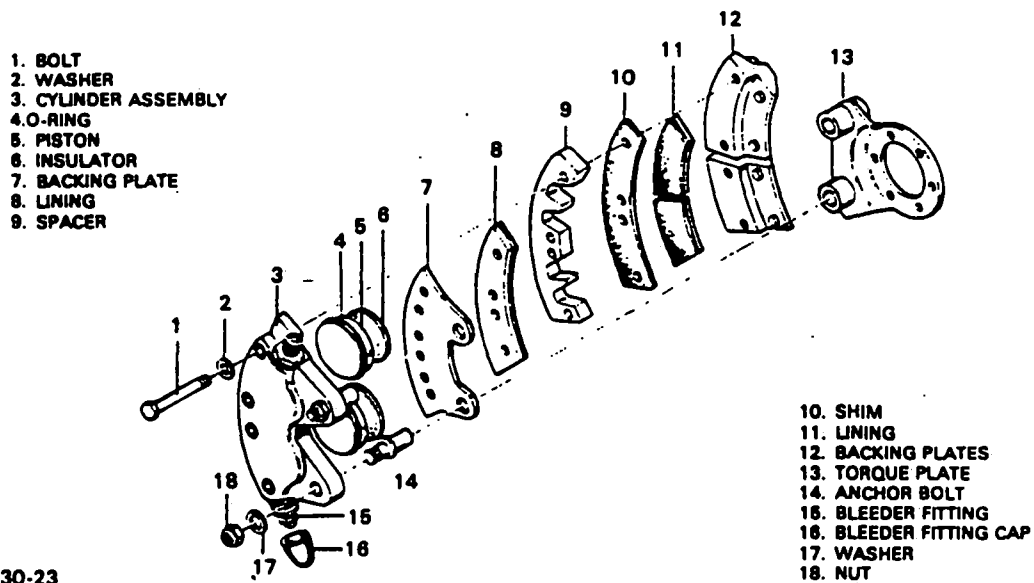


Figure 7-22. Wheel Brake Assembly

**7-64. CLEANING, INSPECTION AND REPAIR OF WHEEL BRAKE ASSEMBLY.**

- a. Clean the assembly with a suitable solvent and dry thoroughly.
- b. Check the walls of the cylinder housing and pistons for scratches, burrs, corrosion, etc., that may damage "O" rings.
- c. Check the general condition of the brake bleeder screw and lines.
- d. Check the brake disc for wear, grooves, scratches, pits or coning. Coning beyond .015 in either direction would be cause for replacement. Wear of the disc should not be less than 0.345 of an inch at its thinnest point. A single groove or isolated grooves up to 0.031 of an inch deep would not necessitate replacement, but a grooving of the entire surface would reduce lining life and necessitate replacement of the lining. Should it become necessary to remove the wheel disc, refer to paragraph 7-66.
- e. If a powdery rust appears on the disc, it can be cleared up by one or two taxi braking applications. Heavier rust may require removal of the disc so that it may be wire brushed and then sanded with 220 grit sandpaper.
- f. The old lining can be removed by prying it from the back plate and pressure plate and a new lining snapped into place.

**NOTE**

Linings should be replaced when the thickness of any one segment is 0.093 of an inch or less, or the lining is worn uneven.

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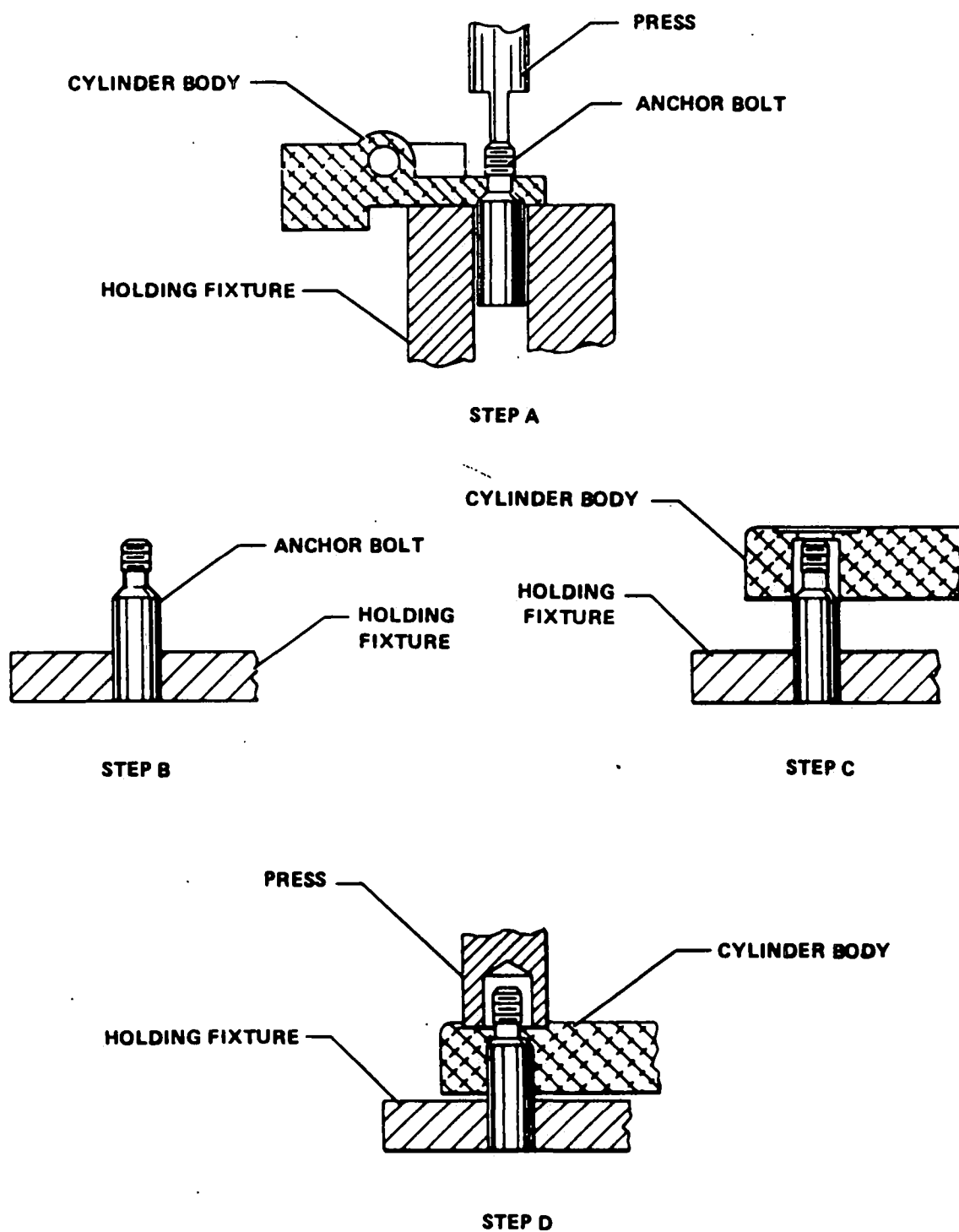


Figure 7-22a. Removal and Installation of Anchor Bolts

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LANDING GEAR AND BRAKE SYSTEM



**7-65. ASSEMBLY AND INSTALLATION OF WHEEL BRAKE ASSEMBLY. (Refer to Figure 7-22.)**

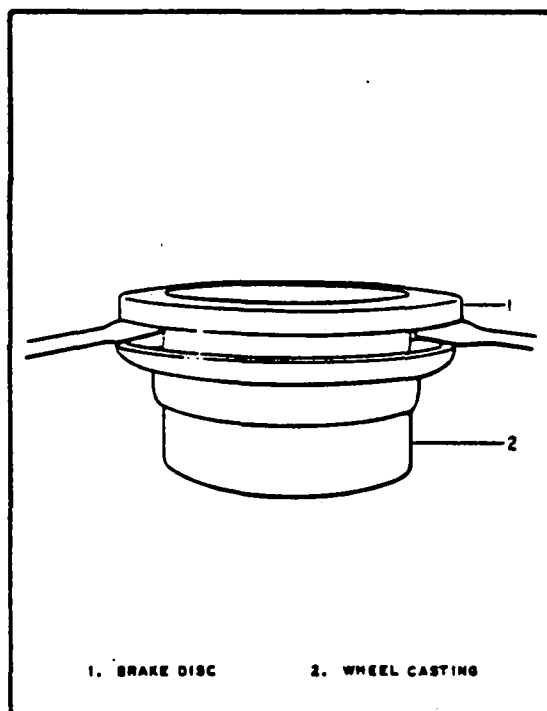
- a. Lubricate the piston "O" rings (4) with fluid (MIL-H-5606) and install on pistons (5).
- b. Slide the pistons in cylinder housing (3) until flush with surface of housing.
- c. Slide the lining pressure plate (7) onto the anchor bolts (14) of the housing.
- d. Slide the cylinder housing assembly on the torque plate (13) of the landing gear.
- e. Position the lining back plates (13) between the wheel and brake disc. Insert the spacer block (9) and spacer shim (10) between the back plates and cylinder housing, and install the four bolts (1) to secure the assembly. Torque to 60 inch-pounds and safety.
- f. Connect the brake line to the brake cylinder housing.
- g. Bleed the brake system as described in paragraph 7-72.

**NOTE**

Replacement brake linings should be conditioned. Perform three consecutive hard braking applications from 45 to 50 mph. Do not allow the brake discs to cool substantially between stops. This procedure will wear off high spots and generate sufficient heat to glaze the linings.

**7-66. REPLACEMENT OF WHEEL BRAKE DISC.**

- a. Place wheel half assembly into boiling water for five minutes and remove disc from wheel casting by use of pry bars. (Refer to Figure 7-23.)
- b. Clean casting thoroughly and apply heavy coat of zinc chromate paint in brake disc recess.
- c. Place wheel casting into boiling water for a few minutes; remove and insert new replacement brake disc into the expanded wheel. Ascertain that bolt holes are aligned and brake disc is properly seated.



**Figure 7-23. Removal of Wheel Brake Disc**

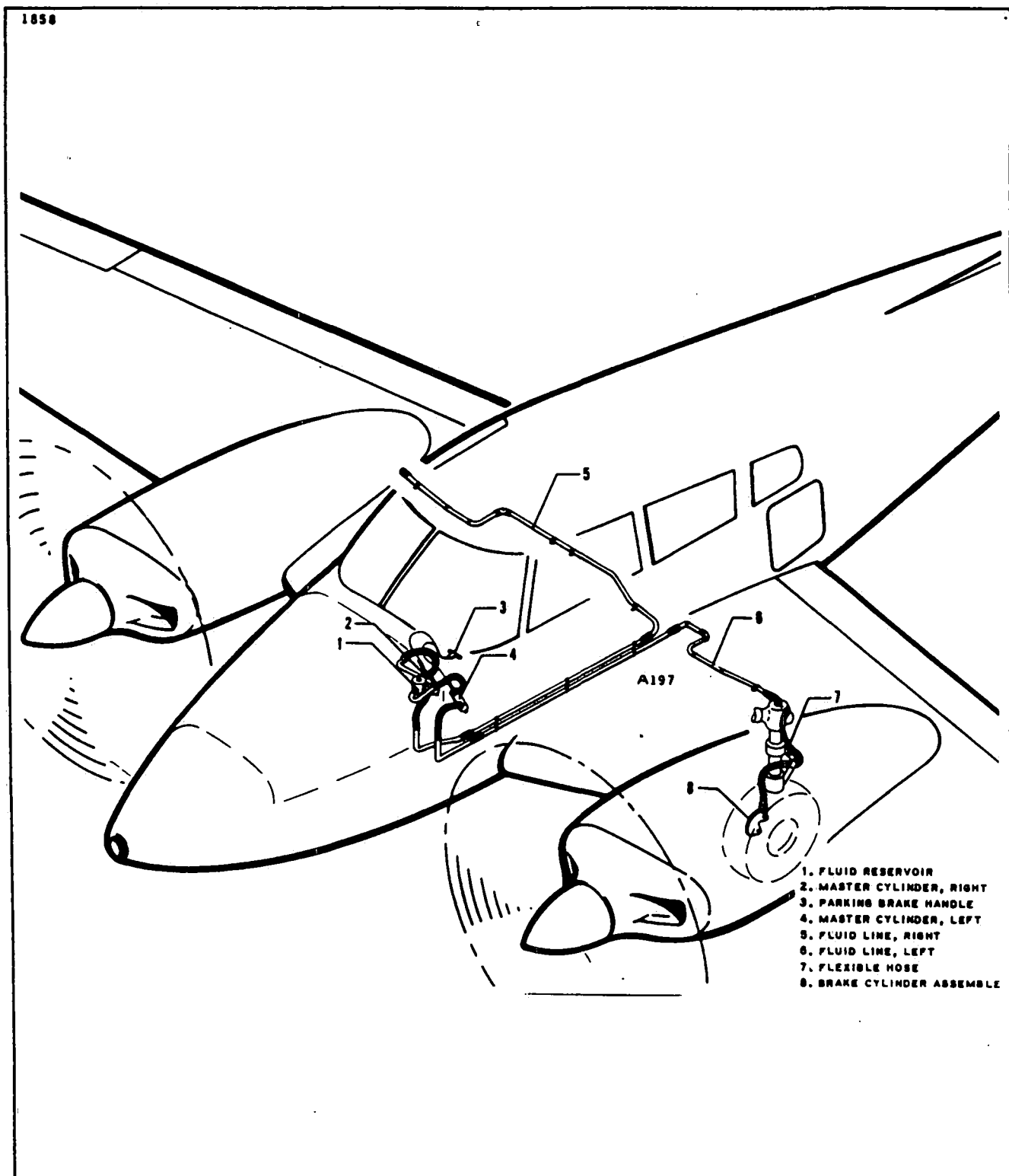


Figure 7-24. Brake System Installation

**7-67. REMOVAL OF BRAKE CYLINDER.**

- a. Disconnect the upper and lower brake lines from the cylinder and cap the lines to prevent leakage or drain the fluid from the reservoir and cylinder.
- b. Remove the cylinder from its attachment fittings by removing the attaching cotter pins, nuts, washer and clevis bolts.
- c. Remove parking brake cable from cylinder by removing attaching clamp at the top of the cylinder and loosening the set screw and pulling the cable from the arm.

**7-68. DISASSEMBLY OF BRAKE CYLINDER. (Refer to Figure 7-25.)**

- a. Loosen the gland packing nut (5) and slide the piston rod assembly (8) out of the cylinder assembly (15).
- b. Remove the snap ring (14) at the bottom of the piston rod assembly and slide off bushing (13), spring (12), piston (10), washer (9), packing nut (7) and spring (4).
- c. Remove the nut (24), washer (23), spring (22), bushing (21) and "O" ring (20) attaching the parking brake arm (25) to the cylinder housing (15).
- d. Remove the lower fluid line fitting (19) and pull out the spring (18), "O" ring (17) and valve (16).

**7-69. CLEANING, INSPECTION AND REPAIR OF BRAKE CYLINDER.**

- a. Clean the cylinder parts with a suitable solvent and dry thoroughly.
- b. Inspect the interior walls of the cylinder for scratches, burrs, corrosion, etc.
- c. Inspect the general condition of the fitting threads of the cylinder.
- d. Check the piston and valve for scratches, burrs, corrosion, etc.
- e. Repairs to the cylinder are limited to polishing out small scratches, burrs, etc. and replacing valve washer seal and "O" rings.

**7-70. ASSEMBLY OF BRAKE CYLINDER. (Refer to Figure 7-25.)**

**NOTE**

Use a small amount of hydraulic fluid (MIL-H-5606) on the "O" ring and component parts to prevent damage and ease of handling during reassembly.

- a. Install the "O" ring (17) on the parking valve (16) and insert it into the cylinder housing.

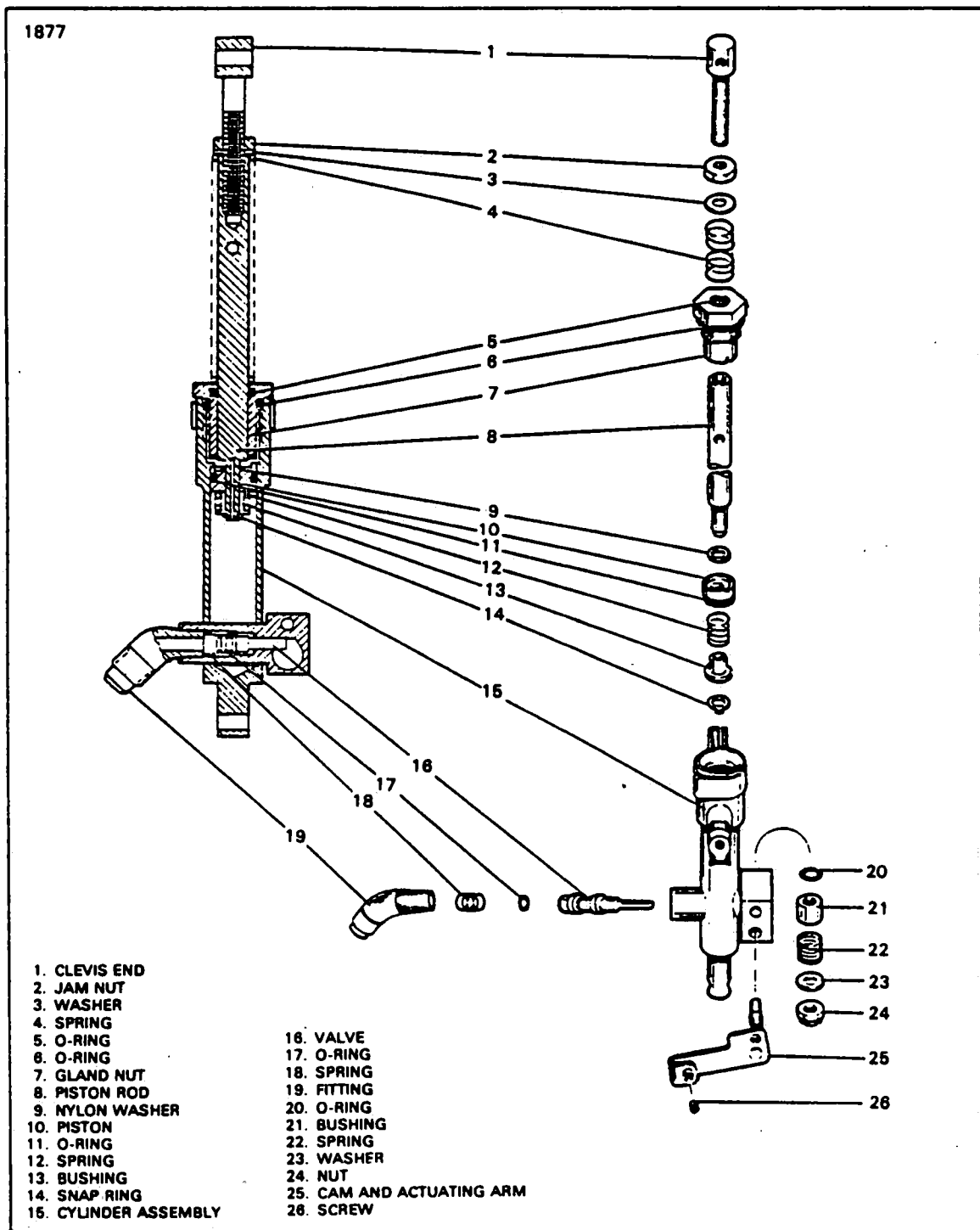


Figure 7-25. Brake Master Cylinder Assembly

- b. Install spring (18) and fluid line fitting (19).
- c. Slide the actuating arm (25) into the cylinder housing and install "O" ring (20), bushing (21), spring (22), washer (23) and secure with nut (24).
- d. Install "O" ring on inside (5) and outside (6) of gland packing nut (7).
- e. Slide spring, gland packing nut (7), washer (9), piston (10) with "O" ring (11), spring (12) and bushing (13) on piston rod (8) and secure with snap ring (14).
- f. Insert the piston rod assembly into the cylinder assembly and tighten gland nut.

**7-71. INSTALLATION OF BRAKE CYLINDER. (Refer to Figure 7-26a.)**

- a. Position the cylinder in its mounting bracket and insert the upper mounting bolts from the inboard side of each cylinder along with the appropriate hardware as shown in Figure 7-26a.

**WARNING**

The correct upper mounting bolt must be installed as shown in Figure 7-26a for the particular serial numbered aircraft being serviced.

- b. Insert the parking brake cable through the bushing in the actuating arm and secure with set screw.
- c. Clamp the cable housing to the upper part of the cylinder assembly.
- d. Connect the brake fluid lines to the cylinder fittings.
- e. Bleed the brake system per instructions given in paragraph 7-72.

**7-72. BLEEDING PROCEDURE.** If the brake line has been disconnected for any reason, it will be necessary to bleed the brake and line as described below.

- a. Place a suitable container at the brake reservoir to collect fluid overflow.
- b. Remove the rubber bleeder fitting cap located on the bottom of the brake unit housing on the landing gear.
- c. Slide a hose over the bleeder fitting, loosen the fitting one turn 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. Tighten bleeder fitting and remove the hose. Check brakes for proper pedal pressure.
- e. Repeat this procedure on the other gear.
- f. Drain excess fluid from reservoir to Fluid Level line with a syringe.

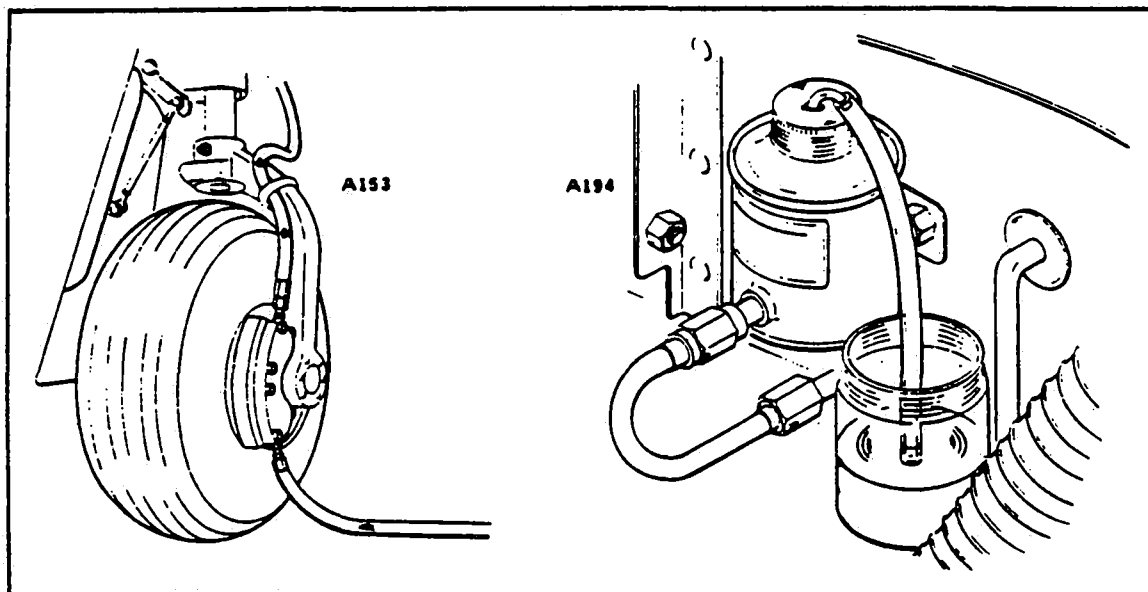


Figure 7-26. Bleeding Brakes

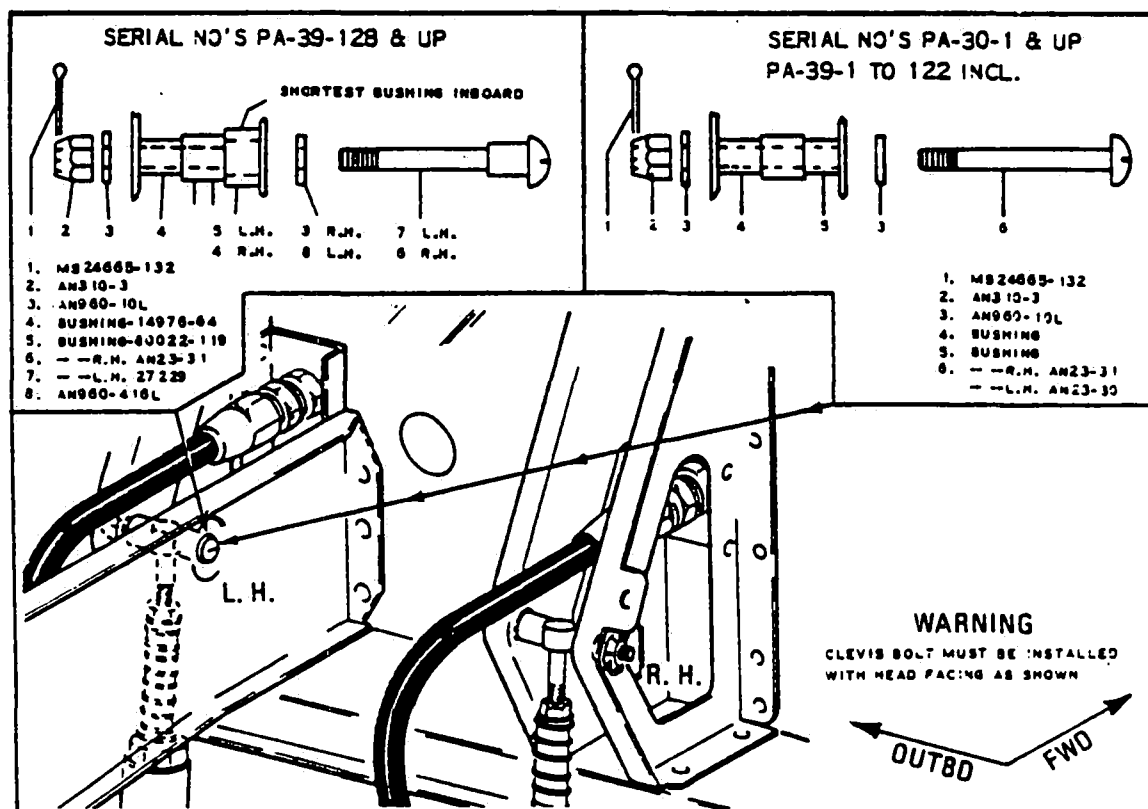


Figure 7-26a. Brake Cylinder Installation

TABLE VII-II. TROUBLESHOOTING CHART (LANDING GEAR SYSTEM)

Trouble	Cause	Remedy
Landing gear retraction system fails to operate.	Gear motor circuit breaker open.	Reset circuit breaker.
	Wire broken on safety switch.	Check safety switch and repair wire connection.
	Transmission motor assembly inoperative.	Repair wiring and replace motor if necessary.
	Transmission motor assembly burned out.	Replace transmission motor assembly.
Warning horn fails to operate when throttles are closed and landing gear is retracting.	Micro switches on throttles out of adjustment.	Adjust micro switch. (Refer to Paragraph 7-54.)
	Nose gear down limit switch inoperative.	Repair wires and replace limit switch if necessary.
	Warning horn assembly.	Adjust or replace if necessary.
Transmission assembly motor does not stop when landing gear is in the fully extended position.	Landing gear down limit switches out of adjustment.	Adjust down limit switches.
Amber GEAR UP light out.	Lamp burned out.	Replace lamp.

TABLE VII-II. TROUBLESHOOTING CHART (LANDING GEAR SYSTEM) (cont)

Trouble	Cause	Remedy
Amber GEAR UP light out. (cont)	Landing gear up limit switch out of adjustment.	Adjust limit switch.
	GEAR INDICATOR LIGHTS circuit breaker open.	Reset circuit breaker.
Warning horn fails to stop when throttles are closed and landing gear is extended.	Micro switches at throttle controls out of adjustment.	Adjust micro switch. (Refer to Paragraph 7-54.)
	Nose gear down limit switch inoperative.	Repair wires and replace limit switch if necessary.
Transmission motor assembly does not shut off when gear is in fully retracted position.	Landing gear up limit switch out of adjustment.	Adjust limit switch at retraction torque tube arm.
Green GEAR DOWN light out.	Lamp burned out.	Replace lamp.
	Gear down limit switches out of adjustment.	Adjust limit switches.
	GEAR INDICATOR LIGHTS circuit breaker open.	Reset circuit breaker.



TABLE VII-II. TROUBLESHOOTING CHART (LANDING GEAR SYSTEM) (cont)

Trouble	Cause	Remedy
Transmission screw operates but release tube remains stationary.	Bearing retainer sleeve hits pin.	Rig landing gear system so that when transmission motor assembly stops, bearing retainer sleeve is 1/8 inch or more from the roll pin stop.
	Bearing retainer sleeve hits other restriction.	Remove restriction.
Landing gear will retract with oleo strut in a depressed condition.	Safety switch out of adjustment.	Adjust safety switch.

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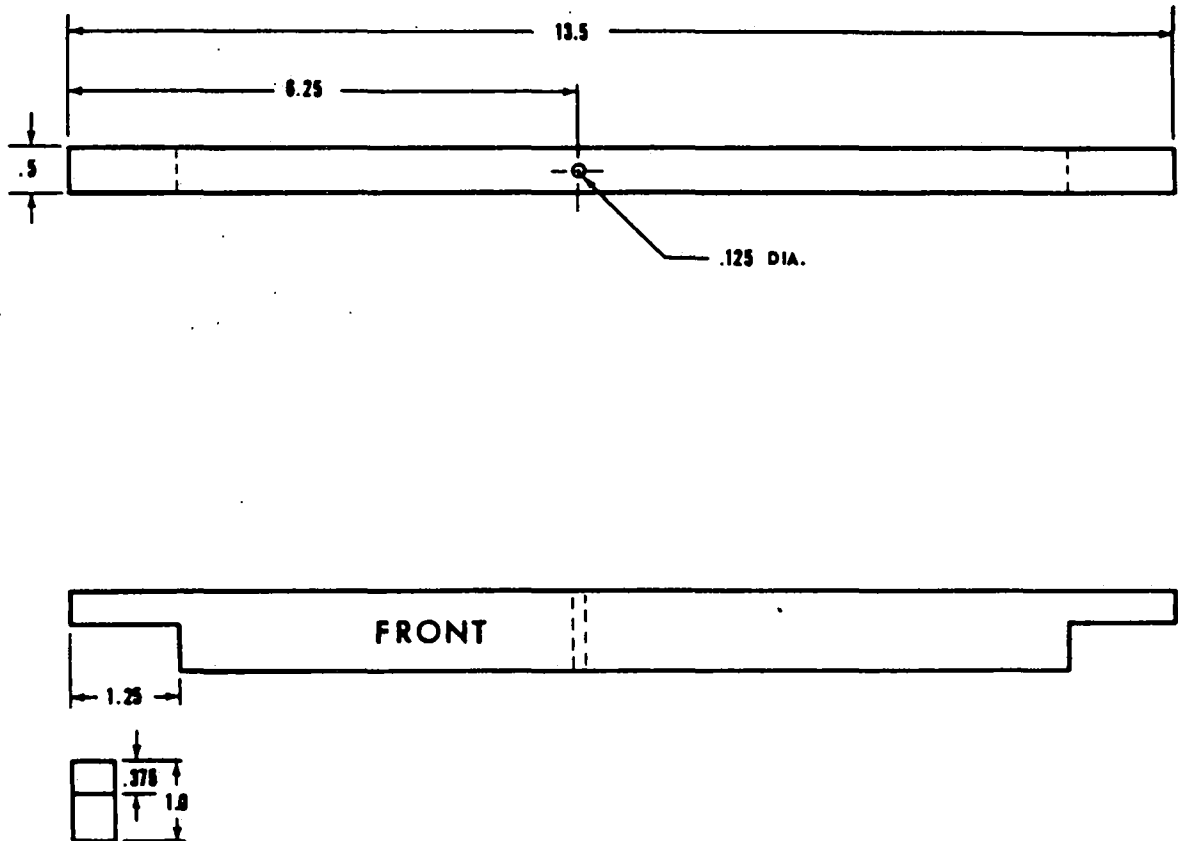
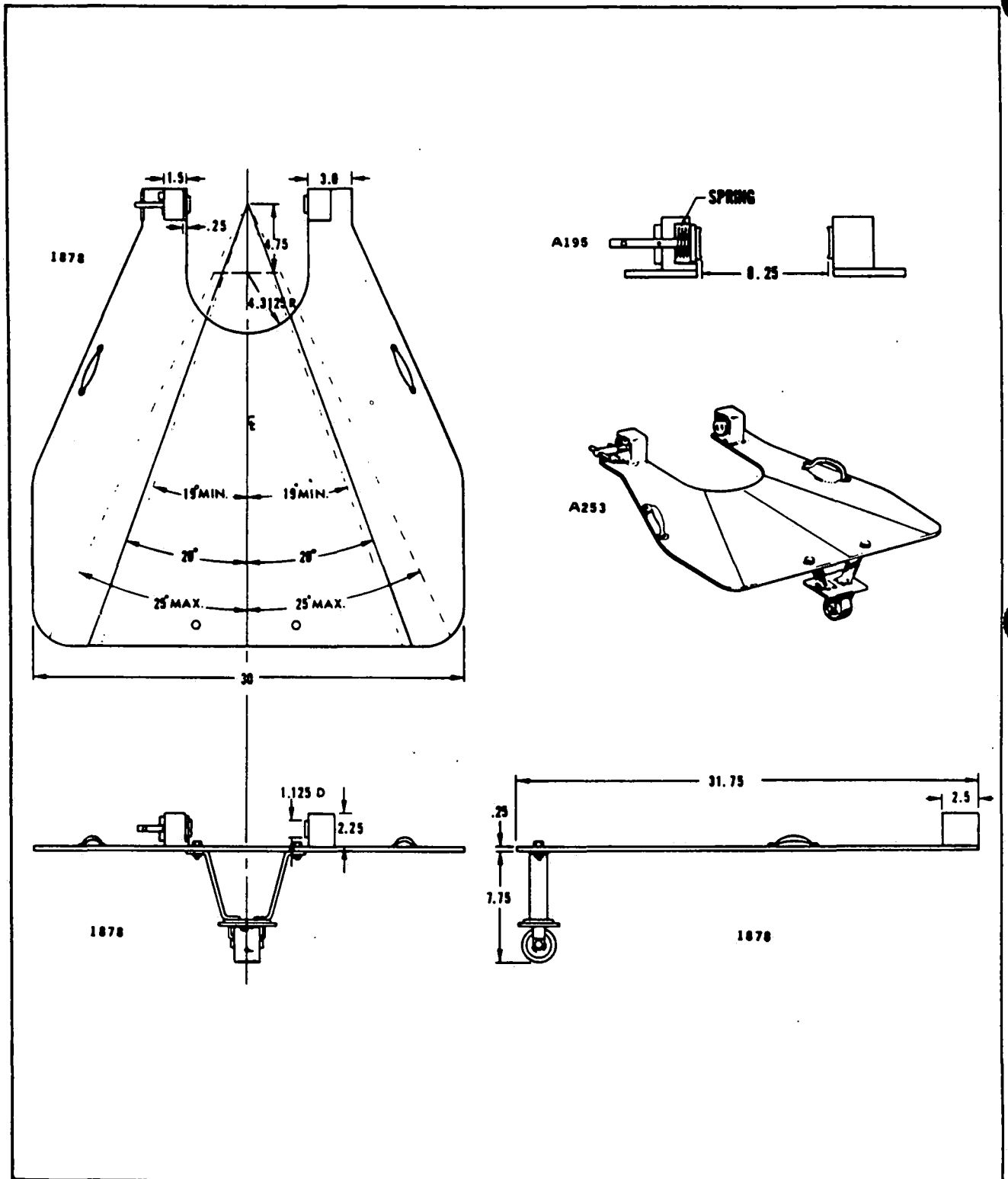


Figure 7-27. Fabricated Plumb Bob Tool



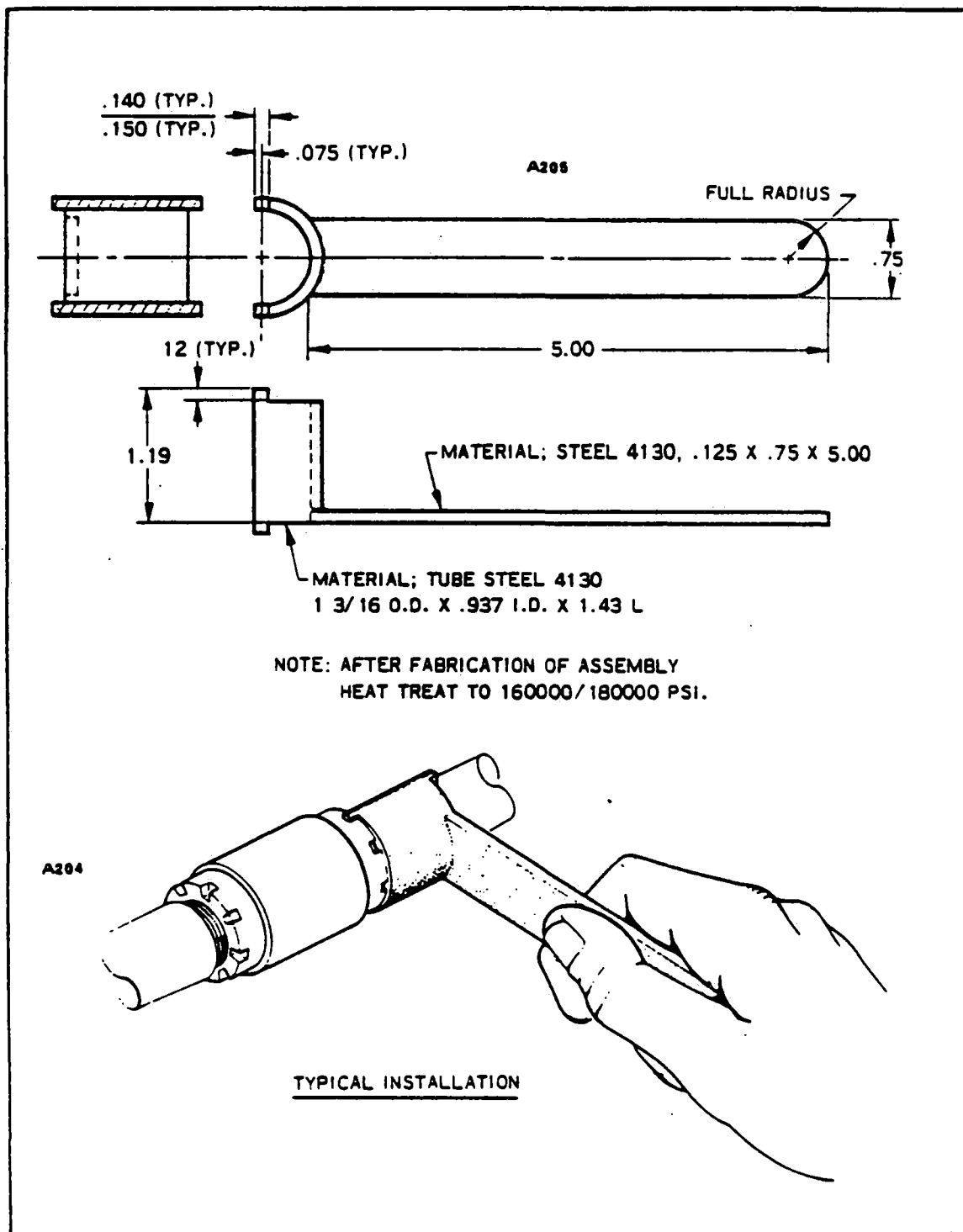


Figure 7-29. Fabricated Spanner Wrench

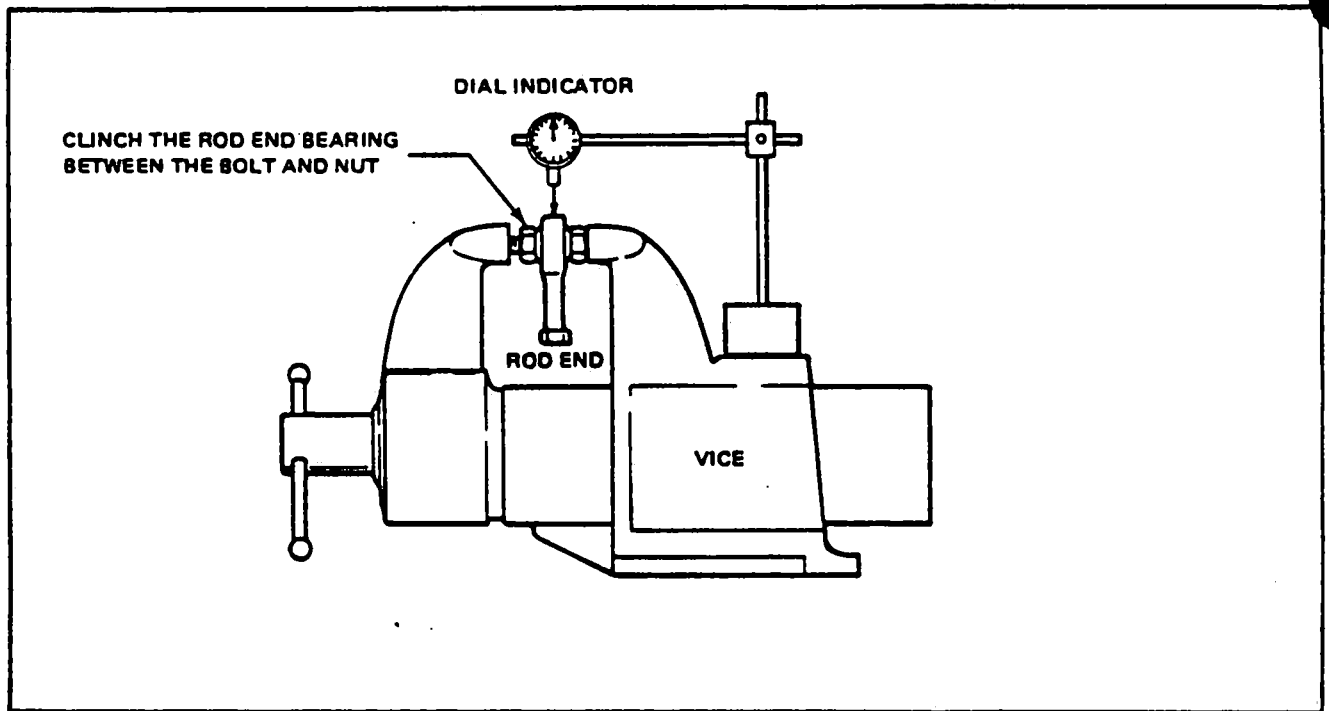


Figure 7-30. Inspection of Rod End Bearings

**7-73. INSPECTION OF THE LANDING GEAR MANUAL RETRACTION SYSTEM.** (Reference material from Section VII of this Service Manual.)

- a. Place the airplane on jacks. (Refer to Paragraph 2-12.)
- b. Disconnect each gear from the actuator. (Refer to Paragraphs 7-37 and 7-38.) Also disconnect the past center locking springs.
- c. Inspect all components for condition and wear. (Refer to Paragraph 7-39 and Tables VII-III and VII-IV for wear limits.)
- d. Inspect rod end bearings for wear by clinching the bearing between a bolt and nut arrangement as shown in Figure 7-30, and using a dial indicator measure the total free play between the ball and race, the maximum service limit is .005 of an inch.
- e. Check the thru center travel of both the left and right drag links on the nose gear. (Refer to Paragraph 7-10 and Figure 7-2.)

**NOTE**

Insure that both nose gear drag links contact their stops simultaneously. (Refer to Paragraph 7-12, Step "h.")

- f. Check the thru center travel of each main gear side brace link. (Refer to Paragraph 7-23 and Figure 7-8a.)
- g. Install the downlock springs on the nose gear. If only one spring is used, obtain Piper Service Kit for additional spring installation. (Refer to Paragraph 7-11 for installation instructions.)
- h. Disconnect and inspect main gear push-pull cables prior to installation. (Refer to Paragraph 7-39.)
- i. Hookup both main gears and check manual retraction only. (Transmission not connected.) (Refer to Paragraph 7-41.) Coordinate the overcenter locks. (Refer to Paragraph 7-46.)
- j. Hookup the nose gear (refer to Paragraph 7-40) and rig to operate with the main gear. (Transmission not connected.) Coordinate the overcenter locks. (Refer to Paragraph 7-47.)

**NOTE**

At this point the landing gear is now in a downlocked serviceable condition, without the benefit of the transmission.

- k. Perform a landing gear retraction load test per Paragraph 7-49.
- l. Connect transmission and perform a retraction and extension cycle of the landing gear electrically. Make the necessary limit switch adjustments per information given in Paragraphs 7-42 thru 7-54.
- m. Insure that the landing gear is down and locked; then remove the airplane from jacks. Make the appropriate logbook entries.

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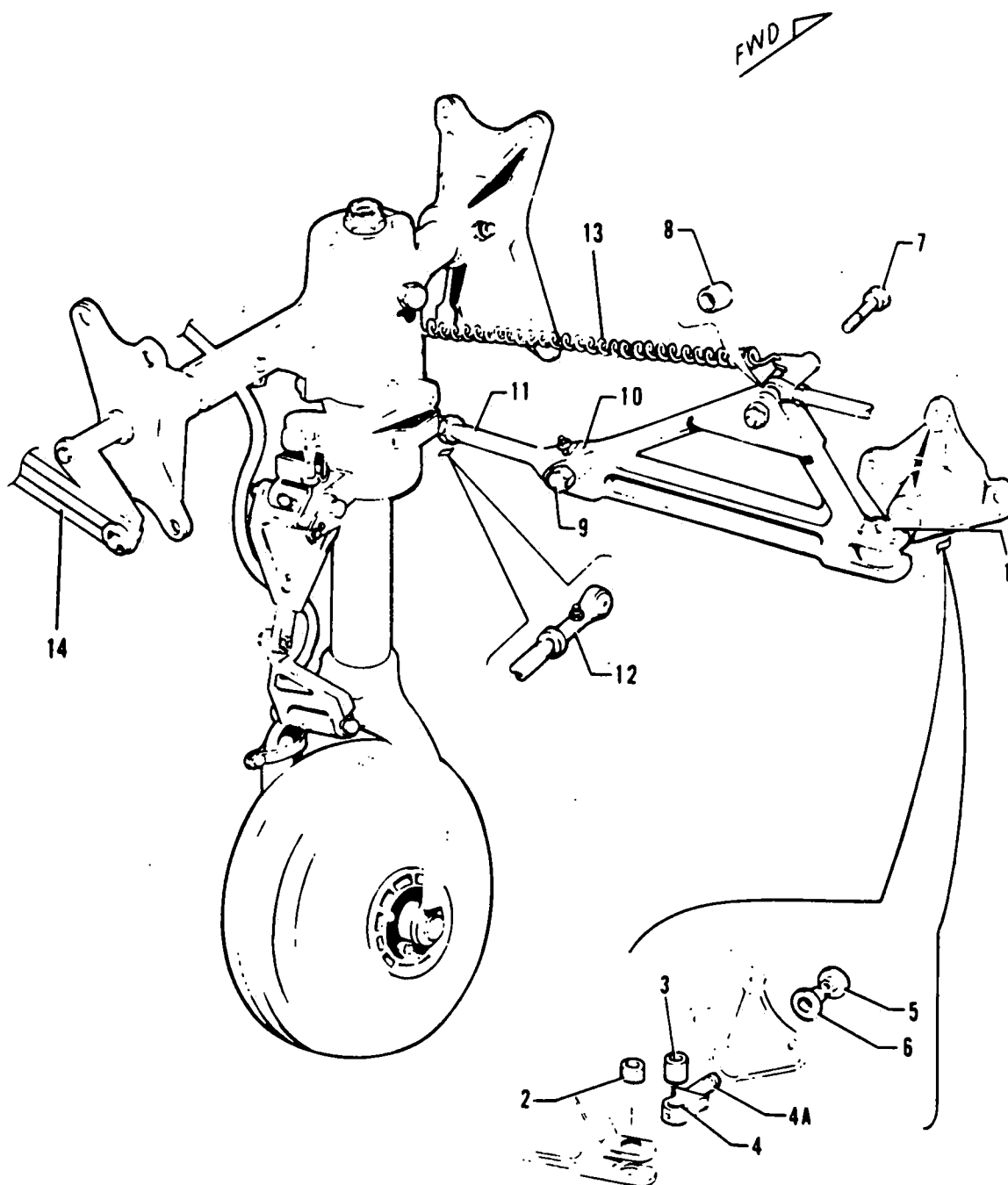


Figure 7-31. Main Gear Wear Limits

LANDING GEAR AND BRAKE SYSTEM

Revised: 4/6/81

TABLE VII-III. MAIN GEAR WEAR LIMITS

Index No.	Part No.	Item	Mfg. Limits		Service Limits	
			I.D.	O.D.	Min.	Max.
1	AN26	Bolt		.373/.371	.370	.373
2	14843-16	Bushing	.375/.373		.373	.376
3	14843-30	Bushing	.374/.376	.435/.433	.374 .432	.377 .435
4	20829	Stud	.4365/.4385		.4365	.4395
4	22512	Stud	.4365/.4385		.4365	.4395
4a	20829	Stud		.497/.495	.494	.497
4a	22512	Stud		.560/.558	.557	.560
5	20737-6	Bushing	.498/.500		.498	.501
5	20737-14	Bushing	.561/.563		.561	.564
6	20737-5	Bushing	.498/.500		.498	.501
6	20737-13	Bushing	.561/.563		.561	.564
7	AN4	Bolt		.249 +.000 -.003	.245	.249
8	20737-8	Shoulder Bushing	.251/.249		.249	.252
9	AN26	Bolt		.373/.371	.370	.373
10	14843-60	Bushing	.373/.375	.435/.433	.373 .432	.376 .435
11	24911	Link	.4365/.4385		.4365	.4395
11	25046	Link	.4365/.4385		.4365	.4395
11	20768	Link	.4365/.4385		.4365	.4395
11	22577	Link				
12	23412	Bearing-				
12	22943	Rod End				
13	83302-40	Main Spring	Spring is servicable when a 12 pound tension load extends the spring to $7-7/16 \pm 1/8$ inch (measured at the inside of end loops.)			
14		Bungee Cord	Inspect for frayed protective covering, breaks, and soft areas. Replace cords exhibiting these conditions.			



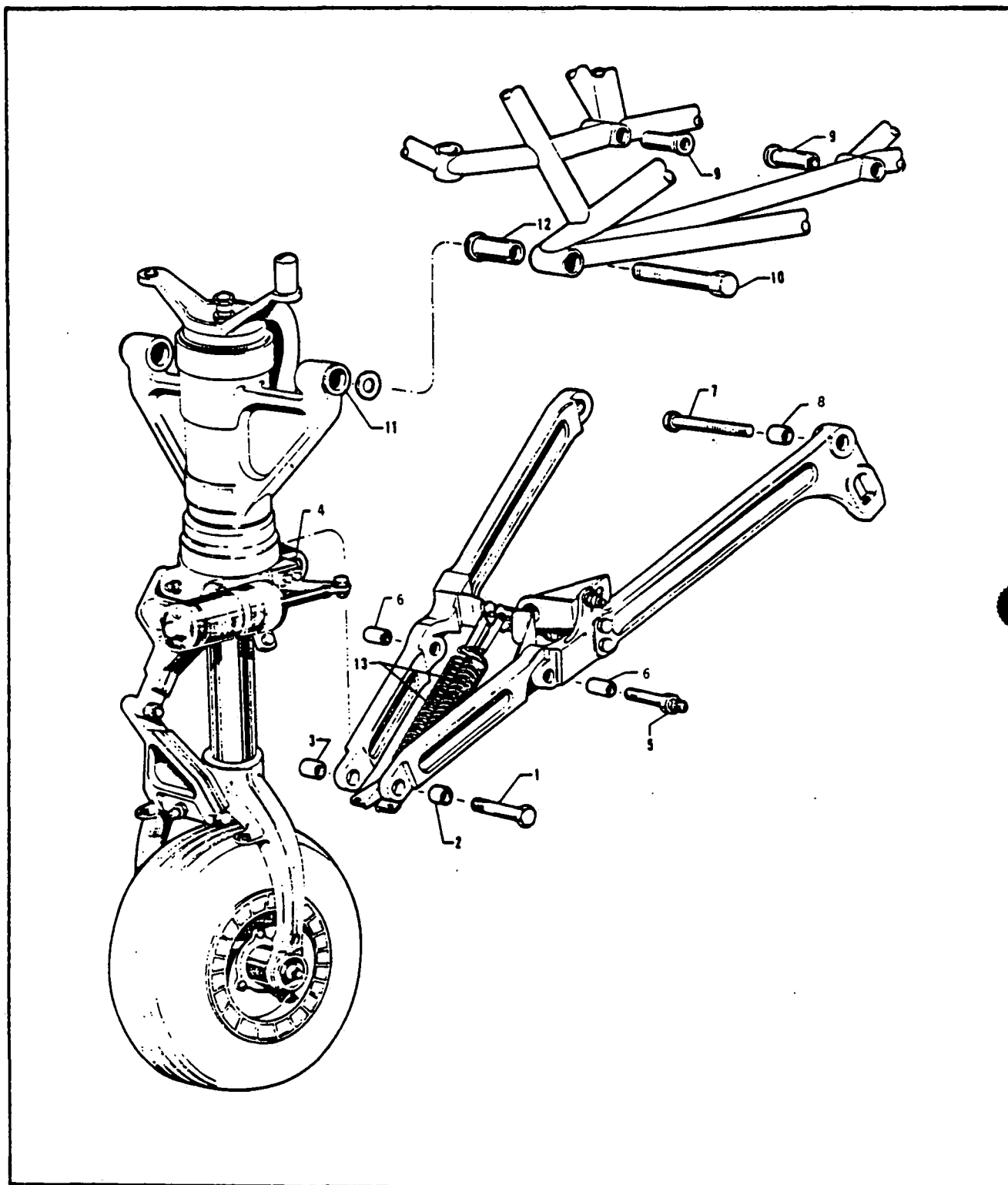


Figure 7-32. Nose Gear Wear Limits

LANDING GEAR AND BRAKE SYSTEM

Revised: 10/6/77

TABLE VII-IV. NOSE GEAR WEAR LIMITS

Index No.	Part No.	Item	Mfg. Limits		Service Limits Min.	Limits Max.
			I.D.	O.D.		
1	AN6	Bolt		.374 +.000 -.003	.370	.374
2	14843-18	Bushing	.3745/.3755		.3745	.3765
3	14843-18	Bushing	.3745/.3755		.3745	.3765
4	20737-4	Bushing	.374/.376		.374	.377
5	22066	Bolt		.3742/.3737	.3727	.3742
6	14843-18	Bushing	.3745/.3755		.3745	.3765
7	AN6	Bolt		.374 +.000 -.003	.370	.374
7	AN6	Bolt		.374 +.000 -.003	.370	.374
8	14843-18	Bushing	.3745/.3755		.3745	.3765
8	14843-19	Bushing	.3745/.3755		.3745	.3765
9	20803	Bushing	.374/.376		.374	.376
10	AN178	Bolt		.4991/.4986	.4976	.4991
11	20777	Bushing	.5015/.5000		.5000	.5025
11	31766	Bushing	.5015/.5000		.5000	.5025
12	17164-0	Bushing	.4995/.5005		.4995	.5015
12	17164-4	Bushing	.4995/.5005		.4995	.5015
13	13095 2 Reg.	Nose Springs	Spring is servicable when a $45 \pm 5$ pound tension load extends the spring to 4 inches (measured at the inside of the end loops.)			

LANDING GEAR AND BRAKE SYSTEM

Revised: 4/26/78

# SECTION VIII

## POWER PLANT

### (Normally Aspirated)

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Revised: 10/28/82

## SECTION VIII

### POWER PLANT (Normally Aspirated)

8-1. INTRODUCTION. This section covers power plants used in the PA-30 and is comprised of instructions for the removal, minor repair, service and installation of the engine cowl, propeller, propeller governor, engine, engine shock mounts, induction system, fuel injector, fuel air bleed nozzles, ignition system and lubrication system.

8-2. DESCRIPTION. The PA-30 is powered by two Avco-Lycoming IO-320-B1A, four cylinder, direct drive, wet sump, horizontally opposed, fuel injected, air cooled engines with a compression ratio of 8.5:1 rated at 160 HP at 2700 RPM and designed to operate on 91/96 minimum octane aviation grade fuel.

Cowling completely encloses the engines and consists of two side access panels, an upper and lower section and a nose section. The cowl flap is an integral part of the lower cowl and is operated manually through mechanical linkage.

Propellers are Hartzell full feathering, constant speed, each controlled by a governor mounted on the engine supplying oil through the propeller shaft at various pressures. Oil pressure from the governor moves the blades into low pitch (high RPM). The centrifugal twisting moment of the blades also tends to move the blades into low pitch. Opposing these two forces is a force produced by compressed air between the cylinder head and the piston, which tends to move the blades into high pitch in the absence of governor oil pressure. Thus, feathering is accomplished by compressed air.

The airplane's induction system consists of a dry type air filter and an alternate air door. The fuel system of the IO-320-B1A engines consists of a Bendix RSA-5AD1 type fuel injector and an AC fuel supply pump as an integral part of the fuel injector system. These engines are normally aspirated with no restrictions on maximum power output.

Bendix Scintilla S4LN-21 series magnetos are installed on both engines. Each system consists of two single contact point magnetos with impulse couplings on the magneto drive shafts to obtain the retard spark necessary for starting.

In addition to the aforementioned components; each engine is equipped with a generator, on the earlier models, or an alternator, on the later models; a geared starter and vacuum pump. Engine mounts are steel tubing construction

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attached at the firewall and incorporate vibration absorbing mounts.

The lubrication system is of the full pressure wet sump type. The oil pump, which is located in the accessory housing, draws oil through a drilled passage leading from the oil suction screen located in the sump. The oil from the pump then enters a drilled passage in the accessory housing, which feeds the oil to a threaded connection on the rear face of the accessory housing, where a flexible line leads the oil to the external oil cooler. Pressure oil from the cooler returns to a second threaded connection on the accessory housing from which point a drilled passage conducts oil to the oil pressure filter. In the event that cold oil or an obstruction should restrict the oil flow to the cooler, an oil cooler by-pass valve is provided to pass the oil directly from the oil pump to the oil pressure filter.

The oil pressure filter screen or element, located on the accessory housing, is provided as a means to filter from the oil any solid particles that may have passed through the suction screen in the sump. After being filtered through the pressure filter, the oil is fed through a drilled passage to the oil pressure relief valve, located in the upper right side of the crankcase forward of the accessory housing.

This relief valve regulates the engine oil pressure by allowing excessive oil to return to the sump, while the balance of the pressure oil is fed to the main oil gallery in the right half of the crankcase. Residual oil is returned by gravity to the sump where, after passing through a screen, it is again circulated through the engine.

**8-2a. STANDARD PRACTICES - ENGINES.** 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, 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 required 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

Ensure 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 ensure identification during ordinary handling, storage and final assembly of parts.

8-3. TROUBLESHOOTING. Troubles peculiar to the power plant are listed in Table VIII-II in the back of this section, along with their probable causes and suggested remedies. When troubleshooting engines, ground the magneto primary circuit before performing any checks on the ignition system.

#### 8-4. ENGINE COWLING.

8-5. REMOVAL OF ENGINE COWLING. The procedure for removing the cowl is the same for both engines.

- a. Release the fasteners and remove the two side access panels.
- b. Remove the screws that secure the top cowl and then remove cowl.
- c. Disconnect the flap control rods by removing cotter pin, washer and pin.
- d. Support the bottom cowl and remove attaching screws.

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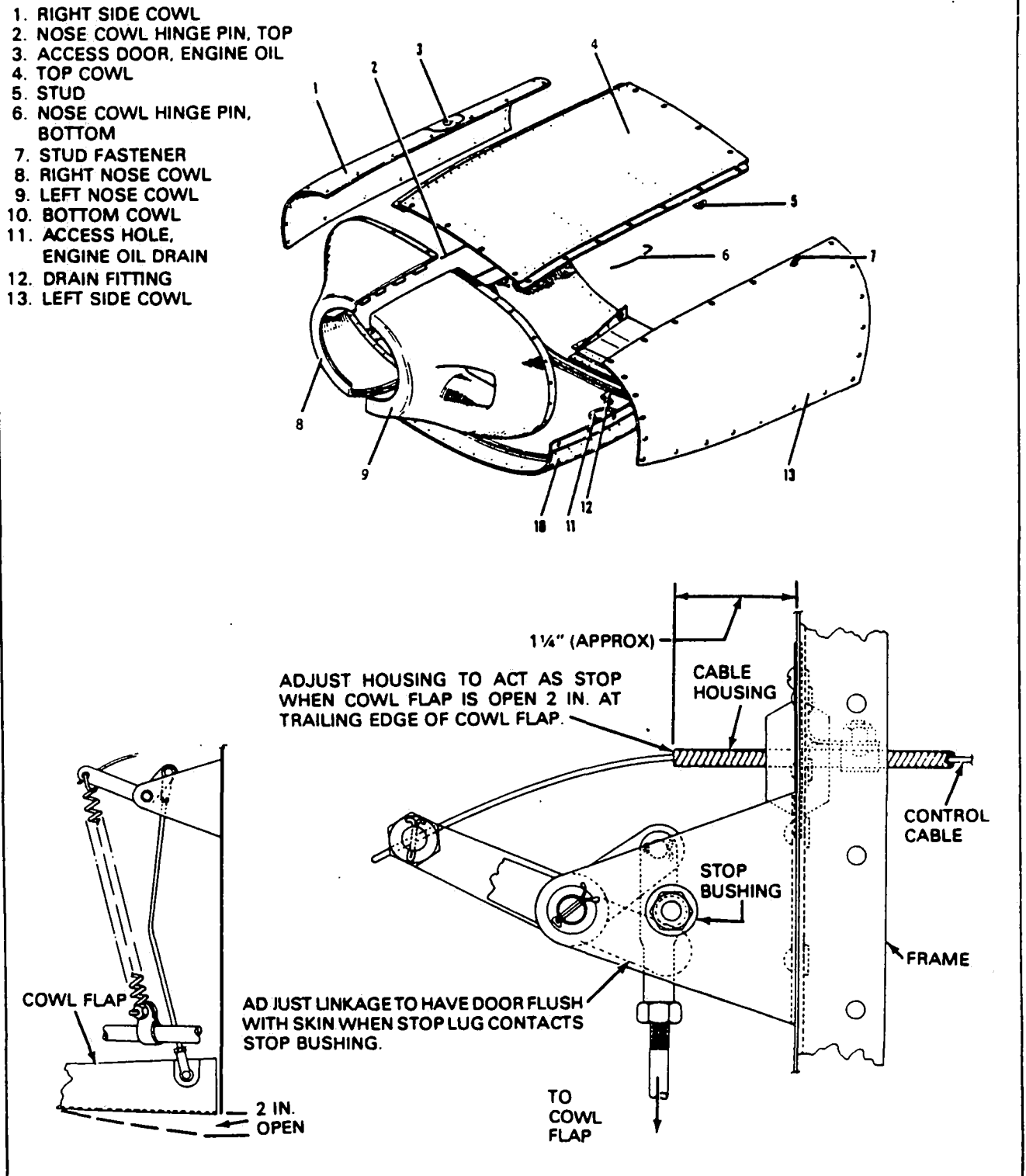


Figure 8-1. Engine Cowling and Cowl Flap Rigging



- e. Lower cowl a few inches and disconnect drain lines.
- f. The nose cowl may be removed by pulling out the upper and lower hinge pins and splitting the cowl.

#### 8-6. CLEANING, INSPECTION AND REPAIR OF ENGINE COWLING.

- a. The cowling should be cleaned with a suitable solvent and then wiped with a clean cloth.
- b. Inspect the cowling for dents, cracks, loose rivets, damaged or missing fasteners, and damaged fiberglass areas.
- c. Repair all defects to prevent further damage. Fiberglass repair procedures may be accomplished according to Fiberglass Repairs, Section IV.

#### 8-7. INSTALLATION OF ENGINE COWLING. The procedure for installing the cowl is the same for both engines.

- a. Position the two nose cowl halves on the front of the engine and secure with hinge pins.
- b. Position the bottom cowl and connect the drain lines.
- c. Attach the bottom cowl to the aft nacelle section and the nose cowl with screws.
- d. Position the top cowl and secure with attaching screws.
- e. Connect the cowl flap control rods to cowl flap with attaching pin, washer and cotter pin.
- f. Position the side access panels and secure with fasteners.

#### 8-7a. COWL FLAP RIGGING (Refer to Figure 8-1.)

- a. Adjust the cowl flap control cable housing to act as the stop when the cowl flap is open 2 inches at its trailing edge in relation to the bottom engine cowl.
- b. Adjust the cowl flap linkage to have the cowl flap flush with the bottom engine cowl when the stop lug contacts the stop bushing (closed position).

#### 8-8. PROPELLER.

#### 8-9. REMOVAL OF PROPELLER. (Refer to Figure 8-2.) This includes all propellers, standard and with spring backup kit installed, identified by a letter "S" in the dash number.

#### NOTE

When removing the propeller, it is unnecessary to remove the spinner, feather the blades, or remove the air charge. When the propeller is removed for service or overhaul, the propeller with the spring kit installed should be feathered on the aircraft (see following "CAUTION") and the spinner on either prop must be removed according to section d of this paragraph.

### WARNING

Do not attempt to disassemble the propeller assembly any further than stated in this manual. Only personnel at a certified repair shop are authorized for repair and overhaul of the propeller mechanism.

### CAUTION

Under NO condition should blade paddles be used on either propeller, except to unfeather a propeller with the spring kit installed (see paragraph 8-11). If a propeller is to be feathered on the ground, it should be done with the engine operating, by use of the propeller control on the throttle quadrant.

### CAUTION

Prior to performing any work on the propeller, ascertain that the master switch and magneto switches are OFF (grounded) and the mixture control is in the IDLE CUT-OFF position.

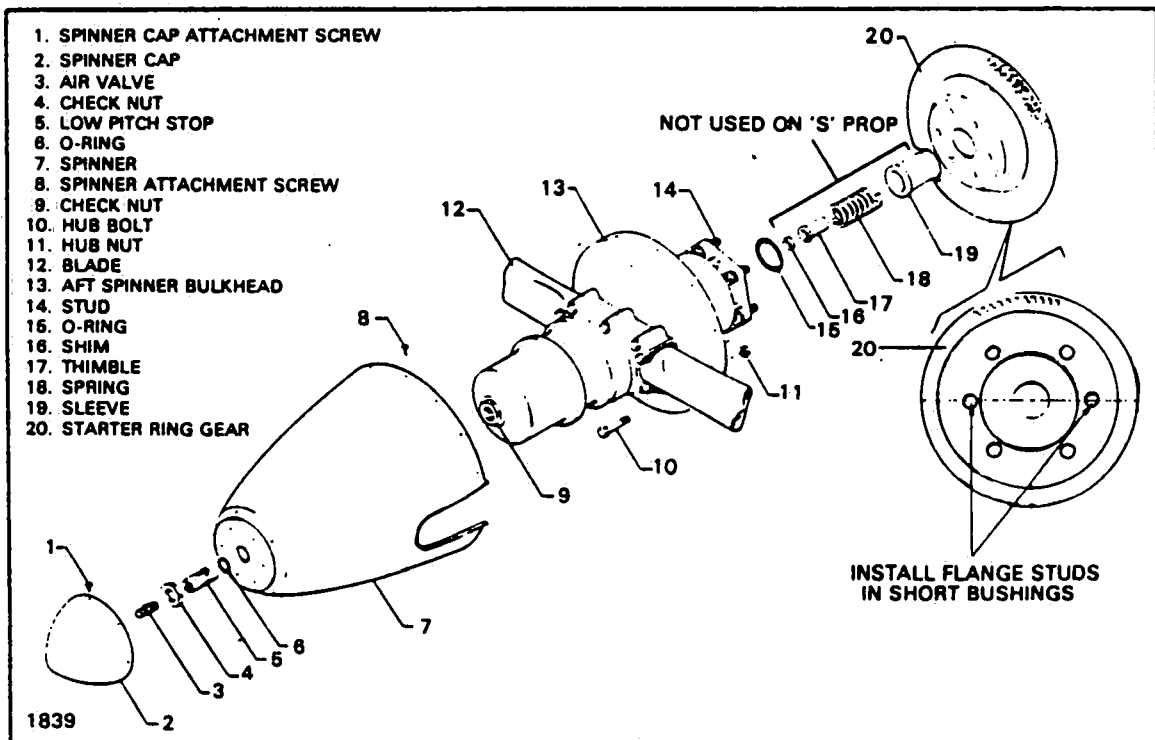


Figure 8-2. Standard Propeller Installation

a. Remove all hardware that attaches the nose cowl to the top and bottom engine cowl. The top and side panels of the main cowl assembly may be removed for greater accessibility. Work the nose cowl as far forward as possible, reach through the opening and split the cowl by pulling the upper and lower hinge pins. Pliers may be needed to remove the pins. The two halves of the cowl may be pulled forward and to either side of the propeller, which should be in a vertical position for ease in removing the cowl.

**NOTE**

In some appropriate manner, index the propeller and starter ring to facilitate installation. (Example - paint stripe). Do not scratch the surface.

b. Place a drip pan under the propeller to catch oil spillage.

c. Cut safety wire around the propeller mounting studs and remove the studs (14) from the engine flange by wrenching the nuts. These nuts are "frozen" to the studs with loctite and secured with roll pins, so the studs should turn with the nuts. Pull the propeller from the engine shaft.

d. In the event that the spinner and spinner bulkhead are to be removed for cleaning, inspection, adjustment of pitch stop, etc., remove the spinner nose cap attaching screws and cap (1 and 2). Remove the spinner (7) by removing the safety wire and check nut (4) from the propeller at the forward end of the forward spinner bulkhead and the screws (8) that secure the spinner to the aft bulkhead (13). The aft spinner bulkhead may be removed from the hub by removing the locknuts (11).

**8-10. CLEANING, INSPECTION AND REPAIR OF PROPELLER.**

**CAUTION**

Prior to performing any work around propeller, discharge the dome pressure.

- a. Check for oil and grease leaks.
- b. Clean the spinner, propeller hub and blades with a non-corrosive solvent.
- c. Inspect the hub parts for cracks.
- d. Steel hub parts should not be permitted to rust. Use aluminum paint to touch up, if necessary, or replate during overhaul.
- e. Check all visible parts for wear and safety.

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f. Check the blades of the standard propeller to determine whether they turn freely on the hub pivot tube. This can be done by rocking the blades back and forth through the slight freedom allowed by the pitch change mechanism. Do this by hand being careful not to slam the internal mechanism against the stops. If blades appear tight and are properly lubricated, the propeller may need internal repair. (See WARNING on page 8-4.) This cannot be done with the spring propeller due to the pressure exerted by the spring even though the dome pressure is discharged.

g. Inspect blades for damage or cracks. Nicks in leading edges of blades should be filed out and all edges rounded, as cracks sometimes start from such places. Use fine emery cloth for finishing. Refer to Figure 8-3 for propeller blade care.

h. Check condition of propeller mounting nuts and studs.

### NOTE

It is recommended that for severe damage, internal repairs and replacement of parts, the propeller should be referred to the Hartzell Factory or Certified Repair Station.

i. Each blade face should be sanded lightly with fine sandpaper and painted, when necessary, with a flat black paint to retard glare. A light application of oil or wax may be applied to the surfaces to prevent corrosion.

j. Grease the blade hub through the zerk fittings. Remove one of the two fittings for each propeller blade; alternate the next time. Apply grease through the zerk fitting until fresh grease appears at the fitting hole of the removed fitting. Care should be taken to avoid blowing out the hub gaskets.

k. Check for air leaks by applying a soap solution around the air valve and stop adjustment nut. Internal leakage will show up as air flows through the piston rod.

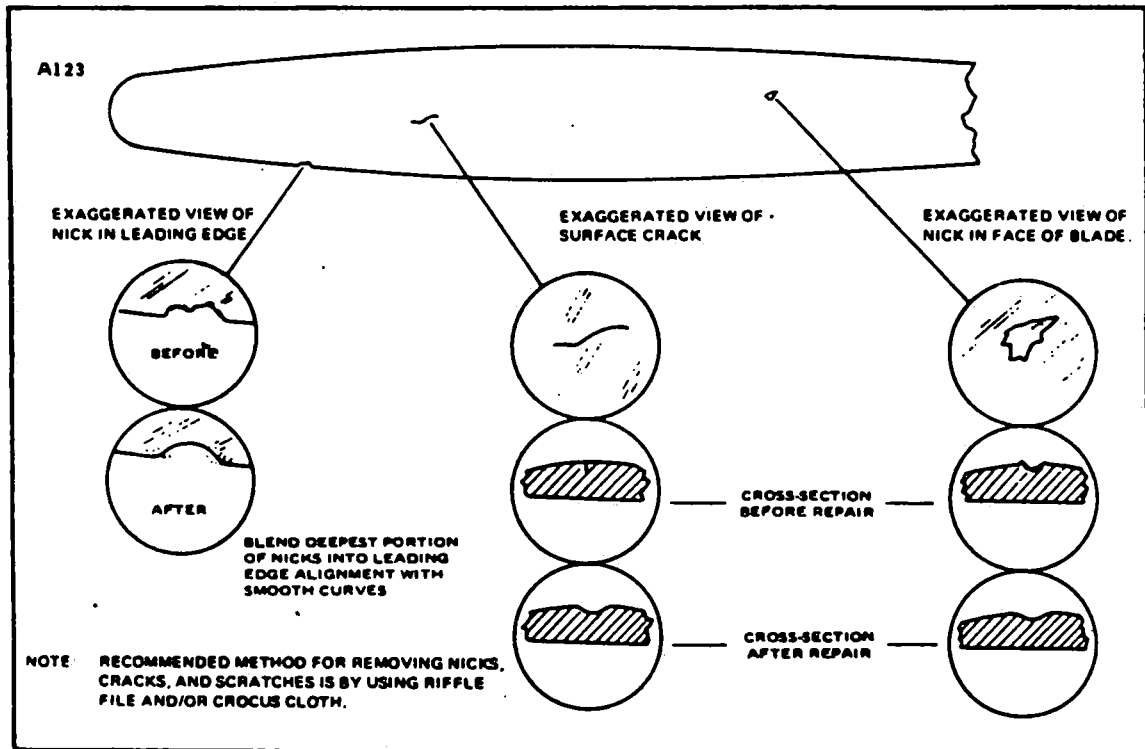


Figure 8-3. Typical Nicks and Removal Methods

#### 8-11. INSTALLATION OF PROPELLER. (Refer to Figure 8-2.)

##### CAUTION

Prior to performing any work around propeller, ascertain that the master switch and magneto switches are OFF (grounded) and the mixture control is in the IDLE CUT-OFF position.

- Clean the propeller flange, starter ring and crankshaft flange.
- Install spinner bulkhead (13) on propeller hub and secure with locknuts. Torque bolts to specifications given in Table VIII-I.
- Ascertain that the starter ring gear is properly on the crankshaft flange. The oversize hole in the starter ring must go over the oversize bushing.
- Position the prop flange and starter ring gear so the two short bushings are horizontal. (Refer to Figure 8-2.)
- Lubricate and install "O" ring (15) in prop hub.
- Install sleeve (19), spring (18), thimble (17) and shim (16) in engine crankshaft on

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propeller installations NOT using the spring back-up system in the hub.

g. Place the propeller in a horizontal position and mount to the engine crankshaft. Check alignment of paint stripe (refer to NOTE under Paragraph 8-9). Screw each stud into its mating engine flange bushing a few threads at a time until all are tight. Torque the studs to the specifications given in Table VIII-1.

h. Safety studs with MS20995-C41 wire. Safety wire is inserted through the roll pins.

i. Install spinner (7). Torque spinner screws (8) and check nut (4) per Table VIII-1. Safety check nut with MS20995-C41 wire.

**NOTE**

Do not check pressure or charge cylinder with **PROPELLER** in the feathered position.

**CAUTION**

To obtain an accurate pressure reading when checking propeller dome air pressure or to insure complete release of all air pressure, place the propeller **CONTROL** in the feather detent before measuring or releasing propeller air pressure. This procedure will insure the free flow of all air within the prop dome and prevent possible error in pressure readings or injury to service personnel should the low pitch stop be removed.

**NOTE**

If the propeller is in feather on the ground, it is undesirable to run it out of feather through engine operation due to roughness which will occur possibly causing severe damage to engine mount and exhaust system. Remove the air charge, unfeather the blades with equal pressure applied by means of blade paddles used on both blades as close to the hub as possible. Listen for the quite distinctive "clicks" of the high pitch stop pins, then stop and remove the paddles.

j. Charge the cylinder through air valve (3) with dry air or nitrogen gas to the prescribed pressure. Refer to Table VIII-I of this manual for an exact pressure for the existing temperature. It is most important that an accurate charge be maintained.

k. The amount of air pressure per existing temperature, as shown by Table VIII-I, is very important and should always be used. If excessive pressure is used in the propeller, there is a possibility of feathering taking place at idle speed when the engine is warm and the oil viscosity is low. An accurate air pressure gauge should always be used. A pressure gauge and valve kit, number 756 771, may be purchased through a Piper Dealer or Distributor.

l. When recharging the propeller, dry air or nitrogen gas should be used. It is important not to allow moisture to enter the air chamber as this could cause the piston to freeze during cold weather operation.

m. Test for leakage by using a soap solution or equivalent and applying it around the air valve stem and adjustment stop nut.

n. To reinstall engine cowling, first put the propeller in a vertical position then fit the two halves of the nose cowl together behind the spinner bulkhead and pin them together with the two hinge pins through the top and bottom hinges. Slide the nose cowl back and into proper location with the engine cowls. Locate holes and install all hardware that attaches the cowls together. Install top and side engine cowl panels if removed. Install spinner cap.

TABLE VIII-I

PROPELLER SPECIFICATIONS (PA-30)

Blade Angle	Low Pitch (High RPM)	12° ± 0.015°	
	High Pitch (Low RPM)	78° (Feathered)	
(1) MEASURE TAKEN AT 30 INCH STATION.			
Propeller RPM Setting	Engine Static High RPM Engine Static Low RPM	2700 max 1850 ± 50 min	
Propeller Torque Limits	Description	Required Torque (Dry)	
	Spinner Bulkhead (Aft)	22 foot-pounds	
	Propeller Mounting Bolts	50 foot-pounds	
	Propeller Mounting Studs	40-42 foot-pounds	
	Spinner Bulkhead Check Nut	35-40 foot-pounds	
	Spinner Attachment Screws	40 inch-pounds	
CHAMBER PRESSURE REQUIREMENTS WITH TEMPERATURE <u>HC-E2YL-2, HC-E2YL-2B or HC-E2YL-2BF</u>			
Temp. °F	Press. (psi)	Temp. °F	Press. (psi)
100	188	30	165
90	185	20	162
80	182	10	159
70	178	0	154
60	175	-10	152
50	172	-20	149
40	168	-30	146
<u>HC-E2YL-2BS or HC-E2YL-2BSF</u>			
	Temp. °F	Press. (psi)	
	100	53	
	70	50	
	40	47	
	10	44	
	-20	42	
NOTE: Do not check pressure or charge with propeller in feather position.			



## 8-12. ADJUSTMENT OF LOW PITCH BLADE ANGLE AND STOP.

### NOTE

Both types of propellers referred to, come from the factory with the low pitch stop adjusted for proper blade angle. If, however this adjustment has been disturbed, the procedure given below is used for obtaining blade angle, but applies only to the propeller without the spring kit A-2273 installed. There is no way to check the low pitch blade angle of the propeller, with the spring kit installed, in the field. This is due to the internal spring producing a force near to that of the air charge in the standard propeller which can and has to be released to make this adjustment. The spring supplies constant pressure to the blades making it very difficult to rotate the blades to a point where the low pitch stop is contacted. Therefore, if the blade angle on a spring propeller is suspected to be wrong it should be referred back to the Hartzell factory or Certified repair shop.

#### a. Procedure for obtaining blade angle and adjusting low pitch stop.

1. The blade angle (refer to Table VIII-I) is determined by placing a propeller protractor on the face side of the propeller at the 30 inch station as measured from the hub centerline. The blade must be horizontal.
2. The low pitch stop is adjusted by rotating a screw in the nose of the propeller cylinder. Rotating the screw clockwise increases the low pitch angle and reduces the static RPM by about 100 RPM for each half turn, or vice versa.

### CAUTION

Before adjusting the low pitch stop screw, the air pressure should be dropped to zero. Unless this is done, it is possible to unscrew the low stop far enough to disengage the threads, allowing the air pressure to blow the stop screw out with great force. To insure the complete discharge of all air pressure within the dome, place the propeller **CONTROL** in the feather detent. There should be at least four threads of the stop screw engaged.

b. After the low pitch stop has been adjusted for proper blade angle, torque the low pitch stop jam nut to 30 foot-pounds. The governor should then be adjusted to obtain maximum rated engine RPM during take-off and climb (2700 RPM.)

**8-13. BLADE TRACK.** Blade track is the ability of one blade tip to follow the other, while rotating, in almost exactly the same plane. Excessive difference in blade track - more than 0.062 inch - may be an indication of bent blades or improper propeller installation. Check blade track as follows:

a. With the engine shut down and blades vertical, secure to the aircraft a smooth board just under the tip of the lower blade. Move the tip fore and aft through its full "blade-shake" travel making small marks with a pencil at each position. Then center the tip between these marks and scribe a line on the board for the full width of the tip.

b. Carefully rotate propeller by hand to bring the opposite blade down. Center the tip and scribe a pencil line as before and check that lines are not separated more than 0.062 inch.

c. Propellers having excessive difference in blade track should be removed and inspected for bent blades, or for parts of sheared O-ring, or foreign particles which have lodged between hub and crankshaft mounting faces. Bent blades will require repair and overhaul of assembly. Other conditions will require installation in the prescribed manner. (Refer to paragraph 8-11.)

#### **8-14. PROPELLER GOVERNOR.**

#### **8-15. REMOVAL OF PROPELLER GOVERNOR.**

- a. Remove the left and right side panels of the engine cowl.
- b. Remove the top engine cowl by removing attaching screws.
- c. Disconnect governor control cable from control arm by removing nut and washer from ball joint.
- d. Disconnect control cable from bracket by removing nuts, washers and screws from clamp.
- e. Remove nut and washer from governor adapter mounting stud allowing the control cable bracket to be removed.
- f. Remove the governor mounting stud nuts. It will be necessary to move the governor from its mounting pad as the nuts are being removed before the nuts can be completely removed.
- g. Remove the mounting gasket. If the governor is to be removed for a considerable length of time and another unit is not substituted, it is advisable to cover the mounting pad to prevent damage caused by foreign matter.

# 8-16. INSTALLATION OF PROPELLER GOVERNOR.

a. Clean the mounting pad thoroughly making very certain that there are no foreign particles in the recess around the drive shaft.

b. Place the governor mounting gasket in position with the raised portion of the screen facing away from the engine.

c. Install the control cable bracket on the governor.

d. Align the splines on the governor shaft with the engine drive and the cable bracket with the governor adapter mounting stud and slide the governor into position.

e. With the governor in position, raise the governor enough to install washers and start mounting nuts. Secure bracket to adapter with washer and nut, torquing nuts evenly.

f. Connect the control cable end to the governor control arm. The ball stud is installed in the inner hole of the control arm.

g. Secure the control cable to bracket with clamp, screw, washer and nuts.

h. Adjust governor control per paragraph 8-17.

i. Install engine cowl per paragraph 8-7.

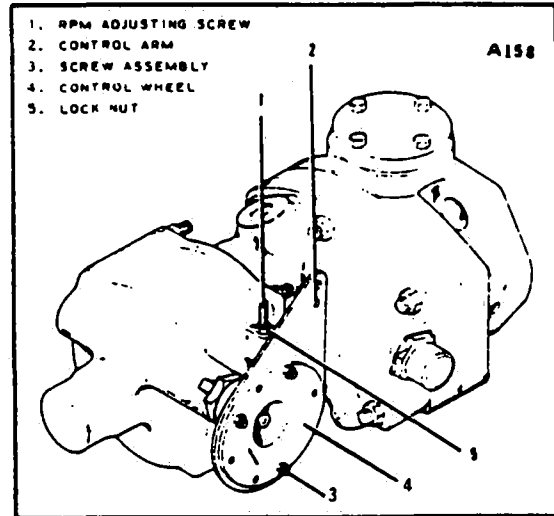


Figure 8-4. Propeller Governor

# 8-17. ADJUSTMENT OF PROPELLER GOVERNOR. (Refer to Figure 8-4.)

a. Start the engine, park at 90 degrees to wind direction, and warm in the normal manner.

b. To check high RPM, low pitch setting, move the propeller control all the way forward. At this position, the governor speed control arm (2) should be against the high RPM fine adjustment screw (1). With the throttle full forward, observe engine RPM which should be 2700 RPM with high RPM properly adjusted.

c. Should engine RPM not be as required, the high RPM setting should be adjusted as follows:

1. Shut down the engine and remove the left side access panel.

2. Adjust governor by means of the fine adjustment screw for 2700 RPM. Loosen the screw locknut (5) and turn the screw in a clockwise direction to decrease engine speed or in a counterclockwise direction to increase engine speed.

NOTE

One revolution of the fine adjustment screw will increase or decrease the engine speed approximately 20 RPM.

3. After adjustment is made, secure adjusting screw with jam nut.
4. With the high RPM adjustment complete, the control system should be adjusted so that the governor control arm will contact the high RPM stop when the cockpit lever is 0.062 inch from its full forward stop which is located in the control quadrant. To adjust the control lever travel, disconnect the control cable end from the control arm, loosen the cable end jam nut and rotate the end to obtain the desired lever clearance. Reconnect the cable end and tighten jam nut.
5. Install side access panel and secure with studs.
6. It is usually only necessary to adjust the high RPM setting of the governor control system, as the action automatically takes care of the positive high pitch setting.

8-18. ENGINE.

8-19. REMOVAL OF ENGINE. (Refer to Figure 8-5.) The removal of either engine is basically the same procedure, though the routing of some wires, cables and lines do vary between engines. Each line should be identified to facilitate reinstallation and covered where disconnected, to prevent contamination.

- a. Turn off all cockpit switches and disconnect the battery ground wire at the battery.
- b. Move the fuel valve control levers, located on the fuselage floor between the two front seats, to the OFF position.
- c. Remove the engine cowling per paragraph 8-5.
- d. Remove the access panels on the top of the nacelle aft of the firewall.
- e. Drain the engine oil, if desired, and reinstall drain plug.
- f. Remove the propeller per paragraph 8-7.
- g. Disconnect the starter cable at the starter, remove the cable clamps at the left side of the engine and engine mount, and draw the cable aft through the engine baffle to the firewall.
- h. Disconnect the generator or alternator leads at the unit and cylinder head temperature lead on No. 3 cylinder, remove the clamps securing the wires and draw them back to the firewall.

- i. Disconnect the exhaust temperature lead, if installed.
- j. Disconnect the oil temperature electrical lead and tachometer cable at the accessory housing.
- k. Disconnect the fuel pressure, fuel flow meter vent, oil pressure and manifold pressure lines at the firewall.
- l. Disconnect the engine breather hose, vacuum hose, fuel line and heater fuel supply hose (right engine only).
- m. Disconnect the magneto "P" leads from the magnetos.
- n. Disconnect the governor control, throttle and mixture control cables.
- o. Disconnect the alternate air door control cable.
- p. Disconnect the cowl flap return spring from the engine mount.
- q. Disconnect the exhaust stack hangers from the firewall.
- r. Remove the air filter box from the firewall by removing attaching nuts and bolts.
- s. Attach a one-half ton (minimum) hoist to the hoisting hooks and relieve the tension on the engine mount.
- t. Remove the nuts and washers from the bolts that attach the engine mount to the firewall.
- u. Remove the engine mount mounting bolts and swing the engine a few inches from the firewall. Check the engine for any attachments remaining to obstruct its removal.
- v. Swing the engine clear and place on a suitable support.

8-20. INSTALLATION OF ENGINE. The installation of either engine is basically the same procedure, though the routing of some wires, cables, lines, etc. does vary between engines. Before starting, ascertain that all components of the engine, such as engine mount, exhaust stacks, etc., are installed.

- a. With a one-half ton hoist (minimum) attached, swing the engine in position.
- b. Align the mounting holes in the engine mount with the mounting holes in the firewall. Install the mounting bolts through from the aft side of the firewall. Install washers and nuts, and dry torque to 200-240 inch pounds.
- c. Connect throttle and mixture control cables to the injector, install clamps and rig per paragraph 8-34.
- d. Connect governor control cable to the governor, install bracket and clamps and rig per paragraph 8-17.
- e. Attach the air filter box to the firewall and connect the alternate air door control cable to the air door control arm and adjust the cable end on the control arm so that when the control knob in the cockpit is full on, there will be approximately one-eighth inch between the control arm roller and the fully closed door.

- f. Connect the fuel line from the fuel pump to the fitting on the lower center portion of the firewall and the heater fuel supply line (right engine only).
- g. Connect the hose from the vacuum pump to the fitting on the firewall.
- h. Connect the engine breather hose to the breather tube on the firewall and clamp.
- i. Connect starter electrical cable to starter and clamp to prevent chafing.
- j. Connect electrical leads to the generator or alternator exhaust temperature, if installed, and cylinder head temperature. Clamp the wires to prevent chafing.
- k. Connect "P" leads to magnetos and safety.
- l. Connect oil temp electrical lead to temperature bulb tachometer cable to accessory housing.
- m. Connect manifold pressure and oil pressure lines to fittings on firewall.
- n. Connect fuel pressure and fuel flow vent line to fittings on firewall.
- o. Attach exhaust stack hangers to firewall.
- p. Attach cowl flap return spring to flap linkage and engine mount.
- q. Ascertain that the magneto switches are off and install the propeller per paragraph 8-11.
- r. Install the proper grade and amount of engine oil.
- s. Connect the battery ground cable at the battery.
- t. Turn on the fuel valve, open the throttle full and turn on the electric fuel pump and check the fuel lines for leaks.
- u. Install the access panels on the engine nacelle and the cowling per paragraph 8-7.
- v. To prevent possible high speed bearing failure due to lack of lubrication during the initial start, refer to the latest revision of Lycoming Service Instructions No. 1241.
- w. Perform an engine operational check.

#### 8-21. ENGINE SHOCK MOUNTS.

8-22. REPLACEMENT OF ENGINE SHOCK MOUNTS. Refer to Figure 8-5 for the proper arrangement of the engine shock mount assemblies. The top shocks are assembled so the gold colored shock is aft the silver colored shock is forward. The lower shock mounts are installed opposite of the top shock mounts. Torque shock mount bolts to 450 to 500 in. lbs. and safety.

#### 8-22a. INSTALLATION OF OIL COOLER.

- a. 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.
- b. If a pipe thread fitting is used, it should be installed only far enough to seal with sealing compound.
- c. Apply Lubon No. 404 to all male pipe thread fittings; do not allow sealant to enter the system.
- d. If fitting cannot be positioned correctly using a torque of 10 to 15 foot-pounds, another fitting should be used.
- e. When attaching lines to the cooler, a backup wrench should be used.
- f. After installation, inspect the cooler for distorted end cups.
- g. Run-up engine. After run-up, check for oil leaks.

8-23. INDUCTION AIR FILTER.

8-24. REMOVAL OF INDUCTION AIR FILTER.

- a. Remove the right side access panel from the engine nacelle to expose the air filter box.
- b. Turn the three studs and remove the air filter box cover.
- c. Lift the air filter from the filter box.

8-25. SERVICE INSTRUCTIONS. The useable life of the filter should be restricted to one year or 500 hours, whichever comes first.

- a. To clean the filter, tap gently to remove dirt particles. Do not use compressed air or cleaning solvents.
- b. Inspect filter. If paper element is torn or ruptured or gasket is damaged, the filter should be replaced.

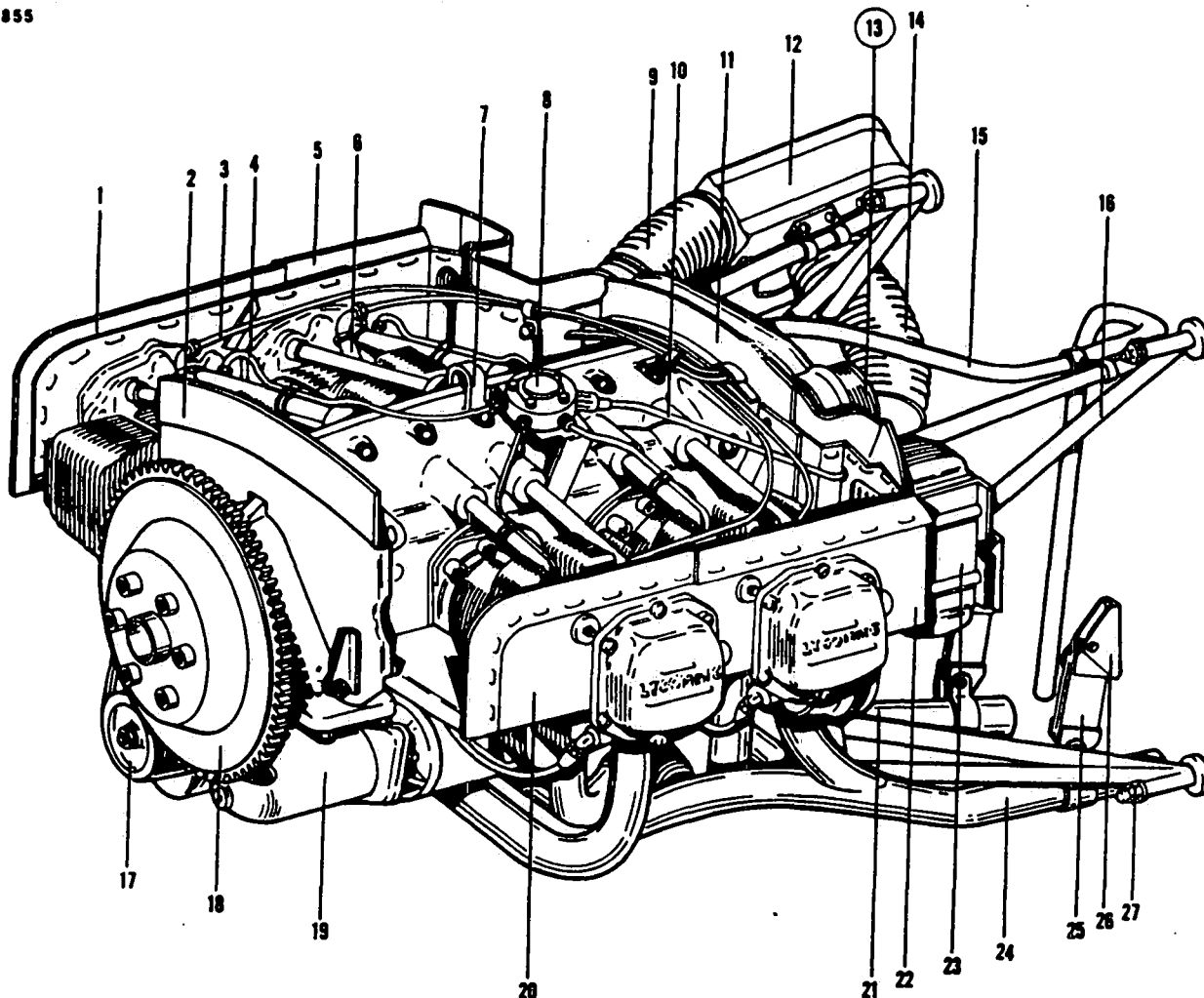
8-26. INSTALLATION OF AIR FILTER.

- a. Place the air filter in the filter box.
- b. Position the cover on the box and secure with three stud fasteners.
- c. Position the side access panel on the engine nacelle and secure with fasteners.

8-27. ALTERNATE AIR DOOR. The alternate air door located in the induction system, on the back side of the air plenum, just before the injector unit is to provide a source of air should there be an air stoppage through the filter system. The following should be checked during inspection:

- a. Door seals are tight and hinges are secure.
- b. Actuate the door to determine that it is not sticking or binding.
- c. Check cockpit control cable for free travel.
- d. Check that when the control knob in the cockpit is full in, the cable is adjusted to allow approximately one-eighth inch between the actuating arm roller and the door when fully closed.

1855



1. BAFFLE, RIGHT FRONT
2. BAFFLE, FRONT
3. SPARK PLUG LEAD
4. INJECTOR NOZZLE FUEL LINE
5. BAFFLE, RIGHT REAR
6. SPARK PLUG
7. LIFTING STRAP
8. FUEL DISTRIBUTOR VALVE
9. INTAKE AIR DUCT
10. FUEL PRESSURE INDICATOR LINE
11. BAFFLE, REAR
12. AIR FILTER BOX
13. ENGINE SHOCK MOUNT (SEE SKETCH A)
14. INTAKE AIR DUCT
15. ENGINE BREATHER TUBE
16. ENGINE MOUNT
17. ALTERNATOR

18. STARTER RING GEAR
19. STARTER MOTOR
20. BAFFLE, LEFT FRONT
21. EXHAUST STACK
22. BAFFLE, LEFT REAR
23. OIL COOLER
24. EXHAUST STACK
25. EXHAUST STACK HANGER
26. HANGER MOUNTING BRACKET
27. BOLT ASSEMBLY
28. NUT
29. SPACER
30. SHOCK MOUNT, SILVER
31. SHOCK MOUNT, GOLD
32. WASHER
33. BOLT
34. SPACER

Figure 8-5. Engine Installation



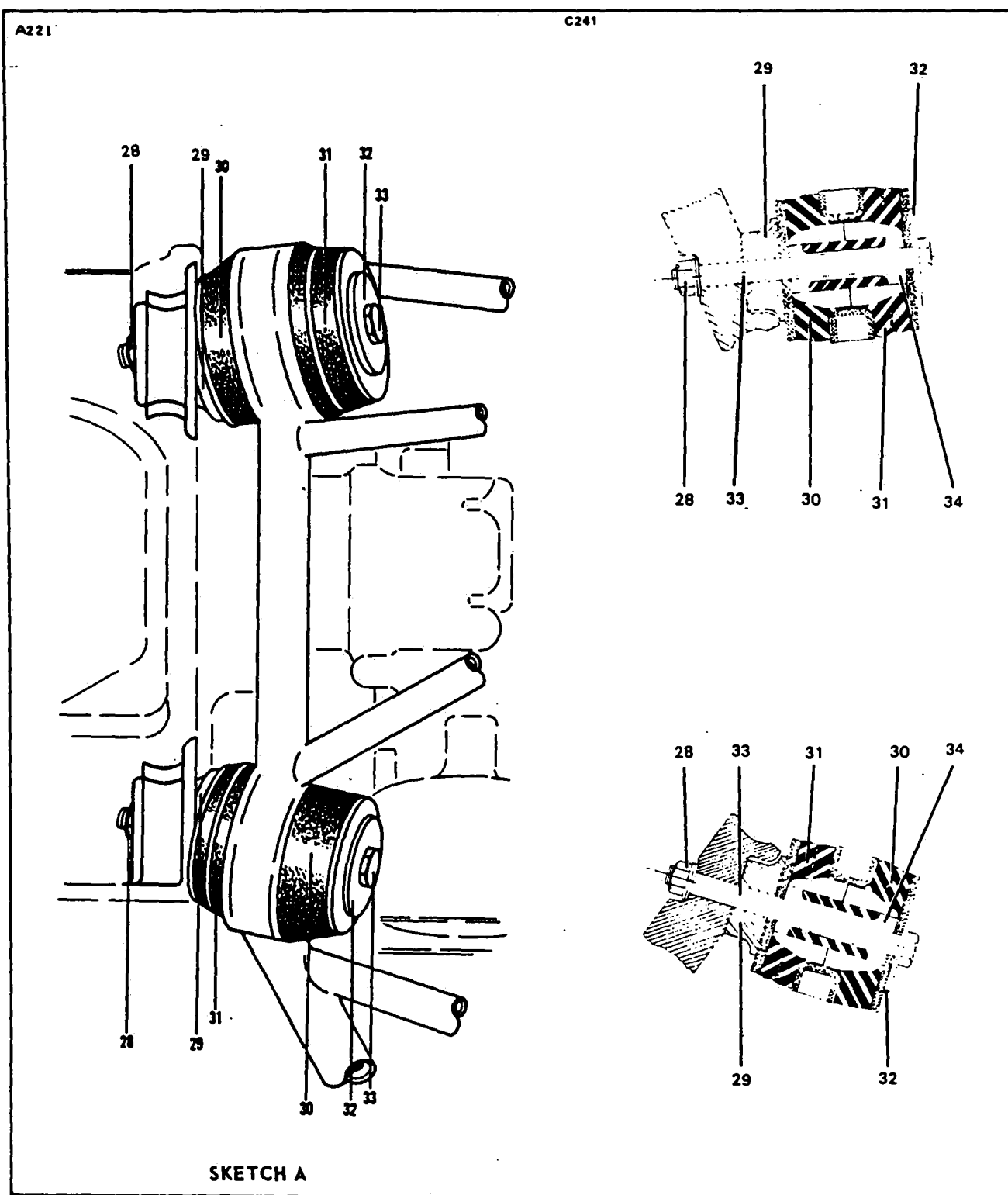


Figure 8-5. Engine Installation (cont.)

8-28. FUEL INJECTOR.

8-29. FUEL INJECTOR MAINTENANCE.

a. In general, little attention is required between injector overhauls. However, it is recommended that the following items be checked during periodic inspection of the engine.

1. Check tightness and lock of all nuts and screws which fasten the injector to the engine.

2. Check all fuel lines for tightness and evidence of leakage. A slight stain adjacent to the air bleed nozzles is not cause for concern.

3. Check throttle and mixture control rods and levers for tightness and lock.

4. Remove and clean the injector fuel inlet strainer at the first 25 hour inspection and each 50 hour inspection thereafter. Damaged strainer "O" rings should be replaced.

b. Tests prove that gasoline which becomes stale due to prolonged storage absorbs oxygen rapidly. This stale oxidized gasoline acquires a very distinctive odor similar to varnish and causes rapid deterioration of synthetic rubber parts, and also forms a gummy deposit on the internal metal parts. This condition, however, does not occur during normal operation of the injector where fresh fuel is being constantly circulated.

8-30. LUBRICATION OF FUEL INJECTOR.

a. There is very little need for lubrication of the injector in the field between regular overhauls. However, the clevis pins used in connection with the throttle and manual mixture control levers should be checked for freedom of movement and lubricated, if necessary.

b. Place a drop of engine grade oil on the end of the throttle shaft in such a manner that it can work into the throttle shaft bushings.

8-31. REMOVAL OF FUEL INJECTOR.

a. Remove the cowling per paragraph 8-5.

b. Remove clamps securing throttle and mixture control cables to cable brackets.

c. Disconnect throttle and mixture control cables from injector unit by removing nut and washer from ball joints.

d. Remove the safety wire and cap bolts attaching the air plenum to the injector unit.

- e. Disconnect the fuel lines at the injector unit.
- f. Remove the pal locknuts and nuts securing the injector to the engine.
- g. Pull the air plenum back to allow the injector unit to be removed.

8-32. PREPARATION FOR STORAGE. Any unit taken out of service, or units being returned for overhaul, must be flushed with preserving oil (Specification MIL-O-6081, Grade 1010) using the following procedure:

- a. Remove plugs and drain all fuel from the injector. If available, apply 10 to 15 psi air pressure to the fuel inlet until all fuel is discharged from the injector.
- b. Replace plugs and apply flushing oil filtered through a 10-micron filter at 13-15 psi to the injector fuel inlet until oil is discharged from the outlet.
- c. Replace fuel inlet shipping plug.

#### CAUTION

Do not exceed the above air pressures as internal damage to the injector may result.

d. After filling with preservative oil, the injector should be protected from dust and dirt and given such protection against moisture as climatic conditions at the point of storage require. In most cases, storing the unit in a dry area will be sufficient.

e. If the unit is to be stored near or shipped over salt water, the following precautions should be observed:

- 1. Spray the exterior of the injector with an approved preservative oil.
- 2. Pack in a dustproof container, wrap the container with moisture and vapor-proof material, and seal. Pack the wrapped unit in a suitable shipping case. Pack a one-half pound bag of silica gel crystals in the dustproof container with injector. The bag must not touch the injector.

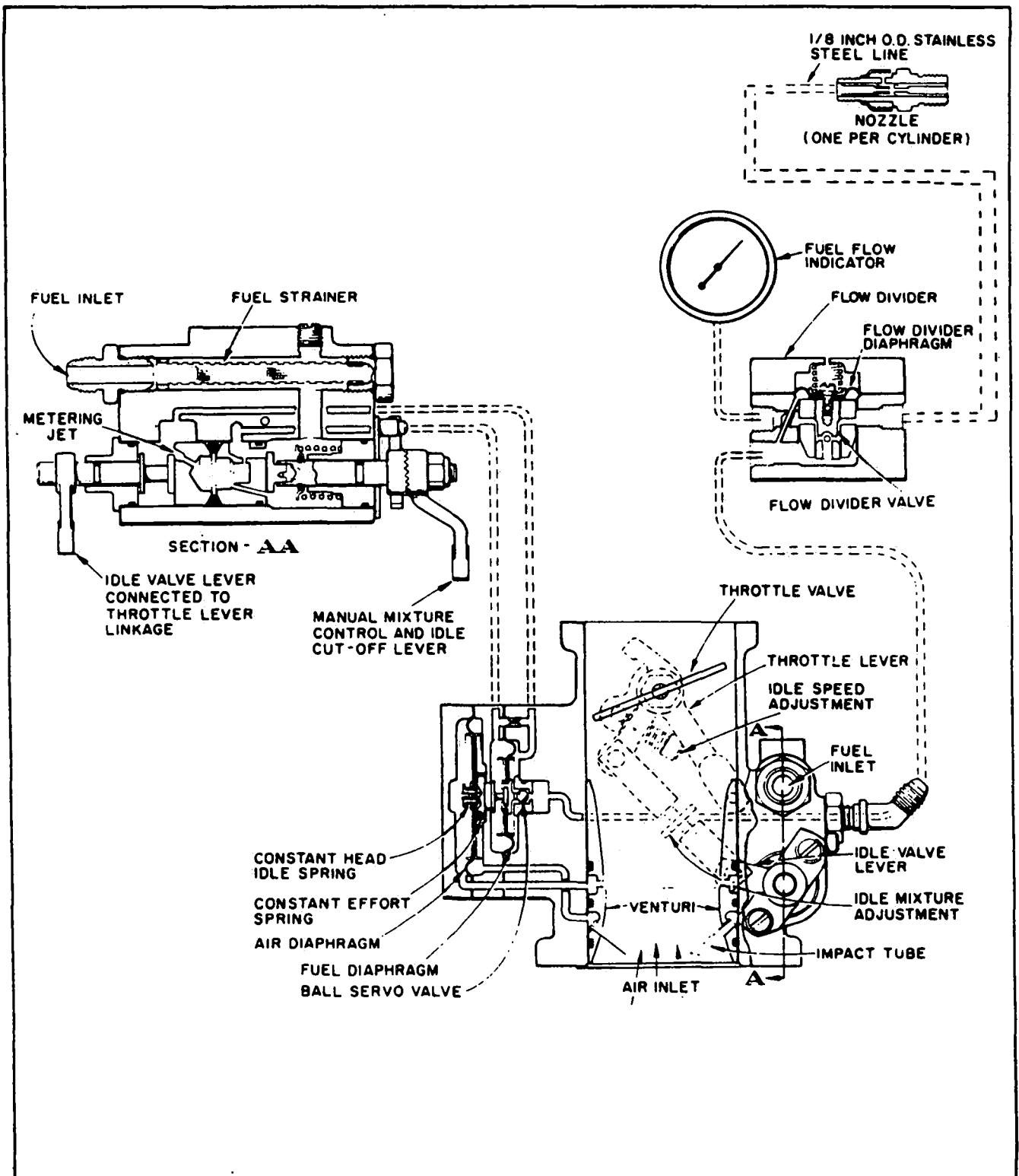


Figure 8-6. Schematic Diagram of RSA Fuel Injector System

**CAUTION**

Extreme caution should be exercised when handling or working around the injector to prevent oil or fuel from entering the air sections of the injector. As explained previously, damage to the air diaphragm will result. Fluid can easily enter the air section of the injector through the impact tubes or the annular groove around the venturi. For this reason, a protective plate should be installed on the scoop mounting flange when performing routine maintenance on the engine, such as washing down the engine and air scoop, servicing the air filter (surplus oil on the element), or when injecting preservative into the engine prior to storing or shipping.

**8-33. INSTALLATION OF FUEL INJECTOR.**

- a. Move the injector air inlet plenum aft enough to allow the injector with gasket to be installed. Install mixture control cable bracket on injector mounting studs and secure bracket and injector to engine with nuts and pal locknuts.
- b. Secure inlet air plenum to injector with cap bolts and safety.
- c. Connect the fuel lines to injector unit.
- d. Connect throttle and mixture control cables to injector unit.
- e. Clamp control cables to cable brackets and adjust per paragraph 8-34.
- f. Adjust idle speed and mixture per paragraph 8-35.
- g. Install cowling per paragraph 8-7.

**8-34. ADJUSTMENT OF THROTTLE AND MIXTURE CONTROLS.** The throttle and mixture controls are adjusted when the throttle arm on the injector is rotated against its full throttle stop and the mixture arm is rotated against its full rich stop, their respective cockpit control levers should be 0.062 of an inch in from their full forward stops, which are located in the control pedestal.

- a. At the injector, disconnect the throttle and/or mixture control cable end from its control arm.
- b. Loosen the jam nut securing the cable end.
- c. Adjust the linkage by rotating the cable end to obtain the 0.062 of an inch springback of the cockpit control lever when the throttle or mixture control arm contacts its stop.

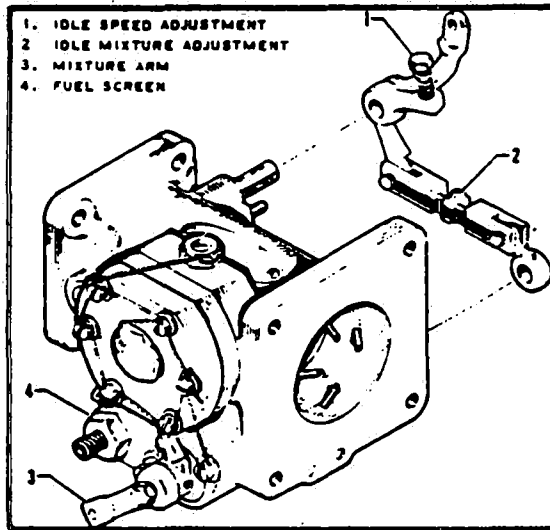


Figure 8-7. Fuel Injector

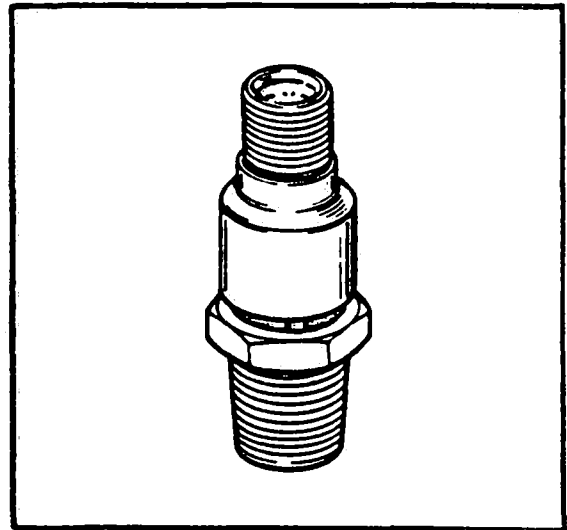


Figure 8-8. Fuel Air Bleed Nozzle

- d. Reconnect the cable end to its control arm and secure jam nut.
- e. Pull the throttle and mixture control lever in the cockpit full aft to ascertain that the injector idle screw contacts its stop and the mixture control arm contacts its lean position.

#### 8-35. ADJUSTMENT OF IDLE SPEED AND MIXTURE.

- a. Start the engine and warm up in the usual manner until oil and cylinder head temperature are normal.
- b. Check magnetos. If the "mag-drop" is normal, proceed with idle adjustment.
- c. Close the throttle to idle. If the RPM changes appreciably after making the idle mixture adjustment during the succeeding steps, readjust the idle speed to the desired RPM.

#### NOTE

The idle mixture must be adjusted with the fuel boost pump ON.

d. When the idling speed has been stabilized, move the cockpit mixture control lever with a smooth, steady pull toward the Idle Cut-Off position and observe the tachometer for any change during the "leaning" process. Caution must be exercised to return the mixture control to the Full Rich position before the RPM can drop to a point where the engine cuts out. An increase of more than 50 RPM while "leaning out" indicates an excessively rich idle mixture. An immediate decrease in RPM (if not preceded by a momentary increase) indicates the idle mixture is too lean.

e. If the above indicates that the idle adjustment is too rich or too lean, turn the idle mixture adjustment in the direction required for correction, and check this new position by repeating the above procedure. Make additional adjustments as necessary. Each time the adjustment is changed, the engine should be run up to 2000 RPM to clear the engine before proceeding with the RPM check. Make final adjustment of the idle speed adjustment to

obtain the desired idling RPM with closed throttle. The above method aims at a setting that will obtain maximum RPM with minimum manifold pressure. In case the setting does not remain stable, check the idle linkage; any looseness in this linkage would cause erratic idling. In all cases, allowance should be made for the effect of weather conditions and field altitude upon idling adjustment.

#### 8-36. FUEL AIR BLEED NOZZLES.

8-37. REMOVAL OF FUEL AIR BLEED NOZZLES. The nozzles must be carefully removed as they or the cylinders may be damaged.

- a. Remove the side access panels from the engine nacelle.
- b. Disconnect the fuel line from the nozzle.
- c. Carefully remove the nozzle using the correct size deep socket.
- d. Clean and inspect the nozzle as given in paragraph 8-38.

#### 8-38. CLEANING AND INSPECTION OF FUEL AIR BLEED NOZZLE.

- a. Clean the nozzle with acetone or equivalent and blow out all foreign particles with compressed air in the direction opposite that of fuel flow. Do not use wire or other hard objects to clean orifices. (Refer to the latest revision of Lycoming Service Instruction No. 1275.)
- b. Inspect the nozzle and cylinder threads for nicks, stripping or cross-threading.
- c. Inspect for battered or rounded hexagons.
- d. A test procedure for air bleed nozzles is described on the latest revision of the Lycoming Service Instruction No. 1275.

#### 8-39. INSTALLATION OF FUEL AIR BLEED NOZZLES.

- a. It is important for the nozzles to be correctly positioned with the air bleed hole upward.
- b. Install the air bleed nozzles in the cylinder heads and torque 60 inch-pounds.

#### CAUTION

Start nozzles and line couplings by hand to prevent the possibility of cross-threading.

- c. Connect fuel lines to nozzles.
- d. Install side panels.

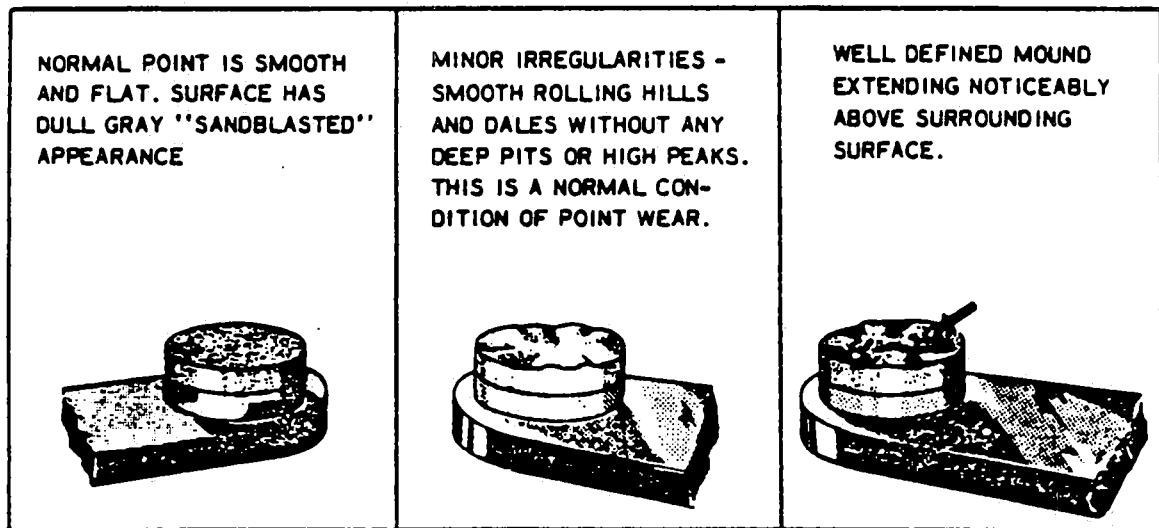


Figure 8-9. Magneto Breaker Points

#### 8-40. IGNITION SYSTEM MAINTENANCE.

#### 8-41. MAGNETO.

#### CAUTION

Ascertain that the primary circuits of both magnetos are grounded before working on the engine.

8-42. INSPECTION OF MAGNETOS. At time of engine inspection or when a magneto has been removed from the engine, the following checks may be performed:

- a. Inspect distributor block contact springs. Top of spring must not be more than 0.422 of an inch below top of tower as shown in Figure 8-10. If broken or corroded, they should be replaced.
- b. Inspect oil felt washer. It should be saturated with oil. If dry, check for worn bushing. If O.K., add Bendix P/N 10-391200 oil.

#### NOTE

Refer to the latest revisions of Bendix Service Bulletin No. 551 or Lycoming Service Bulletin No. 343 for further information on new distributor block lubricant.



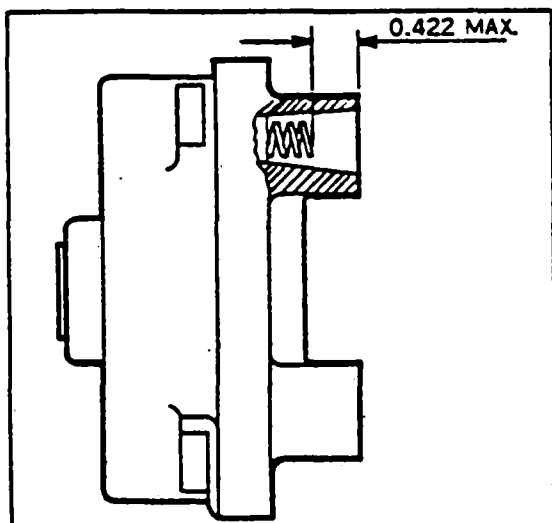


Figure 8-10. Contact Spring Inspection

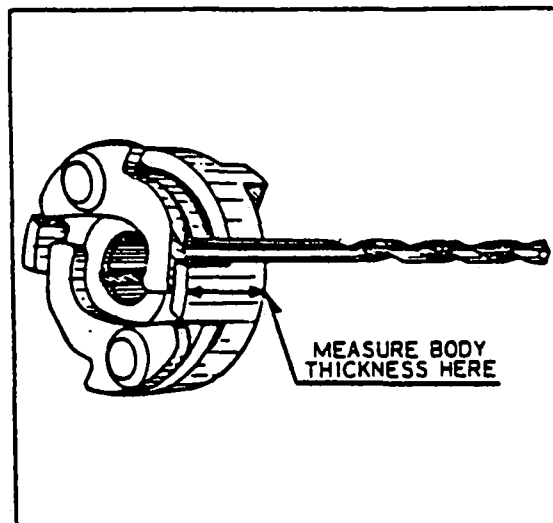


Figure 8-11. Impulse Coupling

c. Inspect distributor block for cracks or burned areas. The wax coating on the block should not be removed. Do not use solvents.

d. Look for excess oil in breaker compartment. If present, it may mean a bad oil seal or oil seal bushing at drive end. Check magneto manufacturer's overhaul procedure.

e. Examine the breaker points for excessive wear or burning. Figure 8-9 shows how the average breaker point will look when surfaces are separated for inspection. Desired contact surfaces have a dull gray, sand-blasted (almost rough) or frosted appearance over the area where electrical contact is made. This means that points are worn in and mated to each other, thereby providing the best possible electrical contact and highest efficiency of performance.

f. Minor irregularities or roughness of point surfaces are not harmful (Refer to Figure 8-9 center). Neither are small pits or mounds, if not too pronounced. If there is a possibility of pit becoming deep enough to penetrate pad, Figure 8-9 right, reject breaker assembly.

#### NOTE

No attempt should be made to stone or dress breaker points. Should breaker assembly have bad points or show excessive wear, the complete breaker assembly should be replaced.

- g. Look for frayed insulation or broken wire strands in leads in back of magneto. See that terminals are secure. Be sure wires are properly positioned.
- h. Inspect capacitor visually. If possible, test for leakage, capacity and series resistance. Remember, an electrical failure of an aircraft capacitor is rare.
- i. Adjustment of breakers must be correct for proper internal timing of magneto. (Refer to Paragraph 8-44.)
- j. Check if breaker cam is clean and smooth, if cam screw is tight (25 in. lbs. ). If new points are installed, blot a little oil on cam.
- k. Inspect impulse coupling flyweights for excessive looseness on the axles. Design couplings having 0.927 of an inch thick body should be checked with 1/8 inch drill. Couplings with 0.974 of an inch thick body are checked with a No. 18 drill. If drill fits between cam and flyweight, the fit is too loose and coupling should be replaced. (Refer to Figure 8-11.)
- l. Check impulse coupling for excess wear on the contact edges of body and flyweights.
- m. Check that the impulse coupling flyweight axle rivets are tight and there are no cracks in body.
- n. Look at the lead conduits. A few broken strands won't hurt, but if the insulation looks tired you may be in for trouble. The special high temperature coating, used on light-weight harnesses, is provided chiefly for vibration resistance and mechanical protection. The integrity of the harness is not sacrificed if small areas of the braid show peeling or flaking of this coating.
- o. Check the springs for breaks, corrosion or deformation. If possible, check continuity from block with tester or light.
- p. Check insulators for cracks, breaks, or evidence of "old age". Be sure they are clean.
- q. Timing and ventilator plugs. Ventilator has drilled holes and should be in lowest hole in magneto to serve also as drain for excess water or oil. Solid plug is used in other hole or in location exposed to rain or water.

NOTE

The magneto service instructions in this manual are to cover minor repairs and timing. For further repairs and adjustments of the magnetos, it is recommended that the magneto manufacturer's service instructions be followed.

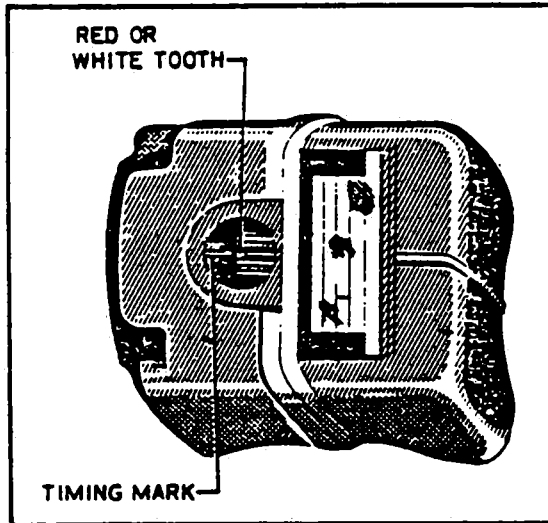


Figure 8-12. Magneto Timing Marks

#### 8-43. REMOVAL OF MAGNETO.

- a. Remove the side access panel from the engine nacelle.
- b. Disconnect the "O" lead from the magneto.
- c. Remove the harness outlet plate from the magneto by removing the four attaching screws.
- d. Remove the two nuts and washers securing the magneto to the engine accessory housing.
- e. Pull the magneto from the engine.

#### 8-44. TIMING PROCEDURE. (INTERNAL TIMING.)

When installing new or adjusting breaker points and before timing the magneto to the engine, it is important that the internal timing of the magneto be correct.

When installing new or adjusting breaker points and before timing the magneto to the engine, it is important that the internal timing of the magneto be correct.

a. To internally time the magneto, it should be removed from the engine to determine "E" gap.

b. To determine "E" gap, find neutral position of the magneto drive by rotating drive coupling in a left hand direction until the red or white chamfered tooth on the distributor gear appears through the timing inspection hole. At the same location, the drive should feel to have fallen into a notch or neutral position.

c. Rotate coupling from neutral in a left hand direction 10 degrees. Appearing through timing hole, when the white or red tooth aligns with the white line of the distributor block the magneto is set at "E" gap. (Refer to Figure 8-12.) Alignment may not vary over  $\pm 4$  degrees.

d. Using the alignment of the chamfered tooth on the distributor gear and the white line on the distributor block as a reference, adjust the breaker points to open at this point.

e. Turn the magneto drive until the cam follower is on high point of the cam lobe. Measure contact clearance, it must be 0.018 of an inch  $\pm$  0.006 with the point opening set at "E" gap. If breaker points do not come within tolerances, they should be replaced.

8-45. INSTALLATION AND TIMING PROCEDURE. (Timing Magneto to Engine.) The magnetos can be installed and timed to the engine by the following procedure:

**NOTE**

Ascertain that the breakers are correct for proper internal timing of magnetos.

a. Remove cowling per paragraph 8-5.

b. Remove the top spark plug from No. 1 cylinder. Place the thumb of one hand over the spark plug hole and rotate the crankshaft in direction of normal rotation until the compression stroke is reached. The compression stroke is indicated by a positive pressure inside the cylinder tending to lift the thumb off the spark plug hole. In this position, both valves of No. 1 cylinder are closed. Turn the crankshaft opposite to its normal direction of rotation until it is approximately 35 degrees BTC on the compression stroke of No. 1 cylinder. Rotate the crankshaft in its normal direction of rotation until the 25 degrees mark on the back of the starter gear and the crankcase parting flange are aligned, or the marks on the front of the starter ring gear and the drilled hole in the starter housing align. Refer to Figure 8-13.

c. Rotate the drive gear on the magneto until the chamfered tooth on the distributor gear inside the magneto aligns with the white pointer as seen through the inspection hole in the magneto housing. Refer to Figure 8-12.

d. Without allowing the gear to turn from this position, install the magneto with gasket on the engine and secure with washers and nuts.

e. Tighten nuts sufficiently to hold magneto in position and yet allow it to be rotated.

f. Fasten the ground lead of the timing light to an unpainted metallic portion of the magneto and one positive lead to the terminal side of the points. Ascertain that the primary ground spring is not touching the magneto case.

g. Turn on the timing light switch.

h. Rotate the magneto housing in direction of the magnet rotation a few degrees until light comes on. Then slowly turn magneto in opposite direction until the timing light just goes out. Secure the magneto housing in this position.

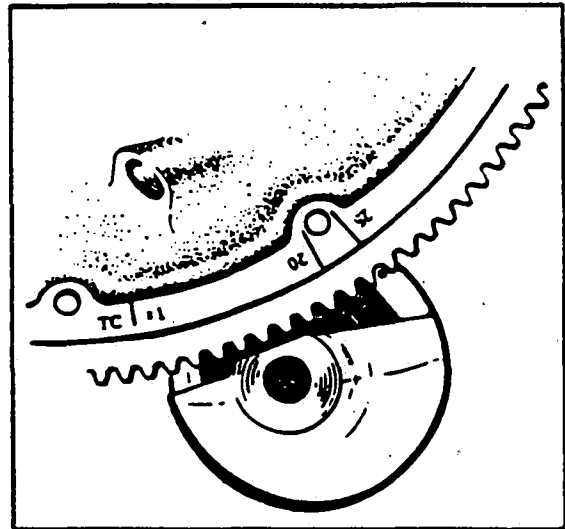


Figure 8-13. Engine Timing Marks

NOTE

Some timing lights operate the opposite of the one mentioned.

- i. Rotate the crankshaft opposite normal rotation until it is approximately 35 degrees BTC on compression stroke No. 1 cylinder.

NOTE

The crankshaft should not be rotated more than 10 degrees in direction opposite normal rotation from the 25 degrees BTC as the pawl on the impulse coupling will engage with the stop pin and late timing will be indicated through the impulse coupling mechanism. If this should happen, rotate crankshaft in normal direction until sharp click is heard; this will indicate that the impulse coupling has passed through firing position. Turn crankshaft in direction opposite normal rotation to approximately 35 degrees BTC and proceed with timing check.

- j. Turn the crankshaft very slowly in direction of normal rotation until the timing mark on the front face of the ring gear aligns with the drilled hole in the starter, as shown in Figure 8-13, or the timing mark on the back of the ring gear aligns with the crankcase parting surface. At this point, the light should go out.

k. If the light does not go out at this point, align timing marks and rotate magneto on mounting flange in the desired direction and repeat the procedure until the light goes out at 25 degrees before top dead center.

- l. Tighten the two mounting nuts and replace the inspection plug.

m. After tightening magneto mounting nuts, check timing to make sure it is still correct.

- n. Install the other magneto and time using the preceding instructions a thru l.

o. With both magnetos timed to the engine and secured, check that they fire together. Rotate the crankshaft opposite normal rotation to approximately 35 degrees BTC with No. 1 cylinder on the compression stroke.

p. If the magnetos are timed correctly, both timing lights will go out simultaneously when the crankshaft is turned in the normal direction aligning the 25 degree mark with either the drilled hole in the starter housing or the crankcase parting surfaces.

- q. Disconnect timing light. Ascertain that the inspection plugs and breaker cover are installed and secure.
- r. Install harness plate and secure with screws.
- s. Connect "P" leads and safety.
- t. Install cowling per paragraph 8-7.

#### 8-46. HARNESS ASSEMBLY.

#### 8-47. INSPECTION OF HARNESS.

a. Check lead assemblies for nicks, cuts, mutilated braiding, badly worn section or any other evidence of physical damage. Inspect spark plug sleeves for chafing or tears and damaged or stripped threads on coupling nuts. Check compression spring to see if it is broken or distorted. Inspect grommet for tears. Check all mounting brackets and clamps to see that they are secure and not cracked.

b. Using an ohmmeter, buzzer, or other suitable low voltage device, check each lead for continuity. If continuity does not exist, wire is broken and must be replaced.

c. For electrical test of harness assembly, use a high voltage, direct current tester such as the TAKK Model 86 or 86A or an equivalent direct current high voltage tester capable of delivering a test potential of 10,000 volts. Connect ground lead of high voltage tester to outer shielding braid of a single lead. Connect plug terminal. Turn tester ON and apply 10,000 volts. The insulation resistance should be 100 megohms minimum. Proceed to check other leads of harness in the same manner.

d. Minor repair of the harness assembly, such as replacement of contact springs, spring retainer assemblies, insulating sleeves or of one lead assembly, can be accomplished with the harness assembly mounted on the engine. However, should repair require replacement of more than one lead assembly or of a cable outlet plate, the harness should be removed from the engine and sent to an overhaul shop.

#### 8-48. REMOVAL OF HARNESS.

- a. Disconnect the clamps that secure the wires to the engine and accessories.
- b. Loosen the coupling nuts at the spark plugs and remove the insulators from the spark plug barrel well. Use caution when withdrawing the insulator not to damage the insulator spring.
- c. Place a guard over the harness insulators.

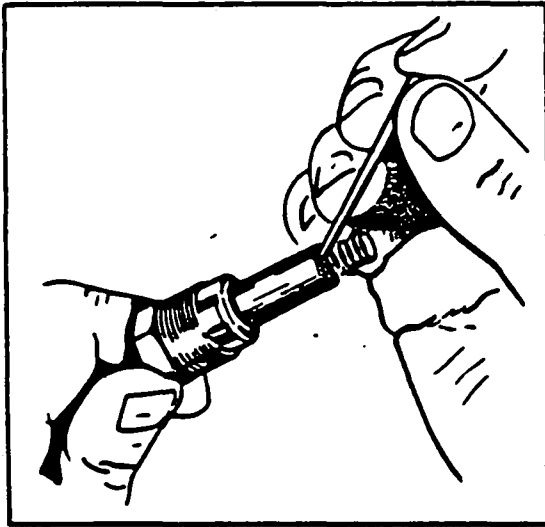


Figure 8-14. Removing Spring  
From Lead Assembly

d. Remove the harness assembly terminal plate from the magneto.

e. Remove the harness from the airplane.

#### 8-49. MAINTENANCE OF HARNESS.

a. To replace contact springs, spring retainer assemblies or insulating sleeves, proceed as follows:

1. Using a Scintilla 11-7073 Needle or a mechanical pencil with the lead retracted, hook the end of the contact spring as shown in Figure 8-14.

2. Using the needle or pencil, unscrew the spring.

3. Slide insulating sleeve and spring retainer assembly off end of lead assembly.

4. Replace defective component and reassemble as follows:

(a) Fabricate a tool as shown in Figure 8-15 for installing the insulating sleeves over cable terminals.

(b) Push the tool thru insulating sleeve and spring retainer assembly as shown in Figure 8-16. Screw the cable terminal into the tool.

(c) Work insulating sleeve and spring retainer assembly into position over the cable and unscrew the tool. Install contact spring on cable terminal.

#### NOTE

It may be necessary to lubricate the cable and insulating sleeve with a thin film of MC200 (200,000 centi-stokes) or commercial grade alcohol to facilitate assembly.

b. To replace one of the lead assemblies, proceed as follows:

1. Remove clamps and brackets from applicable lead assembly. Cut cable ties from assembly and discard.

2. Cut off condemned lead flush with outer surface of cable outlet plate.

3. Grip eyelet of lead with a pair of pliers and pull short length of conductor out of grommet and cable outlet plate.

4. Using a 3 inch long, 0.270 of an inch diameter drift applied at outer surface of plate, drive out tapered ferrule and remaining pieces of insulation and shielding.

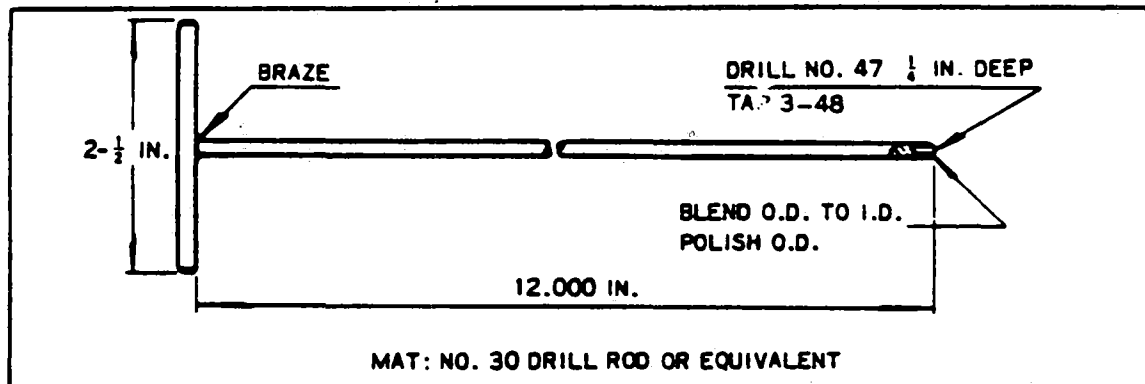


Figure 8-15. Assembly Tool

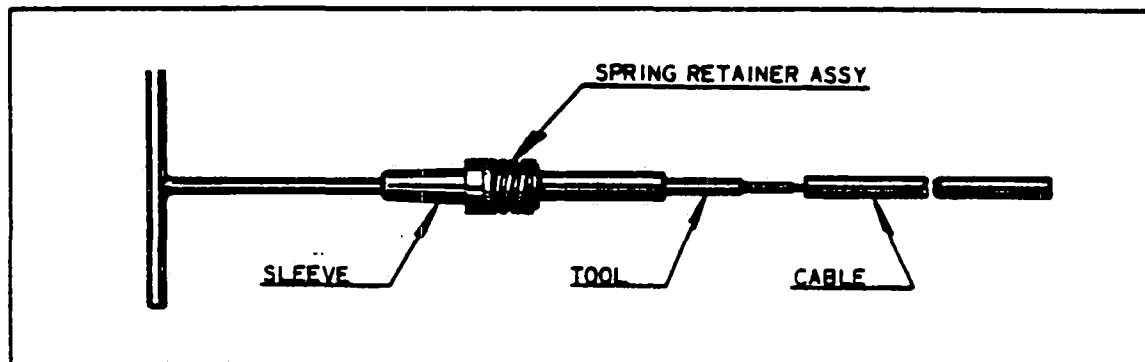


Figure 8-16. Using Assembly Tool

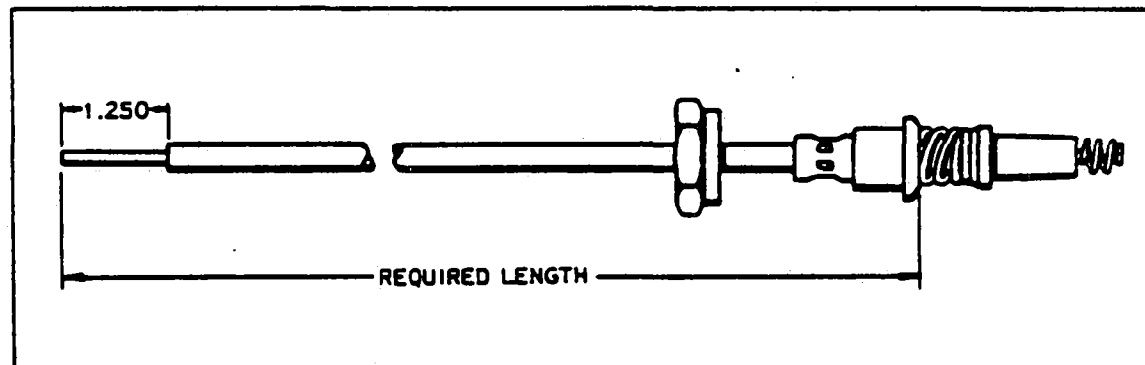


Figure 8-17. Measuring Lead Assembly Length

5. To determine what length the new lead assembly should be cut to, proceed as follows:

(a) Measure the length of the condemned lead assembly. Move coupling nut back on lead assembly and measure from outer end of ferrule at spark plug end (Refer to Figure 8-17.)



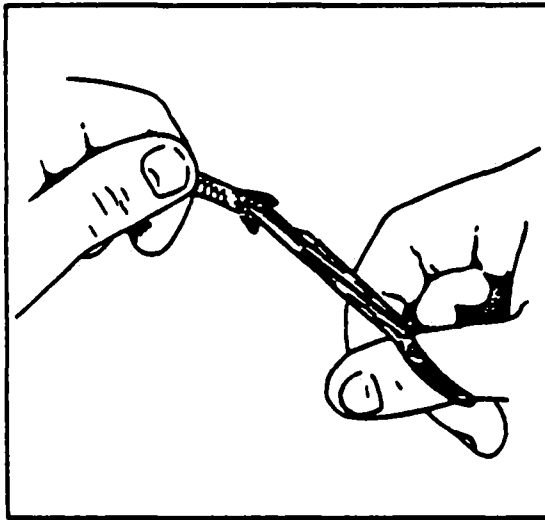


Figure 8-18. Cutting Metallic Braid from End of Lead

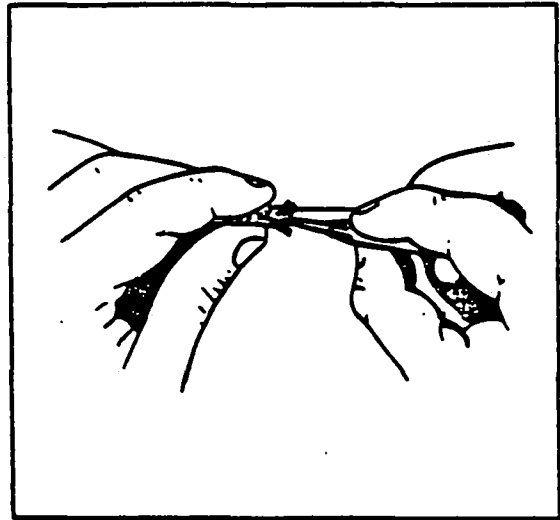


Figure 8-19. Unbraiding Metallic Shielding

(b) To the length determined in step (a), add 1-3/4 inches.

NOTE

Spare part leads are supplied in various lengths. Use a lead which is longer than, but nearest to, the desired length.

6. Cut lead assembly to the length determined in step 5. Mark ferrule on spark plug end of lead with a metal stamp, scribe or rubber stamp to correspond with correct cylinder number.

7. Starting at spark plug location, thread new cable thru grommets and clamps as necessary for correct routing of cut end of cable to magneto location.

8. Using electrician's scissors, carefully remove 1.250 inches of outer braid from end of lead. Refer to Figure 8-18.

CAUTION

Use care not to nick or cut insulation when removing braid.

9. Using a scribe or similar pointed tool, unbraid 3/8 inch of braided shielding. (Refer to Figure 8-19.) Wrap a single thickness of electrical tape around unbraided strands to facilitate insertion of lead end thru hole in cable

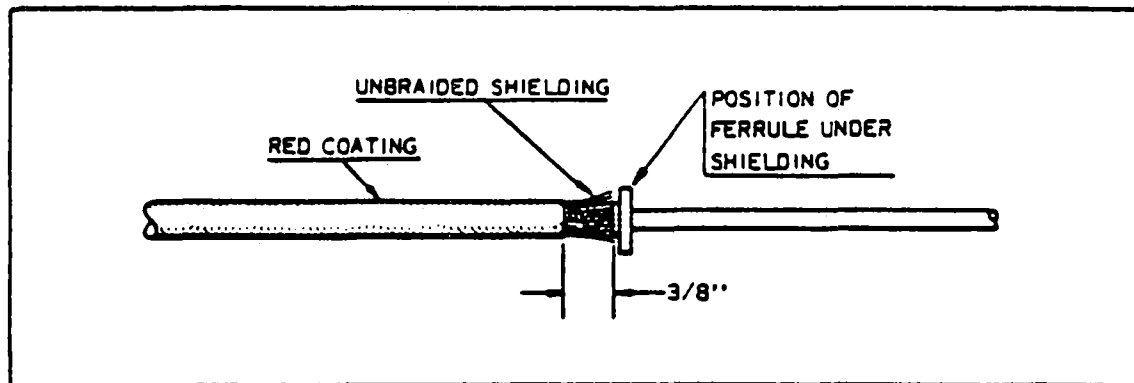


Figure 8-20. Forming Shielding Around Ferrule

outlet plate.

10. Remove cable outlet plate from magneto. Support plate securely and using suitable cutting pliers, split and remove eyelets from leads adjacent to lead being replaced. When splitting eyelet, make certain that wire strands are not cut. Removal of eyelets on adjacent leads will allow grommet to be pulled away from outlet plate to facilitate insertion of new lead.

11. Pass the taped end of new lead through hole in outlet plate. Remove electrical tape from lead and install tapered end of ferrule under the braided strands of shielding. Form strands of shielding evenly around tapered ferrule as shown in Figure 8-20 and pull lead assembly back through cable outlet plate until ferrule binds in the outlet well. Position the Scintilla 11-7074 Ferrule Seating Tool (Figure 8-21) over the wire and firmly seat the ferrule by tapping the seating tool with a hammer or by using an arbor press.

12. Measure 1/2 inch from tapered ferrule and strip remaining insulation from wire. (Refer to Figure 8-23.)

13. Insert Scintilla 11-7073 Needle (Figure 8-22) thru small hole of grom-

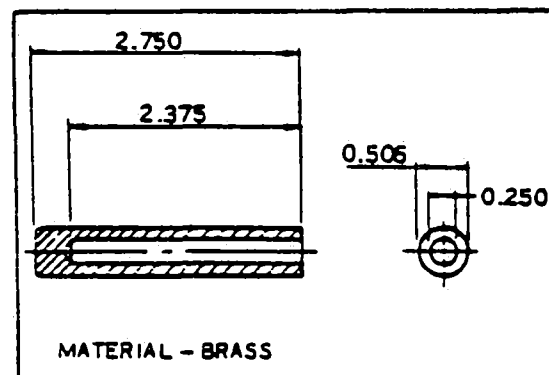


Figure 8-21. Ferrule Seating Tool

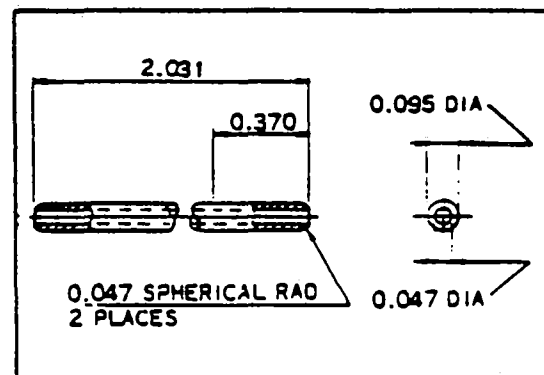


Figure 8-22. Needle

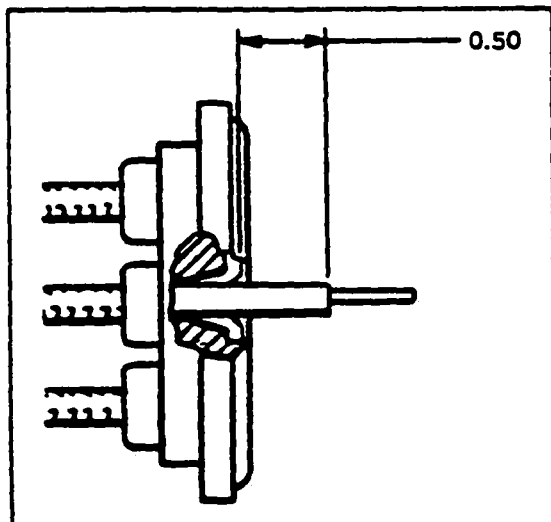


Figure 8-23. Measuring Wire From Top of Ferrule

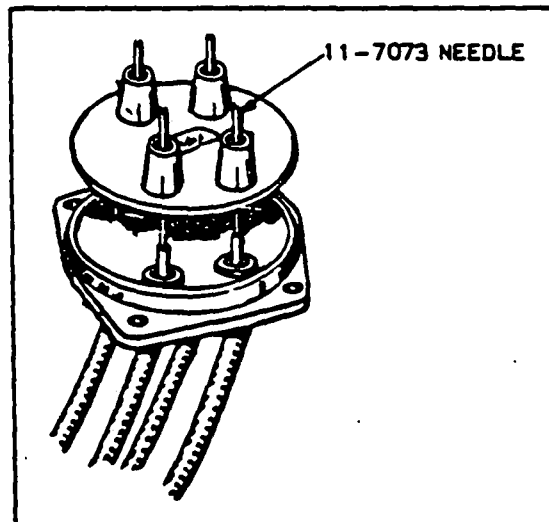


Figure 8-24. Installing Grommet Over Lead Assemblies

met and over stripped end of wire. (Refer to Figure 8-24.) Slide grommet down needle until it seats tightly against the tapered ferrule.

14. Cut wire  $\frac{3}{8}$  inch from top of grommet outlet. (See Figure 8-24.) Double wire over as shown in A of Figure 8-26. Slide eyelet over doubled wire until it is firmly seated in recess of grommet outlet.

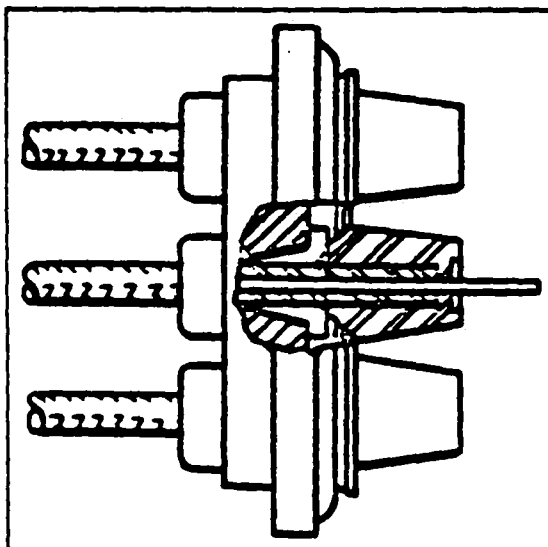


Figure 8-25. Lead Assembly Installed in Grommet

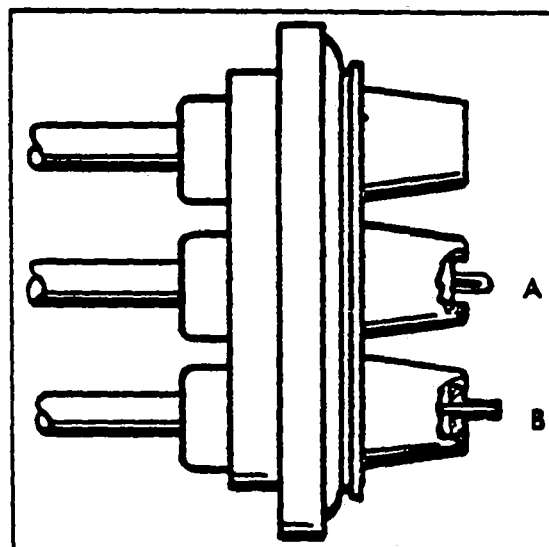


Figure 8-26. Wire Doubled Over For Installation of Eyelet

15. Using the "AB" groove of Scintilla 11-4152 Crimping Tool, or equivalent, crimp eyelet to wire. Approximately 1/32" of wire should extend from end of eyelet after crimping. See B of Figure 8-26.

NOTE

If the crimping tool is not available, a satisfactory connection can be made by soldering with Kester Flux 709 or equivalent and a non-corrosive solder. After soldering, clean solder joints using denatured alcohol.

16. Install clamps and cable ties, as necessary, to secure lead to the engine.

8-50. INSTALLATION OF HARNESS. Before installing harness on magneto, check mating surfaces for cleanliness. Spray entire face of grommet with a light coat of Plastic Mold Spray, SM-O-O-TH Silicone Spray or equivalent. This will prevent harness grommet from sticking to magneto distributor block.

- a. Place the harness terminal plate on the magneto and tighten nuts around the plate alternately to seat cover squarely on magneto. Torque nuts to 18 to 22 inch pounds.
- b. Route ignition wires to their respective cylinders.
- c. Clamp the harness assembly in position.
- d. Connect the leads to the spark plugs.

8-51. SPARK PLUGS.

8-52. REMOVAL OF SPARK PLUGS.

- a. Loosen the coupling nut on the harness lead and remove the terminal insulator from the spark plug barrel well.

NOTE

When withdrawing the ignition cable lead connection from the plug, care must be taken to pull the lead straight out and in line with the center line of the plug barrel; otherwise, a side load will be applied which frequently results in damage to the barrel insulator and connector. If the lead cannot be removed easily in this manner, the resisting contact between the neoprene collar and the barrel insulator will be broken by a rotary twisting of the collar. Avoid undue distortion of the collar and possible side loading of the barrel insulator.

- b. Remove the spark plug from the engine. In the course of engine operation, carbon and other combustion products will be deposited on the end of the spark plug and will penetrate the lower threads to some degree. As a result, greater torque is frequently required for removing a plug than for its installation. Accordingly, the torque limitations given do not apply to plug removal and sufficient torque must be used to unscrew the plug. The higher torque in removal is not as detrimental as in installation since it cannot stretch the threaded section. It does, however, impose a shearing load on this section and may, if sufficiently severe, produce a failure in this location.

NOTE

Torque indicating handle should not be used for spark plug removal because of the greater torque requirement.

- c. Place spark plugs in a tray that will identify their position in the engine as soon as they are removed.

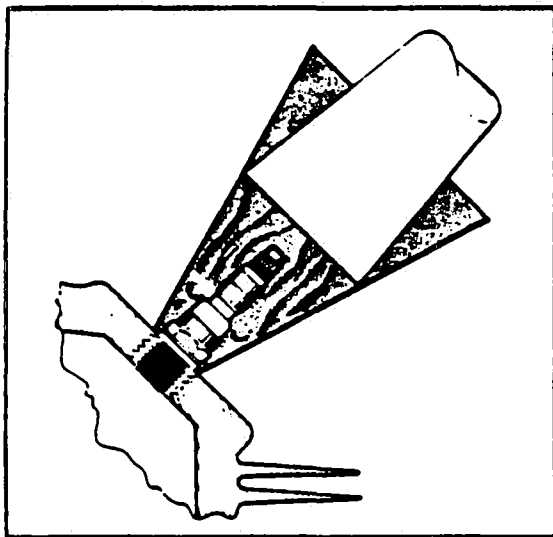


Figure 8-27. Removing Frozen Spark Plug

**NOTE**

Spark plugs should not be used if they have been dropped.

d. 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 at the apex just large enough to accommodate the funnel of a CO<sub>2</sub> bottle. (Refer to Figure 8-27.) 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 CO<sub>2</sub> 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.

e. Do not allow foreign objects to enter the spark plug hole.

**8-53. INSPECTION AND CLEANING OF SPARK PLUGS.**

- a. Visually inspect each spark plug for the following non-repairable defects:
  1. Severely damaged shell or shield threads nicked up, stripped, or cross-threaded.
  2. Badly battered or rounded shell hexagons.
  3. Out-of-round or damaged shielding barrel.
  4. Chipped, cracked or broken ceramic insulator portions.
  5. Badly eroded electrodes worn to approximately 50% of original size.
- b. Clean the spark plug as required, removing carbon and foreign deposits.
- c. Test the spark plug both electrically and for resistance.
- d. Set the electrode gap at 0.018 to 0.022 inches.

8-54. INSTALLATION OF SPARK PLUGS. Before installing spark plugs, ascertain that the threads within the cylinder are clean and not damaged.

a. Apply anti-seize compound sparingly on the threads and install gasket and spark plugs. Torque 360 to 420 inch pounds.

CAUTION

Make certain the deep socket is properly seated on the spark plug hexagon as damage to the plug could result if the wrench is cocked to one side when pressure is applied.

b. Carefully insert the terminal insulator in the spark plug and tighten the coupling nut.

8-55. LUBRICATION SYSTEM.

8-56. ADJUSTMENT OF OIL PRESSURE RELIEF VALVE. Engines are furnished with either a non-adjustable or adjustable oil pressure relief valve located to the rear of No. 3 cylinder. A brief description and setting procedure for both types follows:

a. Oil Relief Valve (Non-Adjustable): The function of the oil pressure relief valve is to maintain engine oil pressure within specified limits (60 psi, min. to 90 psi, max.). This valve is not adjustable; however, the pressure can be controlled by the addition of a maximum of three STD 425 washers under the cap to increase pressure or the use of a spacer (Lyc. P/N 73629 or 73630) under the cap to decrease pressure. Particles of metal or other foreign matter lodged between the ball and seat will result in a drop in oil pressure. It is advisable, therefore, to disassemble, inspect and clean the valve if excessive pressure fluctuations are noted. The oil pressure relief valve is not to be mistaken for the oil cooler by-pass valve, whose function is to permit pressure oil to by-pass the oil cooler in case of an obstruction in the oil cooler.

b. Oil Relief Valve (Adjustable): The adjustable oil relief valve enables the operator to maintain engine oil pressure within the specified limits (60 psi, min. to 90 psi, max.). If the pressure under normal operating conditions should consistently exceed the maximum or minimum specified limits, adjust the valve as follows:

With the engine warmed up and running at approximately 2000 RPM, observe the reading on the oil pressure gauge. If the pressure is above maximum or below minimum specified limits, stop engine and screw the adjusting screw out to decrease pressure and into increase pressure. Depending on installation, the adjusting screw may have only a screwdriver slot and is turned with a screwdriver; or may have the screwdriver slot plus a pinned 0.375-24 castellated nut and may be turned with either a screwdriver or a box wrench.

8-57. OIL SCREENS AND FILTERS. Cleaning and inspection of oil screens and filters can be found in Section II.



TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE)

Trouble	Cause	Remedy
Failure of engine to start.	Lack of fuel.	Check fuel system for leaks. Fill fuel tank. Clean dirty lines, screens or fuel valves.
	Water in fuel injector.	Drain water from fuel system.
	Insufficient prime.	Increase prime.
	Overpriming.	Open throttle and engage starter.
	Lack of sufficient fuel flow.	Clean fuel strainers and screens. Check fuel pump.
	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 II-I for spark plug gap adjustments.
	Defective ignition wire.	Check with electric tester and replace any defective wires.
	Improper operation of magneto to breaker points.	Check internal timing of magnetos. Clean and set points.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
Failure of engine to start. (cont.)	Internal failure.	Check oil sump screen for metal particles. If found, complete overhaul of the engine may be indicated.
	Magnetized impulse coupling.	Demagnetize impulse couplings.
	Frozen spark plug electrodes.	Replace spark plugs or dry out removed plugs.
	Shorted ignition switch.	Check and replace or repair.
Failure of engine to idle properly.	Incorrect idle adjustment.	Refer to paragraph 8-35.
	Idle mixture.	Refer to paragraph 8-35.
	Leak in the induction system.	Tighten all connections in the induction system. Replace any parts that are defective.
	Uneven cylinder compression.	Check cylinder compression.
	Faulty ignition system.	Check entire ignition system.
	Improper spark plug gap setting.	Regap spark plug.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
Failure of engine to idle properly. (cont.)	Clogged injector nozzle.	Remove and clean, paragraph 8-38
	Dirty air filter.	Check and clean.
	Insufficient fuel pressure.	Clean fuel strainer and check fuel pump.
	Induction drains open.	Clean or replace drains.
Low power and uneven running engine.	Mixture too rich; indicated by sluggish engine operation, red exhaust flame and black smoke.	Check injector. Adjust mixture control.
	Mixture too lean; indicated by overheating or backfiring.	Check fuel lines for dirt or other restrictions. Check fuel supply.
	Clogged injector nozzles.	Remove and clean, paragraph 8-38
	Leaks in induction system.	Tighten all connections. Replace defective parts.
	Dirt in injector inlet screen.	Remove screen and clean.
	Defective spark plugs.	Clean or replace spark plugs.
	Improper grade of fuel.	Fill tank with recommended grade.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
Low power and uneven running engine. (cont.)	Magneto breaker points not working properly.	Clean points. Check internal timing of magneto.
	Defective ignition wire.	Check wire with electric tester. Replace defective wire.
	Defective spark plug terminal connectors.	Replace connectors on spark plug wire.
	Improper ignition timing.	Check magnetos for timing and synchronization.
	Clogged nozzle.	Remove and clean, paragraph 8-38.
Flow meter reads high.	Defective fuel injector.	Repair or replace fuel injector.
	Clogged nozzle.	Remove and clean, paragraph 8-38
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.
	Mixture too lean or too rich.	Injector must be recalibrated.
	Restriction in induction air.	Examine air inlet and remove restriction.
	Improper fuel.	Fill tank with recommended fuel.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
Failure of engine to develop full power. (cont.)	Propeller governor put out of adjustment.  Propeller out of adjustment.  Restrictions in inlet air scoop and filter.  Faulty ignition.	Adjust governor.  Adjust propeller low pitch stop.  Examine air scoop and filter and remove restrictions.  Tighten all connections. Check ignition system. Check ignition timing.
Rough running engine.	Cracked engine mounts.  Unbalanced propeller.  Bent propeller blades.  Defective mounting.  Lead deposit on spark plug.  Malfunctioning engine.	Repair or replace engine mount.  Remove propeller and balance.  Replace propeller.  Install new shock mounts.  Clean or replace plugs.  Check entire engine.
Low oil pressure.	Insufficient oil.  Dirty oil screens.	Fill oil sump to proper level.  Remove and clean oil screens.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
Low oil pressure. (cont.)	Relief valve out of adjustment.	Adjust valve.
	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 and crankcase.
	High oil temperature	See "High Oil Temperature" in Trouble Column.
	Stoppage in oil pump intake passage.	Check line for obstruction. Clean suction screen.
	Worn or scored bearings.	Overhaul.
High oil temperature.	Insufficient air cooling.	Check air inlet and outlet deformation or obstruction.
	Insufficient oil supply.	Fill oil sump to proper level.
	Clogged oil lines or screens.	Remove and clean oil screens.
	Clogged oil cooler.	Remove and clean oil cooler.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
High oil temperature. (cont.)	Failing or failed bearing.	Examine sump 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.
	Low grade of oil.	Replace with oil conforming to specifications.
	Improper engine operation.	Check entire engine.
Excessive oil consumption.	Failed or failing bearing.	Check sump 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.

TABLE VIII-II. TROUBLESHOOTING CHART (ENGINE) (cont.)

Trouble	Cause	Remedy
Excessive oil consumption. (cont.)	Failure of rings to seat. (New nitrided cylinders.)	Use mineral base oil. Climb to cruise altitude at full power and operate at 75% cruise power setting until oil consumption stabilizes.
	Low grade of oil.	Replace with oil conforming to specifications.
Inaccurate pressure readings.	Cold weather.	High and low pressure readings due to extremely cold weather are not necessarily a malfunction. Small and long oil lines will not transfer pressure readings accurately until engine is quite warm.



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# SECTION VIIIA

## POWER PLANT

### (Turbocharged)

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**Revised: 10/28/82**

SECTION VIIIA

POWER PLANT  
(PA-30) TURBOCHARGED

**8A-1. INTRODUCTION.** This section covers power plants used in the PA-30 Turbo Twin Comanche and is comprised of instructions for the removal, minor repair, service and installation of the engine cowl, propeller, propeller governor, engine, engine shock mounts, induction system, fuel injector, turbocharger, fuel air bleed nozzles, injection system and lubrication system.

**8A-2. DESCRIPTION .** The PA-30 Turbo Twin Comanche is powered by two Avco-Lycoming IO-320-C1A, four cylinder, direct drive, wet sump, horizontal opposed, fuel injected, air cooled engines with a compression ratio of 8.5:1, rated at 160 HP at 2700 RPM, and designed to operate on 100-130 (minimum) octane aviation grade fuel. The engine contains components which make it adaptable to turbocharging.

Cowling completely encloses the engine and consists of two side access panels, an upper and lower section and a nose section. The cowl flap is an integral part of the lower cowl and is operated manually through mechanical linkage.

Propellers are Hartzell full feathering, constant speed, each controlled by a governor mounted on the engine supplying oil through the propeller shaft at various pressures. Oil pressure from the governor moves the blades into low pitch (high RPM). The centrifugal twisting moment of the blade also tends to move the blades into low pitch. Opposing these two forces is a force produced by compressed air between the cylinder head and the piston, which tends to move the blades into high pitch in the absence of governor oil pressure. Thus, feathering is accomplished by compressed air.

The airplane's induction system consists of a dry type air filter and alternate air door. The engine fuel system consists of a Bendix RSA-5-AD1 type fuel injector and a Lear-Seigler fuel supply pump as an integral part of the fuel injector system. A Rajay model RJO325 turbocharger is mounted as an integral kit to the engine. Manual waste gate control of the turbocharger provides the pilot with complete freedom of choice in turbocharger use. A separate push-pull control with precise vernier adjustment is installed on each engine for actuation of the waste gate.

Bendix-Scintilla S4LN-21 series magnetos are installed on both engines. Each system consists of two single point magnetos with impulse couplings on the magneto drive shafts to obtain the retard spark necessary for starting.

In addition to the aforementioned components, each engine is equipped with a generator on the earlier models, or an alternator on the later models; a geared starter and vacuum pump. Engine mounts are steel tubing construction attached at the firewall and incorporate vibration absorbing mounts. Two exhaust stacks are positioned one for number one and two cylinders and one for number three and four cylinders. From the exhaust stacks, gases are directed to the turbocharger wastegate, through or around the turbo turbine, as required, and overboard at the rear of the engine nacelle.

The lubrication system is of the full pressure wet sump type. The oil pump, which is located in the accessory housing, draws oil through a drilled passage leading from the oil suction screen located in the sump. The oil from the pump then enters a drilled passage in the accessory housing, which feeds the oil to a threaded connection on the rear face of the accessory housing, where a flexible line leads the oil to the external cooler. Pressure oil from the cooler returns to a second threaded connection on the accessory housing from which point a drilled passage conducts the oil to the oil pressure filter. In the event that cold oil or an obstruction should restrict the oil flow to the cooler, an oil cooler by-pass valve is provided to pass the oil directly from the oil pump to the oil pressure filter.

The oil pressure filter screen or element, located on the accessory housing, is provided as a means to filter from the oil any solid particles that may have passed through the suction screen in the sump. After being filtered through the pressure filter, the oil is fed through a drilled passage to the oil pressure relief valve, located in the upper right side of the crankcase forward of the accessory housing.

This relief valve regulates the engine oil pressure by allowing excessive oil to return to the sump, while the balance of the pressure oil is fed to the main oil gallery in the right half of the crankcase. Residual oil is returned by gravity to the sump where, after passing through a screen, it is again circulated through the engine.

The turbocharger is lubricated by engine lubricant which is supplied to the turbo oil gallery by a line connected to the engine accessory housing. Incorporated in the oil supply line is a pressure regulator poppet valve, an oil filter and a pressure switch. The pressure regulator poppet valve reduces engine oil pressure to 30-50 psi pressure required for the turbocharger. The turbo oil filter contains a bronze element which filters out fine dirt particles that may be harmful to the turbo bearings. The oil pressure switch activates a red warning light in the event turbocharger oil pressure is below 27 psi. Oil is scavenged from the turbocharger sump and returned to the engine sump by a scavenger pump installed between the fuel pump and the engine accessory housing. Before any work is done refer to paragraph 8-2a.

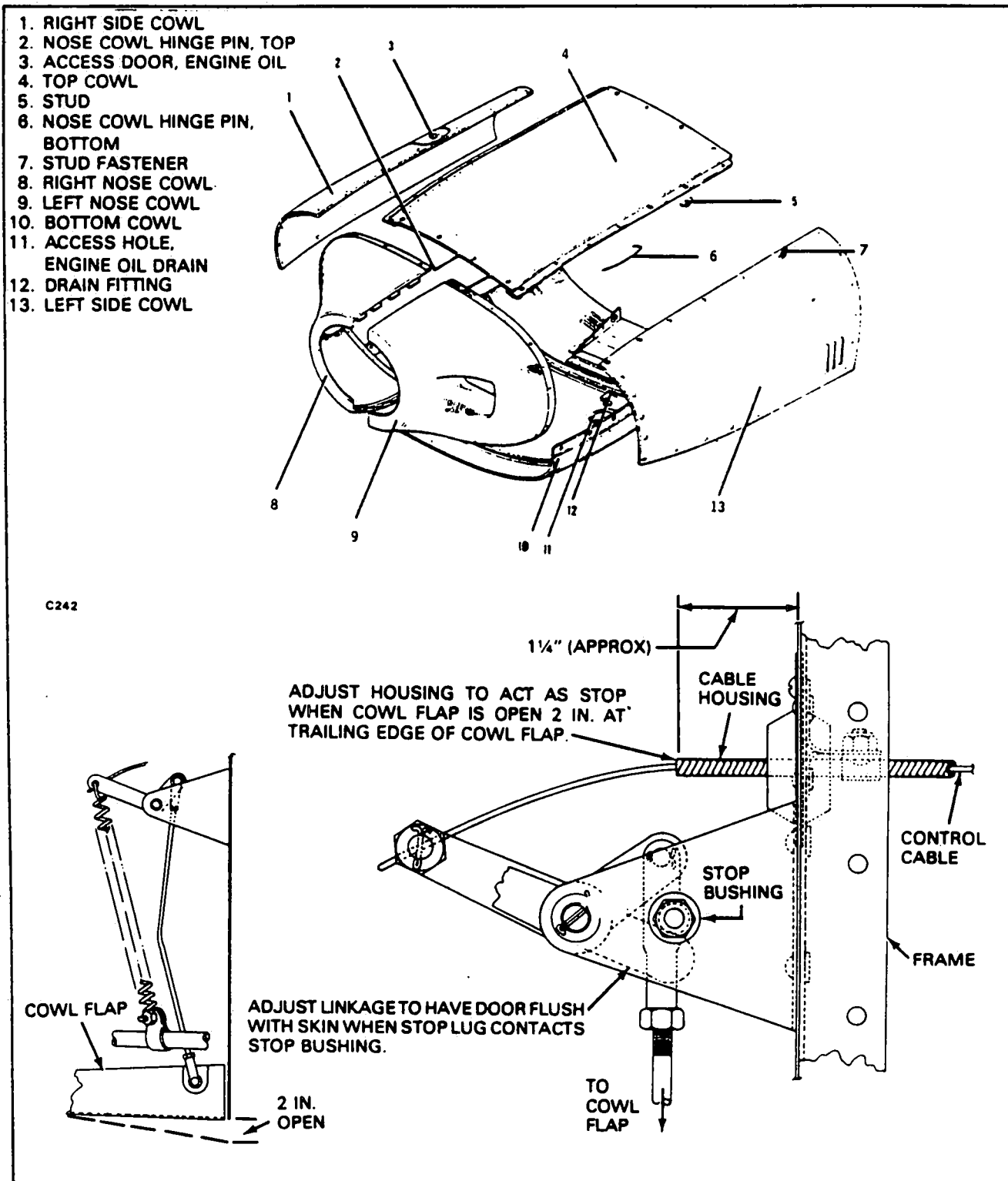


Figure 8A-1. Engine Cowling and Cowl Flap Rigging

8A-3. TROUBLESHOOTING. Troubles peculiar to the power plant are listed in Table VIIIA-II in the back of this section, along with their probable causes and suggested remedies. When troubleshooting engines, ground the magneto primary circuit before performing any checks on the ignition system.

#### 8A-4. ENGINE COWLING.

8A-5. REMOVAL OF ENGINE COWLING. The procedure for removing the cowl-ing is the same for both engines.

- a. Release the fasteners and remove the two side access panels.
- b. Remove the screws that secure the top cowl and then remove cowl.
- c. Disconnect the cowl flap control rods by removing cotter pin, washer and pin.
- d. Support the bottom cowl and remove attaching screws.
- e. Lower cowl a few inches and disconnect drain lines.
- f. The nose cowl may be removed by pulling out the upper and lower hinge pins and splitting the cowl.

#### 8A-6. CLEANING, INSPECTION AND REPAIR OF ENGINE COWLING.

- a. The cowling should be cleaned with a suitable solvent and then wiped with a clean cloth.
- b. Inspect the cowling for dents, cracks, loose rivets, damaged or missing fasteners and damaged fiberglass areas.
- c. Repair all defects to prevent further damage. Fiberglass repair procedures may be accomplished according to Fiberglass Repairs, Section IV.

8A-7. INSTALLATION OF ENGINE COWLING. The procedure for installing the cowl is the same for both engines.

- a. Position the two nose cowl halves on the front of the engine and secure with hinge pins.
- b. Position the bottom cowl and connect the drain lines.
- c. Attach the bottom cowl to the aft nacelle section and the nose cowl with screws.
- d. Position the top cowl and secure with attaching screws.
- e. Connect the cowl flap control rods to cowl flap with attaching pin, washer and cotter pin.
- f. Position the side access panels and secure with fasteners.

## PIPER TWIN COMANCHE SERVICE MANUAL

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### 8A-7a. COWL FLAP RIGGING. (Refer to Figure 8A-1.)

- a. Adjust the cowl flap control housing to act as the stop when the cowl flap is open 2 in. at its trailing edge in relation to the bottom engine cowl.
- b. Adjust the cowl flap linkage to have the cowl flap flush with the bottom engine cowl when the stop lug contacts the stop bushing (closed position).

### 8A-8. PROPELLER.

8A-9. REMOVAL OF PROPELLER. (Refer to Figure 8A-2.) This includes all propellers, standard and with spring backup kit installed, identified by a letter "S" in the dash number.

#### NOTE

When removing the propeller, it is unnecessary to remove the spinner, feather the blades, or remove the air charge. When the propeller is removed for service or overhaul, the propeller with the spring kit installed should be feathered on the aircraft (see following "CAUTION") and the spinner on either prop must be removed according to section d of this paragraph.

#### WARNING

Do not attempt to disassemble the propeller assembly any further than stated in this manual. Only personnel at a certified repair shop are authorized for repair and overhaul of the propeller mechanism.

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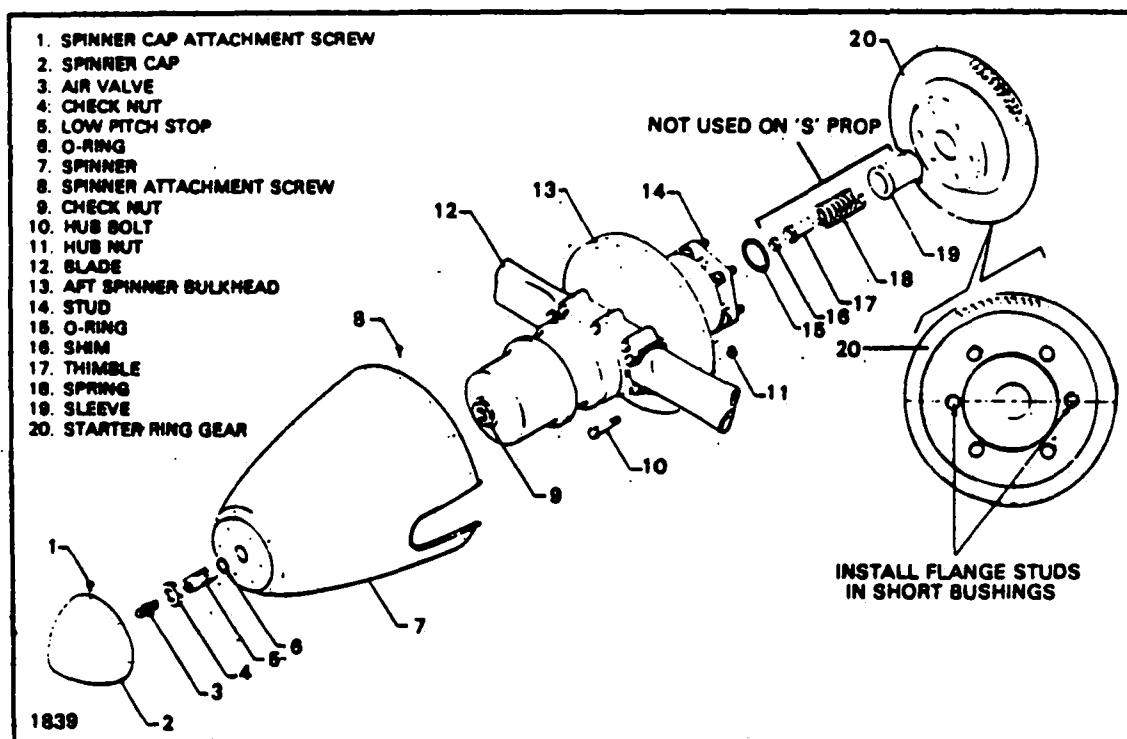


Figure 8A-2. Propeller Installation

**CAUTION**

Under NO condition should blade paddles be used on either propeller, except to unfeather a propeller with the spring kit installed (see paragraph 8A-11). If a propeller is to be feathered on the ground, it should be done with the engine operating, by use of the propeller control on the throttle quadrant.

**CAUTION**

Prior to performing any work on the propeller, ascertain that the master switch and magneto switches are OFF (grounded) and the mixture control is in the IDLE CUT-OFF position.

1. Remove all hardware that attaches the nose cowl to the top and bottom engine cowl. The top and side panels of the main cowl assembly may be removed for greater accessibility. Work the nose cowl as far forward as possible, reach through the opening and split the cowl by pulling the upper and lower hinge pins. Pliers may be needed to pull the pins. The two halves of the cowl may be pulled forward and to either side of the propeller, which should be in a vertical position for ease in removing the cowl.

NOTE

In some appropriate manner, index the propeller and starter ring to facilitate installation. (Example - paint stripe.) Do not scratch the surface.

- b. Place a drip pan under the propeller to catch oil spillage.
- c. Cut safety wire around the propeller mounting studs and remove the studs (14) from the engine flange by wrenching the nuts. These nuts are "frozen" to the studs with loctite and secured with roll pins, so the studs should turn with the nuts. Pull the propeller from the engine shaft.
- d. In the event that the spinner and spinner bulkhead are to be removed for cleaning, inspection, adjustment of pitch stop, etc., remove the spinner nose cap attaching screws and cap (1 and 2). Remove the spinner (7) by removing the safety wire and check nut (4) from the propeller at the forward end of the forward spinner bulkhead and the screws (8) that secure the spinner to the aft bulkhead (13). The aft spinner bulkhead may be removed from the hub by removing the locknuts (11).

8A-10. CLEANING, INSPECTION AND REPAIR OF PROPELLER.

CAUTION

Prior to performing any work around propeller, discharge the dome pressure first.

- a. Check for oil and grease leaks.
- b. Clean the spinner, propeller hub and blades with a non-corrosive solvent.
- c. Inspect the hub parts for cracks.
- d. Steel hub parts should not be permitted to rust. Use aluminum paint to touch up, if necessary, or replate during overhaul.
- e. Check all visible parts for wear and safety.
- f. Check the blades of the standard propeller to determine whether they turn freely on the hub pivot tube. This can be done by rocking the blades back and forth through the slight freedom allowed by the pitch change mechanism. Do this by hand being careful not to slam the internal mechanism against the stops. If blades appear tight and are properly lubricated, the propeller may need internal repair. (See WARNING on page 8A-4.) This cannot be done with the spring propeller due to the pressure exerted by the spring even though the dome pressure is discharged.
- g. Inspect blades for damage or cracks. Nicks in leading edges of blades should be filed out and all edges rounded, as cracks sometimes start from such places. Use fine emery cloth for finishing. Refer to Figure 8A-3 for propeller blade care.
- h. Check condition of propeller mounting nuts and studs.

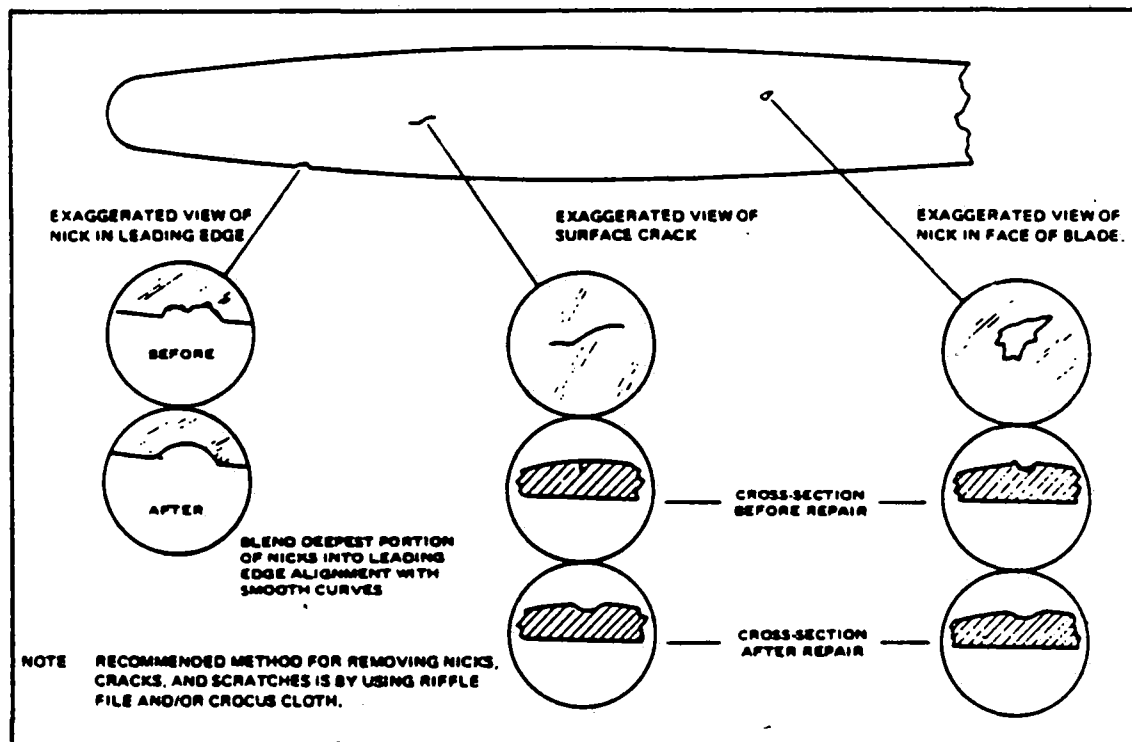


Figure 8A-3. Typical Nicks and Removal Methods

NOTE

It is recommended that for severe damage, internal repairs and replacement of parts, the propeller should be referred to the Hartzell Factory or Certified Repair Station.

- i. Each blade face should be sanded lightly with fine sandpaper and painted, when necessary, with a flat black paint to retard glare. A light application of oil or wax may be applied to the surfaces to prevent corrosion.

8A-11. INSTALLATION OF PROPELLER. (Refer to Figure 8A-2.)

CAUTION

Prior to performing any work around propeller, ascertain that the master switch and magneto switches are OFF (grounded) and the mixture control is in the IDLE CUT-OFF position.

## PIPER TWIN COMANCHE SERVICE MANUAL

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- a. Clean the propeller flange, starter ring and crankshaft flange.
- b. Install spinner bulkhead (13) on propeller hub and secure with locknuts. Torque bolts to specifications given in Table VIIIA-I.
- c. Ascertain that the starter ring gear is properly on the crankshaft flange. The oversize hole in the starter ring must go over the oversize bushing.
- d. Position the prop flange and starter ring gear so the two short bushings are horizontal. (Refer to Figure 8A-2.)
- e. Lubricate and install O-ring (15) in prop hub.
- f. Install sleeve (19), spring (18), thimble (17), and shim (16) in engine crankshaft on propeller installations NOT using the spring back-up system in the hub.
- g. Place the propeller in a horizontal position and mount to the engine crankshaft. Check alignment of paint stripe (refer to NOTE under Paragraph 8A-9.) Screw each stud into its mating engine flange bushing a few threads at a time until all are tight. Torque the studs to the specifications given in Table VIIIA-I.
- h. Safety studs with MS20995-C41 wire. Safety wire is inserted through the roll pins.
- i. Install spinner (7). Torque spinner screws (8) and check nut (4) per Table VIIIA-I. Safety check nut with MS20995-C41 wire.

### NOTE

Do not check pressure or charge cylinder with **PROPELLER** in the feathered position.

### CAUTION

To obtain an accurate pressure reading when checking propeller dome air pressure or to insure complete release of all air pressure, place the propeller **CONTROL** in the feather detent before measuring or releasing propeller air pressure. This procedure will insure the free flow of all air within the prop dome and prevent possible error in pressure readings or injury to service personnel should the low pitch stop be removed.

### NOTE

If the propeller is in feather on the ground, it is undesirable to run it out of feather through engine operation due to roughness which will occur possibly causing severe damage to engine mount and exhaust system. Remove the air charge, unfeather the blades with equal pressure applied by means of blade paddles used on both blades as close to the hub as possible. Listen for the quiet distinctive "clicks" of the high pitch stop pins, then stop and remove the paddles.

j. Charge the cylinder through air valve (3) with dry air or nitrogen gas to the prescribed pressure. Refer to Table VIIIA-I of this manual for an exact pressure for the existing temperature. It is most important that an accurate charge be maintained.

k. The amount of air pressure per existing temperature as shown by Table VIIIA-I is very important and should always be used. If excessive pressure is used in the propeller, there is a possibility of feathering taking place at idle speed when the engine is warm and the oil viscosity is low. An accurate air pressure gauge should always be used. A pressure gauge and valve kit, part number 756 771, may be purchased through a Piper Dealer or Distributor.

Revised: 1/31/74

TABLE VIIIA-I

PROPELLER SPECIFICATIONS (PA-30)

Blade Angle	Low Pitch (High RPM)	12° ± 0.015° "	
	High Pitch ( Low RPM)	78° "	
(1) MEASURE TAKEN AT 30 INCH STATION.		(Feathered)	
Propeller RPM Setting	Engine Static High RPM Engine Static Low RPM	2700 max 1850 ± 50 min	
Propeller Torque Limits	Description	Required Torque (Dry)	
	Spinner Bulkhead (Aft)	22 foot-pounds	
	Propeller Mounting Bolts	50 foot-pounds	
	Propeller Mounting Studs	40-42 foot-pounds	
	Spinner Bulkhead Check Nut	35-40 foot-pounds	
	Spinner Attachment Screws	40 inch-pounds	
CHAMBER PRESSURE REQUIREMENTS WITH TEMPERATURE <u>HC-E2YL-2, HC-E2YL-2B or HC-E2YL-2BF</u>			
Temp. °F	Press. (psi)	Temp. °F	Press. (psi)
100	188	30	165
90	185	20	162
80	182	10	159
70	178	0	154
60	175	-10	152
50	172	-20	149
40	168	-30	146
<u>HC-E2YL-2BS or HC-E2YL-2BSF</u>			
Temp. °F		Press. (psi)	
100		53	
70		50	
40		47	
10		44	
-20		42	
NOTE: Do not check pressure or charge with propeller in feather position.			

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- l. When recharging the propeller, dry air or nitrogen gas should be used. It is important not to allow moisture to enter the air chamber as this could cause the piston to freeze during cold weather operation.
- m. Test for leakage by using a soap solution or equivalent and applying it around the air valve stem and adjustment stop nut.
- n. To reinstall engine cowl, first put the propeller in a vertical position then fit the two halves of the nose cowl together behind the spinner bulkhead and pin them together with the two hinge pins through the top and bottom hinges. Slide the nose cowl back and into proper location with the engine cowls. Locate holes and install all hardware that attaches the cowls together. Install top and side engine cowl panels if removed. Install spinner cap.

### 8A-12. ADJUSTMENT OF LOW PITCH BLADE ANGLE AND STOP.

#### NOTE

Both types of propellers referred to, come from the factory with the low pitch stop adjusted for proper blade angle. If, however this adjustment has been disturbed, the procedure given below is used for obtaining blade angle, but applies only to the propeller without the spring kit A-2273 installed. There is no way to check the low pitch blade angle of the propeller, with the spring kit installed, in the field. This is due to the internal spring producing a force near to that of the air charge in the standard propeller which can and has to be released to make this adjustment. The spring supplies constant pressure to the blades making it very difficult to rotate the blades to a point where the low pitch stop is contacted. Therefore, if the blade angle on a spring propeller is suspected to be wrong it should be referred back to the Hartzell factory or Certified repair shop.

- a. Procedure for obtaining blade angle and adjusting low pitch stop.
  1. The blade angle (Refer to Table VIIIA-1) is determined by placing a propeller protractor on the face side of the propeller at the 30 inch station as measured from the hub centerline. The blade must be horizontal.
  2. The low pitch stop is adjusted by rotating a screw in the nose of the propeller cylinder. Rotating the screw clockwise increases the low pitch angle and reduces the static RPM by about 100 RPM for each half turn, or vice versa.

**CAUTION**

Before adjusting the low pitch stop screw, the air pressure should be dropped to zero. Unless this is done, it is possible to unscrew the low stop far enough to disengage the threads, allowing the air pressure to blow the stop screw out with great force. To insure the complete discharge of all air pressure within the dome, place the propeller **CONTROL** in the feather detent. There should be at least four threads of the stop screw engaged.

b. After the low pitch stop has been adjusted for proper blade angle, torque the low pitch stop jam nut to 30 foot-pounds. The governor should then be adjusted to obtain maximum rated engine RPM during take-off and climb (2700 RPM.)

**8A-13. BLADE TRACK.** Blade track is the ability of one blade tip to follow the other, while rotating, in almost exactly the same plane. Excessive difference in blade track - more than 0.062 inch - may be an indication of bent blades or improper propeller installation. Check blade track as follows:

a. With the engine shut down and blades vertical, secure to the aircraft a smooth board just under the tip of the lower blade. Move the tip fore and aft through its full "blade-shake" travel making small marks with a pencil at each position. Then center the tip between these marks and scribe a line on the board for the full width of the tip.

b. Carefully rotate propeller by hand to bring the opposite blade down. Center the tip and scribe a pencil line as before and check that lines are not separated more than 0.062 inch.

c. Propellers having excessive difference in blade track should be removed and inspected for bent blades, or for parts of sheared O-ring, or foreign particles which have lodged between hub and crankshaft mounting faces. Bent blades will require repair and overhaul of assembly. Other conditions will require installation in the prescribed manner. (Refer to paragraph 8A-11.)

## PIPER TWIN COMANCHE SERVICE MANUAL

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### 8A-14. PROPELLER GOVERNOR.

#### 8A-15. REMOVAL OF PROPELLER GOVERNOR.

- a. Remove the left and right side panels of the engine cowl.
- b. Remove the top engine cowl by removing attaching screws.
- c. Disconnect governor control cable from control arm by removing nut and washer from ball joint.
- d. Disconnect control cable from bracket by removing nuts, washers and screws from clamp.
- e. Remove nut and washer from governor adapter mounting stud allowing the control cable bracket to be removed.
- f. Remove the governor mounting stud nuts. It will be necessary to move the governor from its mounting pad as the nuts are being removed before the nuts can be completely removed.
- g. Remove the mounting gasket. If the governor is to be removed for a considerable length of time and another unit is not substituted, it is advisable to cover the mounting pad to prevent damage caused by foreign matter.

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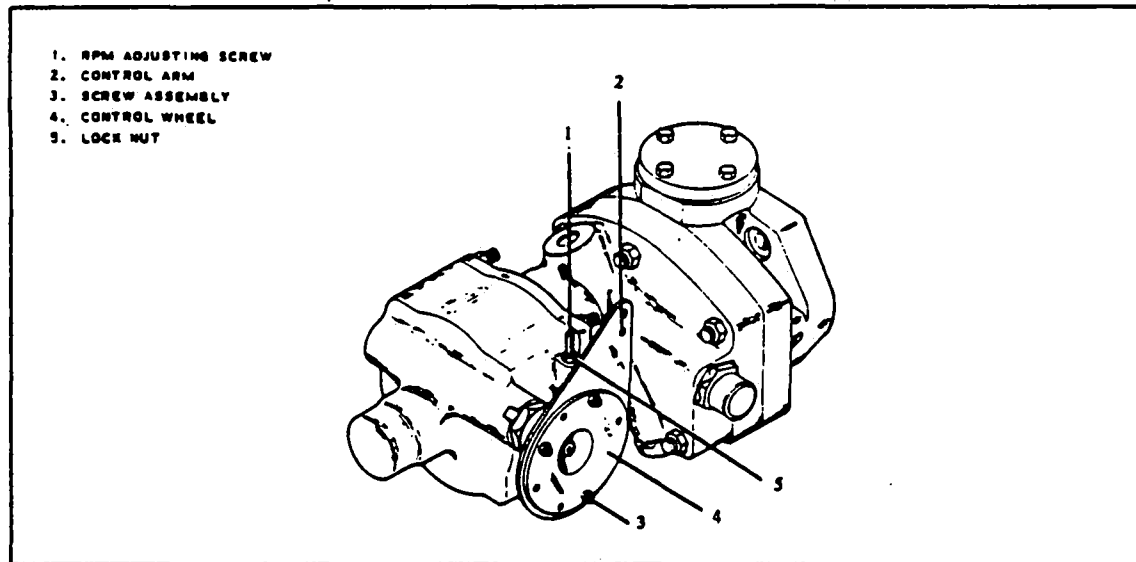


Figure 8A-4. Propeller Governor

#### 8A-16. INSTALLATION OF PROPELLER GOVERNOR.

- a. Clean the mounting pad thoroughly making very certain that there are no foreign particles in the recess around the drive shaft.
- b. Place the governor mounting gasket in position with the raised portion of the screen facing away from the engine.
- c. Install the control cable bracket on the governor.
- d. Align the splines on the governor shaft with the engine drive and the cable bracket with the governor adapter mounting stud, and slide the governor into position.
- e. With the governor in position, raise it enough to install washers and start mounting nuts. Secure bracket to adapter with washer and nut, torquing nuts evenly.
- f. Connect the control cable end to the governor control arm. The ball stud is installed in the inner hole of the control arm.
- g. Secure the control cable to bracket with clamp, screw, washer and nuts.
- h. Adjust governor control per paragraph 8A-17.
- i. Install engine cowl per paragraph 8A-7.

**8A-17. ADJUSTMENT OF PROPELLER GOVERNOR. (Refer to Figure 8A-4.)**

a. Start the engine, park at 90 degrees to wind direction and warm in the normal manner.

b. To check high RPM, low pitch setting, move the propeller control all the way forward. At this position the governor speed control arm (2) should be against the high RPM fine adjustment screw (1). With the throttle full forward, observe engine RPM which should be 2700 RPM with high RPM properly adjusted.

c. Should engine RPM not be as required, the high RPM setting should be adjusted as follows:

1. Shut down the engine and remove the left side access panel.

2. Adjust governor by means of the fine adjustment screw for 2700 RPM. Loosen the screw locknut (5) and turn the screw in a clockwise direction to decrease engine speed or in a counterclockwise direction to increase engine speed.

**NOTE**

One revolution of the fine adjustment screw will increase or decrease the engine speed approximately 20 RPM.

3. After adjustment is made, secure adjusting screw with jam nut.

4. With the high RPM adjustment complete, the control system should be adjusted so that the governor control arm will contact the high RPM stop when the cockpit lever is 0.062 to 0.125 inch from its full forward stop which is located in the control quadrant. To adjust the control lever travel, disconnect the control cable end from the control arm, loosen the cable end jam nut and rotate the end to obtain the desired lever clearance. Reconnect the cable end and tighten jam nut.

5. Install side access panel and secure with studs.

6. It is usually only necessary to adjust the high RPM setting of the governor control system, as the action automatically takes care of the positive high pitch setting.

**8A-18. ENGINE.**

**8A-19. REMOVAL OF ENGINE. (Refer to Figure 8A-5.)** The removal of either engine is basically the same procedure, though the routing of some wires, cables and lines do vary between engines. Each line should be identified to facilitate reinstallation and covered, where disconnected, to prevent contamination.

a. Turn off all cockpit switches and disconnect the battery ground wire at the

battery.

- b. Move the fuel valve control levers located on the fuselage floor between the two front seats to the OFF position.
- c. Remove the engine cowling per paragraph 8A-5.
- d. Remove the access panels on the top of the nacelle aft of the firewall.
- e. Drain the engine oil, if desired, and reinstall drain plug.
- f. Remove the propeller per paragraph 8A-7.
- g. Disconnect the starter cable at the starter, remove the cable clamps at the left side of the engine and engine mount, and draw the cable aft through the engine baffle to the firewall.
- h. Disconnect the generator or alternator leads at the unit, and cylinder head temperature lead on number 3 cylinder. Remove clamps securing wires and draw them back to the firewall.
- i. Disconnect the exhaust temperature lead, if installed.
- j. Disconnect the oil temperature electrical lead and tachometer cable at the accessory housing.
- k. Disconnect the fuel pressure and fuel flow meter vent lines at the firewall.
- l. Disconnect the manifold pressure and oil pressure lines at the firewall.
- m. Disconnect the breather hose from the breather tube attached to the firewall and disconnect the turbo oil line from the engine at the accessory housing.
- n. Disconnect the magneto "P" leads from the magnetos.
- o. Disconnect the vacuum hose and fuel line at the firewall.
- p. Disconnect the heater fuel line (right engine only) from the firewall.
- q. Disconnect the turbo oil line from the bottom of the turbo filter located on the lower left corner of the firewall.
- r. Disconnect the exhaust waste gate and alternate air door control cables.
- s. Disconnect control cables at the governor, throttle and mixture control arms and remove cable clamps at cable brackets.
- t. Disconnect the cowl flap return spring from the engine mount.
- u. Remove the turbo and induction air filter box mounting brackets from the firewall by removing attaching nuts, washers and bolts.
- v. Attach a one-half ton (minimum) hoist to the hoisting hooks and relieve the tension on the engine mount.
- w. Remove the nuts and washers from the bolts that attach the engine mount to the firewall.
- x. Remove the engine mount mounting bolts and swing the engine a few inches from the firewall. Check the engine for any attachments remaining to obstruct its removal.
- y. Swing the engine clear and place on a suitable support.

**8A-20. INSTALLATION OF ENGINE.** The installation of either engine is basically the same procedure, though the routing of some wires, cables, lines, etc. does vary between engines. Before starting, ascertain that all components of the engine such as engine mount, turbocharger unit, exhaust stacks, etc., are installed.

- a. With a one-half ton hoist (minimum) attached, swing the engine in position.
- b. Align the mounting bolts in the engine mount with the mounting holes in the firewall. Install the mounting bolts through from the aft side of the firewall. Install washers and nuts, then dry torque to 200-240 in. lbs.
- c. Attach the air filter box and turbo mounting brackets to the firewall using bolts, washer and nuts.
- d. Connect the throttle and mixture control cables to the injector unit, install cable clamps and rig per paragraph 8A-38.
- e. Connect the governor control cable to governor. Install cable clamps and rig per paragraph 8A-17.
- f. Connect the exhaust waste gate control cable to the gate control lever.
- g. Connect the alternate air door control cable to the air door control arm and adjust the cable end on the control arm so when the control knob in the cockpit is full in, there will be approximately one-eighth inch clearance between the control arm and the door hinge arms.
- h. Connect the turbo oil line to the fitting at the bottom of the turbo oil filter.
- i. Connect the fuel line and heater fuel line (right engine only) to the fittings on the firewall.
- j. Connect the vacuum hose to fitting on the firewall.
- k. Connect the breather hose to the breather tube attached to the firewall and connect the turbo oil line to the engine accessory housing.
- l. Connect the magneto "P" leads to magneto and safety.
- m. Connect the manifold pressure and oil pressure lines to fittings on the firewall.
- n. Connect the fuel pressure and fuel flow meter vent lines to fittings on the firewall.
- o. Connect the oil temperature electrical lead to the oil temperature bulb in the accessory housing and connect the tachometer cable to the accessory housing.
- p. Connect the cowl flap return spring to the engine mount and flap control arm.
- q. Connect electrical leads to the generator or alternator, cylinder head temperature bulb in Number 3 cylinder and exhaust temperature probe, and secure cable with clamps to prevent chafing.
- r. Connect electrical cable to starter and secure cable to engine with clamps to prevent chafing.
- s. Ascertain that the magneto switches are OFF and install propeller per paragraph 8A-11.

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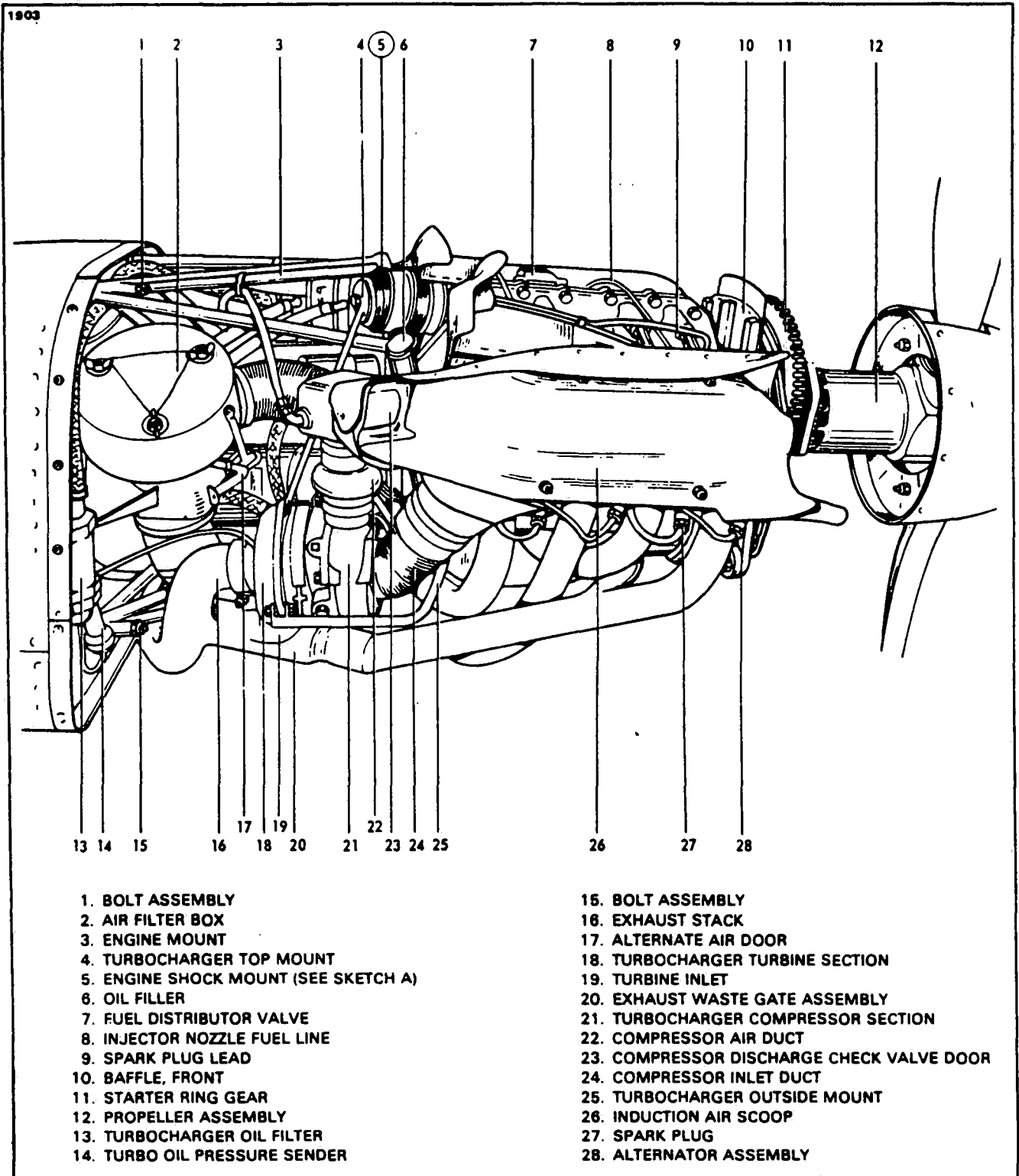


Figure 8A-5. Engine Installation



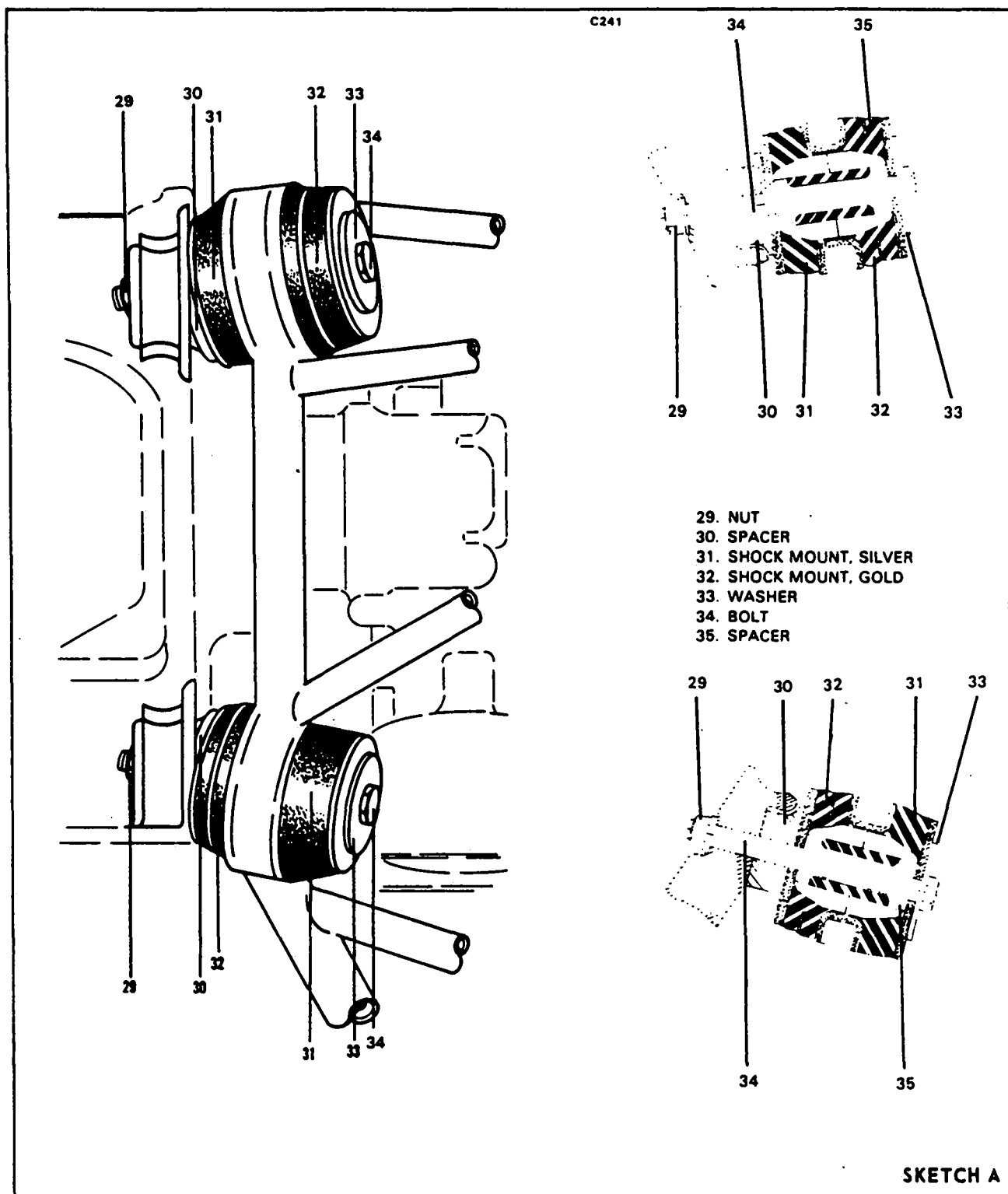


Figure 8A-5. Engine Installation (cont.)

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- t. Connect the battery ground cable at the battery.
- u. Turn on the fuel valve, open the throttle full, and turn on the electric fuel pump and check the fuel lines for leaks.
- v. Install access panels on the engine nacelle and cowling per Paragraph 8A-7.
- w. To prevent possible high speed bearing failure due to lack of lubrication during the start, refer to the latest revision of Lycoming Service Instructions No. 1241.
- x. Perform an engine operational check.

**8A-20a. PROTECTION OF ENGINE MOUNT.** The lower engine mount tubes which are next to the turbochargers have been painted with a special heat resistant paint. Should the mount need repainting, the following procedure must be followed to insure the heat resistant quality:

- a. Strip all old paint from the lower engine mount tubes.
- b. Sand the full length of the tubes and remove all grease and oil.
- c. Apply three brush coats of extra high H-170 Heat Rem. paint, or Krylon high heat aluminum paint #1402, or Randolph products heat resistant coating #K3760 or 3761.

### NOTE

The engine mount tubes should be warm during the paint application, but not hot.

- d. Allow twelve hours between brush coats.

### 8A-21. ENGINE SHOCK MOUNTS.

**8A-22. REPLACEMENT OF ENGINE SHOCK MOUNTS.** Refer to Figure 8A-5 for the proper arrangement of the engine shock mount assemblies. The top shocks are assembled so the gold colored shock is aft and the silver colored shock is forward. The lower shock mounts are installed opposite of the top shock mounts. Torque shock mount bolts to 450 to 500 in. lbs. and safety.

**8A-23. ENGINE TURBOCHARGER.** The turbocharger system requires little attention between turbo overhauls. However, it is recommended that the items outlined in the Inspection Report of Section III be checked during required inspection intervals. Should trouble occur, refer to the Troubleshooting Table in this section and seek out the possible cause. Do not break the clamp seal joining the turbine and compressor units.

**8A-23a. TURBOCHARGER NOMENCLATURE.** Many unfamiliar terms may appear on the following pages of this manual. An understanding of these will be helpful, if not necessary, in performing maintenance and troubleshooting. The following is a list of commonly used terms and names as applied to turbocharging and a brief description.

TERM	MEANING
Supercharge	To increase the air pressure (density) above or higher than ambient conditions.
Supercharger	A device that accomplishes the increase in pressure.
Turbo-Supercharger	More commonly referred to as a "Turbocharger," this device is driven by a turbine. The turbine is spun by energy extracted from the engine exhaust gas.

Compressor	The portion of a turbocharger that takes in ambient air and compresses it before discharging it to the engine.
Turbine	The exhaust driven end of the turbocharger unit.
Waste Gate and Actuator (Exhaust By-Pass)	The waste gate is a butterfly type valve in the exhaust by-pass which, throughout its travel from open to closed, allows varied amounts of exhaust gas to by-pass the turbine, controlling its speed, hence the output of the compressor. The actuator is operated by a hydraulic piston operated by engine oil and cylinder with the piston linked to an arm on the butterfly valve shaft.
Density Controller	The density controller is designed to allow the engine to develop full rated power no matter what ambient temperature and pressure conditions are. This controller regulates waste gate bleed oil only at full throttle position to maintain a constant air density at the injector inlet. The pressure and temperature sensing bellows of the controller react to pressure and temperature changes between the fuel injector inlet and the turbocharger compressor. The bellows, filled with dry nitrogen gas, maintains a constant density by allowing the pressure to increase as temperature increases. Movement of the bellows re-positions the bleed valve, causing a change in quantity of bleed oil, which changes oil pressure to the wastegate piston.
<b>NOTE</b>	
The density controller is designed to keep the air density constant at the injector entrance. As ambient air temperature increases or density decreases due to change in altitude a higher manifold pressure is required to maintain a constant density, also resulting in a higher injector inlet temperature. This is why wide open throttle manifold pressure increases with either altitude or outside air temperature. In a full throttle climb, a gain of 3 to 4 inches of manifold pressure between sea level and critical altitude will be seen.	
Differential Pressure Controller	This controller uses a diaphragm rather than a bellows as is found in the density controller. It is used in conjunction with the density controller. Its function is to override the density controller so that the compressor discharge pressure is not held at an unnecessarily high level when lower manifold pressure is being used. The differential controller will usually maintain a compressor discharge pressure (deck pressure) approximately 6.5" Hg above the selected manifold pressure. In this system, the density controller is only effective at wide open engine throttle conditions.
Ground Boosted or Ground Turbocharged	These phrases indicate that the engine depends on a certain amount of turbocharging at sea level to produce the advertised horsepower. An engine that is so designed will usually include a lower compression ratio to avoid detonation.

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Deck Pressure	The pressure measured in the area downstream of the turbo compressor discharge and upstream of the engine throttle valve. This should not be confused with manifold pressure.
Manifold Pressure	The pressure measured downstream of the engine throttle valve and is almost directly proportioned to the engine power output.
Normalizing	If a turbocharger system is used only to regain power losses caused by decreased air pressure of high altitude, it is considered that the engine has been "normalized."
Overboost	An overboost condition means that manifold pressure is exceeding the limits at which the engine was tested and FAA certified and can be detrimental to the life and performance of the engine. Overboost can be caused by malfunctioning controllers or improperly operating waste gate in the automatic system or by pilot error in a manual controlled system.
Overshoot	Overshoot is a condition of the automatic controls not having the ability to respond quickly enough to check the inertia of the turbocharger speed increase with rapid engine throttle advance. Overshoot differs from overboost in that the high manifold pressure lasts only for a few seconds. This condition can usually be overcome by smooth throttle advance. A good method for advancing the throttle is as follows. After allowing the engine oil to warm up to approximately 140° F, advance the throttle to 28" to 30" manifold pressure, hesitate 1 to 3 seconds and continue advancing to full throttle slow and easy. This will eliminate any overshoot due to turbocharger inertia.
Bootstrapping	This is a term used in conjunction with turbo machinery. If you were to take all the air coming from a turbocharger compressor and duct it directly back into the turbine of the turbocharger, it would be called a bootstrap system and if no losses were encountered, it would theoretically run continuously. It would also be very unstable because if for some reason the turbo speed would change, the compressor would pump more air to drive the turbine faster, etc. A turbocharged engine above critical altitude (waste gate closed) is similar to the example mentioned above, except now there is an engine placed between the compressor discharge and turbine inlet. Slight system changes caused the exhaust gas to change slightly, which causes the turbine speed to change slightly, which causes the compressor air to the engine to change slightly, which in turn again affects the exhaust gas, etc.
Critical Altitude	A turbocharged engine's waste gate will be in a partially open position at sea level. As the aircraft is flown to higher altitude (lower ambient pressures) the waste gate closes gradually to maintain the preselected manifold pressure. At the point where the waste gate reaches its full closed position, the preselected manifold pressure will start to drop and this is considered critical altitude.

### 8A-24. REMOVAL OF TURBOCHARGER.

- a. Remove engine cowling per Paragraph 8A-5.
- b. Remove the turbocharger compressor and turbine assembly by the following procedure:

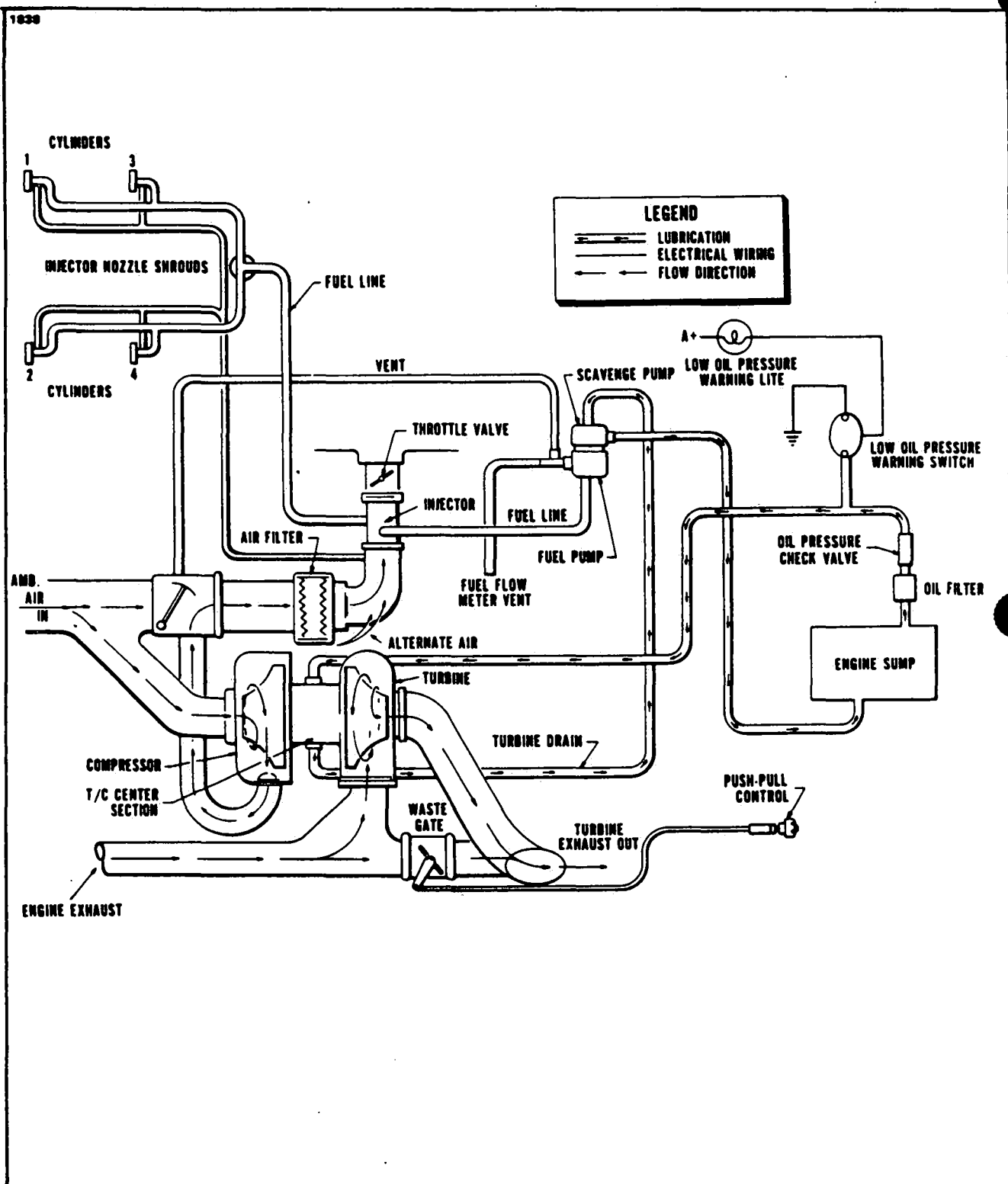


Figure 8A-6. Schematic Diagram of Turbocharged System

1. Disconnect the inlet and outlet oil lines at the turbocharger.
2. Loosen clamps securing the turbo air intake flexible duct and the compressed air duct to the turbocharger unit and slide ducts from unit.
3. Loosen the two "V" band clamps securing the exhaust inlet and outlet ducts to the turbocharger unit.
4. Remove the bolt and nut attaching inside mount to the turbo unit.
5. Remove the two engine sump bolts securing the outside turbo mount to the engine.
6. Remove the turbocharger unit by removing the two bolts, washers and nuts attaching the turbo unit to the top mount.

#### 8A-25. INSTALLATION OF TURBOCHARGER.

- a. Position turbo unit with gaskets on exhaust inlet and outlet ducts and secure with "V" band clamps.
- b. Slide the induction air and compressed air flexible ducts on the air inlet and outlet ports of the turbo unit and secure with clamps.
- c. Align the turbo inside mounting lug with the mounting bracket attached to the lower left engine mount and secure with bolt, washer and nut.
- d. Secure the top of the turbo unit to the mounting bracket attached to the top left engine mount with two bolts, washers and nuts.
- e. Attach the outside bracket to the turbo unit with bolt, washer and nut and to the engine at the crankcase and sump parting surfaces with two bolts, washers and nuts.
- f. Connect the inlet and outlet oil lines to the turbo unit.
- g. Install cowling per Paragraph 8A-7.

#### NOTE

For all "V" band couplings on the exhaust system, be sure parts are concentric before tightening couplings. Coupling will not center parts automatically.

8A-26. ADJUSTMENT OF TURBOCHARGER. It is recommended that adjustments of the turbocharger be conducted by an authorized overhaul facility.

#### 8A-27. INDUCTION SYSTEM AIR FILTER.

#### 8A-28. REMOVAL OF AIR FILTER.

- a. Remove the right side access panel from the engine nacelle to gain access to the air filter box.
- b. Remove the safety wire and the three wing nuts from the studs.
- c. Lift off cover and remove air filter.

**8A-29. CLEANING INDUCTION AIR FILTER.** The air filter should be cleaned at least every 100 hours; however, under dusty conditions it should be cleaned daily.

- a. Clean filter thoroughly with a dry type cleaning solvent or kerosene.
- b. Allow filter to dry thoroughly then dip in SAE-10 weight oil and allow to drain for four hours.

**8A-30. INSTALLATION OF INDUCTION AIR FILTER.**

- a. Wipe excess oil from air filter and install it in the filter box.
- b. Place cover on filter box and secure with wing nuts.
- c. Safety nuts with MS2099-NC32 lockwire.
- d. Install side access panel and secure with fasteners.

**8A-31. ALTERNATE AIR DOOR.** The alternate air door, located in the induction system on the left side of the air filter plenum between the air filter and the fuel injector inlet, is to provide a source of air should there be an air stoppage through the filter system. The following should be checked during inspection:

- a. All door seals are tight and hinges secure.
- b. Actuate the door to determine that it is not sticking or binding.
- c. Check the cockpit control cable for free travel.
- d. Check that when the control knob in the cockpit is full in, the cable is adjusted to allow approximately one-eighth inch between the actuating arm and the door hinge arms when full closed.

**8A-32. FUEL INJECTOR.**

**8A-33. FUEL INJECTOR MAINTENANCE.**

- a. In general, little attention is required between injector overhauls. However, it is recommended that the following items be checked during periodic inspection of the engine.
  1. Check tightness and lock of all nuts and screws which fasten the injector to the engine.
  2. Check all fuel lines for tightness and evidence of leakage. A slight fuel stain adjacent to the air bleed nozzles is not cause for concern.
  3. Check throttle and mixture control rods and levers for tightness and lock.
  4. Remove and clean the injector fuel inlet strainer at the first 25 hour inspection and each 50 hour inspection thereafter. Damaged strainer O-rings should be replaced.
- b. Tests prove that gasoline which becomes stale due to prolonged storage absorbs oxygen rapidly. This stale oxidized gasoline acquires a very distinctive odor similar to varnish and causes rapid deterioration of synthetic rubber parts, and also forms a gummy deposit on the internal metal parts. This condition, however, does not occur during normal operation of the injector where fresh fuel is being constantly circulated.

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### 8A-34. LUBRICATION OF FUEL INJECTOR.

a. There is very little need for lubrication of the injector in the field between regular overhauls. However, the clevis pins used in connection with the throttle and manual mixture control levers should be checked for freedom of movement and lubricated, if necessary.

b. Place a drop of engine grade oil on the end of the throttle shaft in such a manner that it can work into the throttle shaft bushings.

### 8A-35. REMOVAL OF FUEL INJECTOR.

a. Remove the cowling per paragraph 8A-5.

b. Remove clamps securing throttle and mixture control cables to cable brackets.

c. Disconnect throttle and mixture control cables from injector unit by removing nut and washer from ball joints.

d. Remove the safety wire and cap bolts attaching the air plenum to the injector unit.

e. Disconnect the fuel lines at the injector unit.

f. Remove the pal-locknuts and nuts securing the injector to the engine.

g. Pull the air plenum back to allow the injector unit to be removed.

8A-36. PREPARATION FOR STORAGE. Any unit taken out of service, or units being returned for overhaul, must be flushed with preserving oil (Specification MIL-O-6081, Grade 1010) using the following procedure:

a. Remove plugs and drain all fuel from the injector. If available, apply 10 to 15 psi air pressure to the fuel inlet, until all fuel is discharged from the injector.

b. Replace plugs and apply flushing oil filtered through a 10-micron filter at 13 to 15 psi to the injector fuel inlet until oil is discharged from the outlet.

c. Replace fuel inlet shipping plug.

### CAUTION

Do not exceed the above air pressures as internal damage to the injector may result.

d. After filling with preservative oil, the injector should be protected from dust and dirt and given such protection against moisture as climatic conditions at the point of storage require. In most cases, storing the unit in a dry area will be sufficient.

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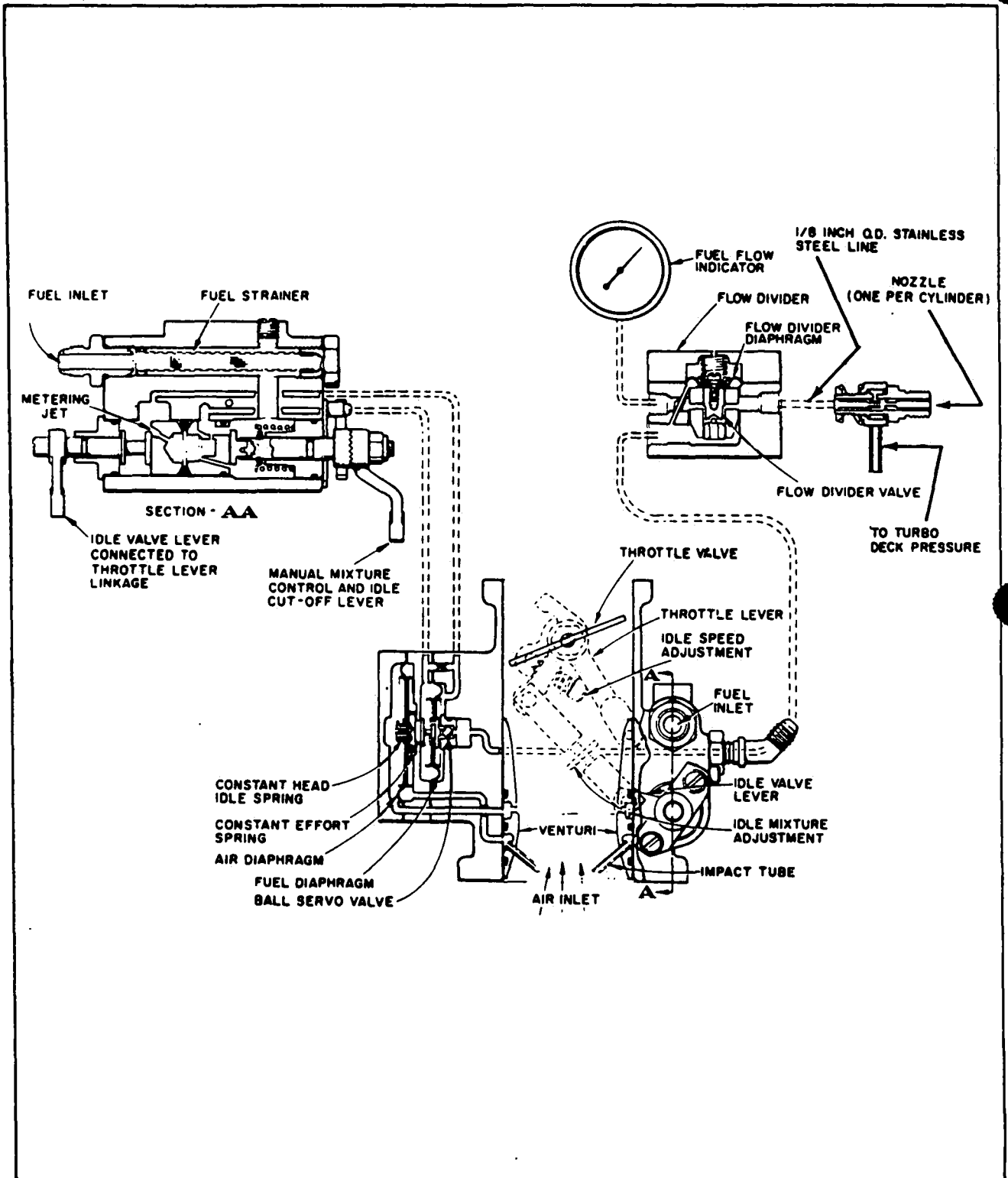


Figure 8A-7. Schematic Diagram of RSA Fuel Injector System

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e. If the unit is to be stored near or shipped over salt water, the following precautions should be observed:

1. Spray the exterior of the injector with an approved preservative oil.
2. Pack in a dustproof container, wrap the container with moisture and vapor-proof material, and seal. Pack the wrapped unit in a suitable shipping case. Pack a one-half pound bag of silica gel crystals in the dustproof container with injector. The bag must not touch the injector.

### CAUTION

Extreme caution should be exercised when handling or working around the injector to prevent oil or fuel from entering the air sections of the injector. As explained previously, damage to the air diaphragm will result. Fluid can easily enter the air section of the injector through the impact tubes or the annular groove around the venturi. For this reason, a protective plate should be installed on the scoop mounting flange when performing routine maintenance on the engine, such as washing down the engine and air scoop, servicing the air filter (surplus oil on the element), or when injecting preservative into the engine prior to storing or shipping.

### 8A-37. INSTALLATION OF FUEL INJECTOR.

- a. Move the injector air plenum aft enough to allow the injector with gasket to be installed. Install mixture control cable bracket on injector mounting studs and secure bracket and injector to engine with nuts and pal locknuts.
- b. Secure inlet air plenum to injector with cap bolts and safety.
- c. Connect fuel lines to injector unit.
- d. Connect throttle and mixture control cables to injector unit.
- e. Clamp control cables to cable brackets and adjust per paragraph 8A-38.
- f. Adjust idle speed and mixture per paragraph 8A-39.
- g. Install cowling per paragraph 8A-7.

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**8A-38. ADJUSTMENT OF THROTTLE AND MIXTURE CONTROLS.** The throttle and mixture controls are adjusted when the throttle arm on the injector is rotated forward against its full throttle stop and the mixture arm is rotated forward against its full rich stop; their respective cockpit control levers should be 0.062 of an inch in from their full forward stops which are located in the control pedestal.

- a. At the injector, disconnect the throttle and/or mixture control cable end from its control arm.
- b. Loosen the jam nut securing the cable end.
- c. Adjust the linkage by rotating the cable end to obtain the 0.062 of an inch springback of the cockpit control lever when the throttle or mixture control arm contacts its stop.
- d. Reconnect the cable end to its control arm and secure jam nut.
- e. Pull the throttle and mixture control lever in the cockpit full aft to ascertain that the injector idle screw contacts its stop and the mixture control arm contacts its lean position.

**8A-39. ADJUSTMENT OF IDLE SPEED AND MIXTURE.**

- a. Start the engine and warm up in the usual manner until oil and cylinder head temperatures are normal.
- b. Check magnetos. If the "mag-drop" is normal, proceed with idle adjustment.
- c. Close the throttle to idle. If the RPM changes appreciably after making the idle mixture adjustment during the succeeding steps, readjust the idle speed to the desired RPM.

#### NOTE

The idle mixture must be adjusted with the fuel boost pump ON.

d. When the idling speed has been stabilized, move the cockpit mixture control lever with a smooth, steady pull toward the Idle Cut-Off position and observe the tachometer for any changing during the "leaning" process. Caution must be exercised to return the Full Rich position before the RPM can drop to a point where the engine cuts out. An increase of more than 50 RPM while "leaning out" indicates an excessively rich idle mixture. An immediate decrease in RPM (if not preceded by a momentary increase) indicates the idle mixture is too lean.

e. If the above indicates that the idle adjustment is too rich or too lean, turn the idle mixture adjustment in the direction required for correction, and check this new position by repeating the above procedure. Make additional adjustments, as necessary. Each time the adjustment is changed, the engine should be run up to 2000 RPM to clear the engine before proceeding with the RPM check. Make final adjustment of the idle speed adjustment to obtain the desired idling RPM with closed throttle. The above method aims at a setting that will obtain maximum RPM with minimum manifold pressure. In case the setting does not remain stable, check the idle linkage; any looseness in this linkage would cause erratic idling. In all cases, allowance should be made for the effect of weather conditions and field altitude upon idling adjustments.

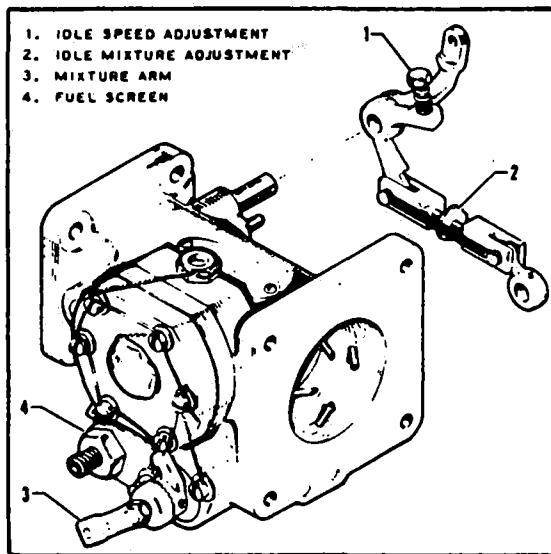


Figure 8A-8. Fuel Injector

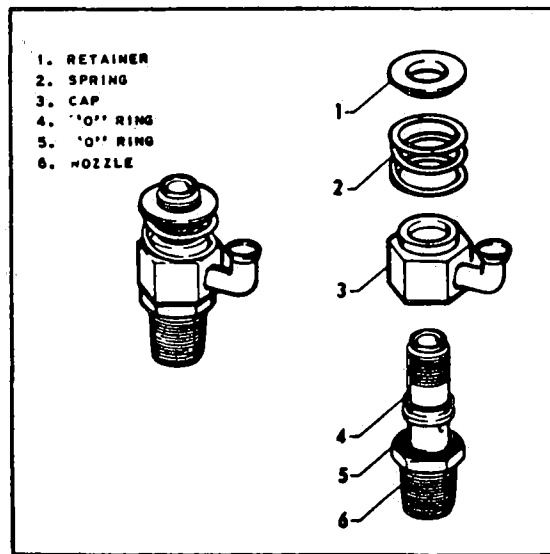


Figure 8A-9. Fuel Air Bleed Nozzle

#### 8A-40. FUEL AIR BLEED NOZZLES.

8A-41. REMOVAL OF FUEL AIR BLEED NOZZLES. The nozzles must be carefully removed as they or the cylinders may be damaged.

- a. Remove the side access panels from the engine nacelle.
- b. Disconnect the fuel line from the nozzle.
- c. Remove the spring retainer and spring from the nozzle stem.
- d. Disconnect the nozzle shroud from the vent hose and remove it from the nozzle.
- e. Carefully remove the nozzle, using the correct size deep socket.
- f. Clean and inspect the nozzle as given in paragraph 8A-42.

#### 8A-42. CLEANING AND INSPECTION OF FUEL AIR BLEED NOZZLE.

- a. Clean the nozzle with acetone or equivalent and blow out all foreign particles with compressed air in the direction opposite that of fuel flow. Do not use wire or other hard objects to clean orifices. (Refer to the latest revision of Lycoming Service Instruction No. 1275.)
- b. Inspect and replace nozzle "O" rings if found to be cracked brittle or distorted.
- c. A test procedure for air bleed nozzles is described in the latest revision of Lycoming Service Instruction No. 1275.

#### 8A-43. INSTALLATION OF FUEL AIR BLEED NOZZLE.

- a. It is important for the nozzles to be correctly positioned with the air bleed hole upward.
- b. Install nozzle and torque 60 inch-pounds.

- c. Ascertain "O" rings are properly installed on the nozzle stem and install nozzle shroud. (Refer to Figure 8A-9.)
- d. Connect vent to nozzle shroud.
- e. Install spring and spring retainer on nozzle stem.
- f. Connect fuel line to nozzle.
- g. Install side panels.

**CAUTION**

Start nozzles and line couplings by hand to prevent the possibility of cross-threading.

**8A-44. IGNITION SYSTEM MAINTENANCE.**

**8A-45. MAGNETO.**

**CAUTION**

Ascertain that the primary circuits of both magnetos are grounded before working on the engine.

**8A-46. INSPECTION OF MAGNETO.** At the time of engine inspection or when a magneto has been removed from the engine, the following checks may be performed:

- a. Inspect distributor block contact springs. Top of spring must not be more than 0.422 of an inch below top of tower as shown in Figure 8A-11. If broken or corroded, they should be replaced.
- b. Inspect oil felt washer. It should be saturated with oil. If dry, check for worn bushing. If O.K., add Bendix P/N 10-391200 oil.

**NOTE**

Refer to the latest revision of Bendix Service Bulletin No. 551 or Lycoming Service Bulletin No. 343 for further information on new distributor block lubricant.

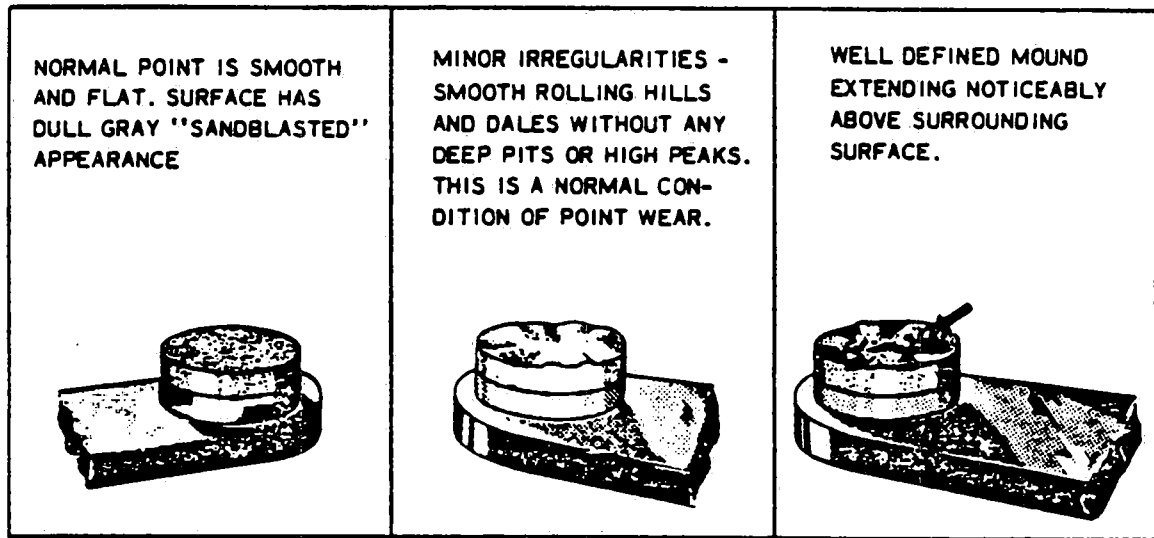


Figure 8A-10. Magneto Breaker Points

c. Inspect distributor block for cracks or burned areas. The wax coating on the block should not be removed. Do not use solvents.

d. Look for excess oil in breaker compartment. If present, it may mean a bad oil seal or oil seal bushing at drive end. Check magneto manufacturer's overhaul procedure.

e. Examine the breaker points for excessive wear or burning. Figure 8A-10 shows how the average breaker point will look when surfaces are separated for inspection. Desired contact surfaces have a dull gray, sand-blasted (almost rough) or frosted appearance, over the area where electrical contact is made. This means that points are worn in and mated to each other, thereby providing the best possible electrical contact and highest efficiency of performance.

f. Minor irregularities or roughness of point surfaces are not harmful (Refer to Figure 8A-10 center). Neither are small pits or mounds, if not too pronounced. If there is a possibility of pit becoming deep enough to penetrate pad, Figure 8A-10, right, reject breaker assembly.

#### NOTE

No attempt should be made to stone or dress breaker points. Should breaker assembly have bad points or show excessive wear, the complete breaker assembly should be replaced.

g. Look for frayed insulation or broken wire strands in leads in back of magneto. See that terminals are secure. Be sure wires are properly positioned.

h. Inspect capacitor visually. If possible, test for leakage, capacity and series resistance. Remember, an electrical failure of an aircraft capacitor is rare.

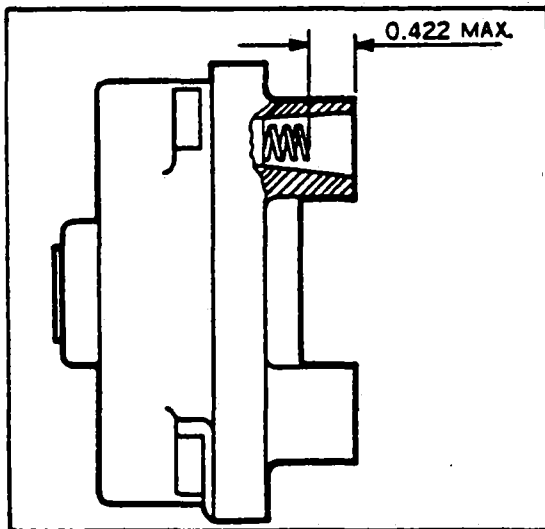


Figure 8A-11. Contact Spring Inspection

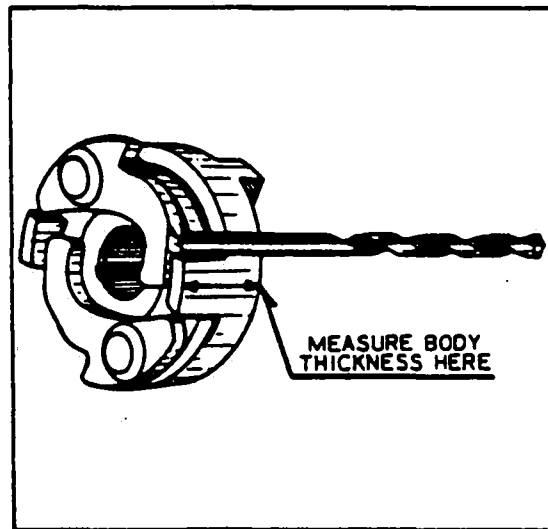


Figure 8A-12. Impulse Coupling

- i. Adjustment of breakers must be correct for proper internal timing of magneto. (See Paragraph 8A-48.)
- j. Check if breaker cam is clean and smooth, if cam screw is tight (25 in. lbs.). If new points are installed, blot a little oil on cam.
- k. Inspect impulse coupling flyweights for excessive looseness on the axles. Desired couplings having 0.927 of an inch thick body should be checked with 1/8 inch drill. Couplings with 0.974 of an inch thick body are checked with a Number 18 drill. If drill fits between cam and flyweight, the fit is too loose and coupling should be replaced. (Refer to Figure 8A-12.)
- l. Check impulse coupling for excess wear on the contact edges of body and flyweights.
- m. Check that the impulse coupling flyweight axle rivets are tight and there are no cracks in body.
- n. Look at the lead conduits. A few broken strands won't hurt, but if the insulation looks tired, you may be in for trouble. The special high temperature coating used on lightweight harnesses is provided chiefly for vibration resistance and mechanical protection. The integrity of the harness is not sacrificed if small areas of the braid show peeling or flaking of this coating.
- o. Check the springs for breaks, corrosion, or deformation. If possible, check continuity from block with tester or light.
- p. Check insulators for cracks, breaks, or evidence of "old age". Be sure they are clean.

q. Timing and ventilator plugs. Ventilator has drilled holes and should be in lowest hole in magneto to serve also as drain for excess water or oil. Solid plug is used in other hole - or in location exposed to rain or water.

NOTE

The magneto service instructions in this manual are to cover minor repairs and timing. For further repairs and adjustments of the magnetos, it is recommended that the magneto manufacturer's service instructions be followed.

8A-47. REMOVAL OF MAGNETO.

- a. Remove the side access panel from the engine nacelle.
- b. Disconnect the "P" lead from the magneto.
- c. Remove the harness outlet plate from the magneto by removing the four attaching screws.
- d. Remove the two nuts and washers securing the magneto to the engine accessory housing.
- e. Pull the magneto from the engine.

8A-48. TIMING PROCEDURE. (INTERNAL TIMING.) When installing new or adjusting breaker points and before timing the magneto to the engine, it is important that the internal timing of the magneto be correct.

a. To internally time the magneto, it should be removed from the engine to determine "E" gap.

b. To determine "E" gap, find neutral position of the magneto drive by rotating drive coupling in a left hand direction until the red or white chamfered tooth on the distributor gear appears through the timing inspection hole. At the same location, the drive should feel to have fallen into a notch or neutral position.

c. Rotate coupling from neutral, in a left hand direction 10 degrees. Appearing through timing hole, when the white or red tooth aligns with the white

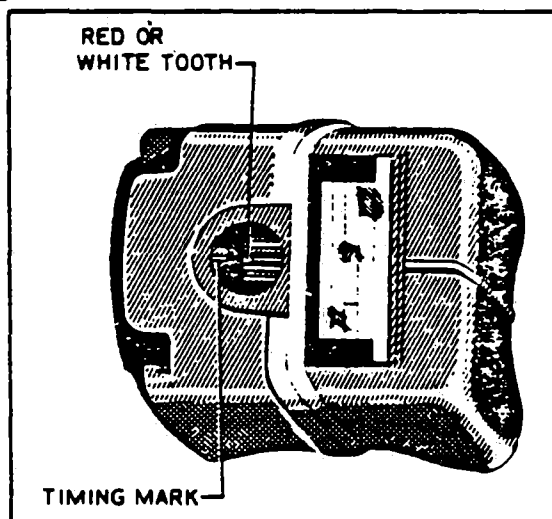


Figure 8A-13. Magneto Timing Marks



line of the distributor block, the magneto is set at "E" gap. (Refer to Figure 8A-13.) Alignment may not vary over  $\pm 4$  degrees.

d. Using the alignment of the chamfered tooth on the distributor gear and the white line on the distributor block as a reference, adjust the breaker points to open at this point.

e. Turn the magneto drive until the cam follower is on high point of the cam lobe. Measure contact clearance, it must be  $0.018 \pm 0.006$  of an inch with the point opening set at "E" gap. If breaker points do not come within tolerances, they should be replaced.

8A-49. INSTALLATION AND TIMING PROCEDURE. (Timing Magneto to Engine.) The magnetos can be installed and timed to the engine by the following procedure:

#### NOTE

Ascertain that the breakers are correct for proper internal timing of magnetos.

a. Remove cowling per paragraph 8A-5.

b. Remove the top spark plug from Number one cylinder. Place the thumb of one hand over the spark plug hole and rotate the crankshaft in direction of normal rotation until the compression stroke is reached. The compression stroke is indicated by a positive pressure inside the cylinder tending to lift the thumb off the spark plug hole. In this position, both valves of Number one cylinder are closed. Turn the crankshaft opposite to its normal direction of rotation until it is approximately 35 degrees BTC on the compression stroke of Number one cylinder. Rotate the crankshaft in its normal direction of rotation until the 25 degrees mark on the back starter gear and the crankcase parting flange are aligned, or the marks on the front of the starter ring gear and the drilled hole in the starter housing align. (Refer to Figure 8A-14.)

c. Rotate the drive gear on the magneto until the chamfered tooth on the distributor gear inside the magneto aligns with the white pointer as seen through the inspection hole in the magneto housing. (Refer to Figure 8A-13.)

d. Without allowing the gear to turn from this position, install the magneto with gasket on the engine and secure with washers and nuts.

e. Tighten nuts sufficiently to hold magneto in position and yet allow it to be rotated.

f. Fasten the ground lead of the timing light to an unpainted metallic portion of the magneto and one positive lead to the terminal side of the points. Ascertain that the primary ground spring is not touching the magneto case.

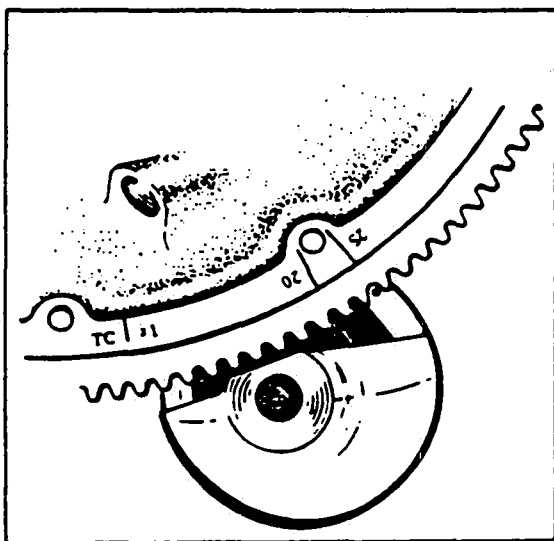


Figure 8A-14. Engine Timing Marks

- g. Turn on the timing light switch.
- h. Rotate the magneto housing in direction of the magnet rotation a few degrees until light comes on. Then slowly turn magneto in opposite direction until the timing light just goes out. Secure the magneto housing in this position.

#### NOTE

Some timing lights operate the opposite of the one mentioned.

- i. Rotate the crankshaft opposite normal rotation until it is approximately 35 degrees BTC on compression stroke Number one cylinder.

#### NOTE

The crankshaft should not be rotated more than 10 degrees in direction opposite normal rotation from the 25 degree BTC as the pawl on the impulse coupling will engage with the stop pin and late timing will be indicated through the impulse coupling mechanism. If this should happen, rotate crankshaft in normal direction until sharp click is heard; this will indicate that the impulse coupling has passed through firing position. Turn crankshaft in direction opposite normal rotation to approximately 35 degrees BTC and proceed with timing check.

- j. Turn the crankshaft very slowly in direction of normal rotation until the timing mark on the front face of the ring gear aligns with the drilled hole in the starter, as shown in Figure 8A-14, or the timing mark on the back of the ring gear aligns with the crankcase parting surface. At this point the light should go out.

- k. If the light does not go out at this point, align timing marks and rotate magneto on mounting flange in the desired direction and repeat the procedure until the light goes out at 25 degrees before top dead center.

- l. Tighten the two mounting nuts and replace the inspection plug.
- m. After tightening magneto mounting nuts, check timing to make sure it is still correct.
- n. Install the other magneto and time using the preceding instructions a thru l.
- o. With both magnetos timed to the engine and secured, check that they fire together. Rotate the crankshaft opposite normal rotation to approximately 35 degrees BTC with Number one cylinder on the compression stroke.
- p. If the magnetos are timed correctly, both timing lights will go out simultaneously when the crankshaft is turned in the normal direction aligning the 25 degree mark with either the drilled hole in the starter housing or the crankcase parting surfaces.
- q. Disconnect timing light. Ascertain that the inspection plugs and breaker cover is installed and secure.
- r. Install harness plate and secure with screws.
- s. Connect "P" leads and safety.
- t. Install cowling per paragraph 8A-7.

#### 8A-50. HARNESS ASSEMBLY.

#### 8A-51. INSPECTION OF HARNESS.

- a. Check lead assemblies for nicks, cuts, mutilated braiding, badly worn section or any other evidence of physical damage. Inspect spark plug sleeves for chafing or tears and damaged or stripped threads on coupling nuts. Check compression spring to see if it is broken or distorted. Inspect grommet for tears. Check all mounting brackets and clamps to see that they are secure and not cracked.
- b. Using an ohmmeter, buzzer, or other suitable low voltage device, check each lead for continuity. If continuity does not exist, wire is broken and must be replaced.
- c. For electrical test of harness assembly, use a high voltage, direct current tester such as the TAKK Model 86 or 86A or an equivalent direct current high voltage tester capable of delivering a test potential of 10,000 volts. Connect ground lead of high voltage tester to outer shielding braid of a single lead. Connect plug terminal. Turn tester ON and apply 10,000 volts. The insulation resistance should be 100 megohms minimum. Proceed to check other leads of harness in same manner.
- d. Minor repair of the harness assembly, such as replacement of contact springs, spring retainer assemblies, insulating sleeves or of one lead assembly, can be accomplished with the harness assembly mounted on the engine. However, should repair require replacement of more than one lead assembly or of a cable

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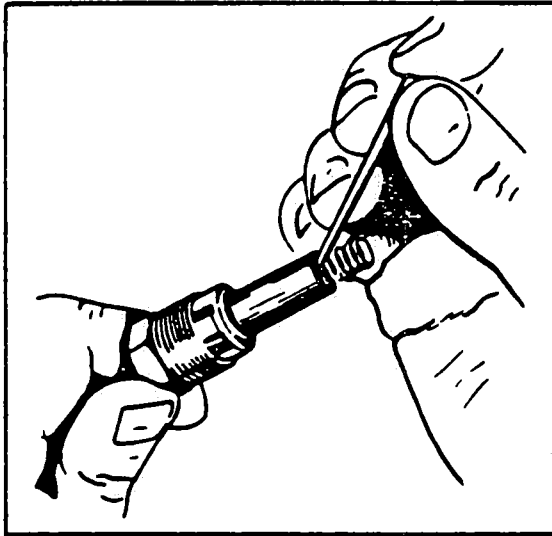


Figure 8A-15. Removing Spring  
From Lead Assembly

outlet plate, the harness should be removed from the engine and sent to an overhaul shop

#### 8A-52. REMOVAL OF HARNESS.

a. Disconnect the clamps that secure the wires to the engine and accessories.

b. Loosen the coupling nuts at the spark plugs and remove the insulators from the spark plug barrel well. Use caution when withdrawing the insulator not to damage the insulator spring.

c. Place a guard over the harness insulators.

d. Remove the harness assembly terminal plate from the magneto.

e. Remove the harness from the airplane.

#### 8A-53. MAINTENANCE OF HARNESS.

a. To replace contact springs, spring retainer assemblies or insulating sleeves, proceed as follows:

1. Using a Scintilla 11-7073 Needle or a mechanical pencil with the lead retracted, hook the end of the contact spring as shown in Figure 8A-15.

2. Using the needle or pencil, unscrew the spring.

3. Slide insulating sleeve and spring retainer assembly off end of lead assembly.

4. Replace defective component and reassemble as follows:

(a) Fabricate a tool as shown in Figure 8A-16 for installing the insulating sleeves over cable terminals.

(b) Push the tool thru insulating sleeve and spring retainer assembly as shown in Figure 8A-17. Secure the cable terminal into the tool.

(c) Work insulating sleeve and spring retainer assembly into position over the cable and unscrew the tool. Install contact spring on cable terminal.

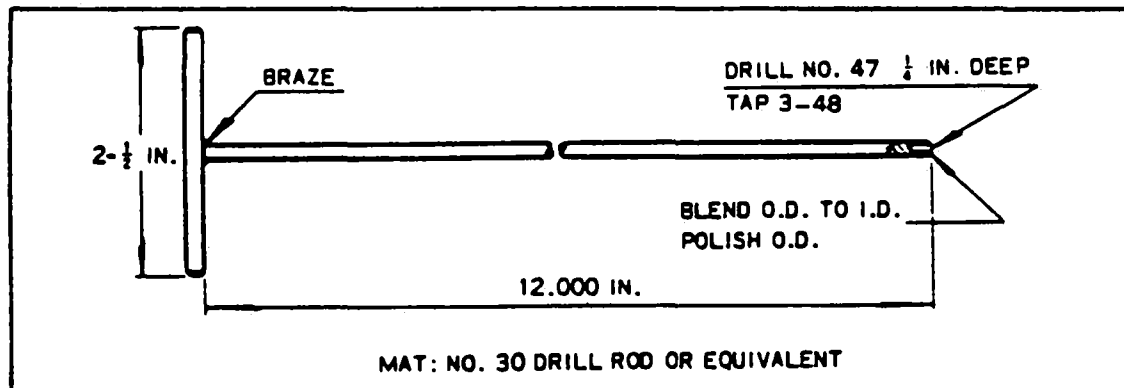


Figure 8A-16. Assembly Tool

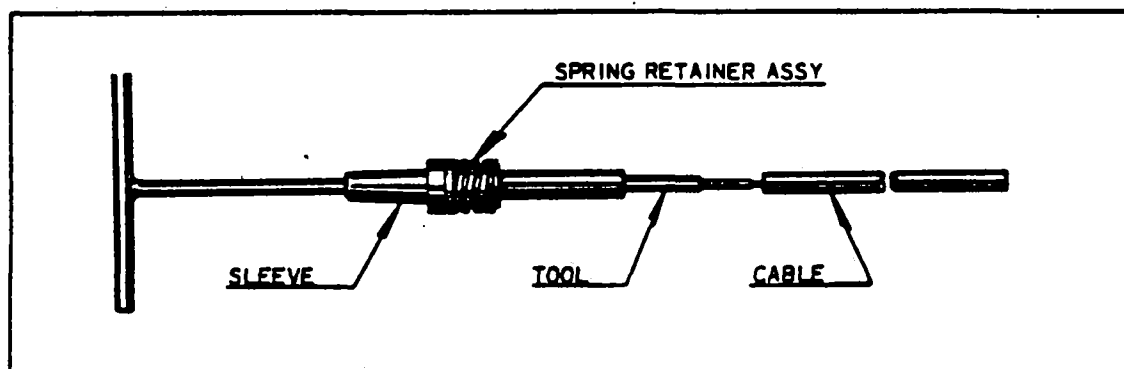


Figure 8A-17. Using Assembly Tool

NOTE

It may be necessary to lubricate the cable and insulating sleeve with a thin film of MC 200 (200,000 centistokes) or commercial grade alcohol to facilitate assembly.

- b. To replace one of the lead assemblies, proceed as follows:
  1. Remove clamps and brackets from applicable lead assembly. Cut cable ties from assembly and discard.
  2. Cut off condemned lead flush with outer surface of cable outlet plate.
  3. Grip eyelet of lead with a pair of pliers and pull short length of conductor out of grommet and cable outlet plate.
  4. Using a 3 inch long, 0.270 of an inch diameter drift, applied at outer surface of plate, drive out tapered ferrule and remaining pieces of insulation and shielding.

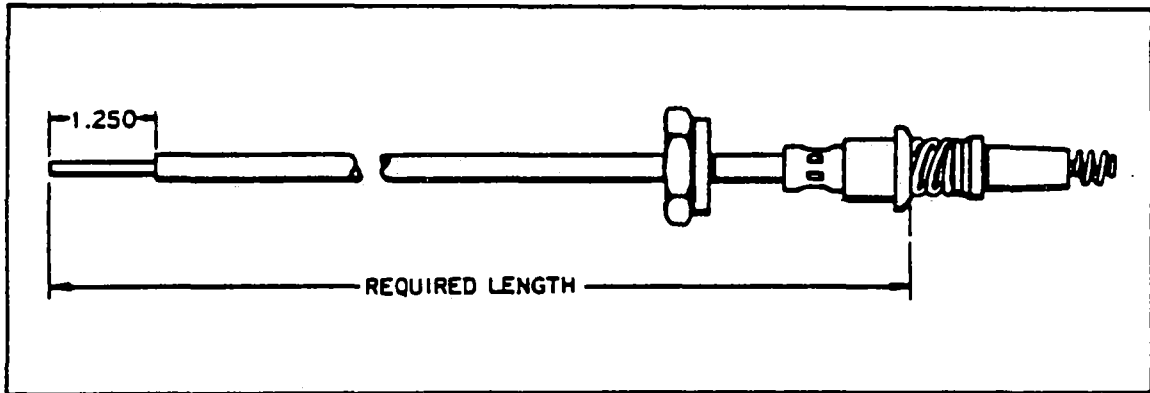


Figure 8A-18. Measuring Lead Assembly Length

5. To determine what length the new lead assembly should be cut to, proceed as follows:

(a) Measure the length of the condemned lead assembly. Move coupling nut back on lead assembly and measure from outer end of ferrule at spark plug end. (Refer to Figure 8A-18.)

(b) To the length determined in step (a), add 1-3/4 inches.

NOTE

Spare part leads are supplied in various lengths. Use a lead which is longer than, but nearest to, the desired length.

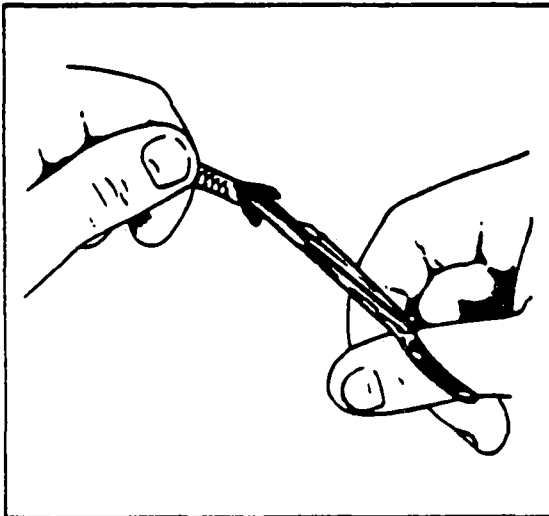


Figure 8A-19. Cutting Metallic Braid From End of Lead

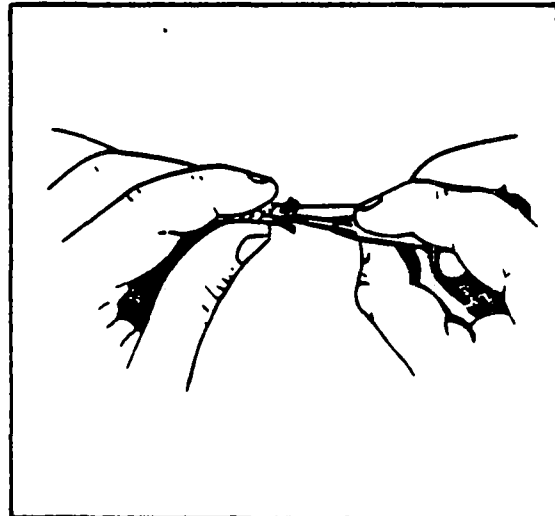


Figure 8A-20. Unbraiding Metallic Shielding

6. Cut lead assembly to the length determined in step 5. Mark ferrule on spark plug end of lead with a metal stamp, scribe or rubber stamp to correspond with correct cylinder number.

7. Starting at spark plug location, thread new cable thru grommets and clamps, as necessary, for correct routing of cut end of cable to magneto location.

8. Using electrician's scissors, carefully remove 1.250 inches of outer braid from end of lead. (Refer to Figure 8A-19.)

9. Using a scribe or similar pointed tool, unbraid  $\frac{3}{8}$  inch of braided shielding. (Refer to Figure 8A-20.) Wrap a single thickness of electrical tape around unbraided strands to facilitate insertion of lead end thru hole in cable outlet plate.

10. Remove cable outlet plate from magneto. Support plate securely and, using suitable cutting pliers, split and remove eyelets from leads adjacent to lead being replaced. When splitting eyelet, make certain that wire strands are not cut. Removal of eyelets on adjacent leads will allow grommet to be pulled away from outlet plate to facilitate insertion of new lead.

11. Pass the taped end of new lead through hole in outlet plate. Remove electrical tape from lead and install tapered end of ferrule under the unbraided strands of shielding. Form strands of shielding evenly around tapered ferrule as shown in Figure 8A-21 and pull lead assembly back through cable outlet plate until ferrule binds in the outlet well. Position the Scintilla 11-7074 Ferrule Seating Tool (Refer to Figure 8A-22) over the wire and firmly seat the ferrule by tapping the seating tool with a hammer or by using an arbor press.

12. Measure  $\frac{1}{2}$  inch from tapered ferrule and strip remaining insulation from wire. (Refer to Figure 8A-24.)

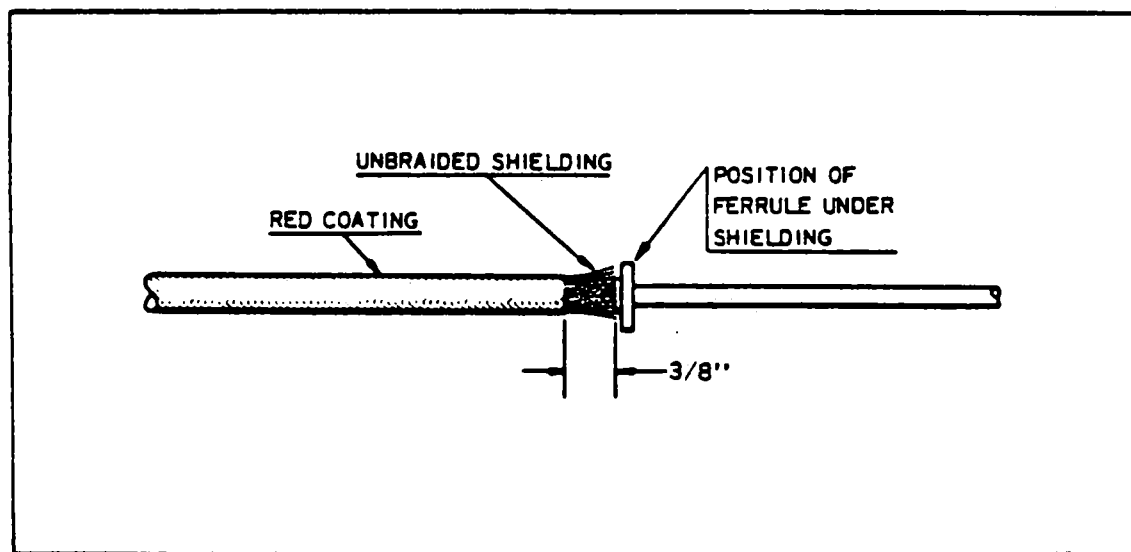


Figure 8A-21. Forming Shielding Around Ferrule

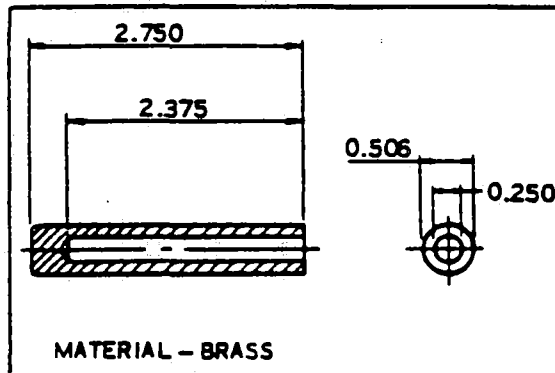


Figure 8A-22. Ferrule Seating Tool

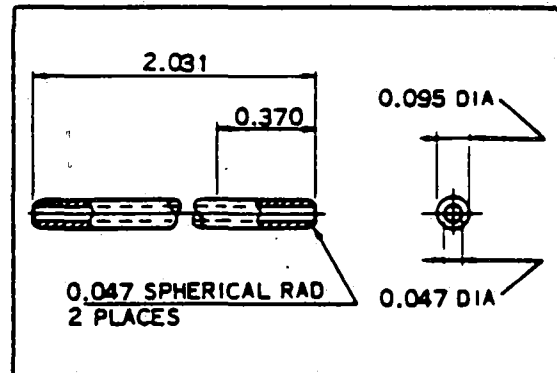


Figure 8A-23. Needle

13. Insert Scintilla 11-7073 Needle (Refer to Figure 8A-23) thru small hole of grommet and over stripped end of wire. (Refer to Figure 8A-25.) Slide grommet down needle until it seats tightly against the tapered ferrule.

14. Cut wire 3/8 inch from top of grommet outlet (Refer to Figure 8A-25). Double wire over as shown in A of Figure 8A-27. Slide eyelet over doubled wire until it is firmly seated in recess of grommet outlet.

15. Using the "AB" groove of Scintilla 11-4152 Crimping Tool, or equivalent, crimp eyelet to wire. Approximately 1/32 inch of wire should extend from end of eyelet after crimping. (Refer to B of Figure 8A-27.)

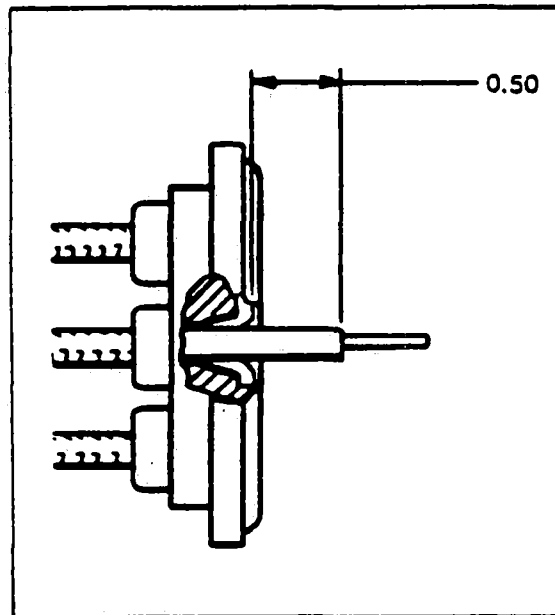


Figure 8A-24. Measuring Wire From Top of Ferrule

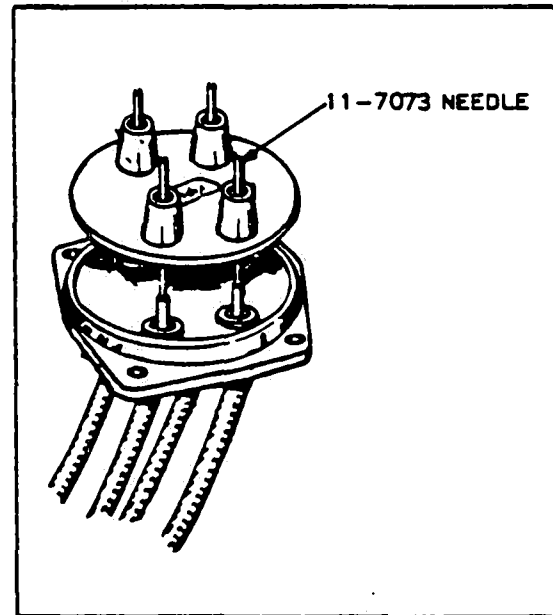


Figure 8A-25. Installing Grommet Over Lead Assemblies



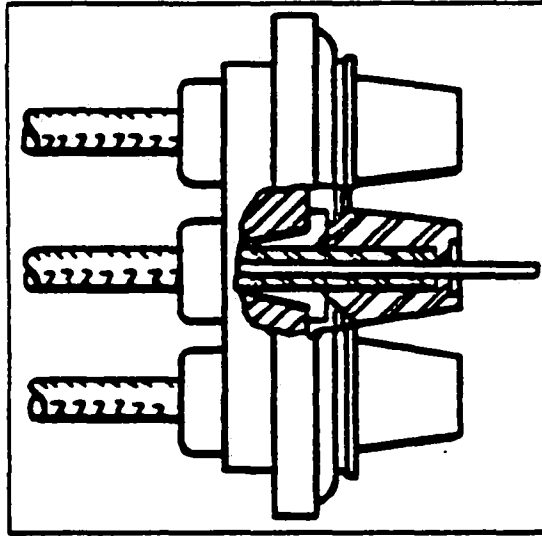


Figure 8A-26. Lead Assembly Installed in Grommet

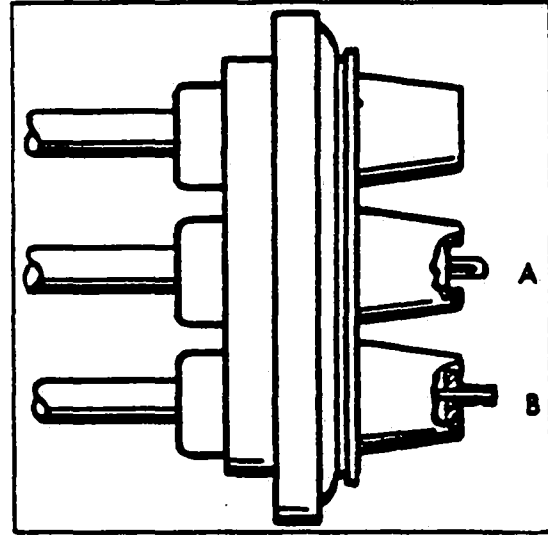


Figure 8A-27. Wire Doubled Over For Installation of Eyelet

NOTE

If the crimping tool is not available, a satisfactory connection can be made by soldering with Kester Flux 709 or equivalent and a non-corrosive solder. After soldering, clean solder joints using denatured alcohol.

16. Install clamps and cable ties, as necessary, to secure lead to the engine.

8A-54. INSTALLATION OF HARNESS. Before installing harness on magneto, check mating surfaces for cleanliness. Spray entire face of grommet with a light coat of Plastic Mold Spray, SM-O-O-TH Silicone Spray or equivalent. This will prevent harness grommet from sticking to magneto distributor block.

- a. Place the harness terminal plate on the magneto and tighten nuts around the plate alternately to seat cover squarely on magneto. Torque nuts to 18 to 22 inch pounds.
- b. Route ignition wires to their respective cylinders.
- c. Clamp the harness assembly in position.
- d. Connect the leads to the spark plugs.

8A-55. SPARK PLUGS.

8A-56. REMOVAL OF SPARK PLUGS.

- a. Loosen the coupling nut on the harness lead and remove the terminal insulator from the spark plug barrel well.

NOTE

When withdrawing the ignition cable lead connection from the plug, care must be taken to pull the lead straight out and in line with the center line of the plug barrel; otherwise, a side load will be applied which frequently results in damage to the barrel insulator and connector. If the lead cannot be removed easily in this manner, the resisting contact between the neoprene collar and the barrel insulator will be broken by a rotary twisting of the collar. Avoid undue distortion of the collar and possible side loading of the barrel insulator.

- b. Remove the spark plug from the engine. In the course of engine operation, carbon and other combustion products will be deposited on the end of the spark plug and will penetrate the lower threads to some degree. As a result, greater torque is frequently required for removing a plug than for its installation. Accordingly, the torque limitations given do not apply to plug removal and sufficient torque must be used to unscrew the plug. The higher torque in removal is not as detrimental as in installation since it cannot stretch the threaded section. It does, however, impose a shearing load on this section and may, if sufficiently severe, produce a failure in this location.

NOTE

Torque indicating handle should not be used for spark plug removal because of the greater torque requirement.

- c. Place spark plugs in a tray that will identify their position in the engine as soon as they are removed.

NOTE

Spark plugs should not be used if they have been dropped.

d. 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 at the apex just large enough to accommodate the funnel of a CO<sub>2</sub> bottle. (Refer to Figure 8A-28.) 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 CO<sub>2</sub> 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.

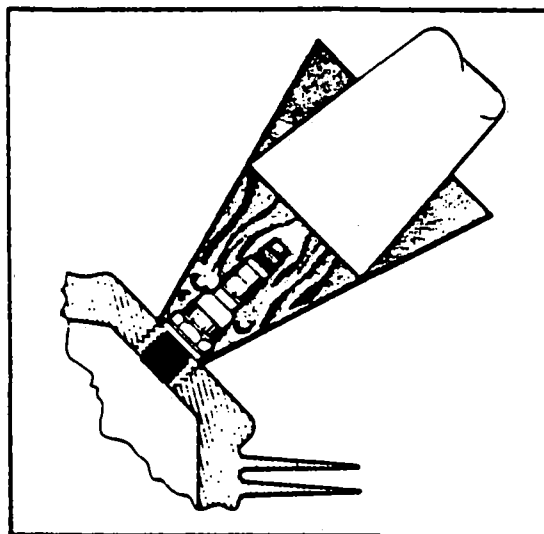


Figure 8A-28. Removing Frozen Spark Plug

e. Do not allow foreign objects to enter the spark plug hole.

8A-57. INSPECTION AND CLEANING OF SPARK PLUG.

- a. Visually inspect each plug for the following non-repairable defects:
  1. Severely damaged shell or shield threads nicked up, stripped or cross-threaded.
  2. Badly battered or rounded shell hexagons.
  3. Out-of-round or damaged shielding barrel.
  4. Chipped, cracked or broken ceramic insulator portions.
  5. Badly eroded electrodes worn to approximately 50% of original size.
- b. Clean the spark plug as required, removing carbon and foreign deposits.
- c. Test the spark plug both electrically and for resistance.
- d. Set the electrode gap at 0.15 to 0.21 of an inch.

**8A-58. INSTALLATION OF SPARK PLUGS.** Before installing spark plugs, ascertain that the threads within the cylinder are clean and not damaged.

a. Apply anti-seize compound sparingly on the threads and install gasket and spark plugs. Torque 360 to 420 inch pounds.

**CAUTION**

Make certain the deep socket is properly seated on the spark plug hexagon as damage to the plug could result if the wrench is cocked to one side when pressure is applied.

b. Carefully insert the terminal insulator in the spark plug and tighten the coupling nut.

**8A-59. LUBRICATION SYSTEM.**

**8A-60. ADJUSTMENT OF OIL PRESSURE RELIEF VALVE.** Engines are furnished with either a non-adjustable or adjustable oil pressure relief valve located to the rear of No. 3 cylinder. A brief description and setting procedure for both types follows:

a. **Oil Relief Valve (Non-Adjustable):** The function of the oil pressure relief valve is to maintain engine oil pressure within specified limits (60 psi, min. to 90 psi, max.). This valve is not adjustable; however, the pressure can be controlled by the addition of a maximum of three STD 425 washers under the cap to increase pressure or the use of a spacer (Lyc. P/N 73629 or 73630) under the cap to decrease pressure. Particles of metal or other foreign matter lodged between the ball and seat will result in a drop in oil pressure. It is advisable, therefore, to disassemble, inspect and clean the valve if excessive pressure fluctuations are noted. The oil pressure relief valve is not to be mistaken for the oil cooler by-pass valve, whose function is to permit pressure oil to by-pass the oil cooler in case of an obstruction in the oil cooler.

b. **Oil Relief Valve (Adjustable):** The adjustable oil relief valve enables the operator to maintain engine oil pressure within the specified limits (60 psi, min. to 90 psi, max.). If the pressure under normal operating conditions should consistently exceed the maximum or minimum specified limits, adjust the valve as follows:

With the engine warmed up and running at approximately 2000 RPM, observe the reading on the oil pressure gauge. If the pressure is above maximum or

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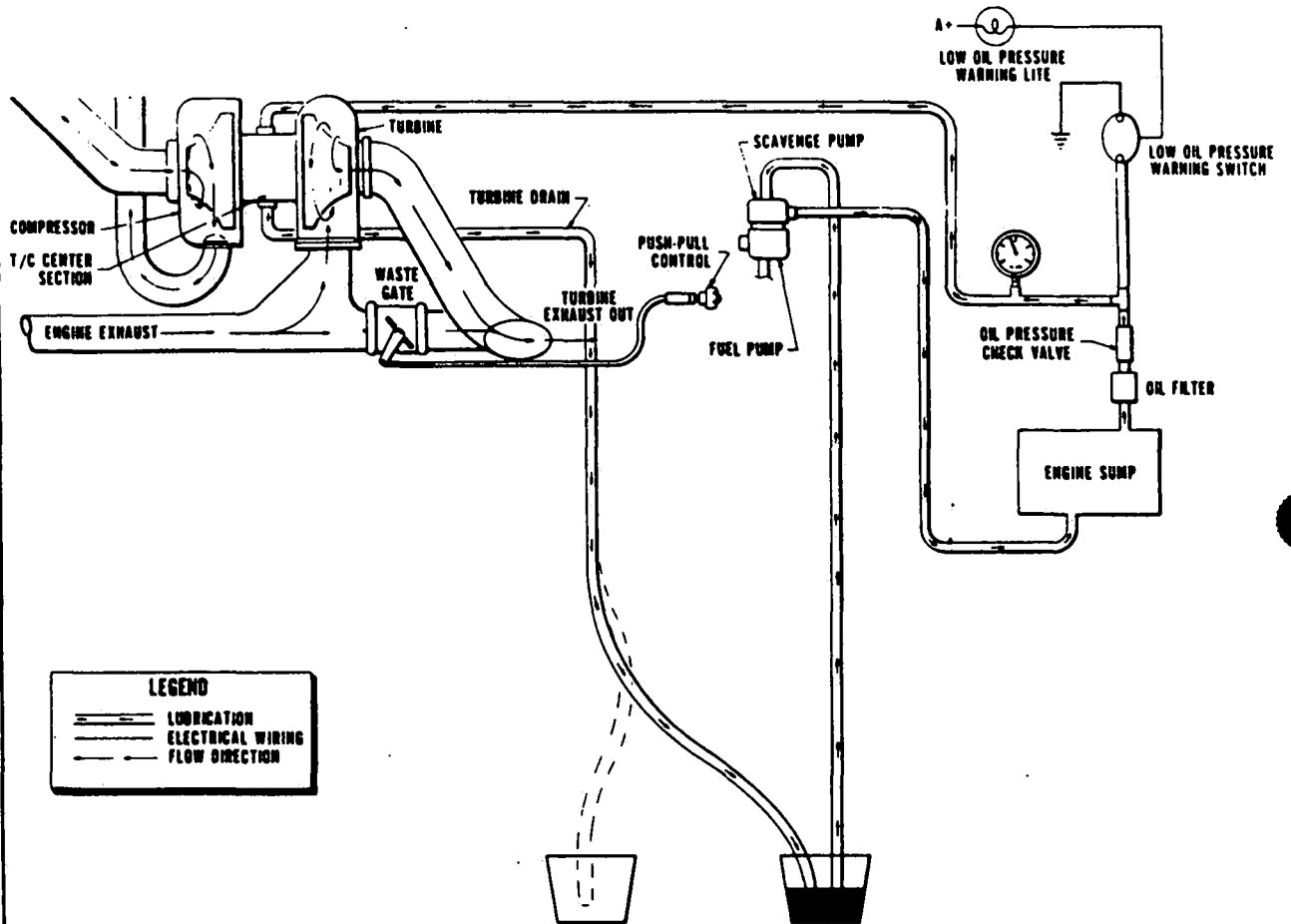


Figure 8A-29. Turbo Oil Flow Check

below minimum specified limits, stop engine and screw the adjusting screw out to decrease pressure and into increase pressure. Depending on installation, the adjusting screw may have only a screwdriver slot and is turned with a screwdriver; or may have the screwdriver slot plus a pinned 0.375-24 castellated nut and may be turned with either a screwdriver or a box wrench.

**8A-61. OIL SCREENS AND FILTERS.** Cleaning and inspection of oil screens and filters can be found in Section II.

**8A-62. TURBO OIL FLOW CHECK.** (Refer to Figure 8A-29.) Should an indication of low turbo oil pressure or flow occur, the following system checks may be accomplished.

- a. Inspect turbo oil filter for restriction due to dirt accumulation. (Refer to Turbo Oil Filter Cleaning Procedure, Section II.)
- b. To check oil pressure, use the following procedure:
  1. Install a pressure gauge with a range of 0 to 80 psi pressure in the pressure line after the turbo oil filter.
  2. Start the engine and warm up in the usual manner until oil temperature is normal.
  3. Idle engine at 1000 RPM and observe pressure gauge. It should indicate a minimum of 30 psi.
- c. To check turbo oil flow, use the following procedure:
  1. Ascertain that the engine oil sump is full as indicated on the dipstick.
  2. Start the engine and warm up in the usual manner until oil temperature is normal.
  3. Stop engine and disconnect inlet oil line at the turbo oil scavenger pump.
  4. Install test line, approximately four feet long, on inlet fitting of turbo oil scavenger pump.
  5. Set two clean one gallon capacity containers under the engine.
  6. Allow the turbo oil drain line and test line to hang in one container.
  7. Start engine and idle at 1000 RPM.
  8. When oil flows from the turbo oil drain line into the container, quickly direct the oil flow into the empty container and immediately start timing for one minute.
  9. When one minute has passed, direct the oil flow into the scavenger container and stop engine.
  10. Measure the oil in the test container. It should be a minimum of 0.5 quart.

TABLE VIII-A-II. TROUBLESHOOTING CHART  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Failure of engine to start.	Lack of fuel .	Check fuel system for leaks. Fill fuel tanks. Clean dirty lines, screens, or fuel valves .
	Water in fuel injector .	Drain water from fuel system .
	Insufficient prime .	Increase prime .
	Overpriming .	Open throttle and engage starter .
	Lack of sufficient fuel flow .	Clean fuel strainers and screens . Check fuel pump .
	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 II-I for spark plug gap adjustments .
	Defective ignition wire .	Check with electric tester and replace any defective wires .
	Improper operation of magneto to breaker points .	Check internal timing of magnetos . Clean and set points .

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Failure of engine to start. (cont.)	Internal failure.	Check oil sump screen for metal particles. If found, complete overhaul of the engine may be indicated.
	Magnetized impulse coupling.	Demagnetize impulse couplings.
	Frozen spark plug electrodes.	Replace spark plugs or dry out removed plugs.
	Shorted ignition switch.	Check and replace or repair.
Failure of engine to idle properly.	Incorrect idle adjustment.	Refer to paragraph 8A-39.
	Idle mixture.	Refer to paragraph 8A-39.
	Leak in the induction system.	Tighten all connections in the induction system. Replace any parts that are defective.
	Uneven cylinder compression.	Check cylinder compression.
	Faulty ignition system.	Check entire ignition system.
	Improper spark plug gap setting.	Regap spark plug.



TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Failure of engine to idle properly. (cont.)	Clogged injector nozzle.	Remove and clean, paragraph 8A-42.
	Dirty air filter.	Check and clean.
	Insufficient fuel pressure.	Clean fuel strainer and check fuel pump.
	Induction drains open	Clean or replace drains.
Low power and uneven running engine.	Mixture too rich: indicated by sluggish engine operation, red exhaust flame and black smoke.	Check injector. Adjust mixture control.
	Mixture too lean: indicated by overheating or backfiring.	Check fuel lines for dirt or other restrictions. Check fuel supply.
	Clogged injector nozzles.	Remove and clean, paragraph 8A-42.
	Leaks in induction system.	Tighten all connections. Replace defective parts.
	Dirt in injector inlet screen.	Remove screen and clean.
	Defective spark plugs.	Clean or replace spark plugs.
	Improper grade of fuel.	Fill tank with recommended grade.

TABLE VIIIA-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Low power and uneven running engine. (cont.)	Magneto breaker points not working properly.	Check internal timing of magneto.
	Defective ignition wire.	Check wire with electric tester. Replace defective wire.
	Defective spark plug terminal connectors.	Replace connectors on spark plug wire.
	Improper ignition timing.	Check magnetos for timing and synchronization.
Flow meter reads high.	Clogged nozzle.	Remove and clean. paragraph 8A-42.
	Defective fuel injector.	Repair or replace fuel injector.
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.
	Mixture too lean or too rich.	Injector must be re-calibrated.
	Restriction in induction air.	Examine air inlet and remove restriction.
	Improper fuel.	Fill tank with recommended fuel.

TABLE VIIA-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Failure of engine to develop full power. (cont.)	Propeller governor put out of adjustment.	Adjust governor.
	Propeller out of adjustment.	Adjust propeller low pitch stop.
	Restrictions in inlet air scoop and filter.	Examine air scoop and filter and remove restrictions.
	Faulty ignition.	Tighten all connections. Check ignition system. Check ignition timing.
Rough running engine.	Cracked engine mounts.	Repair or replace engine mount.
	Unbalanced propeller.	Remove propeller and balance.
	Bent propeller blades.	Replace propeller.
	Defective mounting.	Install new shock mounts.
	Lead deposit on spark plug.	Clean or replace plugs.
	Malfunctioning engine.	Check entire engine.
Low oil pressure.	Insufficient oil.	Fill oil sump to proper level.
	Dirty oil screens.	Remove and clean oil screens.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Low oil pressure. (cont.)	Relief valve out of adjustment.	Adjust valve.
	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 and crankcase.
	High oil temperature.	See "High Oil Temperature" in Trouble Column.
	Stoppage in oil pump intake passage.	Check line for obstruction. Clean suction screen.
	Worn or scored bearings.	Overhaul.
High oil temperature.	Insufficient air cooling.	Check air inlet and outlet deformation or obstruction.
	Insufficient oil supply.	Fill oil sump to proper level.
	Clogged oil lines or screens.	Remove and clean oil screens.
	Clogged oil cooler.	Remove and clean oil cooler.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
High oil temperature. (cont.)	Failing or failed bearing.	Examine sump 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.
	Low grade of oil.	Replace with oil conforming to specifications.
	Improper engine operation.	Check entire engine.
Excessive oil consumption.	Failed or failing bearing.	Check sump 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.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Excessive oil consumption. (cont.)	External oil leakage.	Check engine carefully for leaking gaskets, "O" rings or sand holes.
	Failure of rings to seat. (New nitrided cylinders.)	Use mineral base oil. Climb to cruise altitude at full power and operate at 75% cruise power setting until oil consumption stabilizes.
	Low grade of oil.	Replace with oil conforming to specifications.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Inaccurate pressure readings.	Cold weather.	High and low pressure readings due to extremely cold weather are not necessarily a malfunction. Small and long oil lines will not transfer pressure readings accurately until engine is quite warm.
Loss of, reduction of, or fluctuation of manifold pressure while turbocharging.	Malfunctioning manifold pressure gauge due to faulty gauge or possible oil in MAP reference line or gate.	Repair or replace gauge. NOTE: If the engine changes in power level or the air-speed changes, then actual change in MAP has occurred due to one of the reasons listed below:
	Turbocharger inlet duct blocked.	Check ducting and remove obstruction.
	Turbocompressor discharge duct ruptured or disconnected.	Connect or replace ducting.
	Severe rupture on exhaust stacks causing waste-gate to be ineffective.	Replace defective part.
	Turbocharger rotor jammed.	Replace Turbocharger.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Loss of, reduction of, or fluctuation of manifold pressure while turbocharging. (cont.)	Ruptured manifold gauge line or fitting.	Repair leak.
	Broken waste-gate control.	Replace control cable.
	Air inlet check valve not fully sealing or blocked partly open.	Inspect, repair or replace as needed.
Loss of reduction of fuel pressure when turbocharging.	Out of fuel.	Refuel.
	Partial fuel vapor lock at high altitude due to hot fuel and high power settings.	Turn on boost pumps and/or reduce power.
	Malfunctioning fuel pressure regulating valve or fuel pump.	Turn on boost pumps and/or reduce power.
	Ruptured fuel line or leaking fitting or pump shaft seal.	Shut off fuel shut-off valve, full rich mixture until fuel forward of firewall is consumed by engine. Secure engine.



TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Loss or reduction of fuel pressure when turbocharging. (cont.)	Ruptured boost pressure reference line to fuel pressure regulating valve.	Continue operation until next landing if engine is smooth; otherwise, return engine to naturally aspirated power. Ground check fuel system.
Turbocharger oil pressure warning light on.	Low engine speed: i.e. idle RPM.	This is normal.
	Low engine oil pressure.	Take necessary measures to restore engine oil pressure.
	Clogged Turbocharger oil filter.	Clean and replace Turbocharger oil filter (See illustration.) NOTE: Clogging can occur very rapidly if detergent and non-detergent oils are mixed indiscriminately.
	Shorted oil pressure warning switch.	Replace switch.
	Ruptured Turbocharger oil supply line or leaking fitting.	Replace oil supply line. Tighten or replace faulty fitting.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Turbocharger oil pressure warning light on. (cont.)	Malfunctioning Turbocharger oil pressure reduction valve.	Replace pressure reduction valve. NOTE: To check valve, install a pressure gauge at the Turbocharger inlet. Normal pressure should be 40 to 60 psi. Disconnect turbo oil drain line and measure oil flow into a container. Flow at 40 to 60 psi inlet pressure should be 1 to 2 quarts per minute per turbo.
Engine runs hot (500° or more) when turbocharging or naturally aspirated.	May be due to extreme hot weather.  Cracked or loose cylinder cooling air baffles.  During climb.  Over-boost or RPM too high.  Fuel mixture too lean during very hot weather.  Mis-timed ignition, either retarded or pre-ignition.	Reduce power or open cowl flaps.  Repair or replace as required.  Reduce power or open cowl flaps or increase Indicated Air Speed.  Reduce MAP or RPM.  Enrichen mixture.  Check ignition timing, adjust as necessary.

TABLE VIIA-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Engine runs hot (500° or more) when turbocharging or naturally aspirated. (cont.)	Detonation due to too low octane fuel or item above.	Fuel mixture set too lean or fuel octane too low. Check mixture and fuel grade.
	Faulty cylinder head temperature gauge.	Replace instrument.
	Defective oil cooling system.	Inspect and repair as required.
	Combinations of above.	Systematically eliminate by above steps.
Airplane performance is reduced from normal.	May be due to hot weather.	Speed for the Turbo Twin Comanche will be reduced 2 to 4 mph for 10° F rise in temperature above standard day. This is because Turbochargers, like turbines, are heat sensitive as to performance.
	Tired engines, or out of tune.	Repair engines as required.
	Airplane may have additional drag due to radio antenna, sagging gear or flaps, out of rig, etc.	Inspect airframe and repair as necessary.

TABLE VIII-A-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Fuel consumption is higher than normal.	Mixture set too rich.	Develop proper leaning technique.
	Leak in fuel system.	Locate and repair leak.
	Prolonged high power at full rich mixture.	Reduce power and lean for fuel economy.
	Hot weather.	Hot weather will naturally increase fuel consumption 2 to 4 GPH depending on power, leaning and temperature of the air. This is due to less dense air for the same MAP. Also it has been found from tests that slightly richer mixture should be used for extremely warm weather to maintain a lower head temperature. This will insure good engine life.
Oil leaking out of engine inlet drain. NOTE: care should be taken to make sure oil is from inside engine inlet drain, not on the outside from some other point on engine.	Oil sump or intake valve guide leaking into induction system.	Repair or replace sump or valve guide.
	Failed Turbocharger bearings and compressor seal.	Replace Turbocharger. NOTE: The Turbocharger seal will have to be in very poor condition to permit oil to

TABLE VIIA-II. TROUBLESHOOTING CHART (cont.)  
(ENGINE-TURBOCHARGED)

Trouble	Cause	Remedy
Oil leaking out of engine inlet drain. NOTE: care should be taken to make sure oil is from inside engine inlet drain, not on the outside from some other point on engine. (cont.)	Failed Turbocharger bearings and compressor seal. (cont.)	pass the compressor impeller seal.
	Turbocharger drain line misrouted or plugged.	Reroute for clear flow or remove obstruction from line.
Noisy Turbocharger rotating assembly.	Damaged bearings.	Replace unit.
	Rotating unit rubbing housing as a result of damaged bearings, distorted housings, dirt accumulation on impeller, carbon build-up on turbine or foreign object damage.	Replace unit. NOTE: Allowable shaft play is .017 to .028 inch due to semi-floating bearings. Allowable shaft axial play is .004 to .009 inch.

## SECTION IX

### FUEL SYSTEM

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Issued: 12/29/72

## SECTION IX

### FUEL SYSTEM

9-1. INTRODUCTION. The fuel system components covered in this section consist of fuel cells, fuel selector valves, electric auxiliary fuel pumps, tip tanks, tip tank solenoid valves and fuel selector electrical switches.

This section provides instructions for troubleshooting the system, and removal, cleaning, repair, testing, installation and adjustment of system components.

9-2. DESCRIPTION. The fuel system is contained in two independent units that allow each engine to have its own fuel supply. The systems are connected only by a crossfeed that will allow fuel to be drawn from one set of fuel cells to the engine of the opposite side, in the event of an emergency.

The fuel cells are of the bladder type installed in cavities in the wings, with each inboard (main) cell holding a capacity of 30 U.S. gallons and each outboard (auxiliary) cell holding a capacity of 15 U.S. gallons. Optional wing tip tanks hold a capacity of 15 U.S. gallons each.

For each engine, fuel is taken from each cell through a screen located in the cell outlet fitting and then on to a shut-off selector valve. From the selector valve, fuel is drawn through an electrically operated auxiliary fuel pump and on to an engine driven pump where it is pumped to the injector unit. Fuel from the tip tanks enters the auxiliary fuel line at the solenoid valve located in the cabin at the main spar.

Drains and fuel screens are located in the fuel selector valves which are accessible through an access panel located just ahead of the main spar between the pilot seats or, for service purposes, in the bottom of the fuselage.

The fuel valves are operated through controls located in a panel, just ahead of the main spar, between the pilot seats. Fuel gauges will indicate the quantity of fuel in each cell from which the fuel is being selected.

9-3. TROUBLESHOOTING. Troubles peculiar to the fuel system are listed in Table IX-I at the back of this section, along with their probable causes and suggested remedies. When troubleshooting, check from the fuel supply or from the power supply to the items affected. If no trouble is found by this method, the trouble probably exists inside individual pieces of equipment; they may then be removed from the airplane and overhauled, or identical unit or units tested and known to be good installed in their place. The electrical system diagram for the system may be found in Section XI, Electrical System.



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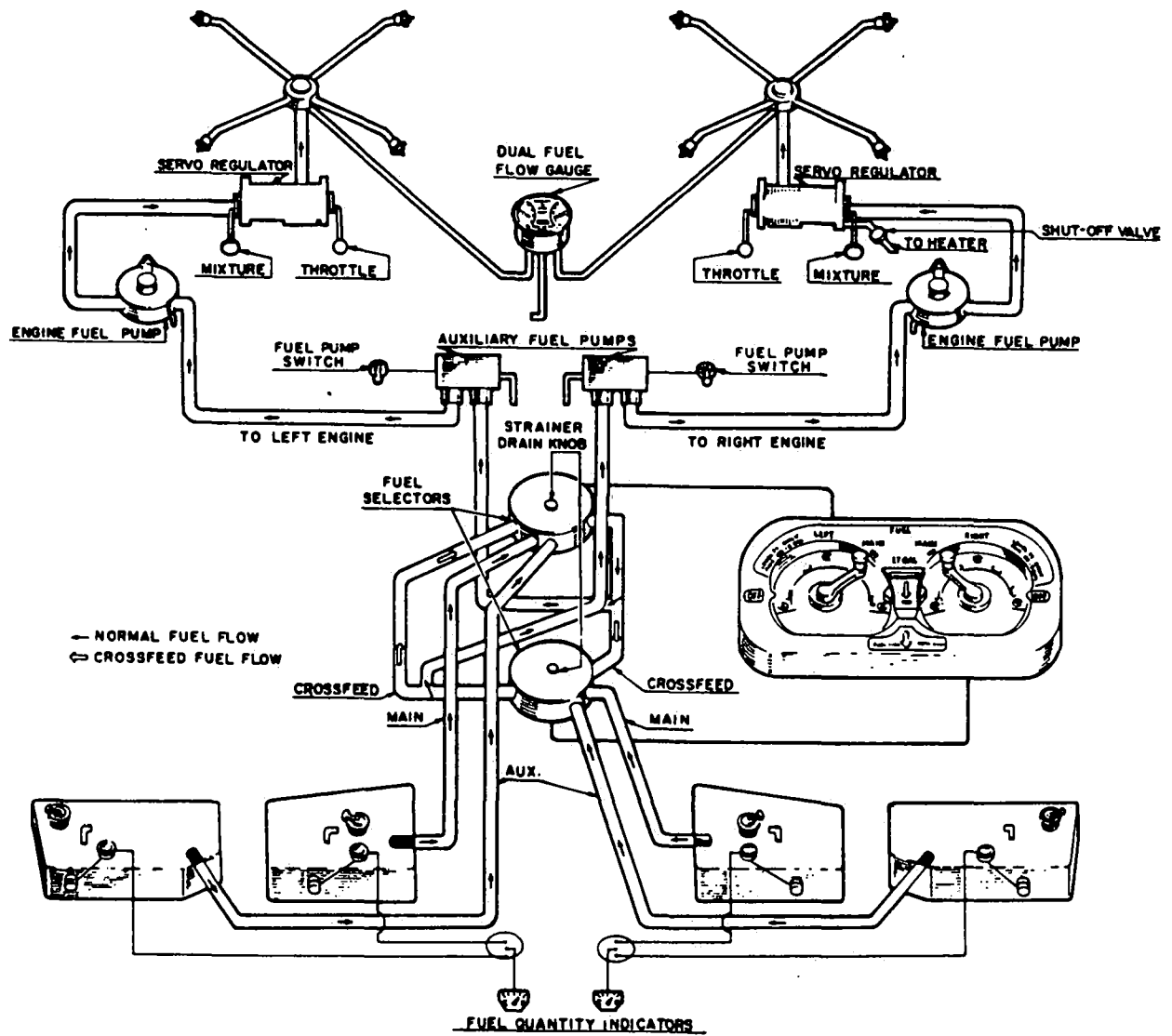


Figure 9-1. Fuel System Schematic (PA-30)

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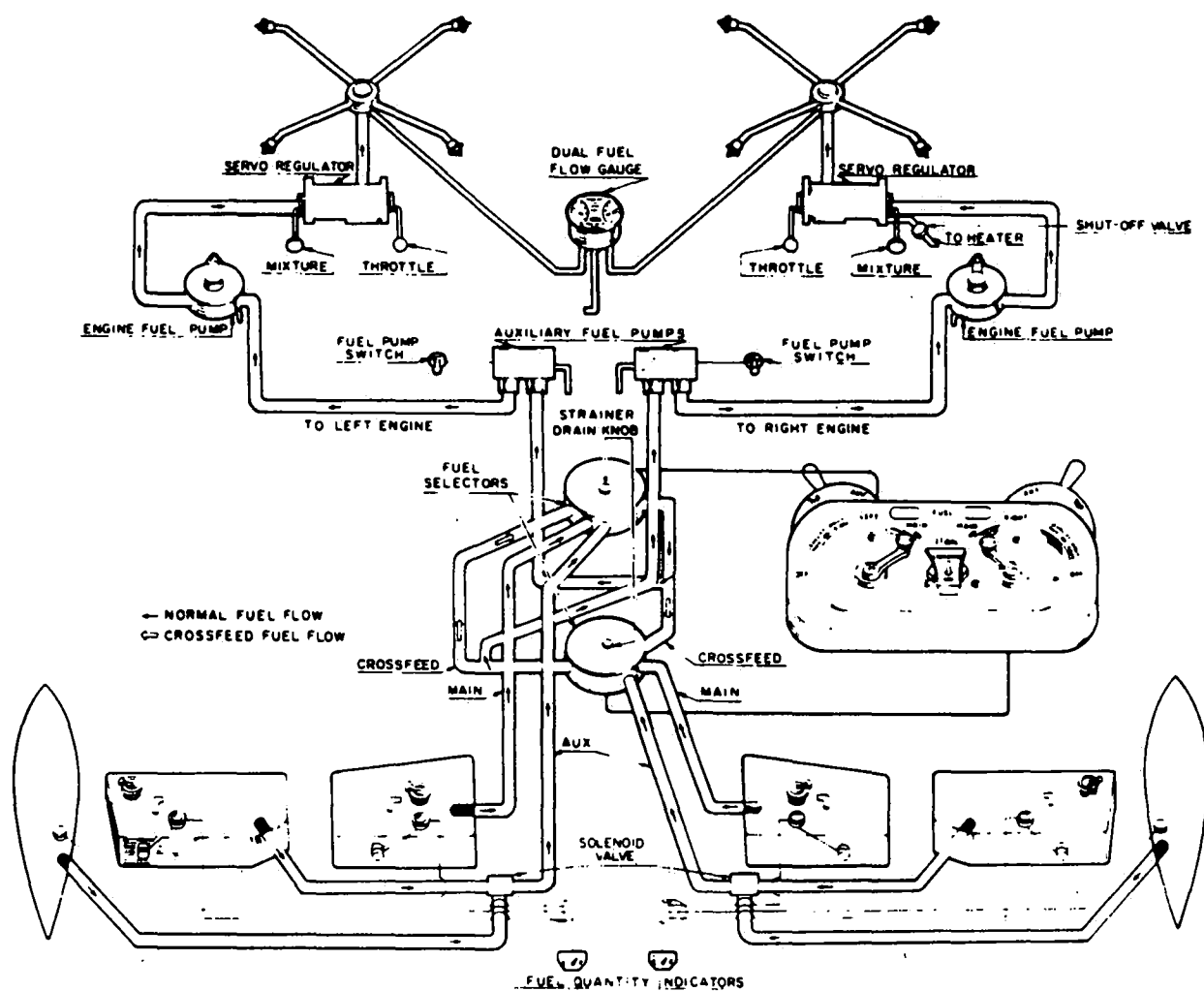


Figure 9-2. Fuel System Schematic (PA-30 Turbo)

#### 9-4. FUEL CELLS.

##### 9-5. REMOVAL OF FUEL CELLS. (Refer to Figures 9-3 and 9-4.)

- a. Drain the fuel cell, then turn the fuel selector valve to the off position. (Refer to Draining Fuel System, Section II.)
- b. If the main fuel cell is to be removed, it will be necessary to remove the nacelle cover aft of the engine firewall.
- c. If removing the main cell, remove the wing butt fairing from that wing. If removing the auxiliary cell, remove the access plate from the aft bottom of the wing.
- d. Loosen the clamp and disconnect the fuel line from the cell outlet nipple.
- e. Remove the oval cover plate (2) from the top of the wing by removing attaching screws (1).
- f. Disconnect the electrical wires from the fuel sender unit (15).
- g. Remove the cap bolts (6) and lockwashers from the sender unit plate (7).
- h. Remove the two countersunk screws attaching the sender unit plate to the top wing skin.
- i. Push the plate down and pull forward, disconnecting it from the vent (18) and fuel drain hose (19).
- j. Remove the sender unit plate and gasket (9) from the fuel cell compartment.
- k. If removing the auxiliary cell, remove the cap bolts (14) from around the filler neck. Remove the circular bolt plate (16) from the top of the filler neck and the gasket (17) from between the fuel cell and filler neck.
- l. Insert your arm between the fuel cell and the top of the wing and release the expansion clips (5). These clips fit into compartment holes and can be released by exerting pressure downward manually. After releasing all upper clips, release lower clips securing the bottom of the cell to compartment.
- m. Fold the fuel cell neatly within the wing and pull it gently through the oval opening at the top of the wing.

##### 9-6. CLEANING, INSPECTION AND REPAIR OF FUEL CELLS.

- a. Fuel cells may be cleaned by the following procedure:
  1. New Cells: It should not be necessary to clean new cells upon removing them from their containers, if they are installed in the airframe cavities promptly. If, for any reason, the cells are not installed immediately and become dirty, they should be cleaned with soap and warm water to remove foreign material prior to installation in a clean cavity.
  2. Used Cells: Prior to removal, the cells are to be drained of fuel, purged with fresh air and swabbed out to remove all traces of fuel. Following removal, the cells are to be cleaned inside and out with soap and warm water.

CAUTION

Use a vapor-proof light for inspection.

b. Fuel cells may be inspected by the following procedure:

1. New Cells: Inspect the cell surface inside and outside for cuts, abraded (scuffed) areas, and accessory damage. Also, inspect the fitting seals for nicks, scratches and foreign material.

2. Used Cells: Cells removed from the airframe cavity for inspection and repair, or cells being returned to service from storage, should be inspected as outlined above.

c. Due to the length of the fuel cell repair procedures, this information will be found in paragraph 9-11.

9-7. FUEL CELL COMPARTMENT.

a. Cell compartment must be thoroughly cleaned of all filings, trimmings, loose washers, bolts or nuts, etc.

b. All sharp edges of the cell compartment should be rounded off.

c. Cell compartments should be inspected just prior to the installation of the cell.

d. Tape over all sharp edges and rough rivets.

9-8. 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 one-quarter inch where possible.

c. Locate the hose clamp on the fabric reinforced area of the nipple.

d. Tighten hose clamp snug. Do this once. Do not re-tighten unless 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 thin film of Simonize wax to metal flow tubes to facilitate installation and removal.

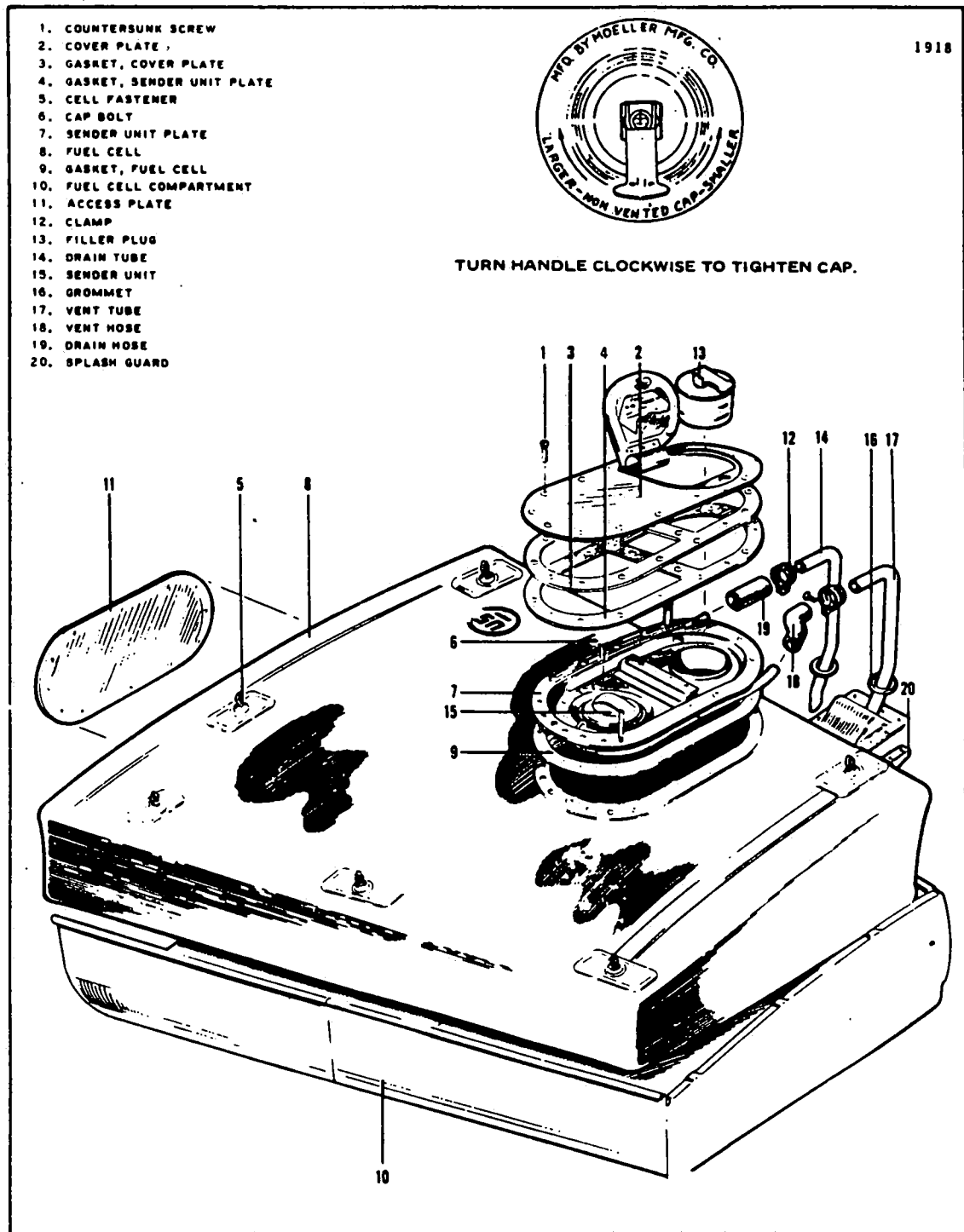


Figure 9-3. Fuel Cell Installation (Main/Inboard)

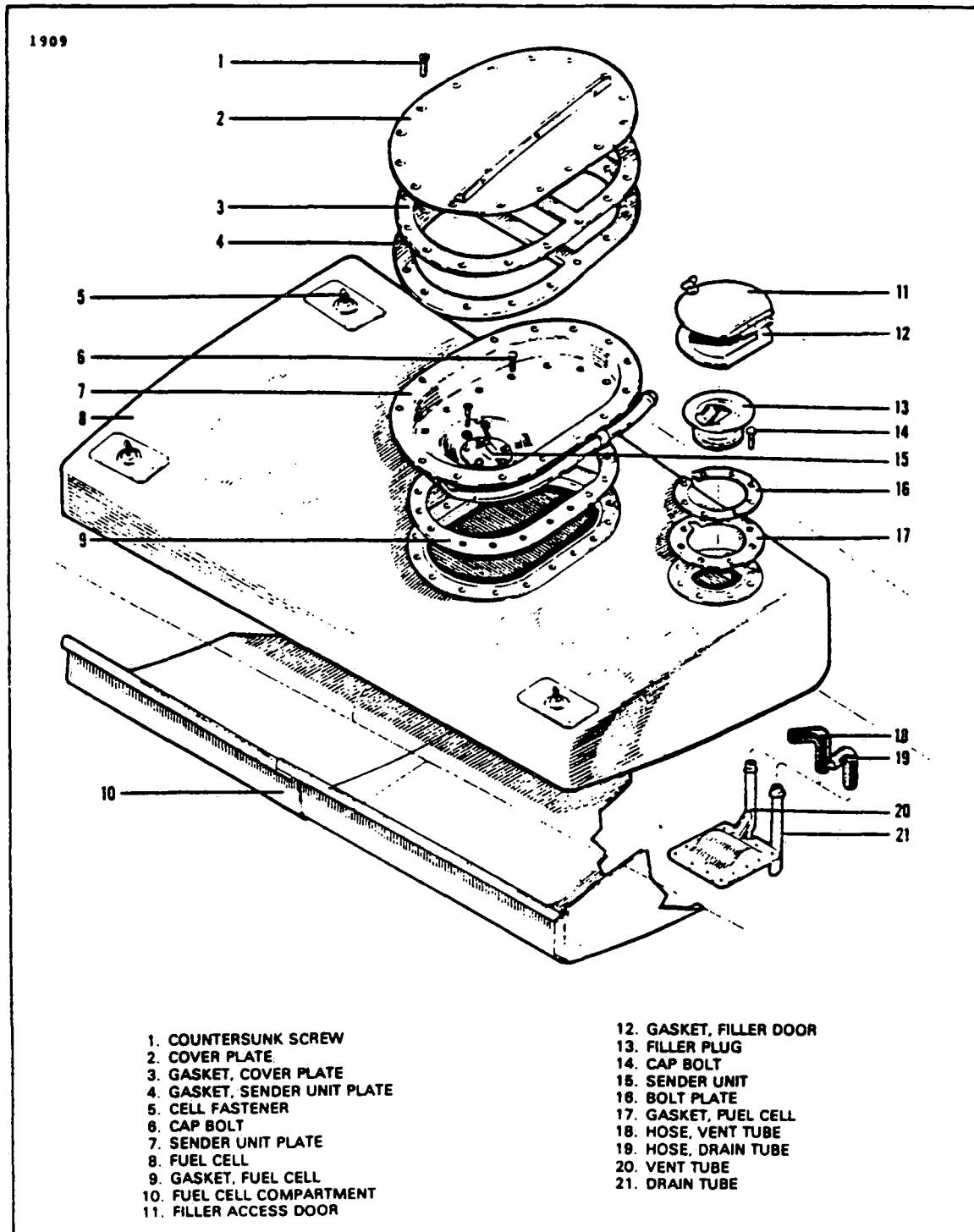


Figure 9-4. Fuel Cell Installation (Auxiliary/Outboard)

9-9. INSTALLATION OF FUEL CELL. (Refer to Figures 9-3 and 9-4.)

- a. Inspect the cell compartment as explained in paragraph 9-7.
- b. Should the cell be in its shipping container, do not remove until ready for installation.
- c. Check to be sure that the cell is warm enough to flex. Do not use sharp tools such as screwdrivers, files, etc. for installation purposes.
- d. Place tape or another protective material over the edges of the elongated access opening to prevent damage to the cell.
- e. Roll the cell into the shape and size which can be inserted through the access opening of the cell compartment.
- f. Unroll the cell and establish correct relationship of the cell to the compartment.
- g. Secure the cell within the compartment by pressing the fasteners (5) into their brackets until they snap lock into place.
- h. Insert the nipple fitting through the hole in the butt rib, slide fuel line into nipple and clamp. Secure the wing fairing with attaching screws. If an auxiliary cell is being installed, insert the nipple through the hole in the cell compartment. Gain access to the nipple through the access hole in the bottom of the wing and insert the fuel line in the nipple and clamp. Reinstall access plate and secure with screws.
- i. If the auxiliary cell is being installed, secure the cell to the filler neck by the following procedure:
  1. Place a gasket (17) between the fuel cell (8) and the bottom of the filler neck.
  2. Place the circular bolt plate (16) on top of the filler neck.
  3. With cap bolts (14) and lockwashers, secure the fuel cell to the filler neck and torque bolts to 25 inch pounds.
  4. Install filler cap (13) and lock in place.
- j. Wipe the inside of the cell clean of all dirt and foreign material with a clean soft lint-free cloth and inspect for cleanliness.
- k. If the old gasket (4) on top of the fuel sender plate (7) is damaged or compressed beyond sealability, replace the gasket and cement a new one in place with No. EC847 3M cement or its equivalent.
- l. Install gasket (9) and sender unit plate on fuel cell and attach with cap bolts (6) and lockwashers.
- m. With gasket (4) cemented to the top of the sender unit plate, pull the plate with fuel cell up to the top wing skin, slide the fuel drain and vent tubes into their hoses (18 and 19) and attach sender plate to top wing skin with two countersunk screws.

- n. Install the remainder of the cap bolts (6) and lockwashers and torque bolts to 25 inch pounds.
- o. Connect electrical wires to sender unit.
- p. Place Presstite tape 1/32 x 1/2, No. 590.5, around the oval opening in the wing skin to take up spaces that the cover plate gasket (3) may not seal.
- q. Cement gasket (3) to cover plate (2) and install over sender unit plate. Secure cover with countersunk screws (1) and install filler plug (13).

#### 9-10. HANDLING AND STORAGE OF FUEL CELLS.

- a. Cells should be removed from the shipping container only at time of installation.
- b. Inspection of the cell and shipping container, after the cell has been removed from the container, should be made for any damage which may have occurred due to crating or removal from crate.
- c. In transporting the cell from storage or inspection, it must not be picked up by the fittings. Under no circumstances should a cell be dragged, nor should cells be stacked, except in their original shipping containers.
- d. Do not allow bladder type cells to remain longer than absolutely necessary in any strong light. When working inside cell, do not allow hot light bulb to come in contact with liner. Fluorescent inspection lights are recommended for use with fuel cells.
- e. When the gasoline is drained from the fuel cell, the plasticizing effect on 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 walls of the cell after the cell has been re-fueled. 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 ten 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.
- f. Cells should be stored only at room temperature and with no more than normal humidity. Cells should not be stored except in their original shipping containers.



9-11. REPAIR OF FUEL CELLS.

CAUTION

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 one inch, are to be repaired in the field.

9-12. REPAIRING 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 two inches from cut in any direction. Buff this material lightly and thoroughly with garnet paper and wash with Methyl ethyl ketone (U.S. Rubber Co. 3339 solution) to remove buffing dust.

2. Cement buffed side to patch with two coats of U.S. Rubber Co. 3230 cement or Minnesota Mining Co. EC-678. Allow each coat to dry 10 to 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 3230 or Minnesota Mining Co. EC-678 cement. Allow each coat to dry 10 to 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 across at a time so as not to trap air between patch and cell. Lay a 50 pound 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 one-half inch with one coat of U.S. Rubber 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 two inches from

cut in any direction. Wash buffing dust off patch with Methylethylketone 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 to 15 minutes.

4. Buff cell area to be patched lightly and thoroughly with fine sandpaper Number 0 and then wash off buffing dust with Methylethylketone 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 to 15 minutes.

6. Freshen cemented area of patch and cemented area of cell with Methylethylketone 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 a 50 pound shot bag to repaired area and do not disturb for six hours.

8. Seal coat patch and one-half inch 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 Number 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. TESTING FUEL CELLS. Either of the following test procedures may be used to detect leaks in the bladder cells.

a. Soap Suds Test.

1. Attach test plates to all fittings.

2. Inflate the cell with air to a pressure of one-quarter psi maximum.

3. Apply a soap and water solution to all repaired areas and any areas suspected of leakage. Bubbles will appear at any point where leakage occurs.

4. After test, remove all plates and wipe soap residue from the exterior of the cell.

b. Chemical Test.

1. Attach test plates to all fitting openings except one.
2. Pour ammonia on an absorbant cloth in the ratio of 3cc per cubic foot of cell capacity. Place the saturated cloth inside the cell and install remaining test plate.
3. Make up a phenolphthalein solution as follows: Add 15 grams phenolphthalein crystals in one-half gallon of alcohol, mix, then add one-half gallon of water.
4. Inflate the cell with air to a pressure of one-quarter psi maximum.
5. Soak a large white cloth in the phenolphthalein solution, wring it out thoroughly, and spread it smoothly on the outer surface of the cell. Press the cloth down to insure detection of minute leaks.
6. Check the cloth for red spots which will indicate a leak. Mark any leaks found and remove the cloth to a new location. Repeat this procedure until the entire exterior surface of the cell has been covered. If red spots appear on the cloth, they may be removed by resoaking the cloth in the solution.
7. The solution and test cloth are satisfactory only as long as they remain clean. Indicator solution that is not in immediate use should be stored in a closed container to prevent evaporation and deterioration.

After the test, remove all plates and test equipment. Allow the cell to air out. In conducting the test outlined above, the cell need not be confined by a cage or jig, providing the one-quarter psi pressure is not exceeded.

NOTE

The chemical test is the more sensitive and preferred test.

9-14. FUEL QUANTITY INDICATING SYSTEM.

9-15. CHECKING AND ADJUSTMENT OF FUEL QUANTITY INDICATING SYSTEM.

- a. General checking of system.
  1. Completely drain the main and auxiliary fuel cells that relate to the gauge that is to be checked. (Refer to Draining Fuel Cells, Section II.)
  2. Level the airplane longitudinally and laterally. (Refer to Leveling, Section II.)
  3. Ascertain that the fuel crossfeed is closed.

4. Connect a 14-volt power supply to the airplane electrical system and observe the fuel quantity gauge. It should read empty with the respective fuel selector lever at both the main and auxiliary ON positions.

5. Add fuel to each cell in the amount of 3.75 U.S. gallons to the auxiliary cell and 7.5 U.S. gallons to the main cell, to bring each cell to one-quarter its full capacity.

6. Again move the selector lever to both ON positions and observe the gauge. At either position the quantity pointer should align with any part of the one-quarter full gauge index.

7. Continue to add fuel in increments of 3.75 and 7.5 U.S. gallons to the auxiliary and main cells respectively for each quarter capacity of the cells. At each quarter increment, until full, check that the quantity pointer aligns with any part of the corresponding index, with the selector lever at either ON position.

8. Should the gauge and the amount of fuel in the cell not correspond, the procedure in steps b thru d may be necessary to isolate the trouble in the system.

b. Sender Check:

1. Remove the fuel sender to be checked. (Refer to Paragraph 9-16.)

2. Secure the sender in the appropriate position on the fabricated jig as shown in Figure 9-5. (The jig may be fabricated from dimensions given in Figure 9-15.)

3. With the float arm against the bottom stop, the float should be just touching the base of the jig. If the float arm is not touching the base of the jig or the bottom stop, adjust the float by bending the arm at a position shown in Figure 9-5.

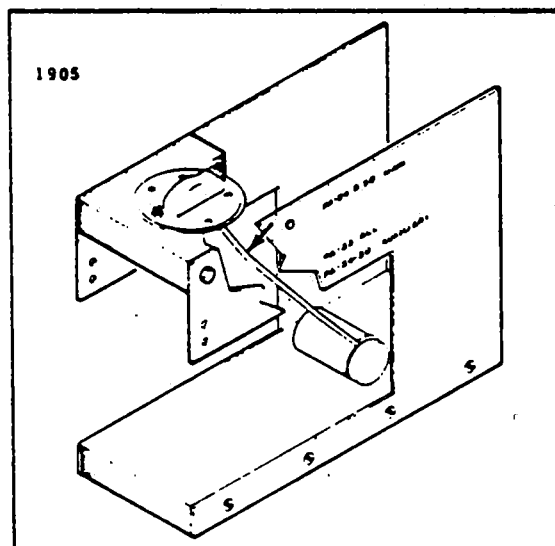


Figure 9-5. Checking Sender Unit

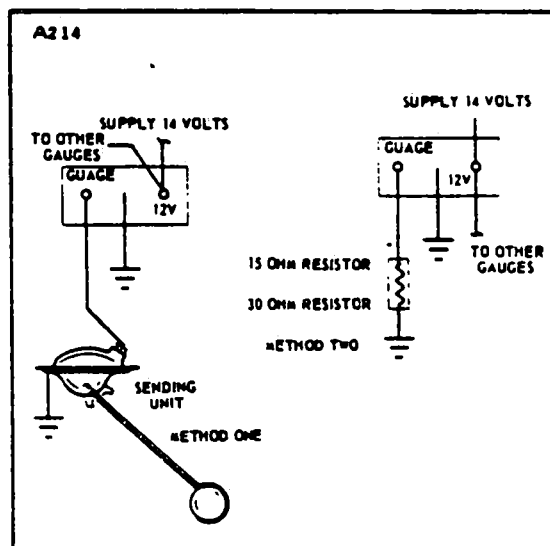


Figure 9-6. Checking Fuel Gauge

4. After the sender has been adjusted, check for the proper amount of resistance by the following procedure:

- (a) Connect an ohmmeter to the sender unit.
- (b) Position the float arm against its bottom stop and ascertain the ohmmeter indicates 0.00 to 0.50 ohms resistance.
- (c) Slowly move the float arm from the bottom stop to the top stop watching the ohmmeter indicator. The ohmmeter needle should steadily move up, without fluctuation, as the float arm is moved.
- (d) With the float arm against its top stop, the ohmmeter should indicate 29.6 to 31.3 ohms resistance.

If incorrect resistance or fluctuation is found, the sender should be replaced.

c. Wiring Check.

1. Check all ground connections throughout the indicating system for corrosion or loose connections that may cause excessive resistance in the circuit.
2. Check all splices and terminal connections for corrosion and security.
3. Check wiring between connections for excessive resistance due to frayed or broken strands.

d. Gauge Check.

1. Sender Method:
  - (a) Position and secure a calibrated sender to the fabricated checking jig.
  - (b) Connect the sender directly to the gauge being checked using Number 16 or larger wire. (Refer to Figure 9-6.)

CAUTION

Make certain the sender resistor is connected to the proper side of the gauge.

- (c) Connect a 14-volt power supply to the electrical system of the airplane.
  - (d) Operate the power supply and move the sender float arm through its travel. Ascertain that the empty and full positions of the sender and the gauge correspond. If not, the gauge should be replaced.
2. Resistor Method:
    - (a) Connect a 15-ohm resistor to the sender unit terminal of the gauge being checked. (Refer to Figure 9-6.)
    - (b) Connect a 14-volt power supply to the electrical system of the airplane.

(c) Operate the power supply and ascertain the gauge indicates one-half full.

(d) Repeat the procedure using a 30-ohm resistor which should cause the gauge to indicate full.

(e) If the gauge does not indicate properly, it should be replaced.

#### 9-16. REMOVAL OF FUEL SENDER.

- a. Remove screws attaching the oval cover plate to the top of the wing.
- b. Disconnect electrical leads from the sender unit.
- c. Remove screws and washers attaching sender to mounting plate and remove sender.

#### 9-17. INSTALLATION OF FUEL SENDER.

- a. Place the sender unit gasket on mounting plate and install sender.
- b. Secure sender to mounting plate with washers and screws.
- c. Connect electrical leads to sender.
- d. Install cover plate and secure with screws.

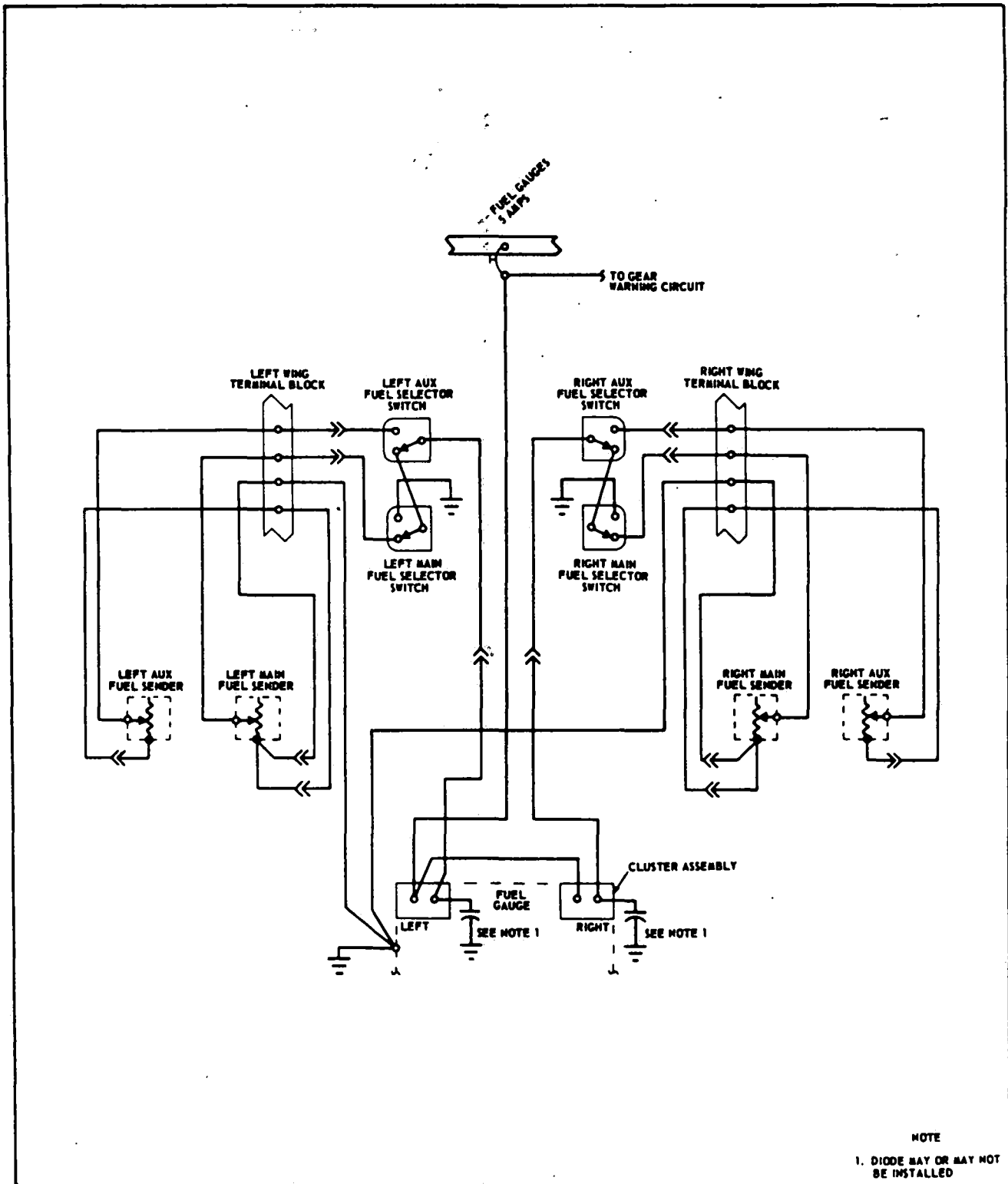


Figure 9-7. Fuel Indicating System Wiring Schematic.

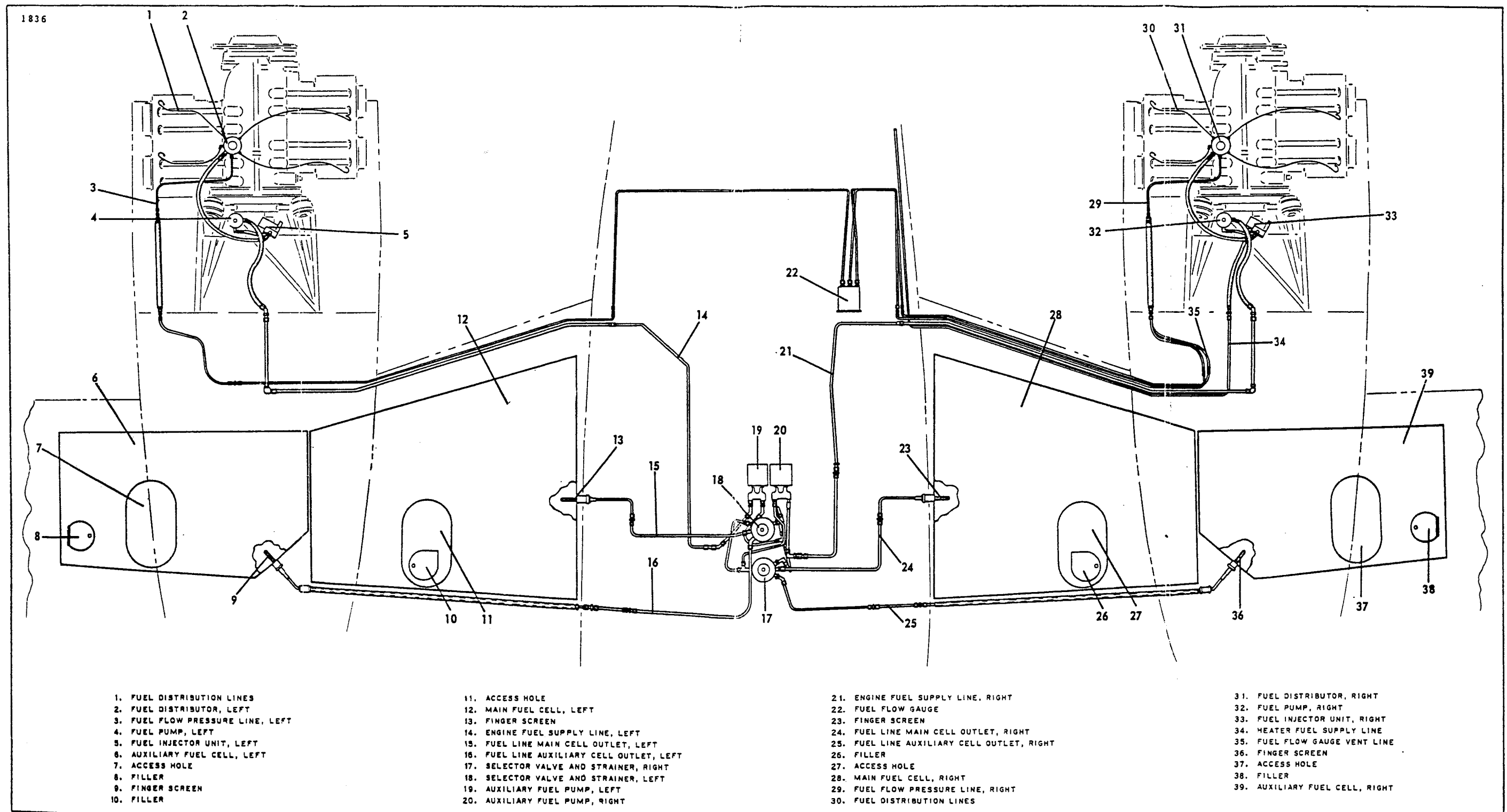


Figure 9-8. Fuel System Installation



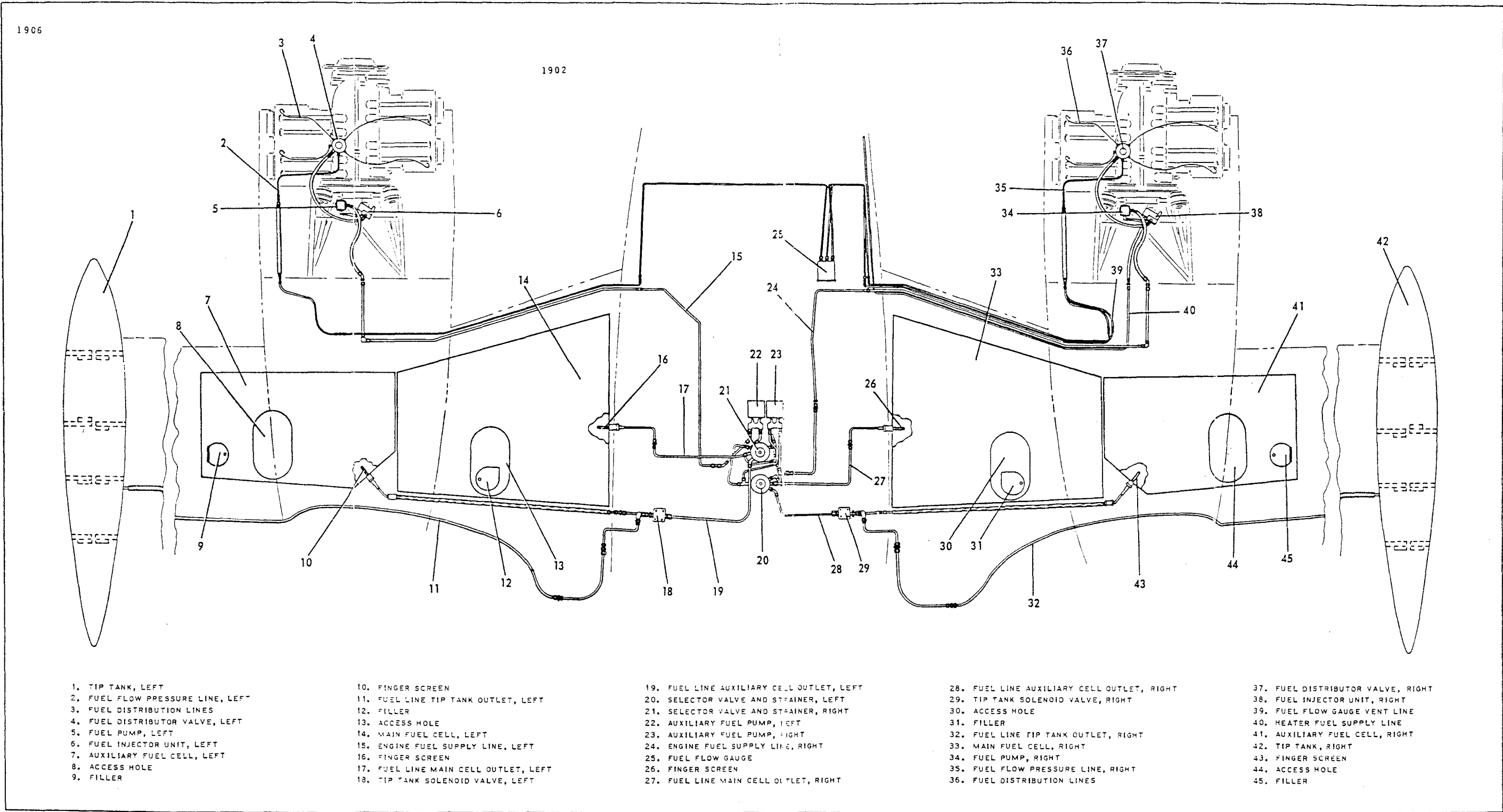


Figure 9-9. Fuel System Installation (Turbo)

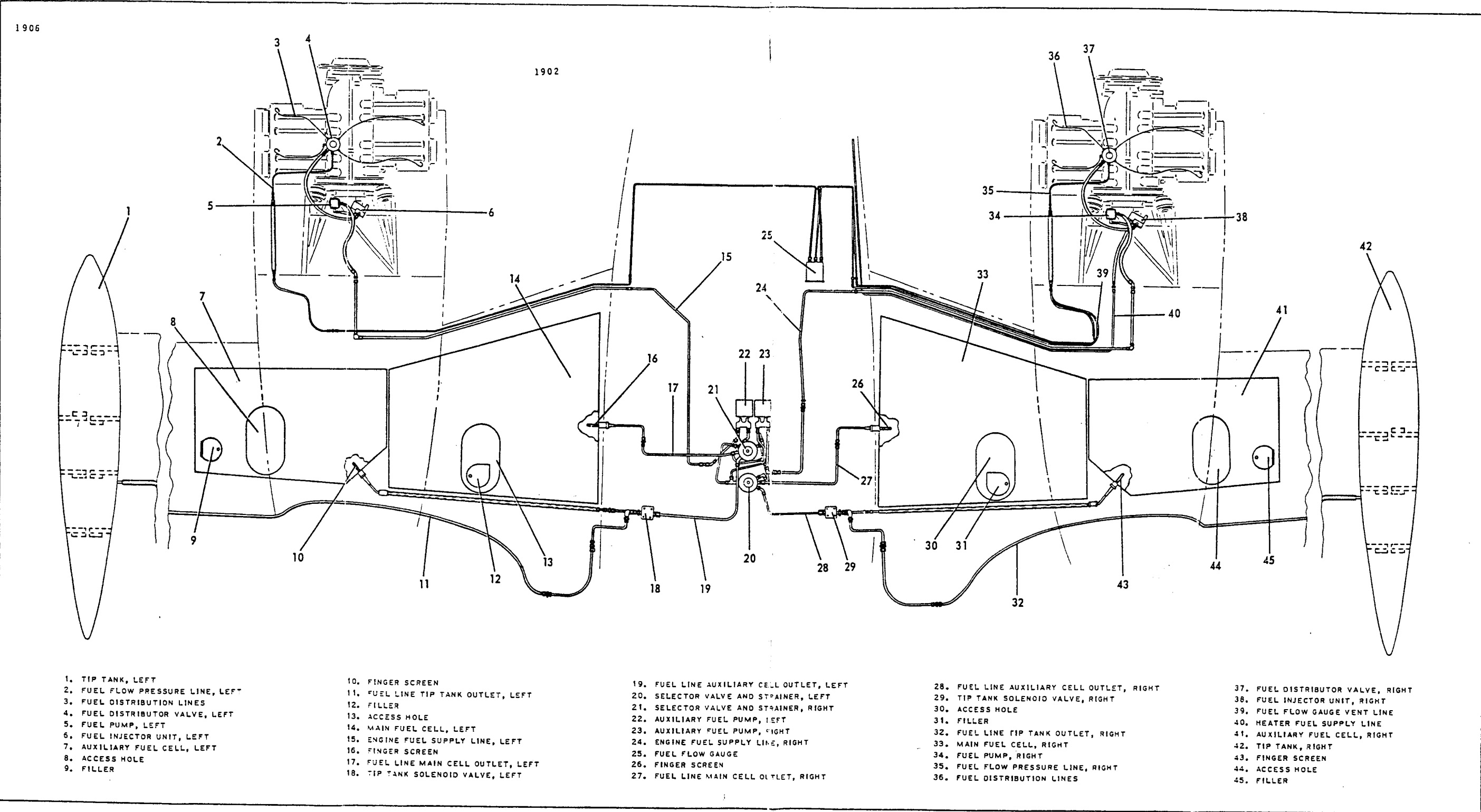


Figure 9-9. Fuel System Installation (Turbo)

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9-18. FUEL SELECTOR VALVES.

9-19. REMOVAL OF FUEL SELECTOR VALVES.

- a. Remove the access panel from the bottom of the fuselage forward of the main spar by removing attaching screws.
- b. Open the selector valve access door located on the cabin floor just aft of the fuel selector control console.
- c. If removing only one fuel valve, turn the other valve to the off position and drain the fuel from the tanks of the one being removed.
- d. If both selector valves are to be removed, drain the fuel from both wings.
- e. Remove the selector valve using the following procedure:
  1. Disconnect the control rod from the valve arm by removing nut, washer and bolt.
  2. Disconnect electrical leads at quick disconnect.
  3. Disconnect all fuel lines at the valve.
  4. Remove the three bolts attaching the valve mounting plate to the floor-board support channel and remove valve through access hole in the bottom of the fuselage.

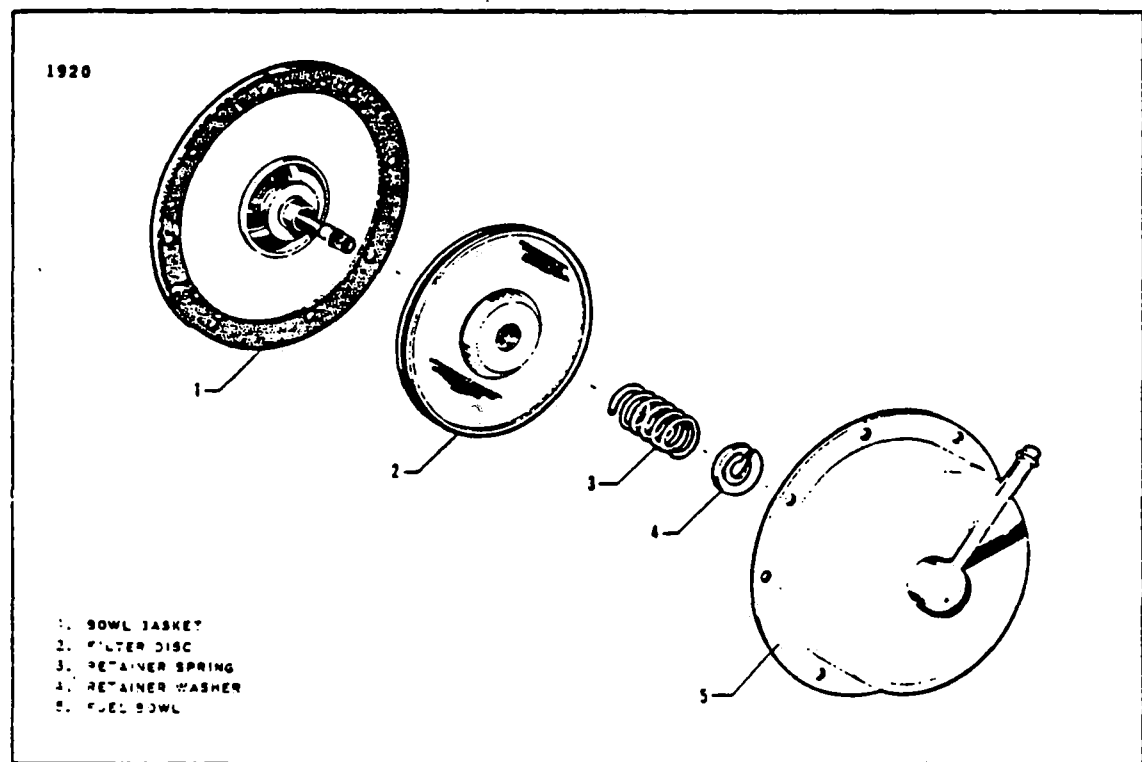


Figure 9-10. Fuel Strainer Assembly

**9-20. CLEANING, INSPECTION AND REPAIR OF FUEL SELECTOR VALVE ASSEMBLY. (Refer to Figure 9-10.)**

- a. Remove the screws securing the fuel bowl (5) and separate the bowl from the valve housing.
- b. Remove the filter disc assembly (2) from stem by compressing filter retainer spring (3) and removing retainer washer (4).
- c. Clean filter by plugging open ends of filter disc to prevent dirt from entering.
- d. Wash the disc with acetone, carbon tetrachloride, trichloroethylene or Bendix cleaner. Heavy dirt, lint or dust deposits may be removed from disc with a soft bristle paint brush.
- e. Drain or blow off cleaning fluid and remove plugs.
- f. Inspect bowl gasket (1) and disc filter for damage and replace if necessary.
- g. Repair is limited to replacement of only those parts offered in the PA-30 Parts Catalog.

**9-21. INSTALLATION OF FUEL SELECTOR VALVE. (Refer to Figure 9-11.)**

- a. Install selector valve through access hole in the bottom of the fuselage and secure valve mounting bracket to the floor support channel with bolts, washers and nuts.
- b. Connect fuel lines to valve assembly.
- c. Connect electrical leads and install shielding over connecting terminals.
- d. Connect the control rod to the valve arm and secure with bolt, washer and nut.
- e. Install access panel on the bottom of the fuselage and secure with screws.
- f. Adjust fuel selector valve. (Refer to Paragraph 9-22.)

**NOTE**

Ascertain that valve handle roll pin lock (furnished in Kit #760 444) is in place before installing fuel selector valve.  
(Refer to Figure 9-12.)

**9-22. ADJUSTMENT OF FUEL SELECTOR VALVES. (Refer to Figure 9-12.)**

- a. With the left fuel selector valve handle in the crossfeed position and the right handle in auxiliary position, adjust right hand linkage so that the valve arm is positively in the detent when the handle is moved to the main position, and just clears the crossfeed link.
- b. Adjust the left hand linkage in a similar manner with the right fuel selector valve handle in the crossfeed position and the left handle in the auxiliary position.
- c. Adjust handle to center in correct hole when valve arm is in mating detent. This should be adjusted as closely as possible.
- d. Turn on the electric fuel pumps and check selector valve for leaks and proper operation.

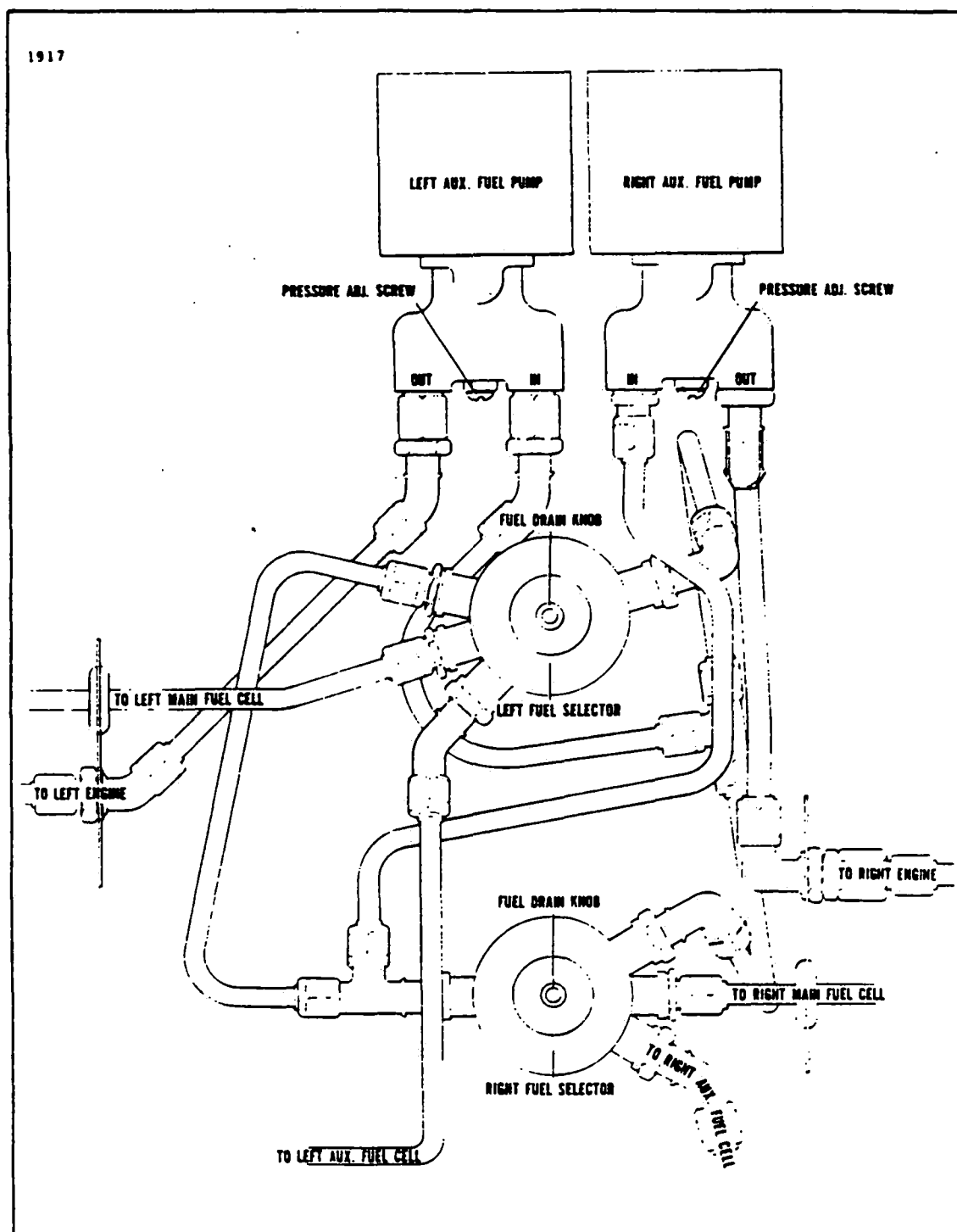


Figure 9-11. Fuel Selector Installation

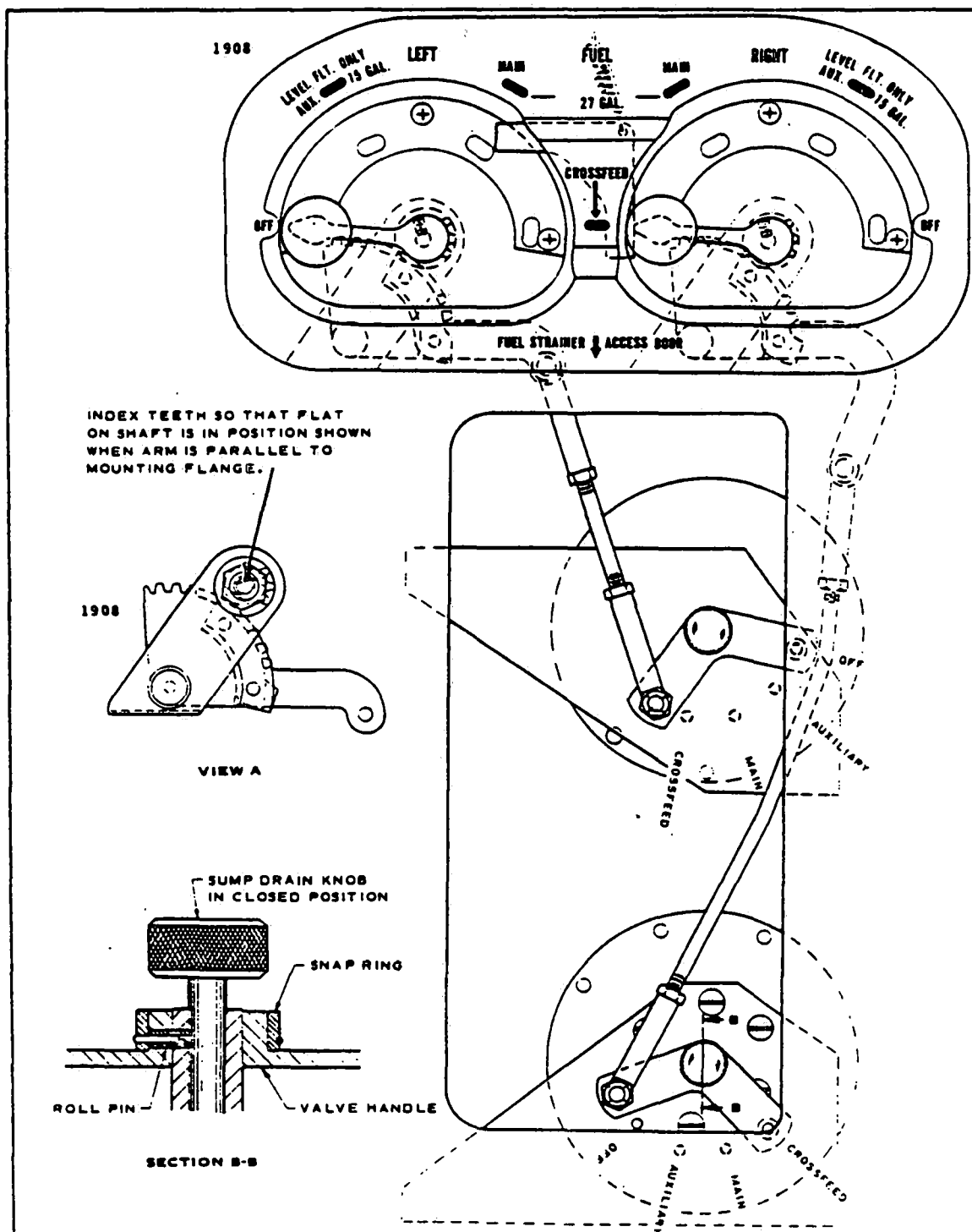


Figure 9-12. Fuel Selector Valve Control Installation

9-23. FUEL SELECTOR ELECTRICAL SWITCHES.

9-24. REMOVAL OF FUEL SELECTOR SWITCHES.

- a. Open the selector valve access door located on the cabin floor just aft of the fuel selector control console.
- b. Remove the access panel from the bottom of the fuselage forward of the main spar by removing attaching screws.
- c. Remove electrical switches from fuel selector valve by removing screw and nut attaching switch bracket to valve assembly.
- d. Remove electrical leads from switch terminals.

9-25. INSTALLATION OF FUEL SELECTOR ELECTRICAL SWITCHES.

- a. Install switches on mounting bracket with attaching screws and nuts.
- b. Solder electrical leads to switch terminals.
- c. Position switch plunger under actuator pin and secure switch bracket to selector valve with screw and nut.
- d. Check for proper operation.
- e. Install access panel on bottom of fuselage.

9-26. ELECTRIC AUXILIARY FUEL PUMP.

9-27. REMOVAL OF ELECTRIC FUEL PUMP. To remove the electric fuel pumps, located beneath the floor panel forward of the fuel selector valves, use the following procedure:

- a. Remove the two front seats and seat tracks.
- b. Remove the seat belts from their brackets on the floor.
- c. Turn the fuel selector valves to the OFF position.
- d. Remove the selector control handles from the control console by loosening the set screws and pulling each handle from its shaft.
- e. Remove the three screws and plate from each selector valve control and remove the cover by unhooking the crossfeed guard link spring.
- f. Roll the carpet back from the spar to the landing gear retraction transmission compartment.
- g. Remove the center access panel located between the retraction transmission and main spar by removing pal nuts and lockwashers from control posts and panel attaching screws.



- h. Remove the access panel on the bottom of the fuselage directly under the fuel selector valves.
- i. Disconnect the control rod from the right control assembly by removing cotter pin, washer and pin.
- j. Remove right control assembly, noting washer on the control handle shaft, by removing attaching screws, washers and nuts.
- k. Disconnect the fuel lines from both fuel pumps and remove the fittings from the left pump.
- l. Turn the fitting on the port marked OUT of the right fuel pump clockwise 90 degrees to facilitate removal.
- m. Disconnect the pump motor ground leads from the floorboard support channel.
- n. Remove the access panel to the right of the fuel pumps and disconnect the pump electrical leads.
- o. Remove the four bolts attaching the fuel pump mounting bracket to the floorboard support channels. Two bolts are located in the fuel selector compartment and two in the landing gear retraction transmission compartment.
- p. Remove pumps and bracket assembly by pulling it up from between the support channels.
- q. Remove pumps from mounting bracket by cutting safety wire and removing attaching bolts.

9-28. DISASSEMBLY, REPAIR AND ASSEMBLY OF FUEL PUMP. (Refer to Figure 9-13.) Overhaul of the fuel pump is not recommended because of special tools required. If overhaul is necessary, the pump should be returned to the Weldon Tool Company, 3000 Woodhill Road, Cleveland, Ohio 44104. However, some minor repairs may be accomplished as follows:

- a. Replacement of shaft seal.
  - 1. Separate the pump end assembly from the motor by removing the four machine screws. Note the relationship of the pump to the motor before separation.
  - 2. The shaft seal is assembled with a light press fit into the insert. It can be pried loose from the insert without disassembly of the pump.
  - 3. Check the shaft for burrs, scratches, or any defects which may cause the seal to wear. Any defect would be a cause for pump replacement.
  - 4. Position a new seal on the shaft and press into place.
  - 5. Assemble the pump end assembly to the motor in the original position and secure with screws and safety.

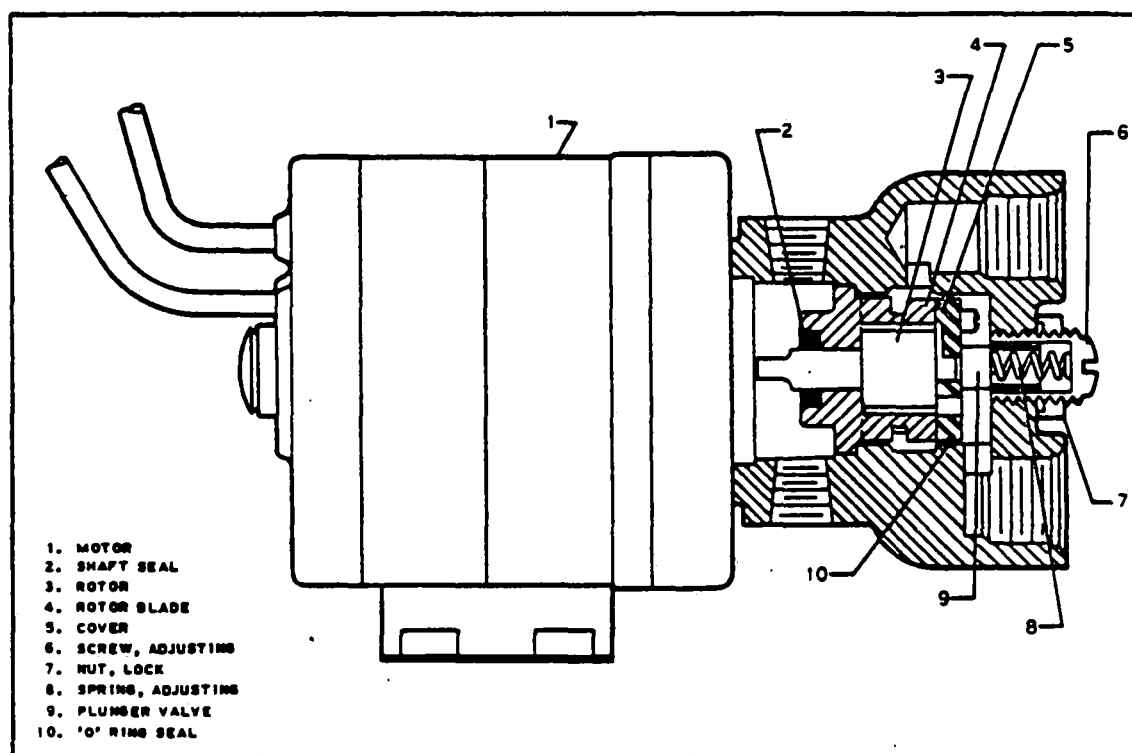


Figure 9-13. Weldon Rotary Fuel Pump

b. Repair of relief valve.

1. Remove the adjusting screw from the pump end assembly. Do not change the position of the jam nut.
2. Remove the valve plunger and spring.
3. Inspect the valve seat, plunger and spring for condition and wear. If the valve seat is damaged, the pump should be replaced.
4. Reassemble the plunger, and spring, and adjusting screw on the pump.
5. Adjust the pump pressure as described in paragraphs 9-30 and 9-31.

9-29. INSTALLATION OF ELECTRIC FUEL PUMP.

- a. Install pumps on mounting bracket and secure each pump with four bolts and safety.
- b. Install the 90 degree fitting on the out port of the right pump and position it pointing toward the port marked in.
- c. Install the pump assembly in the compartment between the fuel selector valves and the landing gear retraction transmission.

- d. Ascertain that grommets are installed between the pump mount bracket and the two support channels at each bolt hole.
- e. Secure the pump assembly to the support channels with bolts.
- f. Connect motor electrical leads and install access panel to the right of the fuel pumps.
- g. Secure the ground wires to the forward support channel with a screw, washer and nut.
- h. Turn the 90 degree fitting so it points down and install the remaining three fittings on the pumps and connect fuel lines.
- i. Install the fuel selector valve control assemblies and secure with screws, washers and nuts. (Refer to Figure 9-12.)
- j. Attach selector control rods to control arm with pin, washer and cotter pin.
- k. Place an AN960-716 washer on the right control handle post only.
- l. Install the center access panel and secure with screws.
- m. Install lockwashers and pal nuts on the control handle posts.
- n. Roll back the carpet and install control cover.
- o. Ascertain that the crossfeed guard link spring is hooked to the bracket on the access panel and secure control cover with plates and six screws.
- p. Install handles on control posts and secure with set screws.
- q. Adjust fuel selector controls. (Refer to Paragraph 9-22.)
- r. Operate fuel pumps and selector valves to insure proper operation and that there are no fuel leaks.
- s. Install access panel on the bottom of the fuselage and secure with screws.
- t. Install seat belts and secure with bolts, washers and nuts.
- u. Install seat tracks and seats.

#### 9-30. ADJUSTMENT OF ELECTRIC FUEL PUMP (BENCH TEST).

- a. Ascertain that the pump is sufficiently lubricated to prevent damage if run dry for a period greater than five minutes.
- b. Connect the electric leads to a 14-volt DC power source.
- c. Using a suitable container with the proper octane fuel, connect a fuel line from a container to the inlet side of the pump.
- d. Connect another line from the outlet side of the pump to a pressure gauge and by-pass valve and back to the container.
- e. Run the pump with the by-pass valve open until a steady flow of fuel is obtained. Then, close the by-pass valve and check the pressure gauge for the proper reading of 26 psig maximum, no flow. Do not keep the by-pass valve closed for more than one minute during pump operation and adjustment.

f. Loosen the locknut and turn the adjusting screw until there is a reading of 26 psig maximum, no flow, on the gauge. Repeat steps e and f until the proper pressure is obtained.

g. Disconnect the power source from the pump and lock the adjustment screw with the locknut. Remove the fuel lines from the pump.

#### 9-31. ADJUSTMENT OF ELECTRIC FUEL PUMP (IN AIRPLANE).

a. With the access panel removed and the fuel selector in the OFF position, remove the fuel line from the outlet end of the pump.

b. Connect a test line with a by-pass valve and pressure gauge to the outlet end of the pump.

c. Place a container below the pump to catch any fuel from the test line during the adjustment of the pump.

d. Turn the fuel selector on, open the by-pass valve on the test line and start the pump.

e. When a steady flow of fuel is obtained, close the by-pass valve and check the reading on the pressure gauge. It should read 26 psig maximum, no flow. Do not keep by-pass valve closed for more than one minute during pump operation and adjustment.

f. Loosen locknut on adjusting screw and turn screw to obtain the proper pressure of 26 psig maximum, no flow. Repeat steps d and e until adjustment is complete. Lock adjusting screw with locknut.

g. Turn off fuel pump and close fuel selector. Remove the test line from the pump.

h. Reconnect the original fuel line to the pump. Open fuel selector and run the pump to check for any fuel leaks.

i. Shut off the pump, close the fuel selector and replace and secure the access panel.

#### 9-32. TIP TANKS.

#### 9-33. REMOVAL OF TIP TANKS.

a. Drain fuel from tank by removing drain plug located in the bottom of tank.

b. Loosen filler cap to aid draining.

c. Remove screws attaching tank to wing tip.

d. Pull tank away from wing enough to disconnect electrical wires and flexible fuel hose.

e. Install drain plug in tank.

**9-34. INSTALLATION OF TIP TANKS.**

- a. Hold the tank up to the wing tip and connect electrical wires to fuel sender gauge and navigation light.
- b. Install clamp on fuel hose and slide hose on tank outlet, tighten clamp.
- c. Slide the tank on wing tip and align screw holes.
- d. Secure tank to wing tip with countersunk screws.

**9-35. TIP TANK SOLENOID VALVE.**

**9-36. REMOVAL OF SOLENOID VALVE.**

- a. Place the fuel selector control to the auxiliary position and drain the auxiliary tank of the wing that the solenoid valve is to be removed.
- b. Remove drain plug from the bottom of the tip tank and drain tank.
- c. Slide the two pilots seats to the forward most position.
- d. Lift the carpet up from the front of the main spar.
- e. Remove the floor shield from in front of the main spar by removing attaching screws.
- f. Disconnect the electrical lead at the quick disconnect terminal.
- g. When the fuel tanks are completely drained, disconnect fuel lines from the solenoid valve.
- h. Remove valve by removing bolt, washer and nut attaching it to the spar.
- i. Install the drain plug in the bottom of the tip tank.

**9-37. CLEANING, INSPECTION AND REPAIR OF SOLENOID VALVE.**

- a. The valve may be flushed with Standard Oil Company stoddard solvent or equivalent. Do not exceed 3 psi during flushing operation.
- b. After flushing, check valve for seal or setting using the following procedure:
  1. Attach a line to the tip tank fuel line connection of the valve and apply stoddard solvent or equivalent at a pressure of 3 psi and check for leaks.
  2. Attach the line to the auxiliary line connection and attach the valve electrical leads to a 12-volt source.
  3. Apply solvent through the line under a pressure of 3 psi and check for leaks.
- c. Overhaul of the valve is not recommended. If overhaul is necessary, the valve should be returned to the Brittain Industries, Inc., 2700 Skypark Drive, Torrance, California 90505.

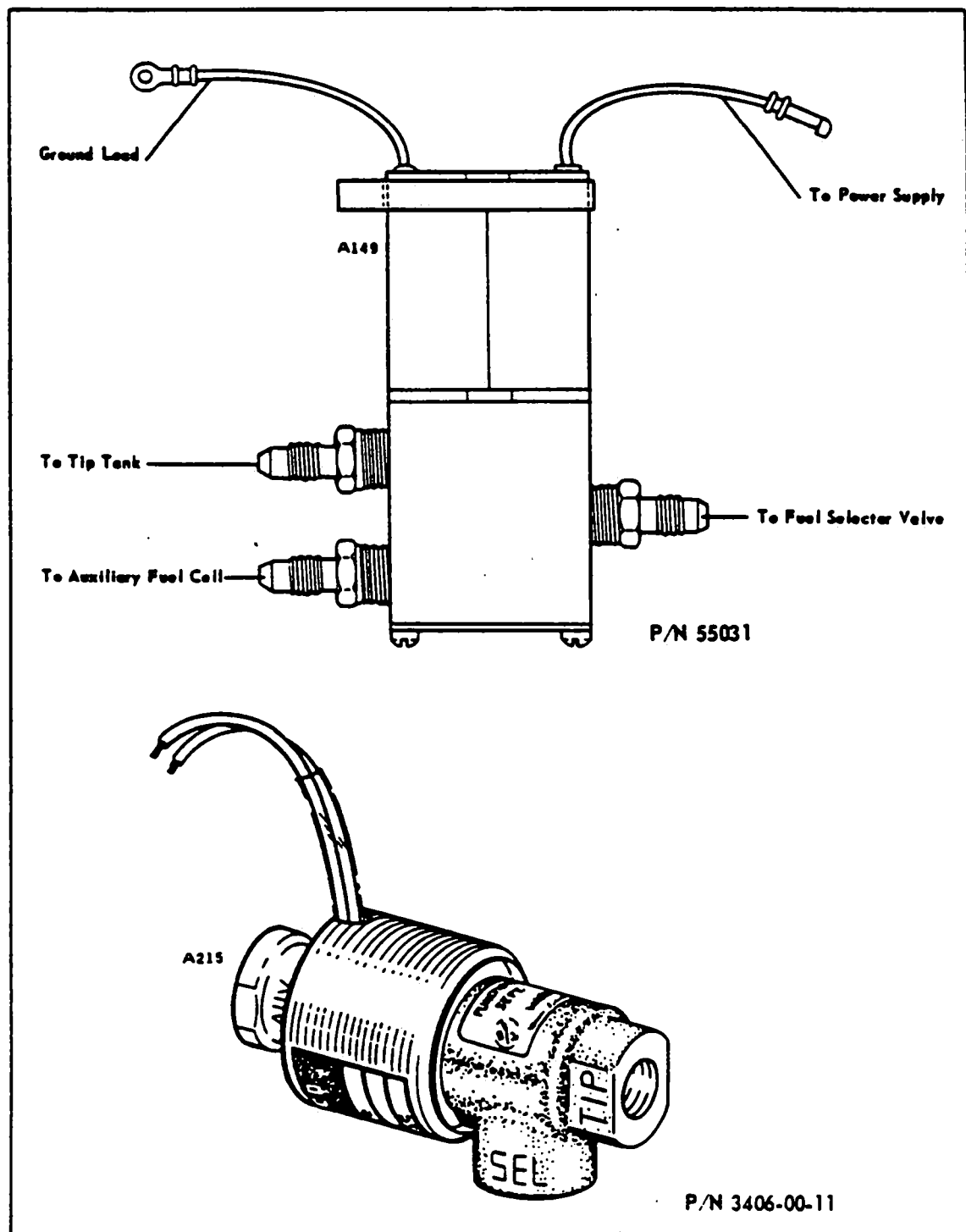


Figure 9-14. Solenoid Valve

**9-38. INSTALLATION OF SOLENOID VALVE.**

- a. Position the valve on the main spar web and secure valve and ground wire with bolt, washer and nut.
- b. Connect fuel lines to valve assembly.
- c. Connect electrical lead and install terminal shielding.
- d. Fill the auxiliary and tip tanks with fuel and operate system to check for leaks and proper operation.
- e. Install floor shield and secure with screws.
- f. Lay the carpet over the spar.

**9-39. CLEANING FUEL SYSTEM.**

- a. To flush fuel tanks and selector valve, disconnect fuel line at the fuel injector unit.
- b. Select a fuel tank, turn on the electric fuel pump and flush fuel through the system until it is determined that there is no dirt and foreign matter in the fuel valve, lines or tank. During this operation, agitation of the fuel within the tank will help pick up and remove any dirt. Repeat this procedure for each tank.
- c. When all tanks are flushed, clean the filter assembly and injector unit inlet screen.

TABLE IX-1. TROUBLESHOOTING CHART (FUEL SYSTEM)

Trouble	Cause	Remedy
Failure of fuel to flow.	Blockage in fuel line.	Flush fuel system
	Failure of mechanical or electrical fuel pump.	Check and replace if necessary.
	Failure of fuel selector to be in proper position.	Check position of selector and adjust if required.
	Damage of fuel selector valve.	Replace fuel valve.
	Dirty fuel strainers and screens.	Clean.
Fuel gauge fails to indicate.	Broken wiring.	Check and repair.
	Gauge not operating.	Replace.
	Float partially or completely filled with fuel.	Replace float.
	Circuit breaker out.	Reset and check.
Fuel gauge indicates full when tanks are not full.	Incomplete ground.	Check ground connections at fuel transmitter in wings.



TABLE IX-1. TROUBLESHOOTING CHART (FUEL SYSTEM) (cont)

Trouble	Cause	Remedy
No fuel flow indication.	Fuel valve stuck.	Check valve.
	No fuel in tanks.	Check fuel, fill.
	Defective fuel pump.	Check pump for pressure build up. Check diaphragm and relief valves in engine pump. Check for obstruction in electric pump. Check by-pass valve. Air leak in intake lines.
	Defective gauge.	Replace gauge.
Fuel flow low or surging.	Obstruction in inlet side of pump.	Trace lines and remove obstruction.
	Faulty by-pass valve.	Replace.
	Faulty diaphragm.	Replace or rebuild pump.
	Dirty fuel strainers and screens.	Clean.
Unidentified leak.	Fuel lines damaged or leaking fitting.	Locate and repair or tighten.
Fuel valve leaks.	Worn "O" rings.	Replace valve.

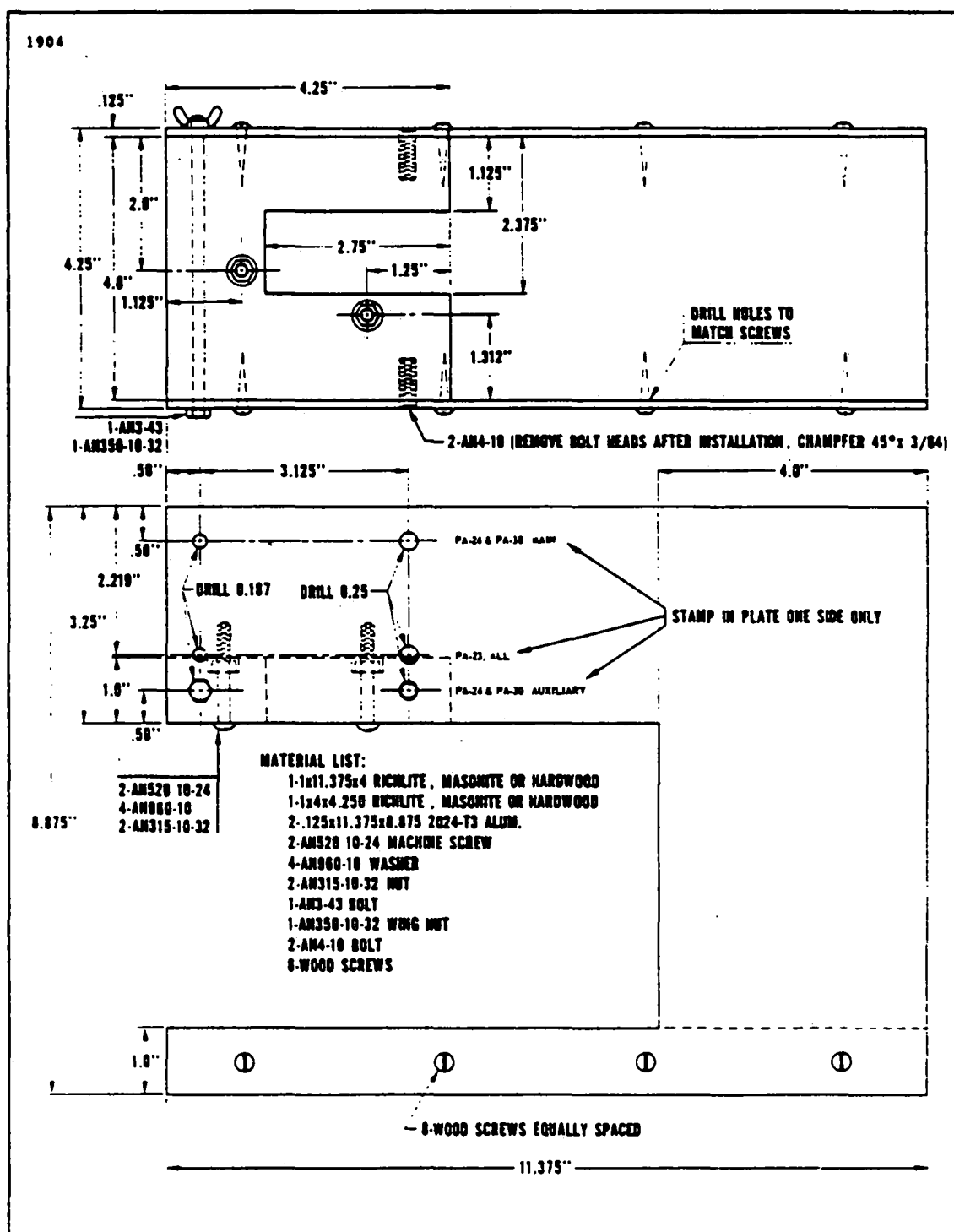


Figure 9-15. Fabricated Fuel Quantity Transmitter Checking Jig

**2 K11**

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**2 K12**

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**2 K13**

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# SECTION X

## INSTRUMENTS

Paragraph		Aerofiche Grid No.
10-1.	Introduction . . . . .	2K15
10-2.	Description . . . . .	2K15
10-3.	Instruments . . . . .	2K19
10-4.	Vacuum Gyro Instruments . . . . .	2K19
10-5.	Pitot Static Instruments . . . . .	2K19
10-6.	Electrical Instruments . . . . .	2K20
10-7.	Miscellaneous Instruments . . . . .	2K21
10-8.	Troubleshooting . . . . .	2K21
10-9.	Removal of Instruments . . . . .	2K21
10-10.	Installation of Instrument . . . . .	2K22
10-11.	Gyro Service Procedure . . . . .	2K22
10-12.	Gyro Installation Inspection . . . . .	2K22
10-13.	Gyro Handling and Shipping . . . . .	2K22
10-14.	Gyro Vacuum System . . . . .	2K23
10-15.	Principal of Operation . . . . .	2K23
10-16.	Removal of Vacuum Pump . . . . .	2K23
10-17.	Installation of Vacuum Pump . . . . .	2K23
10-17a.	Replacing Pump Fittings . . . . .	2K24
10-18.	Removal of Vacuum Manifold . . . . .	2L2
10-19.	Installation of Vacuum Manifold . . . . .	2L2
10-20.	Removal of Vacuum Regulator . . . . .	2L2
10-21.	Installation of Vacuum Regulator . . . . .	2L2
10-22.	Adjustment of Vacuum Regulator . . . . .	2L2
10-23.	Vacuum System Air Filters . . . . .	2L3
10-24.	Replacement of Central Air Filter . . . . .	2L3
10-25.	Replacement of Instrument Air Filters . . . . .	2L3
10-26.	Replacement of Vacuum Regulator Filters . . . . .	2L3
10-27.	Exhaust Gas Temperature Gauge (RADAIR) . . . . .	2L3
10-28.	General . . . . .	2L3
10-29.	Cleaning and Inspection . . . . .	2L3

Revised: 10/6/77

## SECTION X

### INSTRUMENTS

10-1. INTRODUCTION. This section contains procedures for removal and installation of the various instruments and system components installed in the PA-30 Twin Comanche. Also contained in this section is a description of each instrument along with minor adjustments, tests and maintenance. Maintenance, other than described in this section, shall be done by the instrument manufacturer or an authorized repair station.

10-2. DESCRIPTION. The instrumentation of the PA-30 is designed to provide for most all conditions of flight. The instruments give a quick and actual indication of attitude, performance and condition of the airplane. They are divided into four groups: Vacuum Gyro, Pitot-Static, Electrical and Miscellaneous. Some of the instruments are components of indicating systems that indicate conditions at remote parts of the airplane. A few of the instruments, however, are self-contained and merely have to be correctly installed to give an indication. Warning lights are installed to indicate unsatisfactory or dangerous conditions in some systems. Instruments requiring power from the electrical system are provided with circuit breakers to isolate the individual systems in the event of trouble. For night operation, each instrument is individually lighted by shielded post lights or a light incorporated as part of the instrument.

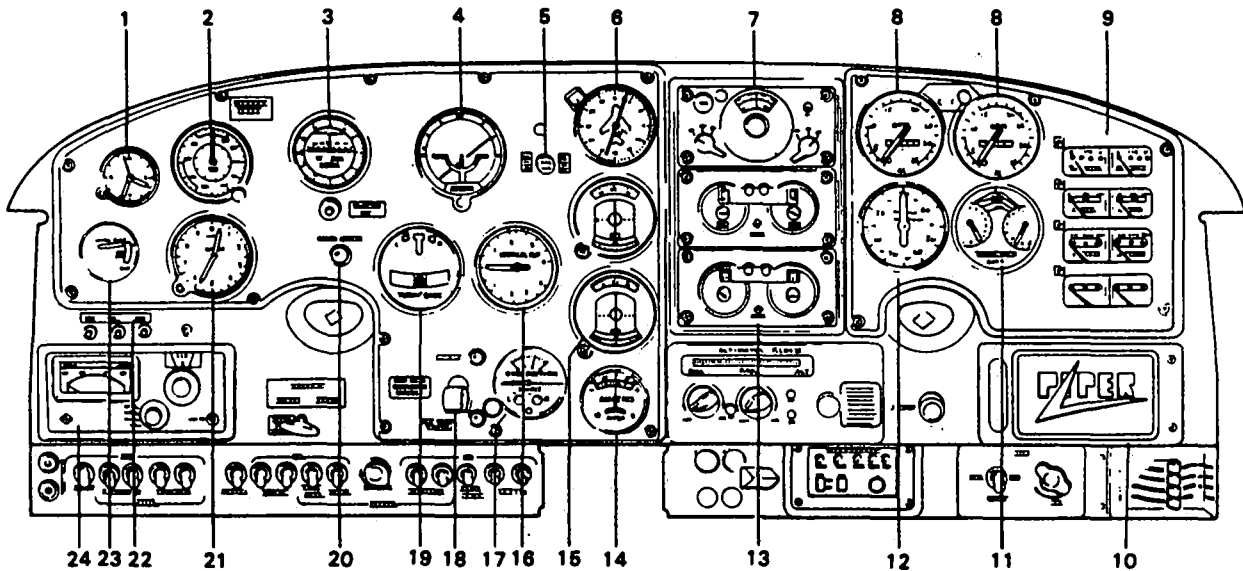
The panel has been arranged to accommodate flight instruments on the left side, in front of the pilot, electronic equipment and some engine instruments in the center, and the remaining engine and miscellaneous instruments to the right. All flight instruments have been shock mounted to minimize vibration and shock.

1912

1. CLOCK
2. AIRSPEED
3. DIRECTIONAL GYRO

4. ARTIFICIAL HORIZON
5. AUTOPILOT
6. ADF INDICATOR

7. ADF RADIO
8. TACHOMETER
9. INSTRUMENT CLUSTER



15. OMNI INDICATOR
16. VERTICAL CLIMB
17. VACUUM GAUGE
18. GEAR CONTROL
19. TURN AND BANK

20. STALL WARNING INDICATOR
21. ALTIMETER
22. MARKER BEACON INDICATOR
23. FLAP POSITION INDICATOR
24. DISTANCE SPEED INDICATOR

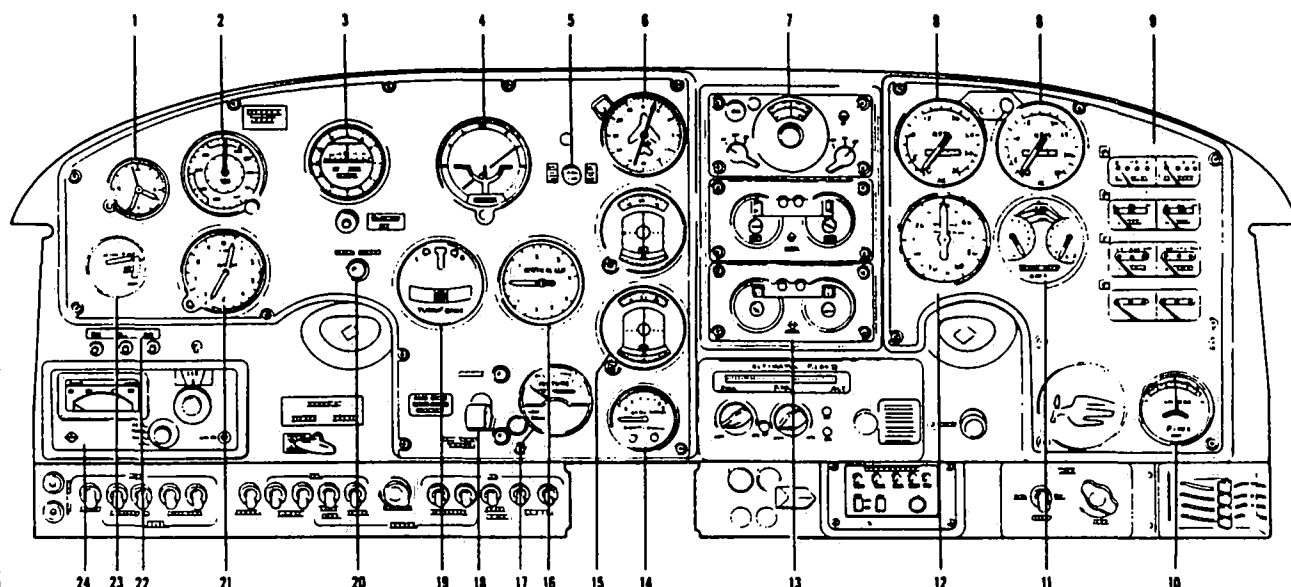
10. GLOVE BOX
11. FUEL FLOW INDICATOR
12. MANIFOLD PRESSURE
13. VHF RADIO
14. AMMETER

Figure 10-1. Instrument Panel  
Serial Nos. 30-1 to 30-852 incl. and 30-854 to 30-901 incl.



1925

- |                     |                       |                       |
|---------------------|-----------------------|-----------------------|
| 1. CLOCK            | 4. ARTIFICIAL HORIZON | 7. ADF RADIO          |
| 2. AIRPSEED         | 5. AUTOPILOT          | 8. TACHOMETER         |
| 3. DIRECTIONAL GYRO | 6. ADF INDICATOR      | 9. INSTRUMENT CLUSTER |



- |                         |                     |                              |
|-------------------------|---------------------|------------------------------|
| 10. AMMETER             | 15. OMNI INDICATOR  | 20. STALL WARNING INDICATOR  |
| 11. FUEL FLOW INDICATOR | 16. VERTICAL CLIMB  | 21. ALTIMETER                |
| 12. MANIFOLD PRESSURE   | 17. MIXTURE MONITOR | 22. MARKER BEACON INDICATOR  |
| 13. VHF RADIO           | 18. GEAR CONTROL    | 23. FLAP POSITION INDICATOR  |
| 14. SUCTION GAUGE       | 19. TURN AND BANK   | 24. DISTANCE/SPEED INDICATOR |

Figure 10-2. Instrument Panel

Serial Nos. 30-853, 30-902 to 30-1716 incl. and 30-1718 to 30-1744 incl.

- |                             |                               |
|-----------------------------|-------------------------------|
| 1. RATE OF TURN INDICATOR   | 26. PARKING BRAKE             |
| 2. AIRSPEED INDICATOR       | 27. POST LIGHTS SWITCH        |
| 3. STALL WARNING LIGHT      | 28. LANDING LIGHT L           |
| 4. GYRO HORIZON             | 29. LANDING LIGHT R           |
| 5. G/S COUPLER LIGHT        | 30. GYRO SUCTION GAUGE        |
| 6. DIRECTIONAL GYRO         | 31. PITOT HEAT                |
| 7. ALTIMETER                | 32. MAP LIGHT SWITCH          |
| 8. RATE OF CLIMB            | 33. AMMETER                   |
| 9. OMNI BEARING SELECTOR    | 34. NAV SELECTOR SWITCH       |
| 10. MARKER BEACON           | 35. LANDING GEAR SELECTOR     |
| 11. TRANSPONDER             | 36. AUTOFLITE                 |
| 12. RADIO SELECTOR PANEL    | 37. ALTERNATOR TEST BUTTONS   |
| 13. ADF RADIO               | 38. MIXTURE CONTROL INDICATOR |
| 14. COMM/NAV TRANSCEIVERS   | 39. FLAP INDICATOR            |
| 15. ALTIMATIC III B         | 40. NAV/APPROACH COUPLER      |
| 16. LEFT TACHOMETER         | 41. FLAP ACTUATOR             |
| 17. MANIFOLD PRESSURE GAUGE | 42. RUDDER TRIM               |
| 18. RIGHT TACHOMETER        | 43. ALTERNATE AIR L - R       |
| 19. FUEL FLOW INDICATOR     | 44. COWL FLAPS L - R          |
| 20. FUEL AND ENGINE GAUGES  | 45. ALTERNATOR SWITCHES       |
| 21. DME                     | 46. OXYGEN CONTROL            |
| 22. MASTER SWITCH           | 47. LIGHTER                   |
| 23. VOLT. REG. SEL. SWITCH  | 48. CIRCUIT BREAKER PANEL     |
| 24. NAV LIGHTS              | 49. CABIN HEAT CONTROLS       |
| 25. ROTATING BEACON         | 50. DEFROSTER CONTROL         |

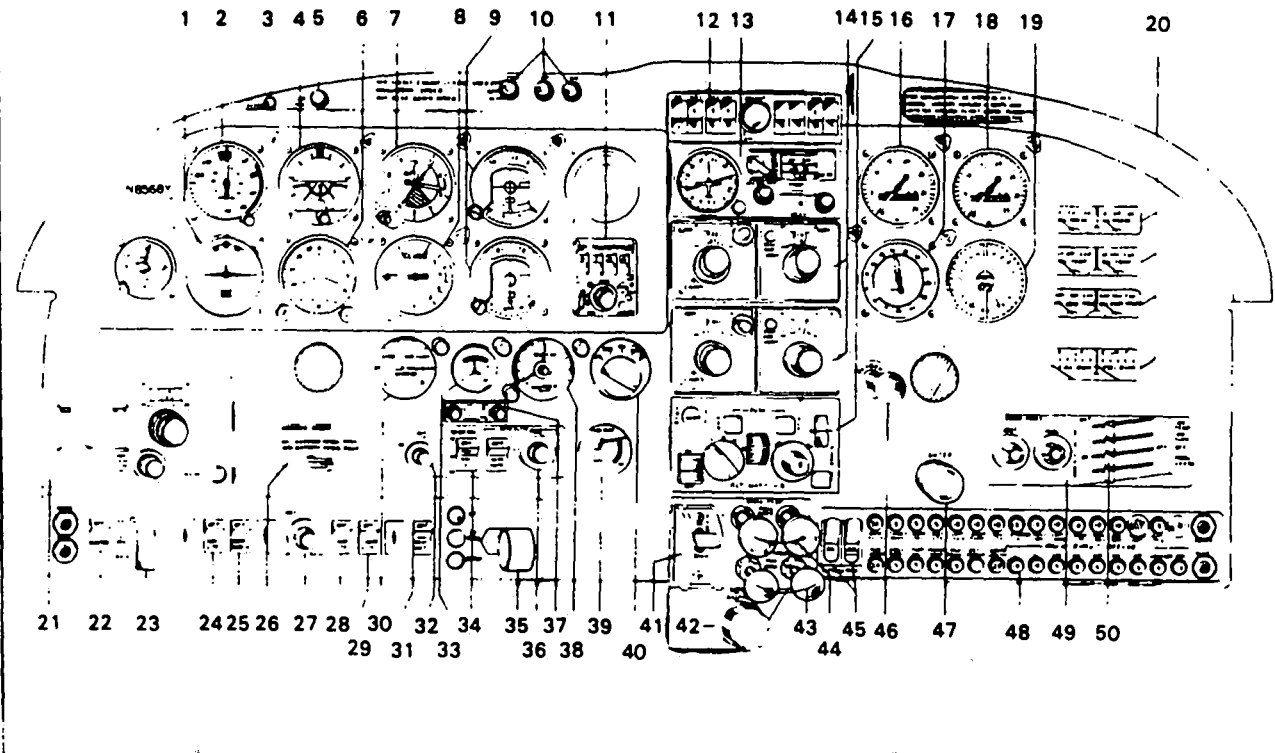


Figure 10-3. Instrument Panel  
Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

### 10-3. INSTRUMENTS.

10-4. VACUUM GYRO INSTRUMENTS. The directional gyro is a flight instrument incorporating an air driven gyro stabilized in the vertical plane. The gyro is rotated at a high rate of speed by air which enters the instrument against the gyro buckets. Air from the instrument is routed through lines to the vacuum pump located on the engine. Due to gyroscopic inertia, the spin axis continues to point in the same direction even though the airplane yaws to the right or left. This relative motion between the gyro and the instrument case is shown on the instrument dial which has a 360 degree direct reading. The dial, when set to agree with the airplane magnetic compass, provides a positive indication free from swing and turning error.

The attitude gyro is essentially an air driven gyroscope rotating in a horizontal plane and is operated by the same principle as the directional gyro. Because of the gyroscopic inertia, the spin axis continues to point in the vertical direction, providing a constant visual reference to the attitude 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 vacuum gauge indicates system vacuum at the attitude gyro. The gauge will also indicate an inoperative vacuum pump by a red left or right indicator button which becomes visible against the vacuum gauge glass.

10-5. PITOT-STATIC INSTRUMENTS. 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 (pressure) 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 move. 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 speed of the airplane.

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 thousands of feet and the shorter pointer in ten thousand feet. A field pressure window is located on the right side of the in-

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 moves, causing the pointers to move through the mechanical linkage.

The rate of climb indicator measures the rate of change in static pressure when the airplane is ascending 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.

**10-6. ELECTRICAL INSTRUMENT.** The turn and bank indicator is an instrument operated electrically and is 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 ammeter will indicate the electrical output-input of the battery. On serial numbers 30-1717, 30-1745 and up, the ammeter is also equipped with two selector switches which enables an independent output check of each alternator.

The two fuel quantity gauges are calibrated in fractional divisions of one-fourth, one-half, three-fourths and full. Dual transmitter units are installed in series 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. 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 fuel level of the cell last selected.

The dual exhaust temperature gauge indicates, in degrees Fahrenheit, the temperature of the exhaust gases as they pass through the exhaust stack of each engine. The sender unit for this instrument is a thermocouple type probe installed in the exhaust stack. (See Figure 10-5)

The oil pressure, oil temperature and cylinder head temperature is a combination gauge, each a complete unit within itself. The oil pressure unit (non-electrical) is connected to the pressurized oil passage of its respective engine. The oil temperature and cylinder head temperatures utilize a ratiometer to control each unit, both of which are connected with the airplane electrical system. The wing flap indicator is a separate instrument with its respective rheostat type sender unit.

10-7. MISCELLANEOUS INSTRUMENTS. The magnetic compass installed in the PA-30 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 above the compass.

The clock is a hand wound, 8-day timepiece. It incorporates a stem wind with the knob at the lower left hand side of the dial. This knob, when pulled and turned, also adjusts the hands. In addition, two dummy hands are controlled by a center knob and they function as elapsed time hands.

The two tachometers provide an indication of crankshaft speed in revolutions per minute for each engine. The tachometers connect to each engine accessory section by flexible drive cables. The drive operates a magnetic drag mechanism that gives smooth operation, practically eliminating all pointer oscillation.

The dual manifold pressure gauge is a direct reading pressure instrument that indicates manifold pressure graduated in inches of mercury. As the pressure in the intake manifolds increases or decreases, the evacuated diaphragms contract or expand, moving the respective pointers through a mechanical linkage.

The dual fuel flow instrument is a differential pressure gauge comprised of diaphragm sensing units with sector and pinion movement to amplify diaphragm movement. The gauge indicates fuel pressure in pounds per square inch by measuring differential pressure between the injector inlet versus deck pressure.

10-8. TROUBLESHOOTING. For troubleshooting of the vacuum system, refer to Table X-I; for various instruments, refer to Table X-II in this section.

10-9. REMOVAL OF INSTRUMENTS. All instruments are mounted in a similar manner and can be removed by the following procedure:

- a. Remove the instrument access panel located on top of the instrument panel by removing attaching screws and lifting it from panel.
- b. If a Royalite cover panel is installed, remove attaching screws and pull it away from instrument panel. The post light electrical leads may be disconnected at quick disconnect terminals, if necessary.
- c. Disconnect the plumbing and/or electrical leads from the back of the instrument. Where two or more lines connect to an instrument, identify each line to facilitate reinstallation. Attach a dust cap or plug to the instrument and line fittings.
- d. Remove the screws that secure the instrument to the panel.
- e. Remove the instrument from the panel.

**10-10. INSTALLATION OF INSTRUMENT.**

- a. Place instrument in its panel cutout and secure with screws.
- b. Connect the plumbing and/or electrical leads to the back of the instrument.
- c. If a Royalite cover panel is installed, connect post light electrical leads and secure cover to instrument panel with screws.
- d. Install the instrument access panel on top of the instrument panel and secure with screws.

**10-11. GYRO SERVICE PROCEDURE.**

**10-12. GYRO INSTALLATION INSPECTION.** The following inspections should be made before removing a suspected gyro instrument from the airplane:

- a. Visual Examination:
  1. Has the instrument been modified?
  2. Has the instrument been damaged?
  3. Does the instrument show any signs of abuse?
- b. Installation Inspection:
  1. Are all pressure and static lines free from bends, restrictions or leaks?
  2. Has the central air filter been replaced?
  3. Is the instrument properly mounted in the panel?
  4. Does the instrument physically touch other instruments, tubing or airframe members when the engines are started or stopped?
  5. Are unused ports correctly sealed against air leaks?
  6. Is the system pressure correct, and does the pressure gauge give an accurate reading?
  7. Is the pressure regulator adjusted correctly and functioning properly?

**10-13. GYRO HANDLING AND SHIPPING.** The following information applies to all three inch directional gyros and attitude horizon instruments installed by the factory or a Piper field service facility.

Gyro instruments being returned to the factory are to be placed in approved containers with all ports properly sealed immediately after removal from the aircraft instrument panel. The instrument must also be accompanied by factory copies of the warranty and credit claim forms. These forms and the special containers should be available at any Piper Dealer and/or Distributor. Should any gyro instrument be received by the factory in an unapproved container or if the ports are not sealed, the warranty will be immediately voided and the instrument returned to the sender. The instrument must be returned immediately after removal from the aircraft (not to exceed 15 days following discovery of defect).

#### 10-14. GYRO VACUUM SYSTEM.

**10-15. PRINCIPAL OF OPERATION.** The PA-30 gyro vacuum system is comprised of two rotary vane, positive displacement vacuum pumps, two regulating valves, two check valves, a manifold assembly, a central air filter, a suction gauge and necessary tubing and fittings.

Due to suction from the vacuum pumps, air enters the central air filter, located on the forward cabin bulkhead, and passes over the instrument gyros causing them to turn. The air is then routed to the vacuum manifold where it enters two individual systems each having its own check valve, regulator and vacuum pump.

The check valve in each system at the vacuum manifold permits air to move in only one direction, from the instrument toward the pump. If one system pump fails, its check valve will close preventing the operative pump from drawing air through the inoperative system.

The system regulators located on the aft side of each fire wall allow air to enter the line to the pumps, preventing system vacuum from exceeding the operating limits.

The vacuum pumps located on each engine accessory housing draw air through the system, causing the gyro instruments to operate.

The suction gauge indicates the amount of vacuum at the attitude gyro as created by the engine driven vacuum pump. Also included in the gauge are a right and left indicator button which become visible when the corresponding pump is inoperative.

#### 10-16. REMOVAL OF VACUUM PUMP.

- a. Release fasteners and remove the two side access panels from the engine nacelle.
- b. Remove screws that secure the top cowl and remove top cowl.
- c. Disconnect hoses from the vacuum pump by removing spring clamps.
- d. Cap vacuum hose to prevent contamination.
- e. Remove the vacuum pump mounting stud, nuts and washers. It will be necessary to pull the pump aft as the nuts are being removed before the nuts can be completely removed.

#### 10-17. INSTALLATION OF VACUUM PUMP.

- a. Clean the mounting pad thoroughly and install pump gasket.
- b. Align the splines on the pump shaft with the engine drive and slide the pump into position.
- c. With the vacuum pump in position, slide the pump aft enough to install washers and start mounting nuts. Torque nuts evenly.
- d. Remove cap, if installed, from vacuum hose.
- e. Connect hoses to pump and secure with spring clamps.
- f. Install cowling securing the top cowl with screws and the side panels with quarter turn fasteners.

**10-17a. REPLACING PUMP FITTINGS.**

a. The handling procedures for securing the pump while installing or removing fittings are as follows:

1. Use two soft wood blocks in a vise to protect pump from vise jaws.
2. The pump square mounting flange must be held between the wood blocks at right angles to the vise jaws. (Refer to Figure 10-3a.)
3. Use only enough vise pressure to hold pump firmly.

**CAUTION**

Do not apply vise pressure to outside diameter or overall length of the pump.

b. Thread lubricant, if required, should be applied sparingly to the external threads of the fitting only. Use a powdered moly sulfide or graphite in dry form or in an evaporating vehicle, or employ a silicone spray.

**CAUTION**

Do not use pipe tape, thread dope, hydrocarbon oil or grease, as these can contaminate pump and cause malfunction.

c. Use the following steps for fitting installation:

1. Secure pump as noted above.
2. Insert fittings in pump ports and hand tighten firmly.
3. Using a wrench, tighten each fitting from one-half to two additional turns.

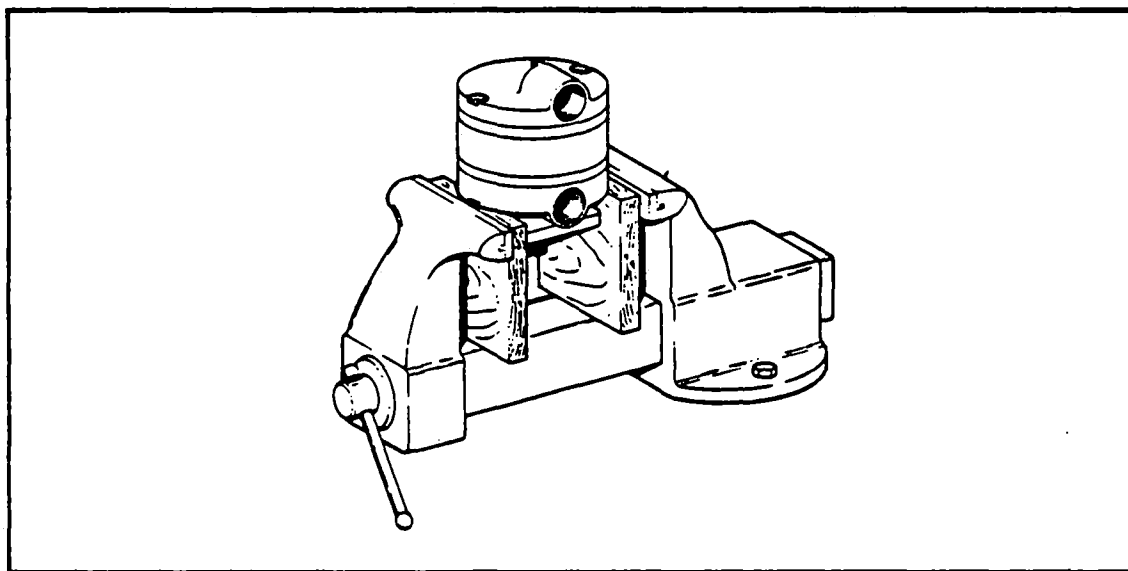


Figure 10-3a. Securing Pump

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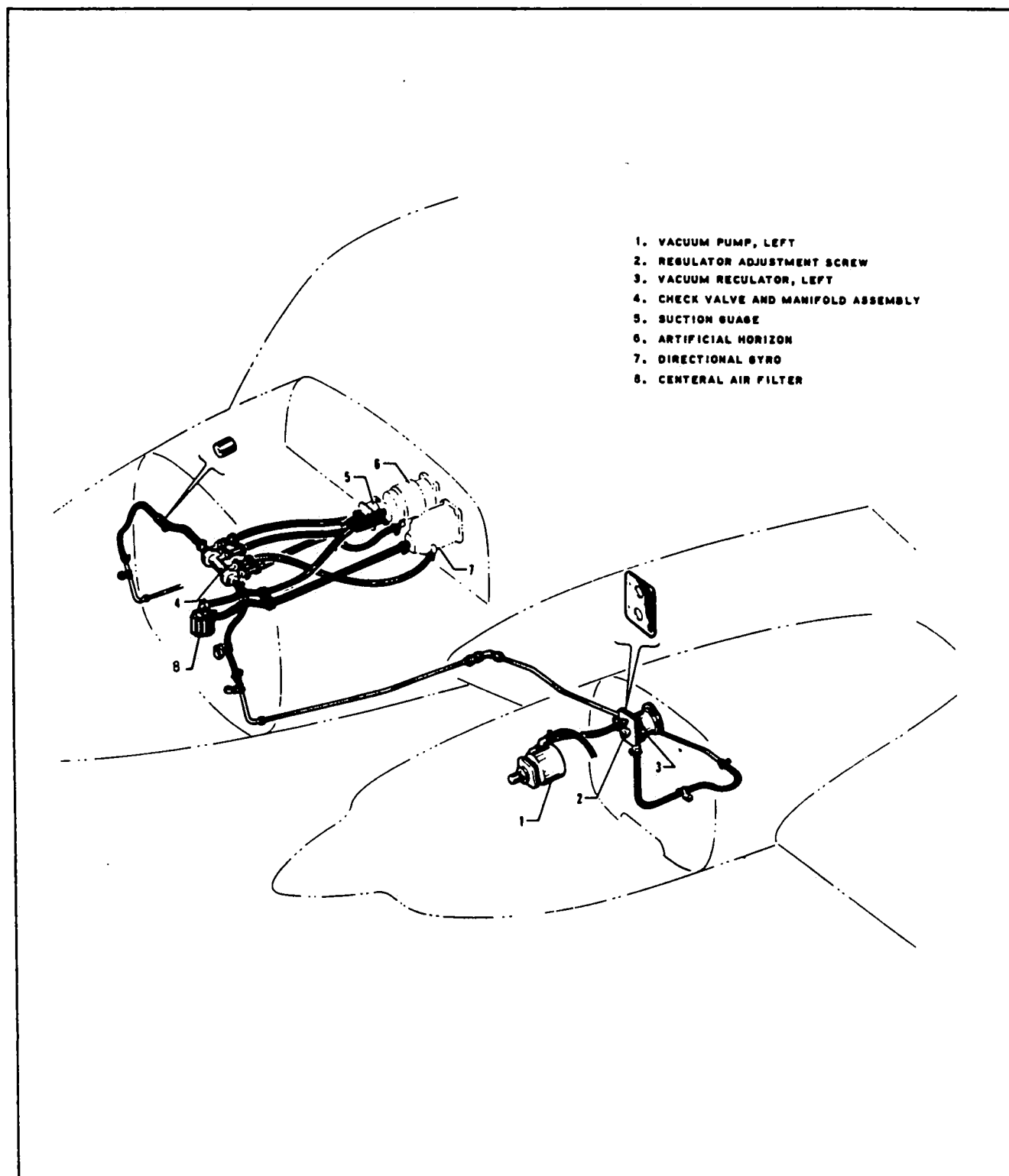


Figure 10-4. Vacuum System Installation

**10-18. REMOVAL OF VACUUM MANIFOLD.**

- a. Remove top nose access panel by loosening the quarter turn fasteners.
- b. Remove vacuum manifold by removing the spring clamps and hoses.
- c. Plug or cap the hoses to prevent contamination.

**10-19. INSTALLATION OF VACUUM MANIFOLD.**

- a. Position the manifold in place at the forward cabin bulkhead and connect vacuum hoses securing them with spring clamps.
- b. Install top nose access panel and secure with quarter turn fasteners.

**10-20. REMOVAL OF VACUUM REGULATOR.**

- a. Remove the side access panels from engine nacelle.
- b. Remove the access panel from top of engine nacelle just aft of the firewall.
- c. Disconnect vacuum hoses from regulator by removing spring clamps. One hose is located in front of the firewall and one aft of the firewall.
- d. Cap hoses to prevent contamination.
- e. Remove the four screws and nuts attaching the regulator to firewall and remove regulator.

**10-21. INSTALLATION OF VACUUM REGULATOR.**

- a. Position regulator back of the firewall and insert tube fitting and adjustment screw through firewall.
- b. Place placard plate and gasket over tube fitting and adjusting screw. Secure assembly to firewall with screws and nuts.
- c. Connect vacuum hoses to regulator fittings and secure with spring clamps.
- d. Install nacelle access panel and side access panels.

**10-22. ADJUSTMENT OF VACUUM REGULATOR.**

- a. With a qualified pilot or other responsible person at the controls, start engine on same side as regulator to be adjusted and allow time for warm up.
- b. With the engine running at medium RPM, the vacuum gauge should indicate between 4.8 to 5.1 inches of mercury. If the vacuum reading fails to fall within this range, shut down the engine and adjust relief valve by loosening the jam nut from valve adjusting screw located on the firewall. Move the valve adjusting screw clockwise to increase the vacuum and counterclockwise to decrease the vacuum.
- c. Start the engine and repeat the check.
- d. When regulator is adjusted properly, tighten jam nut and repeat the check.
- e. Repeat the above procedure for the opposite engine.

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### 10-23. VACUUM SYSTEM AIR FILTERS.

10-24. REPLACEMENT OF CENTRAL AIR FILTER. After each 100 hours of operation, the central air filter, located just forward of the forward cabin bulkhead, should be replaced.

- a. Remove top nose access panel by loosening quarter turn fasteners.
- b. Remove vacuum hoses from filter by removing spring clamps.
- c. Remove nut from stud attaching filter to mounting bracket.

10-25. REPLACEMENT OF INSTRUMENT AIR FILTERS. Remove the filter assembly and replace during the 500 hour inspection of the airplane.

- a. Remove screws attaching air inlet plate to back of instrument.
- b. Remove snap ring that holds the filter in place and remove filter.
- c. Install new filter in adapter and secure with snap ring.
- d. Install air inlet plate to back of instrument and secure with screws.

10-26. REPLACEMENT OF VACUUM REGULATOR FILTERS. After each 100 hours of operation, the regulator filters located aft of the firewall in each engine nacelle, should be replaced.

- a. Remove top access panel from each engine nacelle.
- b. Remove filter from around the regulator and replace with new one.
- c. Install top nacelle access panels and secure with screws.

### 10-27. EXHAUST GAS TEMPERATURE GAUGE (RADAIR).

10-28. GENERAL. This dual instrument, which is commonly referred to as EGT, is used to aid the pilot in setting the most economical fuel-air mixture for cruising flight at a power setting 75% or less. It is a sensing device to monitor the temperature of exhaust gases leaving the engine cylinders. If it is found defective after checking with the troubleshooting chart, it should be replaced. If the leads to the gauge are defective in any way, they must be replaced. When replacing leads, it is necessary to use the same type and length of wire, because the resistance of the leads is critical for the proper operation of this gauge. When troubleshooting this instrument be certain the system being checked coincides with the system on the indicator.

10-29. CLEANING AND INSPECTION. If mechanical damages other than broken glass, bent or broken pointer or broken case are evident, the following checks should be performed before removing the instrument:

- a. The thermocouple probe should be removed and cleaned at each 100 hour inspection. This will insure good and rapid response to temperature changes. The following procedure should be used:
  1. Detach the thermocouple leads from the extension lead if necessary. (Do not detach if the probe can be removed and cleaned with leads attached.) (Refer to Figure 10-5.)

2. Unscrew the attaching clamp and with leverage applied to the CLAMP ONLY, lift out the thermocouple assembly very carefully from the manifold. (Do not attempt to pull the thermocouple by squeezing the spacer washers with vice-grip pliers.)
3. Clean probe with solvent and check for broken weld at tip end or burned off end.
4. Replace the assembly carefully and retighten the clamp. If leads are disconnected, reconnect them using a new pair of Thomas and Betts "Sta-Kon" connectors, make certain connections are tight.
  - b. Examine the extension lead wires for any evidence of chafing on sharp edges. This could cause erratic fluctuation of the EGT indicator.
  - c. Ascertain that the connectors which mate the extension leads to the thermocouple are properly seated. Poor contact may cause indicator fluctuation also.

### CAUTIONS

1. DO NOT cut off any access lead wire from the thermocouple to the indicator, at any time. This will cause the system to be inaccurate.
2. NEVER attempt to check indicator operation or resistance with an ohmmeter. A special bridge is required which is accurate and will not damage the instrument.
3. DO NOT attempt to adjust the indicator. The system was accurately calibrated at the factory.

### NOTE

Local instrument shops can replace broken glass in the bezel and check operation and calibration of the indicator. It is recommended that the indicator be returned to Radair for re-calibration.

- d. If trouble still exists after making the above checks, REMOVE the leads from the indicator and using an ohmmeter check the extension cables and thermocouple for the following:

PROBE RESISTANCE:	1 ohm
EXT. LEAD RESISTANCE:	7 ohms
TOTAL RESISTANCE:	8 ohms
INDICATOR IMPEDANCE:	8 ohms

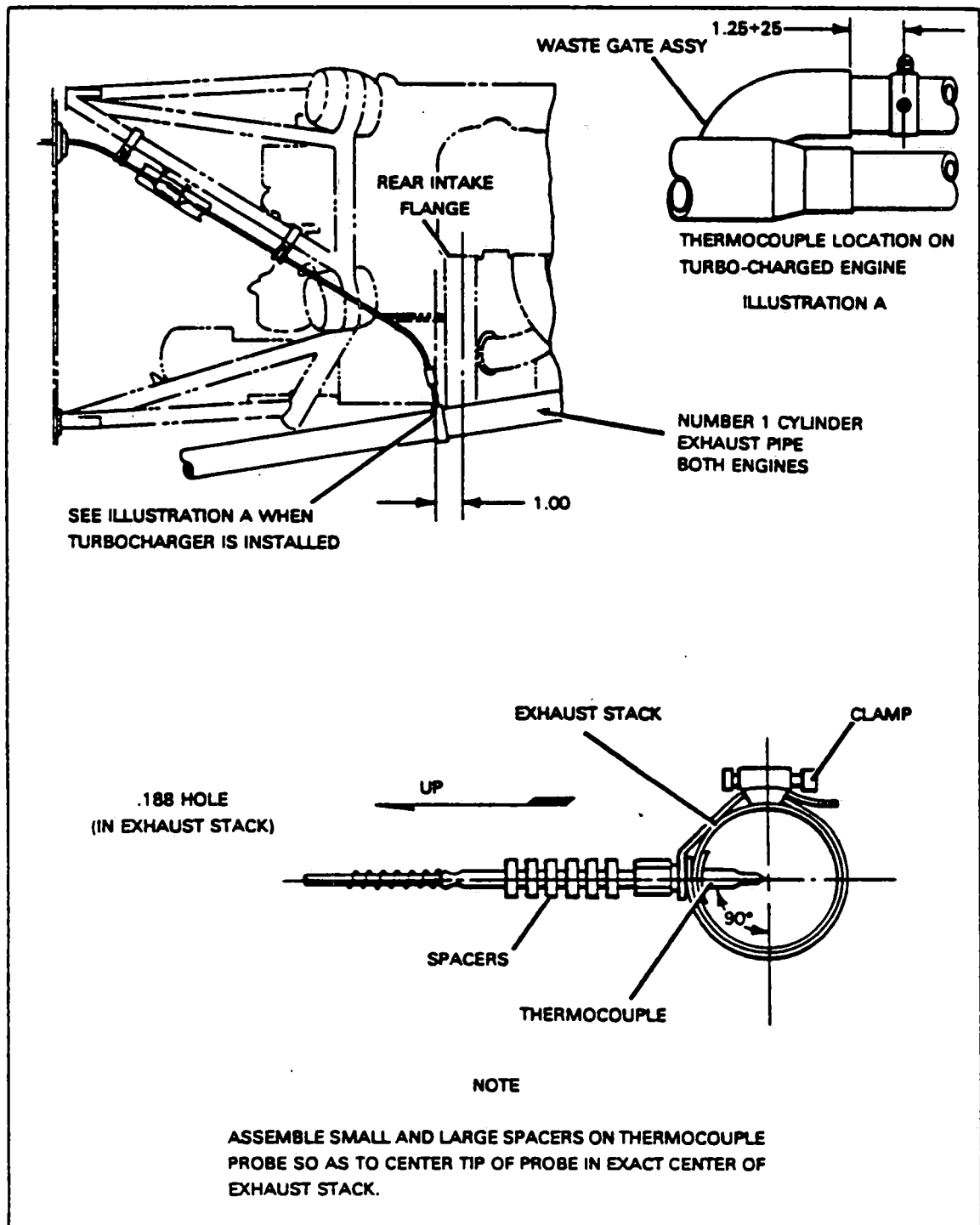


Figure 10-5. EGT Thermocouple Installation

TABLE X-1. TROUBLESHOOTING CHART (VACUUM SYSTEM)

Trouble	Cause	Remedy
No vacuum pressure gauge indication.	Pumps inoperative. Disconnected, broken or restricted lines.	Replace pumps. 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, regulator valve, or vacuum pump.	Check operation of instruments. If operation is normal, replace gauge. If instruments are inoperative, check operation of vacuum pump or regulator valve.
Low vacuum system pressure.	Vacuum regulator valves incorrectly adjusted. Leaking of the system lines or fitting.	Adjust 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. TROUBLESHOOTING CHART (VACUUM SYSTEM) (cont. )

Trouble	Cause	Remedy
High system pressure.	Vacuum regulator valves incorrectly adjusted.	Adjust in accordance with "Adjustments" of this section.
	Vacuum regulator valves sticking or dirty filters.	Clean and check operation of regulator valve.

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TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS)

Trouble	Cause	Remedy
<b>GYRO HORIZON INDICATOR</b>		
Bar fails to respond.	Insufficient vacuum.	Check pump and tubing.
Bar does not settle.	Excessive vibration.	Check shock mounts. Replace if necessary.
	Insufficient vacuum.	Check line and pump. Adjust valve.
	Defective instrument.	Replace.
Bar oscillates or shimmies continuously.	Excessive vibration.	Check shock mounts. Replace if necessary.
	Vacuum too high.	Adjust valve.
	Defective mechanism.	Replace instrument.
<b>DIRECTIONAL GYRO INDICATOR</b>		
Excess drift in either direction.	Excessive vibration with amplitude more than 0.006 inch.	Check shock mounts.



TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
DIRECTIONAL GYRO INDICATOR (cont. )		
Excess drift in either direction. (cont. )	<p>Insufficient vacuum. If vacuum below required inches, check for the following:</p> <ul style="list-style-type: none"> <li>a. Regulator valve improperly adjusted.</li> <li>b. Incorrect gauge reading.</li> <li>c. Pump failure.</li> <li>d. Vacuum line kinked or leaking.</li> </ul> <p>Defective instrument.</p>	<ul style="list-style-type: none"> <li>a. Adjust.</li> <li>b. Recalibrate.</li> <li>c. Repair or replace.</li> <li>d. Check and repair. Check for collapsed inner wall of hose.</li> </ul> <p>Replace instrument.</p>
Dial spins continuously.	Defective mechanism.	Replace.
RATE OF CLIMB INDICATOR		
Pointer does not set on zero.	Aging of diaphragm.	Reset pointer to zero by means of setting screw. Tap instrument while resetting.
Pointer fails to respond.	Obstruction in static line.	Disconnect all instruments connected to the static line. Check individual instruments for obstruction in lines.

TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
RATE OF CLIMB INDICATOR (cont. )		
Pointer oscillates.	Leaks in static lines.	Disconnect all instruments connected to the static line. Check individual instruments for leaks. Reconnect instruments to static line and test installation for leaks.
	Defective mechanism.	Replace instrument.
ALTIMETER		
Excessive scale error.	Improper calibration adjustment.	Replace instrument.
Excessive pointer oscillation.	Defective mechanism.	Replace instrument.
High reading.	Improper venting.	Eliminate leak in static pressure system and check alignment of airspeed tube.
Setting knob is hard to turn.	Wrong lubrication of lack of lubrication.	Replace instrument.
Inner reference marker fails to move when setting knob is rotated.	Out of engagement.	Replace instrument.

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TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont.)

Trouble	Cause	Remedy
<b>ALTIMETER (cont.)</b>		
Setting knob set screw 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.	Refer to AC 43.13-1.
<b>AIRSPEED TUBES AND INDICATOR</b>		
Tube does not heat or clear itself of ice with switch "ON". (Heated pitot tubes only.)	<p>Circuit breaker open.</p> <p>Open circuit.</p> <p>Loose connections or broken wires.</p> <p>Heating element burned out.</p>	<p>Reset.</p> <p>Repair.</p> <p>Check continuity of wiring.</p> <p>Replace pitot head.</p>

TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
AIRSPEED TUBES AND INDICATOR (cont. )		
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.	Check for leak and seal.
TURN AND BANK INDICATOR		
Pointer fails to 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.

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TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
TURN AND BANK INDICATOR (cont. )		
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.
Pointer sluggish in returning 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.

TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
MAGNETIC COMPASS		
Excessive card error.	Compass not properly compensated. .  External magnetic interference.	Compensate instrument.  Locate magnetic interference and eliminate if possible.
Excessive card oscillation.	Improper mounting on instrument panel.  Insufficient liquid.	Align instrument.  Replace instrument.
Card sluggish.	Weak card magnet.  Excessive pivot friction or broken jewel.  Instrument too heavily compensated.	Replace instrument.  Replace instrument.  Remove excess compensation.
Liquid leakage.	Loose bevel screws.  Broken cover glass.  Defective sealing gaskets.	Replace instrument.  Replace instrument.  Replace instrument.
Discolored luminous markings.	Age.	Replace instrument.

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TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
MAGNETIC COMPASS (cont. )		
Defective light.	Burned out lamp or broken circuit.	Check lamp or continuity of wiring.
ENGINE OIL PRESSURE GAUGE		
Excessive error at zero.	Pointer loose on shaft. Overpressure or seasoning of bourdon 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 of pointer or pressure fails to build up.	Engine relief valve open.	Check and clean.
FUEL FLOW GAUGE		
No fuel pressure indication.	Fuel valve stuck. No fuel in tanks.	Check valve. Check fuel, fill.

TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
<b>FUEL FLOW GAUGE (cont. )</b>		
No fuel pressure indication. (cont. )	Defective fuel pump.	Check pump for pressure build up. Check diaphragm and relief valves in engine pump. Check for obstruction in electric pump. Check bypass valve. Air leak in intake lines.
	Defective gauge.	Replace gauge.
Pressure low or pressure surges.	Obstruction in inlet side of pump.	Trace lines and locate obstruction.
	Faulty bypass valve.	Replace.
	Faulty diaphragm.	Replace or rebuild pump.
<b>MANIFOLD PRESSURE INDICATOR</b>		
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.

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TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
MANIFOLD PRESSURE INDICATOR (cont. )		
Broken or loose cover glass.	Vibration or excessive pressure.	Replace glass and re-seat case.
Dull or discolored luminous markings.	Age.	Replace instrument.
Incorrect reading.	Moisture or oil in line.	Disconnect lines and blow out.
TACHOMETER		
No reading on indicator either permanent or intermittent.	Broken shaft.	Replace instrument.
	Springs weak.	Replace instrument.
Pointer oscillates excessively.	Rough spot on, or sharp bend in shaft.	Repair or replace.
	Excess friction in instrument.	Replace instrument.
FUEL GAUGE		
Fuel gauge fails to indicate.	Broken wiring.	Check continuity and repair.
	Gauge not operating.	Replace panel unit.
	Float is filled with fuel.	Replace sender unit.

TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont. )

Trouble	Cause	Remedy
Fuel gauge fails to indicate. (cont. )	Circuit breaker out.	Check for possible short circuit then reset breaker.
	Defective selector switch.	Check switch installation, replace switch if necessary.
Fuel gauge indicates full constantly.	Incomplete ground.	Check wiring, sender unit and gauge. Repair or replace.
Fuel gauge indicates zero.	Fuel selector in "OFF" position.	Normal.
	Shorted connection at selector switch or other wiring.	Check switch and wiring.
OIL TEMPERATURE INDICATORS		
Instrument fails to show any reading.	Wiring open.	Check engine unit and wiring to instrument.
Excessive scale error.	Improper calibration.	Replace.
Pointer fails to move as engine is warmed up.	Wiring open.	Check engine unit and wiring.
Dull or discolored luminous marking.	Age.	Replace instrument.

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TABLE X-II. TROUBLESHOOTING CHART (INSTRUMENTS) (cont.)

Trouble	Cause	Remedy
EXHAUST GAS TEMPERATURE GAUGE		
Gauge inoperative.	Master Switch OFF. Circuit Breaker OUT. Defective gauge, probe or wiring.	Turn switch ON. Push breaker IN. Check probe and lead wires for chafing, breaks or shorting between wires and/or metal structure.
Fluctuating reading.	Adjusting potentiometer turned off scale. Loose, frayed or broken electrical leads or faulty connections.	Reset potentiometer. Clean and tighten connections. Repair or replace defective leads.

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***TWIN COMANCHE***  
***Service Manual***

CARD 3 OF 4

- PA-30
- PA-39

**PIPER AIRCRAFT CORPORATION**

# **WARNING**

**The information contained in this manual is periodically revised. Piper Aircraft Corporation urges all users of this manual to keep it current. Contact your nearest Piper Aircraft Corporation distributor to arrange for a subscription to future revisions.**

## **NOTE**

**Revision service is available in aerofiche format only.**

## AEROFICHE EXPLANATION AND REVISION STATUS

The Service Manual information incorporated in this set of Aerofiche cards has been arranged in accordance with the general specifications of Aerofiche adopted by the General Aircraft Manufacturer's Association, (GAMA). 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.

### Conversion of Aerofiche alpha/numeric code numbers:

First number is the Aerofiche card number.

Letter is the horizontal line reference per card.

Second number is the vertical line reference per card.

Example: 2J16 = Aerofiche card number two of given set, Grid location J16.

To aid in locating the various chapters and related service information desired, the following is provided:

1. A complete manual Table of Contents is for all fiche in this set.
2. A complete list of Illustrations is given and follows the Table of Contents.
3. A complete list of Tables is given for all fiche in this set and follows the list of Illustrations.
4. A complete list of paragraph titles and appropriate Grid location numbers is given at the beginning of each Chapter relating to the information within that Chapter.
5. Identification of Revised Material:

Revised text and illustrations are indicated by a black vertical line along the left-hand margin of the frame, opposite revised, added or deleted material. Revision lines indicate only current revisions with changes and additions to or deletions of existing text and illustrations. Changes in capitalization, spelling, punctuation, indexing, the physical location of the material or complete page additions are not identified by revision lines.

6. Revisions to this Service Manual issued are as follows:

Revisions	Date	Aerofiche Card Effectivity
PR740131	January 31, 1974	—
PR760628	June 28, 1976	1, 2 and 3
PR771006	October 6, 1977	1 and 2
PR780426	April 26, 1978	1, 2 and 3
PR790910	September 10, 1979	1 and 2
PR810406	April 6, 1981	1, 2, 3 and 4
PR821028	October 28, 1982	1, 2, 3 and 4

The date on Aerofiche cards should not be earlier than the date noted for the respective card effectivity. Consult the latest card in this series for current Aerofiche card effectivity.

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# SECTION XI

## ELECTRICAL SYSTEM

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SECTION XI  
ELECTRICAL SYSTEM

11-1. INTRODUCTION. This section contains instructions for correcting difficulties which may arise in the electrical systems of the PA-30 and PA-39 airplanes. It includes a description and the function of each part of the system along with tests and adjustments. This does not include electronics installations such as Autopilot or radios. For information concerning electronic equipment refer to Section XII, Electronics.

11-2. DESCRIPTION. Electrical power is supplied by a 14-volt, direct current, single wire, negative ground electrical system. A 12-volt battery is incorporated in the system to furnish power for starting and as a reserve power source in case of generator or alternator failure. An external power receptacle can be provided as optional equipment to permit the use of an external power source for cold weather starting. A 50-ampere generator or 70-ampere alternator is supplied with the left engine as standard equipment. An additional generator or alternator of equal amperage may be supplied with the right engine as optional equipment.

Electrical switches and rheostats are located at the left side of the cockpit under the instrument panel. The circuit breakers for the individual circuits are mounted on a panel under the floorboard directly aft of the nose wheel housing on early model airplanes and under the right side of the instrument panel on later model airplanes. The airplane is equipped with standard navigation lights, two landing lights located in the wing tips and a rotating beacon as standard equipment.

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 or alternator, and/or their 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.

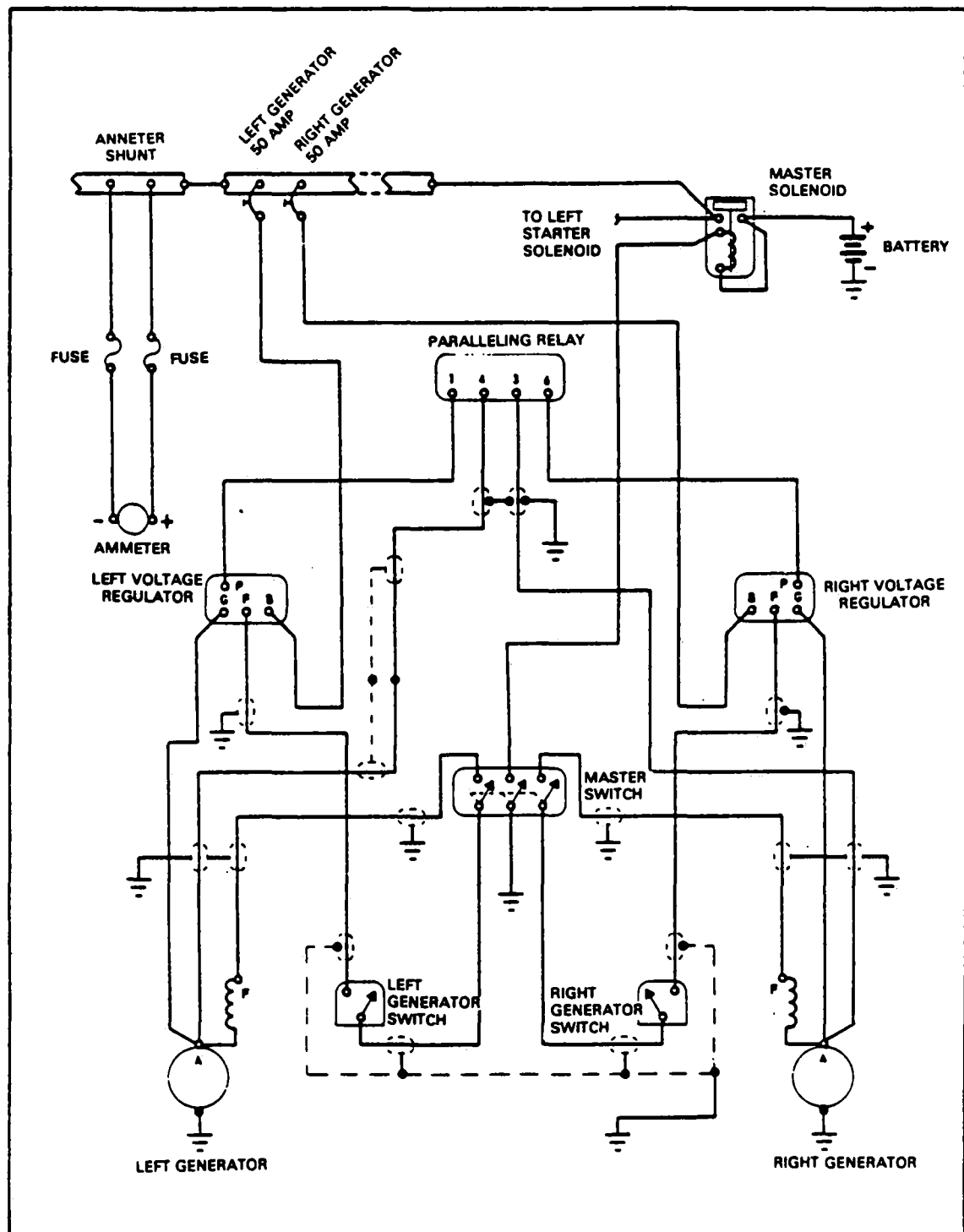


Figure 11-1. Generator Wiring System Schematic

#### 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 principle 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 11-3.) 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 be-

tween 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 accumulations 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.

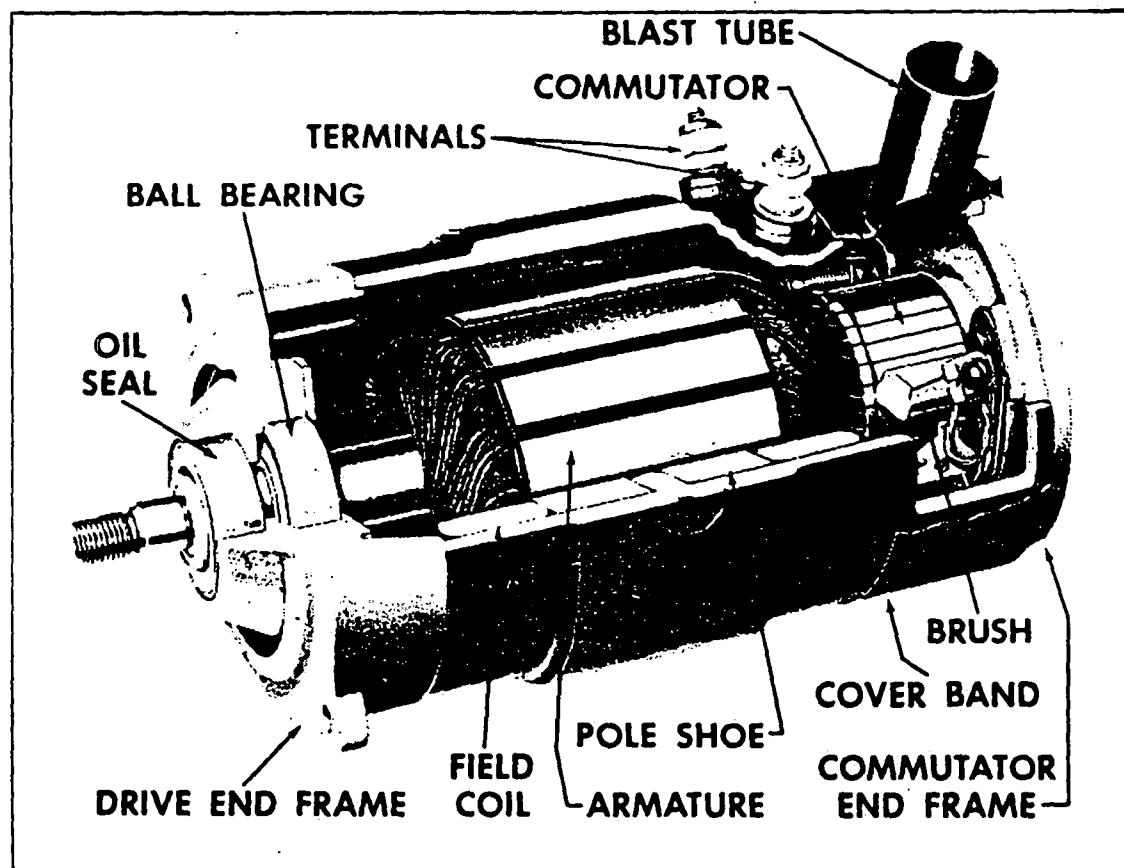


Figure 11-2. Sectional View of Generator

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 11-74.

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 11-7, 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

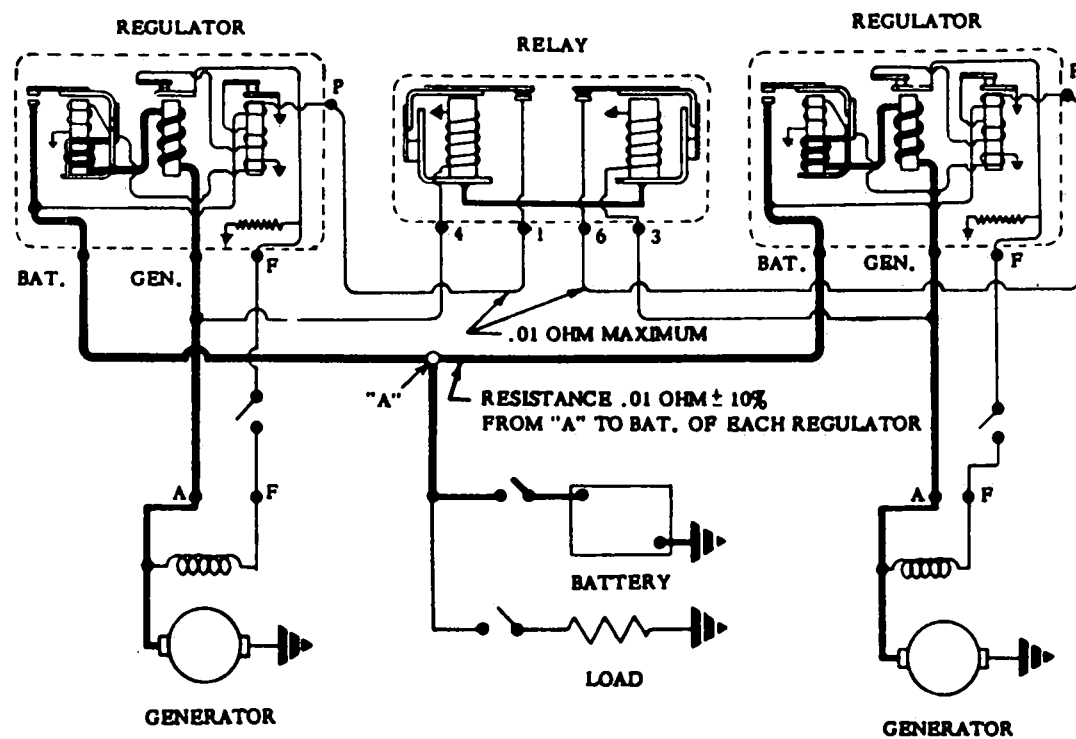


Figure 11-3. Wiring Circuit, Dual Regulators

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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 bush 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 circuit is due to a broken lead or bad connection, it can be repaired, but if the open circuit 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.

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 overcharge 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 reseal 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.

11-23. GENERATOR SERVICE TEST SPECIFICATIONS (DELCO-REMY). Specifications for 14-volt generators installed on PA-30 airplanes are as follows:

Generator	1101915
(DELCO-REMY), Ref. Service Bulletin	1G-150
Brush Spring Tension	24 oz.
Field Current (80° F) Amps Volts	1.62 - 1.72 12
Cold Output Amps Volts Approx. RPM	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 11-4 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 11-4) has two windings, a series winding of a few turns of heavy wire and a shunt winding of many turns of fine wire. 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 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.



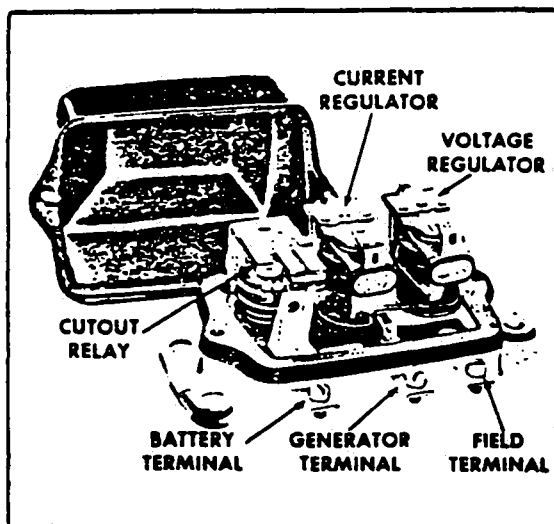


Figure 11-4. Current/Voltage Regulator

d. This reverse flow of current through the series winding causes a reversal 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 11-4) has two windings assembled on a single core, a shunt winding consisting of many turns of fine wire 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 11-4.) 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 e.)

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

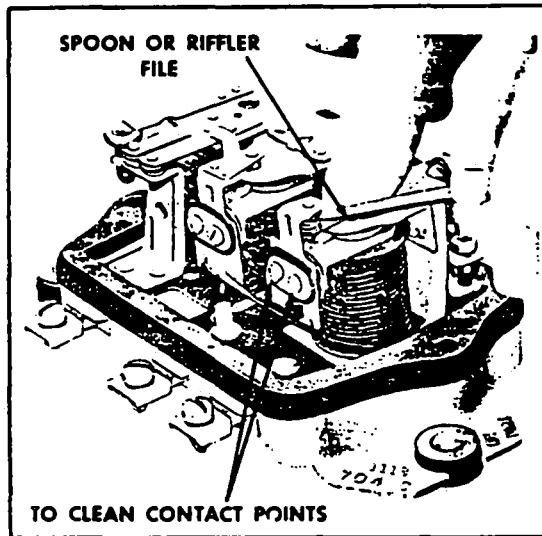


Figure 11-5. Use of Riffler File to Clean Contact Points

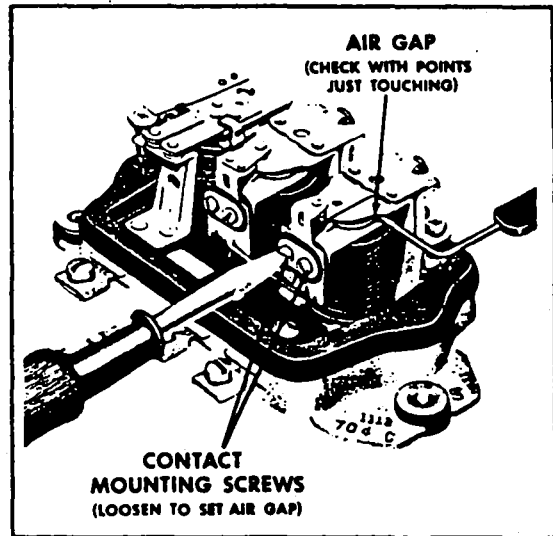


Figure 11-6. Voltage Regulator Air Gap

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

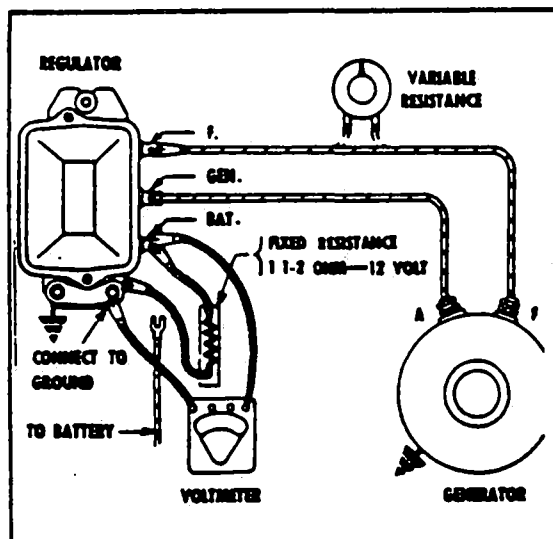


Figure 11-7. Checking Voltage Setting Fixed Resistance Method

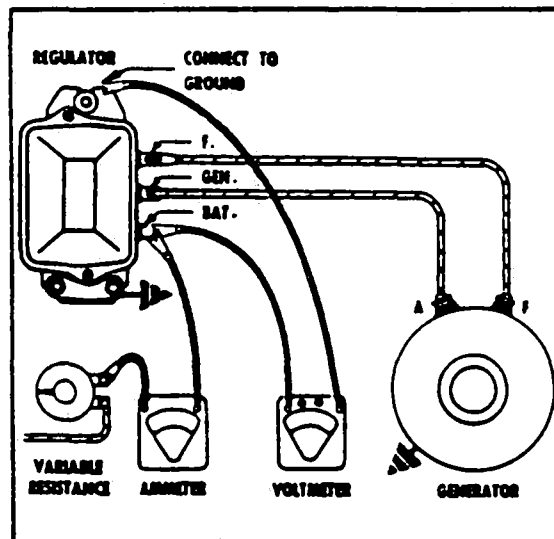


Figure 11-8. Checking Voltage Setting Variable Resistance Method

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 11-6.) 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 11-7 and 11-8.)

##### 1. Fixed Resistance Method:

(a) Connect a fixed resistance between the battery terminal and ground as shown in Figure 11-7 after disconnecting the battery lead from the

battery terminal of the regulator. The resistance must be 1-1/2 ohms for 14-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.

(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 11-8. 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 11-8). 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 11-9.) Turn clockwise to increase setting and counterclockwise to decrease setting.

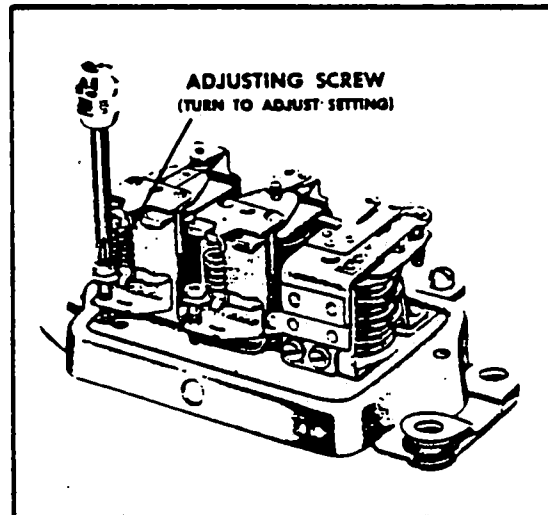


Figure 11-9. Adjusting Voltage Regulator Setting

### 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 11-8.

### NOTE

It is very important that the variable resistance be connected at the "BAT" terminal as shown in Figure 11-8 rather than at the "GEN" terminal even though these terminals are in the same circuit. An examination of the wiring diagram, Figure 11-3, 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

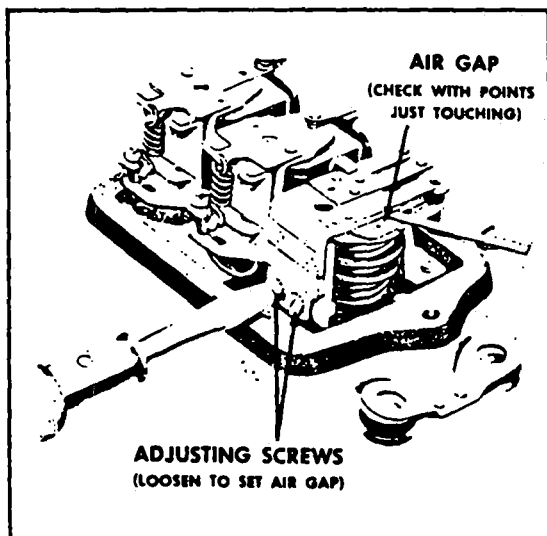


Figure 11-10. Cutout Relay Air Gap Check and Adjustment

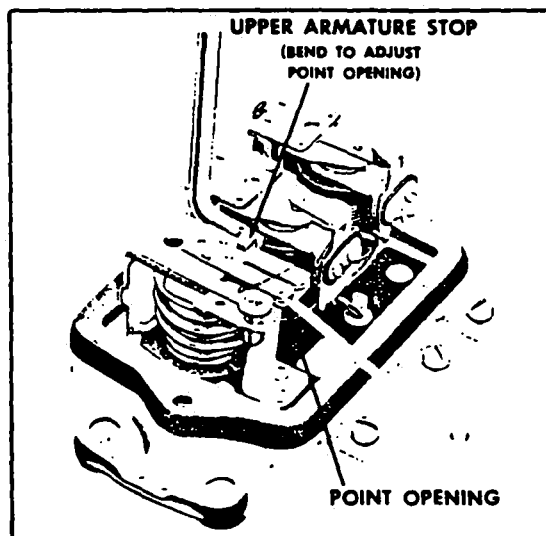


Figure 11-11. Cutout Relay Point Opening Check and Adjustment

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 11-10.) 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.



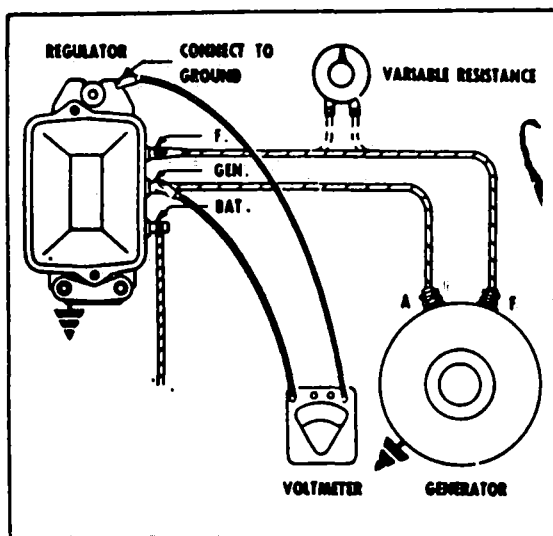


Figure 11-12. Checking Cutout Relay Closing Voltage

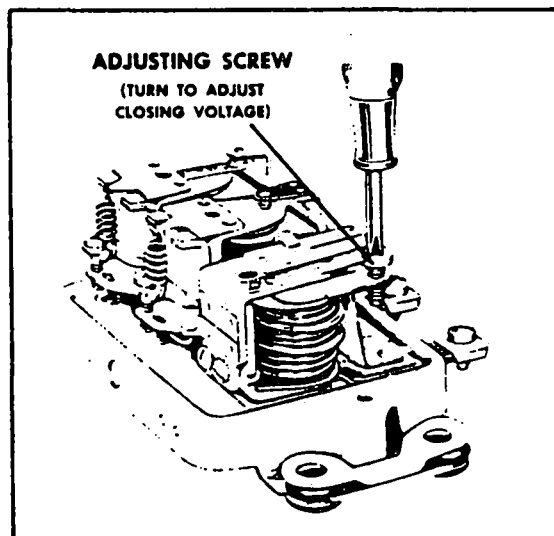


Figure 11-13. Adjustment of Cutout Relay Closing Voltage

b. Point Opening: Check point opening and adjust by bending the upper armature stop. (Refer to Figure 11-11.)

c. Closing Voltage: Connect regulator to proper generator and battery. Connect voltmeter between the regulator "GEN" terminal and ground. (Refer to Figure 11-12.)

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 11-12.) 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 11-13.) 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:

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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 14-volt regulators installed as standard equipment on model PA-30 airplanes are as follows:

Regulator Model	1119246 <sup>11</sup>
(DELCO-REMY), Ref. Service Bulletin	1R-116A
Cutout Relay: Air Gap Point Opening Closing Voltage	.020 in. .020 in. 11.8 - 13.5 volts
Voltage Regulator Air Gap Current Setting	.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. 48 - 52 amps
<sup>11</sup> Paralleling: With no load on battery terminal, add 5 amp load at P-terminal - voltage regulator to operate 2 to 3 volts lower.	

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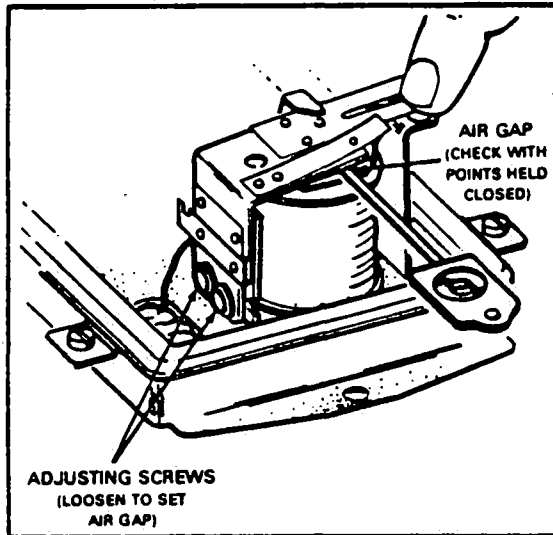


Figure 11-16. Checking and Adjusting Relay Air Gap

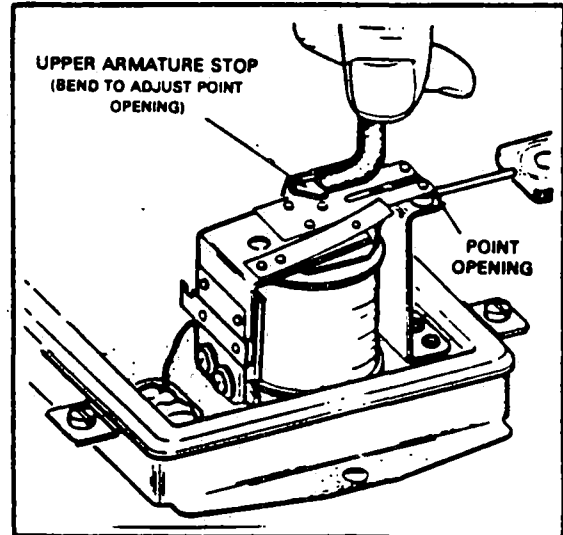


Figure 11-17. Checking and Adjusting Relay Point Opening

#### 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 11-16.) 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 11-17.

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 11-18. Slowly increase the generator speed until the contact points close and read the voltage on the meter. To adjust the closing

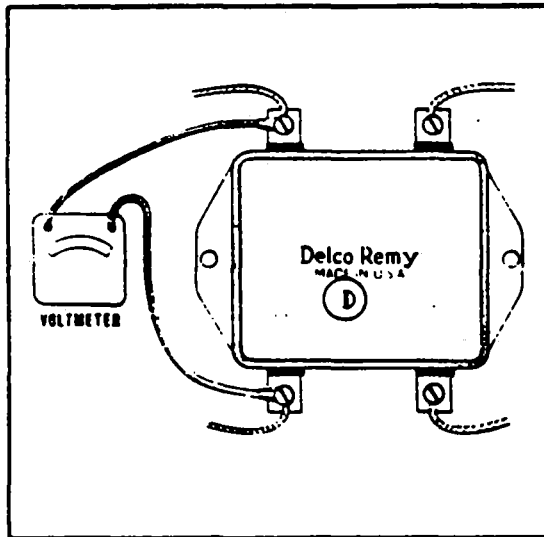


Figure 11-18. Checking Relay Closing Voltage

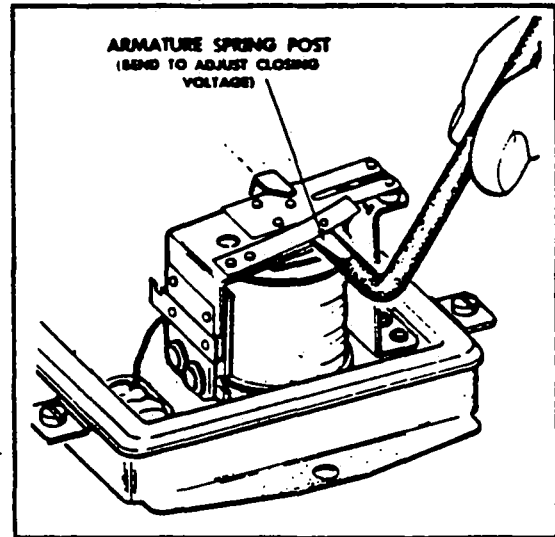


Figure 11-19. Adjusting Relay Closing Voltage

voltage. Shut down the engine and bend the armature spring post (Refer to Figure 11-19.) 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 14-volt relays installed as standard equipment on the model PA-30 airplanes are as follows:

Relay Model	1116887
(DELCO-REMY), Ref.: the latest revision of Service Bulletin 1R100	
Air Gap at Core, Points Closed	.022 $\pm$ 10% in.
Point Opening	.028 in.
Closing Voltage (Range)	10.5 to 12.5
Opening Voltage (Range)	8 minimum

## 11-51. ALTERNATOR SYSTEM.

11-52. DESCRIPTION OF ALTERNATOR SYSTEM. For each alternator, the alternator output circuit is connected in the following order: to an inline filter, to reduce radio interference, to an inline shunt, to monitor alternator output, and finally to a 90 amp magnetic circuit breaker on the airplane's main distribution bus.

Two independent field control circuits are provided. One circuit is identified as the main voltage regulator and the second as the auxiliary voltage regulator. The main and auxiliary circuits are controlled by a selector switch that enables the pilot to select either system. In the event of a failure in the main circuit, the pilot may select the back-up or auxiliary system.

Each field circuit consists of a 10 amp thermal circuit breaker, solid state voltage regulator, inline filter, and an over-voltage cutout relay.

Each field circuit for the alternator is routed through the airplane's master switch and through a ganged switch on the rear of the 90 amp circuit breaker so that when the respective alternator output is interrupted, the field circuit is also opened to prevent high voltage build up.

The airplane's battery is connected to the bus through an inline ammeter used to monitor battery condition.

11-53. CHECKING ALTERNATOR SYSTEM. The ammeter is equipped with a selector switch which enables an independent output check of each alternator, as well as the electrical output-input of the battery. Should either alternator show no output on the ammeter, check the alternator output and field thermo circuit protectors, and ammeter line fuses. If a further check of the ammeter shows no output from both alternators, switch to the auxiliary voltage regulator and over-voltage relay. If switching to the auxiliary system indicates no electrical output, further check the alternator system. (Refer to Figure 11-20.)

- a. Ascertain that the ammeter is operating properly.
- b. Ascertain that all electrical units are off and the battery is fully charged.
- c. Disconnect the battery lead (+) at the alternator.
- d. Disconnect the field leads (F1 and F2) at the alternator.
- e. Turn the master switch on.
- f. To check the alternator output circuit, connect a voltmeter or 14-volt test light to the battery lead and to ground. If a reading of approximately 14-volts registers on the voltmeter or the test light lights, the battery circuit is operational. Should there be no indication of voltage, trace back through the output circuit until voltage is indicated. (Refer to Figure 11-20.) A component that allows no voltage to pass through it should be replaced.

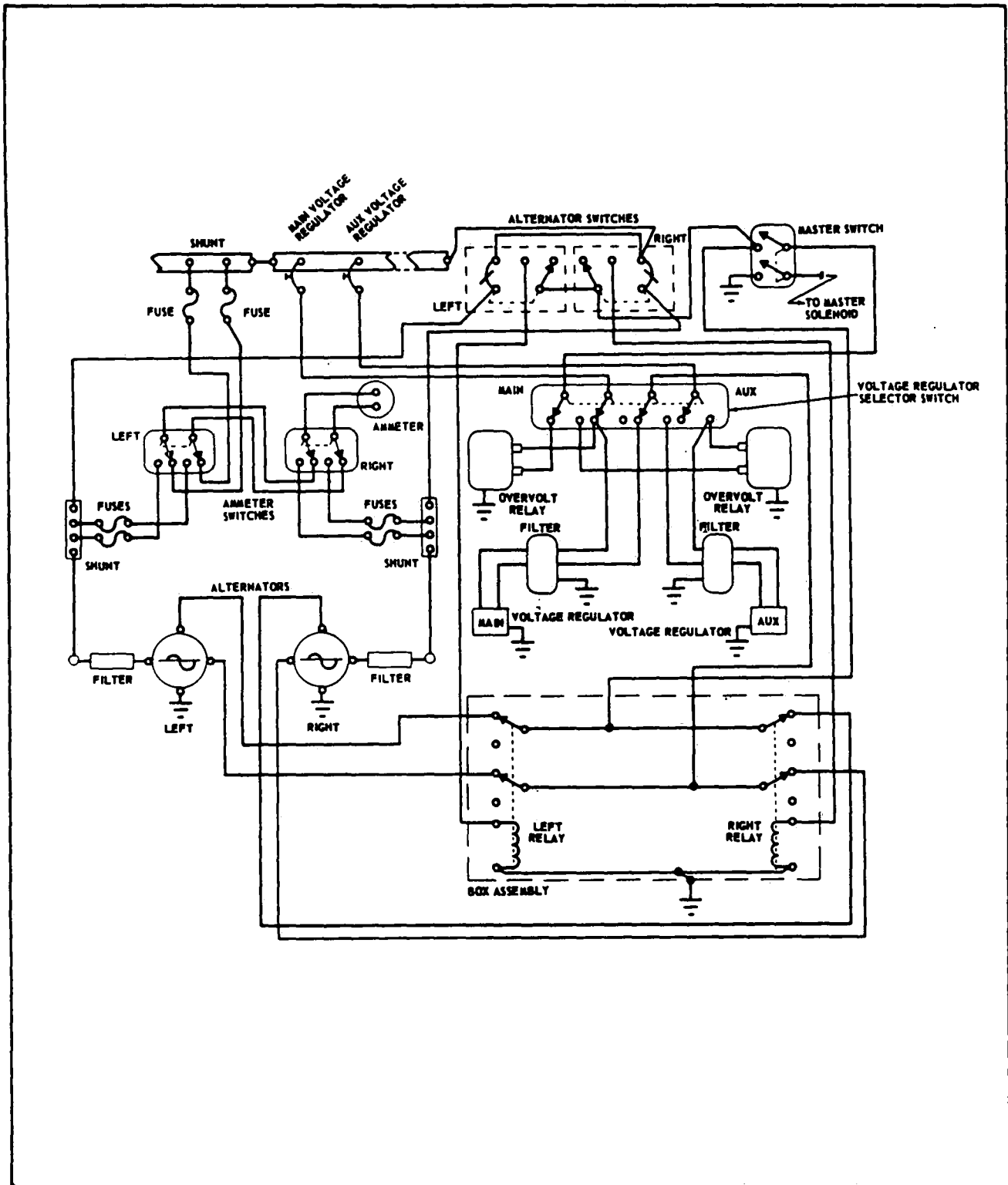


Figure 11-20. Alternator Wiring System Schematic

g. To check the field circuit, connect a voltmeter or 14-volt test light to each field lead and to ground, and separately check as follows:

1. A check of the F1 circuit will give a variable voltage: if any voltage is indicated on the voltmeter or if any filament glow is indicated on the test light, the circuit is operational.

2. The check of the F2 circuit should give a reading of approximately 14-volts on the voltmeter or the test lamp should glow normally for an operational circuit.

3. Both the main and auxiliary field circuits may be checked in a like manner.

4. If indication shows a possible malfunction of the voltage regulator and before installing a new regulator, refer to paragraph 11-65. For the overvoltage control, refer to paragraph 11-71.

h. If voltage is indicated at both the battery lead and field lead, the alternator should be checked for possible malfunction. (Refer to paragraph 11-61.)

11-54. ADJUSTMENTS. The only adjustments necessary to maintain the alternator system is the adjustment of the voltage control on the voltage regulator. A voltage of 14-volts is maintained. All other control adjustments are made at time of installation and need not be reset.

#### IMPORTANT

Since the alternator and regulator are designed for use on only one polarity system, the following precautions must be observed when working on the charging unit. Failure to observe these precautions will result in serious damage to the electrical equipment.

a. When installing a battery, always make absolutely sure the ground polarity of the battery and the ground polarity of the alternator are the same.

b. When connecting a booster battery, make certain to connect the negative battery terminals together and the positive battery terminals together.

c. When connecting a charger to the battery, connect the charger positive lead to the battery positive terminal and the charger negative lead to the battery negative terminal.

d. Never operate the alternator on open circuit. Make absolutely certain all connections in the circuit are secure.

e. Do not short across or ground any of the terminals on the alternator or regulator.

f. Do not attempt to polarize the alternator.

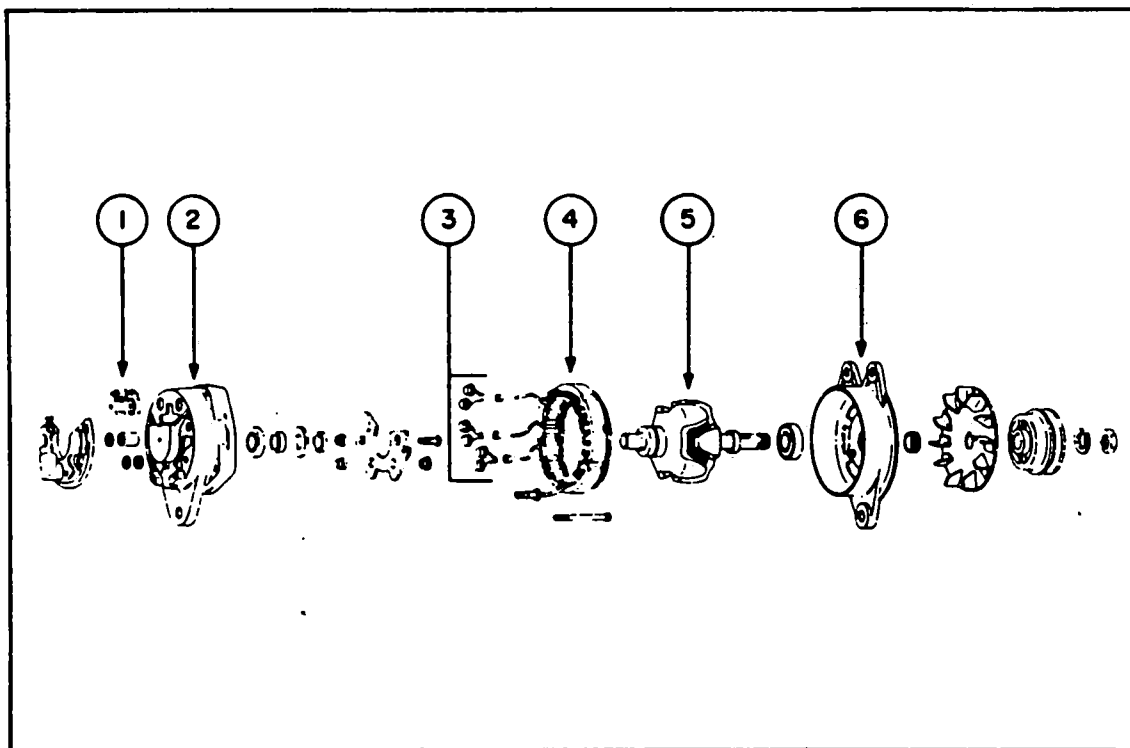


Figure 11-21. Exploded View of Alternator

#### 11-55. ALTERNATOR AND COMPONENTS.

11-56. DESCRIPTION OF ALTERNATOR. (Refer to Figure 11-21.) The principal components of the alternator are the brush holder assembly (1), the slip ring end head (2), the rectifiers (3), the stator (4), the rotor (5) and the drive end head (6).

a. The brush and holder assembly contains two brushes, two brush springs, a brush holder and insulators. Each brush is connected to a separate terminal stud and is insulated from ground. The brush holder assembly can easily be removed for inspection or brush replacement purposes.

b. The slip ring end head provides the mounting for the rectifiers and rectifier mounting plate, output and auxiliary terminal studs, and the brush and holder assembly. The slip ring end head contains a roller bearing and outer race assembly and a grease seal.

c. The rectifiers used in these units are rated at 150 peak inverse voltage (PIV) minimum for transient voltage protection. Three positive rectifiers are mounted in the rectifier mounting plate while the three negative rectifiers are mounted in



the slip ring end head. Each pair of rectifiers is connected to a stator lead with high temperature solder. The stator leads are anchored to the rectifier mounting plate with epoxy cement for vibration protection.

d. The stator contains a special lead which is connected to the center of the three phase windings and is used to activate low voltage warning systems or relays. The stator has been treated with a special epoxy varnish for high temperature resistance.

e. The rotor contains the slip ring end bearing inner race and spacer on the slip ring end of the shaft. The rotor winding and winding leads have been specially treated with a high temperature epoxy cement to provide vibration and temperature resistance characteristics. High temperature solder is used to secure the winding leads to the slip rings.

f. The drive end head supports a sealed, prelubricated ball bearing in which the drive end of the rotor shaft rotates.

11-57. OVERHAUL OF ALTERNATOR. When repairing the alternator, complete disassembly may not be required. In some cases it will only be necessary to perform those operations which are required to effect the repair. However, in this section, the complete overhaul is covered step-by-step to provide detailed information on each operation. In actual service practice, these operations may be used as required.

#### 11-58. DISASSEMBLY OF ALTERNATOR.

a. Remove the two Number 10-24 screws holding the brush holder assembly in the slip ring end head. Remove the brush and holder assembly from the end head.

b. Remove the safety wire from the through bolts. Hold the pulley with a strap wrench and remove the pulley nut. The pulley must be removed with a puller. Remove the fan, woodruff key and spacer from the shaft.

c. Remove the four through bolts and tap the drive end head lightly to separate the drive end head and rotor, as a unit, from the stator and slip ring end head.

d. Remove the nuts, lock washers, flat washers and insulators from the output and auxiliary terminal studs. Note carefully the correct assembly of the insulator washers and bushings. Using the special tools shown in Figure 11-22, support the end head and press out the three negative rectifiers. The end head can now be separated from the stator assembly.

e. To remove the slip ring end bearing and grease seal, it will be necessary to have a hook type or impact type bearing puller as shown in Figure 11-23. Do not remove the bearing unless replacement is necessary.

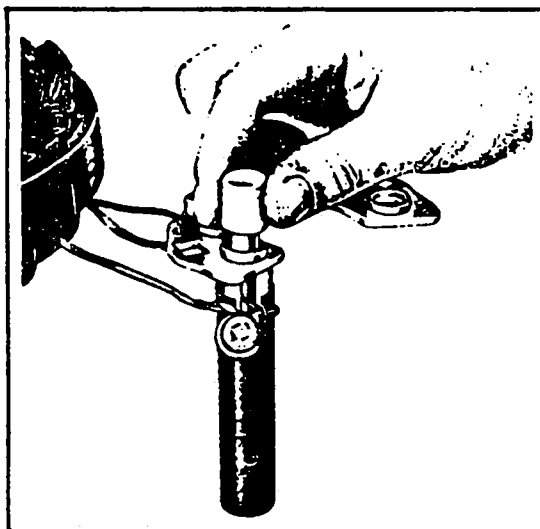


Figure 11-22. Removal of Rectifier

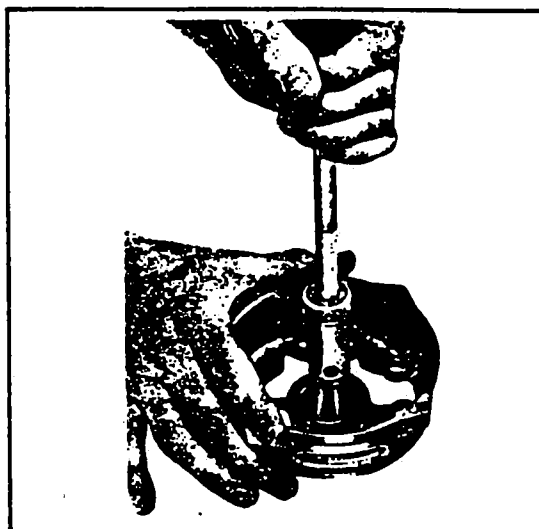


Figure 11-23. Removal of Slip Ring End Bearing

NOTE

The inner race of the slip ring end bearing is pressed onto the rotor shaft. When bearing replacement is necessary, always replace the complete bearing assembly, including the inner race.

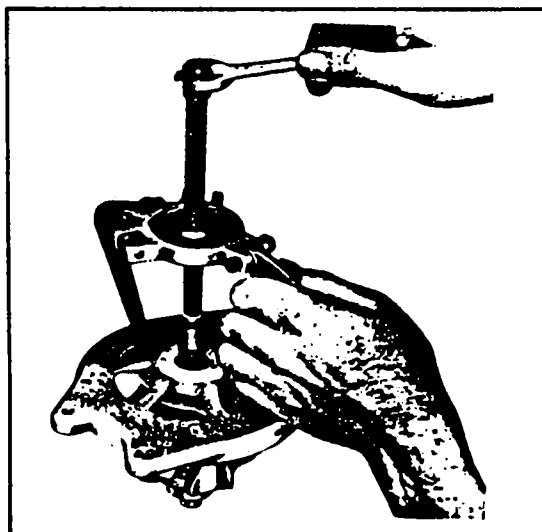


Figure 11-24. Removal of Drive End Head

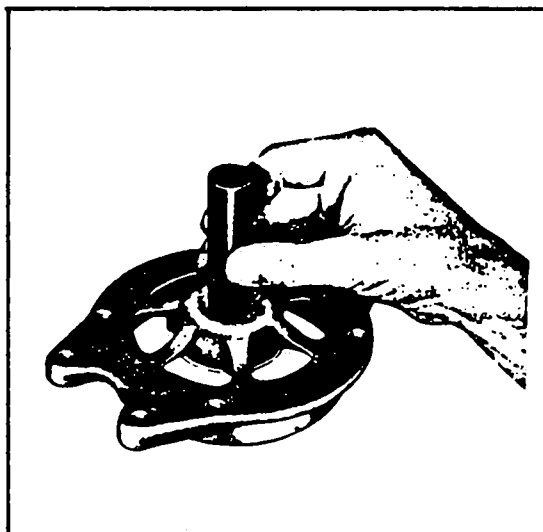


Figure 11-25. Removal of End Head Bearing

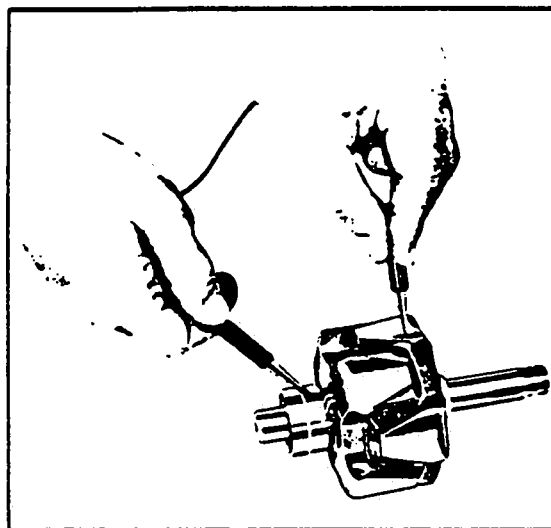


Figure 11-26. Testing Rotor For Grounds

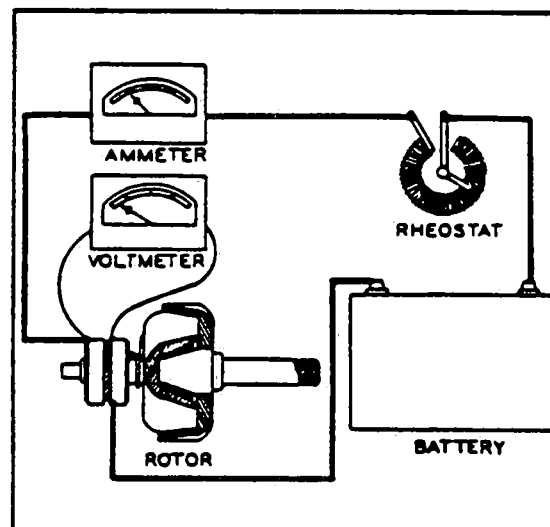


Figure 11-27. Testing Rotor For Shorts

f. To remove the drive end head from the rotor shaft, use a puller that grips on the bearing retainer plate as shown in Figure 11-24. Do not attempt to remove by supporting the end head and pressing on the shaft, as this may result in distortion of the end head or stripping of the retainer plate screws. Remove the three retainer plate screws and press the bearing out of the end head. (Refer to Figure 11-25.)

11-59. INSPECTION AND TESTING OF COMPONENTS. Upon completion of the disassembly, all parts should be cleaned and visually inspected for cracks, wear or distortion and any signs of overheating or mechanical interference.

a. Rotor: The rotor should be tested for grounded or shorted windings. The ground test can be made with test probes, connected in series with a 110-volt test lamp, an ohmmeter or any type of continuity tester. (Refer to Figure 11-26.) There must not be any continuity between the slip rings and the rotor shaft or poles. To test for shorted turns in the rotor winding, connect a voltmeter, ammeter and rheostat as shown in Figure 11-27, or use an ohmmeter. Rotor current draw and resistance are listed in the individual specification pages. Excessive current draw or a low ohmmeter reading indicates shorted windings. No current draw or an infinite ohmmeter reading would indicate an open winding.

b. Rectifiers: A diode rectifier tester will detect and pinpoint open or shorted rectifiers without going through the operation of disconnecting the stator leads. However, if a tester is not available, test probes and a No. 57 bulb, connected in series with a 12-volt battery, can be used in the following manner. Touch one

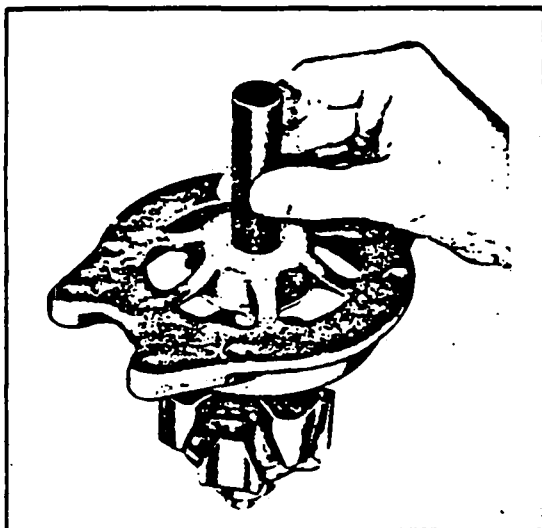


Figure 11-28. Installation of Bearing

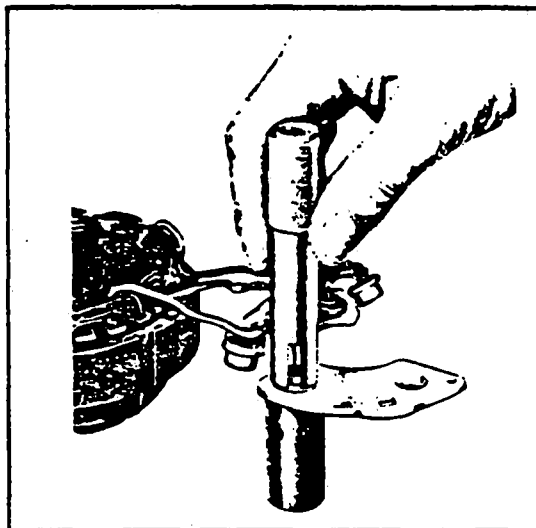


Figure 11-29. Installation of Rectifier

test probe to a rectifier heat sink and the other test probe to a lead from one of the rectifiers in that heat sink. Then reverse the position of the leads. The test bulb should light in one direction and not light in the other direction. If the test bulb lights in both directions, one or more of the rectifiers in that heat sink is shorted. To pinpoint the defective rectifier, the stator leads must be disconnected and the above test repeated on each rectifier. Open rectifiers can only be detected, when using the test bulb, by disconnecting the stator leads. The test bulb will fail to light in either direction if the rectifier is open.

c. Stator: The stator can be tested for open or grounded windings with a 12-volt test bulb, described in the rectifier section, or an ohmmeter, in the following manner. Separate the stator from the slip ring end head just far enough to insert a fold of rags or blocks of wood. In other words, insulate the stator from the end head. To test for grounded windings, touch one test bulb or ohmmeter probe to the stator frame. If the test bulb lights, or the ohmmeter indicates continuity, the stator is grounded. To test for open windings, connect one test probe to the auxiliary terminal or the stator winding center connection and touch each of the three stator leads. The test bulb must light, or the ohmmeter must show continuity. Due to the low resistance in the stator windings, shorted windings are almost impossible to locate. However, shorted stator windings will usually cause the alternator to "growl" or be noisy during operation and will usually show some signs of overheating. If all other electrical checks are normal and the alternator fails to supply its rated output, the stator should be replaced to determine whether or not it is the faulty component.

d. Bearings and Seals: Whenever the alternator is overhauled, new bearings and oil or grease seals are recommended, even though the bearings and seals

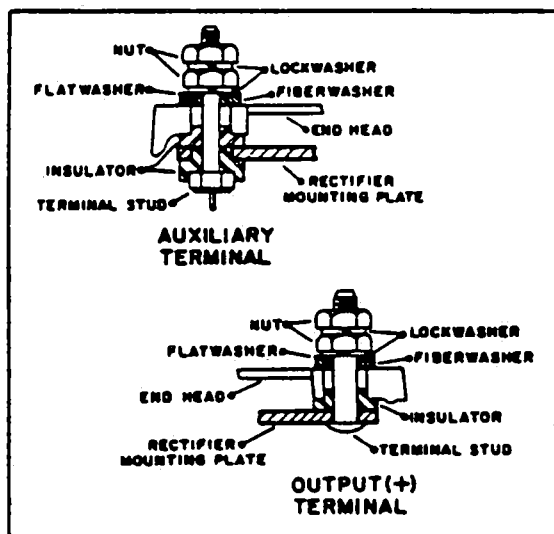


Figure 11-30. Terminal Assembly

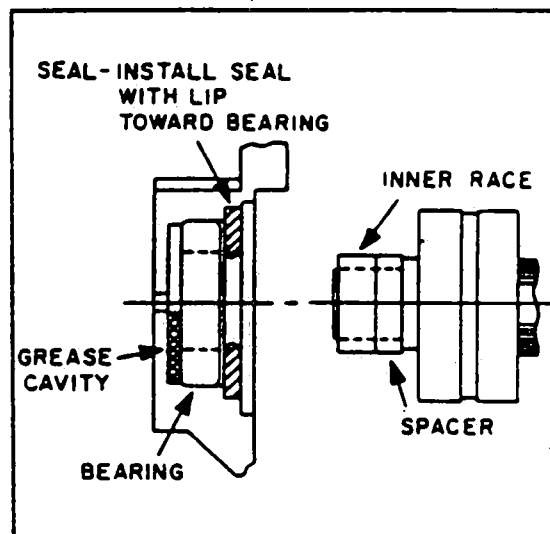


Figure 11-31. Slip Ring End Bearing Assembly

appear to be in good condition. A faulty seal can cause an alternator to fail within a very short period of time.

#### 11-60. ASSEMBLY OF ALTERNATOR.

a. Press the ball bearing into the drive end head using a flat block approximately two inch square so that the pressure is exerted on the outer race of the bearing. Install the retainer plate. With the snap ring and retainer cup in place on the rotor shaft, use a tool that fits over the shaft and against the inner bearing race, and press until the inner bearing race is against the snap ring retainer cup. (Refer to Figure 11-28.)

b. Carefully install the rectifiers in the slip ring end head or rectifier mounting plate by supporting the unit and using the special tools illustrated in Figure 11-29.

#### CAUTION

Use an arbor press, do not hammer. Reconnect the stator leads to the rectifiers. When soldering these connections, use pliers as a heat dam on the lead between the solder joint and the rectifier. Too much heat will damage the rectifiers.

c. Reassemble the rectifier mounting plate studs and insulators, making sure

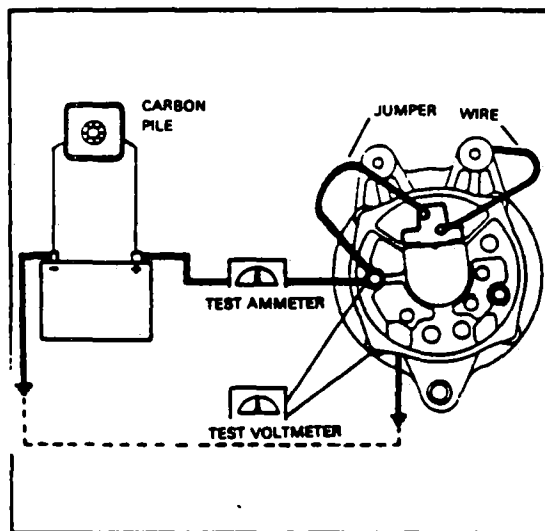


Figure 11-32. Testing Alternator

they are in the correct order. (Refer to Figure 11-30.)

d. After the slip ring end head is completely assembled, the stator and rectifier leads must be secured to the rectifier mounting plate with epoxy. Make sure the stator leads are positioned so that they do not interfere with the rotor.

e. Install the slip ring end bearing and oil seal. Make sure the lip of the oil seal is toward the bearing. Correct assembly of bearing, seal, inner race and spacer is shown in Figure 11-31.

f. Assemble the alternator and install the through bolts. Spin the rotor

to make sure there is no mechanical interference. Torque the through bolts to 30 to 35 inch pounds. Safety wire should be installed after the unit has been bench tested for output. Install spacer, woodruff key, fan, pulley, lockwasher and nut. Torque the nut to 35 foot pounds, using a strap wrench to hold the pulley. Do not install the blast tube assembly until after the unit has been bench tested.

g. Install the brush and holder assembly and retaining screws. Spin the rotor and check for interference between the brush holder and rotor. Check across the field terminals with an ohmmeter. The ohmmeter must indicate the amount of rotor resistance listed on the individual specifications page.

#### 11-61. TESTING OF ALTERNATOR.

a. Wiring connections for bench testing the alternator are shown in Figure 11-32. Refer to the individual specification pages for output test figures. Adjust the carbon pile, if necessary, to obtain the specified voltage.

b. After bench testing the alternator, install the safety wire and blast tube and install the alternator on the engine.

#### NOTE

Always refer to the wiring diagram (Refer to Figure 11-20 when installing the alternator or testing the alternator.

11-62. PRECAUTIONS. The following precautions are to be observed when testing or servicing the electrical system.

a. Disconnect the battery before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental grounding or shorting at the regulator, alternator, ammeter or accessories, will cause severe damage to the units and/or wiring.

b. The alternator must not be operated on open circuit with the rotor winding energized.

c. Do not attempt to polarize the alternator. No polarization is required. Any attempt to do so may result in damage to the alternator, regulator or circuits.

d. Grounding of the alternator output terminal may damage the alternator and/or circuit and components.

e. Reversed battery connections may damage the rectifiers, wiring or other components of the charging system. Battery polarity should be checked with a voltmeter before connecting the battery. Most aircraft are negative ground.

f. If a booster battery or fast charger is used, its polarity must be connected correctly to prevent damage to the electrical system components.

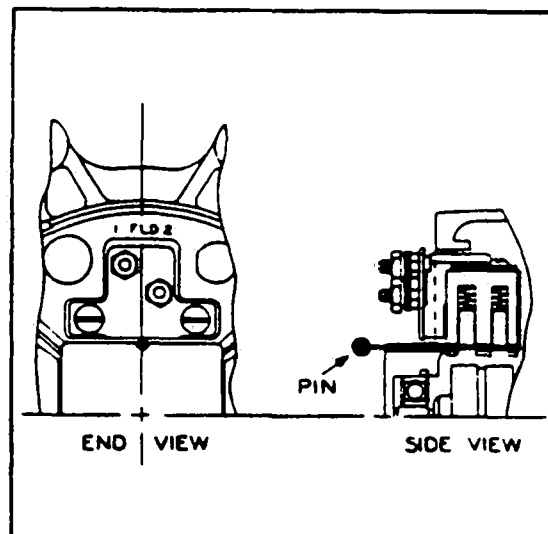


Figure 11-33. Brush Installation

#### 11-63. ALTERNATOR NOMENCLATURE.

a. Bearings: These units have a sealed ball bearing at the drive end and a two-piece roller bearing at the slip ring end. The inner race is pressed onto the rotor shaft and the rest of the bearing is in the slip ring end head. When the unit is assembled, the inner race aligns with the bearing. When the bearing is replaced, the new inner race must be installed on the rotor shaft.

b. Lubrication: The slip ring end bearing should be lubricated whenever the alternator is disassembled. The bearing should be thoroughly cleaned and repacked with Shell Alvania No. 2 or an equivalent bearing lubricant. The cavity behind the bearing should be packed one-third to one-half full with the same lubricant.

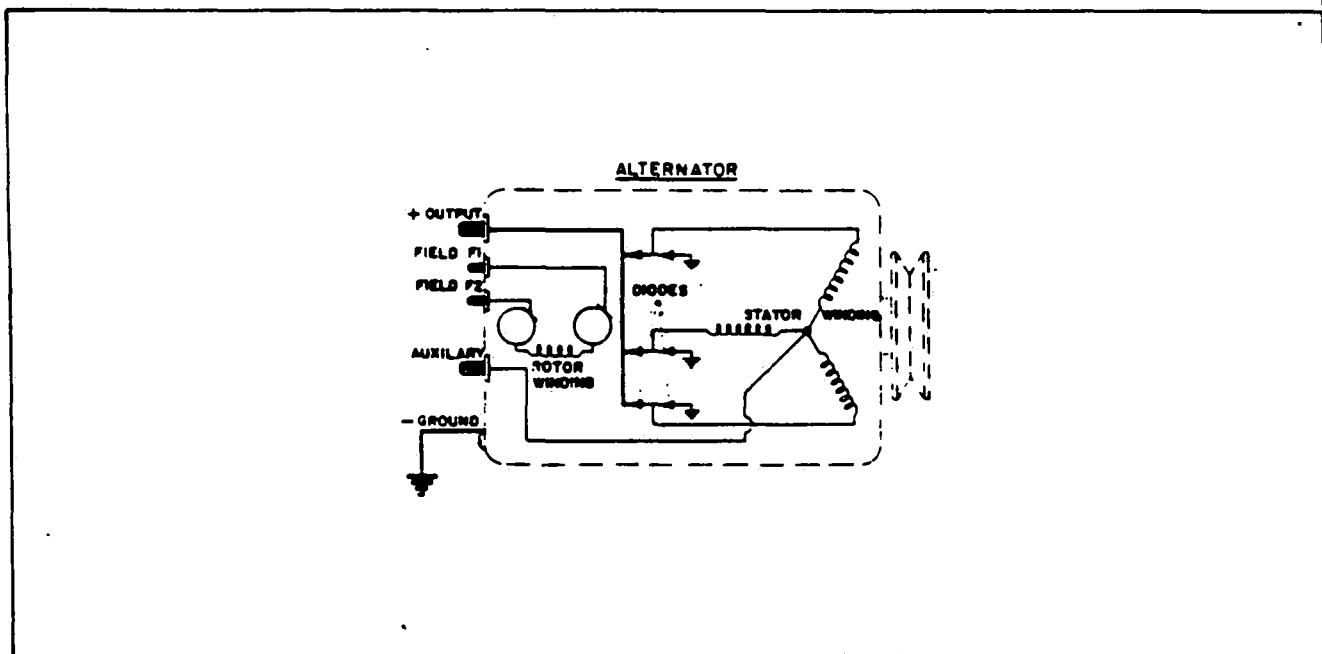


Figure 11-34. Internal Wiring Diagram

- c. **Brushes:** These units have a separate brush holder assembly that is installed after the alternator has been assembled. The brush holder has a small hole that intersects the brush cavities. Use a pin or a piece of wire as shown in Figure 11-33, to hold the brushes in the holder during assembly. Remove the pin after the brush holder retaining screws have been tightened. Make a continuity check to be sure the brushes are seated against the slip rings.
- d. **Drive Pulley:** Torque the drive pulley retaining nut to 35 foot pounds.
- e. **Ventilation:** The 8400 Series units use a slip ring end cover that has a hose type connection for air pressure ventilation. Remove this cover when bench testing the alternator.



**11-64. ALTERNATOR SERVICE TEST SPECIFICATIONS (PRESTOLITE).** Specifications for the 14-volt alternator installed as standard equipment on PA-30 and PA-39 airplanes are as follows:

Alternator Model	ALX8403	
Voltage	14-volts	
Rated Output	70 amperes	
Ground Polarity	Negative	
Rotation	Bi-Directional	
Rotor: Current Draw (77° F) Resistance (77° F)	2.9 to 3.3 amps @ 12.0-volts 3.7 to 4.1 ohms	
Output Test (77° F) Volts Amperes Output Field Amperes Alternator RPM or Engine RPM	13.0 10.0 2.85 1780 min. 550	14.2 71.5 3.15 5000 min. 1540

**11-64a. ALTERNATOR PARALLELING SYSTEM.**

**11-64b. DESCRIPTION OF ALTERNATOR PARALLELING SYSTEM.** The positive output terminal of each alternator is connected to the aircraft electrical bus through separate 90-ampere circuit breaker switches. Each alternator has a shunt installed between aircraft electrical bus and its positive output terminal in order to monitor output current on an ammeter.

The field circuit for each alternator is wired through a section of a Dual Master Switch (L or R as appropriate), an auxiliary switch which is ganged to the circuit breaker switch, an overvoltage relay and a voltage regulator. Field voltage can be manually disconnected from either alternator by turning off the appropriate section (L or R) of the Dual Master Switch. Turning both sections of the Master Switch off completely disconnects all electrical power from the aircraft Bus Bar. Field voltage will be automatically removed from an alternator whenever its overvoltage relay actuates or its circuit breaker switch trips.

The system has one ammeter installed to measure system currents. The output current of either alternator may be checked by pressing the appropriate button "Left" or "Right" located below and to either side of the ammeter. A shunt is installed between aircraft electrical bus and the positive terminal of the battery to allow measuring of the battery charge and discharge current with the ammeter.

An alternator inoperative ("INOP") warning light is provided for each alternator. The appropriate light will illuminate whenever its respective alternator fails to provide output voltage.

The 90-ampere circuit breaker switches should not be turned off when their associated alternator is operating normally. Turning "OFF" one of these switches while it is carrying current could cause a high voltage transient to occur on the electrical bus with possible subsequent damage to the semiconductor equipment attached to it.

**11-64c. DESCRIPTION OF ALTERNATOR.** For a complete description of the alternator, refer to Paragraph 11-56.

**11-64d. CHECKING ALTERNATOR PARALLELING SYSTEM.** The alternator paralleling system incorporates an ammeter which provides for an independent check of each alternator, as well as the charge/discharge current of the battery. In the event either ALTERNATOR INOPERATIVE light begins to glow or the ammeter check for either alternator fails to indicate an output, check the appropriate alternator circuit breaker switch, also the voltage regulator circuit breaker. If the circuit breakers are in their normal operating position a further check of the alternator system should be accomplished. (Refer to Figure 11-34a.)

- a. Verify that the ammeter is operating properly.
- b. Disconnect the output (+) lead at the alternator.
- c. Disconnect the field F-2 lead at the alternator.

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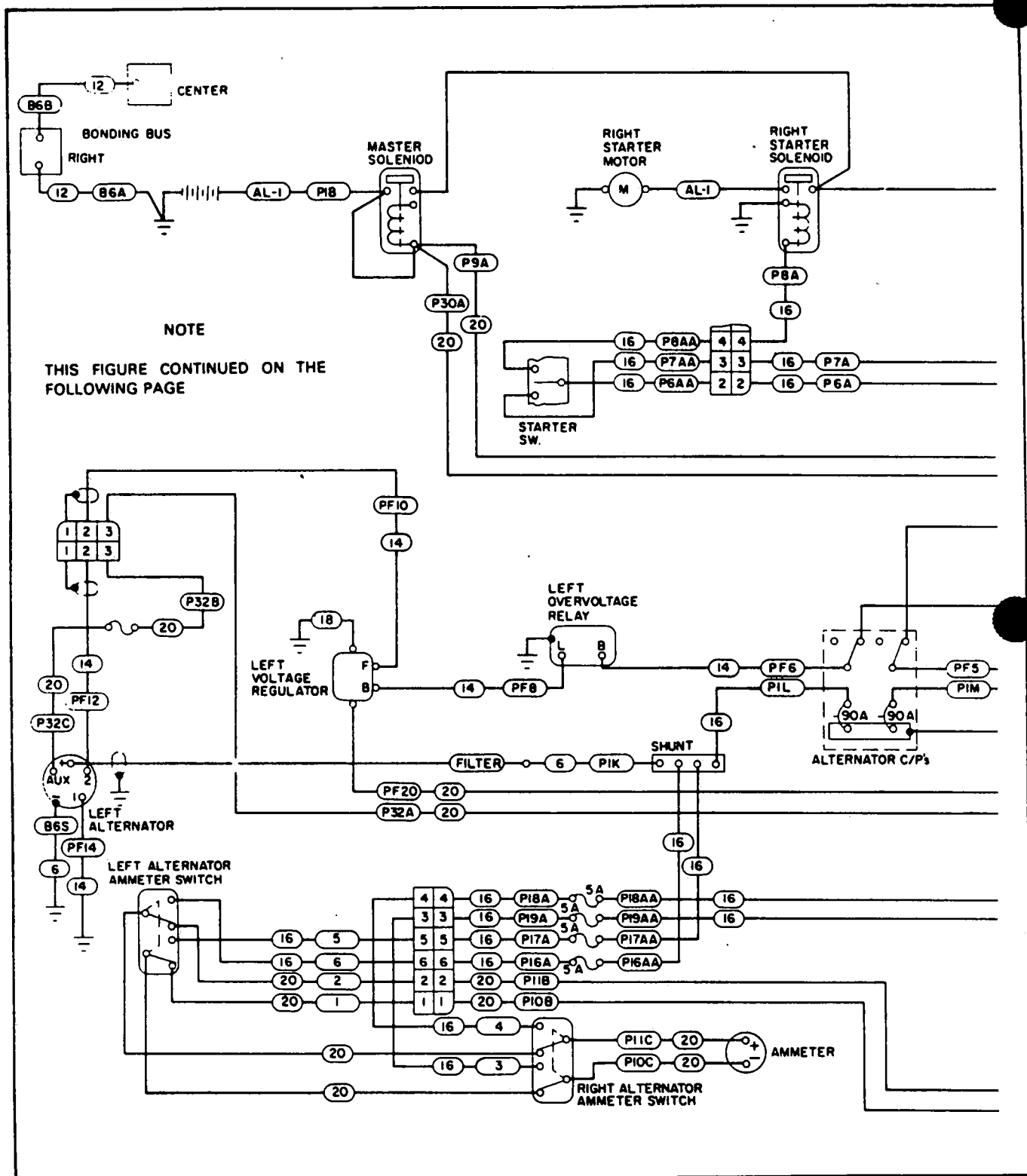


Figure 11-34a. Alternator Paralleling System

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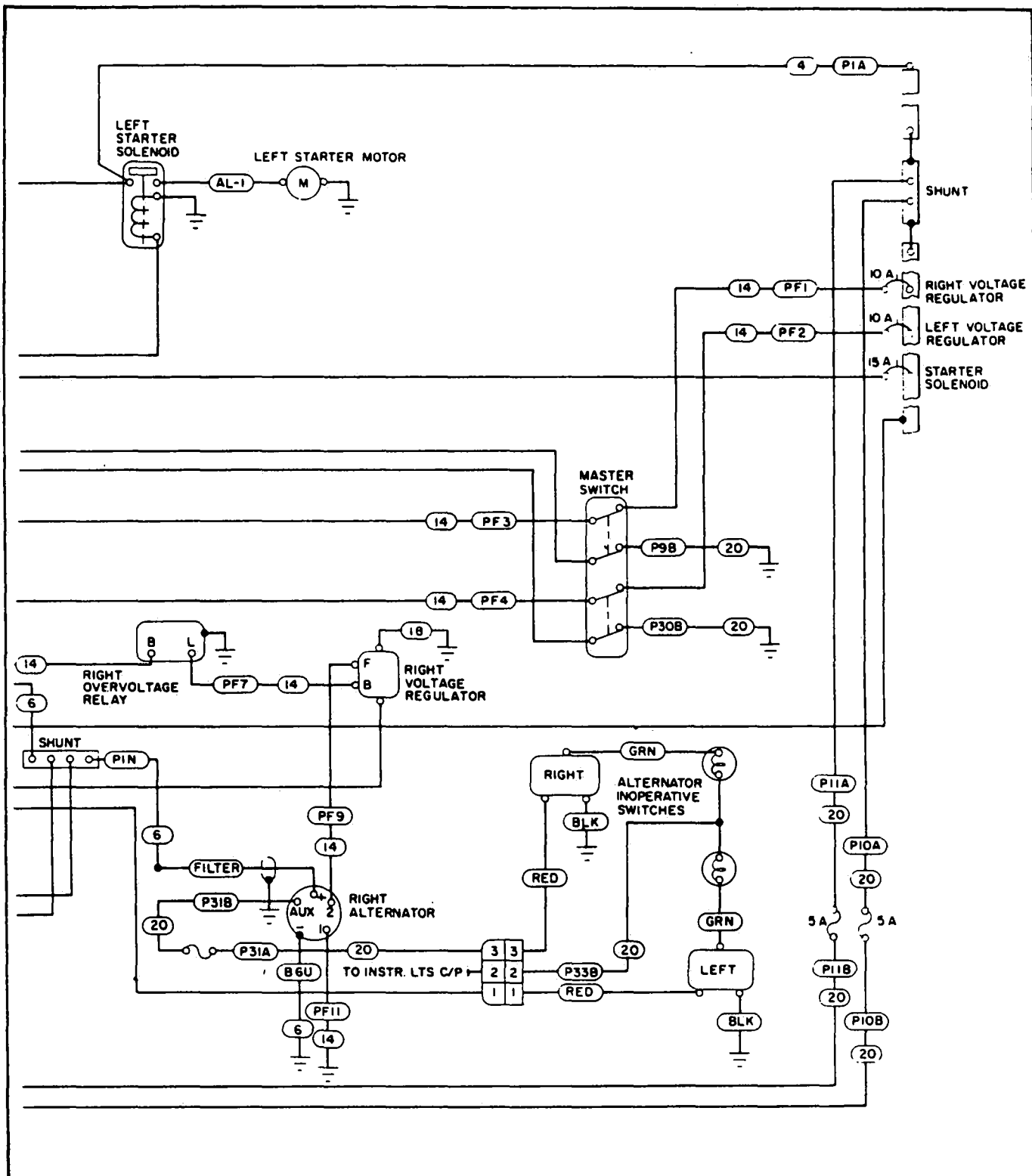


Figure 11-34a. Alternator Paralleling System (cont.)

**CAUTION**

**DO NOT ALLOW THE FIELD LEAD TO COME IN CONTACT WITH AIRFRAME GROUND WHEN THE MASTER SWITCH IS ON AS THE VOLTAGE REGULATOR WILL BE DAMAGED.**

- d. Verify that all electrical units are off and the battery is fully charged.
- e. Turn ON the section of the master switch for the alternator being tested. (L or R.)
- f. To check the alternator output circuit, connect a voltmeter or 14-volt test light to the previously disconnected output (+) lead. Check that the circuit breaker switch for the alternator under test is turned on. If a reading of approximately 14-volts is obtained on the voltmeter, or the test light glows, the output circuit is operational.
- g. Should there be no indication of voltage, trace back through the output circuit until voltage is indicated. (Refer to Figure 1-1-34a.) A component that does not indicate voltage at both its input and output terminals should be replaced.
- h. Check the field circuit by connecting a voltmeter to previously disconnected field (F-2) lead. If a reading of approximately 14 volts is obtained on the voltmeter, the field circuit is operative.
- i. If voltage is present at both the output and field leads, the alternator should be checked for a possible malfunction. (Refer to Paragraph 11-57.)

**11-65. REGULATOR.**

**11-66. REGULATOR COMPONENTS (PRESTOLITE).** Alternator output voltage can, within the limits of the design capability of the alternator, be controlled by properly varying the average level of current flow in the rotor winding and the (PRESTOLITE) full electronic solid state regulator is well suited for this purpose. The (PRESTOLITE) alternator, due to its design, has self-limiting current characteristics and needs no current-limiting unit in the regulator.

- a. Transistor: The transistor is an electronic switch which can turn on and turn off the flow of current in an electric circuit. It has no mechanical or moving parts to wear out.
- b. Rectifier Diode: The rectifier diode will pass current in one direction only (forward direction); and in this respect, it may be compared to a one-way check valve.
- c. Zener Diode: The Zener diode, in addition to passing current in the forward direction, will pass current in the reverse direction only when a particular value of voltage is applied in the reverse direction. It is this Zener action which makes it adaptable for use as a voltage sensing device in the regulator.
- d. Resistor: The resistor is a device which is used to limit current flow.

11-66a. **REGULATOR COMPONENTS (LAMAR).** Alternator output voltage can, within limits of the design capability of the alternator, be controlled by properly varying the average level of current flow in the rotor winding. The LAMAR solid state electronic regulator is well suited for this purpose. The alternator, due to its design, has self-limiting current characteristics and therefore needs no current-limiting element in the regulator.

a. **Transistor:** The transistor (Symbol "Q") is an electronic device which can control the flow of current in an electric circuit. It has no mechanical or moving parts to wear out.

b. **Rectifier Diode:** The rectifier diode (Symbol "D") will pass current in only one direction (forward direction); and in this respect it may be compared to a check valve.

c. **Zener Diode:** The zener diode (Symbol "Z") in addition to passing current in the forward direction, will also pass current in the reverse direction when a particular value of reverse voltage is applied. This property makes it useful as a voltage reference device in the regulator.

d. **Capacitor:** The capacitor (Symbol "C") is a device which will store electrical energy for short periods of time. This property makes it useful as a filter element to smooth variations of voltage.

e. **Resistor:** The resistor (Symbol "R") is a device which is used to limit current flow.

#### 11-67. OPERATION OF REGULATOR (PRESTOLITE). (Refer to Figure 11-35.)

a. When the alternator switch is turned on, battery voltage is applied to the "I" terminal of the regulator.

b. The npn (negative-positive-negative) power transistor, T3, is turned on by current flow from the ignition terminal through R6 and the collector emitter junction of T2 through D2 through the base emitter junction of T3 to ground.

c. Whenever the power transistor, T3, is on (T2 is also on and T1 is off), current will flow from the ignition terminal through the field winding, through the collector - emitter of T3 to ground.

d. With the ignition switch on, current will flow from the "I" terminal regulator ground through a voltage dividing network consisting of R1, R2 and P1. This network determines the system operating voltage relative to the Zener diode, Z1, reverse conducting voltage.

e. When the system voltage connected to "I" terminal reaches a value at which the Zener diode connected to the divider network conducts, current will flow from the "I" terminal through R1 through Z1 and through the base emitter junction of T1 to ground. This causes the collector emitter junction of T1 to conduct which diverts the base current of T2 flowing from "I" terminal through R4 to ground, turning off T2 which turns off T3, de-energizing the rotor winding; then, when the alternator output voltage falls to a value which permits Z1 to cease conduction, T1 will turn off which turns on T2 and T3, re-energizing the rotor winding.

f. This sequence is performed so rapidly that the rotor current average appears as a value usually less than full rotor current depending on rotor RPM and system load connected.

- g. Each time the power transistor, T3, is turned off, current flow in the rotor winding is reduced. This causes the rotor magnetic field to collapse which would generate high voltage at the power transistor, T3, if a path were not provided so that the field current can decay at a slower rate. The field suppression diode, D1, provides this path, thus protecting the system and regulator from possible damage.
- h. Temperature compensation is flat which means the regulator will hold the alternator output voltage constant with temperature increase or decrease after initial warm-up.
- i. The (PRESTOLITE) solid state regulator uses three NPN silicon transistors.
- j. Capacitor, C1, is used to filter ripple and alternator diode switching spike when operating batteryless.
- k. Neon lamp, L1, provides transient voltage protection acting as a surge suppressor.
- l. Control P1 is used to provide a limited range of voltage adjustment.

**11-67a. OPERATION OF REGULATOR (LAMAR). (Refer to Figure 11-35a.)**

- a. When the alternator is turned on, battery voltage is applied to the "BUS" terminal of the regulator and via Q4 through the "FIELD" terminal of the regulator to the alternator field terminal F2. The amount of voltage applied to the field of the alternator is controlled automatically by action of the regulator in response to alternator output as described below.
- b. Current flow through R6 and Z1 establishes a reference voltage across Z1.
- c. Resistors R1 and R2/R3 comprise a voltage divider which is adjustable by means of the variable portion R3. Voltage at the junction of R1 and R2 and the reference voltage across Z1 are applied to comparison transistor Q1. R3 is adjusted so that these voltages are balanced with the desired alternator output voltage present on the "BUS" terminal of the regulator.
- d. Thereafter, whenever alternator output voltage (as applied to the "BUS" terminal) falls below the desired regulation value, the comparison transistor Q1 will supply increased current to driver transistors Q2/Q3, which in turn will drive power transistor Q4 to a higher value of field current. This will result in alternator output voltage increasing to a value which will restore balance between the two voltages applied to Q1.
- e. Conversely, if alternator output voltage (as applied to the "BUS" terminal) increases due to a greater engine speed or reduced loading of the electrical system, the comparison transistor Q1 will act to reduce current flow to the driver transistors Q2/Q3, and thus reduce the drive to power transistor Q4. This will result in a reduction of alternator field current and automatically restore balance between the two voltages applied to comparison transistor Q1.
- f. Capacitors C1 and C2 function, together with their related transistors, in a way to smooth alternator output ripple and voltage spikes so that the alternator field current is controlled at a steady value.
- g. The LAMAR solid state regulator controls alternator field current to a steady value as required by the electrical load conditions and engine speed. It does not continuously switch field current between high and low values as do mechanical regulators and the switching type of electronic regulators.
- h. The design of this unit is such as to provide an alternator output voltage that does not vary with ambient temperature.



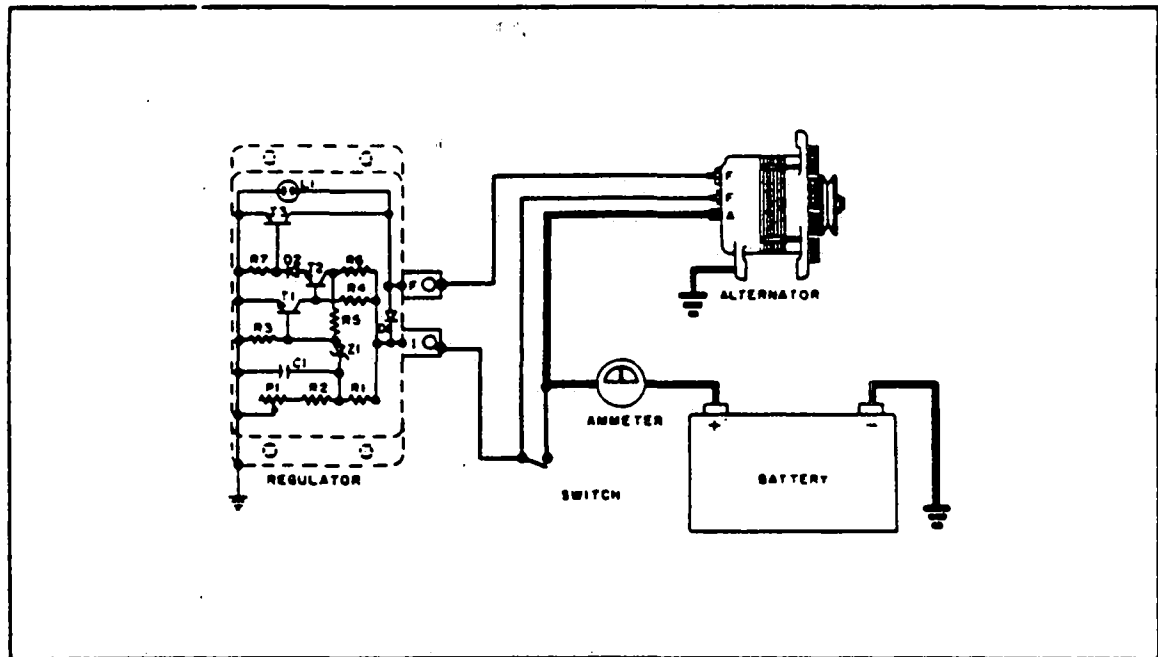


Figure 11-35. Regulator Diagram (PRESTOLITE)

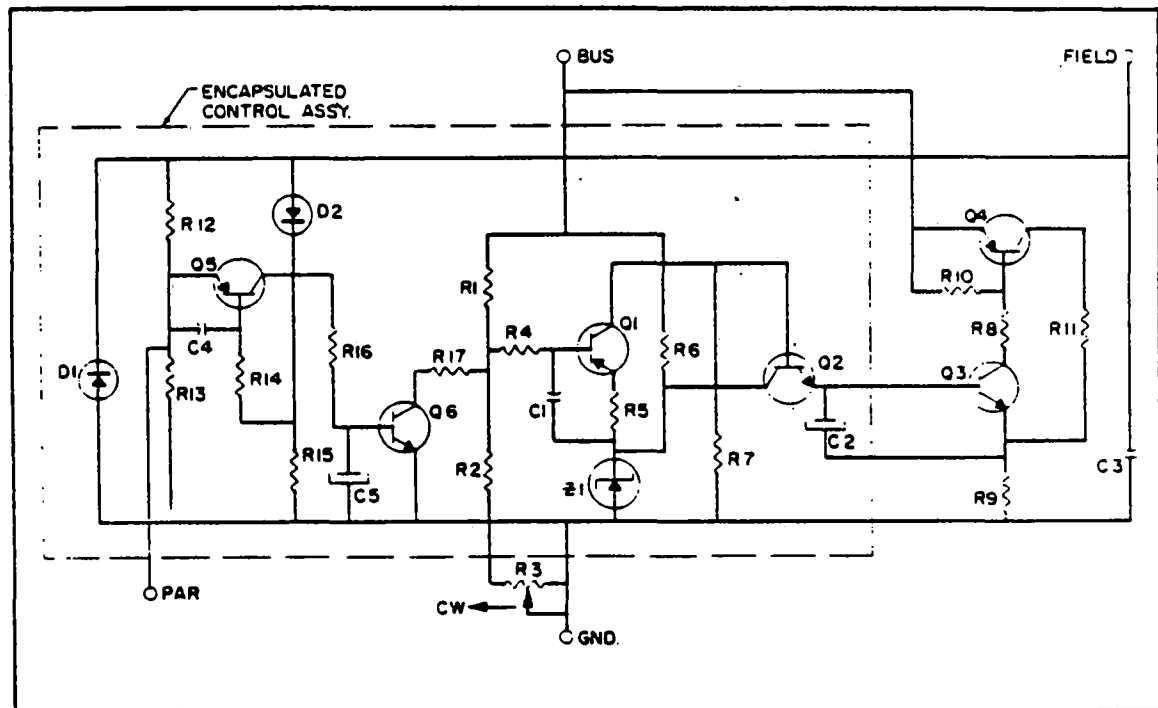


Figure 11-35a. Regulator Diagram (LAMAR)

11-67b. **BALANCING CIRCUIT OPERATION (LAMAR).** (Considering two identical alternators and regulators having the "PAR" terminals of the regulators connected.)

- a. Balancing circuit operation is initiated within one regulator whenever individual field voltages delivered by the regulator units to their related alternators are not equal.
- b. When a difference in individual field voltages occurs, one-half the difference is impressed across R12 within each regulator and is thus applied to the input of Q5.
- c. In that regulator which is delivering the lower field voltage, the polarity of R12 voltage drop causes Q5 collector current flow.
- d. Q5 collector current flow results in conduction occurring in the collector circuit of Q6.
- e. Q6 collector current flows from regulator divider R1/R2+R3 through limiting resistor R17 to ground.
- f. Conduction through R17 effectively alters the ratio of the regulator divider R1/R2+R3 in the direction to increase Q1 collector current flow.
- g. As described above under **REGULATING CIRCUIT OPERATION**, increased Q1 current results in increased output from the regulator to the field of its related alternator.
- h. Feedback action results in Q6 collector current stabilizing at a value that results in nearly equal field voltage being delivered by the two regulators to their respective alternator fields.
- i. The balancing circuit will thus automatically maintain, at a low value, the difference voltage applied to the alternator fields. In a parallel system having identical alternators operating at the same RPM, the output currents of the alternators will thus be maintained nearly equal.
- j. In whichever regulator of a pair is set to deliver the highest voltage, the balancing circuits are inactive. Thus system voltage is determined by the regulator of a pair which is set to higher voltage. The lower set regulator will adjust itself automatically, as described above, to deliver the same field voltage as the one which is set higher, within the limits of its design capability.
- k. The balancing regulator system as described provides for automatic load balancing of parallel operated alternators having independent field excitation circuits. The pilot can, while in flight, remove either alternator system completely from the aircraft system and maintain operation of the other system.

11-68. **PREPARATION FOR TESTING.** (Regulators may be tested using the aircraft's alternator or an alternator test stand.)

#### CAUTION

Do not interchange regulator leads. This will destroy regulator and void warranty.

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- a. The aircraft technician or other electrical systems specialist, must disconnect the battery ground cable at the battery before connecting or disconnecting a test ammeter or other test equipment or before making wiring changes in the electrical system.
- b. Voltmeters with test probes or clips are not recommended. Fully insulated bolted terminal connections are best, and these should be attached when all power is removed as described above.
- c. When installing a battery in an aircraft, be sure that the battery negative terminal is in a position so that this terminal can be connected to the battery ground cable for negative ground systems.
- d. The regulator under test to be mounted on a grounded metallic surface using three No. 8 screws pulled up tight. For extended test periods the heat transfer from regulator to the mounting surface is significant.
- e. A ground wire between the regulator "GND" terminal and the aircraft or test stand structure is essential for proper operation. The alternator frame must also be solidly bonded to the system ground.
- f. The alternator does not need to be polarized; therefore, never connect ground, even momentarily, to either the regulator field terminal or to the alternator field terminals. Do not interchange I and F leads to regulator as this will destroy the regulator.
- g. The LAMAR regulator is intended for use with alternator systems having one field terminal grounded to the alternator. The other field terminal F2 of the alternator is connected to the "FIELD" terminal of the regulator. NEVER UNDER ANY CIRCUMSTANCE PERMIT A GROUND TO CONTACT THIS CIRCUIT EVEN FOR AN INSTANT WHILE POWER IS APPLIED TO THE SYSTEM. Due to this precaution, the mechanic should not use tools near these circuits while power is applied.
- h. The alternator should be in good condition and capable of producing full output, and the alternator drive belt must be adjusted tight enough to prevent slippage.
- i. The battery must be in good condition and should be fully charged.
- j. The voltmeter and ammeter should be of the best quality and should be accurate.
- k. A carbon-pile connected across the battery may be used to load the charging circuit while testing the regulator.

### 11-69. TESTING REGULATOR (PRESTOLITE).

- a. The procedure for testing the regulator, whether on the airplane or on the test bench remains the same. Connect test meters as shown in Figure 11-36.
- b. All circuit connections should be clean and tight. This includes the test instrument connections which must not come loose or open the charging circuit at any time while the system is operating.
- c. The voltmeter will not indicate the true regulator setting until the regulator has been operating in the charging system or on the test bench for at least one minute, at a charge rate of from 10 to 15-amperes.
- d. Connect the voltmeter and the ammeter as shown in Figure 11-36. Start the engine and adjust the speed to approximately 920 to 1250 RPM to obtain 3,000 to 4,000 alternator RPM. Turn on accessories as needed to establish 10 to 15-ampere electrical load, or use a carbon-pile across the battery to obtain this charge rate.

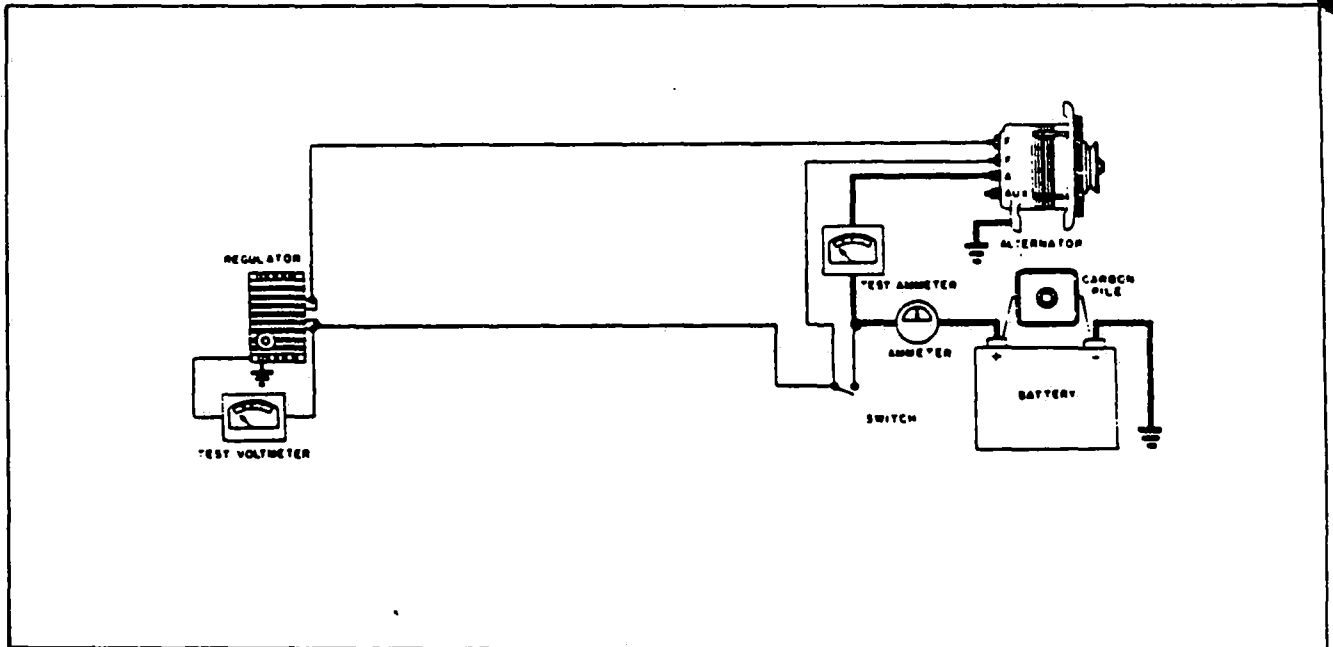


Figure 11-36. Testing Regulator (PRESTOLITE)

e. After one minute operating time, check the regulator operating voltage as indicated by the voltmeter. Refer to Alternator Service Test Specifications, Paragraph 11-64 for the correct operating voltage. The operating voltage is shown for the ambient temperature in which the regulator is operating.

f. If the voltmeter reading indicates that the operating voltage is not within limits, lift the plastic plug from top of regulator and adjust the voltage to the desired value. Replace the plug after adjustment. Before condemning the regulator, recheck the alternator and the battery; making sure that they are in good condition. Recheck all circuit connections and all wiring for unwanted resistance (voltage drop test). Recheck the voltmeter for accuracy and repeat the engine operating test.

#### 11-69a. TESTING REGULATOR (LAMAR).

a. The procedure for testing the regulator, whether on the airplane or on the test bench, remains the same. Connect the test meters and regulator wiring as shown in Figure 11-36a.

b. All circuit connections should be clean and tight. This includes the test instrument connections which must not come loose or open the charging circuit at any time while the system is operating.

c. The voltmeter will not indicate the true regulator setting until the regulator has been operating in the charging system or on the test bench for at least five minutes, at a charge rate of from 10 to 15 amperes.

d. With the connections made as shown in Figure 11-36a, start the engine and adjust its speed to approximately 920 to 1250 RPM to obtain 3,000 to 4,000 alternator RPM. Turn on accessories as needed to establish a 10 to 15 ampere load value. Note that the battery charge current is indicated by the ammeter. Therefore, the current value may change downward at the beginning of a test run. This will be especially true if the battery was used for engine starting.

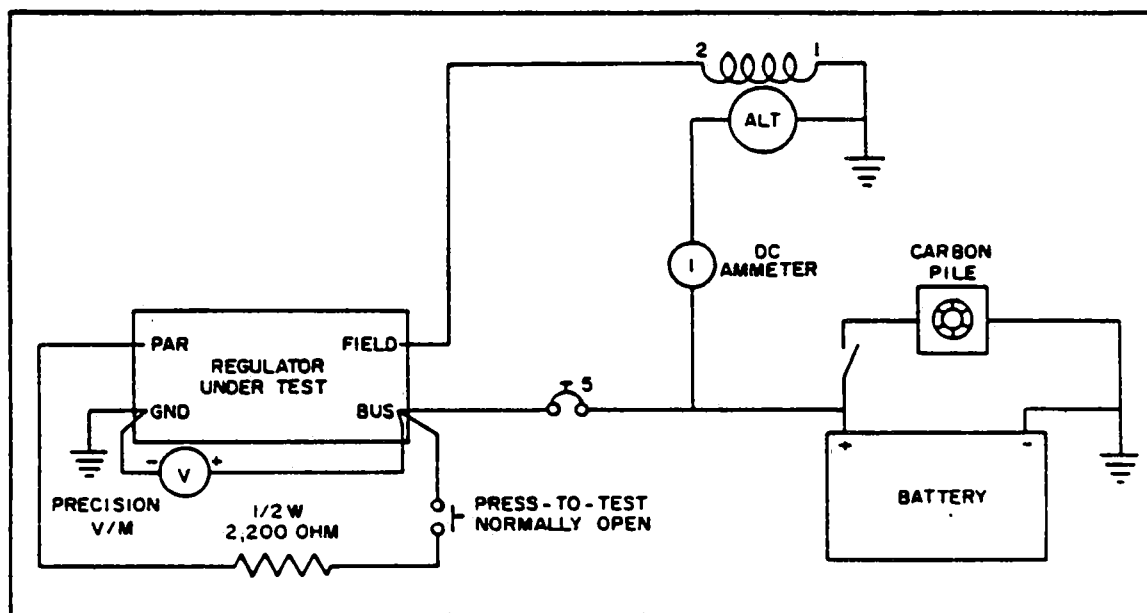


Figure 11-36a. Testing Regulator (LAMAR)

e. After five minutes operating time, check the regulator operating voltage as indicated by the voltmeter. Refer to Alternator Service Test Specifications as outlined in Paragraph 11-64 for correct operating voltage. The operating voltage is shown for ambient temperature in which the regulator is operating.

f. If the voltmeter reading indicates that the operating voltage is not within limits, carefully insert a small screwdriver (Phillips #0) in the voltage adjustment access hole on top of the regulator and adjust voltage adjustment slowly to obtain desired value. Before condemning the regulator, recheck the alternator and the battery: making sure that they are in good condition. Recheck all circuit connections and all wiring for unwanted resistance (voltage drop test). Recheck the voltmeter for accuracy and repeat the entire operating test.

g. Balance circuit operation is confirmed by closing the press-to-test switch momentarily and observing that the alternator output current increases abruptly to a higher level. Upon release of this switch, the alternator output will be restored to its previous level, except that minor differences may be noted which are due to battery charge conditions.

#### 11-70. ADJUSTING REGULATOR (PRESTOLITE).

a. Adjustment: These units have an external adjustment located under the plastic plug on top of the regulator. The regulator has an adjustment spread ranging from 13.0-volts to 15.0-volts. Output is increased by turning the adjustment clockwise.

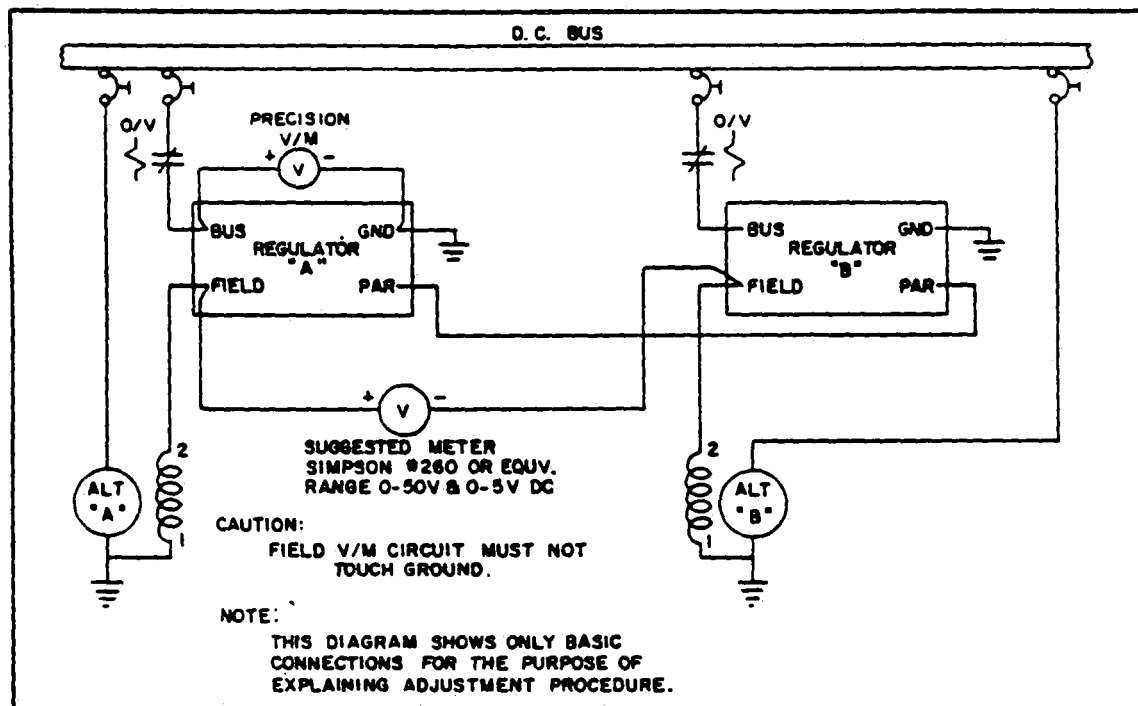


Figure 11-36b. Adjusting Regulator (LAMAR)

b. Operating Voltage: The regulator should be adjusted to 14.2-volts when controlling a load of 10 to 15-amperes after one minute operation. These units are not affected by ambient temperatures. The voltmeter must be connected from the "I" or switch terminal to ground.

c. Caution Notes:

1. Use only with insulated (ungrounded) field alternators.
2. Regulator base must have a good ground connection.
3. Do not connect ground power to aircraft until voltage regulator "I" terminal has been disconnected from electrical system.
4. Do not (even momentarily) connect the two voltage regulator terminals together.
5. Do not connect battery into system with polarity reversed.
6. Do not force the voltage adjustment screw.
7. This is a sealed unit and not repairable. Replace with a new unit.

#### 11-70a. ADJUSTING REGULATOR (LAMAR).

a. These regulators are normally used in parallel alternator systems of multi-engine aircraft. Their final adjustment should be made in actual operation in the aircraft system with test equipment connected as shown in Figure 11-36b. The balance adjustment is made while operating only one engine, either left or right. The engine to be operated must be selected so as to permit the technician a completely safe access to both of the regulators, so that they may be adjusted while the engine is operating without danger. We shall designate the engine selected to be operated as "LEFT" and the inoperative engine as "RIGHT" for purposes of discussion.

b. Lift the wire from the "PAR" terminal of either regulator and insulate the free end so it will not contact other circuits or ground during the adjustment procedure. Breaking this circuit disables the balancing circuits in both regulators.

c. Turn off the "RIGHT" alternator field switch. All the "LEFT" alternator switches are to be on.

d. Operate the "LEFT" engine and alternator system with a load of at least 15-amperes and the engine speed at 920 to 1250 RPM to obtain 3,000 to 4,000 alternator RPM for at least one minute. If required, carefully set the "LEFT" regulator voltage adjustment to the correct voltage value as measured with the precision voltmeter connected to the regulator terminals. Replace the snap plug in the "LEFT" regulator adjustment access hole.

#### CAUTION

**DO NOT MAKE ANY FURTHER ADJUSTMENT OF THE "LEFT" REGULATOR.**

e. While continuing "LEFT" engine operation with electrical load the same as before, turn on the "RIGHT" alternator system switches. (The "RIGHT" engine, however, is NOT operating.)

f. Now very slowly rotate the "RIGHT" regulator voltage adjustment while observing the field circuit voltmeter. (Suggested range 0-50V.) If a reverse (downscale) reading is obtained, turn the "RIGHT" regulator adjustment counterclockwise to bring the meter up scale. Then, very slowly turn the "RIGHT" regulator adjustment clockwise to make the field voltmeter read near zero. A stable reading should not be expected. A correct adjustment has been achieved when the meter will remain briefly in the vicinity of zero, swinging both upscale and downscale. The use of a low range on the voltmeter is recommended for the final adjustment. (0-5V is suggested.)

g. Replace the snap plug in the "RIGHT" regulator adjustment hole.

h. Shut down the engine and master switch, then replace the connection to the "PAR" terminal which was removed in step b. Remove all voltmeter leads and test equipment.

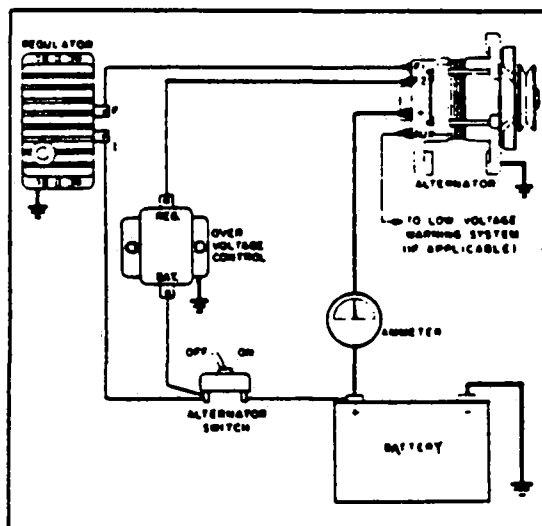


Figure 11-37. Application of Overvoltage Control

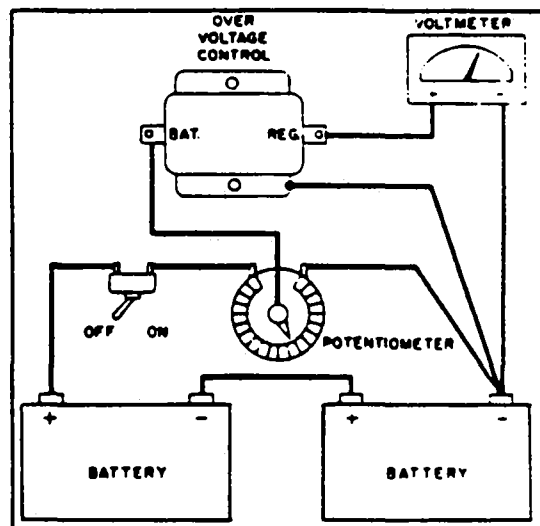


Figure 11-38. Testing Overvoltage Control

#### 11-71. OVERVOLTAGE CONTROL.

##### 11-72. PURPOSE AND OPERATION.

a. The overvoltage control is used to protect electrical circuits and electronic equipment from excessive voltage in the event of a charging circuit malfunction.

b. The overvoltage control consists of a mechanical relay and a solid state triggering device. The solid state triggering device activates the mechanical relay, when the voltage reaches a preset value, thereby opening the relay contacts and disconnecting the field circuit of the alternator.

c. The relay contacts will remain open until the alternator switch is turned off. Figure 11-37 illustrates the overvoltage control connected in a typical (PRESTOLITE) insulated field alternator.

11-73. TEST PROCEDURE. Connect the relay as shown in Figure 11-38. Use a 100-ohm potentiometer of 15-watt rating, or more, to adjust the voltage. The voltmeter is used to read the voltage until the relay opens, at which time the voltmeter reading will drop to zero. See tabulation for voltage reading. Test figures are at 75 degrees Fahrenheit. Relay contacts open between 16.2 and 16.8-volts. Use 18-volts to test.

#### NOTE

These units are not adjustable. Replace the overvoltage control if it does not test to specifications.



**11-73a. OVERVOLTAGE RELAY OPERATIONAL CHECK (NON-PARALLELING SYSTEM).** This check should be made at each 500 hour inspection, per the following instructions:

- a. Pull out (OFF) all circuit breakers except the main and auxiliary voltage regulators (5-amp).
- b. Turn off the right and left alternator output circuit breaker switches (90-amp).
- c. Set the voltage regulator selector switch to MAIN.
- d. Obtain a variable D.C. voltage power supply and set it to zero output.
- e. Connect the power supply to the aircraft through the external power receptacle. On aircraft without an external power receptacle, disconnect the battery cables and connect the power supply to the cables.
- f. Obtain a volt/ohmmeter and set it to 60 volts D.C. Connect the meter VOM lead to the output (REG.) terminal of the MAIN overvoltage relay. Connect the meter COM lead to the airframe ground.
- g. Turn the aircraft master switch ON.
- h. Increase the output voltage of the variable D.C. power supply until the MAIN overvoltage relay trips out. (An audible click will be heard when the relay operates and the VOM needle must drop to zero volts.) Record the power supply voltmeter reading which was indicated just previous to the overvoltage relay operating. Voltage limits are: Min. 15.5-volts - Max. 16.5-volts.
- i. Reduce the power supply voltage to zero. Open the master switch. Another click will be heard when the overvoltage relay resets itself for normal operation.
- j. Change the voltage regulator selector switch from MAIN to AUX. Reconnect the volt/ohmmeter to the AUX. overvoltage relay and repeat steps g thru i.

**11-73b. OVERVOLTAGE RELAY OPERATIONAL CHECK (PARALLELING SYSTEM).** This check should be accomplished at each 500 hours inspection per the following instructions:

- a. Pull all circuit breakers to the out (OFF) position except the left and right voltage regulator (5-amp) circuit breakers.
- b. Obtain a variable D.C. voltage power supply and set it to zero output.
- c. Connect the power supply to the aircraft through the external power receptacle.
- d. Turn ON the left alternator section of the Dual Master Switch.
- e. Obtain a volt/ohmmeter and set it to 60 volts D.C. Connect the positive lead of the VOM to the output (LOAD) terminal of the LEFT overvoltage relay. Connect the negative lead of the VOM to airframe ground.
- f. Increase the output voltage of the variable D.C. power supply until the LEFT overvoltage relay trips out. (An audible click will be heard when the relay operates and the VOM needle must drop to zero volts.) Record the power supply voltmeter reading which was indicated just prior to the overvoltage relay operating. Voltage limits are: Min 15.50-volts - Max. 16.50-volts.
- g. Reduce the power supply to zero. Turn OFF the left alternator section of the Dual Master Switch. Another click will be heard when the overvoltage relay resets itself for normal operation.
- h. Turn ON the right alternator section of the Dual Master Switch. Reconnect the volt/ohmmeter to the right overvoltage relay and repeat steps f and g.

**11-74. CHECKING GENERATOR OR ALTERNATOR BELT TENSION.** If properly installed, tensioned and checked periodically, the generator or alternator drive belt will give very satisfactory service. However, an improperly tensioned belt will wear rapidly and may slip and reduce generator or alternator output. Consequently, a belt should be checked for proper tension at the time it is installed, again after 24 hours of operation and each 100 hours thereafter.

There are two satisfactory methods of checking generator or alternator 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 alternator 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 b with torque specified in the following chart. Adjust belt tension accordingly.

Width of Belt	Condition	Torque Indicated at Generator or Alternator 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 or alternator.

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.

## 11-75. STARTING MOTOR (DELCO-REMY).

11-76. OPERATION OF STARTING MOTOR. When the starting 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.

11-77. CHECKING STARTING MOTOR. Several checks, both visual and electrical, should be made in a defective starting 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 starting 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 starting 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 starting 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 starting 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.

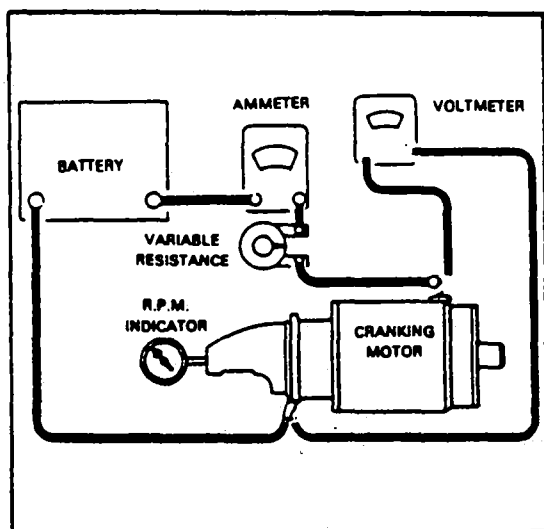


Figure 11-39. No-load Test Hookup

# 11-78. TEST AND MAINTENANCE OF STARTING MOTORS.

11-79. INSPECTION. With the starting 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.

11-80. NO LOAD TEST. (Refer to Figure 11-39.) Connect the starting 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 11-86. Interpret the test results as follows:

- a. Rated current draw and no-load speed indicate normal condition of the starting 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.

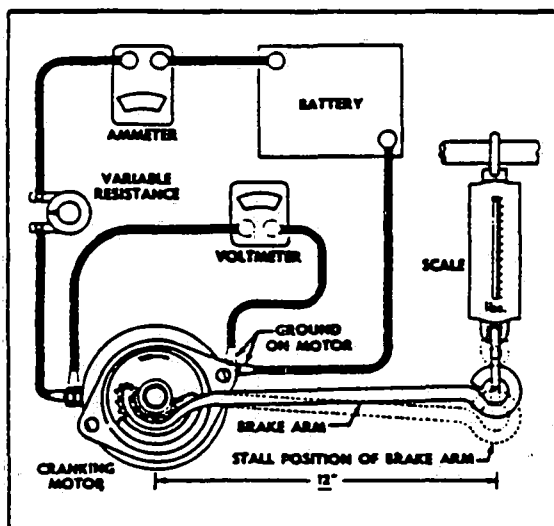


Figure 11-40. Lock-Torque Test Hookup

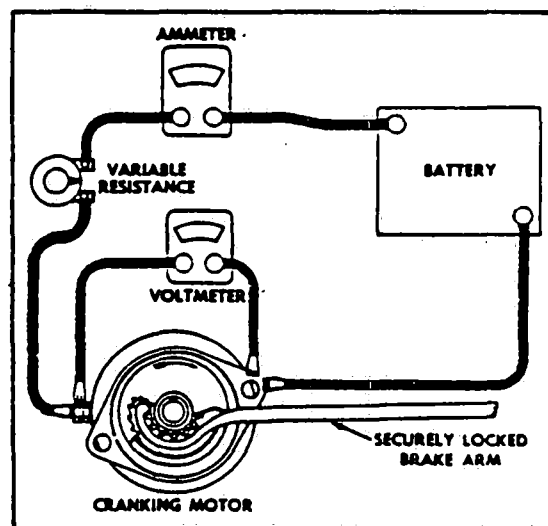


Figure 11-41. Resistance Test Hookup

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.

11-81. LOCK-TORQUE TEST. (Refer to Figure 11-40.) The lock-torque test requires the equipment illustrated. A variable resistance with a high current capacity should be used. The starting 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 11-86. If the torque is low, the motor must be disassembled for further tests and repair.

**11-82. RESISTANCE TEST.** (Refer to Figure 11-41.) 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 11-86. A high current indicates grounded or shorted conductors, and a low current indicates excessive resistance.

**11-83. 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 starting 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 starting motor. Following are general instructions for disassembling a typical Bendix drive starting 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.

**11-84. 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 11-86.) 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.

11-85. 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.

11-86. STARTING MOTOR SERVICE TEST SPECIFICATIONS (DELCO-REMY). Specifications for 14-volt starting motors installed as standard equipment on the PA-30 airplanes are as follows:

Motor Model	1109511
(DELCO-REMY), Ref., the latest revision of Service Bulletin 1M-110	
Minimum Brush Tension	24 oz. min.
No-Load Test	
Volts	10.6
Min. Amps	----
Max. Amps	60
Min. RPM	3000
Max. RPM	----
Lock Test	
Amps	300
Torque (ft. -lbs. )	18 min.
Approx. Volts	7.3
Resistance Test	
Volts	
Min. Amps	
Max. Amps	



11-87. STARTING MOTORS (PRESTOLITE).

11-88. DESCRIPTION. The gear reduction starting motor consists of six major components: The Commutator End Head Assembly, The Armature, The Frame and Field Assembly, the Gear Housing, The Pinion Housing, and The Bendix Drive Assembly. Refer to Figure 11-42.

11-89. OPERATION. When the starting circuit is energized, battery current is applied to the starting motor terminal. Current flows through the field coils, creating a strong magnetic field. At the same time, current flows through the brushes to the commutator, through the armature windings to ground. The magnetic force created in the armature combined with that created in the field windings begins to turn the armature.

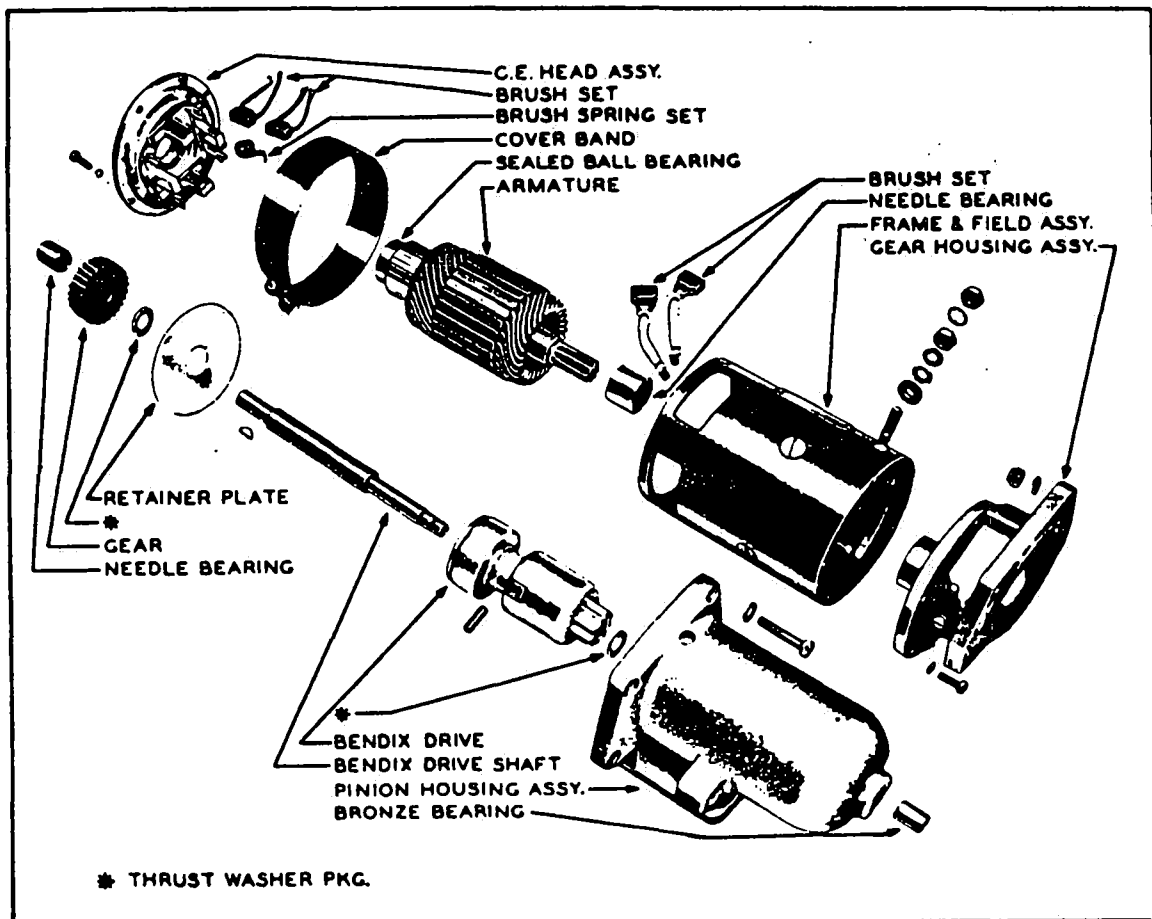


Figure 11-42. Exploded View of Gear Reduction Starting Motor

The gear cut on the drive end of the armature shaft extends through the gear housing, where it is supported by a roller bearing. The gear mates with the teeth of the reduction gear that drives the bendix shaft. The shaft is keyed to the reduction gear. The Bendix drive is held in position on the shaft by a "spiral" pin. The shaft is supported in the gear housing by a closed end roller bearing and in the pinion housing by a graphitized bronze bearing.

When the armature turns the reduction gear, the Bendix drive pinion meshes with the flywheel ring gear by inertia and action of the screw threads within the Bendix sleeve. A detent pin engages in a notch in the screw threads which prevents demeshing if the engine fails to start when the starting circuit is de-energized.

When the engine reaches a predetermined speed, centrifugal action forces the detent pin out of the notch in the screw shaft and allows the pinion to demesh from the flywheel.

11-90. MAINTENANCE. The starting circuit should be inspected at regular intervals, the frequency of which should be determined by the amount of service and the conditions under which the airplane is operated. It is recommended that such inspection be made at least twice a year and include the following:

a. The battery should be checked with a hydrometer to be sure it is fully charged and filled to the proper level with approved water. A load test should be made to determine battery condition. If dirt and corrosion have accumulated on the battery, it should be cleaned with a solution of baking soda and water. Be sure none of the solution enters the battery cells.

b. The starting circuit wiring should be inspected to be sure that all connections are clean and tight and that the insulation is sound. A voltage loss test should be made to locate any high-resistance connections that would affect starting motor efficiency. This test is made with a low-reading voltmeter while cranking the engine or at approximately 100 amperes, and the following limits should be used:

1. Voltage loss from insulated battery post to starting motor terminal - 0.3-volt maximum.
2. Voltage loss from battery ground post to starter frame - 0.1-volt maximum.

#### NOTE

If voltage loss is greater than the above limits, additional tests should be made over each part of the circuit to locate the high-resistance connections.

c. No lubrication is required on the starting motor except at the time of overhaul. Then lubricate the entire shaft under Bendix Drive, fill grooves in armature shaft at drive end and pack gear box with 1.3 to 2.0 ounces of Lithium Soap Base Grease #1925 Molytex "O" or equivalent.

d. The starting motor should be operated for a few seconds with the ignition switch off to make sure that the pinion engages properly and that it turns freely without binding or excessive noise. Then the engine should be started two or three times to see that the pinion disengages properly when the engine is turned off.

11-91. OVERHAUL. If during the above inspection any indication of starting motor difficulty is noted, the starting motor should be removed from the engine for cleaning and repair.

11-92. REMOVAL. To remove the starting motor from the engine, first disconnect the ground cable from the battery post to prevent shortcircuiting. Disconnect the lead from the starting motor terminal, then take out the mounting bolts. The motor can then be lifted off and taken to the bench for overhaul.

#### 11-93. DISASSEMBLY.

a. Remove the frame screws from the commutator end head and pull end head and armature from frame. Lift the brushes and lock in elevated position with brush springs. Use a puller to remove the end head from the armature. Use a special bearing puller to remove the sealed ball bearing from the armature shaft.

b. Remove the frame screws that secure the gear housing to the frame. Remove bolts and nuts holding the gear housing to the pinion housing and separate the two units. Pull Bendix shaft from pinion housing. Do not lose the steel spacer that is located on the pinion end of the shaft. Remove reduction gear, woodruff key and steel spacer from shaft.

c. Turn the Bendix pinion until it locks in the extended position. Locate "spiro" pin and use a punch to remove. Slide drive assembly off the shaft. Do not attempt to disassemble the drive and do not dip it in cleaning solvent.

d. To remove the roller bearings from the gear housing, use an arbor press and the correct bearing arbor. DO NOT HAMMER OUT. Each part should be cleaned and inspected for excessive wear or damage. Bearings should be checked for proper clearance and evidence of roughness or galling. Oil and dirt should be removed from insulation and the condition of the insulation checked.

11-94. **BRUSHES.** Check the brushes to see that they slide freely in their holders and make full contact on the commutator. If worn to half their original length or less, they should be replaced.

11-95. **ARMATURE.**

a. Check the commutator for uneven wear, excessive glazing or evidence of excessive arcing. If only slightly dirty, glazed or discolored, the commutator can be cleaned with 00 or 000 sandpaper. If the commutator is rough or worn, it should be turned in a lathe. Refer to Figure 11-43. The armature shaft should be inspected for rough bearing surfaces and rough or damaged splines.

b. To test the armature for grounds, a set of test probes connected in series with a 110-volt light should be used. Touch one probe to a commutator segment and the other to the armature core. If the test lamp lights, the armature is grounded and should be replaced.

c. To test for shorted armature coils, a growler is used. (Refer to Figure 11-44.) The armature is placed on the growler and slowly rotated by hand while a steel strip is held over the core so that it passes over each armature core slot. If a coil is shorted, the steel strip will vibrate.

d. A quick check for opens can be made by inspecting the trailing edge (in direction of rotation) of the commutator segments for excessive discoloration. This condition indicates an open circuit.

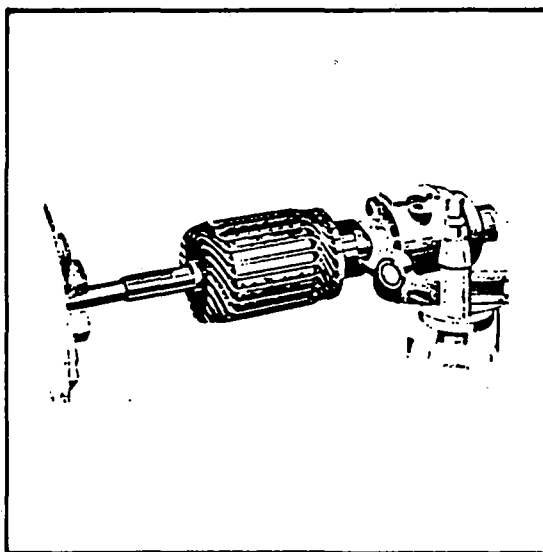


Figure 11-43. Turning Starting Motor Commutator

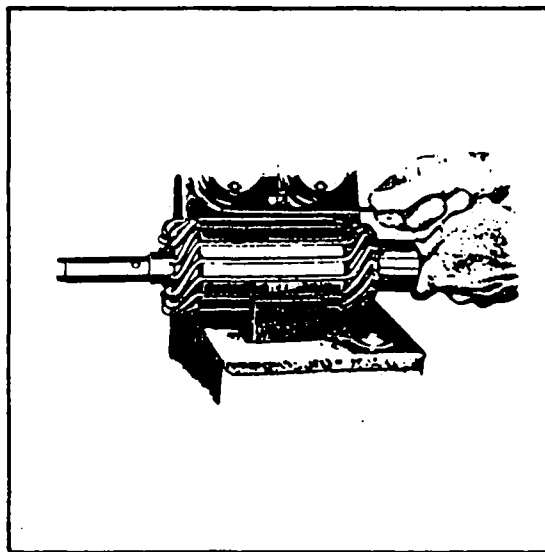


Figure 11-44. Testing Motor Armature for Shorts

**11-96. FIELD COILS.**

a. Check the field coils for grounds (Refer to Figure 11-45) by placing one test probe on the frame and the other on the starter terminal. Be sure the brushes are not accidentally touching the frame. If the lamp lights, the fields are grounded. Repair or replace.

b. Inspect all connections to make sure they are clean and tight and inspect insulation for deterioration.



**Figure 11-45. Testing Motor Fields for Grounds**

**11-97. BRUSH HOLDERS.**

a. To test brush holders, touch one test probe to the brush plate and the other to each brush holder.

b. The test lamp should light when the grounded brush holders are touched and should not light when the insulated brush holders are touched.

**11-98. GEAR AND PINION HOUSING.** Inspect housings for cracks and bearings for excessive wear. Remove rust, paint or grease from mounting surfaces.

**11-99. BENDIX DRIVE.** The Bendix Drive should be wiped clean with a dry cloth. The pinion should turn smoothly in one direction and should lock in the other direction. Replace drive if it fails to check as above or if the pinion teeth are excessively worn or damaged.

**11-100. ASSEMBLY.**

a. When assembling the starting motor, always use an arbor press and the proper bearing arbor for installing graphitized bronze and roller bearings. The Bendix shaft should have a thin film of Lubriplate #777 or equivalent on the Bendix portion of the shaft. End play should be .005 to .050 of an inch.

b. New brushes should be properly seated when installing by wrapping a strip of 00 sandpaper around the commutator (with the sanding side out) 1-1/4 to 1-1/2 times maximum. Drop brushes on sandpaper covered commutator and turn the armature slowly in the direction of rotation. Dust should be blown out of the motor after sanding.

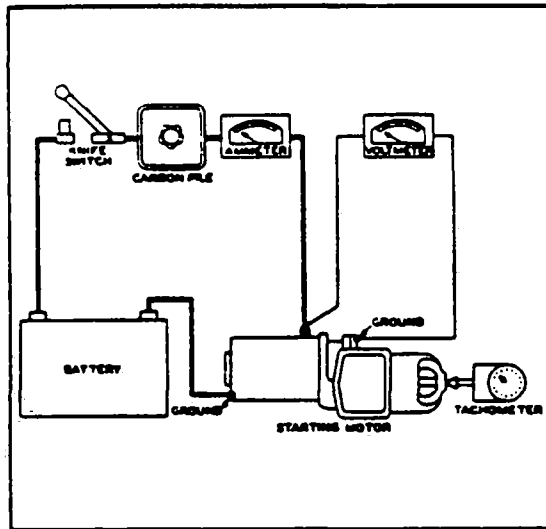


Figure 11-46. No-Load Test Hookup

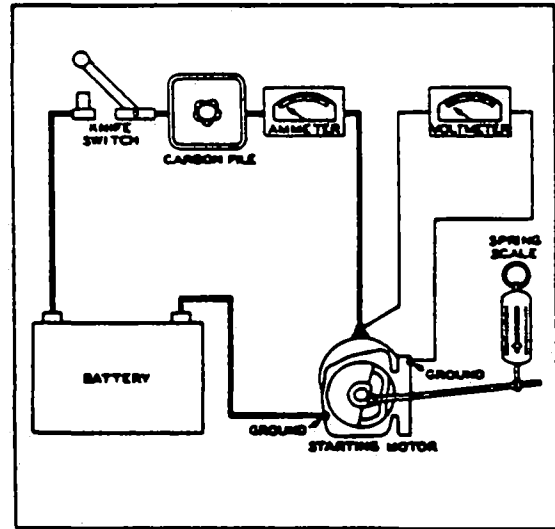


Figure 11-47. Stall-Torque Hookup

NOTE

The spring tension is 32 to 40 ounces with new brushes. This tension is measured with the scale hooked under the brush spring near the brush and the reading is taken at right angles to the line of force exerted by the brush spring.

c. Check the position of the pinion to be sure the unit will mesh properly with the flywheel ring gear. See specifications for unit for correct dimensions. Refer to Paragraph 11-103.

11-101. BENCH TESTS.

a. After the starting motor is reassembled, it should be tested to see that the no-load current at a certain voltage is within specifications as given in paragraph 11-103. To make this test, connect as shown in Figure 11-46. If current is too high, check the bearing alignment and end play to make sure there is no binding or interference. Two or three sharp raps on the frame with a rawhide hammer will often help to align the bearings and free the armature.

b. If no difficulty is indicated in the above test, a stall torque test may be made to see if the starting motor is producing its rated cranking power. Make test connections as shown in Figure 11-47.

c. If torque and current are not within specifications, check the seating of the brushes and internal connections for high resistance. If these checks are made and found to be in good order, replace frame and field assembly and retest starter.

#### 11-102. STARTING MOTOR CONTROL CIRCUIT.

a. Inspect the control circuit wiring between the battery, solenoid and manual starting switches for breaks, poor connections and faulty insulation. Tighten all connections and make sure solenoid is firmly mounted and makes a good ground connection.

b. Check the voltage loss across the switch contacts during normal starting. If loss is in excess of 0.2 volts per 100 amperes, the solenoid should be replaced.

c. If solenoid fails to operate when the manual is turned on or if it fails to release when the manual switch is released, it should be removed and tested to specifications. If either opening or closing voltages are not specified, replace the solenoid.

11-103. STARTING MOTOR SERVICE TEST SPECIFICATIONS (PRESTOLITE). Specifications for 14-volt cranking motors installed as standard equipment on the PA-30 and PA-39 are as follows:

Motor Model	MZ-4206
Min. Brush Tension Max. Brush Tension	32 oz. 40 oz.
No-Load Test (77° F) Volt Max. Amps Min. R.P.M.	10 75 2000
Stall Torque Amps Min. Torque, Ft. lbs. Approx. volts	560 38.0 4.0
Pinion Position* Drive at rest Drive extended	1.748" - 1.855" 2.388" - 2.495"
<p>*This dimension is measured from the centerline of the mounting hole nearest the drive end head to the edge of the pinion.</p>	



11-104. BATTERY.

11-105. SERVICING BATTERY. The battery is located just aft of the baggage compartment in airplanes with Serial Nos. 30-2 to 30-852 inclusive and 30-854 to 30-901 inclusive, and in the nose section in airplanes with Serial Nos. 30-853, 30-902 and up, and in PA-39 airplanes Serial Nos. 39-1 and up. It is enclosed in a stainless steel box with a vent system and a drain. The vents allow fresh air to enter the box and draw off fumes that may accumulate due to the charging process of the battery. The drain is clamped off from the bottom of the fuselage and should be opened occasionally to drain any accumulation of liquid or during cleaning of the box. 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 in the battery. All connections must be clean and tight. If the battery is not up to normal charge, recharge starting with a charging rate of four-amperes and finishing with two. A fast charge is not recommended.

HYDROMETER READING AND BATTERY CHARGE PER CENT	
Hydrometer Reading	Per cent of Charge
1280	100
1250	75
1220	50
1190	25
1160	Very little useful capacity
1130 or below	Discharged

11-106. REMOVAL OF BATTERY. Access to the battery is through a panel located at the aft side of the baggage compartment of airplanes with Serial Nos. 30-2 to 30-852 inclusive and 30-854 to 30-901 inclusive, or by removing the nose section access panel of airplanes with Serial Nos. 30-853, 30-902 and up, and in PA-39 airplanes Serial Nos. 39-1 and up.

- a. Cut the safety wire and remove the wing nuts that secure the battery box cover.
- b. Disconnect the battery cables.

NOTE

Always remove the ground cable first and install last to prevent accidental short circuiting or arcing.

- c. Lift the battery from the box.

11-107. INSTALLATION OF BATTERY.

- a. Ascertain that the battery and battery box have been cleaned and are free of acid.
- b. Install battery in box located just aft of the baggage compartment of airplanes with Serial Nos. 30-2 to 30-852 inclusive and 30-854 to 30-901 inclusive, and in the nose section of airplanes with Serial Nos. 30-853, 30-902 and up, and in PA-39 airplanes with Serial Nos. 39-1 and up.
- c. Connect the positive lead to the positive battery terminal and secure.
- d. Connect the ground cable to the negative battery terminal and secure.
- e. Install the battery box cover and secure with wing nuts.
- f. Safety wing nuts to box.
- g. Install access panel on rear wall of the baggage compartment of airplanes with Serial Nos. 30-2 to 30-852 inclusive and 30-854 to 30-901 inclusive, and install nose access panel on airplanes with Serial Nos. 30-853, 30-902 to 2000 inclusive, and in PA-39 airplanes with Serial Nos. 39-1 and up.

11-108. CHARGING BATTERY. If the battery is not up to normal charge, remove the battery and recharge starting with a charging rate of 4 amps and finishing with 2 amps. A fast charge is not recommended.

CAUTION

External power should not be connected to or removed from aircraft with master switch ON.

11-109. BATTERY BOX CORROSION PREVENTION. The battery should be checked for spilled electrolyte or corrosion at each 50 hour inspection or at least every 30 days, whichever comes first. Should this be found in the box, on the terminals or around the battery, the battery should be removed and both the box and battery cleaned by the following procedure:

- a. Open the clamp on the battery box drain tube and drain off any electrolyte that may have overflowed into the box.
- b. Clean the battery and the box. Corrosion effects may be neutralized by applying a solution of baking soda and water mixed to a consistency of thin cream. The application of this mixture should be applied until all bubbling action has ceased.

**CAUTION**

Do not allow soda solution to enter battery.

- c. Rinse the battery and box with clean water and dry.
- d. As necessary, paint the battery box with an acid resistant paint. Allow paint to dry thoroughly.
- e. Close battery box drain tube clamp.
- f. Reinstall the battery.

**11-110. NAVIGATION LIGHTS.**

**11-111. REMOVAL OF WING NAVIGATION LIGHT.**

- a. To remove bulb, remove the screws securing the plexiglas window.
- b. Remove screws securing the lens retainer.
- c. Remove lens and bulb.

**NOTE**

To remove the complete lamp assembly, the wing tip must be removed.

**11-112. INSTALLATION OF WING NAVIGATION LIGHT.**

- a. Install bulb, lens and lens retainer and secure with appropriate screws.
- b. Place plexiglas window in position on wing tip and secure with appropriate screws.

**11-113. REMOVAL OF TAIL NAVIGATION LIGHT.**

- a. To remove bulb, remove the screws securing the light assembly to the rudder tip and remove the lens.
- b. Remove the bulb.

**NOTE**

To remove the complete light assembly, unsolder the electrical lead from the base of the light assembly and disconnect the remaining electrical lead at the connector.

**11-114. INSTALLATION OF TAIL NAVIGATION LIGHT.**

- a. Install bulb and lens in light assembly.
- b. Place light assembly in position on rudder tip and secure with appropriate screws.

**11-115. REMOVAL OF LAMP IN ANTI-COLLISION WING TIP STROBE LIGHT.** The lights are located in both wing tips next to the navigational lights.

- a. Remove the screws securing the plexiglas window to the wing tip and remove window.
- b. Remove the screw securing the navigational light cover and remove cover.
- c. Remove the three screws securing navigational light bracket assembly and remove light assembly.
- d. Remove the strobe lamp by cutting the wires on the lamp beneath the mounting bracket.
- e. Remove the defective lamp.
- f. Remove and discard the plug with the cut wires from the electrical socket.

**11-116. INSTALLATION OF LAMP IN ANTI-COLLISION WING TIP STROBE LIGHT.**

- a. Route the wires from the new lamp down through the hole in the navigational light bracket.
- b. Insert the wire terminals in the plastic plug supplied with the new lamp. Wire according to the schematic diagram located in the electronics section.
- c. Position strobe lamp on navigational light bracket.
- d. Secure navigational light assembly and bracket with appropriate screws.
- e. Install navigational light cover and secure with appropriate screws.
- f. Install plexiglas window on wing tips and secure with appropriate screws.

**11-117. REMOVAL OF LAMP IN ANTI-COLLISION LIGHT.** The light is located on the upper section of the vertical fin.

- a. Loosen the screw in the clamp securing the light cover.
- b. Remove the light cover.
- c. Remove the defective lamp from the socket.

**11-118. TROUBLESHOOTING PROCEDURE FOR ANTI-COLLISION AND WING TIP STROBE LIGHT SYSTEMS.** The strobe light assembly functions as a condenser discharge system. A condenser in the power supply is charged to approximately 450 volts D.C., then discharged across the Xenon flash tube at intervals approximately 45 flashes per minute. The condenser is parallel across the Xenon flash tube which is designed to hold off the 450 volts D.C. applied until the flash tube is triggered by an external pulse. This pulse is generated by a solid state timing circuit in the power supply.

When troubleshooting the strobe light system, it must first be determined if the trouble is in the flash tube or the power supply. Replacement of the flash tube will confirm if the tube is defective. A normal operating power system will emit an audible tone of 1 to 1.5 KHC. If there is no sound emitted check the system according to the following instructions. When troubleshooting the system utilize the appropriate schematic in the manual.

- a. Ascertain the input voltage at the power supply is 14 volts.

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### CAUTION

When disconnecting and connecting the power supply input connections do not get the connection reversed. Reversed polarity of the input voltage for just an instant will permanently damage the power supply. The reversed polarity destroys a protective diode in the power supply, causing self-destruction from overheating of the power supply. This damage is sometimes not immediately apparent, but will cause failure of the system in time.

- b. Check for malfunction in interconnecting cables.
  - 1. Ascertain pins 1 and 3 of interconnecting cable are not reversed.
  - 2. Using an ohmmeter check continuity between pin 1 and 3 of interconnecting cable. If you obtain a reading on the meter the cable is shorted and should be replaced.

### NOTE

A short of the type described in steps 1 and 2 will not cause permanent damage to the power supply but the system will be inoperative if such a short exists. Avoid any connection between pins 1 and 3 of the interconnecting cable as this will discharge the condenser in the power supply and destroy the trigger circuit.

### CAUTION

When disconnecting the power supply allow five minutes of bleed down time prior to handling the unit.

- c. Check interconnecting cables for shorts.
  - 1. Disconnect the output cables from the power supply outlets.
  - 2. The following continuity checks can be made with an ohmmeter.
  - 3. Check for continuity between the connectors of each interconnecting cable by checking from pin 1 to pin 1, pin 2 to pin 2, and 3 to pin 3. When making these checks if no continuity exists the cable is shorted and should be replaced.
  - 4. Check continuity between pins 1 and 2, 1 and 3, and 2 and 3 of the interconnecting cable. If continuity exists between any of these connections the cable is shorted and should be replaced.
  - 5. Check for continuity from pins 1, 2 and 3 to airplane ground. If continuity exists the cable is shorted and should be replaced.
- d. Check the tube socket assembly for shorts.
  - 1. Disconnect the tube socket assembly of the anti-collision light from the interconnecting cable.
  - 2. The following continuity checks can be made with an ohmmeter.

3. Check for continuity between pin 1 of AMP connector to pin 1 of tube socket, pin 2 of AMP connector to pins 6 and 7 of tube socket and pin 3 of AMP connector to pin 4 of tube socket. When making these tests if no continuity exists the tube socket assembly is shorted and should be replaced.

**11-119. INSTALLATION OF ANTI-COLLISION LIGHT.**

- a. Plug in new lamp using correct number.
- b. Replace light cover.
- c. Tighten screw in clamp to secure light cover.

**11-120. REMOVAL AND INSTALLATION OF LANDING LIGHT. (Refer to Pages 4-3 and 4-4.)**

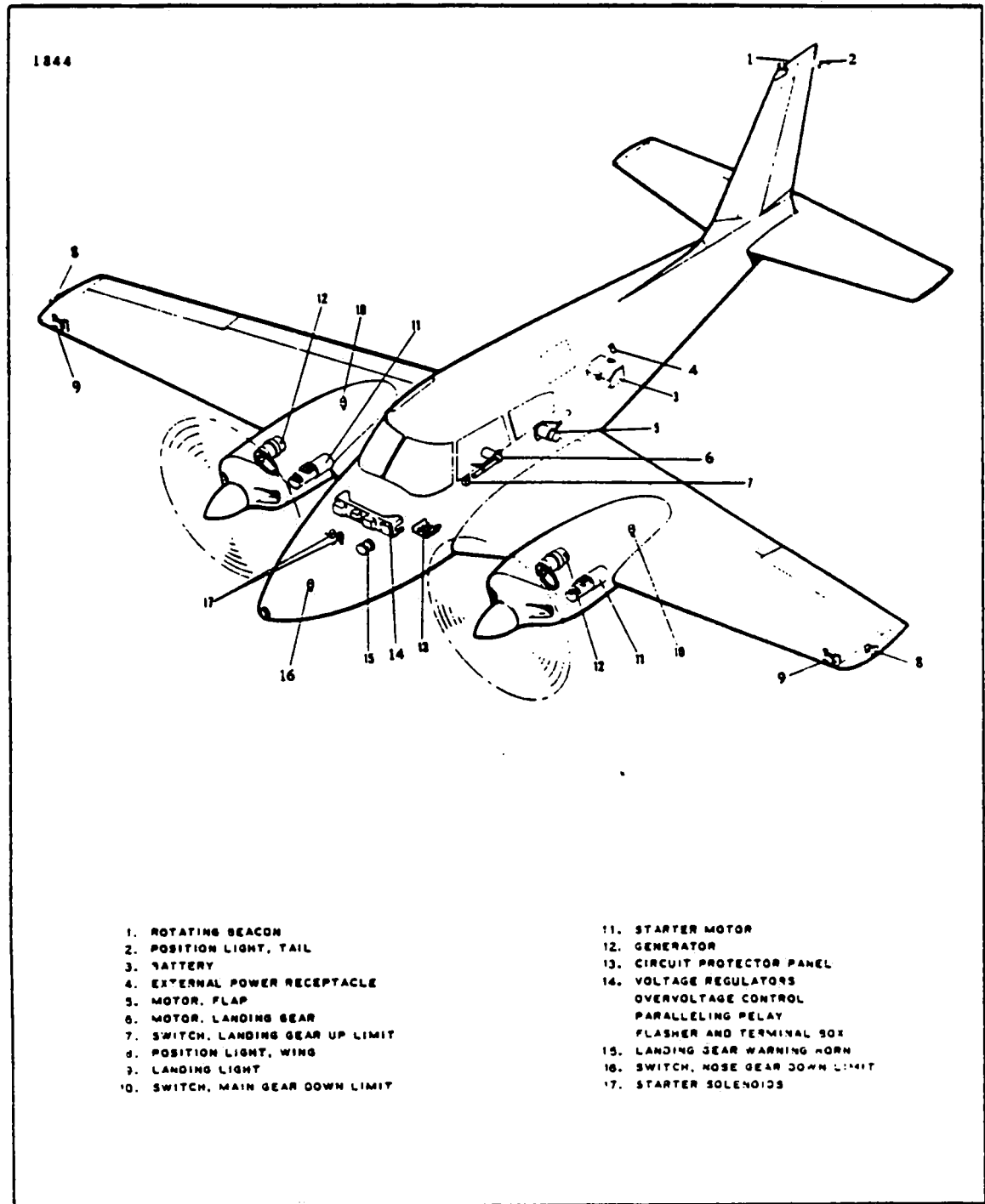


Figure 11-48. Electrical System Components  
PA-30. Serial Nos. 30-1 to 30-852 incl. and 30-854 to 30-901 incl.

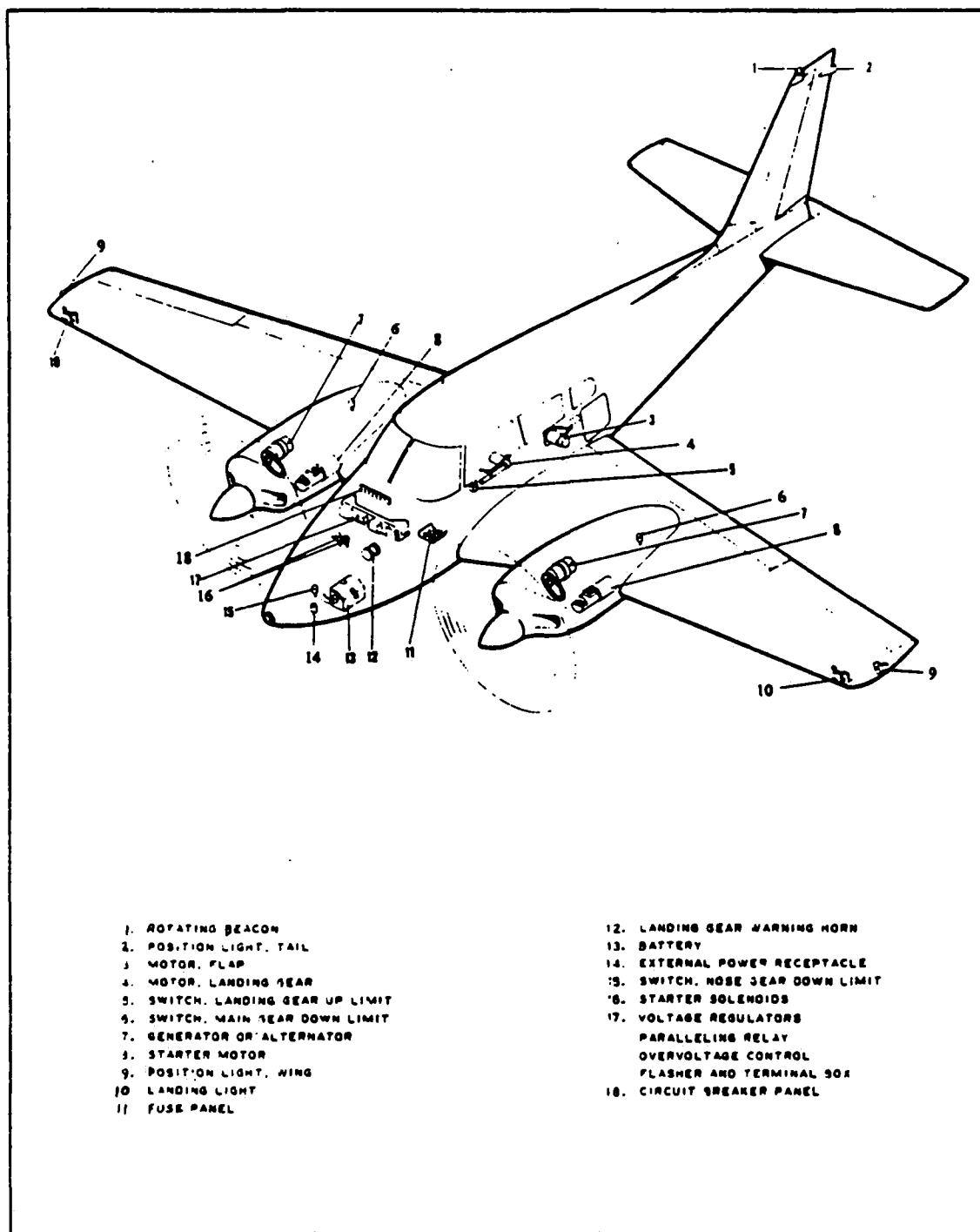


Figure 11-49. Electrical System Components. PA-30 Serial Nos. 30-853, 30-902 to 30-2000. PA-39 Serial Nos. 39-1 and up



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# PIPER TWIN COMANCHE SERVICE MANUAL

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM)

Trouble	Cause	Remedy
	GENERATOR	
Generator operating within rated speed range but voltage output low.	<p>If the voltage is low, the generator is operating on residual magnetism.</p> <p>Loose or high-resistance electrical connections.</p> <p>Brushes excessively worn.</p>	<p>Check for loose or high resistance connections; clean and tighten.</p> <p>Clean and tighten all electrical connections.</p> <p>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.</p> <p><b>CAUTION</b></p> <p>Do not use abrasives of any description to assist in seating the brushes.</p>

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range but voltage output low. (cont.)	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.
		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 coils.	Replace armature.
	Improper operations of the voltage regulator.	Adjust regulator.

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
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.
	Grounded field coil assembly.	Replace entire yoke 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 voltage regulator. Same as "Generator operating within rated speed range but voltage output low," above.	Replace voltage regulator. Use remedy under "Generator operating within rated speed range but voltage output low," above.

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
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 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 above and check to see that reverse-current relay is operating properly.
<p style="text-align: center;">NOTE</p> <p>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.</p>		



TABLE XI-I. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (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.
ALTERNATOR		
No output from alternator.	Malfunction of alternator output circuit or field circuit.	Check alternator output and field circuits. (Refer to Paragraph 11-53.)
		Check alternator. (Refer to Paragraph 11-53.)
Reduced output from alternator.	Open diode.	Check alternator. (Refer to Paragraph 11-53.)

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
<b>STARTER</b>		
Starter 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.
	Defective starter solenoid or control switch.	Replace faulty unit.
	Binding, worn or improperly seated brush, or brushes with excessive 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 sandpaper between the brush and commutator with the sanded side next to the brush. Pull sandpaper in direction of rotation, being careful to keep it in the same contour as the commutator.

TABLE XI-I. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
Starter fails to operate. (cont.)	Binding, worn, or improperly seated brush, or brushes with excessive play. (cont.)	<p><b>CAUTION</b></p> <p>Do not use coarse sand paper or emery cloth.</p> <p>After seating, clean thoroughly to remove all sand and metal particles to prevent excessive wear. Keep motor bearing free from sand or metal particles.</p>
	Dirty commutators.	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.
Starter operates at proper speed but fails to crank engine.	Faulty Bendix drive.	Remove Bendix drive assembly. Clean and check, replace.
Low starter cranking speed.	Worn, rough, or improperly lubricated motor or starter gearing.	Disassemble, clean, inspect and relubricate, replacing ball bearings, if worn.

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
Low starter cranking speed. (cont.)	Same electrical causes as listed under "Motor fails to operate."	Same remedies listed for these troubles.
Excessive arcing or starter brushes	Binding, worn or improperly seated brush or brushes, with excessive side play.	See information above dealing with this trouble.
	Dirty commutator, rough, pitted or scored.	Clean as already outlined above.
	Grounded or open field circuit.	Test and replace defective parts.
Excessive wear and arcing of starter brushes.	Rough or scored commutator.	Remove and turn commutator down on a lathe.
	Armature assembly not concentric.	Reface commutator.
	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 the ground; use external power wherever possible.

TABLE XI-I. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
Battery will not hold charge. (cont.)	Standing too long.	Remove and recharge battery if left in unused airplane one week or more.
	Equipment left "ON" accidentally.	Remove and recharge. (Refer to paragraph 11-108.)
	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.
Cracked cell.	Hold down loose.	Replace battery and tighten.
	Frozen battery.	Replace.

TABLE XI-1. TROUBLESHOOTING CHART (ELECTRICAL SYSTEM) (cont.)

Trouble	Cause	Remedy
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 over-fillings.	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-II. LAMP REPLACEMENT GUIDE

Location	Piper Part No.	Lamp No.
Tail Navigation Light	753 431	1073
Wing Navigation Light	751 381	1512
Rotating Beacon	751 448	WRM-44
Landing Light	472 661	4509
Instrument Post Lights	472 037	330
Gear Indicator Lights	472 054	G.E.330
Stall Warning Light	472 054	330
Map Light	472 040	1816
Circuit Breaker Compartment	472 050	1815
Fuel Control Consol	753 472	1488
Dome Lights	472 036	89
Reading Lights	472 026	90
Instrument Panel Light		93

TABLE XI-III. ELECTRICAL SYSTEM SCHEMATIC INDEX

	Figure	Aerofiche Grid No.
Alternator System	11-68	3F19
Anti-Collision	11-50	3E18
Anti-Collision (Strobe)	11-71	3G7
Cigar Lighter	11-62	3F6
Cylinder Head Temperature	11-59	3F2
Dome Lights	11-51	3E19
Exhaust Gas Temperature	11-72	3G8
External Power	11-52	3E20
Flap Motor	11-60	3F4
Flap Motor	11-74	3G9
Flap Solenoid	11-60	3F4
Flap Solenoid	11-74	3G9
Fuel Pumps	11-53	3E21
Fuel Quantity Indicators	11-73	3G1
Landing Gear Motor	11-70	3G3
Landing Gear Solenoid	11-70	3G3
Landing Gear Warning	11-70	3G3
Generator System	11-61	3F5
Heater	11-62	3F6
Hour Meter	11-73	3G8
Instrument Lights	11-63	3F8
Landing Lights	11-54	3E23
Magneto Switches	11-66	3F15
Map Lights	11-63	3F8
Oil Pressure Warning (Turbocharger)	11-55	3E24
Oil Temperature	11-59	3F2
Pitot Heat	11-56	3E24
Position Lights	11-64	3F11
Stall Warning	11-65	3F13
Starter System	11-66	3F15
Tip Tanks	11-67	3F17
Turn and Bank Indicator	11-57	3F1
Windshield Heat	11-58	3F1



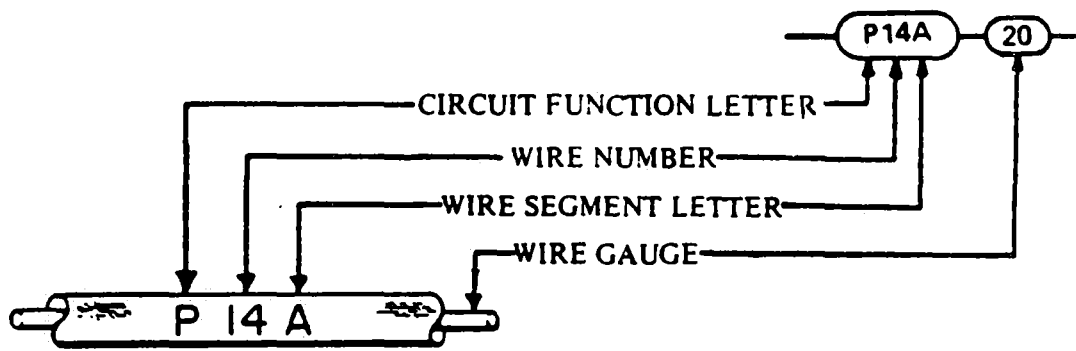
TABLE XI-IV. CIRCUIT LOAD CHART

CIRCUIT	CIRCUIT PRO- TECTOR RAT- ING IN AMPS	ITEM	NO. OF UNITS OPERATING SIMULTAN- EOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT	
				12.0 V.	14.3 V.
GEAR MOTOR	30	LANDING GEAR ACTUATING MOTOR	1	14.70	17.50
TURN & BANK	5	TURN & BANK ELEC. GYRO	1	0.25	0.30
GEAR SOLENOID	5	GEAR MOTOR CONTROL SOLENOID	1	2.20	2.60
		GEAR INDICATOR LIGHTS & FLASHER	1	0.08	0.09
INST. LTS.	5	SPOT LIGHTS	2	0.56	0.68
		ROCKER SWITCH LIGHTS	AS INSTL.	0.08	0.09
		GLAR-BAN BOLT LIGHTS	AS INSTL.	0.08	0.09
		MAP LIGHT - CONTROL WHEEL	1	0.28	0.33
		TRIM INDICATOR ILLUMINATING LIGHT	1	0.18	0.15
		OMNI COUPLER LIGHTS	2	0.08	0.09
		ALTIMATIC IIIIB PANEL LIGHTS	4	0.08	0.09
		AUTOCONTROL III PANEL LIGHTS	2	0.08	0.09
LEFT FUEL PUMP	10	L. FUEL PUMP MOTOR	1	6.04	7.02
RIGHT FUEL PUMP	10	R. FUEL PUMP MOTOR	1	6.04	7.02
NAV LTS.	10	WING TIP POSITION LIGHTS #1512	2	1.40	1.67
		TAIL POSITION LIGHT #1073	1	1.62	1.93
STARTER SOL.	15	LEFT & RIGHT STARTER SOLENOIDS	1	8.40	10.00
PITOT HEAT	15	PITOT HEATING ELEMENT	1	6.20	7.30
LEFT LANDING LIGHT	10	L. LANDING LIGHT #4509	1	7.13	8.50
RIGHT LANDING LIGHT	10	R. LANDING LIGHT #4509	1	7.13	8.50
VOLTAGE REGULATOR - MAIN	10	MAIN VOLTAGE REG., OVERVOLT RELAY, ALTERNATOR FIELDS L & R	1 SYSTEM	3.03	3.56
VOLTAGE REGULATOR - AUX.	10	AUX. VOLTAGE REG., OVERVOLT RELAY, ALTERNATOR FIELDS L & R	1 SYSTEM	3.03	3.56
WINDSHIELD HEAT	15	WINDSHIELD HEATING ELEMENT	1	11.54	13.75
ELECTRIC TRIM	5	PITCH TRIM SERVO	1	0.84	1.00
TIP TANKS	5	L & R SOLENOID VALVES L & R TIP TANK INDICATOR LIGHTS 2 - #1488 BULBS	2 2	0.54 0.25	0.64 0.21
T/C CTL		TURBO CHARGER CONTROL "LOW ( #330 LAMPS) TURBO OIL WARNING LIGHTS"	2	0.08	0.09
FLAP MOTOR	20	FLAP ACTUATING MOTOR	1	18.30	21.80
STALL WARNING	5	FLASHER UNIT, HORN & LIGHT HORN - 0.08 LAMP - 0.08	1 SYSTEM	0.78	0.89
FLAP SOL.	5	FLAP ACTUATING SOLENOID & INDICATOR	1 SYSTEM	2.28	2.69
CYL & OIL TEMP.	5	L & R CYL. HEAD TEMP. GAGES L & R OIL TEMP. GAGES	2 2	0.06 0.06	0.07 0.07
FUEL GAGE	5	L & R FUEL GAGES GEAR WARNING HORN W/FLASHER UNIT	2 1	0.09 0.70	0.11 0.80
ANTI-COL. - RED	10	ROTATING BEACON - RED STROBE LIGHT - RED W/POWER SUPPLY	1 1	4.03 1.40	4.80 2.45
ANTI-COL. - WHITE	10	TIP STROBE LIGHTS W/POWER SUPPLY (WHITE)	2	3.80	4.45
HEATER - LIGHTER	20	CIGAR LIGHTER CABIN HEATER SYSTEM COMPLETE - GROUND OPERATION HEATER IGNITION & VENT BLOWER COMBUSTION BLOWER	1 MAX. 1 1	6.60 11.66 6.76 4.90	7.90 13.80 8.00 5.80

TABLE XI- IV. CIRCUIT LOAD CHART (cont.)

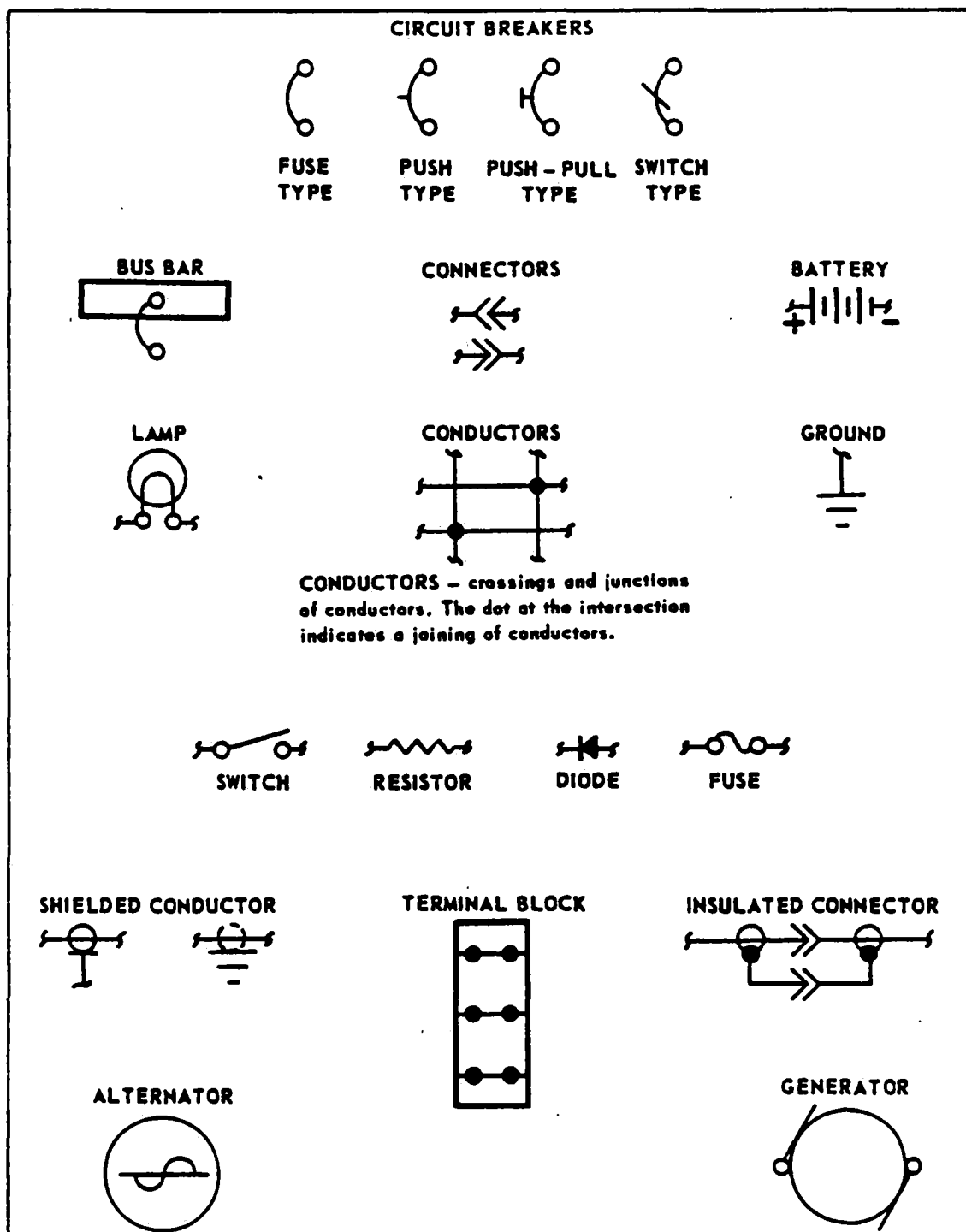
CIRCUIT	CIRCUIT PRO- TECTOR RAT- ING IN AMPS.	ITEM	NO. OF UNITS OPERATING SIMULTAN- EOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT	
				12.0 V.	14.3 V.
NAV COM 1	10	MK-12B OR MK-12A TRANSCIVER	XMITT.	6.92	8.25
			RCV.	4.03	4.79
		MK-16 TRANSCIVER	XMITT.	4.21	5.02
			RCV.	0.63	0.75
		VOA-8 OMNI INDICATOR		0.36	0.39
		VOA-8 OMNI INDICATOR		0.36	0.39
		VOA-40(M) VOA-60(M)		-	-
NAV COM 2	10	SIMILAR TO NAV COM 1 KING KR-85 ADF RECEIVER		0.87	1.04
ADF	5	BENDIX T12C ADF RECEIVER		0.66	0.78
		NARCO ADF-31A RECEIVER		0.56	0.67
G/S	5	NARCO UGR-2 GLIDE SLOPE RECEIVER		0.19	0.23
M/B	5	NARCO MBT-12 MARKER BEACON RECEIVER		0.17	0.20
		PM-1 PIPER MARKER BEACON		0.17	0.20
ACC (ACCESSORY)	5	AUDIO AMPLIFIER - KING KA-25	1	0.96	1.14
		NARCO AUDIO JUNCTION BOX VP224	1	0.23	0.27
A/P	5	ALTIMATIC IIIB (AUTOPILOT)		1.34	1.60
		AUTOCONTROL III		0.80	0.96
XPONDER	5	TRANSPONDER NARCO ATS-A OR AT6-A		1.76	2.09
		TRANSPONDER NARCO UAT-1		3.05	3.63
DME	10	DISTANCE MEASURING EQUIP. NARCO UDI-4		5.69	6.77

TABLE XI-V. ELECTRICAL WIRE CODING



CIRCUIT IDENTIFICATION	CIRCUITS
A	AUTOMATIC CONTROLS
C	CONTROL SURFACE
E	ENGINE INSTRUMENT
F	FLIGHT INSTRUMENTS
G	LANDING GEAR SYSTEM
H	HEATER, VENTILATING
J	IGNITION SYSTEM
L	LIGHTING SYSTEM
M	CIGAR LIGHTER
P	PRIMARY POWER
PF	ALTERNATOR FIELD
Q	FUEL AND OIL
RG	RADIO GROUND
RP	RADIO POWER
RZ	RADIO AUDIO AND INTERPHONE

TABLE XI-VI. ELECTRICAL SYMBOLS



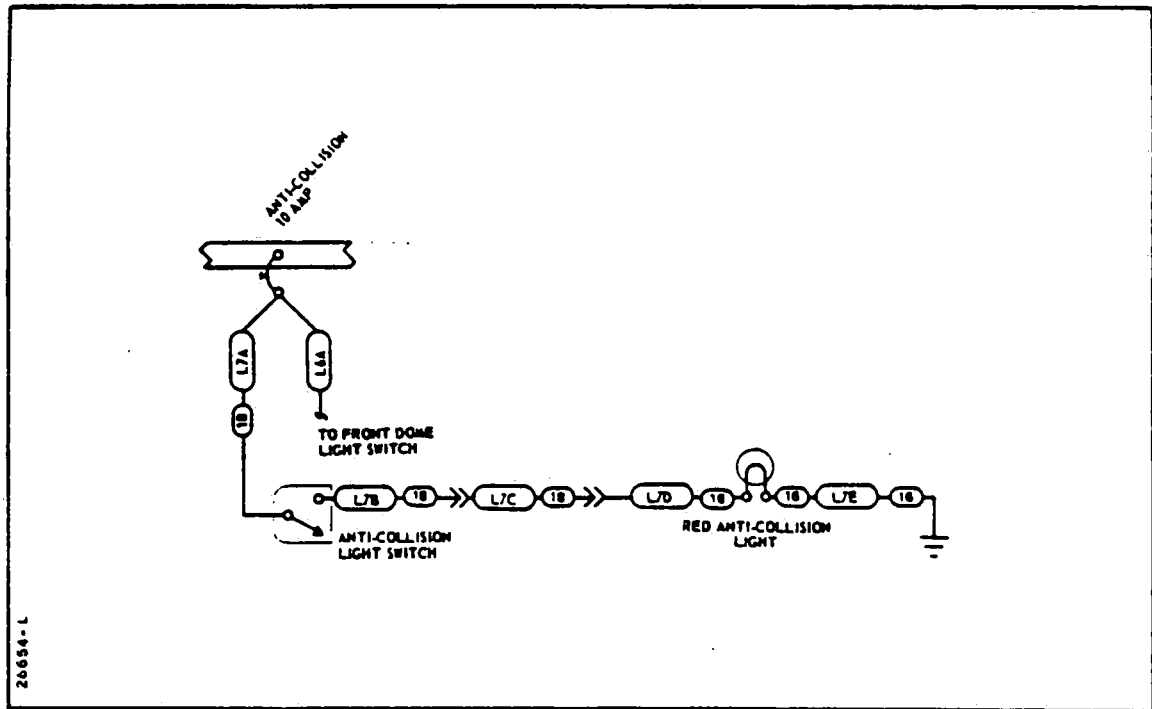


Figure 11-50. Anti-Collision Light

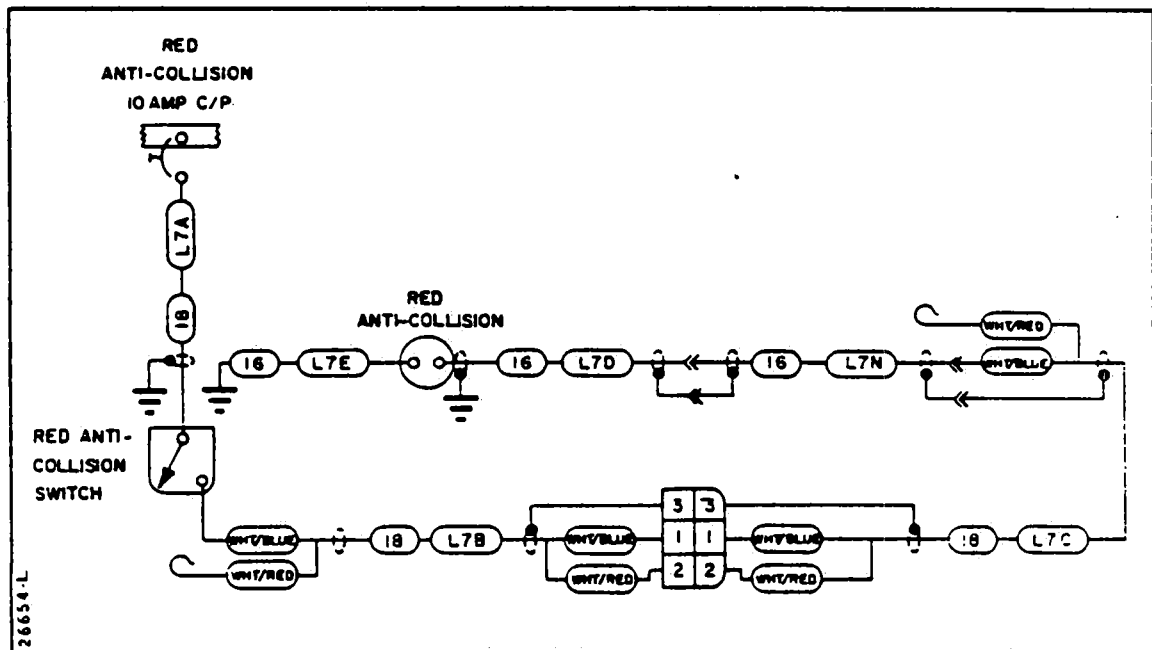


Figure 11-50a. Anti-Collision Light

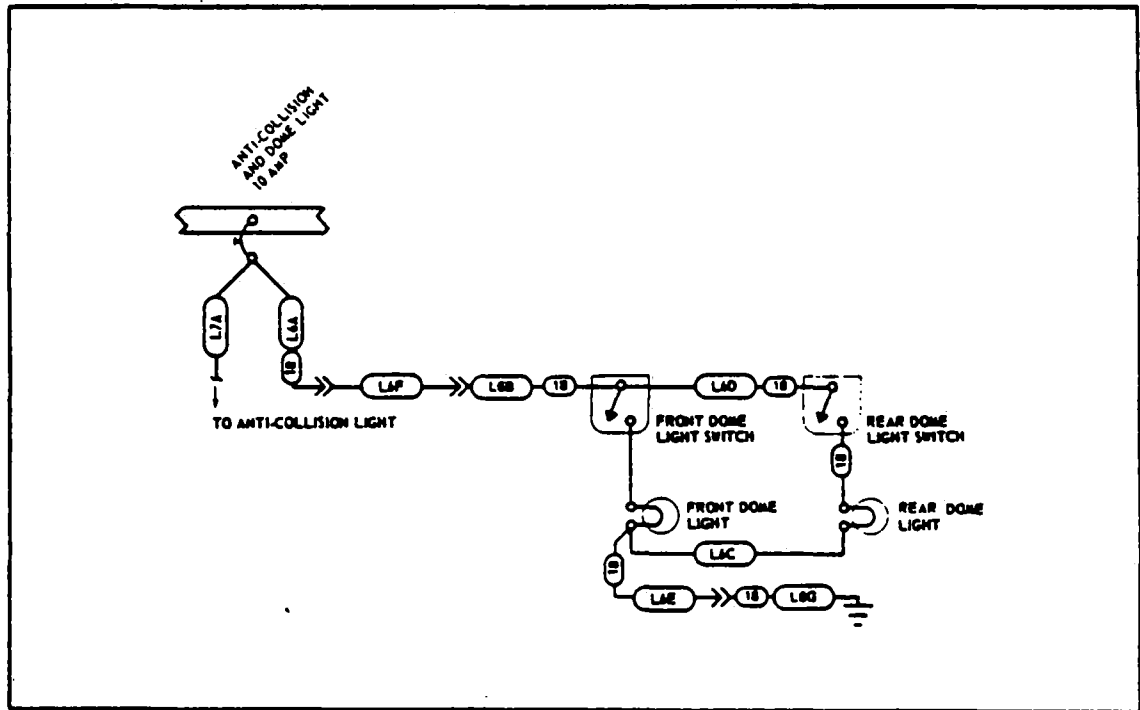


Figure 11-51. Dome Light  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

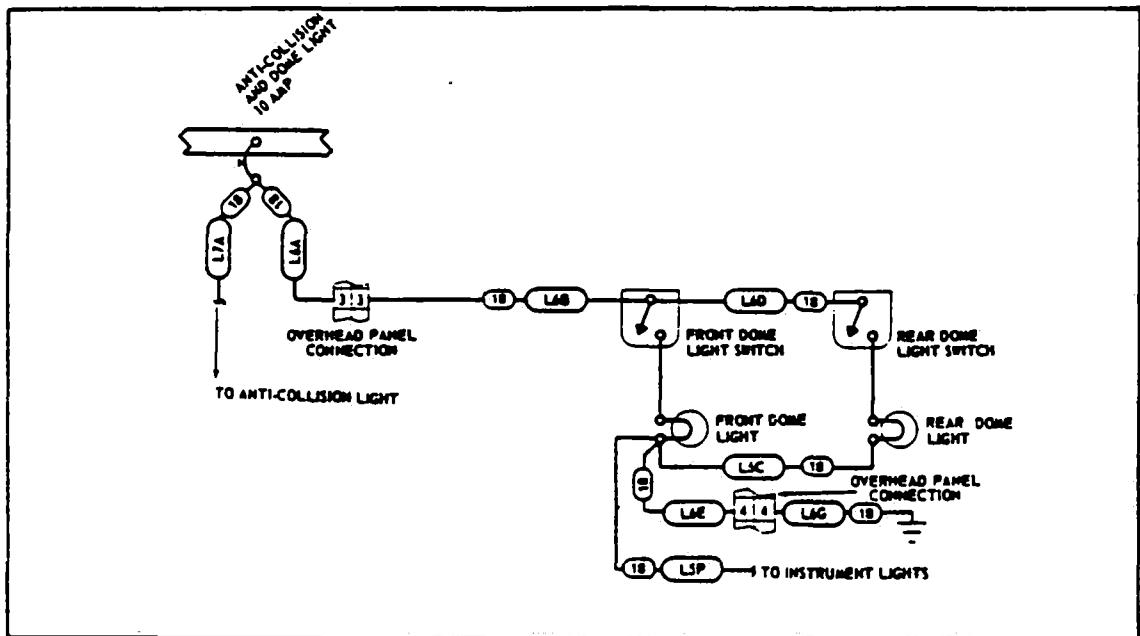


Figure 11-51a. Dome Light. Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

EXTERNAL POWER RECEPTACLE

EXTERNAL POWER SAFETY SOLENOID

DIODE SR-1100

MASTER CONTACTOR

BATTERY 12V

TO BUS BAR AND STARTER CIRCUIT

MASTER SWITCH

4

20

20

### 3 E20

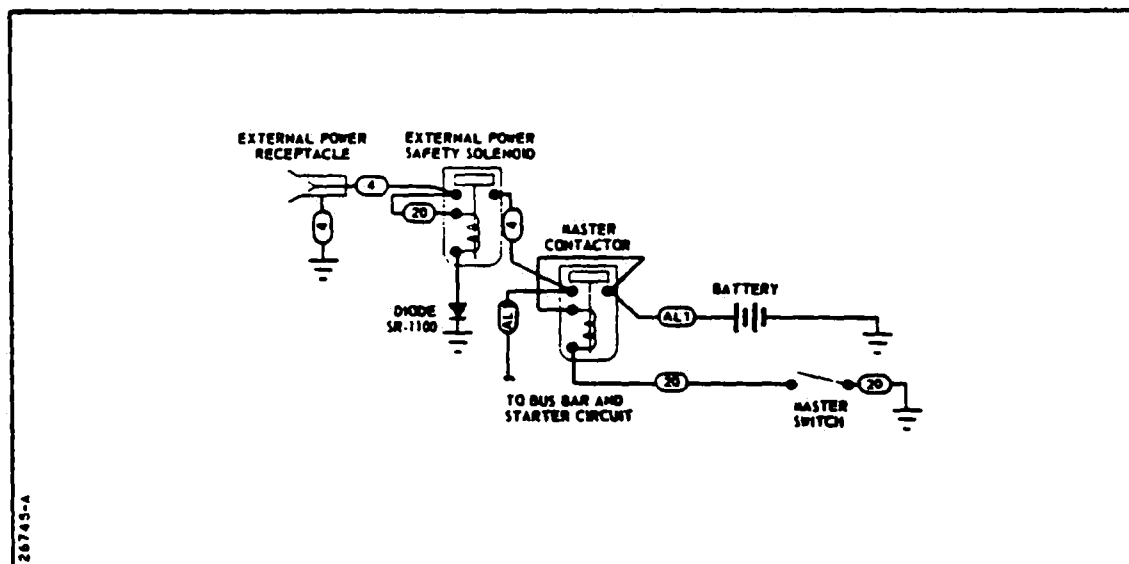


Figure 11-52a. External Power Supply, Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

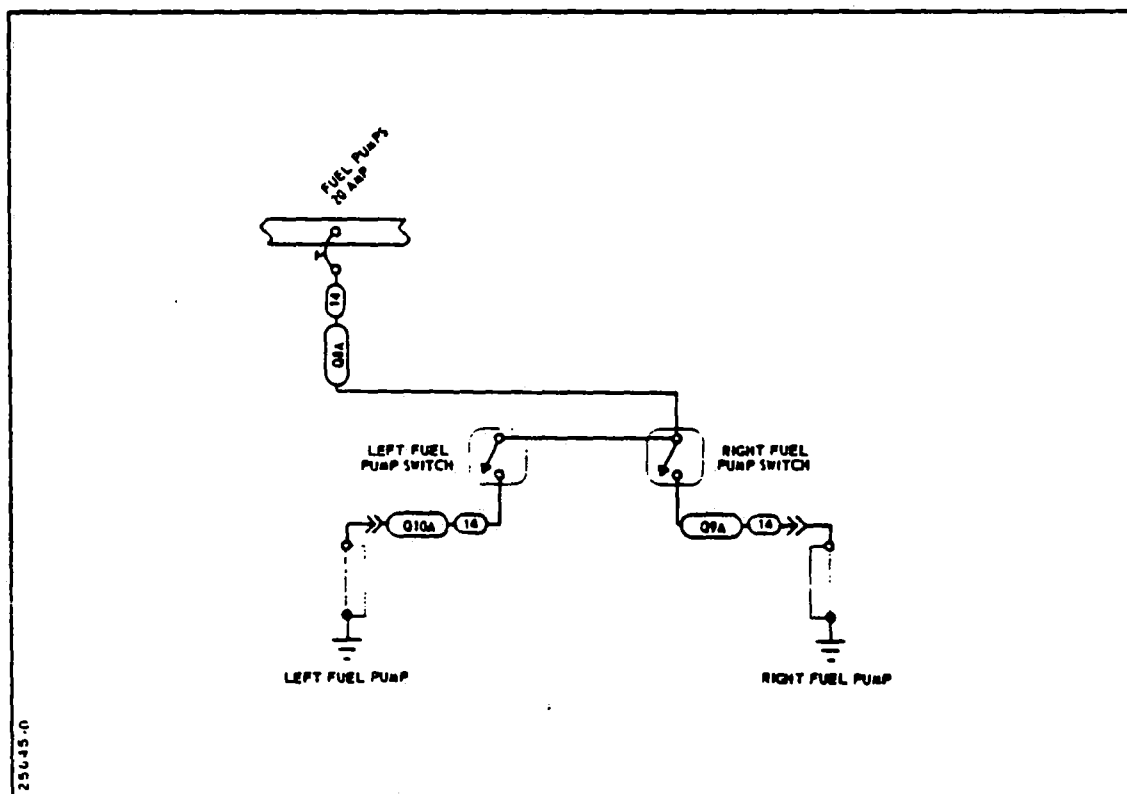


Figure 11-53. Fuel Pumps  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive



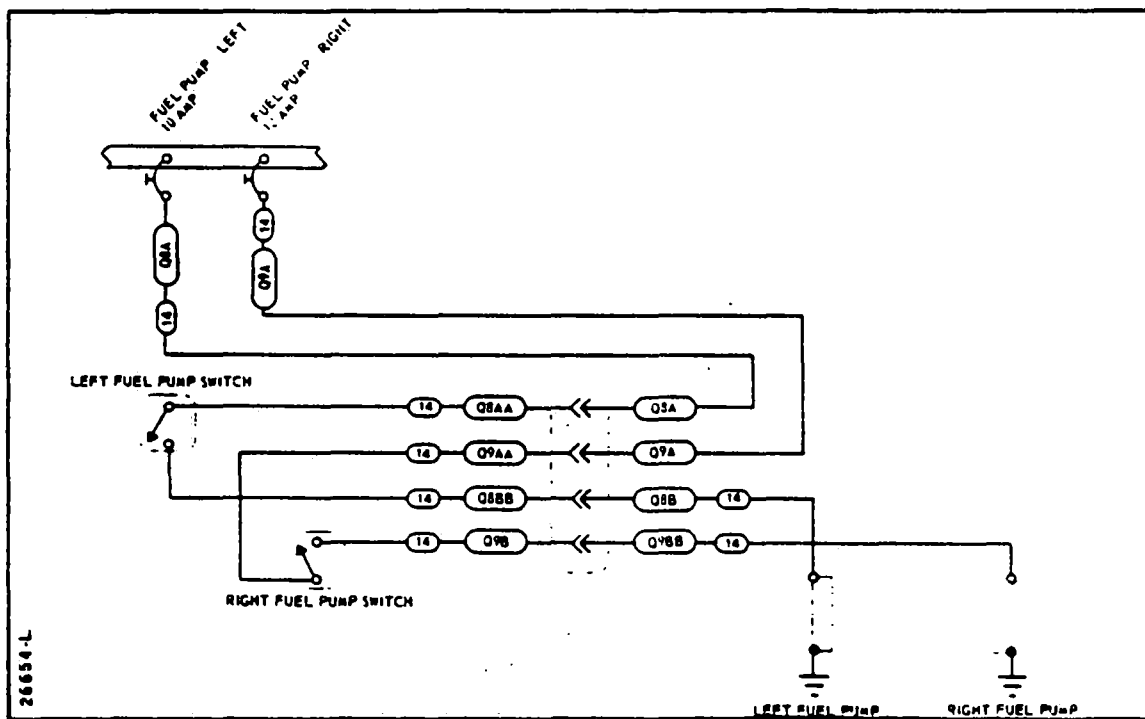


Figure 11-53a. Fuel Pumps, Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

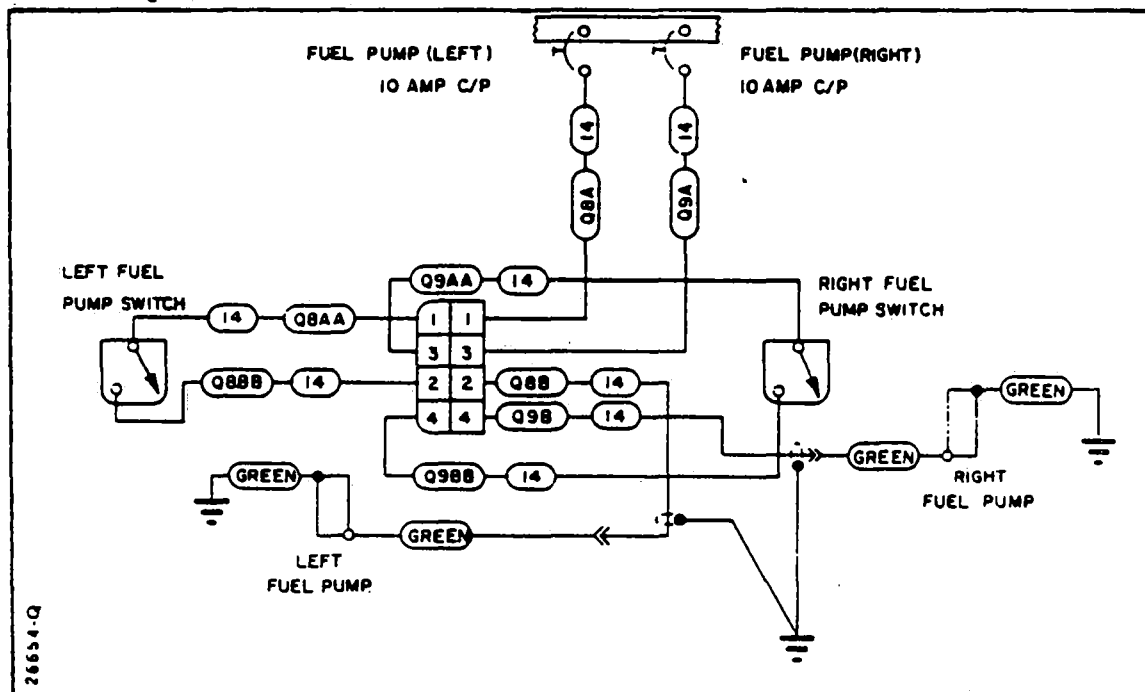


Figure 11-53b. Fuel Pumps

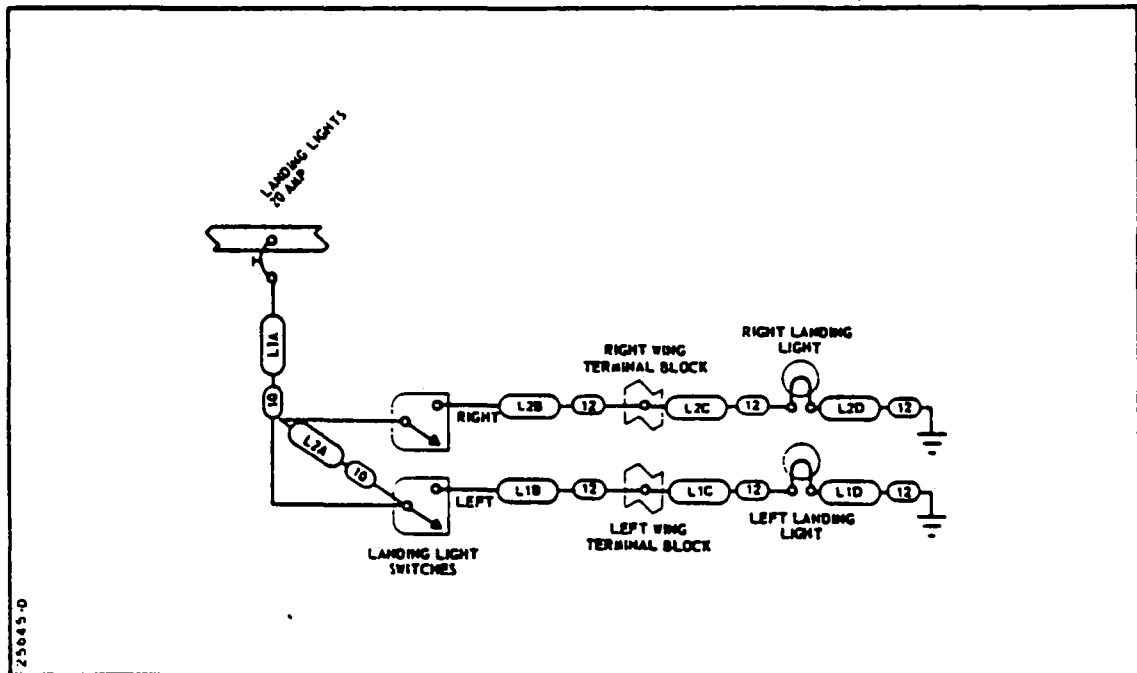


Figure 11-54. Landing Lights  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

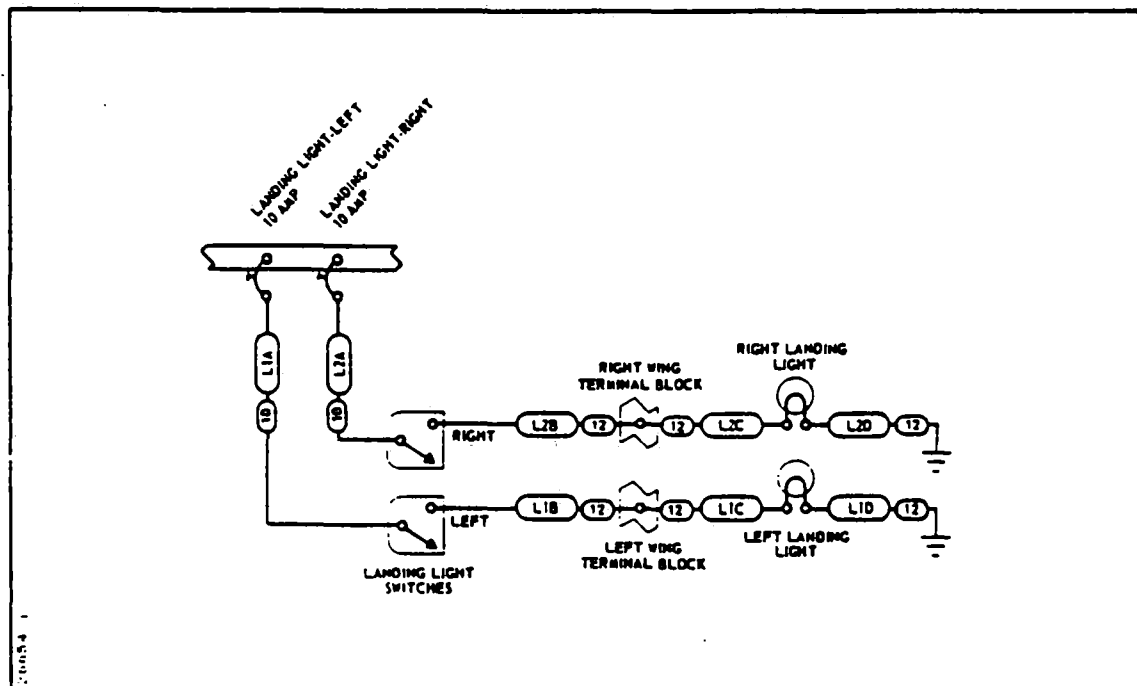


Figure 11-54a. Landing Lights, Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

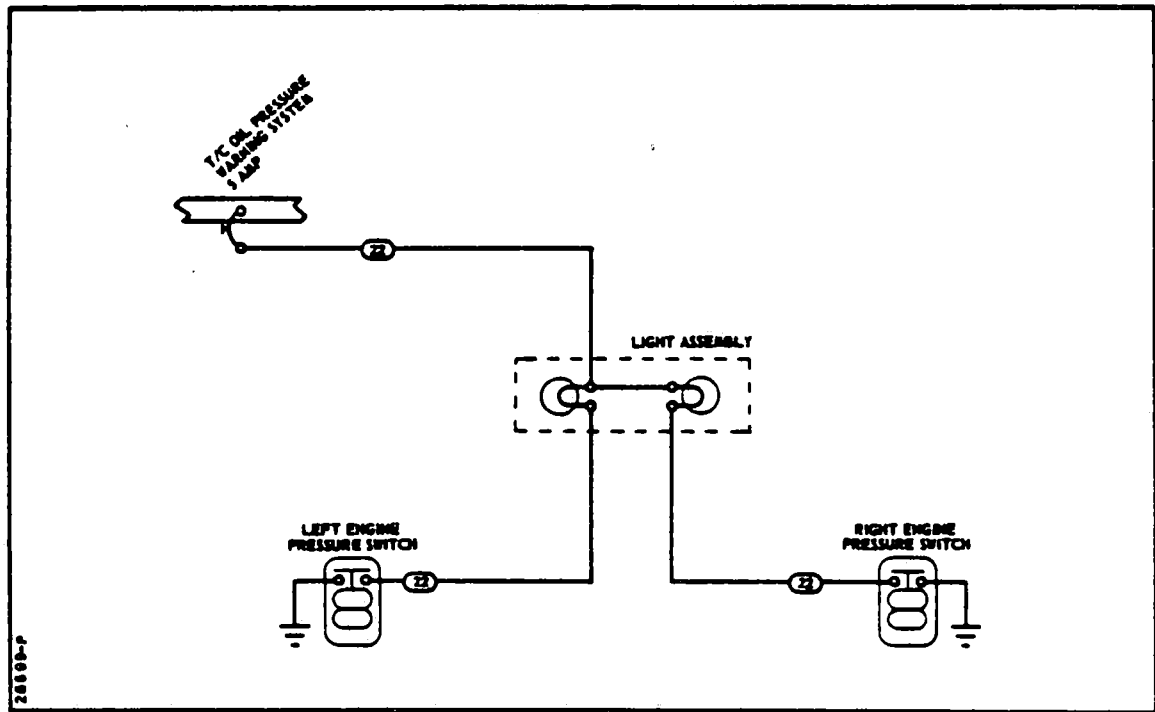


Figure 11-55. Oil Pressure Warning (Turbocharger)

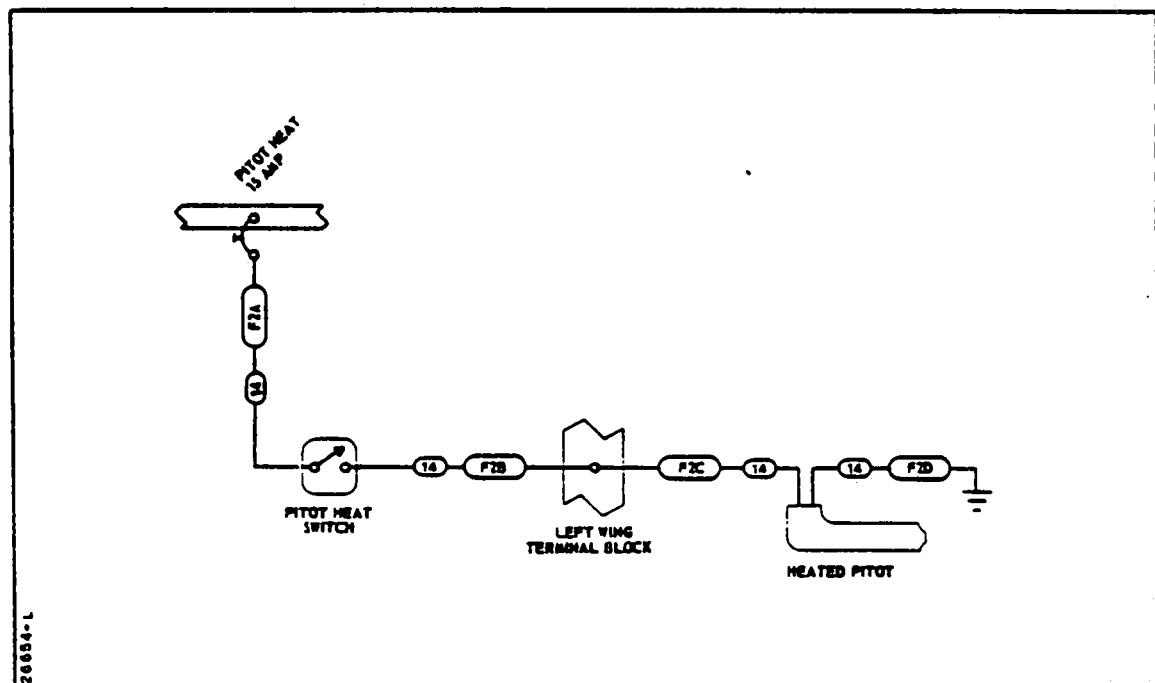


Figure 11-56. Pitot Heat

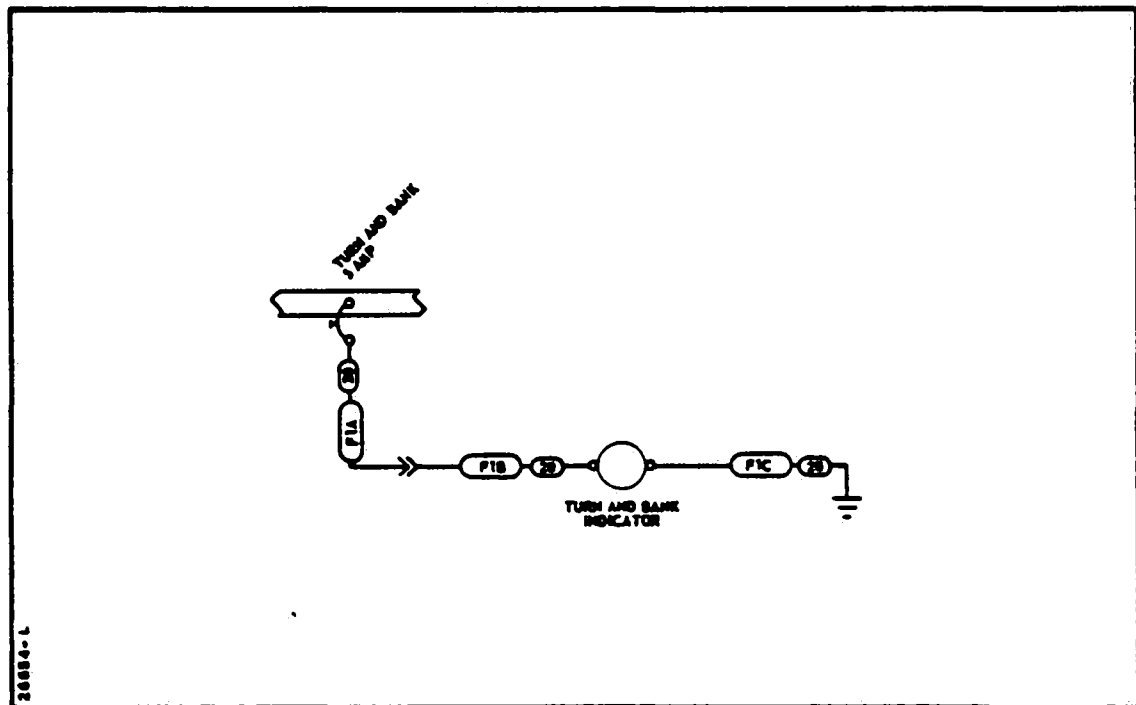


Figure 11-57. Turn and Bank Indicator

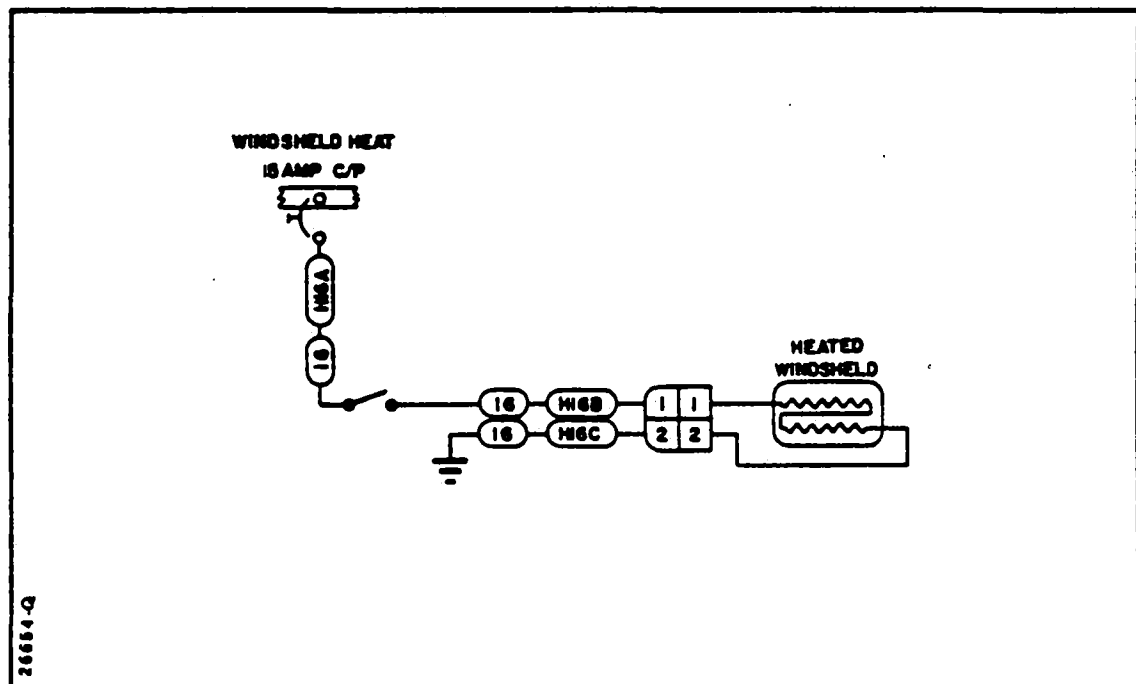


Figure 11-58. Windshield Heat

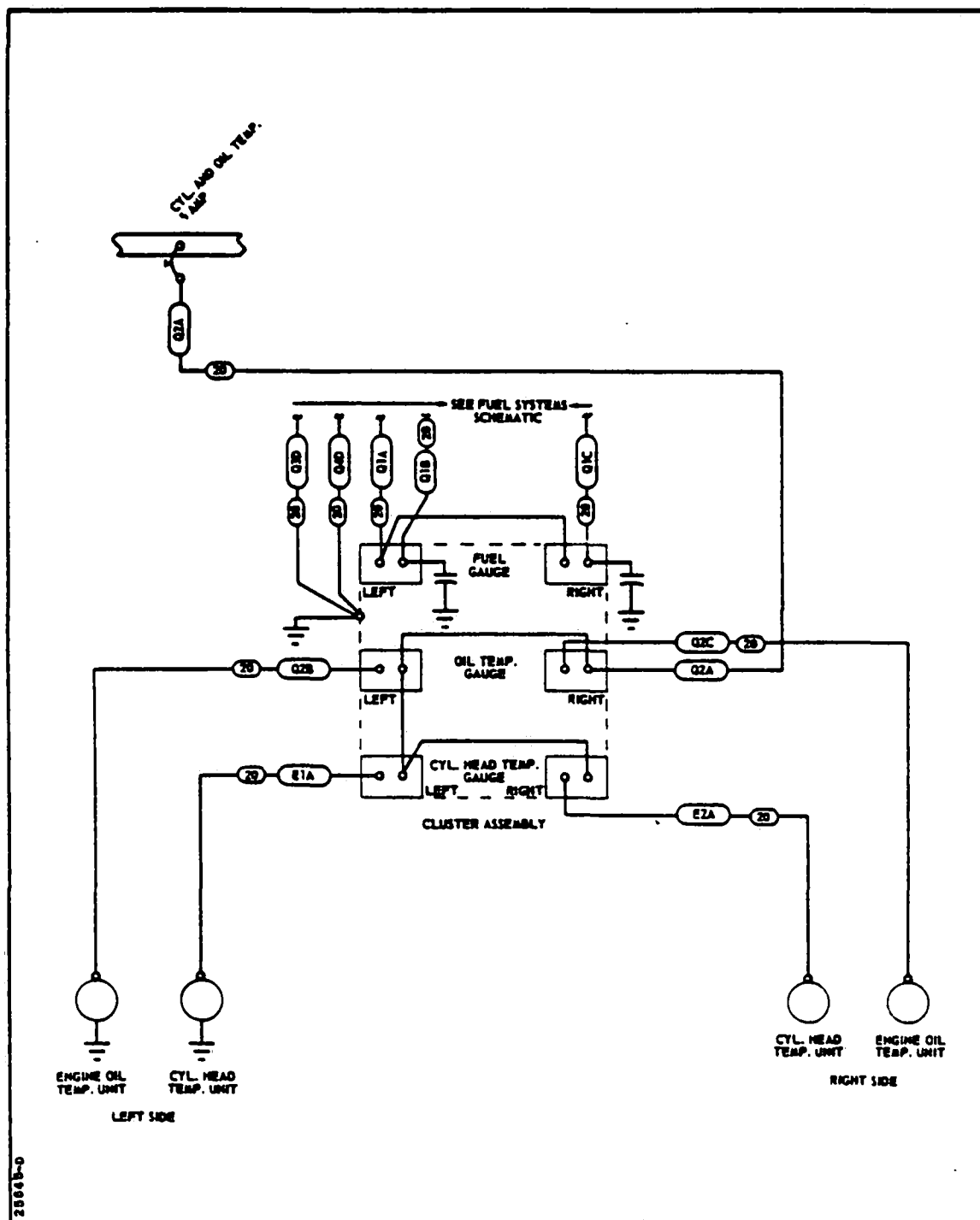


Figure 11-59. Cylinder Head Temperature and Oil Temperature  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

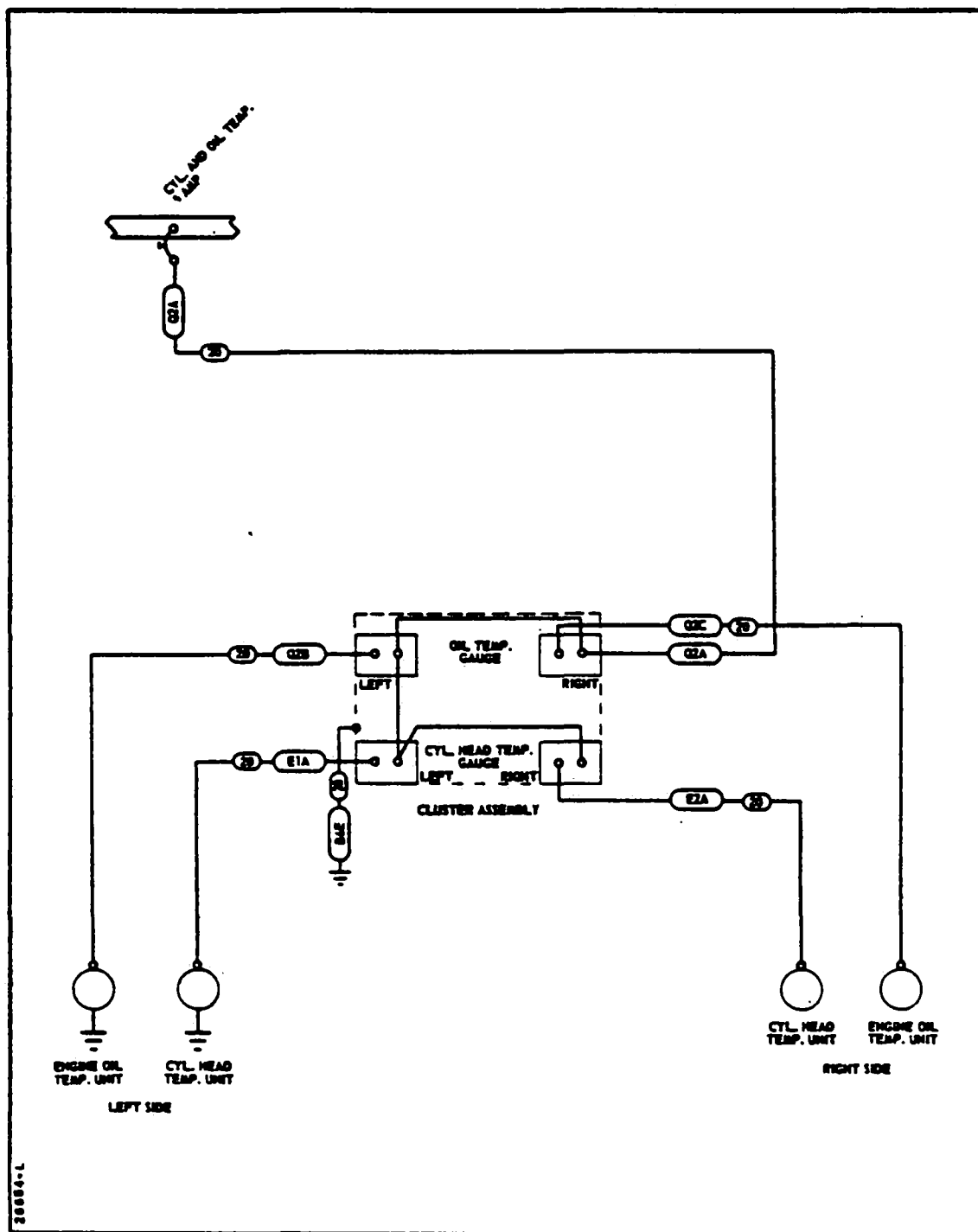


Figure 11-59a. Cylinder Head Temperature and Oil Temperature  
Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

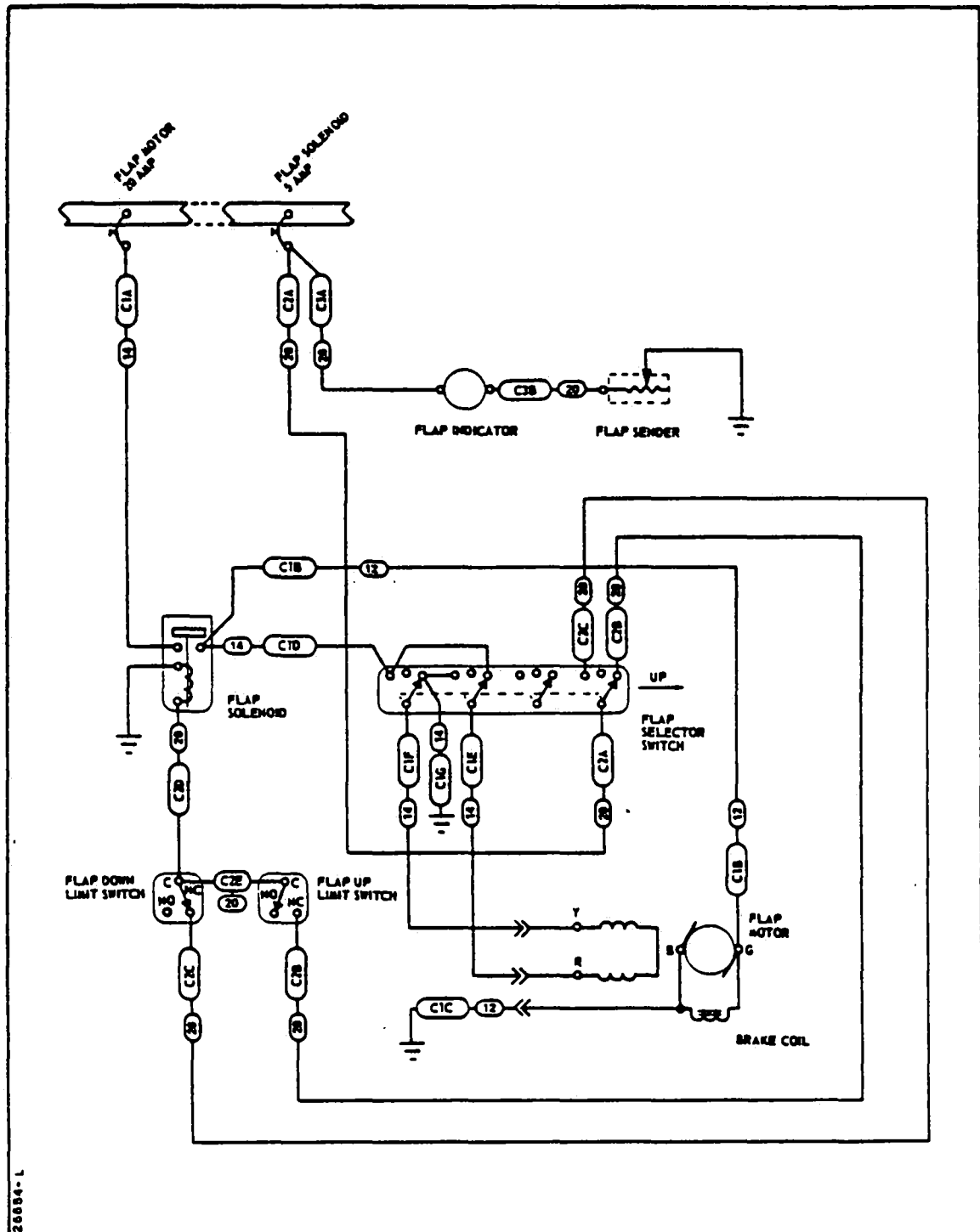


Figure 11-60. Flap Motor and Flap Solenoid

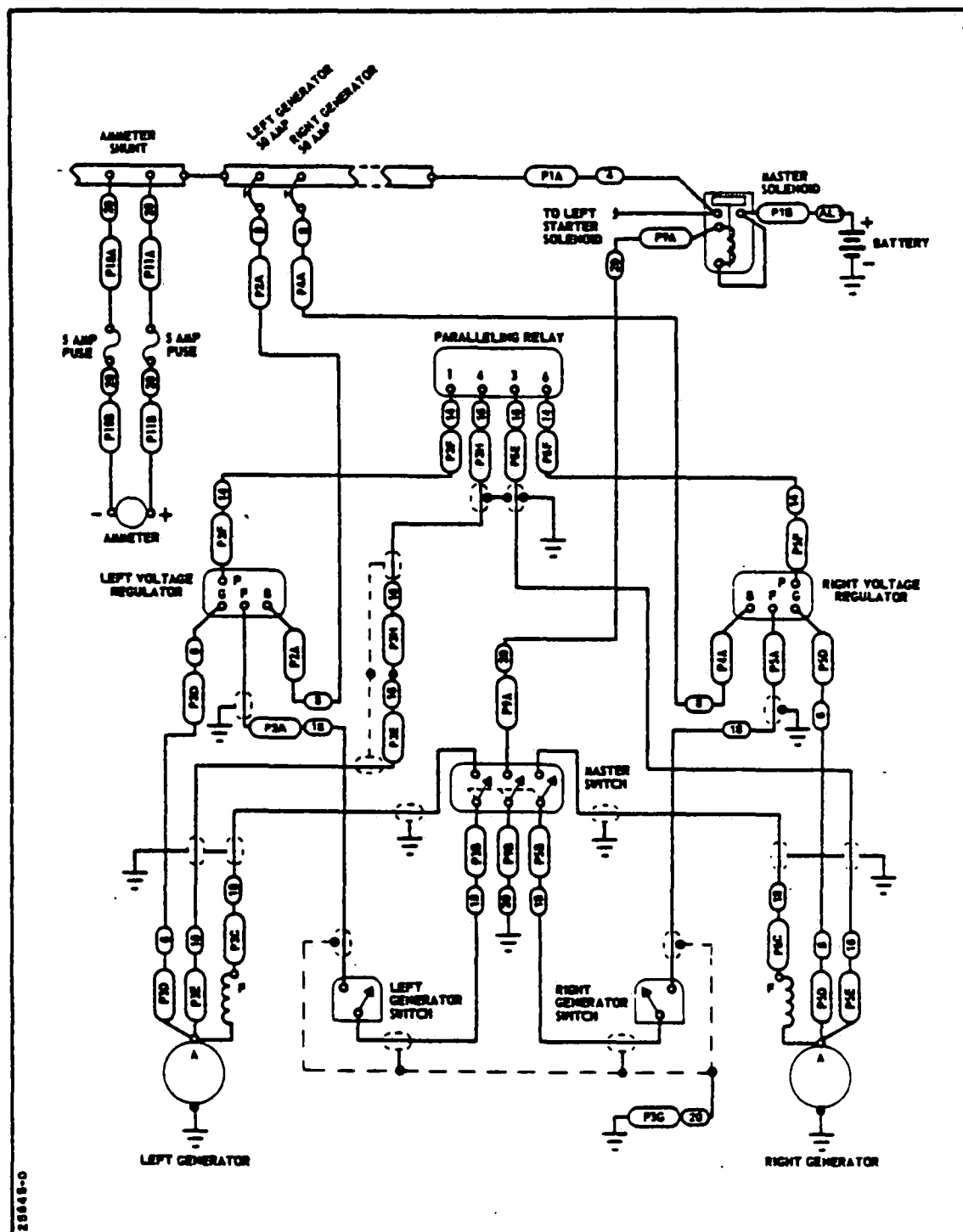


Figure 11-61. Generator System

ELECTRICAL SYSTEM

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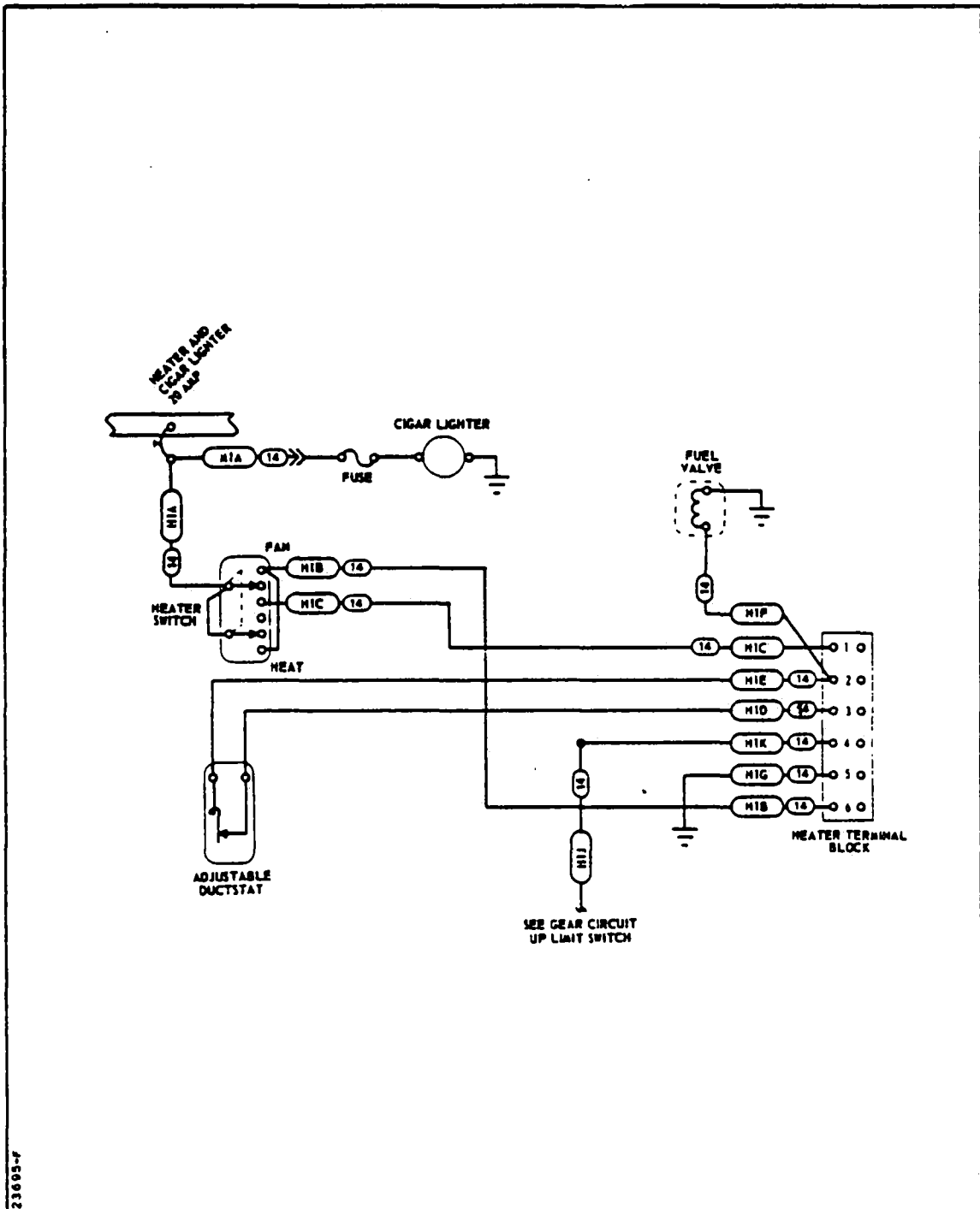


Figure 11-62. Heater (Southwind) and Cigar Lighter  
Serial Nos. 30-2 to 30-401 inclusive

ELECTRICAL SYSTEM

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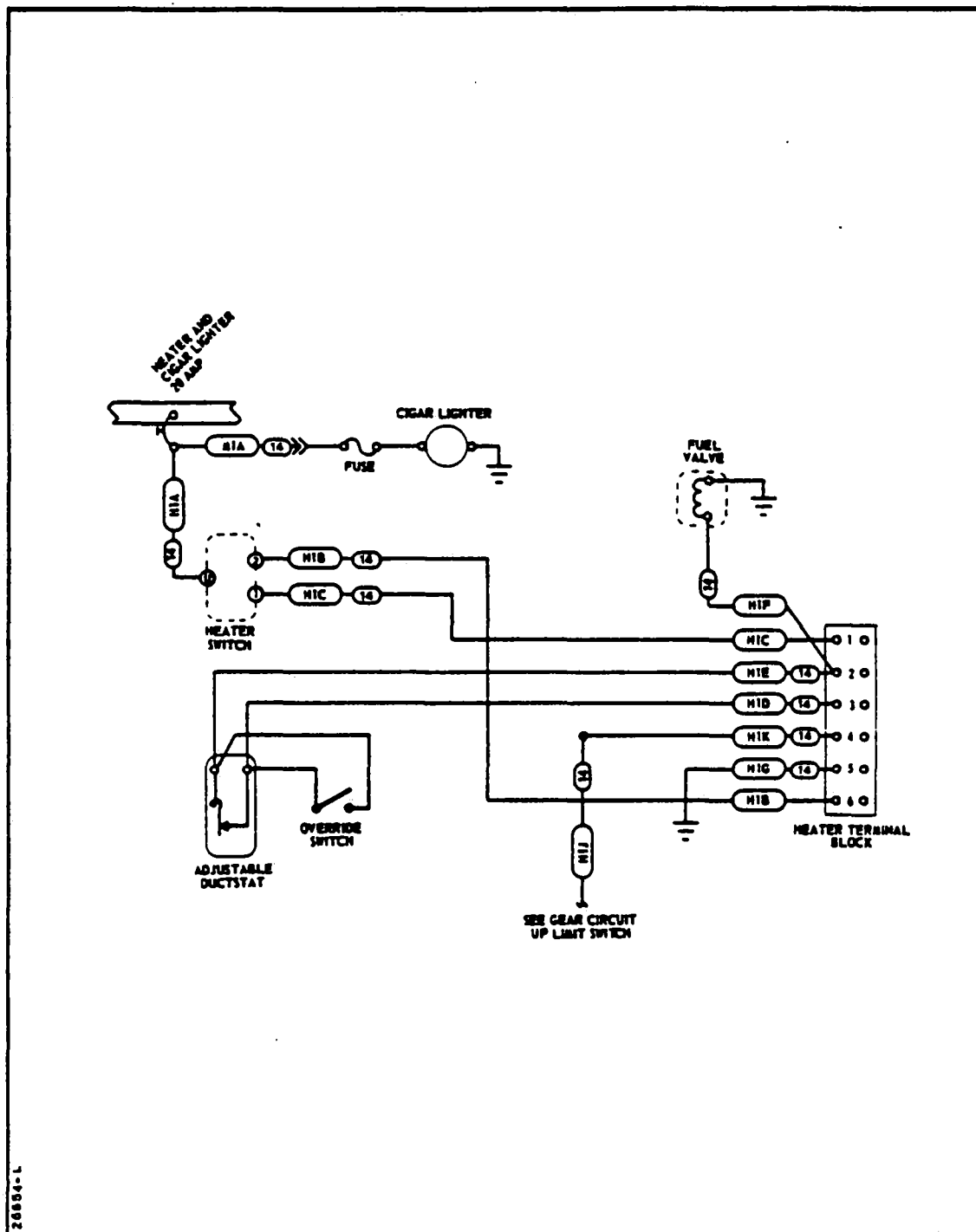


Figure 11-62a. Heater (Janitrol) and Cigar Lighter  
Serial Nos. 30-402 to 30-2000 incl.

ELECTRICAL SYSTEM

Issued: 12/29/72

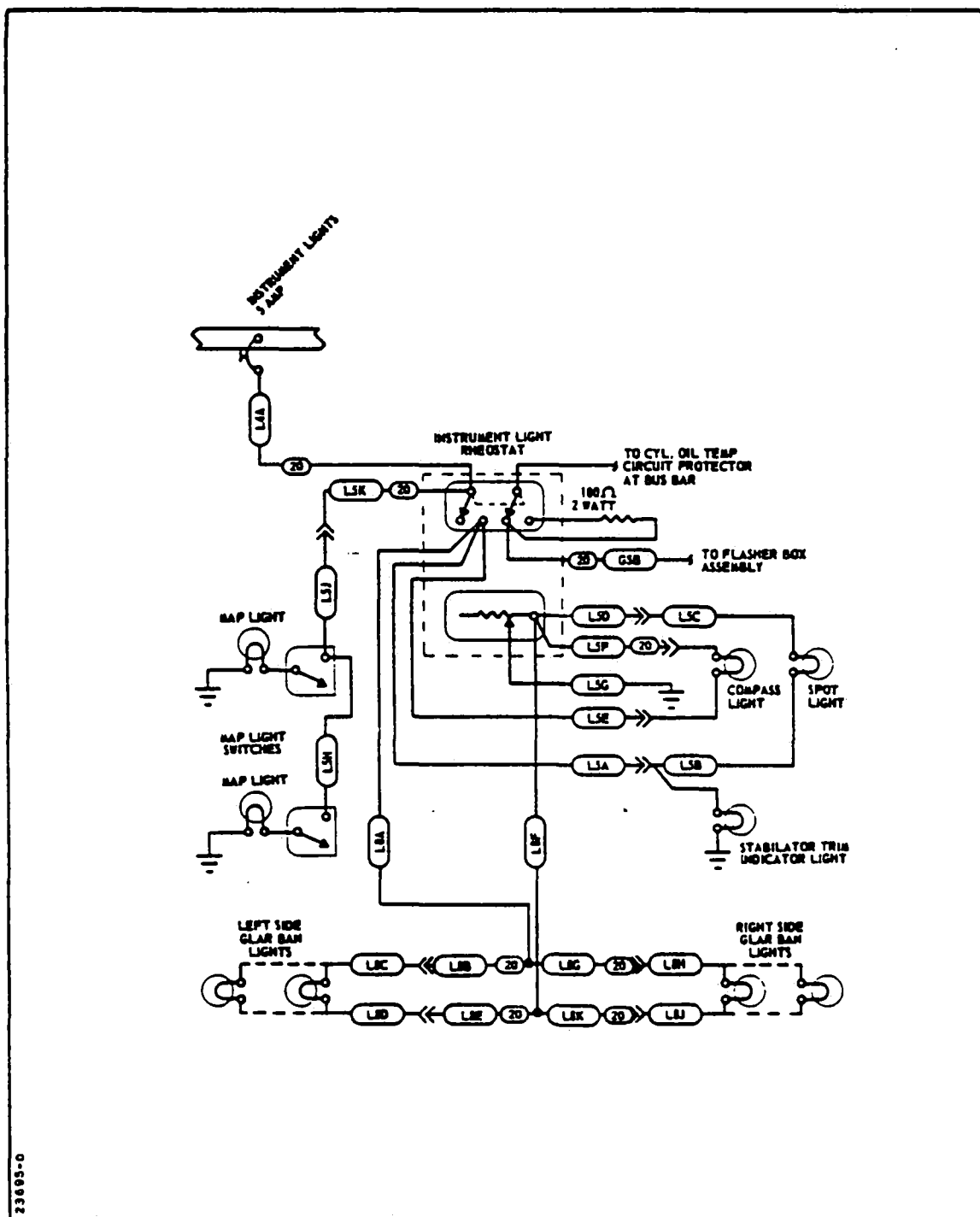


Figure 11-63. Instrument and Map Lights  
Serial Nos. 30-2 to 30-1102 inclusive

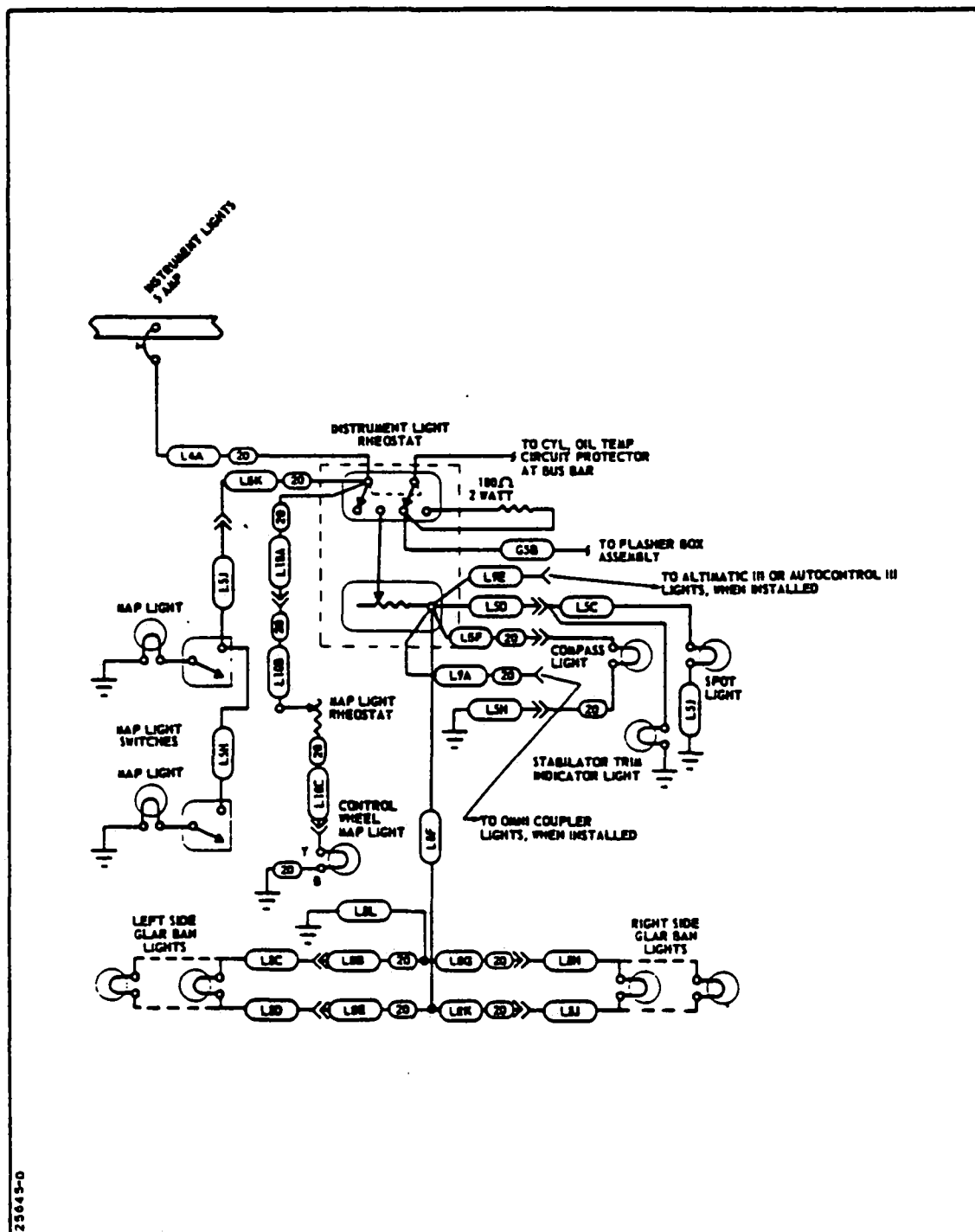


Figure 11-63a. Instrument and Map Lights  
Serial Nos. 30-1102 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

ELECTRICAL SYSTEM  
Issued: 12/29/72

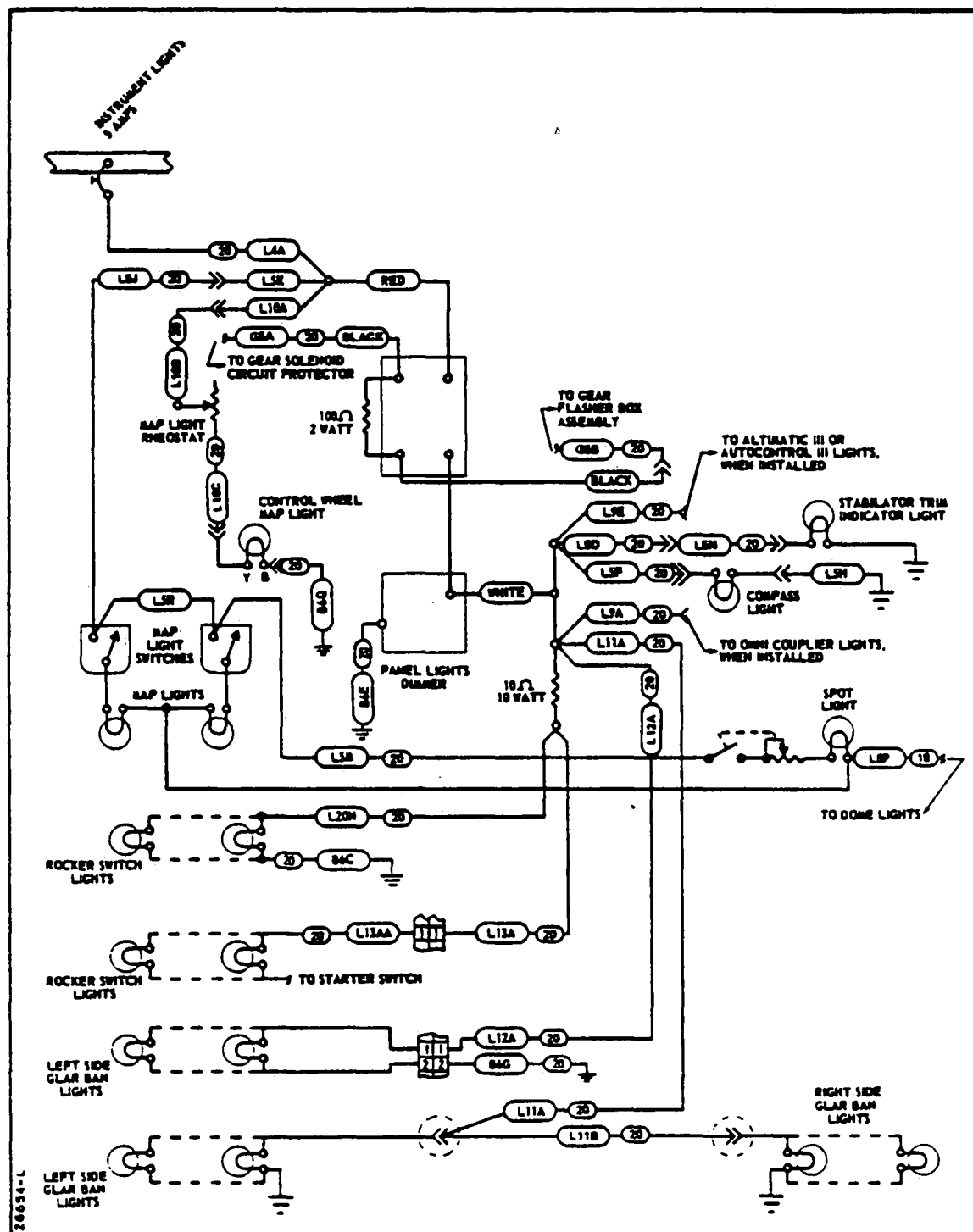


Figure 11-63b. Instrument and Map Lights, Serial Nos. 30-1717, 30-1795 to 30-2000 incl.

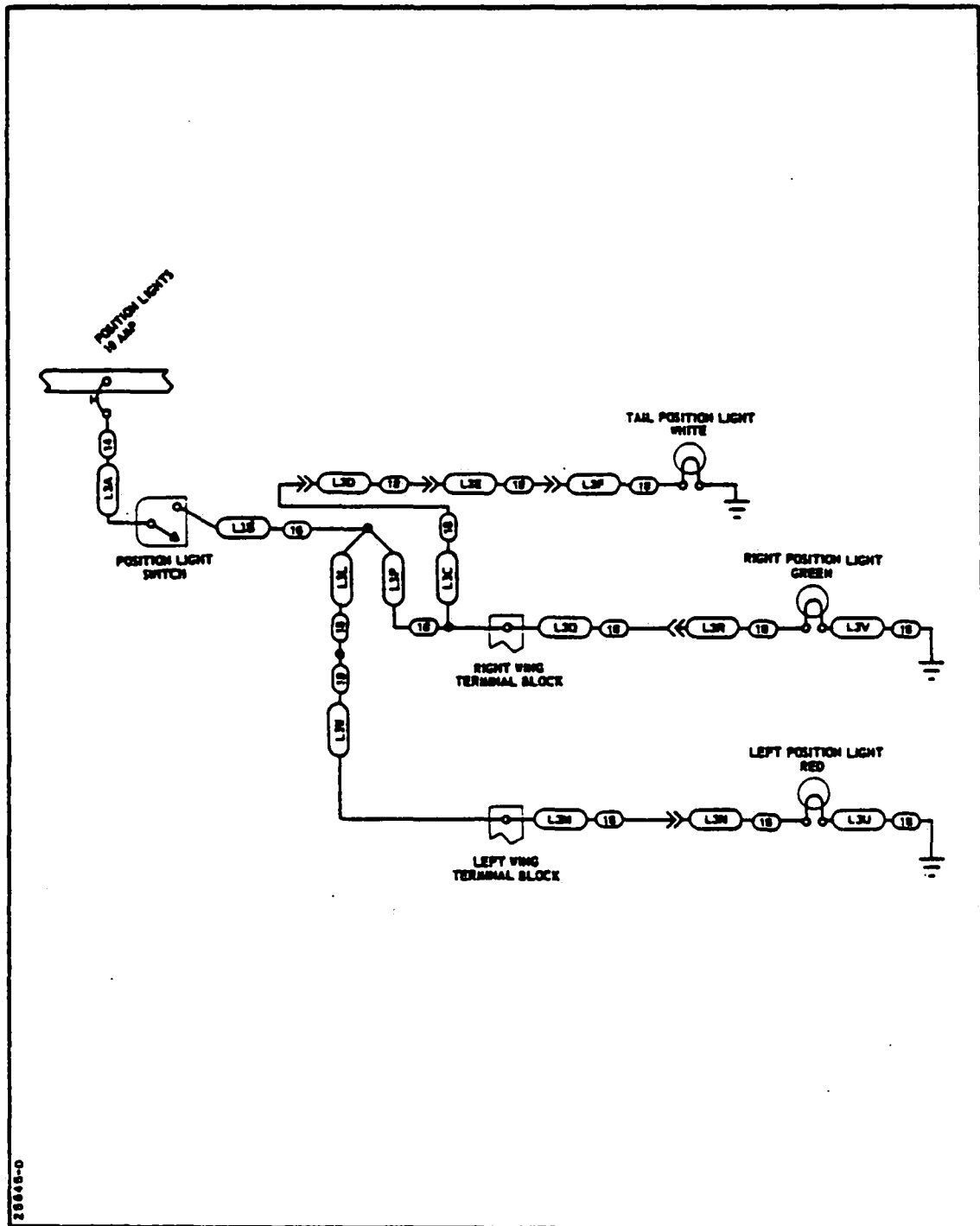


Figure 11-64. Position Lights  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

ELECTRICAL SYSTEM  
Issued: 12/29/72

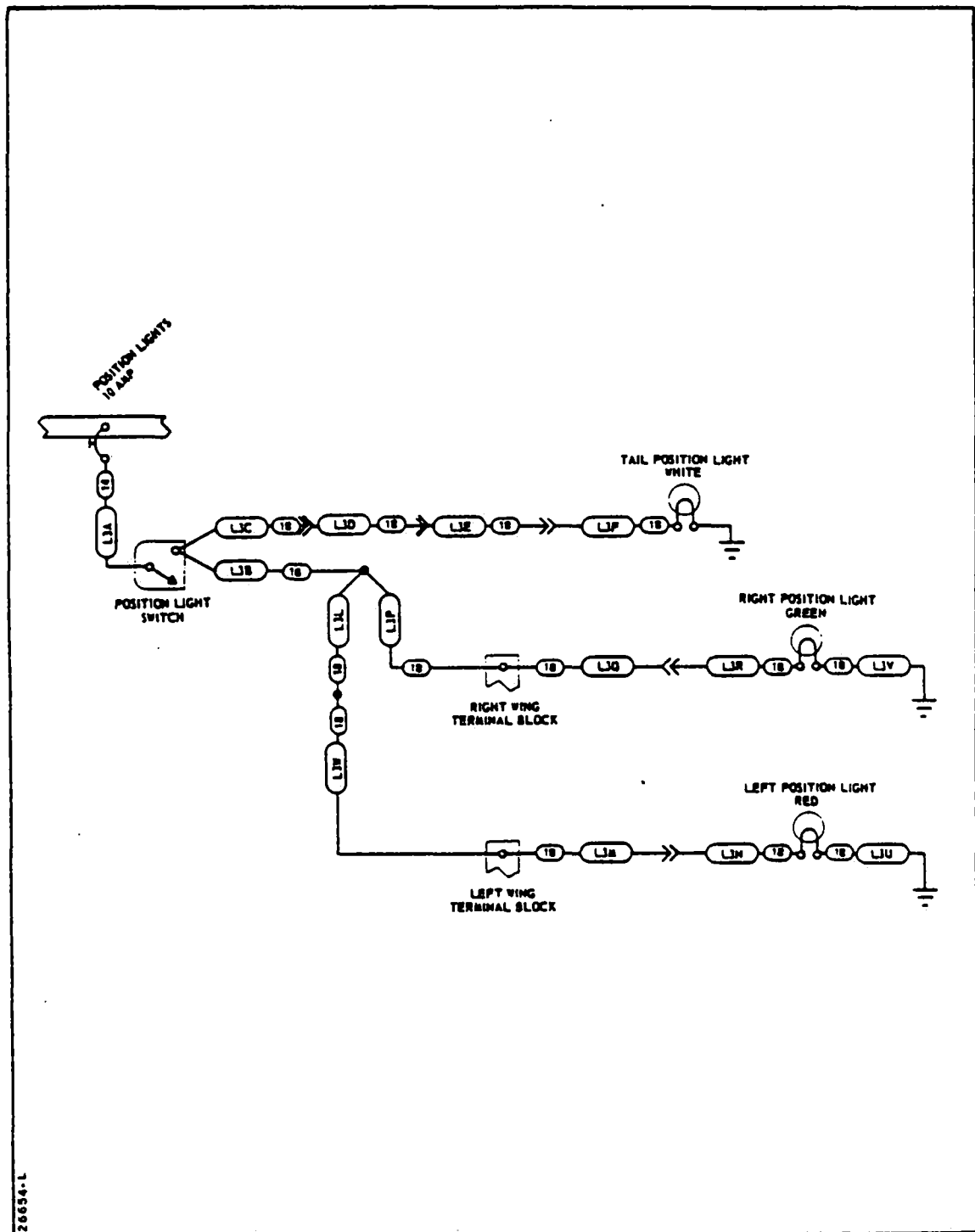


Figure 11-64a. Position Lights, Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

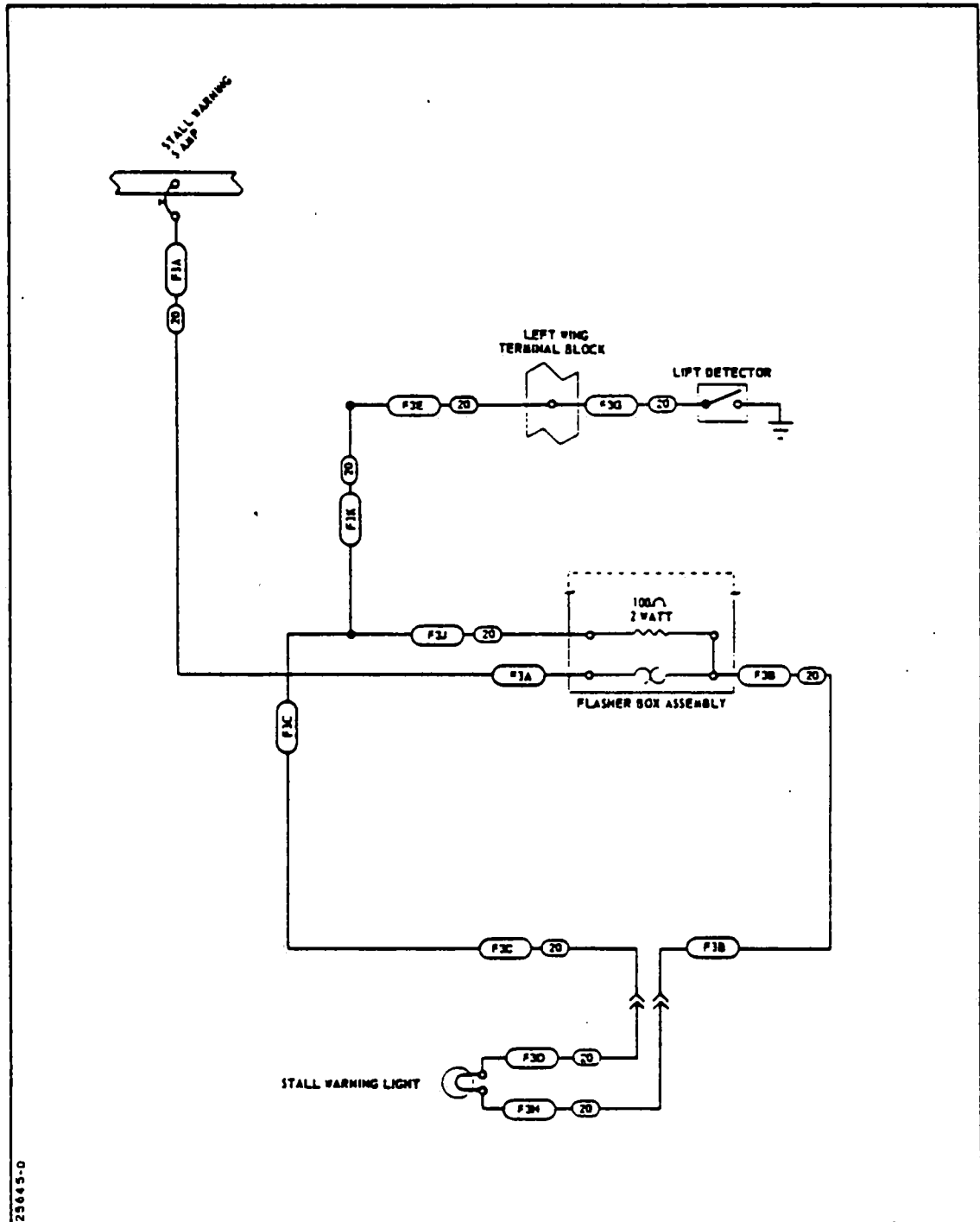


Figure 11-65. Stall Warning  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive



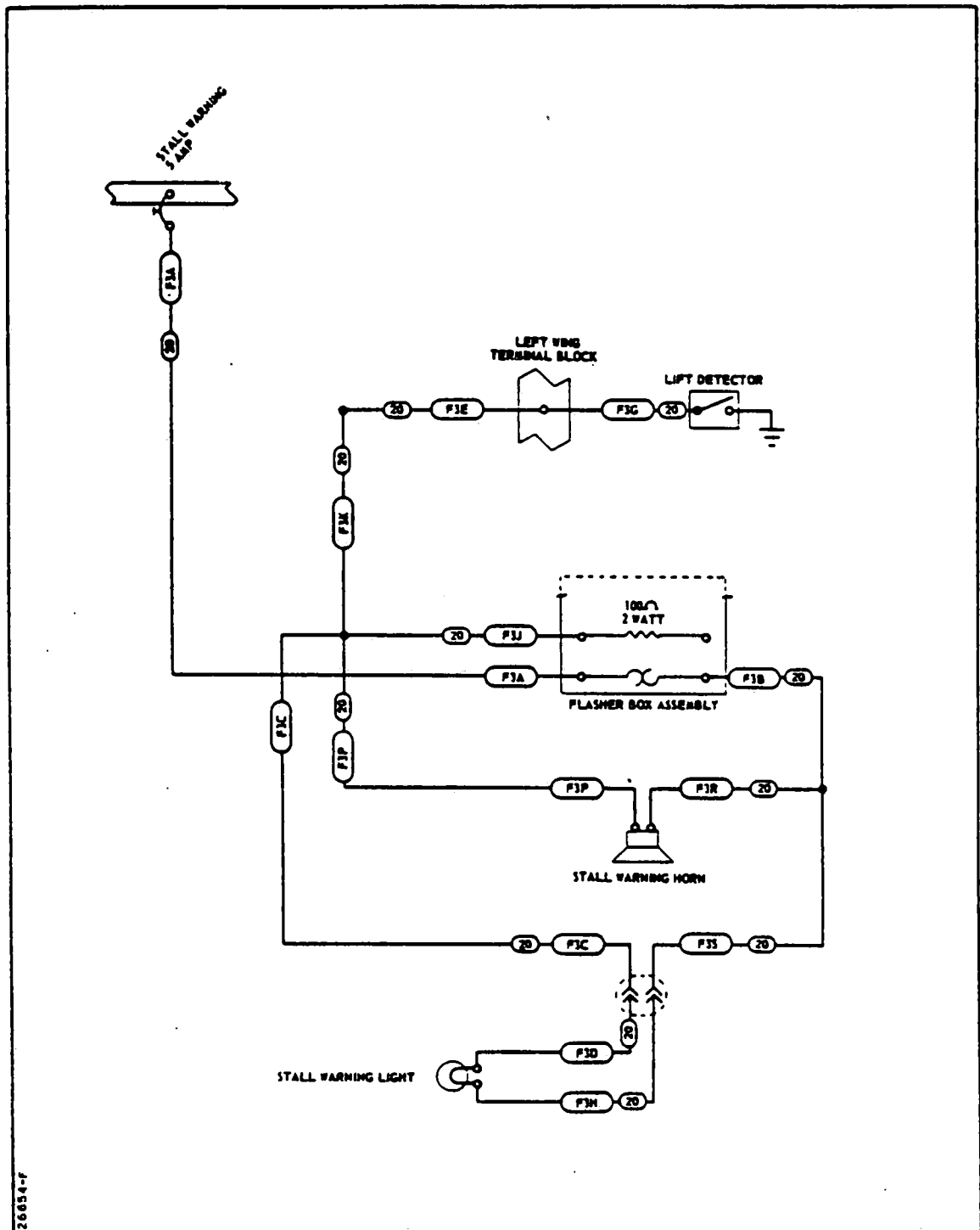


Figure 11-65a. Stall Warning, Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

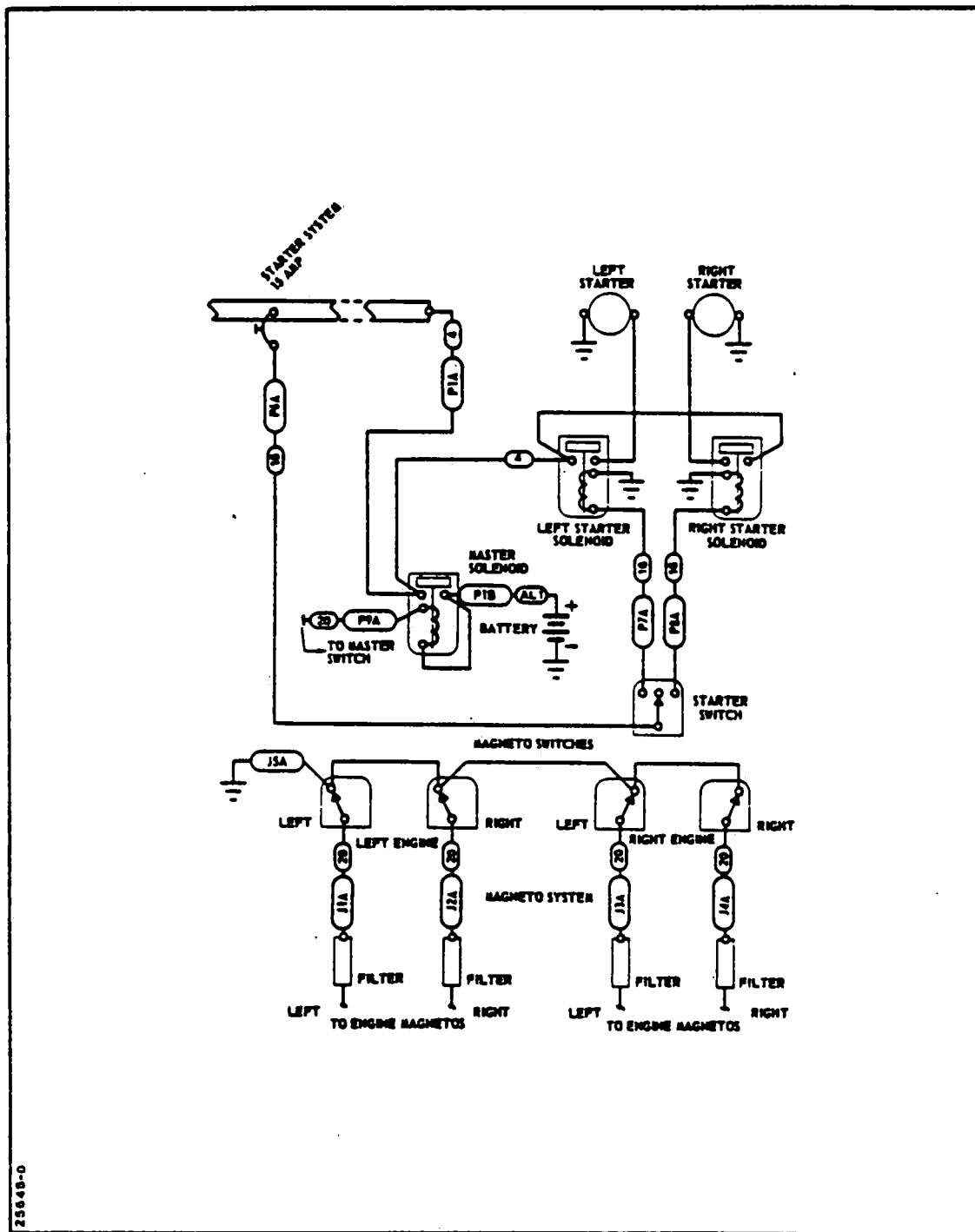


Figure 11-66. Starter System and Magneto Switches  
Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

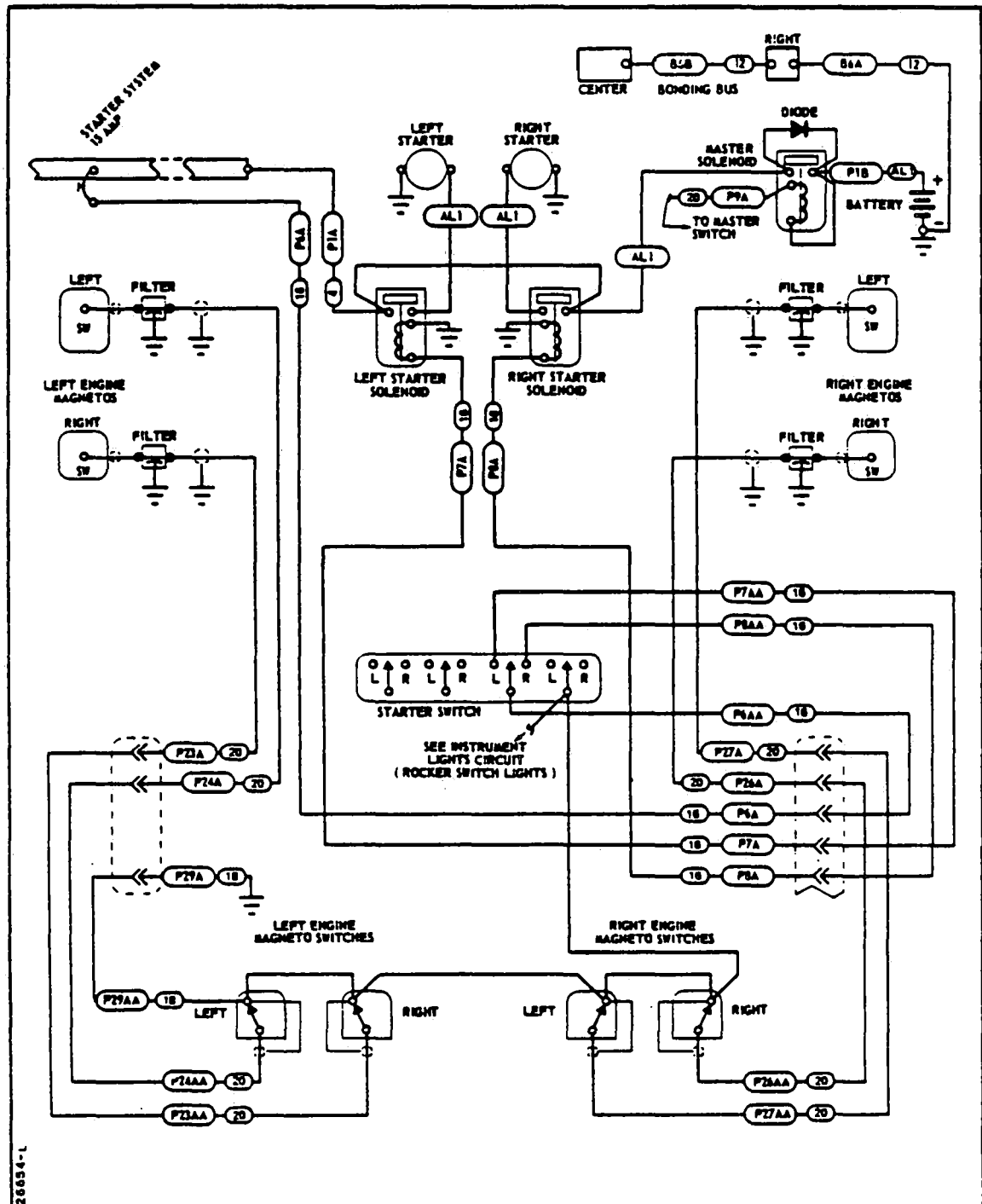


Figure 11-66a. Starter System and Magneto Switches  
Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

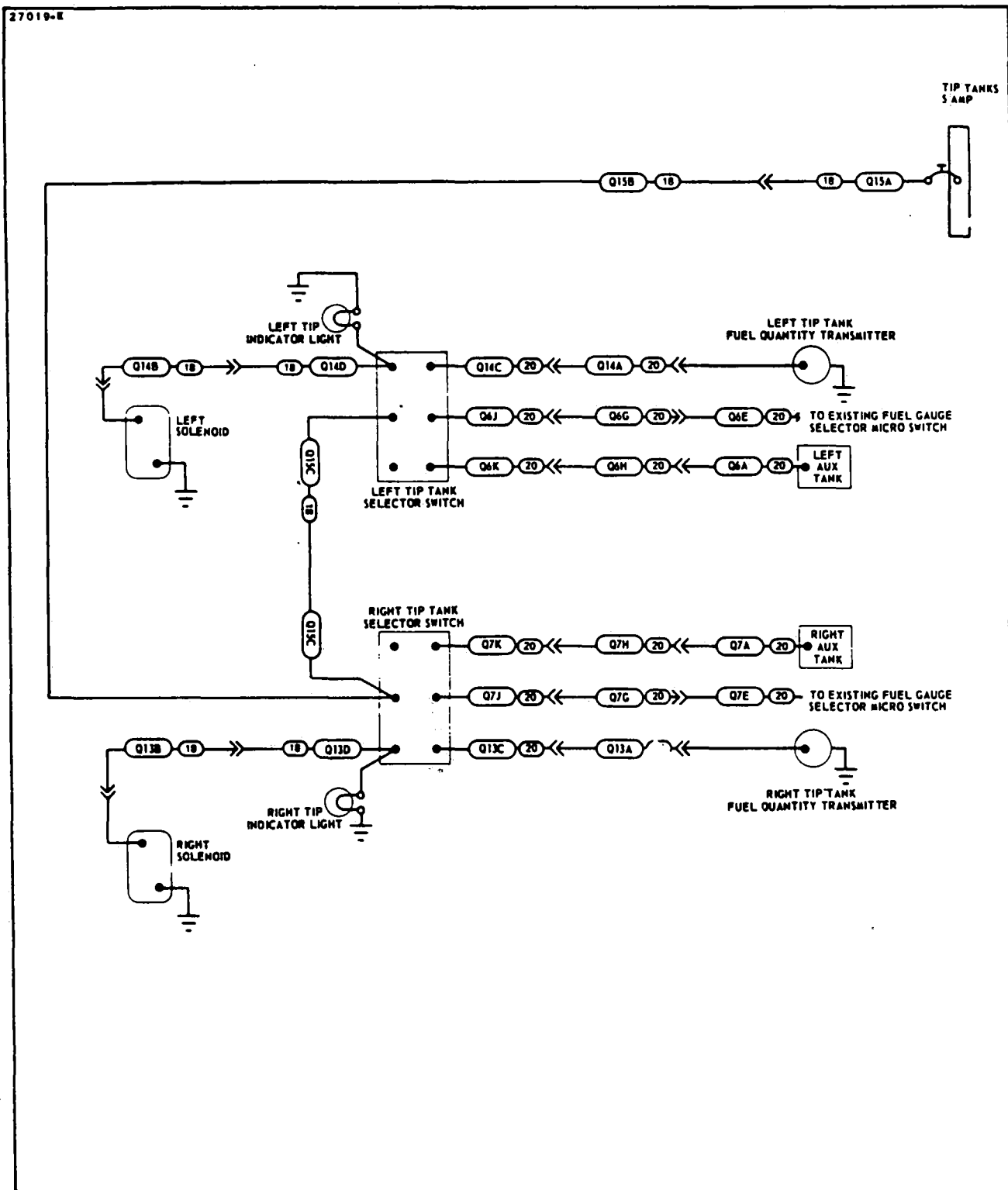


Figure 11-67. Tip Tanks

**3 F18**

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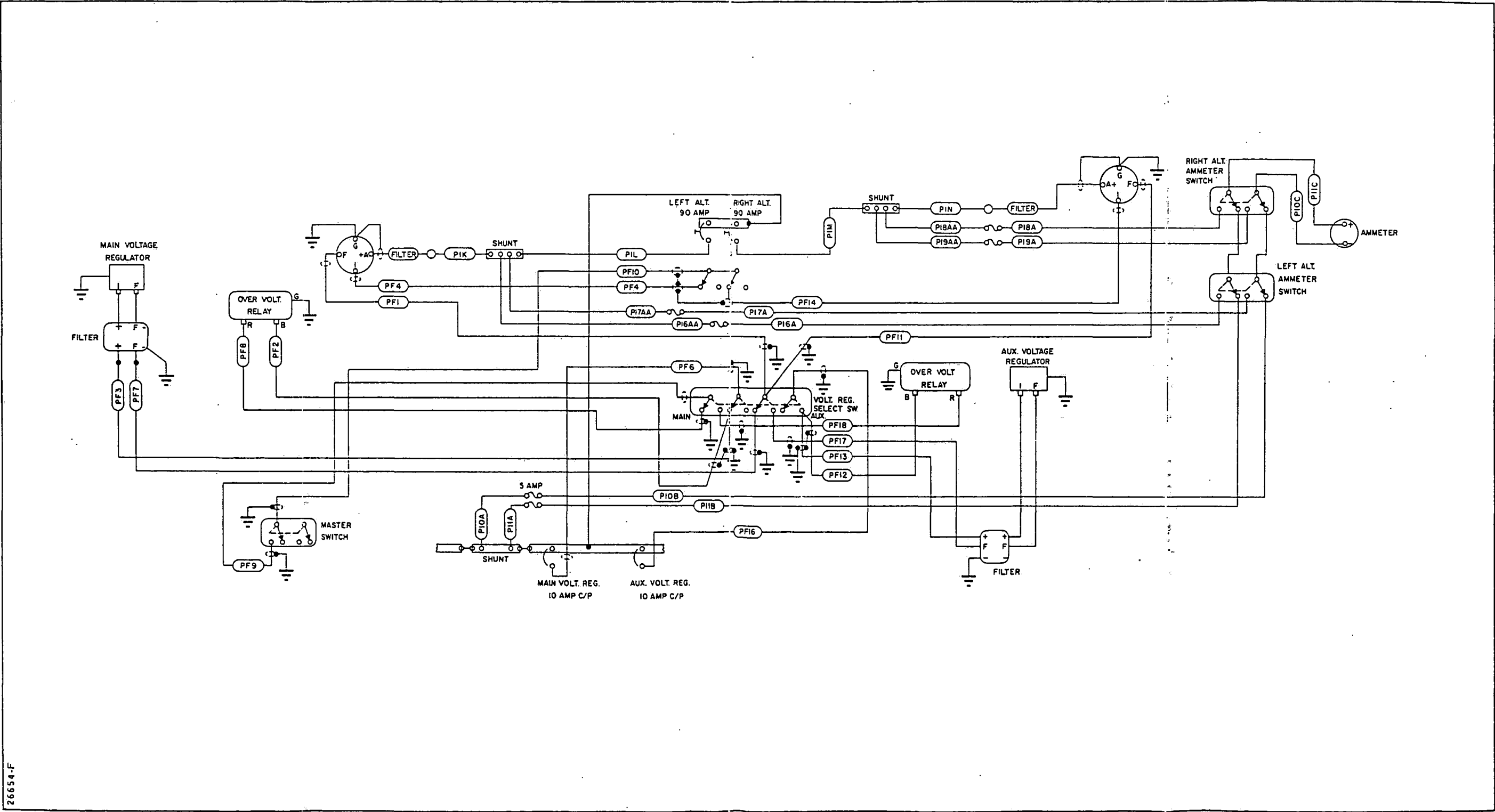


Figure 11-68. Alternator System (Nonparalleling)

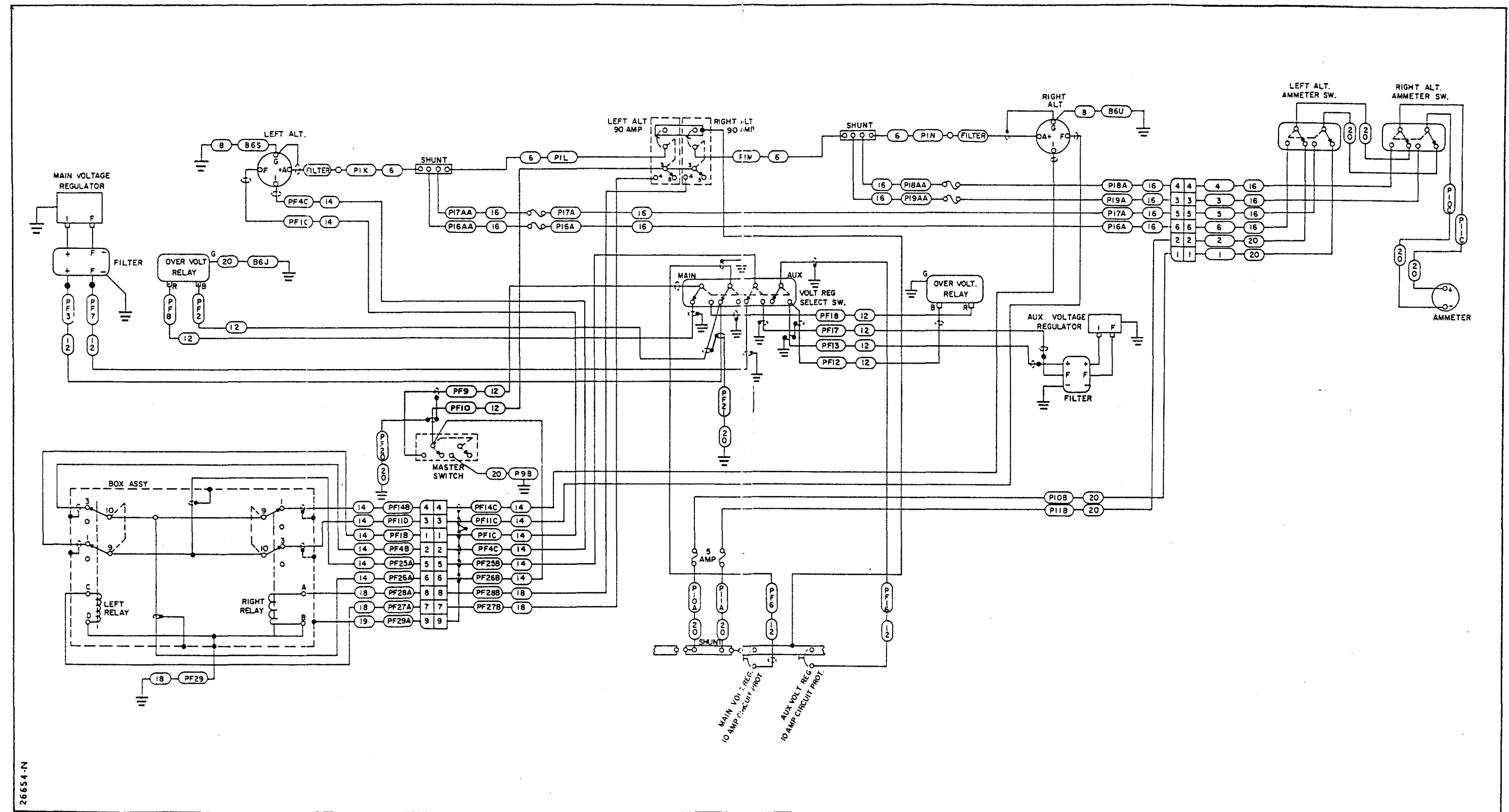


Figure 11-68a. Alternator System (Nonparalleling)

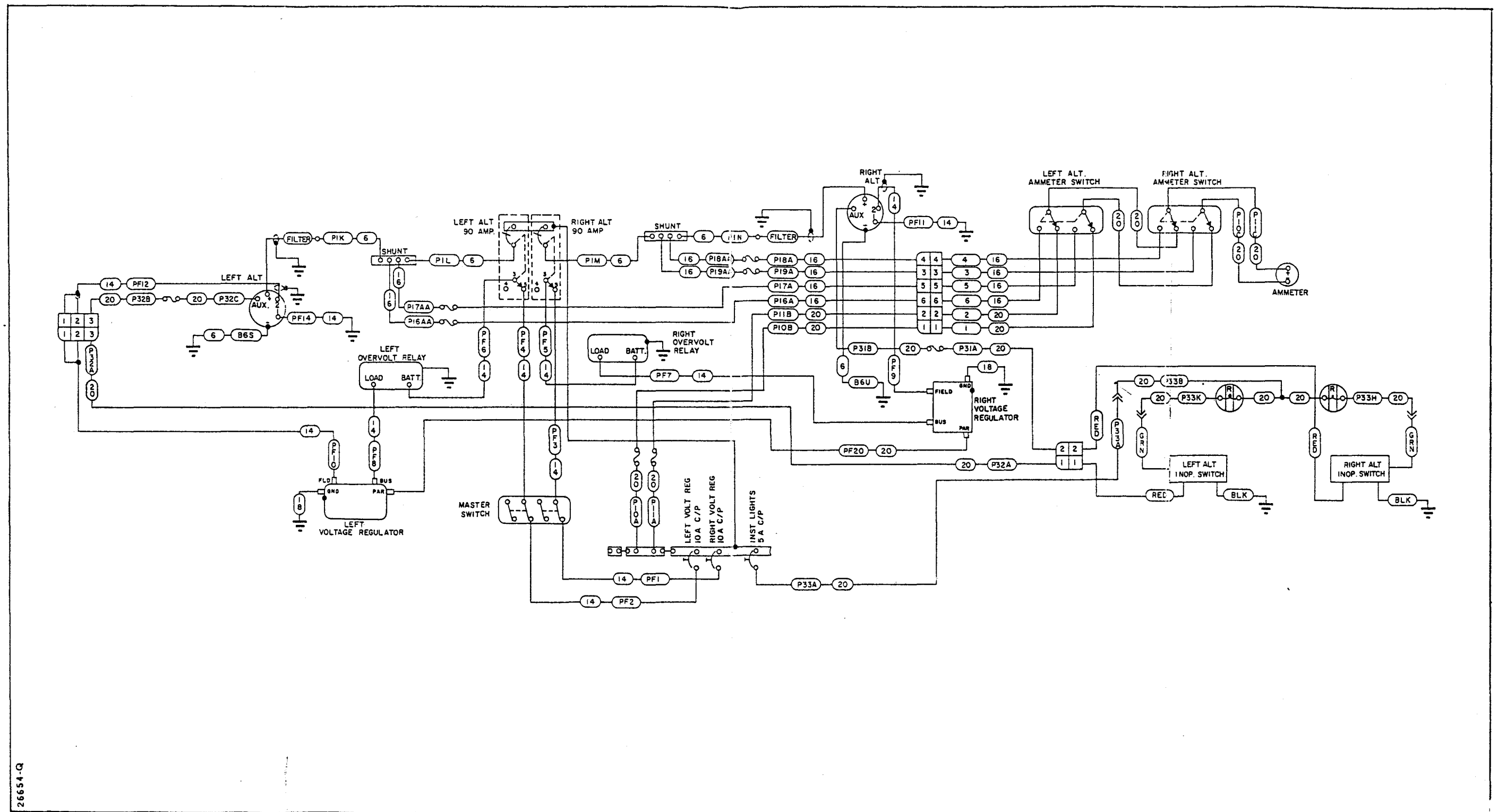
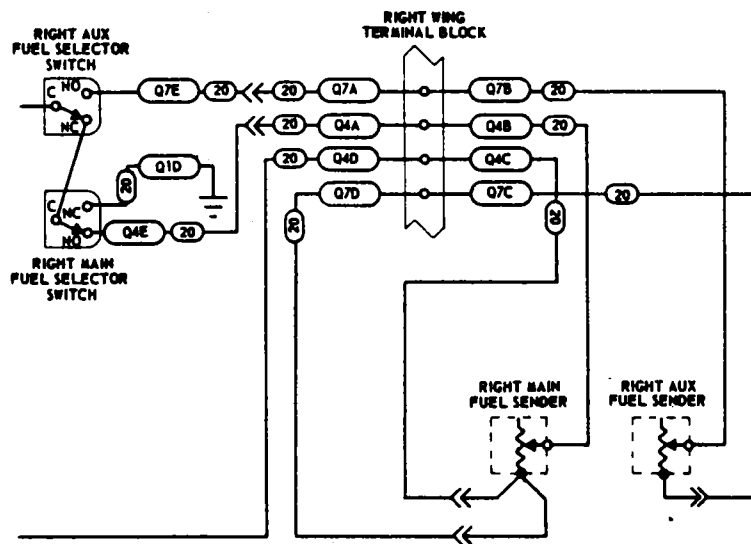


Figure 11-68b. Alternator System (Paralleling)







NOTE

1. CAPACITORS MAY OR MAY NOT BE INSTALLED

Figure 11-69. Fuel Quantity Indicators (cont.)

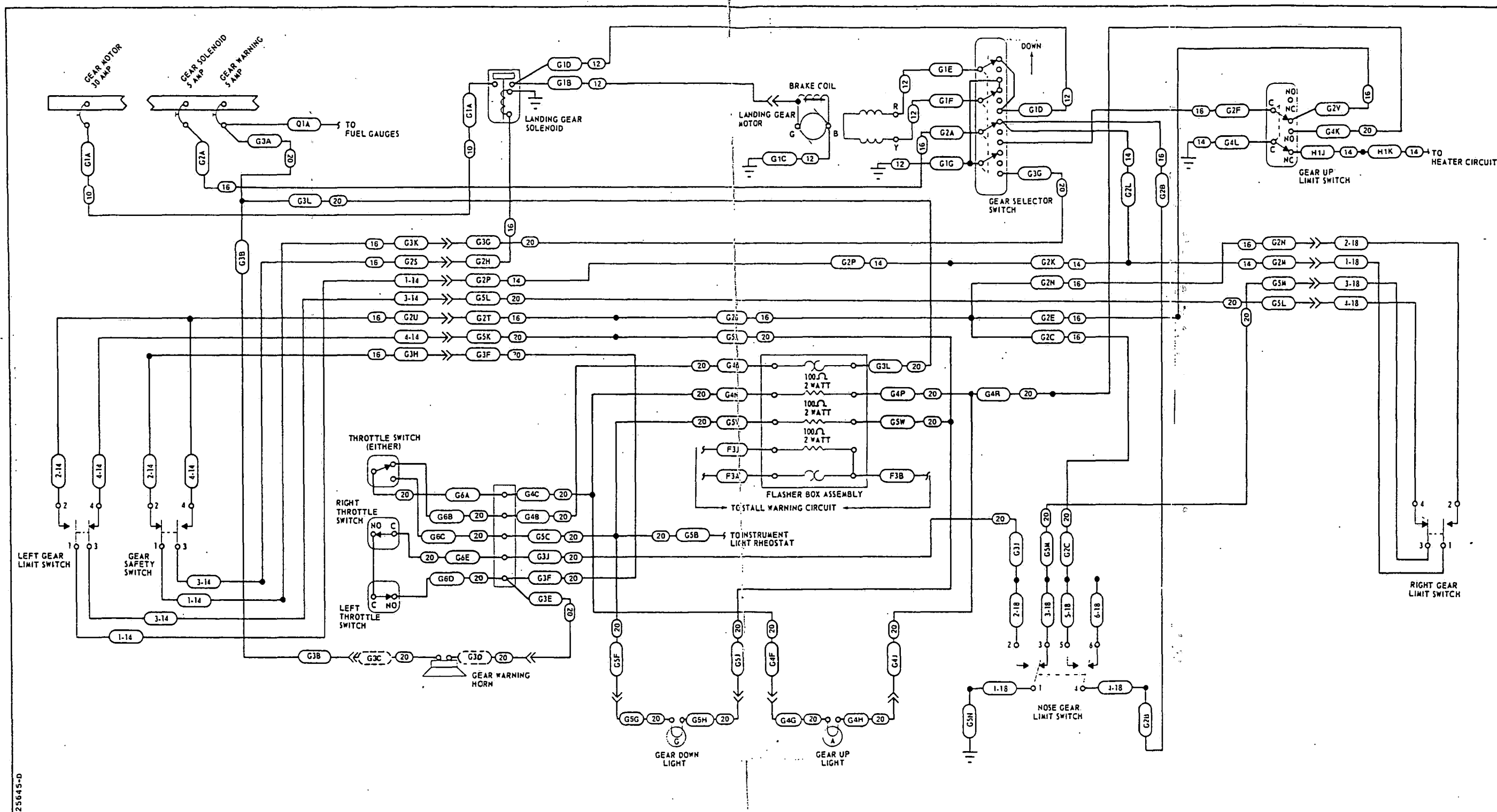


Figure 1-1-70. Landing Gear Motor, Landing Gear Solenoid, Landing Gear Warning, Serial Nos. 30-2 to 30-1716 inclusive and 30-1718 to 30-1744 inclusive

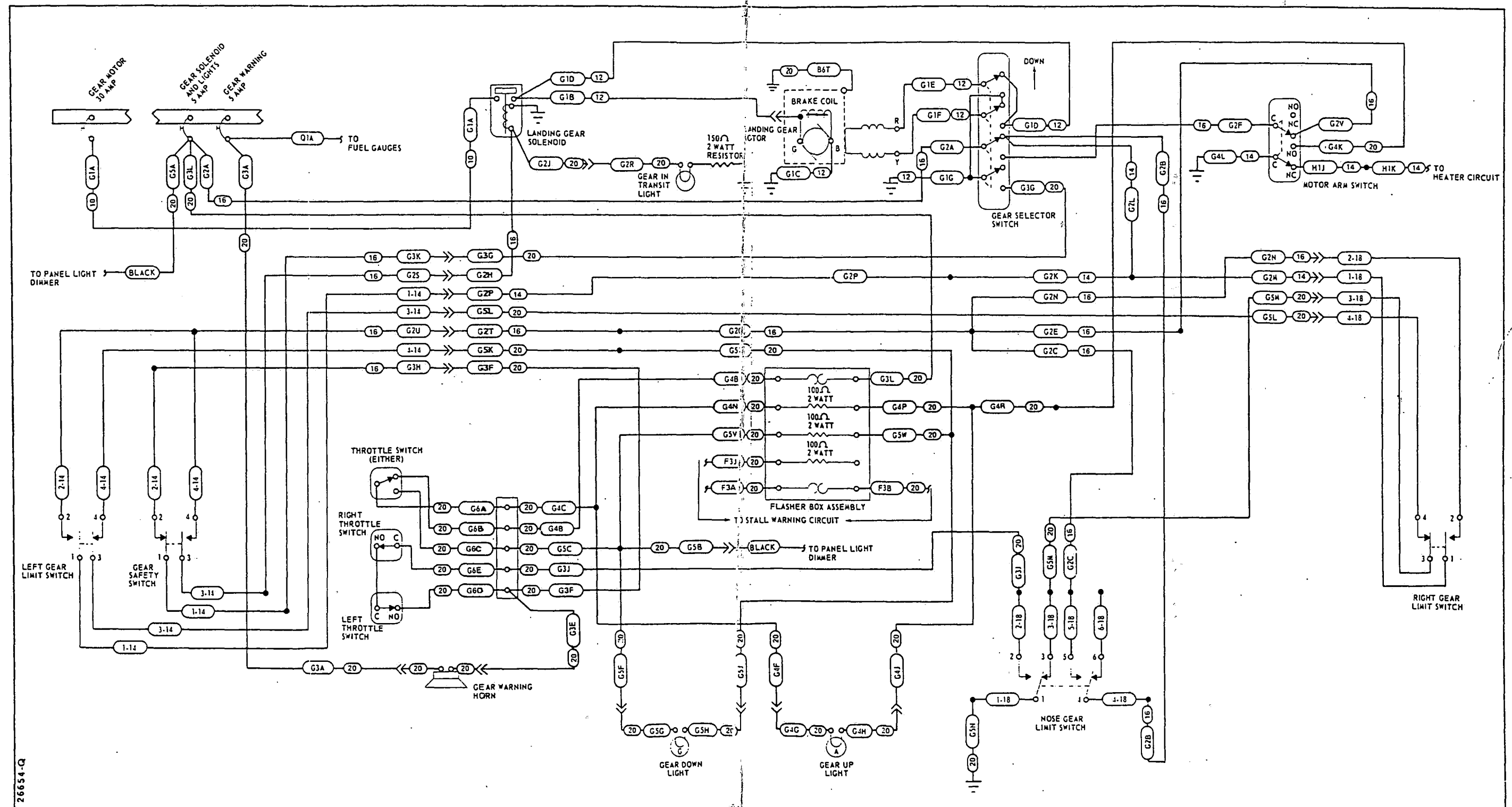


Figure 11-70a. Landing Gear Motor, Landing Gear Solenoid, Landing Gear Warning, Serial Nos. 30-1717, 30-1745 to 30-2000 incl. and 39-1 and up.

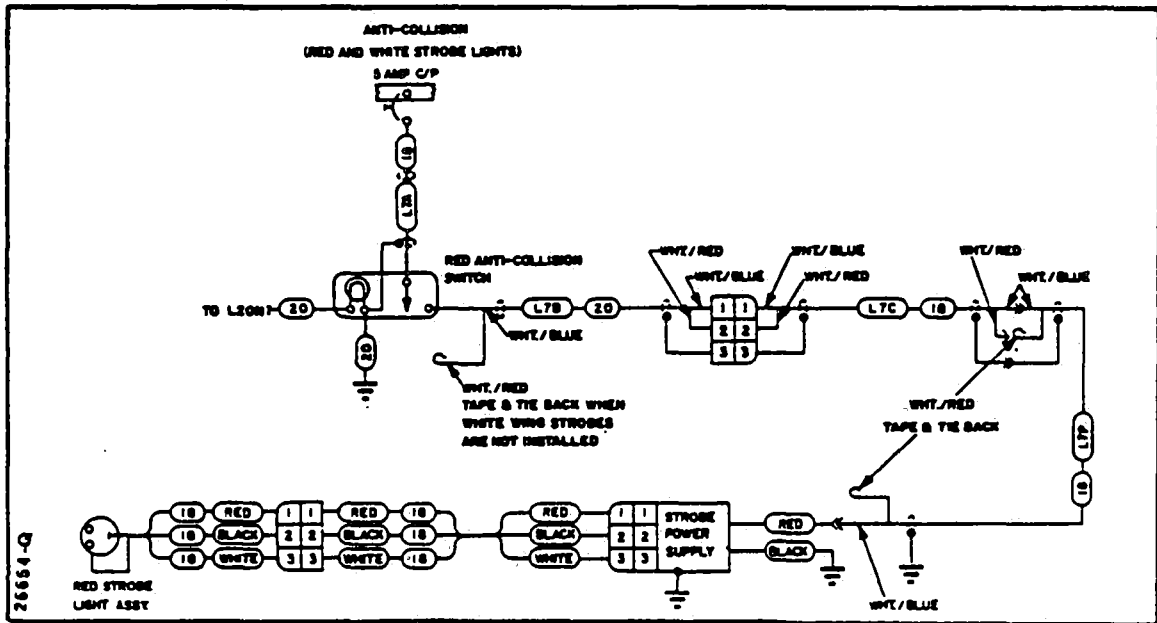


Figure 11-71. Anti-Collision (Strobe)

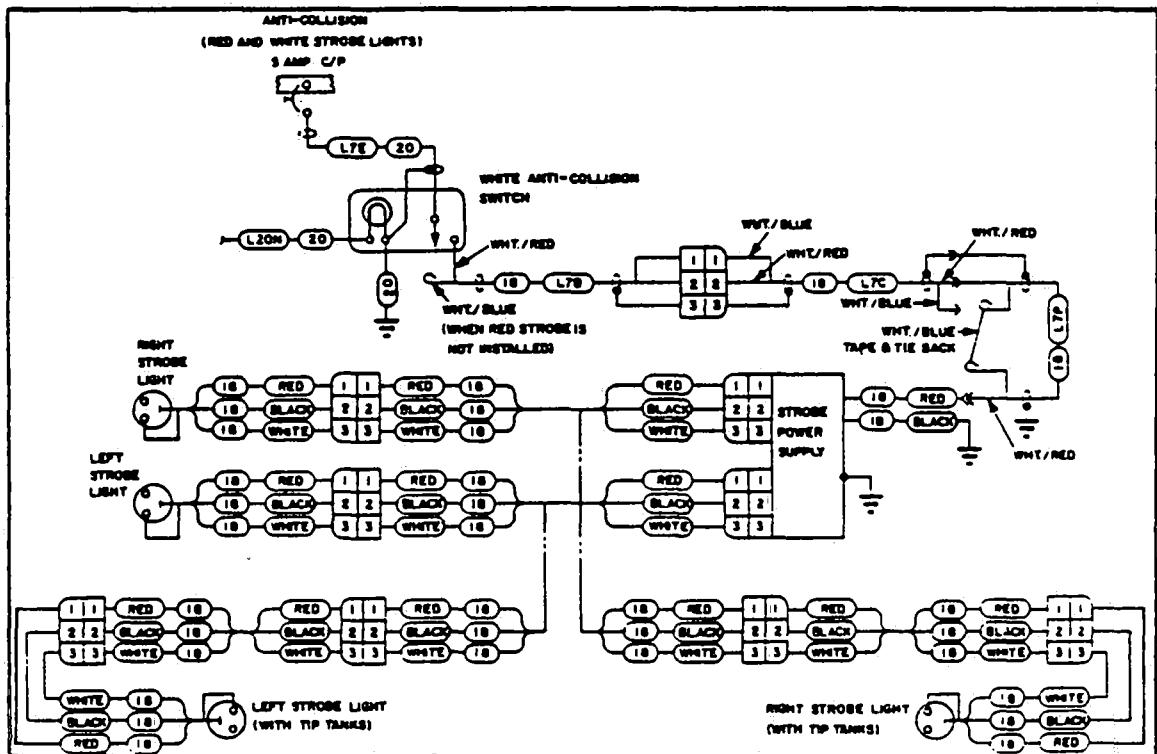


Figure 11-71a. Anti-Collision (Strobe)

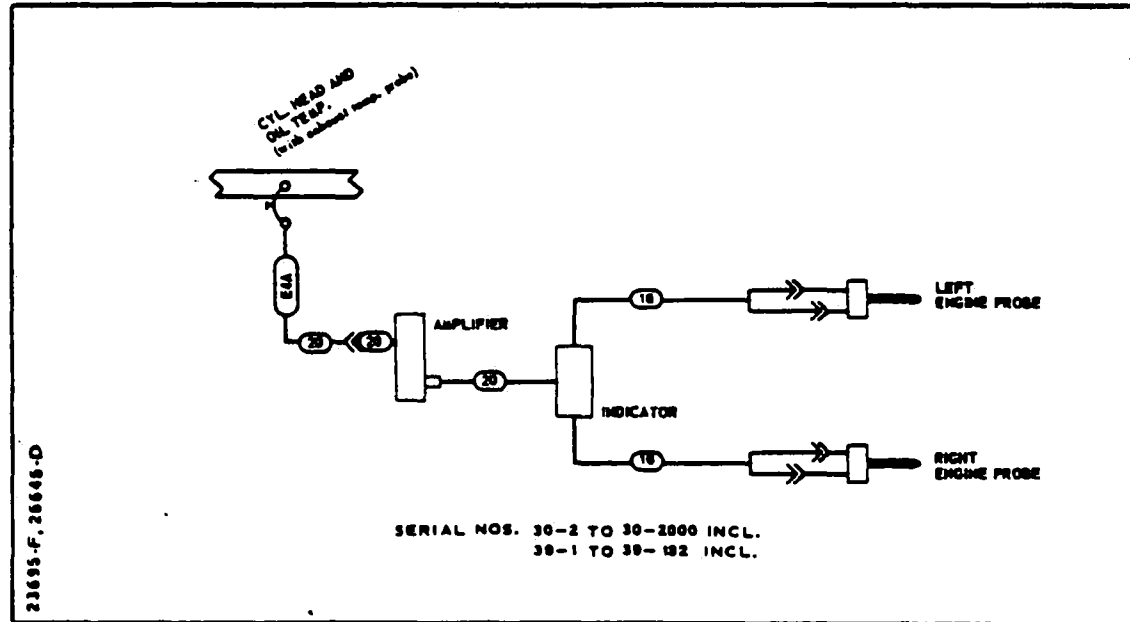


Figure 11-72. Exhaust Gas Temperature

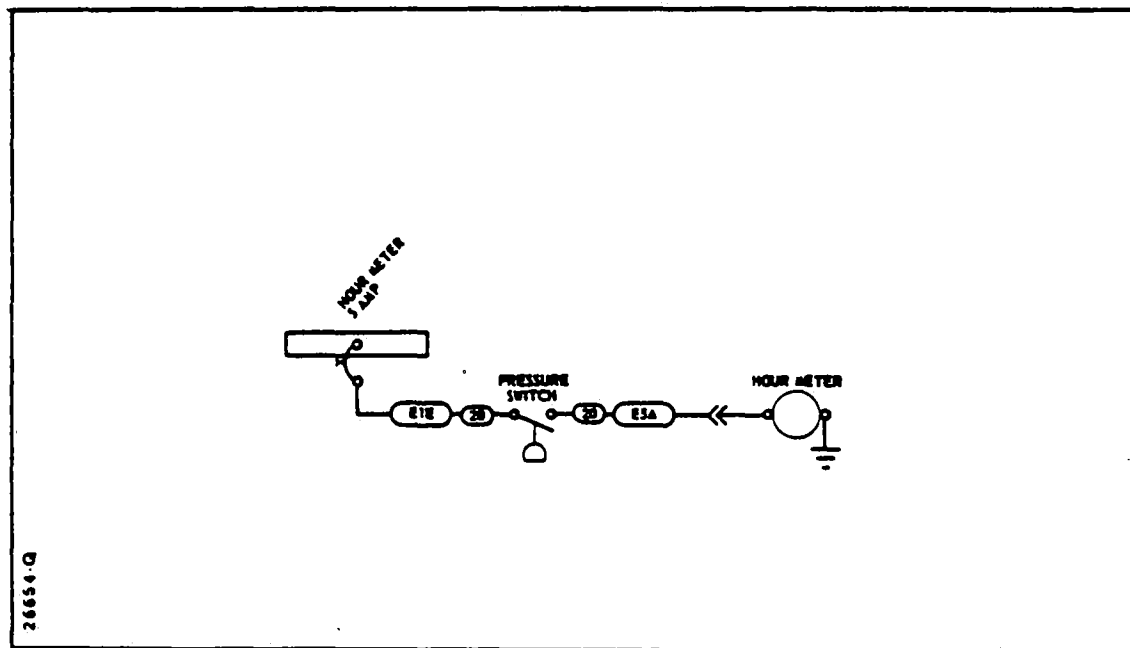


Figure 11-73. Hour Meter

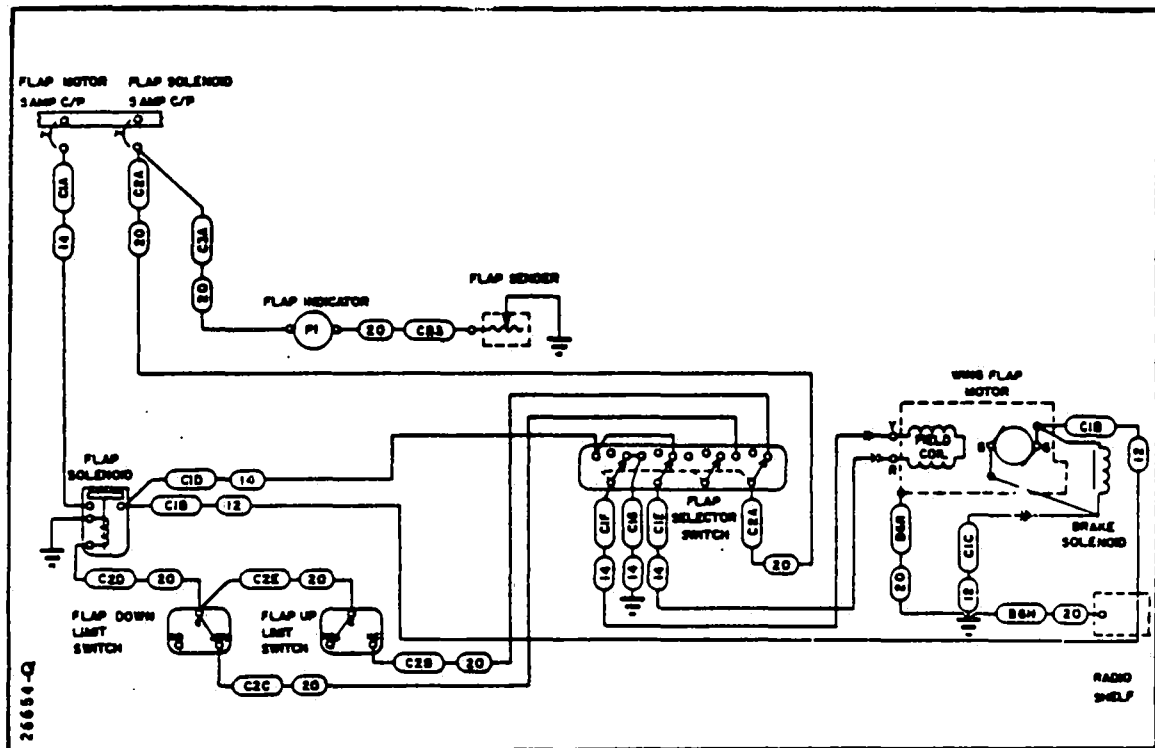


Figure 11-74. Flap Motor and Solenoid

**3 G10**

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**3 G11**

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## SECTION XII ELECTRONICS

Paragraph		Aerofiche Grid No.
12-1.	Introduction .....	3G16
12-2.	Piper Automatic Locator Transmitter .....	3G16
12-3.	Testing Locator Transmitter .....	3G17
12-4.	Battery Removal and Installation (Narco) .....	3G19
12-5.	Autoflight .....	3G21
12-6.	General .....	3G21
12-7.	Non-Piper A.F.C.S. Equipment Manufactures .....	3G21
12-8.	Piper A.F.C.S. Equipment .....	3G21

### CAUTION

It is very important to never use a substitute trim system component part, for an original design part, because the fail-safe characteristics of the system might be compromised. Refer to the POH for ground check of electric Pitch Trim System before the first flight after servicing. A trim system running the wrong direction is the same as a run-away. It is possible to experience excessive pilot yoke force in only 3-4 seconds under such conditions.

**3G13 THRU 3G15**  
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## SECTION XII

### ELECTRONICS

12-1. INTRODUCTION. This section of the manual is divided into two parts. The first part consists of the information necessary to perform an operational check of the Piper Automatic Locator Transmitter along with the appropriate removal and installation instructions to facilitate battery replacement. The second part consists of wiring diagrams of the various configurations of avionics equipment installations.

#### 12-2. PIPER AUTOMATIC LOCATOR TRANSMITTER.

The automatic locator transmitter when installed is located under the access panel on the dorsal fin. This unit operates on its own self-contained battery. This battery has a service life of four years. However, to comply with FAA regulations it must be replaced after two years. If the transmitter is activated during this two year period or it has more than one hour of periodical test activations performed, the battery pack should be replaced at that time. To replace the battery pack in the transmitter it is necessary to remove the unit from the airplane. The following instructions should be used:

- a. Remove the access panel located on the dorsal fin.
- b. Remove the switch guard and set the ON/ARM/OFF switch to the OFF position.
- c. Disconnect the whip antenna cable at the transmitter.
- d. Remove the rear mounting bracket and remove the transmitter from the airplane.
- e. Remove and keep the four screws securing the transmitter's plain end cap. Carefully remove the end cap, trying not to damage the sealant.
- f. Carefully withdraw the battery pack from the transmitter until the connector is exposed. Disconnect the battery from the connector and discard the battery.
- g. Before installing the new battery pack, check the replacement date. Transfer the self-sticking date placard on the battery to the placard on the transmitter case.
- h. Connect the new battery pack to the connector and carefully install it into the transmitter - connector end first. It may be necessary to rotate the battery slightly to get it seated properly in the transmitter case.
- i. Check the sealant on the end cap before putting it on the transmitter. If the sealant is damaged, replace it with fresh silicone sealant, such as the type supplied by General Electric Co. Secure the end cap to the transmitter with the four screws previously removed.
- j. Install the assembled unit into the airplane and secure with aft mounting bracket. Connect the whip antenna and set the ON/ARM/OFF switch to ARM.

#### NOTE

Inspect the external whip antenna for any damage. Avoid bending the whip. Any sharply bent or kinked whip should be replaced. Antenna damage may cause structural failure of whip inflight.

### ELECTRONICS

Issued: 12/29/72

## PIPER TWIN COMANCHE SERVICE MANUAL

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### NOTE

It may be advisable to test the unit operation before installing the access cover on the dorsal fin. Refer to paragraph 12-3 for test procedures.

- k. Install the access cover and make an entry in the aircraft log book.

### 12-3. TESTING LOCATOR TRANSMITTER.

Before performing any operational test of the transmitter, the following precautions should be observed.

### CAUTION

The transmitter operates on the emergency frequencies of 121.5 and 243 MHz, both these frequencies are monitored by the various FAA installations. With this in mind it is advisable to notify your local control tower, etc., of your intentions to test the locator transmitter before doing so, and to keep your test transmission to a minimal duration.

- a. Remove the access panel or cover to gain access to the transmitter.
- b. Tune the aircraft communications receiver to 121.5 MHz and switch the receiver ON, deactivate squelch, and turn the receiver volume up until a slight background noise is heard.

### NOTE

If the aircraft is not fitted with a communications receiver, request the tower to listen for your test.

- c. Remove the ON/ARM/OFF switch guard from the switch and set the ON/ARM/OFF switch to ON. Keep the switch ON for a few seconds only, then set the switch to OFF.

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**NOTE**

The test transmission should have been picked up by the aircraft communications receiver and/or control tower. During cold weather there may be a slight delay before transmission occurs.

d. A transmitter which is functioning properly should emit a characteristic downward swept tone.

e. When the test is completed reposition the ON/ARM/OFF switch from the OFF position to the ARM position and reinstall the switch guard, and any access panel or cover removed.

**WARNING**

Whenever the unit is checked by moving the selector switch from the "ARM" to "ON" position, it must then be moved to the "OFF" position before reverting to the "ARM" position again.

**12-4. BATTERY AND REMOVAL AND INSTALLATION (NARCO). (Refer to Figures 12-1 and 12-2.)**

- a. Set the ON/OFF/ARM switch on the transmitter to OFF.
- b. Disconnect antenna coaxial cable from ELT.
- c. Remove ELT from its mounting bracket by releasing the latch on the strap and sliding ELT off the bracket.
- d. Extend the portable antenna.
- e. Unscrew the four screws that hold the control head to the battery casing and slide apart.
- f. Disconnect the battery by unsnapping the snap-off battery pigtail terminals from the bottom of the transmitter printed circuit board.
- g. Discard old battery pack. (DO NOT EXPOSE TO FLAME.)

**CAUTION**

The battery pack is shipped with a sealant on the inside lip so that a water tight seal will be retained. **DO NOT REMOVE THIS SEALANT.**

- h. Connect new battery pack terminals to the bottom of the circuit board.
- i. Reinsert the control head section into the battery pack being careful not to pinch any wires, and replace the four screws. If the four holes do not line up, rotate the battery pack 180° and reinsert.
- j. Slide the portable antenna back into the stowed position.
- k. Place transmitter into its mounting bracket and fasten the strap latch.
- l. Connect the antenna coaxial cable to the ELT and ensure that the contact separator is inserted between the antenna contact finger and the portable antenna. (Refer to Figure 12-1.)
- m. Press RESET button and set ON/OFF/ARM switch to ARM.
- n. Make an entry in the aircraft logbook, including the new battery expiration date.
- o. A unit operational check may now be performed on the ELT. (Refer to Testing Emergency Locator Transmitter.)

**NOTE**

Inspect the external whip antenna for any damage. Avoid bending the whip. Any sharply bent or kinked whip should be replaced. Antenna damage may cause structural failure of whip in flight.

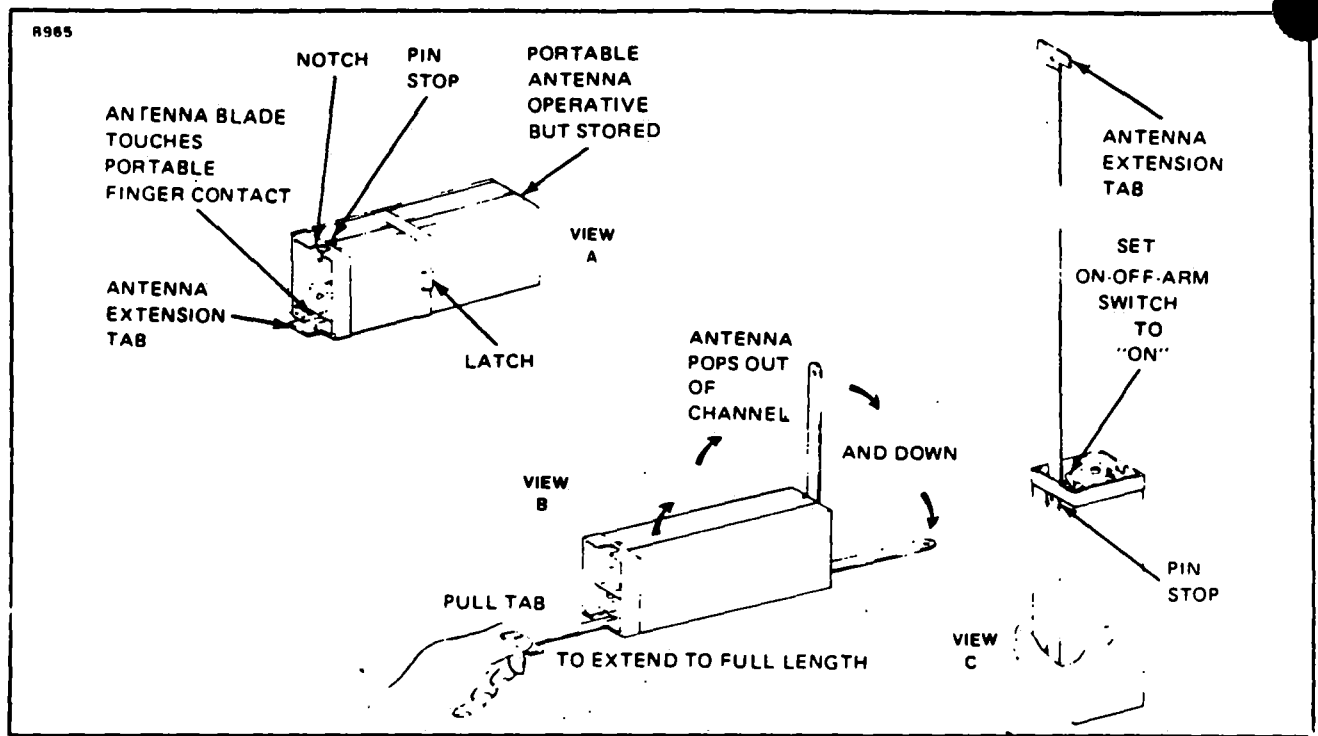


Figure 12-1. ELT Portable Folding Antenna (Narco)

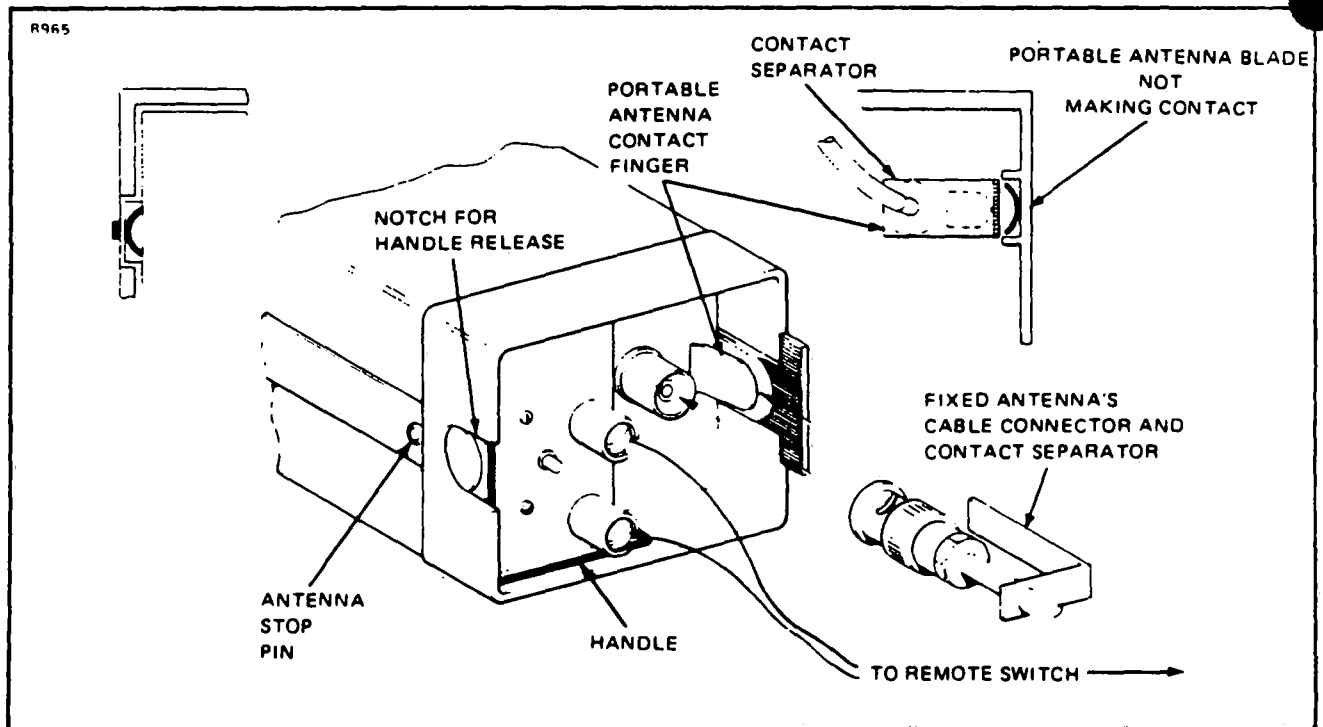


Figure 12-2. ELT Using Fixed Aircraft Antenna (Narco)



## PIPER TWIN COMANCHE SERVICE MANUAL

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### 12-5. AUTOFLIGHT.

12-6. GENERAL. Due to the wide variety of A.F.C.S. (Automated Flight Control System) options, it is mandatory to follow the service literature published by the individual manufacturer of the A.F.C.S. equipment installed in any particular airplane. This includes mechanical service such as; adjusting bridle cable tension, servo removal & installation, servo clutch adjustments, etc.

12-7. NON-PIPER A.F.C.S. EQUIPMENT CONTACTS. Refer to the following list of Autopilot, Flight Director manufacturers to obtain service direction, parts support, and service literature.

Bendix Avionics Division  
2100 N.W. 62nd Street  
Fort Lauderdale, Fla. 33310  
(305) 776-4100/TWX 5109559884

Collins General Aviation Division  
Rockwell International  
Cedar Rapids, Iowa, 52406  
(319) 395-3625 Telex: 464-421

Edo Corporation - Avionics Division  
Box 610  
Municipal Airport  
Mineral Wells, Texas, 76067  
(817) 325-2517 Telex: 76067

King Radio Corporation  
400 North Rodgers Road  
Olathe, Kansas, 66061  
(913) 782-0400 Telex: 4-2299-Kingrad

Sperry Flight Systems/ Avionics Div.  
8500 Balboa Blvd.  
P.O. Box 9028  
VanNuys, CA, 91409  
(213) 894-8111 Telex: 65-1367

Global Navigation  
2144 Michelson Drive  
Irvine, CA. 92715  
(714) 851-0119

12-8. PIPER A.F.C.S. EQUIPMENT. In the case of early models, Piper Autopilot equipment bears the Piper name, and the appropriate Piper Autopilot/Flight Director Service Manual shall be used.

### NOTE

If a Roll Axis-only Autopilot is installed, or if no Autopilot is installed, consult the Piper Pitch Trim Service Manual - 753 771 for manual electric pitch trim service information.

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The following is a complete listing of Piper A.F.C.S. equipment service literature. It is imperative to correctly identify the Autopilot system by "faceplate" model name, in order to consult the appropriate service manual. Each manual identifies the revision level and revision status as called out on the Master Parts Price List - Aerofiche published monthly by Piper. Consult the aircrafts parts catalog for replacement parts.

NAME	PIPER PART NO.
AutoControl I/II & AltiMatic I/II	753 798
AutoControl III and AltiMatic III and IIIB	753 723
AutoControl IIIB and AltiMatic IIIB-I	761 502
AltiMatic IIIC	761 602
AltiMatic V and V-I	761 525
AltiMatic V F/D and V F/D-I	761 526
AltiMatic X F.D./A.P. & X.A.P.	761 668
AutoFlite	753 720
AutoFlite II	761 481
Piper Pitch Trim (Manual-Electric)	757 771

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***TWIN COMANCHE***  
***Service Manual***

CARD 4 OF 4

- PA-30
- PA-39

**PIPER AIRCRAFT CORPORATION**

## AEROFICHE EXPLANATION AND REVISION STATUS

The Service Manual information incorporated in this set of Aerofiche cards has been arranged in accordance with the general specifications of Aerofiche adopted by the General Aircraft Manufacturer's Association, (GAMA). 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.

### Conversion of Aerofiche alpha/numeric code numbers:

First number is the Aerofiche card number.

Letter is the horizontal line reference per card.

Second number is the vertical line reference per card.

Example: 2J16 = Aerofiche card number two of given set, Grid location J16.

To aid in locating the various chapters and related service information desired, the following is provided:

1. A complete manual Table of Contents is for all fiche in this set.
2. A complete list of Illustrations is given and follows the Table of Contents.
3. A complete list of Tables is given for all fiche in this set and follows the list of Illustrations.
4. A complete list of paragraph titles and appropriate Grid location numbers is given at the beginning of each Chapter relating to the information within that Chapter.
5. Identification of Revised Material:

Revised text and illustrations are indicated by a black vertical line along the left-hand margin of the frame, opposite revised, added or deleted material. Revision lines indicate only current revisions with changes and additions to or deletions of existing text and illustrations. Changes in capitalization, spelling, punctuation, indexing, the physical location of the material or complete page additions are not identified by revision lines.

6. Revisions to this Service Manual issued are as follows:

Revisions	Date	Aerofiche Card Effectivity
PR740131	January 31, 1974	—
PR760628	June 28, 1976	1, 2 and 3
PR771006	October 6, 1977	1 and 2
PR780426	April 26, 1978	1, 2 and 3
PR790910	September 10, 1979	1 and 2
PR810406	April 6, 1981	1, 2, 3 and 4
PR821028	October 28, 1982	1, 2, 3 and 4

The date on Aerofiche cards should not be earlier than the date noted for the respective card effectivity. Consult the latest card in this series for current Aerofiche card effectivity.

# **WARNING**

**The information contained in this manual is periodically revised. Piper Aircraft Corporation urges all users of this manual to keep it current. Contact your nearest Piper Aircraft Corporation distributor to arrange for a subscription to future revisions.**

## **NOTE**

**Revision service is available in aerofiche format only.**

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## SECTION XIII

### HEATING AND VENTILATING SYSTEM

13-1. INTRODUCTION. This section contains instructions for operation, maintenance, overhaul and adjustments of the different heating and ventilating systems found in the PA-30 Twin Comanche. 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. The flow of air for heating and defrosting the Twin Comanche is taken through an inlet located in the nose and regulated by controls located in the lower right side of the instrument panel.

Heated air for the cabin and windshield defrosting is provided by a South Wind (Serial Nos. 30-1 to 30-401 inclusive) or Janitrol (Serial Nos. 30-402 and up) heater installed in the right side of the nose section and is accessible by removing the nose access cowl.

The heater uses gasoline from the fuel injector on the right engine. Therefore, anytime the right fuel selector is off the heater is inoperative. In case of right engine failure, the heater can be operated by leaving the fuel selector on and operating the auxiliary pump. The mixture control must be closed. Before the heater is operated under these conditions, it must be determined that no fuel leaks are present between the tank and engine.

Ventilating air for the cabin interior is obtained from two individual sources. The two ventilators located at each side of the instrument panel obtain air from the inlet in the fuselage nose. Air for the two overhead vent outlets is obtained from a scoop mounted on the dorsal fin. Each individual vent is adjustable for the desired airflow. Located in the aft section of the cabin is an exhaust vent to improve the circulation of air in the cabin interior.

13-2a. TROUBLESHOOTING. Troubles peculiar to the South Wind heater are listed in Table XIII-I, along with their probable causes and suggested remedies. Troubles peculiar to the Janitrol heater are listed in Table XIII-II at the back of this section.

HEATING AND VENTILATING

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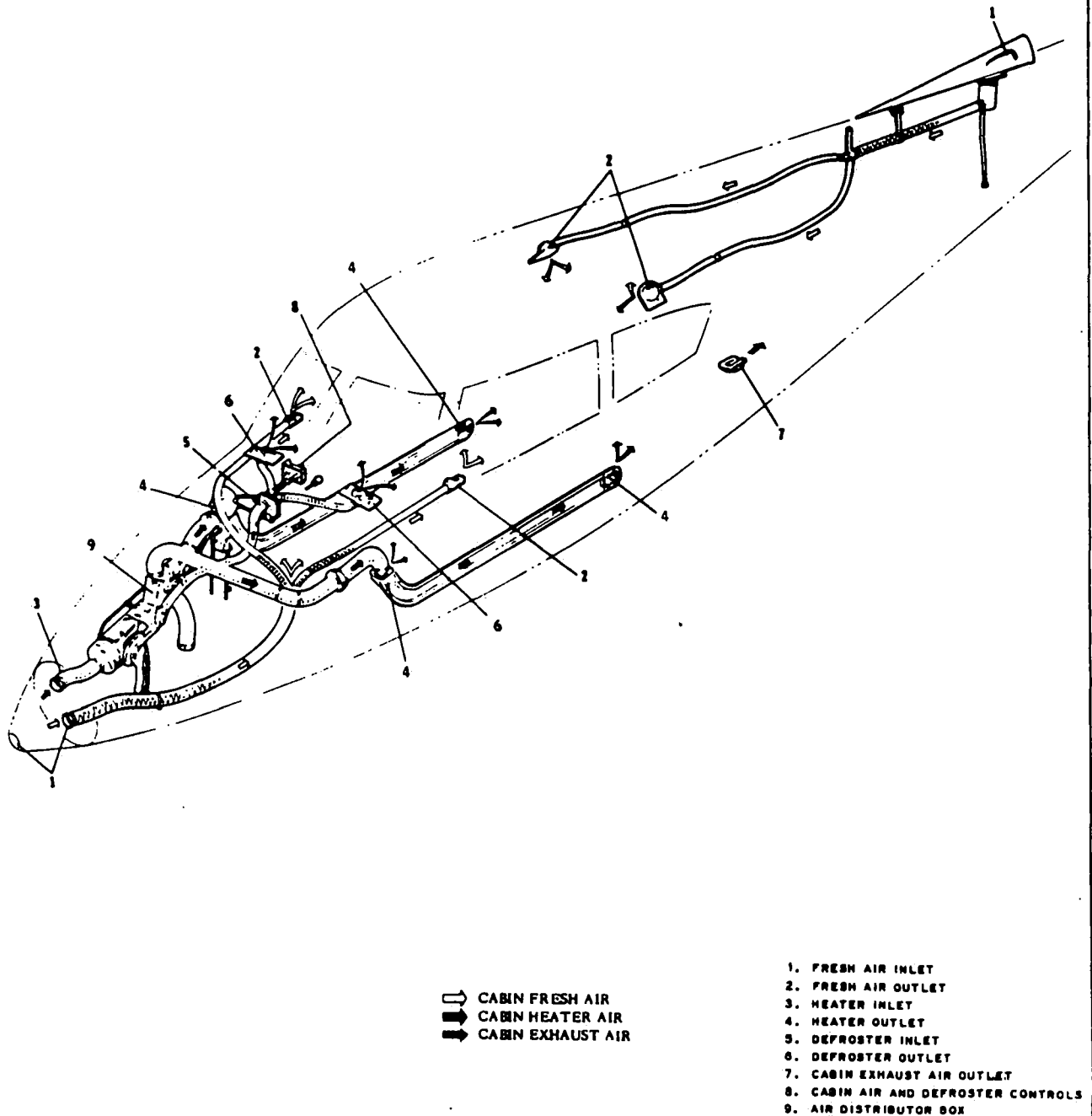


Figure 13-1. Heating and Ventilating System  
Serial Nos. 30-1 to 30-401 incl.

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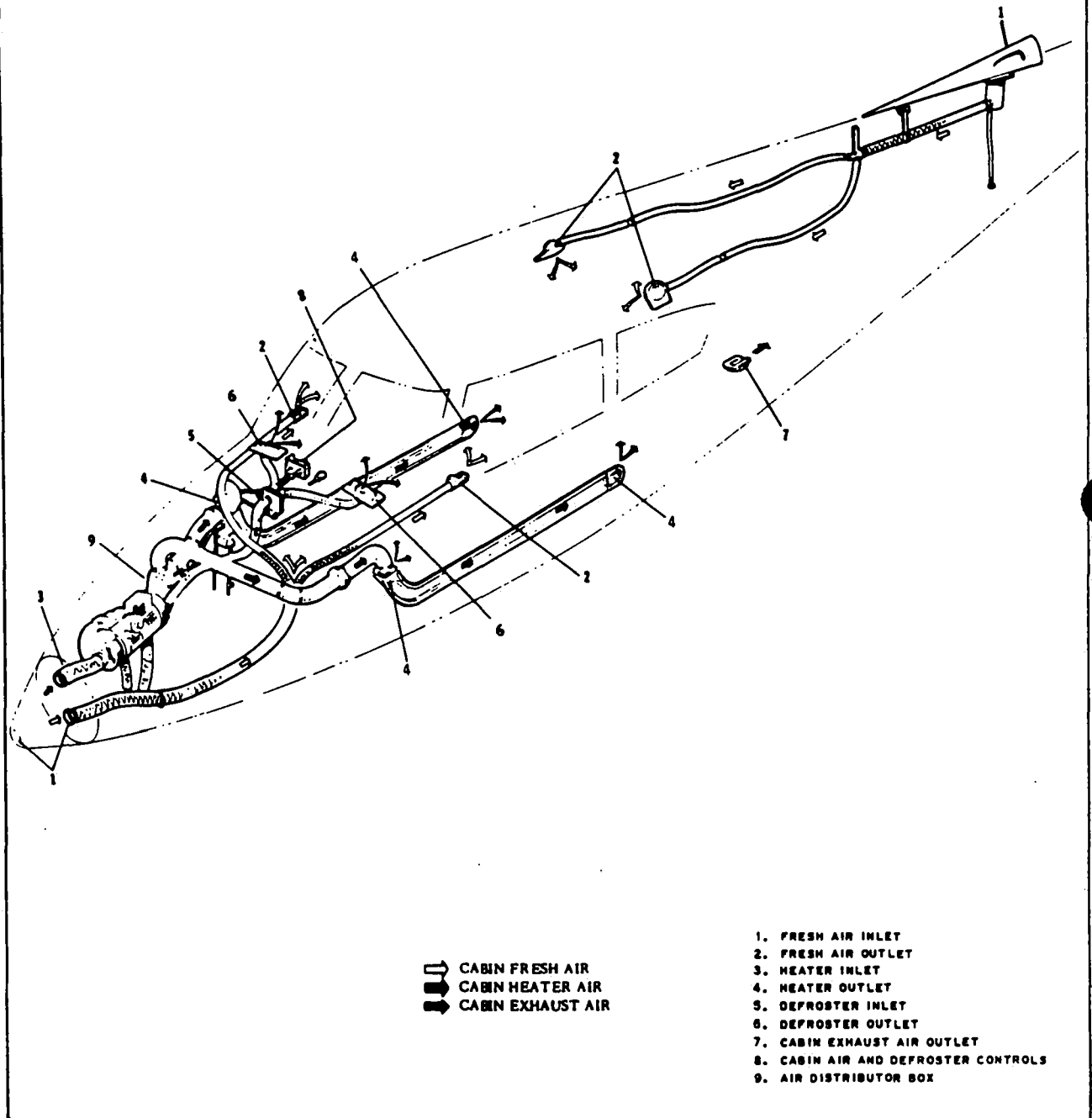


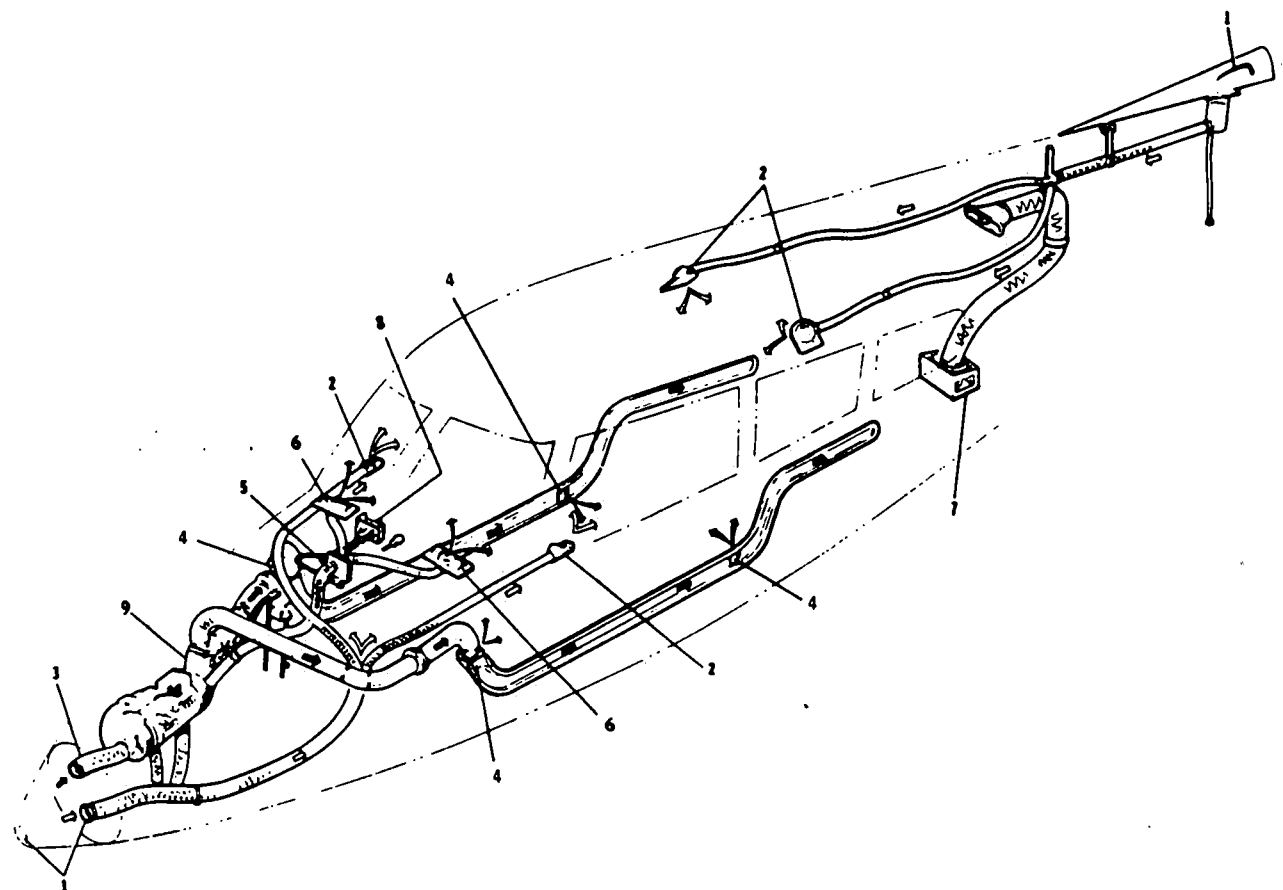
Figure 13-2. Heating and Ventilating System  
 Serial Nos. 30-402 to 30-852, 30-854 to 30-901 incl.

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HEATING AND VENTILATING

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 CABIN FRESH AIR  
 CABIN HEATER AIR  
 CABIN EXHAUST AIR

1. FRESH AIR INLET
2. FRESH AIR OUTLET
3. HEATER INLET
4. HEATER OUTLET
5. DEFROSTER INLET
6. DEFROSTER OUTLET
7. CABIN EXHAUST AIR OUTLET
8. CABIN AIR AND DEFROSTER CONTROLS
9. AIR DISTRIBUTOR BOX

Figure 13-3. Heating and Ventilating System  
Serial Nos. 30-853, 30-902 and up

13-3. HEATER OPERATION (SOUTH WIND). Operation of the South Wind heater is controlled by an Off-Prime-Low-High heat switch which is located on the lower right instrument panel. The ventilating fan motor operates and provides air flow through the heater system whenever the heater switch is in the low or high heat position. In flight, additional air is supplied by ram air pressure through the nose inlet. This arrangement assures an adequate flow of air through the heater at all times.

To turn the heater on, first ascertain that the heater fuel valve (located on heater control panel) is full on, then move the heater 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 1 to 1-1/2 minutes of warm-up.

Use of the high heat position on the ground may result in excessive exhaust smoke from the heater; therefore, high heat should only be used in flight and the low heat position be used for heating the cabin during ground operation.

To heat the cabin - (1) turn the heater switch to high or low heat as desired, (2) adjust the air flow control as required to heat the rear seat, (3) control the heat to the front seats with the adjustable air outlet located below the right and left corners of the instrument panel. There is a dump valve arrangement in the heater bonnet to exhaust excessive heat; thereby, making it possible to operate the heater with all controls in the closed position.

After the heater switch is turned to the "OFF" position combustion in the heater stops, both the combustion fan and the circulating air fan continues 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 South Wind 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.

13-4. HEATER OPERATION (JANITROL). Operation of the Janitrol heater is controlled by a three position switch, labeled "FAN", "OFF" and "HEAT". The "FAN" position will operate the vent blower only and may be used for cabin ventilation on the ground or windshield defogging when heat is not desired.

For heat, the manual heater fuel valve must be on and the three position switch turned to "HEAT". This will start fuel flow and ignite the burner simultaneously. With instant starting and no need for priming, heat should be felt within a few seconds.

Regulation of heat, airflow and defroster operation is controlled by levers on the heater control console. The top lever is connected to an adjustable thermostat which makes it possible to select a temperature of heated air through a

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wide range. Since the air temperature is controllable, it is unnecessary to have an overboard dump for excess hot air.

Cabin temperature and air circulation can be maintained by using various combinations of lever settings, to suit individual desires. To minimize the feeling of drafts, a low air flow-high heat combination may be used.

Windshield defrosting may be regulated by various settings of the defroster lever and in severe windshield fogging or icing conditions, it may be desirable to restrict the heater air, since this will drive more air through the defrosters.

It is desirable when the heater has been operating with the airplane on the ground, to turn the switch to "FAN" for several minutes to cool the heater and then turn it to the "OFF" position.

**13-5. HEATER SAFETY LIMIT SWITCH.** Located in the South Wind and Janitrol heaters is a heat limit switch, which acts as a safety device to render the heater system inoperative if a malfunction should occur causing excessively high temperatures. This control is located in the downstream end of the vent jacket, with the reset button on the heater shroud. It is reached only through the nose section to insure that the malfunction causing the overheat condition is corrected prior to future heater operation.

**13-6. 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 affected components and wipe clean with a slightly oily cloth.

**13-7. SOUTH WIND HEATER.**

**13-8. REMOVAL OF HEATER. (Refer to Figure 13-4.)**

- a. Turn the heater control switches off.
- b. Remove the nose access panel from the airplane.
- c. As desired, remove the distribution box (8) from the aft end of the heater by removing the box attachment screws and sliding the box off the heater or removing the cabin heat hoses (6) & (7), defroster hose (11) and hot air dump hose (12) from the air distribution box by releasing the hose clamps.
- d. If the air distribution box was not removed from the heater, disconnect the heat control cable (10) from the left side of the air box.
- e. Note the hook-up of the electrical wires to facilitate reinstallation and disconnect the leads from the terminal block (23).
- f. Disconnect the fuel line (2) by removing the cover of the fuel control valve (3) to gain access to the fuel fitting.
- g. Disconnect the ventilating air inlet hose (18) from the forward end of the heater by releasing the attachment clamp.
- h. Slide the fuel valve drain tube (15) up from bottom panel of the nose section.
- i. Disconnect the cabin air control cable (10) where it is supported at the combustion air blower.

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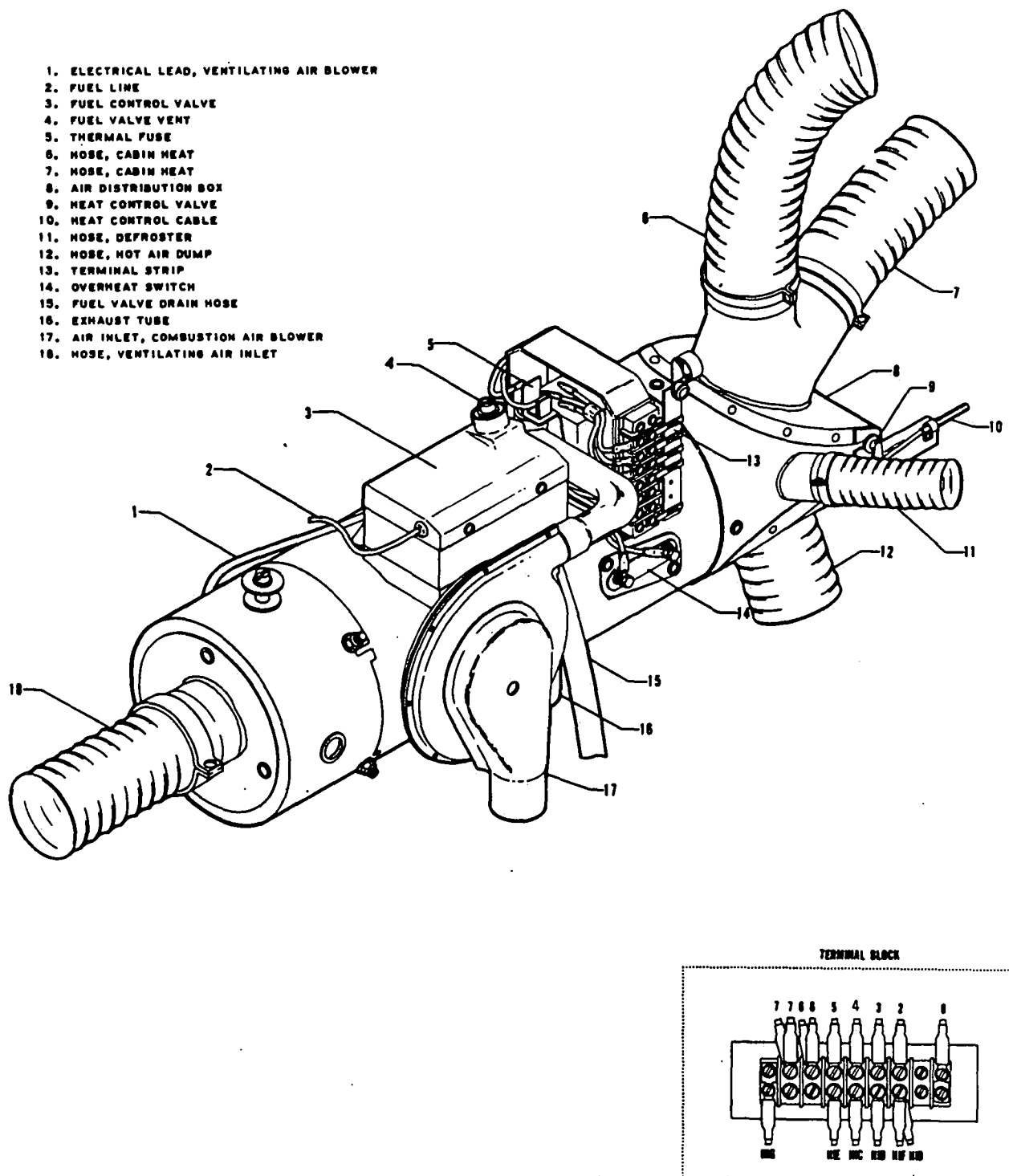


Figure 13-4. Heater Installation (South Wind)  
 Serial Nos. 30-1 to 30-401 incl.

- j. Disconnect the combustion air inlet hose from the combustion air blower air inlet (17) by removing nut, washer and screw at the upper end of the tube.
- k. Loosen the clamps from around the heater.
- l. Lift the heater and remove it from the airplane.

**13-9. INSTALLATION OF HEATER. (Refer to Figure 13-4.)**

- a. Position the heater on its mounting brackets. Extend the exhaust tube (16) through and the lower end of the shroud, over the fitting that is attached to the bottom panel of the nose section.
- b. Connect the combustion air inlet hose to the combustion air blower (17) and secure with screw, washer and nut.
- c. Attach the cabin air control cable to the combustion air blower.
- d. Insert the fuel valve drain hose through the hole in the bottom panel of the nose section. Ascertain that the tube is protected at the panel by a grommet.
- e. Connect the ventilating air inlet hose (18) to the forward end of the heater and secure with clamp.
- f. Connect the fuel line (2) to the fuel control valve (3) and then replace valve cover.
- g. If the air distribution box (8) was not installed during heater build-up before installation, install the box and secure with screws.
- h. If the air heat control cable (10) was disconnected from the air distribution box (8), connect the cable at the valve arm and on the box. Position the cable wire and shroud to allow the valve full travel in the box. Ascertain that the wire attachment assembly rotates freely on the valve arm.
- i. Also if disconnected, connect the cabin heat hoses (6) & (7), defroster cable (11) and hot air dump hose (12) on the air distribution box and secure with clamps.
- j. Connect the electrical leads to the terminal block of the heater as shown in Figure 13-4.
- k. Check operation of the heater.
- l. Install the nose section access panel.

**13-10. PRINCIPLES OF OPERATION.** The South Wind Heater produces heat by burning a mixture of gasoline and air in a sealed, all-welded, stainless steel heat exchanger. (Refer to Figure 13-5.) Air for combustion is obtained from a blower on the side of the heater housing and 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 13-6.) 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 13-5.) 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 lowest temperatures.

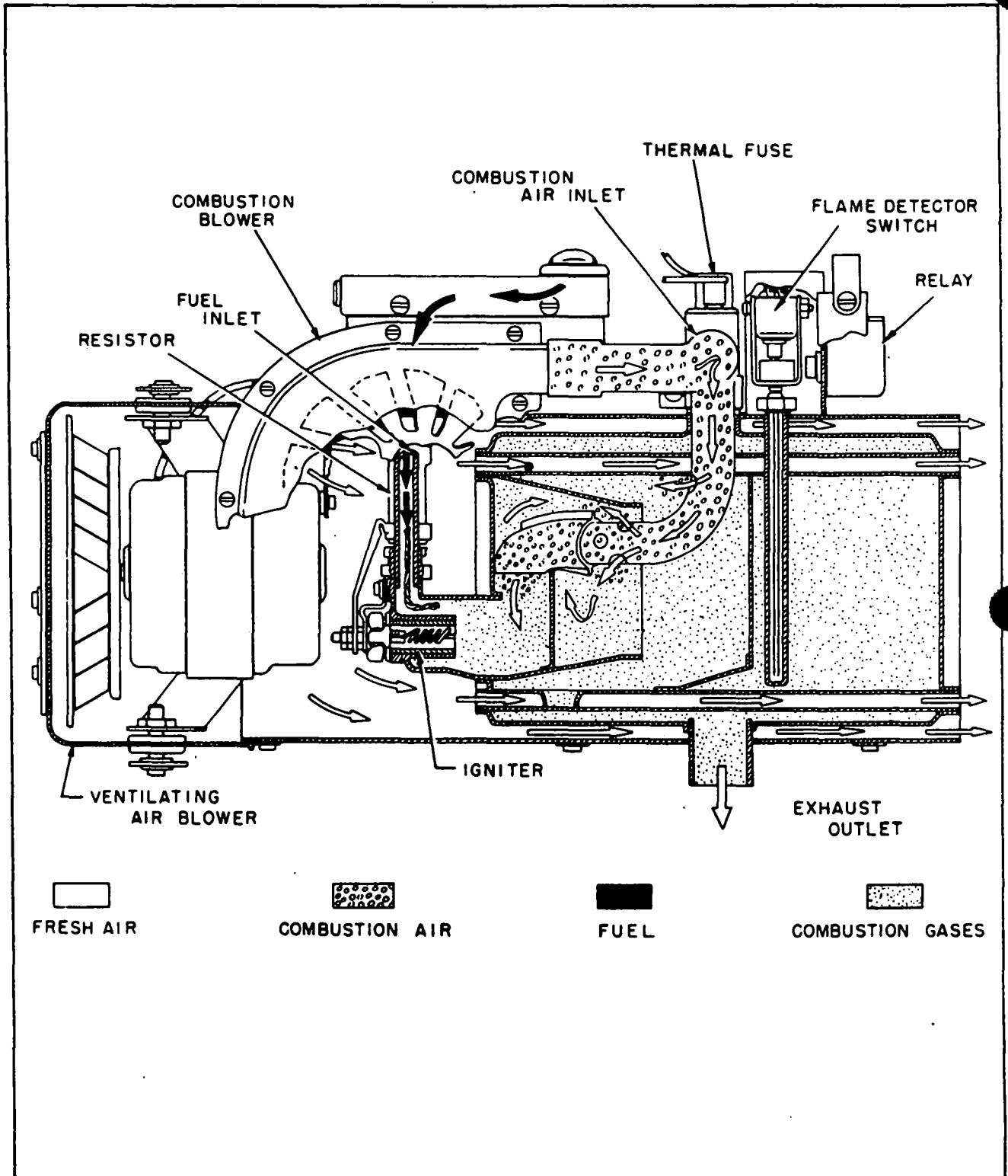


Figure 13-5. Flow System (South Wind Heater)



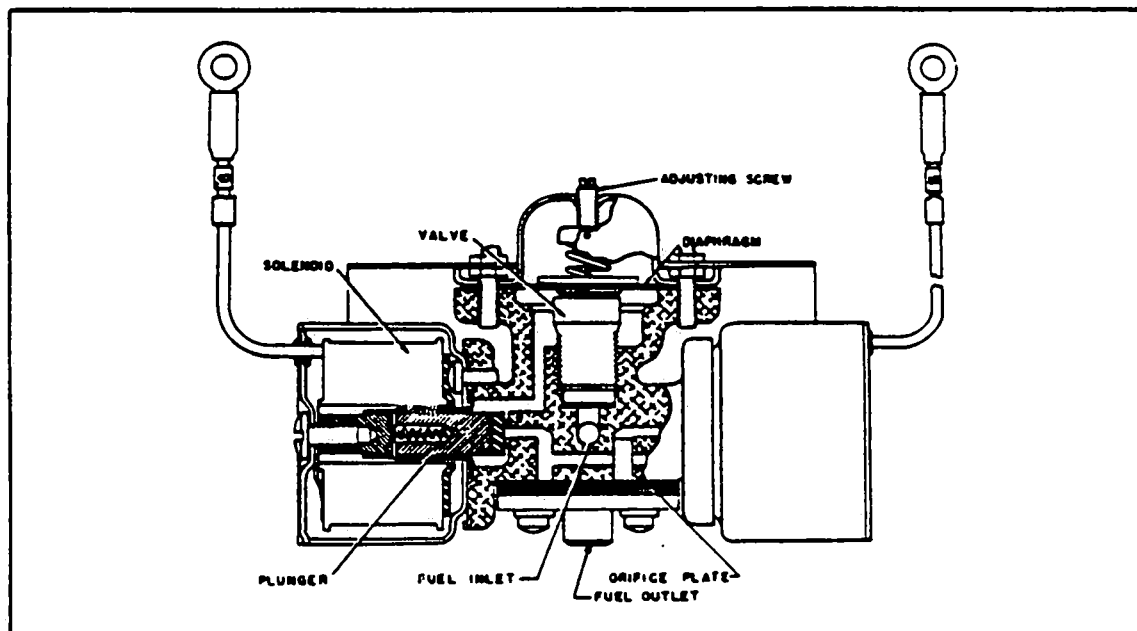


Figure 13-6. Fuel Control Valve (Cutaway View)

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 13-7.) which also turns on the ventilating air blower at this time. Since the standpipe is not heated by combustion in the heat exchanger, preheating is no longer required and the preheater is also turned off.

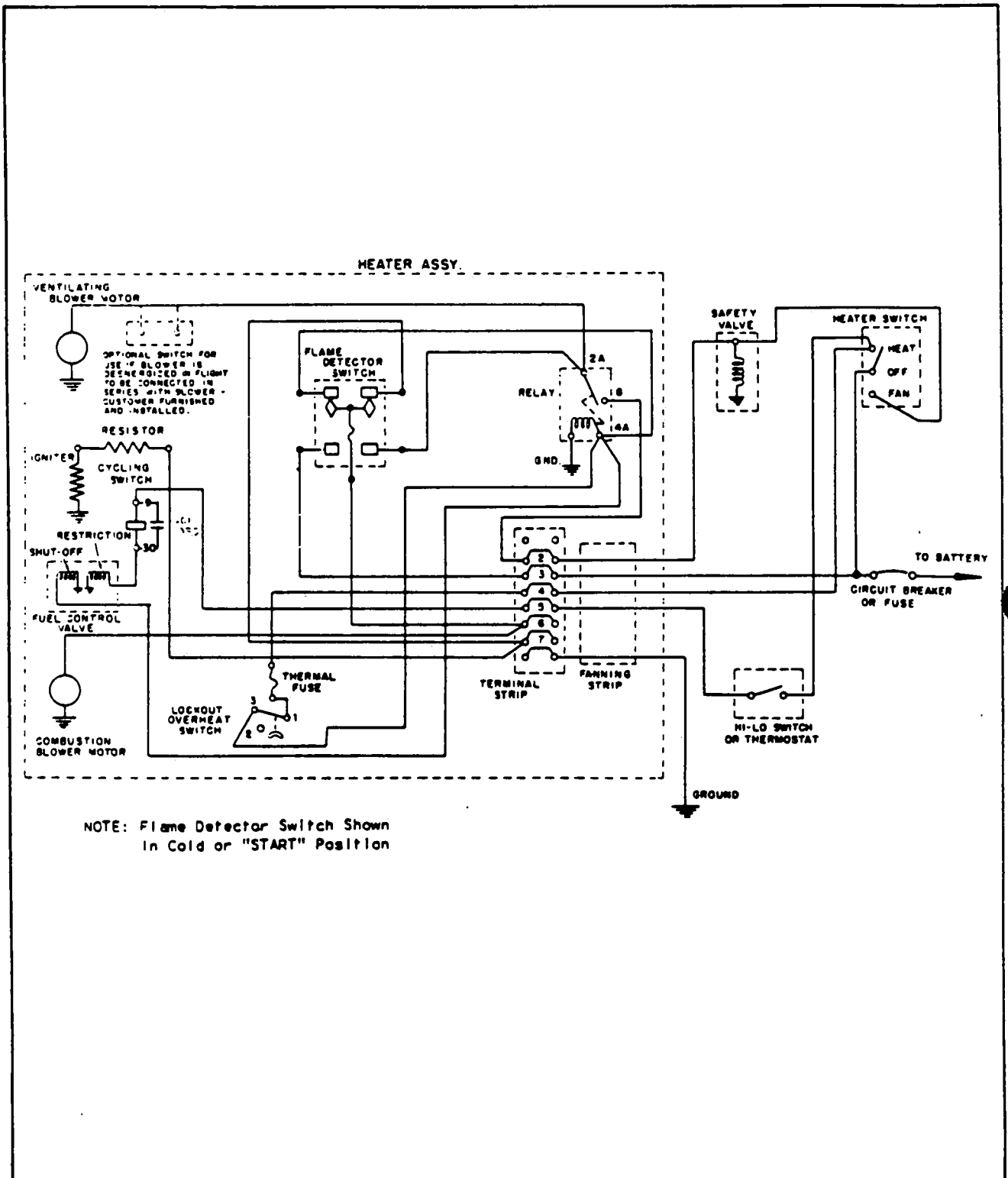


Figure 13-7. Wiring Diagram for South Wind Heater, Model 940-DC12

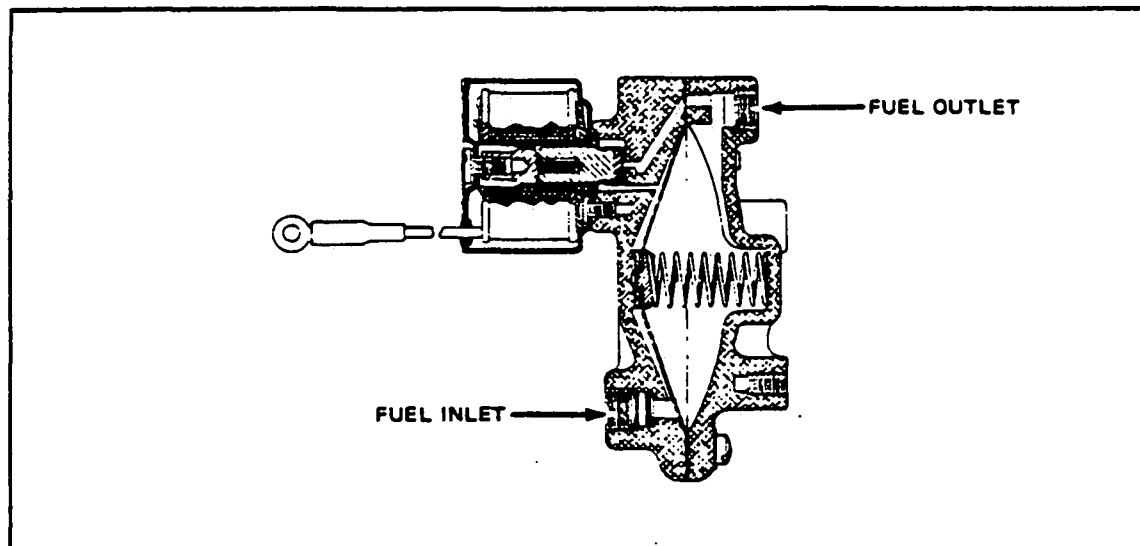


Figure 13-8. Fuel Safety Valve (Cutaway View)

**13-11. SAFETY VALVE.** The safety valve (Refer to Figure 13-8,) which is supplied with the 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.

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.

13-12. LOCKOUT OVERHEAT SWITCH. Federal Regulations for light aircraft require heaters to be equipped with a lockout-type overheat switch which will shut off ignition and shut off fuel at two points, in the event of an overheat condition. The heater is equipped with a snap-action type overheat switch with a manual reset button. This switch is connected in series with the thermal fuse so that functioning of either device will cause a complete shut down of the heater. In this event, the fuel control valve solenoid and the safety valve solenoid will both close at the same time. Both of these devices also shut off the igniter.

13-13. THERMAL FUSE. The thermal fuse 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 aircraft heaters be equipped with a device which will prevent operation at any time that combustion air flow is insufficient for safe operation. 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.

13-14. CYCLING SWITCH. The cycling temperature limit switch is set at a lower temperature. Its purpose is to prevent unnecessary operation of the lockout overheat switch by limiting heater outlet temperature.

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13-15. 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.

13-16. FUEL SYSTEM. The fuel system consists of the safety valve (which was described under Safety Features), the heater fuel control valve, and the standpipe. The heater is designed to operate with a fuel pressure between 20 and 35 psi. Less than 20 pounds may not be sufficient to operate the safety valve diaphragm, and more than 35 pounds may damage the pressure regulator in the heater fuel control valve.

13-17. FUEL CONTROL VALVE. The fuel control valve (Refer to Figure 13-6,) 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 13-5.)

13-18. 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 13-5.) 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.

13-19. 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.

**13-20. 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.

**13-21. 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 13-9.) 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.

**13-22. IGNITER.** The igniter is an electric "glow plug" type of heating element which glows red hot when energized. (Refer to Figure 13-5.) To prolong the life of the igniter, it is shut off by the flame detector switch as soon as combustion starts.

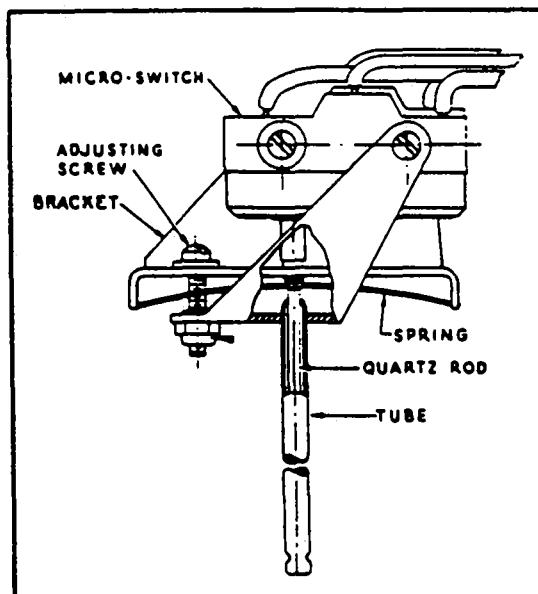


Figure 13-9. Flame Detector Switch (Cutaway View)

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13-23. CYCLE OF OPERATION. When the heater switch is turned on, several things occur simultaneously. (Refer to Figure 13-7.)

a. The shut-off solenoid is energized through terminal No. 4 of the terminal strip, the overheat switch, and through the thermal fuse. 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.

13-24. 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. 3 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 in a suitable position in the cabin.

13-25. 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	20 to 35 psi
Heat Output	
High Heat	27,500 BTU/HR
Low Heat	15,000 BTU/HR
Overheat Switch Operating Temperature	350° F
Cycling Switch Operating Temperature	220° F



13-26. SERVICE.

13-27. 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 begin with Paragraph 13-43. The assemblies need not be removed in the order shown since each unit is designed for separate replacement.

13-28. PERIODIC SERVICE.

- a. A complete overhaul of the heater is recommended at 1,000 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 connections and condition of insulation.

13-29. 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 13-9.) 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.

13-30. TROUBLESHOOTING. The 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. (Refer to TABLE XIII-L)

13-31. EXTERNAL CAUSES OF TROUBLE.

13-32. ELECTRICAL 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 12 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.

13-33. FUEL SUPPLY. The heaters require a supply of fuel under pressure of at least 20 pounds 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 for proper metering of fuel through the orifice plate. If fuel pressure at the control valve inlet is less than 20 pounds, 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 20 and 35 pounds will provide satisfactory operation.

13-34. 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 of 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 a high fuel rate.)

NOTE

The heaters require ram air at the combustion air inlet, and the symptoms noted above will always appear if this heater is substituted for one of the other models without making ram air provision. These symptoms will also appear if these heaters, even when properly installed, are operated for an extended period on the ground.

13-35. 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.

c. In extreme cases where air flow is drastically reduced, or completely shut off, the lockout overheat switch may operate, shutting the heater completely off.

**13-36. 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. 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 is 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 check 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 Paragraph 13-37, c, since the blower circuit will not be in question.

**13-37. STARTING CIRCUIT CHECK.**

a. Check voltage at terminal No. 4 of the terminal strip, with a test light or voltmeter, then check progressively at both sides of the thermal fuse, at terminal 4A of the relay, and at terminal No. 6 of the terminal strip. Loss of voltage at the thermal fuse indicates a defective fuse; at terminal No. 4A a defective lockout overheat switch; at terminal No. 6, a defective flame detector switch.

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b. If there is voltage at terminal No. 6 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.

c. 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.

d. 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. 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 and the valve must be replaced.

13-38. 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.

13-39. 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 Paragraph 13-29, 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 the 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.

13-40. 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.

13-41. 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, Paragraph 13-31. 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.

13-42. TROUBLESHOOTING CHART. The Troubleshooting Chart, Table XIII-I, is a brief summary of the defects and remedies discussed in this Section. This chart may be used as a guide when servicing a heater which fails to perform properly when installed and can be found following Paragraph 13-79.

13-43. DISASSEMBLY, REPAIR AND REASSEMBLY. An overhaul of the 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 sub-assemblies without disturbing other parts.

The instructions in the following paragraphs cover all models of the 940 Series heaters. Figure 13-10 is a composite exploded parts view, showing all

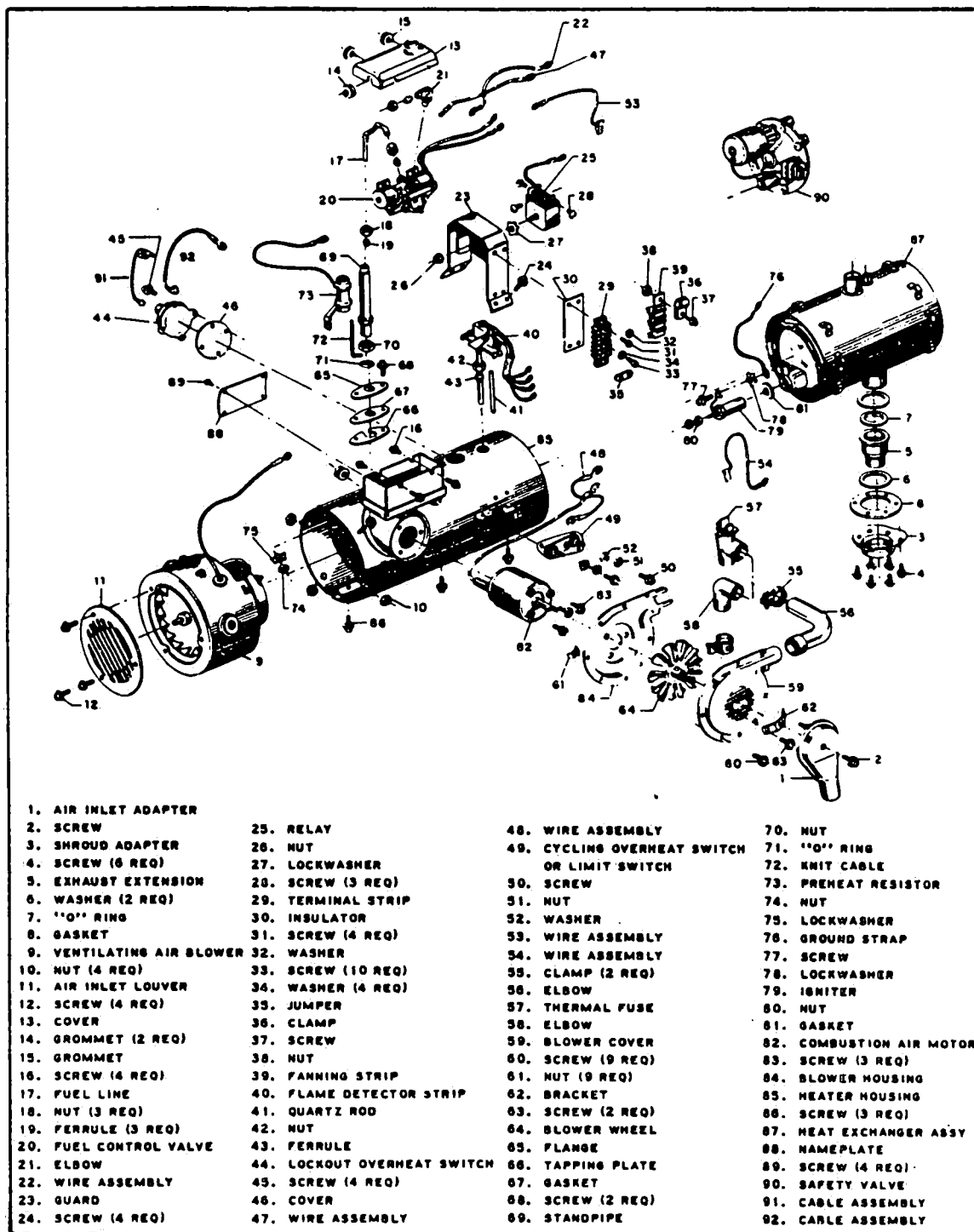


Figure 13-10. Exploded Parts View, Heater Assembly

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.

**13-44. DISASSEMBLY. (Refer to Figure 13-10.)**

- a. Remove the combustion air inlet adapter (1) by removing the sheet-metal screw (2) in its center (Refer to Figure 13-10.)
- 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.

**13-45. VENTILATING AIR BLOWER.**

- 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).



13-46. FUEL CONTROL VALVE.

- 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.
- c. 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.

13-47. FLAME DETECTOR SWITCH.

- a. Disconnect leads of the flame detector switch (40) from the terminal strip, or from terminal strip and relay, according to heater model.
- b. 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.

13-48. LOCKOUT OVERHEAT SWITCH.

- 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).
- b. On older model heaters, the leads (91 and 92) are attached to the switch.

13-49. CYCLING OVERHEAT SWITCH. Remove the cycling overheat switch (49) by removing the two attaching screws (50). Also remove the capacitor (93).

13-50. COMBUSTION AIR BLOWER.

a. Loosen the clamp (55) which attaches the combustion air elbow (56) and thermal fuse (57). 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.

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.

13-51. STANDPIPE AND PREHEAT RESISTOR.

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 (79) 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.

13-52. IGNITER.

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).

13-53. COMBUSTION AIR MOTOR.

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 standpipe, 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.

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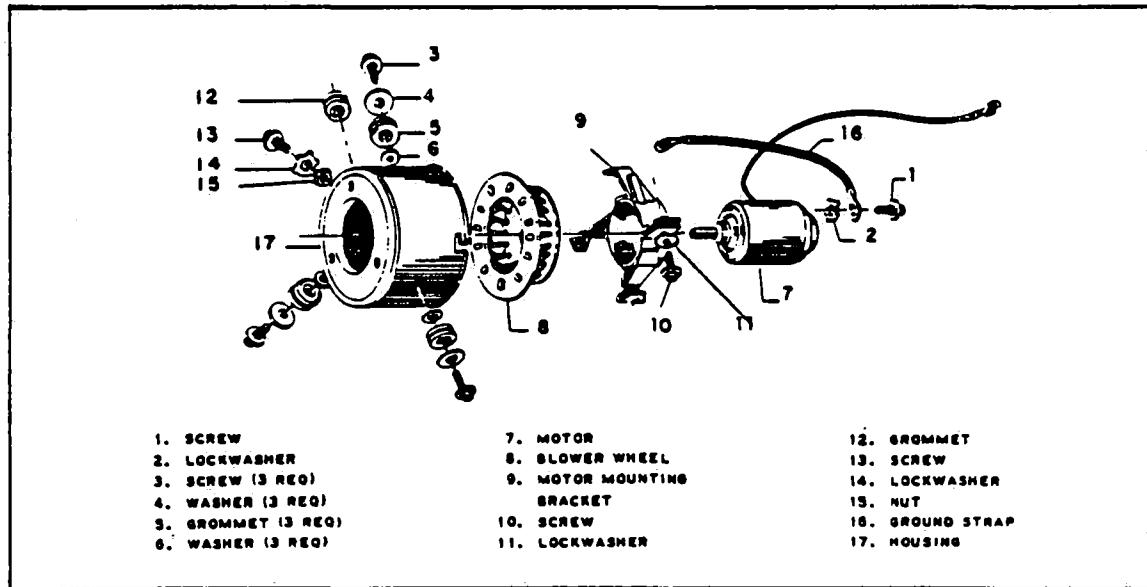


Figure 13-11. Ventilating Air Blower Assembly

13-54. HEAT EXCHANGER. 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.

13-55. VENTILATING AIR BLOWER. (Refer to Figure 13-11.)

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 position of the mounting bracket (9) on the motor (7) and remove the bracket by loosening screw (10).

e. Remove the screw, lockwasher, and nut (13, 14 and 15) from the blower housing to free the ground strap (16), then remove the grommet (12) from the housing.

13-56. INSPECTION, CLEANING AND REPAIR.

13-57. 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".

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.

13-58. FUEL CONTROL VALVE. Replace valve if found defective.

13-59. 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

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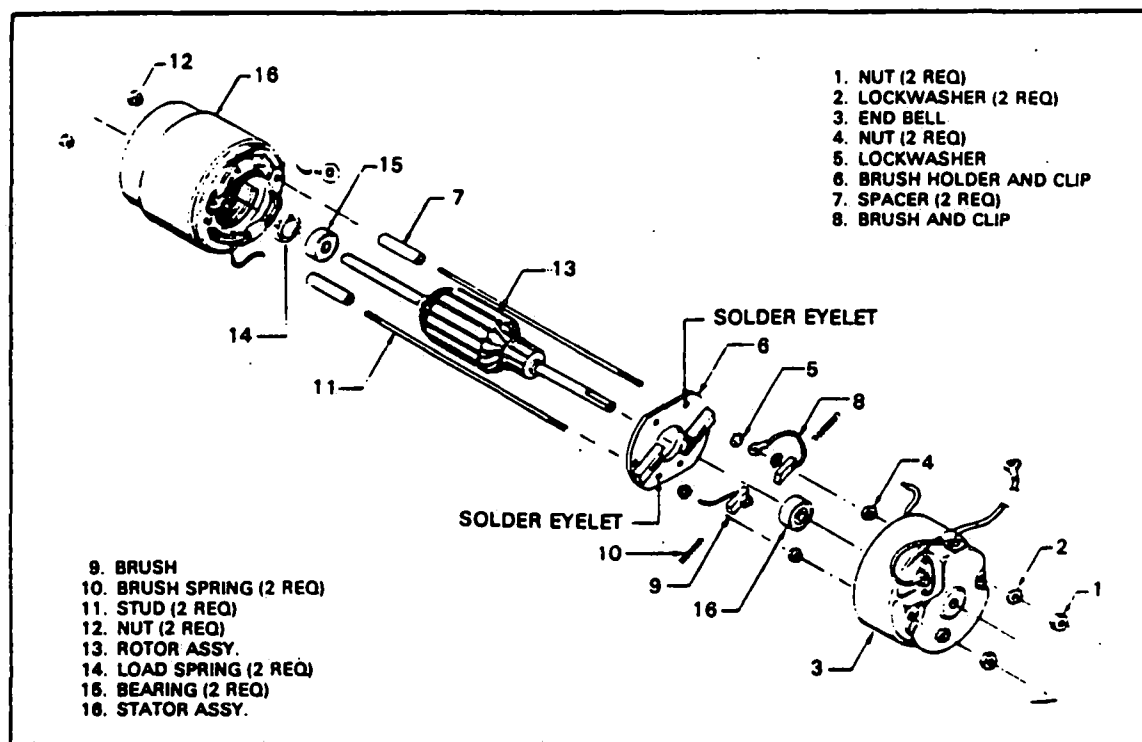


Figure 13-12. Ventilating Air Blower Motor

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.

**13-60. VENTILATING AIR BLOWER MOTOR OVERHAUL.** An overhaul kit, PAC Part No. 754 306, is available for the ventilating air blower motors. This kit contains new bearings, brushes, and other parts required for installation. To overhaul the motor, proceed as follows: (Refer to Figure 13-12.)

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.

#### 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.

13-61. COMBUSTION AIR BLOWER MOTOR OVERHAUL. An overhaul kit, PAC Part No. 754 307, is available for overhaul of the combustion air blower motor. To overhaul motor, proceed as follows. (Refer to Figure 13-13.)

- 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 screwdriver 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.

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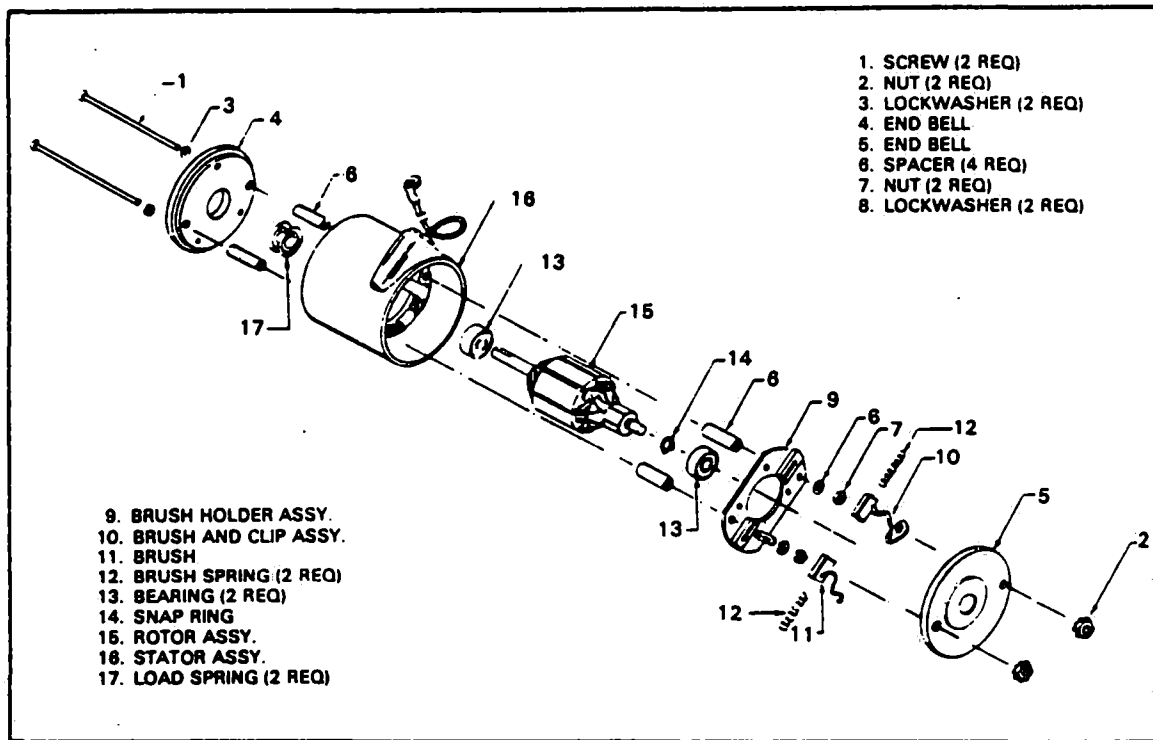


Figure 13-13. Combustion Air Blower Motor

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 re-installed in the heater. More extensive repairs than those described should not be attempted.

13-62. HEATER HOUSING.

- a. Clean inside and out with dry cleaning solvent, and inspect housing for roundness and dents. Straighten or reshape as necessary.
- b. Replace all rubber grommets in the housing.

13-63. 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 microswitch 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 microswitch 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 microswitch mounting nuts to lock switch securely in place.

13-64. OVERHEAT SWITCH AND CYCLING SWITCH. Visually inspect the 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.

13-65. LOCKOUT OVERHEAT SWITCH.

- a. Connect wires to the two connector wires of the lockout overheat switch, and suspend this assembly in an oven with an accurate thermometer. Provide a test light or meter to indicate opening of the switch contacts. Press the reset button of the switch.
- b. Slowly raise the oven temperature until the switch contacts open. Note temperature in the oven at the moment of switch operation. The switch must open at a temperature of 205 to 245° F. If not within limits, install a new switch. This unit is not adjustable.

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**13-66. 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 attaching screws and condition of 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.

**13-67. 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.

**13-68. 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.

**13-69. 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.

**13-70. REASSEMBLY.**

**13-71. VENTILATING AIR BLOWER. (Refer to Figure 13-11.)**

- 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 overtighten screws (3), since this will defeat the purpose of the shock-mounting grommets.

d. Reconnect the ground wire (16) to the end of the motor by re-installing the screw (1) and lockwasher (2).

**13-72. HEATER ASSEMBLY.** (Refer to Figure 13-10.) 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. Place the preheat resistor (73) around the standpipe, and install the nut (80) to attach the preheat conductor to the igniter terminal.

f. 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.

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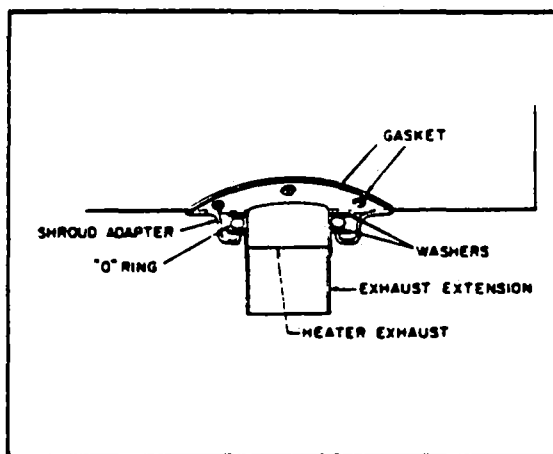


Figure 13-14. Detail of Exhaust Extensions Installation

h. Fit the large combustion air elbow (56) and 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), by reinstalling the four screws (45).

j. Reinstall the flame detector switch (29) 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 (29) and insulator (30) on the flame detector switch guard (23) by reinstalling the four screws (31). Also, reinstall the relay (25) 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, and connect leads of all electrical 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.

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.

### 13-73. TESTING.

13-74. 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 "lead 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 13-56 prior to reassembly.

13-75. 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 20 to 35 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 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.

13-76. 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.

13-77. 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 (Refer to Figure 13-10, Ref. 17.) in the fuel control valve outlet, in its normal position. Support the valve in its normal mounting position 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.

13-78. LOCKOUT OVERHEAT SWITCH. The test for the lockout overheat switch is described in Paragraph 13-64. This test is normally performed during overhaul, before the switch is installed, but the switch may be removed and tested at anytime its operation is in doubt.

13-79. 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 minutes twenty seconds (time from instant the switch is turned off).

TABLE XIII-I. TROUBLESHOOTING CHART (SOUTH WIND HEATER)

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.
Blower runs when switch is in HEAT position but heater will not ignite.	Defective overheat switch.	Replace switch.
	No fuel pressure.	Check fuel supply.
	Defective igniter.	Replace igniter.
	Defective fuel control valve.	Replace valve.
	Defective cycling overheat switch.	Replace switch.
Heater ignites but ventilating air blower will not start.	Defective preheat resistor.	Replace resistor.
	Broken quartz rod.	Replace rod.
Heater ignites but ventilating air blower will not start.	Defective or improperly adjusted flame detector switch.	Replace or reset switch.

TABLE XIII-I. TROUBLESHOOTING CHART (SOUTH WIND HEATER) (cont.)

Trouble	Cause	Remedy
Heater starts and runs, but goes out later.	Restricted ventilating air flow.	Remove restriction.
	Defective cycling over-heat 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.
	HIGH-LOW switch on LOW.	Turn to HIGH.
	Thermostat out of calibration.	Replace thermostat.
	Cycling switch out of calibration.	Replace switch.



TABLE XIII-I. TROUBLESHOOTING CHART (SOUTH WIND HEATER) (cont.)

Trouble	Cause	Remedy
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.

13-80. JANITROL HEATER. The following contains information for operation, service and overhaul of the combustion heater, Part No. 751 959, and combustion air blower, Part No. 753 905 (used with the heater). Refer to Figure 13-15.

13-81. REMOVAL OF HEATER. (Refer to Figure 13-15.)

- a. Turn the heater control switches off.
- b. Remove the nose section access panel from the airplane.
- c. Disconnect the heat outlet hoses (1) and the defroster hose (2) from the heater air distribution box (3) by releasing the hose attachment clamps.
- d. Disconnect the air outlet control cable (4) and the heat control cable (5) from the left side of the air distribution box.
- e. Note the hook-up of the electrical wires to facilitate reinstallation, and disconnect leads from the heater terminal block.
- f. Disconnect the fuel drain (6) from the bottom of the heater and allow it to slide down.
- g. Disconnect the fuel supply line (10) by first releasing the clamps that secure the sleeve (16) of the fuel supply line shroud (9). Slide the sleeve and shroud up and disconnect the fuel line. Slide the drain tube (11) up from the hole in the bottom panel of the nose section.
- h. Disconnect the air inlet hose (12) from the forward end of the heater by releasing the hose attachment clamps.
- i. Disconnect the combustion air blower inlet hose (13) from the tube attached to the bottom panel of the nose section by removing the attachment nut, washer and screw.
- j. Loosen the clamps (14) from around the heater.
- k. Lift the heater and remove it from the airplane.
- l. With the heater removed, remove the necessary components as required. The exhaust tube (8) may be removed by first loosening the exhaust shroud clamp and sliding the shroud (7) off the heater flange. The exhaust tube may then be removed by loosening its attachment clamp.

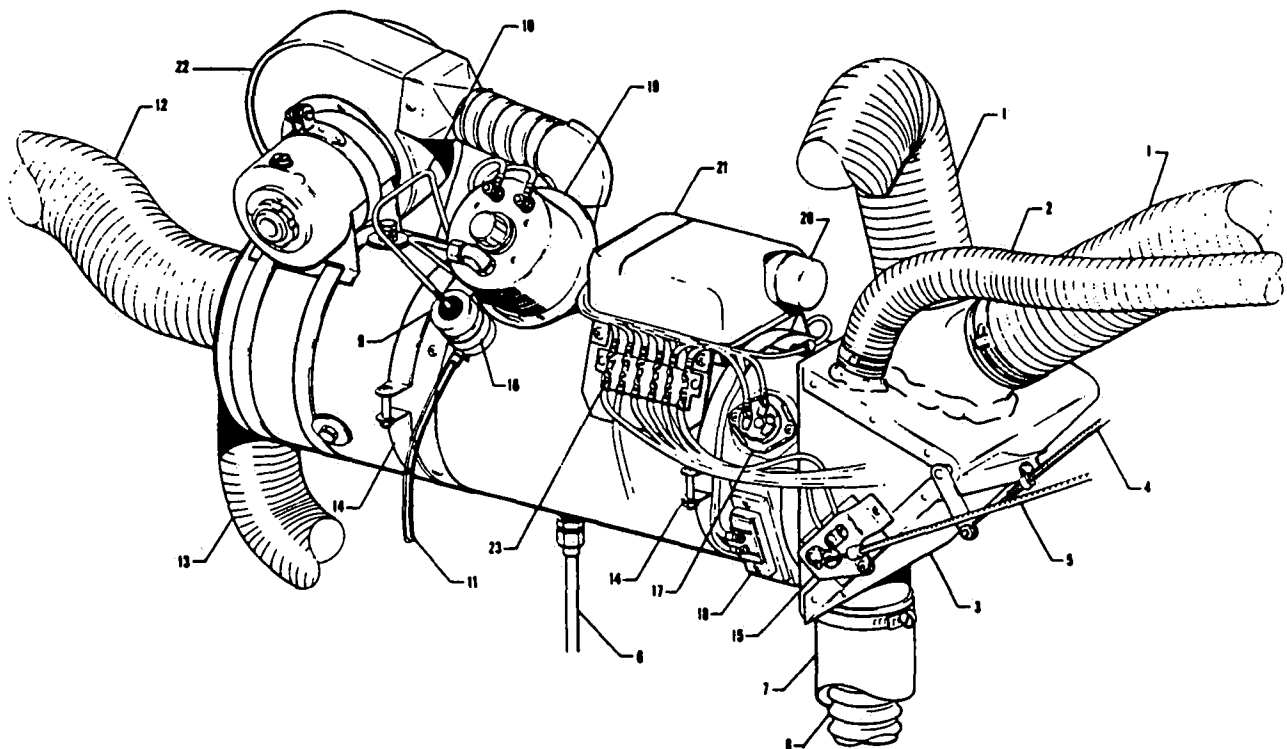
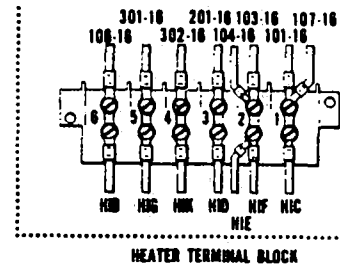
13-82. INSTALLATION OF HEATER. (Refer to Figure 13-15.)

- a. Assemble the heater components on the heater. Do not tighten the exhaust tube shroud clamp thus allowing the exhaust tube shroud (7) free to rotate.
- b. Position the heater on its mounting brackets. Extend the exhaust tube (8) through the lower end of the exhaust shroud (7) over the fitting that is attached to the bottom panel of the nose section.
- c. Slide the heater fore or aft to obtain best fit of the exhaust tube shroud (7) and then tighten the shroud clamp. Place the heater clamps (14) around the heater and bracket flanges and tighten.

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- |                             |                               |
|-----------------------------|-------------------------------|
| 1. HEAT OUTLET HOSES        | 12. AIR INLET HOSE            |
| 2. DEFROSTER HOSE           | 13. COMBUSTION AIR INLET HOSE |
| 3. AIR DISTRIBUTION BOX     | 14. HEATER CLAMPS             |
| 4. AIR OUTLET CONTROL CABLE | 15. HEATER CONTROL SWITCH     |
| 5. HEAT CONTROL CABLE       | 16. SLEEVE                    |
| 6. FUEL DRAIN               | 17. LIMIT SWITCH              |
| 7. EXHAUST SHROUD           | 18. CYCLING SWITCH            |
| 8. EXHAUST TUBE             | 19. PRESSURE SWITCH           |
| 9. FUEL SUPPLY LINE SHROUD  | 20. IGNITION VIBRATOR         |
| 10. FUEL SUPPLY LINE        | 21. IGNITION ASSEMBLY         |
| 11. FUEL DRAIN TUBE         | 22. COMBUSTION AIR BLOWER     |
|                             | 23. TERMINAL BLOCK            |

Figure 13-15. Airplane Heater Assembly and Combustion Air Blower

- d. Connect the combustion air blower inlet hose (13) to the tube attached to the bottom panel of the nose section and secure with screw, washer and nut.
- e. Connect the fuel drain (6) to the bottom of the heater.
- f. Connect the air inlet tube (12) to the forward end of the heater and secure with clamp.
- g. Connect the fuel supply line (10) to the heater. Slide the shroud sleeve (16) and shroud (9) into place and secure with clamps.
- h. Attach the air outlet control cable (4) to the air distribution box (3) of the heater and secure. Position the cable wire and shroud to allow the valve full travel in the distribution box. Also, ascertain that the wire rotates freely on the valve arm.
- i. Attach the heat control cable (5) to the heat control switch (15). Ascertain that the cable is attached to allow full travel of the control arm. (Refer to Paragraph 13-106, c, for additional adjustments.
- j. Connect the electrical leads to the terminal block of the heater as shown in Figures 13-15 and 13-19.
- k. Connect the heat outlet hoses (1) and the defroster hose (2) to the air distribution box and secure with clamps.
- l. Check operation of the heater.
- m. Install the nose section access panel.

### 13-83. DESCRIPTION OF HEATER AND BASIC COMPONENTS.

13-84. SPARK-SPRAY IGNITION. (Refer to Figure 13-16.) The controlled atomized spray from a specially designed spray nozzle, coupled with high voltage spark plug ignition, insures instant firing and continuous burning under all flight conditions.

Heat is produced by burning a fuel-air mixture in the combustion chamber of the heater. Aviation gasoline is injected into the combustion chamber through the spray nozzle. The resulting cone-shaped fuel spray mixes with combustion air and is ignited by a spark from the spark plug. Electric current for ignition is supplied by an ignition unit which converts 12 volts to high-voltage oscillating current to provide a continuous spark across the spark plug gap. A shielded, high-voltage lead connects the ignition assembly to the spark plug. Combustion air enters the combustion chamber tangent to its surface and imparts a whirling or spinning action to the air. This produces a whirling flame that is stable and sustains combustion under the most adverse conditions because it is whirled around itself many times. Therefore, ignition is continuous and the combustion process is self-piloting. The burning gases travel the length of the combustion tube, flow around the inside of the inner tube, pass through cross-over passages

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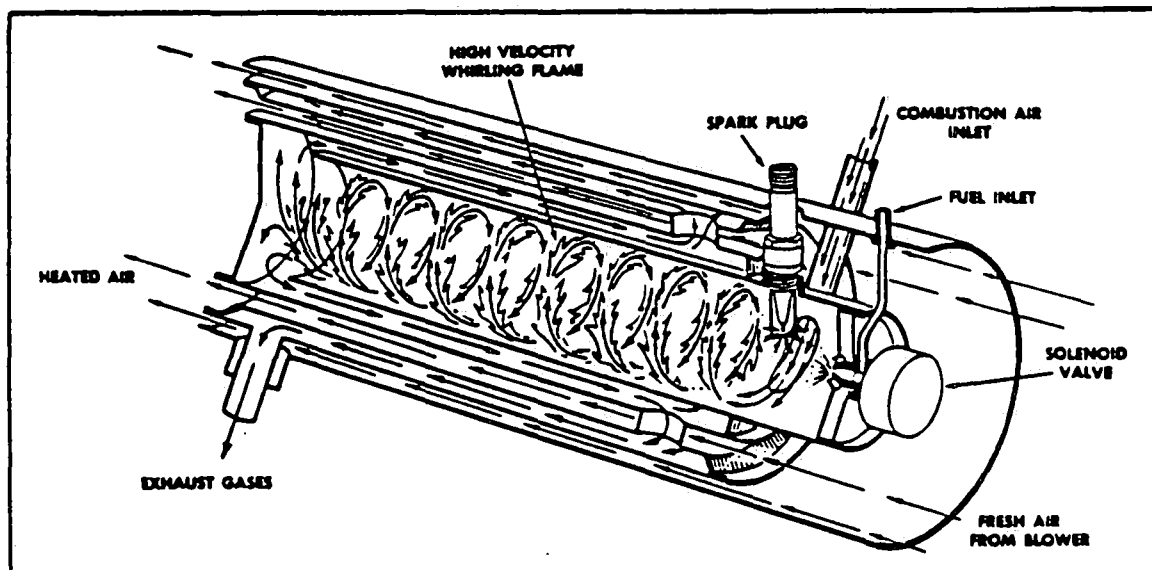


Figure 13-16. Diagrammatic Cutaway of Heater to Show Whirling Flame Action

into an outer radiating area, then travel the length of this surface and out the exhaust.

Ventilating air passes through the heater between the jacket and combustion tube assembly outer surface and through an inner passage in the assembly. Consequently, ventilating air comes into contact with two or more heated cylindrical surfaces.

#### 13-85. FUEL REGULATOR AND SHUTOFF VALVE. (Refer to Figure 13-17.)

This unit provides preset, regulated fuel pressure as well as remote shutoff to the heater, regardless of fuel inlet pressure variations. It is adjustable from 1 to 12 psi, depending upon installation requirements, with inlet pressures up to 50 psi. The shutoff valve is operated by a solenoid.

13-86. DUCT SWITCH. (Refer to Figure 13-18.) This switch is installed in the ventilating air duct downstream from the heater to sense the ventilating air outlet temperature. To select the desired cabin temperature, the switch may be adjusted manually from a high of  $225^{\circ}\text{F} \pm 10^{\circ}$  downward through a range of  $146^{\circ}\text{F} \pm 6^{\circ}$ . The switch has a differential of  $10^{\circ}\text{F} \pm 5^{\circ}$  at any given setting. On airplanes with serial numbers 30-1717, 30-1745 and up or when kit number 760 249 has been installed, a micro override switch has been added to a 250 degree duct switch to override the duct switch at the last portion of its travel to the high heat position cancelling the duct stat control only at the maximum heat position.

13-87. COMBUSTION AIR BLOWER. This centrifugal-type blower supplies combustion air to the combustion chamber of the heater. Performance of the combustion air blower is assisted by the use of ram air during flight.

13-88. VENTILATING AIR BLOWER. This blower is attached to the inlet end of the heater assembly and provides a source of ventilating air through the heater. Ram air from the ventilating air intake scoop is used during flight.

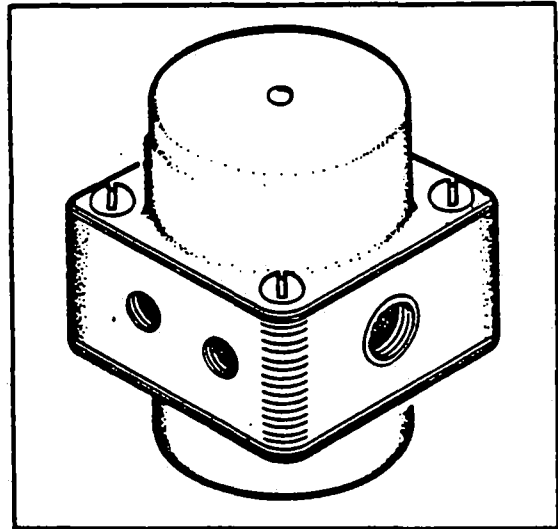


Figure 13-17. Fuel Regulator and Shutoff Valve

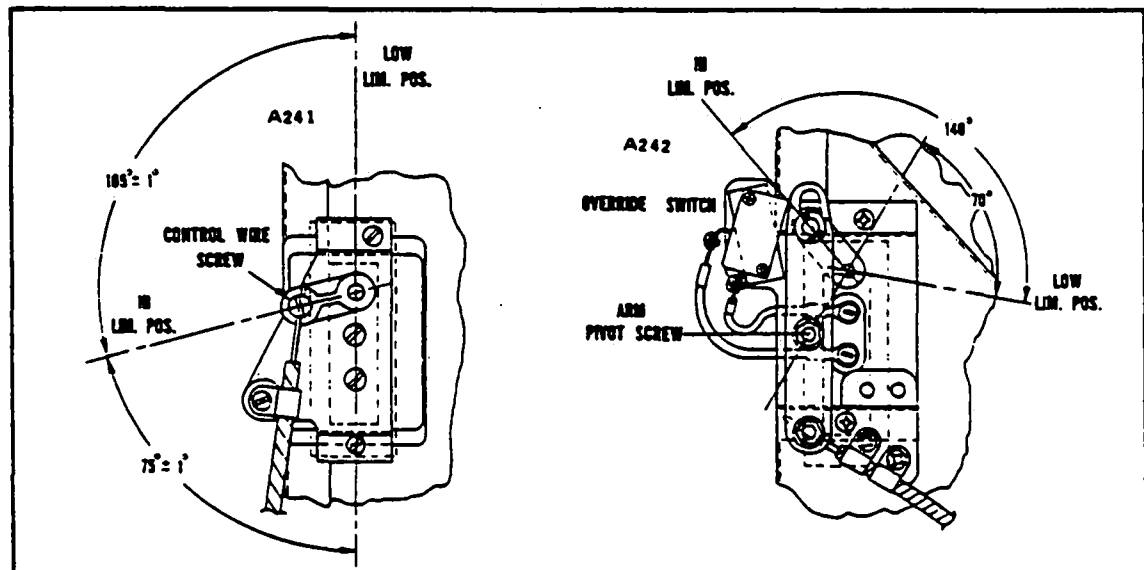


Figure 13-18. Top View - Duct Switch

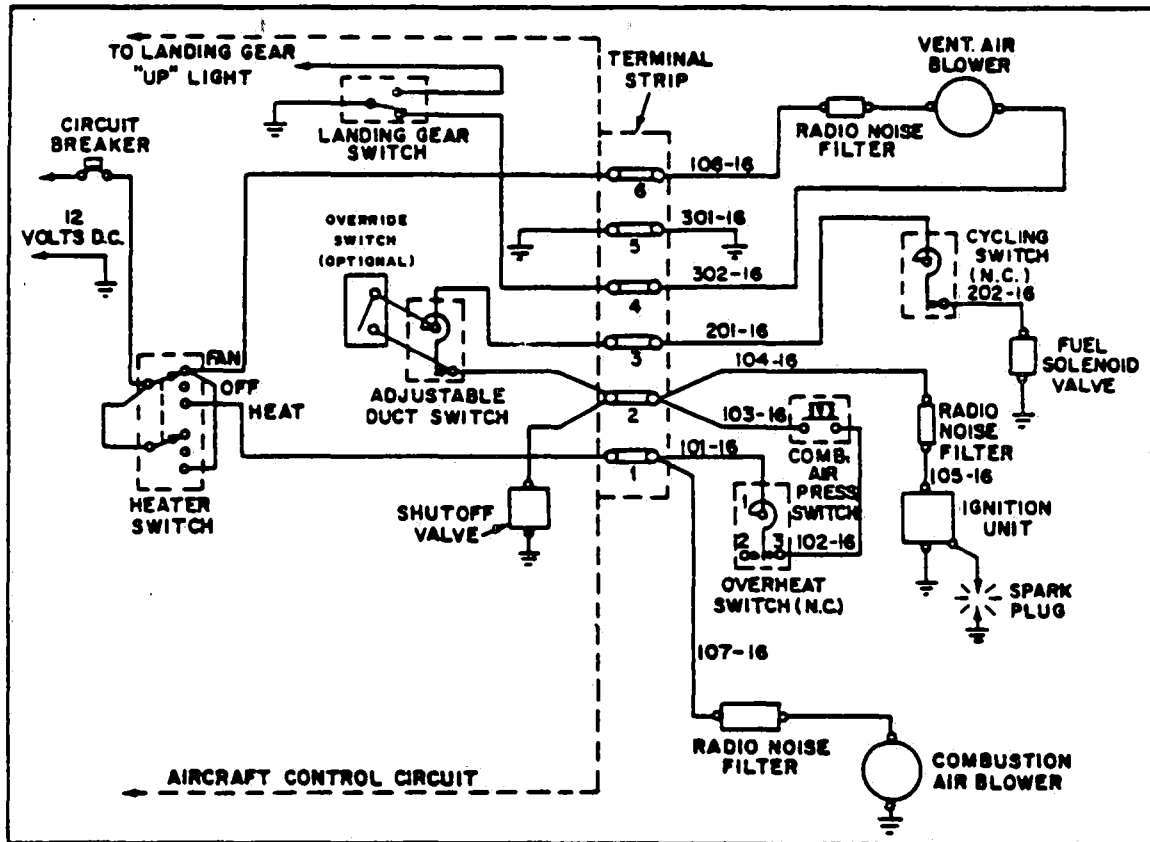


Figure 13-19. Wiring Diagram

13-89. OPERATING CONTROLS. (Refer to Figure 13-19.)

NOTE

The schematic diagram (Figure 13-19) shows the heater circuit, including the electrical wiring in the airplane.

- a. The HEATER SWITCH is connected in the line that supplies electrical power to all heater equipment and controls. When this switch is in the OFF position, the entire heater system is inoperative. This switch has a FAN position which permits use of the ventilating air blower to circulate cool air through the system for summer ground operation. With the switch in FAN position, the heater is inoperative and only the ventilating air blower is energized.

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b. The HEATER SWITCH is a normally open switch that supplies power to lock-in the safety relay through which power is supplied to the ignition and fuel circuits of the heater.

13-90. OPERATING PROCEDURE. (Refer to Figure 13-19.)

- a. Place the HEATER SWITCH in the ON (or HEAT) position. The ventilating air and combustion air blowers should operate.
- b. The heater will ignite and continue to operate.
- c. The DUCT SWITCH can be set to regulate the cabin temperature for desired comfort level. If this switch is set for ground operating comfort, it may be necessary to reposition it after being airborne, since ram air will increase the ventilating air flow and the heater output.
- d. To stop heater operation, turn off the HEATER SWITCH.
- e. It is desirable to operate the fan several minutes to cool the heater after operation. To stop fan operation, turn OFF the HEATER SWITCH.

13-91. MAINTENANCE SERVICE. Instructions contained in this section consist of periodic inspection, adjustments, and minor corrections required at normal designated intervals for the purpose of maintaining the heating system in peak operating condition. These inspections assume that a heating system includes accessory components mentioned in preceding paragraphs.

13-92. 50-HOUR INSPECTION.

- a. Inspect the ventilating air inlet scoop, combustion air inlet scoop, exhaust outlet and fuel drain for possible obstructions. Make sure that all of these openings are clear of any restrictions and that no damage has occurred to air scoop protrusions.
- b. Perform an operational check as follows:
  1. Place the HEATER SWITCH in the ON (or HEAT) position. The ventilating air blower and combustion air blower should operate.

NOTE

To proceed with the operational check, follow paragraph 13-90 entitled "Operating Procedure," steps a through e. The above procedure should be repeated one or more times.



**13-93. 100-HOUR INSPECTION.**

- a. Perform 50-Hour Inspection check as described in paragraph 13-92.
- b. Inspect ventilating air and combustion air inlets and exhaust outlet for restrictions and security at the airplane skin line.
- c. Inspect the drain line to make sure it is free of obstructions. Run a wire through it if necessary to clear an obstruction.
- d. Check all fuel lines for security at joints and shrouds, making sure that no evidence of leaks exists. Also check for security of attachment of fuel lines at the various attaching points in the airplane.
- e. Inspect electrical wiring at the heater terminal block and components for loose connections, possible chafing of insulation, and security of attachment points.
- f. Inspect the high-voltage cable connection at the spark plug to make sure it is tight. Also, examine the cable sheath for any possible indications of arcing, which would be evidenced by burning or discoloration of the sheath.
- g. Inspect the combustion air blower assembly for security of mounting and security of connecting tubing and wiring. Tighten any loose electrical terminals and air tube connections.

**13-94. TROUBLESHOOTING.** The service troubles and suggested remedies found in Table XIII-II are provided to assist in locating and correcting malfunctions in the heating system. The following procedure is based upon the use of optional components. This Table may be found following Paragraph 13-120.

**13-95. ELECTRICAL CONTINUITY CHECK.** These tests are listed as an aid in isolating open circuited or inoperative components.

**NOTE**

The schematic wiring diagram (Figures 13-19, 13-20 and 13-21) shows, in addition to the heater circuitry, a suggested aircraft control circuit. For the purposes of this manual, the circuitry shown in these illustrations will be utilized to describe electrical continuity checks.

It must be assumed that power, which is furnished through the heater circuit breaker, is present at the HEATER SWITCH at all times. Always check the circuit breaker before performing electrical continuity checks.

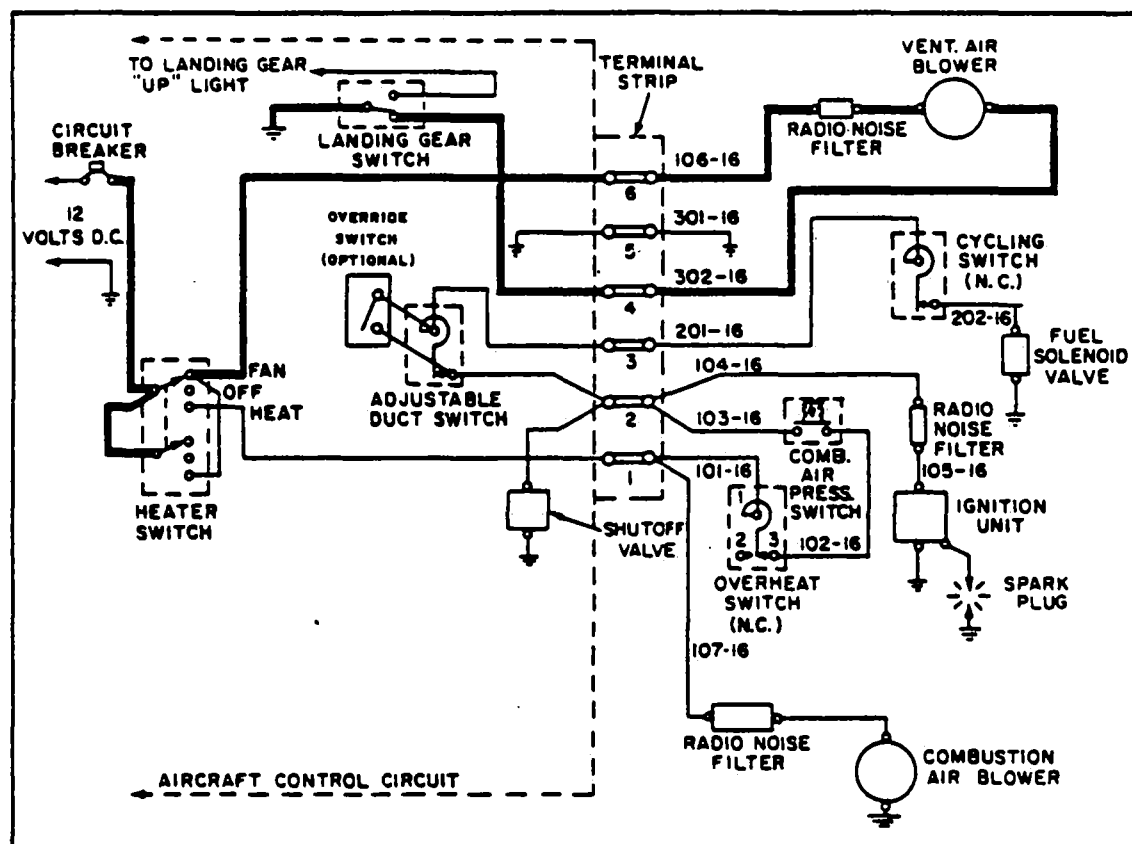


Figure 13-20. Primary Power Circuit

### 13-96. VENT BLOWER POWER CIRCUIT CHECK.

a. With the HEATER SWITCH in the FAN position, electrical continuity (12 volts nominal) should be present at the following locations. (Refer to Figure 13-20.)

1. Terminal No. 6 on the heater terminal strip.
2. From terminal No. 6 of the heater terminal strip through the radio noise filter to the ventilating air motor.
3. Electrical ground circuit for the ventilating air motor is provided from terminal No. 4 of the heater terminal strip through the LANDING GEAR SWITCH when the landing gear is down. Ventilating air motor is inoperative when the landing gear is up.

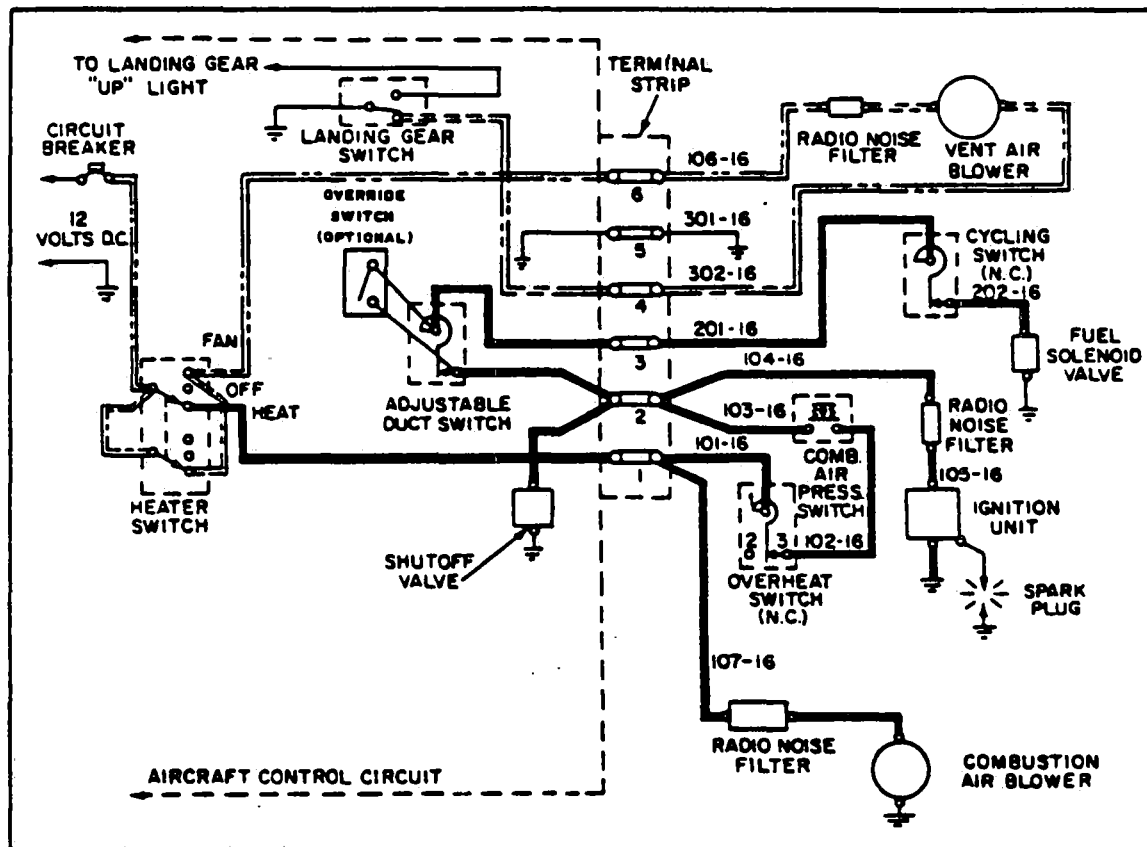


Figure 13-21. Starting Power Circuit

#### 13-97. HEATER POWER CIRCUIT CHECK.

- a. With the HEATER SWITCH in the HEAT position, electrical continuity should be present at the following locations. (Refer to Figure 13-21.)

#### NOTE

Power for the ventilating air blower is the same as described above except that power is now supplied through the HEAT side of the HEATER SWITCH.

1. Terminal No. 1 of the heater terminal strip.
2. From terminal No. 1 of the heater terminal strip through the radio noise filter to the combustion air motor and to terminal No. 1 of the overheat switch.
3. From terminal No. 3 of the overheat switch through the combustion air pressure switch to terminal No. 2 of the heater terminal strip.

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4. From terminal No. 2 of the heater terminal strip through the radio noise filter to the ignition unit; to the shut off valve and through the adjustable duct switch to terminal No. 3 of the heater terminal strip.

5. From terminal No. 3 of the heater terminal strip through the cycling switch to the fuel solenoid valve.

In the event that electrical continuity is not present at one or more of the above listed points, the wiring must be traced back to the power source. If components are still inoperative after the wiring inspection, check the individual inoperative components for continuity and, if necessary, replace them.

13-98. GENERAL MAINTENANCE. Instructions in this paragraph pertain to maintenance of the basic heater and components while the heater is installed in the airplane. Instructions for removal of components are included provided the installation permits accessibility.

#### NOTE

No special service tools are required for normal periodic maintenance.

#### 13-99. COMBUSTION AIR BLOWER.

##### a. Removal.

1. Disconnect wire at quick-disconnect terminal.
2. Disconnect the inlet tubing from the inlet air adapter.
3. Loosen the clamps that hold the combustion air blower assembly in the support bracket and slide the motor out of the bracket.

##### b. Replacing Motor Brushes. (Refer to Figure 13-26.)

1. Remove the brush cap at one of the brush locations. Note position of brush inside the guide and carefully lift the brush and brush spring out of the guide. Be sure to hold the brush so that it can be reinstalled in precisely the same position if no brush replacement is required.
2. Inspect the brush for wear. A new brush is .531 of an inch long. If brushes are worn to a length of .187 of an inch, they must be replaced.
3. Looking through the brush guide, inspect the commutator, which should be smooth and medium brown to dark brown in color. Remove all dust from commutator with compressed air. If the commutator is grooved in the brush track, gouged, scored or shows signs of having burned spots, replace the complete motor assembly. If the commutator is in good condition, install new motor brushes, and tighten brush caps into place. Make sure each brush is oriented so that the curved end fits the curvature of the commutator.

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4. After installing new brushes, it is advisable to run-in the brushes as follows: Connect the motor to a controlled voltage supply (rheostat in a 12-volt line). Operate the motor at approximately 1/2 its normal speed for the first hour, then gradually increase the speed until it is rotating at approximately normal speed. Continue the run-in operation for at least two hours to properly seat the brushes before installing the blower in the aircraft.

c. Installation.

1. Prior to installing the combustion air blower, inspect all parts of the assembly for loose screws, loose nuts and poor ground connection on the blower housing. Make sure the blower wheel is tight on the shaft and properly located in the housing. It should have just enough clearance to rotate at full speed without binding against the spill plate. Blower performance is based upon this close-tolerance clearance. It is recommended that correct voltage be applied for this clearance check.

2. Install the blower inlet adapter in the same orientation as before removal.

3. Place the combustion air blower assembly in position in the attaching clamp so the air tubing can be connected, and slide the tubing into position at the point where it was disconnected during removal. Do not tighten until after tightening the motor in the attaching strap.

4. Tighten the blower motor mounting strap securely, making certain the air tubing is in proper alignment.

5. Secure the air tubing by tightening the clamp or installing the sheet metal attaching screws.

6. Connect the wire lead at the quick-disconnect terminal. Be sure to slide an insulating sleeve over the connection (or tape it) in order to prevent any possible short circuits. Tie the sleeve in place.

7. Connect the ground lead securely to the mounting bracket.

8. Check motor operation. By disconnecting the wire at the No. 3 terminal on heater terminal strip, blower can be operated without fuel flow to the heater.

13-100. SPARK PLUG.

a. Removal. (Refer to Figure 13-25.)

1. Remove the necessary access panels to expose the spark plug area of the heater assembly.

NOTE

Insure that heater electrical circuits are de-energized.

2. Unscrew and remove the high-voltage lead connector at the spark plug. Exercise care to avoid fouling or damaging the connector.

3. Remove the grommet (23).

4. Using a 7/8 inch deep hex socket, unscrew and remove the spark plug (22). Make sure the spark plug gasket is removed with the spark plug. It will normally stick on the spark plug threads, but if loose, it might drop into the ventilating air passages of the heater. Should this happen, remove the gasket with a wire hook.

b. Inspection and Servicing (Spark Plug).

1. If the spark plug appears to be in good condition, except for a mild coating of oxide on the porcelain and electrodes, it may be cleaned and reused. Cleaning is accomplished on a conventional airplane-type spark plug cleaner, except that it will be necessary to use two or more adapters in order to raise the long extension of the plug far enough out of the cleaner nozzle opening to perform an effective job. Plug the ceramic insert cavity at the terminal end of the plug with a piece of paper or cloth to keep out any of the cleaning sand. Wipe this cavity out thoroughly with a cloth wet with carbon tetrachloride. If, after cleaning, the spark plug porcelain is white, and the electrodes are not eroded, re-gap the spark plug by carefully bending the ground electrode until a 0.055-inch feeler gauge can be inserted between the end of the center electrode and the ground electrode.

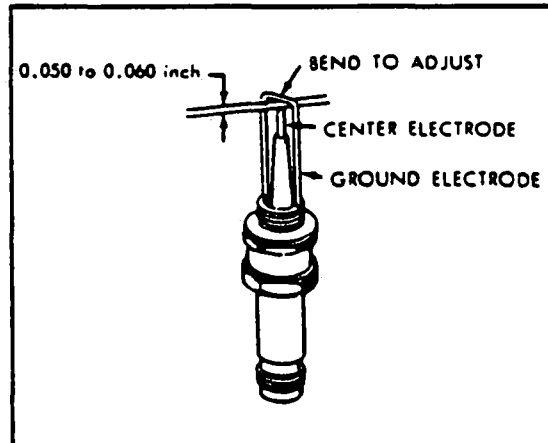


Figure 13-22. Spark Plug Gap Adjustment

#### NOTE

If the spark plug fails to clean up properly and/or if electrodes are badly eroded, it should be replaced.

c. Installation. (Refer to Figure 13-22.)

1. If a new spark plug is being installed, be sure to measure the gap, which should be between 0.050 and 0.060 inches. Do not bend the center electrode.

NOTE

The spark plug can be checked visually for sparking across the gap prior to installing the plug as follows: Disconnect the wire from the No. 3 terminal on the heater wiring side of the terminal strip to de-energize the fuel solenoid valve. Connect the high-voltage lead temporarily and lay the sparkplug on the heater jacket.

WARNING

Be sure to plug the sparkplug hole in the heater to prevent any possibility of residual fuel blowing out and igniting. Do not touch the sparkplug while energized because of dangerously high voltage.

2. Place a new spark plug gasket on the threads. If the gasket does not hold on the threads and would be likely to fall off during installation, place a small drop of Aviation Permatex, or similar material, on the gasket to stick it temporarily to the plug shell.
3. Screw the sparkplug into the heater with a deep socket wrench. Tighten to a torque of 28 foot pounds.
4. Install the grommet (23, Figure 13-25) in the heater jacket opening.
5. Carefully insert the spring connector on the high-voltage lead into the spark plug shell, press down gently and start the nut on the threads. Tighten the nut to 20 foot pounds.
6. Reconnect the wire to the No. 3 terminal on terminal strip, if disconnected for above tests.
7. Operate the heater to check dependability and close all access openings.

13-101. VIBRATOR ASSEMBLY. (Refer to Figure 13-25.)

- a. Measure the distance the vibrator protrudes out of the ignition assembly to determine when the new unit is inserted properly. Grasp the vibrator (19) and with a slight back-and-forth movement, pull it straight out of the ignition unit. (For a friction grip, it may be necessary to use a piece of masking or friction tape around the exposed portion of vibrator.)
- b. Carefully rotate the new vibrator until the index marks are aligned and the connector pins on the vibrator can be felt entering the pin sockets in the vibrator socket, then press the vibrator fully and firmly into position.
- c. Check the heater for operation.

### 13-102. IGNITION ASSEMBLY.

- a. Removal. (Refer to Figure 13-25.)

#### NOTE

Make sure heater electrical circuits are de-energized.

1. Disconnect the primary wire (5) from the primary terminal of the ignition assembly (18).
2. Carefully unscrew and disconnect the high-voltage ignition cable at the spark plug. Exercise care to avoid fouling or damaging the connector.
3. Remove the four attaching screws (20) and lockwashers (21) and lift the ignition assembly (18) off the mounting brackets on heater jacket.

- b. Installation. (Refer to Figure 13-25.)

1. Place the ignition assembly in position on the brackets attached to the heater jacket, with the high-voltage cable facing the spark plug end of the heater.
2. Install the four screws (20) and lockwashers (21). Tighten the screws securely.
3. Carefully connect the high-voltage lead to the spark plug. (Refer to Paragraph 13-100, c.)
4. Connect the primary lead (5) to the primary terminal on the ignition unit (18) and tighten the nut securely.
5. Check for proper heater operation.

### 13-103. CYCLING SWITCH AND LIMIT (OVERHEAT) SWITCH. (Refer to Figure 13-25.)

- a. Removal.

1. If the limit switch (27) is damaged or defective, disconnect the two electrical leads from the switch terminals. Be sure to mark the leads for proper reassembly. (The switch terminals are identified by numbers "1," "2," and "3.")
2. Remove the two attaching screws (28), lockwashers (29) and plain washers (30) and lift the limit switch (27) and spacers (gaskets) (31) from the jacket opening.
3. If the cycling switch (32) is damaged or defective, disconnect the electrical leads, being sure to mark them for proper reassembly.
4. Remove the two screws (33), lockwashers (34) and plain washers (35) and lift the cycling switch (32) from the jacket opening.



NOTE

No attempt should be made to repair either of these switches. If they do not operate properly, they should be replaced. (Refer to paragraph 13-120, m and n for test instructions.)

b. Installation. (Refer to Figure 13-25.)

1. Install the limit switch (27) and spacer (gasket) (31) by placing them in position in the heater jacket opening and installing two screws (28), lockwashers (29) and plain washers (30).

2. Tighten screws securely, then reconnect the electrical leads in accordance with markings made during disassembly. (Refer to wiring diagram, Figure 13-19.)

3. Install the cycling switch (32, Figure 13-25) by placing it in position in the heater jacket opening and securing it with the two screws (33), lockwashers (34) and plain washers (35). Tighten screws securely, then reconnect the electrical leads to their respective terminals as marked during disassembly. (Refer to wiring diagram, Figure 13-19.)

13-104. COMBUSTION AIR PRESSURE SWITCH. (Refer to Figure 13-25.)

a. Removal.

1. Disconnect electrical leads from the terminals of the combustion air pressure switch (41), being sure to mark them for proper reassembly. Disconnect the tube from the switch cap. Exercise caution not to exert excessive bending of the tube. (It is "tacked" to the combustion chamber inside the jacket.)

2. Unscrew and remove the combustion air pressure switch from the fitting on the combustion air inlet tube.

b. Installation.

1. Install the combustion air pressure switch (41) by rotating it on the threaded fitting of the combustion air inlet tube and tighten it securely. Exercise caution not to over-torque the switch as this could change the setting.

2. Connect electrical leads to their respective terminals in accordance with markings made during removal. If in doubt regarding proper connections, refer to the wiring diagram, Figure 13-19. Connect the tube to the switch cap.

3. Check for proper heater operation.

**13-105. FUEL REGULATOR AND SHUTOFF VALVE. (Refer to Figure 13-26.)**

**a. Removal.**

1. Disconnect the electrical lead from the valve.
2. Disconnect the fuel lines from the inlet and outlet openings. Take note of these connections for correct installation.
3. Remove the two attaching screws to free the unit from its mounting.

**b. Installation.**

1. Attach the fuel regulator and shut-off valve to its mounting with the two attaching screws.
2. Place the fuel regulator and shut-off valve into position between the fuel line connections and install and tighten connections securely.
3. Connect the electrical lead. Be sure to slide an insulating sleeve (or tape) over the connection to avoid a short circuit and tie the sleeve in place.
4. Operate the heater to make sure the unit is functioning properly.

**13-106. DUCT SWITCH. (Refer to Figure 13-26.)**

**a. Removal.**

1. Disconnect the electrical leads from the terminals on the exposed face of the switch and mark to facilitate installation.
2. Remove the two attaching screws and washers from the duct switch bracket.
3. Carefully lift out the switch and gasket (if gasket is used).

**b. Cleaning and Inspection.**

1. Brush off any dust or lint from the switch operating mechanism (exposed inside the duct) and wipe the external surfaces with a clean cloth.

**c. Installation.**

1. Insert the switch carefully with gasket (if used) into the ventilating duct opening and secure with the two attaching screws and washers.
2. Connect the two electrical leads to their respective terminals on the face of the switch as marked during removal.
3. Operate the heater with the duct switch set above ambient temperature to check operation. Refer to paragraph 13-120, step 1, for additional switch tests and setting instructions.

**4 C23**

**INTENTIONALLY LEFT BLANK**

**4 C24**

**INTENTIONALLY LEFT BLANK**

13-107. OVERHAUL INSTRUCTIONS. At 1000-hour airplane inspection, the heater should be removed from the airplane, disassembled, all parts thoroughly inspected and necessary repairs and replacements made prior to reassembly. Detailed step-by-step instructions are included for a complete heater overhaul. In some instances, however, inspections may reveal that it is unnecessary to remove certain parts, and, if so, those portions of the overhaul procedures may be eliminated.

NOTE

For disassembly and reassembly operations, refer to the exploded-view drawings and the parts list.

13-108. DISASSEMBLY. (Refer to Figure 13-25.)

- a. Remove the screw (4) and slide the elbow adapter (3) off the combustion air inlet tube.
- b. Disconnect and remove electrical wiring and individual wires from the various components on the heater. If wires appear to be in good condition, it may be desirable to remove wire harness assembly intact. First, disconnect wires at terminal strip and components. The ventilating air blower housing must be removed so that the two motor wires and solenoid valve quick-disconnect connections may be released.

NOTE

It is advisable to label all wires, prior to removal, to insure correct connections during reassembly. Cable straps and clips must be replaced if removed, as they cannot be re-used.

- c. Carefully disconnect the high-voltage ignition lead at the spark plug. Handle the spring connector on the end of this lead with care to prevent fouling or damage.
- d. Remove the four screws (20), lockwashers (21) and cable straps (17) to free the ignition assembly (18) from the heater jacket and remove the ignition assembly. The vibrator may be removed by exerting a firm pull straight away from the ignition assembly case.
- e. Remove the two screws (25) and lockwashers (26) to release the radio-noise filter (24) from the jacket (84).
- f. Remove the grommet (23) from the jacket (84) and remove the spark plug (22) with a 7/8 inch deep socket. Make sure the spark plug gasket is removed.

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- g. Remove the two screws (28), lockwashers (29) and plain washers (30) and lift out the overheat (limit) switch (27) and spacer gaskets (31).
- h. Remove the two screws (33), lockwashers (34) and plain washers (35) and lift out the cycling switch (32).
- i. Remove the four screws (37) and lockwashers (38) to release the terminal strip (36) and insulator (39) from the jacket (84).
- j. Disconnect the tube fitting (40) at the cover of the combustion air pressure switch (41). (Refer to paragraph 13-104, a, 1 for precaution on tube bending.) Unscrew and remove the combustion air pressure switch (41) from the combustion air inlet tube.
- k. Remove vent air inlet adapter (50) from the blower housing by removing the three screws (51) and lockwashers (52).
- l. Loosen the four screws (48) and rotate the blower and motor housing (49) to disengage the notched end from the four screws in the end of the heater jacket. Remove the grommet (47) and separate the two electrical quick-disconnects after sliding back the insulator sleeves on the wire ends.
- m. Reach inside the inlet end of the jacket assembly (84) with a 3/4 inch open-end wrench and, while holding the fuel-tube fitting at the jacket, remove the reducing bushing adapter (42). Then, with 3/4 inch deep socket, remove the nut (44), fuel fitting shroud (43) and gasket (46).
- n. Remove the two screws (72) and lockwashers (73) and carefully withdraw the nozzle holder and valve assembly from the combustion tube assembly (86). Remove the gasket (82).
- o. Remove the screws (88, 89 and 90), lockwashers (91) and remaining cable straps (17), if not previously removed, from the seam of the jacket assembly (84). Note positions of cable straps as they are removed. Spread the jacket (84) at the seam and remove it from the combustion tube assembly (86). This will free the rope gasket (85), which can be removed from the particular part to which it remains attached.
- p. Carefully unscrew and remove the spray nozzle (83) from the nozzle holder and solenoid valve assembly.

#### CAUTION

Handle the nozzle with care to avoid damage to the tip. The material around the orifice is very thin and any sharp blow on the face of the nozzle can distort the spray pattern and cause malignition or improper combustion.

- q. Remove the screw (76), lockwasher (77), cover (75) and "O" ring (78). Then carefully slide the solenoid coil (79) off the valve assembly. It is not necessary to remove the base plate (80) unless it is warped.

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- r. Loosen the nut (55) and remove the screw (53), flat washer (45) and rubber grommet (58) from blower housing.
- s. Remove the two screws (54), flat washers (45) and rubber grommets (58) at the other two locations around the blower motor housing (59).
- t. Slide the ventilating air blower motor out of the blower housing (59) with the motor bracket assembly (71) and blower wheel (60) attached. Loosen the set screw in the blower wheel (60) and slide it off the end of the motor shaft. The flat washers (56) and rubber washers (57) will fall out when the bracket is removed. Then remove the motor bracket assembly (71). If these parts are in good condition, they need not be disassembled further.
- u. Remove the screw (62) and lockwasher (63) to free the capacitor assembly (61) with attached leads.

**13-109. DISASSEMBLY OF COMBUSTION AIR BLOWER ASSEMBLY.** (Refer to Figure 13-26.)

- a. Remove the combustion air blower inlet adapter (2) by removing three screws, lockwashers, cover plate and gasket.
- b. Remove the outlet adapter (5) by removing the two screws (6) and lockwashers (7).
- c. Remove the inlet flange (8) by removing the three screws (9) and lockwashers (10).
- d. Remove screws (12 and 16) and lockwashers (13 and 17), then separate the back plate (20), with motor (25) attached, from the blower housing (15) and free the motor leads and capacitor (11) from the back plate (20).
- e. Loosen the set screw in the blower wheel (19) and slide it off the motor shaft.
- f. Remove the two hex nuts (21), lockwashers (23) and flat washers (22), and slide the back plate (20) off the motor through bolts. The spacer (24) will dropout.
- g. Install new motor brushes as described in paragraph 13-99, b. If the motor commutator is badly worn, or if the motor is defective in any respect, it must be replaced.

**13-110. CLEANING.** (Refer to Figure 13-25.)

- a. Clean individual metal parts (except those parts containing switches and electrical wiring) and the combustion tube assembly, by immersing them in dry-cleaning solvent, such as Stoddard solvent (Federal Specification P-D-680). A bristle brush should be used to assist the cleaning process if foreign accumulations are stubborn to remove.

CAUTION

Do not attempt to buff or scrape off any deposits on face of spray nozzle. The face of the nozzle is very susceptible to damage from mishandling. Carefully repeat cleaning process using only a bristle brush and repeated applications of solvent to loosen any stubborn deposits.

- b. Use compressed air or lintless cloth to dry the parts, unless sufficient time is available for them to air dry.
- c. Wipe electrical components with a clean, dry cloth. If foreign material is difficult to remove, moisten the cloth in carbon tetrachloride or electrical contact cleaner and clean all exterior surfaces thoroughly.

13-111. CLEANING AND INSPECTING THE COMBUSTION TUBE ASSEMBLY.  
(Refer to Figure 13-25.)

a. Slight scaling and discoloration of the combustion tube assembly (86) is a normal condition for units that have been in service up to 1000 airplane hours. The slight scaling condition will appear to be mottled and a small accumulation of blue-gray powder may be present on the surface in certain areas. This condition does not require replacement of the combustion tube assembly, unless severe overheating has produced soft spots in the metal.

NOTE

This assembly should be inspected prior to cleaning in order to prevent the removal of visible evidences of damage.

b. Look inside the exhaust outlet to determine if the combustion tube appears to be heavily scaled or mottled. Deformation is more difficult to detect visually but can usually be observed by looking straight through the combustion tube assembly and sighting along the outer surface of the inner combustion tube. An assembly that has been obviously deformed should be replaced. Slight deformation will not affect heater operation unless it is extensive and localized enough to reduce the flow of ventilating air through the heater more than 10 percent.

c. The combustion tube assembly may be cleaned by either of two methods:

- 1. One method is to soak the combustion tube assembly overnight in an Oakite M-S Stripper solution, made by mixing one pound of Oakite salts with each gallon of water used. The solution should be maintained at a temperature of be-

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tween 190°F and 210°F. After soaking overnight, rinse the combustion tube assembly thoroughly in water to remove all traces of the Oakite solution. In order to reach all areas of the combustion tube assembly, it is advisable to let it stand in the rinsing water for as long as 1/2 hour, while occasionally agitating it to circulate the water. All openings should be left open during this operation. Be sure to dry the combustion tube assembly thoroughly after cleaning.

2. A second method of cleaning is what is commonly known as hand "tumbling." Insert shot or other metallic particles through the exhaust outlet opening, then close all openings and shake the combustion tube assembly vigorously, while rotating it and changing from end-to-end frequently. Be sure to pour out all of the particles and loosened material, then with all openings uncovered, direct a stream of compressed air into the combustion tube assembly from first one opening, then the other. Make sure all loose material is removed.

**13-112. INSPECTION OF REMAINING COMPONENTS. (Refer to Figure 13-25.)**

a. Discard all rubber parts such as grommets, gaskets, etc. These items should always be replaced at overhaul. Also discard the rope gasket (85).

b. Inspect all wires and wiring harnesses for damage to insulation, damaged terminals, chafed or cracked insulation and broken plastic bands. Individual wires can be replaced by making up new wires from No. 16 AWG stock and cut to correct length. It is advisable to use an acceptable crimping tool for installing terminals, rather than solder for all heater wiring connections. If wiring harness damage is visible, the entire harness assembly should be replaced. If only one or more wires are damaged, cut the cable ties, make up new wires, install them in the harnesses, and restore all cable ties and clamps. If heater controls were operating properly at the time of removal, reinstall them.

c. Inspect all hard parts, consisting of bolts, screws, nuts, washers and lock-washers. Replace damaged parts.

d. The combustion air pressure switch (41) must respond to delicate pressure changes and should always be checked and/or replaced at overhaul. (Refer to Paragraph 13-113, c, and Figure 13-24.)

e. Replace the vibrator in the ignition unit at each overhaul.

f. Inspect the ignition assembly (18, Figure 13-25) for dented case, loose or damaged primary terminal insulator and broken or obviously damaged high-voltage lead. Give particular attention to the condition of the spring connector at the end of the lead. If the spring is burned off, visibly eroded, or carbon tracked, the ignition assembly should be replaced.

NOTE

Do not attempt a field repair of the ignition unit, as it is a sealed assembly.

g. Inspect the terminal strip (36) for distortion and cracks and replace it if either condition exists.

h. Inspect radio-noise filters for short circuits by checking from either terminal to ground with an ohmmeter. An open-circuit reading should be obtained.

i. Inspect the spray nozzle (83) with a magnifying glass for any obstructions in the nozzle orifice and any sign of damage to the slight conical protrusion at the nozzle tip. Use compressed air to remove obstructions and re-examine the orifice to make sure it is open. Exercise care when handling the nozzle to avoid pressing or rapping on the tip face. Do not buff or scrape off deposits on the tip face. After cleaning, it is advisable to store the nozzle in a polyethylene bag until ready for reassembly.

j. Replace the nozzle at overhaul.

NOTE

The nozzle (83) can be spray tested by installing it in the holder and connecting the fuel tube to a 7 psi fuel pressure source. Connect the solenoid leads to a 12-volt battery to open the solenoid valve. The conical angle spray pattern should be even and dispersed the same in all directions. Exercise caution to keep atomized fuel away from fire.

k. Inspect the nozzle holder and solenoid valve assembly for damaged threads at the fuel-tube fitting and for crimped or cracked fuel line or distorted housing. The only part in this assembly that can be replaced is the solenoid winding. Check the solenoid for continuity by connecting across each wire lead with an ohmmeter. A reading of between 18 and 22 ohms should be obtained at room temperature. If not within these limits, or if the solenoid winding shows any form of physical damage or overheating, it should be replaced.

l. Remove the brushes, one at a time, from the ventilating air blower motor (66) by removing the brush cap and carefully withdrawing the brush from its guide. Remove foreign material from the brush guide and commutator with a stream of filtered compressed air. Check for brush wear (Refer to Paragraph 13-99). Inspect the commutator for grooved brush track, pitting or burning. The commutator surface should be smooth and medium brown in color. Replace the motor if the commutator or other parts show damage.

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- m. Inspect the combustion air blower motor as described in the preceding step.
- n. Inspect the blower wheel for broken or bent vanes and replace it for either condition.

13-113. TESTING. The following tests should be performed as outlined in the succeeding paragraphs.

a. Check ventilating air and combustion air motors for correct RPM and current draw:

1. Connect motor to 12-volt DC power supply. Rotation should be counter-clockwise when viewed from the shaft end.
2. Both motors should rotate at approximately 7500 RPM at rated voltage. Current draw is approximately five amperes.
3. If current draw is excessive, or if speed is too low, replace the brushes. Recheck both current draw and RPM after brushes are properly run-in. (Refer to Paragraph 13-99, b.)
4. If after replacing brushes, operation is still unsatisfactory, replace the motor.

#### NOTE

The motor checks described above should be made without the blower housing attached, for both the ventilating air and combustion air motors.

b. Test the combustion tube assembly (86) for leaks as follows:

1. Fashion a sealing plate from approximately 1/8 inch thick flat stock to seal the nozzle holder opening in the combustion tube assembly. (Refer to Figure 13-23.) Use a rubber gasket under the plate and attach the plate with two screws.
2. Make up seals for all remaining openings, except the one used to connect the air pressure source. (Refer to Figure 13-23.) Use rubber stoppers as shown. The combustion air inlet tube can be sealed best with a drilled stopper and clamp. Other openings should be sealed with expansion plugs. The seal used in the exhaust tube should be formed so that it will not deform the air pressure switch tube which protrudes into the exhaust.
3. Install plugs and caps in all openings except the one to which the combustion air pressure switch is attached. (Any opening can be used to connect the air pressure source; however, the combustion air pressure switch opening is usually the most convenient. The drain opening would normally be considered a second choice.)
4. Connect a regulated air supply to the opening that has not been plugged

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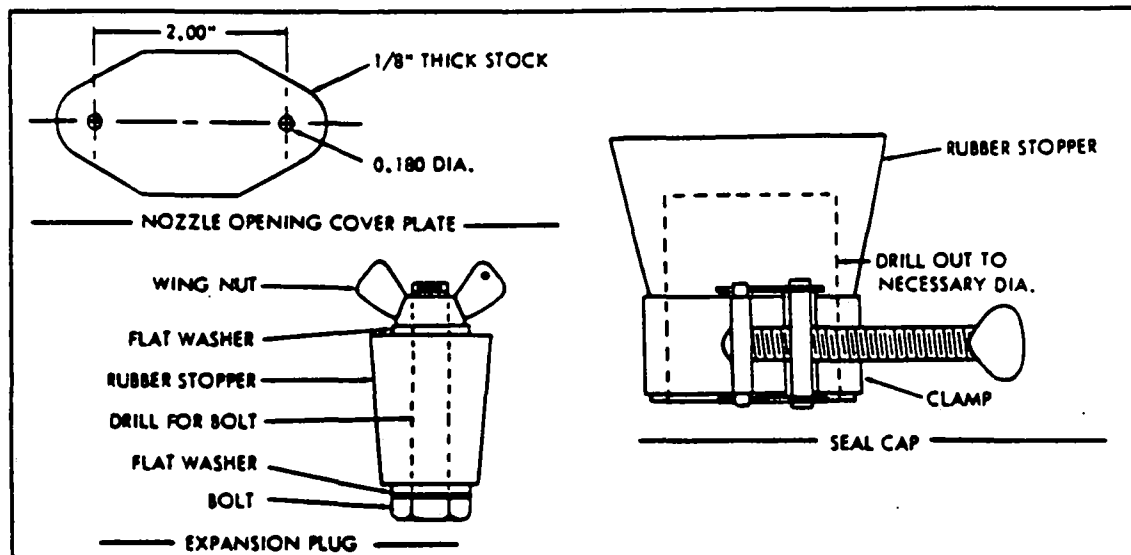


Figure 13-23. Suggested Design for Seal Plate, Plugs and Caps for Combustion Tube Leakage Test

and apply a pressure of between three and five psi to the combustion tube assembly.

5. Submerge the combustion tube assembly in water for several minutes while watching for bubbles, which would indicate leaks. The presence of a small leak, due to a pinhole in the metal or at welded joints, can be repaired successfully, provided it is located in an accessible area and the welder is familiar with stainless steel welds and does not create excessive weld stress concentrations. Be sure to recheck the assembly for leaks after welding.

c. Test the combustion air pressure switch as follows:

1. Connect an adjustable air pressure line that can be controlled in a range of zero to 5.0 psi (maximum) of water to the switch opening with a water manometer and needle valve in the line ahead of switch. Switch must be tested in 45-degree position as shown in Figure 13-24.

2. Connect an ohmmeter across the switch terminals to determine the exact instant of switch closing.

3. Apply air pressure allowing it to build up very slowly from zero. The switch contacts should close at  $0.5 \pm 0.1$  inches of water which will be indicated on the manometer.

#### NOTE

The switch cover has a differential pressure tap and this opening must be left open to atmosphere during test.

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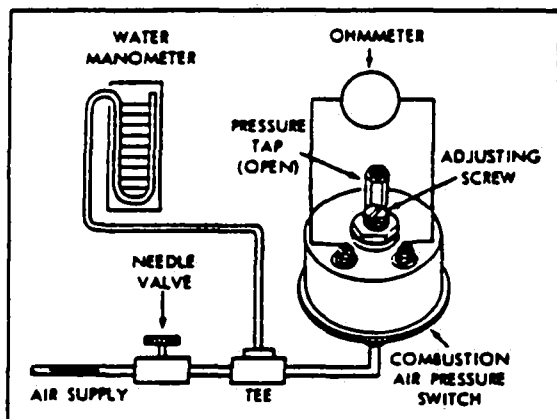


Figure 13-24. Test Set-Up for Combustion Air Pressure Switch

4. Make several trials to insure switch reliability. Be sure to increase and decrease the air pressure slowly in order to produce accurate indications.

5. If an adjustment is required, rotate the adjusting screw clockwise to increase settings and counterclockwise to decrease settings.

d. Test the fuel line and fuel line shroud tube for leaks as follows:

1. Using filtered compressed air, apply 20 psi to the shroud drain port, located on the surface near the threaded nozzle cavity.

2. Immerse the fuel feed and

nozzle holder assembly in clean water with the fuel inlet and nozzle cavity left open.

3. Observe for bubbles which would indicate leakage. If bubbles appear at either fuel fitting, there is a leak in the fuel tube. If bubbles appear externally on the shroud tube, or at either end of the shroud tube juncture, the shroud tube is leaking.

4. In either of the above cases, the complete fuel feed and nozzle holder assembly must be replaced.

e. Spray test the nozzle (83, Figure 13-25) as follows:

1. Install the nozzle in the fuel feed and nozzle holder assembly and connect the fuel tube to a 7-psi fuel pressure source.

2. Connect the solenoid leads to a 12-volt battery. Connect a switch in the line to open and close the solenoid when desired.

3. With the switch closed (solenoid valve energized) and the fuel line connected, observe the fuel spray pattern. It should be conical in shape with even dispersion in all directions.

### WARNING

Be sure to keep the atomized spray away from fire.

4. Energize and de-energize the solenoid several times. The spray should shut off permanently each time the solenoid is de-energized. There should be no sign of dribbling at the nozzle tip in excess of one or two drops.

5. If the spray pattern is distorted, check for an obstruction and clean the nozzle as described in paragraph 13-112, i. If this fails to provide a normal spray pattern, replace the nozzle.

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6. If the nozzle continues to dribble, the solenoid valve is not closing properly and the fuel feed and nozzle holder assembly must be replaced.

#### 13-114. REPAIR OF COMBUSTION TUBE ASSEMBLY.

a. If welding is attempted, clean the area thoroughly with a stainless steel brush.

#### CAUTION

Do not use a brush with ordinary steel bristles, as it would cause subsequent damage to the metal.

b. Wipe the area to be welded with a 30-percent solution of nitric acid, then weld with stainless steel rod (SAE Type 309, using Solar No. 16GH flux) if welding is accomplished with an acetylene torch. If the Heilarc method is used, use either Solar Type I or Type B flux. If a stainless steel rod is not available, a piece of scrap heater may be used as repair material. Make sure severe welding stresses are not present after welding.

#### NOTE

After welding, test the combustion tube assembly for leaks as outlined in the preceding paragraph.

#### 13-115. REASSEMBLY. (Refer to Figure 13-25.)

a. If removed during disassembly, slide the solenoid coil (79) on the stem of the nozzle holder and solenoid valve assembly. Install the "O" ring (78), cover (75), screw (76) and lockwasher (77), then tighten the screw securely. Be careful to avoid pinching the wire leads connected to the solenoid core.

b. Insert the ventilating air motor (56) into the motor bracket assembly (71), slide the blower wheel (60) on the end of motor shaft and rotate it until the set screw is aligned with the flat side of the motor shaft. Tighten the set screw just tight enough to hold it at this time.

c. Attach the capacitor and leads assembly (61) to the motor bracket (71) with the screw (62) and lockwasher (63). Make sure a good electrical ground connection is made at this point.

d. Insert this assembly into the blower housing (50) and position it so the long screw (53) is in alignment with the gap on the inner ring of the motor bracket assembly (71). This is the screw used to secure and align the motor in the bracket.

e. Slide the flat washer (58) and rubber washer (57) into position between the

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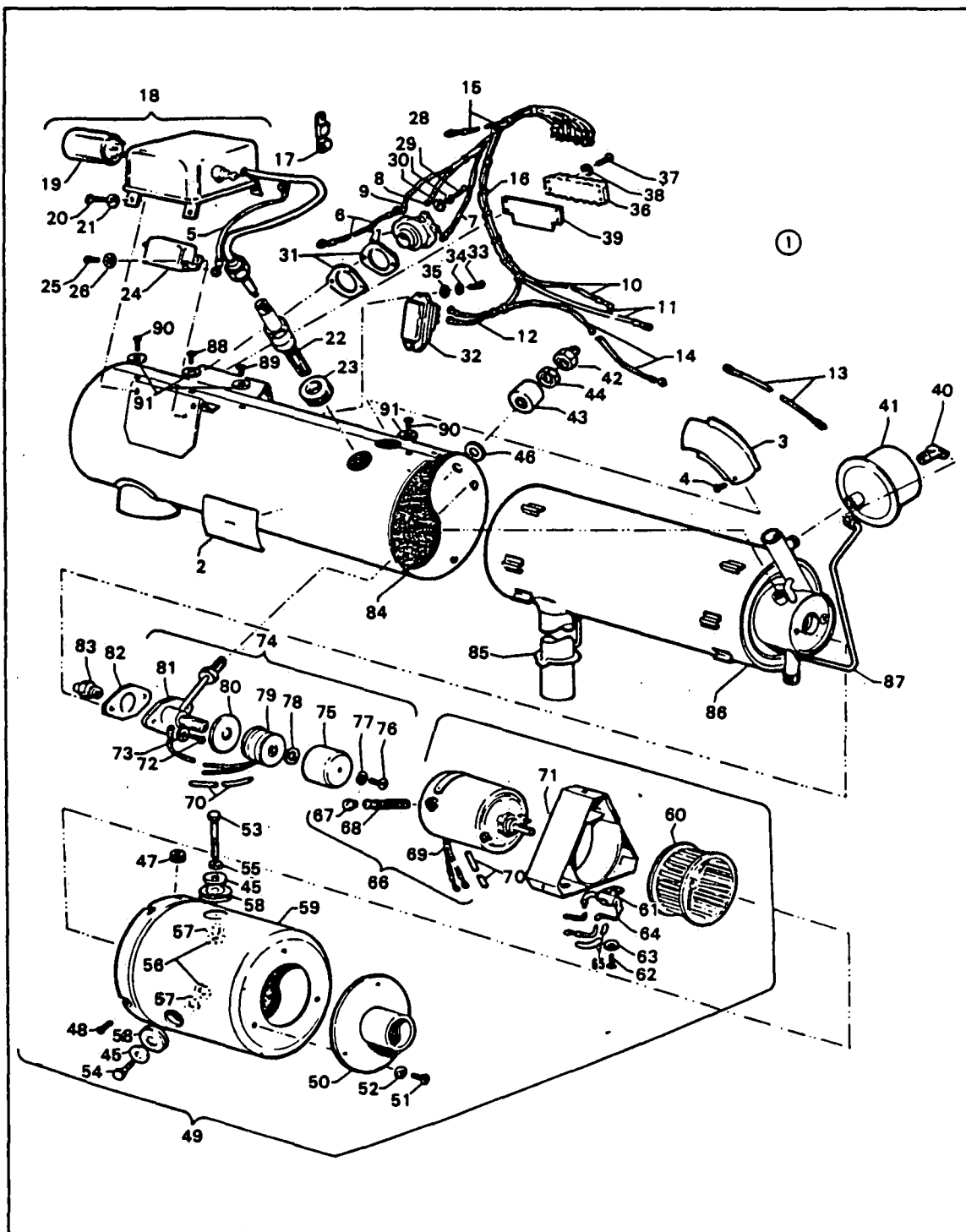


Figure 13-25. Exploded View of Heater Assembly No. 751 959

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← Legend for Figure 13-25.

- |   |  |
|---|--|
| 1. HEATER ASSEMBLY                                      | 47. GROMMET - MS35489-35               |
| 2. PLATE - IDENTIFICATION                               | 48. SCREW                              |
| 3. ADAPTER - ELBOW                                      | 49. BLOWER ASSEMBLY - VENT AIR         |
| 4. SCREW - AN530-6R6                                    | 50. ADAPTER                            |
| 5. WIRE ASSEMBLY - IGNITION TO FILTER                   | 51. SCREW - AN515-6R5                  |
| 6. WIRE ASSEMBLY - BLOWER GROUND                        | 52. WASHER - AN936A8                   |
| 7. WIRE ASSEMBLY - HEATER GROUND                        | 53. SCREW - MACHINE                    |
| 8. WIRE ASSEMBLY - TERMINAL 1 TO OVERHEAT SWITCH        | 54. SCREW - MACHINE                    |
| 9. WIRE ASSEMBLY - TERMINAL 2 TO IGNITION FILTER        | 55. NUT - AN338-4                      |
| 10. WIRE ASSEMBLY - TERMINAL 6 TO BLOWER FILTER         | 56. WASHER - FLAT                      |
| 11. WIRE ASSEMBLY - TERMINAL 2 TO PRESSURE SWITCH       | 57. WASHER                             |
| 12. WIRE ASSEMBLY - TERMINAL 3 TO CYCLE SWITCH          | 58. GROMMET - MS35489-6                |
| 13. WIRE ASSEMBLY - PRESSURE SWITCH TO OVERHEAT SWITCH  | 59. HOUSING - BLOWER                   |
| 14. WIRE ASSEMBLY - CYCLE SWITCH TO FUEL VALVE          | 60. FAN - VENT AIR BLOWER              |
| 15. WIRE ASSEMBLY - TERMINAL 1 TO COMBUSTION AIR BLOWER | 61. CAPACITOR ASSEMBLY                 |
| 16. TIE - CABLE   | 62. SCREW - AN515-6R6                  |
| 17. STRAP - CABLE                                       | 63. WASHER - AN936A8                   |
| 18. IGNITION ASSEMBLY                                   | 64. WIRE ASSEMBLY - BLOWER GROUND      |
| 19. VIBRATOR - IGNITION                                 | 65. SLEEVE - HIGH TEMPERATURE          |
| 20. SCREW - AN515-6R7                                   | 66. MOTOR ASSEMBLY - VENT AIR BLOWER   |
| 21. WASHER - AN936A8                                    | 67. CAP - BRUSH ASSEMBLY               |
| 22. PLUG - SPARK  | 68. BRUSH ASSEMBLY - MOTOR             |
| 23. GROMMET - AN531-10-20, MS35489-10                   | 69. TERMINAL                           |
| 24. FILTER - RADIO NOISE                                | 70. SLEEVE - HIGH TEMPERATURE          |
| 25. SCREW - AN515-6R5                                   | 71. BRACKET ASSEMBLY - MOTOR           |
| 26. WASHER - AN936A8                                    | 72. SCREW - AN515-6R7                  |
| 27. SWITCH - LIMIT                                      | 73. WASHER - AN935-6                   |
| 28. SCREW - AN515-6R6                                   | 74. FUEL FEED, NOZZLE HOLDER AND VALVE |
| 29. WASHER - AN936A8                                    | 75. COVER - SOLENOID                   |
| 30. WASHER - AN960-6                                    | 76. SCREW - AN515-6R6                  |
| 31. GASKET - LIMIT SWITCH                               | 77. WASHER - AN935-6                   |
| 32. SWITCH - CYCLING                                    | 78. PACKING - "O" RING                 |
| 33. SCREW - AN515-6R6                                   | 79. COIL ASSEMBLY - SOLENOID           |
| 34. WASHER - AN936A8                                    | 80. PLATE - SOLENOID BASE              |
| 35. WASHER - AN960-6                                    | 81. VALVE ASSEMBLY - FUEL              |
| 36. STRIP - TERMINAL                                    | 82. GASKET - VALVE ASSEMBLY            |
| 37. SCREW - AN515-6R10                                  | 83. NOZZLE - FUEL SPRAY                |
| 38. WASHER - AN936A8                                    | 84. JACKET ASSEMBLY                    |
| 39. INSULATOR - TERMINAL STRIP                          | 85. GASKET - ASBESTOS                  |
| 40. ELBOW - PRESSURE SWITCH                             | 86. TUBE - COMBUSTION                  |
| 41. SWITCH - PRESSURE                                   | 87. TUBE - COMBUSTION AIR SWITCH       |
| 42. BUSHING - AN894-4-2                                 | 88. SCREW - AN515-6R4                  |
| 43. SHROUD - FUEL FITTING                               | 89. SCREW - AN515-6R5                  |
| 44. NUT - AN924-4                                       | 90. SCREW - AN515-6R6                  |
| 45. WASHER - FLAT                                       | 91. WASHER - AN936A8                   |
| 46. GASKET - AN900-6                                    |  |

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legs of the motor bracket (71) and blower housing (59).

f. Make sure all wires are routed and grommets as they were prior to disassembly and install the two screws (54), flat washers (45) and new grommets (58) at the two lower edges securing the motor bracket assembly (71). Then install the grommet (58), flat washer (45), nut (55) and screw (53) in the remaining (upper) corner of the motor bracket assembly (71).

g. Center the motor bracket (71) in the housing and tighten the screw (53) to secure it. The motor (66) should be positioned in the bracket (71) to locate the blower wheel (60) properly in the blower housing (59). The blower wheel should be positioned so it will rotate freely and just clear the contoured spill plate in the blower housing. Tighten the allen-head set screws and spin the blower wheel by hand for a clearance check. Then apply appropriate voltage to run the motor as a final clearance check.

h. Attach the inlet adapter to the end of blower housing (59) with three screws (51) and lockwashers (52).

i. Place a new rope gasket (85) in position on the exhaust outlet, spring the jacket assembly (84) open at the seam and insert the combustion tube assembly (86) carefully into the jacket. Exercise care to clear the pressure switch tube in the exhaust outlet and see that the rope gasket (85) is properly located. Close the gap on the jacket assembly and install screws (88, 89 and 90) and lockwashers (91) to secure it at the seam. (Two leads ground under these screws. See notations made during disassembly.) Make sure the tongue and channel at the seam are in good condition and a tight fit is effected.

j. Install cable straps at locations noted during disassembly.

k. Remove the spray nozzle (83) from the polyethylene bag. Screw the nozzle into nozzle holder and tighten to 75-100 inch pounds. It is very important to torque the nozzle to this value as incorrect tightening could cause improper heater operation and "drool."

#### CAUTION

The spray nozzle has a slight protrusion on the nozzle face. If this area has been struck by any object which would make a dent or destroy the original contour, the nozzle must be replaced. It cannot be disassembled for cleaning.

l. Insert the fitting on end of nozzle fuel tube through the opening in jacket (84) and attach the nozzle holder to the combustion tube assembly (86) with the two screws (72) and lockwashers (73). It may be necessary to place a slight bend in the shrouded fuel tube to permit alignment of screw holes. Be sure to use a new gasket (82) and connect the solenoid ground wire under one of these screws. Make

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sure a good electrical ground connection exists at this point.

m. Using a new spark plug gasket, install the spark plug (22) and tighten to a torque of 28 foot pounds. Install the grommet (23) in the jacket around the spark plug.

n. Install the ignition assembly (18) on the jacket assembly (84) with the four screws (20) and lockwashers (21). Connect the high-voltage lead to the spark plug and tighten it to 20 foot pounds.

o. Attach the radio-noise filter (24) to the jacket assembly (84) with the two screws (25) and lockwashers (26).

p. Attach the overheat limit switch (27) and spacer gaskets (31) to the jacket assembly (84) with the two screws (28), lockwashers (29) and flat washers (30). Tighten the screws securely.

q. Attach the cycling switch (32) to the jacket assembly (84) with the two screws (33), lockwashers (34) and flat washers (35).

r. Place the terminal strip insulation (39) in position on the jacket (84), followed by the terminal strip (36). Secure both parts by installing the two screws (37) and lockwashers (38). The two screws are located at two diagonal corners of the terminal strip.

s. Center the fuel fitting in jacket opening. Place the fuel fitting shroud gasket (46) and shroud (43) on the fuel fitting and install the nut (44) finger tight. Insert a 3/4 inch open-end wrench inside the jacket and hold the fuel-tube fitting while tightening the nut (44) with a 3/4 inch deep socket. Install the reducer fitting (42).

t. Rotate the combustion air switch (41) onto the threaded fitting on the combustion air tube and tighten it firmly.

u. Slide the grommet (47) over the combustion air tube and connect the tube to the elbow fitting (40) on the combustion air pressure switch (41).

v. Install the wiring harness and connect all wire leads to their respective terminals. (Refer to the wiring diagram, Figure 13-19.) Place the grommet (47, Figure 13-27) in position in the jacket (84), locate the ventilating air blower (49) at the end of the jacket. Thread the quick-disconnect on the wiring harness through the grommet (47) and connect it to the mating connector on the motor lead.

w. Place the blower housing in position on the jacket assembly (84) and secure it by installing the four screws (48), if removed at disassembly. This operation is easier if the screws (48) are started into their threads and the blower housing rotated into place, allowing the screws to enter the notched openings in edge of blower housing. Tighten all screws securely.

x. Install the elbow adapter (3) with the screw (4).

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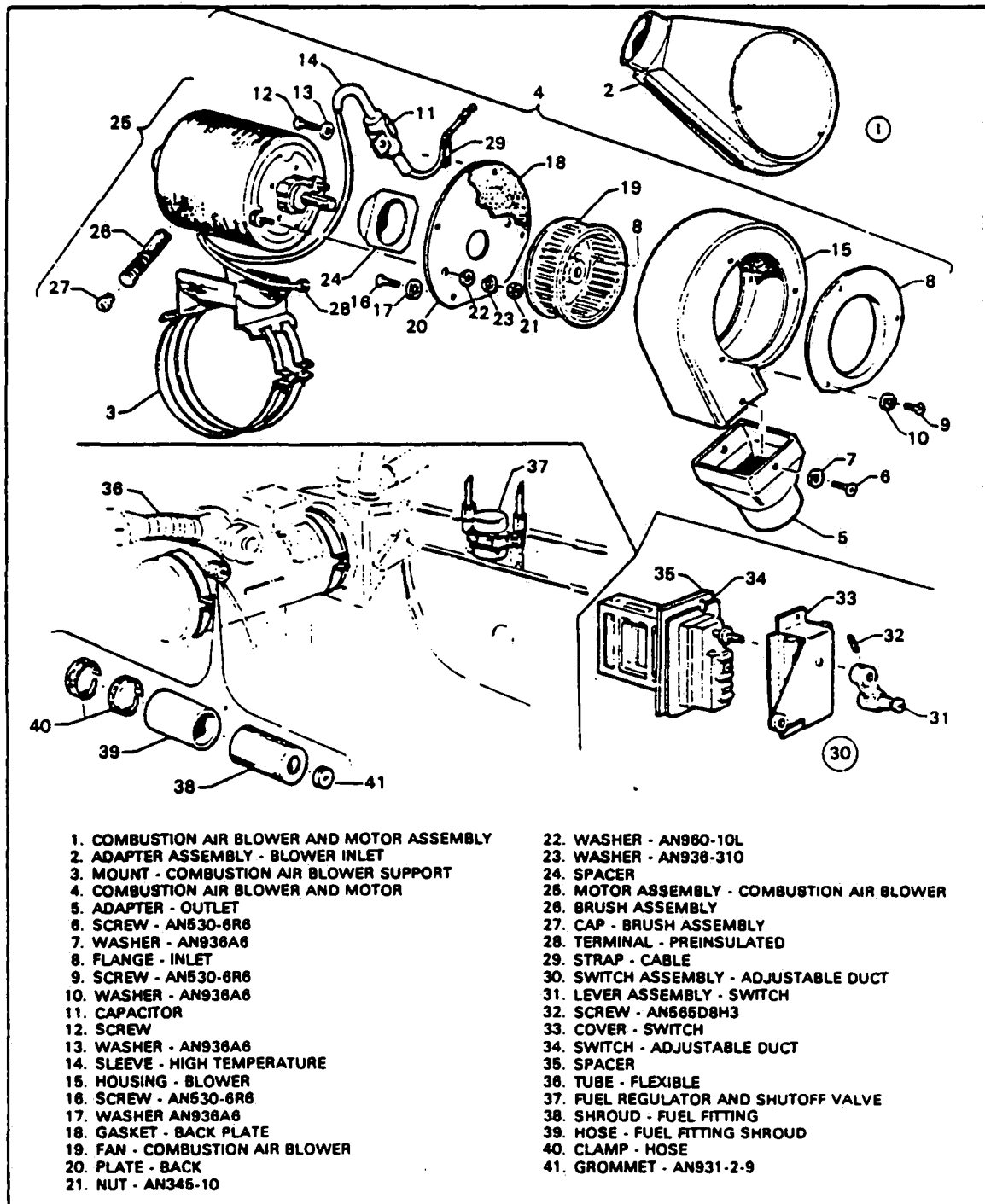


Figure 13-26. Exploded View - Combustion Air Blower and Motor Assembly No. 753 905

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13-116. REASSEMBLY OF COMBUSTION AIR BLOWER ASSEMBLY. (Refer to Figure 13-26.)

- a. Place the spacer (24) over the end of the motor shaft and attach the motor assembly (25) to the back plate (20) with the two self-locking nuts (21), flat washers (22) and lockwashers (23).
- b. Slide the blower wheel (19) on the motor shaft and tighten the set screw lightly against the flat portion of the motor shaft.
- c. Place the blower housing (15) in position on the back plate (20) and install screws (16) and lockwashers (17).
- d. Attach the radio-noise filter (11) at the point shown with the screw (12) and lockwasher (13). The motor ground lead terminal (28) can be grounded to the motor support bracket (3).
- e. Attach the inlet flange (8) and blower inlet adapter (2) to blower housing (15) with three screws (9) and lockwashers (10).
- f. Loosen the allen set screw in the blower wheel (19) and shift the wheel on the motor shaft until it is near the inlet in the blower housing. Tighten the set screw securely. The blower wheel should just clear the inlet flange when rotated at full RPM. Spin the blower wheel by hand for clearance check; then apply proper voltage to run motor and recheck for proper clearance.
- g. Slide the blower outlet adapter (5) on the blower housing outlet (15) and install the two screws (6) and lockwashers (7).

13-117. TEST PROCEDURE.

13-118. GENERAL INFORMATION. A test of all components should have been made after overhaul to insure proper operation. Some shops may not have complete testing facilities for measuring air flows, pressure drops and other factors which would be accomplished in a laboratory-type test. If such a test cannot be made, install the heater and check operation on the ground and in the air to determine if operation is normal. In shops where complete test equipment is available and a complete functional test can be performed, the test routine described in subsequent paragraphs should be made.

13-119. EQUIPMENT REQUIRED. (Refer to Figure 13-27.)

- a. An improvised stand to hold the heater during test. The heater should be located far enough away from any combustible material or atmosphere to avoid hazard. A location should be chosen where exhaust can be dispelled. Do not add an excessive extension to the heater exhaust.
- b. A source of fuel capable of being regulated at seven psi.

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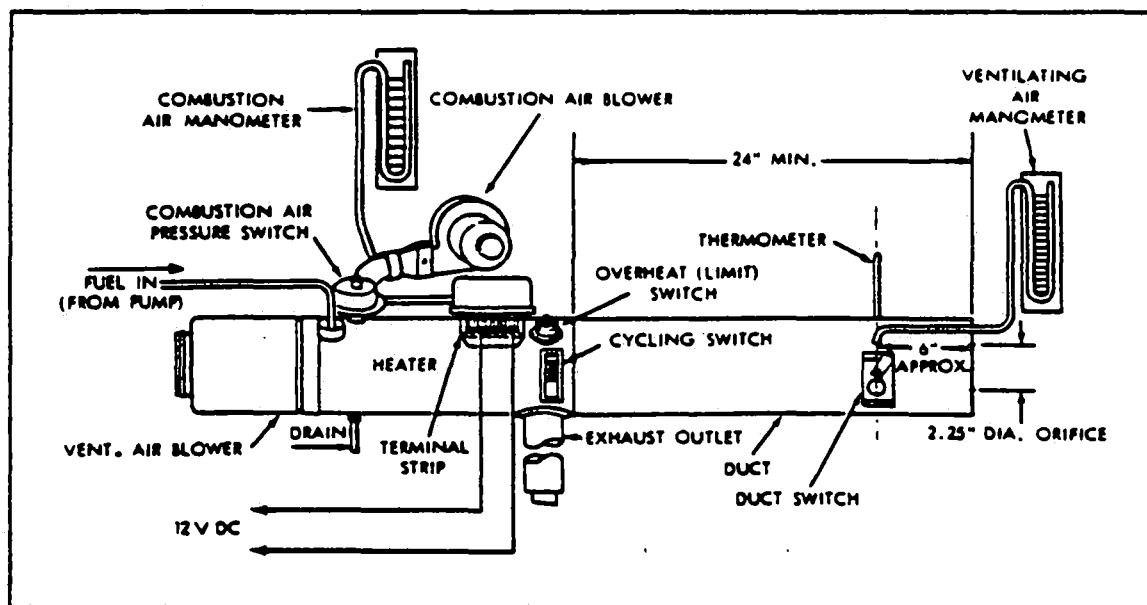


Figure 13-27. Suggested Set-Up for Heater Operation Test

- c. The combustion air blower to be used with the heater should be used for the test.
- d. A 12-volt current supply, which may be a DC generator with a rheostat, ammeter and voltmeter in the line to control and indicate the current draw and voltage output.
- e. Two water manometers (zero to 5.0 inch water column) for measuring the pressure in the ventilating air duct and in the combustion air stream.
- f. A piece of duct to be attached to the downstream end of the heater. It should have a minimum length of 24-inches and the same diameter as the heater being tested. A 2.25-inch diameter orifice should be centrally located at the outlet end. An aperture should be provided for the thermometer and duct switch, and a static tap should be attached as shown in Figure 13-27.
- g. A thermometer with 500°F scale.
- h. A fuel-pressure gauge.
- i. A controlled source of compressed air for final leakage test.

#### 13-120. OPERATIONAL TEST. (Refer to Figure 13-27 and 13-28.)

- a. Connect the heater to the test setup as shown in Figure 13-27. Make sure the combustion air blower is mounted securely and that the heater is clamped to its supporting stand.
- b. Insert the duct switch in the sheet-metal extension tube at the location shown in Figure 13-27.

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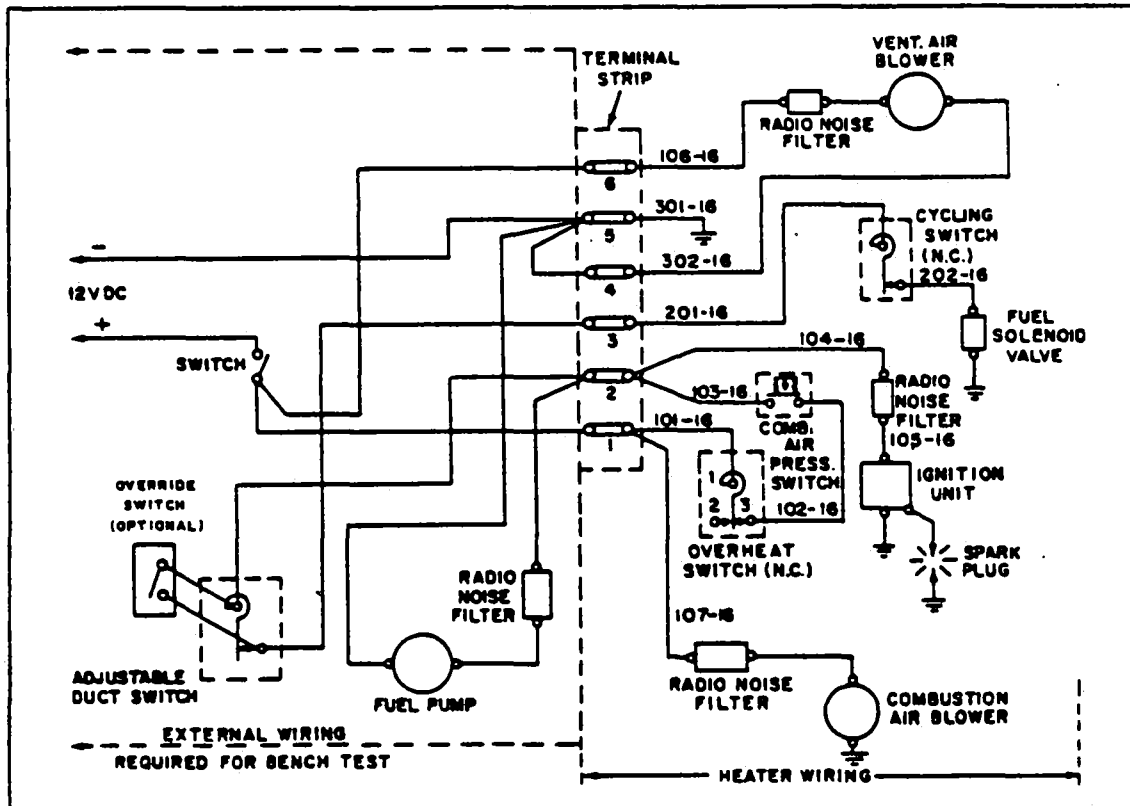


Figure 13-28. Wiring Connections for Heater Operation Test

- c. Connect components and heater as outlined in the wiring connection diagram, Figure 13-28. The power supply switch should be open.
- d. Connect the power source to the heater.
- e. Disconnect wire lead from terminal "3" on the heater side of heater terminal strip to prevent the heater from lighting and close the power source switch to check operation of blowers. The combustion air blower and ventilating air blower should operate at full speed with no blower wheel interference. If either blower fails to run, locate and correct the trouble before proceeding with the test.
- f. Connect a voltmeter from open side of combustion air pressure switch terminal to ground to determine if the switch is closed, which would be indicated by a full voltage reading on the meter. If a full voltage reading is not obtained, the combustion air supply is either inadequate or the switch is defective or improperly adjusted. Make necessary corrections.
- g. Observe the manometer connected to the ventilating air pressure tap, which should show a reading of 1.1 inches of water (minimum) at rated voltage.
- h. Observe the manometer connected to the combustion air tube tap, which should show a reading of 1.5 inches of water (minimum) at rated voltage.

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i. Open the power supply switch and reconnect the terminal lead disconnected in preceding step e.

j. Close the power supply switch and turn on the fuel supply. The heater should light within five seconds (may require slightly longer for air to be purged from fuel lines on the first trial).

k. Observe operation of duct switch, which should control heater operation according to the switch setting.

l. If the duct switch fails to control the temperature according to the setting, place the control lever in high "H" position and notice the control variation. A high reading of  $225^{\circ}\text{F} \pm 10^{\circ}$  should be obtained (reading will vary in different applications).

1. On airplanes with serial numbers 30-1717, 30-1745 and up or when kit number 760 249 has been installed, a micro override switch has been installed on a 250 degree duct switch and can be adjusted by moving the heat control to the full high heat position. Slide the micro switch toward the duct switch arm until micro switch closes and secure in place. This switch is meant to override the duct switch at the very last movement of the duct switch arm toward the high position.

2. Check for proper operation of control arm.

m. Connect a jumper across the terminals of the duct switch to make it inoperative and observe action of the cycling switch. When micro override switch is installed, move the heat control to the full high position. The cycling switch should cycle to control the outlet air temperature at approximately  $250^{\circ}\text{F}$  (nominal). This is a function of ambient temperature and air flow conditions. If operation is within a range of  $190^{\circ}\text{F}$  to  $290^{\circ}\text{F}$ , the switch is operating normally. If the switch is out of range it can be reset in the same manner as described for the duct switch, except that no control lever or indicator stop are used. If adjustment fails to restore proper temperature range, replace the switch.

n. With duct switch still jumped, place a jumper across the cycling switch terminals to check operation of the overheat switch. Block the ventilating air outlet and notice if the overheat switch shuts off the heater. It should open at between  $300^{\circ}\text{F}$  and  $400^{\circ}\text{F}$ . (This is also a function of ambient temperature and air flow.) After the switch shuts off, remove ventilating air restriction; remove jumpers from cycling and duct switches and press firmly on the overheat switch reset button until it "clicks." The heater should light and operate.

o. Shut down the heater and check all components visually to make sure no damage has occurred to any of them.

p. Remove heater and other components from the test set-up and install it in the airplane.

**13-121. REMOVAL OF HEATER FUEL VALVE.** The heater fuel control valve, located in the upper right hand corner of the forward cabin bulkhead, may be removed by the following procedure:

- a. Turn the heater fuel control knob, located on the right side of the instrument panel, to position valve lever in a horizontal position.
- b. Remove top nose access panel by loosening the attaching fasteners.
- c. Remove fuel lines from valve.
- d. Remove mounting bracket by removing attaching screws.
- e. Slide bracket and valve assembly to the left toward the center of the airplane far enough to clear other routed lines.
- f. Remove valve from mounting bracket by removing attachment screws.

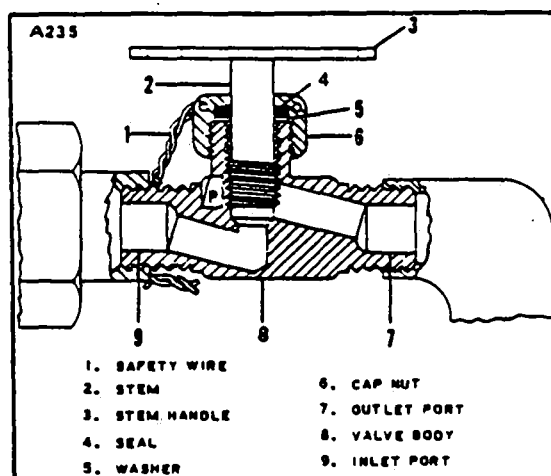


Figure 13-29. Heater Fuel Valve

**13-122. INSPECTION AND REPAIR OF HEATER FUEL VALVE.** (Refer to Figure 13-29.)

- 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).

**13-123. INSTALLATION OF HEATER FUEL VALVE.**

- a. Align the pressure side of the valve with the fuel line from the right engine. 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. Align valve lever with control rod and secure valve assembly and mounting bracket with screws to the forward cabin bulkhead.
- c. Connect inlet fuel line to valve.
- d. Turn valve to the off position. Turn on electric fuel pump and check for leakage around the valve stem and outlet port.
- e. Connect heater fuel line to valve; turn valve on, and check for leaks.

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TABLE XIII-II. TROUBLESHOOTING CHART (JANITROL HEATER)

Trouble	Cause	Remedy
Heater fails to light.	Heater switch or circuit breaker off.	Turn on heater switch or close circuit breaker.
	Low voltage supply.	Apply external power supply. Attempt to start heater. (Refer to paragraph 13-89.)
	Fuel cut off from tank.	Turn on manual shutoff valve or master solenoid.
	Regulator not operating properly.	Check for low pressure or replace regulator. (Refer to paragraph 13-105.)
	Restriction in fuel nozzle orifice.	Remove the nozzle and clean or replace it. (Refer to paragraph 13-108, m and n; 13-110 and 13-112, i and j.)
	Fuel heater solenoid not operating.	Remove and check solenoid. Replace if faulty. (Refer to paragraph 13-108; 13-112, k and 13-115, a.)
	Fuel lines clogged or broken.	Inspect all lines and connections. It may be necessary to disconnect lines at various points to determine where the restriction is located.

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TABLE XIII-II. TROUBLESHOOTING CHART (JANITROL HEATER) (cont)

Trouble	Cause	Remedy
Heater fails to light (cont).	Ignition vibrator inoperative.	Replace vibrator. Check for defective radio noise filter. (Refer to paragraph 13-101 and 13-112.)
	Manual reset limit (overheat) switch open.	Press reset button firmly and recheck to determine reason for switch opening.
	Combustion air pressure switch open. (Defective switch or low combustion air blower output.)	Check for low blower output due to low voltage and correct it. If switch is defective, replace it. (Refer to paragraph 13-104.)
	Cycling switch open.	Replace if defective. (Refer to paragraph 13-103.)
	Duct switch open.	Operate control to see if switch will come on. Replace switch if defective. (Refer to paragraph 13-106.)
Ventilating air blower	Heater switch "OFF". Broken or loose wiring to motor.	Energize the heater switch. Check and repair wiring.
	Circuit breaker open.	Close circuit breaker.
	Worn motor brushes.	Replace motor brushes. (Refer to paragraph 13-99.)

TABLE XIII-II. TROUBLESHOOTING CHART (JANITROL HEATER) (cont)

Trouble	Cause	Remedy
Ventilating air blower fails to run (cont.)	Blower wheel jammed.	Remove and check the ventilating air blower wheel and realign if necessary. (Refer to paragraph 13-115, g.)
	Motor burned out.	Remove blower assembly and replace motor. (Refer to paragraph 13-108, l and r thru u; 13-115, b thru g.)
	Defective radio-noise filter.	Replace filter.
Combustion air blower fails to run.	Faulty wiring to motor.	Inspect and replace faulty wiring.
	Poor ground connection.	Tighten ground screw.
	Worn motor brushes.	Replace motor brushes. (Refer to paragraph 13-99, b.)
	Blower wheel jammed. (Usually indicated by hot motor housing.)	Overhaul the combustion air blower. (Refer to paragraphs 13-108 and 13-115.)
	Defective radio-noise filter.	Replace filter. (Refer to paragraphs 13-108 and 13-115.)

TABLE XIII-II. TROUBLESHOOTING CHART (JANITROL HEATER) (cont)

Trouble	Cause	Remedy
Combustion air blower fails to run (cont).	Faulty or burned-out motor.	Remove combustion air motor for overhaul or replacement of motor. (Refer to paragraphs 13-99, 13-109 and 13-116.)
Heater fires but burns unsteadily.	Insufficient fuel supply.	Inspect fuel supply to heater, including shut-off valve, solenoid valve and fuel lines. Make necessary repairs.
	Spark plug partially fouled.	Replace spark plug. (Refer to paragraph 13-100.)
	Loose primary connection at ignition assembly.	Tighten the connection.
	Faulty vibrator.	Replace the vibrator. (Refer to paragraph 13-101.)
	Combustion air blower speed fluctuates. (Can be caused by low voltage, loose blower wheel, worn brushes or motor.	Remove and overhaul the combustion air blower assembly as required or correct low voltage condition. (Refer to paragraphs 13-99, 13-109, 13-113 and 13-116.)

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TABLE XIII-II. TROUBLESHOOTING CHART (JANITROL HEATER) (cont)

Trouble	Cause	Remedy
Heater fires but burns unsteadily (cont).	High voltage leak in lead between ignition assembly and spark plug.	Replace ignition assembly. (Refer to paragraph 13-102.)
	Inoperative ignition assembly.	If vibrator is in good condition, replace ignition assembly only. (Refer to paragraph 13-102.)
	Restriction in fuel nozzle orifice.	Remove nozzle for cleaning or replacement. (Refer to paragraphs 13-108, m and n; 13-112, i and 13-115 k and l.)
	Nozzle loose in retainer or improper spray angle.	Tighten or replace the nozzle as required. (Refer to paragraphs 13-112, i; 13-115, k.)
Heater starts then goes out.	Lack of fuel at heater.	Check fuel supply through all components from the tank to the heater. Make necessary corrections.
	Inoperative or chattering combustion air pressure switch.	Adjust or replace switch. (Refer to paragraph 13-104.)
	Inoperative overheat switch.	Replace switch. (Refer to paragraph 13-103.)

TABLE XIII-II. TROUBLESHOOTING CHART (JANITROL HEATER) (cont)

Trouble	Cause	Remedy
Heater starts then goes out (cont).	Inoperative cycling switch.	Adjust or replace the switch. (Refer to paragraph 13-103.)
	Low voltage.	Attach external power.
Heater fails to shut off.	Fuel solenoid valve in heater stuck open.	Remove and replace solenoid assembly. (Refer to paragraphs 13-108, q; 13-112, k; and 13-115, a.)
	Inoperative duct and cycling switch.	Check and repair. (Refer to paragraphs 13-103 and 13-106.)
	Defective heater switch.	Replace the heater switch.

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## SECTION XIV

### ACCESSORIES AND UTILITIES

Paragraph		Aerofiche Grid No.
14-1.	Introduction . . . . .	4E8
14-2.	Oxygen System . . . . .	4E12
14-3.	Description and Principle of Operation . . . . .	4E12
14-4.	Troubleshooting . . . . .	4E12
14-5.	Safety Precautions . . . . .	4E12
14-6.	Inspection and Overhaul Time Limits . . . . .	4E12
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14-8.	Maintenance . . . . .	4E13
14-9.	Cleaning Operations . . . . .	4E14
14-10.	Removal of Oxygen Cylinder and Regulator . . . . .	4E14
14-11.	Installation of Oxygen Cylinder and Regulator . . . . .	4E15
14-12.	Removal of Filler Valve . . . . .	4E15
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14-15.	Installation of Pressure Gauge . . . . .	4E16
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14-18.	Purging Oxygen System . . . . .	4E16
14-19.	Cleaning of Face Masks . . . . .	4E17
14-20.	Engine Synchrophaser . . . . .	4E19
14-21.	Description of Synchrophaser System . . . . .	4E19
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Revised: 10/28/82

## SECTION XIV

### ACCESSORIES AND UTILITIES

14-1. INTRODUCTION. This section covers accessories which are available in this airplane and are not covered in other sections of this Service Manual. This information provides instructions for remedying difficulties which may arise in any of the accessories and the instructions are organized so the mechanic may refer to whichever component or system he must repair or adjust.

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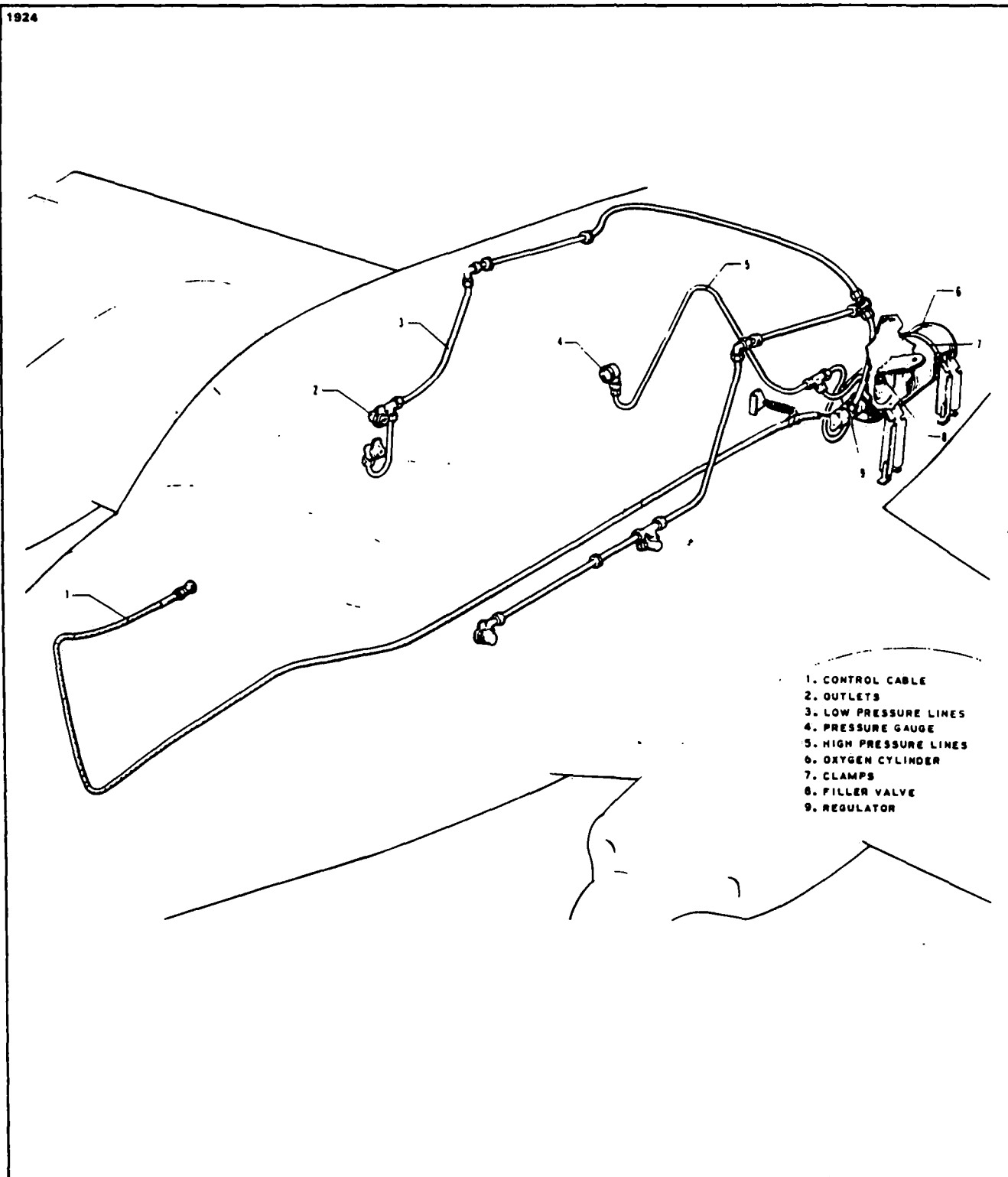


Figure 14-1. Oxygen System Installation  
Serial Nos. 30-2 to 30-852 incl., 30-854 to 30-901 incl.

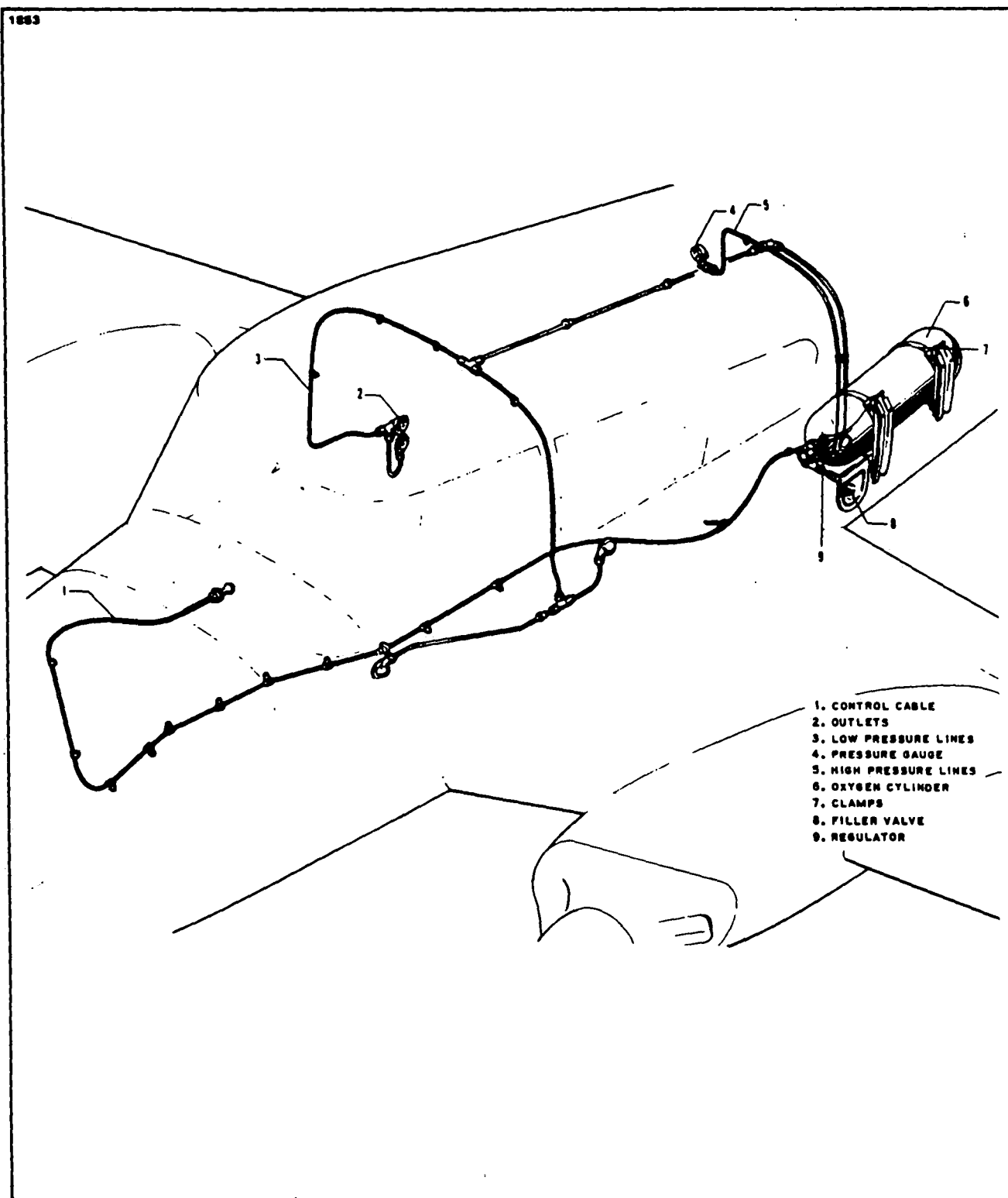


Figure 14-2. Oxygen System Installation

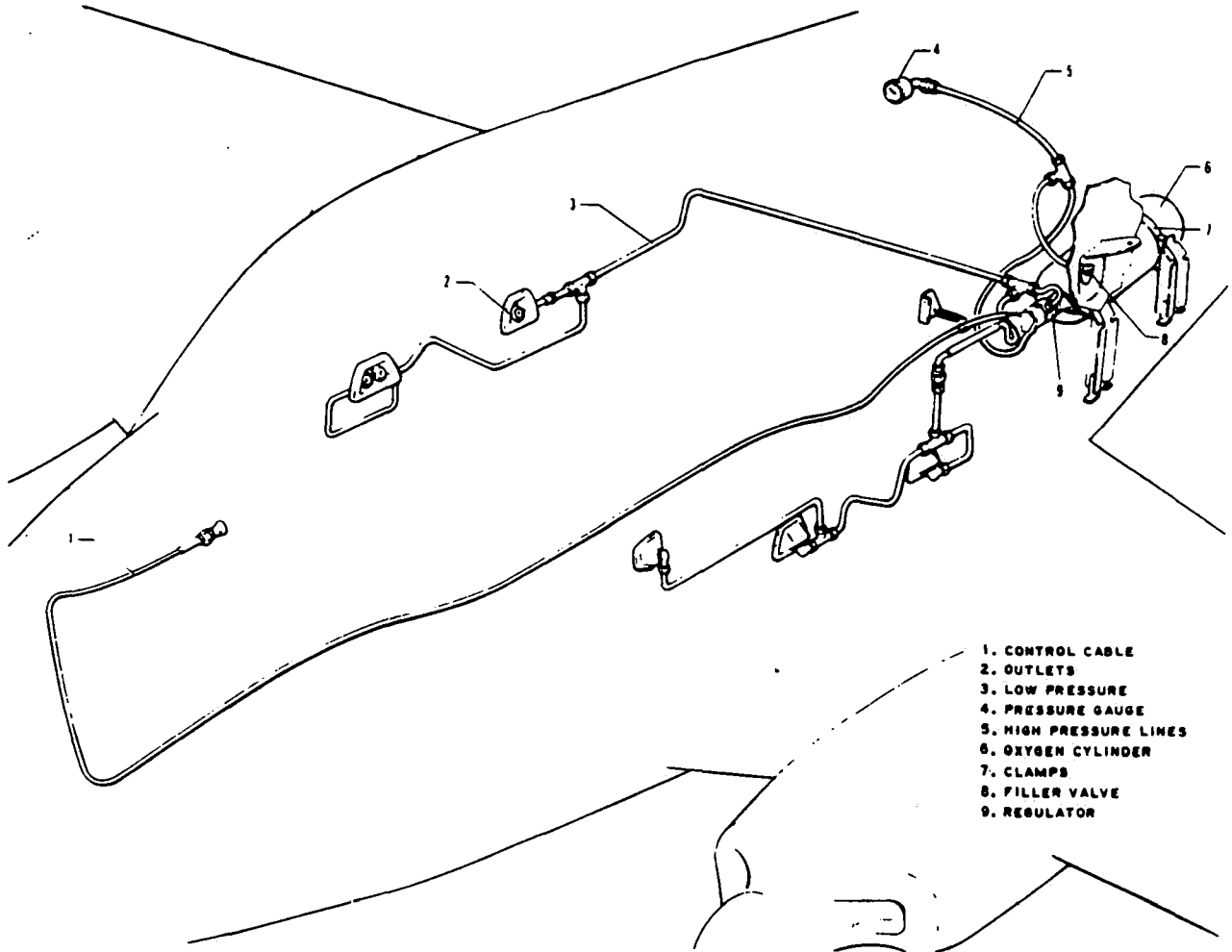
Serial Nos. 30-853, 30-902 to 30-1716 incl. and 30-1718 to 30-1744 incl

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1. CONTROL CABLE
2. OUTLETS
3. LOW PRESSURE
4. PRESSURE GAUGE
5. HIGH PRESSURE LINES
6. OXYGEN CYLINDER
7. CLAMPS
8. FILLER VALVE
9. REGULATOR

Figure 14-3. Oxygen System Installation  
Serial Nos. 30-1717, 30-1745 to 30-2000 incl.

## 14-2. OXYGEN SYSTEM.

14-3. DESCRIPTION AND PRINCIPLE OF OPERATION. The oxygen system for the PA-30 consists of an oxygen cylinder and regulator, filler valve, pressure gauge, outlets and masks and an ON/OFF control. High pressure is routed from the cylinder and regulator to the pressure gauge. Low pressure oxygen is routed from the cylinder and regulator to the outlets and masks whenever the control knob is pulled to the ON position. Each outlet has a spring-loaded valve which prevents the flow of oxygen until a mask hose is engaged in the outlet.

14-4. TROUBLESHOOTING. A troubleshooting chart is located at the back of the oxygen system portion of this section.

14-5. SAFETY PRECAUTIONS. Utmost care must be exercised in servicing, handling and inspection of the oxygen system. A fully charged oxygen cylinder contains enough pressure to cause serious injury to personnel and damage to equipment. Keep hands, tools and working area clean and post NO SMOKING signs. Keep all components of the system free from oil, grease, gasoline and all readily combustible material. Never allow electrical equipment to come in contact with the oxygen cylinder. Keep fire and heat away from oxygen equipment and take care not to generate sparks with carelessly handled tools.

14-6. 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 time 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 lightweight cylinder (ICC or DOT 3HT 1850) must be hydrostatic tested every 3 years and retired from service after 15 years or after 4,380 pressurizations, whichever comes first. The month and year of the last test is stamped on the 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.

## ACCESSORIES AND UTILITIES

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PARTS	INSPECTION	OVERHAUL
Regulator	300 Flight Hrs.	5 Yrs.
Pressure Gauge	300 Flight Hrs.	5 Yrs.
High Pressure Lines	300 Flight Hrs.	
Low Pressure Lines	300 Flight Hrs.	
Outlets (Cabin)	300 Flight Hrs.	5 Yrs.
External Recharge Valve	Each Use	Replace Every 5 Yrs.
Masks	Each Use	Replace as Necessary

14-7. TESTING FOR LEAKS. Apply detector fluid type CD-1 solution or its equivalent. The solution should be shaken to obtain suds or foam. The suds or foam should be applied sparingly to the joints of a closed system. Look for traces of bubbles. No visible leakage should be found. Repair or replace any defective parts and retest system. With the system pressurized to service pressure, further test can be made. The rate of any leak should not exceed one percent of the total supply per 24 hour period. All traces of the detector fluid should be wiped off at the conclusion of the examination.

#### 14-8. MAINTENANCE.

- a. Check that all lines have sufficient clearance between all adjacent structures and are secured in place. Also check the cylinder to be sure it is securely mounted.
- b. Check the cylinder for the ICC identification number and for the date of the last FAA inspection and test.
- c. If cylinder is completely empty, it must be completely disassembled and inspected in an FAA approved facility before recharging.
- d. Any lines that are defective should be replaced with factory replacements.
- e. Clean all lines and fittings as described in paragraph 14-9.
- f. Use Ribbon Dope Thread Sealant (Permacel 412) on male ends of fittings only. Wrap thread in direction of thread spiral, beginning with the second thread on the fitting. Avoid getting any sealant into the lines.
- g. Refer to FAA Manual AC 43.13-1 for more details.

14-9. CLEANING OPERATIONS. To remove oil and grease from tubing and fittings, one of the following cleaning methods may be used:

a. First Method:

1. A vapor degreasing with stabilized trichlorethylene conforming to specification MIL-T-7003 shall be used.

2. Blow tubing clean and dry with a stream of clean, dried, filtered air. Care shall be taken to insure that the interior of the tubing and fittings are thoroughly cleaned.

b. Second Method:

1. Flush with naptha conforming to specification TT-N-95.

2. Blow clean and dry off all solvent with water pumped air.

3. Flush with anti-icing fluid conforming to specification MIL-F-566 or anhydrous ethyl alcohol.

4. Rinse thoroughly with fresh water.

5. Dry thoroughly with a stream of clean, dried, water pumped air or by heating at a temperature of 250° to 300° F for a suitable period.

6. The solvents may be reused provided they do not become excessively contaminated with oil. This condition shall be determined as follows:

(a) Evaporate 100 milliliters of the liquid to dryness in a weighed glass dish. Evaporation may be accomplished by heating at 200° F for one-half hour.

(b) After evaporation, cool and weigh the residue. The solvent shall not be used if the residue exceeds 100 milligrams in weight.

c. Third Method:

1. Flush with hot inhibited alkaline cleaner until free from oil and grease.

2. Rinse thoroughly with fresh water.

3. Dry thoroughly with a stream of clean, dried, water pumped air or by heating at a temperature of 250° to 300° F for a suitable period.

14-10. REMOVAL OF OXYGEN CYLINDER AND REGULATOR. The cylinder is located in the left side of the fuselage aft of the baggage area at station 157.

a. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the access panel from the rear wall of the baggage compartment. In airplanes with Serial Nos. 30-853 and 30-902 and up, remove the rear seats, if installed, and the back access panel.

CAUTION

Be sure the valve on the cylinder is closed before disconnecting any lines from the regulator.

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- b. Disconnect the control cable from the regulator.
- c. Disconnect lines from regulator.
- d. Loosen and separate the clamps holding the cylinder in place.
- e. The cylinder can be removed by first sliding it back to remove the safety cable.

**14-11. INSTALLATION OF OXYGEN CYLINDER AND REGULATOR.**

- a. With the regulator attached to the cylinder, place it into the airplane through the access opening with the regulator forward. Be careful not to bump the regulator and cylinder when installing them.
- b. Install safety cable around cylinder neck and position cylinder so regulator aligns with control cable and pressure lines.
- c. Secure cylinder in place by connecting and tightening the two clamps.
- d. Connect the pressure lines and control cable to the regulator.
- e. Install access panel on the rear wall of the baggage area.

**14-12. REMOVAL OF FILLER VALVE.**

- a. In airplanes with Serial Nos. 30-1 to 30-852 inclusive and 30-854 to 30-901 inclusive, remove the access panel from the rear wall of the baggage compartment. In airplanes with Serial Nos. 30-853 and 30-902 and up, remove the rear seats, if installed, and the back access panel.
- b. Open the valve access door located on the left side of the fuselage and remove the cap from the valve.
- c. Be sure the cylinder valve is closed and disconnect the line from the filler valve.
- d. Remove the three nuts, washers and screws holding the filler valve in place and remove valve through the access door.

**14-13. INSTALLATION OF FILLER VALVE.**

- a. Place the valve into position through the access door and secure with screws, washers and nuts.
- b. Install cap on valve and close access door.
- c. Connect filler line to valve.
- d. Install access panel aft of the baggage area.

14-14. REMOVAL OF PRESSURE GAUGE. Ascertain that the control valve is closed and there is no pressure in the system.

- a. Disconnect the connector from the back of the pressure gauge.
- b. Loosen and remove the retainer nut and clamp holding the gauge in place.
- c. Pull the gauge out from the front of the panel.

14-15. INSTALLATION OF PRESSURE GAUGE.

- a. Place the gauge into the panel from the front and replace the clamp and retainer nut on the back of the gauge. Be sure the gauge is positioned properly before tightening the clamp.
- b. Reconnect the connector at the rear of the gauge.

14-16. REMOVAL OF OUTLETS.

- a. Using a suitable spanner wrench, remove the outer half of the outlet.
- b. Remove the screws holding the trim panel and remove the panel.
- c. The outlet can now be removed from the low pressure line.

14-17. INSTALLATION OF OUTLETS.

- a. Apply sealant to the male end of the fitting.
- b. Connect the outlet to the low pressure line.
- c. Position the trim panel and secure with screws.
- d. Position the outer half outlet and secure with a suitable spanner wrench.
- e. Torque the fittings into the outlets approximately 30 inch-pounds. Do not over torque as this could damage the outlet.

14-18. PURGING OXYGEN SYSTEM. The system should be purged whenever the cylinder pressure falls below 50 psi or if any lines are left open for any length of time. Also, whenever there are any offensive odors present, it will be necessary to purge the system. Use the following procedure:

- a. Park the airplane in a NO SMOKING area.
- b. Keep all doors and windows open.
- c. Be sure all electrical systems are shut off.
- d. Connect the oxygen recharging unit to the filler valve.
- e. Plug the oxygen masks into the outlet valves and turn on the system.
- f. Set the recharging unit pressure regulator to deliver 50 psi and let the system purge for one hour. If any odor is still present, repeat the procedure for one or more hours. If the odor persists after the second purging, replace the cylinder.

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14-19. **CLEANING OF FACE MASKS.** The disposable masks are designed for one-time use and require no maintenance. The pilots and co-pilots masks can be cleaned as follows:

- a. Remove the microphone from the mask.
- b. Remove the sponge rubber discs from the mask currents. Do not use soap to clean sponge rubber discs, as this would deteriorate the rubber and give off unpleasant odors. Clean in clear water and squeeze dry.
- c. Wash the rest of the mask with a very mild solution of soap and water.
- d. Rinse the mask thoroughly to remove all traces of soap.
- e. Make sure the sides of the breathing bag do not stick together while drying, as this may decrease the life of the rubber in the bag. The mask can be sterilized with a solution of 70 percent ethyl alcohol.

TABLE XIV-1. TROUBLESHOOTING CHART (OXYGEN SYSTEM)

Trouble	Cause	Remedy
No indication of pressure on pressure gauge.	Cylinder empty or leak in system has exhausted pressure.	Charge system and check for leaks.
	Pressure gauge defective.	Replace pressure gauge.
Pressure indication normal but no oxygen flowing.	Oxygen cylinder regulator assembly defective.	Replace regulator assembly.
Offensive odors in oxygen.	Cylinder pressure below 50 psi. Foreign matter has entered the system during previous servicing.	Purge the oxygen system. Refer to Paragraph 14-18.

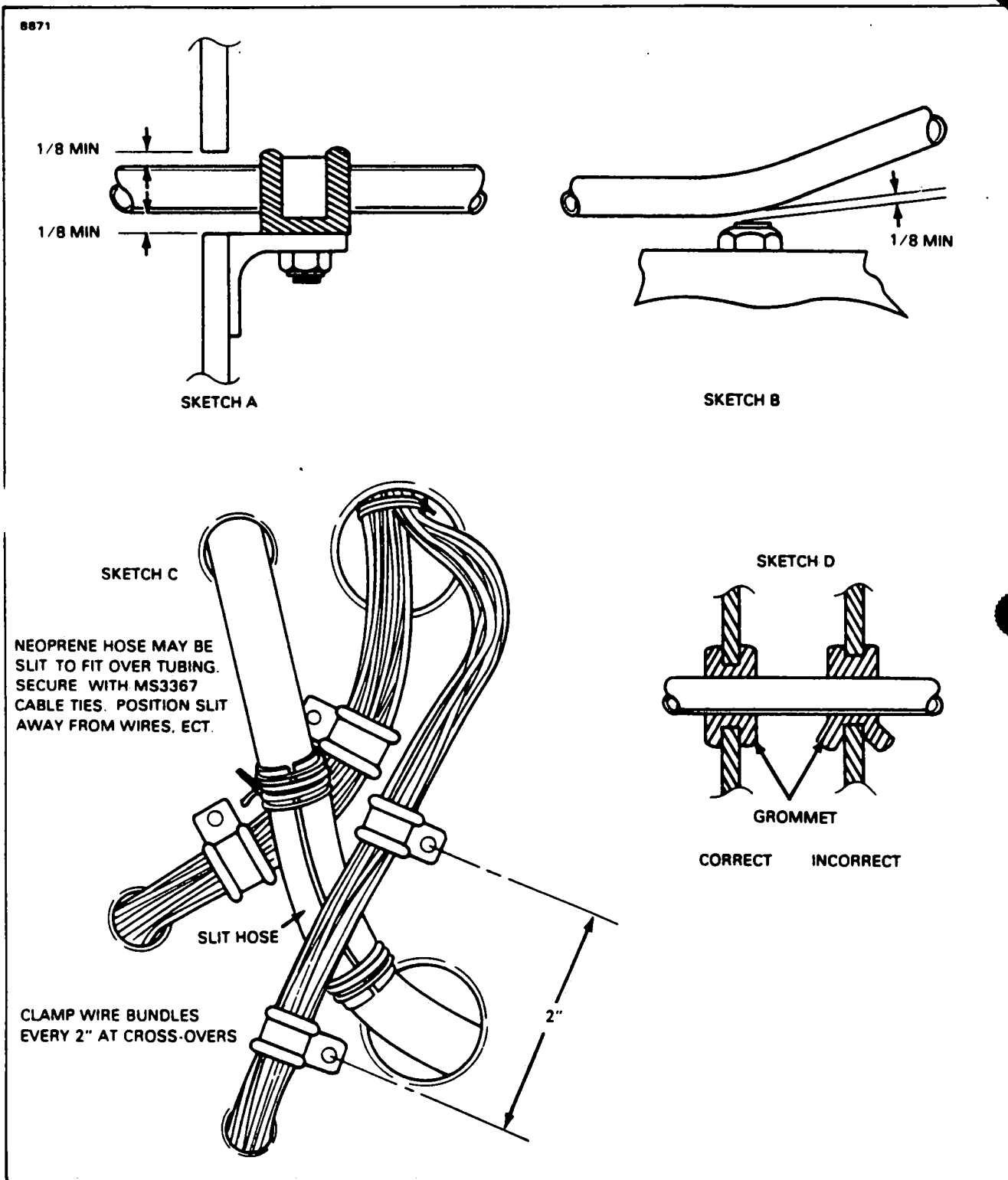


Figure 14-3a. Oxygen Tubing Installations

## 14-20. ENGINE SYNCHROPHASER

### 14-21. DESCRIPTION OF SYNCHROPHASER SYSTEM. (Refer to Figure 14-4.)

This system consists of a pulse generator, a strobe sensor, a computer, and an electrical control solenoid.

The pulse generator, located on the master LEFT engine supplies timing information to the strobe sensor on the slave RIGHT engine. The resultant error signal, generated by the strobe sensor is fed to the computer that in turn drives the servo amplifiers. The output of the servo amplifiers controls the electrical solenoid on the slave engine governor. This control action keeps the slave engine in phase with the rotation of the master engine.

The pulse generator is mechanically driven by the camshaft of the master LEFT engine. One rotation of the camshaft constitutes one cycle of engine operation of a four stroke engine. This permits the pulse generator to be timed to any relationship to the firing order of the engine. The strobe sensor is likewise driven by the camshaft on the slave engine. This gives a latitude of selection, permitting any selection of corresponding operation between master and slave engine.

The selector switch on the panel has two positions, manual or phase. In the manual position, engines and propellers are operated and controlled in the conventional manner. After manually synchronizing engines, the selector switch can be set to the phase position. This permits the synchrophaser to hold engines in RPM agreement and also in the preselected phase relationship.

### 14-22. SYSTEM OPERATING PROCEDURE.

The selector switch should be in the manual position during engine start, taxi and warmup. The switch may be turned to phase position after the take-off run has started, if desired.

### NOTE

With full throttle and full RPM the governors should be set within the synchrophasing range, if not consult Section VIII or VIIIA of this Service Manual for high RPM setting adjustment.

The propeller RPM should be manually adjusted as close to synchronization as possible for cruise, and the quadrant friction control set. Turn the switch to the phase position, if the unit does not synchronize the props, return the selector switch to manual. After 45 seconds adjust engine RPM manually to within 25 to 30 RPM of each other and return the selector switch to the phase position.

Keep the function switch in manual position except when desiring automatic control. The engine synchrophaser will bring into phase, engines with an RPM difference of over 30 RPM. However, the closer the RPM is set manually the sooner automatic phasing will be established.

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Note the lack of an audio beat when the propellers are in phase; this should be checked in flight. When an audible beat is heard with the system operating, it is undoubtedly not holding the slave engine in phase with the master engine. Return the selector switch to its' manual position for 45 seconds and readjust engine RPM manually to operating RPM. Set selector switch to phase position for automatic operation. If the phasing is not established after the above procedure, it is possible that some unit of the system is not operating properly, and further ground checks should be made.

**14-23. OPERATIONAL CHECKS.** The following checks maybe made to evaluate system operating condition. A test unit should be fabricated to perform the required checks. Refer to Figure 14-8 for parts and wiring schematic to fabricate the test unit.

a. Connect an ammeter with a two ampere scale to the meter jack on the front panel of computer amplifier. Refer to Figure 14-8 . Use a suitable cable and 1/4 inch phone plug to connect to the computer.

**NOTE**

When fabricating this test box, it is advisable to make the connecting cable long enough to extend from the computer into the cockpit.

b. Connect a zero center reading 12 volt voltmeter to pins A and B in the six pin plug which connects to the computer.

**NOTE**

Short lengths of wire (8 to 10 inches) can be connected to the A and B pins in the plug to facilitate connecting the voltmeter, and when the tests are completed they can be taped and tied back. Refer to Figure 14-8.

c. With meters connected as shown in Figure 14-8 , proceed with the ground checks to determine if various units are working properly.

d. Connect the phone plug from the test box to the computer and observe the ammeter, it should show a reading with the master switch ON. This will confirm that there is voltage to the computer.

**NOTE**

The following steps should be performed from within the cockpit with the use of the aircraft starter switches.

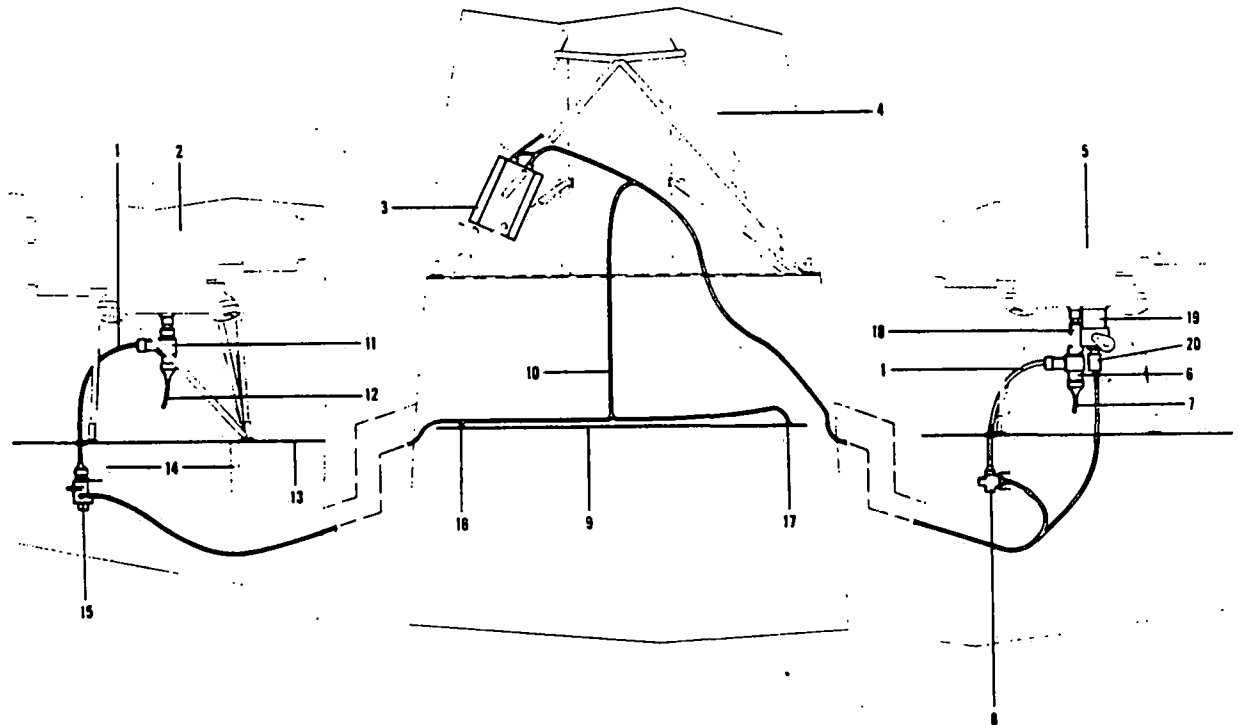
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# PIPER TWIN COMANCHE SERVICE MANUAL

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- |                                     |                                     |
|-------------------------------------|-------------------------------------|
| 1. TACH SHAFT                       | 11. DUAL DRIVE ADAPTER, LEFT ENGINE |
| 2. MASTER ENGINE                    | 12. EXISTING TACHOMETER SHAFT       |
| 3. COMPUTER                         | 13. FIREWALL                        |
| 4. NOSE LANDING GEAR MOUNT          | 14. NACELLE BULKHEADS               |
| 5. SLAVE ENGINE                     | 15. PULSE GENERATOR                 |
| 6. DUAL DRIVE ADAPTER, RIGHT ENGINE | 16. SWITCH                          |
| 7. EXISTING TACHOMETER SHAFT        | 17. CIRCUIT BREAKER                 |
| 8. STROBE SENSOR                    | 18. ADAPTER                         |
| 9. INSTRUMENT PANEL                 | 19. GOVERNOR                        |
| 10. WIRE HARNESS                    | 20. SOLENOID                        |

Figure 14-4. Synchrophaser Installation

e. Ascertain that the magneto switches are OFF. Turn the master switch ON, and set the synchrophaser switch on MANUAL. Read the solenoid current on the ammeter. A stabilized reading should be 1 ampere  $\pm$  .2 ampere.

NOTE

When first selecting the manual operation, the meter current maybe near zero or near maximum of meter scale. The solenoid current is slowly corrected and takes five to thirty-five seconds to stabilize.

NOTE

The above step must always proceed phase operation when flying or making ground checks. Always use manual selection for stand-by service.

f. Start and adjust the master LEFT engine at near cruise RPM (2200 RPM or above). Set the selector switch to propeller sync. Rotate the slave RIGHT engine with the use of the starter (right Magneto switch OFF) until the zero center reading voltmeter deflects to the right or left of center. A full deflection to the right indicates a photo conductor is supplying a signal to the computer amplifier and must cause the ammeter to increase slowly to a maximum of approximately 1.75 amperes.

g. When the above condition is met, rotate the slave RIGHT engine with the use of the starter to a position that will cause the zero center reading voltmeter to deflect to left of center. A full deflection to left must cause a slow amperage decrease to 0 amps. This indicates that the other photo conductor is supplying a signal to the computer amplifier.

NOTE

A decrease in solenoid current indicates the slave engine is increasing RPM. An increase in solenoid current indicates the slave engine is decreasing RPM.

When conditions of step h and i are met, it will confirm that all components are operating.

h. Return the selector switch to manual and start the slave RIGHT engine. Operate the master LEFT engine at near cruise RPM. Set the selector switch to propeller sync position and advance the slave engine speed slightly over that of the master engine noting the deflection of the voltmeter. If it remains to the right decidedly longer than it remains on left, it confirms that the signals from the photo conductors are correct.

i. While still operating the master engine at near cruise RPM, retard revolutions of the slave engine to less than that of master engine. Note the deflection of the voltmeter. If it remains to the left decidedly longer than it remains on the right, it confirms that the signals from the photo conductors are correct.

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**NOTE**

The voltmeter readings will change from side to side with RPM and phase changes, but will show a definite tendency to stay to right or left of zero when engine RPM's are not in phase.

**14-24. TROUBLESHOOTING.** The following checks should be made when a malfunction of the system is suspected. The checks are divided into two parts, Mechanical and Electrical, and should be performed in that order. A troubleshooting chart is also supplied at the end of these instructions.

**CAUTION**

Before proceeding any further be certain that the magneto switches are OFF.

a. **MECHANICAL CHECKS:** Inspect the short tach cables used to drive the pulse generator, strobe sensor and related components for the following conditions:

1. Insufficient lubrication. Lubricate with a suitable High Temperature Grease.
2. The retainer clip on the drive end of the tach cable is not chafing against the bell housing. No signs of chafing should be evident.
3. The square ends of the tach cable is fraying. If so, dip the end in silver solder or braze it. Then file the end square to fit mating unit core.
4. Be certain the core of the pulse generator and strobe sensor rotates when the propeller is turned.
5. Check the dual drive units for possible broken parts.
6. Check the engine drive pad for possible damage.

b. **ELECTRICAL CHECKS:** Perform the following checks to isolate any trouble in the electrical components of the system.

**NOTE**

To perform some of the following checks will require a standard multimeter with a 50 volt AC scale and/or other test equipment which can be fabricated from easily obtainable components. It is advisable to make the connecting cables long enough to extend into the cockpit.

1. Pulse generator, glow lamps and wire harness checks:
  - (a) Ascertain that all tach shafts are in position and rotate the pulse generator and strobe sensor with rotation of the respective engines.
  - (b) Start and run master engine at near cruise RPM. Set selector switch at Prop Sync.
  - (c) Disconnect plug PL3 at the strobe sensor and measure AC voltage at pins D to ground coming from the computer.
  - (d) Measure AC voltage at pin E to ground coming from the computer.
  - (e) These open circuit readings should be from 30 to 40 volts AC.

#### NOTE

The pulse generator may be removed and checked with the use of an electric drill or air motor regulated to limit the RPM to 1750. Drive the generator from the tang end of the core. A patch cable junction box may be fabricated to simplify the following checks. (Refer to Figure 14-12.)

- (f) Install the fabricated patch cable and check the volt ohmmeter readings at the patch cable junction box with the pulse generator running or the simulator installed.
  - (g) If this test is positive, a bad aircraft harness lead may be present. Check the harness with a megger ohmmeter.
  - (h) Check the resistance and continuity through the pulse generator harness. Pins D and E of the small plug attached to the computer should be approximately 200 ohms.
  - (i) Check the direction of the pulse generator by operating it from both ends and observe if lights in the strobe sensor illuminate. (Use the volt ohmmeter to check light illumination. A decrease in resistance should be read when the lights glow. Connect meter at pins A to C or B to C of the large plug.) (The strobe sensor can also be disassembled for a direct visual check.)
  - (j) To ascertain that the pulse generator is supplying timing information to strobe sensor, disconnect plug PL2 from the computer chassis and measure the AC voltage across contacts E and D while operating the master engine at near cruise RPM. A reading of .2 volts AC  $\pm$  .1 volts is considered normal. If no voltage is supplied, replace the pulse generator.
2. Computer amplifier:
  - (a) If the system operates in the manual mode but not in the phase mode, listen to the computer for an audible relay click when the system is switched from the manual mode to phase mode. The relay is on the bottom deck of the computer assembly. The use of a 2 amp meter and test plug will simplify this check. (Refer to Figure 14-8.)
  - (b) If no AC voltage is supplied to the strobe sensor as outlined in step 1d, it is suspected that the lamp amplifier in the computer chassis is defective and the computer should be replaced. (Refer to paragraphs 14-29 and 14-30.)

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- (c) Inspect the inside of the computer to ascertain that the circuit boards are secure and that the tang plugs are free of corrosion. Also check for any loose wires.
- 3. Strobe sensor:
  - (a) Connect the fabricated strobe sensor tester (Refer to Figure 14-10) to the strobe sensor plug in the right nacelle.
  - (b) Slowly rotate the strobe sensor core (if the tach shaft is disconnected) or propeller and watch for a drop in the photo conductor resistance. Check both A and B lights. The resistance should be 200,000 ohms with the lights covered and 180 ohms with the lights uncovered.
  - (c) If the latter test (step b) proves negative the sensor unit must be disassembled for a visual check of lamp illumination. If the lamps do work the trouble is in the photo conductors. To be sure, aim the photo conductor cells at a source of light and move a finger or some object back and forth in front of the conductors. If the tester does not indicate a drop in resistance when the conductor cells are exposed to the light, they are inoperative and must be replaced.
  - (d) Connect the strobe sensor simulator. (Refer to Figure 14-11.) Move the potentiometer and listen to the computer. The motor should run at approximately 7 volts.
  - (e) Adjust the potentiometer just short of motor operation. Move the pressure-drain switch from ON - Pressure to OFF and then ON again; the current on the governor coil should be .05 amps.
  - (f) Move the switch from ON - drain to OFF and then ON again, the current on the governor coil should be .05 amps.

#### CAUTION

The pressure or drain should not be adjusted unless it is absolutely necessary and the system still does not synchronize.

**14-25. REMOVAL OF STROBE SENSOR.** This unit is located in the right engine nacelle aft of the firewall. (Refer to Figure 14-4.)

- a. Remove the access panel on top of the nacelle.
- b. The strobe sensor is mounted on the inboard side of the inboard longitudinal bulkhead.
- c. Loosen the knurled nuts which secure the tach shafts to the front and rear of the strobe sensor and slide the tach shafts out of the unit.
- d. Disconnect the electrical plug connector.
- e. Loosen the clamp and remove the sensor from the mounting bracket fastened to the bulkhead.

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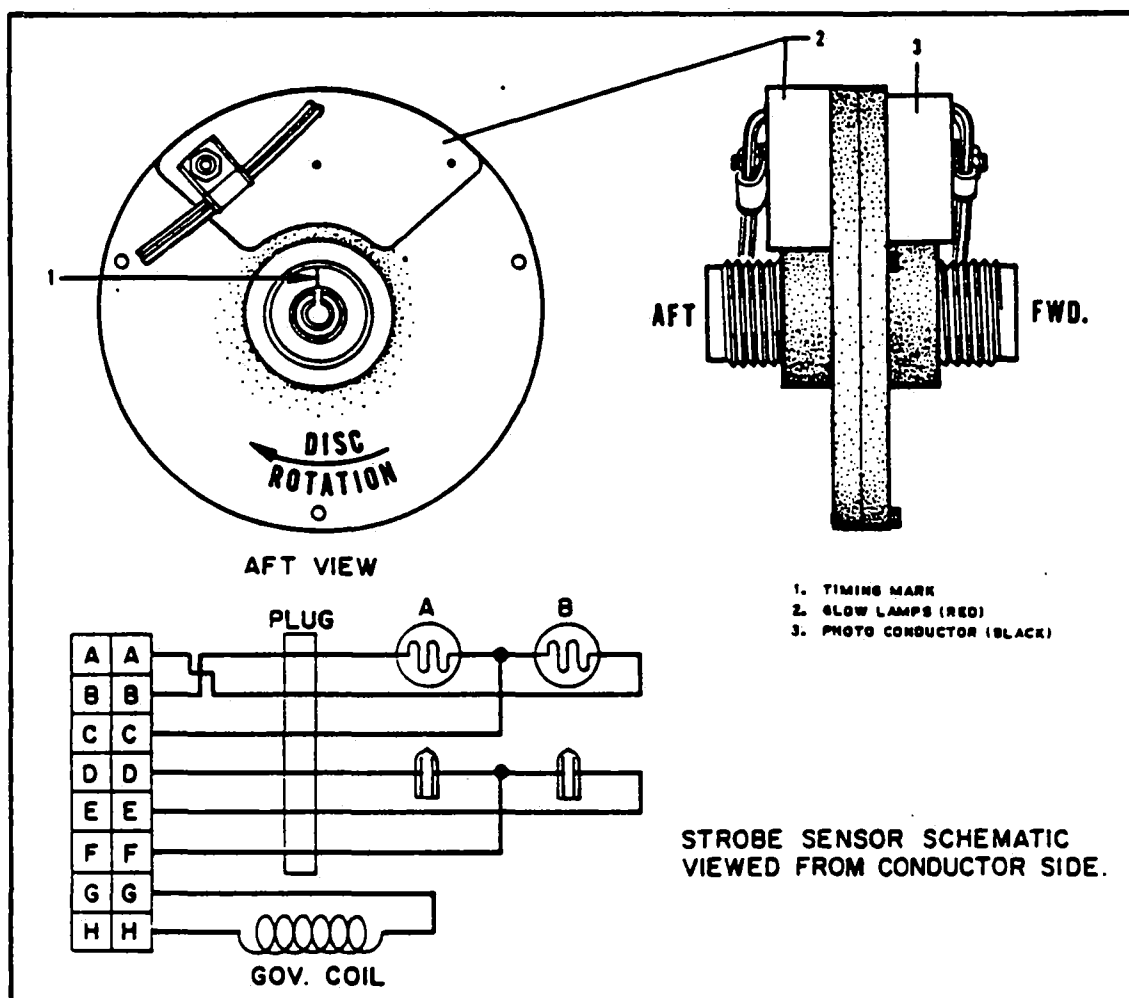


Figure 14-5. Strobe Sensor

14-26. INSTALLATION AND ADJUSTMENT OF STROBE SENSOR. (Refer to Figure 14-5.)

- a. Position the strobe sensor into the mounting bracket located on the inboard side of the longitudinal bulkhead and secure loosely with the clamp.

NOTE

The front end of the strobe sensor can be defined by the square hole in the center of the unit to accept the square end of the tach shaft.

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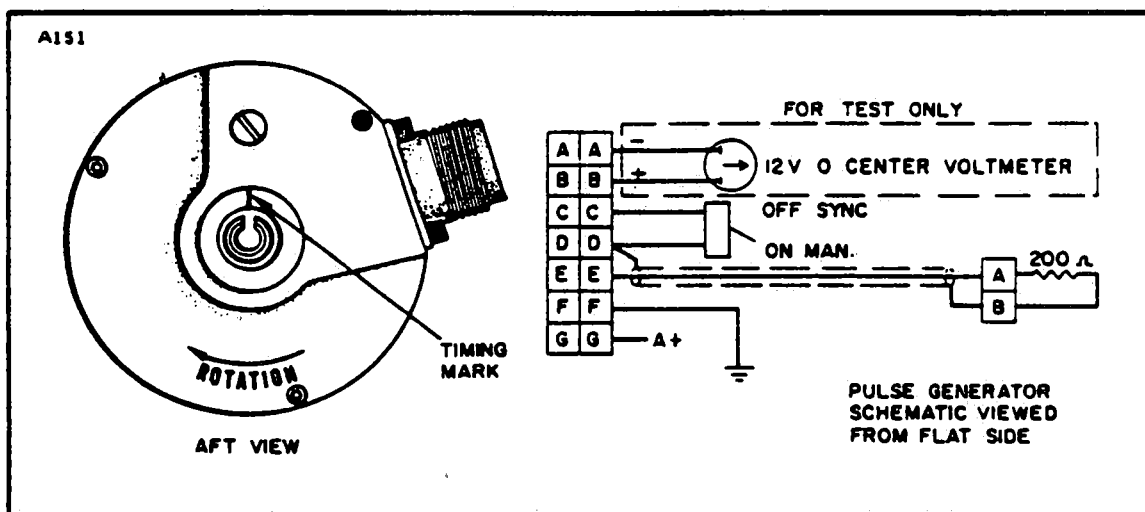


Figure 14-6. Pulse Generator

b. Install the auxiliary tach shaft to the forward end of the strobe sensor and loosely connect the knurled nut.

c. Rotate the strobe sensor case counterclockwise (viewed from the rear) until the photo conductor block is approximately on the bottom and secure the clamp.

#### CAUTION

Before proceeding any further be certain the Magneto Switches are OFF.

d. Turn the engine in the direction of rotation to locate No. 1 piston at T.D.C. on the ignition stroke. Listen for an audible magneto impulse click.

e. Place a pencil line on the spinner adjacent to the nose cowl split line, or mark the gear tooth that is adjacent to the timing mark on the starter housing.

f. Measure along the rear spinner surface (from the first line) 3.25 inches opposite the direction of rotation and place a pencil line, or count 12 teeth opposite the direction of rotation from the previously marked tooth and place a mark.

g. Move the propeller in the direction of rotation to align the new mark with the split line or timing mark. This is the phase position.

#### CAUTION

If you miss this position do not turn the propeller backwards, start over.

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h. Carefully loosen the clamp on the strobe sensor and rotate it clockwise to align the timing mark with the CENTER of the keyway on the aft end of the unit. The use of an inspection mirror will be required to view the end of the unit.

i. Secure the clamp and knurled nut when the timing marks align.

j. Pull the propeller through (in the direction of rotation) two complete revolutions and stop at the phase position as described in step g. Check the timing mark alignment. Reset if necessary.

k. Connect tach shaft to aft end of strobe sensor and secure with knurled nut.

l. Connect the electrical plug connector and install the access panel.

**14-27. REMOVAL OF PULSE GENERATOR.** This unit is located in the left engine nacelle aft of the firewall. (Refer to Figure 14-4.)

a. Remove the access panel on top of nacelle.

b. The pulse generator is mounted on the outboard side of the outboard longitudinal bulkhead.

c. Loosen the knurled nuts which secure the tach shafts to the front and rear of the pulse generator, and slide the tach shafts out of the unit.

d. Disconnect the electrical plug connector from the unit.

e. Loosen the clamp and remove the pulse generator from the mounting bracket fastened to the bulkhead.

**14-28. INSTALLATION AND ADJUSTMENT OF PULSE GENERATOR.** (Refer to Figure 14-6.)

a. Position the pulse generator into the mounting bracket located on the outboard side of the outboard longitudinal bulkhead, and loosely secure with the band clamp.

#### NOTE

The front of the pulse generator can be defined by the square hole in the center of the unit to accept the square end of a tach shaft.

b. Install the auxiliary tach shaft to the forward end of the pulse generator and loosely connect the knurled nut.

c. Rotate the pulse generator case counterclockwise (viewed from the rear) in the bracket as far as possible and secure the clamp.

#### CAUTION

Before proceeding any further be certain the magneto switches are OFF.

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d. Turn the engine (in the direction of rotation) to locate No. 1 piston at T.D.C. on the ignition stroke (use ring gear mark or first audible magneto impulse click).

**NOTE**

If you miss this point, do not turn the engine backwards, start over.

e. Carefully loosen the clamp on the pulse generator and rotate it clockwise to align the timing mark with the CENTER of the keyway on the aft end of the unit. The use of an inspection mirror will be required to view the end of the unit.

f. Secure the band clamp and the knurled nut of the tach shaft.

g. Pull the propeller through (in the direction of rotation) two complete revolutions and stop at the timed or T.D.C. position. Check the timing mark alignment on the aft side of the pulse generator. Reset the unit if necessary.

**NOTE**

The pulse generator timing mark is always set up when the master engine is at T.D.C. of No. 1 cylinder on the ignition stroke. The slave engine is then set at the desired propeller position, cylinder number and ignition stroke. This is predetermined at the factory and is different for each model aircraft.

h. Connect the tach shaft to the aft end of the pulse generator and secure with knurled nut.

i. Connect the electrical plug connector to the pulse generator and install the access panel on the nacelle.

**14-29. REMOVAL OF COMPUTER ASSEMBLY.** This unit is located in the nose section of the aircraft, mounted on the lower left portion of the nose gear mount. (Refer to Figure 14-3.)

- a. Remove the nose access panel.
- b. Disconnect the two electrical plugs connected to the computer assembly.
- c. Remove the three machine screws and related hardware used to secure the computer assembly to the gear mount, and remove the unit from the aircraft.

**14-30. INSTALLATION OF COMPUTER ASSEMBLY.** (Refer to Figure 14-4.)

- a. Position the computer assembly on the lower left portion of the nose gear mount.
- b. Secure the unit in place with three clamps and related hardware.
- c. Connect the two electrical plugs to the computer assembly.

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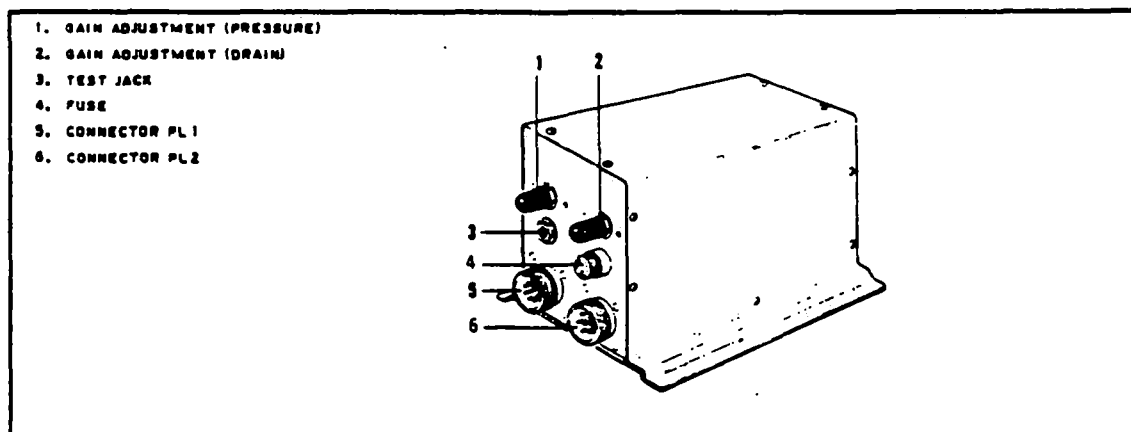


Figure 14-7. Computer Assembly

- d. Check the fuse to ascertain that it is in good condition and of the proper size (3 amp - 250 volts).
- e. Install and secure the nose access panel.

#### 14-31. REMOVAL AND INSTALLATION OF GLOW LAMPS.

- a. Remove the strobe sensor in accordance with instructions given in paragraph 14-24.

#### NOTE

Place a reference mark on the edge of the sensor to aid in alignment upon reassembly.

- b. Remove the three allen cap screws holding the two halves of the strobe sensor together. It may be necessary to tap the center shaft to separate the halves.
- c. Reconnect plug PL3 and visually observe if both glow lamps light with the master engine turning at near cruising RPM. A pulse generator simulator may be used according to paragraph 14-24 and Figure 14-13.
- d. If either of the glow lamps is inoperative, the red colored block that holds the lamps must be replaced. This is done by removing the three countersunk screws, one with an external nut, from inside the strobe sensor case and removing the block assembly. Install the new one by using the removal method in reverse.
- e. If the photo conductors are inoperative, the black colored block assembly may be replaced in the same method as the glow lamps, step d, above.
- f. Place the two halves of the strobe sensor together and align the previously made reference marks.
- g. Secure the two halves of the unit together with the three allen cap screws.
- h. Install the strobe sensor in the airplane and adjust it in accordance with paragraph 14-26.

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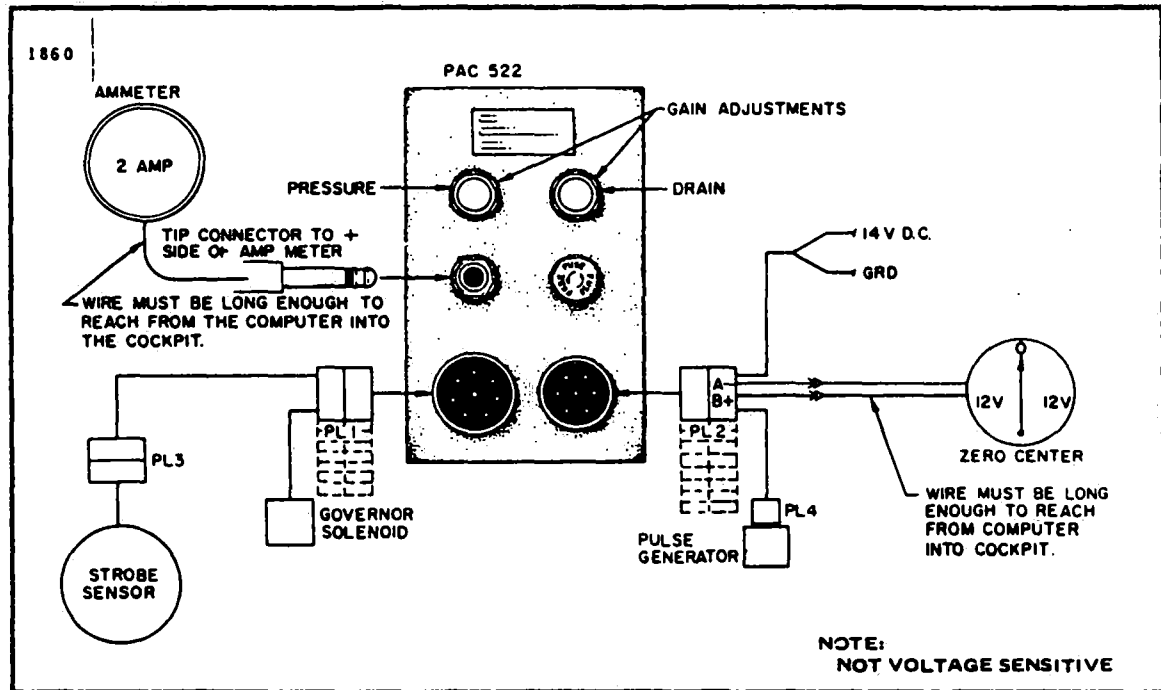


Figure 14-8. Fabricated Test Box

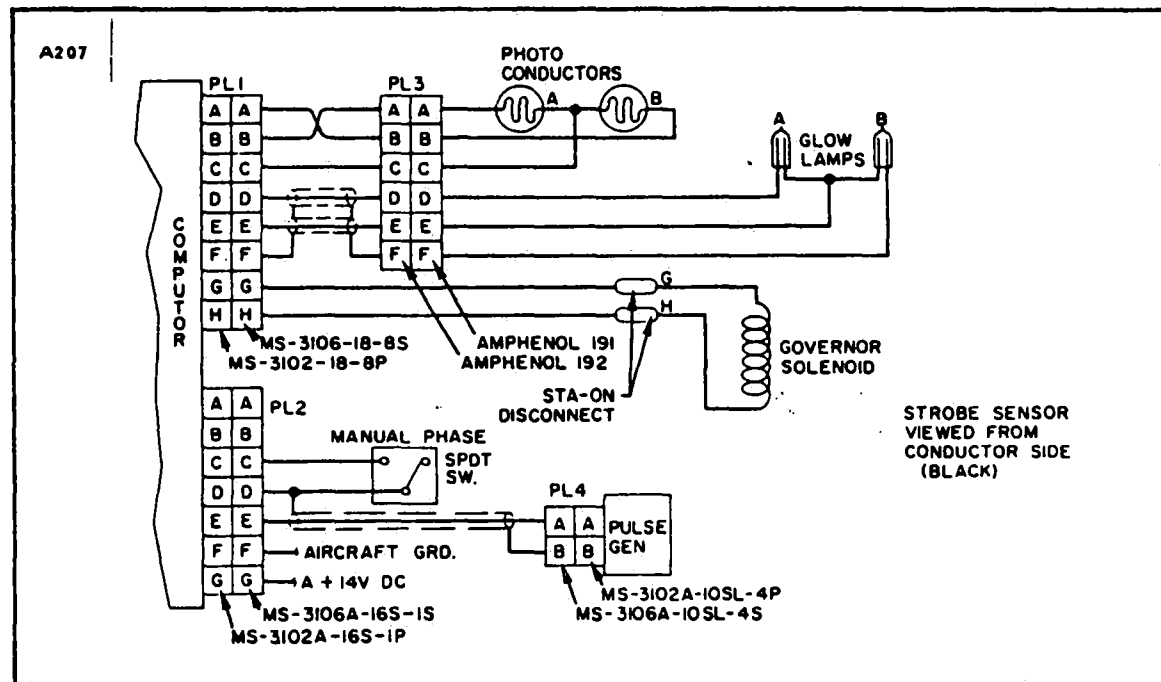


Figure 14-9. Electrical Schematic

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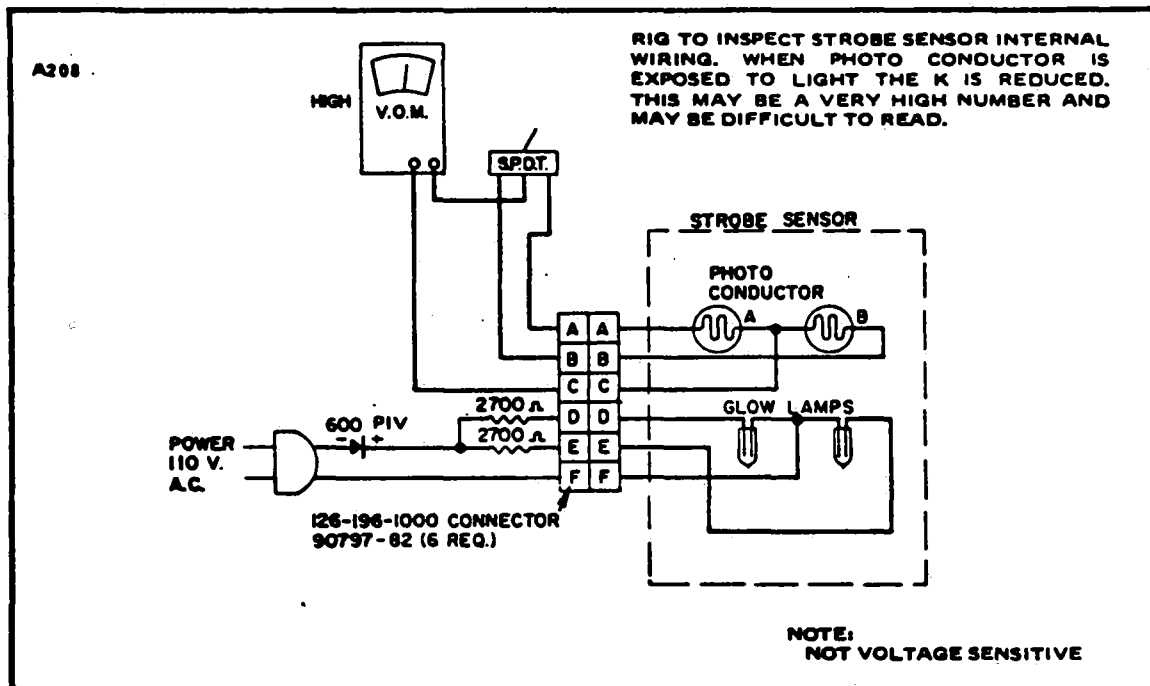


Figure 14-10. Strobe Sensor Internal Wiring Test Unit

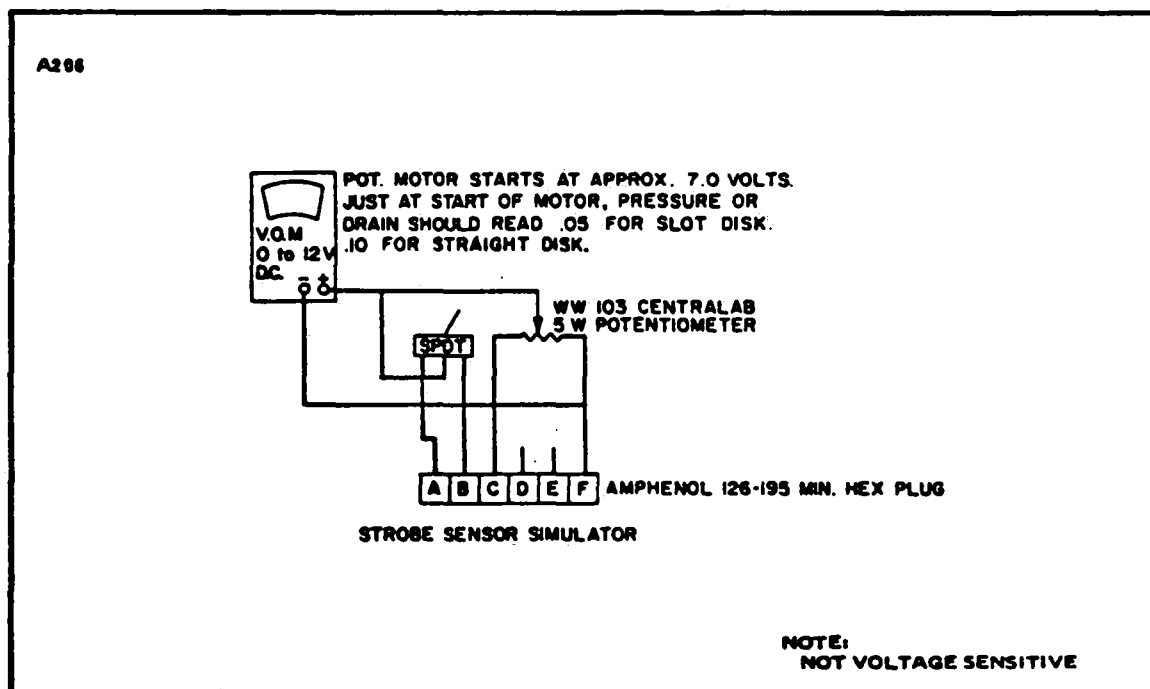


Figure 14-11. Strobe Sensor Simulator

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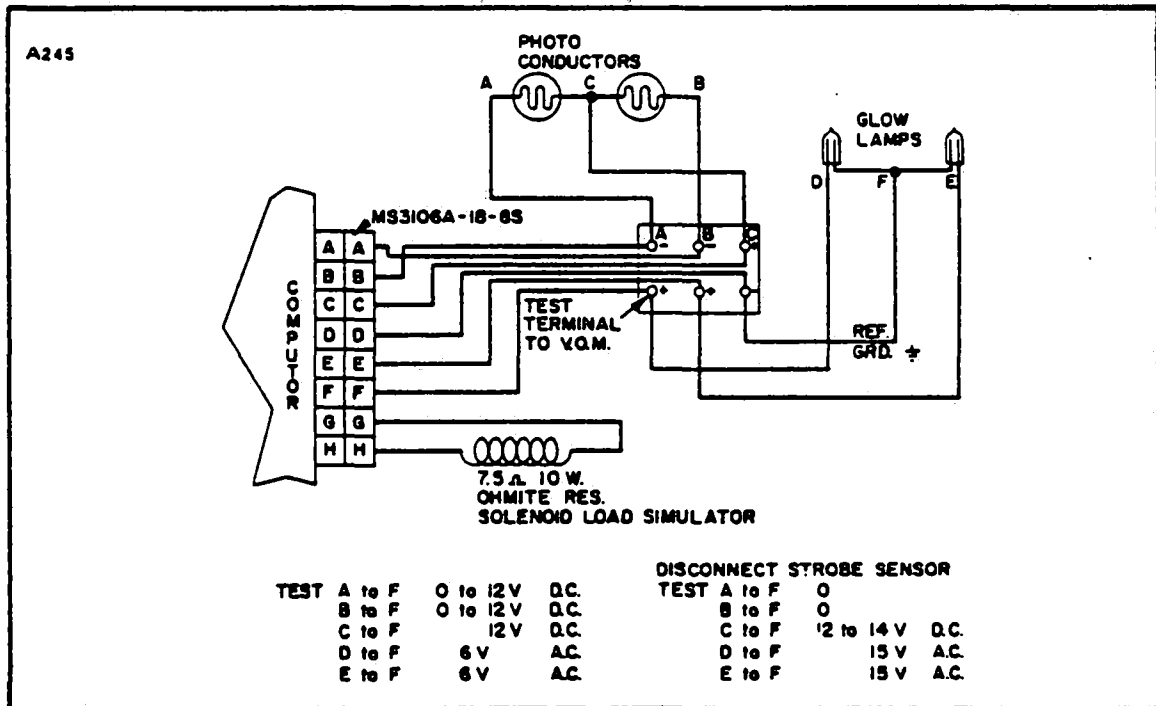


Figure 14-12. Patch Cable and Test Terminal

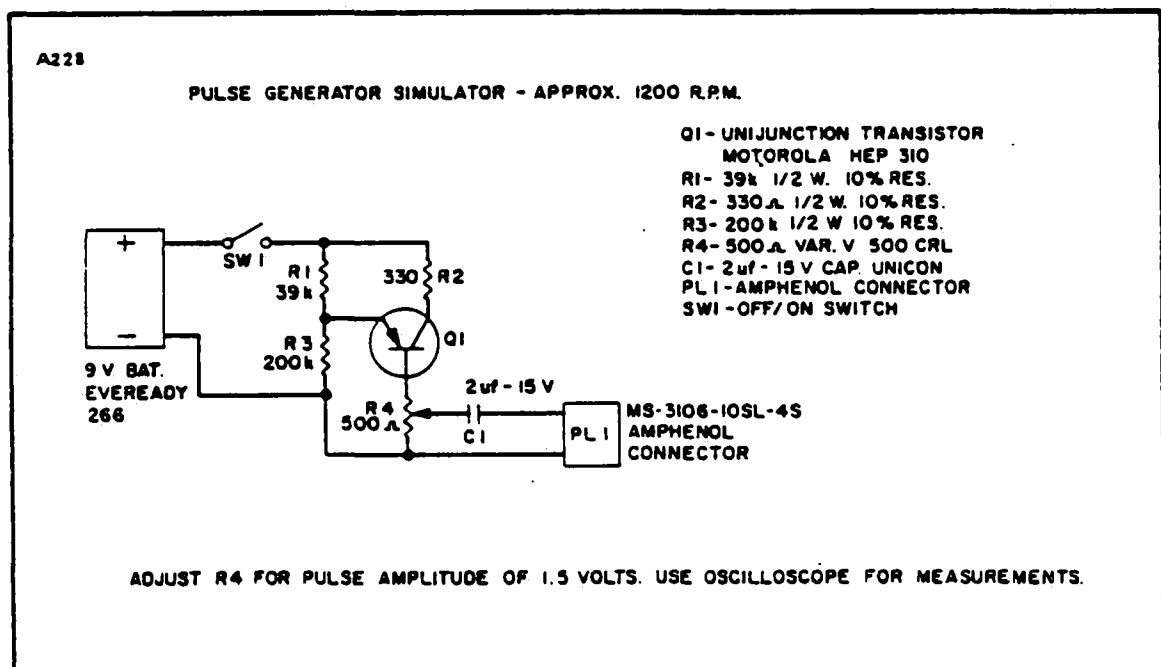


Figure 14-13. Pulse Generator Simulator

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## **PART II**

### **PA-39**

Part II (Grid 4G1 thru 4I3) contains service information peculiar to PA-39 model only. See Part I (Grid 1A15 thru 4F9) for information common to PA-30 and PA-39 models. When obtaining PA-39 service information from Part I involving PA-30 serial numbers use information pertaining to the highest serial number.

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## PART II

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## **PART II**

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# PART II

## SECTION I

### INTRODUCTION

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# PIPER TWIN COMANCHE SERVICE MANUAL

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## SECTION I

### INTRODUCTION

1-1. GENERAL. This manual contains service and maintenance instructions for the Piper PA-39 Twin Comanche, designed and manufactured as a versatile airplane in the personal and business aviation field, by the Piper Aircraft Corporation, Lock Haven, Pennsylvania.

The description of the airplane included in this section is limited to general information. For a more detailed description of the airplane, refer to the Owner's Handbook.

1-2. DESCRIPTION. The Piper PA-39 Twin Comanche is a four-place (optional 5th and 6th seat) twin engine, low-wing monoplane of all-metal construction. Paragraphs 1-3 through 1-13 provide descriptions of the major components and systems.

1-3. FUSELAGE. The fuselage consists of three basic units: the nose section, the cabin section, and the tail cone section.

1-4. WING. The laminar flow wing is of all-metal stressed-skin, full-cantilever 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 wing flaps are electrically operated.

1-5. EMPENNAGE. The empennage consists of the fin, rudder, stabilator and stabilator trim tab. The rudder and stabilator are dynamically and statically balanced.

1-6. FLIGHT CONTROLS. The flight controls are conventional, consisting of a control wheel which operates the ailerons and stabilators, and foot pedals which operate the rudder. Duplicate controls are provided for the co-pilot.

1-7. LANDING GEAR. The landing gear is an electrically operated tricycle gear, consisting of a nose wheel and two main wheels.

### INTRODUCTION PART II

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1-8. BRAKE SYSTEM. The brakes on the PA-39 are hydraulically operated by toe pedals.

1-9. ENGINES AND PROPELLERS. The airplane is powered by two Avco-Lycoming four cylinder, direct drive, wet sump, horizontally opposed, fuel injected engines. The propellers are Hartzell full feathering, constant speed units controlled by a governor mounted on each engine. Some propellers are equipped with a backup spring which allows operation of the propeller in case of loss of air from the air cylinder. These propellers are identified by the letter "S" after the hub dash number, such as HC-E2YL-2BS. The "S" propeller should not be intermixed with the other propellers. Each model with its engines and particular propellers are as follows:

Model	Engine	Propeller	H.P.	Octane
PA-39 Left Engine	IO-320-B1A	HC-E2YL-2 HC-E2YL-2S HC-E2YL-2SF	160	100/130
PA-39 Right Engine	LIO-320-B1A	HC-E2YL-2BL HC-E2YL-2BLS HC-E2YL-2BLSF	160	100/130
PA-39 Turbo Left Engine	IO-320-C1A	HC-E2YL-2 HC-E2YL-2S HC-E2YL-2SF	160	100/130
PA-39 Turbo Right Engine	LIO-320-C1A	HC-E2YL-2BL HC-E2YL-2BLS HC-E2YL-2BLSF	160	100/130

1-10. FUEL SYSTEM. The fuel system consists of four rubber-type cells located in the wings with a total fuel capacity of 90 U.S. gallons, (Optional 15 U.S. gallons each, tip tanks) two engine-driven fuel pumps, two electric auxiliary fuel pumps and two combination fuel selectors and strainer valves.

1-11. INSTRUMENTS. Provisions for the instrument installation includes panels for engine instruments and advance flight instruments. The panel is shock mounted to minimize vibration to the instruments.

1-12. ELECTRONIC EQUIPMENT. Provision for electronic equipment includes various combinations of radio installations and AutoPilot.

1-13. HEATING AND VENTILATING SYSTEM. Heated air for the cabin and defroster is obtained from a 25,000 BTU gasoline heater installed in the nose section. Fresh air for the cabin interior is obtained from two individual sources; one from the nose section and the other from a scoop located in the speed fairing ahead of the vertical fin.

**PART II**  
**SECTION II**  
**HANDLING AND SERVICING**

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TABLE II-I. LEADING PARTICULARS AND PRINCIPAL DIMENSIONS

MODEL	PA-39, PA-39 Turbo
ENGINE	
Manufacturer	Avco-Lycoming
Model	Left: IO-320B1A <sup>(1)</sup> , IO-320C1A <sup>(2)</sup> Right: LIO-320B1A <sup>(1)</sup> LIO-320C1A <sup>(2)</sup>
FAA Type Certificate	1E12
Rated Horsepower	160
Rated Horsepower, RPM:	
Full Throttle	160 hp @ 2700 RPM
Performance Cruise (75% rated)	120 hp @ 2450 RPM
Economy Cruise (65% rated)	104 hp @ 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, Counterclockwise <sup>(3)</sup>
Bore	5.125 in.
Stroke	3.875 in.
Displacement	319.8 cu. in.
Compression Ratio	8.50:1
Weight (With Starter and Alternator)	287 lbs., 294 lbs. <sup>(2)</sup>
Dimensions:	
Height	19.22 in.
Width	32.24 in.
Length	33.59 in.
Oil, SAE Number	Refer to Table II-III <sup>(4)</sup>
Oil Sump Capacity	8 quarts
Oil Consumption, Maximum	0.010 lb./bhp/hr.
Fuel, Aviation Grade, Minimum	
Octane	100/130 Octane
Fuel Injector, Bendix	RSA-5AD1
Magneto(2), Scintilla	S4LN-21, S4RN-21 <sup>(3)</sup>
Magneto Drive, Ratio to Crankshaft	1:1
Magneto Drive, Rotation	Clockwise, Counterclockwise <sup>(3)</sup>
Magneto Timing	25 degrees BTC
Magneto Point Clearance	0.018 ± 0.006

(1) PA-39 ONLY.

(2) PA-39 TURBO ONLY.

(3) ALL RIGHT ENGINES ONLY.

(4) REFER TO PART I.

## HANDLING AND SERVICING PART II

Revised: 1/31/74

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

MODEL	PA-39, PA-39 Turbo
<b>ENGINE (cont.)</b>	
Spark Plugs (Shielded):	
AC	SR-88D, 171 <sup>(1)</sup>
Champion	REM-40E, REB-37N <sup>(1)</sup>
Spark Plug Gap Setting (in.) <sup>(2)</sup>	0.018 to 0.022 in. 0.015 to 0.021 in. <sup>(1)</sup>
Firing Order	1-3-2-4, 1-4-2-3 <sup>(3)</sup>
Tachometer Drive, Ratio to Crankshaft	0.5:1
Tachometer Drive, Rotation	Clockwise, Counterclockwise <sup>(3)</sup>
Starter:	
Prestolite, 12-Volt	Model: MZ4206, MZ4216 <sup>(3)</sup>
Starter Drive, Ratio to Crankshaft	13.55:1
Starter Drive, Rotation	Counterclockwise, Clockwise <sup>(3)</sup>
Alternator, Prestolite	12-volt, ALX 8403
Voltage Regulator, Prestolite	VSF 7203 8A
Overvoltage Control, Prestolite	X17621
Vacuum Pump	200 cc, 200 cw <sup>(3)</sup>
Vacuum Pump Drive, Ratio to Crankshaft	1.30:1
Vacuum Pump Drive, Rotation	Counterclockwise, Clockwise <sup>(3)</sup>
Propeller Governor Drive	AN20010 Type XX
Propeller Governor Ratio	0.866:1
Fuel Pump	AC-GP6440296 Lear-Siegler RG17980 <sup>(1)</sup> Lear-Siegler RG17980-K <sup>(4)</sup>
<b>PROPELLER</b>	
Manufacturer	Hartzell
Type	Constant Speed Feathering
Hub	HC-E2YL-2B, HC-E2YL-2BF, HC-E2YL-2BS or HC-E2YL-2BSF HC-E2YL-2BL, HC-E2YL-2BLF, HC-E2YL-2BLS or HC-E2YL-2BLSF <sup>(3)</sup>
Blade (2)	7663-4 or F7663-4 J7663-4 or FJ7663-4

(1) PA-39 TURBO ONLY.

(2) REFER TO LYCOMING SERVICE INSTRUCTION NO. 1042.

(3) ALL RIGHT ENGINES ONLY.

(4) PA-39 TURBO RIGHT ENGINE ONLY.

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

MODEL	PA-39, PA-39 Turbo
PROPELLER (cont.)	

Diameter	72 in.
Diameter, Minimum	70 in.
Blade Angle, Low <sup>(1)</sup>	12.0 ± 0.015 degrees
Blade Angle, High <sup>(1)</sup>	78 degrees
Control Governor	Hartzell
Governor Model	F-6-3S or F-6-3A, F-6-3AL <sup>(2)</sup>

FUEL CELL CAPACITIES

Inboard (Main) Fuel Cells	Two
Capacity (Each)	30 U.S. gallons
Unusable Fuel (Each)	3 U.S. gallons
Outboard (Auxiliary) Fuel Cells	Two
Capacity (Each)	15 U.S. gallons
Tip Tanks	Two <sup>(3)</sup>
Capacity (Each)	15 U.S. gallons

LANDING GEAR

Type	Electrically retractable
Shock Strut Type	Combination Air and Oil
Fluid Required (Struts & Brakes)	MIL-H-5606 (Red)
Strut Extension (Static Load)	2.75 in.
Maximum Air Pressure (Strut)	100 psi
Tread (Width from each tire center)	9 ft. 9.5 in.
Wheel Base	7 ft. 3.625 in.
Nose Wheel Travel	25° Max. 19° Min. (right)
	25° Max. 19° Min. (left)
Main Wheel Toe-In	0 degrees
Turning Radius (Min.)	28 ft. 1.5 in. 28 ft. 11 in. <sup>(4)</sup>
Wheel, Nose	Cleveland 38501
Wheel, Main	Cleveland 40-90
Brake Type	(Disc) Cleveland 30-23
Tire, Nose	6:00 x 6, 6 ply rated
Tire, Main	6:00 x 6, 6 ply rated
Tire Pressure	42 psi

- (1) BLADE ANGLE AT 30 IN. RADIUS.  
 (2) ALL RIGHT ENGINES ONLY.  
 (3) OPTIONAL ON PA-39.  
 (4) PA-39 TURBO ONLY.

HANDLING AND SERVICING PART II  
 Revised: 1/31/74

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

MODEL	PA-39, PA-39 Turbo
<b>OVERALL</b>	
Gross Weight	3600 lbs., 3725 lbs. <sup>(1)</sup>
Gross Weight Landing	3600 lbs., 3725 lbs. <sup>(1)</sup>
Width (Span)	35 ft. 11.75 in.
Length	36 ft. 9.625 in. <sup>(1)</sup>
Height (Static Ground Line)	25 ft. 1.9375 in.
Height, Propeller Hub,	8 ft. 2.875 in.
Thrust Line Level	4 ft. 6 in.
Clearance, Propeller Tips,	
Thrust Line Level	11.5 in.
<b>FUSELAGE</b>	
Length (Including Tail Cone	
Fairing)	23 ft. 0.950 in.
Width (Without Stabilator)	47.875 in.
Height (Without Vertical Fin)	53.875 in.
<b>WINGS</b>	
Span (Width)	35 ft. 11.75 in.
	36 ft. 9.625 in. <sup>(1)</sup>
Chord:	
Station 25 inches	7 ft. 1 in.
Station 62 inches	5 ft. 5 in.
Station 211 inches	3 ft. 3 in.
Dihedral (Leading Edge)	5 degrees
Incidence	2 degrees
Wing Twist	0 degrees
Length of Flap	110.90 in.
Length of Aileron	75.30 in.
<b>EMPENNAGE</b>	
Stabilator Overall Span	12 ft. 6 in.
Fin Setting, Fixed	0 degree centerline

(1) PA-39 TURBO ONLY.

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

MODEL	PA-39, PA-39 Turbo
AREAS	
Total Wing Area (Including Aileron and Flaps)	178 sq. ft.
Aileron	14.1 sq. ft.
Flap	20.2 sq. ft.
Stabilator, including trim tab	32.5 sq. ft.
Fin	9.0 sq. ft.
Rudder	5.9 sq. ft.

CONTROL SURFACES TRAVEL

| REFER TO TABLE V-I, PART II.

CONTROL SURFACE CABLE TENSION

| REFER TO TABLE V-I, PART II.

**PART II**  
**SECTION III**  
**INSPECTION**

**NOTE**

**Refer to Part I**

**Issued: 12/29/72**

**4 G15**

**PART II**  
**SECTION IV**  
**STRUCTURES**

Paragraph	Aerofiche Grid No.
4-1.      Checking and Balancing Stabilator . . . . .	4G17

**NOTE**

Refer to Part I for Rudder and Aileron.

Revised: 6/28/76

SECTION IV  
PART II  
STRUCTURES

4-1. CHECKING AND BALANCING STABILATOR. (Serial Nos. 39-1 to 39-155 inclusive.) (Refer to Figure 4-1 .)

a. Whenever a stabilator has been repaired and/or repainted, it must be balanced before the airplane is flown.

b. Stabilator installation must be complete before balancing, including tabs and paint. Stabilator control cables (2 and 3) must be disconnected from stabilator balance arm (1) and tab actuator arm must be disconnected from stabilator tab horn during balancing. Hardware used to connect the extension spring cable and stabilator control cables should be removed. Hardware holding balance arm weight in place should be installed. A small piece of tape should be used to hold tabs neutral with stabilator. It is very important to have the stabilator free to rotate with a minimum of frictional resistance.

NOTE

If the bearing resistance is too great, it is necessary to loosen the nuts holding the stabilator torque horn to the stabilator torque tube, and those holding the stabilator to the torque tube as well as the nuts holding the stabilator stop to the torque tube. Measure the bearing resistance again. When this is done, the nuts must be tightened just enough to take the play out of the washers. The bolts holding the stabilator bearing blocks to the fuselage should be loosened and tightened finger tight during balancing. After balancing is completed, stabilator bearing block bolts should be torqued to a value of 135 to 140 inch-pounds. Ascertain that the stabilator is free to rotate with minimum friction.

c. Master check weight (6) (P/N 23584-00) (weight 1.58 pounds) should be placed on top of balance weight (5) (P/N 23594-00) with the side marked "FRONT" facing forward. (Refer to Figure 4-11.) If this is not enough weight to obtain static balance with the balance arm level, plates (4) (P/N 23179-00) must be added to the forward balance weight attaching bolt until 100% static balance is obtained or until up to two plates more than that required for balance have been added. Generally, it should not be necessary to use more than eight plates. If a total of more than eight plates is necessary to obtain balance, recheck the procedure in Steps "b" and "c."

d. Should it be necessary to obtain a stabilator without a master check weight, a temporary balancing can be accomplished by using the procedure given in "b" above. A sensitive and accurate spring scale can be used to get a balance with  $49 \pm 0.3$  inch-pounds of torque. Plates should be added (up to eight) until a lifting force between 2.71 and 2.88 pounds will balance the stabilator with the spring scale hooked to the bolt that fastens the two stabilator-connecting tabs (arm of 17 inches). As soon as a master check weight is available, the balance should be checked for accuracy.



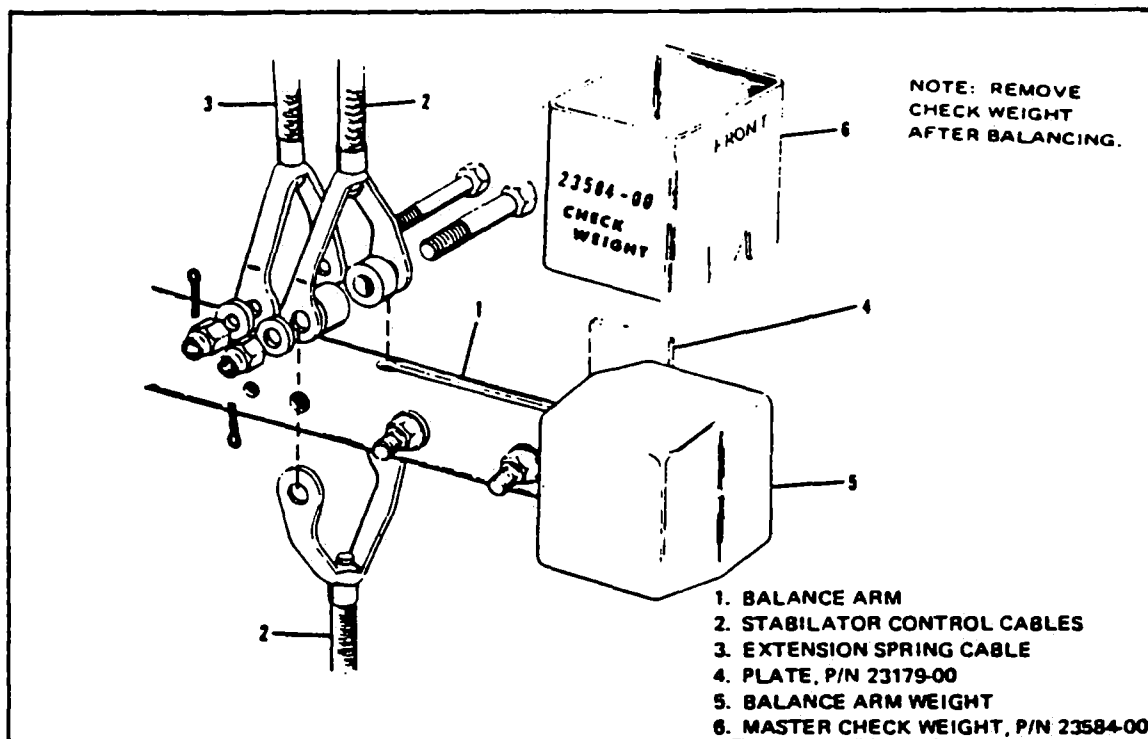


Figure 4-1. Balancing Stabilator, Serial Nos. 39-1 to 39-155 inclusive

e. After balancing is accomplished, the check weight (or spring scale) should be removed and the plates should be distributed equally on both sides of the stabilator balance tube and the bolt secured.

f. All stabilator and tab controls should be reconnected.

g. The stabilator control extension spring link should be adjusted to obtain one-half inch minimum extension of the spring with the stabilator stops adjusted and the control wheel in the full forward position.

h. The operation and feel of the stabilator controls should then be checked for proper movement.

Added: 6/28/76

STRUCTURES PART II

**PART II**  
**SECTION V**  
**SURFACE CONTROLS**

Paragraph		Aerofiche Grid No.
5-1.	Rigging and Adjustment of Stabilator Controls . .	4G20
5-2.	Adjustment of Interconnecting Control Cables . .	4G23
5-3.	Checking Stabilator Frictional Resistance . . .	4G23

Revised: 6/28/76

SECTION V

PART II

SURFACE CONTROLS

5-1. RIGGING AND ADJUSTMENT OF STABILATOR CONTROLS.

- a. Level the airplane. (Refer to Leveling, Section II of Part I.)
- b. To check and set the correct degree of stabilator travel, the following procedure may be used:
  1. Check the travel by placing a rigging tool on the upper surface of the stabilator as shown in Figure 5-1. (This tool may be fabricated from dimensions given in Figure 5-19 of Part I.)
  2. Set on a bubble protractor the number of degree up travel as given in Table V-I and place it on the rigging tool. Raise the trailing edge of the stabilator and determine that when the stabilator contacts its stops, the bubble of the protractor is centered.

NOTE


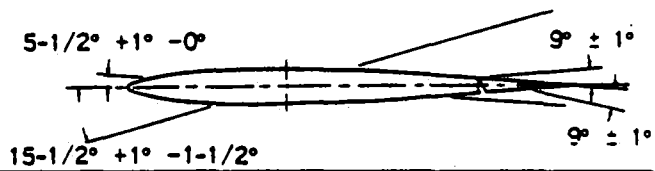
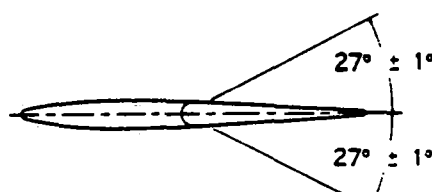
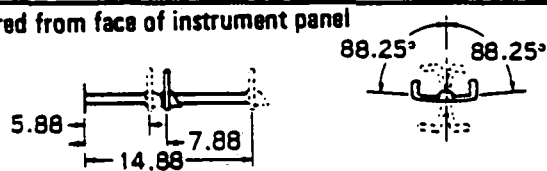
The stabilator should contact both of its stops before the control wheel contacts its stops.

3. Set on the protractor the number of degrees down travel as given in Table V-I and again place it on the rigging tool. Lower the trailing edge of the stabilator and determine that when it contacts its stops, the bubble of the protractor is centered.
4. Should the stabilator travel be incorrect in either the up or down position, remove the tail cone fairing by removing the attaching screws and with the use of the stabilator rigging tool and bubble protractor, turn the stops located at the left bearing block of the torque tube in or out (Refer to Figure 5-5 of Part I.) to obtain the correct degree of travel.
5. Ascertain that the locknuts of the stop screws are secure and reinstall the tail cone fairing.

SURFACE CONTROLS PART II

Issued: 12/29/72

TABLE V-I. CONTROL SURFACE TRAVEL AND CABLE TENSION

Control Surface Travel Aileron	
Stabilator Stabilator Trim Tab	
Rudder	 (MEASURED PERPENDICULAR TO HINGE CL)
Flaps	27° ± 1° down
Control Wheel	Measured from face of instrument panel 
Rudder Pedals	Neutral position 13° aft vertical Neutral to Fwd 3.51 in. Neutral to Aft 3.18 in. } 6.69 Total
Cable Tension Aileron Stabilator Stabilator Trim Tab Rudder <sup>(1)</sup> Rudder Trim	26 lbs ± 20% 18 lbs ± 20% 12 lbs ± 20% 25 lbs. to 40 lbs. 10 lbs ± 20% <div style="text-align: right;">NOTE CABLE TENSIONS GIVEN APPLY ONLY TO AIRPLANES WITHOUT AUTOPILOT BRIDLE CABLES ATTACHED. REFER TO APPROPRIATE AUTOPILOT SERVICE MANUAL FOR PROPER CABLE TENSIONS WHEN ATTACHING BRIDLE CABLES.</div>

(1) MEASUREMENT TAKEN AT THE FLEXIBLE PORTION OF THE CABLE NEAR THE FORWARD CABIN BULKHEAD.

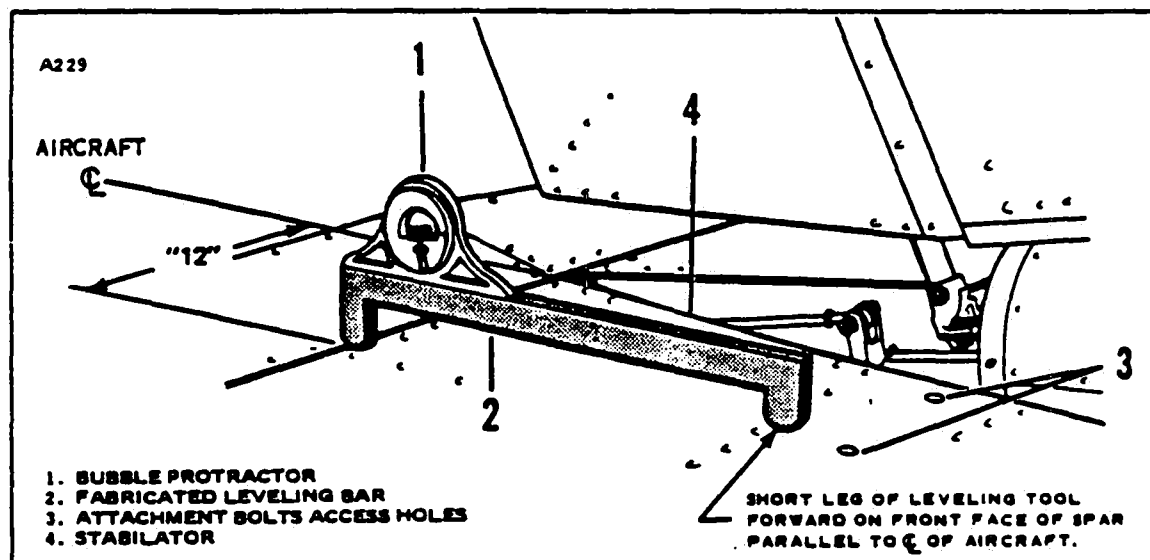


Figure 5-1. Stabilator Rigging Tool

c. To check and set stabilator control tension, and neutral relation of the control wheels with the stabilator, the following procedure may be used:

1. Ascertain that the stabilator balance (Refer to Checking and Balancing Stabilator, Section IV.) and travel are correct.

2. Remove the access panel from the rear wall of the baggage compartment or area.

3. Position and maintain the stabilator in a neutral position with the use of the bubble protractor set at zero and placed on the rigging tool.

4. With the stabilator neutral, check that the control wheel is neutral fore and aft, and the control cable tension is correct as required in Table V-I. Neutral position of the control wheel is 7.88 inches from the metallic surface of the instrument panel as measured along the underside of the control column to the wheel.

5. Should the neutral position of the control wheel and/or cable tension be incorrect, adjust the turnbuckles in the aft section of the fuselage to obtain correct position and tension. With this correct, the turnbuckles should be positioned approximately at station 172.5 to assure turnbuckle clearances.

d. Check and, if required, adjust the stabilator control extension spring located in the extreme aft portion of the fuselage to obtain 0.5 inch minimum extension of the spring with stabilator stops at correct adjustment and control wheel at the full forward position. Access to the spring is gained by removing the access panel located on the right side of the fuselage just forward of the stabilator.

e. Check the full travel of the control wheel with relation to the full travel of the stabilator to determine that the stabilator contacts its stops before the control wheel contacts its stops.

f. Check safety of turnbuckles and bolts.

g. Remove the airplane from jacks.

h. Install access plates and panels.

**5-2. ADJUSTMENT OF INTERCONNECTING CONTROL CABLES.** (Refer to Figure 5-2.) Adjust the interconnecting control cables, located under the cabin floor to the left of the flap transmission between stations 105.375 and 136.500 by the following procedure:

a. Remove the two rear seats and 5th and 6th seats, if installed.

b. Remove the seat tracks and carpet from the left side only.

c. Remove floor panels from the left side of the cabin.

d. Ascertain that rudder and aileron controls are completely installed and rigged.

e. Place the aileron and rudder controls in neutral position.

f. Adjust the interconnecting cable turnbuckles (13) and (20) so the springs (18) and (25) have 0.06 inch extension with ailerons and rudder in neutral position.

g. If necessary the left interconnecting spring (25) extension may be increased up to a maximum of 0.38 inch to allow the aileron controls to spring back to neutral approximately equal amounts from the right and left stops with the rudder controls held in the neutral position.

h. Ascertain turnbuckles have no more than three threads exposed from either end and safety.

i. Install floor panels and carpet.

j. Install seat tracks and seats.

**5-3. CHECKING STABILATOR FRICTIONAL RESISTANCE.** (Refer to Figure 5-3.)

a. Ascertain control system is completely installed, balanced and lubricated.

b. Draw an index line one inch below and parallel to the tail cone skin lap.

c. Attach an accurate spring scale (50 lb. scale) to the stabilator halves connection tabs in such a manner that the scale can be raised vertically. Measurements should be made at average room temperature whenever possible.

d. Measure up force by smoothly pulling up on the spring scales and recording measurement as the stabilator leading edge passes through the index mark.

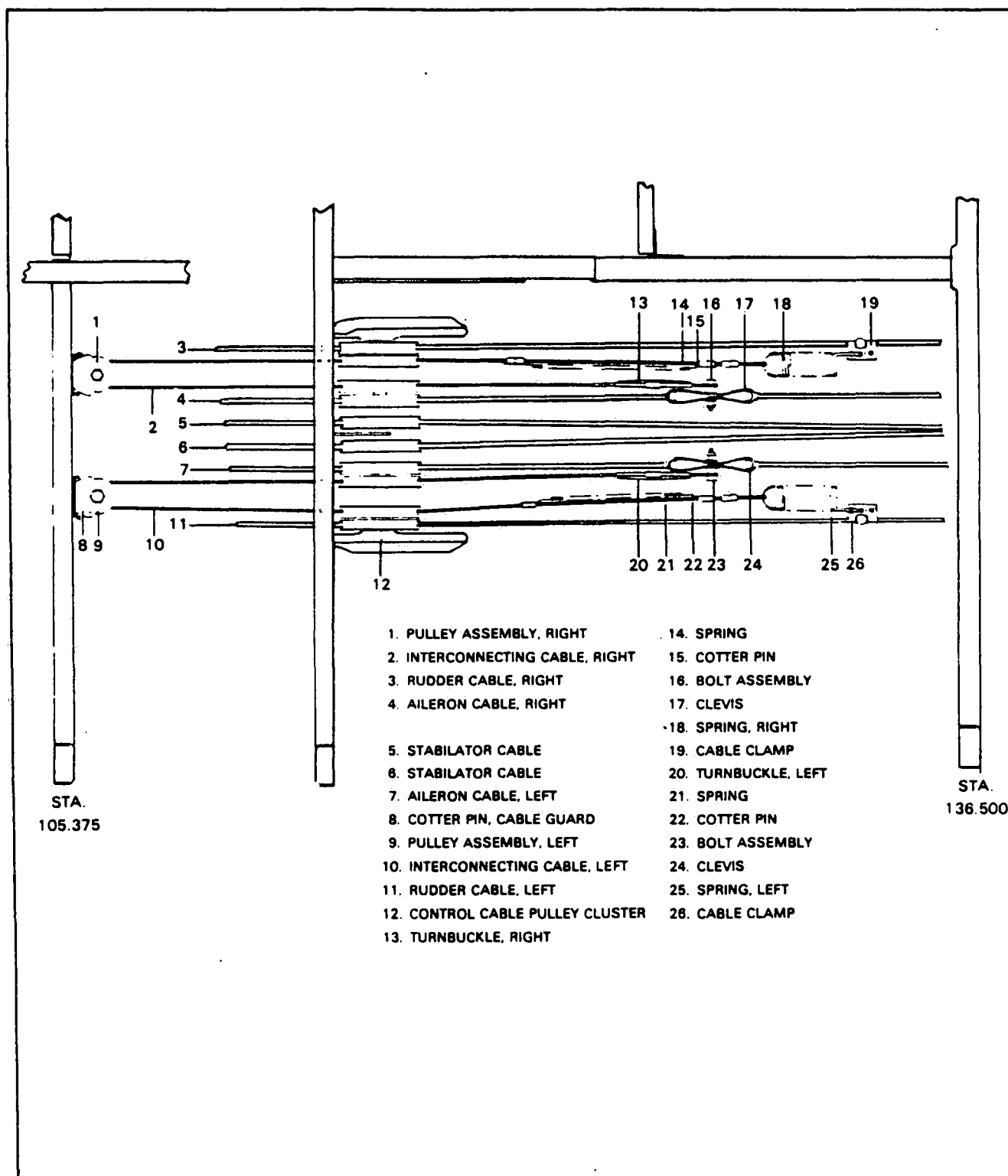


Figure 5-2. Interconnecting Control Cable Installation

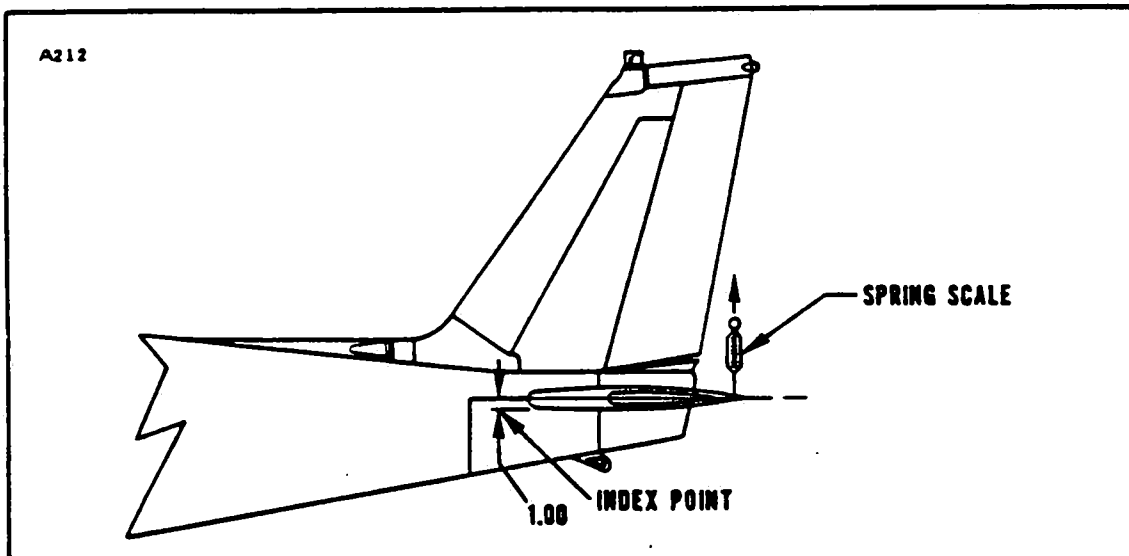


Figure 5-3. Checking Stabilator Friction

e. Measure pull "relaxing" force by maintaining tension on the spring scale and allowing the stabilator to slowly return to neutral and recording the measurement as the stabilator leading edge passes the index mark.

f. Several measurements should be made and the average used in the friction calculations which are as follows:

1. To determine system friction subtract pull relaxing force from pull up force.

EXAMPLE

Pull up force	=	25 lbs.
Pull Relaxing force	=	-5 lbs.
System friction	=	<u>20 lbs.</u>

2. Maximum permissible system friction is 25 lbs.

3. To determine average down spring force divide the system friction by 2 and add the pull relaxing force.

EXAMPLE

System friction  $\frac{20 \text{ lbs.}}{2} + 5 \text{ lbs. pull relaxing}$   
 force = 15 lbs. Average Down Spring Force.



4. Minimum permissible down spring force is 15 lbs.

g. Determine minimum permissible down spring force according to total system friction as follows:

Total System Friction	Average Down Spring Force
25 lb. max.	17 lb. min.
22 1/2 lb.	16 lb. min.
20 lb.	15 lb. min.

Example: If the friction is 25 lb. the down spring must be at least 17 lb.

h. If system friction is more than 25 lbs. check control system for binding bearings, pulleys and fairleads, and control wheel tube for sufficient lubrication.

#### NOTE

Additional friction resistance checks must be taken following any adjustment to the primary and/or bridle cables.

**PART II**  
**SECTION VI**  
**HYDRAULIC SYSTEM**

**NOTE**

**Refer to Part I**

**Issued: 12/29/72**

**PART II**  
**SECTION VII**  
**LANDING GEAR AND BRAKE SYSTEM**

**NOTE**

**Refer to Part I**

**Issued: 12/29/72**

**PART II**  
**SECTION VIII**  
**POWER PLANT**  
**(Normally Aspirated)**

Paragraph		Aerofiche Grid No.
8-1	Magneto Timing Procedure (Internal Timing) . .	4H6
8-2	Magneto Installation and Timing Procedure (Timing magneto to Engine ) . . .	4H7

Revised: 6/28/76

SECTION VIII

POWER PLANT

(Normally Aspirated)

8-1. MAGNETO TIMING PROCEDURE. (INTERNAL TIMING.) When installing or adjusting breaker points and before timing the magneto to the engine, it is important that the internal timing of the magneto be correct.

a. To internally time the magneto, it should be removed from the engine to determine "E" gap.

b. To determine "E" gap, find neutral position of the magneto drive by rotating drive coupling of S4LN-21 Magnetos in the left hand direction and S4RN-21 magnetos in the right hand direction until the red or white chamfered tooth on the distributor gear appears through the timing inspection hole. At the same location, the drive should feel to have fallen into a notch or neutral position.

c. Rotate coupling from neutral in the direction of rotation 10 degrees. Appearing through timing hole, when the white or red tooth aligns with the white line of the distributor block the magneto is set at "E" gap. (Refer to Figure 8-1.)

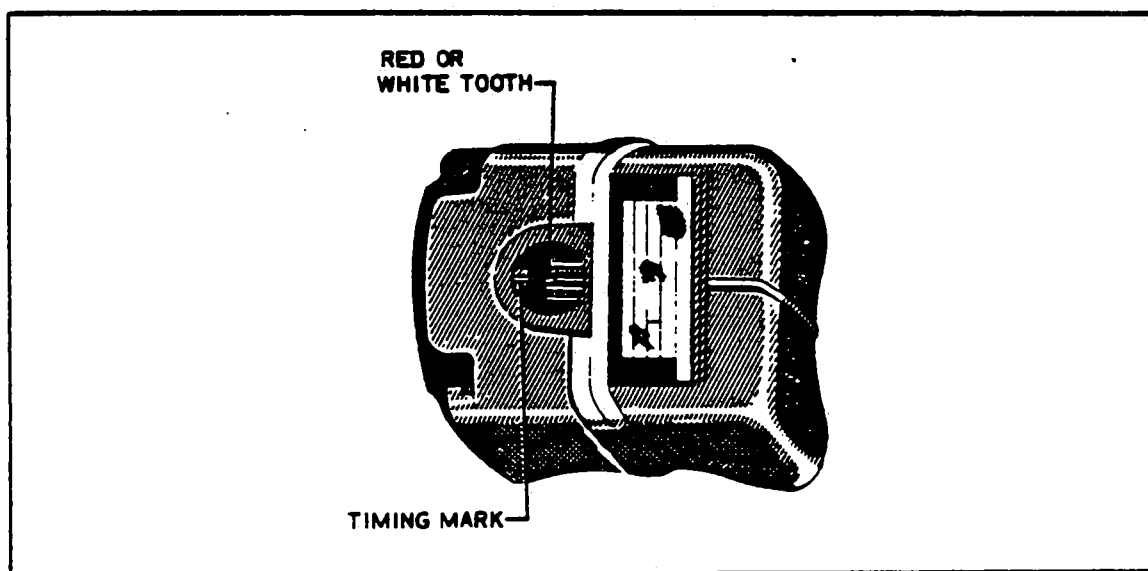


Figure 8-1. Magneto Timing Marks

d. Using the alignment of the chamfered tooth on the distributor gear and the white line on the distributor block as a reference, adjust the breaker points to open at this point.

e. Turn the magneto drive until the cam follower is on high point of the cam lobe. Measure contact clearance, it must be 0.018 of an inch  $\pm$  0.006 with the point opening set at "E" gap. If breaker points do not come within tolerances, they should be replaced.

**8-2. MAGNETO INSTALLATION AND TIMING PROCEDURE.** (Timing Magneto to Engine.) The magnetos can be installed and timed to the engine by the following procedure:

**NOTE**

Ascertain that the breakers are correct for proper internal timing of magnetos.

a. Remove cowling per section VIII of Part I.

b. Remove the top spark plug from No. 1 cylinder. Place the thumb of one hand over the spark plug hole and rotate the crankshaft in direction of rotation until the compression stroke is reached. The compression stroke is indicated by a positive pressure inside the cylinder tending to lift the thumb off the spark plug hole. In this position, both valves of No. 1 cylinder are closed. Turn the crankshaft opposite to its direction of rotation until it is approximately 35 degrees BTC on the compression stroke of No. 1 cylinder. Rotate the crankshaft in its direction of rotation until the 25 degrees mark on the back of the starter gear and the crankcase parting surface are aligned, or the marks on the front of the starter ring gear and the drilled hole in the starter housing align. (Refer to Figure 8-2.)

c. Rotate the drive gear on the magneto until the chamfered tooth on the distributor gear inside the magneto aligns with the white pointer as seen through the inspection hole in the magneto housing. (Refer to Figure 8-1.)

d. Without allowing the gear to turn from this position, install the magneto with gasket on the engine and secure with washers and nuts.

e. Tighten nuts sufficiently to hold magneto in position and yet allow it to be rotated.

f. Fasten the ground lead of the timinglight to an unpainted metallic portion of the magneto and one positive lead to the terminal side of the points. Ascertain that the primary ground spring is not touching the magneto case.

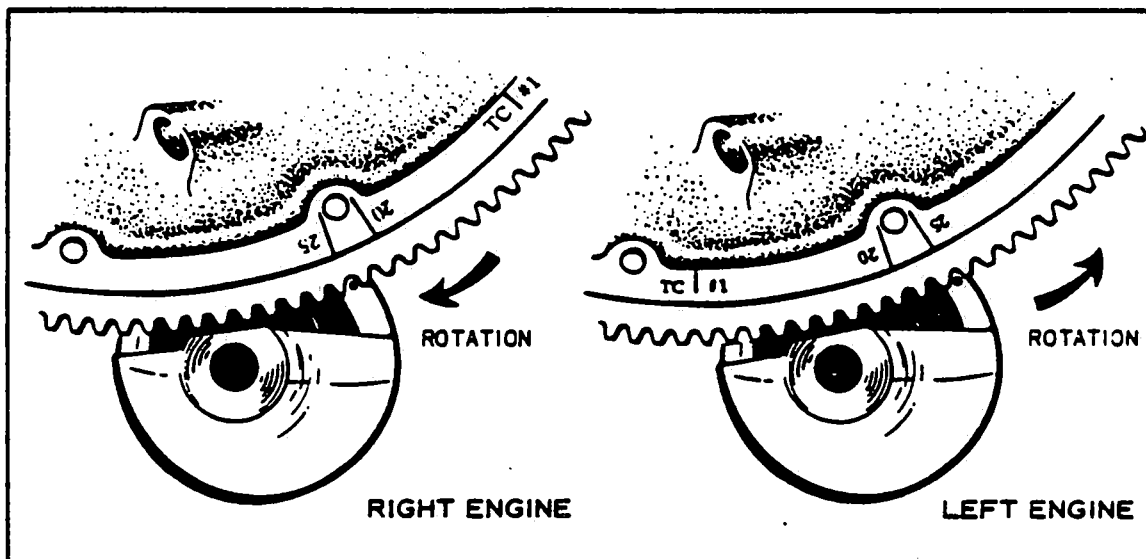


Figure 8-2. Engine Timing Mark

- g. Turn on the timing light switch.
- h. Rotate the magneto housing in direction of the magnet rotation a few degrees until light comes on. Then slowly turn magneto in opposite direction until the timing light just goes out. Secure the magneto housing in this position.

NOTE

Some timing lights operate the opposite of the one mentioned.

- i. Rotate the crankshaft opposite rotation until it is approximately 35 degrees BTC on compression stroke No. 1 cylinder.

NOTE

The crankshaft should not be rotated more than 10 degrees in the direction opposite rotation from the 25 degrees BTC as the pawl on the impulse coupling will engage with the stop pin and late timing will be indicated through the impulse coupling mechanism. If this should happen, rotate crankshaft in direction of rotation until sharp click is heard; this will indicate that the impulse coupling has passed through firing position. Turn crankshaft in the direction opposite rotation to approximately 35 degrees BTC and proceed with timing check.

- j. Turn the crankshaft very slowly in direction of rotation until the timing mark on the front face of the ring gear aligns with the drilled hole in the starter, as shown in Figure 8-2, or the timing mark on the back of the ring gear aligns with the crankcase parting surface. At this point, the light should go out.
- k. If the light does not go out at this point, align timing marks and rotate magneto on mounting flange in the desired direction and repeat the procedure until the light goes out at 25 degrees before top dead center.
- l. Tighten the two mounting nuts and replace the inspection plug.
- m. After tightening magneto mounting nuts, check timing to make sure it is still correct.
- n. Install the other magneto and time using the preceding instructions a thru l.
- o. With both magnetos timed to the engine and secured, check that they fire together. Rotate the crankshaft opposite rotation to approximately 35 degrees BTC with No. 1 cylinder on the compression stroke.
- p. If the magnetos are timed correctly, both timing lights will go out simultaneously when the crankshaft is turned in the direction of rotation aligning the 25 degree marks with either the drilled hole in the starter housing or the crankcase parting surfaces.
- q. Disconnect timing light. Ascertain that the inspection plugs and breaker cover are installed and secure.
- r. Install harness plate and secure with screws.
- s. Connect "P" leads and safety.
- t. Install cowling per section VIII of Part I.



TABLE VIII-I.

PROPELLER SPECIFICATIONS (PA-39)

Blade Angle	Low Pitch (High RPM)	12° ± 0.015° (1)	
	High Pitch (Low RPM)	78° (1) (Feathered)	
(1) MEASURE TAKEN AT 30 INCH STATION.			
Propeller RPM Setting	Engine Static High RPM Engine Static Low RPM	2700 max 1850 ± 50 min	
Propeller Torque Limits	Description	Required Torque (Dry)	
	Spinner Bulkhead (Aft)	22 foot-pounds	
	Propeller Mounting Bolts	50 foot-pounds	
	Propeller Mounting Studs	40-42 foot-pounds	
	Spinner Bulkhead Check Nut	35-40 foot-pounds	
	Spinner Attachment Screws	40 inch-pounds	
CHAMBER PRESSURE REQUIREMENTS WITH TEMPERATURE <u>HC-E2YL-2B, HC-E2YL-2BL or HC-E2YL-2BLF</u>			
Temp. °F	Press. (psi)	Temp. °F	Press. (psi)
100	188	30	165
90	185	20	162
80	182	10	159
70	178	0	154
60	175	-10	152
50	172	-20	149
40	168	-30	146
<u>HC-E2YL-2BS, HC-E2YL-2BLS or HC-E2YL-2BLSF</u>			
	Temp. °F	Press. (psi)	
	100	53	
	70	50	
	40	47	
	10	44	
	-20	42	
NOTE: Do not check pressure or charge with propeller in feather position.			

POWER PLANT PART II

Revised: 1/31/74

**PART II**  
**SECTION VIIIA**  
**POWER PLANT**  
**(Turbocharged)**

<b>Paragraph</b>		<b>Aerofiche Grid No.</b>
<b>8A-1</b>	<b>Magneto Timing Procedure (Internal Timing) . . .</b>	<b>4H12</b>
<b>8A-2</b>	<b>Magneto Installation and Timing Procedure (Timing magneto to Engine) . . . .</b>	<b>4H13</b>

**Revised: 6/28/76**

SECTION VIII

POWER PLANT

(Turbocharged)

8A-1. MAGNETO TIMING PROCEDURE. (INTERNAL TIMING.) When installing or adjusting breaker points and before timing the magneto to the engine, it is important that the internal timing of the magneto be correct.

a. To internally time the magneto, it should be removed from the engine to determine "E" gap.

b. To determine "E" gap, find neutral position of the magneto drive by rotating drive coupling of S4LN-21 Magnetos in the left hand direction and S4RN-21 magnetos in the right hand direction until the red or white chamfered tooth on the distributor gear appears through the timing inspection hole. At the same location, the drive should feel to have fallen into a notch or neutral position.

c. Rotate coupling from neutral in the direction of rotation 10 degrees. Appearing through timing hole, when the white or red tooth aligns with the white line of the distributor block the magneto is set at "E" gap. (Refer to Figure 8A-1.)

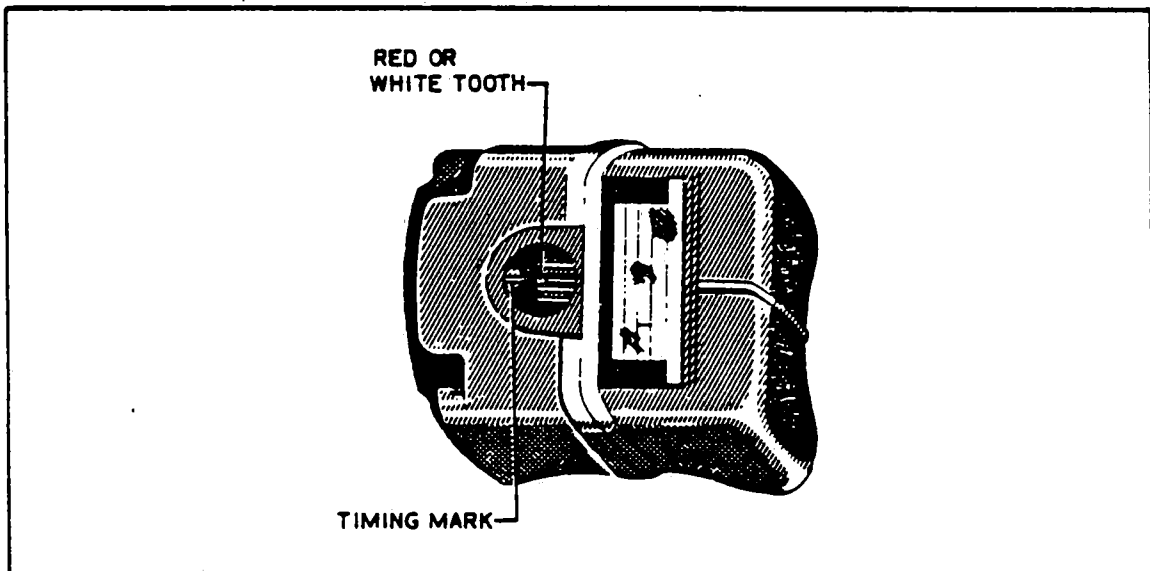


Figure 8A-1. Magneto Timing Marks

POWER PLANT PART II

Issued: 12/29/72

d. Using the alignment of the chamfered tooth on the distributor gear and the white line on the distributor block as a reference, adjust the breaker points to open at this point.

e. Turn the magneto drive until the cam follower is on high point of the cam lobe. Measure contact clearance, it must be 0.018 of an inch  $\pm$  0.006 with the point opening set at "E" gap. If breaker points do not come within tolerances, they should be replaced.

**8A-2. MAGNETO INSTALLATION AND TIMING PROCEDURE.** (Timing Magneto to Engine.) The magnetos can be installed and timed to the engine by the following procedure:

**NOTE**

Ascertain that the breakers are correct for proper internal timing of magnetos.

a. Remove cowling per section VIIIA of Part I.

b. Remove the top spark plug from No. 1 cylinder. Place the thumb of one hand over the spark plug hole and rotate the crankshaft in direction of rotation until the compression stroke is reached. The compression stroke is indicated by a positive pressure inside the cylinder tending to lift the thumb off the spark plug hole. In this position, both valves of No. 1 cylinder are closed. Turn the crankshaft opposite to its direction of rotation until it is approximately 35 degrees BTC on the compression stroke of No. 1 cylinder. Rotate the crankshaft in its direction of rotation until the 25 degrees mark on the back of the starter gear and the crankcase parting surface are aligned, or the marks on the front of the starter ring gear and the drilled hole in the starter housing align. (Refer to Figure 8A-2.)

c. Rotate the drive gear on the magneto until the chamfered tooth on the distributor gear inside the magneto aligns with the white pointer as seen through the inspection hole in the magneto housing. (Refer to Figure 8A-1.)

d. Without allowing the gear to turn from this position, install the magneto with gasket on the engine and secure with washers and nuts.

e. Tighten nuts sufficiently to hold magneto in position and yet allow it to be rotated.

f. Fasten the ground lead of the timing light to an unpainted metallic portion of the magneto and one positive lead to the terminal side of the points. Ascertain that the primary ground spring is not touching the magneto case.

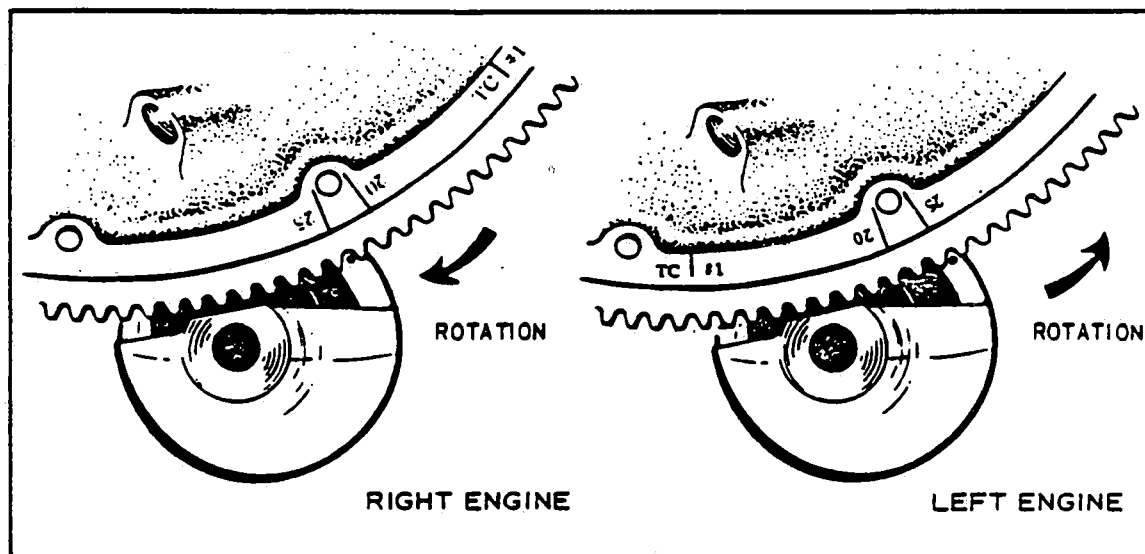


Figure 8A-2. Engine Timing Marks

- g. Turn on the timing light switch.
- h. Rotate the magneto housing in direction of the magnet rotation a few degrees until light comes on. Then slowly turn magneto in opposite direction until the timing light just goes out. Secure the magneto housing in this position.

NOTE

Some timing lights operate the opposite of the one mentioned.

- i. Rotate the crankshaft opposite rotation until it is approximately 35 degrees BTC on compression stroke No. 1 cylinder.

NOTE

The crankshaft should not be rotated more than 10 degrees in the direction opposite rotation from the 25 degrees BTC as the pawl on the impulse coupling will engage with the stoppin and late timing will be indicated through the impulse coupling mechanism. If this should happen, rotate crankshaft in direction of rotation until sharp click is heard; this will indicate that the impulse coupling has passed through firing position. Turn crankshaft in the direction opposite rotation to approximately 35 degrees BTC and proceed with timing check.

j. Turn the crankshaft very slowly in direction of rotation until the timing mark on the front face of the ring gear aligns with the drilled hole in the starter, as shown in Figure 8A-2, or the timing mark on the back of the ring gear aligns with the crankcase parting surface. At this point, the light should go out.

k. If the light does not go out at this point, align timing marks and rotate magneto on mounting flange in the desired direction and repeat the procedure until the light goes out at 25 degrees before top dead center.

l. Tighten the two mounting nuts and replace the inspection plug.

m. After tightening magneto mounting nuts, check timing to make sure it is still correct.

n. Install the other magneto and time using the preceding instructions a thru l.

o. With both magnetos timed to the engine and secured, check that they fire together. Rotate the crankshaft opposite rotation to approximately 35 degrees BTC with No. 1 cylinder on the compression stroke.

p. If the magnetos are timed correctly, both timing lights will go out simultaneously when the crankshaft is turned in the direction of rotation aligning the 25 degree marks with either the drilled hole in the starter housing or the crankcase parting surfaces.

q. Disconnect timing light. Ascertain that the inspection plugs and breaker cover are installed and secure.

r. Install harness plate and secure with screws.

s. Connect "P" leads and safety.

t. Install cowling per section VIIIA of Part I.

**PART II**  
**SECTION IX**  
**FUEL SYSTEM**

**NOTE**

**Refer to Part I**

**Issued: 12/29/72**

**PART II**  
**SECTION X**  
**INSTRUMENTS**

Issued: 12/29/72

**4 H17**



- |  |                             |
|--|-----------------------------|
| 1. RATE OF TURN INDICATOR                        | 26. PARK, BRAKE HANDLE      |
| 2. AIRSPEED INDICATOR                            | 27. POST LIGHTS SWITCH      |
| 3. STALL WARNING LIGHT                           | 28. LANDING LIGHT L         |
| 4. GYRO HORIZON                                  | 29. LANDING LIGHT R         |
| 5. G/S COUPLER LIGHT                             | 30. PITOT HEAT              |
| 6. DIRECTIONAL GYRO                              | 31. MIXTURE INDICATOR       |
| 7. ALTIMETER                                     | 32. MAP LIGHT               |
| 8. RATE OF CLIMB                                 | 33. AMMETER                 |
| 9. OMNI BEARING SELECTOR                         | 34. NAV. SELECTOR SWITCH    |
| 10. MARKER BEACON                                | 35. LANDING GEAR SELECTOR   |
| 11. TRANSPONDER                                  | 36. AUTOFLIGHT              |
| 12. RADIO SELECTOR PANEL                         | 37. ALTERNATOR TEST BUTTONS |
| 13. ADF RADIO                                    | 38. GYRO SUCTION GAUGE      |
| 14. COMM/NAV TRANSCEIVERS                        | 39. FLAP INDICATOR          |
| 15. ALTIMATIC IIIB                               | 40. NAV/APPROACH COUPLER    |
| 16. LEFT TACHOMETER                              | 41. FLAP ACTUATOR SWITCH    |
| 17. MANIFOLD PRESSURE GAUGE                      | 42. RUDDER TRIM             |
| 18. RIGHT TACHOMETER                             | 43. ALTERNATE AIR CONTROLS  |
| 19. FUEL FLOW INDICATOR                          | 44. COWL FLAPS L - R        |
| 20. FUEL AND ENGINE GAUGES                       | 45. ALTERNATOR SWITCHES     |
| 21. DME  | 46. OXYGEN CONTROL          |
| 22. MASTER SWITCH                                | 47. CIGAR LIGHTER           |
| 23. VOLT. REG. SEL. SWITCH                       | 48. CIRCUIT BREAKER PANEL   |
| 24. NAV LIGHTS                                   | 49. CABIN HEAT CONTROLS     |
| 25. RED, ANTI-COLLISION<br>WHITE, ANTI-COLLISION | 50. DEFROSTER CONTROL       |

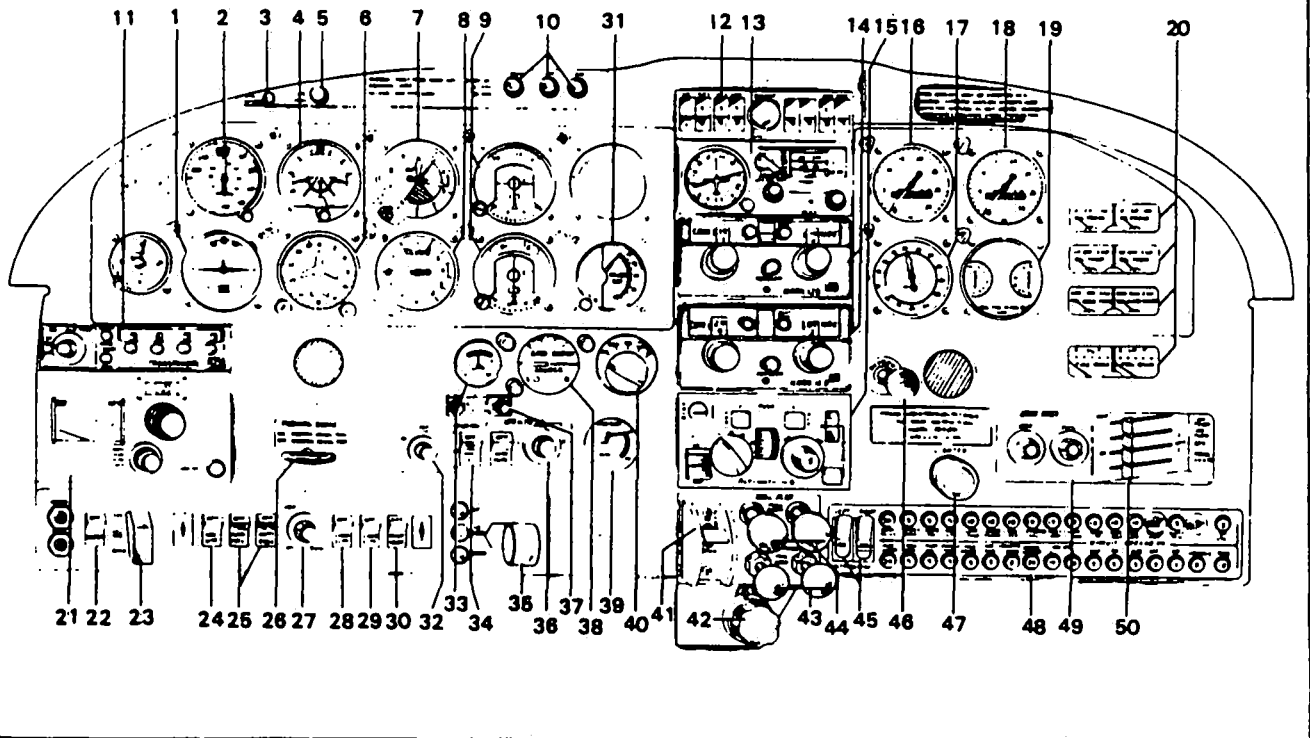


Figure 10-1. Instrument Panel

**PART II**  
**SECTION XI**  
**ELECTRICAL SYSTEM**

Issued: 12/29/72

**4 H19**

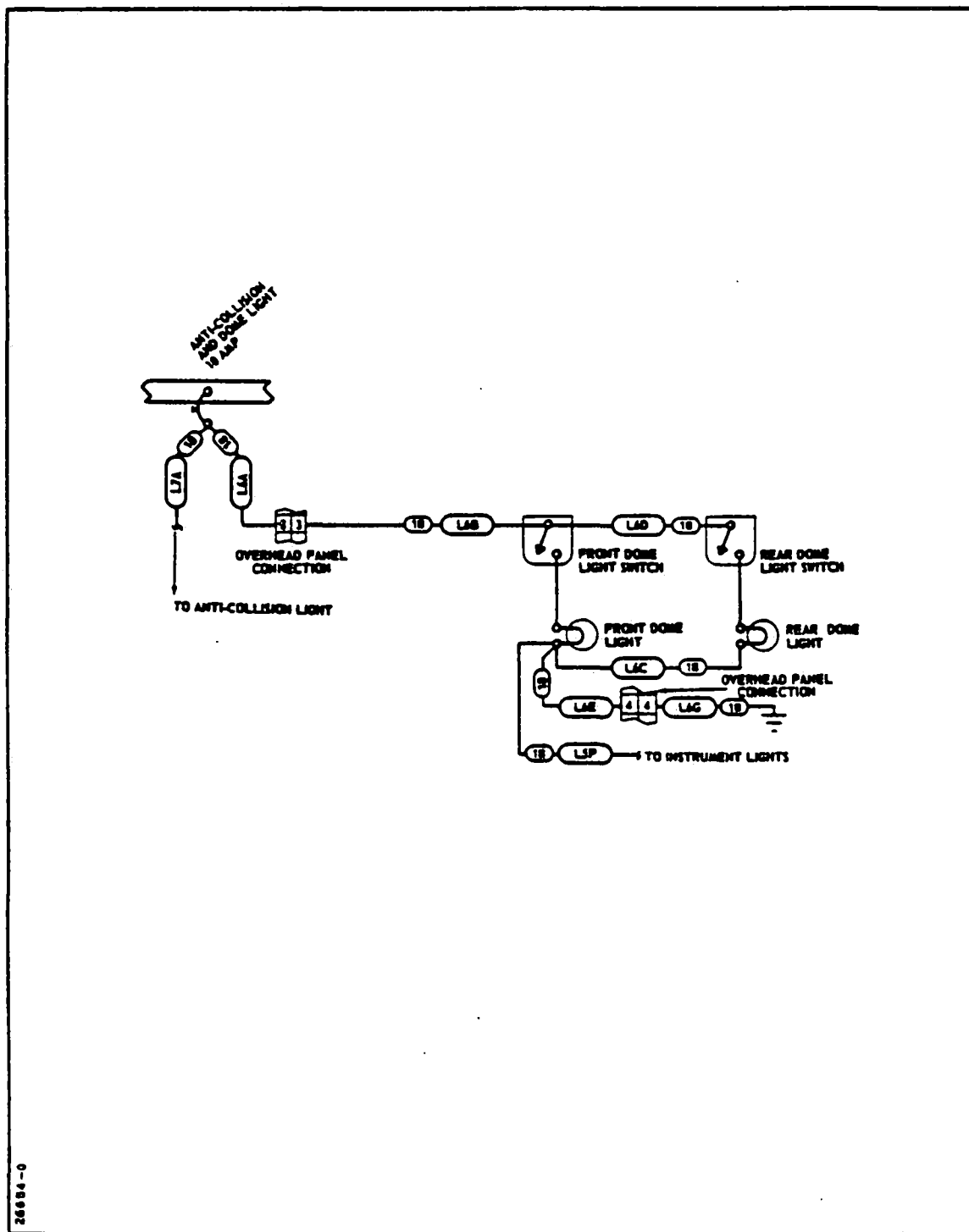


Figure 11-1. Dome lights Schematic

ELECTRICAL SYSTEM PART II

Issued: 12/29/72

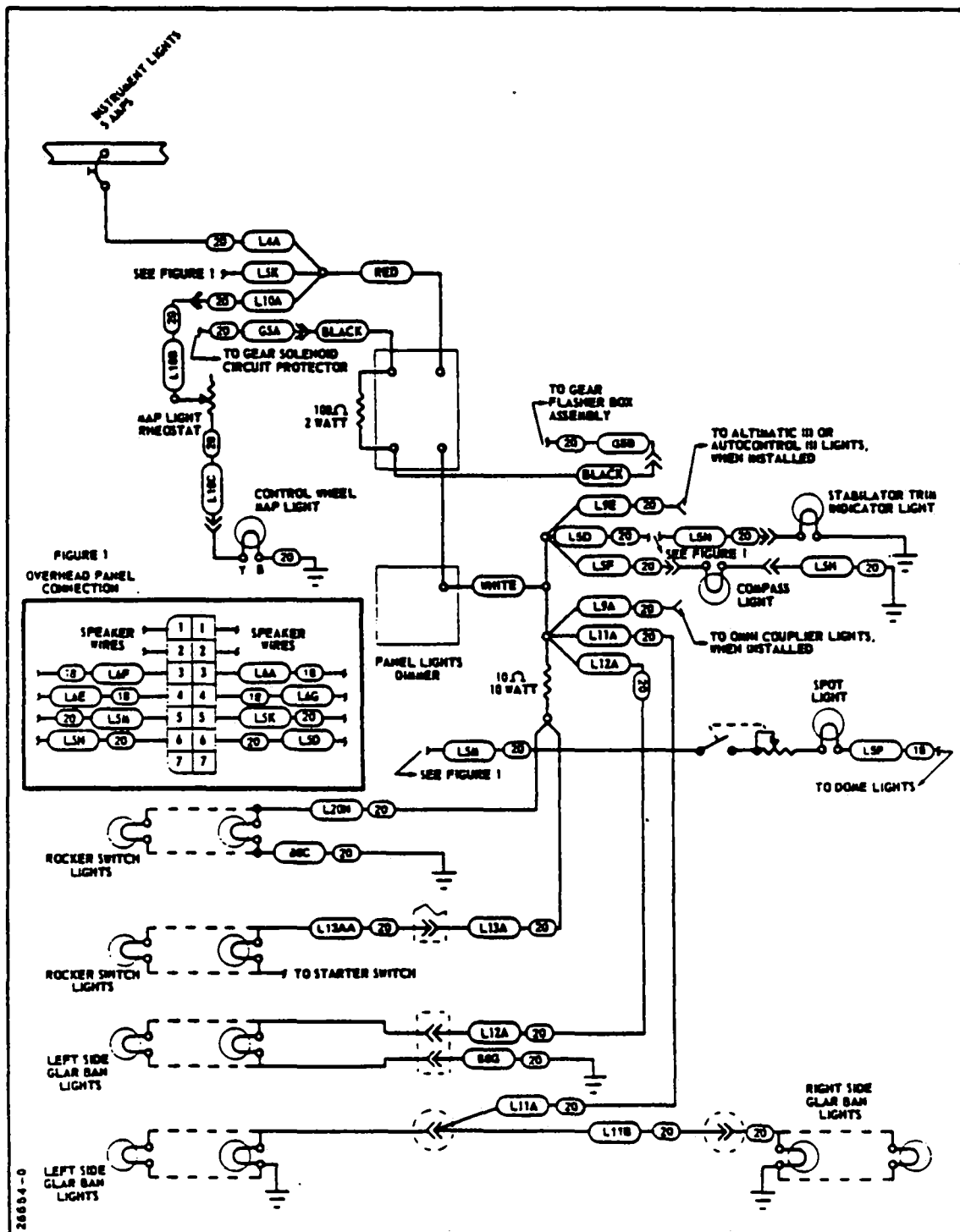


Figure 11-2. Instrument lights Schematic

ELECTRICAL SYSTEM PART II

Issued: 12/29/72

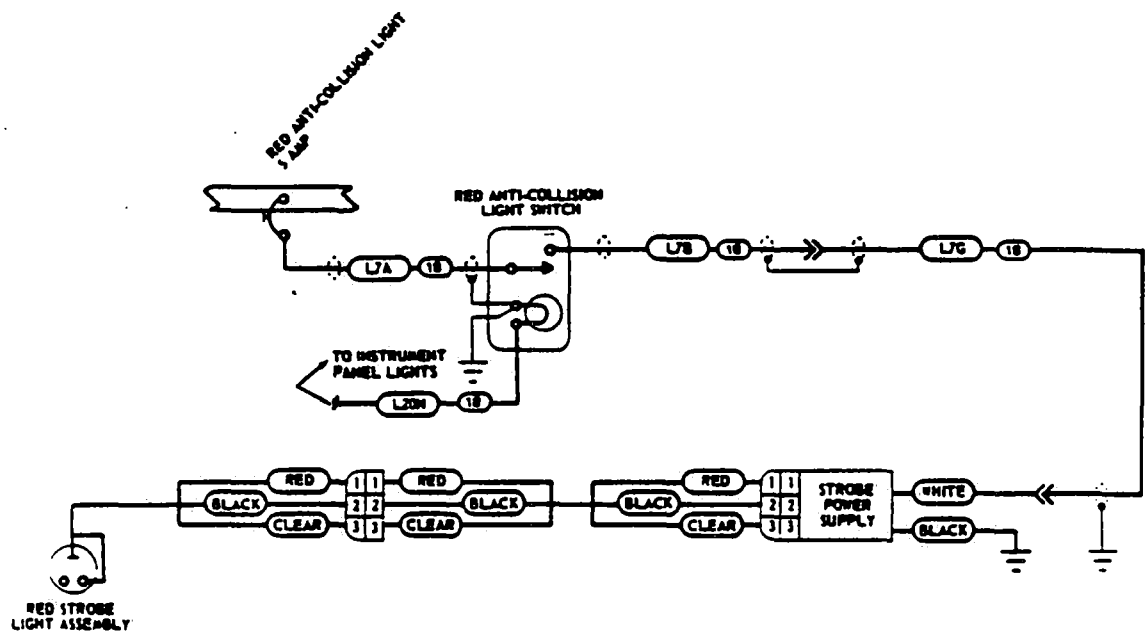


Figure 11-3. Red Strobe light Schematic

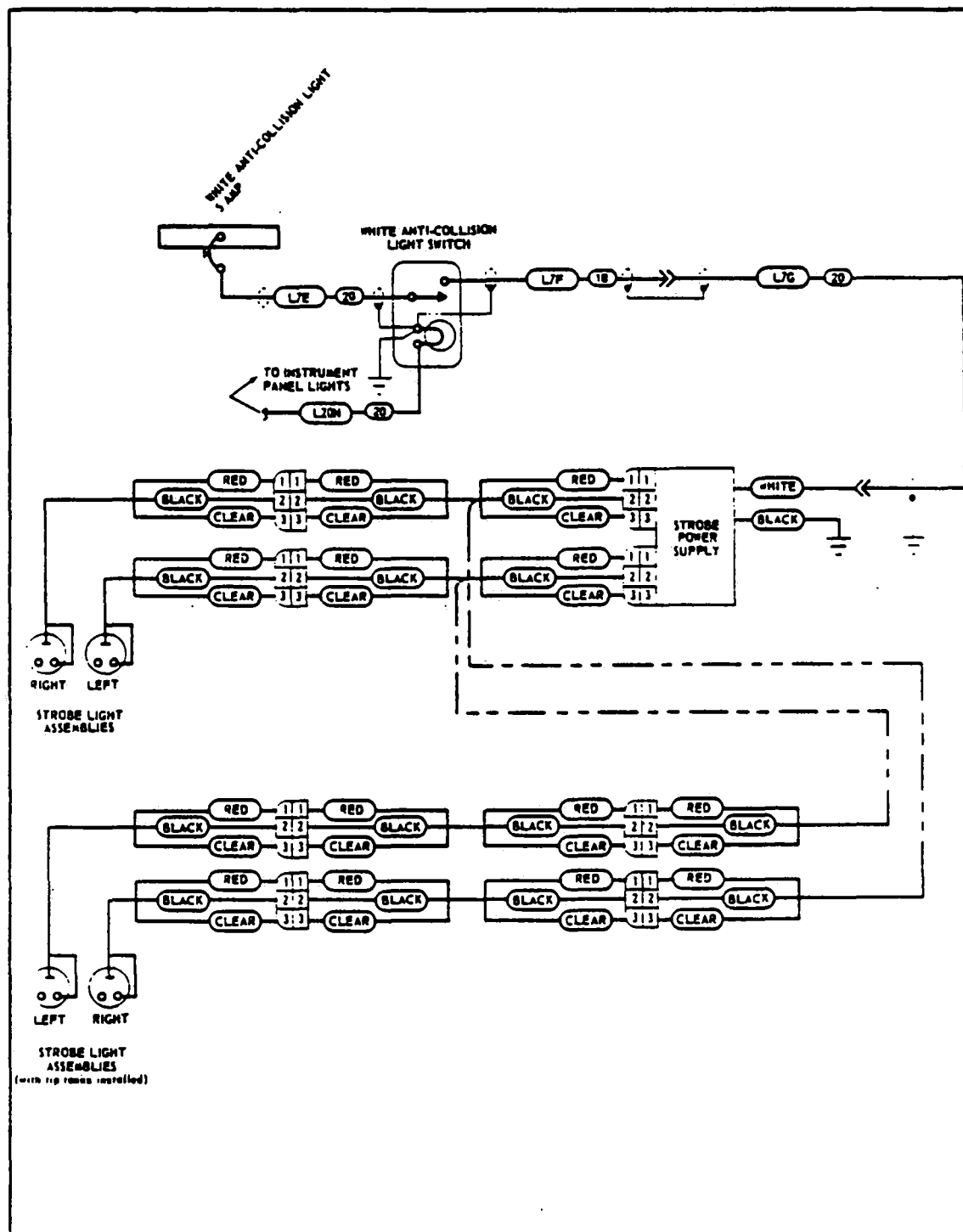


Figure 11-4. White Strobe lights Schematic

**4 H24**

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## **PART II**

### **SECTION XII**

### **ELECTRONICS**

#### **NOTE**

**For Autopilot and Automatic Trim service and maintenance information, refer to the appropriate Service Manual:**

<b>Subject Manual</b>	<b>Part Number</b>
<b>AutoControl III and AltiMatic III Service Manual</b>	<b>753 723</b>
<b>AltiMatic IIIB-1 Service Manual</b>	<b>761 502</b>
<b>AutoFlite Service Manual</b>	<b>753 720</b>
<b>AutoFlite II Service Manual</b>	<b>761 481</b>
<b>Pitch Trim Service Manual</b>	<b>753 771</b>

**For radio service and maintenance, refer to the appropriate manufacturers service manual.**

**For information on the Piper Automatic Locator Transmitter, refer to Part I, Section XII.**

**Issued: 12/29/72**



**PART II**  
**SECTION XIII**  
**HEATING AND VENTILATING**

**NOTE**

**Refer to Part I**

**Issued: 12/29/72**

**PART II**  
**SECTION XIV**  
**ACCESSORIES AND UTILITIES**

**NOTE**

**Refer to Part I**

**Issued: 12/29/72**

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