AN 01-40AJ-2

ERECTION AND MAINTENANCE INSTRUCTIONS

FOR

ARMY MODELS

A-26B and A-26C AIRPLANES

Published under joint authority of the Commanding General, Army Air Forces, the Chief of the Bureau of Aeronautics, and the Air Council of the United Kingdom.

NOTICE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C., 31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

25 DECEMBER 1944

REVISED 20 MAY 1945

POLICY GOVERNING DISTRIBUTION AND USE OF THIS PUBLICATION

Instructions Applicable to Army Personnel:

1. This publication is intended for technical aid and education of military and civilian personnel engaged in promoting the war effort. Its maximum distribution and use is therefore encouraged. However, since the publication is "restricted" within the meaning of AR 380-5, the following security regulations will be observed:

a. *Members of Armed Forces and civilian employees of War Department* will be given access to this publication whenever required to assist in the performance of their official duties (including expansion of their knowledge of AAF equipment, procedures, etc.).

b. *Personnel of War Department contractors and subcontractors* may be given possession of this publication, on a loan basis, or knowledge of its contents, only when required to assist in the performance of War Department contracts. Releases will be made in accordance with the requirements of T. O. No. 00-5-2.

c. *Representatives of other governments* will be given possession of this publication, or knowledge of its contents, only in accordance with AAF Letter No. 45-6.

2. This publication is restricted because the information contained in it is restricted. It does not follow that the physical article to which it relates is also restricted. Classification of the materiel or component must be ascertained independently of the classification of this document.

3. Neither this publication nor information contained herein will be communicated to press or public except through Public Relations channels.

Instructions Applicable to Navy Personnel:

Navy Regulations, Article 76, contains the following statements relating to the handling of restricted matter:

"Par. (9) *(a)*. Restricted matter may be disclosed to persons of the Military or Naval Establishments in accordance with special instructions issued by the originator or other competent authority, or in the absence of special instructions, as determined by the local administrative head charged with custody of the subject matter."

"*(b)* Restricted matter may be disclosed to persons of discretion in the Government service when it appears to be in the public interest."

"*(c)* Restricted matter may be disclosed, under special circumstances, to persons not in the Government service when it appears to be in the public interest."

The Bureau of Aeronautics Aviation Circular Letter No. 90-44 contains the following paragraph relative to the use of aeronautical technical publications:

"Par. 8. *Distribution to All Interested Personnel.* In connection with the distribution of aeronautical publications within any activity, it should be borne in mind by the offices responsible for such distribution that technical publications, whether confidential or restricted, are issued for use not only by officer personnel, but also by responsible civilian and enlisted personnel working with or servicing equipment to which the information applies."

Disclosure of technical information in this publication may be made to representatives of foreign governments in instances where those foreign governments have been cleared to receive information concerning all equipment covered by this publication.

Instructions Applicable to British Personnel:

FOR OFFICIAL USE ONLY.—Not to be communicated to anyone outside of His Majesty's Service. Not to be published. The information given in this document is not to be communicated, either directly or indirectly, to the press or to any person not holding an official position in His Majesty's Service.

LIST OF REVISED PAGES ISSUED

NOTE: A heavy black vertical line, to the left of the text on revised pages, indicates the extent of the revision. This line is omitted where more than 50 percent of the page is revised.

Page No.	*Latest Revision Date*
5	20 May 1945
41	15 April 1945
111	20 May 1945
197	20 May 1945
271	15 April 1945
244	20 May 1945
500	15 April 1945
724	20 May 1945
724A	20 May 1945

ADDITIONAL COPIES OF THIS PUBLICATION MAY BE OBTAINED AS FOLLOWS:

AAF ACTIVITIES.—In accordance with T. O. No. 00-5-2, base Air Inspectors, Technical will submit requisitions (AAF Form 104B) to:

Commanding General
Fairfield Air Technical Service Command
Patterson Field
Fairfield, Ohio
Attn: Publications Distribution Branch

NAVY ACTIVITIES.—Submit requests to Chief, BuAer, Navy Department, Washington, D. C., Attention: Publications Branch on order form NAVAER-140. For complete listing of available material and details of distribution see Naval Aeronautic Publications Index, NavAer 00-500.

BRITISH ACTIVITIES.—Submit requirements on Form 294A, in duplicate, to the Air Publications and Forms Store, New College, Leadhall Lane, Harrogate, Yorkshire, England.

TABLE OF CONTENTS

SECTION I—*Description, Dimensions and Leading Particulars* **1-5**

1. Description 1
2. Dimensions 1
3. Leading Particulars 1

SECTION II—*Shipment and Erection Procedure* **7-12**

1. Shipment of Aircraft 7
2. Erection Procedure 11

SECTION III—*Handling and General Maintenance Instructions* **13-53**

1. Access and Inspection Provisions 13
2. Ground Handling 13
3. Ground Operating Instructions 37
4. Special Tools and Equipment 43
5. Lubrication 45

SECTION IV—*Major Component Parts and Installations* **54-647**

1. Wing 54-57
   - *a.* General 54
   - *b.* Wing 54
   - *c.* Wing Tips 57
   - *d.* Nacelles 57

2. Empennage 58-60
   - *a.* General 58
   - *b.* Horizontal Stabilizers 58
   - *c.* Vertical Stabilizers 58

3. Movable Surfaces and Surface Controls 61-101
   - *a.* General 61
   - *b.* Movable Surfaces 61
   - *c.* Surface Controls 72
   - *d.* Trouble Shooting List 100

4. Fuselage 102-108
   - *a.* General 102
   - *b.* Nose 102
   - *c.* Nose Wheel Well 104
   - *d.* Pilot's Compartment 104
   - *e.* Bomb Bay 106
   - *f.* Gunner's Compartment 106
   - *g.* Fuselage Aft Section 107
   - *h.* Tail Cone 107

5. Alighting Gear 109-140
   - *a.* General 109
   - *b.* Main Landing Gear 109
   - *c.* Nose Wheel Gear 127
   - *d.* Tail Skid 138
   - *e.* Trouble Shooting List 139

6. Engine Section 141-173
   - *a.* General 141
   - *b.* Engine Assembly 141
   - *c.* Trouble Shooting List 167

7. Carburetor Fuel-Air Induction System 174-177
   - *a.* General 174
   - *b.* Air Scoops 174
   - *c.* Carburetor 176
   - *d.* Trouble Shooting List 177

8. Ignition System 178-191
   - *a.* General 178
   - *b.* Scintilla Magnetos, Distributors, and Ignition Harness 178
   - *c.* General Electric Ignition System ... 182

9. Engine Controls 192-197
   - *a.* General 192
   - *b.* Throttle 192
   - *c.* Carburetor Mixture Control 192

d. Engine Blower Control 192
e. Carburetor Air Control 197
f. Carburetor Air Filter Controls 197
g. Trouble Shooting List 197

10. Propeller and Propeller Controls ... 198-216
a. General 198
b. Propeller 199
c. Constant Speed Control Unit 208
d. Auxiliary Feathering Pump Assembly 210
e. Propeller Controls 212
f. Trouble Shooting List 214

11. Fuel System 217-245
a. General 217
b. Filling the Fuel System 217
c. Draining the Fuel System 217
d. Fuel System Controls and Instruments 219
e. Fuel Tank Selection 226
f. Fuel System Adjustments 226
g. Fuel Transfer 226
h. Fuel Cells and Tanks 226
i. Engine-Driven Fuel Pumps 236
j. Fuel Booster Pumps 239
k. Fuel Selector Valves and Controls .. 239
l. Fuel Strainers 242
m. Carburetors 243
n. Engine Priming and Oil Dilution Solenoid Valves 243
o. Fuel System Check Valves 244
p. Fuel System Lines and Fittings 244
q. Trouble Shooting List 245

12. Oil System 246-260
a. General 246
b. Oil System Instruments and Controls 246
c. Filling the Oil System 246
d. Draining the Oil System 246
e. Oil System Adjustments 250
f. Cleaning the Oil System 250
g. Oil Tank 250
h. Oil Temperature Regulator 254
i. Oil Dilution System 258
j. Propeller Feathering System 258
k. Oil System Lines 259
l. Trouble Shooting List 259

13. Instruments 261-282
a. General 261
b. Instrument Panel 261
c. Pitot-Static Instruments and Equipment 261
d. Vacuum Actuated Instruments and Equipment 266
e. Electrically Operated Instruments .. 271
f. Pressure Instruments 272
g. Clock 278
h. Drift Meter 279
i. Astro-Compass 279
j. Trouble Shooting List 279

14. Hydraulics 283-356
a. General 283
b. Supply, Pressure, and Return Hydraulic System 283
c. Landing Gear Hydraulic System ... 299
d. Bomb Bay Doors and Spoilers Hydraulic System 313
e. Brake Hydraulic System 330
f. Emergency Hydraulic System 336
g. Brake Emergency Air System 347
h. Tubing and Flexible Hoses 352
i. Clips, Clamps and Miscellaneous Fittings 353
j. Complete Hydraulic System Test ... 353
k. Trouble Shooting List 355

15. Electrical System 357-527
a. General Description 357
b. Sources of Power 357
c. Power Distribution 370
d. Electrically Operated Equipment ... 387
e. Electrical Trouble Shooting List ... 484

16. Communications Equipment 528-549
a. General 528
b. Radio Set SCR-274-N 529
c. Radio Compass Equipment 538
d. Radio Set SCR-595-A (or SCR-695-A) 541
e. Interphone Equipment 544
f. Radio Set SCR-515 546
g. Radio Set SCR-522 546

17. Armament 550-592
a. General 550
b. Loading Instructions 550
c. Bombing Equipment 550
d. Chemical Tanks 558
e. Torpedo Carrying Equipment 558
f. Gunnery Equipment 566
g. Armor Plate 590
h. 75 mm Cannon Trouble Shooting List 590

18. Photography 593-595
a. General 593
b. G.S.A.P. Camera 593
c. Orientation Camera 594
d. Gunner's Camera Equipment 595

19. Heating and Ventilating 596-622
a. General 596
b. Heaters 596
c. Air Regulator Valves 603
d. Modulator Temperature Control Unit 610
e. Fuel-Air Mixture Solenoid Shut-off Valve 612
f. Scoops, Ducts, Hose and Lines 612
g. Fuselage Air Exhaust 613
h. Controls and Operations 613
i. Heating and Ventilating System Test 619
j. Trouble Shooting List 622

20. Ice Elimination 623-641
a. General 623
b. De-icing System 623
c. Anti-icing Equipment 635
d. Trouble Shooting List 641

21. Furnishings and Miscellaneous Equipment 642-647

22. Pyrotechnics 647
a. General 647
b. Signal Flare Container 647
c. Pyrotechnic Pistol Holder 647

SECTION V—*Useful or Military Load Installations* **648-659**
1. General 648
2. Bomb Hoist 648
3. Loading Procedure 649
4. Table of Ammunition Weights and Capacities 658

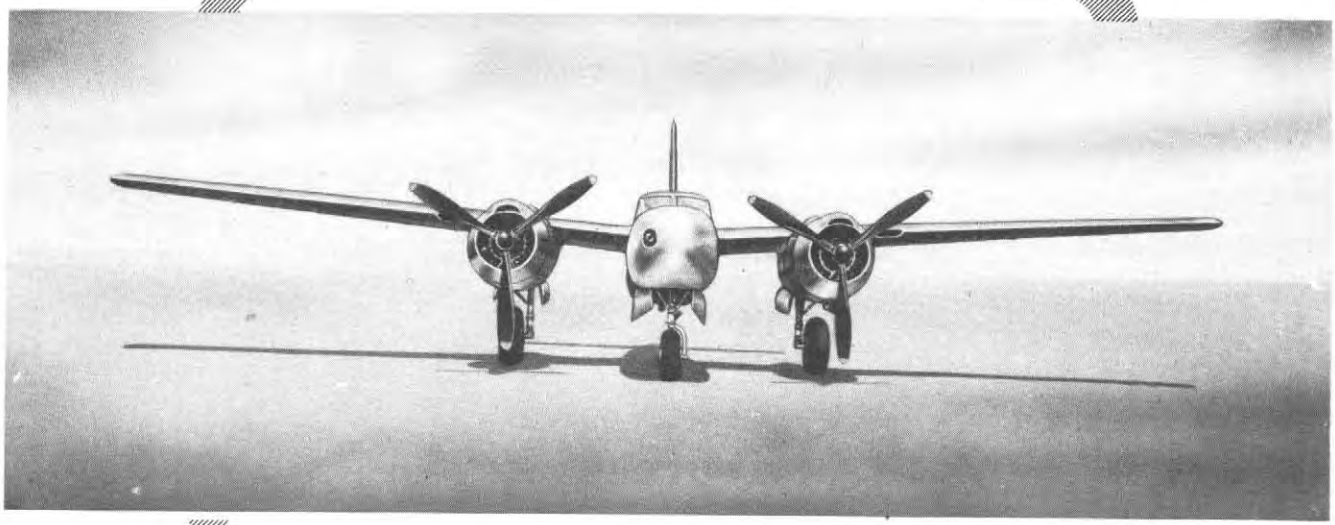
SECTION VI—*Materials of Construction* . **660-676**

SECTION VII—*Finish Specification* **677-685**
1. General 677
2. General Instructions for Cleaning of Surfaces Before Finishing 678
3. Initial Organic Protective Coatings 679
4. Cadmium Plating 680
5. Final Treatment 680

SECTION VIII—*Tubing Information* **686-689**
1. General 686
2. Tubing Identification 686
3. Replacing Tubing 686

SECTION IX—*Charts and Tables* **691-706**

SECTION X—*Service Inspection* **707-736**



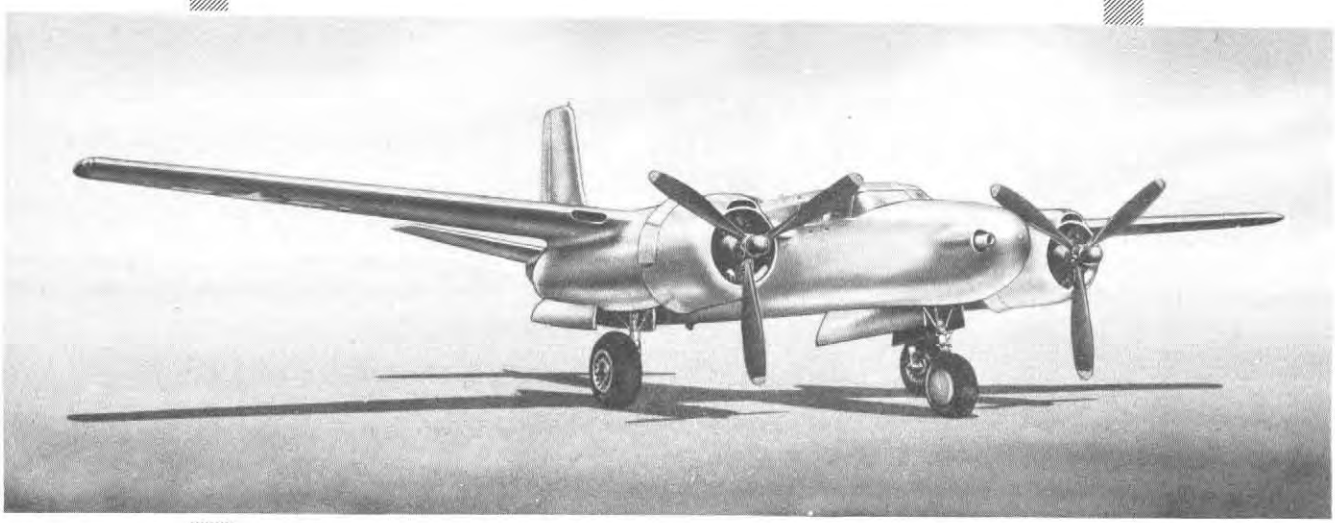


Figure 1 — Airplane Views (Sheet 1 of 2)

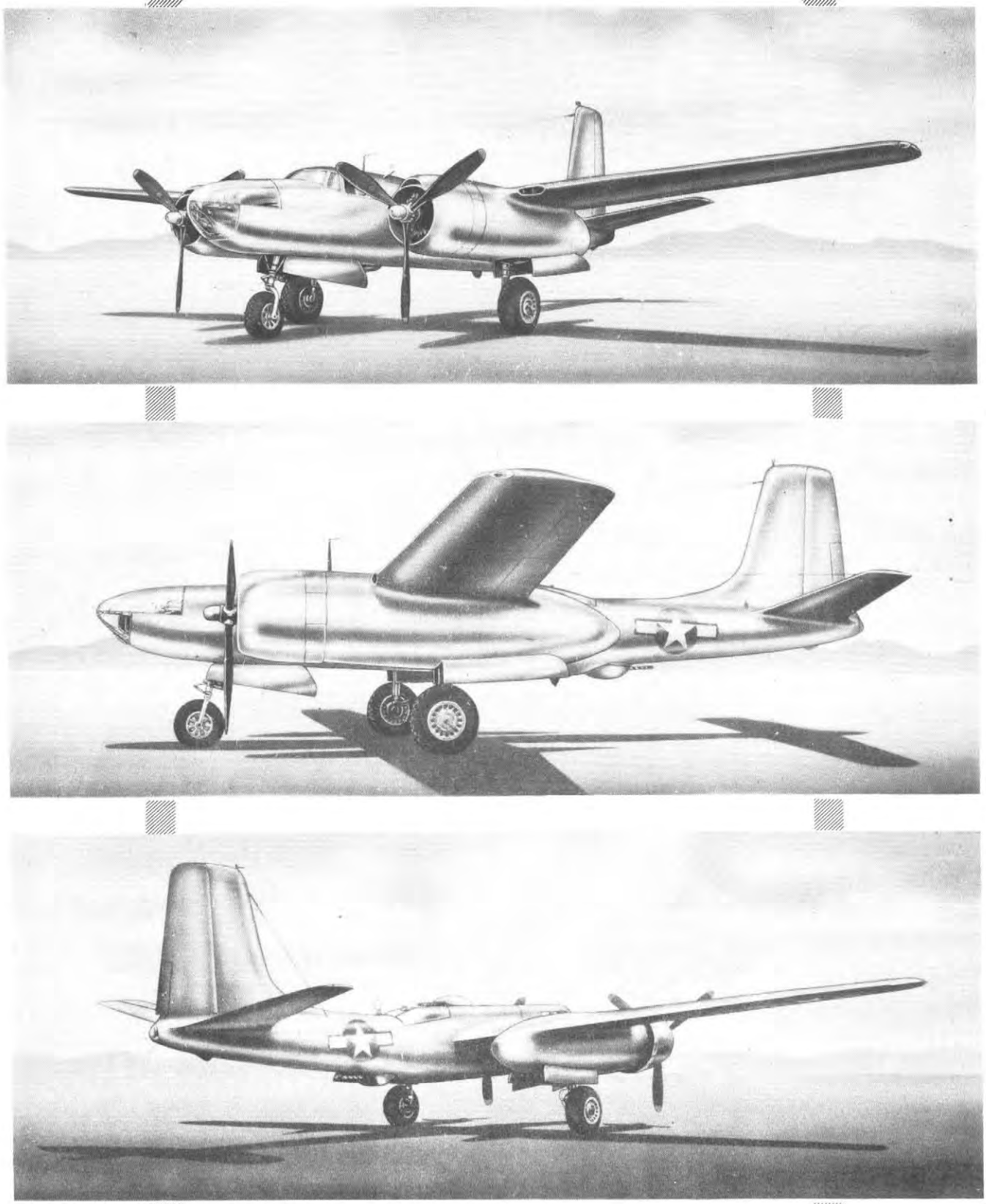


Figure 1 — Airplane Views (Sheet 2 of 2)

SECTION I

DESCRIPTION, DIMENSIONS AND LEADING PARTICULARS

1. DESCRIPTION.

This airplane is a three place, bi-motored attack bomber of all metal construction. Two Pratt and Whitney, two speed radial engines each rated at 2000 horsepower at take-off, provide the power for this airplane. The tricycle type alighting gear is retracted and extended hydraulically.

The manufacturer provides two type noses for this airplane: the All Purpose (Multi-Gun) nose which has provisions for the installation of cannon(s), machine guns or both and the Bombardier Nose which includes bombing controls, bomb sight brackets, two .50 cal. machine guns, etc. These noses are interchangeable. When equipped with the bombardier nose the airplane model designation is A-26C – with the all purpose nose A-26B.

2. DIMENSIONS. —*(See dimension drawing Figure 2.)*

(airplane at rest)

3. LEADING PARTICULARS.

PRINCIPAL DIMENSIONS

(Aircraft in level flight position unless otherwise stated)

GENERAL	
Span	70 ft. 0 in.
Length (overall fuselage)	A-26B 50 ft. 9 in.
	A-26C 51 ft. 3 in.
Height (at rest)	18 ft. 6 in.
WINGS	
Airfoil section (curve identification)	
Root	65,2-215 a=.8 b=1.0
Tip	65,2-215 a=.5 b=1.0
Chord at root	128 in.
Chord near tip (35 ft. from fuselage centerline)	58 in.
Incidence	Root 2°
	Tip 1°
Dihedral (measured on top face of front beam)	4.5°
Sweepback at station #123 (20% wing chord)	0°
Maximum wing depth	18 in.
STABILIZER	
Span	23 ft. 1 in.
Maximum chord (Root)	7 ft. 5 in.
Incidence	0°
Dihedral	10° 35′ 1″

FUSELAGE

Width (maximum)	5 ft. 2.04 in.
Height (maximum)	5 ft. 10 in.
Length (less cannon)	49 ft. 11 in.

AREAS

WINGS (less ailerons)	513.3 sq. ft.
WINGS (with flaps extended) Increases Area	10%
AILERONS (total)	27.2 sq. ft.
FLAPS (total)	55.9 sq. ft.
STABILIZERS (including elevators)	116.51 sq. ft.
ELEVATORS (two) (including tabs) (aft hinge line)	32.7 sq. ft.
ELEVATOR TRIM TABS (total)	2.6 sq. ft.
FIN	48.23 sq. ft.
RUDDER (including tab) (aft hinge line)	23.1 sq. ft.
RUDDER TRIM TAB (total)	2.28 sq. ft.

SETTING AND RANGES OF MOVEMENT OF CONTROL SURFACES

AILERONS	up (from neutral)	20° ± 1°	5-31/32 in. ± 5/16 in.
	down (from neutral)	15° ± 1°	4-15/32 in. ± 5/16 in.
FLAPS	(total)	52° ± 2°	
ELEVATOR	up (from neutral)	30° ± ½°	14 in ± 7/32 in.
	down (from neutral)	16° ± ½°	7-17/32 in. ± 7/32 in.
RUDDER	right (from neutral)	17° ± ½°	11-9/32 in. ± 7/32 in.
	left (from neutral)	17° ± ½°	11-9/32 in. ± 7/32 in.
TRIM TABS			
Elevator	up (from neutral)	12° ± 2°	1-3/8 in. ± 1/4 in.
	down (from neutral)	17° ± 2°	1-31/32 in. ± 1/4 in.
Rudder	right (from neutral)	20° ± 2°	3-1/4 in. ± 11/32 in.
	left (from neutral)	20° ± 2°	3-1/4 in. ± 11/32 in.
Aileron	up (from neutral)	7° ± 1½°	5/8 in. ± 1/8 in.
	down (from neutral)	7° ± 1½°	5/8 in. ± 1/8 in.

ALIGHTING GEAR

Type	Hydraulically retractable
TREAD (width from center of tire to center of tire)	19 ft. 5.6 in.
SHOCK STRUT (main)	
Type	Oleo-pneumatic (air-oil)
Manufacturer	Cleveland Pneumatic Tool Co.
Part Number	8211
Fluid Required	
A. N. Specification	AAF3580 Navy M-339
British Equivalent	DTD 585
Approximate Maximum Air Pressure	Filled to full mark on strut.

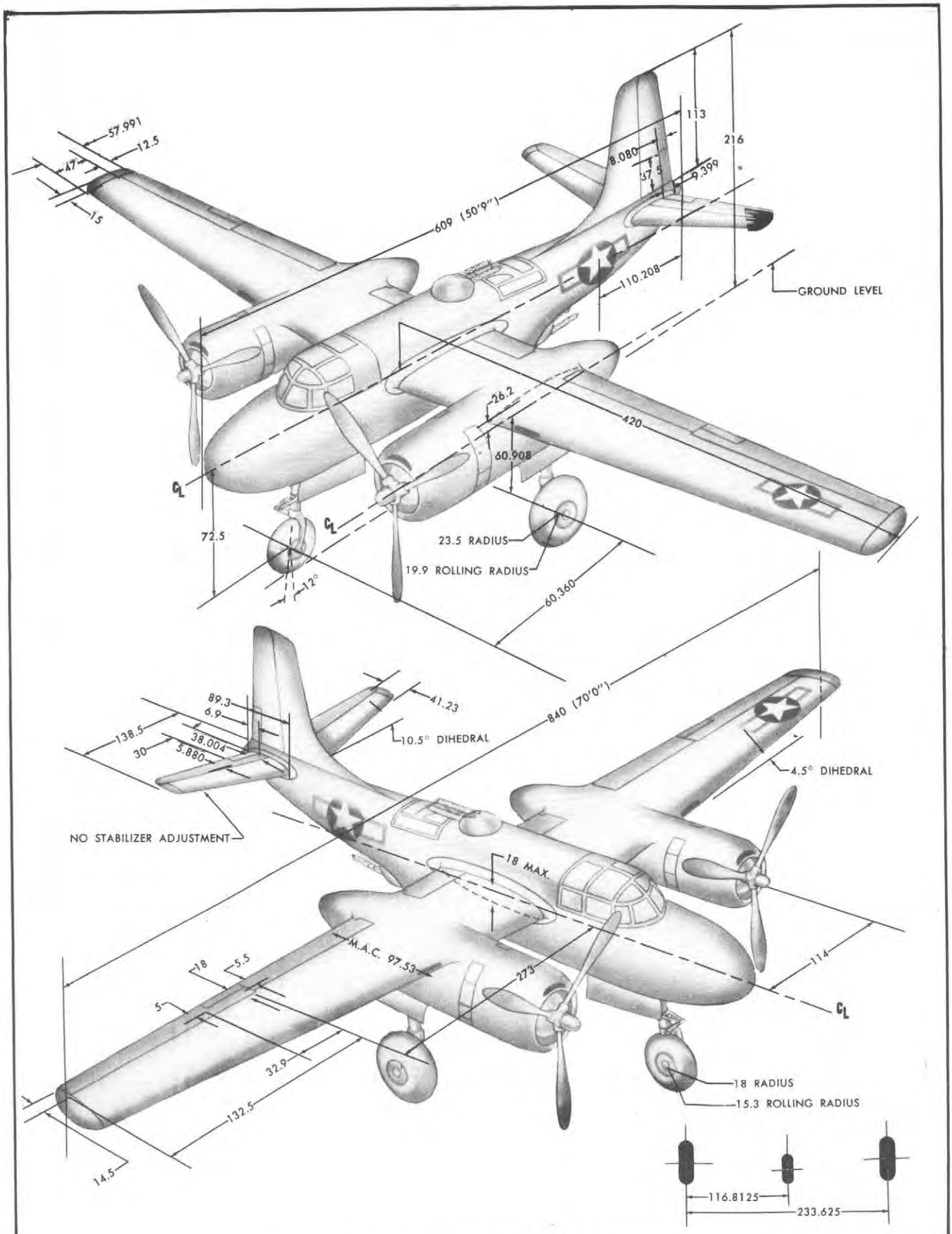
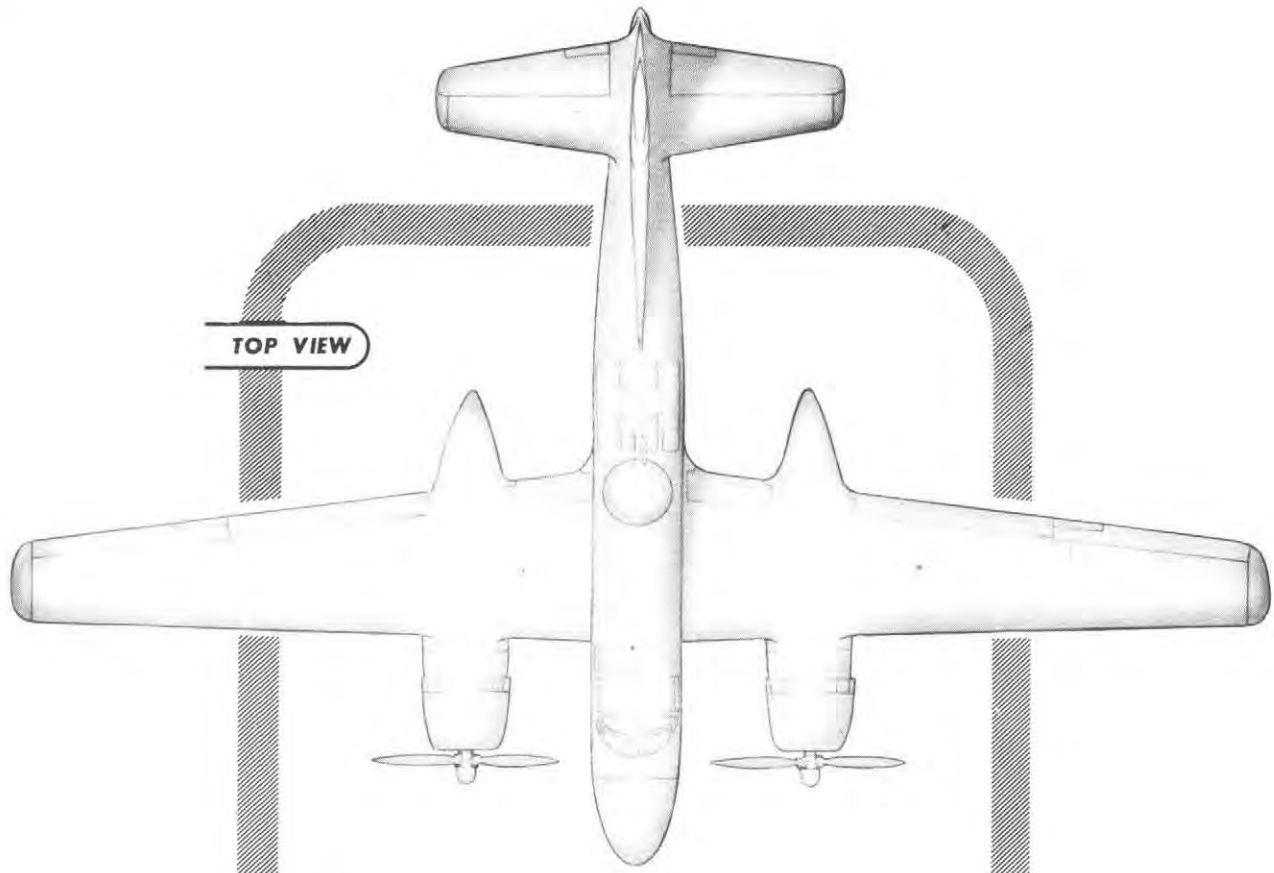
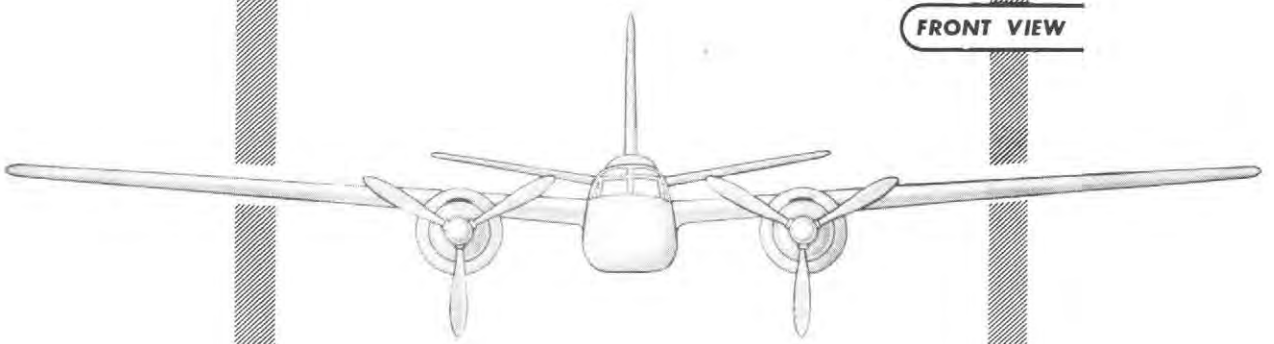


Figure 2 — Dimensions Diagram





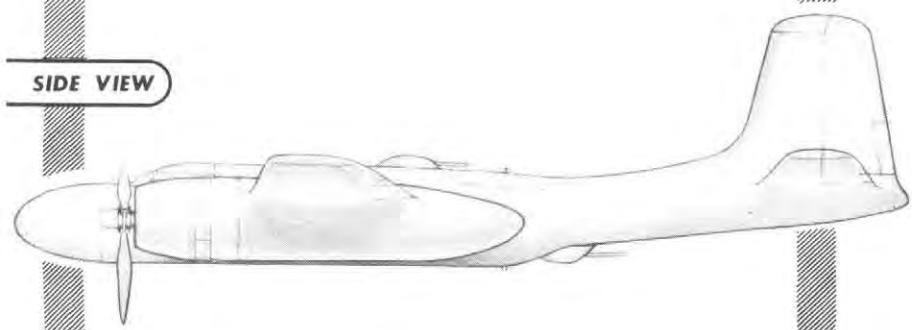


Figure 3 — Three Views of Airplane

WHEELS (main)
- TYPE ..... Goodyear 530005M Type 3 47 in.
- TIRE ..... Goodyear or equiv.—Smooth contour—10 Ply-47 in.
- PRESSURE-AIR ..... At 27,603 pounds gross weight 54 p.s.i.

BRAKES
- TYPE ..... Hydraulically operated Goodyear 510675M 47in., 12.7 x 14 disc type

NOSE WHEEL UNIT
- TYPE ..... Hydraulically retractable
- SHOCK STRUT:
  - TYPE ..... Oleo-pneumatic (air-oil)
  - MANUFACTURER ..... Cleveland Pneumatic Tool Co.
  - PART NUMBER 8239
  - FLUID REQUIRED:
    - A. N. SPECIFICATION ..... AAF3580 Navy M-339
    - BRITISH EQUIVALENT DTD-585
  - APPROXIMATE MAXIMUM AIR PRESSURE ..... Filled to full mark on strut

WHEEL (Nose)
- TYPE ..... Goodyear P/N 4109-530033 or Bendix P/N 4109-58175 36 in.
- TIRE ..... Goodyear or equiv.—Smooth contour—36 in. 8 Ply
- PRESSURE-AIR ..... At 27,603 pounds gross weight 38 p.s.i.

ENGINES (2)

NUMBER DESIGNATION	Pratt & Whitney – R 2800-BG AAF 2800-27 or -71
GEAR RATIO	2:1
OIL	Spec. AN-VV-O-446a – grade 1100a
FUEL	100 Octane – Spec. AN F28 grade 130

PROPELLERS

MANUFACTURER	Hamilton Standard
TYPE	3 blade (dural)
HUB NUMBER	23-E-50
BLADE NUMBER	6359A-18
DIAMETER	12 ft. 7 in.
CONTROL NUMBER	4G8-G15D Hamilton
PITCH SETTING	
LOW (FINE)	26° at 42 in. station
HIGH (COARSE)	90° at 42 in. station

CONTAINER CAPACITY

FUEL:	GALLONS EACH	
NACELLE (MAIN) CONTAINERS (2)	300 U.S. Gals.	250 Imp. Gals.
FUSELAGE (BOMB BAY) CONTAINER (1)	125 U.S. Gals.	104 Imp. Gals.
WING (AUXILIARY) CONTAINER (2)	100 U.S. Gals.	83.3 Imp. Gals.
FERRY TANK (1)	675 U.S. Gals.	562 Imp. Gals.
FUEL – TOTAL LESS FERRY TANK	925 U.S. Gals.	771 Imp. Gals.
FUEL – TOTAL INCLUDING FERRY TANK	1600 U.S. Gals.	1332 Imp. Gals.

OIL:	GALLONS EACH	
TANK (1) for each engine	34 U.S. Gals.	28.3 Imp. Gals.
EXPANSION SPACE	3.5 U.S. Gals.	2.91 Imp. Gals.
TOTAL OIL	68 U.S. Gals.	56.6 Imp. Gals.

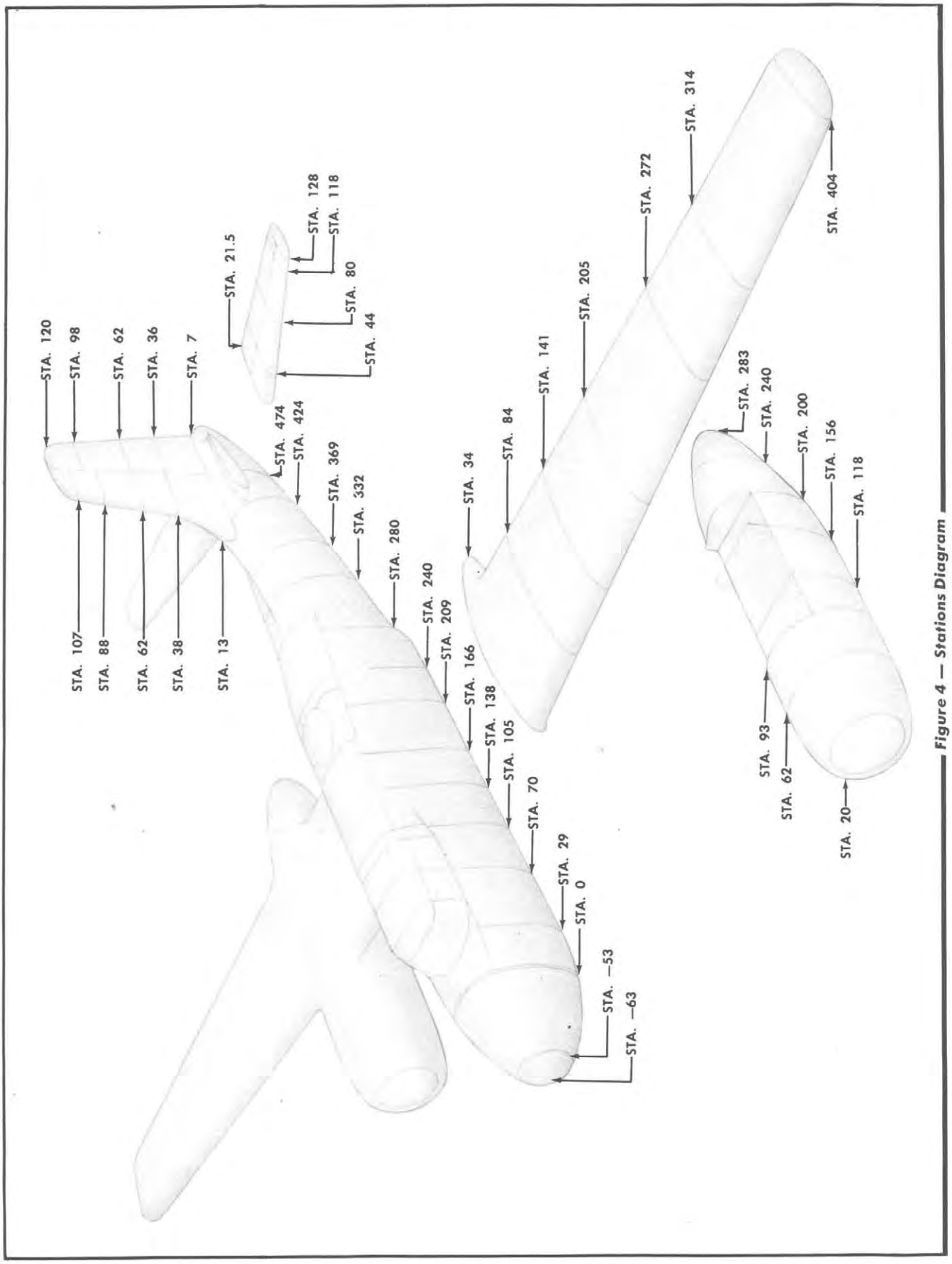
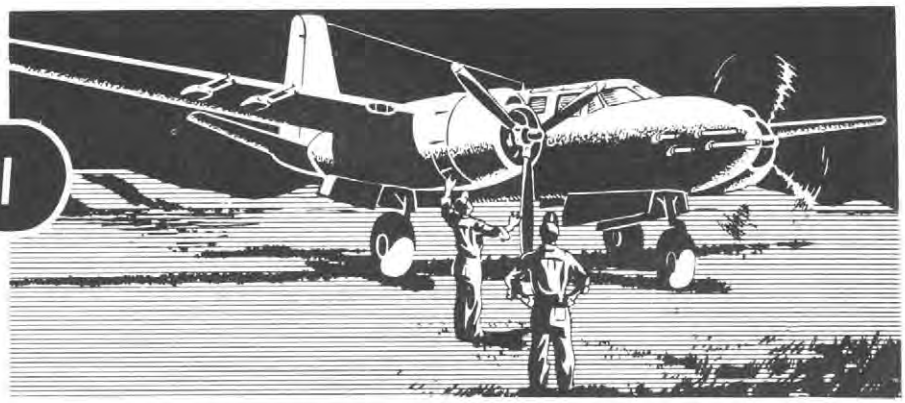


Figure 4 — Stations Diagram

SECTION II



SHIPPING AND ERECTION PROCEDURE

This airplane is equipped with a ferry fuel tank when delivered. The additional fuel capacity thus provided makes possible the delivery and point to point transfer by the FLY-AWAY method. If dismantling for shipment is necessary, the following drawing and chart indicate the component parts readily removable from the airplane, the text location for the removal and installation of these parts and their weights and sizes.

Due to the size of the wing (including nacelle) the route of transit should be carefully planned and checked to make certain there will be adequate clearance under bridges and in tunnels enroute.

1. SHIPMENT OF AIRCRAFT.

a. PREPARING THE ENGINES AND PROPELLERS FOR SHIPMENT.

(1) GENERAL.—Since the preparation of the ignition, fuel, and oil systems is necessary for the proper preparation of the engines for shipment, dismantling of the airplane should not be attempted until such preparation has been completed. The procedure outlined below should be carried out for each engine *within 48 hours* after arrival of the airplane at the disassembly point.

(2) PROCEDURE.

(a) CLEANING.—If necessary, clean the engine thoroughly with an approved solvent and dry it with an air blast. (Refer to Specs. AN-C-80 and AF28480.)

(b) CLEAR FUEL RUN.

1. Drain leaded fuel from all of the fuel containers.

2. Safety the landing gear in the "DOWN" position; then run the engine for a minimum period of 15 minutes on unleaded fuel, Grade 65, under its own power and at 40 to 45 percent of its rated speed. While the engine is running, the oil intake line should feed from an auxiliary oil tank which contains a blend of three parts lubricating oil, Grade 1120, and one part corrosive - preventive compound, AN-VV-C-576). Wash the screens and filters with solv- (Spec. AN-VV-C-576). A fresh supply of the oil-compound mixture should be used for each engine. If an auxiliary tank is not available, the engine's own tank may be drained and filled with the oil-compound mixture.

3. Before stopping the engine, make certain that the cylinder heads have been properly cooled. Shift the propeller to LOW rpm. Do not exceed 20 inches Hg. manifold absolute pressure. Just before stopping the engine increase its speed to between 1500 and 1600 rpm for approximately 30 seconds to permit maximum scavenging of the crankcase oil.

4. Stop the engine by moving the mixture control to the "IDLE CUT-OFF" position. When the engine has stopped firing, turn the ignition switch to the "OFF" position.

CAUTION

Do not stop the engine by running out of fuel.

5. Drain the residual fuel from the system.

(c) COWLING.—Remove all cowling according to the procedure outlined in Section IV, paragraph 6., ENGINE SECTION.

(d) SPARK PLUGS.—While the engine is hot, remove all spark plugs to permit the escape of the vapors of the last explosion before condensation takes place. When the plugs have cooled, clean them with solvent and adjust the gaps. Coat each electrode with corrosion-preventive compound (Spec. AN-VV-C-576), and install a brass thread-protector cap. Wrap each spark plug in waxed paper and pack all plugs together with their copper gaskets in a cardboard container.

(e) OIL SYSTEM.—Remove the drain plugs and allow the oil to drain from the system. Slush the drain plugs in corrosion-preventive compound (Spec. ent and dip them in corrosion-preventive compound (Spec. AN-VV-C-576). Reinstall all screens and filters.

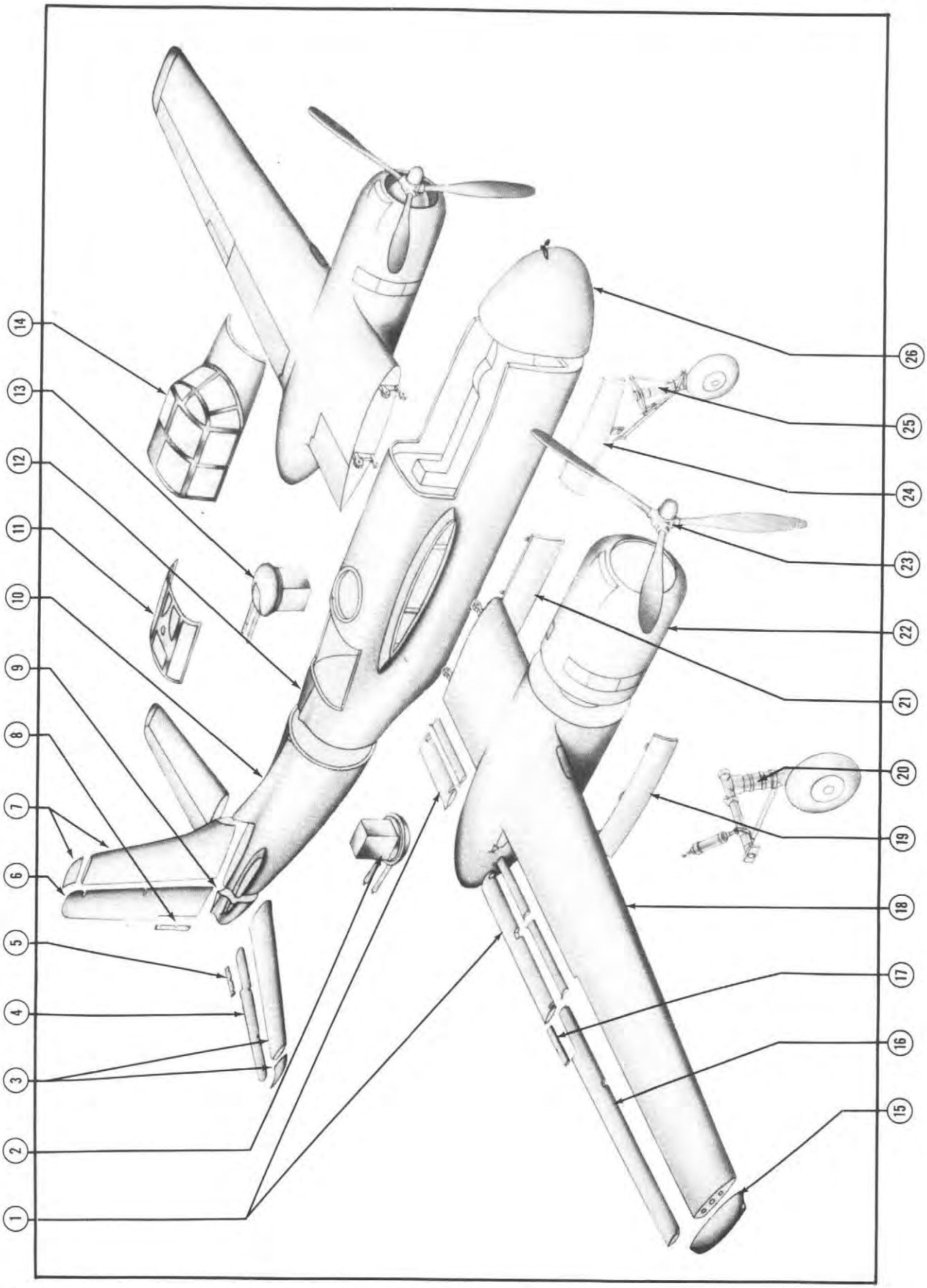


Figure 5 — Airplane Component Parts

KEY TO FIGURE 5 — MAJOR COMPONENT PARTS

Key	Name	Removal Reference	Installation Reference	Weight Ea., lbs.	Width (Max.)	Length (Max.)	Depth (Max.)
1	Wing Flaps (Outer and Inner) (2 sets)	Sec. IV, Para. 3., *b.*, (8), *(b), 1 & 2.*	Sec. IV, Para. 3., *b.*, (8), *(t).*	142	32″	143½″	13½″
2	Lower Turret	Sec. IV, Para. 15., *d.*, (16), *(c), 2.*	Sec. IV, Para. 15., *d.*, (16), *(c), 4.*	429	41″	62″	42″
3	Horizontal Stabilizer and Tip (2)	Sec. IV, Para. 2., *b.*, (2).	Sec. IV, Para. 2., *b.*, (5).	102	56″	119″	8½″
4	Elevator (2)	Sec. IV, Para. 3., *b.*, (4), *(b).*	Sec. IV, Para. 3., *b.*, (4), *(d).*	71.2	38″	118″	6½″
5	Elevator Trim Tab (2)	Sec. IV, Para. 3., *b.*, (5), *(b).*	Sec. IV, Para. 3., *b.*, (5), *(d).*	1.77	7¼″	30″	2″
6	Rudder	Sec. IV, Para. 3., *b.*, (6), *(b).*	Sec. IV, Para. 3., *b.*, (6), *(d).*	91.6	50″	113″	7½″
7	Vertical Stabilizer and Tip	Sec. IV, Para. 1., *c.*, (2).	Sec. IV, Para. 1., *c.*, (5).	126	89½″	113″	9½″
8	Rudder Trim Tab	Sec. IV, Para. 3., *b.*, (7), *(b).*	Sec. IV, Para. 3., *b.*, (7), *(d).*	3.4	9″	37″	2″
9	Fuselage Tail Cone	Sec. IV, Para. 4., *h.*, (2).	Sec. IV, Para. 4., *h.*, (5).	71	41″	41½″	32″
10	Fuselage Aft Section	Sec. IV, Para. 4., *g.*, (2).	Sec. IV, Para. 4., *g.*, (4).	330	54½″	145″	46¾″
11	Gunners' Compartment Enclosure	Sec. IV, Para. 4., *f.*, (2).	Sec. IV, Para. 4., *f.*, (4).	74	56″	64″	13″
12	Fuselage Main Section (incl. 866 lbs. Useful Load)	To remove or install — The instructions given in Items 1, 15, 19, 24 and 26 must be followed.	To remove or install — The instructions given in Items 1, 15, 19, 24 and 26 must be followed.	5562	62″	352″	70″
13	Upper Turret	Sec. IV, Para. 15.,*d.*, (16), *(b), 2.*	Sec. IV, Para. 15., *d.*, (16), *(b), 4.*	409	40½″	62″	40½″
14	Pilots' Compartment Enclosure	Sec. IV, Para. 4., *d.*, (2).	Sec. IV, Para. 4., *d.*, (5).	146	55½″	97″	17″
15	Wing Tip (2)	Sec. IV, Para. 1., *c.*, (2).	Sec. IV, Para. 1., *c.*, (4).	8	16½″	61″	9½″
16	Aileron (2)	Sec. IV, Para. 3., *b.*, (2), *(b).*	Sec. IV, Para. 3., *b.*, (2), *(b).*	60	25½″	132½″	6½″
17	Aileron Trim Tab (2)	Sec. IV, Para. 3., *b.*, (3), *(b).*	Sec. IV, Para. 3., *b.*, (3), *(d).*	1.85	10½″	32″	2″
18	Wing Complete (2)	Sec. IV, Para. 1., *(b).*, (2).	Sec. IV, Para. 1., *b.*, (4).	3165	190″	405″	59″
19	Nacelle Doors (2 pr.)	Sec. IV, Para. 5., *b.*, (6), *(b).*	Sec. IV, Para. 5., *b.*, (6), *(e).*	41	30½″	86½″	28″
20	Main Landing Gear (2)	Sec. IV, Para. 5., *b.*, (1), *(b).*	Sec. IV, Para. 5., *b.*, (1), *(e).*	729	47″	72″	28¼″
21	Bomb Bay Doors (2)	Sec. IV, Para. 14., *d.*, (10), *(b).*	Sec. IV, Para. 14., *d.*, (10), *(d).*	68	26½″	172″	7″
22	Engine Section (2)	Sec. IV, Para. 6., *b.*, (2).	Sec. IV, Para. 6., *b.*, (4).	2923	60″	96″	60″
23	Propeller (2)	Sec. IV, Para. 10., *b.*, (2).	Sec. IV, Para. 10., *b.*, (6).	499	12'7″	12'7″	30″
24	Nose Wheel Doors (2)	Sec. IV, Para. 5., *c.*, (2), *(b).*	Sec. IV, Para. 5., *c.*, (2), *(d).*	40	23½″	83″	6″
25	Nose Wheel Gear	Sec. IV, Para. 5., *c.*, (1), *(b).*	Sec. IV, Para. 5., *c.*, (1), *(e).*	303	36″	71″	32″
26	Fuselage Nose Section (Bombardier Type — incl. guns and ammunition) (All Purpose — incl. mounts)	Sec. IV, Para. 4., *b.*, (2). Sec. IV, Para. 4., *b.*, (2).	Sec. IV, Para. 4., *b.*, (4). Sec. IV, Para. 4., *b.*, (4).	984 316	58″ 58″	59½″ 59½″	54¾″ 54¾″

Reinstall all drain plugs except the sump plugs, which should be replaced with crankcase dehydrator plugs (AN4061) screwed to a tight seal. The regular sump plugs should be wrapped in waterproof paper, tagged, and tied to the engine structure adjacent to the sump.

(f) FUEL PUMP.–Disconnect the inlet line from the fuel pump and insert one end of a piece of hose. Insert a funnel into the other end of the hose; fill the funnel with 1 pint of corrosion-preventive compound (Spec. AN-VV-C-576), and drain the compound into the pump; rotate the propeller by hand in the normal direction. Drain the excess compound from the pump by turning the propeller in the opposite direction. Replace the fuel line.

CAUTION

Do not use the self-sealing fuel line for this operation as corrosion-preventive compound will be destructive to the line.

(g) CARBURETOR.–Drain the remaining fuel from the carburetor. Remove the fuel lines and the intake fittings, and insert brass nipples in the holes. Attach hose to the nipples, and connect them to a gallon can filled with Grade 1065 lubricating oil. Allow the oil to drain into the carburetor while the throttle and mixture controls are being operated. Remove the hose and the nipples, and allow the carburetor to drain thoroughly. Replace the intake fittings and the fuel lines. Lock the throttle in the "OPEN" position.

(h) VALVE ROCKER ASSEMBLY.–Remove the valve rocker box covers. Wash the rocker assembly with solvent and spray it with corrosion-preventive compound (Spec. AN-VV-C-576). Replace the covers carefully, and install new gaskets in place of any that may be damaged.

(i) CYLINDERS.

1. Through the spark plug holes, spray the inside of each cylinder with corrosion-preventive compound (Spec. AN-VV-C-576); rotate the propeller slowly during the spraying operation.

CAUTION

Insert the nozzle of the spray gun carefully to avoid damaging the spark plug insert threads.

2. Install and connect the dehydrator plugs (AN4062) in all of the cylinders.

(j) PROPELLER.

1. Remove the propeller according to the procedure outline in Section IV, paragraph 10, PROPELLER AND PROPELLER CONTROLS. Refer to Spec. AN-P-30.)

2. Plug the hydraulic oil connections of the propeller shaft, and spray the inside of the shaft with corrosion-preventive compound (Spec. AN-VV-C-576).

3. Thoroughly lubricate the threads on the end of the propeller shaft, and install a propeller shaft thread protecter cap (AN5012).

4. Coat the outside of the propeller shaft with Rust Veto A-5; wrap the shaft in waxed paper, and then in oilcloth; tie the oilcloth securely in place.

5. Cover the hub and dome openings with waxed paper and then with oilcloth to prevent the entrance of foreign matter into the propeller pitch actuating assembly.

(k) FINAL PROTECTIVE MEASURES.

1. Remove the engine from the nacelle according to the procedure outlined Section IV, paragraph 6., ENGINE SECTION. ENGINE ACCESSORIES AND ENGINE CONTROLS.

2. Mask all rubber and synthetic rubber fittings, and spray the entire engine section, including the accessories, with corrosion-preventive compound.

3. Seal all exterior openings with moisture-proof seals.

4. Fit an engine envelope (AN4073) to an engine case anchor plate or a saddle; fit the plate or the saddle and the envelope to the engine. Place the engine in the case and fasten the anchor plate or the saddle to the case. Distribute dehydrator bags symmetrically about the engine. Seal the envelope and lower the case cover over the enclosed engine; be careful not to break the envelope.

b. DISMANTLING THE AIRPLANE.

(1) GENERAL.–In order to reduce both disassembly and reassembly time to a minimum, it is strongly urged that, whenever practicable, major assemblies be detached complete in themselves rather than disassembled into their component subassemblies. For example, whereas the wing can be disassembled into panel, flaps, aileron, and tip, it is far more desirable to ship the wing complete unless shipping conditions necessitate such dismantling.

(a) TAGGING OF PARTS REMOVED AND REPLACEMENT OF SMALL PARTS.

1. A tag showing the airplane's serial number and the name and location (RH or LH) of the part should be attached to each part removed from the airplane before it is boxed or crated.

2. Assembly items such as nuts, bolts, washers, spacers, cotterpins, etc. should be replaced in their respective locations as soon as each part has been removed. Items which cannot be returned to their fittings should be packed together in a bag and securely attached to their unit; the bag should be tagged for identification.

3. Before disconnecting the adjusting rods, turnbuckles, etc., apply a thin strip of adhesive tape to the male fittings to indicate the points at which proper reassembly should be made with the female fittings.

(b) CHECK-OFF LIST.—Each assembly, together with its attaching parts, should be listed when it is dismantled and checked off when it is packed for shipment. It is recommended that a check-off list be made to cover all of the assemblies which are removed from an individual airplane. The list should be identified by the model and serial number of the airplane, and should be made in duplicate, one copy to be filed by the disassembly crew and the other copy to be forwarded with the shipment.

c. PREPARATION FOR SHIPMENT.

(1) GENERAL.—Preservation of the units to be shipped is accomplished by the application of protective compounds and/or wrappings.

(a) CLEANING.—Clean and thoroughly dry all surfaces before using protective compounds or dehydrating methods. Stoddard's solvent or naphtha are preferable as cleaning compounds.

(b) RUBBER AND SYNTHETIC RUBBER PARTS.—Before applying corrosion-preventive compounds to surfaces which are adjacent to rubber and synthetic rubber parts, mask all tires, tubing, etc. with waterproof adhesive shipping tape. Door and hatch sealing strips should be removed from the airplane and wrapped in Kraft paper before they are packed for shipment.

(c) UNPROTECTED METAL SURFACES.—Coat bare metal parts with corrosion-preventive compound (Spec. AN-C-52) all cables, tracks, unpainted landing gear parts, fittings, bolts, hinges, etc. Apply the compound by brush, spray, or dipping, and allow the parts to dry thoroughly before they are packed.

(d) GLASS AND PLEXIGLAS.—Cover glass or Plexiglas with three layers of Kraft paper which is held in place with tape (AN P-12).

CAUTION

Do not apply tape directly to any glass or Plexiglas surface. Reaction of the adhesive to the compound used to remove the tape causes serious crazing of the glass.

(e) DOPED FABRIC.—Completely cover all doped fabric with waterproof paper and tape the paper in place. Do not permit corrosion-preventive compound to contact any doped fabric surface.

(f) BATTERY.—Whether the battery remains installed in the nacelle or is shipped separately depends, generally, on the method of shipment. In either event, preparation is the same:

1. Disconnect both terminal cables; clean them thoroughly, and tie them securely away from the battery posts.

2. Clean the battery; check the cell contents, and add water if it is needed; or charge the battery, if necessary.

3. Coat each battery post with corrosion preventive compound (Spec. AN-C-52).

4. Make sure the battery drain hole is unobstructed, so that gases can escape from the container.

d. CRATING.

(1) GENERAL.—All units of the airplane can be crated for shipment. (See the preceding illustration.) However, because of the length of the wing panel and the location, height, and length of its integral nacelle structure, it is recommended that the wing be transported without crating if possible.

(2) MATERIAL.—Boxes or crates should be made of suitable wood or wood-cleated plywood. The choice of material depends principally on the size of the individual box and the weight of its contents.

(3) CONSTRUCTION.—Boxes or crates should be reinforced by struts or cleats at points of internal or external stress. As far as it is practicable, the individual members of crates should be bolted or screwed together so that the crates can be knocked down for reuse. Crates should be lined with waterproof paper; if they are double-walled, they should be interlined with waterproof paper. To facilitate handling, large crates should be constructed on skids which have been notched for hoisting slings.

(4) SPECIAL SUPPORTS.—Units with vulnerable contours, such as engines, tail cones, etc., should be padded, cradled, and/or bulkheaded so that they will be protected from damage by crate walls or by other items which may come adrift during transit. Parts which can be rigidly attached to or supported from the floor or the framework of the crate should be fastened, braced, or blocked to prevent shifting or straining caused by motion or distortion of the crate.

(5) INSTRUCTIONS FOR UNPACKING.—When a crate has been constructed for special parts and in such a manner as to be reusable, instructions to facilitate its unpacking should be prepared and forwarded with the crate.

(6) PAINTING AND MARKING. — Unless otherwise directed, the exteriors of all boxes and crates which contain aircraft or aircraft materiel should be painted with nonspecular paint and marked with the destination and other appropriate shipping data.

2. ERECTION PROCEDURE.

a. UNCRATING.

(1) GENERAL.—No assembly should, as a general rule, be uncrated until it is needed for installation on the airplane.

(2) PROCEDURE.

(a) Unpack all items carefully and in accordance with the instructions forwarded by the packer.

(b) Check all items against the packing or check list which accompanies the shipment.

(c) Knock down and save all crates suitable for reuse.

b. DEPRESERVATION AND INSTALLATION.

(1) GENERAL.—Functional assemblies, such as propellers, should not be depreserved until immediately before installation, especially in areas where damp or humid weather conditions prevail and where corrosive action can be inhibited by positive protective measures only.

(a) Remove paper and oilcloth wrapping.

(b) Remove adhesive tape and protective compound coatings by cleaning the part with solvent, naphtha, or vapor.

(c) When the part is thoroughly clean, air dry it and apply proper lubricants to parts requiring lubrication.

(2) WING GROUP.

	DEPRESERVATION
(a) Main panel.	Clean, if necessary.
(b) Tip.	Clean, if necessary.
(c) Aileron tab.	Remove paper.
(d) Flaps and deflectors.	Clean, if necessary.
(e) Main landing gear.	Clean.
(f) Battery.	Clean.

(g) Engine and propeller.—The engine and propeller require a series of operations to refit them for service after they have been preserved for storage or shipment. The recommended procedure is as follows:

1. Install the engine on the airplane according to the procedure outlined in Section IV, paragraph 6., ENGINE SECTION.

2. Remove protective coatings from all exterior surfaces of the engine with naphtha or solvent. Dry the surfaces with compressed air.

3. Remove the engine cylinder dehydrator plugs (dummy spark plugs).

4. Unpack and clean the propeller. Install the propeller according to the procedure outlined in Section IV, paragraph 10., PROPELLER AND PROPELLER CONTROLS.

5. Remove the dehydrator plugs from the oil sump and allow the corrosion-preventive mixture to drain from the engine; at the same time rotate the propeller to facilitate drainage. If necessary, use a hand pump to insure complete removal of the mixture.

6. Remove all screens; wash them thoroughly in solvent, and reinstall them.

7. Remove the three lowest intake manifold pipes in each cylinder bank, and allow the corrosion-preventive mixture to drain from the cylinders. If any excess mixture is found, remove the adjacent intake pipes and examine them; continue removal toward the top until no excess of the mixture appears. After they have been drained, reinstall all of the intake pipes which have been removed.

8. Slush the carburetor thoroughly with solvent or gasoline to remove the protecting oil.

9. Install and connect all spark plugs.

10. To insure that all excess oil and corrosion-preventive compound have been drained from the engine, rotate the crankshaft by hand *at least four complete revolutions.* Reinstall the regular drain plugs.

11. Place sufficient gasoline in one fuel tank, and enough oil in the oil tank to insure a minimum ground run-up of one-half hour, and run the engine to complete the depreservation. Upon completion of the run-up, drain the oil from the engine and from the oil system. Fill the system with fresh oil before again running the engine.

(3) FUSELAGE GROUP.

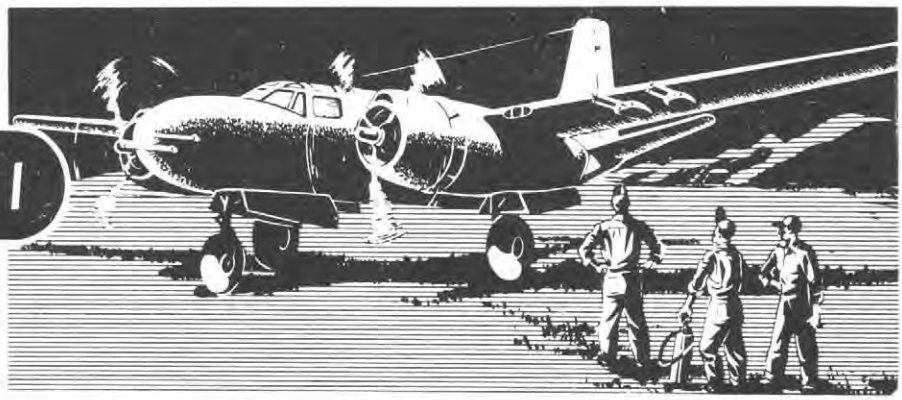
	DEPRESERVATION
(a) Fuselage.	Clean, if necessary.
(b) Nose section.	Remove paper and tape.
(c) Nose wheel gear.	Clean.
(d) Turrets.	Clean, if necessary.
(e) Armament.	Remove wrapping.
(f) Communications equipment.	Remove wrapping.
(g) Instruments.	Remove wrapping.

(4) EMPENNAGE GROUP.

(a) Horizontal stabilizer.	Clean, if necessary.
(b) Elevator.	Remove paper and tape.
(c) Vertical stabilizer.	Clean, if necessary.
(d) Rudder.	Remove paper and tape.
(e) Tail cone.	Remove paper and tape.

c. FINAL CHECK AFTER ERECTION.–Installation of the various members and the connection of electrical, hydraulic, fuel, and oil lines complete the erection of the airplane. It is assumed that the tightness of all connections will be tested at the time of assembly; the adjustment of the surface controls should be made with absolute accuracy to assure proper flying qualities for the airplane. These surface control adjustments are outlined in Section IV, paragraph 3.

SECTION III



HANDLING AND GENERAL MAINTENANCE INSTRUCTIONS

1. ACCESS AND INSPECTION PROVISIONS.

Inspection doors and cover plates are installed throughout the airplane. *(See figures 6, 7, 8, and 9.)*

2. GROUND HANDLING.

a. HOISTING PROVISIONS.

(1) HOISTING COMPLETE AIRPLANE.

(a) HOISTING POINTS. *(See figure 10.)*—The airplane is equipped with six hoisting points built into the structure. These are located in the following positions:

1. Two points, one on each side of the forward section of the fuselage where the nose joins the fuselage.

2. Two points located on top of the fuselage immediately aft of the rear gunner's compartment. (Used for hoisting fuselage-wings removed.)

3. One lifting point is located on the top of the rear spar at the center line of each nacelle.

(b) HOIST. *(See figure 11.)*—The standard hoisting sling provided for lifting the complete airplane is constructed of four ¾ inch diameter flexible steel cables complete with hooks and plugs. The two front suspension cables are held separate and in position by a spreader bar. Attached to the ends of the front cables are two plugs which fit and lock into sockets in the forward section of the fuselage. *(See figure 11.)* The two rear cables are fitted with hooks that engage into the attachments installed on the outboard surface of each nacelle.

(c) HOISTING.*(See figure 11.)*—Suspend the hoist directly over and aft of the pilot's enclosure; insert the plugs of front sling into sockets located in fore section of fuselage. With the hoist are two sets of shackles complete with pins. These shackles engage into built-in fittings located on the top of the rear spar, at center line of each nacelle. Remove the cover plates and attach shackles in place, then engage the rear sling hooks into them. After hoisting the airplane, these shackles and bolts shall be removed and stowed with the hoist.

CAUTION

When the four hoisting cables have been fitted into their respective positions, the hoist should be pulled taut, but before the airplane is lifted, a safety check should be made to ascertain that all hoisting fixtures have safely engaged. Raise the airplane a few feet and check for counterbalance.

(2) HOISTING COMPLETE AIRPLANE WITH WING TIPS REMOVED.—Proceed as in paragraph (c), above.

Note

As the amount of space gained by removing the wing tips is almost negligible, this procedure, therefore, is not recommended.

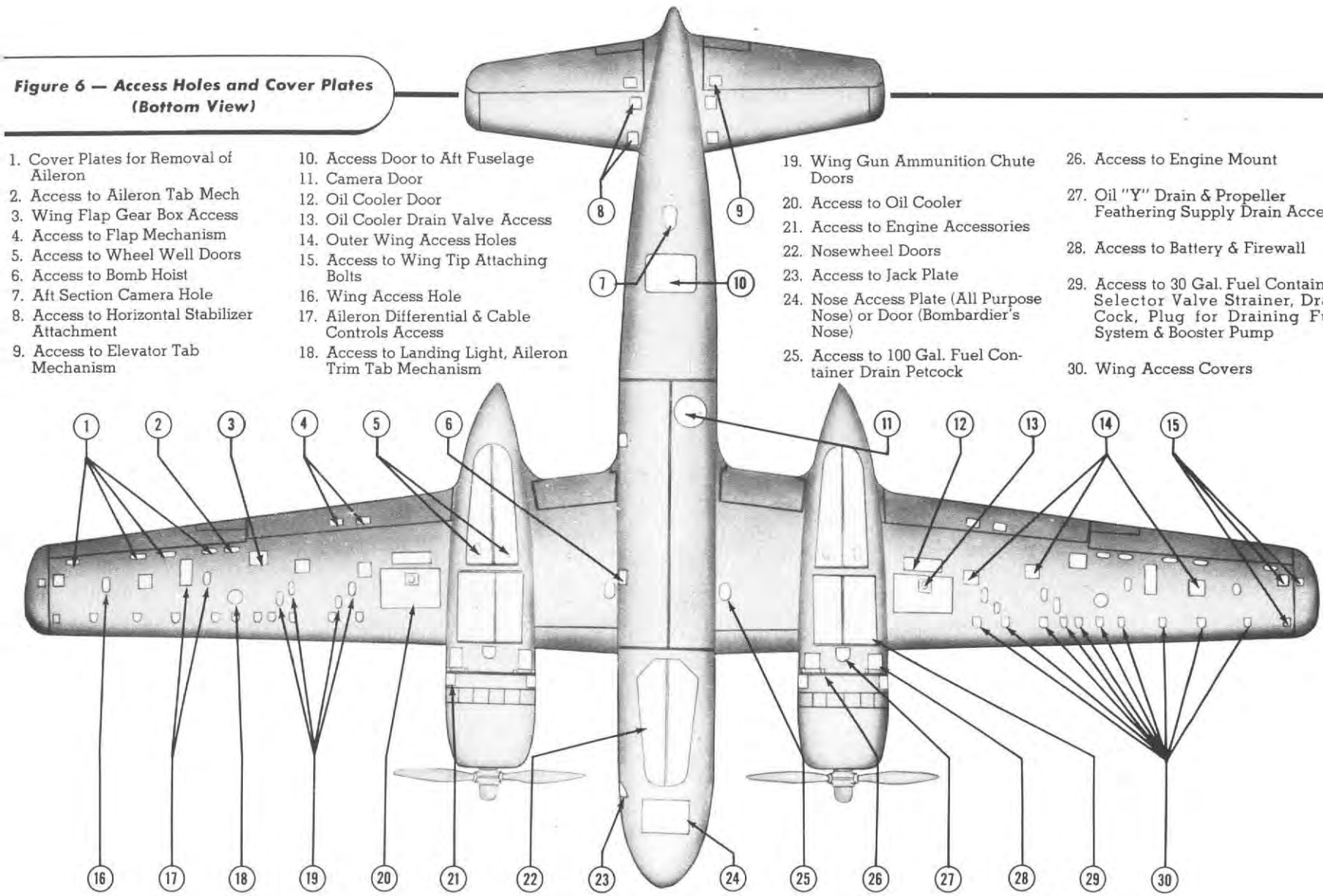
(3) HOISTING AIRPLANE WITH WING PANELS REMOVED. *(See figure 12.)*

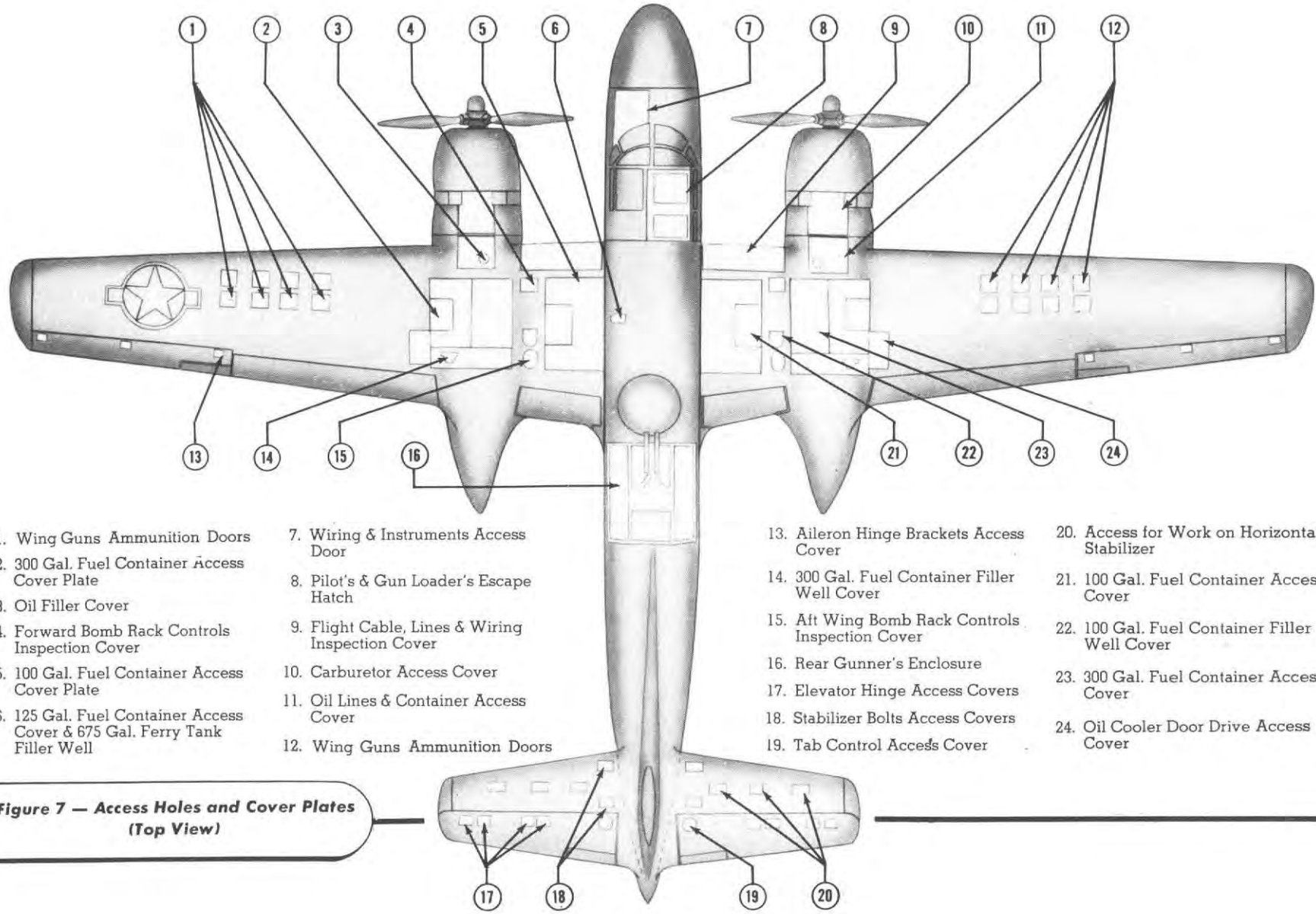
(a) HOIST.–The hoisting equipment for lifting the fuselage should be constructed of preformed flexible steel cable. A 4½" Dia. x 298" Blue Iron pipe acts as a spreader bar separating the front and rear slings. This hoist should be capable of carrying a safe load of 7000 lbs.

(b) HOISTING.—When the wing panels have been removed, the hoist should be suspended directly over the fuselage and the two plugs attached to the forward cables must be engaged into the two sockets built in the structure and located in the forward section of fuselage where the nose section attaches.

Figure 6 — Access Holes and Cover Plates (Bottom View)

1. Cover Plates for Removal of Aileron
2. Access to Aileron Tab Mech
3. Wing Flap Gear Box Access
4. Access to Flap Mechanism
5. Access to Wheel Well Doors
6. Access to Bomb Hoist
7. Aft Section Camera Hole
8. Access to Horizontal Stabilizer Attachment
9. Access to Elevator Tab Mechanism
10. Access Door to Aft Fuselage
11. Camera Door
12. Oil Cooler Door
13. Oil Cooler Drain Valve Access
14. Outer Wing Access Holes
15. Access to Wing Tip Attaching Bolts
16. Wing Access Hole
17. Aileron Differential & Cable Controls Access
18. Access to Landing Light, Aileron Trim Tab Mechanism
19. Wing Gun Ammunition Chute Doors
20. Access to Oil Cooler
21. Access to Engine Accessories
22. Nosewheel Doors
23. Access to Jack Plate
24. Nose Access Plate (All Purpose Nose) or Door (Bombardier's Nose)
25. Access to 100 Gal. Fuel Container Drain Petcock
26. Access to Engine Mount
27. Oil "Y" Drain & Propeller Feathering Supply Drain Access
28. Access to Battery & Firewall
29. Access to 30 Gal. Fuel Container, Selector Valve Strainer, Drain Cock, Plug for Draining Fuel System & Booster Pump
30. Wing Access Covers





1. Wing Guns Ammunition Doors
2. 300 Gal. Fuel Container Access Cover Plate
3. Oil Filler Cover
4. Forward Bomb Rack Controls Inspection Cover
5. 100 Gal. Fuel Container Access Cover Plate
6. 125 Gal. Fuel Container Access Cover & 675 Gal. Ferry Tank Filler Well
7. Wiring & Instruments Access Door
8. Pilot's & Gun Loader's Escape Hatch
9. Flight Cable, Lines & Wiring Inspection Cover
10. Carburetor Access Cover
11. Oil Lines & Container Access Cover
12. Wing Guns Ammunition Doors
13. Aileron Hinge Brackets Access Cover
14. 300 Gal. Fuel Container Filler Well Cover
15. Aft Wing Bomb Rack Controls Inspection Cover
16. Rear Gunner's Enclosure
17. Elevator Hinge Access Covers
18. Stabilizer Bolts Access Covers
19. Tab Control Access Cover
20. Access for Work on Horizontal Stabilizer
21. 100 Gal. Fuel Container Access Cover
22. 100 Gal. Fuel Container Filler Well Cover
23. 300 Gal. Fuel Container Access Cover
24. Oil Cooler Door Drive Access Cover

Figure 7 — Access Holes and Cover Plates (Top View)

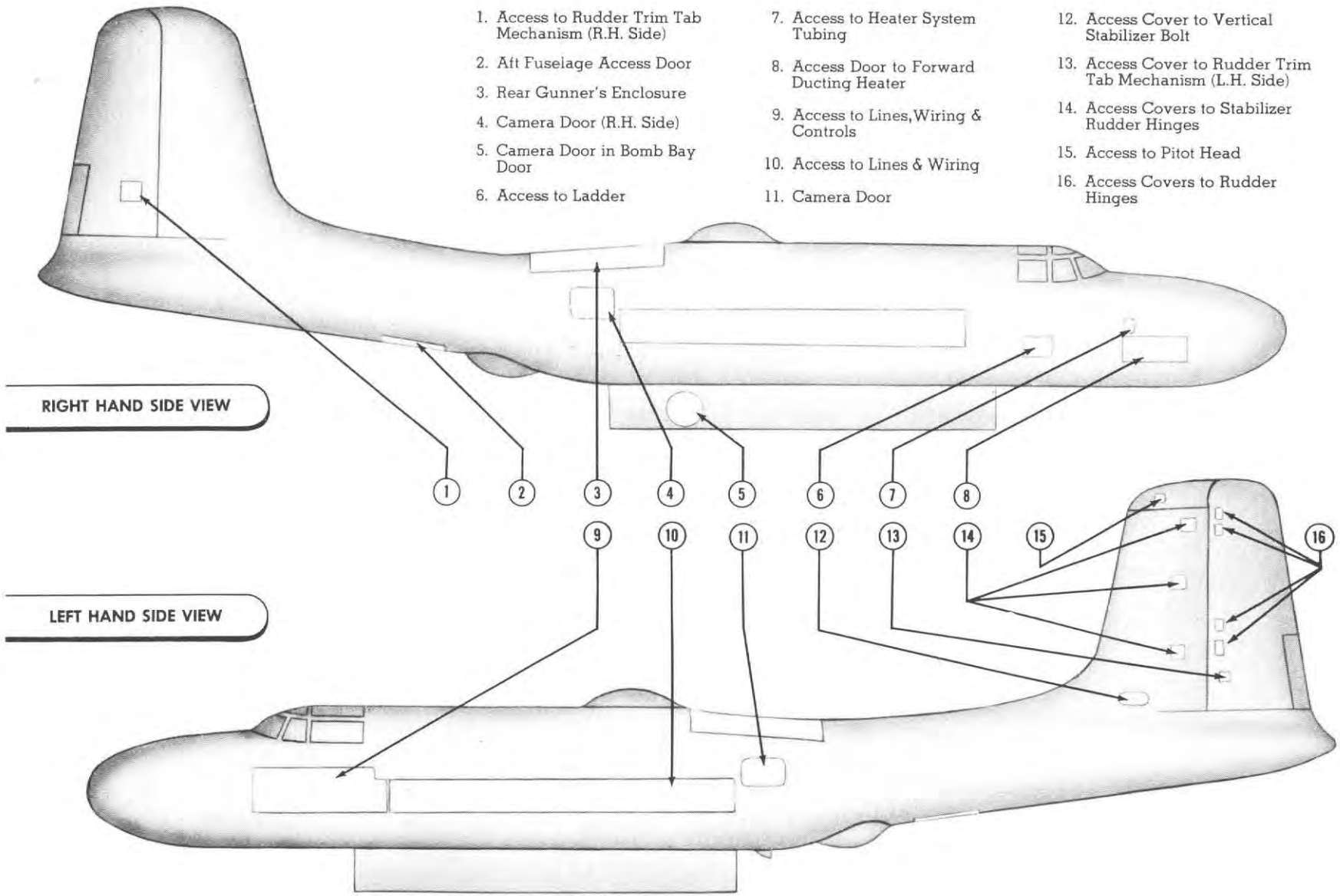


Figure 8 — Access Holes and Cover Plates (Side Views)

Two AN48 eyebolts should be inserted into the two built-in hoisting fixtures aft of the rear gunner's compartment and securely bolted into place *(figure 12)*. With the hoist spreader bar suspended parallel with the fuselage the two hooks attached to the rear sling shall be engaged into the eyebolts. These eyebolts are stowed in the miscellaneous handling equipment roll located in the rear of the left-hand nacelle.

CAUTION

Before lifting the airplane, the cables should be pulled taut and the four hoisting points checked to assure safe engagement. Then the fuselage should be raised a few feet to check for counterbalance.

(4) HOISTING FUSELAGE AFT SECTION. *(See figure 13.)*—In order to hoist the fuselage aft section, a cradle type sling may be constructed that will accomplish easier handling of this assembly. With the use of this sling, even balance is assured and no strain is placed upon the horizontal stabilizers. The upper frame of the sling secures the vertical stabilizer and rudder. This type hoist sling will be a great asset in preventing damage to the section when lifting fuselage aft section for any purpose.

(5) HOISTING VERTICAL STABILIZER AND RUDDER. *(See figure 15.)*—A sling may be fabricated that will greatly facilitate the handling of the vertical stabilizer with rudder attached. The hoist is so designed that the sling attachments fit and securely attach to the stabilizer by the removal of two screws from the second and twelfth screw holes (counting from the rear) at top spar of stabilizer and installing "T" screw plates *(3, figure 15)*.

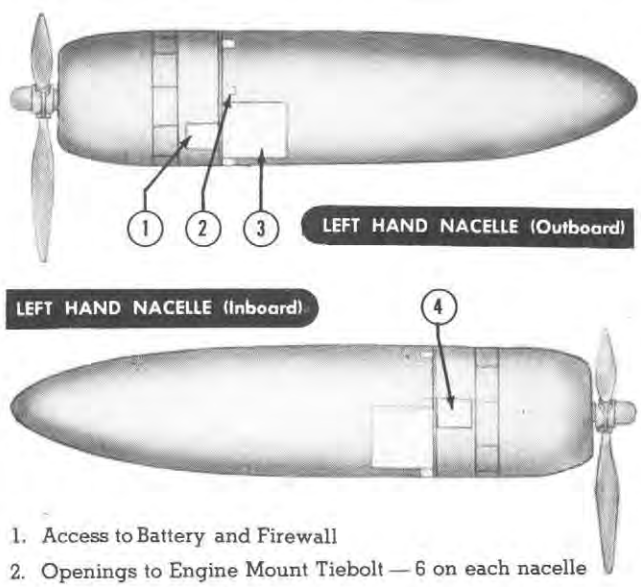
The sling is designed to hoist the complete assembly with the rudder secured. The attachments fitting into the vertical stabilizer at the spars, support the entire weight without strain. The screws removed should immediately be replaced when lifting attachments have been removed and hoisting operation completed.

(6) HOISTING THE PROPELLER. *(See figure 180)*—A simple yet practicable hoist sling may be constructed that will enable easy handling of this assembly. Two leather covered steel cables secured around the base of the propeller blades by means of safety lock hook, hold it in an inverted "Y" position. The vertical blade rests in a leather faced slot which prevents damage and slipping. The propeller, slung in this method, permits free working from either side in complete safety. It is important to check that the safety hook is correctly engaged into the shackle and that no metal parts of the sling come into direct contact with the propeller thereby causing nicking or scratching the assembly during the process of hoisting.

(7) HOISTING ENGINE. *(See figure 14.)*—Four hoisting attachments are built into the engine for convenience of lifting it during installation or removal. The engine sling must withstand a proof load of at least 8400 lbs. T sling *(figure 14)* may be constructed that will answer this purpose. It is essential that the correct specifications given be observed regarding length of cables to ensure correct balance. When hoisting the engine one man must always be alert to prevent the engine spinning when in the hoist, and it should be lifted slowly and without jerking. After the hoist hooks have been engaged in their respective connections the hoist cables should be pulled taut. Before clearing the engine from its supports make certain every hook is properly connected, then lift slowly, care being taken to observe balance.

(8) FUSELAGE NOSE ASSEMBLY SLING. *(See figure 17.)*—For the purpose of lifting either of the two types of nose a very practical sling may be devised with the use of leather covered cables and 3" cotton belting. Two lifting eyeplates are attached to each end of a "T" cross bar. From these plates, two cables are suspended and attached to the belting by riveted plates. The belting straps around the fore and aft section of the nose are secured at the bottom by a hook and eye. There are two side cables attaching the fore and aft sling that prevent the hoist from slipping during the hoisting operation.

b. MAIN LANDING GEAR HANDLING DOLLY. *(See figure 16.)*—In order to facilitate the handling and moving of the landing gear wheels when demounted from the airplane, a special portable dolly



1. Access to Battery and Firewall
2. Openings to Engine Mount Tiebolt — 6 on each nacelle
3. Access to Engine Accessories
4. Access to Flap Mechanism

Figure 9 — Access Holes and Cover Plates (Nacelle)

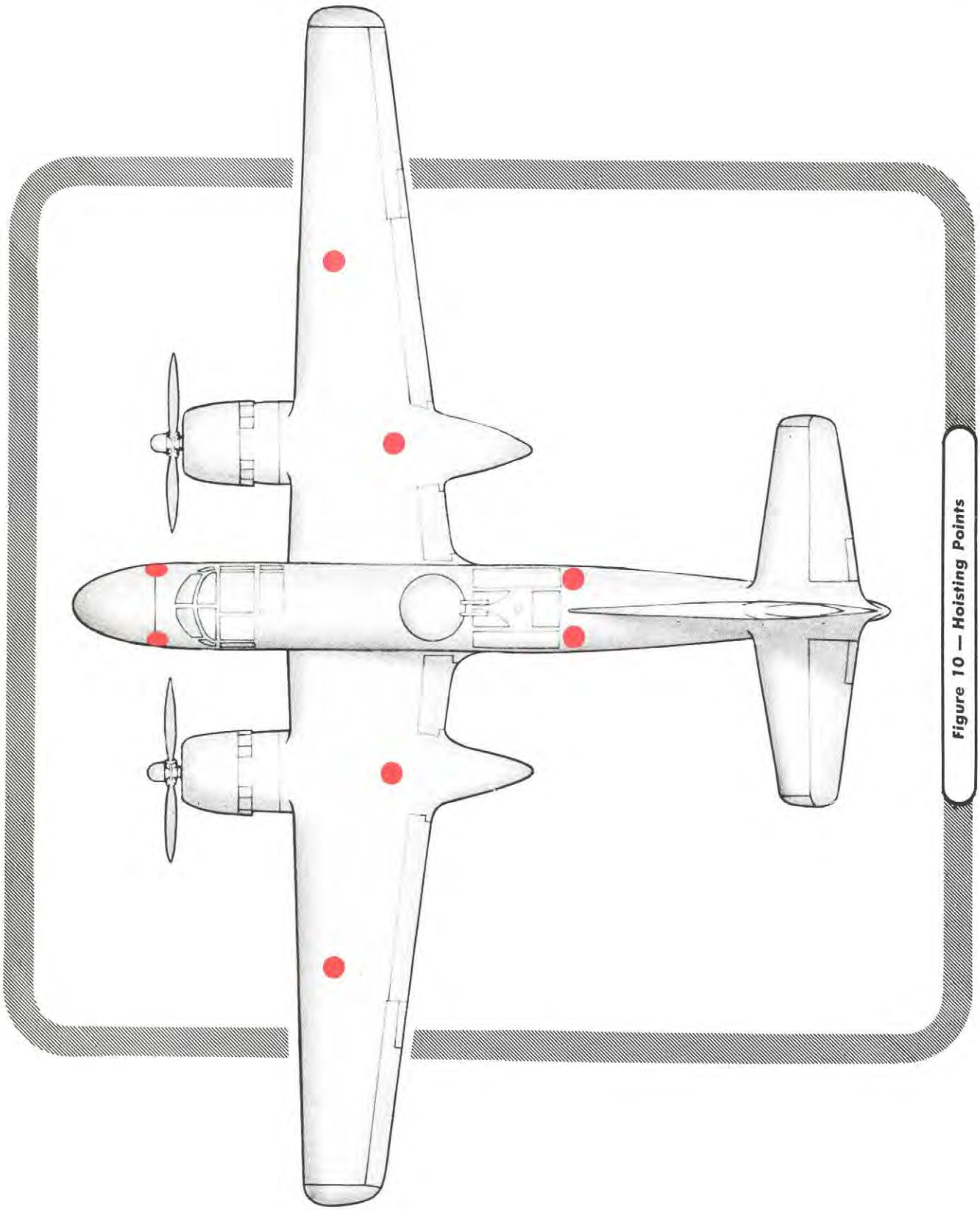


Figure 10 — Hoisting Points

may be constructed for this purpose. This type of dolly will be found convenient for supporting the main landing gear and wheel assembly when moving it from place to place as may be required; it also assists in eliminating possible damage. One man only is required to adjust the dolly in place or move it when this heavy assembly is loaded upon it. To attach the dolly to the landing gear, proceed as follows: Open the "T" handle bolt *(2, figure 16)* on the sleeve Push the dolly against the strut until the half sleeve fits flush. Close the sleeve and "T" handle bolt. To align the dolly in correct position, turn the adjustment screw bolts *(3, figure 16)* at top of dolly. The dolly is now in position to receive the full weight of the wheel. Care should be taken to check that the cross arm pads are pressing against the wheel rim and that the gear assembly is resting in the cradle arms before dismounting the gear assembly from airplane. Dismount wheel and pull dolly from under airplane. The dolly should be standing on a level area and the casters chocked or turned to prevent free motion.

c. JACKING PROVISIONS.–Jacks should be used for lifting the airplane to permit testing, replacement or servicing of the landing gear. With the exception of the nose and tail, it is practicable to jack at any jacking point on the airplane with a single jack. However, to jack at any point except under the main wheel axles, it will be necessary to secure a jack pad to the point.

Note

Some jacks are equipped with jack pads. If using a single jack, do not jack through a range of more than seven inches without counterbalancing with another jack, as there is danger of slipping.

It is not necessary to do this at the main wheel jacking points because they are equipped with pads. The jack pads are carried in the miscellaneous handling equipment roll stowed on the outboard shelf in the left-hand nacelle. Jacking points are located as follows:

(1) FUSELAGE. *(See figure 26.)*—The fuselage forward jacking provisions are located on the lower surface of the fuselage, on the left-hand side, just aft of where the nose joins the fuselage. Remove the access cover plate *(23, figure 6)* to reach this jacking point. The fuselage aft jacking point is located directly forward of the tail skid fairing.

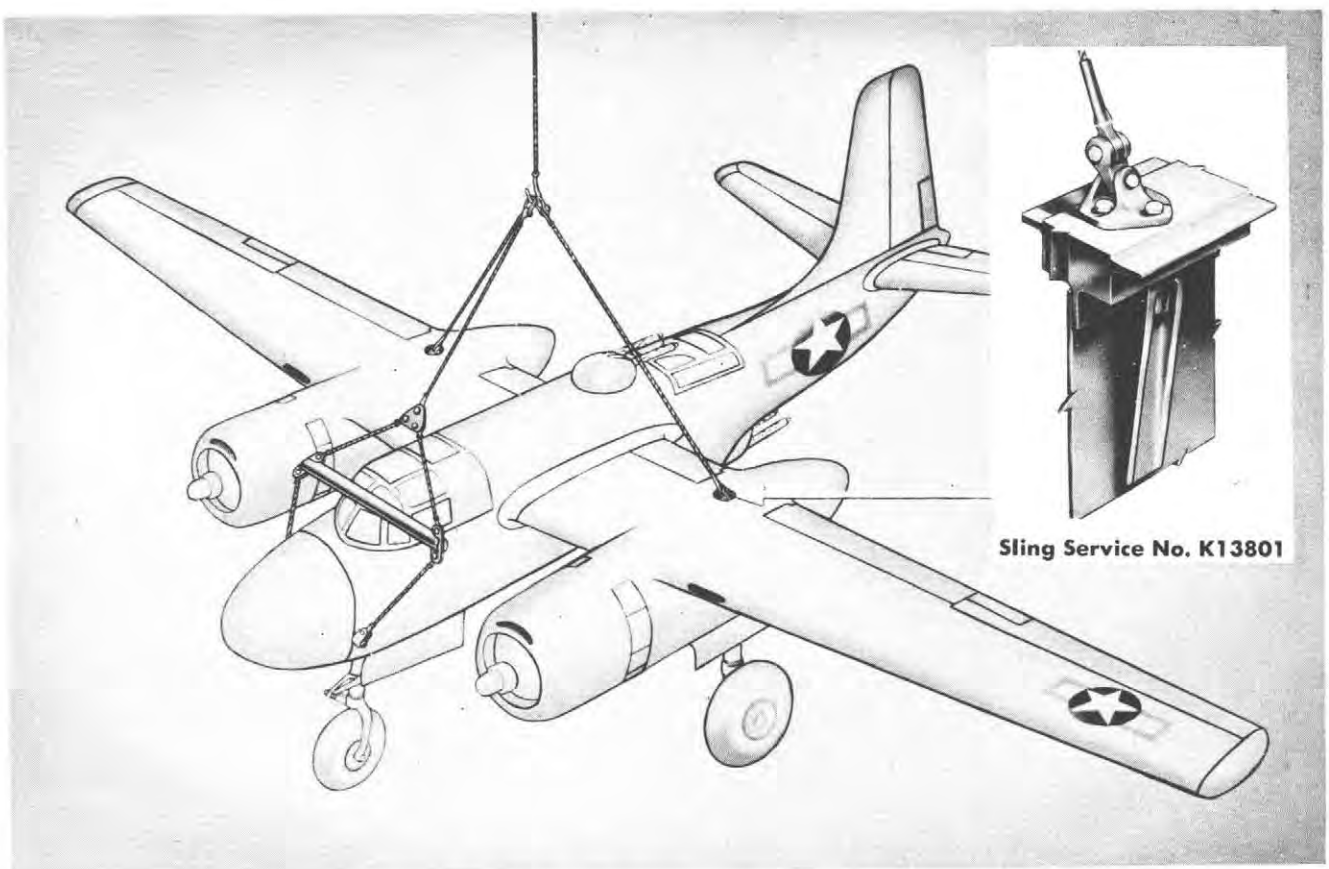
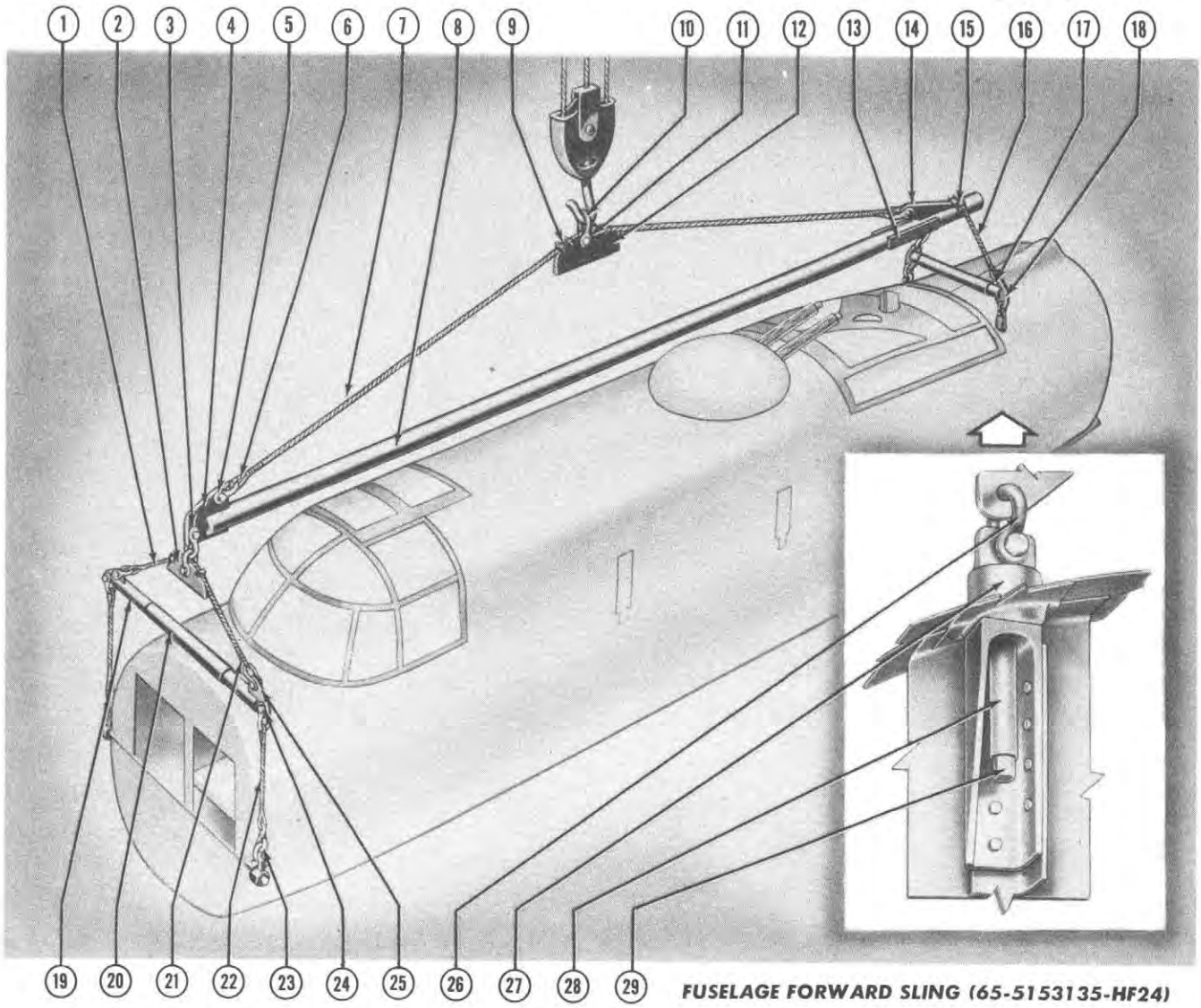


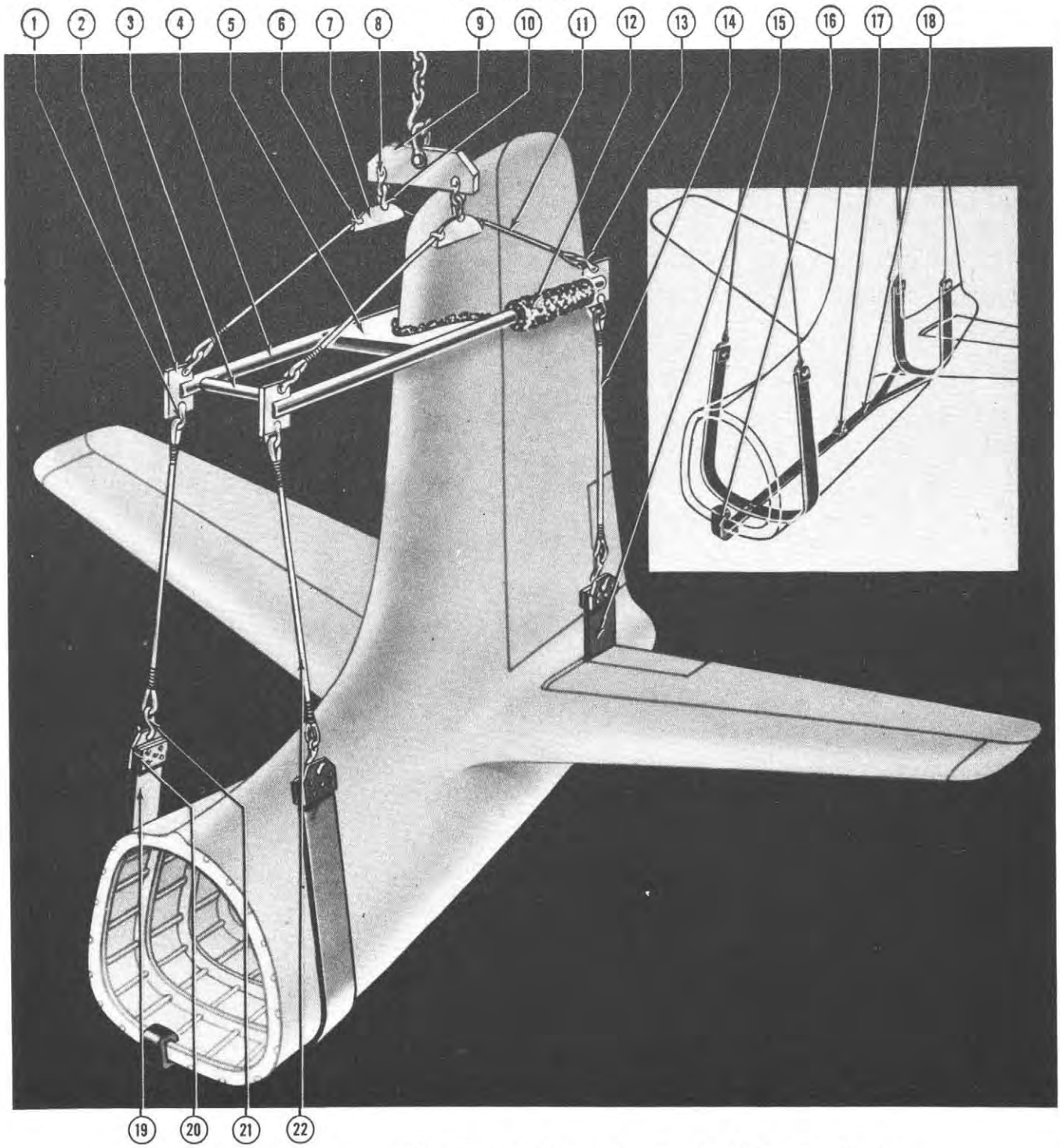
Figure 11—Hoisting Complete Airplane



FUSELAGE FORWARD SLING (65-5153135-HF24)

Ref. No.	Name	Size and Material	No. Req.
1.	Roebling Blue Center Wire Rope	1/2 x 126-1/2 (6 x 19)	1
2.	Eye Lift	1/2 (Cable Size)	1
	Plate	4 x 10-1/8 x 3/8 SAE 1020 CR	1
	Cable Clip (Ducommun)		2
	Anchor Shackle	3/8 x 11/16 x 7/8	1
3.	Round Pin Anchor Shackle	2-3/4 x 6-13/16 x 2-1/8	5
	Drop Forging	SAE 1025	5
	Hex. Nut	7/8-9	5
	Hex. Head Bolt	7/8-9 x 4-1/4	5
	Cotter Pin	1/16 x 1-1/4	5
4.	Plate	5/8 x 8-3/4 x 9-1/2 SAE 1020 HR	1
5.	Spacer	2 Dia. x 1/2 SAE 1020 HR	10
6.	Thimble	Cable Dia. 5/8 2-1/8 x 7/8 x 11/16 x 1-1/4 Wire Rope	2
7.	Roebling Blue Center Wire Rope	5/8 x 398 (6 x 19)	1
8.	STD. B.I. Pipe	4-1/2 Nom. x 298-7/8	1
9.	Cable Clamp (U Type)	5/8	4
10.	Round Pin Anchor Shackle	Drop Forging SAE 1025	1
	Hex. Nut	1-8	1
	Hex. Head Bolt	1-8 x 5-1/2	1
	Cotter Pin	1/16 x 1-1/4	1
11.	Spacer	2-1/2 Dia. x 3/8 SAE 1020 CR	2
12.	Plate	3/4 x 5-1/2 x 14-1/2 SAE 1020 HR	1
13.	Weights	As Req. For Balance	As Req.
14.	Plate	5/8 x 8-3/4 x 9-3/4 SAE 1020 HR c/s	1
15.	Eye Lift	3/8 Cable Size	1
	Plate	4 x 10-1/8 x 3/8	1
	Cable Clip (Ducommun)		2
	Anchor Shackle	11/16 x 3/8 x 7/8	1
16.	Roebling Blue Center Cable	5/16 Dia. x 37 Length (6 x 19)	1
17.	STD. B.I. Pipe	1-1/2 Nom. x 35	1
18.	Plate	5/8 x 6 x 9 SAE 1020 HR c/s	2
19.	STD. B.I. Pipe	1-1/2 Nom. x 61	1
20.	Cover	1/4 soft Gray Felt	As Req.
	Cover	12 oz. Canvas	As Req.
21.	Thimble	Cable Dia. 12-15/16 x 11/16 x 1-9/32 x 1-1/16 Wire Rope	2
22.	Roebling Blue Center Cable	5/16 Dia. x 31-1/4 Length (6 x 19)	2
23.	Roebling Hook with Safety Catch	#5	2
24.	Flat Washer	5/8	4
25.	Plate	1/2 x 6 x 8-3/16 SAE 1020 HR	2
26.	Round Pin Anchor Shackle	Drop Forging SAE 1025	6
	Hex. Nut	5/8-11	6
	Hex. Head Bolt	5/8-11 x 3-1/2	6
	Cotter Pin	1/16 x 1	6
27.	Bolt Assembly		2
	Pin	1/8 Dia. x 2 SAE 1020 CR	2
	Screw	1/2 Dia. x 4 SAE 4140 HR	2
	Hard White Felt	1/4 x 2 Dia.	2
	Head	2 Dia. x 3-3/4 SAE 1020 CR	2
28.	Nut (within Fuselage)	7/8 Dia. x 4-1/4 SAE 1020 CR	2
29.	Hex. Bar	7/16 x 3/4 SAE 1020 CR	2

Figure 12—Hoisting Fuselage Forward Section



1. 5/16" Shackle
2. 3/16" x 2-1/2" x 4" Mild Steel Plate
3. 1" I.P. x 10" Std. B.I. Pipe
4. 1" I.P. x 94" Std. B.I. Pipe
5. 2" x 12" x 9" Oregon Pine cut to fit
6. 5/16" "U" Type Cable Clip
7. 3/8" x 3" x 6" Mild Steel Plate
8. 7/16" Shackle
9. 3/8" x 3" x 12" Mild Steel Plate
10. 1/2" Shackle
11. 5/16" Dia. x 144" Finish Length Roebling Blue Center Cable
12. 1/2" Felt and Canvas
13. 5/16" Shackle
14. 1/4" Dia. x 66-1/2" Finish Length Roebling Blue Center Cable
15. 4" x 1/4" x 92" Rusco Woven Webbing or equivalent
16. 1/8" x 1-1/2" x 6-1/2" Mild Steel Bent Plate
17. 1-1/2" Harness Buckle
18. 1-1/2" x 3/16" x 148" Rusco Woven Webbing or equivalent
19. 4" x 1/4" x 121" Rusco Woven Webbing or equivalent
20. 3/16" x 4" x 4-1/2" Mild Steel Plate (Rivet as required)
21. #5 Roebling Safety Hook
22. 1/4" Dia. x 58-1/2" Finish Length Roebling Blue Center Cable

Figure 13—Hoisting Fuselage Aft Section

Sling Service No. K13601

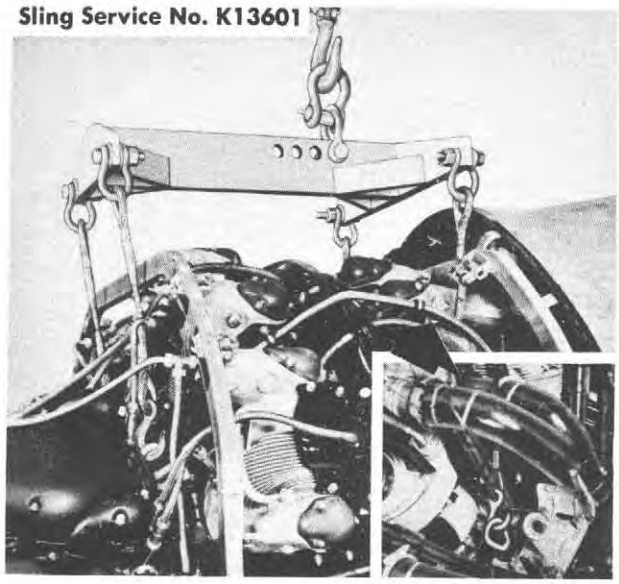
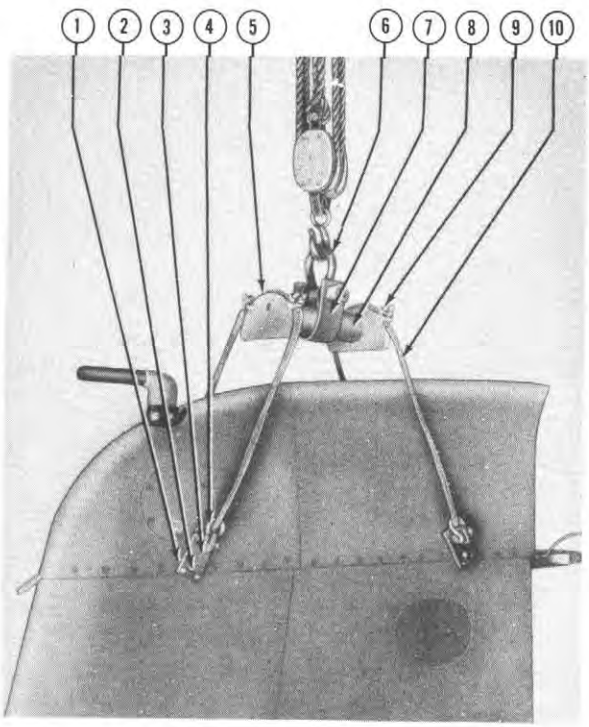
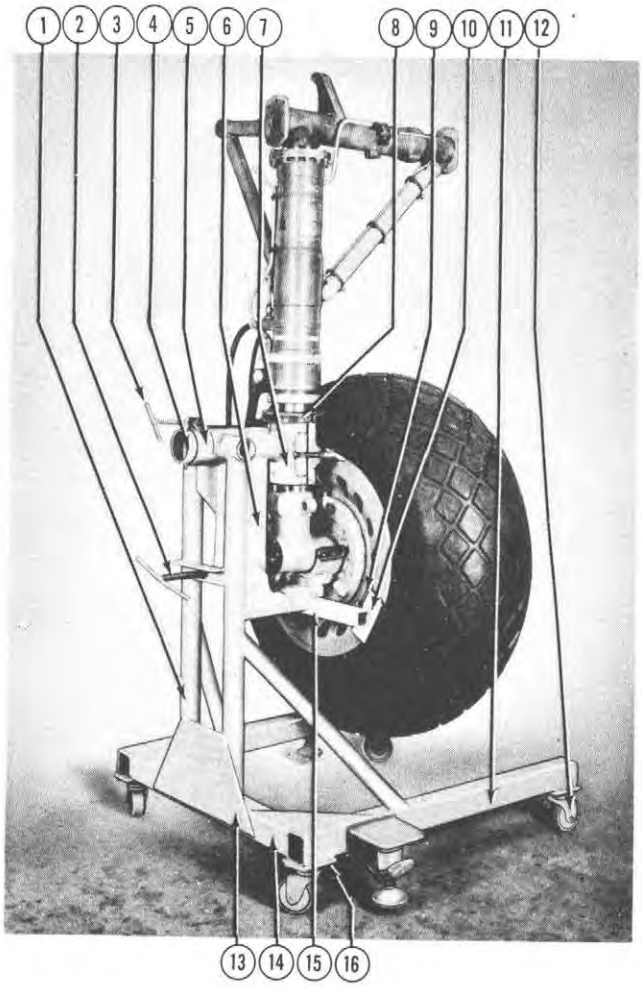


Figure 14 — Hoisting Engine



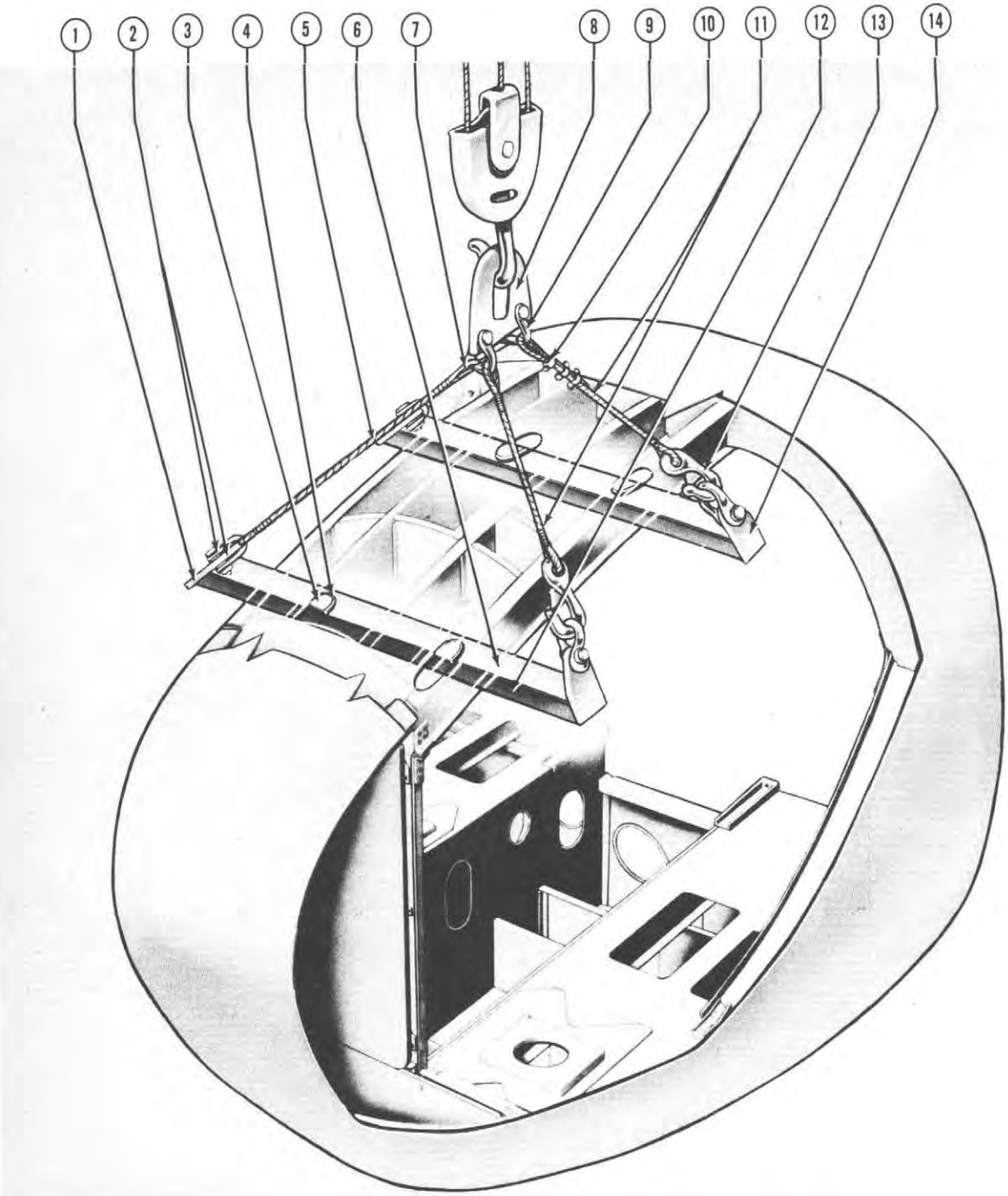
1. 1/8" Leather Cover
2. 10-24 Machine Screw
3. 1½" x 1½" x ¼" x 3" Tee
4. ¼" Shackle
5. ⅜" x 3" x 6" Mild Steel Plate
6. ⅝" Shackle
7. ¼" x 2" x 9" Mild Steel Plate
8. 1½" Inside Dia. x 7½" STD. B.I. Pipe
9. ¼" "V" Type Cable Clamp
10. ¼" Dia. x 36" Finish Length Roebling Blue Center Cable

Figure 15 —Hoisting Vertical Stabilizer



1. 2" Inside Dia. x 40" Standard Blue Iron Pipe
2. ¾" — 10 Tee Bolt
3. ⅝" — 11 Tee Bolt
4. 3½" Inside Dia. x 15" Standard Blue Iron Pipe
5. 4" Inside Dia. x 7" Standard Blue Iron Pipe
6. 3" x 3" x .200" x 24" SAE 1025 H.R. Square Tube
7. 5" Inside Dia. x 7¾" Standard Blue Iron Pipe
   ½" Dia. Hinge Pin
8. ¼" Leather
9. ¼" Leather
10. ⅜" x 2½" x 6" Mild Steel Plate
11. 3" x 3" x .200" x 43" SAE 1020 H.R. Square Tubing
12. 1-74C1 Darnell Castor or equiv.
13. ¼" x 10" x 20" Mild Steel Plate
14. 3" x 3" x .200" x 32" SAE 1025 H.R. Sq. Tubing
15. 2" x 2" x .145" x 22" SAE 1025 H.R. Steel Tube
16. ¼" x 10" x 20" Mild Steel Plate

Figure 16 — Main Landing Gear Wheel Dolly



Sling Service No. K13901

Ref. No.	Name	Size and Material	No. Req.
1.	Bracket	1/4 x 3 x 4-9/16 SAE 1020 CR	2
2.	Spacer	1-1/2 Dia. x 3/16 SAE 1020 CR	8
3.	Plate	1/2 x 1-1/4 x 2-5/8 SAE 1020 CR c/f	4
4.	Pad	1/8 x 1/2 x 4 Leather	4
5.	Roebling Blue Center Cable	1/4 x 37 (6 x 19)	2
6.	Hard White Felt Covering	3/16	As Req.
7.	Wire Rope Thimble	1/4 Dia. 11/16 Width 1-3/8 Length	2
8.	Hoisting Link	5-3/4 x 4-1/4 x 1/2 SAE 1020 HR	1
9.	Anchor Round Pin Shackle	1-7/16 x 2-7/32	6
	Drop Forging	SAE 1025	6
	Hex. Nut	7/16-14	6
	Hex. Head Bolt	7/16-14 x 2	6
	Cotter Pin	1/16 x 3/4	6
10.	Safety Wire Rope Clip	1-4 Dia. x 2400 lbs. Wt.	6
11.	Roebling Blue Center Cable	1/4 x 35 (6 x 19)	2
12.	Tube	1/2 Sq. x .140 Wall x 33-1/2 SAE 1025 HR	2
13.	Chain Safety Snap Hook	For Chain Size 1/4 Load 450 lbs.	2
14.	Bracket	1/4 x 2 x 4-9/16 SAE 1020 CR	2

Figure 17 — Hoisting Fuselage Nose

CAUTION

The nose wheel should not touch the ground when jacking at this point.

(2) WING.—Each wing has two jacking points on the rear spar: one point *(figure 21)* is on the inner wing panel; the other point is outboard of the nacelle. If jacks high enough to reach the wing jacking points are not available, use supporting stands for shorter jacks. Make certain the stands are strong enough to support the airplane. With wing jacks of ample jacking range, it is not necessary to use restraining links on the oleos.

(3) LANDING GEAR.—A jack point *(figure 21)* is located on the lower end of each main landing gear shock absorber strut. Use either of these points when it is necessary to remove a tire or wheel, etc.

Service No. K14001

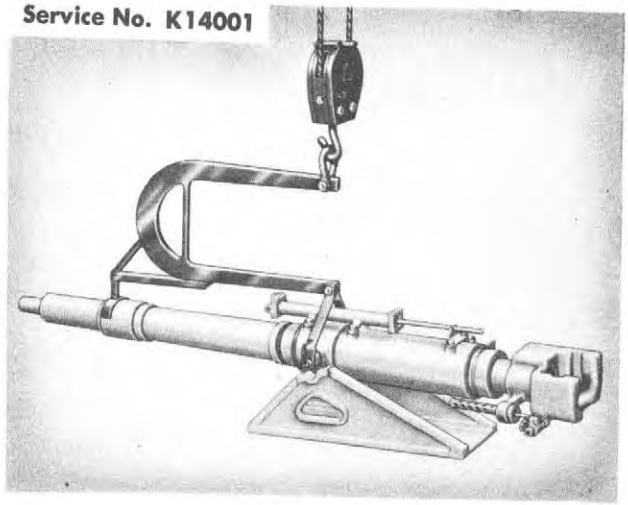


Figure 19 — Hoisting 75 mm Cannon

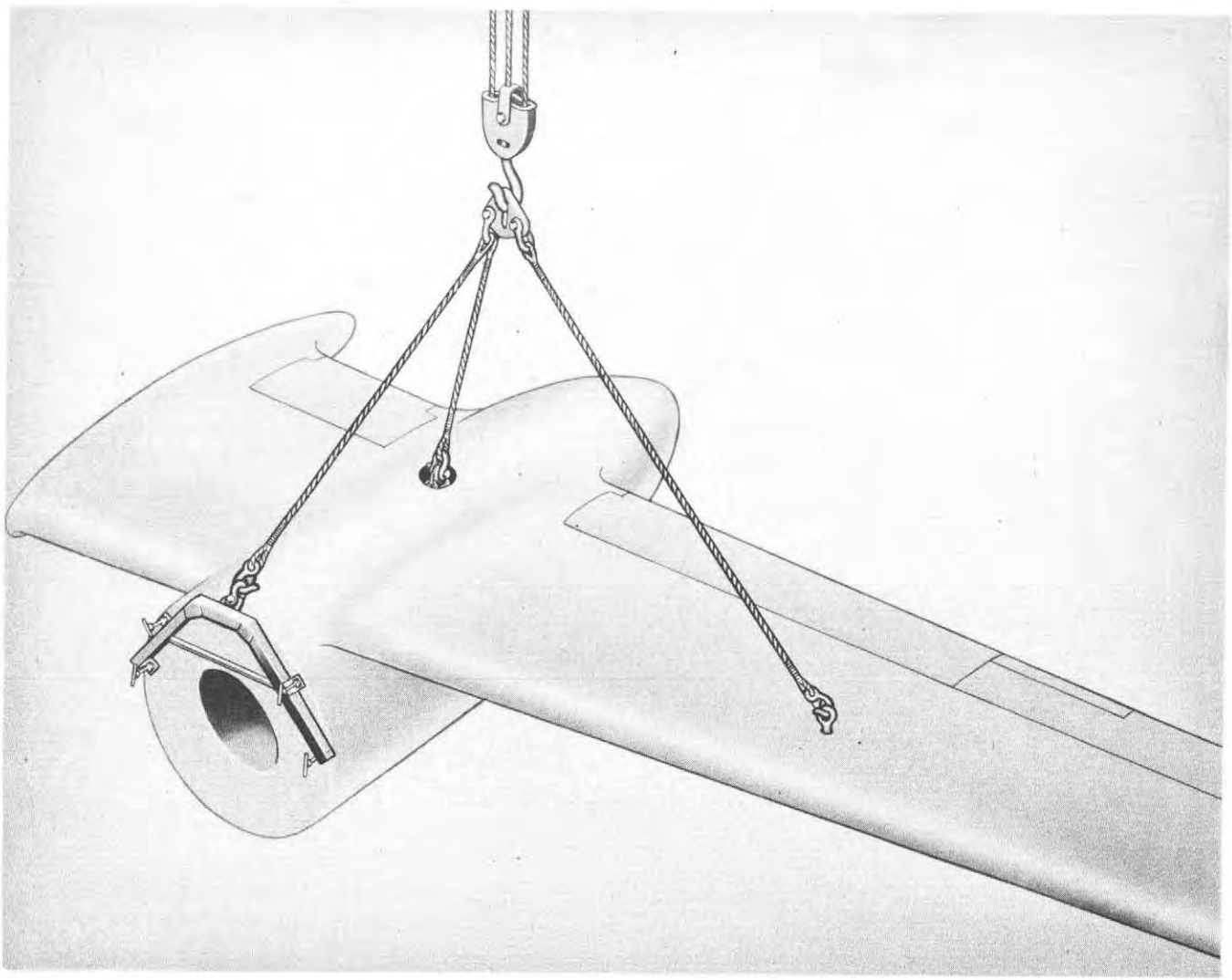
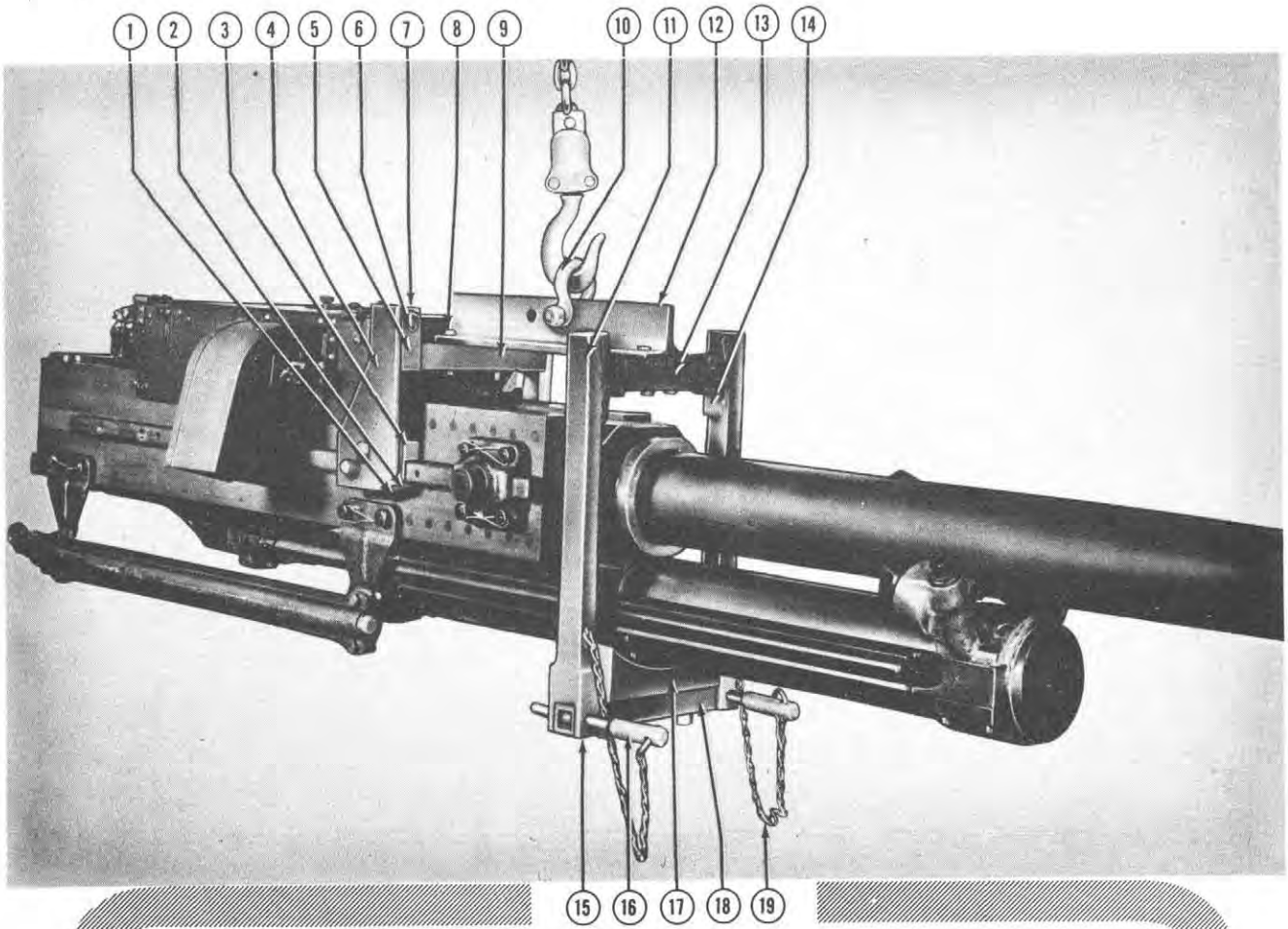


Figure 18 — Hoisting Wing



37 MM CANNON SLING C654-5202516-3HF1

Ref. No.	Name	Size and Material	No. Req.
1.	Angle	2½ x 2½ x ¼ x 3½	2
2.	Bar	⅛ x ½ x 3½ SAE 1020 CR	2
3.	Bar	¾ x ¾ x 3½ SAE 1020 CR	2
4.	Bar	¼ x 3½ x 7 SAE 1020 CR	2
5.	Bar	¼ x 1 x 2¼ SAE 1020 CR	2
6.	Bar	⅜ dia. x 1¾ SAE 1020 CR	2
7.	Bar	1 x 1 x 1 SAE 1020 CR	2
8.	Hex. Head Cap Screw & Nut	¼ — 20 x 1¾	4
9.	Square Tube	1 x 1 x .125 Wall x 6⅜ SAE 1025 HR	1
10.	Shackle Assembly (K65-9648-5STK)		
	Drop Forging	Dia. ½ W. 1 13/16 L. 4¼	1
	Hex. Head Bolt	⅝ — 11 x 3½	1
	Hex. Nut	⅝ — 11	1
	Cotter Pin	1/16 x 1	1
11.	Square Tube	1 x 1 x .125 Wall x 12⅝ SAE 1025 HR	2
12.	Tee Angle	2 x 2 x ¼ x 12⅛	1
13.	Square Tube	1 x 1 x .125 Wall x 6 7/16 1025 HR	1
14.	Angle	1 x 1 x 3/16 x 1	6
15.	Bar	¼ x 1 x 2½ SAE 1020 CR Pin Hole Size .3750	2
16.	Jig Slip-Fit Pin (K652-9660-102 STK)	SAE 1020 CR	2
	Pin	Length 4⅜ Dia. .3745	2
	Handle	Length 2⅜ Dia. ⅜	2
	Chain Hole	Dia. 5/16	2
17.	Micarta Bar	2 x 2 x 6	1
18.	Square Tube	1 x 1 x .125 Wall x 8½ 1025 HR	1
19.	Sash Chain		As Req.

Figure 20 — Hoisting 37 mm. Cannon

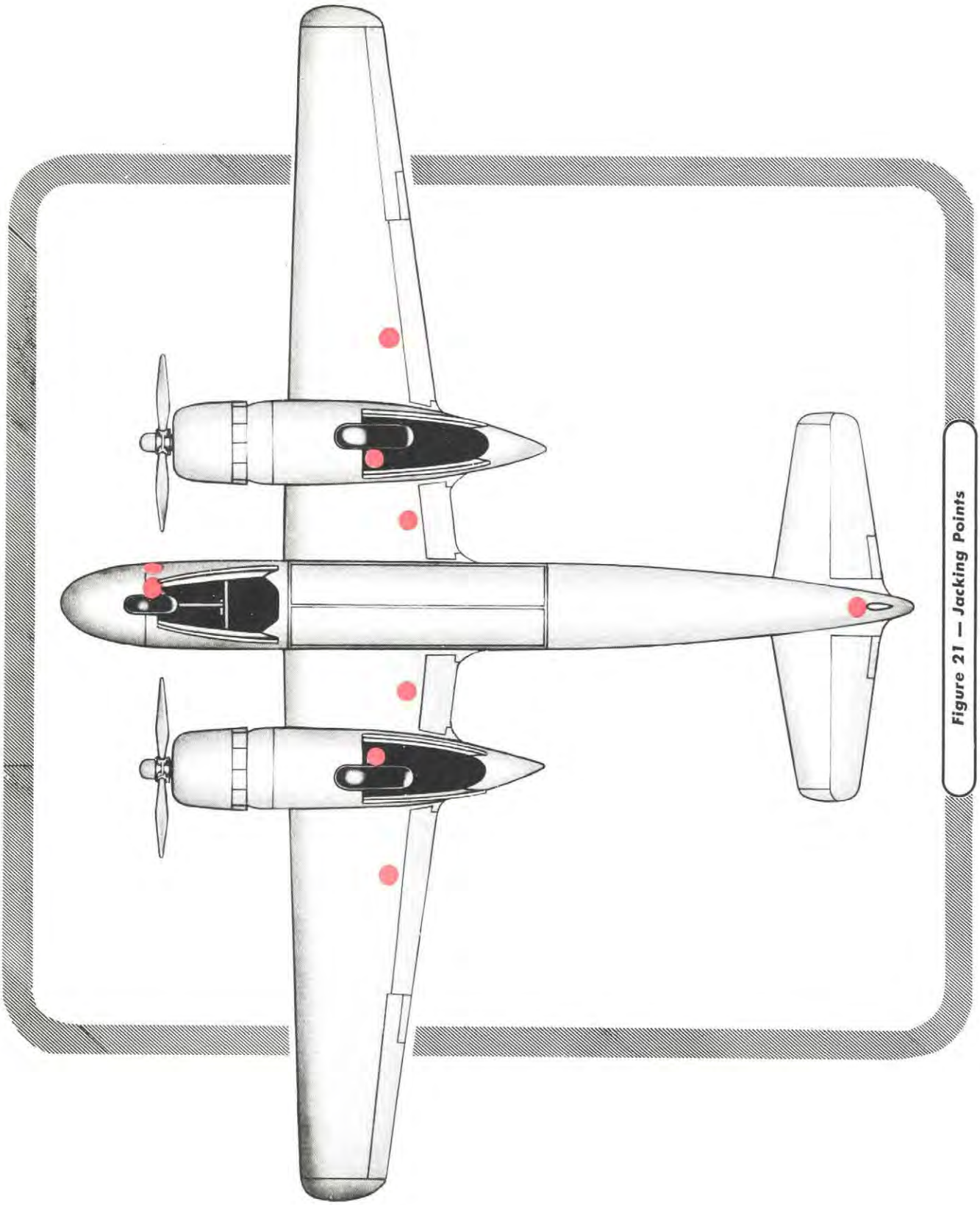


Figure 21 — Jacking Points

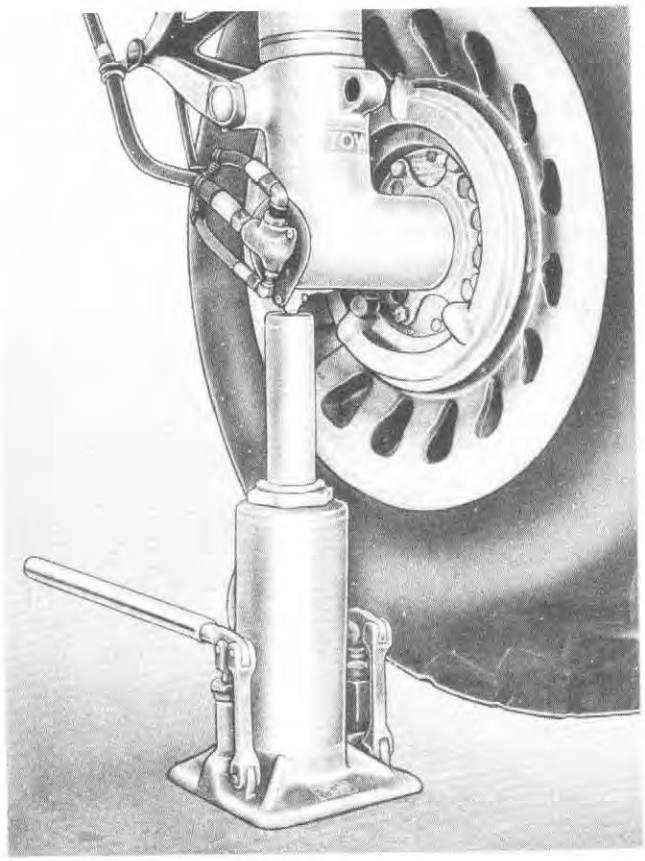


Figure 22 — Wheel Jack Installed

CAUTION

For complete safety, the wing should also be jacked as there is danger of the wheel jack slipping.

Obviously neither may be used when it is necessary to retract the landing gear.

Figure 23 — Wing Jack Pad

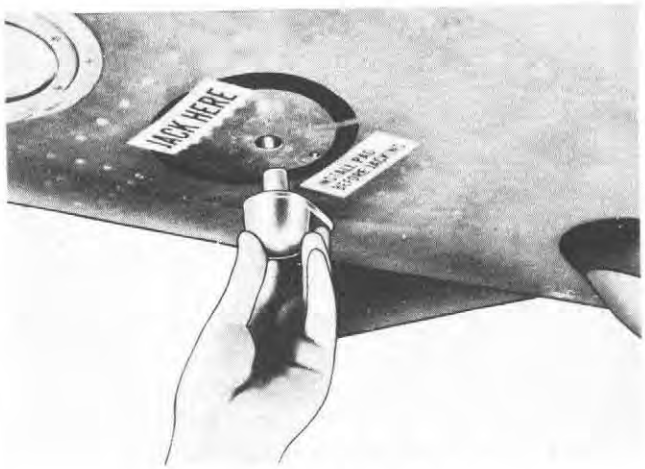
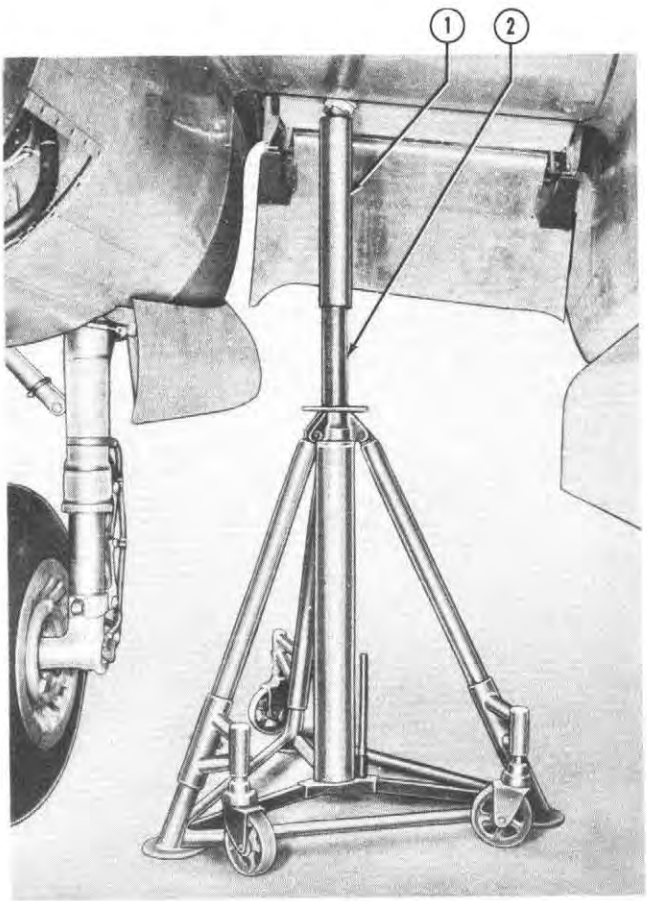


Figure 24 — Tail Jack Pad



Name	*No. Req.*	*Material*	*Dimensions*
1. Hydraulic Jack Adapter			
Bar	1	SAE 1020 H.R.	5 Dia. x 3½
Seamless Mech. Tube	1	Steel	4¾ O.D. x .375 W x 27
Pipe	1	B. Iron	3½ Nom. x 15¼
Bar	1	SAE 1020 H.R.	4 Dia. x ¾
Pipe	1	B. Iron	3½ Nom. x 11
2. Murcell Jack	1	Steel	Serial 2 M-900

Figure 25 — Wing Jack Installed

(4) ENTIRE AIRPLANE.—To raise the entire airplane it is preferable to use at least four jacks. Jacks at the nose and tail are advisable in any combination of the four; and the other two must be separated by the fuselage.

WARNING

The airplane may be raised without the use of a tail jack; however, if the engines were removed or there were any other condition shifting the center of gravity toward the tail, it would be imperative to use a tail jack to prevent tipping the airplane back onto its tail. Considerable difficulty has been encountered in the field because of the single nose wheel jack having insufficient clearance for the retraction of the nose wheel. In such contingencies temporary jack pads or fittings may be fabricated to attach to the two nose hoisting points for the application of two jacks. One of these points is just above and aft of the regular nose jacking point; the other is in the same position on the right side of the fuselage. By employing two jacks in this manner, sufficient clearance for retracting the nose wheel is gained.

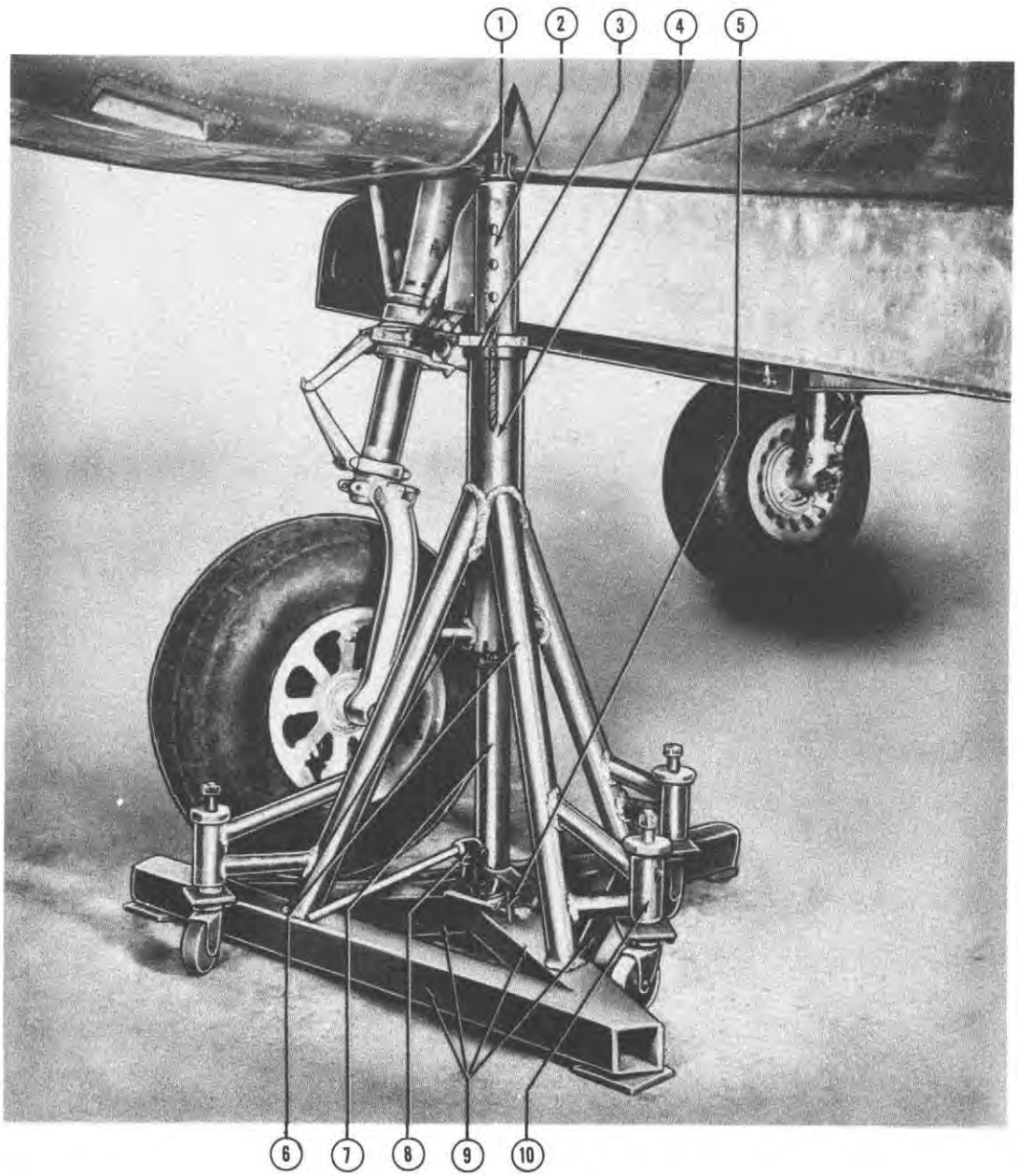


Figure 26 — Nose Jack Installed

KEY TO FIGURE 26—NOMENCLATURE NOSE JACK

NAME	NO. REQ.	MATERIAL	DIMENSION
1. Jack Pad Assem.			
Bar	1	SAE 1020 C.R.	5/8 Dia. x 1
Zerk Fitting	1		1/4
Pipe	1	Std. B.I. Pipe	2 Nom. x 2 1/4
Base Plate	1	SAE 1020 C.R.	2 3/4 Dia. x 1/8
Belata Belting	1		1/4 x 2 1/2 Dia.
Plate	1	SAE 1020 C.R.	2 1/4 Dia. x 3/8
Plate	1	SAE 1020 C.R.	2 Dia. x 1/2
2. Plunger Assem.			
Pipe	1	Std. B.I. Pipe	3 1/2 Nom. x 23 3/4
Pipe	1	SAE 1020 C.R.	4 1/2 Dia. x 1
Pipe	1	Std. B.I. Pipe	2 Nom. x 1/2
3. Lock Pin Assem.			
Bar	1	SAE 1020 C.R.	3/4 Dia. x 6
Bar	1	SAE 1020 C.R.	1 Dia. x 10
Safety Pin	1	SAE 1020 C.R.	
Elwel Chain	1		#5
4. Barrel Assem.			
Angle	3	SAE 1020 C.R.	1 1/2 x 1 1/2 x 1/4 x 1
Pipe	1	Std. B.I. Pipe	4 Nom. x 5 1/2
Pipe	1	Std. B.I. Pipe	4 1/2 Nom. x 26 3/4
Collar	1	SAE 1020 C.R.	5 1/2 Dia. x 1
5. Pin	1	SAE 1020 H.R.	3/4 Dia. x 4
Pin	1	SAE 1020 H.R.	1/2 Dia. x 4 1/2
6. Support Assem.			
Pipe	2	Std. B.I. Pipe	2 1/2 Nom. x 43
Pipe	1	Std. B.I. Pipe	2 1/2 Nom. x 44 1/2
Pipe	2	Std. B.I. Pipe	1 1/2 Nom. x 4 1/2
Pipe	1	Std. B.I. Pipe	1 1/2 Nom. x 6
7. Jack Shaft			
Pipe	1	Std. B.I. Pipe	3/4 Nom. x 30
Pipe	2	Std. B.I. Pipe	1 Nom. x 4
8. Jack	1	Hein-Werner Hyd.	(C654-40873-D.P.) 5 Ton
9. Base			
Boiler Plate	1	SAE 1020 H.R.	1/2 x 14 x 12 1/4
Hex. Hd. Cap Screw	4		3/8 x 16 x 1 1/2
Tube	2	SAE 1025 H.R.	4 x 4 x .250 Wall x 33 1/2
Tube	1	SAE 1025 H.R.	4 x 4 x .250 x 61
Channel	1	SAE 1025 H.R.	4 x 6.25 x 35 1/2
Tube	1	SAE 1025 H.R.	4 x 4 x .250 x 24
Channel	1		4 x .625 x 23 3/4
Plate	3	SAE 1020 H.R.	.063 gage x 3 3/4 x 3 3/4
10. Roller Assem.			
Pipe	1	Std. B.I. Pipe	1 1/2 Nom. x 12 1/2
Pipe	1	Std. B.I. Pipe	1 1/2 Nom. x 7 3/4
Pipe	2	Std. B.I. Pipe	1 1/2 Nom. x 9 1/2
Pipe	2	Std. B.I. Pipe	1 1/2 Nom. x 5
Pipe	3	SAE 1020 C.R.	1 Dia. x 10 1/8
Nut	3	Std. Hex. Castellated	1/8
Plate	3	SAE 1020 H.R.	3 1/2 Dia. x 1
Spring	3	(Danley-9-0604-11)	3/8 x 3/16 x 1 (10 lbs.)
Pipe	3	Std. B.I. Pipe	2 1/2 Nom. x 5 7/8
Plate	3	SAE 1020 H.R.	2 Dia. x 3/4
Pipe	3	Std. B.I. Pipe	2 Nom. x 5 7/8
Caster Carriage	3		
Caster	3	Darnell	1-75-C1
Plate	3	SAE 1020 H.R.	1/2 x 5 x 6

(5) ENGINE SUPPORT JACK.—When work is to be performed on the wing above the nacelle that will require the removal or loosening of the stress plates, the engine must be supported to avoid any excessive strain. This support may be accomplished by jacking as shown in *figure 27*. A piece of wood approximately 4 x 8 x 36 should be cut so that one edge fits the contour of the engine. Place this on the jack head and pump jack until the curved edge fits under the engine rocker box covers. The jack head must never be placed against the rocker box covers directly; otherwise serious damage will result. If the jack is not of sufficient height a pedestal may be constructed by using a piece of wood of a suitable length and approximately 6 x 6. Fasten this in a vertical position to a base wide enough to avoid tipping. Brace the four sides. Secure the jack on top firmly. When the pedestal and jack are in position place the shaped piece of wood on top of the jack holding it in place as the jack is pumped. When the support is tight, it should be checked for center balance then jacked to take all extra strain from nacelle and wing.

Figure 27 — Engine Support Jack Installed

(6) HOISTING AND JACKING PRECAUTIONS.—Observe the following precautions when hoisting the airplane or supporting it on jacks.

(a) Be sure that the jacks are of sufficient capacity to support the airplane safely.

(b) Rest the jacks on a level area.

(c) Airplane should be headed downwind and in no case raised when exposed to winds of more than 15 miles an hour velocity.

(d) Secure the airplane to prevent any yawing motion.

(e) Operate all jacks as simultaneously as possible when raising or lowering the airplane. Never use a single jack through a jacking range of over seven inches. Use two or more.

(f) Any movement of the airplane while it is resting on jack pads should be prevented.

(g) If the airplane is to remain supported and unattended for any length of time, ladders or other equipment should not be left where they will damage the airplane should a jack fail because of leakage of the hydraulic fluid. As a further safety precaution, in such cases, jacks should be supplemented with hoists from above or with shoring stands from below.

(h) Be sure a safety pin is used in the jack as a precaution against hydraulic failure if the airplane is to be left unattended.

(i) Disengage parking brakes before starting to jack.

d. LEVELING.—The airplane may be leveled, both longitudinally and laterally, to correctly adjust the instruments and armament. Place the leveling instrument in the following leveling points. (See *figure 585* for location of leveling points.)

(1) On the cross tie plate in the bomb bay.

(2) On the keel, inside the bomb bay.

e. SECURING.

(1) The airplane may be tied down, or moored, with cables or ropes which are attached to rings on the underside of each outer wing, and anchored to the ground. When mooring the airplane, proceed as follows: *(See figure 28* for location of tie-down and mooring points.)

(a) Head the airplane into the wind.

(b) Lock the surface controls *(15, figure 61)* in neutral position.

(c) Place the nose wheel in the fore and aft direction.

(d) Place wheel chocks in the fore and aft direction.

(e) Attach the mooring ropes to the tie-down fittings provided on the front of the main landing

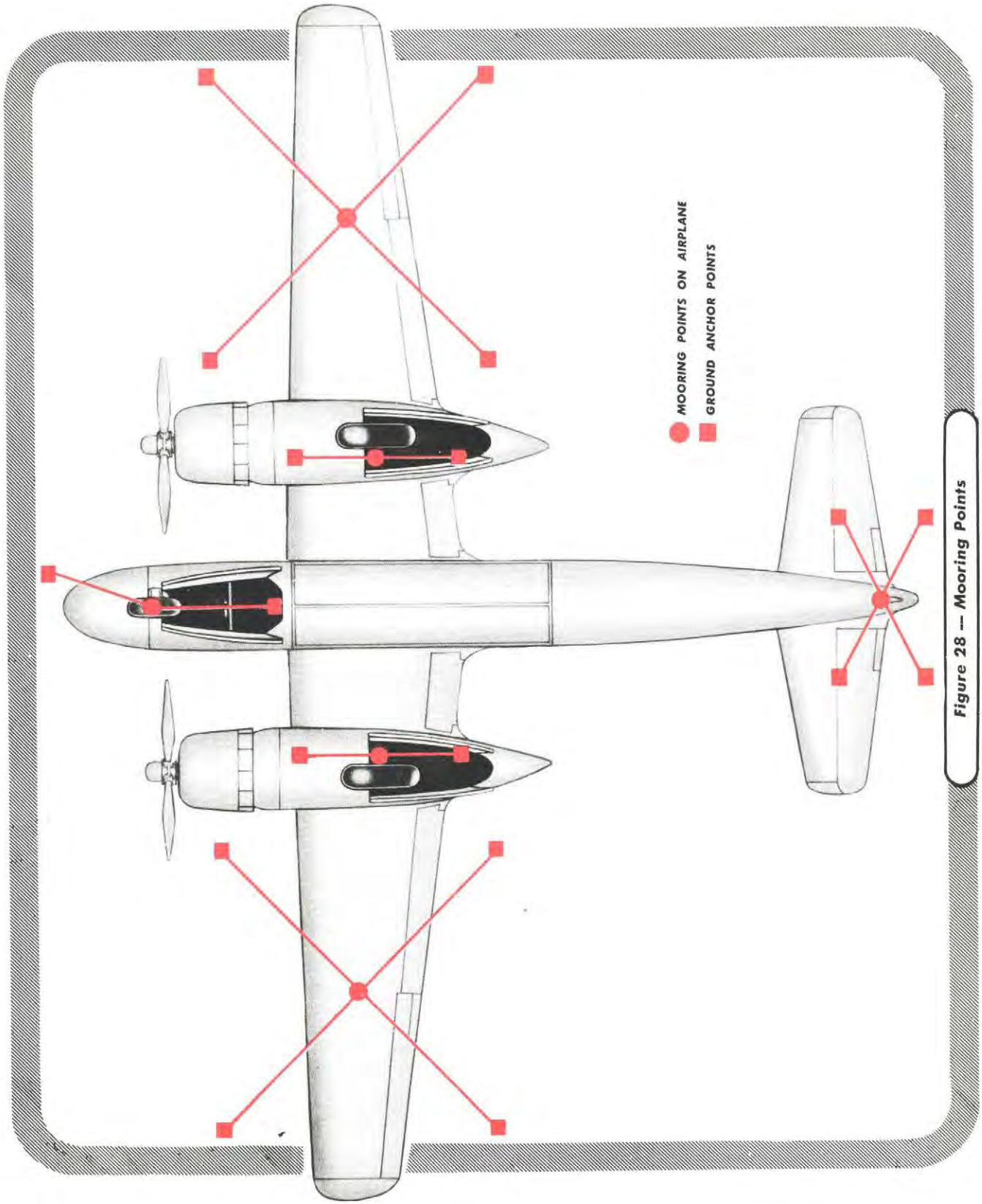


Figure 28 — Mooring Points

gear and nose wheel struts. The airplane must be parked in a level area.

(f) Gain access to the aft tie-down fitting *(figure 28)* by peeling back the rubber streamline fairing that encloses it.

(g) Engage the parking brakes.

(h) Be sure there is from 12 to 16 inches of slack in wing cables or ropes. Other lashings must be taut.

Note

Wing and tail ropes should be suspended at 45° angle.

(2) For emergencies, when warning of storms or high winds is received, install felt-padded, wooden clamps to lock securely all movable control surfaces. The clamps should be fabricated and used even though internal surface control locks are available. A spoiler should be clamped on the wings so as to avoid damage to the fabric covering of the aileron. The spoiler may consist of a wooden two-by-four, with a length equal to approximately 75% of the wingspan. It should be located at 10 to 15% of the average Sp. chord aft of and parallel to the leading edge of the wing, with the four inch dimension perpendicular to the wing surface and in such a manner that little or no space exists between the bottom of the spoiler and the wing surface.

(3) The diameter of the mooring cable should be ⅜ of an inch. If rope is to be used, it should be 1 inch in diameter.

f. SPECIAL MOORING EQUIPMENT.

(1) The location, number, and adequacy of permanent mooring rings on concrete aprons or ramps at activities having airplanes that must be moored in the open is a responsibility of the Director of Base Services, Headquarters, Army Air Forces. The attachment of mooring lines to airplanes moored on the aprons will conform as closely as possible to the mooring diagram outlined in *figure 28.*

(2) To use the type D-1 mooring kit, the anchor rod, part No. 36A4468 is screwed into the arrow, part No. 36A4467, and the driving rod, part No. 36A4466, slipped over the anchor rod and into the socket of the arrow. The cam on the driving rod must be turned so that the prongs of the arrow will not be spread by driving. If the ground is hard, the hardened surface will be broken first by using the ground breaking pin, part No. 38B3323. Care must be taken to align

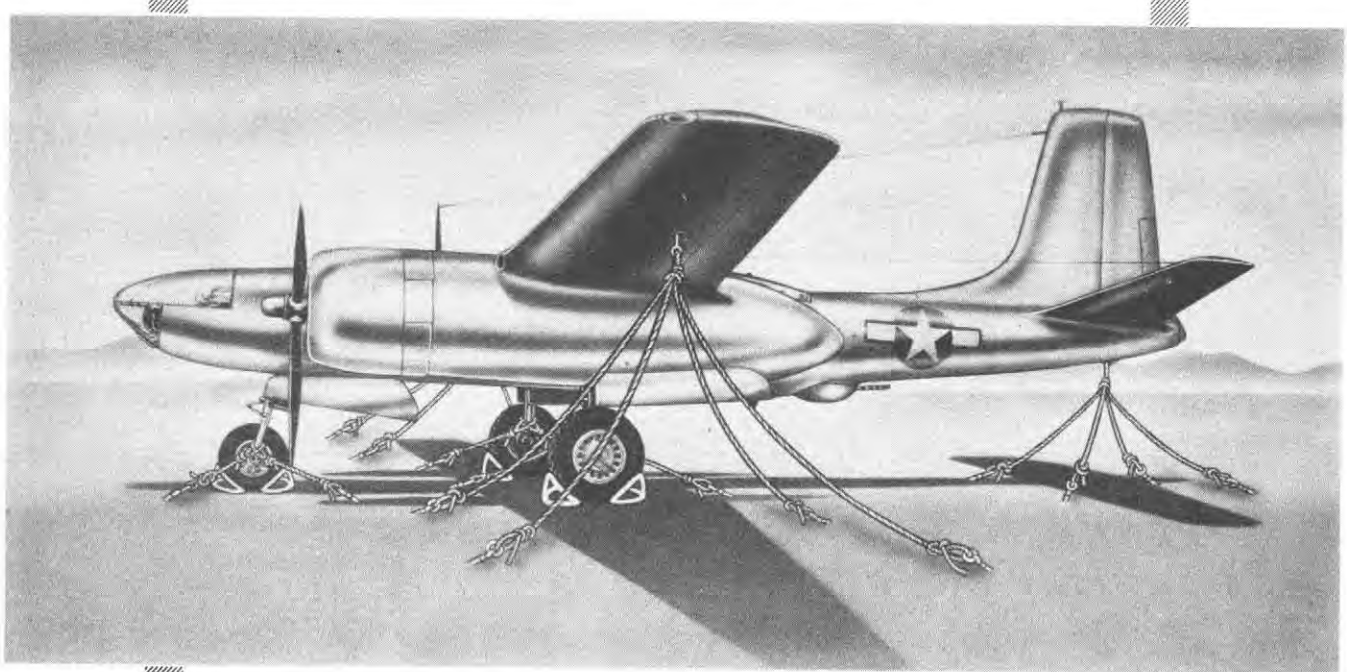


Figure 29—Ropes in Mooring Position

the rod with the point of attachment on the airplane. The arrow will be driven into the ground until the driving rod handle is within approximately three inches of the ground, the handle rotated approximately 90 degrees, and the driving rod given a sharp blow to spread the prongs of the arrow. The driving rod is then returned to the driving position and withdrawn from the ground. The squared socket of the eye assembly, part No. 36A4469, will then be aligned with the squared end of the anchor rod, fitted into place, and the knurled nut secured. The mooring rope will then be attached to the eye assembly and given an upward pull to spread and set the arrow prongs, as shown in *figure 29*. The mooring ropes will then be secured in accordance with the mooring diagram in *figure 29*. To withdraw the anchor rods, the mooring ropes are detached and the anchor rods unscrewed by turning the ring of the eye assemblies counterclockwise, leaving the arrows in the ground.

(3) Arrows for the type D-1 kit are expendable, and should be replaced upon return to the home station. The remaining items are also expendable but recoverable. Replacements will be obtained by requisitioning individual items. Property records and reports will likewise cover the component items, and not kit assemblies. This material will be carried and reported in Class 19.

(4) For semi-permanent and temporary mooring in the field, the "dead-man" mooring anchor may be used. The "dead-man" consists of a block of wood at least one foot long and of a square cross section at least 3 inches x 3 inches. Any other suitable material of equal strength or stronger that is available may be used. One end of a cable will be secured around the "dead-man" by splicing or the use of a cable clamp. A loop will be formed in the same manner at the free end to accommodate mooring ropes. The cable should be at least ¾" in diameter. The "dead-man" will be buried on its side at a depth of 3 feet to 6 feet, depending upon the firmness of the earth, with the cable aligned with the airplane mooring fitting. In no case should the load on the cable be such as to cause the cable to assume a position perpendicular to the ground.

(5) Stakes similar to tent pegs may also be used. The stakes should be 2 inches to 3 inches in diameter and 3 feet to 5 feet long driven into the ground at an angle not to exceed 30 degrees from the vertical. The position of the stakes should be such that the load imposed by the mooring rope will tend to pull the stake into a vertical position. At no time should the direction of the rope be in line with the axis of the stake.

g. TOWING.

(1) When it is necessary to tow the airplane, extreme care must be taken to prevent damaging the fuselage or nose wheel assembly. Keep the towing speed low, avoiding quick starts and stops.

(2) The length of tow ropes if used should be approximately 3½ times the tread of the airplane, especially when towing over soft ground. Always attach tow rope to two main wheels, never to the nose wheel.

(3) The nose wheel fork on the subject airplane is provided with eye fittings for attachment of a towing bar. To attach the towing bar, place the towing bar fittings over the eye fittings on the nose wheel fork and insert a retaining pin. Insert the key chained to the towing bar in the end of the snubber release pin, and disengage the pin to allow 360° caster of the nose wheel.

CAUTION

The release plunger cap nut must be removed before the key can be inserted in the release pin.

Do not tow airplane with nose wheel strut fully extended.

Replace nose wheel towing release plunger cap nut after towing.

(4) There should always be one man in the cockpit to operate the brakes, one man or more at the tail, and a man at each wing tip when the airplane is being towed near a hangar or other airplanes.

CAUTION

Disengage parking brakes and make certain hydraulic pressure is at least 800 lbs. before towing airplane.

h. PARKING BRAKES AND CONTROL LOCKS.

(1) PARKING BRAKES.

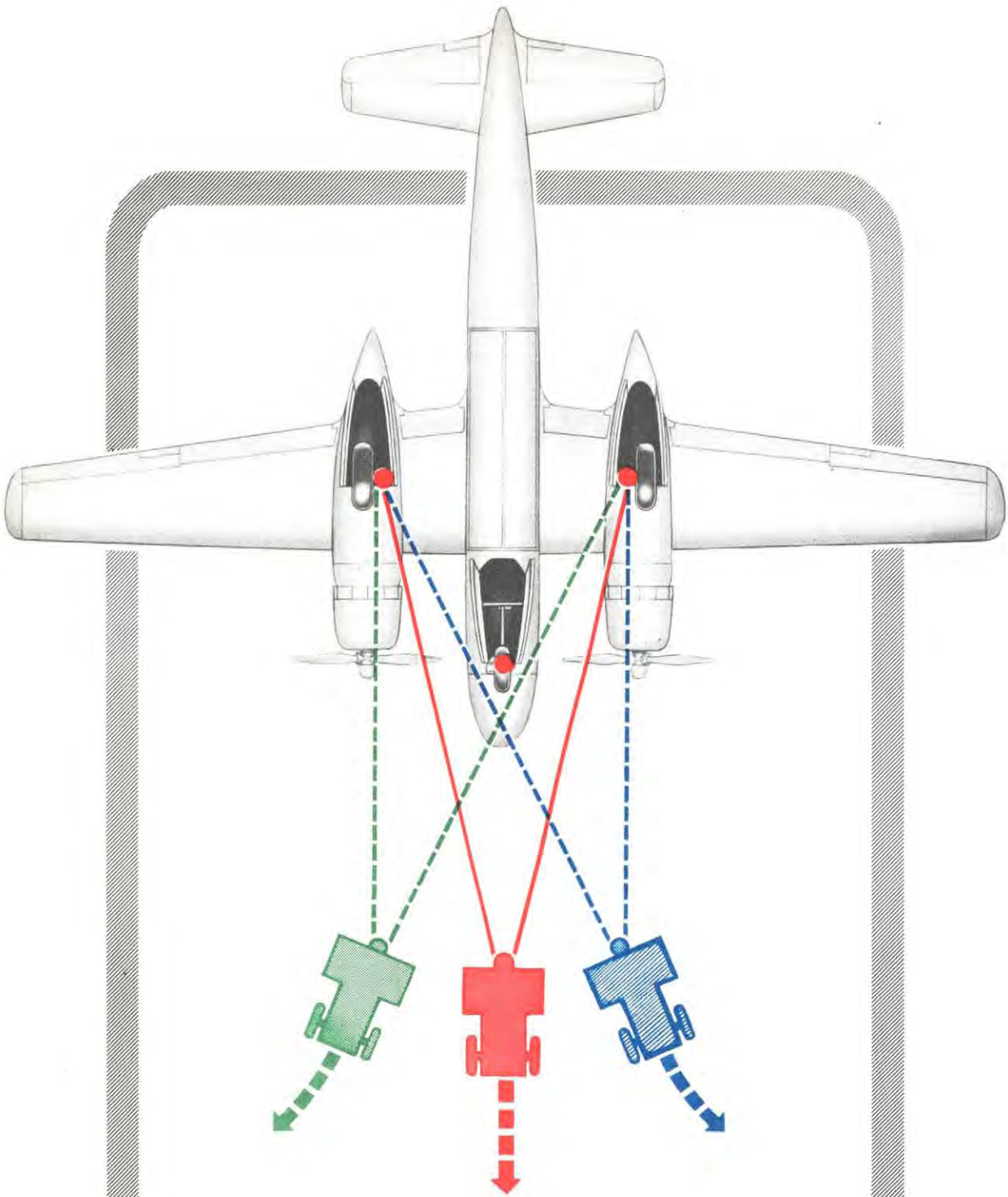
(a) A pull-type rod control mounted below the instrument panel, on the left-hand side, controls the parking of the wheel brakes.

(b) To set the parking brakes, depress the brake pedals and pull out the control knob; release the pedals before releasing the knob.

(c) To disengage the brakes, depress the pedals; the knob automatically returns to the "OFF" position.

(d) For satisfactory operation of the parking brakes, the hydraulic pressure gage should register 800 pounds per square inch minimum pressure.

(2) SURFACE CONTROL LOCKS. To engage the built-in surface control locks when parking the airplane, proceed as follows:



When using landing gear towing lugs, use ropes.

When using nose wheel landing gear towing lug, always use tow bar *(See Figure 31)*.

Figure 30 — Towing Points

1. Place the ailerons in a neutral position.

2. Move the control column to the neutral position.

3. Place the rudder and elevators in the neutral position.

4. The locking mechanism is operated by a lever in the forward bank of controls in the control pedestal. The throttles are stopped near the closed position by the control lock.

i. SERVICE INSTRUCTIONS.

(1) TO FILL THE FUEL CONTAINER.

(a) Each engine nacelle contains a self-sealing fuel container of 300 U. S.-249 Imp. gallon capacity and 9 U. S.-7.5 Imp. gallon expansion space. The containers are filled by means of a filler well, adjacent to the aft outboard corner of each container, and are accessible from the top side of the wing. A drain line from the filler well allows the excess fluid to flow to the ground at a point immediately outboard of the nacelle door.

(b) An auxiliary fuel container of the self-sealing type is located between the front and rear wing spars directly inboard of the nacelle in each wing. This container has a 100 U. S.-83 Imp. gallon capacity and 3.5 U. S.-2.9 Imp. gallon expansion space. The filler wells, which are inboard of the nacelle containers, are accessible from the top side of the wing. A drain line permits excess gas to flow from the filler neck to the ground.

(c) A self-sealing bomb bay container of 125 U. S.-104 Imp. gallon capacity is installed in the forward section of the bomb bay. The filler well is at the top of the fuselage on the left-hand side, half-way between the forward and the second bomb rails. A drain line at the filler permits excess gas to flow to the ground. The ferry fuel tank, when installed, is attached to the bottom of the bomb bay fuel container. Both tanks are filled through the bomb bay tank filler neck. The ferry tank has a capacity of 675 U. S.-554 Imp. gallons.

(d) All fuel delivery hose should be metal-lined or otherwise bonded between the nozzle and the fittings on the opposite end. In addition, one end of a flexible bonding wire or cable should be permanently attached to the discharge nozzle. Whenever a fuel container is to be filled, the free end of this bonding wire will be attached to a convenient uninsulated metallic part of the airplane to insure an electrical bond between the container and the delivery hose. The bonding wire, however, must not be attached adjacent to the filler neck of the container. For convenience in quickly attaching or removing the bonding wire to or from the aircraft, a standard test clip can be used as a terminal on the free end. This bond must always be effected before removing the filler cap of the container, and not be disconnected until the cap has been replaced.

CAUTION

When fuel containers are being filled or drained, the work should be done out of doors. Care must be taken to avoid spilling the fuel. Smoking is prohibited as a guard against possible source of ignition. When fuel trucks are used, they must be equipped with a suitable static ground chain.

(e) Care must be exercised in servicing aircraft to avoid damage to the filler necks in the fuel containers. The nozzle is to be held by personnel, and should not be allowed to remain in the container without support.

1. Chain (Attaching Cap Nut and Key)
2. Cap Nut
3. Key
4. Tow Bar
5. Chain (Attaching Retaining Pin and Tow Bar)
6. Retaining Pin

Figure 31 — Tow Bar Installed

(2) TO FILL OIL CONTAINERS.

(a) An oil container is located in each engine nacelle, directly behind the firewall, and is of the bullet-sealing type. To reach the oil filler cap, remove the labeled access cover plate on top of the nacelle.

(b) The oil container filler opening is located on top of the container and is designed to facilitate filling without the use of a special funnel.

(c) A dip stick, which measures the oil in the tank, indicates the level as ¼, ½, ¾ and normal. Capacity of each oil tank is 39 U. S.-33 Imp. gallons; 30 U. S.-25 Imp. gallons of oil, and 9 U. S.-7.5 Imp. gallons of expansion space.

(3) TO FILL THE HYDRAULIC RESERVOIR.

(a) The main hydraulic reservoir is supported by brackets on the right hand side of the aft bulkhead in the pilot's compartment. A sight gage for determining the fluid level is incorporated in the reservoir, which has a fluid capacity of 1¾ U. S.-1½ Imp. gallons.

(b) The main hydraulic reservoir supplies fluid to the emergency reservoir in addition to the system.

(c) To fill the main hydraulic reservoir, proceed as follows using hydraulic fluid per AN Spec. AN-VV-O-366:

1. Use the funnel stowed in back of the pilot's seat for the purpose of filling the reservoir with hydraulic fluid. Fill the reservoir until the emergency reservoir is filled and the fluid registers to the normal level mark on the main hydraulic reservoir sight gage.

2. With the landing gear in the DOWN position, and the bomb doors OPEN, operate the hydraulic hand pump until the hydraulic pressure gage registers 1000 psi.

Note

If the hydraulic system has become airbound (caused by the replacing of lines, actuating cylinders, etc.) the airplane should be placed on stands and the landing gear and bomb bay doors should be operated through a complete cycle several times to force trapped air out through the reservoir vent.

(4) TO FILL THE ACCUMULATOR.

(a) Release all hydraulic system pressure, and check the hydraulic pressure gage for zero reading.

(b) Inflate the accumulator with an air bottle or air booster pump to between 600 and 750 pounds psi.

(c) The accumulator air pressure can be checked as follows:

1. Make certain that there is a zero reading on the hydraulic pressure gage.

2. Operate the hydraulic hand pump. The gage will remain at zero momentarily and then rise suddenly. The pressure reading after the rise is the amount of air pressure in the accumulator.

3. Release the system pressure by applying and releasing the brakes.

(5) FILLING THE ANTI-ICING FLUID TANKS.

(a) There are two anti-icing fluid tanks in this airplane; one carries 6 U. S.-5 Imp. gallons of alcohol for the propeller anti-icing system, the other carries 1 U. S.-.833 Imp. gallons of alcohol for the periscope anti-icing system. The propeller anti-icing system fluid tank is installed in the right-hand nacelle tail cone. The periscope system tank is located on the right-hand side of the gunner's compartment.

(b) Fill the propeller anti-icing system fluid tank as follows:

1. From inside the right-hand main landing gear wheel well, remove the canvas door which covers the entrance to the tail cone compartment.

2. Unscrew the filler neck cap and check the fluid level mark on the measuring stick attached to the filler cap. Fill as necessary with AN F-13 isopropyl alcohol.

(c) To fill the periscope anti-icing system fluid tank, remove the filler neck cap and check the fluid level mark on the measuring stick which is attached to the filler neck cap. Fill as necessary with AN F-13 isopropyl alcohol.

(6) TO INFLATE PNEUMATIC EQUIPMENT.

(a) MAIN LANDING GEAR TIRE. – The proper inflation pressure for the main landing gear tires depends upon the gross weight at which the airplane is to be operated. The tires should be inflated in accordance with the deflection mark on the tire. Normal pressure at 27,603 pounds gross weight is 54 psi.

(b) NOSE WHEEL TIRE.–The pneumatic tire on the nose wheel should be inflated in accordance with the deflection mark on the tire. Normal pressure at 27,603 pounds gross weight is 38 psi.

(c) LANDING GEAR SHOCK STRUT.

1. Remove the hex cap from the air valve on the upper end of the strut *(15, figure 94 and 11, figure 111)* and use a high pressure air pump, booster pump, or air bottle to inflate the strut.

WARNING

Compressed oxygen must not be used for this purpose.

2. Inflate the strut until the red line on the piston tube is 1⅞ inches from the end of the packing gland nut with the airplane at the operating load.

3. While inflating the strut, rock the airplane to alternately extend and compress the strut in order to overcome packing friction.

4. After the strut has been inflated, use soapy water to test the air valve, the valve core, and the filler plug for leaks. Replace the hex cap.

(d) FILLING SHOCK STRUTS.

1. Fill the strut with hydraulic fluid, Specification AAF 3580 through the filler plug hole until the fluid is level with the hole.

2. Insert the plug loosely and cause the strut to extend and compress completely several times in order to eliminate air traps.

3. Remove the plug and check the fluid level. If fluid is added, repeat the process again.

4. Insert the filler plug carefully to avoid damaging the threads. Screw it down tightly.

Note

Each time the filler plug is removed, replace the copper gasket in the filler plug seat.

(7) ARMAMENT LOADING INSTRUCTIONS.–For information on the loading of ammunition, bombs, and torpedoes, refer to section V.

3. GROUND OPERATING INSTRUCTIONS.

a. GENERAL.–The following instructions are applicable to normal starting, warm-up, and stopping procedures and are primarily intended for the use of the ground crew. Information regarding engine troubles, etc., will be found in paragraph 6., section IV.

b. BEFORE ENTERING THE COCKPIT.

(1) See that chocks are in front of the wheels.

(2) Check the gross weight, balance, and security if take-off is contemplated.

(3) Engage nose wheel snubbing pin.

Note

Destructive nose wheel shimmy will result if snubbing pin is not engaged.

(4) Remove pitot head cover.

(5) See that landing gear pins are installed.

(6) Visually check contents of fuel and oil tanks.

(7) Plug in battery cart receptacle. *Always use a ground battery cart for starting rather than the airplane batteries if the former is available.* Be sure battery switches are "OFF" if using a battery cart; "ON" otherwise.

c. ENTERING THE COCKPIT.–Enter the pilot's compartment through the compartment enclosure. Extend the access ladder by holding down on the access ladder control rod located within the foot step. Retraction of the ladder is accomplished by pushing the ladder up from the ground, or by pulling it up from within the pilot's compartment.

d. IN THE COCKPIT.

(1) Check hydraulic fluid supply for "NORMAL LEVEL" on gage.

(2) Hydraulic purolater–turn handle three or four times.

(3) Emergency air brake pressure gage–450 psi minimum.

(4) Parking brakes must be set.

(5) Carburetor air filter controls–"DIRECT" position. In dusty or desert areas "FILTER."

(6) Landing Gear Control lever–"DOWN."

(7) See that control surfaces are unlocked and free. Check flight controls for freedom of movement or slack. Set trim tabs at zero.

(8) Emergency hydraulic system selector valve control–"SYSTEM" position.

(9) Hydraulic hand pump lever–actuate lever and observe the hydraulic pressure gage for pressure increase.

(10) Observe the voltmeter to make certain the voltage output from the external power supply (ground battery cart) does not exceed 28.5 volts. Higher voltages may damage the radio and other electrical equipment.

(11) Check the functioning of the oil cooler doors by holding the oil cooler door switches in the "OPEN" position long enough (15 to 20 seconds) for the oil cooler doors to reach the full open position. Hold them in the "CLOSE" position long enough (15 to 20 seconds) for the oil cooler doors to reach the full closed position.

(12) Radio equipment–Check functioning.

(13) Compass and instruments–Check for proper settings and indications.

(14) Fuel quantity gages–Adequate supply.

e. SPECIAL CHECK FOR NIGHT FLIGHTS.

(1) Pilot's compartment lights–"ON."

(2) Instrument panel lights–"ON."

(3) Cockpit lamps—"ON."

(4) Adjust the rheostat for the engine instrument lights and flight instrument lights so that all instruments can be easily read.

(5) Navigation lights switch—"ON."

(6) Extend the landing lights and test the operation. Use landing lights only as necessary to conserve bulb life and to avoid current load on the batteries when the engines are not running. Retract the landing lights as soon as climb has been established and ground contact has been lost.

(7) Test operation of the recognition lights. *Do not allow the recognition lights* to remain "ON" longer than necessary (10 seconds maximum) when the airplane is on the ground. Prolonged use will cause the lenses to melt.

f. STARTING PROCEDURE.—If the engines have been idle for more than two hours, or if excessive priming has caused flooding of the engine, manually rotate the propeller twelve blades. If excessive compression exists remove the spark plugs from the lower cylinders and drain.

CAUTION

Make certain the ignition switches are "OFF."

(1) SET THE FOLLOWING CONTROLS FOR BOTH ENGINES.

(a) Fuel container selector valve controls—"MAIN ON."

Note

Each carburetor vapor vent line returns fuel at approximately 10 gallons per hour to the respective main container; therefore, when using fuel from other than the main fuel containers, room should be made in the main containers to accommodate this return.

(b) Fuel cross feed bomb bay tanks selector valve control "OFF."

CAUTION

If the control is in the "ON CROSS FEED" position, discharge of fuel to the engine not being started will cause excessive priming to that engine and a fire hazard. Have fire fighting equipment near engine being started.

(c) Mixture controls "IDLE CUT-OFF."

(d) Throttle controls—"¼ OPEN."

CAUTION

Do not move the throttle control levers more than necessary when the engines are inoperative, because movement of the throttles discharges fuel into the induction system. This may result in overpriming and/or backfiring.

(e) Propeller governor controls—"INCREASE RPM." (Low Pitch.)

(f) Supercharger blower ratio control levers—"LOW."

(g) Carburetor air temperature control levers—"COLD."

CAUTION

The control should not be in the "HOT" position; serious damage or fire may result from a backfire.

(h) Cowl flap switches "OPEN."

CAUTION

Do not close cowl flaps under any circumstances. If closed, the cylinder head temperature will quickly rise and exceed the critical temperature, 232°C (450°F); resulting in damaged spark plug elbow insulation.

(i) Oil cooler doors—Set to desired position.

(j) Master ignition switch—"ON."

(k) Generator switches—"ON."

(l) Instrument vacuum selector valve control—"R. H. PUMPS."

(2) START THE RIGHT ENGINE:

(a) Right wing fuel booster pump switch—"LOW BOOST" (7-9 psi).

(b) Primer switch—"ON" approximately 2 seconds.

Note

This is not intended as a priming operation, but to fill the priming lines with fuel so that priming is immediately effective.

(c) Prime the engine as necessary before and while accomplishing steps *(c)* through *(f)* below.

(d) Energize switch "R" about 20 seconds to bring starter up to speed.

(e) Engage switch "R" continuing to depress the energize switch.

CAUTION

After turning the energize switch and the engage switch "ON," continuous direct cranking must not exceed 30 seconds. If the engine does not start after 30 seconds, the starter must be allowed to cool for one minute before attempting to start the engine.

(f) Right engine ignition switch – "BOTH" after engine has turned over three or four times. Hold engage switch in "R" position until the engine fires.

CAUTION

In order to prevent backfiring, do not turn the ignition switch to "BOTH" until the engine is turning over.

Note

When engines are handcranked, they should be *manually* meshed (by pulling the meshing cable)—NOT electrically meshed. After the propeller starts to turn, the man in the pilot's compartment should turn "ON" the MESH switch until the engine fires (this connects the induction vibrator circuit). Then turn on the ignition switch. Before handcranking the engine starter, pull the manual meshing cable to lift brushes off the commutator (to prevent drag). Before electrically starting ("ENERGIZE") starter, momentarily push MESH switch to drop brushes on commutator.

CAUTION

After starter acceleration and meshing with the engine, continuous direct cranking must not exceed 30 seconds. If the engine does not start after 30 seconds of cranking, the starter must be allowed to cool for one minute before attempting to start the engine again.

(g) If the engine starts immediately, move the mixture control to "AUTOMATIC RICH." Adjust the throttle control to maintain 700 rpm for the first 30 seconds after starting. Watch for an indication of oil pressure on the gage.

CAUTION

If the oil pressure is not indicated within 30 seconds, stop the engine and investigate.

(h) If the engine does not start almost immediately after the engage switch is moved to "R," move the mixture control from "IDLE CUT-OFF" to "AUTOMATIC RICH" while maintaining 7-9 psi fuel pressure. If the engine does not start within approximately three seconds, return the mixture control to "IDLE CUT-OFF." If starting is not accomplished within the next five seconds, while the mixture control is in "IDLE CUT-OFF," continue to operate the starter, and repeat the above procedure. One to three repetitions will usually start the engine.

(i) If the engine does not start, it is probably due to one of the following conditions:

1. *Over-loaded engine*: An overloaded warm engine is indicated by a discharge of fuel from the engine blower drain. An overloaded cold engine is not necessarily indicated by discharge of fuel from this drain but by the presence of liquid fuel in the exhaust. If the engine is overloaded, "clear the engine out" by opening the throttle and turning the engine over either manually or with the starter.

2. *Underprimed engine*: If there is no fuel odor or vapor in the exhaust, it is probable, especially in cold weather, that the engine has not been sufficiently primed even though fuel may be draining from the blower. For this reason, priming is necessary to prevent flooding the blower and thus obviate a fire hazard. Additional priming should be accomplished cautiously. *Do not pump the throttle as this will discharge fuel into the blower throat.*

(j) Fuel primer switch—"ON" if necessary.

Note

When the engine is cold and has been exposed to outside temperatures below 15°C (60°F), it is usually necessary to prime the engine. Prime the engine 5 - 20 seconds, dependent upon the engine temperature.

(k) Idle engine at 700-800 rpm.

CAUTION

Running the engine for a long period of time below 700 rpm will foul the spark plugs.

(l) Oil pressure gage–25 psi minimum.

Note

Due to the thermostatic action of the oil pressure relief valve, an abnormally high oil pressure gage indication may exist until an oil temperature of 40°C (104°F) is attained.

(m) Fuel pressure gage—15 to 17 psi.

(n) Fuel booster pump switches—"OFF."

(o) Hydraulic pressure gage—850 psi minimum.

Note

Observe the hydraulic system pressure gage indication, open and close the bomb bay doors, then return the bomb bay door control lever to "NEUTRAL." As the bomb bay doors are being opened and closed the hy-

draulic system pressure will lower. After the bomb bay doors have reached the closed position, the hydraulic system pressure should increase to normal. This indicates that the right engine - driven pump is functioning properly.

(p) Suction gage—4.2 inches Hg.

(3) START THE LEFT ENGINE.—The starting procedure for the left engine is the same as that for the right engine.

Note

After starting the engine, move the instrument vacuum selector valve control to "L.H. PUMP" position. Recheck the instrument suction gage (for 4.2 inches Hg. indication) to ascertain that the left engine vacuum pump is functioning properly.

(4) ENGINE WARM-UP.

(a) With the nose of the airplane headed into the wind, idle the engines at 1000 rpm. Check the instruments for indication consistent with engine speed, excessive pointed oscillation, and over sensitivity.

(b) Momentarily decrease engine speed to 700 rpm, then open the manifold pressure gage drain cock for a period of 30 seconds in each position to clear the line of liquids and vapors.

(c) Allow the engines to idle at 1000 rpm until the following conditions exist:

1. Oil temperature indicator—40°C (104°F).

2. Oil pressure indicator–50-100 psi and relatively steady.

3. Cylinder head temperature indicator — 120°C (250°F) minimum.

CAUTION

Do not close cowl flaps.

(d) Open the throttle controls as necessary for 200 rpm.

Note

If the oil pressure "drops" when the throttle controls are open, further engine warm-up is necessary.

1. OIL TEMPERATURE — 40°C to 70°C (104°F to 158°F) 60°C (140°F) desired.

2. OIL PRESSURE—70 to 85 psi.

3. CYLINDER HEAD TEMPERATURE—232°C (450°F) maximum.

4. FUEL PRESSURE—15 to 17 psi.

CAUTION

Avoid operating the engines for prolonged periods at more than 1500 rpm. Do not exceed 2100 rpm: 2000 rpm engine speed should not be maintained for periods exceeding 30 seconds.

(e) Oil cooler door switches—"AUTOMATIC."

(5) ENGINE AND ACCESSORIES GROUND TEST.

(a) GENERATORS.

1. Check each generator "out-put."

a. Throttle controls set for 2000 rpm.

b. Note both ammeter indications.

c. Move the voltmeter check switch from neutral position to "L," then to "R." The voltmeter indication should not exceed 28.5 volts, and both indications must be the same.

2. Check generator "cut-in."

a. Set the throttles for 1000 rpm.

b. Right engine generator:

(1) Turn the battery switches and the left engine generator switch "OFF"; right "ON."

(2) Turn voltmeter check switch—"R" position.

(3) Move the right engine throttle gradually toward "OPEN," and observe the rpm at which the voltmeter shows the right engine generator to have started charging (1500 rpm desired).

Note

The generator is set to "cut-in" at approximately 1500 engine rpm.

3. Left engine generator: Check "cut-in" of the left engine generator in a similar manner.

CAUTION

Turn on both battery switches and both generator switches.

(b) IGNITION SYSTEM.—Check both magnetos at the same time at the same engine power.

Note

This will result in no disturbance of the nose wheel alignment. It also has the advantage of

easily establishing the comparative positions of the throttles for even power by checking the dual indicators.

1. Open the throttle to 30 inches Hg. manifold pressure.

2. Move the left and right engine ignition switches from "BOTH" to "LEFT"—observe for a "drop-off" of 100 rpm maximum (50 to 100 rpm normal).

3. Return the ignition switches to "BOTH."

Note

Leave the switches in "BOTH" position until the engines have "picked up" the loss of rpm.

4. Move switches from "BOTH" to "RIGHT" —observe for a "drop-off" of 100 rpm (50-100 rpm normal).

5. Move switches from "RIGHT" to "BOTH."

6. If, during the test, one of the following conditions exist, stop the engines and inspect for malfunctions:

a. If the "drop-off" exceeds 100 rpm on either "LEFT" or "RIGHT."

b. If the difference between the "drop-offs" exceed 40 rpm with the switches in either "LEFT" or "RIGHT" positions.

c. If the engine vibrates excessively.

CAUTION

Make this check in as short a time as practicable. (30 seconds maximum.) Cooling of the cylinder heads, barrels, and ignition harness is insufficient when the engines are operated for prolonged periods above 1400 rpm. Do not allow the cylinder head temperature to exceed 232°C (450°F).

(c) TWO SPEED SUPERCHARGERS. – This test is made to help prevent sludge accumulation and to check the operation of the blower mechanism.

1. Set the throttle controls for 1700 rpm. The oil pressure should be at least 40 psi.

Note

40 psi oil pressure is necessary for the blower clutch to operate.

2. Supercharger blower control – shift to "HIGH" position: At the same time observe the engine oil pressure gage for a momentary "drop" in pressure, and check the manifold pressure gage to make certain that the manifold pressure does not lower.

Note

Prolonged fluctuation or loss of manifold pressure indicates improper clutch engagement: In this case the supercharger blower control should be returned to the "LOW" position, the engine speed reduced to 1000 rpm, the engine operated at 1000 rpm for two minutes, and the test repeated.

3. Open the throttle to obtain approximately 2000 rpm and lock the throttle control at that setting.

4. Immediately shift the supercharger blower control to "LOW" position without hesitation between stops (in order to avoid dragging or slipping the clutches). At the same time observe the manifold pressure gage for an indication of a sudden "pressure-drop."

Note

A manifold "pressure-drop" is positive indication that the control system is functioning properly. If the manifold pressure does not lower, operate the engine at 1000 rpm for two minutes. This permits the heat generated during the clutch operation to dissipate.

5. As soon as the test is complete reduce the engine speed to 1000 rpm.

6. Supercharger blower control—"LOW" position when the test is complete.

(d) PROPELLERS.—With the propeller control set for full increase rpm, advance the throttle until rpm reaches 2000. Move the propeller control toward decrease rpm until rpm drops to 1800. Return propeller control to full increase rpm, and note that the rpm returns to 2000.

Note

Minimum governing speed is 1200 rpm.

(e) FUEL CONTAINER SELECTION TEST.

1. Operate the engines, using fuel from each fuel container, for a period of 3 minutes to make certain the selector valves operate properly. Operate the engines for 3 minutes with the cross-feed valve control set at "ON CROSS FEED" with either the right or left selector valve "OFF" and the other set at "MAIN ON."

CAUTION

When fuel is being used from other than the main fuel containers, be certain that the fuel level in these containers is such that it will permit the return of 10 gallons of fuel per hour from the carburetor.

2. After the test has been completed return the cross-feed valve control to "OFF" and both selector valves to "MAIN ON."

g. STOPPING ENGINES.

(1) STOPPING ENGINES DURING WARM WEATHER.

(a) Supercharger blowers.—Check for proper functioning.

(b) Cowl flap switches—"OPEN."

Note

This facilitates the circulation of air over the engines. Residual heat above 120°C (248°F) within the engine section may damage the spark plug electrical insulation.

(c) Propeller governor controls—"INCREASE RPM."

(d) Fuel booster pump switches—"OFF."

(e) Idle the engines at 1000 rpm a sufficient length of time to allow the cylinder head temperature to decrease below 205°C (400°F).

(f) Stop the right engine in the following manner:

1. Carburetor mixture control – "IDLE CUT-OFF."

2. Throttle—"CLOSED" *immediately.*

Note

If the engine does not stop, turn off the ignition switch. Slowly open the throttle wide. An improperly adjusted carburetor is indicated if it is necessary to stop the engine by turning the ignition switch "OFF."

3. Ignition switch—"OFF" *after* the engine stops.

4. Generator switch and battery switch—"OFF."

(g) Check the left engine driven hydraulic pump for proper functioning by actuating the bomb bay doors until the hydraulic pressure drops below normal. Observe the hydraulic pressure gage for a pressure recovery above normal (850 psi).

(h) Stop the left engine in a manner similar to that for stopping the right engine. Turn off the ignition, battery, generator, and all other switches.

(2) STOPPING ENGINES DURING COLD WEATHER.—The following oil dilution procedure is applicable if a temperature below 5°C (41°F) is anticipated to exist before the next engine start:

(a) Idle the engine or allow the engine to remain inoperative until the cylinder head temperature is less than 150°C (300°F) and until the engine oil temperature is less than 50°C (120°F).

(b) With the engine idling at 800 to 900 rpm hold the oil dilution switch "ON" (one to ten minutes, depending on the expected temperature and the grade and amount of oil in the system) until a drop in oil pressure indicates the oil dilution system is functioning.

1. For ground temperature from 5°C (40°F) to —7°C (20°F)—"ON" for approximately two minutes.

2. For temperatures from —7°C (20°F) to —30°C (—20°F)—"ON" for approximately four minutes.

3. For temperature below —30°C (—20°F)—"ON" approximately ten minutes.

Note

At the end of the oil dilution period increase the engine speed to 1200 rpm. Move the propeller governor control slowly from "INCREASE RPM" to "DECREASE RPM" to allow diluted oil to enter the propeller dome. Return the control to "INCREASE RPM" and repeat this procedure three times.

(c) Carburetor mixture control—"IDLE CUT-OFF" as soon as the oil is diluted as much as desired.

(d) Continue the oil dilution until the engine stops, then turn off all switches.

h. BEFORE LEAVING THE PILOT'S COMPARTMENT.

(1) Fuel container selector valves—"OFF."

(2) Mixture controls—"IDLE CUT-OFF."

(3) Fuel cross-feed & bomb bay containers selector valve control—"OFF."

(4) All electrical switches—"OFF."

(5) Radio equipment switches—"OFF."

(6) Landing gear control—"DOWN" (and solenoid locking pin in extended position).

(7) Wing Flaps Control—"NEUTRAL."

(8) Throttle lever lock control—"LOCKED" position.

(9) Aileron, elevator and rudder trim tab controls—set at "0" degrees.

(10) Surface control lock lever—"LOCK" position.

(11) Parking brake control—"LOCK" position.

4. SPECIAL TOOLS AND EQUIPMENT.

a. HOISTS AND JACKS. – These have been adequately covered in this section where part numbers and specifications may be readily found.

b. TOOL KITS.

(1) PROPELLER TOOL KIT.–For contents refer to paragraph 21. *gg.*, section IV.

(2) MISCELLANEOUS HANDLING EQUIPMENT ROLL. – For contents refer to paragraph 21. *gg.*, section IV.

(3) ENGINE TOOL KIT.–The Engine Tool kit, part No. PWA-1798, is stowed in the aft section of the left nacelle and contains the following items:

Part No.	*Item*
36D	Tool Container
211G	Bag, Tool Kit
459F	Depressor-Valve Spring
672H	Gage-Valve Clearance
996A	Aligning Strip May Breaker Points
1059B	Mirror 4″ x 2½″
2835C	Wrench-Valve Adj. Screw and Lock Nut
1217C	Distributor Gland Nut
1265C	Wrench-Oil Flange
1392D	Depressor-Rocker Arm
1395A	Drift-Fibre
1396A	Extension 16″ 38″ sq.
1424B	Wrench–Push Rod Cover Nut
1437B	Wrench–1⅜″ Hex
1471C	Wrench–Starter of Generator
1560D	Wrench–Cylinder Nut
1585B	Wrench–1¼″ OE. Rel Cover Valve
1609C	Wrench Palnut 7/16″
1657B	Wrench–Push Rod Cover Nut
1683B	Wrench–Spark Plug Elbow
1786	Wrench–Int. Pipe Nut
1858A	Wrench–Starter Stud Nut
1886C	Wrench–Adjustable Strap
1950A	Wrench–1 1/16″ Crow Foot
2210C	Wrench–Oil Sump Support Stud
2254C	Wrench–Spark Plug
2410A	Wrench–1⅛″ Crow Foot
2334A	Seal for Tool Kit Bag
2682B	Wrench–⅜″ x 7/16″ Box End

Note

Engine tools, not having any of these numbers, are service tools from other kits.

---

(4) OTHER KITS AND SERVICE TOOLS.–Listed in the following:

GROUND EQUIPMENT

Service Number	*Douglas Drawing Number*	*Nomenclature*
K13601	C65-5153327-HF7	Sling Quick Change Engine Unit
K13701	C65-5157240-HF1	Sling Fuselage Nose Assembly
K13801	C65-5195491-HF1	Sling Aircraft Hoisting
K13901	C65-5153004-HF11	Sling Outer Panel
K14001	C65-5157285-HF3	Sling 75mm Cannon
K14101	K652-3530-1HF	Stand Tail

SPECIAL TOOLS

K33801		Kit Tool Operational Squadron Assembly
K33901		Box Tool Operational Squadron Tool Kit
K34001		Kit Tool Service Squadron Assembly
K34101		Box Tool Service Squadron Tool Kit
K34201		Kit Tool Major Overhaul Assembly
K34301		Box Tool Major Overhaul Tool Kit
K27707	K652-3051-7GT	Spanner Wrench, Nose Oleo Packing Nut (8239-48)
K39701	K652-3144-1GT	Spanner, Wrench, Bearing Stop Nut, Nose Oleo (8239-74)
K27704	K65-3051-4GT	Spanner, Wrench, Piston Head, Nose Oleo (8239-3)
K26422	K65-3038-22GT	Spanner, Wrench, Lock Nut Nose Wheel Actuating Cylinder

Service Number	*Douglas Drawing Number*	*Nomenclature*
K26424	K65-3038-24GT	Spanner, Wrench, Shiming Damper Yoke Nut-N-L-G (8239-28)
K26421	K65-3038-21GT	Spanner, Wrench Lock Nut Nose Wheel Snubber (2150751)
K24305	K65-2964-5GT	Wrench, Angle Nut, M.L.G. and N.L.G.
K26423	K65-3038-23GT	Spanner, Wrench, Main Oleo Packing Nut
K33301	K65-3109-1GT	Spanner, Wrench, Plunger Nut, M.L.G.
K27705	K65-3051-5GT	Spanner, Wrench, Piston Head, M.L.G.
K27706	K65-3051-6GT	Spanner, Wrench, Cross Tube Packing Nut, M.L.G.
K26427	K65-3038-27GT	Spanner, Wrench, Lock Nut Main Wheel Actuating Cylinder
K26419	K65-3038-19GT	Spanner, Wrench-Lock Nut Nose Wheel Door Actuating Cylinder
K23302	K652-3041-2GT	Wrench, Propeller Governor
K26420	K65-3038-20-GT	Spanner, Wrench, Lock Nut Bomb Door Forward Actuating Cylinder
K26418	K65-3038-18GT	Spanner, Wrench, Lock Nut Bomb Door Rear Actuating Cylinder
K33101	K652-3114-1GT	Wrench, Engine Mount Bolts
K34401	K652-7138-1GT	Pin, Expansion-Aligning Wing to Fuselage (Front Spar)
K34402	K652-7138-2GT	Pin, Expansion-Aligning Wing to Fuselage (Rear Spar)
K26428	K65-3038-28GT	Wrench, Spanner, Wing Flap Gear Box
K33701	K652-3115-1GT	Wrench, Spanner, Control Column Cap
K33501	K652-3111-1GT	Adapter, Wrench, 37mm Cannon Receperator
K33401	K652-7135-1GT	Pin, Wing Joint Alignment
K33402	K652-7135-2GT	Pin, Wing Joint Alignment
K32002	K65-6823-2GT	Hose, Brake Bleeder (Add Hose)
K22908	K652-2910-108GT	Gage, Spacer-Brake Plate (Same as C-54)
K33601	K65-3110-1GT	Wrench, Accumulator
	403193 (Bendix)	
K35507	K652-3112-7GT	Wrench, Double End Open End Offset $^{11}/_{16}$" x ¾"
K35509	K652-3112-9GT	Wrench, Double End Open End Offset $^{13}/_{16}$" x ⅞"
K35511	K652-3112-11GT	Wrench, Double End Open End Offset $^{15}/_{16}$" x 1"
K35513	K652-3112-13GT	Wrench, Double End Open End Offset 1$^{1}/_{16}$" x 1⅛"
K35515	K652-3112-15GT	Wrench, Double End Open End Offset 1$^{3}/_{16}$" x 1¼"
K35517	K652-3112-17GT	Wrench, Double End Open End Offset 1$^{5}/_{16}$" x 1⅜"
K35519	K652-3112-19GT	Wrench, Double End Open End Offset 1$^{7}/_{16}$" x 1½"
K35521	K652-3112-21GT	Wrench, Double End Open End Offset 1$^{9}/_{16}$" x 1⅝"
K35523	K652-3112-23GT	Wrench, Double End Open End Offset 1$^{11}/_{16}$" x 1¾"
K35525	K652-3112-25GT	Wrench, Double End Open End Offset 1$^{13}/_{16}$" x 1⅞"
K35527	K652-3112-27GT	Wrench, Double End Open End Offset 1$^{15}/_{16}$" x 2"
K22220	K652-6976-20GT	Adapter, Internal Wrenching Nut $^{5}/_{16}$" across flats
K22221	K652-6976-21GT	Adapter, Internal Wrenching Nut ⅜" across flats
K22222	K652-6976-22GT	Adapter, Internal Wrenching Nut ½"
K22224	K652-6976-24GT	Adapter, Internal Wrenching Nut ⅝" across flats
K22225	K652-6976-25GT	Adapter, Internal Wrenching Nut $^{11}/_{16}$" across flats
K22228	K652-6976-28GT	Adapter, Internal Wrenching Nut ⅞" across flats
K34403	K652-7138-3GT	Pin Expansion-Aligning Wing to Fuselage Lower Front Spar

5. LUBRICATION.

a. GENERAL. – Parts and mechanisms requiring lubrication must be lubricated at hourly intervals. See *figure 33* for requirements at 25 hr., 50 hr., and other periods, and for code to symbols.

b. APPLICATION.–Oil is usually applied with a squirt can. On some parts it is applied with a brush. Apply grease to all Zerk fittings with a grease gun. Grease is applied to bearings by hand and some greases such as permalube are applied with a brush.

c. LUBRICATION OF BEARINGS.

(1) SEALED BEARINGS. – Do not lubricate sealed bearings. These have sufficient grease sealed within for normal service, after which they should be replaced.

Note

Do not subject sealed bearings to excessive amounts of solvents such as gasoline. Solvents will seep through the seals and remove the grease within. Wiping or cleaning the outside of a sealed bearing with a solvent moistened rag is permissible, but take care not to saturate the bearing.

When absolutely necessary, sealed bearings must be re-lubricated. Apply an AAF tool No. 37B5054, Alemite tool No. 6212 or a similar purpose tool per T. O. No. 29-1-3, or latest revision thereof, to the bearing. Be sure all of the old grease is thoroughly flushed out. Use AN-G-3 preferably, or AN-G-10 if AN-G-3 is unobtainable.

(2) OPEN BEARINGS.–Unlike sealed bearings, open bearings require cleaning and repacking at regular intervals. *Figure 32* illustrates the cleaning and repacking of a main wheel bearing, which is typical for any open bearing. In cleaning the bearing, be sure to remove all old grease with a suitable solvent. Where equipment is unavailable to repack bearings under pressure, grease should be thoroughly worked into the bearing races and around the rollers with the palm of the hand until the grease can be seen oozing out on the other side. Smearing the grease on the outside of the rollers will not lubricate the inner bearing races and may cause freezing or failure of the bearing.

d. LUBRICATION IN VARYING CLIMATES AND TEMPERATURES.–The lubricants supplied in the airplane *(figure 33)* are suitable for operation in a wide temperature and climatic range. Special lubrication is not required for extremely cold temperature except for the following:

(1) WHEEL BEARINGS.–Change the AAF-3560 grease to AN-G-3 in the wheel bearings, socket joints, and other heavily loaded parts of the landing gear prior to take-off or landing in temperatures below −40°F (−40°C).

(2) OILED PARTS.–Below minus twenty degrees Fahrenheit (−29°C), use AXS 777 light oil on all oil parts calling for AN-VV-O-446A–Grade 1065, (Navy O-2), or SAE LOW (Low Pour) at higher temperatures.

(3) DRY, DUSTY CLIMATES. – Dust, dirt or sand combines with grease, oil or graphite to form a grinding compound. Therefore, remove excess lubricants from all moving parts subject to extreme dust conditions and from cables where they travel over pulleys. In desert operation, force out such dirt as may work into internal grease fittings by cutting lubrication period in half and removing all excess grease. Clean as often as possible.

CAUTION

Bomb racks and bombing control system parts should not be greased or oiled. Clean racks when necessary with Federal Specification P-S-661 dry cleaning solvent, unleaded gasoline, or light naphtha.

(4) SALT AIR CLIMATES.–Use oil, grease and rust preventive plentifully to prevent corrosion. Do not wipe off excess oil or grease as in desert climates. Service all landing gear fittings immediately after exposure to extremes of wet or salty atmosphere.

(5) CONTROL CABLES.–Inspect control cables every fifty hours for wear of anti-corrosion coating and touch up, if necessary, with AN-C-52, Type I, or equivalent. If the anti-corrosion coating is undamaged, oil cables, particularly where they contact pulleys, drums, or fair-leads, lightly with ARMY ORDER (AXS-777) NAVY ORDER (OS-1361) lubricating and preservative oil.

e. MISCELLANEOUS LUBRICATION REQUIREMENTS.

(1) Lubricate surface control system activating and adjusting screws and trim tab actuating screws and nuts by hand with AN-G-10 grease.

(2) For treatment of air filters use three parts of engine oil (AN-VV-O-446 Grade 1120) to one part corrosion preventive concentrate, Spec. (AN-VV-C-576). See T.O. No. 01-1-23 for application.

(3) On the overlapping rub-point areas of engine cowl flaps which have been treated with permalube or with black enamel and graphite, re-treat when operating conditions warrant as given in the following:

(a) When the old graphite begins to wear thin, strip off coating and mask off area to be painted.

(b) Apply one coat of Amberry quick-drying dull black enamel (Berry loid made by Berry Bros. of Detroit, Michigan) or equivalent.

(c) Allow to dry for only a few minutes.

(d) Before paint is entirely dry, blow powdered flake graphite (No. 2-633 made by Jos. Dixon Crucible Co., Ticonderoga, New York), or equivalent over paint and allow to dry.

Note

Fill an old rubber hydrometer tube (for testing batteries) with the graphite and blow it on the surface.

(e) Add paint and graphite when necessary. The above method is preferable, but the graphite may be mixed with the enamel and applied by brush.

(4) MACHINE GUNS.—For treatment of machine guns refer to T. O. No. 11-1-28.

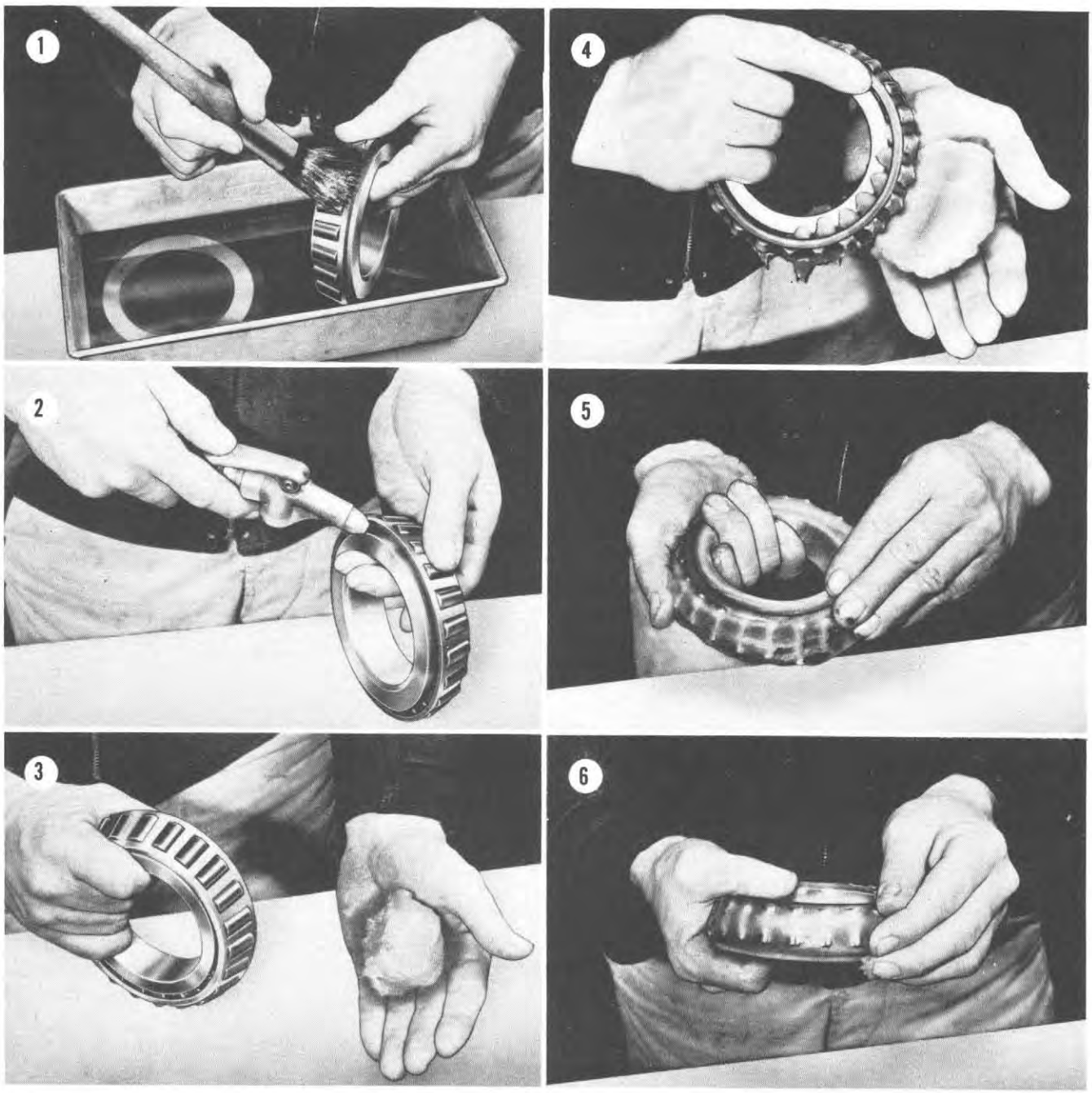


Figure 32 — Steps in Lubricating Wheel Bearings

TABLE OF LUBRICANTS

IDENTIFICATION	BASE SPECIFICATION	TYPE OF LUBRICANT	TEMP. RANGE (AMBIENT AIR T.) °F.	USES (HEREIN)	RECOMMENDED PRODUCT	APPROVED EQUIVALENT
A	AN G-3 (Nearest British Equiv. Spec. DTD577)	Grease—Low Temperature Lubricating	−65 to +160	All Zerk Fittings and Other Places Requiring Medium Body Grease. To Be Used in Wheel Bearings at Extreme Low Temperature (Below −40 °F.)	Beacon Lubricant M-285 (Std. Oil Co. of N. J.)	Kendall Formula "C" (Kendall Refining Co.)
B	AAF3560 Medium Grade	Grease—High Melting Point	−40 to +160	Wheel Bearings (Above −40 °F.)	PD433B—Medium (Socony-Vacuum Co.)	Andok Lubricant "B" (Std. Oil Co. of N. J.)
C		Grease—Graphited Lubricating	−65 to +160	Places Where Graphited Grease of Good Adhesive and Low Temperature Characteristics Are Required	W. S. 700 (RD-320-43) (S.O.N.J.)	AN G-3 Plus 3-5% Graphite (Compounded Thoroughly)
D	SAE ±10 W; or AN-VV-O-446 (Grade 1065)	Oil, Lub. (Light) Oil, Lub. (Medium)	−50 to +100 −10 to +160	General "Squirt Can" Lubrication	Triton 10W (low Pour (Union Oil Co., Cal.) Commercially Available	Commercially Available
E	Army Ord. AXS-777 Navy Ord. OS-1361	Oil—Low Temperature Lubricating and Preserving	−65 to +20	For Moderate Low and Extreme Low Temperature "Squirt Can" Lubrication—Control Cables	Commercially Available	
F	Navy O-2	Oil—Graphited Penetrating	+20 to +160	Exposed Hinge and Pin Joint Lubrication—Moderate Temperatures	Commercially Available	
H	Army 2-64	Graphite in Following Forms: Stick, Cake, Powder or Powder in Lacquer Base		Graphite Lubrication for Sliding Surfaces and General "Residual" Type Lubrication	Commercially Available	Dixon "Microfyne" (J. Dixon Co.) Powder, Cake & Stick "Permalube" (Lacquer Base Lubricant) (Andrew Brown Company, Los Angeles)
I	AN-VV-C-566 (British Equiv. DTD589)	Mica Base Anti-seize Compound		Surfaces Subjected to High Temperatures and Limited Motion (Exhaust Manifold Brackets, Etc.)	B. G. Mica Lubricant A719 (B. G. Corp., New York, N. Y.)	
J	AN G-10	Low Temp. Grease with Extreme Pressure Properties	−65 to +160	Control Surfaces Operating Mechanisms (Flap Gear Box, Tabs, Etc.)	W. S. 338 (S.O.N.J.)	Commercially Available
Y	AN-VV-C-576 (Nearest British Equiv. DTD587)	Corrosion Preventive Compound (concentrate)		Use One Part Compound Concentrate to 3 Parts Engine Oil AN-VV-O-446, Grade 1120, for Treatment of Carburetor Filters	"Rustban 606" (Concentrate) "Rustban 604" (Prepared Mixture with AN-VV-O-446, Grade 1120, in Correct Proportion) (S.O.N.J.)	Commercially Available "Stop Rust B" (Concentrate) "Stop Rust BB" (Prepared Mixture with AN-VV-O-446, Grade 1120, in Correct Proportion) (Union Oil Co., Cal.)
Z	AN-C-52 TYPE 1 (Nearest British Equiv. DTD279B)	Corrosion Preventive Exterior Surface		Cable Coating as Corrosion Preventive	Paralketone Type B (Alox Corp., Niagara, N. Y., or American Oil Supply Company of Newark, N. J.)	Commercially Available

APPLICATION SYMBOLS

ZERK OR ALEMITE GUN | OIL CAN | BRUSH | HAND

FREQUENCY SYMBOLS

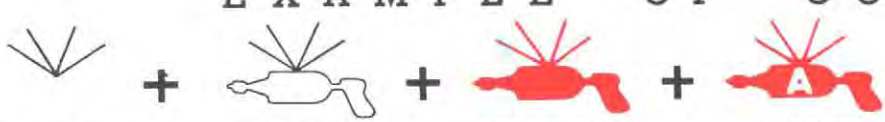
RED — *EVERY 25 HOURS*

YELLOW — *EVERY 50 HOURS*

GREEN — *EVERY 100 HOURS*

PURPLE — *FREQUENCY OVER 100 HOURS*

EXAMPLE OF CODING



POINTS OF LUBRICATION + METHOD OF APPLICATION + FREQUENCY OF APPLICATION + TYPE OF LUBRICANT =

Indicated points lubricated with Zerk or Alemite gun every 25 hours using type "A" lubricant AN G-3. (See above table of lubricants.)

✳ ANG-3 GREASE DURING MAJOR OVERHAUL

✝ PERMALUBE DURING MAJOR OVERHAUL

Figure 33 — Lubrication Chart (Sheet 1 of 5)

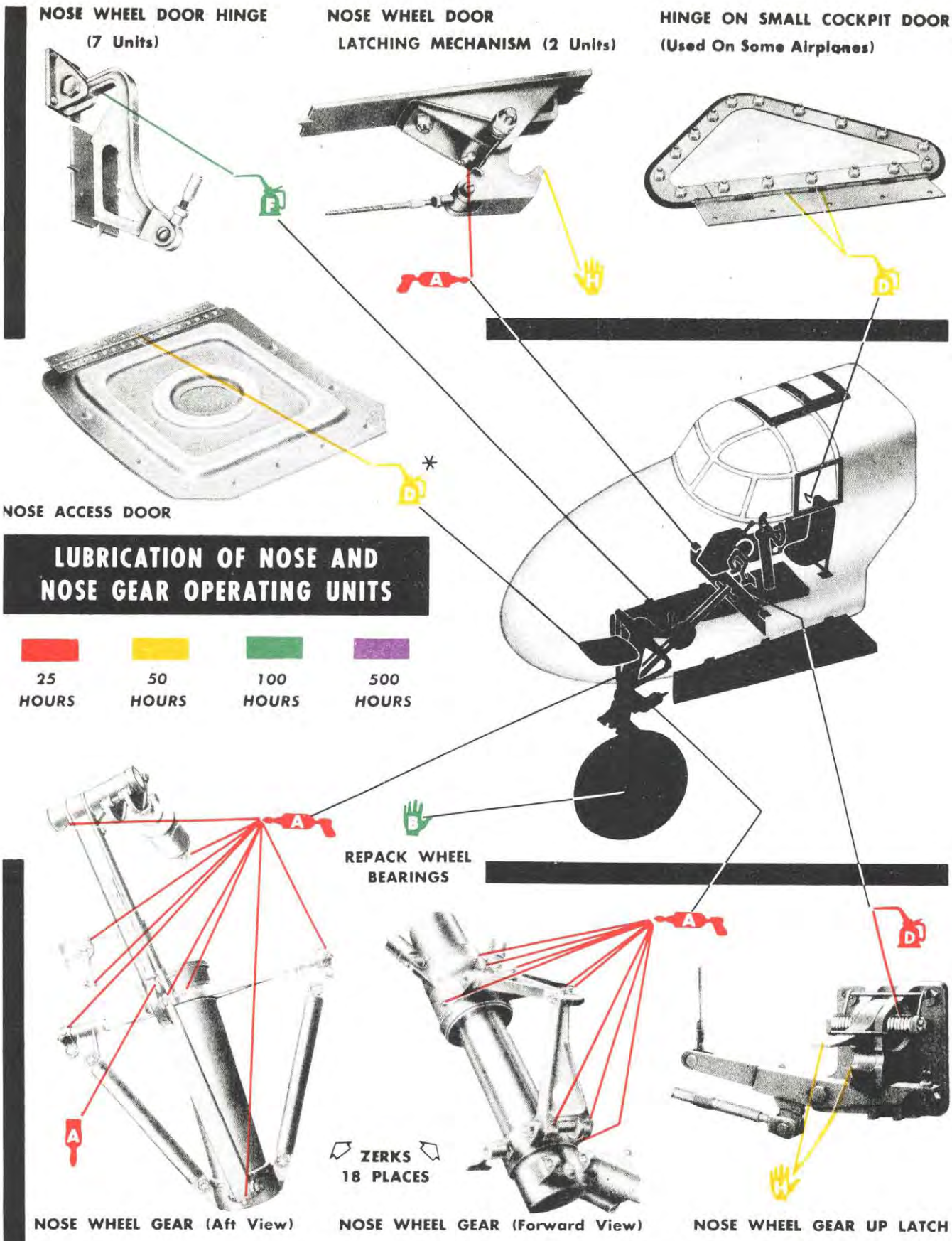
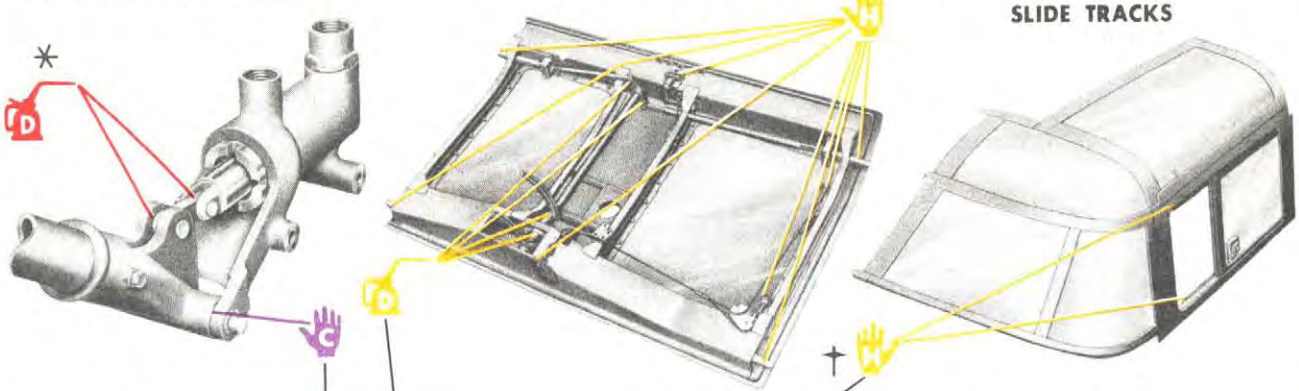


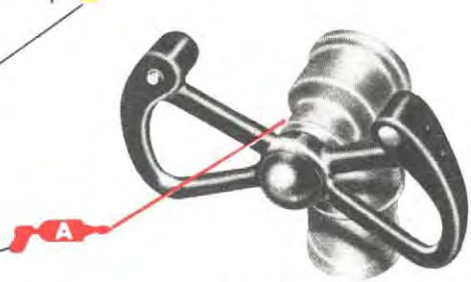
Figure 33 — Lubrication Chart (Sheet 2 of 5)

HYDRAULIC HAND PUMP

PILOT'S ACCESS DOOR

COCKPIT SIDE WINDOW SLIDE TRACKS

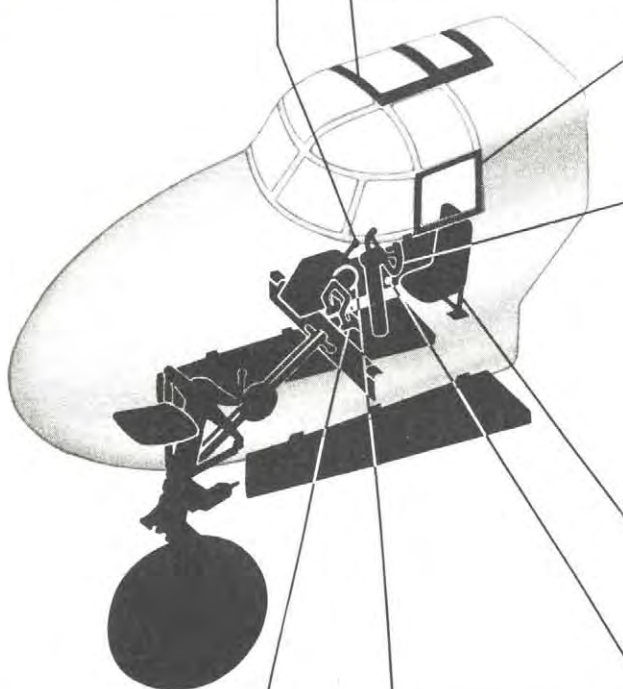


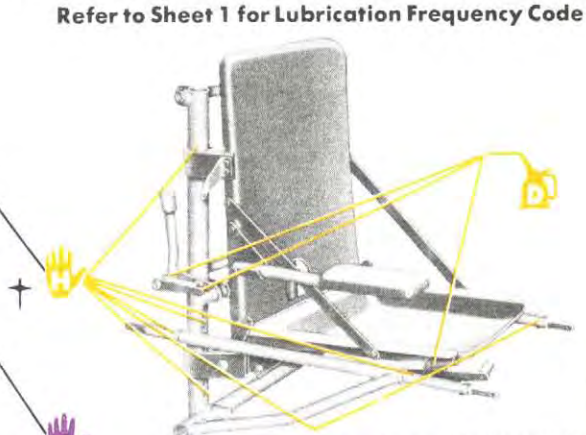


CONTROL COLUMN

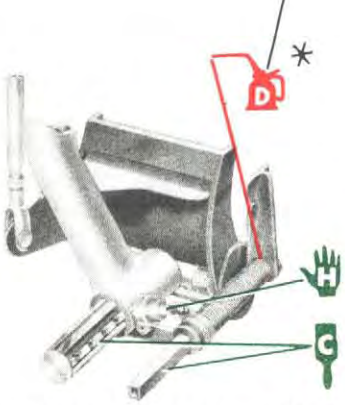
LUBRICATION OF PILOT'S COMPARTMENT OPERATING UNITS

Refer to Sheet 1 for Lubrication Frequency Code

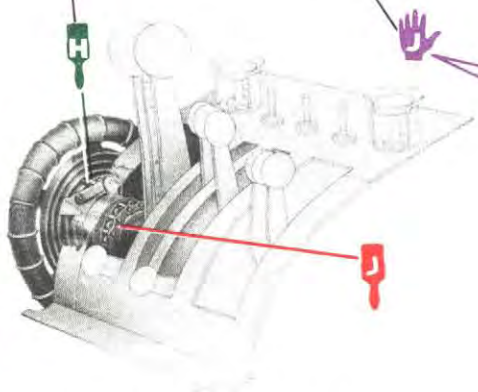




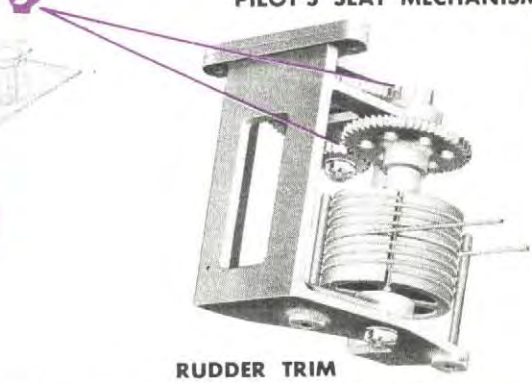
PILOT'S SEAT MECHANISM



RUDDER PEDAL AND BRAKE



ELEVATOR TRIM TAB INDICATOR SLIDE AND CONTROL CHAIN



RUDDER TRIM TAB CONTROL MECHANISM

Figure 33 — Lubrication Chart (Sheet 3 of 5)

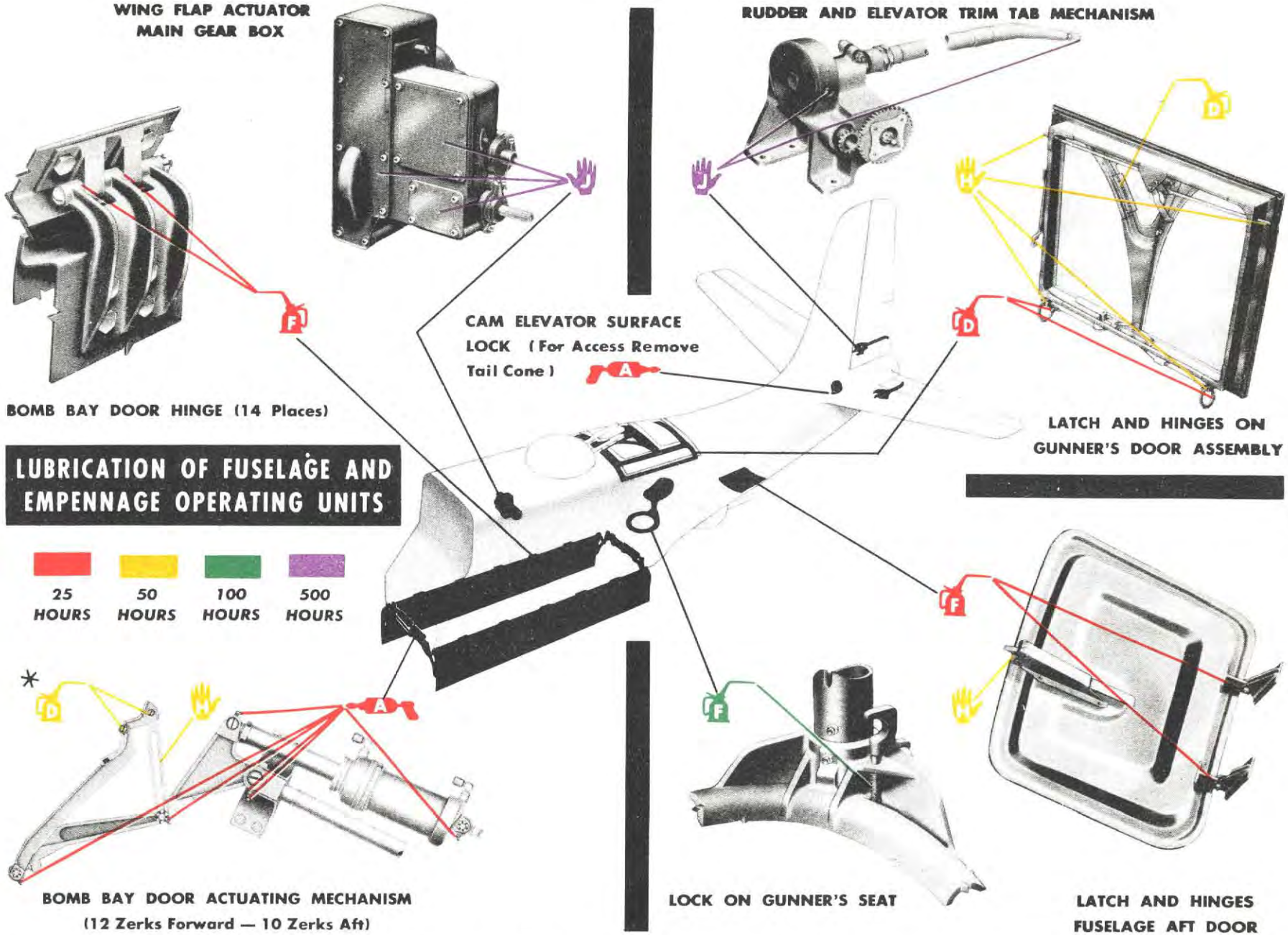


Figure 33 — Lubrication Chart (Sheet 4 of 5)

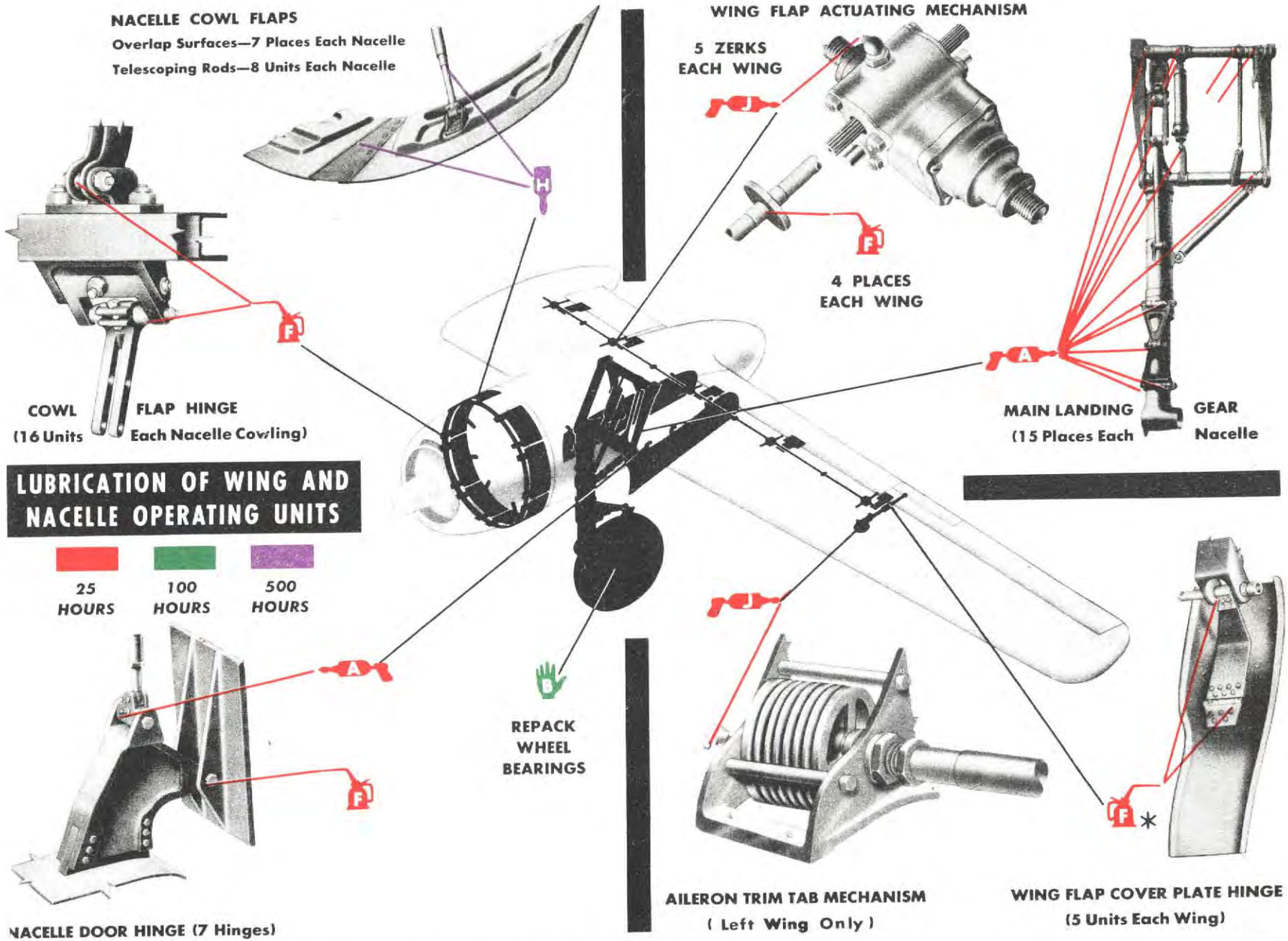


Figure 33 — Lubrication Chart (Sheet 5 of 5)

f. SPECIFICATION LUBRICATION REQUIREMENTS.–The oil or grease, the method and interval of its application to the particular part, and the code are fully covered in the following charts. It should be noted that a letter symbol such as A refers to AN-G-3, low temperature lubricating grease, etc. Very often only the symbol such as A, H, J, etc., will be given and it will be necessary to associate the symbol with the specification and method of application. The table of lubrication sets forth the lubricants and their commercial equivalents to aid commercial operators in selecting the correct lubricant. For safety and best results the *table should be strictly adhered to.*

Note

Specialized lubrication requirements of instruments, engines, and accessories are covered in their respective sections, not in this section.

To simplify and consolidate the table, some general observations may be made of the specific requirements as follows:

(1) SLIDING SURFACES.–Use H on sliding surfaces including the following:

(a) RUDDER PEDAL SPLINES AND TRACKS.–Apply graphite stick by hand–100 hrs.

(b) SLIDING GUIDES ON THE BOMB BAY DOOR ACTUATING MECHANISMS. – Apply graphite stick by hand–25 hours.

(c) LATCHES.–Apply graphite stick by hand to all door and hatch latches, latch points, and sliding contacts–50 hours.

Note

Remove emergency hatches, thoroughly clean, and lubricate every 50 hours.

(d) PILOT'S SEAT TUBES AND WINDOW TRACKS.–Apply graphite stick by hand–50 hours.

(e) TAB INDICATOR SLIDE. – Brush with permalube (graphite powder in lacquer base) – 100 hours.

(f) COWL FLAP TELESCOPING ROD.–Brush with permalube (graphite powder in a lacquer base)–500 hours.

(2) HINGES.–Apply F with a squirt can at 25 hours to the following hinges:

(a) COWL FLAP (16).

(b) NACELLE DOOR (7).

(c) FUSELAGE DOOR (aft door).

(d) BOMB BAY DOORS.

(e) NOSE WHEEL DOORS.

(f) WING FLAP COVER PLATE.

(g) SMALL COCKPIT ENCLOSURE VENTILATOR DOOR.–Apply D at 50 hours.

(3) BUSHINGS.–Apply D with a squirt can to the following bushings:

(a) PILOT'S ACCESS DOOR CENTER LATCH (4 places)–50 hours.

(b) NOSE WHEEL DOOR UP LATCH (pivot points)–25 hours.

(c) NOSE ACCESS DOOR–25 hours.

(d) BOMB BAY DOOR–50 hours.

(e) GUNNER'S DOOR EMERGENCY LATCH –25 hours.

(f) HYDRAULIC HAND PUMP–25 hours.

(4) ZERK FITTINGS. – Apply grease with an alemite gun at 25 hours to the following zerks:

(a) MAIN LANDING GEAR.–Apply A to 15 places.

(b) NOSE LANDING GEAR.–Apply A to 18 places.

(c) TOP OF CONTROL COLUMN.–Apply A to zerk.

(d) FORWARD BOMB BAY DOOR ACTUATING MECHANISM.–Apply A to 12 places.

(e) AFT BOMB BAY DOOR ACTUATING MECHANISM.–Apply A to 10 places.

(f) NACELLE DOOR MECHANISM.–Apply A to 7 places.

(g) AILERON TRIM TABS.–Apply J to the zerk in each trim tab.

(h) WING FLAP GEAR BOXES.–Apply J to zerk in each box–(10 boxes).

(5) GEARS.–Apply grease by hand to these as follows:

(a) WING FLAP ACTUATOR (main gear box in bomb bay).–Repack with J at 500 hours.

(b) RUDDER TRIM TAB CONTROL (in pilot's compartment).–Apply J to gears at 500 hours.

(c) ELEVATOR AND RUDDER TRIM TAB MECHANISMS (in empennage).–Apply A to needle bearing at end and repack gear box with A–500 hours.

(6) THREADS.–Brush the wing flap gear box threads with J at 25 hours.

(7) CHAINS.–Brush the control pedestal (chain elevator tab chain) with J at 25 hours.

(8) LINKAGE.–Apply D with a squirt can to the control pedestal linkage at 25 hours.

(9) BEARINGS.–Apply B by hand to the landing wheel bearings (6 places 2 in each wheel) at 100 hours.

(10) MISCELLANEOUS ITEMS.

(a) WING FLAP TORQUE TUBE GUIDES (plastic fairings).–Apply F with a squirt can at 25 hours.

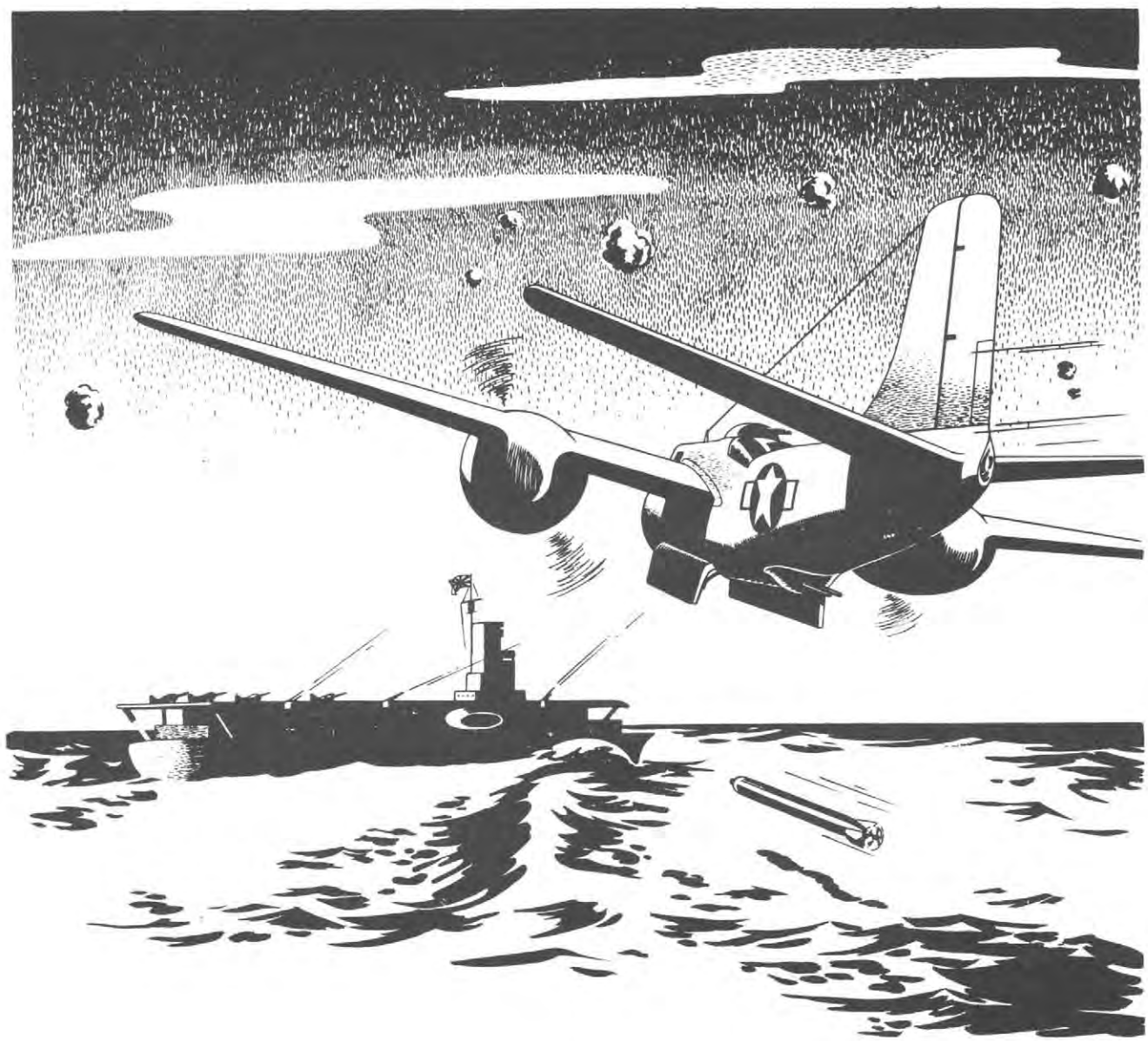
(b) LOCK ON GUNNER'S SEAT. – Apply F with a squirt can at 100 hours.

(c) PILOT'S SEAT ADJUSTING LEVER PIVOT POINT.–Apply D with a squirt can at 50 hours.

(d) HYDRAULIC HAND PUMP.–Apply C by hand to the socket joints at 500 hours. Apply D with a can to bushings at 25 hours.

(e) DISC (at top of lower retracting link on the nose wheel landing gear). – Brush shiny surface with C at 25 hours.

(f) RUDDER PEDALS. – Apply C to splines and spring slides by hand. Apply H to pin slide. Apply D to spring bushings. All 25 hours.



SECTION IV

MAJOR COMPONENT PARTS AND INSTALLATIONS

1. WING GROUP

a. GENERAL.—The wing is a two-spar, aluminum alloy frame-and-sheet structure fabricated in four parts. These are the left and right wing panels and left and right wing tips. A nacelle is built as part of each wing panel with the major portion protruding below the wing panel. The span of the full cantilever wing is 70 feet. Maximum width is 10 feet and maximum depth is 18⅓ inches. Aluminum alloy wing flaps and deflectors are installed inboard and outboard of each nacelle. Fabric-covered ailerons extend from the outboard end of each outboard flap to the wing tip. The wing tips are fabricated from molded plywood or metal.

b. WING.

(1) DESCRIPTION.—The inboard end of each wing panel houses spar fittings which extend into, and are attached to, the fuselage structure by means of steel pins and bolts. Equipment installed in each wing panel includes a self-sealing auxiliary fuel container located inboard of the nacelle; an oil temperature regulator with a removable air scoop, installed in the wing outboard of each nacelle; four ammunition boxes of dural construction which are permanently installed in each panel outboard of the nacelles, and located between the front and rear spars; and actuating mechanisms for the wing flaps and ailerons. Provision also is made for the installation of two rack supports attached to the under-surface of each wing panel, for carrying bombs, machine guns or chemical tanks. A removable nose section located in each wing panel between the fuselage and nacelle, provides access to wing systems lines, control cables, and electrical wiring. Access also is provided at the wing-to-fuselage fillet, which is removable in four parts.

(2) REMOVAL AND DISASSEMBLY.

(a) Support the wing at the jack points *(figure 21)* both inboard and outboard of the nacelle.

(b) Drain all fuel from the nacelle fuel container and the auxiliary wing fuel container as outlined in paragraph 11. *c.*, this section.

(c) Drain the oil container, as outlined in paragraph 12. *d.*, this section.

(d) Remove the engine, as outlined in paragraph 6. *b.* (2), this section.

(e) Remove the landing gear assembly as outlined in paragraph 5. *b.* (1) *(b)*, this section.

(f) Remove the flush head screws attaching the removable nose section of the wing and remove the nose section.

(g) Remove the complete fillet which fairs the wing to the fuselage.

(h) By means of the access gained by removal of the wing-to-fuselage nose fillet and the nose section, disconnect all lines, control cables, and electrical disconnect plugs at this location. Tape all surface control cables at the drums before disconnecting them.

(i) Disconnect the cross-feed fuel line at the fuel cross-feed valve located on the aft portion of the control pedestal.

(j) Disconnect all wires at the aft wing electrical disconnect terminal panel on the left-hand side of the aft bomb bay.

(k) Disconnect the fuel booster pump electrical plug in the forward bomb bay.

(l) In the pilot's compartment near the aft bulkhead disconnect the following equipment:

1. Forward wing disconnect electrical plug.
2. Forward wing disconnect instrument plug.
3. Voltage regulator electrical plug.
4. Ignition plug.
5. Main wing bus.

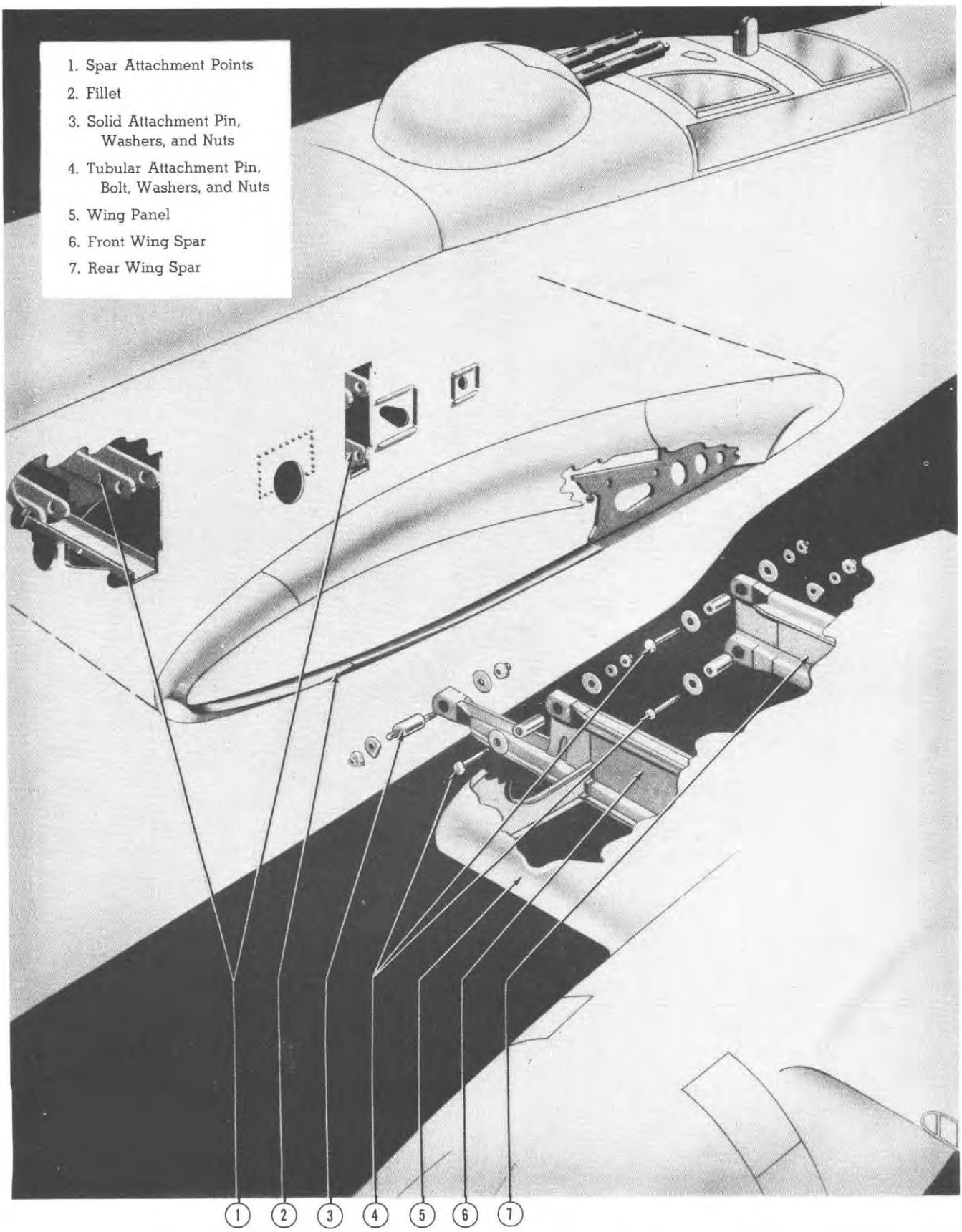


Figure 34 — Wing Attachment

(m) Remove the two solid pins *(3, figure 34)* from the forward inboard spar cap and the lock bolt and pin from the forward outboard spar cap.

(n) Remove the two lock bolts *(4, figure 34)* and pins from the rear spar caps.

(o) Remove the wing by moving it outward until the spar caps are clear of the fuselage skin. The wing flap actuating rod incorporates a universal slip joint, located inside the fuselage aft of the rear spar, which will separate when the wing is removed.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—Ordinarily minor skin repairs can be made at Army Air Forces stations. Due to the heavy loads carried by the wing skin, damage cannot be ignored unless it consists of smooth dents which have not distorted the frame structure or caused rivets to shear. Dents should be carefully inspected to make certain they are not the result of high stress caused by the failure of any part of the structure. For instructions on skin and structural repairs, refer to Structural Repair Handbook (No. AN01-40AJ-3).

(4) ASSEMBLY AND INSTALLATION.

(a) Jack the wing panel until it is level with the wing attaching frames. Support the wing panel at the jacking points.

(b) Carefully move the front and rear wing spar fittings into the respective positions in the fuselage.

(c) Align the hole in each spar fitting with its frame attaching hole as closely as possible; then insert expansion bolts, and tighten them until the holes are perfectly aligned.

(d) Remove the expansion bolts one at a time and insert the wing attaching pins.

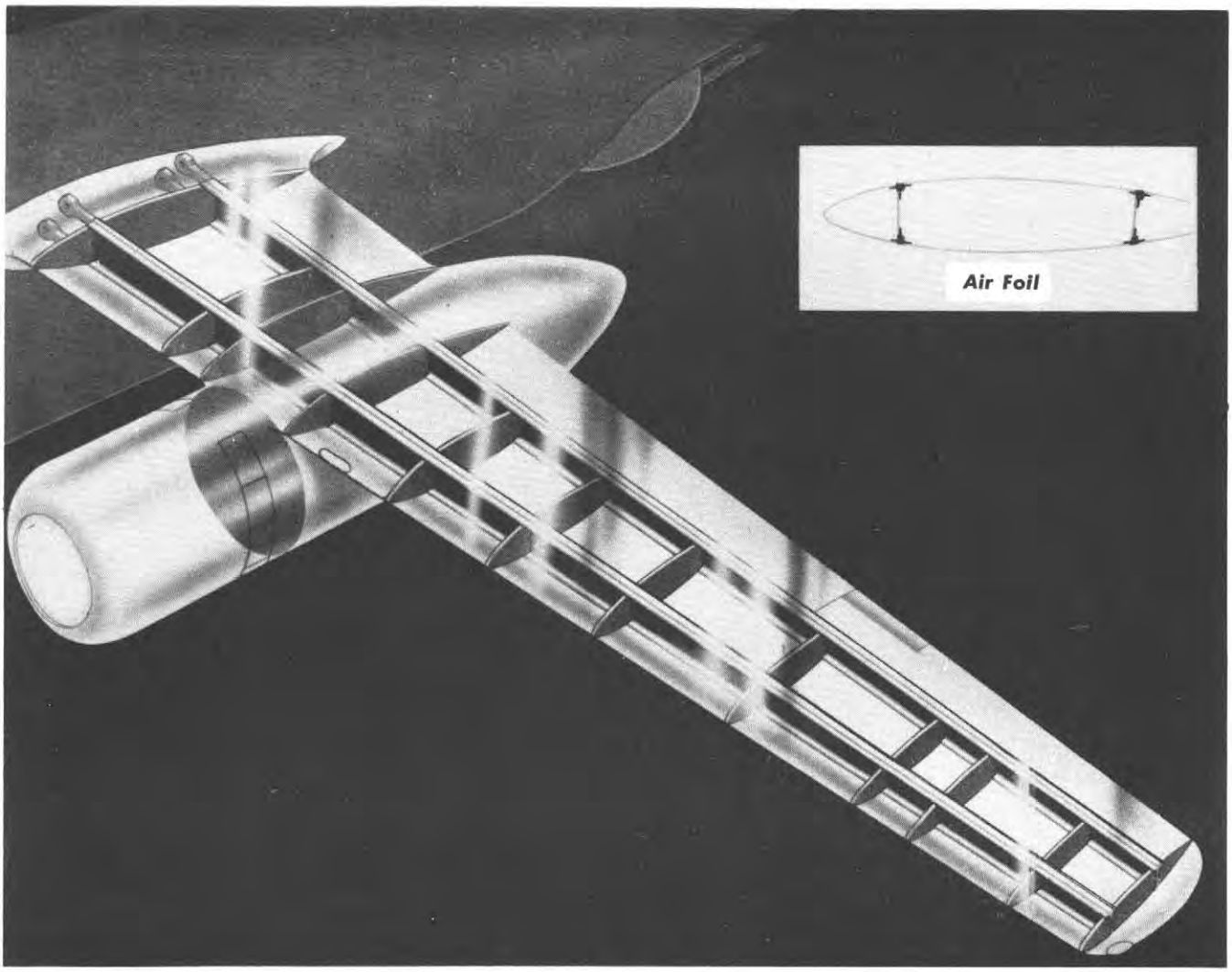


Figure 35 — Wing Structure

(e) Install the lock bolts in the pins, add the washers and tighten nuts. Because of clearance problems, install washers on lower inboard pins before pushing pin completely through the cap.

(f) Complete the wing installation by reversing the REMOVAL procedure.

(5) TEST AFTER INSTALLATION. – Make a trial operation of all systems which were disconnected when the wing panel was removed from the fuselage.

c. WING TIPS.

(1) DESCRIPTION.–Molded plywood or dural tips are installed on the wing panels. Each tip is attached to the wing panel spars with four bolts. Mounted in the forward part of each wing tip is a position lamp which is protected by a removable transparent plastic cover.

(2) REMOVAL.

(a) Remove the access door located on the under side of the wing tip.

(b) Remove the two access doors *(15, figure 6)* from the under side of the wing. Open the aileron seal zipper in the aft access opening.

(c) Remove the position lamp assembly as illustrated in *figure 36*. Disconnect the electrical wiring from the lamp.

(d) Detach the wing tip from the front wing spar by holding the nuts in the wing with an open end wrench and removing the two bolts.

(e) Remove the four bolts which attach the wing tip to the front and rear wing spar. Hold the nuts in the wing panel with an open end wrench and turn out the bolts in the wing tip with a socket wrench.

(3) MAINTENANCE REPAIR OR REPLACEMENT.–For repairs to the structure and skin refer to Structural Repair Handbook (No. AN01-40AJ-3).

(4) ASSEMBLY AND INSTALLATION. – Reverse the procedure outlined in paragraph (2), above.

(5) TEST AFTER INSTALLATION. – Test the position lamp for proper operation.

d. NACELLES.

(1) DESCRIPTION.–The nacelles are one piece, all metal structures which are permanently attached to the wing by means of bolts and rivets. A stainless steel firewall incorporating a removable center section separates each nacelle structure from the engine. An oil container and a main, self-sealing fuel container are located in the forward half of each nacelle and are made accessible through removable wing panels. The aft half of each nacelle contains a retractable main landing gear assembly. Nacelle doors which are mechanically operated by the movement of the landing gear, completely close the landing gear well when the gear is retracted.

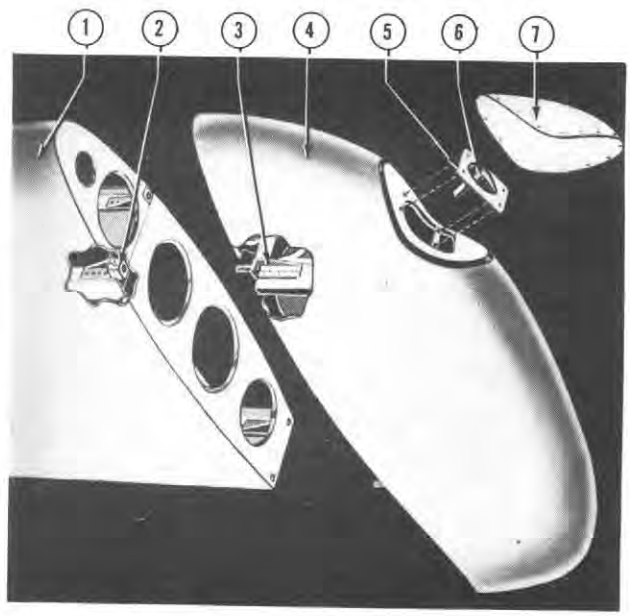
(2) REMOVAL AND DISASSEMBLY.

(a) NACELLES.–The nacelles are permanently attached to the wing structure and cannot be removed as a maintenance operation.

(b) NACELLE DOORS.–Refer to paragraph 5. *b.* (6), this section.

(c) ALIGHTING GEAR.–Refer to paragraph 5., this section.

(3) MAINTENANCE REPAIR.–For instructions on repair of the nacelle skin and framework refer to Structural Repair Handbook (No. AN01-40AJ-3).



1. Wing
2. Wing Tip Attaching Fitting (4 places)
3. Wing Tip Attaching Fitting (4 places)
4. Wing Tip
5. Position Lamp Support
6. Position Lamp
7. Plexiglas Cover

Figure 36 — Wing Tip Attachment

2. EMPENNAGE

a. GENERAL.—The empennage, or tail surface assembly, consists of two horizontal stabilizers, a vertical stabilizer, two elevators, each equipped with a trim tab, and the rudder and rudder trim tab.

The following information is applicable only to the removal, installation, and maintenance of the horizontal and vertical stabilizers. The movable control surfaces and surface controls are described in paragraph 3., this section.

b. HORIZONTAL STABILIZERS.

(1) DESCRIPTION.—The horizontal stabilizers are metal structures consisting of aluminum alloy structural members covered with alclad plating. Each stabilizer has a metal tip which is removable. Four steel bolts staked into the fuselage structure, securely attach each stabilizer to the fuselage. The joints between each stabilizer and the fuselage are sealed with strips of sponge neoprene cemented to the fuselage structure.

(2) REMOVAL.

(a) Remove the elevators as described in paragraph *3. b.* (4) *(b)*, this section.

(b) Working inside the fuselage aft section, disconnect and cap the de-icer air supply lines.

(c) Remove the end of the aerial attached to left-hand horizontal stabilizer, and coil it for safety against damage.

(d) As each horizontal stabilizer weighs 103 lbs., at least two men are required to remove this part, or damage to attaching fittings will result. One should support the stabilizer, while the other unscrews the four cover plates over the access holes *(14, figure 37)* located in each stabilizer. Through these access holes, remove the nuts and washers *(13, figure 37)* which secure the stabilizer to the fuselage.

(e) Pull and lift the stabilizer horizontally from the fuselage until it is clear of the bolts. If the stabilizer does not come free immediately, jar it gently until it can be released from the fuselage.

CAUTION

Do not rock the stabilizer in any manner as so doing will cause serious damage to the four attaching bolts.

(3) DISASSEMBLY.—To remove the tip of the horizontal stabilizer, remove the attaching screws, and pull the tip horizontally away from the stabilizer.

(4) MAINTENANCE REPAIR OR REPLACEMENT.

(a) Instructions on the repair of the horizontal stabilizer plating and structure will be found in the Structural Repair Handbook No. AN01-40AJ-3 stowed in this airplane as part of equipment.

(b) Damaged or worn sealing strips of sponge neoprene should be replaced. Following is the recommended procedure for attachment of new sealing strips to the fuselage:

1. First, prime the metal surface with cement primer, preferably 624N, manufactured by B and D Chemical Company, or equivalent.

2. After the primer has dried, apply a thin, even coat of neoprene cement, preferably DuPont Fairprene No. 1 or 4, or equivalent, on both the metal surface and the sealing strip. Allow the cement to dry until the solvent odor and the sheen are gone.

3. Press the neoprene sealing strip into place.

(5) ASSEMBLY AND INSTALLATION.—To install the horizontal stabilizer on the fuselage, reverse the REMOVAL procedure. Attach the four elastic stop nuts and washers to the fuselage bolts with a torque wrench force equal to 2900-3200 inch-pounds.

c. VERTICAL STABILIZER.

(1) DESCRIPTION.—The vertical stabilizer is a rigid, metal assembly consisting of an aluminum alloy structure covered with alclad plating. The stabilizer is secured to the fuselage at three points by means of five steel bolts which project from the fuselage. The joint between the structures is sealed with sponge neoprene strips cemented to the fuselage. The stabilizer has a removable metal tip which is secured by screws. A pitot-static tube and an aerial attachment are located on the leading edge of the tip assembly and a remote compass transmitter is mounted inside the stabilizer.

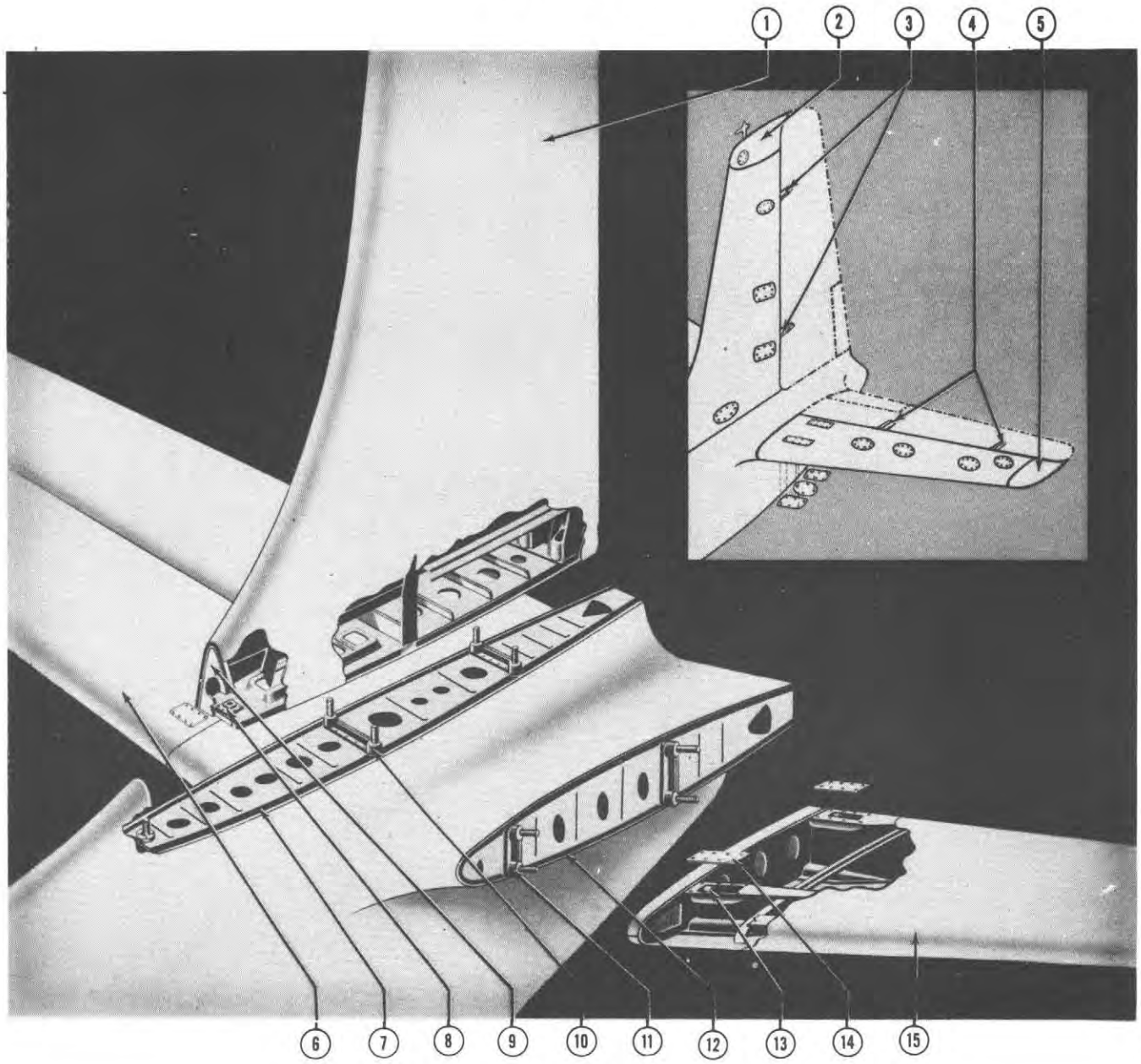
(2) REMOVAL.

(a) Remove the rudder as described in paragraph *3. b.* (6) *(b)*, this section.

(b) Working within the fuselage aft section, disconnect the pitot-static instrument lines, the de-icer boot lines, and the pitot-static tube heater electric wire.

(c) Disconnect the aerial from the tip of the vertical stabilizer, and coil it.

(d) The weight of the vertical stabilizer is 140 lbs. and at least two men are required to remove it. One should work from within the fuselage, removing



1. Vertical Stabilizer
2. Vertical Stabilizer Tip (Removable)
3. Rudder Hinges
4. Elevator Hinges
5. Horizontal Stabilizer Tip
6. Horizontal Stabilizer
7. Sealing Strip (96 inches long)
8. Anchor Nut
9. Sealing Strip (22 inches long)
10. Vertical Stabilizer Attachment Bolt (5 places)
11. Horizontal Stabilizer Attachment Bolt (4 places)
12. Sealing Strip (85 inches long)
13. Elastic Stop Nut
14. Cover Plate
15. Horizontal Stabilizer

Figure 37 — Stabilizer Attachment

the five bolts which secure the vertical stabilizer in position on the fuselage structure. The nuts may be held through the access door provided between the spars on the vertical stabilizer.

(e) Lift the vertical stabilizer from the fuselage until it is clear of bolts and lines.

(3) DISASSEMBLY.–Remove the tip of the vertical stabilizer as follows:

(a) Disconnect and cap the instrument lines and disconnect the heater wire, working through the access hole located beneath the pitot-static tube.

(b) Remove the screws at the bottom of the tip, and lift the tip from the stabilizer.

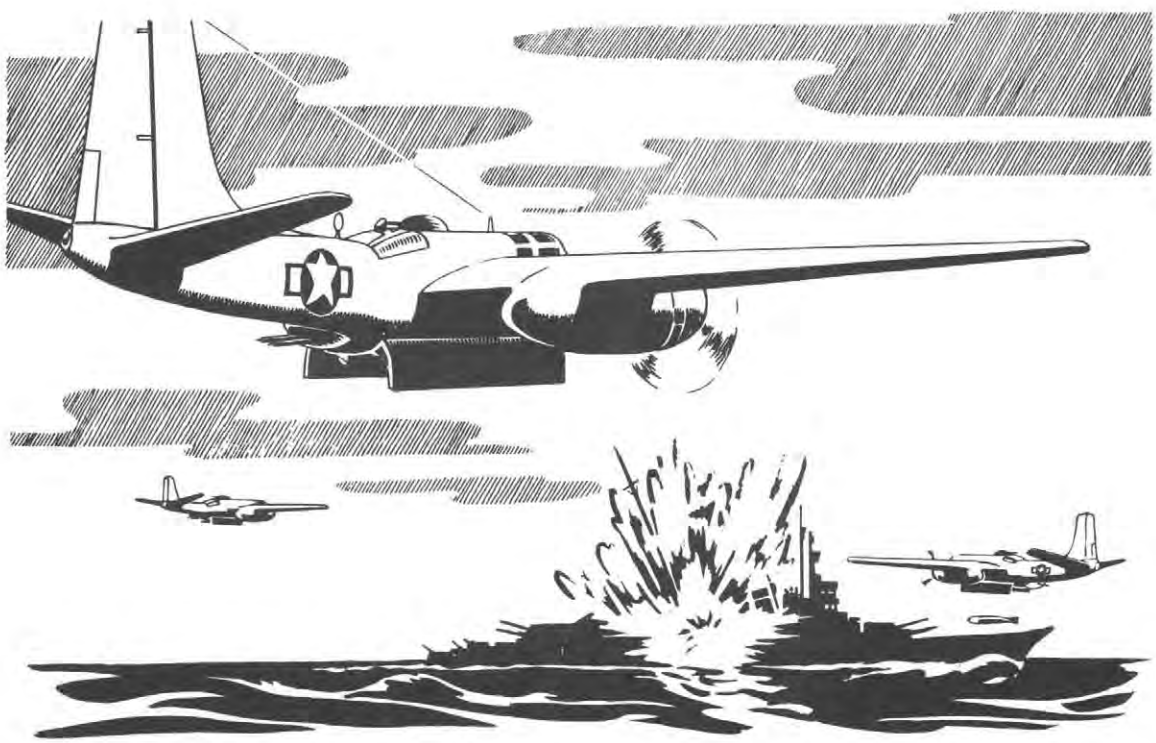
(4) MAINTENANCE REPAIR OR REPLACEMENT.

(a) Instructions on the repair of the vertical stabilizer plating and structure will be found in the Structural Repair Handbook AN01-4AJ-3 supplied with this airplane.

(b) Damaged or worn sealing strips *(5, figure 47)* should be replaced. For instructions on replacement, refer to paragraph 2. *b.* (4) *(b)*, this section.

(5) ASSEMBLY AND INSTALLATION.–To install the vertical stabilizer, reverse the REMOVAL procedure. Attach the four bolts *(10, figure 37)* with a torque wrench force equal to 2900-3200 inch-pounds.

d. ELEVATORS, RUDDER, AND TRIM TABS.–Refer to paragraph 3., this section, for all information about these movable surfaces.



3. MOVABLE SURFACES AND SURFACE CONTROLS.

a. GENERAL.—The ailerons, elevators, rudder and trim tabs installed on the airplane are conventional in design and are operated by means of a single set of standard manual controls installed in the pilot's compartment. The similarity with other airplanes ends at this point, however, as several types of mechanisms are used to actuate the flight surfaces.

The wing flaps also differ from those used on most airplanes. They are attached to the wing by a linkage which permits greater extension than the standard flap mechanism provides. Efficiency is further increased by the use of deflectors which direct air flow to the top of the flap, providing additional drag.

b. MOVABLE SURFACES. *(See figure 38.)*

(1) GENERAL.—Movable surfaces used to control the airplane while it is in flight consist of two fabric-covered ailerons, two metal aileron trim tabs, two fabric-covered elevators and tabs, a fabric-covered rudder and tab, and four metal wing flaps equipped with self-acting deflectors.

To facilitate the pilot's control of the airplane, the ailerons, elevators and rudder are balanced aerodynamically and statically, and all the moving surfaces are attached with hinges containing sealed-in-grease bearings. A rubberized canvas gap seal is installed in the openings between the ailerons and the wing, the elevators and the horizontal stabilizers, and the rudder and the vertical stabilizer. The method of installation permits quick removal of the seals from the fixed surfaces.

(2) AILERONS. *(See figure 39.)*

(a) DESCRIPTION.–One aileron is attached to each wing panel, extending inboard from the wing panel tip for a distance of 11 feet. The rubber-impregnated gap seal which covers the opening between the ailerons and the wing is attached to the surfaces with screws and equipped with a metal zipper. The zipper permits rapid removal of the ailerons from the wing.

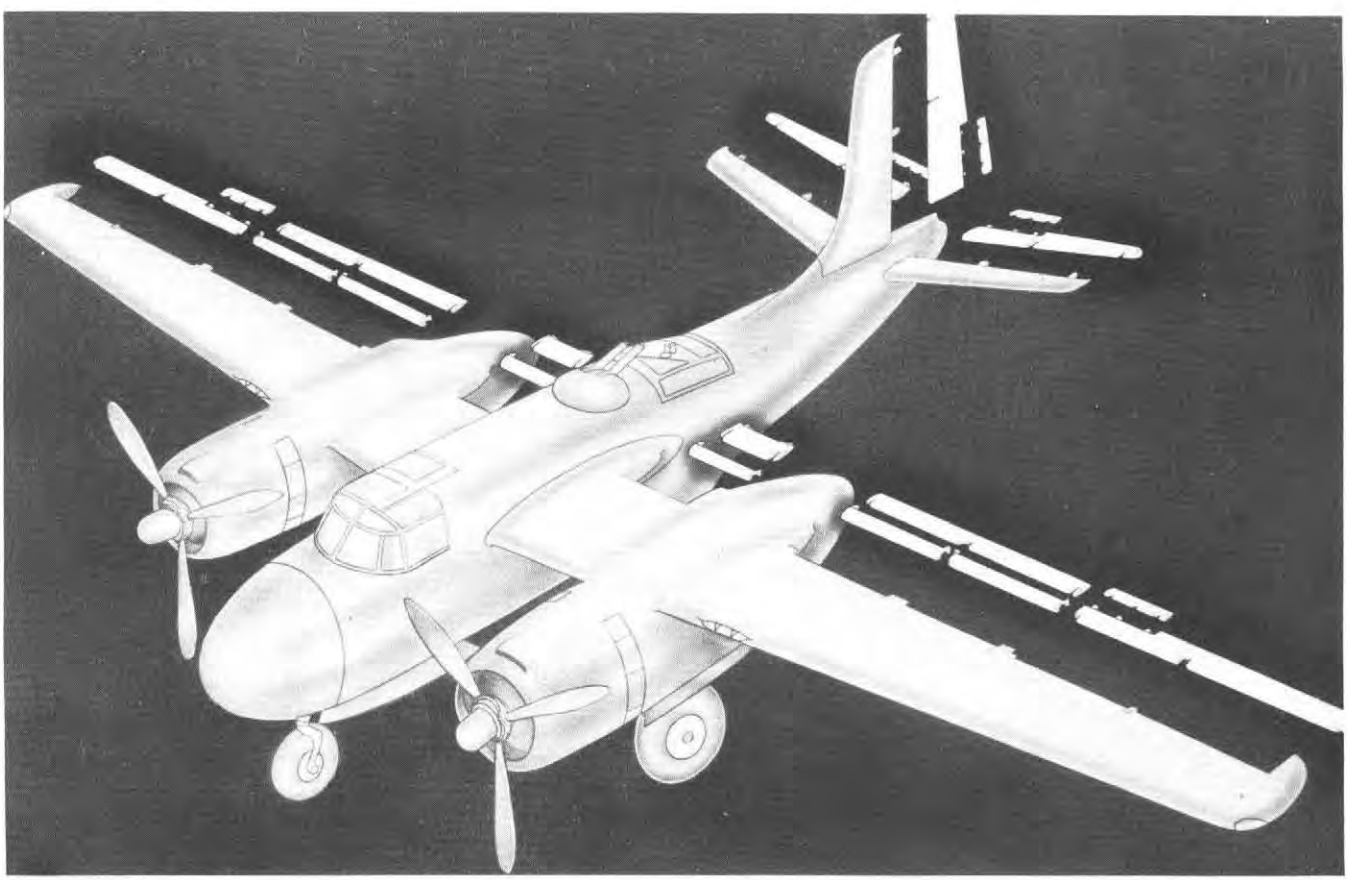


Figure 38—Movable Surfaces

The ailerons are operated simultaneously by revolving the pilot's control wheel to the left or right. The aileron control mechanisms are described in paragraph 3. *c.* (2), this section.

(b) REMOVAL.

1. Remove the aileron push-pull tube fairing and the aileron trim tab push-pull tube fairing.

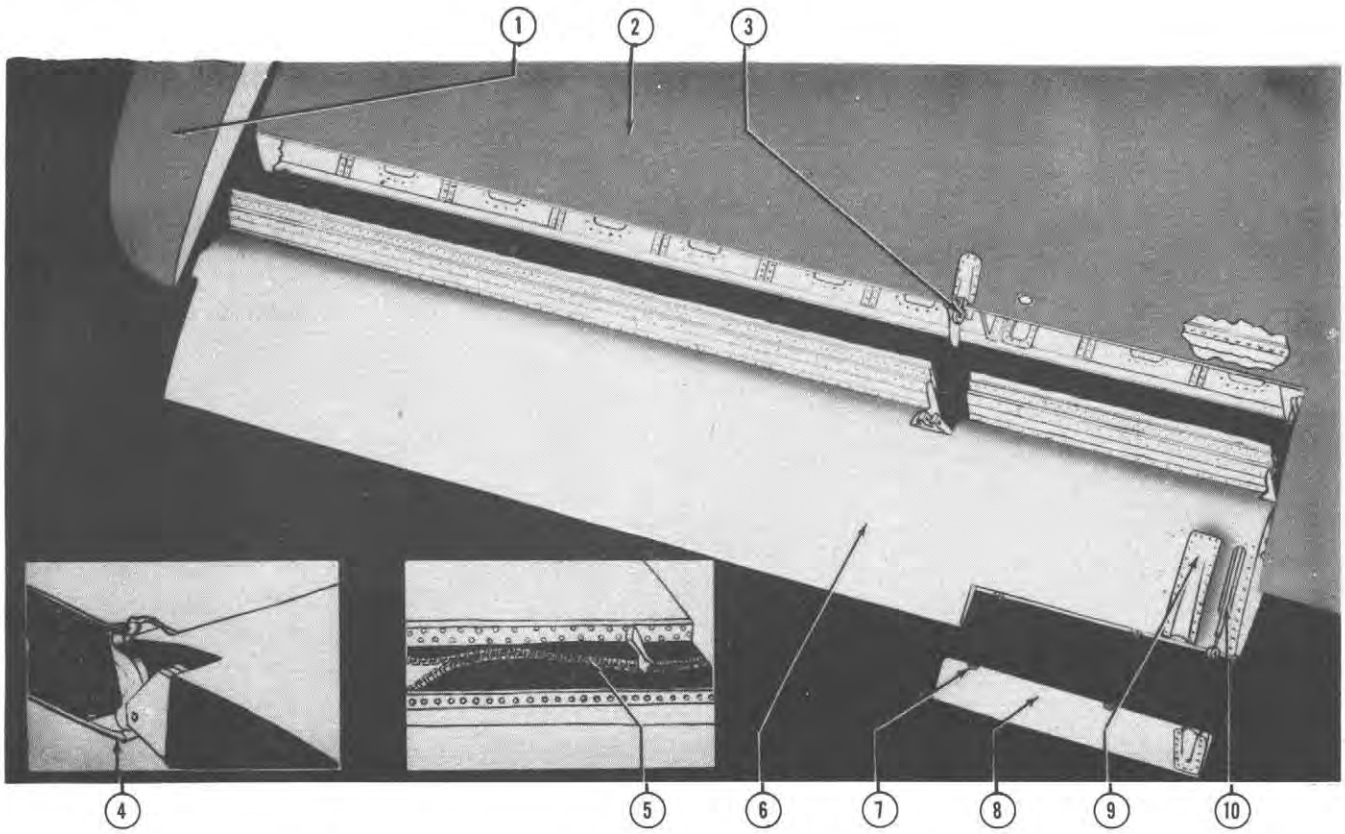
2. Disconnect the aileron push-pull tube and the aileron tab push-pull tube by removing the bolts at the aft fittings.

3. Open all the access doors located on the under side of the wing immediately forward of the aileron. *(See 1, figure 6.)*

4. Working through the access doors, starting at the center hinge, open the aileron gap seal zippers.

5. Disconnect the three bonding strips connected to the wing and the aileron at the three hinge points. To remove the bonding strip at the outboard hinge it will be necessary to work through the opening between the hinge and the wing tip, using a socket wrench and a 90 degree offset screw driver. Insert the wrench through the opening from the underside and bend the bonding strip attaching clip on the wing until the wrench can be fitted over the nut. After inserting the wrench, pull the aileron down and remove the screw by inserting the 90 degree screw driver from the upper side of the aileron.

6. Remove the inboard and outboard hinge bolts. The inboard bolt is reached through the inspection plate located on the top of the aileron. Hold the bolt head with a $\frac{7}{16}$ inch, deep socket wrench and, with the wing flaps in the DOWN position, remove the nut with a deep socket wrench. To remove the outboard hinge bolt, remove the access door on the top of the aileron. Hold the nut with a $\frac{7}{16}$ inch deep socket wrench and turn the bolt with a $\frac{7}{16}$ inch offset box wrench inserted through the gap between the hinge and the wing tip. To remove the center



1. Wing Tip
2. Wing
3. Aileron Push-Pull Tube
4. Typical Hinge
5. Zipper Seal
6. Aileron
7. Aileron Trim Tab Hinge
8. Aileron Trim Tab
9. Push-Pull Tube Fairing
10. Trim Tab Push-Pull Tube

Figure 39 — Aileron and Aileron Trim Tab

hinge bolt, remove the aileron access cover on top of the wing and hold the bolt head while removing the nut through the aileron hinge fairing opening.

Note

Two men are required to remove an aileron properly, and three men are required in the installation procedure.

(c) INSTALLATION.—Reverse the REMOVAL procedure given in paragraph *(b)* above. Install the outboard hinge bolt first, using a mechanical finger to put the bolt in place. Safety-wire the hinge bolts.

Note

The right and left hand ailerons are not interchangeable.

(d) ADJUSTMENTS.

1. Correct aileron travel UP is 20 degrees, ± 1 degree, or $5^{31}/_{32}$ inches, ± $5/16$ inch. Correct aileron travel DOWN is 15 degrees, ± 1 degree, or $4^{15}/_{32}$ inches, ± $5/16$ inch. The measurement is made from the inboard trailing edge of the surface.

2. The degree of aileron movement is regulated by adjusting the stops *(1, figure 58)* which limit the movement of the aileron differential crank. An access door *(17, figure 6)* is provided on the under side of the wing. When the adjustments are made, the aileron differential crank should strike the stops but not with undue pressure. Left and right aileron movement must be symmetrical.

3. Neutral alignment of the ailerons relative to the trailing edge of the wing is obtained as follows:

a. Lock the controls in the neutral position.

b. Open the access doors *(17, figure 6)* on the under side of the wing.

c. Loosen the nuts at each end of the rod *(9, figure 58)* and turn it to the right or left as required

4. As control wheel is turned clockwise left aileron goes down, right aileron goes up.

Note

The stops which limit the movement of the control wheel are not adjustable.

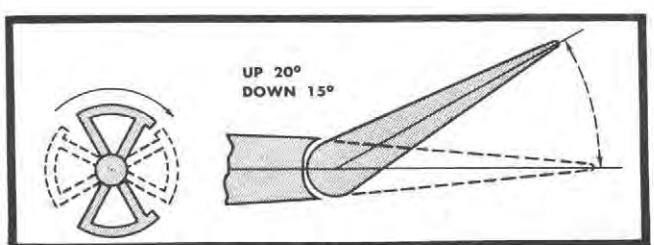


Figure 40 — R. H. Aileron Motion

(3) AILERON TRIM TABS. *(See figure 39.)*

(a) DESCRIPTION.—An all-metal trim tab is built into each aileron at the inboard trailing edge. The tabs operate automatically with the aileron, moving in the opposite direction. In addition, provision is made for the individual control of the left hand trim tab. The aileron tab control mechanisms are described in paragraph 3. *c.* (3), this section.

(b) REMOVAL.

1. Remove the tab push-pull tube fairing, screwed on the upper side of the aileron immediately forward of the tab inboard hinge.

2. Disconnect the push-pull tube at the tab.

3. Remove the hinge pins from the under side of the tab.

4. Disconnect the bolted bonding strip and remove the tab.

(c) MAINTENANCE REPAIR.—For repairs to the structure and skin, refer to the Structural Repair Handbook (No. AN01-40AJ-3).

(d) INSTALLATION.—Reverse the REMOVAL procedure given in paragraph *(b)* above.

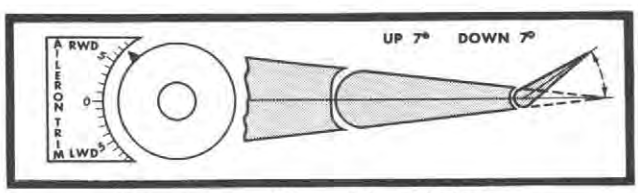


Figure 41 — Aileron Trim Tab Motion

Note

The right and left hand aileron trim tabs are not interchangeable.

(e) ADJUSTMENTS.

1. Correct travel of the left hand aileron trim tab is UP or DOWN 7 degrees ± 1½ degrees or ⅝ inch ± ⅛ inch. The measurement is made at the inboard trailing edge of the surface. The indicator *(22, figure 232)* and the tab must be in phase within ± 1½ degrees. When indicator points to "RWD" (right wing down) the left-hand trim tab is up.

2. The degree of L.H. aileron trim tab movement is regulated as follows:

a. Set the control dial in the pilot's compartment at zero.

b. Remove the fairing *(2, figure 59)* which covers the trim tab push-pull tube assembly in the aileron.

c. Loosen the end fitting on the push-pull tube assembly and remove the bolt which attaches the tab to the tube.

d. Adjust the tube.

3. If the adjustment at the push-pull tube is insufficient, proceed as follows:

a. Remove the landing light in the wing to gain access to the aileron trim tab drum.

b. Screw out the adjusting nut *(12, figure 59)* on the aileron trim tab drum, located in the wing adjacent to the tab.

c. Move the trim tab drum aft until the nut disengages from the drum.

d. Turn the nut to the right or left to obtain proper travel of the tab.

e. With the cables properly rigged and the tab control set at zero, re-engage the adjusting nut so that the drum is free to rotate and has a minimum of side play.

f. For a final adjustment, regulate the aileron tab push-pull tube assembly.

g. To obtain neutral alignment of the left hand aileron trim tab, adjust the cables at the turnbuckles.

h. Neutral alignment of the right aileron automatic trim tab is obtained by removing the fairing which covers the tube assembly, loosening the locknut at the tube end fitting, and turning the fitting to left or right. Travel ratio of the automatic tab is 1 degree for each degree of aileron motion, namely, 20 degrees $\pm$ 1½ degrees, or 1¾ inches, $\pm$ ¼ inch, measured at the inboard end.

(f) TEST AFTER INSTALLATION.—Check the left hand aileron trim tab for proper degree of travel.

(4) ELEVATORS. *(See figure 43.)*

(a) DESCRIPTION.—Each elevator is hinged to the horizontal stabilizer by two brackets fitted with sealed anti-friction bearings. The axis of rotation is located approximately eight inches aft of the leading edge of each elevator. When an elevator is raised or lowered, the surface forward of the hinge line provides aerodynamic balance. The openings between the elevators and horizontal stabilizers are covered with rubberized canvas gap seals. The seals are attached to the horizontal stabilizers with wing studs and grommets, and to the elevators with bolts and nut plates. The elevators are operated by moving the pilot's control column fore or aft of the neutral position. The elevator mechanisms are described in paragraph 3. *c.* (4), this section.

(b) REMOVAL.

1. Remove the tail cone and armor plate as described in paragraph 4. *b.* (2), this section.

2. Disconnect the elevator trim tab control cables by removing the cable drum from the gear box which is located beneath the cover plate at the inboard leading edge of the elevator. The cable drum is removed by detaching the bolt in the large composition gear at the bottom of the box. A small hole is provided in the elevator above the gear box, through which the nut may be held when the bolt is removed. After freeing the drum, tape it to prevent the cables from unwinding and lay it in the fuselage.

3. Disconnect the elevator torque tube by removing the bolts which secure it to the horn inside the fuselage.

4. Remove the gap seal installed along the trailing edge of the stabilizer by turning the wing studs with the fingers.

5. Detach the bond strip at the hinge points.

6. Remove hinge bolts.

7. Lift the elevator away from the fuselage.

(c) MAINTENANCE REPAIR.—For instructions on the repair of the elevator skin and structure, refer to the Structural Repair Handbook (T.O. No. AN01-40AJ-3).

(d) INSTALLATION. — Reverse the removal procedure given in paragraph *(b)* above.

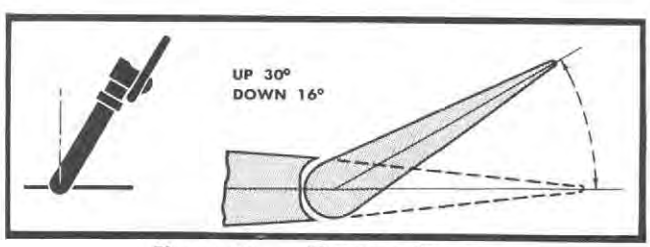


Figure 42 — Elevator Motion

(e) ADJUSTMENTS.

1. Correct elevator movement UP is 30 degrees $\pm$ ½ degree, or 14 inches $\pm$ $^{7}/_{32}$ inches. Elevator movement DOWN is 16 degrees $\pm$ ½ degree, or $7\,^{17}/_{32}$ inches $\pm$ $^{7}/_{32}$ inches. The measurement is made from the inboard trailing edge of the surface. The elevators must align with each other within $\pm$ ¼ degree or $^{1}/_{16}$ inch. When the control column is aft, the elevators are up.

2. Elevator movement is regulated by removing the tail cone, as described in paragraph 4. *b.* (2), this section, and adjusting the four stops *(29, figure 73)* attached to the control support assembly. The stops limit the movement of the elevator horns.

3. Neutral alignment of the elevators is obtained by locking the controls in the neutral position, and adjusting the cable action at the turnbuckles. After making the adjustment, check cable tension *(figure 74)* with a tensiometer. Safety-wire the turnbuckles.

4. Fore and aft movement of the control column *(figure 54)* is adjusted by regulating the two stops *(11, figure 54)* which limit the travel of the elevator horns attached to the control column.

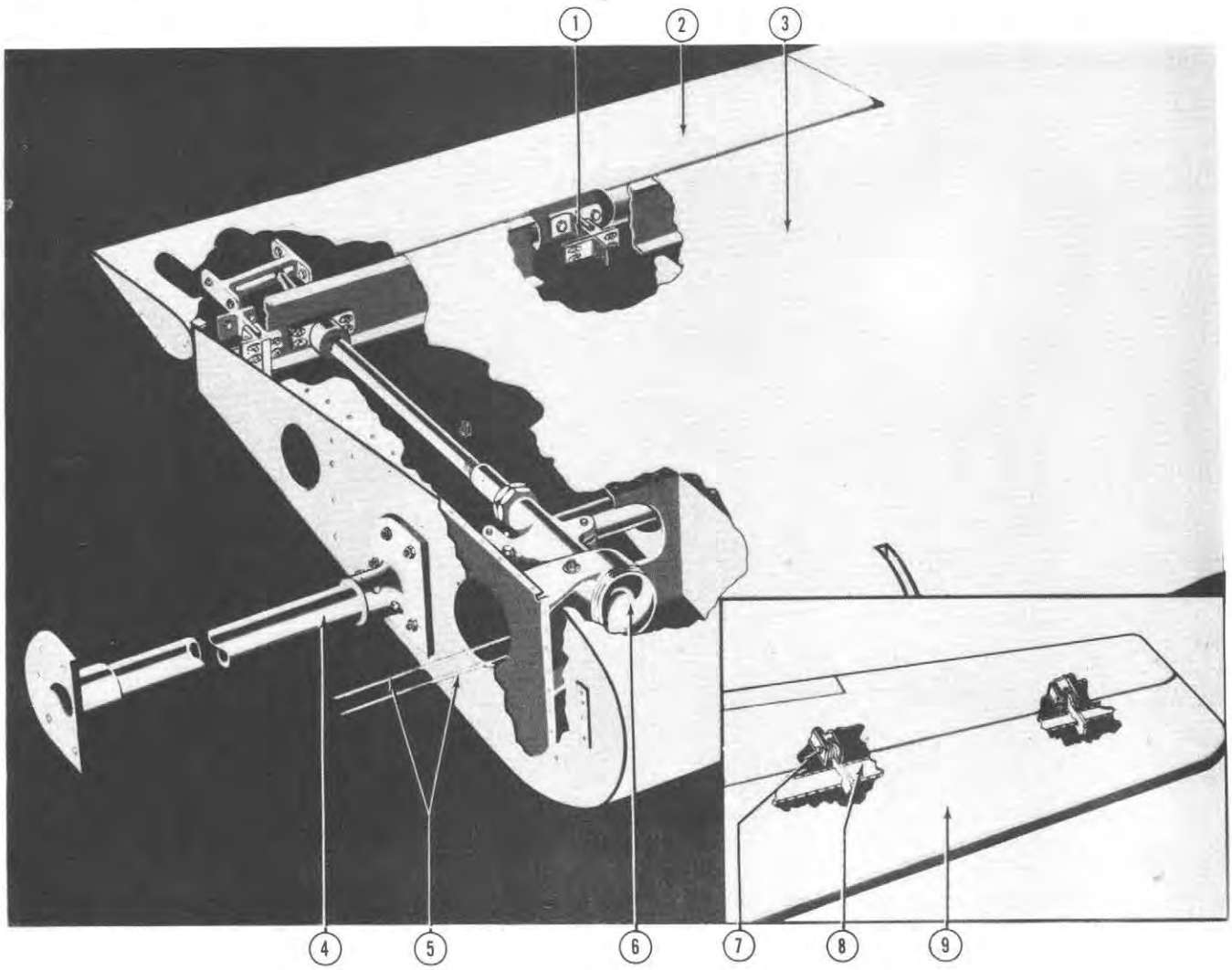
a. When the control column is aft and the elevator horn in the empennage is resting against the top stop, the distance between the forward edge of control column head and the instrument panel should be 18½ inches ± ¼ inch. Clearance between the pilot's compartment elevator horn and the aft stop should be $\frac{5}{16}$ of an inch, ± $\frac{1}{16}$ inch.

b. When the control column is forward and the elevator horn in the empennage rests against the bottom stop, the distance between the forward edge of control column head and the instrument panel should be 3 inches ± ¼ inch. The clearance between the pilot's compartment elevator horn and the forward stop should be $\frac{5}{16}$ inch ± $\frac{1}{16}$ inch.

(f) TEST AFTER INSTALLATION.—Make an operating test of the elevator controls and check for proper movement.

(5) ELEVATOR TRIM TABS. *(See 2, figure 43.)*

(a) DESCRIPTION.—A trim tab is installed on



1. Elevator Trim Tab Hinge
2. Elevator Trim Tab
3. Elevator
4. Torque Tube
5. Trim Tab Control Cables
6. Trim Tab Gear Box
7. Elevator Hinge
8. Elevator Seal
9. Horizontal Stabilizer

Figure 43 — Elevator

the inboard trailing edge of each elevator to provide for the longitudinal trim of the airplane. The elevator trim tabs are raised or lowered simultaneously by revolving a wheel *(figure 61)* located on the forward left hand side of the control pedestal. The elevator trim tab mechanisms *(figures 61 & 64)* are described in paragraph 3. *c.* (5) this section.

(b) REMOVAL.–Remove the three hinge bolts and pull the tab horizontally away from the elevator until it is clear of the tab actuating torque tube. Be careful not to lose the needle bearing installed in the tab slot.

(c) MAINTENANCE REPAIR.–For instructions on the repair of the elevator trim tab structure, refer to Structural Repair Handbook (No. AN01-40AJ-3).

(d) INSTALLATION. – Reverse the removal procedure given in paragraph *(b)* above. Be sure that the actuating torque tube is inserted in the bearing in the tab slot.

Note

The right and left hand elevator tabs are interchangeable.

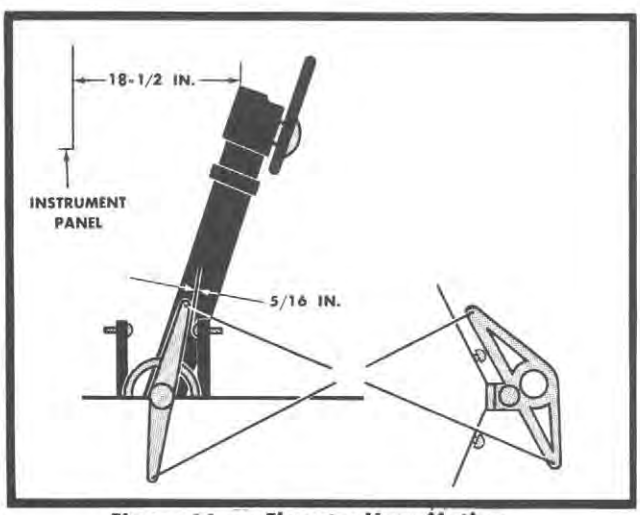


Figure 44 — Elevator Horn Motion

(e) ADJUSTMENTS.

1. Elevator tab movement UP is 12 degrees ± 2 degrees, or 1⅜ inches ± ¼ inch. Elevator tab movement DOWN is 17 degrees ± 2 degrees or $1^{31}/_{32}$ inches ± ¼ inch. The measurement is made from the outboard trailing edge of the surface. Indicator and tab must be in phase within ± 1½ degrees. Tabs must align with elevator ± 1 degree or ± $1/16$ inch when dial is set at zero. The tabs must be in line with each other ± ½ degree at all positions. When tab indicator indicates "NOSE DOWN," tabs are up.

2. Travel of the elevator trim tabs is adjusted at the gear boxes in the elevators. (The stops on the control in the pilot's compartment are not adjustable.) When either tab is to be adjusted, place elevators in the neutral position. Loosen the nut on the larger of the two gears *(7, figure 64)* on the side of the gear box, and slip the larger gear out of mesh with the smaller gear *(See 6, figure 64)*. Set the trim tab control in the pilot's compartment to neutral. With the fingers, rotate the smaller gear on the tab gear box in the elevator until the tab is in neutral. Then remesh the larger gear with the smaller gear. Check both elevator tabs for correct travel by operating the tab control in the pilot's compartment. Check cables for proper tension.

Note

When the elevator trim tab control in the pilot's compartment is set at neutral, the drum in the pedestal (visible from the nose wheel well) should be wound as shown in *figure 62*. If the turns on each side of the drum are not equal, the trim tab cable is not properly rigged.

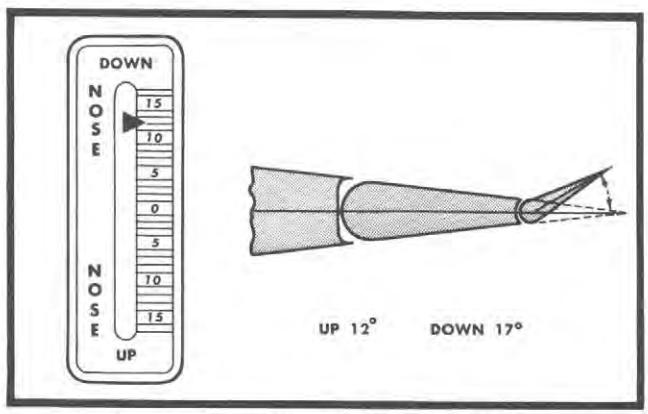


Figure 45 — Elevator Trim Tab Motion

(f) TEST AFTER INSTALLATION.–Operate the elevator trim tabs and check them for neutral alignment and proper travel.

(6) RUDDER. *(See figure 47.)*

(a) DESCRIPTION.–The rudder is hinged to the vertical stabilizer at two points and the opening between the two surfaces is covered with a rubberized canvas gap seal *(5, figure 47)*. The seal is attached to the vertical stabilizer with wing studs and grommets, and to the rudder with bolts and nuts. The rudder is operated by means of pedals *(figure 65)* installed in the pilot's compartment. The pedals are adjustable, fore or aft, over a range of four inches to accommodate pilots of varying stature. The rudder actuating mechanisms are described in paragraph 3. *c.* (6), this section.

(b) REMOVAL.

1. Remove the tail cone *(1, figure 81)* and the armor plate as described in paragraph 4. *b.* (2), this section.

2. Disconnect the rudder tab control cables by removing the cable drum from the gear box *(figure 66)* which is located beneath a cover plate on the lower right hand side of the rudder near the leading edge. The cable drum is removed by detaching the bolt *(7, figure 64)* in the large composition gear at the bottom of the box. A small hole is provided in the rudder directly above the gear box, through which the nut may be held when the bolt is removed.

3. Disconnect the rudder torque tube *(figure 46)* by removing the bolts which secure it to the horn *(32, figure 73)* within the fuselage.

4. Remove the rudder gap seal from the stabilizer by turning the wing studs with the fingers.

5. Detach the bonding strips at the hinge points.

6. Remove the two hinge bolts and lift the rudder until the torque tube clears the fuselage.

(c) MAINTENANCE REPAIR.—For instructions on the repair of the rudder structure and skin, refer to the Structural Repair Handbook (No. AN01-40AJ-3).

(d) INSTALLATION. – Reverse the removal procedure given in paragraph *(b)* above.

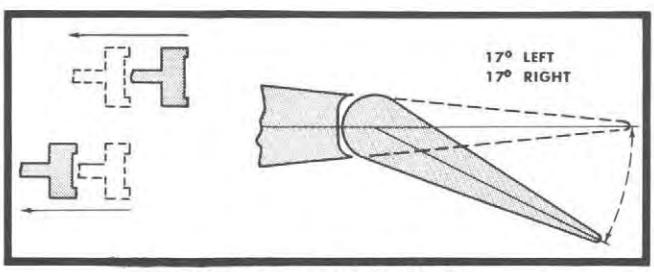


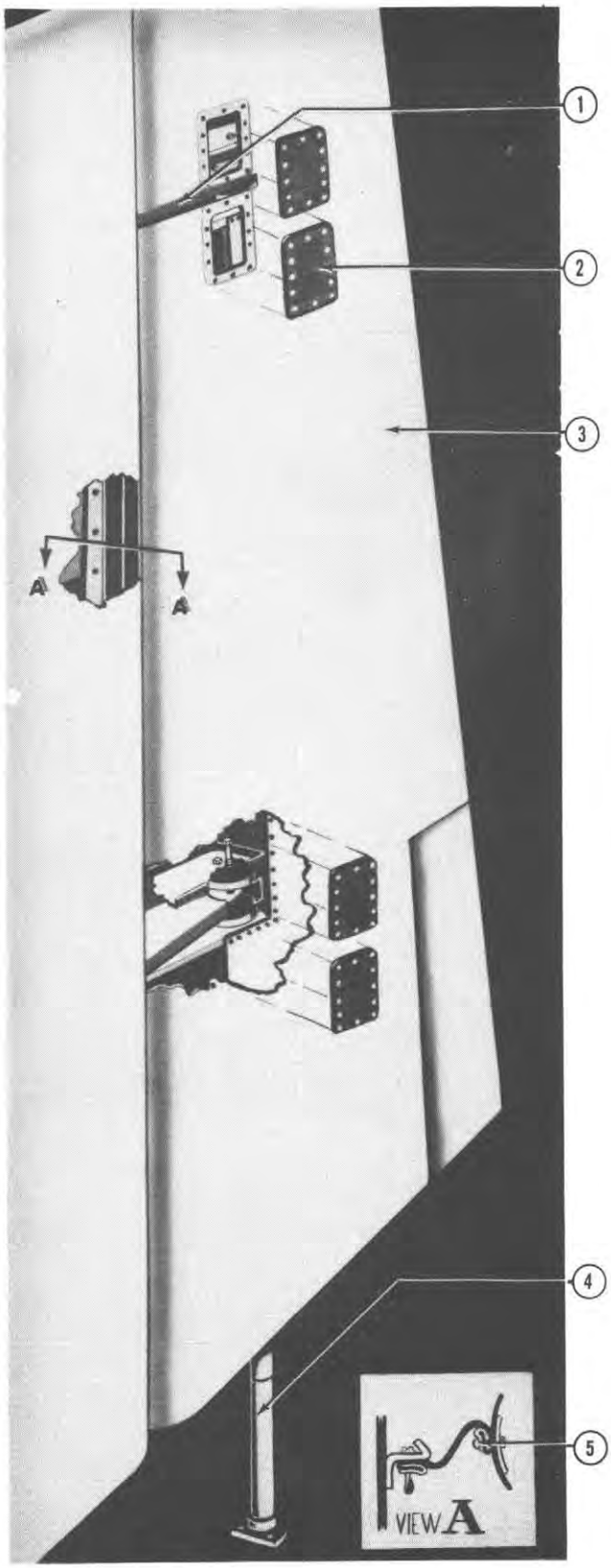
Figure 46 — Rudder Motion

(e) **ADJUSTMENTS.**

1. Correct movement of the rudder to the LEFT or RIGHT is 17 degrees ± ½ degree, or $11\frac{9}{32}$ inches ± $\frac{7}{32}$ inch. The measurement is made at the bottom inboard edge. When the left rudder pedal is depressed, rudder moves to the left.

2. Movement of the rudder pedals is limited by adjusting the two stops *(10, figure 65)* attached to the pedal torque tube support. A clearance of $\frac{5}{16}$ of an inch between the torque tube arm *(14, figure 65)* and the pedal stop is required when the horn at the aft support assembly is in contact with the stop at that location.

3. Neutral alignment of the rudder pedals, relative to each other, is obtained by regulating the two adjustable rods *(3, figure 65)* which connect the pedals with the torque tube assembly.



1. Rudder Hinge (2 places)
2. Hinge Access Doors
3. Rudder Assembly
4. Torque Tube
5. Rudder Seal

Figure 47 — Rudder Attachment

4. The rudder is adjusted for movement and neutral alignment as follows:

a. Lock the controls in the neutral position.

b. Adjust the action of the rudder at the turnbuckles *(figure 71)* until the proper movement and alignment is obtained.

c. Check the cables for proper tension. *(See figure 74.)*

d. Safety the turnbuckles with wire.

(f) TEST AFTER INSTALLATION.—Make an operating test of the rudder controls and check the rudder surface for proper alignment and movement.

(7) RUDDER TRIM TAB. *(See figure 66.)*

(a) DESCRIPTION.—The rudder trim tab is installed in the bottom trailing edge of the rudder. The tab is hinged to the rudder at three points. The tab is operated by revolving a dial installed on the control pedestal. The mechanism which actuates the tab is described in paragraph 3. *c.* (7) this section.

(b) REMOVAL.—Remove the three hinge bolts and lift the tab aft and away from the rudder until it clears the trim tab torque tube.

(c) MAINTENANCE REPAIR.—For instructions on the repair of the skin and structure of the rudder trim tab, refer to the Structural Repair Handbook (No. AN01-40AJ-3).

(d) INSTALLATION. — Reverse the removal procedure given above, making certain that the trim tab torque tube is properly inserted in the bearing located in the tab slot.

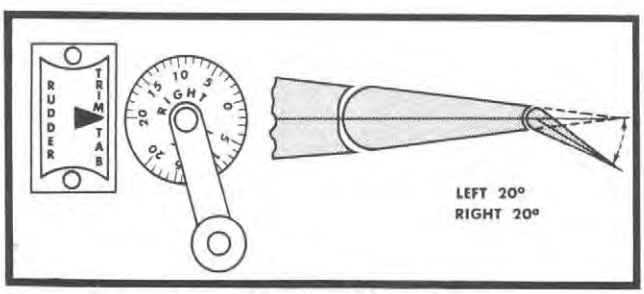


Figure 48 — Rudder Trim Tab Motion

(e) ADJUSTMENTS.

1. The correct movement of the rudder trim tab to the LEFT or RIGHT is 20 degrees ± 2 degrees, or 3¼ inches ± $^{11}/_{32}$ inch. The measurement is made at the bottom aft edge of the tab. Indicator and tab must be in phase within ± 1½ degrees. When the rudder tab indicator indicates "RIGHT" the tab has moved to the left. Tab must align with rudder ± ½ degree or ± $^{1}/_{16}$ inch.

Rudder tab movement must be adjusted at the tab gear box in the rudder. Place rudder in neutral. Loosen the nut on the larger of the two gears *(7, figure 64)* located on the gear box, and slip the larger gear out of mesh with the smaller gear. *(See 6, figure 64).* Set the trim tab control in the pilot's compartment to neutral. With the fingers, rotate the smaller gear on the tab gear box in the rudder until the tab is in neutral. Then remesh the larger gear with the smaller gear. Check tab for correct travel by operating the trim tab control in the pilot's compartment. Check cables for correct tension.

Note

When the rudder trim tab control in the pilot's compartment is set at neutral, the drum in the pedestal (visible from the nose wheel well) should be wound as shown in *figure 67*. If the turns on each side of the drum are not equal, the drum is not properly wound.

e. Safety-wire the turnbuckles.

(8) WING FLAPS. *(See figure 50.)*

(a) DESCRIPTION.—Two flaps are installed on each wing panel, one inboard of the nacelle and the other outboard of the nacelle. Attached to each flap is an air flow deflector which moves automatically with the flap. Each inboard flap and deflector is attached to the wing by two hinge assemblies. Each outboard flap and deflector is attached to the wing by three hinge assemblies.

The flaps and deflectors are electrically operated by the control lever *(figure 49)* which is installed on the control pedestal. LANDING position of the flaps is down 52 degrees ± 2 degrees.

For take-off the wing flaps may be operated to any desired downward position by moving the electric control lever to the "DOWN" position and holding it there until the desired degree of travel is ob-

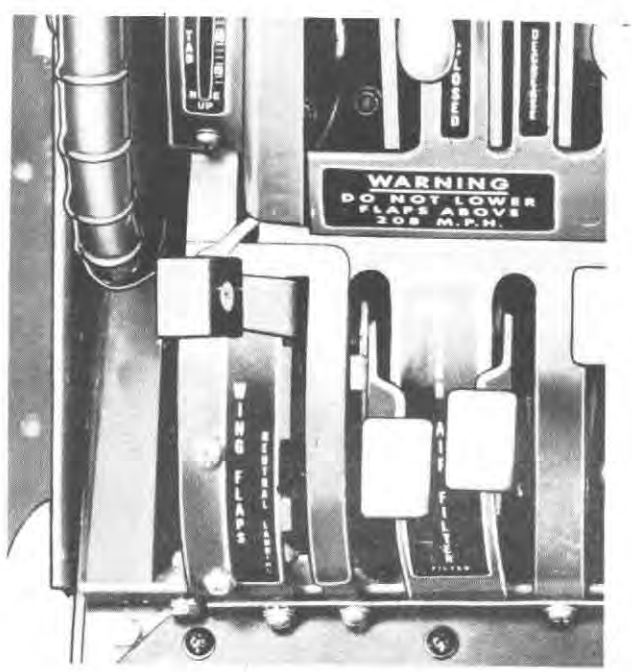


Figure 49—Wing Flap Control Lever

tained. At this point the control lever must be moved to the "NEUTRAL" slot. The wing flap mechanisms are described in paragraph 3. *c. (11)*, this section.

(b) REMOVAL.

1. INBOARD FLAPS.

a. Operate the flap to the 52 degrees down (landing) position. At least two men are required for the removal procedure. Adequate support must be provided so that hinge assemblies will not be damaged.

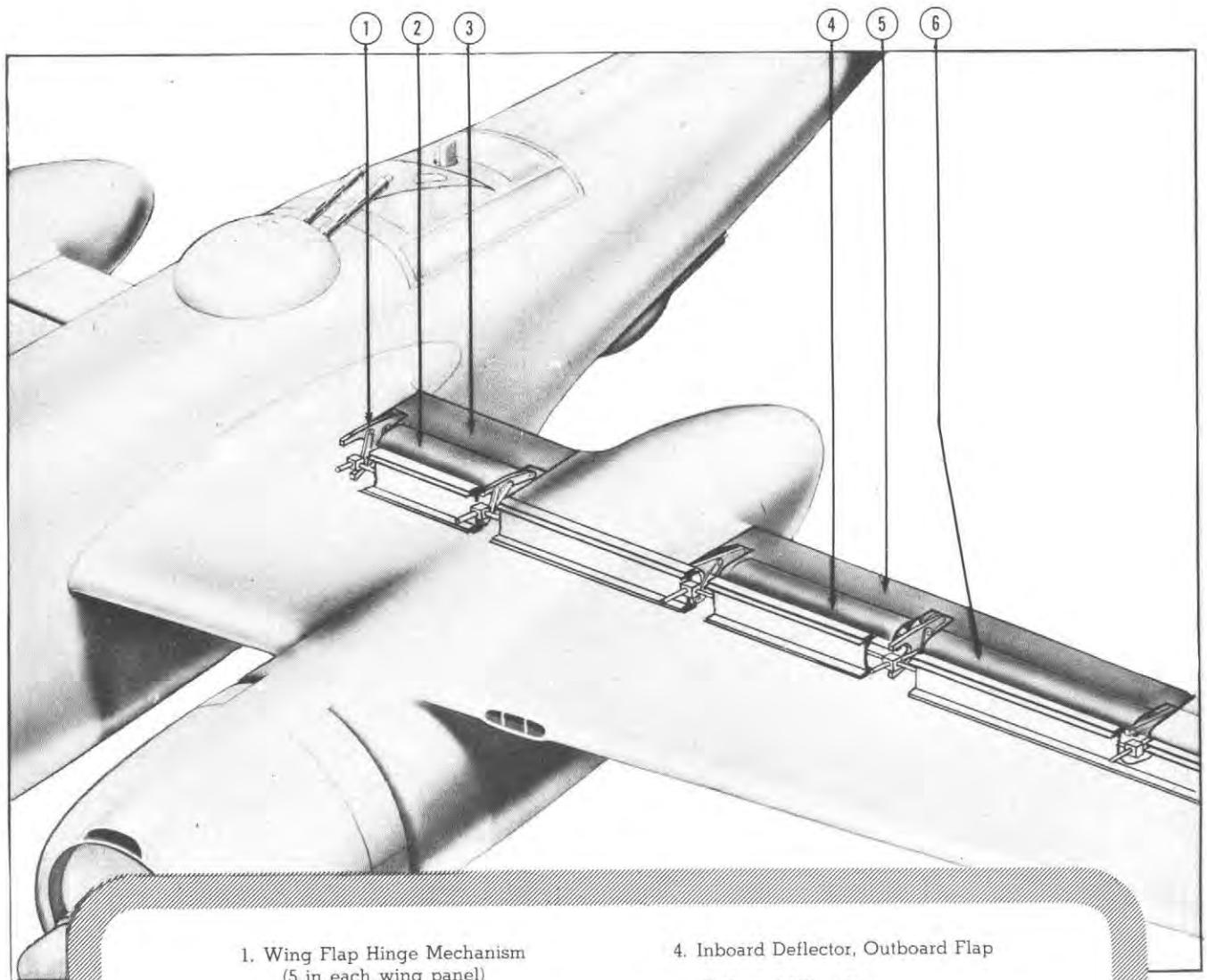
b. Disconnect the bolts from the top of the adjustment rods *(10, figure 51)* in each hinge assembly, relieving the pressure on the actuating screws *(3, figure 51.)*

c. Disconnect the actuating screw from the linkage in each hinge assembly by removing the bolt from the bearing or fork on each actuating screw.

d. Measure the extension of each actuating screw from the shoulder of the gear box to the center line of the bearing or fork and make a notation of the distance so that the actuating screws can be restored to the same positions when the flap is re-installed.

e. Turn the actuating screws into the gear boxes *(figure 78)* so that they will not be subject to damage.

f. Detach the links *(2 & 9, figure 51)* from the supports on each end of the flap by removing the



1. Wing Flap Hinge Mechanism (5 in each wing panel)
2. Inboard Wing Flap Deflector
3. Inboard Wing Flap
4. Inboard Deflector, Outboard Flap
5. Outboard Wing Flap
6. Outboard Deflector, Outboard Flap

Figure 50 — Wing Flaps and Deflectors

bolts. Provide adequate support for the flap so that the hinge assemblies will not be damaged.

g. Remove the flap and attached deflector.

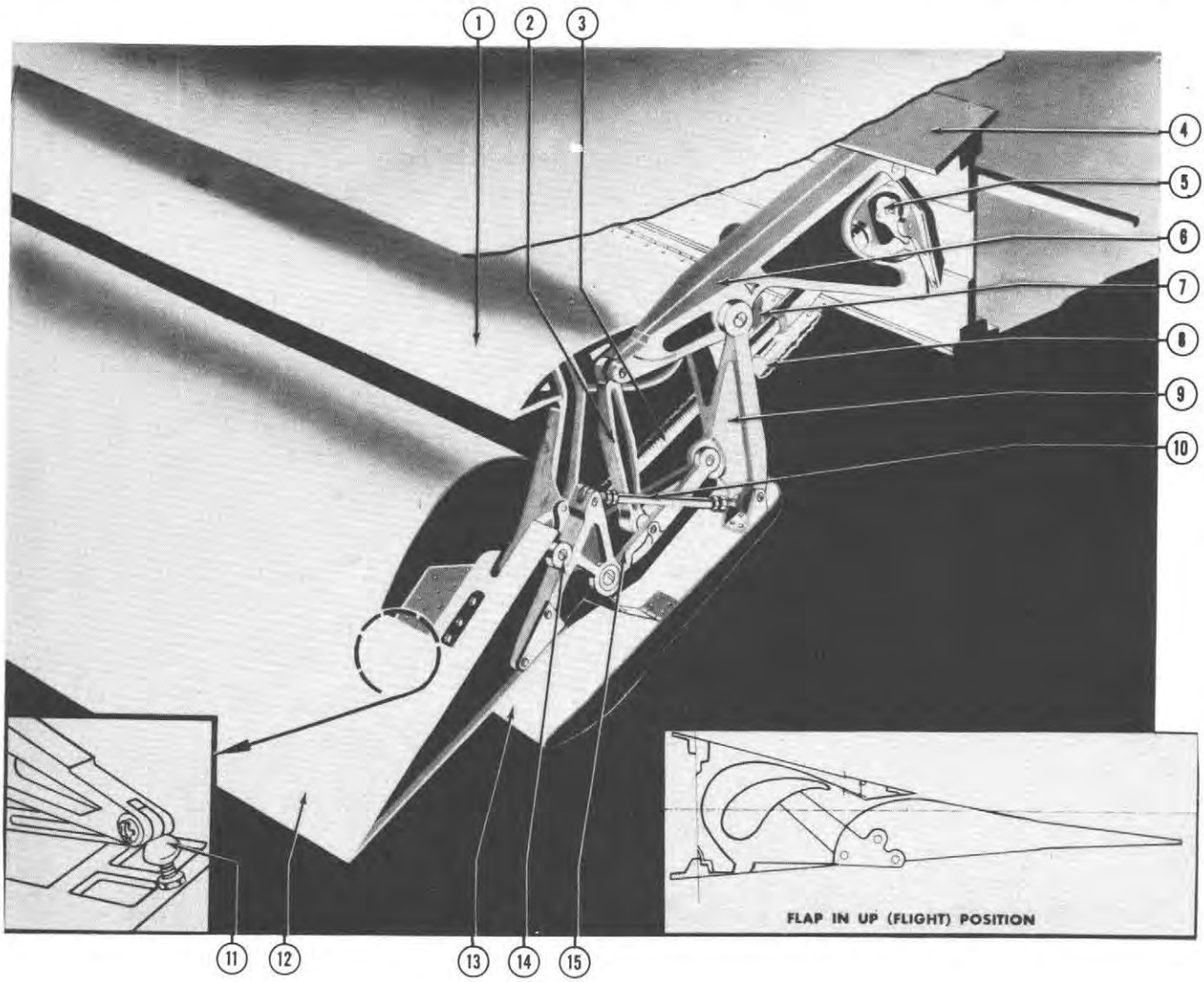
2. OUTBOARD FLAPS.

a. Operate the flap to the 52 degrees down (landing) position. At least two men are required to remove the flap. Adequate support must be provided so that hinge assemblies will not be damaged.

b. Disconnect the bolts from the top of the adjustment rods *(13, figure 53)* on each of the three hinge assemblies, relieving the pressure on the actuating screws. The forward bolts should be removed first.

c. Disconnect the actuating screw *(7, figure 53)* from the linkage in each hinge assembly by removing the long bolt from the bearing.

d. Measure the extension of the actuating screw from the gear box. Make a notation of the distance so that the actuating screws can be extended to the same position when the flaps are re-installed. Use



1. Wing Flap Deflector
2. Link Assembly
3. Flap Actuating Screw
4. Rear Wing Spar
5. Gear Box
6. Hinge Support
7. Flap Door Push Rod
8. Wing Flap Door
9. Link
10. Rotating Rod
11. Adjustable Stop for UP Position
12. Wing Flap
13. Cover
14. Rotating Rod Stationary Hinge
15. Hinge

Figure 51 — Typical Wing Flap End Hinge Assembly

the shoulder of the gear box and the center line of the bearing as measuring points. Make the measurement as precise as possible. Each thread length represents approximately one half of one degree of travel in the flaps.

e. Turn the actuating screws into the gear boxes *(figure 78)* so that they will not be damaged.

f. Beginning at the center hinge, detach the link assemblies *(8 & 12, figure 53)* from the supports at each hinge by removing the two bolts. Support the flap in the landing position until all of the bolts have been removed.

g. Remove the flap and attached deflector.

(c) DISASSEMBLY.—To remove the deflector from either the inboard or outboard flap remove the three bolts from each hinge point.

(d) MAINTENANCE REPAIR OR REPLACEMENT.—Damaged or worn bolts, links and bearings in the wing flap hinge assemblies shall be replaced. Structural repairs shall be made in accordance with the instructions given in the Structural Repair Handbook (No. AN01-40AJ-3).

(e) ADJUSTMENTS.

1. VERTICAL ALIGNMENT. – To raise either end of the flap, relative to the trailing edge of the wing, turn the adjustment rod to the left. To lower the flap, turn the adjustment rod to the right.

2. HORIZONTAL ALIGNMENT.—To move either end of the flap aft from the wing, remove the bolt which attaches the actuating screw to the linkage and revolve the screw to the left; to move the flap forward, turn the screw to the right.

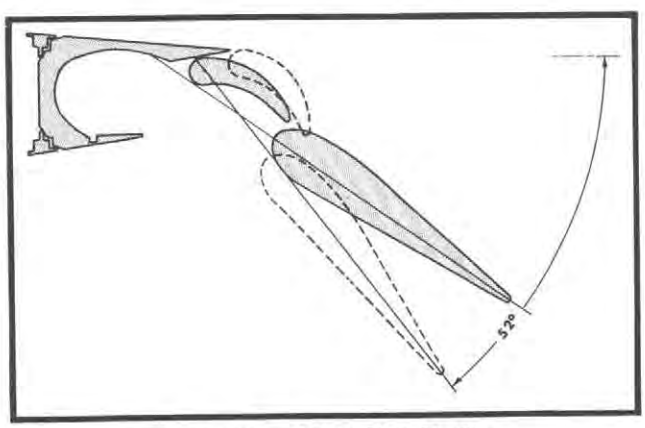


Figure 52 — Wing Flap Motion

3. CORRECT MOVEMENT.—Movement of the wing flaps when they are operated electrically is limited by two limit switches *(7, figure 76)* installed in the main gear box. The switches are operated by two cams mounted on a splined shaft in the gear box. When a cam depresses one of the limit switch box levers, the circuit to the flap motor is opened, halting the flaps at the desired position. The cams are labeled in the illustration as A and C. Cam A (the inboard cam) stops the lowering flaps in the LANDING position. Cam C stops the rising flaps in the UP or retracted position.

Movement of the wing flaps either up or down can be changed five degrees by turning the adjustment screws installed on the limit switches above the cams. If the flaps move too far either UP or DOWN, turn the proper adjustment screw up or counterclockwise; if the flaps do not attain required position, turn the adjustment screw down, or in a clockwise direction. Measurements of the degree of wing flap movement should be made by attaching a free swinging protractor to the trailing edge of the surface. DOWN position of the flaps is 52 degrees, ± two degrees.

WARNING

Check the wing flaps for proper travel both up and down after making an adjustment of the limit switches.

4. ALIGNMENT OF INDIVIDUAL FLAP.—If an individual flap fails to move to its proper position in respect to the other flaps, make the following adjustment:

a. Operate the flaps to the UP position.

b. Disconnect the flap from the torque tube at the disconnects located in the wing adjacent to each flap. *(See figure 78.)*

c. Rotate the shaft on the affected flap by hand until it has been returned to the proper position.

d. Reconnect the torque tube.

5. FORWARD MOVEMENT OF FLAPS.—The forward and upward movement of the flaps into the wing is limited to the proper fairing position by means of two adjustable stops *(3, figure 53)* installed on each flap.

Note

For instructions on the adjustment of the wing flap position transmitter *(figure 76)* mounted on the main gear box, refer to paragraph 15. *b.* (12) *(i)*, this section.

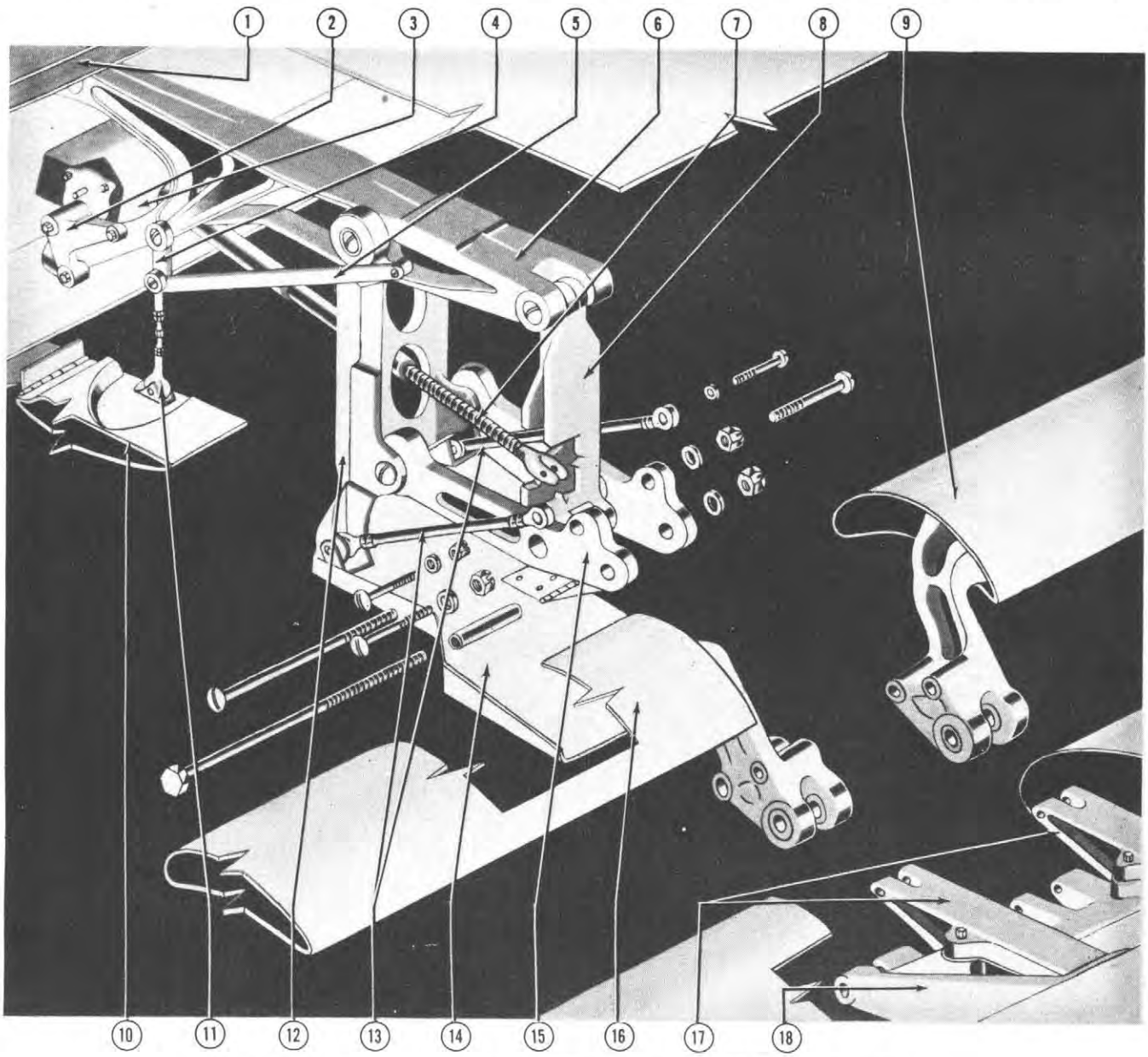
(f) INSTALLATION. – To install the wing flaps, reverse the REMOVAL procedure given above. Provide adequate support for the flaps to avoid damaging the hinge assemblies. Extend the gear box actuating screws to the point noted at time of removal. If

this measurement is lacking, extend the screws to the approximate landing position. After the flaps have been installed, operate them to the UP position and if necessary, synchronize them by disconnecting the torque tubes and rotating the gear boxes by hand until the proper adjustment is obtained.

(g) TEST AFTER INSTALLATION. – Check the flaps for proper movement with a free swinging protractor. Make certain that the landing gear and flap position indicator gives the correct indication of flap position.

c. SURFACE CONTROLS.

(1) GENERAL. – Controls for the ailerons, elevators, rudder, trim tabs and wing flaps are provided in the pilot's compartment. The ailerons and elevators are operated manually by means of a conventional type



1. Rear Wing Spar
2. Wing Flap Gear Box Support
3. Wing Flap Gear Box
4. Flap Door Up Link
5. Flap Door Aft Link
6. Hinge Support Fitting
7. Flap Actuating Screw
8. Flap Aft Link
9. Deflector
10. Flap Door
11. Flap Door Push Rod
12. Forward Link
13. Flap Rotating Rod
14. Flap Mechanism Cover
15. Flap Moving Hinge
16. Deflector
17. Flap Rotating Rod Hinge
18. Wing Flap Hinge

Figure 53 — Center Hinge Mechanism Outboard Wing Flaps

control column and wheel. The rudder is operated manually by means of pedals. The aileron trim tabs operate automatically with the aileron to ease the pressure on the control wheel. In addition, the left hand aileron trim tab can be adjusted separately for lateral trim of the airplane by turning a knob connected to a cable drum assembly in the control pedestal. The elevator and rudder trim tabs are operated similarly from the control pedestal. The wing flaps are operated electrically and are controlled by a lever installed on the control pedestal. Flexible carbon steel cables with swaged fittings and anti-friction bearing pulleys are used throughout the system. Doors *(figures 6, 7, 8, & 9)* installed in the wing panels, fuselage and empennage, provide access to the actuating mechanism.

(2) AILERON CONTROLS. *(See figure 69.)*

(a) GENERAL. – Aileron movement is controlled by rotation of the control wheel *(figure 54)* which is connected to a pulley shaft and cable assembly *(3, figure 54)* in the head of the control column. From the control column, cables run to the aft section of the pilot's compartment where they wind around a drum mounted on a torque tube *(14, figure 54))*. Cables wound around a second drum on the tube are directed outboard into each wing panel where they are connected to a differential crank assembly *(figure 58)*. Movement of the crank assembly actuates a push-pull tube *(9, figure 58)* which raises or lowers the aileron. Aileron movement is limited by adjustable stops *(1, figure 58)* attached to the wing structure adjacent to the differential crank. The stops which limit the movement of the pilot's control wheel are not adjustable. Access to the aileron mechanism is obtained through doors *(figures 6 and 7)* installed in the wing.

Note

The adjustment of the angular movement of the ailerons, and their position in relation to the wing surfaces is described in paragraph *3., b.,* (2), *(d)*, this section.

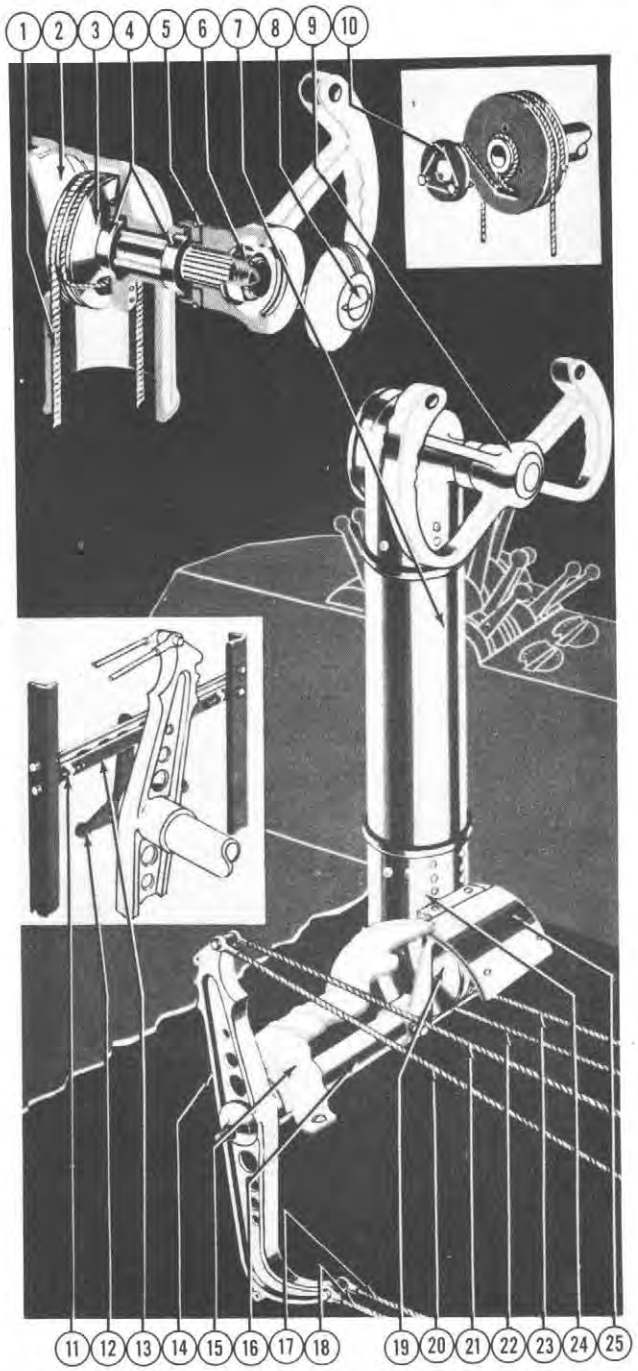
(b) CONTROL WHEEL ASSEMBLY. *(See figure 54).*

1. DESCRIPTION. – The control wheel assembly is mounted on the pilot's control column. The wheel is turned to the left or right to actuate the ailerons.

2. REMOVAL.

a. Remove spring cap *(8, figure 54)* from the control wheel, and detach the nut *(6, figure 54)* from the shaft.

b. Remove cover *(2, figure 54)* from rear of control column head, and detach electrical disconnect plugs.



1. Cable
2. Cover
3. Pulley Shaft Assembly
4. Bearings
5. Cap and Lock Ring
6. Nut and Lock Ring
7. Post Assembly
8. Cap
9. Control Wheel
10. Ring
11. Adjustable Stop
12. Support
13. Stop Support
14. Horn
15. Cover
16. Tube
17. Left Elevator Up Cable
18. Right Elevator Up Cable
19. Pulley
20. Left Elevator Down Cable
21. Right Elevator Down Cable
22. Left Aileron Down Cable
23. Right Aileron Down Cable
24. Pivot Housing
25. Cover

Figure 54 — Pilot's Control Column

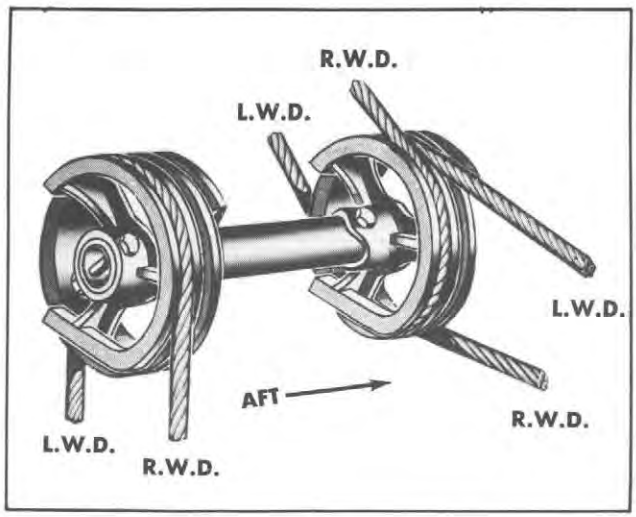


Figure 55 — Aileron Torque Drums Rigging

c. Lift off the control wheel.

d. Tape cables at pulley shaft drum *(3, figure 54)* in control column head and at forward drum *(figure 57)* in torque tube assembly located in aft part of pilot's compartment.

e. Disconnect cable ends at the turnbuckles *(figure 69)*, removing pulleys and fairleads where necessary.

f. Slide the pulley shaft and cable assembly out of column head through the opening in the back.

3. MAINTENANCE REPAIR OR REPLACEMENT. – Replace worn or damaged parts. Check the cable ends for security.

Note

A special wrench designed for removal of the control column head bearing retaining cap is supplied in the miscellaneous tool roll.

4. INSTALLATION. – Reverse the REMOVAL procedure above. Wrap cables onto drum in control column head as shown in *(figure 56)*.

5. ADJUSTMENTS.–To obtain proper cable tension, refer to Cable Rigging Chart *(figure 74)*.

6. TEST AFTER INSTALLATION.–Rotate the control wheel the maximum distance left and right and check the ailerons for proper degree of travel.

(c) AILERON TORQUE TUBE AND DRUMS ASSEMBLY. *(See figure 57.)*

1. DESCRIPTION. – The assembly, consisting of a tube and two drums, provides a means for simultaneous operation of both ailerons. The assembly is located in the aft part of the pilot's compartment.

2. REMOVAL.

a. Remove the radio shelf and equipment located back of the pilot's seat.

b. Tape the cables at the drums to prevent the cables from unwinding. *(See figure 56.)*

c. Disconnect the cables at the turnbuckles *(figure 69)*. Remove the fairleads and pulley wheels or guard pins where necessary.

d. Remove the nut from the forward end of the torque tube and the bolts from the bushing plate at the same end.

e. Slide complete assembly forward to allow the aft end of the assembly to clear the pulley guard and mount at the aft end.

f. Lift out the assembly, being careful not to damage surrounding lines and wires.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. Replace drums if cracked or worn.

b. Check cable ends for security.

4. INSTALLATION.–Reverse the REMOVAL procedure given above. Wrap drums as shown in *figure 55*.

(d) AILERON DIFFERENTIAL CRANK ASSEMBLY. *(See figure 58.)*

1. DESCRIPTION. – An aileron differential bell crank assembly consisting of a horn and an arm assembly, is installed in each wing panel. The bell crank assembly actuates a push-pull tube assembly attached to each aileron.

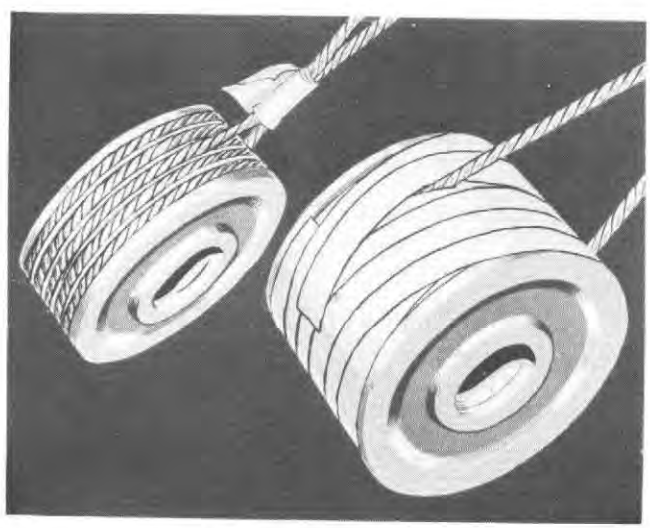
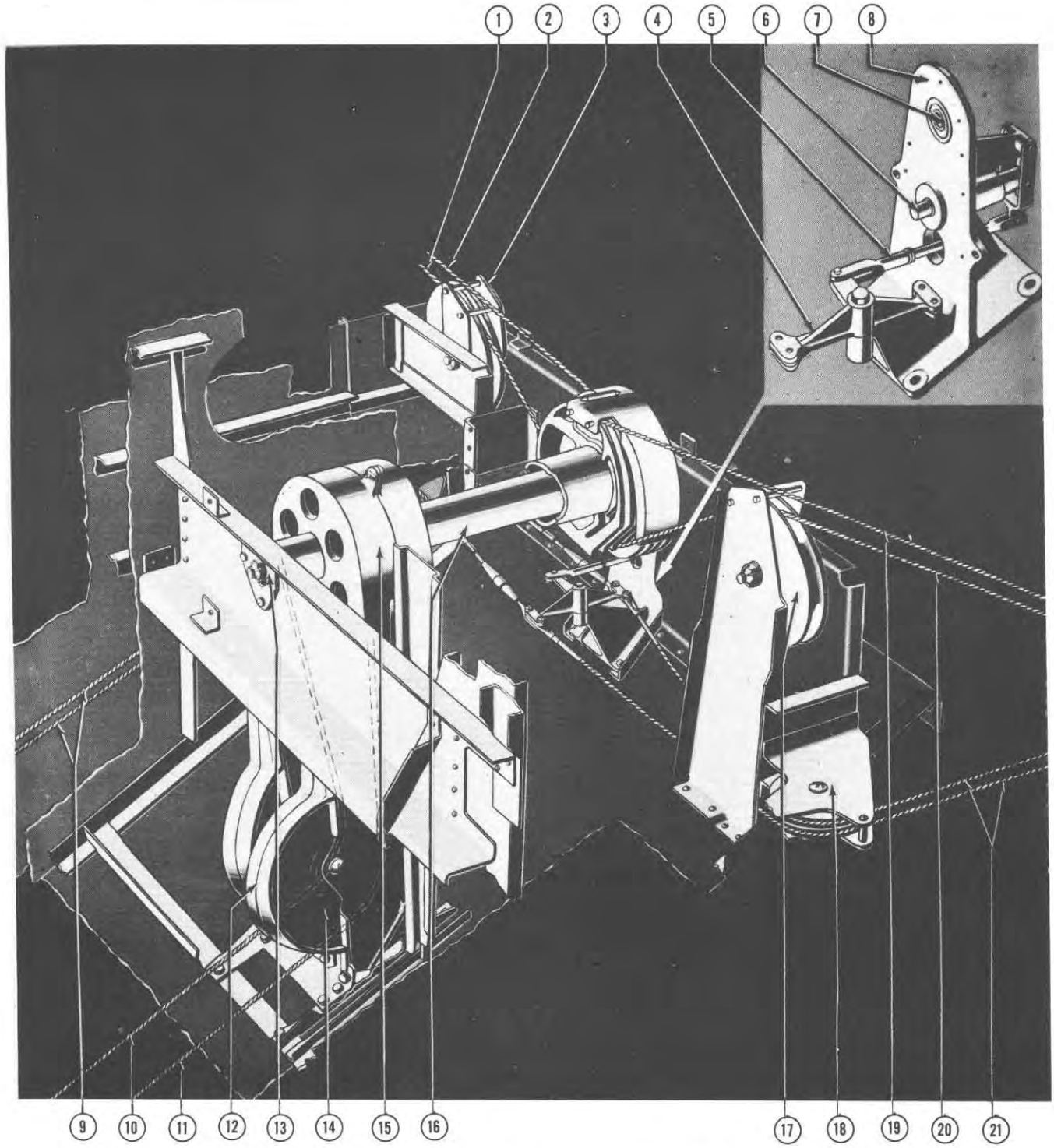


Figure 56 — Drum Taping Methods



1. Right Aileron Up Cable
2. Right Aileron Down Cable
3. Pulley
4. Bell Crank
5. Control Rod
6. Lock Pin
7. Torque Tube Bearing
8. Support
9. Control Lock Cables
10. Right Aileron Down Cable
11. Left Aileron Down Cable
12. Guard
13. Housing
14. Pulley
15. Guard
16. Torque Tube
17. Pulley
18. Guard
19. Left Aileron Up Cable
20. Left Aileron Down Cable
21. Control Lock Cables

Figure 57 — Aileron Torque Tube and Control Lock

2. REMOVAL.

a. Loosen the cable tension at turnbuckles.

b. Remove the bolts *(6, figure 58)* attaching the cables to the ends of the crank assembly.

c. Remove the crank assembly attaching nut, and the push-pull tube attaching bolt.

d. Remove the crank assembly through the access door *(17, figure 6)*.

3. MAINTENANCE REPAIR OR REPLACEMENT.

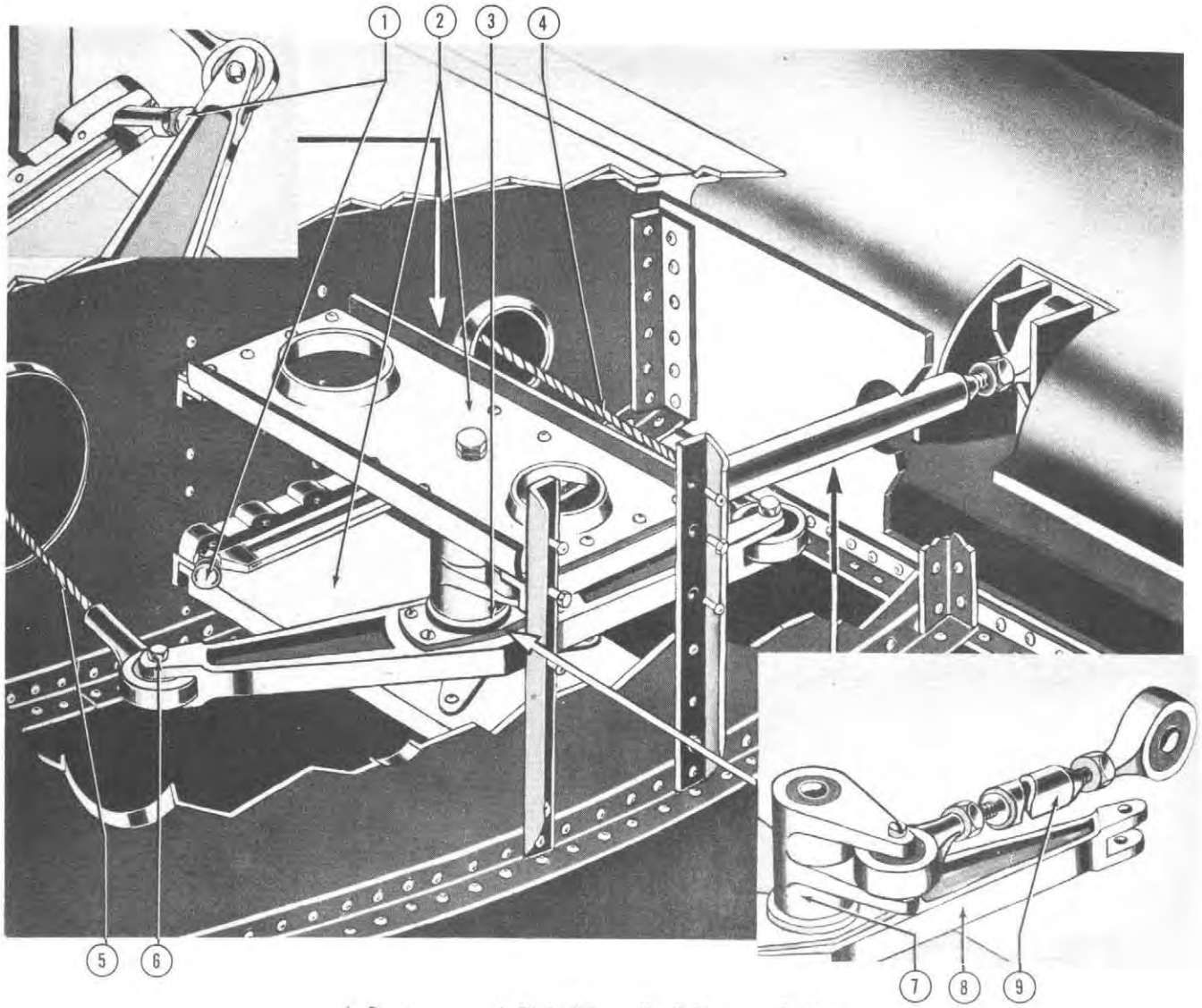
a. Replace the differential crank assembly if worn or cracked.

b. Replace the horn pivot stud if cracked or worn.

c. Check differential crank brackets for security and condition. Replace damaged brackets.

4. INSTALLATION.—Reverse the REMOVAL procedure above.

5. ADJUSTMENTS.—The stops *(1, figure 58)* which limit the movement of the aileron differential



1. Stop
2. Support
3. Bell Crank
4. Right Aileron Up Cable
5. Right Aileron Down Cable
6. Cable Attachment Bolt
7. Arm
8. Horn
9. Tube

Figure 58 — Aileron Differential Mechanism

crank are used to regulate the movement of the ailerons. For instructions on adjustment of aileron travel refer to paragraph 3. *b.* (2) *(d)*, this section.

6. TEST AFTER INSTALLATION. – Check the cables for proper tension and check differential crank for proper movement.

(e) AILERON PUSH-PULL TUBE ASSEMBLY. *(See 9, figure 58.)*

1. DESCRIPTION. – An aileron push-pull tube assembly is installed in each wing panel to transmit motion from the aileron differential crank assembly to the ailerons.

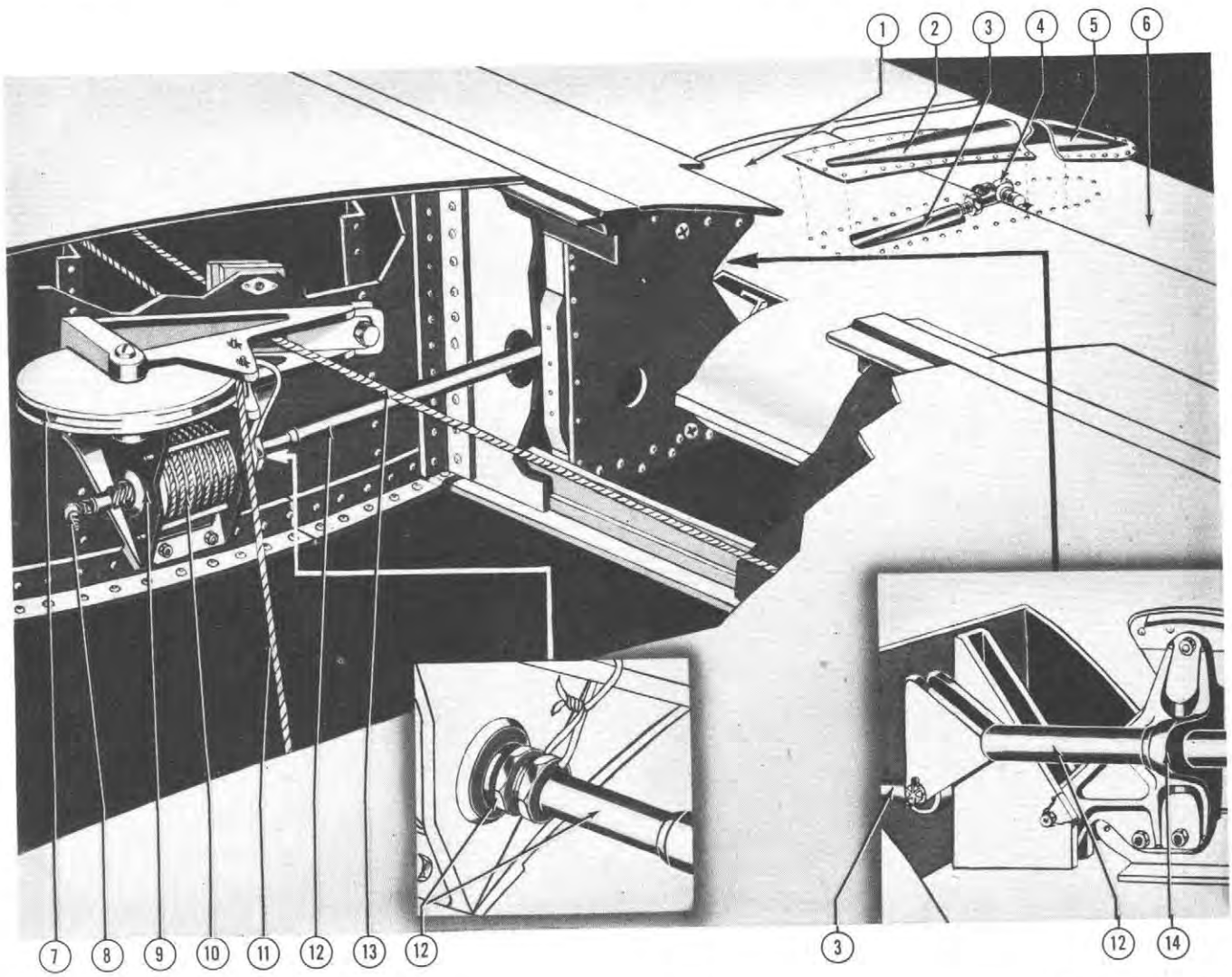
2. REMOVAL.

a. Remove the bolt which attaches the push-pull tube assembly to the aileron.

b. Remove the bolt which attaches the push-pull tube assembly to the differential crank assembly.

c. Remove the push-pull tube assembly through access door *(17, figure 6)*.

3. MAINTENANCE REPAIR OR REPLACEMENT.–If the threads on the push-pull tube are damaged, replace the rod.



1. L. H. Aileron
2. Actuating Tube Fairing
3. Tab Actuating Tube Aft
4. End Assembly
5. Fairing
6. L. H. Aileron Trim Tab
7. Pulley
8. Alemite Fitting
9. Bracket
10. Cable Drum
11. Right Aileron Down Cable
12. Actuating Tube (Forward) and Adjusting Nut
13. Left Aileron Down Cable
14. Fitting

Figure 59 — Aileron Left Hand Trim Tab Mechanism

4. INSTALLATION.–Reverse the REMOVAL procedure given above.

5. ADJUSTMENT. – Neutral alignment of the ailerons is obtained by loosening the nut and turning the rod *(9, figure 58)* to the right or left until the desired position is obtained. The controls should be locked in neutral while the adjustment is being made.

6. TEST AFTER INSTALLATION. – Check the aileron controls for proper operation. Make certain that the aileron is in line with the trailing edge of the wing when the control wheel is in the neutral position.

(3) AILERON TRIM TAB CONTROLS. *(See figure 69).*

(a) GENERAL.–Both the left-hand and right-hand aileron trim tabs move automatically with the aileron, but if so desired, the left-hand trim tab can be controlled separately by turning a dial *(14, figure 61)* on the control pedestal. The dial is connected to a drum with attached cables which are directed outboard into the left-hand wing. In the wing, the cables wind around a drum *(10, figure 59)* attached to a rod assembly *(12, figure 59)* which actuates the aileron tab. Doors providing access to the mechanisms are illustrated in *figures 6 and 7.*

Note

Adjustment of the angle of movement of the left hand trim tab, and of the position of both the left and right hand tabs is described in paragraph 3. *b.* (3) *(e)*, this section.

(b) AILERON TAB DRUM IN PEDESTAL. *(See 14, figure 61.)*

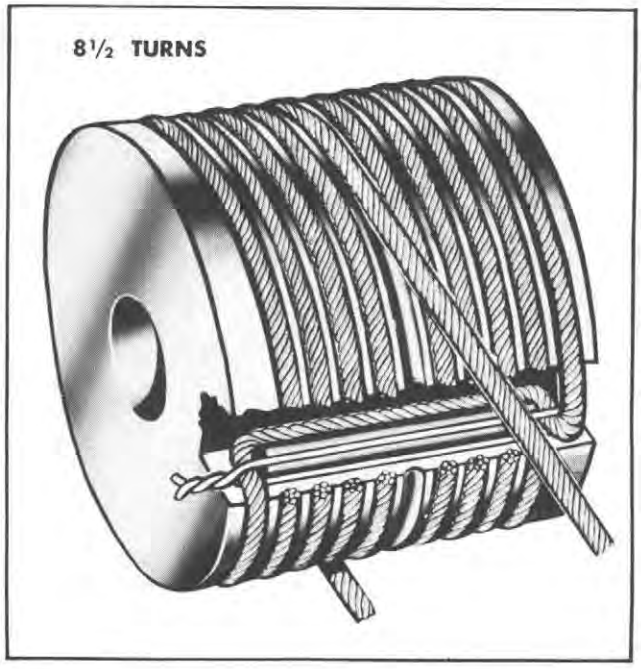


Figure 60 — Aileron Tab Drum Rigging

1. DESCRIPTION.–The aileron tab drum installed in the control pedestal is a part of the equipment provided for the individual adjustment of the position of the left hand aileron trim tab.

2. REMOVAL.

a. Remove the nut from the under side of the drum and slide the drum out of the control pedestal.

b. Tape the cables at the drum to prevent the cables from unwinding. *(See figure 56.)*

c. Disconnect the cables at the turnbuckles *(figure 69).*

d. Remove the cable fairleads and pulley guards if necessary.

3. MAINTENANCE REPAIR OR REPLACEMENT. – Replace drum if worn or cracked. Check the cable ends for security.

4. INSTALLATION.

a. Reverse the REMOVAL procedure given above.

b. If the cables must be rewrapped on the drum, refer to *figure 60.*

c. To restore cables to proper tension, refer *figure 74.*

(c) AILERON LEFT HAND TAB MECHANISM IN WING. *(See figure 59.)*

1. DESCRIPTION.–The mechanism, located in the left hand wing forward of the aileron, consists of a cable drum and gear assembly which actuates a push-pull tube assembly.

2. REMOVAL.

a. Remove the landing light assembly by removing the attaching screws.

b. Disconnect the electric wiring at the lamp motor, and remove grounding strap from wing structure.

c. Tape the cable drums *(10, figure 156)* to prevent unwinding.

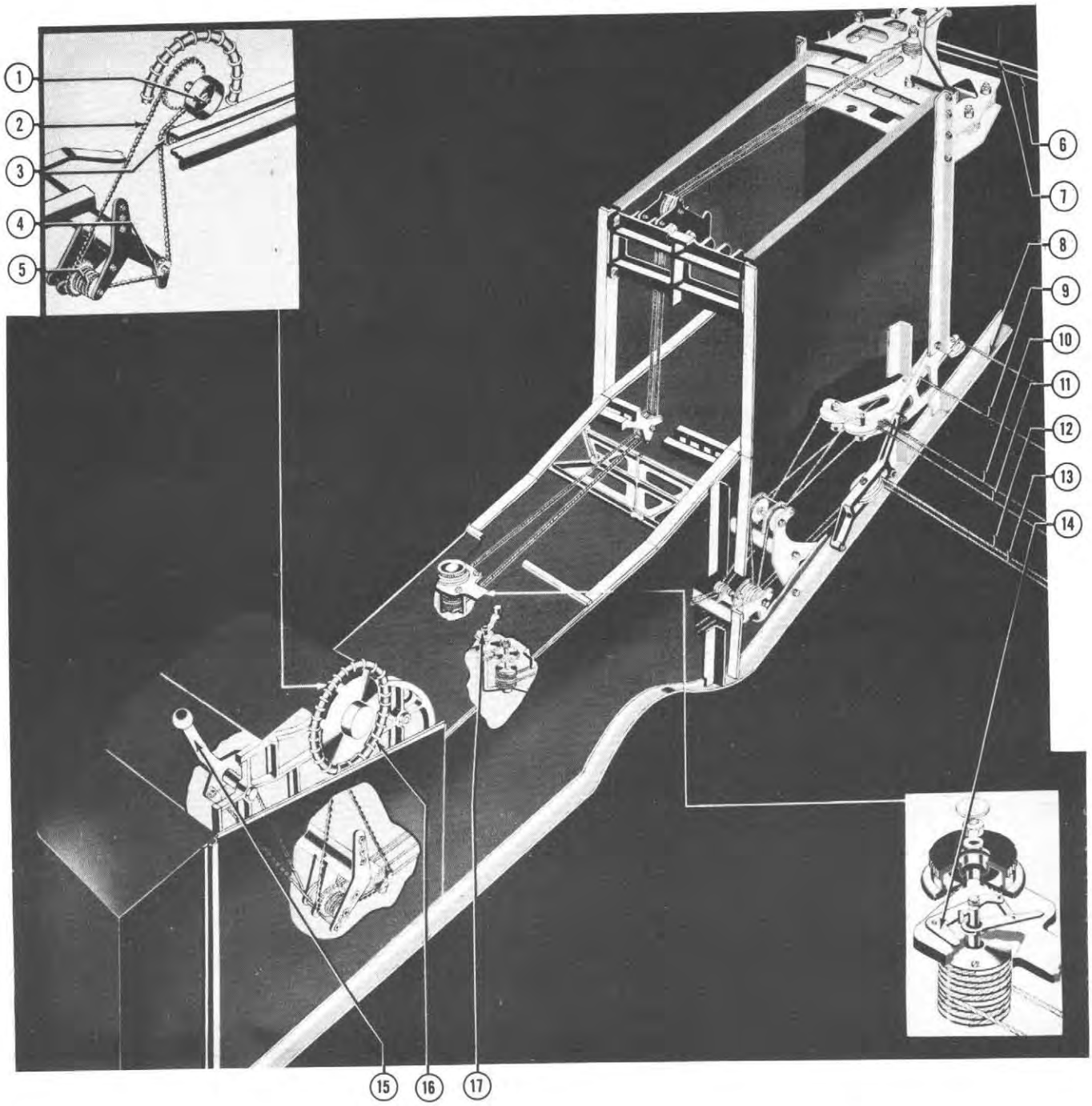
d. Disconnect the tab control cable at the turnbuckle *(figure 69).*

e. Remove the aileron as described in paragraph 3. *b.* (2) *(b)*, this section.

f. Remove the control pulley *(7, figure 59)* at the drum.

g. Loosen the four attaching bolts.

h. Remove the zerk fitting from the forward end of the acme threaded rod *(8, figure 59).*



1. Friction Adjustment Nut
2. Diamond Roller Chain
3. Sprocket
4. Adjustable Idler Sprocket
5. Drum and Cable Assembly
6. Aileron Trim Tab Down Cable
7. Aileron Trim Tab Up Cable
8. Control Lock Locked Cable
9. Control Lock Unlocked Cable
10. Rudder Trim Tab Right Cable
11. Rudder Trim Tab Left Cable
11. Elevator Trim Tab Up Cable
13. Elevator Trim Tab Down Cable
14. Aileron Trim Tab Control Assembly
15. Surface Lock Control Lever
16. Elevator Trim Tab Control Wheel
17. Rudder Trim Tab Control Assembly

Figure 61 — Trim Tab and Surface Lock Controls

i. Slide the complete assembly aft sufficiently to allow the end of the rod assembly to clear the wing structure. Unscrew this rod assembly and remove it from the airplane.

j. The drum and bracket mechanism is now to be removed through the landing light hole.

3. MAINTENANCE REPAIR OR REPLACEMENT.—Replace any part that is damaged or badly worn. For cable maintenance see paragraph 3. *c.* (8) *(c)*, this section. Lubrication is to be performed at service inspection periods.

4. INSTALLATION. – Installation is the reverse of the REMOVAL procedure. See Cable Rigging Chart *(figure 74)* for cable tensions. If the cables must be rewrapped on the drum, refer to *figure 60.*

5. ADJUSTMENT.—Refer to paragraph 3. *b.* (3) *(e)*, this section.

6. TEST AFTER INSTALLATION. – Make trial operation of the tab controls, measuring the travels and checking for correct neutral setting.

(4) ELEVATOR CONTROLS. *(See figure 70.)*

(a) GENERAL. – Elevator movement is controlled by the conventional fore and aft movement of the control column. The elevator control cables extend from the control column torque tube horn to the support assembly in the tail section where they are connected to the elevator torque tube horns.

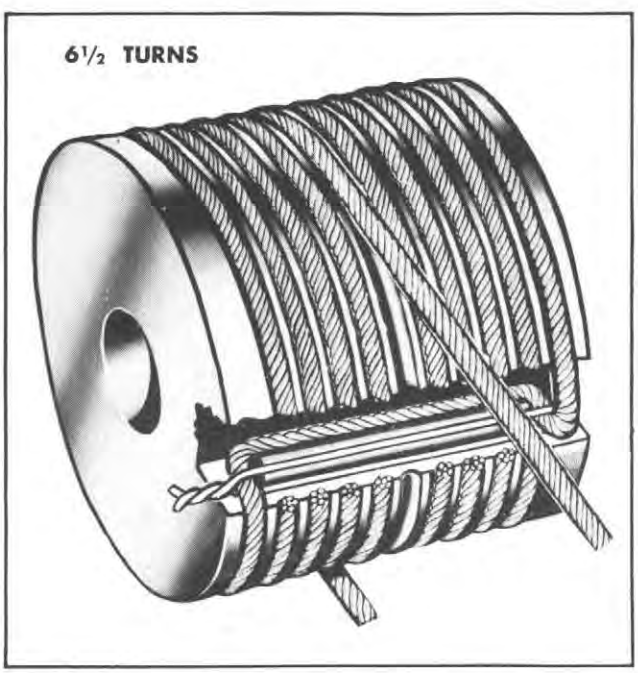


Figure 62 — Elevator Tab Drum Rigging (Pedestal)

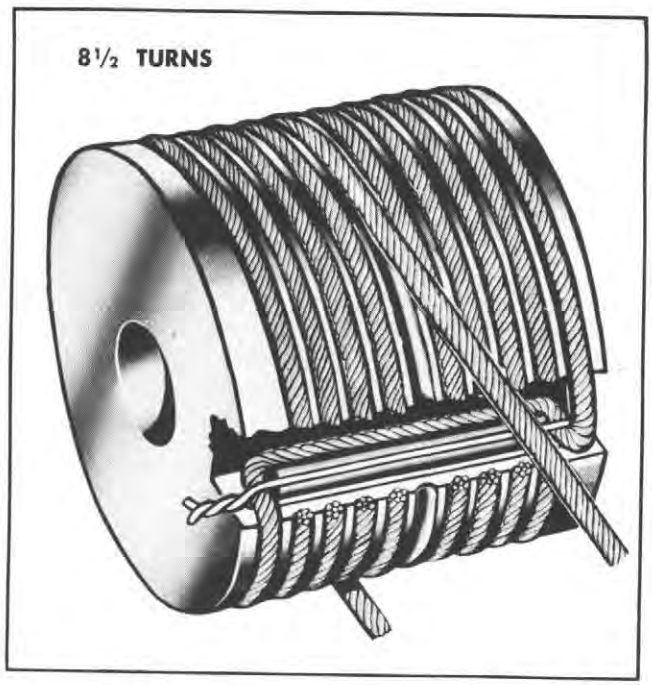


Figure 63 — Elevator Tab Drum Rigging (Elevator)

Note

The adjustment of the angular movement of the elevators, and their position in relation to the wing surfaces is described in paragraph 3. *b.* (4) *(e)*, this section.

(b) ELEVATOR CONTROL COLUMN ASSEMBLY. *(See figure 54.)*

1. DESCRIPTION.—The assembly consists of a control column and a horn. Two cables, one for each elevator, are attached to each end of the horn.

2. REMOVAL.

a. Disconnect the elevator control cables extending aft from the ends of the control column horn *(14, figure 54).*

b. Tape the forward drum in the aileron torque tube and drums assembly *(figure 57)* located in the aft portion of the pilot's compartment.

c. Disconnect the aileron cables at the turnbuckles *(figure 69).* Remove the cable fairleads where necessary.

d. Remove the dome-shaped cover on each side of the control column base.

e. Remove the radio compass loop azimuth control *(figure 505)* mounted on the control column by disconnecting the tach-shaft and the electrical plug and removing the screws which attach the unit to the bracket.

f. Remove the bracket-attaching bolts on the inboard end of the horizontal torque tube (lower member of the control column assembly), leaving the bracket attached to the column by the hinge bolt.

g. Remove the nut from the stud on the outboard end of the torque tube, freeing the complete control column assembly.

h. For removal of the wheel and drum assembly in the control column refer to paragraph 3. *c.* (2) *(b)* 2., this section.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. Check the complete assembly for freedom of movement of the moving parts, and for cracks and worn bearing surfaces.

b. Check the cable ends for security of swaged fittings

c. Replace any worn or damaged parts.

4. ADJUSTMENTS.—For instructions on the adjustment of the stops *(11, figure 54)* which limit the forward and aft movement of the control column, refer to paragraph 3. *b.* (4) *(e)*, this section.

5. INSTALLATION.—Reverse the REMOVAL procedure given above. To restore the cables to the proper tension refer to the Cable Rigging Chart *(figure 74)*.

6. TEST AFTER INSTALLATION.—Operate controls and check control wheel, control column and elevator surfaces for proper movement. If adjustments are required, refer to paragraph 3. *b.* (4) *(e)*, this section.

(c) ELEVATOR HORNS IN EMPENNAGE. *(See 14 ,figure 73.)*

1. DESCRIPTION.—Two horns, one for each elevator, are installed in the control support assembly. Cables extend from the horns to the control column in the pilot's compartment.

2. REMOVAL.

a. Remove the tail cone as described in paragraph 4. *b.* (2), this section.

b. Remove the armor plate*(figure 555)*.

c. Disconnect the cables attached to the elevator horns.

d. Disconnect the two elevator torque tubes by removing the three bolts on each side.

e. Remove the hinge bolts *(13, figure 73)* which attach the elevator horns to the control support assembly.

f. Remove the elevator horns.

3. MAINTENANCE REPAIR. — A damaged elevator horn shall be replaced.

4. INSTALLATION.—To install the elevator horn in the control support assembly in the empennage, reverse the REMOVAL procedure given above.

5. ADJUSTMENT. — Travel of the elevator torque tubes and horns is regulated by adjustable stops attached to the control support assembly. For data on the proper travel of the elevators refer to paragraph 3. *b.* (4) *(e)*, this section.

6. TEST AFTER INSTALLATION. — Operate controls and check elevator surfaces for proper movement.

(5) ELEVATOR TRIM TAB CONTROLS. *(See figure 70.)*

(a) GENERAL. — The elevator trim tabs are operated simultaneously by means of a control wheel *(16, figure 61)* located on the control pedestal. The control wheel is attached to a sprocket and chain assembly which is connected to a sprocket and drum located beneath the control wheel in the control pedestal. An adjustable idler sprocket *(4, figure 61)* attached to the pedestal structure keeps the bicycle chain under proper tension. From the drum in the pedestal the cables extend aft to the elevators where they wind around drums installed in gear box assemblies. Connected to the gear boxes are torque tubes which raise or lower the elevator tabs when the control wheel is turned. Access to the mechanisms in the control pedestal is obtained by means of removable panels. The tab mechanisms in the elevators are reached through access doors *(figures 6 and 7)* located in the elevator surfaces.

Note

The adjustment of the elevator trim tabs to the neutral position is described in paragraph 3. *b.* (5) *(e)*, this section.

(b) ELEVATOR TRIM TAB CHAIN. *(See 2, figure 61.)*

1. DESCRIPTION. — The elevator trim tab chain is installed in the control pedestal and connects the elevator trim tab control wheel to the trim tab drum.

2. REMOVAL AND DISASSEMBLY.

a. Loosen the idler sprocket *(4, figure 61)* at the slotted fitting and lift chain from sprocket.

b. The chain may be taken apart by removing the spring slip on the connecting link and pulling the link from the chain.

3. MAINTENANCE REPAIR.—The elevator trim tab chain may be repaired by replacing the damaged links with roller-type links.

4. INSTALLATION.

a. Reverse the REMOVAL procedure outlined above.

b. After the chain is in place, move the idler sprocket in the slot to take up the slack. The chain should be held in place firmly but it should not be taut.

(c) ELEVATOR TRIM TAB DRUM IN PEDESTAL. *(See 5, figure 61.)*

1. DESCRIPTION.–The elevator trim tab drum in the control pedestal revolves on a special bolt which extends from one side of the pedestal to the other.

2. REMOVAL.

a. Tape the cables at the drum to prevent the cables from unwinding. *(See figure 56.)*

b. Disconnect the cables at the turnbuckles *(figure 70)*. Remove cable fairleads and pulleys if necessary.

c. Remove the nut from the bolt on the right-hand side of the pedestal. Pull the bolt out from the left-hand side of the pedestal far enough to free the drum.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. Replace the cable drum if it is worn or cracked.

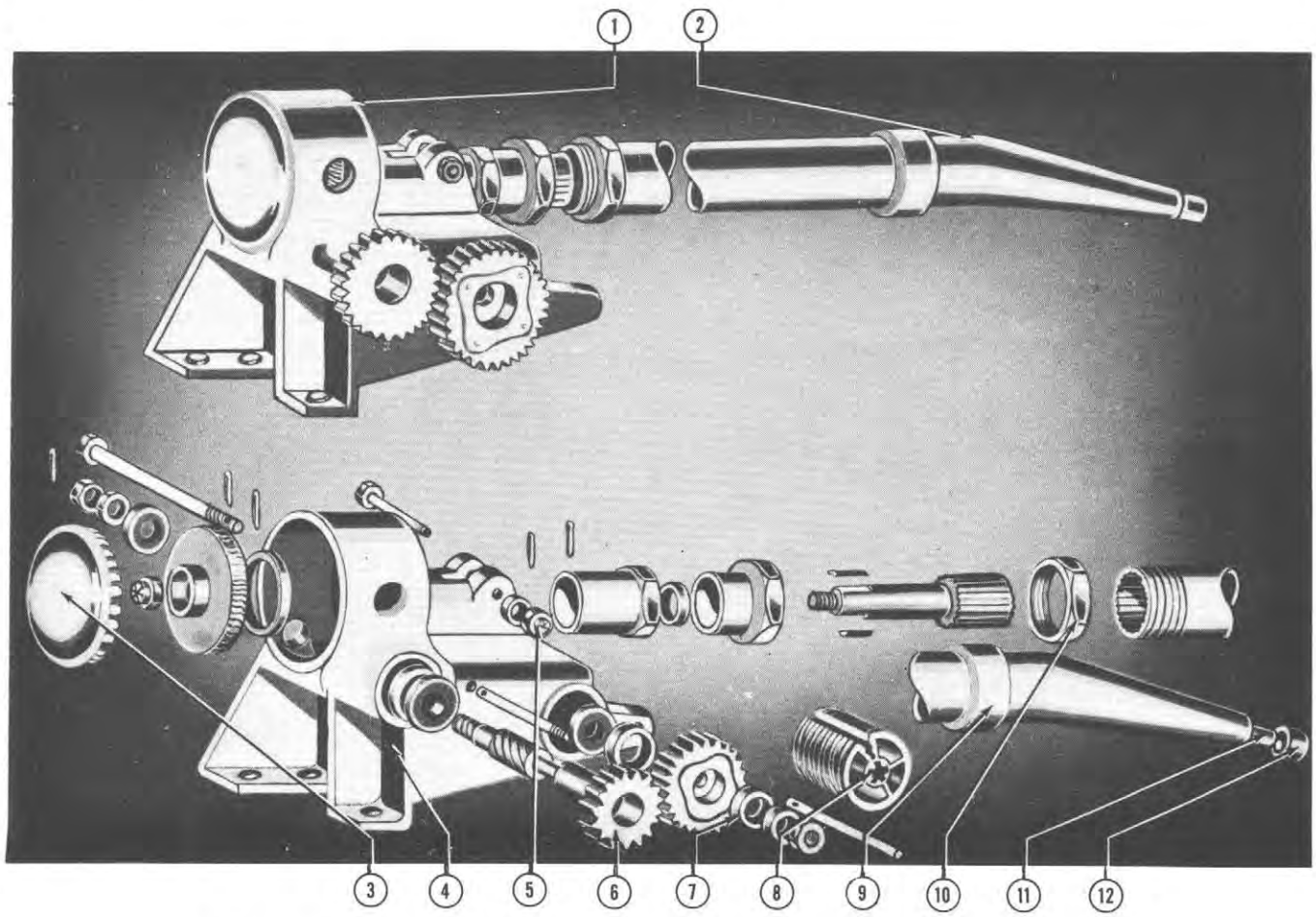
b. If it is necessary to rewrap the cables on the drum, refer to *figure 63.*

4. INSTALLATION. – Reverse procedure given in REMOVAL above. For proper cable tension refer to *figure 74.*

5. TEST AFTER INSTALLATION.–Check elevator tab controls for proper operation.

(d) TRIM TAB DRUM AND GEAR BOX ASSEMBLY IN ELEVATOR. *(See figure 43.)*

1. DESCRIPTION.–A cable drum and gear box assembly is installed in each elevator and is connected to a tube assembly which actuates the elevator trim tab.



1. Gear Box Assembly
2. Actuating Tube
3. Dot Plug
4. Housing
5. Tube Assembly Clamping Bolt
6. Worm Gear
7. Gear Assembly
8. Cable Drum
9. Sleeve
10. Nut
11. Pin
12. Bearing

Figure 64 — Trim Tab Mechanism (Typical for Elevator and Rudder)

2. REMOVAL.

a. Disconnect the gear box assembly from the actuating assembly at the fitting *(2, figure 64)*.

b. Remove the drum from the gear box by detaching the bolt *(7, figure 64)* from the large composition gear at the bottom of the box.

c. Tape the cables at the drum *(8, figure 64)* to prevent the cables from unwinding and put the drum to one side.

d. Remove the attaching bolts at the bottom of the box.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. If the drum is cracked or worn, it shall be replaced.

b. If the composition gear is damaged or worn, it shall be replaced.

c. If necessary to rewrap the cable on the drum, refer to *figure 62*.

4. INSTALLATION.

a. Reverse the REMOVAL procedure above.

b. To restore cables to the proper tension, refer to Cable Rigging Chart *(figure 74)*.

(e) ELEVATOR TAB ACTUATING TUBE ASSEMBLY. *(See figure 64.)*

1. DESCRIPTION.—The tube assembly is the connecting unit between the drum and gear box assembly and the tab in each elevator.

2. REMOVAL.

a. Disconnect the tube from the fitting on the aft end of the gear box.

b. Remove the elevator tab from its hinges.

c. Pull the actuating tube out of the elevator.

3. MAINTENANCE REPAIR OR REPLACEMENT.—Check the actuating tube, fitting bushings, and the bearing at the tab end of the tube and replace any of the parts which are worn or damaged.

4. INSTALLATION.—Reverse the REMOVAL procedure given above.

5. TEST AFTER INSTALLATION. — Make operating test of the elevator trim tabs.

(6) RUDDER CONTROLS. *(See figure 71.)*

(a) GENERAL. — Movement of the rudder is controlled by the rudder pedals located in the pilot's compartment. The rudder pedals actuate a rudder pedal torque tube *(14, figure 65)* and horn assembly *(15, figure 65)* to which cables are attached. The rudder cables extend aft to the control support *(figure 73)* in the empennage, where they are connected to a torque tube and horn assembly *(32, figure 73)* which actuates the rudder. The rudder pedals are adjustable fore or aft to accommodate pilots of varying stature. Movement of the rudder pedals is limited by adjustable stops *(29, figure 73)* attached to the fuselage structure.

Note

Adjustment of the travel and position of the rudder and rudder pedals is described in paragraph 3. *b.* (6) *(e)*, this section.

(b) RUDDER PEDAL ASSEMBLY. *(See figure 65.)*

1. DESCRIPTION. — The rudder pedal assembly, installed in the pilot's compartment, consists principally of a torque tube and a horn, to which the rudder cables are attached.

2. REMOVAL.

a. Disconnect the brake rod assembly *(1, figure 65)* at the rudder pedals.

b. Remove the rudder pedal rod assembly *(3, figure 65)* which attaches the rudder pedal arms *(2, figure 65)* to the torque tube assembly *(14, figure 65)* by removing the top rod attaching bolts.

c. Remove the hinge bolts from the rudder pedal arms and lift out the pedal assemblies.

d. If rudder follow-up cables are installed, remove the bolts which attach them to the rudder torque tube assembly.

e. Loosen the rudder control cables at the turnbuckles *(figure 71)*.

f. Disconnect the cable ends from the rudder pedal horn *(15, figure 65)*.

g. Remove the two attaching bolts at the hinge points and lift out the rudder pedal horn and torque tube assembly.

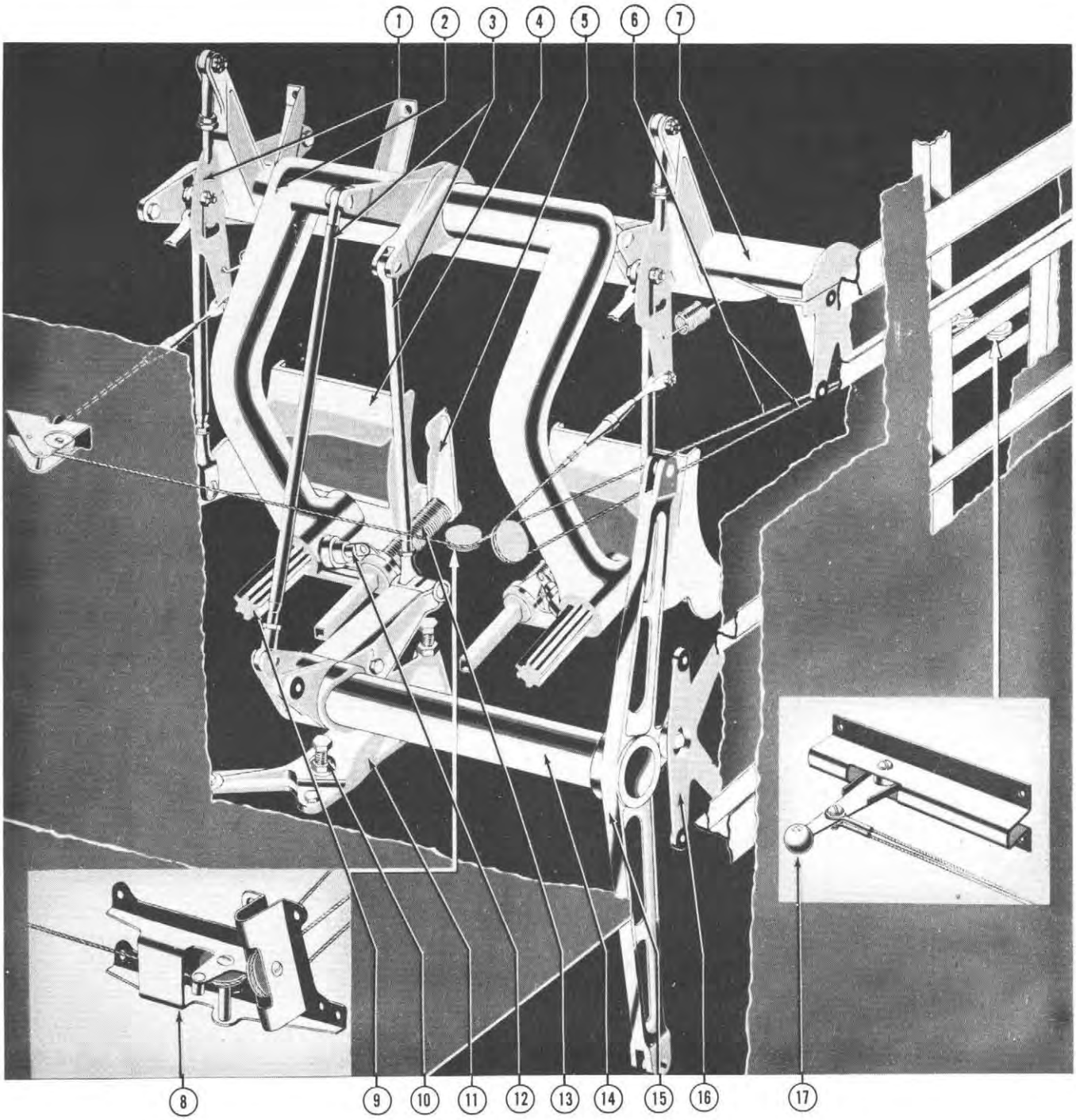
3. MAINTENANCE REPAIR OR REPLACEMENT.—Replace all parts found to be worn or damaged.

4. INSTALLATION.—Reverse the REMOVAL procedure above.

5. ADJUSTMENTS.

a. For instructions on the adjustment of the rudder pedal assembly refer to paragraph 3. *b.* (6) *(e)*, this section.

b. For instructions on the adjustment of main landing gear wheel brake valves, operated by means of the rudder pedals, refer to paragraph 14. *e.* (2) *(d)*, this section.



1. Brake Control Mechanism *(See Figure 286)*
2. Arm
3. Rod
4. Rudder Pedal
5. Pedal Adjustment Lever
6. Brake Control Cables
7. Support
8. Pulley Bracket
9. Splined Shaft
10. Adjustable Stop
11. Support
12. Pedal Adjustment Pin
13. Spring
14. Torque Tube
15. Horn
16. Support
17. Brake Control Lever

Figure 65 — Rudder Pedal Mechanism

6. TEST AFTER INSTALLATION. – Make an operating test of the rudder pedal mechanism.

(c) RUDDER HORN IN EMPENNAGE. *(See 32, figure 73.)*

1. DESCRIPTION.–The rudder horn is installed in the control support assembly in the empennage. The horn is attached to a torque tube which actuates the rudder. Cables extend from the horn to the rudder pedal assembly in the pilot's compartment.

2. REMOVAL.

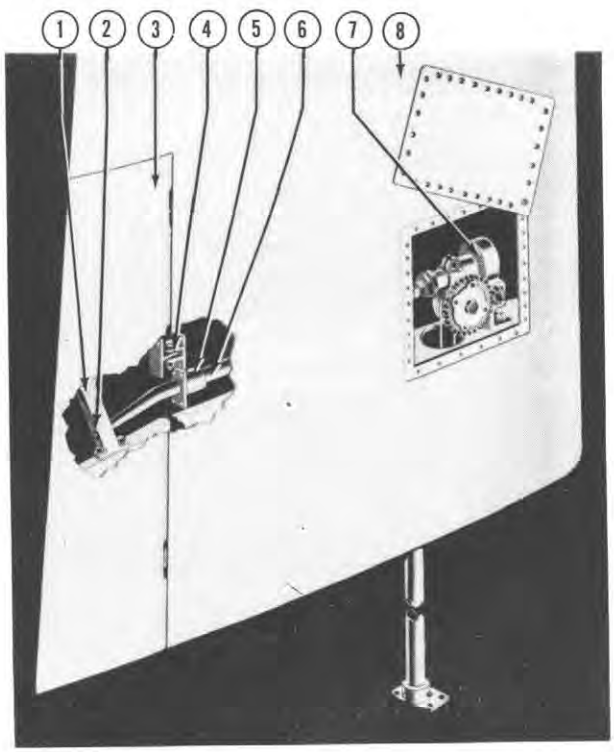
a. Remove the tail cone as described in paragraph 4. *b. (2)*, this section.

b. Remove the piece of armor plate *(figure 555)*, secured by 12 bolts.

c. Remove the rudder cables at the turnbuckles *(figure 71)*.

d. Remove the four bolts which attach the rudder horn to the rudder torque tube.

e. Detach the clevis hinge pin *(30, figure 73)* and remove the rudder horn.



1. Bearing Track
2. Bearing
3. Tab Assembly
4. Hinge (3 places)
5. Housing Assembly
6. Actuating Tube
7. Gear Box Assembly
8. Rudder

Figure 66 — Rudder Trim Tab Mechanism Installed

3. MAINTENANCE REPAIR OR REPLACEMENT. – A damaged rudder horn must be replaced.

(7) RUDDER TRIM TAB CONTROLS. *(See figure 71.)*

(a) GENERAL. – The rudder trim tab is controlled by a handle and dial *(17, figure 61)* installed on the control pedestal. Rotation of the handle operates a gear drum in the pedestal to which the rudder tab control cables are attached. From the pedestal drum, the cables extend aft to the rudder where they are attached to a geared drum and torque tube assembly *(7, figure 66)*. Actuation of the torque tube causes the rudder trim tab to turn to the right or left. The door providing access to the trim tab mechanism in the rudder is illustrated in *figure 66*.

Note

Adjustment of the rudder trim tab travel and position is described in paragraph 3. *b.* (7) *(e)*, this section.

(b) RUDDER TAB PEDESTAL CONTROLS. *(See 17, figure 61.)*

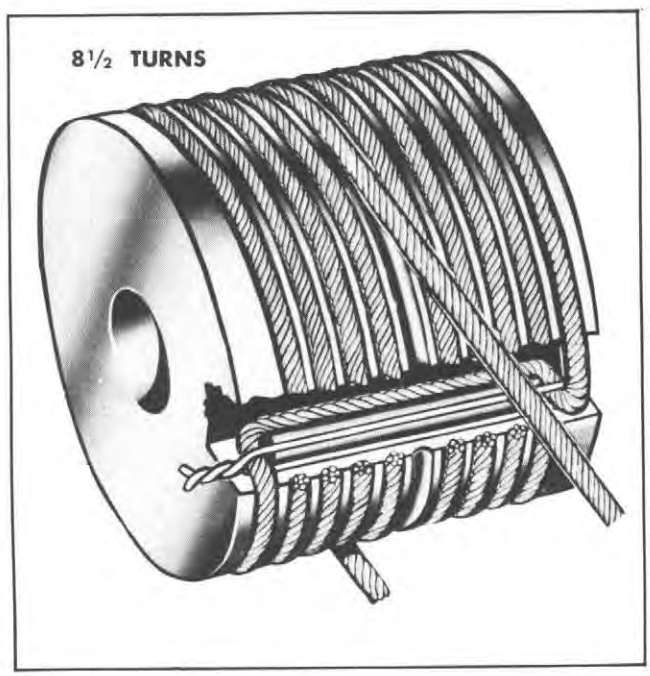


Figure 67 — Rudder Tab Drum Rigging (Pedestal)

1. DESCRIPTION.–The rudder tab controls consist of a handle and a dial mounted on the control pedestal and a cable drum located within the pedestal.

2. REMOVAL AND DISASSEMBLY.

a. Disconnect the nut at the top of the handle and remove the handle from the shaft.

b. Remove the four attaching bolts freeing the complete assembly.

c. Remove the three nuts on the under side of the assembly, which will make it possible to disassemble all the parts.

d. Tape the cables at the drum to prevent the cables from unwinding. *(See figure 56.)*

e. Disconnect the cables at the turnbuckles *(figure 71)*, remove fairleads and pulleys where necessary, and pull the cable and drum assembly from the pedestal.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. Replace the worn or cracked cable drums.

b. Replace the worn or chipped gears.

c. Replace the worn or damaged attaching bolts and brackets.

4. INSTALLATION.

a. Reverse the REMOVAL procedure given above.

b. If the rudder trim tab drum in the pedestal must be rewrapped, refer to *figure 67*.

c. To restore the cables to proper tension refer to Cable Rigging Chart *(figure 74)*.

5. TEST AFTER INSTALLATION.—Check the rudder trim tab controls for proper operation.

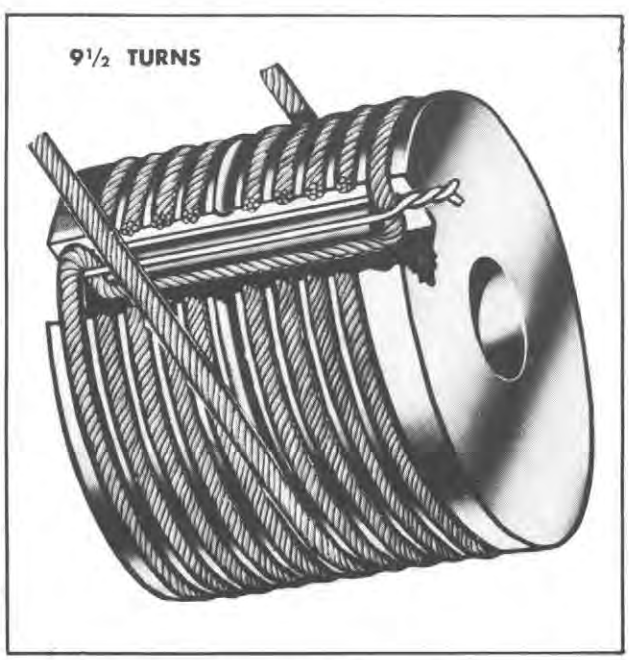


Figure 68 — Rudder Tab Drum Rigging (Rudder)

(c) RUDDER TAB ACTUATING MECHANISM. *(See figures 64 and 66.)*

1. DESCRIPTION. — The rudder tab actuating mechanism installed in the rudder consists of a cable drum and gear box assembly to which a rudder tab actuating tube is attached.

2. REMOVAL.

a. Tape the rudder tab drum *(8, figure 64)* to prevent the cables from unwinding. *(See figure 58.)*

b. Disconnect the cables at the turnbuckles *(figure 71)*.

c. Disconnect the gear box assembly from the actuating tube assembly at the fitting *(10, figure 64)*.

d. Remove the drum from the gear box by detaching the bolt from the large composition gear at the aft end of the box.

e. Remove the attaching bolts at the bottom of the box.

f. Remove the rudder tab from its hinges *(figure 66)* and pull the actuating tube out of the rudder.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. Replace the rudder tab drum if worn or cracked.

b. Replace the rudder tab drum gear if worn or cracked.

c. Replace the actuating tube if damaged.

d. Replace the bearing at the rudder tab end of the actuating tube if it shows wear.

e. Replace the fitting bushings if worn or damaged.

4. INSTALLATION.

a. Reverse the REMOVAL procedure given above.

b. If it is necessary to rewrap the cables on the drum, refer to *figure 68*.

c. To restore the rudder trim tab cables to the proper tension, refer to Cable Rigging Chart *(figure 74)*.

5. TEST AFTER INSTALLATION. — Check the rudder trim tab controls for proper operation.

(8) CONTROL CABLES.

(a) DESCRIPTION. — Flexible steel cables, equipped with swaged fittings and turnbuckles, are used to actuate the ailerons, elevators and rudder, the left-hand aileron trim tab, the elevator trim tabs and the rudder trim tab. The cables are guided through

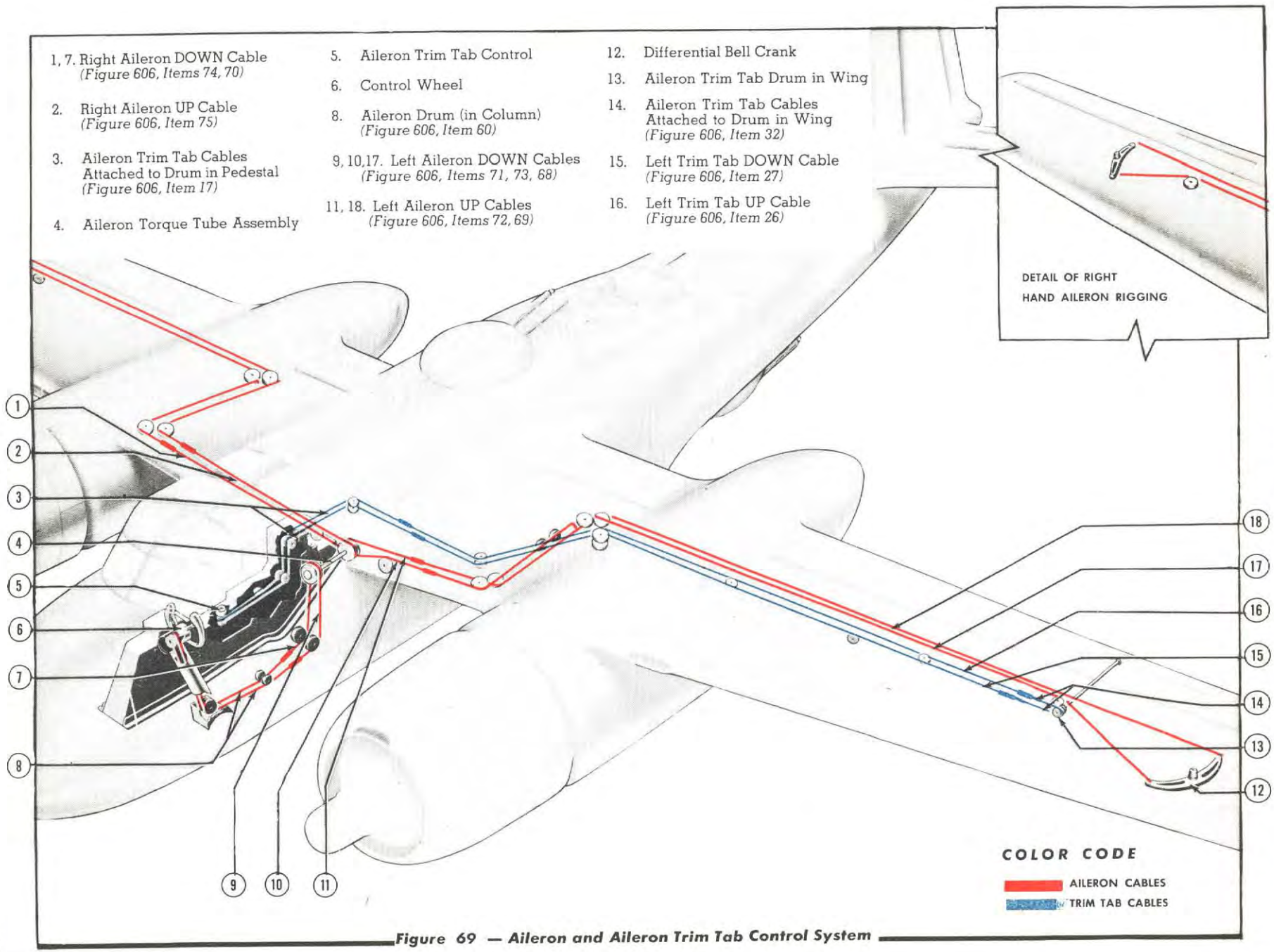


Figure 69 — Aileron and Aileron Trim Tab Control System

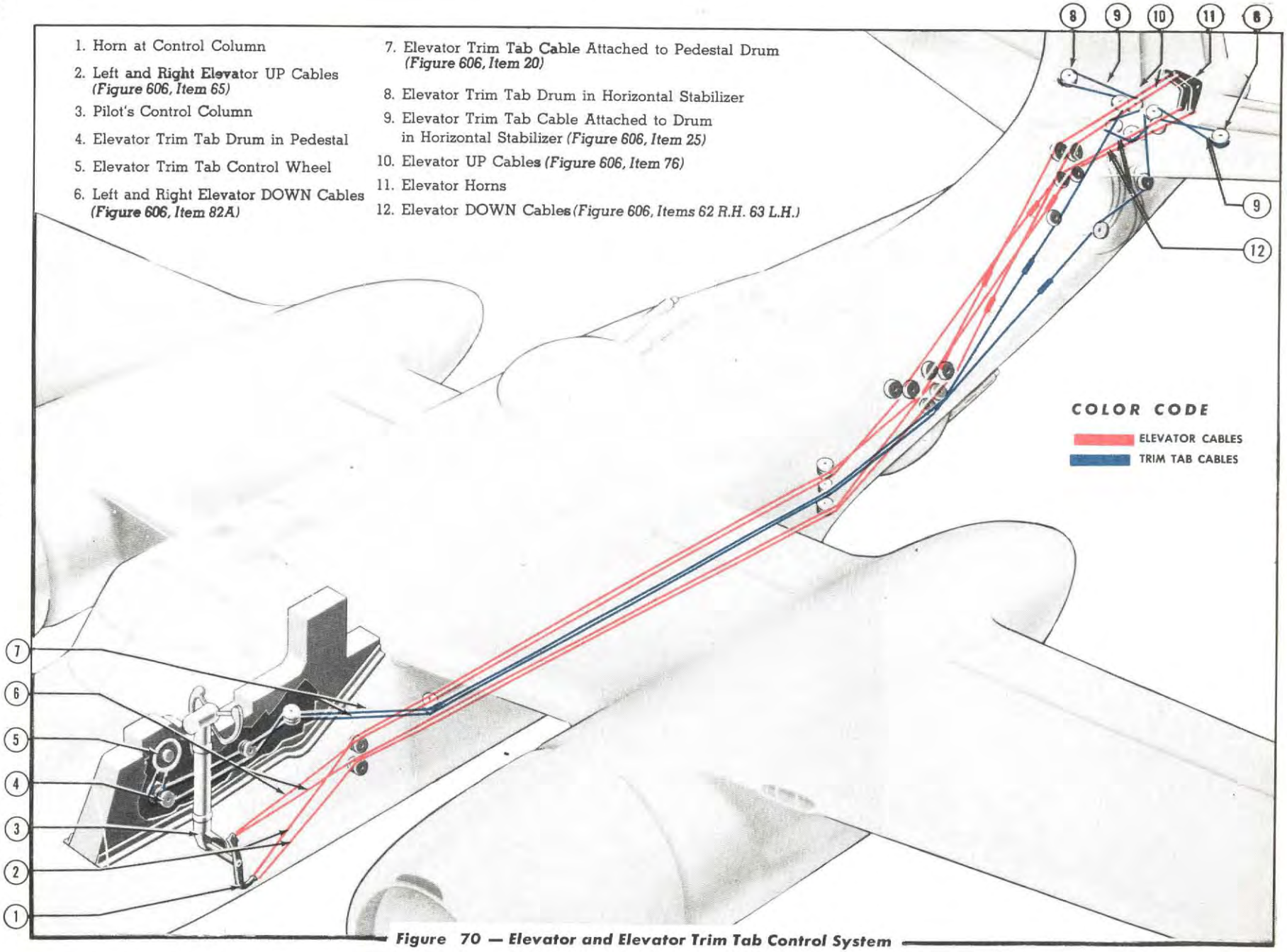


Figure 70 — Elevator and Elevator Trim Tab Control System

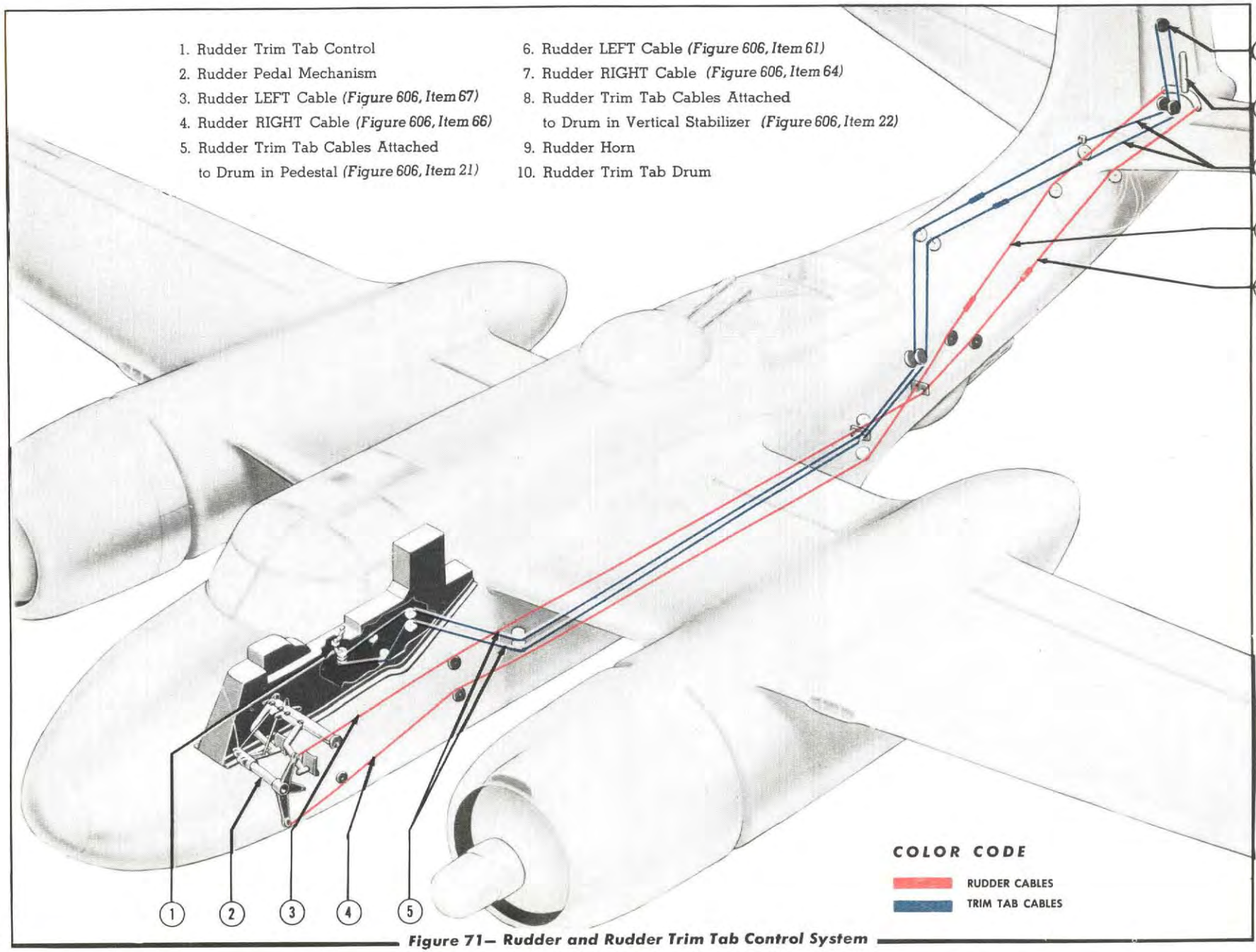


Figure 71— Rudder and Rudder Trim Tab Control System

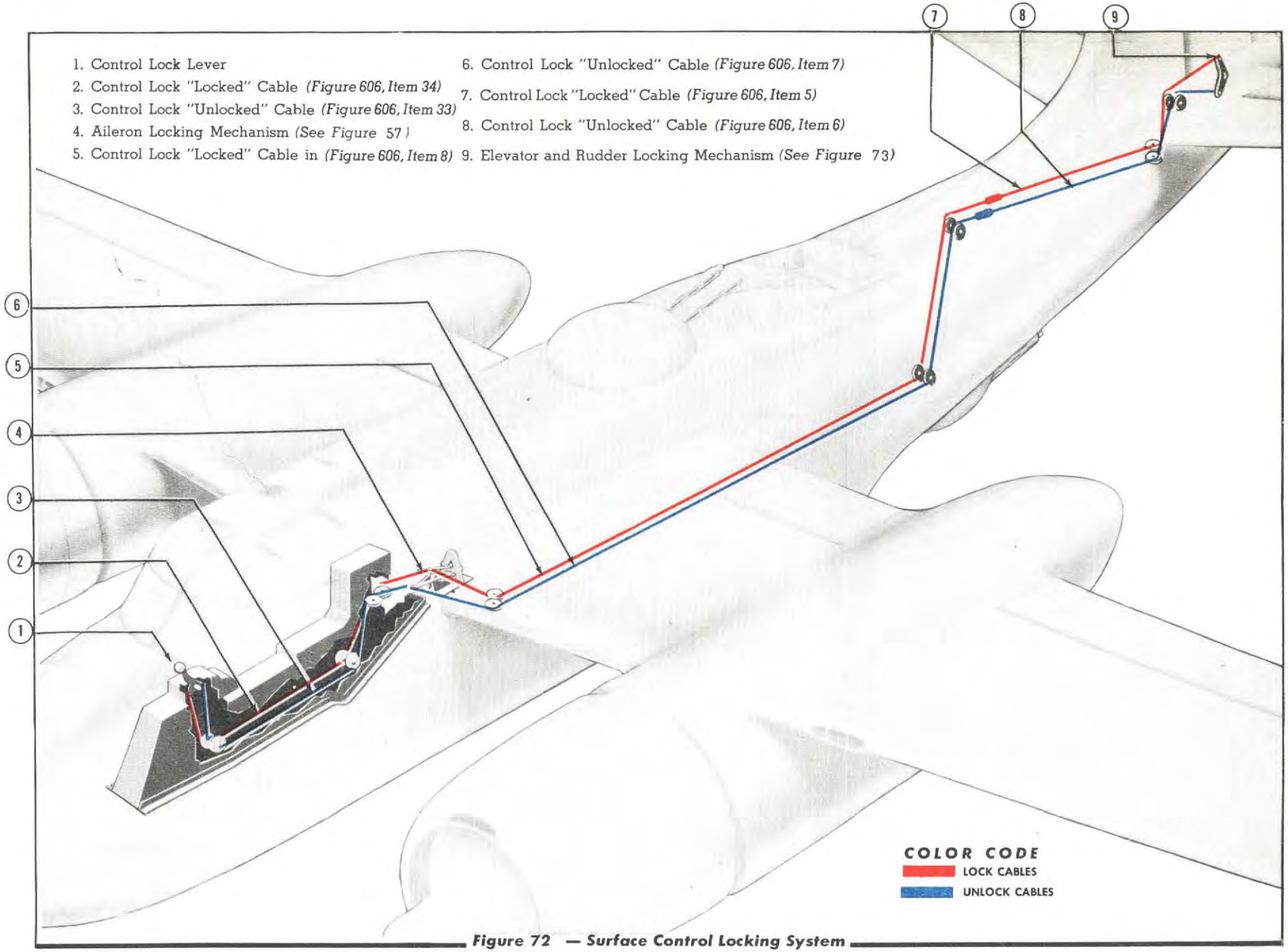
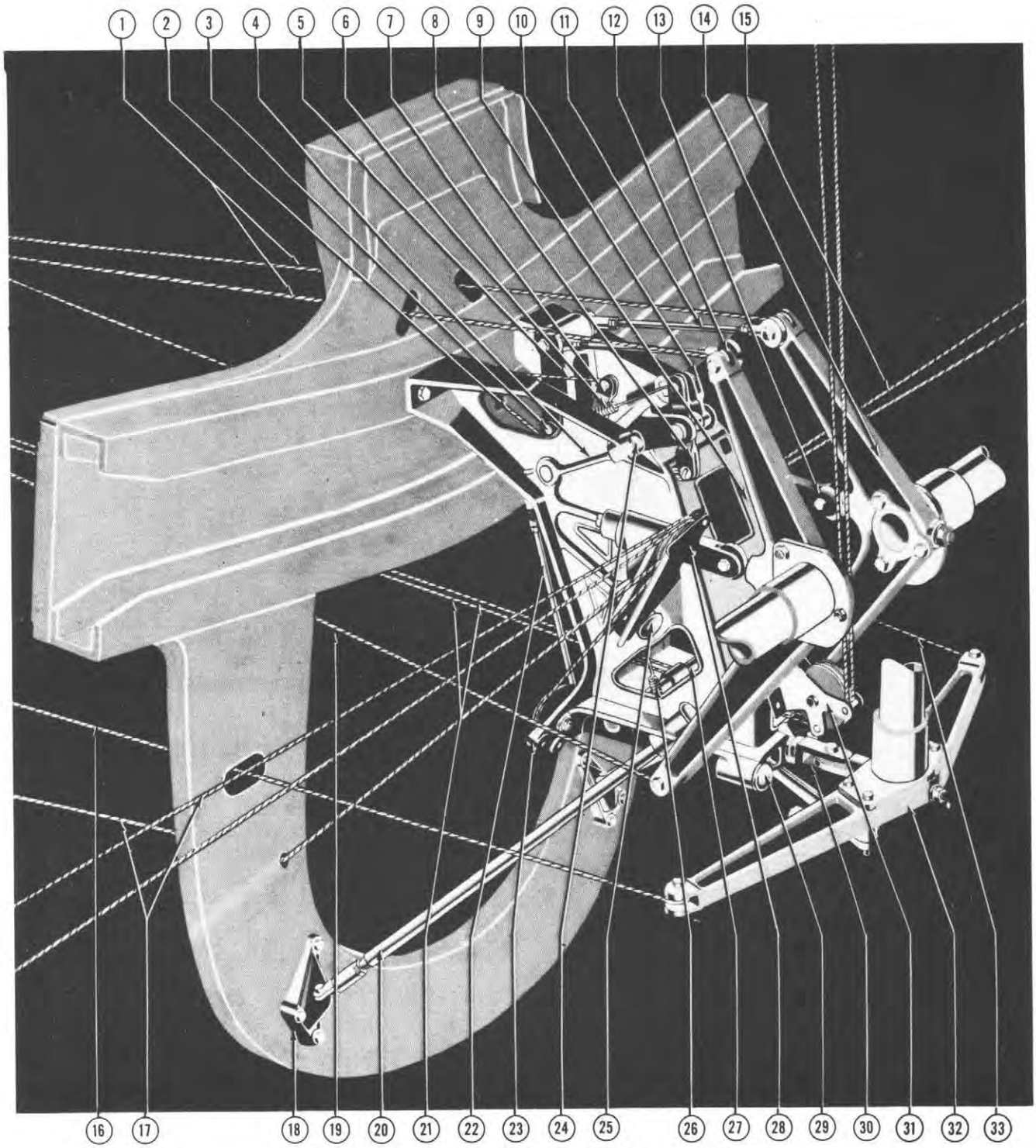


Figure 72 — Surface Control Locking System



1. Elevator Up Cables
2. Control Lock Release Cable
3. Surface Lock Actuating Crank
4. Elevator Idler Link Shaft
5. Control Lock "Locked" Cable
6. Surface Lock Tension Spring
7. Surface Lock Actuating Bell Crank
8. Surface Lock Actuating Idler Lever
9. Bracket
10. Lever
11. Elevator Interconnecting Rod
12. Cable Attachment Bolt
13. Elevator Horn Attach Bolt
14. Elevator Horn
15. Elevator Trim Tab Cables
16. Rudder Left Cable
17. Elevator Tab Down Cable
18. Bracket
19. Elevator Down Cable
20. Position Adjustment Rod
21. Rudder Trim Tab Cables
22. Rudder Lock Rod
23. Support
24. Elevator UP Stop (Adjustable)
25. Elevator DOWN Stop (Adjustable)
26. Surface Lock Tension Spring
27. Rudder Surface Lock Shaft
28. Pulley Bracket
29. Rudder Left Stop (Adjustable)
30. Rudder Clevis
31. Rudder Bracket
32. Rudder Horn
33. Rudder Right Cable

Figure 73 — Flight Control Mechanism—Fuselage Aft Section

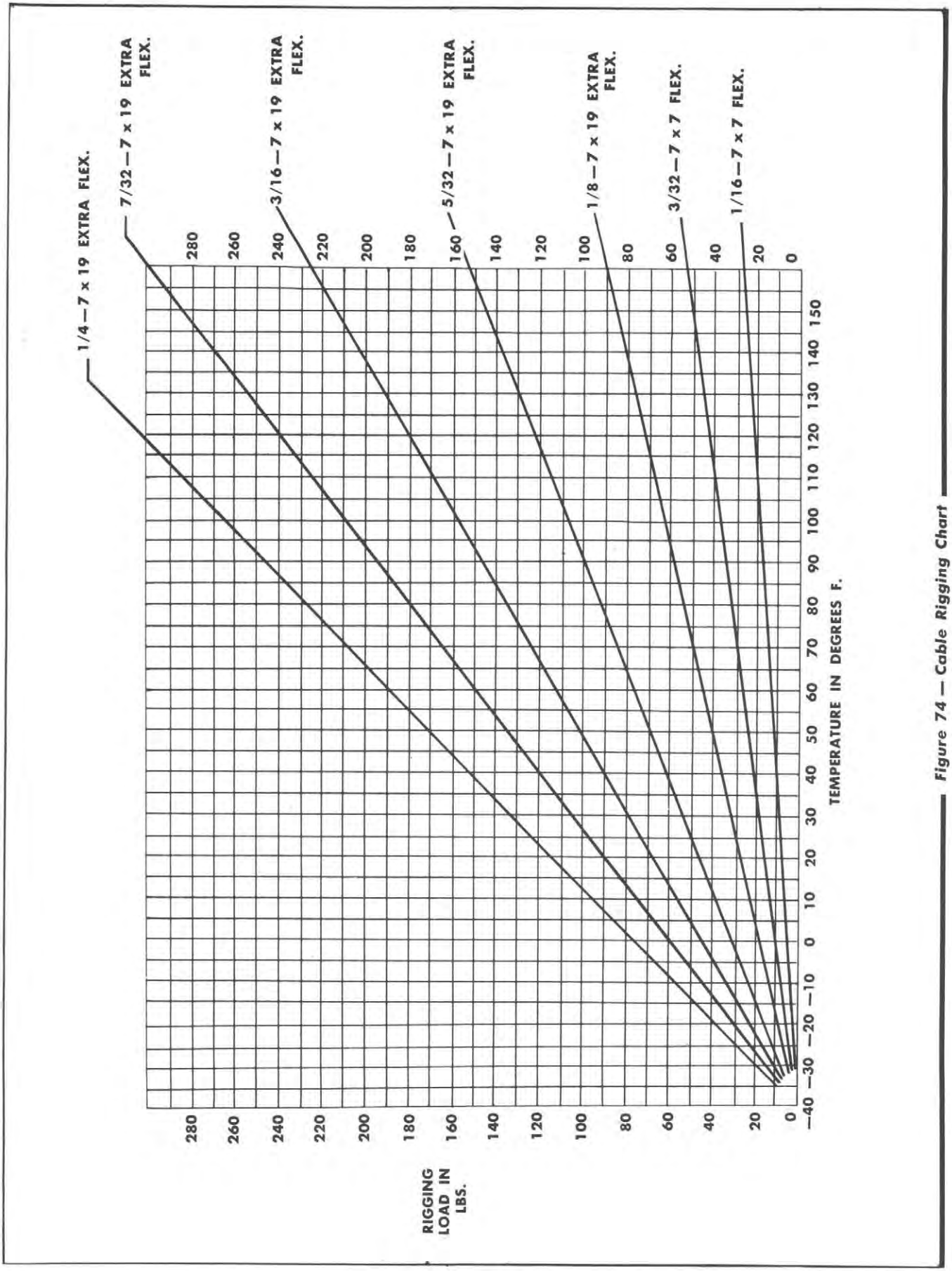


Figure 74 — Cable Rigging Chart

the fuselage and wing structures by means of micarta pulleys and fairleads. The various cable systems are illustrated in this section.

(b) REMOVAL.

1. Remove fairleads.

2. Free cables from pulleys by removing the guard pins or the pulley wheels if the guard pins are the pressed type.

3. Attach thread line to far end of cable and leave it in place of the cable. The line will serve as a guide when replacing the cable.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Worn or damaged flight control cables with swaged fittings cannot be repaired. Frayed 7 x 19 cables shall be considered serviceable unless there are six or more broken wires in any one-inch section of the cables. Frayed 7 x 7 cables shall be considered serviceable unless there are more than two broken wires in any one-inch section.

2. Fairleads which are cracked, broken or worn must be removed and replaced.

3. Pulleys which are cracked, worn or broken must be replaced. Pulleys with bearings which leak grease also should be replaced.

(d) INSTALLATION.—Install the cables as illustrated in this part. Before installing the cables, immerse them in a protective mixture consisting of one part grease and one part klenzine, by weight. (AAF Specification 35688.) A commonly used commercial mixture is "NO-OX-ID Grade A Special." The cables should be left in the liquid until thoroughly saturated, and then hung up to dry. After installing the cables, wire the turnbuckles and guard pins. Single .040 soft steel wire is recommended for turnbuckle safetying.

(e) ADJUSTMENT. – Use the Cable Rigging Chart *(figure 74)* at all times to obtain correct cable tension adjustment.

(9) SURFACE CONTROL LOCKS. *(See figure 72.)*—The ailerons, elevators, and rudder can be locked in the neutral position by means of a locking mechanism controlled by a lever *(15, figure 61)* which is located on the forward left hand corner of the control pedestal. Cables connected to the control lever extend to the aileron lock *(figure 57)* located aft of the aileron drum assembly. From the aileron lock, the cables run aft to the elevator and rudder locks on the control support assembly. When the lever is moved to the aft position, pins in the locks enter their respective stops, and thereby lock the controls. The lever also automatically restricts the throttle, limiting engine speed to 1,500 rpm.

(10) CONTROL SUPPORT ASSEMBLY. *(See figure 73.)*

(a) DESCRIPTION.—The control support assembly, located in the tail section, supports the elevator and rudder horns and torque tubes, the elevator and rudder control locks, and the pulley brackets for the elevator and rudder trim tabs. Provisions are made to adjust the assembly vertically. *(See 20, figure 73.)*

(b) REMOVAL.

1. First remove the tail cone, as described in paragraph 4. *b. (2)*, this section.

2. Remove the armor plate *(figure 555)*.

3. Remove the tension on all of the cables that extend to this assembly by loosening the turnbuckles until the cables sag.

4. Disconnect the four elevator cables and the two rudder cables at the horns.

5. Remove the two surface lock cables at the attaching points.

6. Remove the six elevator tab pulleys and the two rudder tab pulleys from the support.

7. Remove the two elevator torque tubes by removing the three bolts on each side. It is not necessary to remove the elevator horn.

8. Remove the four bolts which attach the rudder horn to the rudder torque tube.

9. Detach the clevis hinge pin and remove the rudder horn.

10. Remove the two adjusting rods *(20, figure 73)* which attach the bottom support to the fuselage structure.

11. Hold the support from the aft end while the two bolts at the top of the casting are being removed.

12. Remove the support through the aft section of the fuselage.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—A damaged control support assembly shall be replaced.

(d) ADJUSTMENT.—A slight vertical adjustment can be made on the control support assembly by removing the tail cone and armor plate and regulating the two adjustable rods which attach the control support to the fuselage.

(e) INSTALLATION. – To install the control support assembly reverse the REMOVAL procedure given above.

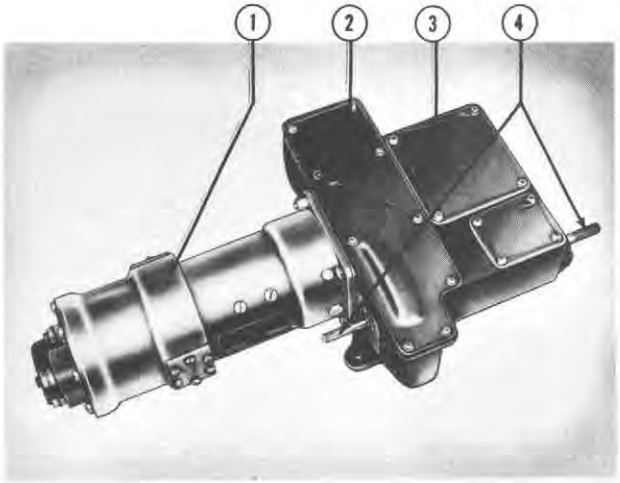
(11) WING FLAP CONTROLS.

(a) GENERAL.—The wing flaps are controlled electrically by means of a lever *(figure 49)* installed on the control pedestal. Operation of the pedestal control closes a circuit and starts an electrical drive unit *(figure 75)* installed on the rear spar cross tie plate in the bomb bay. The electrical drive unit consists of an electric motor *(1, figure 75)* attached to a main gear box *(2, figure 75)*. The motor actuates the main gear box, which in turn actuates torque tubes *(3, figure 78)* which extend into both wings and connect with smaller gear boxes. There are two of these wing gear boxes *(figure 80)* for each inboard flap and three for each outboard flap. When the gears in the wing gear boxes are revolved, they operate actuating screws *(8, figure 80)* which raise or lower the flaps. Position of the wing flaps is recorded on an electrically controlled flap and landing gear position indicator (Instrument Section) installed on the pilot's instrument panel. Wing flap flutter is prevented by an irreversible gear contained in the operating mechanism at each end of the flaps.

Note

The adjustment of the wing flaps for angular movement and for their position in relation to the wings is described in paragraph 3. *b.* (8) *(e)*, this section.

(b) WING FLAP ELECTRICAL CONTROL LEVER. *(See figure 49.)*—For instructions on the removal, maintenance repair and installation of the wing flaps electrical control lever mechanism on the control pedestal, refer to paragraph 15. *d.* (3), this section.



1. Electric Motor
2. Main Gear Box Access Door
3. Limit Switch Access Door
4. Torque Tube Actuating Shaft

Figure 75 — Wing Flap Electrical Drive Unit

(c) MAIN GEAR BOX.

1. DESCRIPTION.—The main gear box *(figure 76)* is a part of the wing flaps electrical drive unit installed on the rear spar cross tie plate in the bomb bay. Attached to the main gear box are an electric motor which actuates the gears, and torque shafts which extend into each wing panel. The main gear box is an assembly which consists of reduction gears, shafts, limit switches, cams and a wing flap position indicator transmitter. The limit switches and cams turn off the electric motor when the flaps have reached their proper degree of travel.

2. REMOVAL.

a. Remove the bolts from the torque shaft *(3, figure 76)* on either the right-hand or left-hand side of the main gear box.

b. Remove the cover *(2, figure 76)* from the limit switches on the right-hand side of the gear box.

c. Disconnect the electrical wiring from each limit switch.

Note

If these wires are not numbered according to their positions, they should be labeled to facilitate installation.

d. Disconnect the cam shaft *(8, figure 76)* on the middle right-hand side of the box by loosening the fitting.

e. Disconnect the electrical wiring from the motor.

f. Remove the electrical plug from the position indicator transmitter on the upper left-hand corner of the gear box.

g. Remove the nuts from the four mounting bolts and remove the gear box from the tie plate.

3. DISASSEMBLY.

a. Remove the motor *(1, figure 75)* attached to the gear box with four bolts.

b. Remove the limit switches *(7, figure 76)* by removing the screw assembly and the two adjusting bolts and springs.

c. Remove the oblong cover *(2, figure 75)* from the front of the gear box.

d. Remove the cap *(10, figure 76)* from the lower right-hand side of the box.

e. Remove the nut from the right-hand side of the flap drive shaft *(3, figure 76)*.

f. Remove the bolt from the main (largest) gear.

g. Tap on the right-hand side of the drive shaft *(3, figure 76)* to remove the left-hand bearing, the oil seal and the lock ring.

h. Pull the drive shaft to the left.

i. Remove the drive shaft, then remove the right-hand bearing.

j. Remove the lock ring and washer from the limit switch cam shaft *(4, figure 76)* and tap out the plug.

k. Remove the nut and 2 washers from the bronze cam shaft.

l. Pull out the cams.

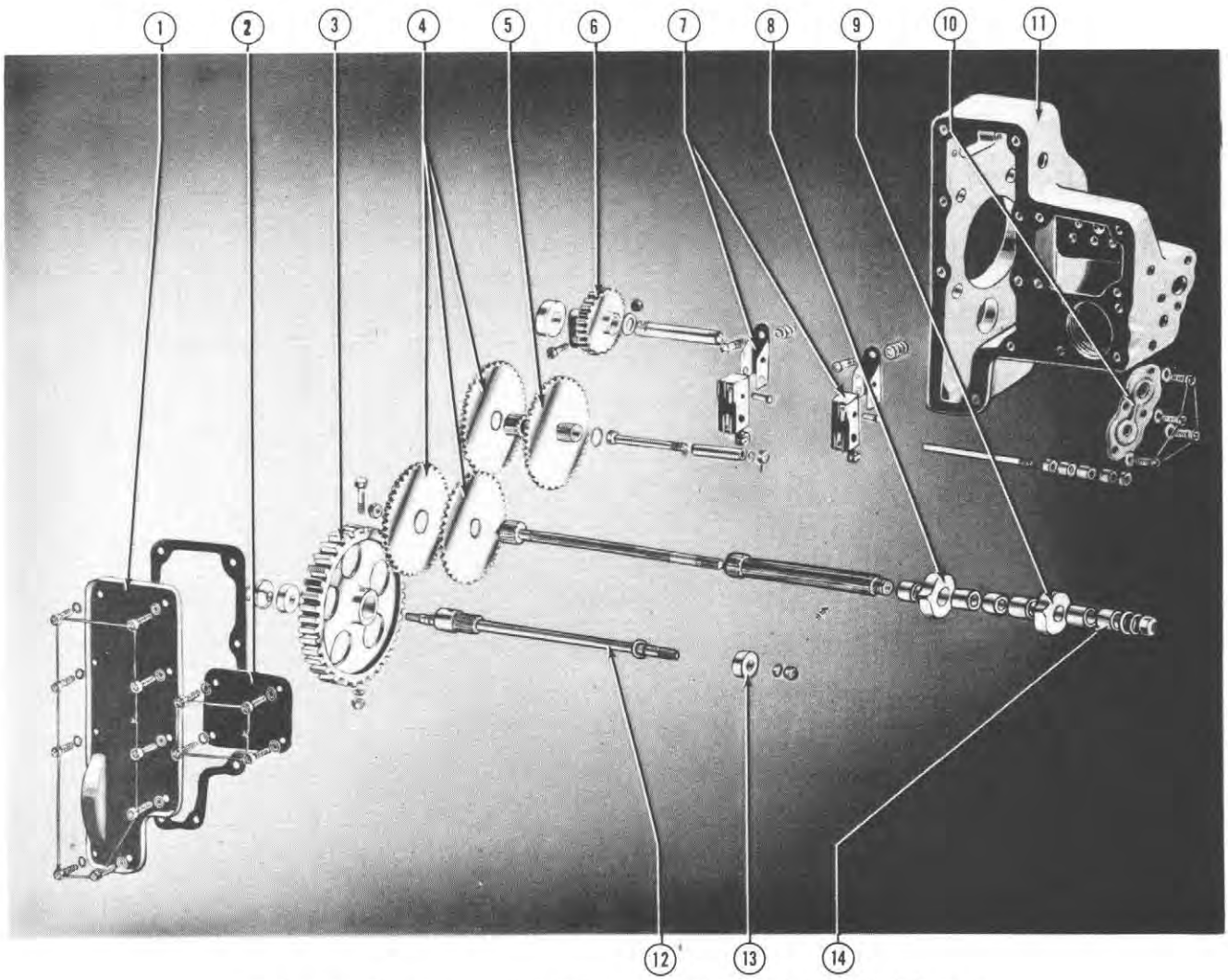
m. Remove the nut from the gear on the steel cam shaft *(4, figure 76)* on the left-hand side of the gear box and remove the gears.

n. Remove the steel cam shaft through the motor mounting hole.

o. Remove the bronze cam shaft.

p. Remove the upper bronze gears *(4, figure 76)* by removing the short bolt through the side of the box.

q. Loosen the bolt in the indicator gear *(6, figure 76)* in the upper part of the gear box and tap the shaft on the right-hand side of the box to remove the shaft and the left-hand seal from the left-hand side of the box. Protect the oil seal from the rivet on the shaft with a steel disc.



1. Wing Flap Gear Case Inspection Cover
2. Wing Flap Limit Switch Cover
3. Main Shaft Gear
4. Intermediate Gear
5. 1/10 Revolution Idler Spur Gear
6. Indicator Gear
7. Limit Switch
8. Cam A
9. Cam C
10. Main Shaft Bearing Cap
11. Wing Flap Actuator Case
12. Main Shaft
13. Fafnir Bearing
14. Spacers

Figure 76—Wing Flap Actuator (Main Gear Box)

4. MAINTENANCE REPAIR OR REPLACEMENT.–Replace worn or damaged parts in the gear box.

5. ASSEMBLY AND INSTALLATION.–Reverse the removal and disassembly procedure given above.

CAUTION

Install the motor mounting bolts in the proper positions on the main gear box before starting to assemble the gear box. Install the cams and bronze gears before final installation of the main (largest) gear. Do not disassemble the cams from the bronze shaft unless repair or replacement is required. If the cams must be removed, mark them so that they can be returned to the same place and position. Cam "C" *(9, figure 76)* should be in the position which causes the limit switch to be depressed. After the gear box has been assembled, spread Spec. G-10 grease on all of the gears. If adjustment of the limit switches or the gear box is required following installation of the main gear box, refer to paragraph 3. *b.* (8) *(e)*, this section.

6. ADJUSTMENTS.–To adjust the travel of the wing flaps, refer to paragraph 3. *b.* (8) *(e)*, this section.

7. TEST AFTER INSTALLATION.

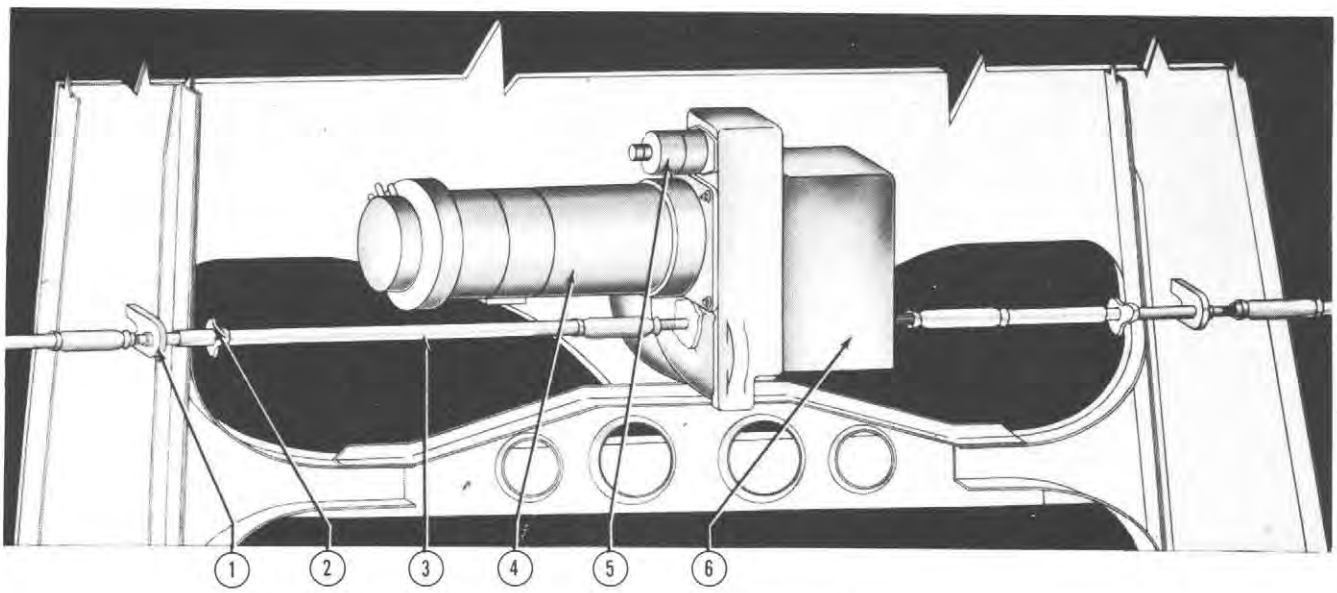
a. Place the control lever in the "UP" position and check for alignment of the flaps relative to the trailing edge of the wing.

b. Check the LANDING position in the same manner; the correct travel is 52 ± 2 degrees.

c. If the tests show any error in movement of the flaps, refer to the instructions on adjustment, paragraph 3. *b.* (8) *(e)*, this section.

(d) WING FLAP GEAR BOXES. *(See figure 80.)*

1. DESCRIPTION.–Five small gear box and actuating screw assemblies are installed on the aft spar in each wing panel. The gear boxes are connected to the torque shafts *(3, figure 78)* which extend from the main gear box in the bomb bay into each wing panel. When the wing flap gear boxes are actuated, the force is transmitted to the flaps by means of the actuating



1. Wing Flap Actuating Torque Tube Support
2. Wing Flap Actuating Torque Tube Disconnect
3. Wing Flap Actuating Torque Tube
4. Electric Motor
5. Wing Flap Position Indicator Transmitter
6. Wing Flap Actuator

Figure 77 — Wing Flap Operating Mechanism in Bomb Bay

screws. Protective shrouds *(6, figure 79)* are installed on the actuating screws on both sides of the gear boxes to keep out foreign matter which causes wear. Tubular shrouds, attached with clamps and sealed with friction tape, are installed on both ends of the actuating screws on the inboard flaps and on the forward end of the actuating screws in the outboard flaps. Telescopic shrouds attached with snap rings are installed on the outboard flap actuating screws aft of the gear boxes. The telescopic shrouds are assembled in two pieces and may be removed without removing the actuating screws from the gear boxes.

2. REMOVAL.

a. INBOARD FLAP GEAR BOXES.

(1) Operate the flaps to the down position.

(2) Disconnect the flap door actuating links *(7, figure 51)* and let the door hang down to make ample room for the removal of the gear box.

(3) Detach the torque tube *(5, figure 79)* at the disconnect *(7, figure 79)* between the two boxes.

(4) Remove the fairlead support at the center of the torque tube and remove the tube section from the airplane.

(5) Disconnect the aft shroud attaching clamp. *(See 1, figure 79.)*

(6) Disconnect the actuating screw *(10, figure 51)* from the linkage.

(7) Rotate the screw with the fingers to remove it from the gear box and the aft shroud. The shroud will remain suspended in the support. If desired the shroud may be taken out later by pushing it back into the opening left by the removal of the gear box.

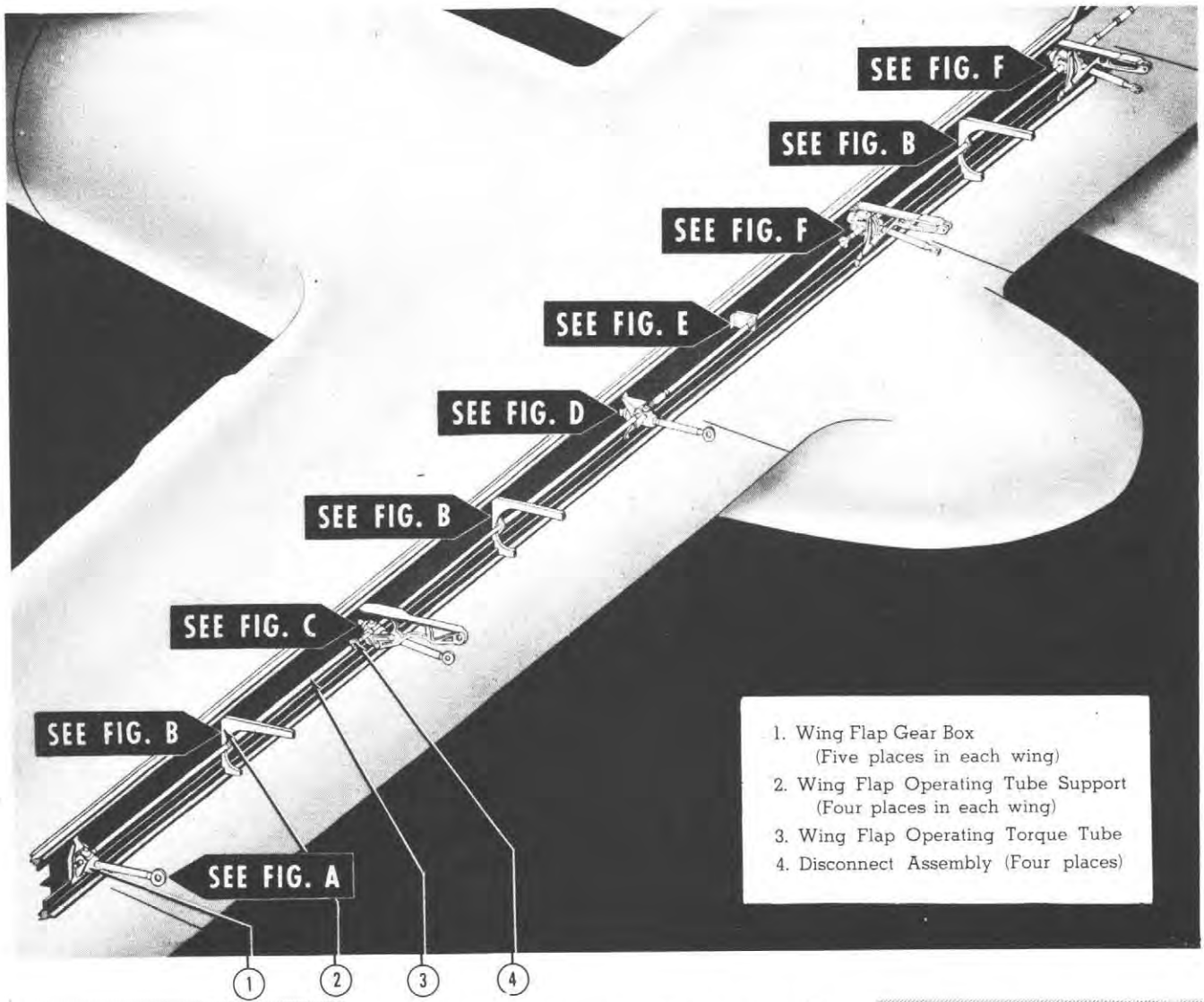
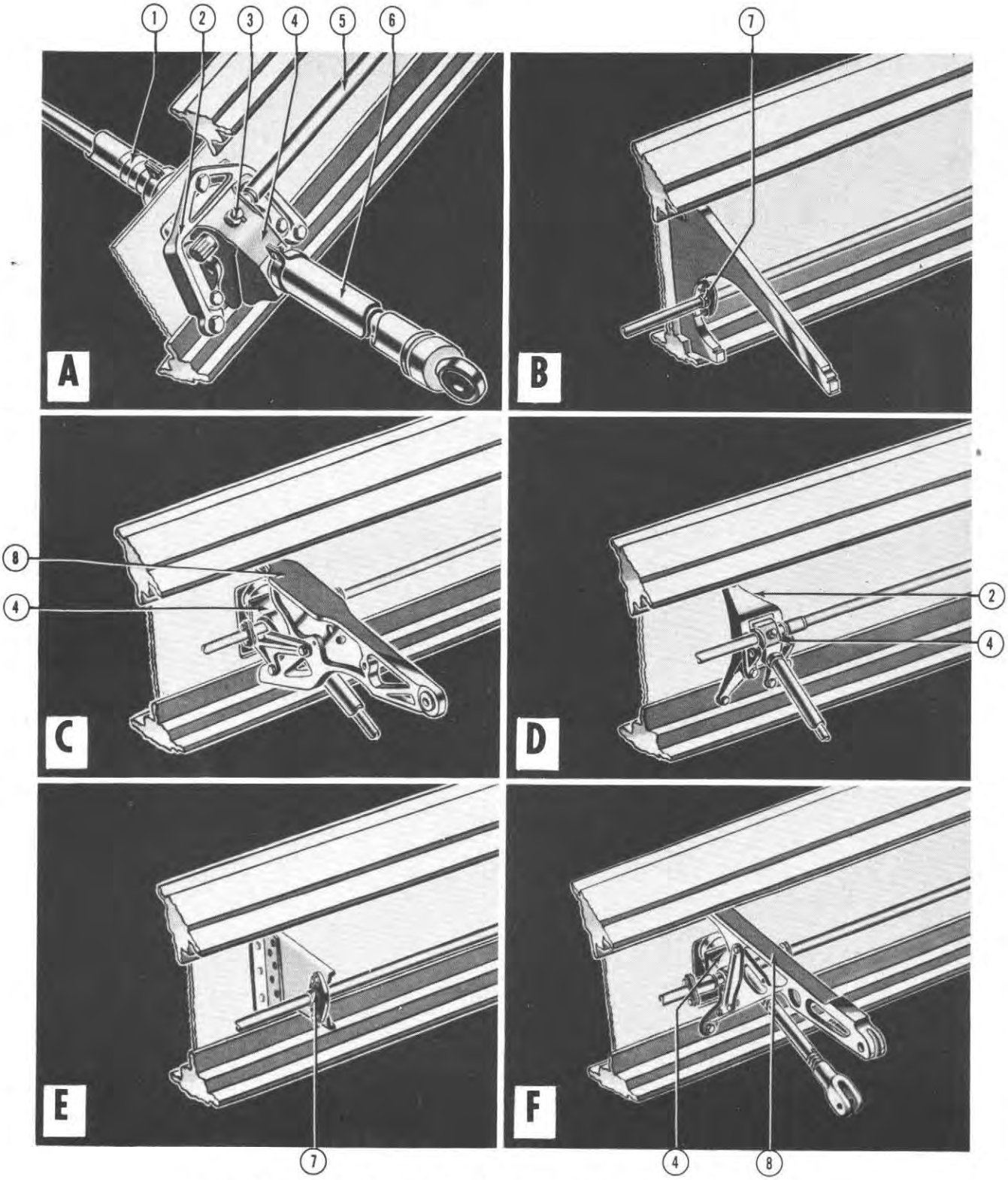


Figure 78 — Flap Operating Mechanism in Wing



1. Wing Flap Actuating Screw Shroud (Forward)
2. Gear Box Support
3. Alemite Lubricator
4. Flap Gear Box
5. Flap Actuating Torque Tube
6. Actuating Screw Shroud (Aft)
7. Torque Tube Support
8. Hinge Support

Figure 79 — Detail—Wing Flap Operating Mechanism

(8) Remove the brackets *(2, figure 79)* which attach the gear box to the wing rear spar.

(9) Remove the forward shroud from the gear box by loosening the attaching clamp. Be careful not to bend or damage the shroud.

(10) Remove the gear box and the shroud.

b. OUTBOARD FLAP GEAR BOXES.— The procedure for the removal of the outboard flap gear boxes is the same as that for the inboard flaps with the following exceptions:

(1) In the case of the center and outboard gear boxes the aft shroud will be removable from the airplane with the actuating screws.

(2) In the case of the inboard gear box the aft shroud will be removable with the actuating screw and the gear box and the forward shroud will be removable as an assembly.

3. DISASSEMBLY.

a. Remove the three bolts *(1, figure 80)* which secure both side plates on the case.

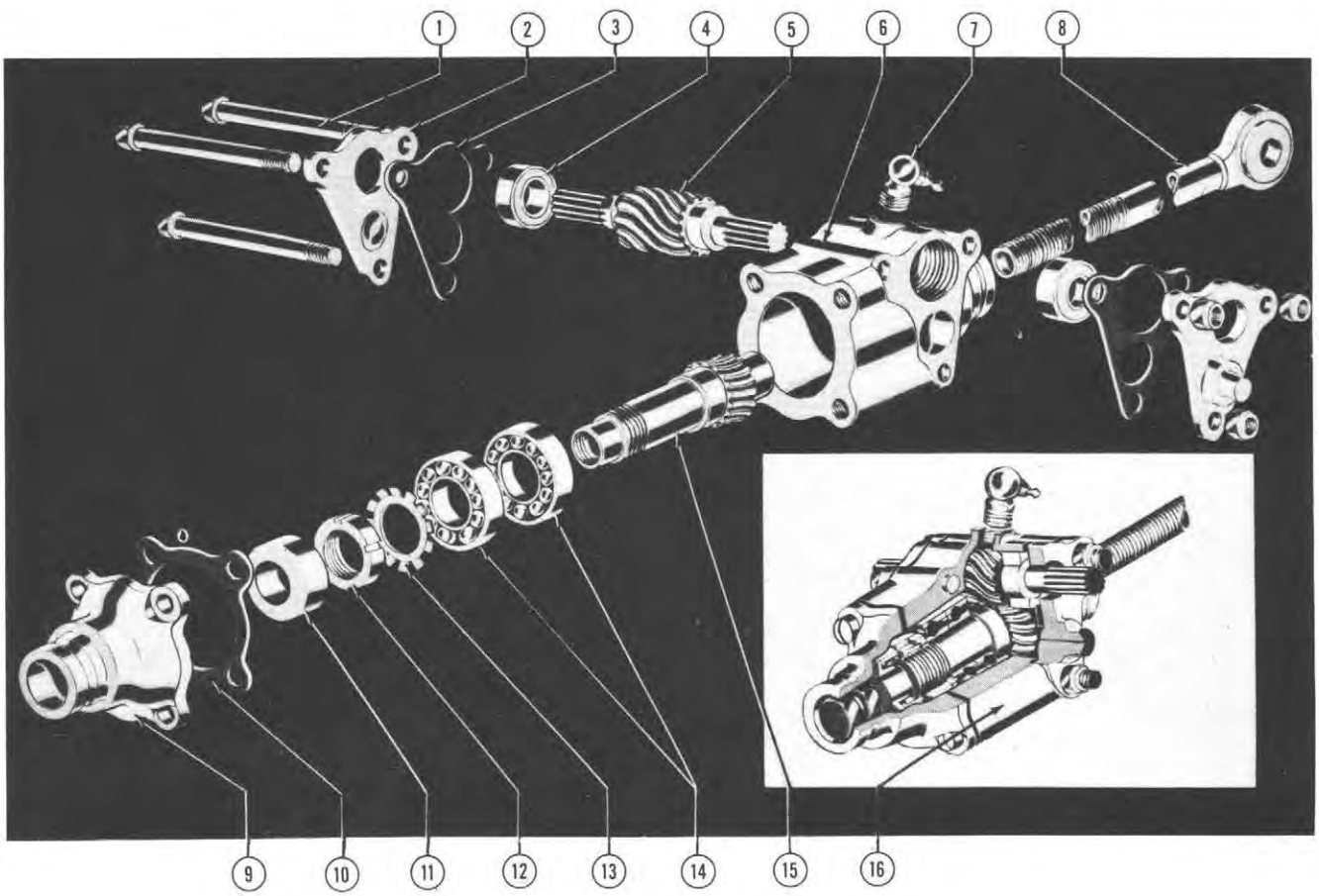
b. Remove the side plate gaskets carefully to avoid damaging them.

c. Remove the worm gear and shaft *(5, figure 80)* by hitting the end of the shaft on a wooden bench or block to force the shaft and one bearing out of one end.

d. Remove the four bolts and the cap *(9, figure 80)* from the end of the case.

e. Remove the gasket carefully to avoid damaging it.

f. With the gear box in hand, hit the end



1. Bolt (3 places)
2. Plate
3. Gasket
4. Bearing
5. Worm
6. Housing
7. Alemite Lubricator
8. Actuating Screw
9. Cap
10. Gasket
11. Oil Retainer
12. Nut
13. Washer
14. Fafnir Bearing
15. Worm Wheel (Phosphor Bronze)
16. Gear Box Assembly

Figure 80 — Typical Wing Flap Gear Box

of the actuating screw *(8, figure 80)* on a wooden bench or block to force the worm wheel and bearings out of the case.

g. Remove the actuating screw from the worm wheel.

4. MAINTENANCE REPAIR OR REPLACEMENT.—Worn or damaged actuating screws or worm gears in the wing flap gear boxes shall be replaced. Wear may be revealed by a chattering noise made when the gear boxes are operated, or it may be revealed on visual inspection of the actuating screws. However, wear is most apt to occur in the phosphor bronze worm wheel in the gear box. With the flap in any position other than up, excessive play can be detected by shaking the flap by hand.

5. ASSEMBLY.

a. If the bearings *(14, figure 80)* have been removed from the worm wheel, re-install them so that the marked sides are face to face.

b. Install the lock washers and the ring nut on the worm wheel *(15, figure 80)*; the tabs on the lock washer must be bent into slots on the ring nut.

c. Press the worm wheel and bearings into the case.

d. If the gaskets are not torn or damaged, they may be used again.

e. Place the gasket and cap *(9 & 10, figure 80)* on the end of the case, and secure with the four bolts and washers.

f. Press the worm gear *(5, figure 80)* and bearing into the case.

g. Place the gaskets and side plates *(2 & 3, figure 80)* on the side of the case, and secure them with the three through bolts and washers.

h. Fill the case with Beacon M-285 (Spec. ANG-3) grease or the equivalent.

6. INSTALLATION.

a. Place the gear box in position with the pivot pin inserted in the bracket.

b. Install the pivot bracket on the opposite side.

c. Screw the actuating screw into the gear box far enough to allow the other end to be connected to the hinge assembly.

d. Attach the shroud to the gear box with the clamp or snap rings. Seal the tubular shrouds with masking tape.

e. Slide the splined connection on the drive shaft of the gear box; install the bolts in the torque shaft connection and attach fibre stop nuts.

(e) TORQUE TUBES IN WING. *(See 3, figure 78.)*

1. DESCRIPTION.—The five wing flap gear boxes installed in each wing panel are actuated by a series of four torque tube assemblies attached to the aft side of the rear spar. The tubes extend from the main wing flap gear box in the bomb bay to the outboard end of the outboard flap. The tubes are interconnected by means of the splined shaft which extends through each wing flap gear box.

2. REMOVAL.—To remove any one or all of the torque tube assemblies from the trailing edge of the wing proceed as follows:

a. Operate the flaps to the down position.

b. Remove the fairlead support installed half way between the gear boxes by removing the two screws.

c. Disconnect the torque tube at the disconnect assembly by removing the three bolts.

d. Pull the other end of the torque tube from the joint assembly.

e. Remove the torque tube.

---

d. MOVABLE SURFACES TROUBLE SHOOTING LIST.

AILERON, ELEVATOR AND RUDDER CONTROLS

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Surface cannot be moved.	*a.* Foreign object in controls.	*a.* Remove the object.
	b. Broken control cable.	*b.* Replace cable. See Cable Rigging Chart, *figure 74.*
	c. Broken rudder pedal.	*c.* Replace broken part. *(See figure 65.)*
	d. Missing or broken cable connecting bolt.	*d.* Install a new bolt.
	e. Broken or damaged actuating rod.	*e.* Replace the actuating rod. See paragraph 3. *c.* (2).
	f. Broken rudder, elevator or aileron horn.	*f.* Replace the broken part. See paragraph 3. *c.* (2).
	g. Frayed cable in control column head.	*g.* Replace the cable. *(See figure 69.)*

TROUBLE	PROBABLE CAUSE	REMEDY
2. Insufficient travel.	*a.* Broken fairleads.	*a.* Replace broken fairlead.
	b. Cracked or damaged pulley.	*b.* Replace the pulley.
	c. Insufficient cable tension.	*c.* Adjust the tension according to the Cable Rigging Chart. *(See figure 74)*
	d. Improper setting of control horn stop.	*d.* Adjust the stop as outlined in this paragraph.

TRIM TAB CONTROLS

1. Tab cannot be moved.	*a.* Foreign object in controls.	*a.* Remove the object.
	b. Broken cable.	*b.* Replace the cable. See Cable Rigging Chart, *figure 74.*
	c. Broken operating control.	*c.* Replace the broken part.
	d. Broken or damaged actuating rod.	*d.* Replace the rod. See paragraph 3. *c.* (5).
2. Insufficient tab travel.	*a.* Foreign object in controls.	*a.* Remove the object.
	b. Incorrect position of tab operating control.	*b.* Remove control, turn it to zero position when tab is in neutral position, and reinstall control.
	c. Broken pulley bracket.	*c.* Replace the bracket.
	d. Cracked or damaged pulley.	*d.* Replace the pulley.
	e. Cracked or broken fairlead.	*e.* Replace the fairlead.
	f. Drums improperly wrapped.	*f.* Re-wrap drum. (Illustrated in text.)
3. Excessive tab travel.	*a.* Incorrect position of tab control.	*a.* Remove control, turn it to zero position when tab is in neutral position, and reinstall control.

WING FLAP CONTROLS

1. Flap comes up too tightly against stop.	*a.* Cam "C" limit switch out of adjustment.	*a.* Turn the adjustment screw on Cam "C" limit switch counterclockwise. See paragraph 3. *c.* (11), this section, and instructions inside cover on main gear box.
2. Flap does not come up far enough.	*a.* Cam "C" limit switch out of adjustment.	*a.* Turn the adjustment screw on Cam "C" limit switch counterclockwise. See paragraph 3. *c.* (11), this section, and instructions inside cover on main gear box.
3. Flaps travel beyond LAND- position.	*a.* Cam "A" limit switch out of adjustment.	*a.* Turn the adjustment screw on Cam "A" limit switch counterclockwise. See paragraph 3. *c.* (11), this section, and instructions inside cover on main gear box.
4. Flaps travel short of LANDING position.	*a.* Cam "A" limit switch out of adjustment.	*a.* Turn the adjustment screw on Cam "A" limit switch counterclockwise. See paragraph 3. *c.* (11), this section, and instructions inside cover on main gear box.
5. One flap out of alignment.	*a.* Actuating screws not set properly.	*a.* Detach the torque tubes from flap at disconnects, rotate torque tube on flap. See paragraph 3. *c.* (11), this section.
6. Motor runs but flaps fail to operate.	*a.* Gears jammed in main gear box.	*a.* Repair or replace main gear box. *(See figure 76.)*
	b. Torque tubes disconnected.	*b.* Connect the torque tubes. *(See 3, figure 78.)*
7. Motor fails to operate.	*a.* Broken electrical wire or faulty electrical connection.	*a.* Check the wiring. See Wiring Diagram following paragraph 15, this section.
	b. Oily commutator.	*b.* Clean commutator. See paragraph 15. *b.* (2), *(b)* 3. d., this section.
	c. Brushes worn.	*c.* Replace brushes. See paragraph 15. *b.* (2), *(b)* 3. b., this section.
	d. Motor burned out.	*d.* Install new motor.

4. FUSELAGE

a. GENERAL. – The fuselage of this airplane is an all-metal structure of alclad skin, shaped and reinforced by aluminum alloy ribs, bulkheads and longitudinal members.

Length of fuselage is 50 feet 9 inches (A-26B), 51 feet 3 inches (A-26C); maximum width is 5 feet, 2.04 inches; maximum height is 5 feet, 10 inches.

The fuselage is assembled in six parts: the nose, main fuselage, pilot's compartment enclosure, gunner's compartment enclosure, aft section, and tail cone. Entrance to these parts is accessible by means of doors *(figures 6, 7 & 8)* with the exception of the tail cone.

The nose wheel well, bomb bay, and pilot's and gunner's compartments are integral parts of the fuselage.

The alclad skin of the fuselage is fortified in vital areas *(figure 555)* by $\frac{5}{16}$-inch dural plates designed to deflect angular shell fire. The pilot's and gunner's compartment enclosures are fabricated of plexiglas.

b. NOSE. *(See figures 82 & 83.)*

(1) DESCRIPTION.–This nose section is located forward of the pilot's enclosure and is removable as a complete unit. Two types of interchangeable noses are manufactured for this airplane: a bombardier nose, and an all-purpose (multi-gun) nose. An access door is located on the under side and an access window for cleaning the bomb sight window from inside.

(a) BOMBARDIER NOSE.–The upper half of the bombardier nose consists of plexiglas. The bottom and side skin of the nose is made of $\frac{5}{16}$-inch dural deflector plating. At the forward end is a bomb sight window of laminated glass. The access door in the bottom of the nose is opened by pulling down a lever in the door. The lever releases latches inside and lets the door swing down to a vertical position. At the bottom end of the extended door is a sliding ladder for entrance.

(b) ALL PURPOSE NOSE.–The access door of the all-purpose nose *(24, figure 6)* contains no opening

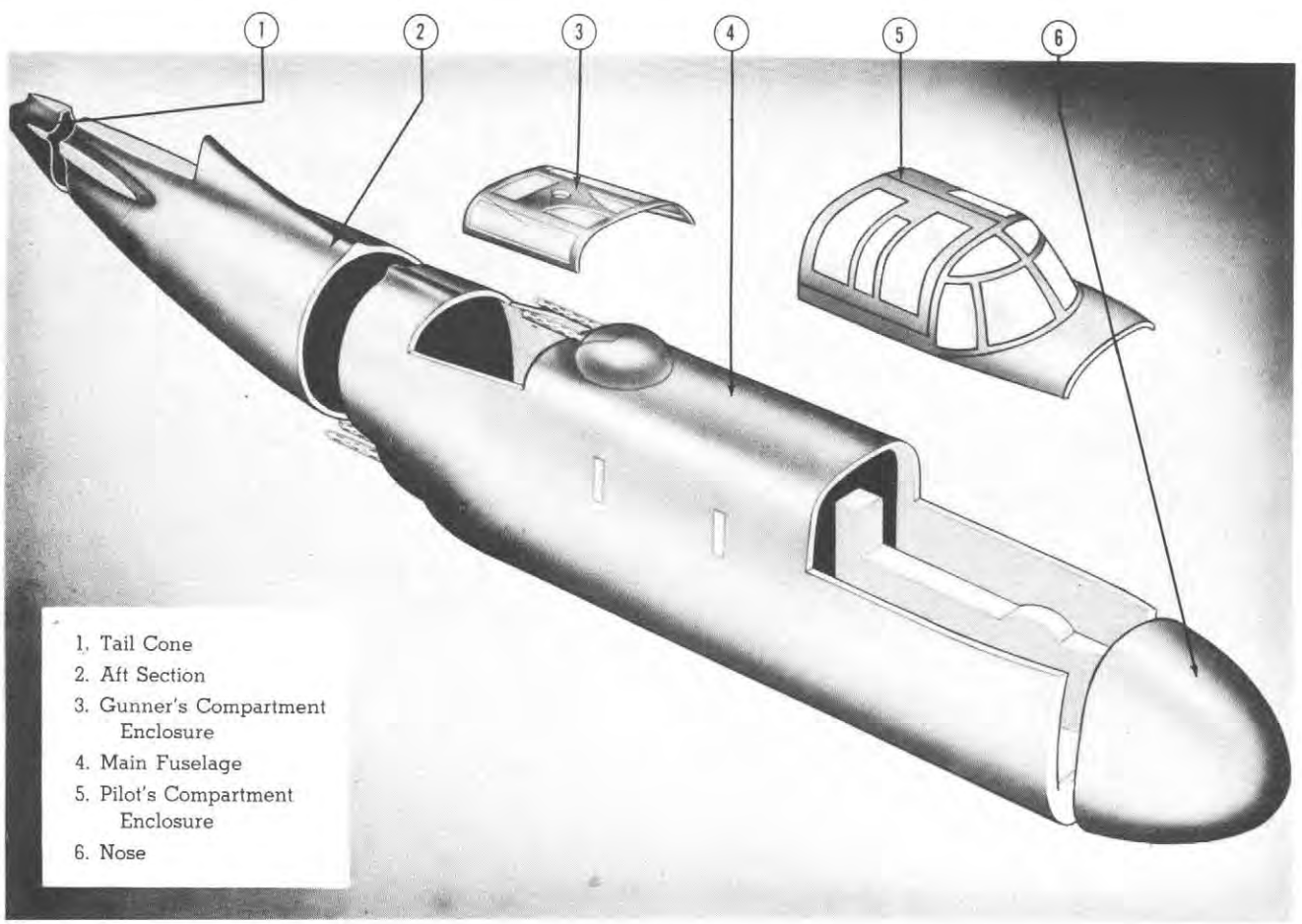


Figure 81 — Fuselage (Disassembled)

Figure 82—All-Purpose Nose

lever. The door must be opened by releasing the Dzus fasteners around the panel. The upper structure is all metal rather than plexiglas. On either side at the top are two access panels to the guns, and below these, two gun or cannon fairing access panels. The four panels may be removed by releasing the Dzus fasteners around the panels. Seals are provided where the guns penetrate the nose to keep out dust. Other seals at station No. 0 prevent the smoke resulting from the firing of the guns from entering the pilot's compartment. Heavy armor plate of "Rey" metal covers the entire area at station No. 0 where the nose is bolted to the main fuselage.

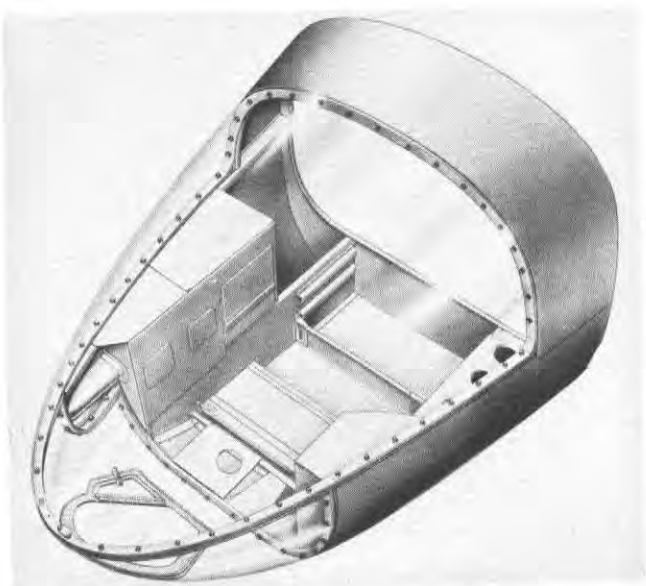


Figure 83—Bombardier Nose (Exterior View)

(2) REMOVAL.

(a) Support the nose section as shown in *figure 17.*

(b) If the nose is the bombardier type, disconnect the electrical plugs, bombing controls, heating system ducts, etc.

(c) Remove the tape covering the juncture of the fuselage and nose section.

(d) With the nose section securely supported, disengage the four lower steel bolts from within the fuselage. After rechecking to make certain that all wiring has been disconnected, remove the two remaining steel bolts at the top, and carefully move the nose section away from the airplane. On the all-purpose nose there are eight bolts, two on top and six on the bottom.

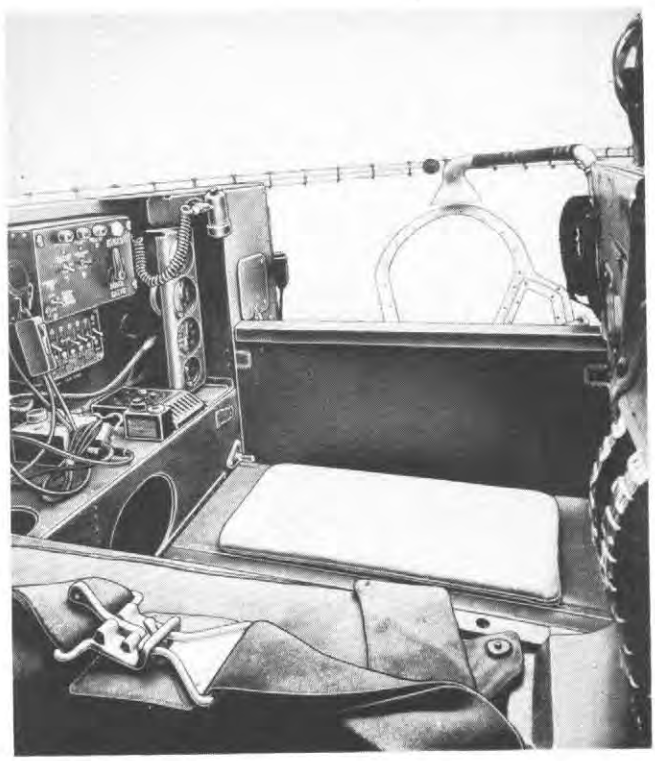


Figure 84—Bombardier Nose (Interior View)

(3) DISASSEMBLY.

(a) To remove the fixed plexiglas panels from the nose section of the bombardier model, remove the attaching bolts located at the edge of each panel.

(b) To remove the access door, remove the pins securing the bungee cord and latching arm; remove the wire from the strip hinge and remove the door.

(4) MAINTENANCE REPAIR OR REPLACEMENT.—For instructions on the repair of the nose skin and structure, refer to the Structural Repair Handbook (T.O. No. AN01-40AJ-3).

(5) ASSEMBLY AND INSTALLATION. – Reverse the procedure outlined in paragraphs (2) & (3) above. Attach cotton fabric sealing tape with clear nitrate dope. Install and tighten the NAS 147 bolts in the nose to a torque force equal to 570-640 inch-pounds.

(6) TEST AFTER INSTALLATION.–Check all equipment affected by removal of the nose for efficient operation.

c. NOSE WHEEL WELL. *(See 22, figure 6.)*–A nose wheel well, provided with hydraulically operated doors which are closed when the airplane is in flight, is located under the pilot's compartment. Description of nose wheel and doors, with maintenance instructions, will be found in paragraph 5. *c.* (6), this section.

d. PILOT'S COMPARTMENT.

(1) DESCRIPTION.–The pilot's compartment is located immediately aft of the nose section. In this compartment, compactly arranged, are the flight and engine controls for the airplane with seats for the pilot and gunloader. The normal entrance to the pilot's compartment is by means of a hinged door through the top of the enclosure. This door is also an emergency escape hatch. Entrance to this compartment can also be made through an opening from the bomb bay, provided the bomb bay is not loaded with torpedoes or bombs larger than the 300-pound size, or that the SCR-522 radio set is not installed behind the gunloader's seat. The entry is accomplished by detaching the cannon shellcase catcher, which is held over the opening by a zipper fastener, and raising the gunloader's hinged seat. A cable and ball assembly attached to the top of the pilot's enclosure is provided to hold the seat in the raised position. Insert the cable in the slot on the forward edge of the seat so that the ball catches under the forward edge. To the right of the gun-loader's seat is a dural collapsible ladder used for entrance and exit to and from the pilot's compartment. The ladder slides through the lower right side of the fuselage to an easy access distance from the ground.

The windshield *(5, figure 81)* consists of slanted panels of laminated glass. Plexiglas panels cover the top and sides of the enclosure. Neoprene seals are fitted between panels to exclude outside air and vibration. The enclosure may be fabricated in any one of the three following combinations:

No. 1. Sliding panels on the sides with a fixed panel and hatch at the top.

No. 2. Two fixed curved panels on the top and left with a small ventilating panel in the front panel, and a hatch on the top and right.

No. 3. Two panels hinged to the sides (clam shell type) and separated from a beam at the top. Each of the above hatches contain two release levers. One releases latches to lift the hatch for normal entrance and exit. The other (emergency) releases pins in the hinges and lets the air stream carry away the hatch for emergency exit.

CAUTION

When cleaning plexiglas, be certain that the agent used does not contain an abrasive or a solvent. The best cleaner is soap and water solution applied with a clean, soft cloth or sponge. Do not use aviation gasoline, Ethyl gasoline, acetone, lacquer cleaners, benzine, or fire extinguisher fluids, because these solvents will soften or "craze" the surface. If any of these fluids come into contact with the plexiglas at any time, they should be washed off immediately. As most window cleaning sprays may contain solvents, they should not be used on plexiglas. Kerosene or clear gasoline may be used to remove grease or oil.

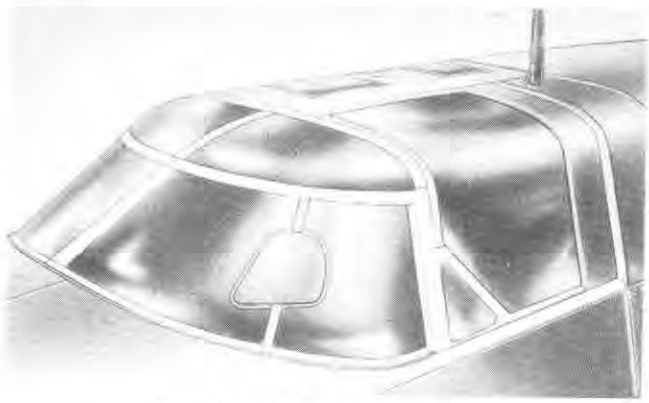


Figure 85—Pilot's Enclosure

(2) REMOVAL.

(a) PILOT'S COMPARTMENT ENCLOSURE.

1. Disconnect the windshield defroster ducts inside the nose section.

2. Disconnect the lines at the unions at the forward right-hand corner of the enclosure.

3. Working within the nose section, remove the sheet metal screws from the cowling plate located below the windshield.

4. Disconnect the four vacuum lines from the vacuum selector valve located above and aft of the pilot's seat.

5. Remove the clip from the line installed inboard of the radio shelf.

6. Disconnect the forward end of the radio equipment shelf located in back of the pilot's seat. Block up the shelf from below to prevent bending of the attached end of the shelf.

7. Remove the vertical brace supporting the instrument panel.

8. Disengage the bolts which attach the enclosure to the fuselage and remove the enclosure.

(b) WINDSHIELD.—To remove the windshield without removing the pilot's compartment enclosure, detach the screws installed around the edges of the windshield and lift off the retaining strip.

(c) SLIDING WINDOWS. (On some airplanes.)

1. Remove the upper and lower aft tracks.

2. Remove the latching lever.

3. Slide the window aft and out from the enclosure.

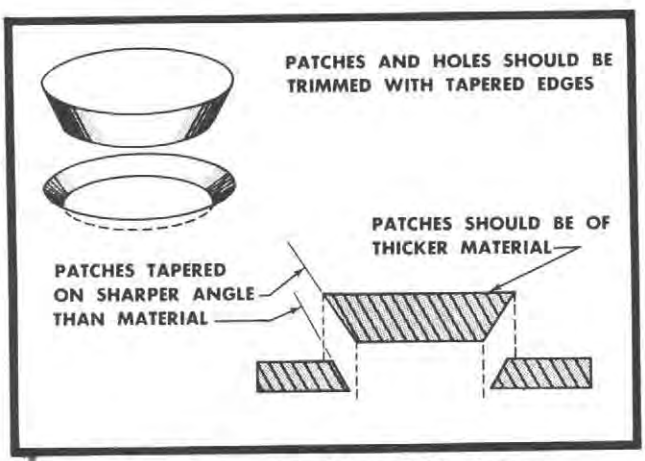


Figure 86 — Patching of Plexiglass

(d) FIXED PLEXIGLAS PANELS. — Remove the screws and the sealing strip, and lift out the panel.

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) WINDSHIELD.—Replace if damaged.

(b) PLEXIGLAS PANELS.—Plexiglas panels, when damaged, may be repaired temporarily. The material is easy to work and readily softened by the application of heat or solvent. When replacement panels are not available, the following methods of repairing certain kinds of damage may be used:

1. CRACKS.—At the first sign of cracking, a hole $\frac{1}{8}$ inch to $\frac{3}{16}$ inch in diameter should be drilled at the end of the crack. This helps prevent further splitting by distributing the strain over a larger area. A quick method of patching involves the use of wing fabric or other tough cloth applied with a solvent, a plexiglas cement, or in emergency, acetate "dope." If a crack extends from channel to channel, a simple method of repair is to drill holes along each side of the crack at least one-half inch away from it, and bind the two pieces together by lacing them with flexible wire or stout cord. A more satisfactory method of patching a cracked panel until it can be replaced, is to cement a plexiglas or possibly a cellulose acetate patch over the crack. If the damaged panel is curved, heat the patch and form it by holding it against the damaged surface. To one of the surfaces, apply a cement such as that which can be made by dissolving plexiglas shavings in acetone or similar solvent until a syrup is obtained; apply the patch to the damaged surface with just enough pressure to force out all the air bubbles. The patch should be held in position from 10 to 20 minutes.

Note

In any repair operations requiring the use of cement, the area adjacent to the damaged surface should be covered with masking tape to protect it from the softening action of the cement.

2. BULLET HOLES.—When a bullet passes through plexiglas, it leaves a number of cracks radiating from the center of the hole. Drill holes at the end of these cracks, and then patch the bullet hole with plexiglas, cellulose acetate or fabric, following the same procedure as that for repairing cracks, described in the preceding paragraph. Another alternative is to insert a plexiglas or wooden plug in the hole until a more permanent patch can be cemented into place.

3. LARGE HOLES.—To patch a large hole in plexiglas, the hole is trimmed to a circle or oval and the edge of the hole is given a slight taper (the larger diameter on the outside). The patch should be cut out of plexiglas slightly thicker than the section to be repaired and given a more oblique taper than the hole itself. Edge of the patch is heated in an oven, or over an alcohol lamp, until it is soft and pliable. The patch is then forced into the hole and allowed to cool. Then it is removed, and its surfaces are masked with a tough masking tape or gummed cellophane, which is impervious to the action of plexiglas cement, or an equivalent such as ethylene dichloride. The edge of the patch is then allowed to soak in the cement until softened, the time varying from two to three minutes for ethylene dichloride, 30-45 minutes for plexiglas cement. The patch is inserted in the hole again, and left under pressure for 24 to 36 hours, preferably longer. Then clean up the patch by filing, sanding, and buffing it to the level of the patched surface.

4. CURVED SURFACES.—When the section to be patched is curved, a perfect fit may be obtained by cutting the patch first, and using it as a template. The patch first is heated until it is pliable, and then formed into the proper shape, by pressing it against the damaged surface. A protective layer of outing flannel or similar soft cloth should be used, while pressure is being applied. Outline of the patch, which should always be round or oval, is then scribed on the damaged surface. Then, saw at least a distance equal to the thickness of the plexiglas within the scribe lines, and sand or file the edges to a smooth 45-degree taper. Soak edge of patch in solvent until soft and then press patch into place. Let stand for 24 to 36 hours, and then dress the repaired surface.

WARNING

Adequate ventilation should be provided when working with plexiglas cements. Fumes from two of the solvents, ethylene dichloride and methylene, are apt to prove toxic if breathed for an extended period.

5. REMOVAL OF SCRATCHES.—When buffing equipment is not at hand, a good automobile body cleaner can be applied with a soft damp cloth to remove minor scratches. The area should be rubbed vigorously but not too long in one place. Rub with a free circular movement over a fairly wide area. When the scratches are removed or considerably reduced, the cleaner should be removed with a damp soft cloth and a good auto wax should be applied. Then polish with a dry, soft cloth. Deep scratches can be removed with a fine grade of sandpaper (320-A is suitable) which has been moistened to reduce the heat of friction. Wrap the paper around a block and sand with a free circular motion over a wide area.

(4) ADJUSTMENTS.—The sliding windows (if installed) in the pilot's compartment are so designed that they press tightly against the rubber seal. If a window is loose from the seal, the necessary tightness may be obtained by adjusting the two rods located above and below the window.

(5) ASSEMBLY AND INSTALLATION. – Reverse the procedure for removal as outlined in paragraph (2) above.

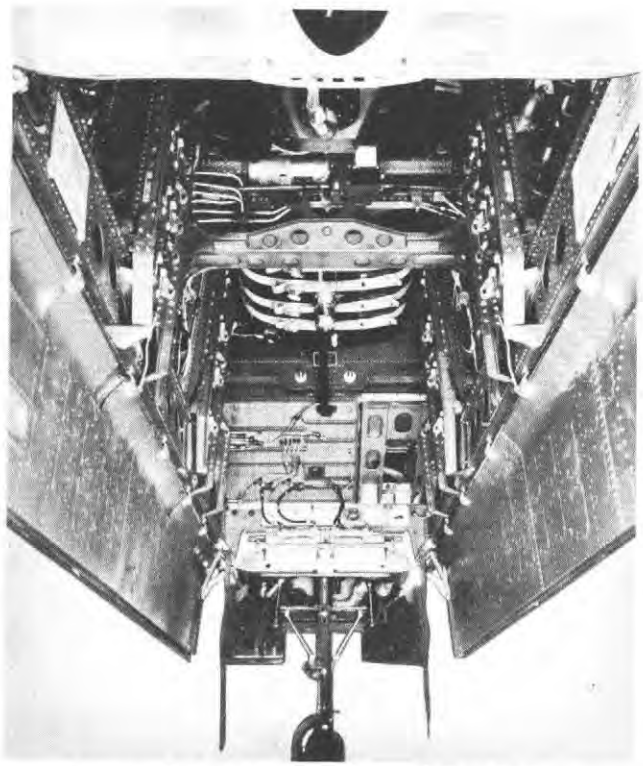


Figure 87—Interior View of Bomb Bay

e. BOMB BAY.—The bomb bay is located in the center portion of the fuselage and is divided by the wing rear spar cross tie plates into two compartments, fore and aft. The two hydraulically operated bomb bay doors, when closed, form part of the lower fuselage surface. Doors installed in the fore and aft bulkheads provide access to the pilot and gunner compartments, except when the bomb bay is carrying certain loads. (See *f.* (1), this section.) The right-hand bomb bay door incorporates a small removable door through which cameras may be operated.

Note

Maintenance of the bomb bay door structure is described in AN01-40AJ-3, Handbook of Structural Repair. Adjustment of the doors is described in paragraph 14. *d.* (10) *(b)*, this section.

f. GUNNER'S COMPARTMENT.

(1) DESCRIPTION.—The sighting station and control mechanism of the upper and lower gun turrets are installed in the gunner's compartment located aft of the bomb bay. The enclosure is constructed of plexiglas. An escape hatch is provided at the top of the enclosure. When the airplane is on the ground and the bomb bay doors are open, normal access to the gunner's compartment is gained by way of a sliding door located in the aft end of the bomb bay. However, when the airplane is loaded with torpedoes, or with bombs larger than the 300-pound size, the gunner's compartment is only accessible by way of the escape hatch *(3, figure 81)* in the gunner's enclosure. A removable camera door is installed in both sides of the compartment.

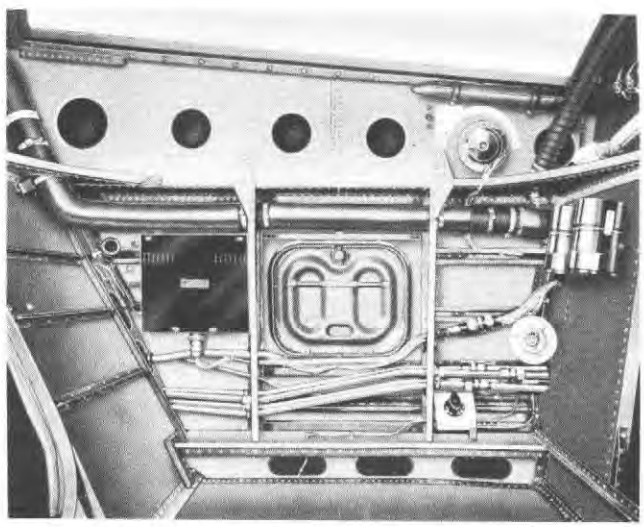


Figure 88—Gunner's Compartment (Sighting Station Not Installed)

(2) REMOVAL.

(a) GUNNER'S ENCLOSURE.

1. Remove the bolts at the upper sighting station bracket.

2. Remove the bolts around the enclosure. Remove the enclosure, being careful not to strike the sighting station.

(b) PLEXIGLAS PANELS.

1. Remove the screws and retainer strip from each panel.

2. Remove the panel and the sealing strip.

3. The sealing strip may be used again if in good condition.

(c) PILOT'S ESCAPE HATCH.—Pull the emergency release lever, freeing the hatch at the hinges and at the supporting braces.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—For the repair of cracks and holes in the plexiglas panels, refer to paragraph 4. *d.* (3) *(b)*, this section.

(4) ASSEMBLY AND INSTALLATION. – To assemble the gunner's compartment enclosure, reverse the removal procedure defined in *f.* (2) *(a)* above.

g. FUSELAGE AFT SECTION. *(See 2, figure 81.)*

(1) DESCRIPTION.—The fuselage aft section extends aft from a point (station 352), aft of the lower turret to the point (station 497) where the tail cone is attached. The fuselage aft section provides the attaching supports for the horizontal and vertical stabilizers, and the surface controls support assembly. This aft-section also houses radio, heating, ventilating, and photographic equipment. An access door for maintenance and inspection purposes is located immediately aft of the lower turret. A camera door is installed just aft of this access door.

(2) REMOVAL.

(a) Provide ample support for the fuselage aft section by means of jacks or hoists.

(b) Disconnect all fuselage lines at the bulkhead (station 352) directly aft of the lower turret compartment.

(c) Disconnect all cable turnbuckles at this location and tie them so that the cable will not unwind from the drums.

(d) Remove the tape which covers the juncture of the main fuselage and the fuselage aft section.

(e) Remove the attaching bolts.

Note

If handling problems make it advisable to remove the stabilizers, elevators, and rudder before detaching the fuselage aft section from the main fuselage, refer to removal instructions given in paragraphs 2. and 3., this section.

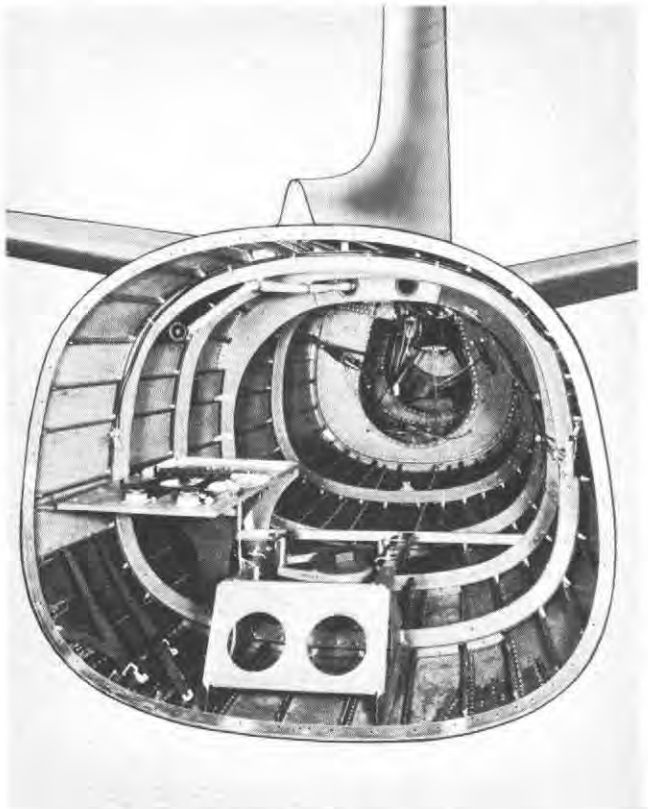


Figure 89—Fuselage Aft Section

(3) MAINTENANCE REPAIR.—For instructions on the repair of the fuselage structure or skin, refer to the structural Repair Handbook (No. AN01-40AJ-3).

(4) ASSEMBLY AND INSTALLATION. – Reverse the removal procedure given in paragraph (2) above. Use clear nitrate dope to attach a cotton fabric sealing tape of the juncture of the two sections. Tighten the AN4 bolts to a torque force equal to 50-60 inch-pounds.

(5) TEST AFTER INSTALLATION. – Check empennage flight controls for proper operation.

h. TAIL CONE. *(See 1, figure 81.)*

(1) DESCRIPTION.—The tail cone is located at the extreme aft end of the fuselage and is attached to the fuselage aft section by means of four bolts. Installed in the aft end of the cone is a plexiglas cover for the position and tail cone signal lamps.

(2) REMOVAL.

(a) A stand should be provided on which to lay the tail cone when it is removed. The working platform should not be more than three feet lower than the tail cone.

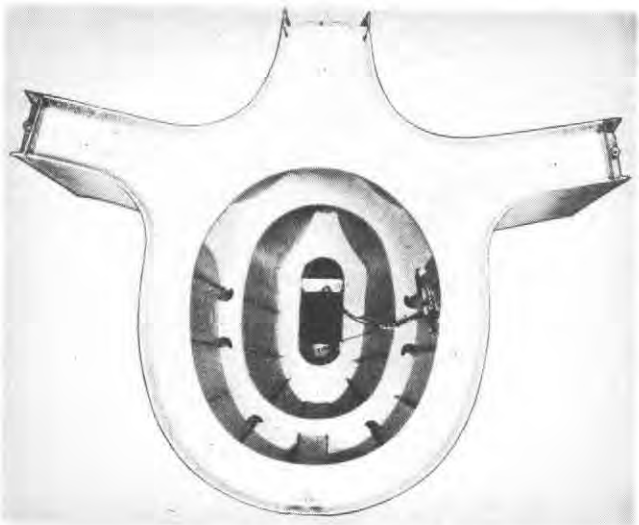


Figure 90—Tail Cone

(b) Remove the tape covering the juncture of the tail cone and the fuselage aft section.

(c) Remove the plate which covers the attaching bolt at the bottom of the tail cone by removing the two screws at the forward end of the cover plate, and pulling the plate forward about one-half inch to disengage the two spring clips which secure the cover plate at its aft end.

(d) Remove the bolt at the bottom of the tail cone.

(e) Removal of the tail cone requires two persons, one to hold the tail cone, while the other removes the remaining three bolts inside the fuselage. The bolts are located outboard of the closing channels, between the tail cone and the elevators, and between the tail cone and the rudder. To gain access to the bolts, move the elevators and rudder off the neutral position.

(f) After the bolts are removed, lay the tail cone on the stand. About three feet of free wire is provided for this purpose.

(g) Disconnect the electric wires at the front of the tail cone.

(3) DISASSEMBLY. – To remove the plexiglas cover from the tail cone, take out the screws located at the forward edge.

(4) MAINTENANCE REPAIR.—For instructions on the repair of cracks or holes in the plexiglas cover, refer to paragraph 4. *d.* (3) *(b),* this section. For instructions on the repair of the skin or framework, see Structural Repair Handbook No. AN01-40AJ-3.

(5) ASSEMBLY.—To install the plexiglas cover on the tail cone, proceed as follows:

(a) Place the plexiglas cover against the adapter.

(b) Place the lower section of the metal strip against the plexiglas and insert the screws.

(c) Turn in the screws until they begin to drag.

(d) To install the upper section of the metal strip, repeat *(b)* and *(c)* above.

(e) Tighten all screws equally.

(6) INSTALLATION. – To install tail cone on fuselage, reverse the REMOVAL procedure given in paragraph (2) above. Use clear nitrate dope to attach the cotton fabric sealing tape.

(7) TEST AFTER INSTALLATION.—Check the position lamp and the tail cone signal lamp for proper operation.

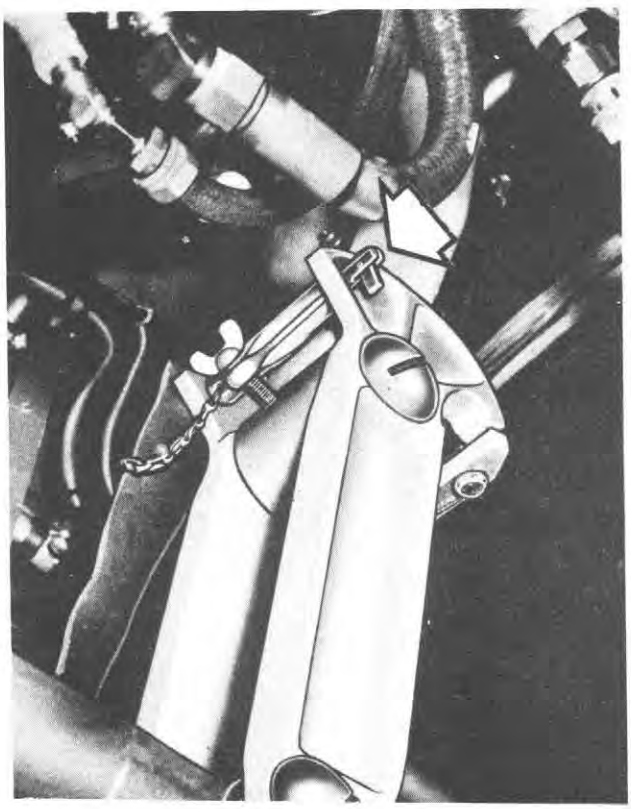
5. ALIGHTING GEAR

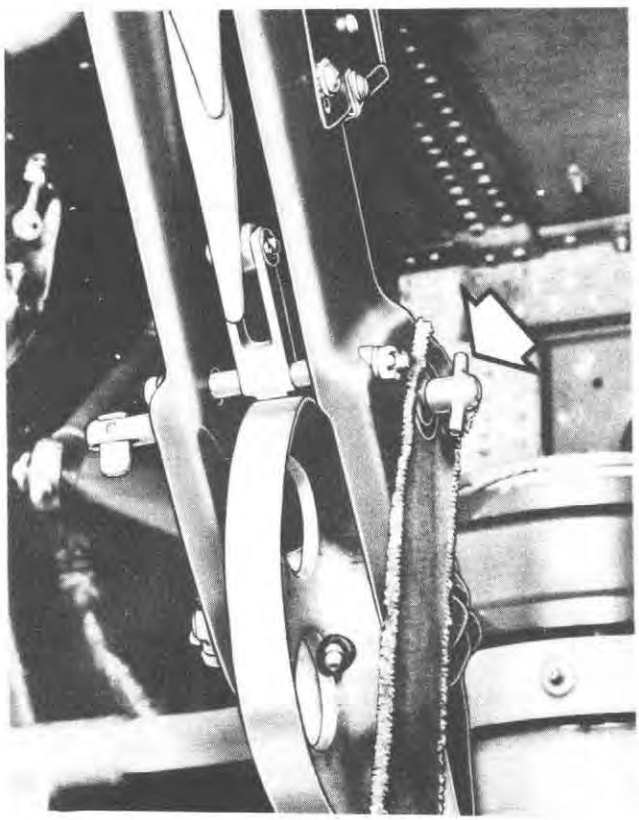
a. GENERAL.—A fully retractable, hydraulically operated tricycle alighting gear is installed. An emergency hydraulic system, operated by a hand pump located in the pilot's compartment, provides for emergency extension of the alighting gear. A control lever for normal operation of the alighting gear, is provided on the pilot's control pedestal. The alighting gear normally extends or retracts in approximately 12 seconds.

b. MAIN LANDING GEAR.

(1) GEAR ASSEMBLY.

(a) DESCRIPTION.—The two main gears extend up and aft into the nacelles and are enclosed by nacelle doors when retracted. Each main gear assembly consists of a wheel assembly, shock strut, and retracting mechanism. Dual, multiple disc brakes are provided in each wheel and are operated normally by hydraulic pressure or, in an emergency, by air pressure. See paragraph 14. *c.*, this section. Braking action is accomplished by applying toe pressure on the rudder-brake pedals. Inter-connecting linkage mechanically coordinates the opening and closing of the nacelle doors with the extension and retraction of the main gears. When extending the alighting gear, move the control lever to the "DOWN" position in a continuous operation. The movement from "NEUTRAL" to"DOWN" should not take longer than two seconds. Do not move the control lever by a series of light taps.





MAIN LANDING GEAR SAFETY PIN

NOSE WHEEL GEAR SAFETY PIN

Figure 91 — Alighting Gear Ground Safety Pins Installed

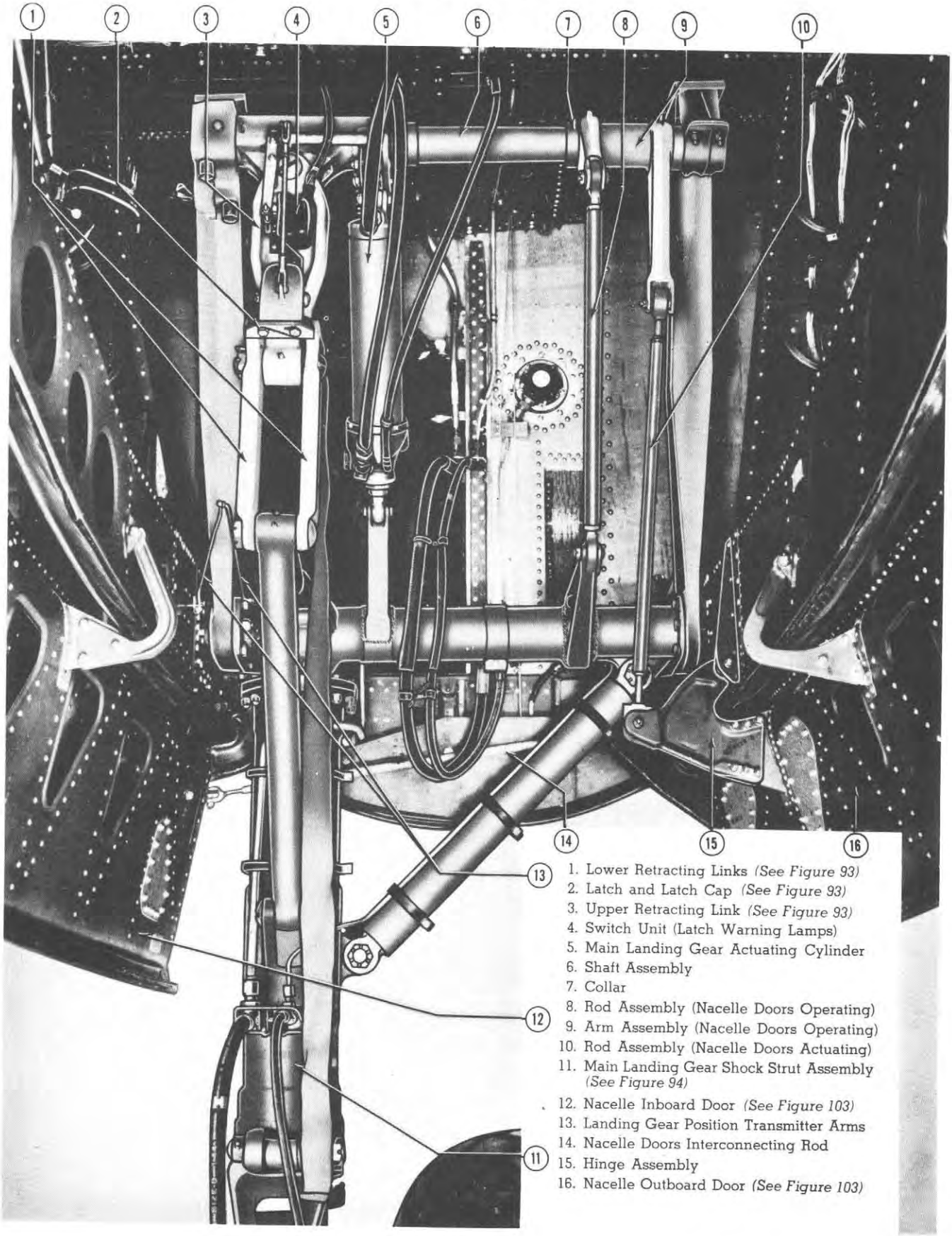


Figure 92 —Main Landing Gear Installed (Looking Forward)

(b) REMOVAL AND DISASSEMBLY.

1. Support the airplane on wing stands. See section III, paragraph 2., *c.* Install a ground safety pin in the nose wheel gear *(figure 91).*

2. Relieve the hydraulic system pressure by applying and releasing the rudder-brake pedals.

3. Disconnect and cap the brake hydraulic and emergency air lines at the clamp on the shock strut cross shaft.

4. Remove the landing gear retraction release switch and electrical wiring attached by clamps to the left main gear shock strut ONLY.

5. Remove the bolt which locks the retracting link shaft (on the inboard end).

6. Disconnect the outboard door actuating rod *(10, figure 92)* and the bell crank actuating rod *(8, figure 92)* from the bell crank arms.

7. Remove the bolts which secure the three collars to the shaft.

8. Remove the half circle cap which holds the shaft to the outboard support. Slide the shaft *(6, figure 92)* out of the inboard support.

9. Remove the bolts used to attach the strut cros shaft to the supports on the nacelle inboard and outboard lower webs, and then remove the landing gear. The two top bolts and the lower aft bolt on the inboard side of the structure must be removed from the outboard side. The remaining three bolts must be removed from the inboard side.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—For maintenance information, refer to the detailed parts on the following pages.

(d) ADJUSTMENTS.

1. Support the airplane on wing stands and nose stand (See Section III, paragraph 2. *(c)*).

2. Install ground safety pins *(figure 91)* on the nose gear and one main gear. This is accomplished by inserting a locking pin in a hole in the retracting link.

Note

Adjust only one gear at a time.

3. Disconnect the door actuating rod.

4. Using either a hydraulic hand pump or engine-driven test stand pump to supply pressure, retract the landing gear, locking it in the UP position.

5. When the gear is retracted, install a ground safety lock.

6. Disconnect the piston rod eyebolt from the retracting arm.

7. With the piston rod FULLY EXTENDED, adjust the eyebolt to align its hole with the hole in the retracting arm.

Note

The entire piston and rod assembly may be rotated within the cylinder if necessary.

8. Lengthen the rod assembly 1/8 inch by turning the eyebolt OUT two full turns.

9. Lock the check nut.

10. Connect the eyebolt to the retracting arm with the grease fitting UP to avoid interference.

11. Place the landing gear control lever in the "UP" position and apply pressure.

12. Remove the ground safety pin and extend the gear.

13. Install the ground safety pin and relieve the pressure in the hydraulic system by applying toe pressure to and releasing the rudder-brake pedals.

14. Turn the bottoming cap IN until flush with the cylinder head end.

15. Turn the cap OUT one full turn.

16. Lock the check nut.

Note

Be sure the piston rod assembly does not turn while locking the check nut.

17. Apply UP pressure to cylinder. Shorten or lengthen latch rod until latch clearance of 1/16 inch minimum is obtained.

18. Latch engagement must have a depth of 5/16 inch minimum and 3/8 inch maximum.

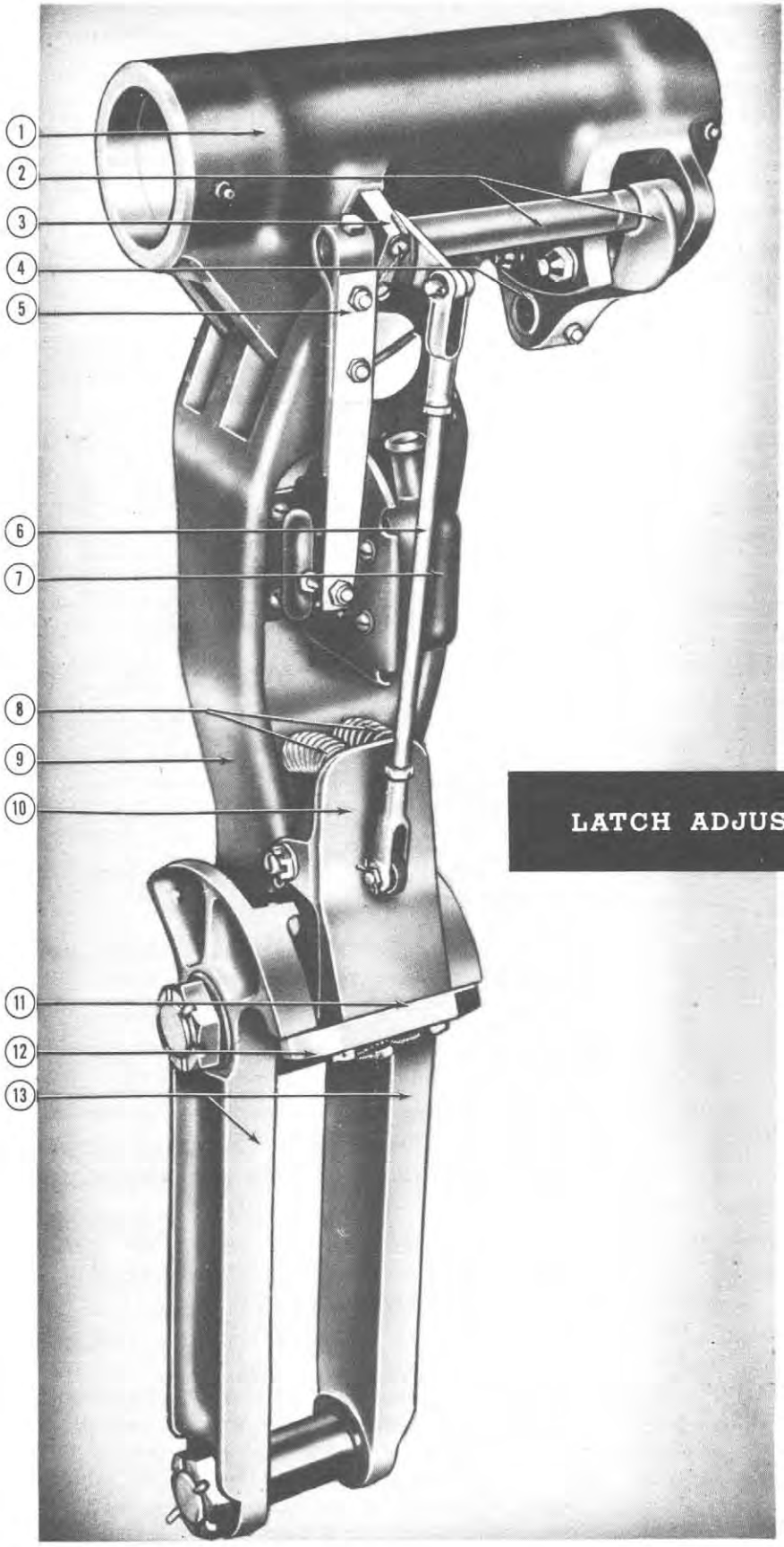
19. Tighten check nuts. Install cotter keys.

(e) ASSEMBLY AND INSTALLATION.—Reverse the procedure outlined in paragraph *(b)*, above.

(f) TEST AFTER INSTALLATION.—With the airplane supported on wing stands, extend and retract the landing gear. Check for any interference.

(2) RETRACTING MECHANISM.

(a) DESCRIPTION. — Power for operation of the main landing gear assembly is supplied by the hydraulic actuating cylinder. This cylinder is attached to bell crank arms on the retracting (upper) shaft and the shock strut cross shaft. *(See 5, figure 92.)* A spring tensioned, mechanical latch is assembled on the upper retracting link and locks against the lower retracting link sectors. A connecting rod extends from the retracting shaft to the latch. The first movement of the actuating cylinder trips the latch and starts retraction of the gear. This same latch secures the



LATCH ADJUSTMENT PROCEDURE ★

1. Adjust stop bolt under latch so that lower link aligns with upper link within .010 inches measured at lower bolt hole. (Use .999 inch bolt and 2.156 inch length spacer to align lower links while making adjustments.)

2. Place shims under latch cap to provide .005 to .015 clearance between engaging parts in latched position.

3. Unlatch and swing lower links to permit latch cap to rest on sectors of lower links. Adjust or file latch cap if necessary to obtain contact on both sectors.

4. Place .120 spacer between latch cap and link sectors and adjust latch actuating rod to provide .000 to .010 clearance between lug and the cam on shaft assembly. (The lug should be pushed toward the shaft as far as it will go when checking this clearance.)

5. Replace link in latched position and check latch engagement, which must be 5/16 inch minimum.

1. Support
2. Shaft and Cam Assembly
3. Bearing
4. Lug (To Attach Actuating Cylinder)
5. Lever (Latch Switch Unit)
6. Latch Actuating Rod (Latch Release)
7. Switch Unit
   (Landing Gear Warning Lamps)
8. Springs
9. Upper Link
10. Latch
11. Latch Cap Shims
12. Latch Cap
13. Lower Links

Figure 93 —Main Landing Gear Retracting Link Assembly

landing gear in either the completely retracted or extended position. A vee shaped brace assembly pivots from the end of the retracting link assembly with one arm attached to the top of the shock strut and the other arm to the center of the shock strut. A mechanical linkage opens or closes the nacelle doors in conjunction with the extension or retraction of the gear.

(b) REMOVAL AND DISASSEMBLY.

1. Support the airplane on wing stands. See section III, paragraph 2. *c.* Install a ground safety pin *(figure 91)* in the nose gear and one main gear. Disconnect the hydraulic line at the shock strut shaft brake line clamp.

2. Remove the bolt attaching the main landing gear actuating cylinder *(5, figure 92)* piston rod eyebolt to the shock strut arm.

3. Remove the bolt attaching the retracting link assembly *(1, figure 92)* to the shock strut brace.

4. Remove the bolt that locks the retracting link shaft *(6, figure 92)* on the inboard end.

5. Remove the bolts which secure the three collars to the shaft.

6. Remove the half circle cap which holds the shaft to the outboard support. Slide the shaft out of the inboard support.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Replace any parts that are bent, rusted or damaged.

2. For actuating cylinder or landing gear position selector valve information, refer to paragraph 14. *c.* (3), this section, and paragraph 14. *c.* (2), this section.

(d) ASSEMBLY AND INSTALLATION.—Reverse the procedure outlined in *(b)* above.

(e) ADJUSTMENTS.—To adjust the retracting link assembly refer to *figure 93.*

(f) TEST AFTER INSTALLATION. — With the airplane supported on wing stands, extend and retract the landing gear. Check for any interference.

(3) MAIN LANDING GEAR SHOCK STRUT ASSEMBLY. *(See figure 94.)*

(a) DESCRIPTION.—A shock strut cross shaft *(2, figure 94)* is bolted to the inboard and outboard walls of the landing gear well of each nacelle. An oleo-pneumatic shock absorber strut *(5, figure 94)* is connected to the inboard end of this shaft. A supporting brace is provided from the outboard end of the shaft to the collar at the center of the strut cylinder. Two torque arms *(7, figure 94)* one of which is attached to the strut cylinder and the other to the strut piston, prevents the piston from rotating inside the cylinder. The axle on which the main wheel is mounted *(11, figure 94)* extends from the lower end of the shock strut and is an integral part of the strut.

(b) REMOVAL AND DISASSEMBLY.

1. Support the airplane as instructed in Section III.

2. Relieve the hydraulic pressure by operating the brakes.

3. Disconnect the hydraulic lines at the shock strut shaft brake line clamp.

4. Remove the strut shaft bolts as instructed in paragraph 5. *b.* (1) *(b)*, this section.

5. Lower the strut assembly from the airplane.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. TIGHTENING THE SHOCK STRUT PACKING.—In case of packing gland leakage as evidenced by fluid seepage, or the presence of air bubbles when soapy water is applied, tighten the packing nut as follows:

a. Release the air pressure in the strut by partially backing off the filler plug *(15, figure 94)* located on the upper aft end of the strut. Packing cannot be tightened properly under pressure.

Note

Air must be completely exhausted from the unit before removing filler plug assembly *(15, figure 94). Do not release the air pressure by depressing the air valve core.*

b. Remove the packing nut lock wire.

c. Loosen packing nut *(6, figure 94)* about one turn and work piston up and down several strokes. Then tighten nut until snug, but not *too* tight.

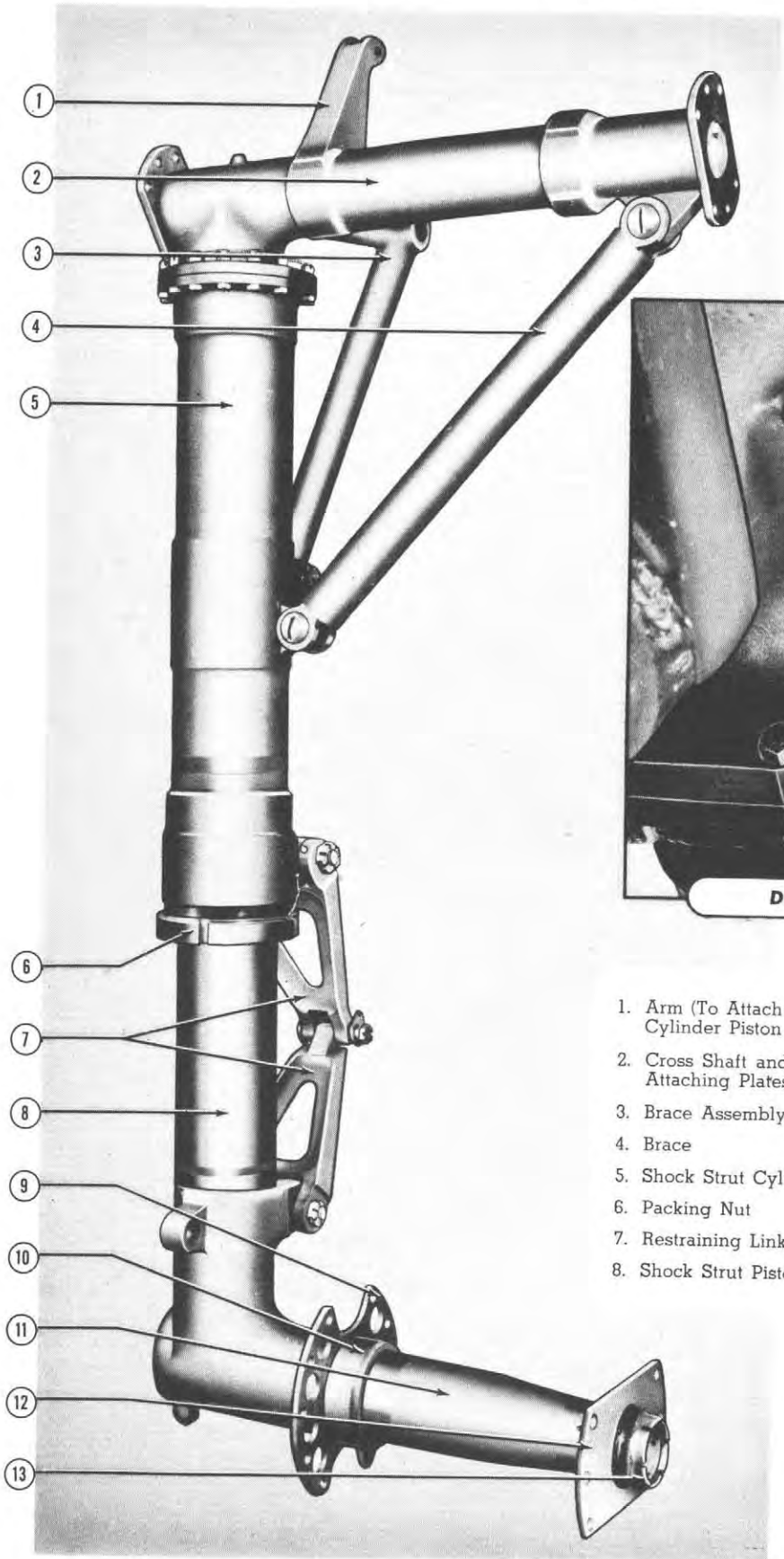
d. Replace the lock wire and inflate the strut as instructed.

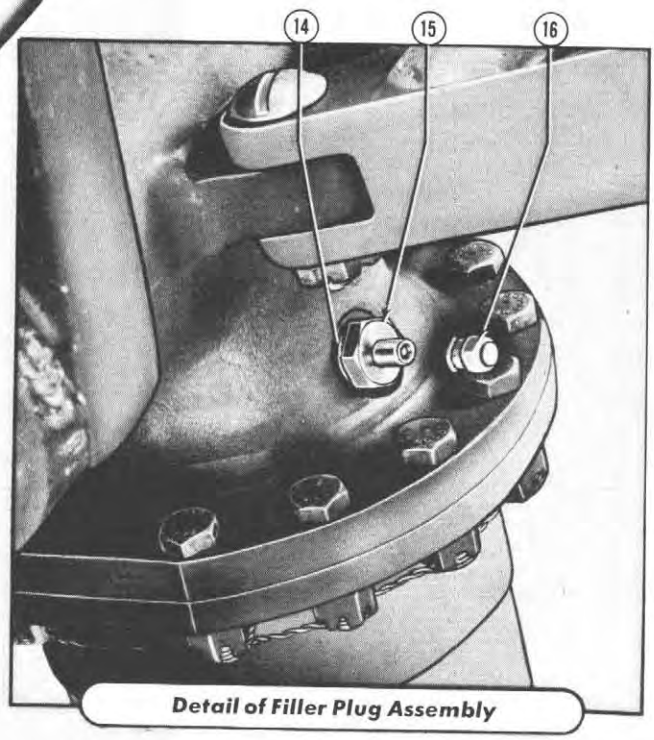
2. FILLING THE SHOCK STRUT.

a. Fill the strut with hydraulic fluid, AAF Specification 3580, through the filler plug hole until the fluid is level with the hole.

b. Insert the plug loosely and cause the strut to extend and compress completely several times to eliminate air traps.

c. Remove the plug and check the fluid level when the strut is fully compressed. If more fluid is added, repeat step b. above to insure that no air has been trapped in the strut.





Detail of Filler Plug Assembly

1. Arm (To Attach Actuating Cylinder Piston Rod)
2. Cross Shaft and Attaching Plates
3. Brace Assembly
4. Brace
5. Shock Strut Cylinder
6. Packing Nut
7. Restraining Links
8. Shock Strut Piston
9. Inboard Brake Torque Plate
10. Wheel Spacer
11. Axle
12. Outboard Brake Torque Plate
13. Main Wheel Axle Nut
14. Gasket
15. Filler Plug and Air Valve Assembly
16. Air Valve Cap (Apply 15 to 25 inch-pounds Torque Preload)

N O T E
Fill shock strut with hydraulic fluid AAF Specification 3580 (Red Color).

Figure 94 — Main Landing Gear Shock Strut Assembly

d. Insert the filler plug carefully to avoid damaging the threads. Screw it down tightly.

Note

Each time the filler plug is removed, replace the copper gasket on the filler plug seat.

3. INFLATING THE SHOCK STRUT.

a. Place airplane in hangar. It is impossible to make an accurate check of strut extension while airplane is subjected to wind force or slipstream from propellers. The strut will be supporting the full normal load of airplane while it is being inflated.

b. Remove the hexagon cap from the air valve on the upper end of the strut *(16, figure 94)* and use a high pressure air pump, booster pump, or air bottle to inflate the strut.

WARNING

Compressed oxygen, hydrogen, or acetylene should NEVER be used for this purpose.

c. Inflate the strut until the red line on the piston tube is 1⅞ inches from the bottom of the packing gland nut. A variation of ±¼ inch from the specified inflation dimension is permissible. Both main gear shock struts and the nose gear shock strut are inflated to the same extension.

d. While inflating the shock strut, rock the airplane to alternately extend and compress the strut in order to overcome packing friction, which might allow over-inflation. Over-inflation causes hard taxiing of the airplane.

Note

Do not reduce over-inflation by depressing the air valve core. To reduce the inflation and still retain accurate control of the air volume, unscrew the filler plug and tighten again rapidly with a wrench. Shake the airplane, if possible, while air is being released from the strut.

e. After the strut has been inflated, use soapy water to test the air valve, the valve core, and the filler plug for air leaks. Install the air valve cap (painted yellow) and preload the cap to 15-25 inch-pounds torque.

4. To reduce wear and the possibility of failure of the packing rings, wipe the exposed section of the piston rods of the alighting gear shock absorber struts free of ice, mud, dust, or sand with a cloth soaked with hydraulic fluid, AAF Specification 3580. In cold climates the piston rod should be cleaned immediately after flight, to prevent ice forming. Hydraulic fluid (second choice kerosene) is recommended for cleaning the alighting gear shock strut pistons.

5. Periodically inspect the entire outside portion of the shock strut assembly, especially in the locality of welds, lugs, and connections, for any evidence of cracks or indications of structural failure. If cracks or other unserviceable conditions are found, remove the strut assembly from the airplane and replace it with a new or reconditioned strut.

6. Inspect the chrome plating on the exposed outer wall of the piston for any evidence of corrosion, pitting or scoring. If plating is deteriorated or worn through at any place so that polishing will not restore it to proper condition, remove the strut from the airplane and replace it with a new or reconditioned strut assembly.

7. Examine cotters and safety wire on all nuts and lock screws for security and at the same time check the tightness of bolts, nuts, and screws. Replace safety wire and cotters that are broken or missing. Tighten all loose nuts, bolts, and screws.

(4) MAIN LANDING GEAR WHEELS AND BRAKES. *(See figure 95.)*

(a) DESCRIPTION.—Goodyear drop center 47 inch wheels with tapered roller bearings are mounted on the axle which extends from the end of the shock strut. Each wheel is equipped with integral, hydraulically operated, dual, multiple disc brakes. The brake assembly includes 14 bronze and 15 steel discs, assembled alternately. The bronze discs *(2, figure 99)* have keys which fit into the keyways on the wheel and therefore rotate with the wheel. The stationary steel discs *(1, figure 99)* are assembled alternately between the bronze discs and fit over keys on the brake anchor bracket which is attached to the axle. The braking action is accomplished when the annular ring piston *(3, figure 99)* is moved by hydraulic pressure and presses the discs together. Each wheel may be braked individually by means of the corresponding rudder-brake pedal. A power brake control valve is located forward and above each rudder-brake pedal. The brakes can be locked by depressing the pedals and pulling back on hte parking brake control knob in the pilot's compartment. For complete information about the brake hydraulic system refer to paragraph 14. *e.*, this section.

(b) REMOVAL AND DISASSEMBLY.

1. WHEEL ASSEMBLY.

a. Raise the shock strut at the jacking point on the bottom of the strut until the wheel clears the ground.

b. Relieve the hydraulic pressure by applying and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

c. Deflate the tire by removing the valve core.

d. Disconnect the brake line at the disconnect coupling *(1, figure 97)* at the outboard brake intake port.

e. Unscrew the axle nut *(2, figure 97)* and remove the outboard brake.

f. Slide the wheel assembly from the axle.

g. Compress and remove the bearing closure lock rings *(1, figure 96).*

h. Remove the bearing closure discs and the felt bearing seals. Remove the inboard and outboard bearings.

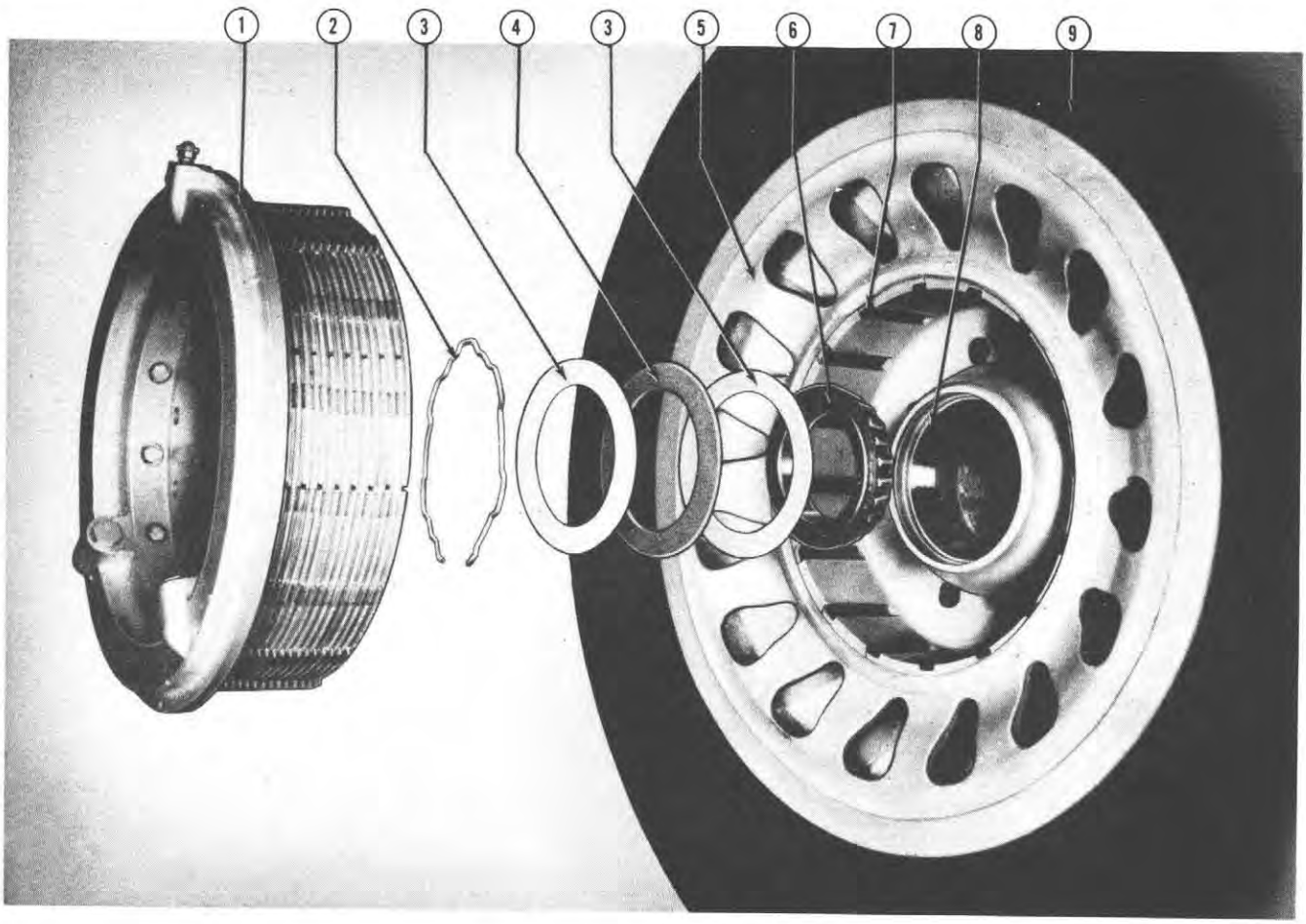
i. The bearing cups are to be removed only in exceptional circumstances. If it is necessary to replace the bearing cups without getting an entire new wheel casting, they must be removed and replaced only with proper heating equipment. A piece of dry ice placed in the bearing cup after heating the wheel will provide a large temperature differential, or the wheel can be placed in boiling water and the cup cooled with ordinary ice. When a temperature differential of approximately 56 degrees C. (100 degrees F.) is obtained, the bearing cup should loosen sufficiently to move freely in the wheel.

Note

Never force a bearing either in or out of a wheel by hammering or pressing.

2. BRAKES.

a. Remove the outboard brake and wheel assembly as described above *(b) 1.* a. through f.



1. AAF Specification 25258-I Brake Assembly (GOODYEAR No. 510675M)
2. Bearing Enclosure Lock Ring
3. Bearing Enclose
4. Felt Grease Retainer
5. AAF Specification 25258-I Wheel Assembly (GOODYEAR No. 530005M)
6. Wheel Bearing
7. Brake Disc Keyway
8. Bearing Cup
9. AAF Specification 26545-E 47 inch Smooth Contour 10 Ply Casing and AAF Specification 26546-C Type II A Inner Tube

Figure 95 —Main Wheel and Brake Assembly (Typical of Both Sides of Wheel)

b. Remove the bolts *(4, figure 97)* that attach the inboard brake to the axle torque plate.

c. Slide the brake off the axle.

d. Either brake unit may be disassembled in the following manner:

(1) Remove the cotter pin from the disc retaining nut lock screw *(1, figure 98)* and remove the lock screw.

(2) Unscrew the disc retaining nut from the brake anchor bracket. By keeping equal pressure applied with each hand at points 180 degrees opposite, the disc retaining nut is kept from binding.

(3) Remove the discs by sliding them out along the anchor bracket keys *(2, figure 98)*.

(4) Remove the insulator disc *(2, figure 98)* from the anchor bracket casting. Extreme care must be observed in removing the insulator disc, as it is fragile and easily damaged.

(5) Using a prying motion and an ordinary screwdriver, remove all piston return springs from the anchor bracket casting *(3, figure 98)*.

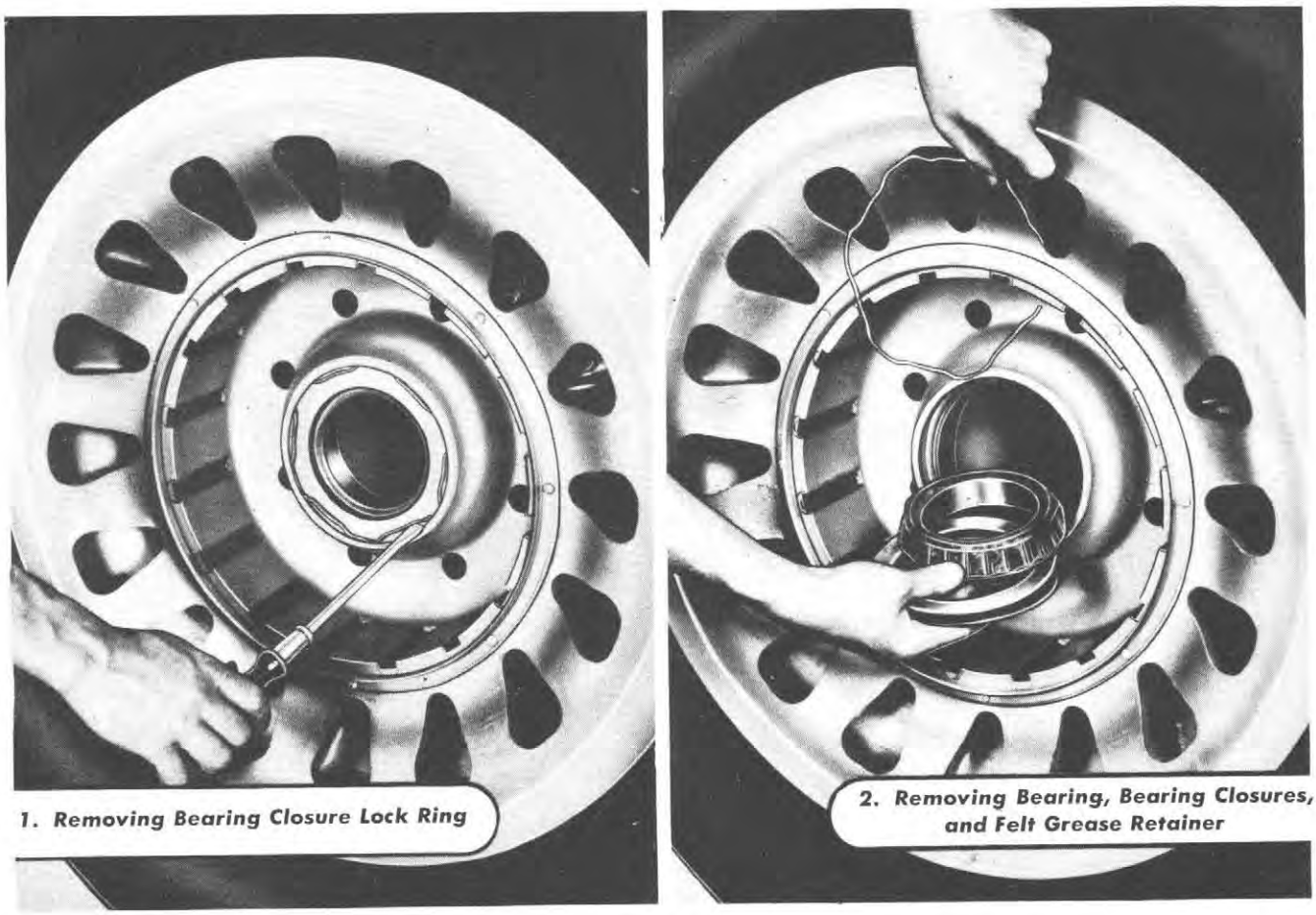
(6) Lift the annular ring piston out of the piston cavity *(4, figure 98)*. If the piston sticks, air pressure by means of a hand pump or pressure hose applied through the inlet port will release the piston.

(7) The piston seal gasket, because of its close fit, will require air pressure through the inlet port to release it from the piston cavity.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. WHEELS.

a. Portions of the wheel where the original finish has been peeled or chipped should be retouched with aluminum lacquer (clear and pigmented) Specification AN-TT-L-51. Two coats may be required. If it is necessary to refinish the entire surface, apply one coat of primer, zinc-chromate, Specification AN-TT-P-656, followed by two coats of lacquer, Specification AN-TT-L-51. Clean the surface thoroughly before applying the primer coat. Remove the old finish with acetone, Specification O-A-51-A. Never use wheels that are corroded on the inside, replace the wheel assembly with a new or serviceable wheel.



1. Removing Bearing Closure Lock Ring

2. Removing Bearing, Bearing Closures, and Felt Grease Retainer

Figure 96 —Removal of Main Wheel Bearing

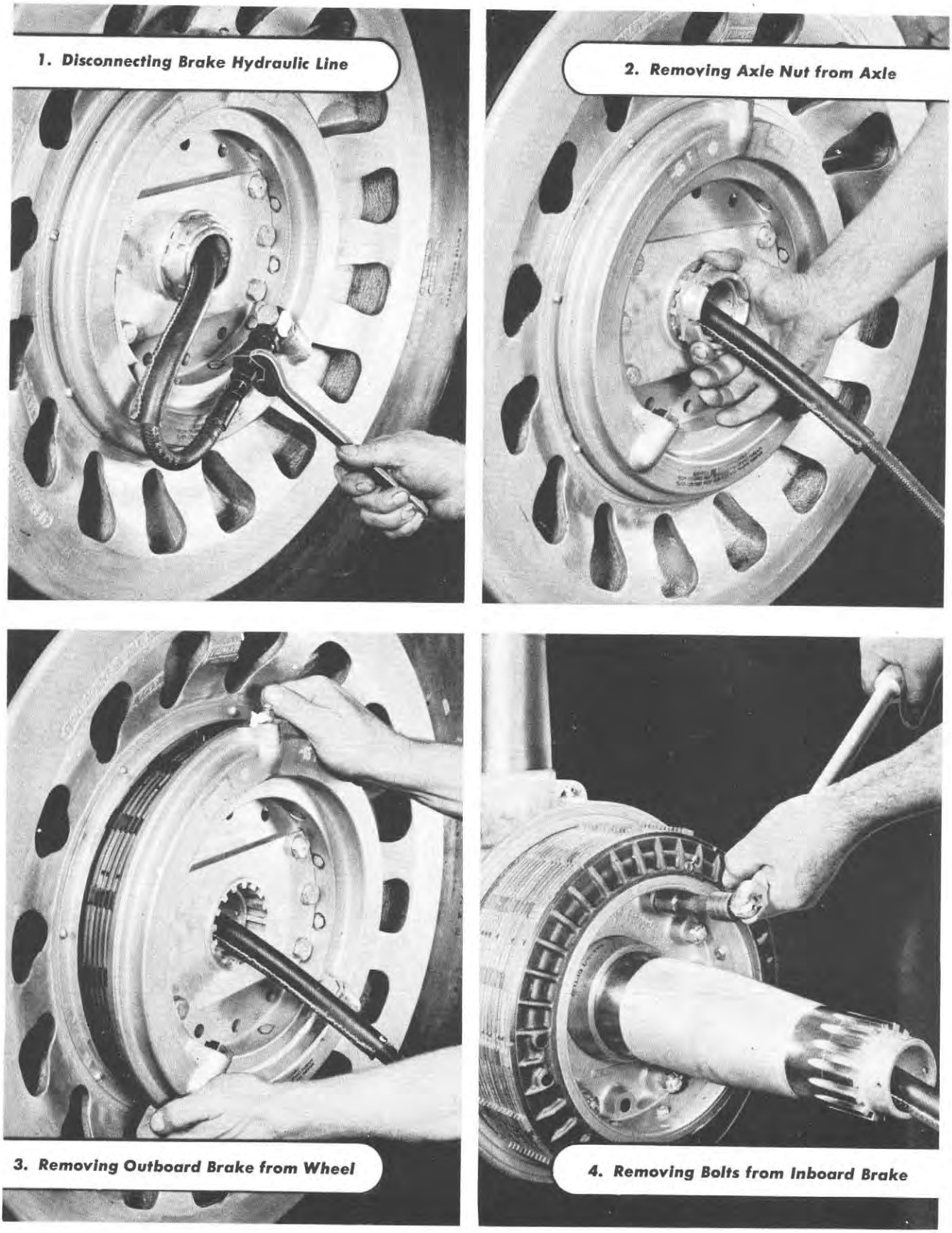
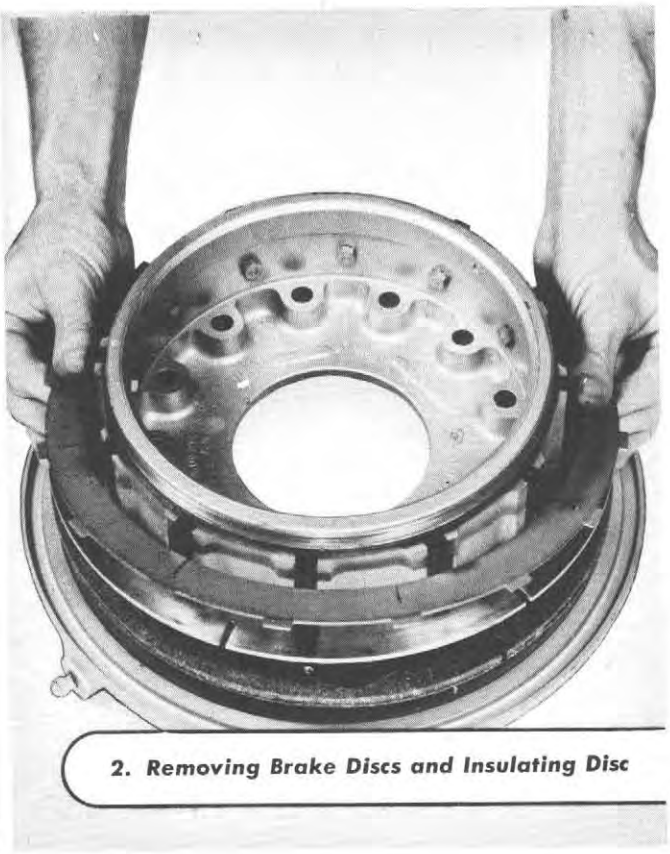


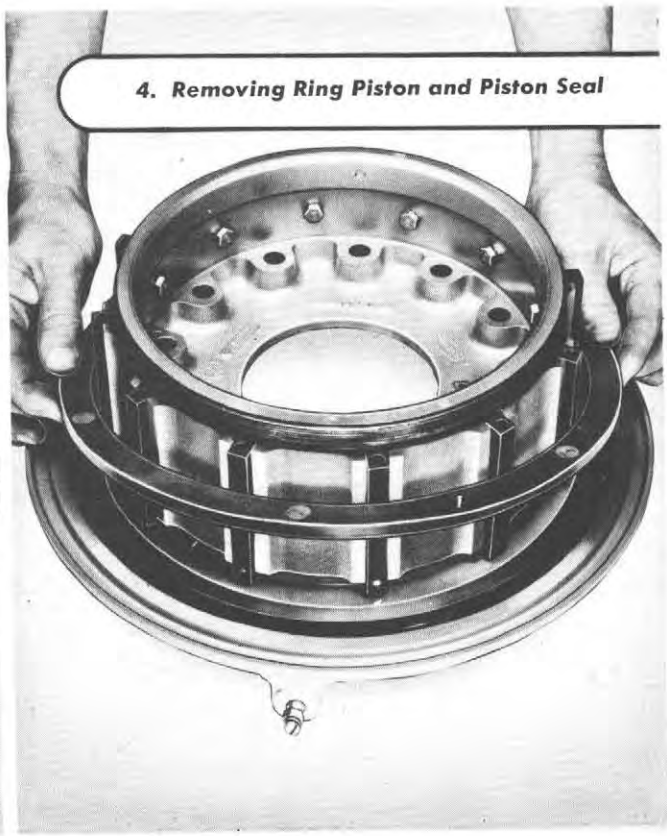
Figure 97 —Removal of Main Wheel Brakes

1. Removing Lock Screw from Disc Retaining Nut



2. Removing Brake Discs and Insulating Disc

3. Removing Piston Return Springs



4. Removing Ring Piston and Piston Seal

Figure 98 —Main Wheel Brake Disassembly

b. Cracks in the wheel casting necessitate replacement of the wheel.

c. Replace felt grease retainers that are saturated. If the grease retainers are in good condition, wash in gasoline and lubricate lightly with light machine oil, Grade 10, Specification VV-O-581.

d. Clean corroded or dirty rims thoroughly. If the rim flanges are cracked or corroded a new wheel must be installed.

e. Lubricate the wheel roller bearings according to the Lubrication Chart in Section III.

f. Replace any cracked or loose bearing cups. Remove and replace bearing cups either by heating the wheel or cooling the bearing sufficiently to permit easy movement of the bearing. A differential temperature of approximately 100 degrees F. between wheel and bearing is necessary. Do not force a bearing in or out of the wheel by hammering or pressing. When new bearing cups are installed, make certain that the cups are seated evenly against the shoulder inside the wheel casting.

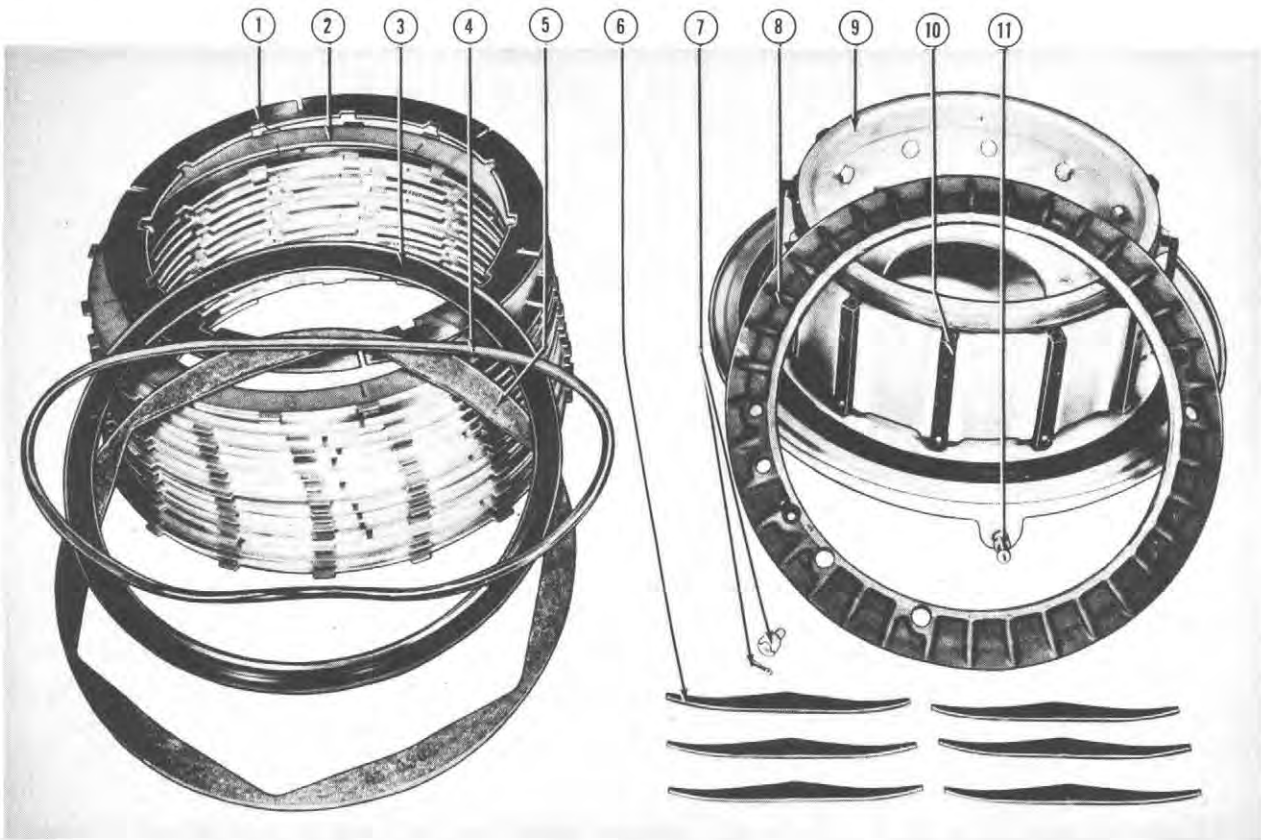
2. BRAKES.

a. Inspect the discs for wear. If bronze discs are worn more than .020 inch, they are no longer sufficiently coated for good service and must be replaced with new parts. The steel discs normally do not receive much wear.

b. Scored or badly distorted discs must be replaced. Slightly distorted discs may be repaired by being tapped with a hammer on a flat plate until they return to a flat condition. If the discs are dished, tap on the outer circumference. If the discs are warped, tap on the inner circumference.

c. Inspect the insulating disc for oil saturation, distortion from compression, and any other condition which would prevent proper heat insulation or return spring movement. Replace defective insulating discs.

d. Replace piston return springs that are weakened or broken.



1. Non-Rotating Disc (15 Required)
2. Rotating Disc (14 Required)
3. Annular Ring Piston
4. Piston Seal
5. Insulating Disc
6. Piston Return Spring
7. Lock Screw and Cotter
8. Disc Retaining Nut
9. Anchor Bracket
10. Anchor Key
11. Bleeder Valve

Figure 99 —Main Wheel Brake Disassembled

e. Replace piston seal gaskets that are shrunken, worn, or remolded.

f. See that the anchor bracket keys are free from grooving or wear from movement of discs.

g. Check fit of disc retaining nut on anchor bracket threads. Push nut as far as possible to one side and take micrometer reading of width of disc retaining plus anchor bracket thickness. Then push the retaining nut in the opposite direction and take a reading at the same place. The difference in the readings should not exceed .012 inch. The threads on the anchor bracket should be lubricated with thread compound, Specification AN-VV-0-566 before assembly.

(d) ADJUSTMENTS.

1. MULTIPLE DISC BRAKES. – Check the clearances of the brake discs and adjust each brake separately by observing the following procedure:

a. Remove the wheel assembly as described in paragraph 5. *b.* (4) *(b) 1.*, this section.

b. Disconnect the brake hydraulic line at the disconnect coupling *(1, figure 97)* at the inboard brake intake port.

c. Remove the bolts used to attach the inboard brake to the axle torque plate *(4, figure 97)* and slide the brake off the axle.

d. Remove the cotter pin from the disc retaining nut lock screw and remove the lock screw *(1, figure 98).*

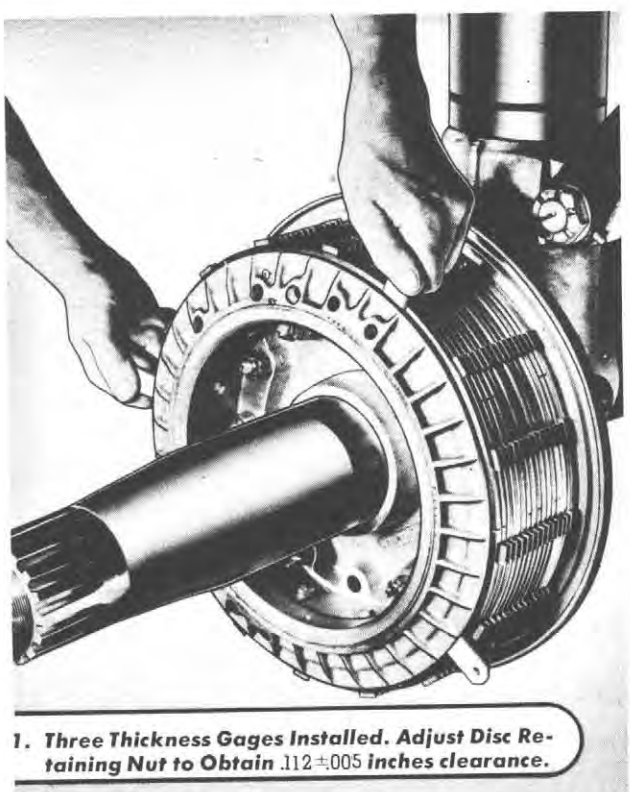
e. Turn the disc retaining nut tight against the discs. Be sure that the discs are free from dirt and foreign particles. Then turn back the disc retaining nut until a clearance of .112 ± .005 inches is obtained. Determine this clearance with three thickness gages inserted between the discs and the disc retaining nut. *(See 1, figure 100.)* Clearance should be inspected and adjusted every 50 hours.

f. When discs are worn to such an extent that the adjusting nut cannot be tightened to the specified clearance of .112 ±.005 inches, insert a stationary steel disc in stack next to adjusting nut and then adjust clearance.

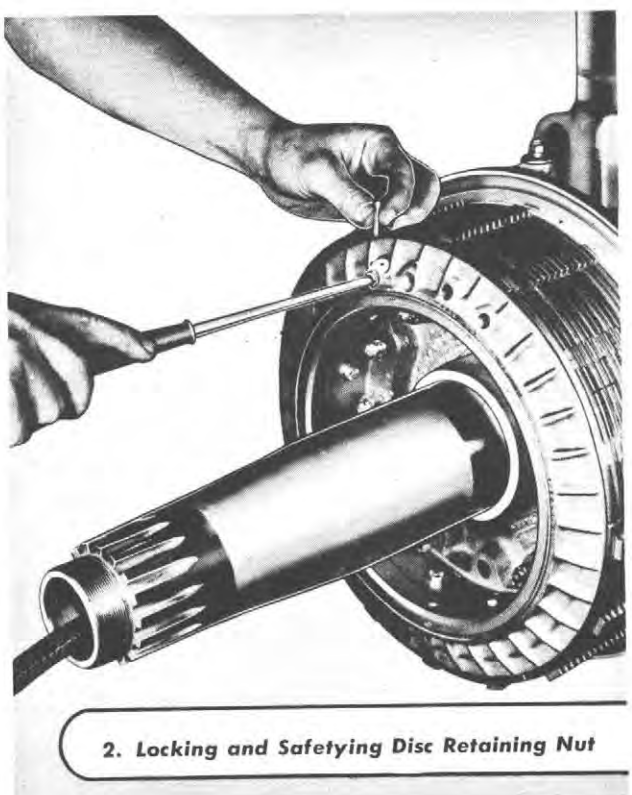
g. When the discs are so thin that adjustment is impossible, replace the set of rotating discs. Normally, the wear on stationary discs is slight, but replacement may be necessary due to warping or dishing caused by extreme heat.

h. Replace the lock screw, lock in the next lock point and insert the cotter key.

i. Connect the inboard brake line to the brake unit.



1. Three Thickness Gages Installed. Adjust Disc Retaining Nut to Obtain .112±.005 inches clearance.



2. Locking and Safetying Disc Retaining Nut

Figure 100—Adjusting Main Wheel Brake Disc Clearance

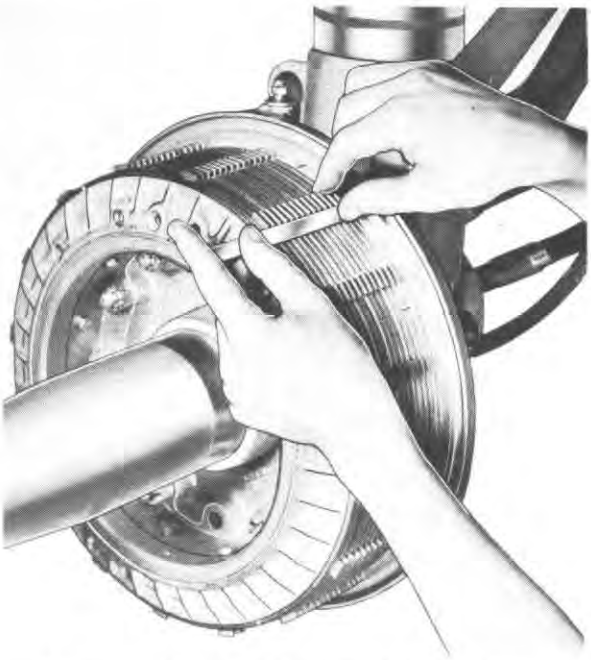


Figure 101—Aligning Brake Disc Keys

j. Line up the keys on the inboard brake unit with a straight edge *(figure 101)*.

k. Operate the hydraulic hand pump to supply pressure and apply the brake to hold the discs in position.

l. Slip the wheel on the axle, then slide it onto the inboard brake, making sure that the keyways in the wheel line up with the keys on the discs, and that the last disc is on the wheel.

m. Relieve the hydraulic pressure.

n. Adjust the outboard brake; align the bronze disc key with a straight edge, then carefully slide the brake along the keyways into the wheel. Make sure that the last disc is on the keyway, and that the bleeder port is on top and on the vertical center line of the wheel.

o. Replace the axle nut and tighten until the wheel will not turn freely; then back off one adjustment hole in the axle and safety with a cotter pin.

p. Connect the outboard brake line at the brake intake port.

q. Bleed the brakes as instructed in paragraph 14. *e.* (2) *(d) 1.*, this section.

r. Threads on the large adjusting nut should be kept lubricated with a coating of thread lubricant, Specification AN-VV-O-566 or equivalent.

2. WHEEL BEARING ADJUSTMENT.

a. Be sure that no brake drag is present.

b. Spin the wheel and adjust the axle nut slowly until the bearing starts to drag.

c. Back off the axle nut to the next castellation.

d. Lock the axle nut with a cotter key.

Note

When adjusting the wheel bearings, brake drag must not be confused with bearing tightness. After adjustment, check the wheel for any side play.

(e) ASSEMBLY AND INSTALLATION.

1. BRAKES.

a. Be certain all parts of the brake unit are thoroughly clean before assembly.

b. Install the piston seal into the piston cavity on the anchor bracket casting. In order to prevent uneven tension of the seal during this operation, press the seal into place from opposite points at the same time, continuing around until the seal is evenly installed in the piston cavity. Do not allow the seal to rotate.

c. Install the piston next to the seal in the piston cavity on the anchor bracket casting.

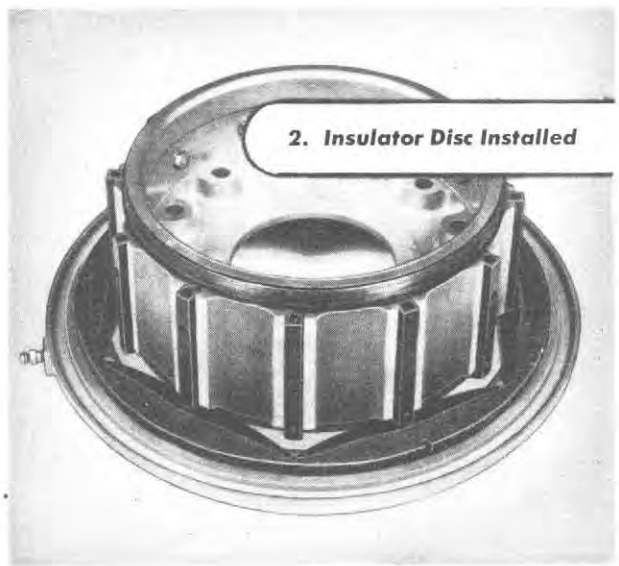
d. Install the piston return springs on the anchor bracket casting. A small piece of sheet steel placed under one end of the spring will prevent the piston from becoming scratched and will aid in sliding the spring into position. When installation is complete, be sure that the ends of the springs rest on the hard steel inserts of the piston *(1, figure 102)*. The spring ends will groove and damage the piston, if allowed to rest on the softer magnesium part of the piston.

e. Install the insulator disc carefully, making sure that the piston dowel pins line up with the holes in the insulator disc.

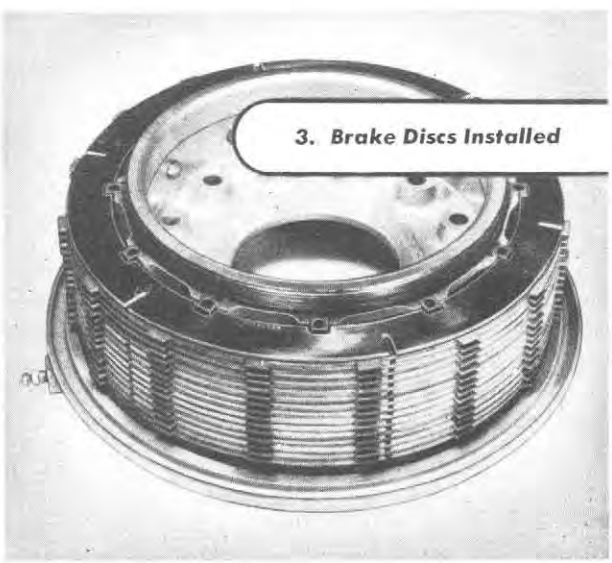
f. Place the discs in position. The first disc next to the insulator disc must always be a stationary steel disc. Then place alternate rotating and stationary discs until all discs are in place. Be sure that the disc stack starts and ends with a stationary steel disc (a steel disc next to the insulating disc and next to the disc retaining nut).

g. Install the disc retaining nut on the anchor bracket casting. Care must be observed to see that the nut is properly started to prevent stripping the threads. Adjust the brake clearances and install the brakes as instructed in paragraph 5. *b.* (4) *(d)*, this section.

1. Installing Piston Return Springs



2. Insulator Disc Installed



3. Brake Discs Installed

Figure 102—Main Wheel Brake Assembly

2. WHEELS.

a. If bearing cups have been removed install as instructed in paragraph 5. *b.* (4) *(c)* **1.** f., this section.

b. Lubricate the wheel bearings as instructed in the Lubrication Chart in section III.

c. Install the wheel bearings. Insert the bearing inner closure rings, felt bearing seals, bearing outer closure rings and lock rings.

d. Install the wheel and brakes on the axle as instructed in paragraph 5. *b.* (4) *(e)*, this section.

(5) MAIN LANDING GEAR TIRES AND TUBES.

(a) DESCRIPTION. — This airplane uses 47-inch, 12-ply, smooth contour tires and smooth contour, type 2-A inner tubes on the main landing gear wheels.

(b) REMOVAL.

1. Remove the wheel assembly as described in 5., this section.

2. Remove valve cap and core and completely deflate the tube.

3. With a tire iron or heavy rubber mallet, break both beads loose from the rim flanges. Force as much of the oposite bead as possible into the well opposite the valve.

4. Starting at the valve stem, insert two tire irons about six inches apart under the outside bead and force it up and over the rim flange. Hold one tire iron in place and with the other pry the remaining portion of the bead over the rim flange in short progressive steps.

5. When the outside bead has been removed, reach inside the tire and remove the tube. Start at the valve to make sure it is free from the valve hole. Do not remove the tube by pulling on the valve.

6. Pry the inside tire bead over the outside rim flange and remove the wheel from the tire.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. At each 50-hour inspection period, the main wheel tires and rims will be inspected visually without removing the casings for the following conditions and remedial action taken as indicated.

a. Remove the casings for recapping when tread wear barely exposes the fabric of the casings.

Note

A frequent check will be made to determine

the proper time to remove casings for recapping. Care should be exercised not to remove casings prematurely, particularly when considerable tread rubber remains or by tardy removal when one or more plies have worn through.

b. If breaks, cuts, blisters, or other visible damage appear, remove the casing, and forward to area Air Service Command for repair.

c. When casings show evidence of cupping from camber condition or toe-in, remove the casing and reverse on the same wheel.

d. When there is evidence of excessive corrosion on the visible outside portion of the wheel rim, remove the casing and inspect it for possible damage. Inspect and refinish wheels as instructed in paragraph 5. *b.* (4) *(c) 1.*, this section.

e. When there is evidence of damage to wheel rim edges due to hard landings or striking obstructions, remove casing and repair or replace wheel as instructed in paragraph 5. *b.* (4) *(c) 1.*, this section.

2. Casings which are known to have struck large stones or other damaging objects or to have been subjected to abnormal usage during service, will be removed as soon as possible and inspected for possible damage to the tube or the interior cord body. If at any time it is necessary to remove the casing, the following inspection will be made.

a. Inspect cord body for ruptures or breaks.

b. Inspect beads for physical damage extending through the outside rubberized chafer strip.

c. Inspect tread for cuts through or cuts exposing fabric to moisture and dirt.

3. When the casing is removed at any time the inner tube will be inspected for the following defects:

a. Valves for physical damage.

b. Tubes for evidence of wrinkles and creases. Evidence of cuts, punctures, or thinning adjacent to the bead caused by brake heat. Indications of chafing or pinching due to casing breaks.

4. All defective tubes will be repaired by a permanent method if possible. If permanent repair facilities for inner tubes are not available, temporary repairs may be made by the cold patch method as follows:

a. Clean tube around hole with solvent. Thoroughly buff an area to which the patch can grip.

b. Spread a thin layer of rubber cement over buffed area covering slightly more area than size of patch to be applied.

c. Let cement set or dry until tacky. Remove half of fabric backing from patch. Center patch over hole and remove remainder of backing, taking care not to touch under side of patch. Roll patch down firmly, making sure it is smooth, and check tube for additional leaks.

5. Inspect the tires daily for indication of slippage on the wheel rims. Tire slippage is evident when the markings on the tire and wheel do not register. Deflate tube and re-align tire to its original position on the wheel. The airplane must not be flown until this re-alignment is completed.

6. Check tire pressures daily. Inflate the main wheel tires by the deflection method. Tires with deflection markers will be inflated, with the airplane loaded approximately as it will be flown, so that the deflection markers just touch the ground. Inflate the tires when the airplane is resting on a smooth, firm, and level surface.

7. Never permit oil or hydraulic fluid to soak into tire, because these fluids soften the rubber and cause rapid wear. Wipe off immediately with a gasoline dampened rag. Always protect the tires with covers whenever working above or near them.

(d) INSTALLATION.

1. Inspect the tire and tube. Inflate the tube so that it is barely rounded out before inserting it in the tire.

2. In order to obtain proper balance of the wheel, casing, and tube when assembled, the mark on the inner tube which represents the heavy portion in the tube, will be lined up adjacent to the red balance marker on the casing which represents the lightest portion of the casing.

Note

The valve stem is off center on the tube and should be inserted so the offset is on the side of the valve hole.

3. Lay the wheel flat with the outside of the wheel, containing the valve hole, facing up. Line up the valve hole. Force one bead of the tire over the flange. It may be necessary to use a tire iron for the last "bite."

4. Pull the valve through the valve hole and attach a valve fishing tool to make certain the valve does not drop back into the wheel.

5. Starting opposite the valve stem and using a tire iron, force the other casing bead over the rim flange and work progressively around the tire, holding the inserted portion of the bead in the wheel well. Proceed until the tire bead is forced over the rim flange.

6. Inflate the tire slowly. Deflate and inflate again to relieve the pressure of any folds or buckles and to allow the tube to assume its proper contour within the casing.

7. Remove the valve fishing tool.

(6) NACELLE DOORS AND OPERATING MECHANISM.

(a) DESCRIPTION.—Each nacelle is provided with an inboard and an outboard door which operate in conjunction with extension and retraction of the main landing gears. The inboard and outboard doors are connected by a rod *(1, figure 103)* and operate simultaneously. Both outboard doors are connected by rods to the door actuating bell crank which moves with the retracting shaft. The bell crank is connected by a rod *(8, figure 92)* extending from the shock strut cross shaft. Extension or retraction of the landing gear mechanically opens or closes the nacelle doors.

(b) REMOVAL.

1. Disconnect the door actuating rod by removing the bolt attaching the rod to the outboard door.

2. Disconnect the door interconnecting rod by removing the bolts attaching the rod at the forward end of the doors.

3. Remove the six hinge bolts (three inboard, three outboard) which fasten the doors to the nacelle structure and remove the nacelle doors.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check for looseness of hinge bolts and actuating rod attaching bolts.

2. Check the doors for freedom from binding or excessive overtravel.

3. Structural repair of the door is described in AN01-40AJ-3.

(d) ADJUSTMENTS.

1. Disconnect the rod that connects the inboard and outboard doors.

2. Retract the gear with the outboard door actuating mechanism connected until the door rod and its actuating arm *(10, figure 92)* are on dead center.

3. From this position adjust the actuating rod *(10, figure 92)* (between the bell crank arm and outboard door) until the door has moved as far out as it will go without binding at the hinges or damaging the nacelle skin.

4. Tighten the check nuts at both ends of the actuating rod.

5. With the gear latched in the "UP" position, adjust the bell crank actuating rod *(8 figure 92)* (which connects the bell crank to the arm on the shock strut cross shaft) until the door fits tightly against the nacelle. No binding, buckling or looseness must be present.

6. Tighten the check nuts at both ends of the rod.

7. Connect the door interconnecting rod.

8. Retract gear to check the preload on the inboard door.

Note

If necessary, extend the gear and adjust only the door interconnecting rod. Do not disturb the adjustments on the other rods.

9. Extend the gear and check the inspection holes in the rods for proper thread engagement.

10. Install cotter keys, after making a final check of all check nuts.

(e) INSTALLATION.—Reverse the procedure outlined in paragraph *(b)*, above.

(f) TEST AFTER INSTALLATION.—Make a trial operation of the main landing gear to check the doors for proper operation.

(7) ALIGHTING GEAR SIGNAL SYSTEM.—Two types of signal systems are installed on the airplane. On some airplanes an electrically operated combination wheel and flap position indication and red and green signal lamps are installed on the instrument panel. The indicator is wired to position transmitters on each gear. The signal lamps are wired to latch position switches on each gear. When the alighting gear is extended and all gears are safely latched down, the green signal lamp is lighted, indicating safe landing condition of the gear. If one or more of the gears is not latched down and the throttles are closed to less than one-fourth segment, the red signal lamp is lighted, indicating unsafe landing condition of the gears. It is possible to determine which gear is not latched down by the wheel position indicator. On other airplanes the wheel position indicator and transmitters are eliminated and four signal lamps are installed on the instrument panel. A green signal lamp is provided for each gear and the green lamp is lighted when the corresponding gear is latched down. The red lamp is lighted when the throttles are closed to less than one-fourth segment with any one or more of the gears not latched down. The unsafe gear is indicated by the unlighted green signal lamp. On all airplanes accidental retraction of the alighting gear, when the airplane is on the ground, is prevented by a solenoid detent pin installed on the landing gear position selector valve. This solenoid detent pin prevents movement of the landing gear control lever from the "DOWN" to the "UP" position when the airplane is

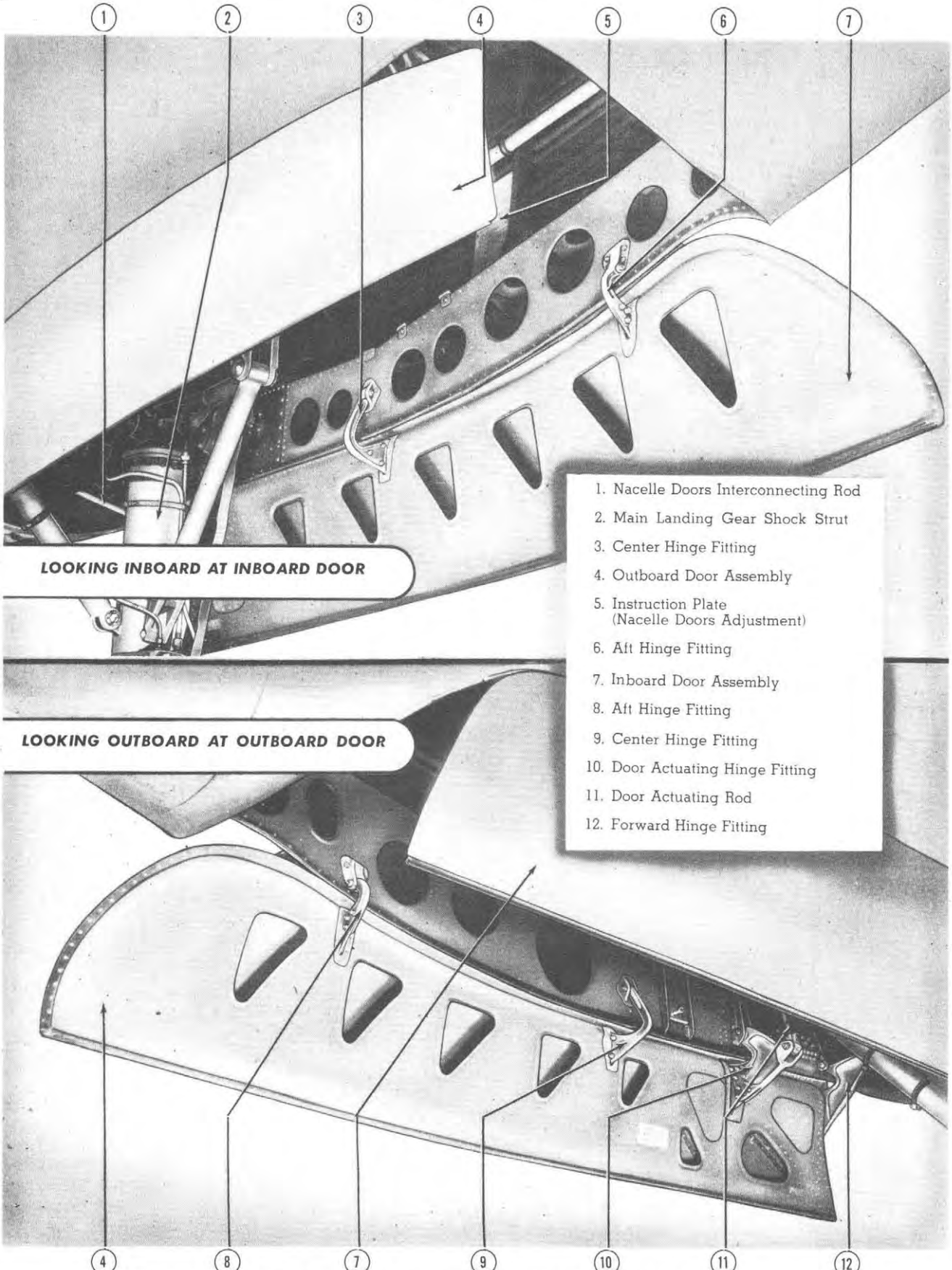


Figure 103—Nacelle Doors Installed (L. H. Nacelle Shown)

on the ground. The solenoid detent pin is controlled by the retraction release switch installed on the left-hand main shock strut. Refer to paragraph 15. *d.* (13), this section for complete details of the alighting gear electrical system.

c. NOSE WHEEL GEAR.

(1) GEAR ASSEMBLY.

(a) DESCRIPTION.—The nose gear is a single strut, fully retractable, cantilever assembly. The nose wheel gear is controlled by the same lever in the pilots' compartment, as is the main landing gear, and all gears receive hydraulic pressure at the same time through the landing gear position selector valve. For emergency purposes a mechanical release is provided to unlock the nose wheel gear up latch hook. This control can be operated by the pilot in the event the nose wheel door mechanism fails to trip the release lever *(9, figure 109)*. The nose wheel gear emergency release handle *(figure 115)* is located on the pilots' side of the control pedestal. A cable extends from the handle down into the nose wheel well and is attached to the up latch hook release bar. A static ground wire is installed on the nose wheel gear to provide a means of discharging into the ground any static electrical charges built up in the airplane. The ground wire is attached to the bottom of the shock strut wheel support.

Note

When extending the alighting gear, move the control lever to the "DOWN" position in a continuous operation. The movement from "NEUTRAL" to "DOWN" should not take longer than two seconds. Do not move the control lever by a series of light taps.

(b) REMOVAL AND DISASSEMBLY.

1. Support the airplane on a nose stand until the nose gear is about three inches above the ground in the extended position (see section III). Install ground safety pins *(figure 91)* on the main landing gears.

2. Relieve hydraulic system pressure by applying toe pressure to the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

3. Remove the bolt attaching the lower retracting link to the shock strut collar.

4. Disconnect the strut rotating arm *(5, figure 105)* from the rotating link *(6, figure 105)* by removing the attaching bolt and sliding the bearing off the arm.

5. Disconnect the nose wheel position indicator rod (if installed) from the indicator lever located at the left of the strut cross beam.

6. Remove the bolts and nuts attaching the two cross beam eyebolts to the supports on the nose wheel well side walls, after the nose wheel gear assembly is supported adequately.

7. Remove the nose wheel gear assembly.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—For this information, refer to the detailed parts on the following pages.

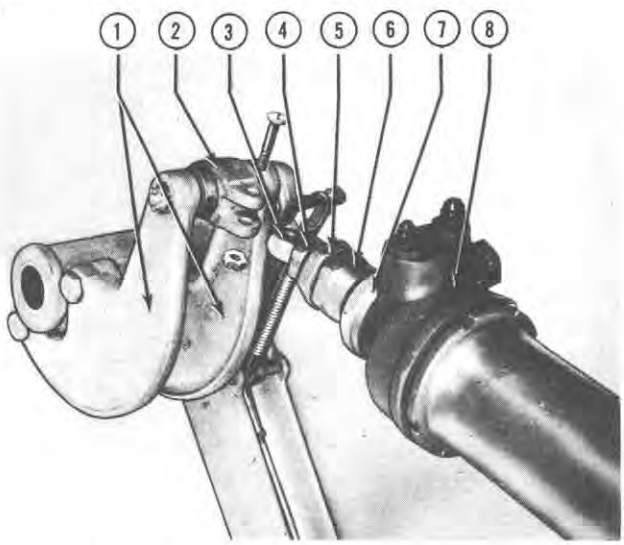
(d) ADJUSTMENTS.

1. To insure correct latching operations for both the nose wheel gear and doors, adjustments must be made at the same time.

CAUTION

Under no condition should the nose gear be retracted after reassembly until the following adjustments have been completed. Failure to make the adjustments before operation of the gear may result in serious damage to the nose wheel gear assembly or doors.

2. Support the airplane on a nose stand and install ground safety pins on the main gears and nose gear *(figure 91)*.



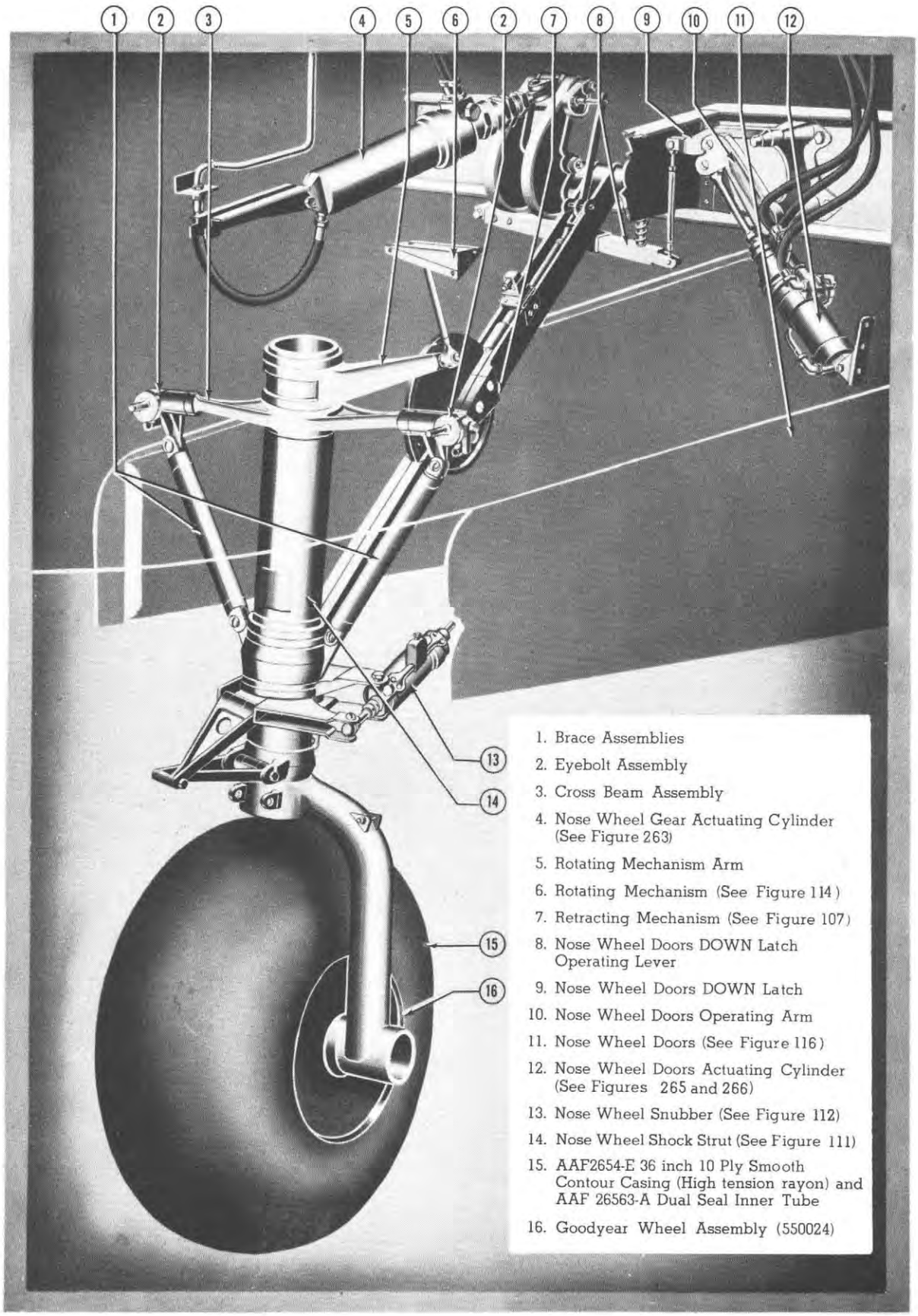
1. Retracting Arms
2. Clevis
3. Piston Rod Eyebolt
4. Eyebolt Check Nut
5. Bottoming Cap Check Nut
6. Bottoming Cap
7. Piston Rod Packing Nut
8. Nose Wheel Gear Actuating Cylinder

NOTE: Turn the bottom cap in until flush with the cylinder end. Then turn the cap out one full turn to create the required down position preload of 1 16 x 1 32-0 inches.

Figure 104—Adjustments of Nose Wheel Gear Actuating Cylinder

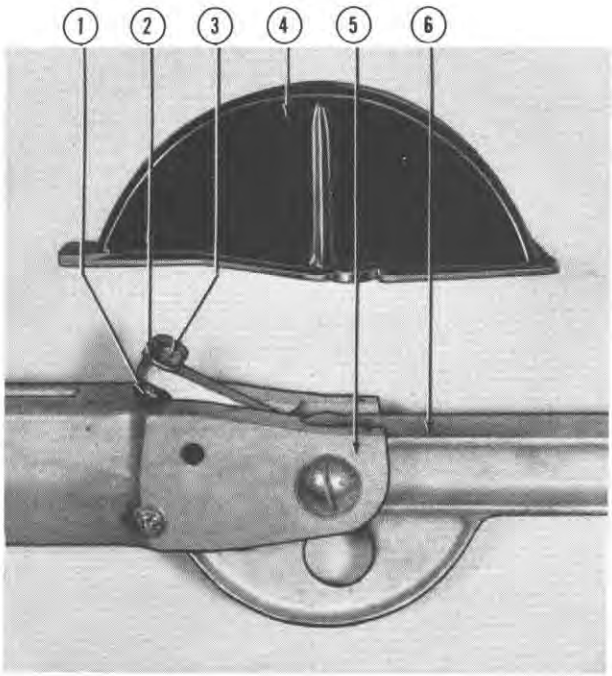
Note

Use either the hydraulic hand pump or an engine-driven test stand pump to supply normal operating pressure during the adjustment procedure.



1. Brace Assemblies
2. Eyebolt Assembly
3. Cross Beam Assembly
4. Nose Wheel Gear Actuating Cylinder (See Figure 263)
5. Rotating Mechanism Arm
6. Rotating Mechanism (See Figure 114)
7. Retracting Mechanism (See Figure 107)
8. Nose Wheel Doors DOWN Latch Operating Lever
9. Nose Wheel Doors DOWN Latch
10. Nose Wheel Doors Operating Arm
11. Nose Wheel Doors (See Figure 116)
12. Nose Wheel Doors Actuating Cylinder (See Figures 265 and 266)
13. Nose Wheel Snubber (See Figure 112)
14. Nose Wheel Shock Strut (See Figure 111)
15. AAF2654-E 36 inch 10 Ply Smooth Contour Casing (High tension rayon) and AAF 26563-A Dual Seal Inner Tube
16. Goodyear Wheel Assembly (550024)

Figure 105—Nose Wheel Gear Installation



1. Retracting Link Stop Bolt
2. Washers and Shims
3. Retracting Link Adjustment Bolt
4. Guard
5. Upper Retracting Link (Latches are located inside this link)
6. Lower Retracting Link

ADJUSTMENT PROCEDURE

a. Disengage leaf spring assembly from latch assembly inside the upper retracting link. (Insert a tool between the leaf spring and latch assembly to maintain disengagement of the spring.)

b. Fully engage retracting link DOWN latch plunger, making certain the lower face of plunger is bottomed against bottom of slot. (Keep down latch plunger against bottom of slot while adjustment is being made.)

c. Use shims as required under head of adjustment bolt until .010 to .013 clearance is obtained between stop bolt and adjustment bolt after adjustment bolt has been tightened to 480 inch-pounds torque.

Figure 106—Adjustment of Nose Wheel Gear Retracting Links (Some Airplanes)

3. Remove the door actuating rods *(1 & 19, figure 109)* from the left and right-hand doors.

4. Disconnect the door actuating cylinder eyebolt from the cylinder attaching arm.

Note

If the nose wheel door UP latches are installed, manually move the cylinder attaching arms *(9, figure 110)* downward until the door latch arms *(3 & 18, figure 109)* engage the door UP latches *(2, figure 109)*. Adjust the door operating link turnbuckle to permit both latch arms to engage the UP latches and to be locked at the same time.

5. Check the ground safety pins to see that they have been properly installed.

6. Move the landing gear control lever in the pilots' compartment into the "UP" position to retract the door actuating cylinder piston rod fully.

7. Adjust the door actuating cylinder to align with the hole in the cylinder attaching arm.

8. Decrease the cylinder length by turning the eyebolt IN one full turn to create the required over-travel on the doors in the CLOSED position.

9. Attach the eyebolt to the arm and tighten the check nut.

Note

If the door UP latches are installed, adjust the latch release cables with the door latch arms engaged by the door UP latches and the landing gear control lever in the "NEUTRAL" position. The cables should be tight with both door UP latches fully engaged. If the control lever cannot be moved to the "DOWN" position, readjust (lengthen) the cable on the right hand door latch to permit the control lever to move to the "DOWN" position. At the same time care must be observed in making this adjustment so that the latches unlatch simultaneously or that the right hand latch unlatches slightly ahead of the left hand latch. This will preclude possible damage to the door mechanism operating link.

10. Place the door operating mechanism in the "OPEN" position.

11. Disconnect the piston rod eyebolt of the nose gear actuating cylinder, back off the bottoming cap until the piston bottoms.

12. Remove the ground safety pin from the nose wheel gear and check the main gear pins to be sure that they are properly installed. *(See figure 91.)*

13. Connect the eyebolt to the clevis between the retracting arm and retract the nose gear to the latched UP position.

14. Relieve pressure in the hydraulic system by operating the brakes, and allow the gear to be supported in the retracted position by the up latch hook.

15. Disconnect the rod end of the cylinder by removing the bolt from the rod and clevis.

16. Apply system UP pressure to the actuating cylinder and adjust the eyebolt to align with the clevis.

17. Increase the cylinder length by turning the eyebolt OUT three full turns to create the required over travel and UP position preload for the nose wheel gear.

18. Relieve the hydraulic system pressure by operating the brakes and reinstall the attaching bolt on the nose wheel gear actuating cylinder.

19. Adjust the door down latch release lever with the gear resting on the UP latch hook, to allow 3/16 inch clearance between the shock strut and the striking pad on the release lever *(1, figure 110)*. This is accomplished by adjusting the bolt located at the left end of the release lever *(3, figure 110)*.

20. Extend nose wheel gear. Install safety pin. The following instructions apply if the up latch hook release arm is actuated by a turnbuckle.

a. Apply full system DOWN pressure by operating the hand pump and allow the left-hand actuating assembly to complete its full over travel.

b. Maintain full DOWN pressure on the door actuating cylinder and adjust turnbuckle on aft side of zee angle to give $5/16 - 1/32^{+1/8}$ inches clearance between the release arm and the uplatch hook.

c. Apply full system UP pressure by operating the hand pump. Check to see that release arm is fully engaged with up latch hook when the roller in the nose wheel door left-hand actuating lever assembly is held by hook of the nose wheel door mechanical down latch assembly.

Note

If the up latch hook release arm is actuated by a screw assembly in the door operating link, the adjustment is made as follows: Fully extend the gear and check the gear up latch assembly for a clearance of 1/8–1/16 inch between the up latch hook and the hook release bar. The desired clearance should permit the nose wheel door cylinder attach arm to engage the door mechanism down latch properly and yet not allow the gear to drop off the up latch hook until the cylinder attach arm properly engages the door down latch. This clearance can be obtained by adjusting the latch up release screw which presses against the hook release bar and is located on the door operating link. In order to simulate flight conditions an additional check should be made as follows: Open the doors slowly (crack selector valve) until doors are approximately 30 degrees from full open position; then return selector valve to neutral. Apply a load on the doors, by having a man push on each door until 950 psi is registered on a gage installed in the down line of door cylinder. Move selector valve handle slowly to doors open position, at the same time retaining enough load on the doors to maintain 950 psi on the gage until the doors open far enough to release the gear. The gear should release when the doors are approximately fully opened. If gear does not release—re-adjust the up latch release screw to give more clearance between the up latch hook and hook release bar. This clearance must not be more than 3/16 inches maximum. Then repeat above procedure.

21. Relieve the hydraulic pressure with the door DOWN latch engaged and adjust the door DOWN latch turnbuckle. The adjustment is correct when the hook is 1/64 inch above the roller in its fully engaged position.

22. With the nose wheel gear in the extended position, relieve the pressure in the hydraulic system by operating the brakes.

23. Turn the nose wheel gear actuating cylinder bottoming cap IN until flush with the cylinder end.

24. Turn the cap OUT one full turn to create the required DOWN position preload of $1/16^{+1/32-0}$ inches.

25. If the nose wheel gear retracting link has an adjustment bolt, refer to *figure 106* for proper adjustment of the bolt.

Note

If the retracting link has an adjusting screw, engage the retracting link DOWN latch fully. Turn the retracting link adjustment screw until it bottoms against the stop bolt in the upper retracting link. Back off the adjustment screw 1/8 turn and lock with the check nut.

26. Retract and extend the nose wheel gear several times, checking all clearances and latch operations for both the gear retracting mechanism and the door operating mechanism.

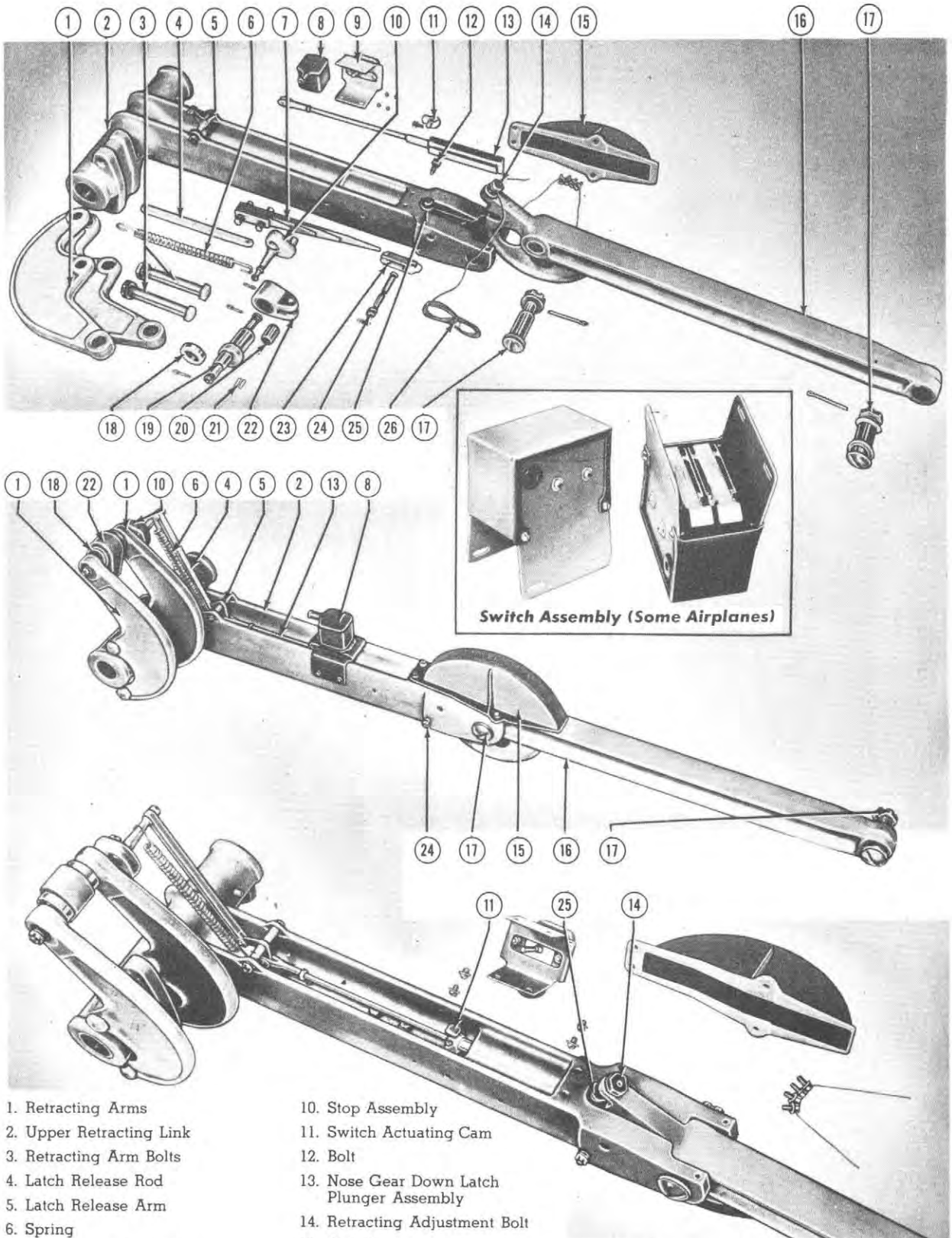
27. Attach the door actuating rod to the left-hand door center hinge only and retract the gear.

28. Manually swing the left-hand door up until it is closed.

29. Align the actuating rod end with the left-hand latch arm by shortening or lengthening the actuating rod.

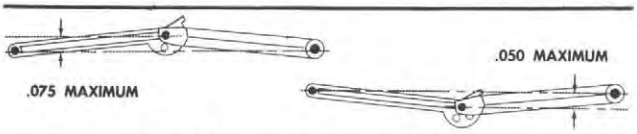
Note

Do not connect the actuating rod to the latch arm. Align them and allow the door to swing open again.



1. Retracting Arms
2. Upper Retracting Link
3. Retracting Arm Bolts
4. Latch Release Rod
5. Latch Release Arm
6. Spring
7. Leaf Spring Assembly
8. Switch Cover
9. Switch Assembly—Nose Wheel Latched Down (Some Airplanes)
10. Stop Assembly
11. Switch Actuating Cam
12. Bolt
13. Nose Gear Down Latch Plunger Assembly
14. Retracting Adjustment Bolt
15. Guard
16. Lower Retracting Link
17. Bolt, Spacer, Washers, and Nut
18. Spacer
19. Cam
20. Spacer
21. Keys
22. Clevis
23. Latch Assembly
24. Bolt, Spacers, and Nut
25. Stop Bolt
26. Lock Wire

Figure 107—Nose Wheel Gear Retracting Mechanism



WITH LATCH ENGAGED, MAXIMUM OFFSET AT CENTER SHOULD NOT EXCEED VALUES SHOWN IF ALL PARTS ARE WITHIN SPECIFIED TOLERANCES

Figure 108—Inspection of Nose Wheel Gear Retracting Mechanism

30. Attach the door actuating rod to the right-hand door center hinge and repeat the alignment of the actuating rod with the latch arm, following the same procedure as used for the left-hand door.

31. Extend the gear and connect the left and right-hand actuating rods to the door latch arms.

32. Retract the gear and check the fairing of the doors with the fuselage skin. The desired fairing can be accomplished by shortening or lengthening the door actuating rods.

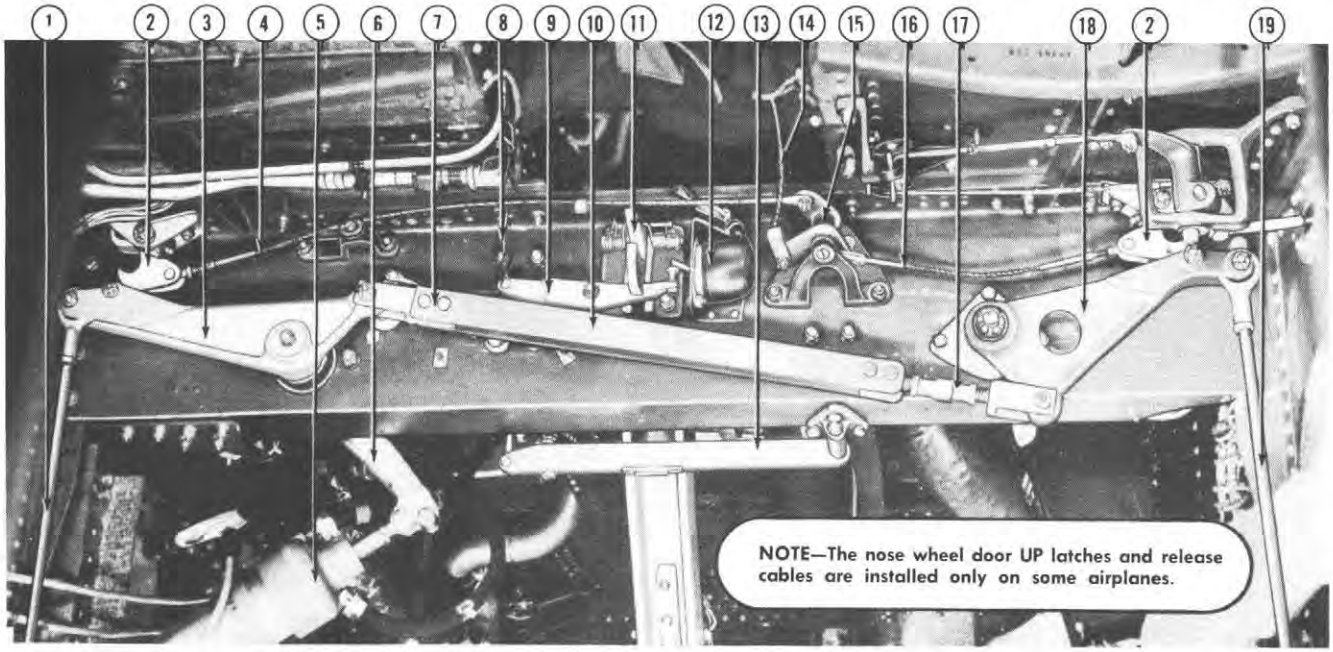
33. Lock all check nuts, tighten all bolts and nuts, and install lock wire and cotter pins as required.

(e) ASSEMBLY AND INSTALLATION.–Reverse the procedure outlined in paragraph 5. *c.* (1) *(b)*, this section.

(f) TEST AFTER INSTALLATION.–Make a trial operation of the nose wheel gear to insure proper operation.

(2) NOSE WHEEL GEAR RETRACTING MECHANISM.

(a) DESCRIPTION.–The nose wheel gear retracting mechanism revolves on a shaft and is operated by the hydraulic actuating cylinder *(4, figure 105)* attached to the pilots' compartment floor. The upper retracting link is connected at one end to the shaft, the other end to the lower retracting link *(16, figure 107)*. The lower retracting link extends from the upper DOWN latch *(13, figure 107)* which is assembled on the upper link, locks into a slot *(16, figure 107)* on the lower retracting link. During retraction, the actuating cylinder first releases the DOWN latch and then retracts the gear into the nose wheel well. One latch locks the gear in the fuly extended position only. A steel



1. L. H. Door Actuating Rod
2. Nose Wheel Door UP Latch
3. L. H. Door Actuating Arm
4. L. H. Door UP Latch Release Cable *(Figure 606, Item 11)*
5. Nose Wheel Doors Actuating Cylinder
6. Nose Wheel Doors Actuating Arm
7. Connecting Link Assembly
8. Nose Wheel Gear UP Latch Emergency Release Cable
9. Nose Wheel Gear UP Latch Release Bar
10. UP Latch Release Adjusting Screw (Located inside Link)
11. Nose Wheel Gear UP Latch Hook
12. Switch (Nose Wheel Gear Latched Up)
13. Nose Wheel Door Mechanism DOWN Latch Release Lever
14. Nose Wheel Door UP Latches Release Cable *(Figure 606, Item 56)*
15. Arm Assembly
16. R. H. Door UP Latch Release Cable *(Figure 606, Item 10)*
17. Connecting Link Turnbuckle
18. R. H. Door Actuating Arm
19. R. H. Door Actuating Rod

Figure 109—Nose Wheel Door Operating Mechanism and Nose Wheel Gear UP Latch Installed

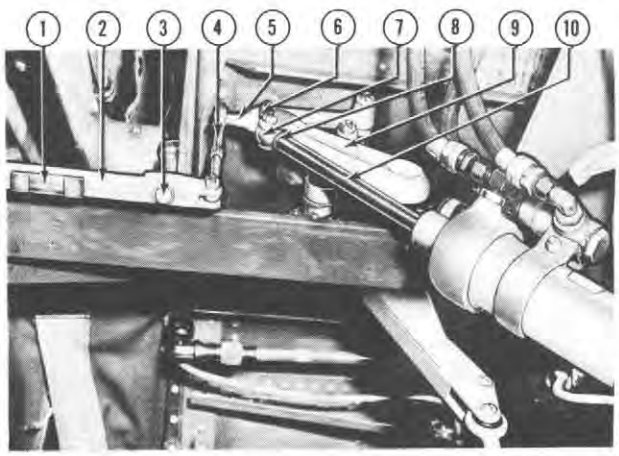
bungee *(7, figure 107)* composed of four leaf-type springs and a small latch are attached to the underside of the upper retracting link. This bungee and latch prevents the retracting links from moving until the DOWN latch plunger has completely unlocked the links. In this manner, any friction which would prevent the unlatching operation of the down latch mechanism is eliminated. The nose wheel gear is latched in the up position by a hook installed on the beam in the nose wheel well.

Note

On some airplanes the nose wheel doors are latched in the fully closed position by spring loaded latches *(2, figure 109)*. The latches are unlocked mechanically by the movement of the landing gear control lever to the "DOWN" position. A cable extends from this lever to a bell crank in the wheel well. From this bell crank a cable extends to each of the door UP lock latches *(2, figure 109)*. On other airplanes the nose wheel doors are held in the closed position by continuous hydraulic pressure in the nose wheel doors actuating cylinder and the air loads on the doors.

(b) REMOVAL AND DISASSEMBLY.

1. Support the airplane on a nose stand.



1. Striking Pad
2. Door Mechanism Down Latch Release Lever
3. Adjusting Bolt
4. Door Mechanism Down Latch Turnbuckle
5. Door Mechanism Down Latch
6. Door Mechanism Down Latch Roller Bearing
7. Actuating Cylinder Eyebolt
8. Actuating Cylinder Eyebolt Check Nut
9. Door Mechanism Actuating Arm
10. Nose Wheel Door Actuating Cylinder

Figure 110—Nose Wheel Door Operating Mechanism DOWN Latch Installed

2. Relieve hydraulic system pressure by operating the brakes.

3. Remove the bolt attaching the piston rod eyebolt to the clevis between the retracting arms.

4. Remove the screws attaching the latched down position switch to the upper retracting link and remove the switch wire clamp from the upper part of the link.

5. Remove the bolt that attaches the lower retracting link to the shock strut collar.

6. Remove the upper retracting shaft which goes through the two supports on each side of the nose wheel well and upon which the upper retracting link revolves. This is done by removing the bolt that locks the shaft to the right-hand support and then sliding the shaft out through the right-hand support.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Damaged parts must be replaced with new parts.

2. For hydraulic actuating cylinder and hydraulic selector valve information, refer to paragraph 14. *c.*, this section.

(d) ASSEMBLY AND INSTALLATION.—Reverse the procedure outlined in paragraph 5. *c.* (1) *(b)*, this section.

(e) ADJUSTMENT.—Refer to *figure 106* and to paragraph 5. *c.* (1) *(d) 25.*, this section.

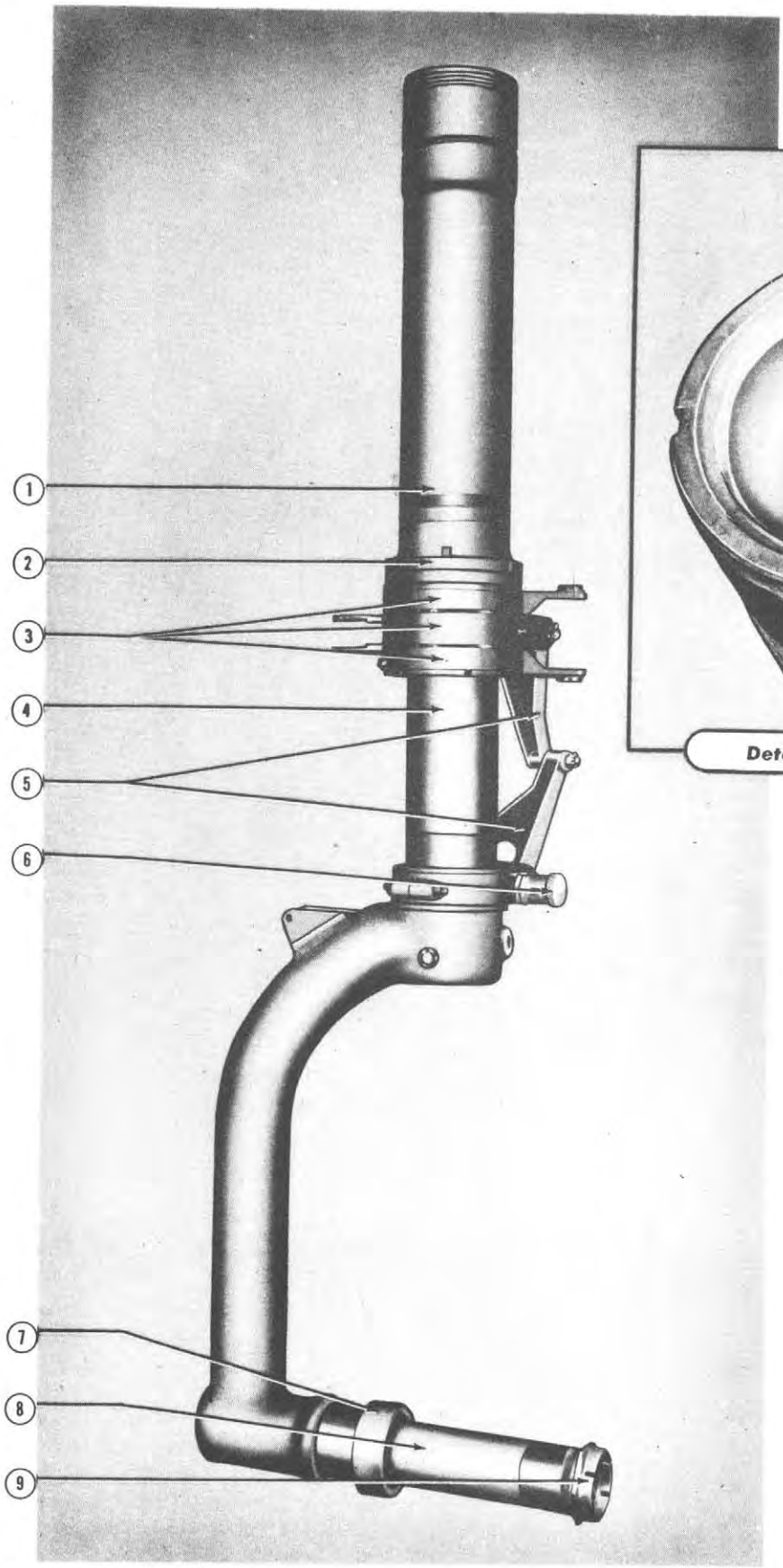
(f) TEST AFTER INSTALLATION.—Retract and extend the nose wheel gear several times to check mechanism for proper operation.

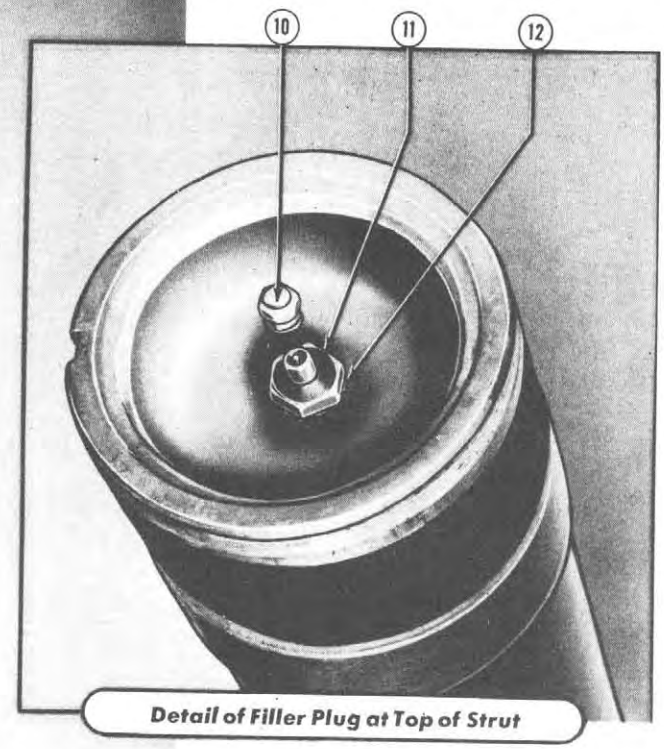
Note

With the down latch engaged, maximum offset at center bolt should not exceed values shown in *figure 108* if all parts are within specified tolerances.

(3) NOSE WHEEL SHOCK ABSORBER STRUT.

(a) DESCRIPTION.—Landing shocks on the nose wheel gear are partially absorbed by the oleopneumatic strut. A yoke *(3, figure 105)* around the top of the strut, bolts onto the side of the nose wheel well. Side braces *(1, fig. 105)* extend from the yoke to the strut collar. The strut is connected to the retracting shaft by the retracting link assembly *(7, fig. 105)*. A rotating arm *(5, fig. 105)* extends from the top of the strut and is controlled by a swivel assembly *(6, fig. 105)* attached to a bracket in the upper left-hand corner of the nose wheel well. The nose wheel shock strut and wheel are rotated 90 degrees during retraction so that the nose wheel lies flat in the nose wheel well.





Detail of Filler Plug at Top of Strut

1. Shock Strut Cylinder
2. Packing Nut
3. Snubber Collars
4. Shock Strut Piston
5. Restraining Links
6. Snubbing Pin and Collar Assembly
7. Nose Wheel Spacer
8. Axle
9. Nose Wheel Axle Nut
10. Air Valve Cap (Apply 15 to 25 inch-pounds Torque Preload)
11. Filler Plug and Air Valve Assembly
12. Gasket

N O T E
Fill shock strut with hydraulic fluid AAF Specification 3580 (Red Color).

Figure 111 — Nose Wheel Shock Strut Assembly

(b) REMOVAL.

1. Support the airplane on a nose stand.

2. Remove the bolt which attaches the rotating arm to the swivel mechanism.

3. Remove the bolt which attaches the lower retracting link to the shock strut collar.

4. Remove the bolts which fasten the strut to the side of the nose wheel well and remove the strut assembly.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. TIGHTENING THE SHOCK STRUT PACKING.—If the packing gland is leaking as evidenced by fluid seepage, or the presence of air bubbles when soapy water is applied, tighten the packing nut as follows:

a. Release the air pressure in the strut by partially backing off the filler plug *(11, figure 111)* located at the top of the strut. Packing cannot be tightened properly under pressure.

Note

Air must be exhausted completely from the strut before removing the filler plug. Do NOT release the air pressure by depressing the air valve core or the valve will be damaged.

b. Remove the packing nut lock wire.

c. Loosen the packing nut about one turn and work piston up and down several strokes. Then tighten packing nut until snug but not too tight.

d. Replace the lock wire on the packing nut and inflate the nose wheel shock strut as instructed in paragraph 5. *b.* (3) *(c)* 3., this section.

2. FILLING THE SHOCK STRUT. — The nose wheel shock strut is filled with hydraulic fluid, AAF Specification 3580, at the filler plug, located at the top of the strut, by the same procedure as given for the main landing gear shock strut. Refer to paragraph 5. *b.* (3) *(c)* 2., this section.

3. INFLATING THE SHOCK STRUT.—Observe the same procedure as given for the inflation of the main landing gear shock strut in paragraph 5. (3) *(c)* 3., this section. The nose wheel shock strut also is inflated until the upper edge of the red line on the piston tube is $1\frac{7}{8}\pm\frac{1}{4}$ inches from the bottom of the packing gland nut when the airplane is supporting a full normal load. For other maintenance information about the nose wheel shock strut refer to paragraph 5. *b.* (3) *(c)* 4. through 7.

(d) INSTALLATION.—To install the nose wheel shock strut reverse the removal procedure given in paragraph 5. *c.* (3) *(b)*, this section.

(4) NOSE WHEEL, TIRE AND TUBE.

(a) DESCRIPTION.—A drop-center wheel is mounted on an off-center support which extends from the axle and is an integral part of the shock strut piston rod. A 36-inch, smooth contour, 10-ply tire and dual seal tube are mounted on the wheel.

(b) REMOVAL.

1. WHEEL ASSEMBLY.

a. Support the airplane on a nose stand.

b. Remove the dust plate (if installed) from the right side of the wheel by removing the Dzus fasteners.

c. Remove the cotter from the axle nut and remove the axle nut and washer from the axle.

d. Slide the nose wheel assembly from the axle.

e. Remove the bearing enclosure lock ring, bearing enclosure rings and felt grease retainers, and bearings from the wheel.

2. TIRE AND TUBE.

a. Deflate the dual seal inner tube by removing valve core and unscrewing valve core housing five complete turns. Removal of the core housing before tube is completely deflated will cause inner compartment to collapse, preventing further deflation.

b. In the event that the inner compartment is collapsed at any time, follow inflation procedure as given in paragraph 5. *c.* (4) *(c)* 2., this section and deflation as given in paragraph 5. *c.* (4) *(d)* 2., this section.

c. After the dual seal inner tube is completely deflated remove the nose wheel tire and tube by observing the procedure given in paragraph 5. *b.* (5) *(b)*, this section.

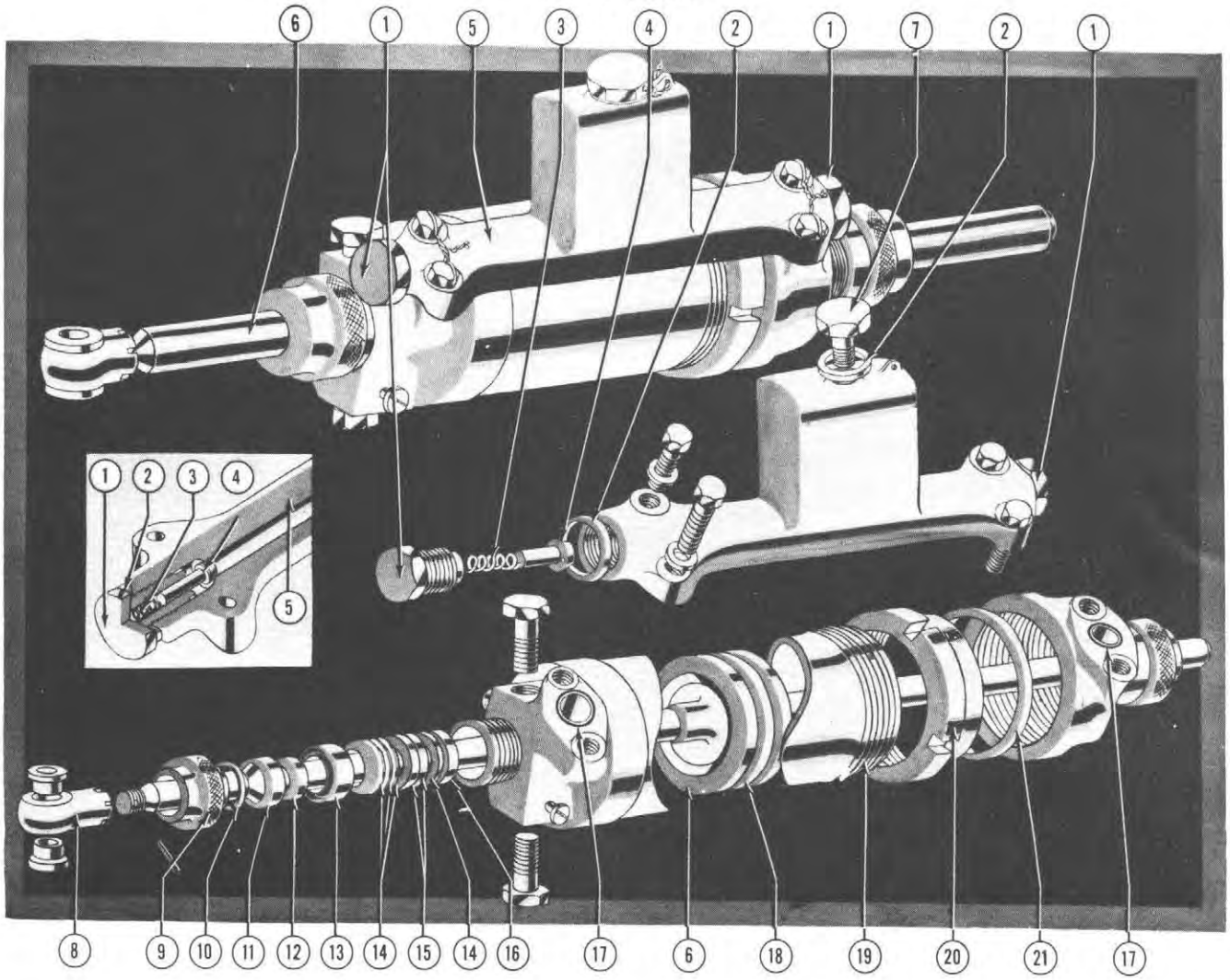
(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. WHEEL.—Maintenance for the nose wheel is the same as that given for the main wheels in paragraph 5. *b.* (4) *(c)*, this section.

2. TIRES AND TUBES.—Because of the tendency for tires with dual seal inner tubes to slip it is necessary to check inflation of the nose wheel tire frequently and with extreme care. Follow the procedure given in paragraph 5. *c.* (4) *(d)* 2., this section. For other maintenance information about tires and tubes refer to paragraph 5. *b.* (5) *(c)*, this section.

(d) INSTALLATION.

1. WHEEL ASSEMBLY.—To install the nose wheel assembly on the axle reverse the removal procedure given in paragraph 5. *c.* (4) *(b)*, this section.



1. Plug
2. Gasket
3. Spring
4. Poppet
5. Manifold Assembly (Reservoir)
6. Piston Assembly
7. Filler Plug
8. End Assembly (Includes Bushings)
9. Packing Nut
10. Lock Ring
11. Wiper
12. Washer
13. Ring
14. AN6225-16 Packing
15. Ring
16. Ring
17. Packing Cup
18. AN6227-34 Packing
19. Barrel Assembly
20. Nut
21. Cylinder Gasket

TEST PROCEDURE

TEST PORT	PISTON POSITION	TEST PRESSURE	MAX. LEAKAGE
AT RESERVOIR PLUG	EXTENDED	250 PSI	NONE
With Reservoir Filled Apply an Axial Force of 250 psi at Piston Rod End Time for Complete Stroke Should be as Follows: To Extend — 13 ± 2 Seconds To Retract — 13 ± 2 Seconds (Lever May Be Used to Apply Force)			

Douglas Drawing No. 5122388

Figure 112—Nose Wheel Snubber

2. TIRE AND TUBE.—Special care is necessary in the installation and use of the dual seal inner tube. Because of the tube's stiffer construction which causes relatively less pressure against the tire head seat and greater weight of the tube, there is more of a tendency for the tire to slip on the rim upon impact with the ground. To eliminate one source of such slippage, before attempting to mount the nose wheel tire and tube, wash all lubricant off the inside of the casing with a cloth dampened in gasoline. Blow out the inside of the casing with air or otherwise make sure that the casing is perfectly dry before continuing with the installation. Install the nose wheel tire and tube as follows:

a. Remove core housing and deflate by hand pressure to facilitate insertion of tube into the casing. Place the tube in the casing.

b. Place the tire and tube on a horizontal plane with the valve down. Force wheel, with valve hole down, into the tire.

c. Invert assembly so valve and valve hole are up.

d. With valve in line with valve hole, force tube over wheel rim.

e. Place valve in valve hole and apply core housing. Screw down tight.

f. Apply second bead to wheel.

g. Check centering of valve in valve hole.

h. Unscrew core housing five full turns from seated position and inflate until both beads are seated on rim.

i. Deflate completely by removing valve core to allow tube to adjust and center itself. (This should be done regardless of type of tube.)

j. Replace valve core and inflate. Wait 30 seconds to allow pressure to equalize in the two chambers. Check inflation which should be 38 psi, measured with an accurate gage. Retighten valve core housing by screwing rubber barrel back tight, then twisting 180 degrees *by hand* to seat securely. *Do not use pliers.* Remove valve core and use spit test on valve tip to check for leakage.

k. Re-install valve core and cap.

l. Check inflation of dual seal tubes frequently and carefully.

(5) NOSE WHEEL SNUBBER.

(a) DESCRIPTION.—The nose wheel snubber is an independent hydraulic unit attached to the nose wheel strut. The manifold assembly located on top of the snubber is the fluid reservoir. Spring loaded poppets are seated in the manifold assembly and restrict the flow of fluid when snubbing pressure is applied. The snubber cylinder assembly incorporates a piston which moves with the wheel and builds up the snubbing pressure. This unit prevents wheel shimmy and restricts the wheel to 36 degrees of movment each side of center. A nose wheel snubber locking mechanism key is attached to the red streamer containing the nose wheel gear safety pin. When in the locked position, the key engages the snubber lock plunger until the red cap (chained to the lower torque arm) can be applied. When installed, this cap insures a positive engagement of the wheel and snubber for flight. When in the unlocked position, the nose wheel key disengages the snubber lock plunger. The plunger, in turn, releases the nose wheel from the snubber, allowing full caster 360 degrees for towing and handling. *(See figure 113.)*

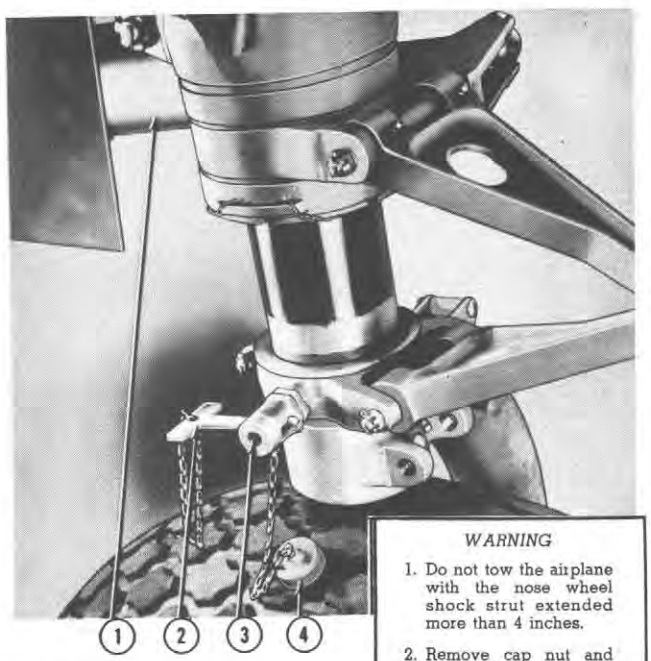
(b) REMOVAL.

1. Remove the bolt at the end of the snubber piston rod.

2. Remove the bolt at the top of the snubber cylinder and remove the snubber assembly from the nose strut collar.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check the snubber reservoir for proper amount of fluid periodically.

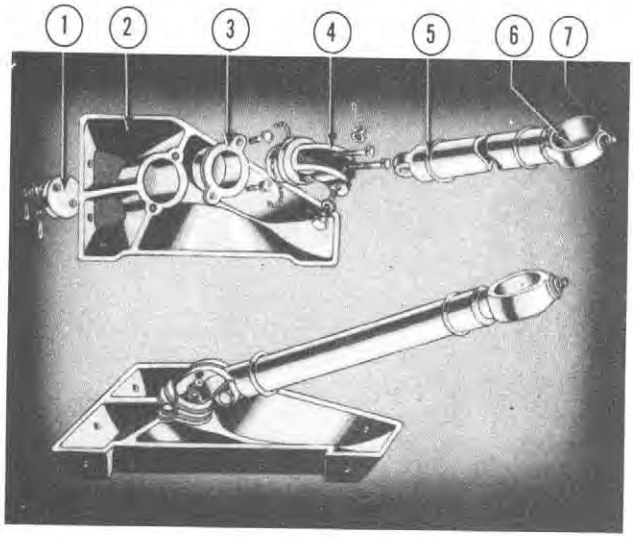


1. Nose Wheel Snubber
2. Lock Pin Key
3. Snubber Lock Pin
4. Lock Pin Engaging Cap Nut

WARNING

1. Do not tow the airplane with the nose wheel shock strut extended more than 4 inches.
2. Remove cap nut and fully engage key before towing the airplane.
3. Remove key and install cap nut after towing the airplane.

Figure 113—Nose Wheel Snubber Lock Pin (Shown Unlocked)



1. Washer
2. Support Fitting
3. Bearing
4. Swivel
5. Rotating Mechanism Link Assembly
6. Link Socket
7. Lubrication Fitting

Figure 114—Nose Wheel Rotating Mechanism

2. Bleed the snubber by moving the wheel to the limit of its travel in both directions two or three times. Refill with fluid and plug the reservoir. Maintain the hydraulic fluid (Specification AN-VV-O-366) level with the bottom of the reservoir filler hole. Whenever excessive leakage becomes evident, disassemble the snubber *(figure 112)* and replace the packing.

(d) INSTALLATION.—Reverse the procedure outlined in *(b)* above.

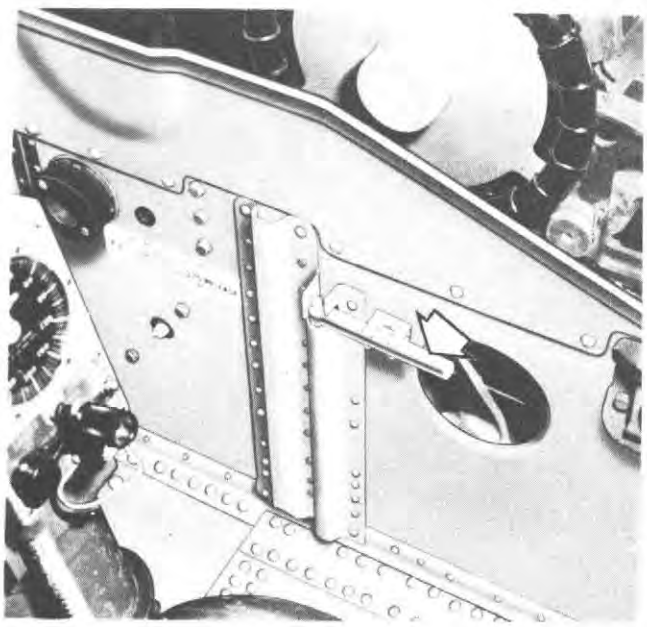


Figure 115—Nose Gear Emergency Release

(e) FILLING THE SNUBBER.

1. Fill the reservoir with hydraulic fluid (Specification AN-VV-O-366) to bottom of filler hole.

2. Remove all air bubbles by slowly extending and compressing the snubber piston fully several times.

3. Add hydraulic fluid to the snubber reservoir if necessary.

(f) TEST AFTER INSTALLATION. – Turn the nose wheel either side of center several times to check snubber operation. Refer to *figure 112* for fluid leak tests of the snubber assembly.

(6) NOSE WHEEL DOORS.—*(See figure 116.)*

(a) DESCRIPTION.—A left and right-hand side door is installed to cover the nose wheel well. These doors are linked to operate with the nose wheel gear, opening completely before the nose wheel gear begins extending and closing only after the nose wheel gear is completely retracted.

(b) REMOVAL AND DISASSEMBLY.

1. Remove the bolts from the door actuating rods.

2. Remove the hinge bolts which attach the doors to the nose wheel well structure. Remove the doors.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check for looseness of hinge bolts and actuating rod attaching bolts.

2. Check doors for freedom from binding or excessive over-travel.

(d) ADJUSTMENTS.—The nose wheel doors and gear are adjusted at the same time. See paragraph 5. *c.* (1) *(d)*, this section.

(e) ASSEMBLY AND INSTALLATION.—Reverse procedure outlined in paragraph 5. *c. (b)*, this section.

(f) TEST AFTER INSTALLATION.—Operate the nose wheel gear and check the doors for proper operation.

(8) NOSE WHEEL GEAR ROTATING MECHANISM.—A rotating mechanism *(figure 114)* is provided in the nose wheel well which turns the nose wheel and shock absorber strut 90 degrees while they are being retracted so that the nose wheel lies flat in the nose wheel well. The unit is attached at one end to a bracket in the left hand forward corner of the well and at the other to the rotating mechanism arm *(5, figure 105)* on the oleo strut.

d. TAIL SKID.—A tail skid is installed on the bottom of the aft fuselage section. This unit is riveted to the fuselage tail structure and is made of molded neoprene, capped by .125 sheet steel.

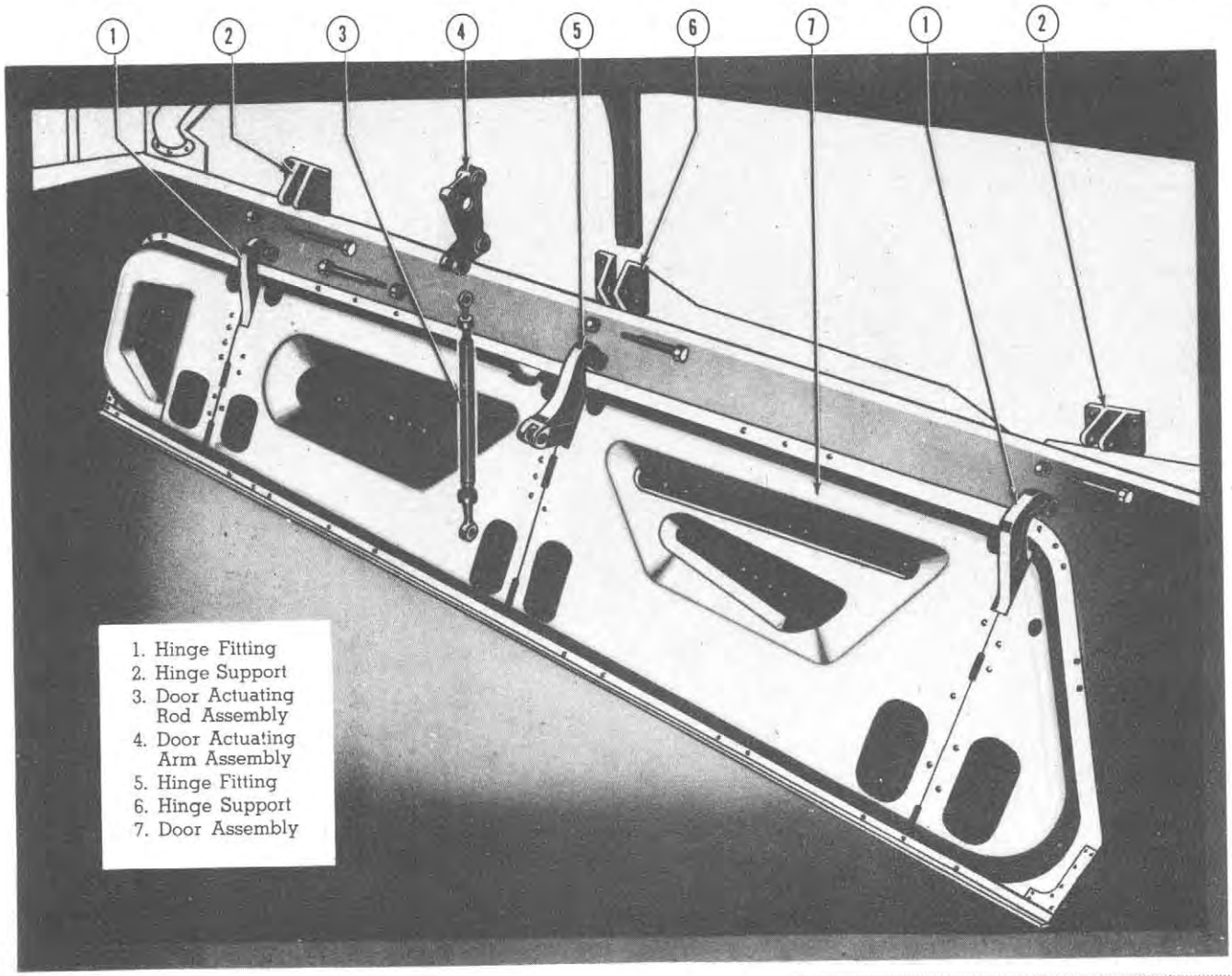


Figure 116—Nose Wheel Door

e. ALIGHTING GEAR TROUBLE SHOOTING LIST.

BRAKE TROUBLE SHOOTING

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Excessive brake pedal travel or insufficient braking action.	*a.* Normal wear of bronze discs.	*a.* As discs wear thinner, the brake piston must travel farther. This results in greater fluid displacement and requires adjustment in disc clearance as instructed in paragraph 5. *b.* (5) *(d)*, this section.
	b. Improper adjustment of clearance between discs.	*b.* Check clearance of discs as a unit. See paragraph 5. *b.* (5) *(d)* c., this section.
	c. Fluid leak in the system.	*c.* If the pedal will gradually depress under pressure, there is a fluid leak in the system. Check the leak. If the piston seal is worn, shrunken or damaged, replace as specified, see paragraph 5. *b.* (4) *(c)* 2., this section.
	d. Air in the brake hydraulic lines.	*d.* A springy, rubbery action of the pedal may indicate air in the system. An excessive amount of air will permit the pedal to go full on under normal pressure. Bleed the system as instructed in paragraph 14. *e.* (2) *(d)* 1., this section.
	e. Lack of fluid in the hydraulic system reservoir.	*e.* Air will enter the system if the reservoir is allowed to go dry. Fill reservoir as instructed on name plate.

e. ALIGHTING GEAR TROUBLE SHOOTING LIST.—Continued

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
2. Dragging brakes.	*a.* Improper adjustment of clearance between discs.	*a.* Adjust clearance. See paragraph 5. *b.* (5) *(d)*, this section.
	b. Binding of brake piston.	*b.* Dust and dirt mixing with the hydraulic fluid at the brake piston may become gummy and cause sticking of brake piston. Remove and clean the brake as instructed in 5., this section.
	c. Dirt in the system.	*c.* Follow instructions outlined in paragraph 5. *b.* (5) *(c)* 2. d., this section.
	d. Weak or broken brake piston return springs.	*d.* Replace with new springs.
	e. Dished or warped bronze or steel discs.	*e.* Return to a flattened condition and install.
	f. Rudder pedal linkage binding.	*f.* Check linkage and eliminate binding.
	g. Parking brakes applied.	*g.* Release the parking brake.

SHOCK STRUT TROUBLE SHOOTING.

CAUTION—RELEASE ALL AIR PRESSURE IN STRUT BEFORE DISASSEMBLING

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Air leaks.	*a.* Undue wear of valve core seat.	*a.* Work valve core up and down to find new seat. If this method fails, replace valve core.
	b. Deterioration of valve seat.	*b.* Screw valve core down. If this fails, replace valve core.
	c. Scratches or nicks in copper gasket.	*c.* Replace gasket.
	d. Improper assembly of valve core or valve body.	*d.* Tighten valve core or valve body.
2. Oil leaks.	*a.* Improper packing adjustment.	*a.* Tighten packing nut just enough to stop leakage.
	b. Deterioration of packing.	*b.* Replace packing.
	c. Improper assembly of packing.	*c.* Replace packing.
3. Improper taxiing characteristics.	*a.* Improper air inflation.	*a.* See name plate for instructions on inflation and oil quantity.
	b. Improper packing adjustment.	*b.* Back off packing nut to allow freedom of piston movement while retaining oil.
	c. Improper inflation of tire.	*c.* Inflate tire properly.
4. Rigid landing characteristics.	*a.* Over-inflation.	*a.* Inflate according to name plate instructions.
	b. Tight packing.	*b.* Back off packing nut to allow freedom of piston movements while retaining oil.
	c. Over supply of oil.	*c.* Fill according to instructions on name plate.
5. Hard landings due to failure of shock absorber.	*a.* Under inflation.	*a.* Inflate according to name plate instructions.
	b. Insufficient oil supply.	*b.* Fill according to instructions on name plate.

6. ENGINES

a. GENERAL.—Power for this airplane is furnished by two Pratt and Whitney R-2800-27 (or R-2800-71) Douglas-Wasp single-stage, two speed radial engines. Critical altitude is listed at 5700 feet for low blower operation, and 13,000 feet for high blower. Refer to AN01-40AJ-1 "Flight Operations" for tables of operating instructions. Engine accessories are reached through access doors in each nacelle. Easily removable anti-drag ring and electrically operated cowl flaps are installed. Engine controls including carburetor air, throttle, supercharger blower, carburetor air filter, and fuel mixture are manually operated from the pilot's compartment.

b. ENGINE ASSEMBLY.

(1) GENERAL.—Each double-row engine has eighteen cylinders, nine in each row, which produce 2000 brake horse-power at take-off. Cylinders are numbered consecutively in the direction of crankshaft rotation (clockwise when viewed from the rear looking forward) beginning with the top cylinder in the rear bank. Left and right directions are determined from behind the engine looking forward. The engine assembly consists of the engine proper and all engine accessories forward of the firewall.

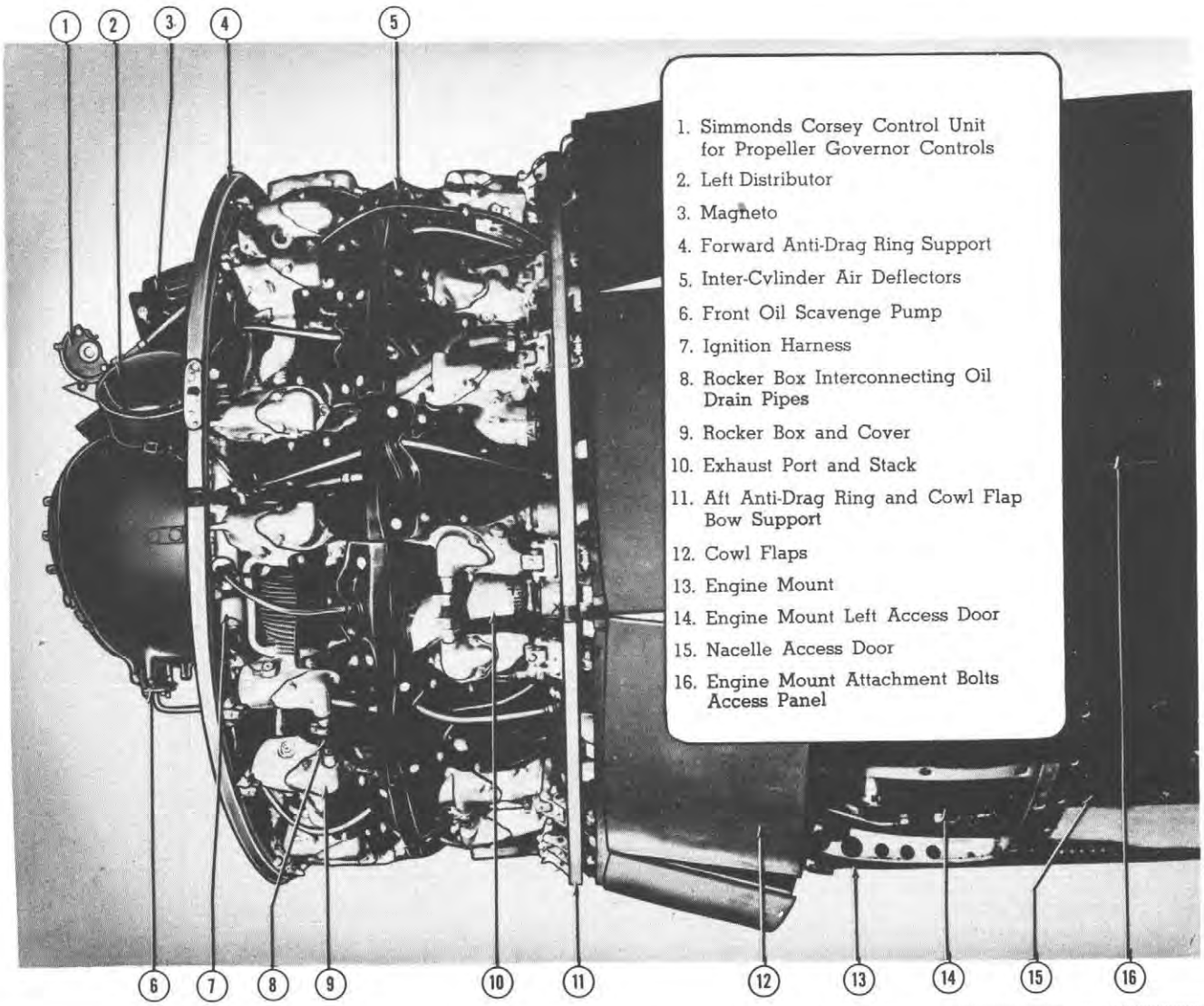
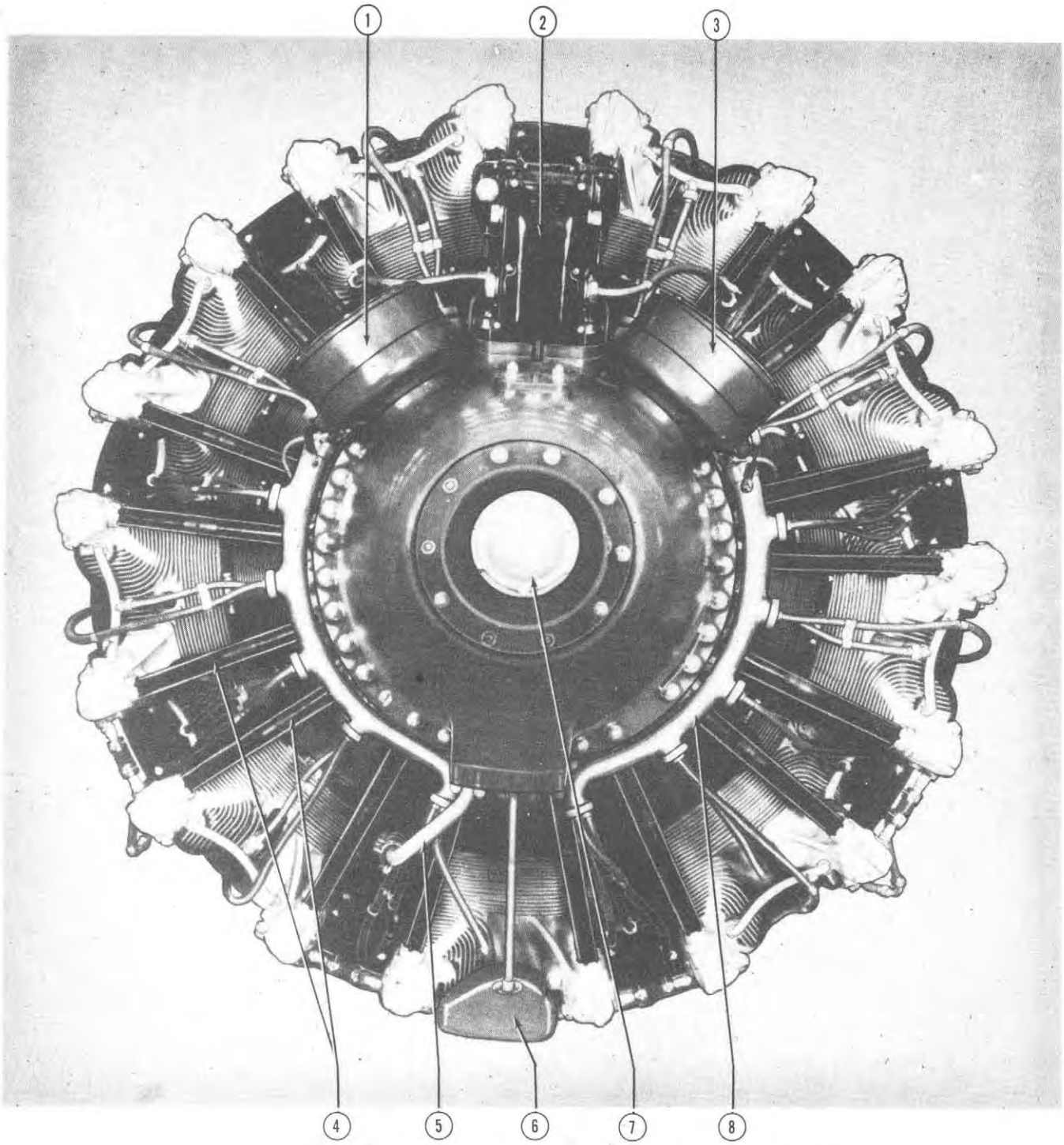
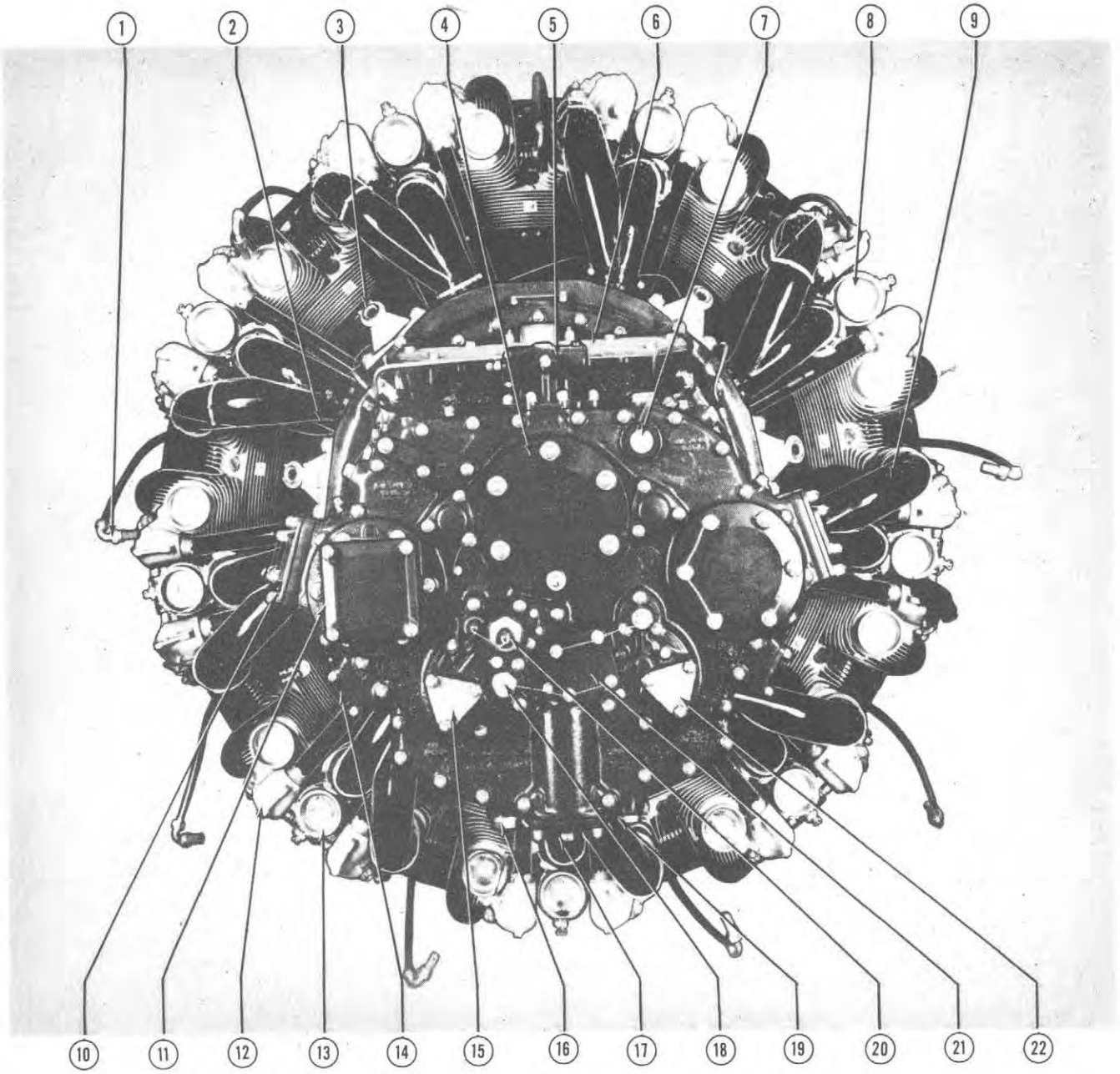


Figure 117—Engine Installed (Side View)



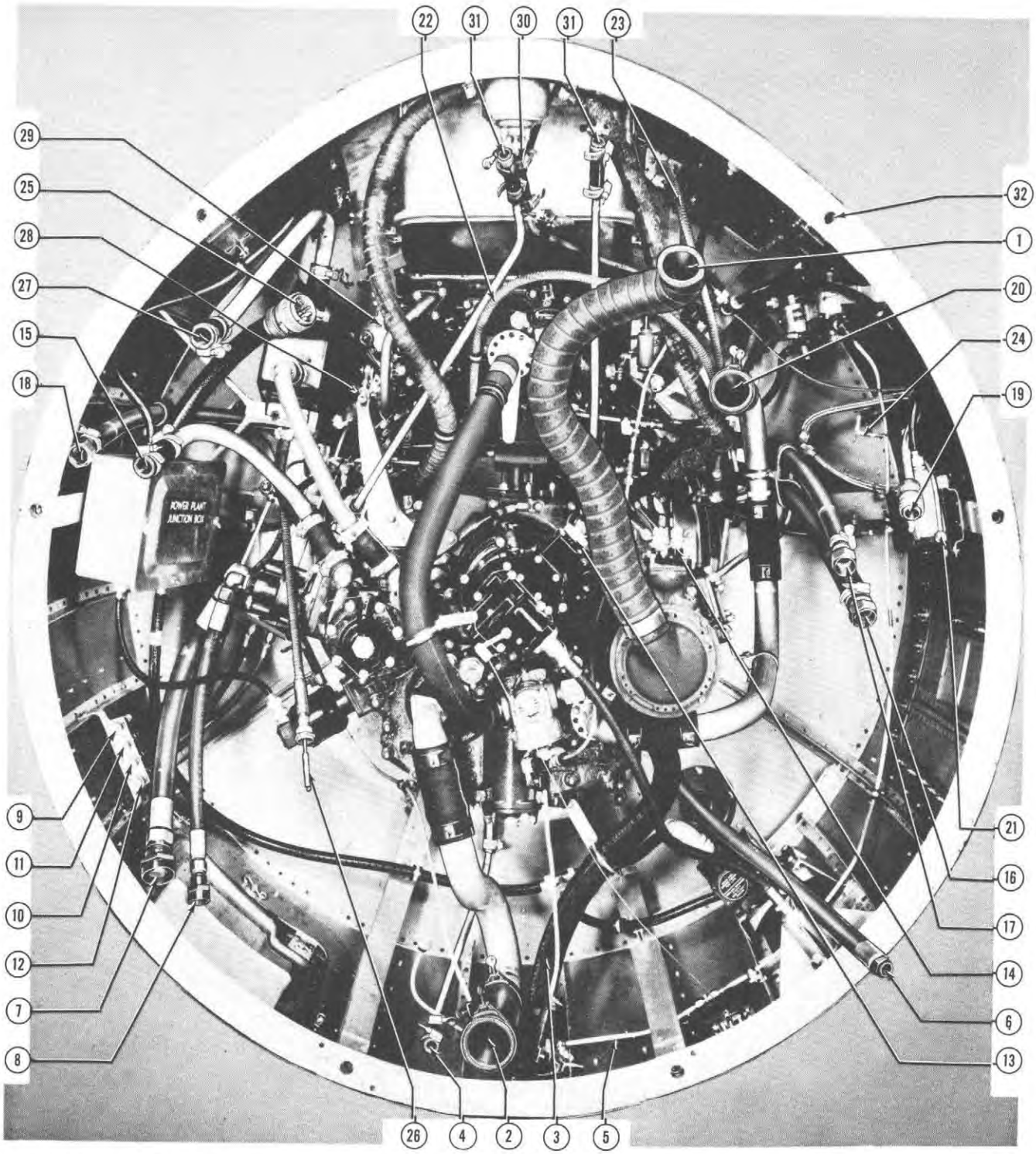
1. Right Distributor
2. Magneto
3. Left Distributor
4. Push Rod Cover Tubes
5. Oil Scavenge Line, Front Section to Blower Section
6. Rocker Box Drain Sump
7. Propeller Shaft
8. Ignition Harness

Figure 118 — Engine (Front View)



1. Spark Plug Lead Elbow
2. Primer Line
3. Engine Mounting Bracket
4. Starter Mounting Pad
5. Supercharger Low Speed Control
6. Carburetor Mounting Pad
7. Oil Tank Vent Connection
8. Exhaust Port
9. Intake Pipe
10. Hydraulic Pump Mounting Pad
11. Vacuum Pump Mounting Pad
12. Rocker Box
13. Rocker Box Interconnecting Pipes
14. Tachometer Drive Pad
15. Oil Inlet Pad
16. Rear Section Oil Drain Plug
17. Oil Pressure Screen Chamber Drain Plug
18. Oil Pressure Screen Chamber By-Pass Valve
19. Rear Section Scavenge Chamber Drain Plug
20. Compensating Relief Valves
21 Fuel Pump Drive Pad
22. Oil Outlet Pad

Figure 119 — Engine (Rear View)



1. Generator Blast Tube (Flexible Tube Not Shown)
2. Engine Oil — In Line
3. Fuel Supply Line
4. Supercharger Drain Line
5. Oil Dilution Line
6. Hydromatic Propeller Feathering Line
7. Hydraulic Supply Line
8. Hydraulic Pressure Line
9. Oil Pressure Transmitter Line
10. Fuel Pressure Gage Vent Line
11. Fuel Pressure Transmitter Line
12. Manifold Pressure Line
13. Starter Electrical Disconnect
14. Generator Electrical Disconnect
15. Vacuum Suction Line
16. Heat and Vent Exhaust Line
17. Heat and Vent Fuel Vapor Line
18. Heat and Vent Fuel Vapor Line
19. Ignition Disconnector Receptacle
20. Engine Oil — Out Line
21. Propeller Anti-Icer Line
22. Blower Control
23. Carburetor Airscoop Control
24. Thermocouple (Cylinder Head Temperature) Disconnector
25. Main Electrical Box Disconnector
26. Propeller Governor Control
27. De-Icer Pressure Line
28. Carburetor Throttle Control Rod
29. Carburetor Mixture Control Rod
30. Carburetor Vapor Vent Line
31. Oil Tank Vent Lines
32. Mount Bolt Hole (6 Holes)

Figure 120 — Quick Engine Change (Rear View of Engine)

(2) REMOVAL (QUICK ENGINE CHANGE).

(a) Remove the propeller as instructed in paragraph 10. *b.* (2), this section.

(b) Remove anti-drag ring cowling as instructed in paragraph 6. *b.* (14) *(b)*, this section.

(c) Remove access doors aft of the firewall which are held by Dzus fasteners.

(d) Remove the firewall center section which is also held by Dzus fasteners.

(e) Place a tail stand in position under the empennage.

(f) Drain the oil system as instructed in 12. *d.*, this section.

(g) Place the fuel container selector valve in the "OFF" position and drain the lines at the fuel strainer.

(h) Disconnect all electrical plugs at the firewall.

(i) Disconnect the two hydraulic lines at the firewall by unscrewing the self-sealing disconnect couplings. When unscrewed, these couplings cut off the flow of fluid immediately.

(j) Disconnect and cap all oil, fuel, and vacuum lines.

(k) Disconnect engine controls at firewall.

(l) Place the engine hoisting stand and equipment in position. Hook the sling cables to the engine hoisting eye brackets.

(m) Remove the four small oblong cover plates on the upper portion of the nacelle, aft of the engine mount.

(n) With the hoist slackened, remove the two lower engine mount bolts which are reached through the lower forward corner of each access door of each nacelle.

(o) With the hoist supporting almost the entire weight of the engine, unscrew the four remaining engine mount bolts and remove the engine.

(3) TOP OVERHAUL. – Refer to information pertaining to the component parts which comprise the engine assembly.

(4) ASSEMBLY AND INSTALLATION.–Reverse the REMOVAL AND DISASSEMBLY procedure. Check the table of recommended torque valves given at the end of this part. Engine mount attaching bolts should be tightened to a torque of 480-690 inch-pounds.

(5) CYLINDER GROUP.

(a) GENERAL.–The cylinder group includes the intake pipes, the valve assembly, cylinders, cooling air baffle and deflectors, and the piston assembly. The valve assembly includes the push rods and covers, the rocker box mechanism and the valves–the piston assembly includes pistons, piston pins, and rings. Only parts which may be removed on the field (TOP OVERHAUL) are considered.

(b) INTAKE PIPES.

1. DESCRIPTION.–Eighteen stainless steel intake pipes are connected by packing nuts to the outlet ports of the blower case and to the inlet ports of the cylinders.

2. REMOVAL.–Loosen the packing nuts at the blower section and at the cylinder end with the Intake Pipe Packing Nut Wrench; then remove intake pipes from the engine.

3. TOP OVERHAUL.–Intake pipes should be replaced.

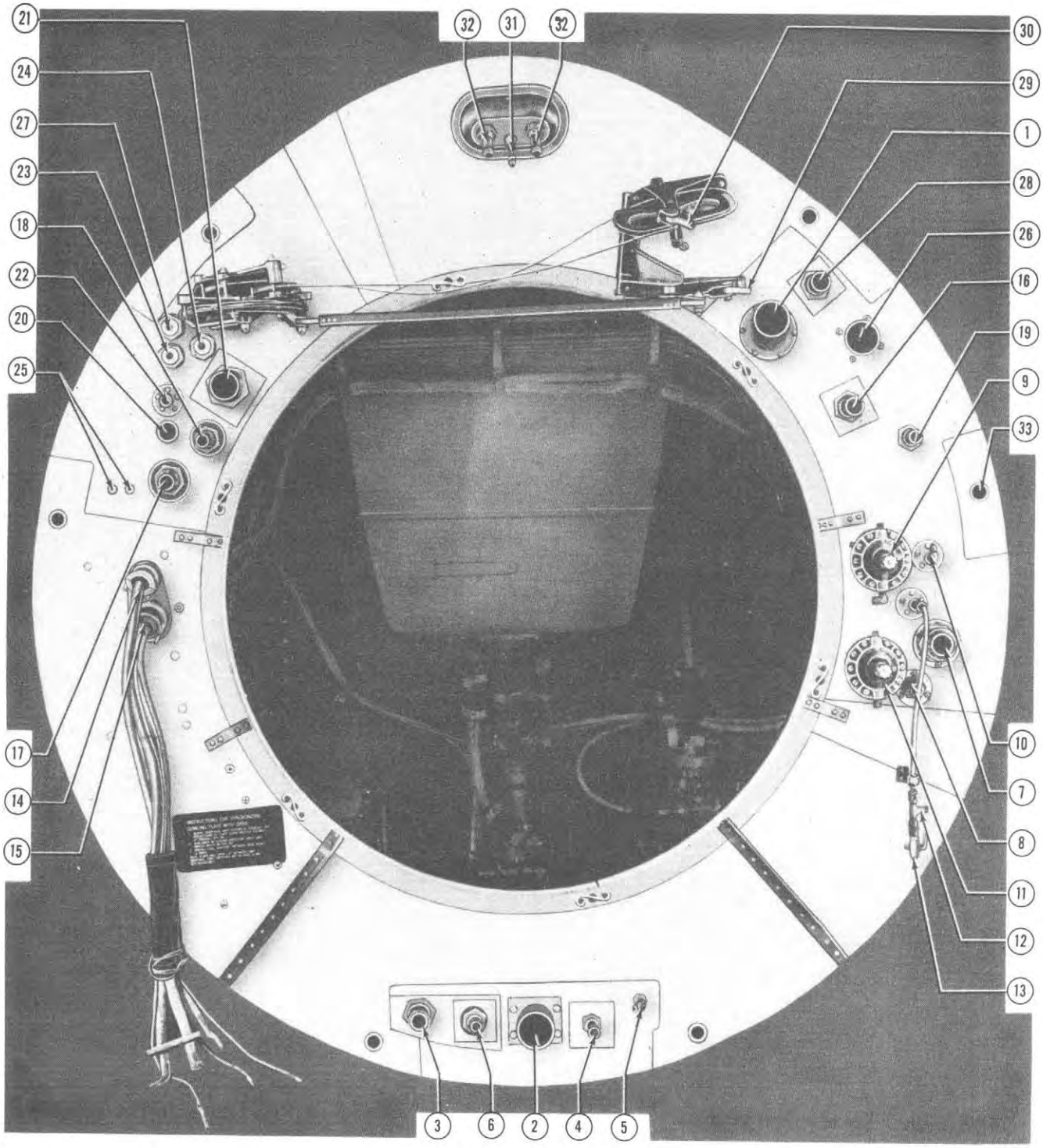
4. INSTALLATION.–Slip the packing and gland nut into place over the blower end of each intake pipe. Install the two rubber seal rings and spacer in place on the cylinder end of each intake pipe. The ring with the larger outer diameter should be placed just forward of the flange, and the one with the smaller outer diameter just to the rear of the flange. In order to prevent leaks around the seals, each pipe should be assembled as follows:

a. Set the pipe in place and tighten the nut at the blower case end one turn. Tighten the nut at the cylinder end of the pipe hand tight; loosen it, pull it back, and inspect the rubber seal rings to make certain that they are properly located inside the intake pipe coupling.

b. When properly located, thread the nut onto the coupling, and tighten it with the Intake Pipe Coupling Nut Wrench. Tighten the nut at the blower case end of the pipe. Care should be used during tightening to avoid damaging the pipe. Secure the coupling nuts with safety wire.

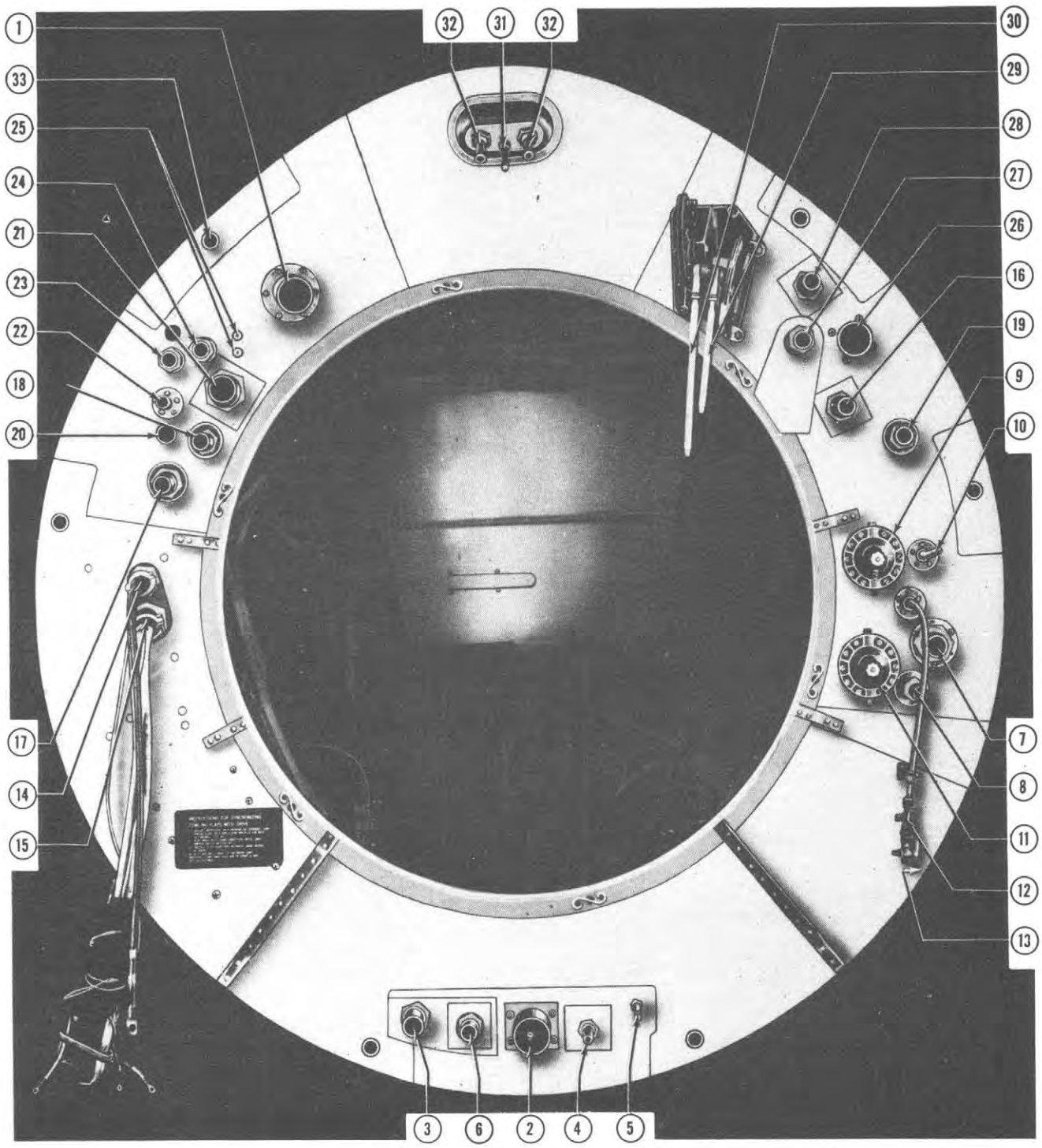
(c) VALVE ASSEMBLY.

1. GENERAL.–The valve assembly consists of the push rods and covers, the rocker box covers, rocker box arms, rocker box drain sump, and the valves. Only parts which may be removed on the field (TOP OVERHAUL) are considered.



1. Generator Blast Tube (Flexible Tube Not Shown)
2. Engine Oil — In Line
3. Fuel Supply Line
4. Supercharger Drain Line
5. Oil Dilution Line
6. Hydromatic Propeller Feathering Line
7. Hydraulic Supply Line
8. Hydraulic Pressure Line
9. Oil Pressure Transmitter
10. Fuel Pressure Gage Vent Line
11. Fuel Pressure Transmitter
12. Manifold Pressure Line
13. Drain Cock
14. Starter Electrical Disconnect
15. Generator Electrical Disconnect
16. Vacuum Suction Line
17. Heat and Vent Exhaust Line
18. Heat and Vent Fuel Vapor Line
19. Heat and Vent Fuel Vapor Line
20. Ignition Disconnector Receptacle
21. Engine Oil — Out Line
22. Propeller Anti-Icer Line
23. Blower Control
24. Carburetor Airscoop Control
25. Thermocouple (Cylinder Head Temperature) Disconnector
26. Main Electrical Box Disconnector
27. Propeller Governor Control
28. De-Icer Pressure Line
29. Carburetor Throttle Control Rod
30. Carburetor Mixture Control Rod
31. Carburetor Vapor Vent Line
32. Oil Tank Vent Lines
33. Mount Bolt Hole (6 Holes)

Figure 121 — Quick Engine Change (L.H. Firewall)



1. Generator Blast Tube (Flexible Tube Not Shown)
2. Engine Oil — In Line
3. Fuel Supply Line
4. Supercharger Drain Line
5. Oil Dilution Line
6. Hydromatic Propeller Feathering Line
7. Hydraulic Supply Line
8. Hydraulic Pressure Line
9. Oil Pressure Transmitter
10. Fuel Pressure Gage Vent Line
11. Fuel Pressure Transmitter
12. Manifold Pressure Line
13. Drain Cock
14. Starter Electrical Disconnect
15. Generator Electrical Disconnect
16. Vacuum Suction Line
17. Heat and Vent Exhaust Line
18. Heat and Vent Fuel Vapor Line
19. Heat and Vent Fuel Vapor Line
20. Ignition Disconnector Receptacle
21. Engine Oil — Out Line
22. Propeller Anti-Icer Line
23. Blower Control
24. Carburetor Airscoop Control
25. Thermocouple (Cylinder Head Temperature) Disconnector
26. Main Electrical Box Disconnector
27. Propeller Governor Control
28. De-Icer Pressure Line
29. Carburetor Throttle Control Rod
30. Carburetor Mixture Control Rod
31. Carburetor Vapor Vent Line
32. Oil Tank Vent Lines
33. Mount Bolt Hole (6 Holes)

Figure 122 — Quick Engine Change (R.H. Firewall)

2. PUSH RODS AND COVER.

a. DESCRIPTION.—Tappets located in the front and rear main crankcase sections actuate the rocker arms by tubular aluminum alloy push rods which have steel ball end caps. The push rods are protected by removable two-piece oil tight push rod cover tubes held in place by a packing nut at each end. The push rod cover tubes telescope together at the center, the joints being covered with short rubber sleeves.

b. REMOVAL AND DISASSEMBLY.

(1) Remove the rocker box cover and rocker arms as instructed in paragraph 6. *b.* (5) *(c)* 3., this section.

(2) Loosen the push rod cover nuts and partially telescope the push rod cover tubes together.

(3) Turn the propeller shaft until the piston in the desired cylinder is at the top of its compression stroke (both valves closed).

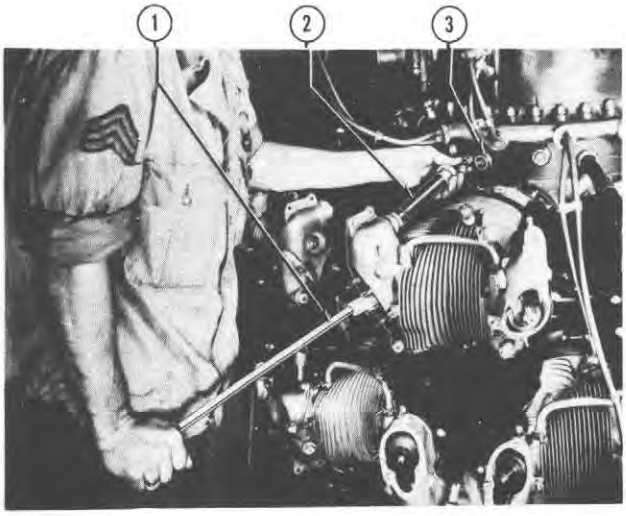
(4) Depress the valve springs with the rocker arm depresser and remove each push rod and cover.

c. TOP OVERHAUL.

(1) Examine push rod ball-ends for looseness and wear (a clear ringing sound when a push rod is dropped on a bench indicates that the ball-ends are tight).

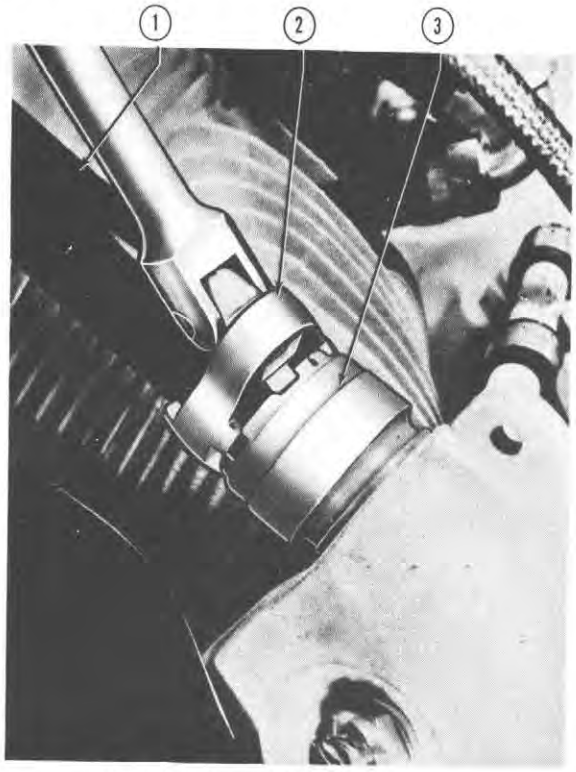
(2) Inspect for cracks.

(3) Test for straightness by rolling on a flat plate.



1. Rocker Arm Depressor
2. Push Rod Cover Tubes
3. Push Rod Socket

Figure 123 — Push Rod Cover Tube Removal



1. Push Rod Cover Tube
2. Push Rod Cover Tube Gland Nut Wrench
3. Push Rod Cover Tube Gland Nut

Figure 124 — Push Rod Cover Tube Gland Nut Removal

(4) Examine push rod covers for cracks, especially at the flange and telescoping ends. Inspect condition of the gland nuts.

Note

If any of the above conditions are extreme, replace the part.

(5) Look for evidence of oil leakage at the push rod cover tube packing nuts, but do not tighten nuts in excess of 75 inch-pounds of torque. Too much tightening will tend to nick the pipes and disturb the packing.

d. ASSEMBLY AND INSTALLATION.

(1) The push rod cover tube assembly consists of a larger and a smaller tube which telescope together with a rubber sleeve covering the joint. To prevent oil leaks at this joint, the smaller tube should be above the larger tube when the engine is installed.

(2) The following table indicates the proper positioning of the tube for each valve:

Small Tube Nearest Cylinder End		*Small Tube Nearest Crankcase End*	
No. 1	Intake	No. 5	Intake
No. 1	Exhaust	No. 7	Intake
No. 3	Intake	No. 7	Exhaust

Small Tube Nearest Cylinder End		*Small Tube Nearest Crankcase End*	
No. 3	Exhaust	No. 9	Intake
No. 17	Intake	No. 9	Exhaust
No. 17	Exhaust	No. 11	Intake
No. 5	Exhaust	No. 11	Exhaust
No. 15	Intake	No. 13	Intake
No. 2	Intake	No. 13	Exhaust
No. 2	Exhaust	No. 15	Exhaust
No. 4	Intake	No. 6	Intake
No. 4	Exhaust	No. 8	Exhaust
No. 16	Intake	No. 8	Intake
No. 16	Exhaust	No. 10	Intake
No. 18	Intake	No. 10	Exhaust
No. 18	Exhaust	No. 12	Intake
No. 6	Exhaust	No. 12	Exhaust
No. 14	Intake	No. 14	Exhaust

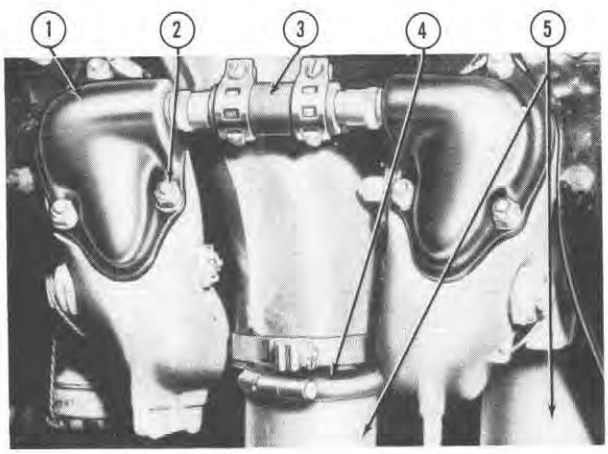
(3) Do not lubricate the tubes before telescoping them.

(4) Assemble each push rod and cover in its proper position with the numbered ball-end at the tappet end. Turn the crankshaft until the tappet which actuates the push rod may be pushed into its guide. Depress the rocker arm with the rocker arm depresser and fit the push rod cover in position. Tighten the push rod cover gland nut at the tappet guide end first; then the nut at the rocker arm end.

CAUTION

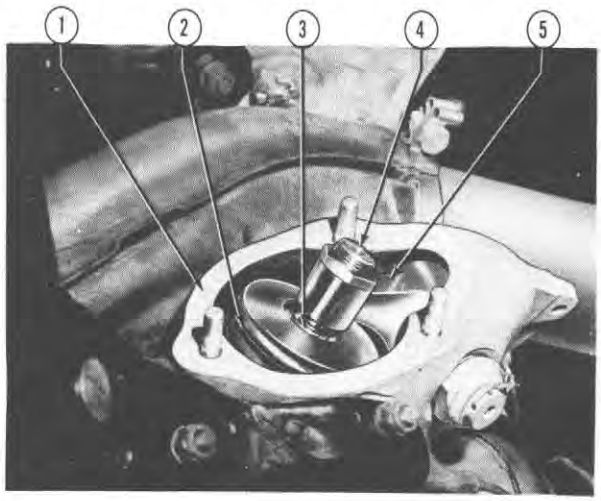
Tighten the nuts to a torque of 75-inch pounds. Excessive tightening may cause tappets to stick in their guides.

(5) The inner exhaust and intake push rod cover gland nuts at the tappet ends should be safety wired together in pairs; the gland nuts at the rocker arm ends must be safety wired to the adjacent rocker shaft nuts.



1. Rocker Box Cover
2. Rocker Box Cover Attaching Nut
3. Rocker Box Interconnecting Drain Pipes
4. Exhaust Stack Clamp (Pratt and Whitney Type)
5. Exhaust Stacks

Figure 125 — Rocker Box Covers and Exhaust Stack Installation



1. Rocker Box
2. Valve Spring
3. Valve Split Locks
4. Valve Adjusting Screw
5. Rocker Arm

Figure 126 — Rocker Arm and Valve Spring Installed

3. ROCKER BOX MECHANISM.

a. DESCRIPTION.—The rocker arms are supported on double row ball bearings in housings cast integral with the cylinder heads. Rocker housing covers are secured by studs and elastic stop nuts. The rocker arms are equipped with valve clearance adjusting screws and lock nuts, the action of the rocker being transmitted to the end of the valve stem through a half-ball and socket in the lower end of each adjusting screw.

b. REMOVAL AND DISASSEMBLY.

(1) ROCKER BOX COVERS.

(a) Unscrew the inner push rod cover gland nuts of the rear bank with the cover gland nut wrench P.W.A. 1600. This allows the oil to drain from the rear bank rocker boxes.

(b) Remove the elastic stop nuts on the rocker box cover.

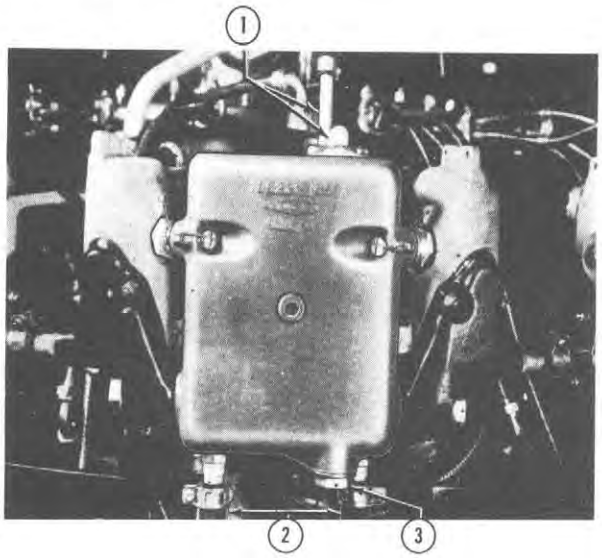
(c) Remove the rocker box covers in pairs with the connecting inter-cylinder scavenge pipes first from the rear bank, and then from the front bank.

(2) ROCKER ARMS.

Note

Be certain that the valve is closed before attempting to remove a rocker arm.

(a) Remove the cap and gasket from the large end of the rocker shaft and the nut and



1. Outlet Line to Front Oil Scavenge Pump
2. Inlet Lines
3. Drain Sump Plug

Figure 127 — Rocker Box Drain Sump

washer from the small end of the rocker shaft.

(b) Tap out the rocker shaft, using a suitable drift, and lift the rocker arm out of the box.

(3) ROCKER BOX DRAIN SUMP.

(a) Disconnect the oil suction pipe that connects the sump to the front scavenge pump.

(b) Remove drain sump plug, drain oil, and replace plug.

(c) Loosen the clamps which secure the two rubber hose connections.

(d) Remove the pipes attached to the reduction gear housing and blower section.

(e) Remove the two fillister head screws which secure the rocker box drain sump to the rocker shafts of number 10 cylinder.

(f) Remove the two plugs at the rear of the rocker housings on number 10 cylinder, and unscrew the two hollow studs using the Rocker Box Drain Sump Support Nut Wrench.

CAUTION

Remove the brass washer, the rubber seal and the steel washer around the hollow stud carefully.

(g) Remove the sump together with the attached number 11 exhaust and number 9 intake rocker box covers.

c. TOP OVERHAUL.

(1) If the movement of the rocker arm bearing on its axis permits a tilt in excess of .015 inch, replace the bearing.

(2) Since the exhaust rocker bearings are subject to greater wear, it is advisable to shift exhaust and intake bearings whenever wear becomes apparent. If only part of a new set of rocker arms are installed, always put them in the exhaust rocker shafts.

(3) Examine the push rod ball sockets for looseness and wear. Replace any socket that has a flat area in excess of 1/32 inch width.

(4) Check the valve adjusting screw assemblies for burred threads. Inspect the half-ball for unusual wear, looseness in its socket, nicks, or a pitted condition. Inspect the screw for cracks.

(5) Face the rocker box covers on a lapping plate with a small amount of lapping compound. This insures that the cover bears evenly on the gasket and prevents oil leakage. Wash the covers thoroughly to remove all traces of the lapping compound.

d. ASSEMBLY AND INSTALLATION.

(1) Align the oil holes in the rocker bearings with the oil passages in the rocker arms. Press the bearings into the rocker arms using an arbor press.

1. Rocker Box Drain Sump Support Nut
2. Rocker Box Drain Sump Support Nut Wrench

Figure 128 — Rocker Box Drain Sump Support Nut Removal

(2) Rotate the inner race of the rocker bearing so that the filling notches (if present) are 180° apart; then install the rocker arms in the cylinders, and install the rocker shafts. Drive the shafts into position with a suitable drift.

(3) Install the necessary gaskets, oil seals, and steel washers and secure the shafts in place with the nuts. The proper procedure for tightening rocker shaft nuts is to tighten snugly (approximately 35 in.-lbs.) and then turn to the next cotter pin hole.

(4) Place a new rocker box gasket in position.

(5) Install the rocker box cover, tightening the nuts to a torque of 75 inch-pounds.

(6) Reverse the procedure outlined above for installation of the rocker box drain sump. Exercise extreme care in getting proper alignment of the washers and rubber seal in order to prevent oil leakage.

e. ADJUSTMENTS.

(1) VALVE CLEARANCE.—No inspection or adjustment of the valve mechanism is necessary between overhauls except in an emergency.

(a) Adjust valve clearances in the same sequence as the firing order of the cylinders. Start with Cylinder No. 1.

(b) Back off the valve clearance adjusting screws several turns to insure that all clearances are loose.

(c) Using the top dead center indicator, place the piston of No. 11 cylinder on exact top dead center of its exhaust stroke. Turn the crankshaft in the direction of normal rotation for all timing procedures.

(d) Using two rocker arm depressers, (PWA 455), relieve the valve spring load on tappets 7 and 15.

Note

Never depress any valve that is not at least half opened. This will prevent the push rod from becoming accidentally disengaged from the rocker arm socket.

(e) The procedure above allows the cam to slide over so that it is in contact with the cam bearing adjacent to the cylinder whose valve clearance is being set *(figure 130)*.

(f) Adjust the valve clearance to .060-inch cold clearance.

CAUTION

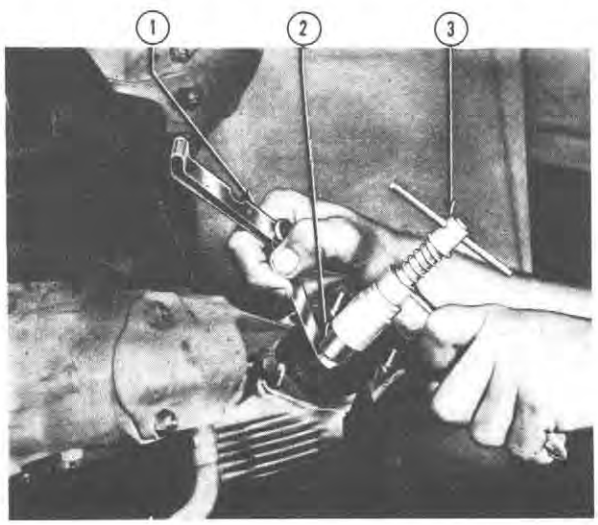
Do not tighten valve adjusting screw locknuts excessively. The recommended torque is 275 inch-pounds.

(g) Adjust all valves in this manner in the order shown in *figure 130*.

(h) Turn the propeller shaft two revolutions with the propeller shaft turning bar, and recheck all clearances in the same order. If clearances vary more than .005 inch from the correct amount, they must be reset.

Note

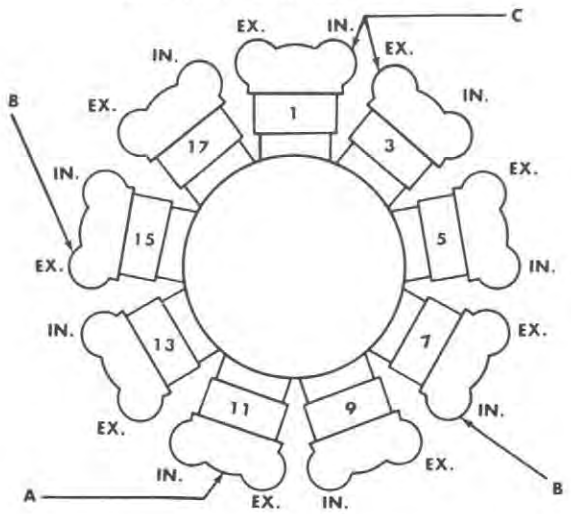
After all the valve clearances have been properly adjusted, not more than 5 threads or less than 1½ threads of any adjusting screw will be showing above the lock nut. There should be at least .031-inch clearance between the edge of the outer valve spring washer and the rocker arm with the valve in the closed position. This clearance may be checked by passing a .031-inch diameter wire between the rocker arm and the outer valve spring washer. If it is necessary to increase this clearance, grind the flat face of one or both of the push rod ball end spacers enough to obtain the correct clearance, providing that the proper positioning of the adjusting screw can be maintained. Do not grind either spacer to less than .060-inch thickness. If it is impossible to obtain a clearance of at least .031-inch and, at the same time, to maintain the proper positioning of the adjusting screw, the radius on the under side of the rocker arm should be checked with the rocker arm template gage, and ground to the correct contour. The spacers should be ground in the previously described manner if more than five threads of the valve adjusting screws show above the lock nut. If less than 1½ threads of the adjusting screws show above the lock nut, replace one or both of the push rod ball end spacers with a thicker spacer. Install spacers with the curved surface toward the ball end, and use only one spacer under each ball end.



1. Feeler Gage 2. Rocker Arm 3. Valve Adjusting Tool

Figure 129 — Adjusting Valves

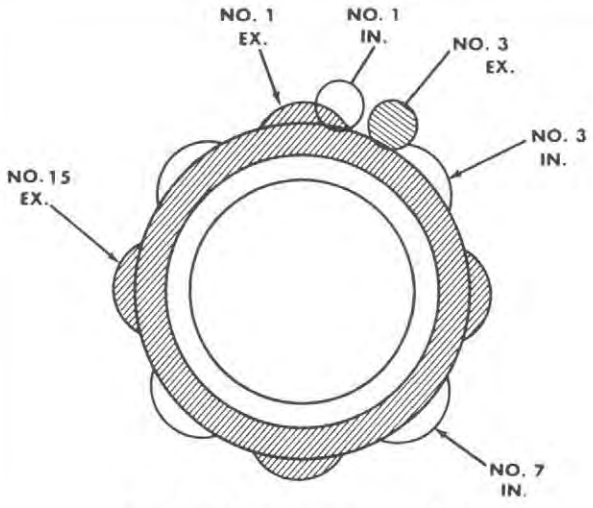
REAR VIEW OF R-2800-REAR BANK



A—SET TO TOP DEAD CENTER ON EXHAUST STROKE

B—MOMENTARILY DEPRESS THESE VALVES SIMULTANEOUSLY

C—SET THESE VALVE TAPPETS



REAR CAM AND TAPPETS (REAR VIEW)

LOADED TAPPETS (ON CAM LIFTS)

TAPPETS TO BE SET (INTAKE)

TAPPETS TO BE SET (EXHAUST)

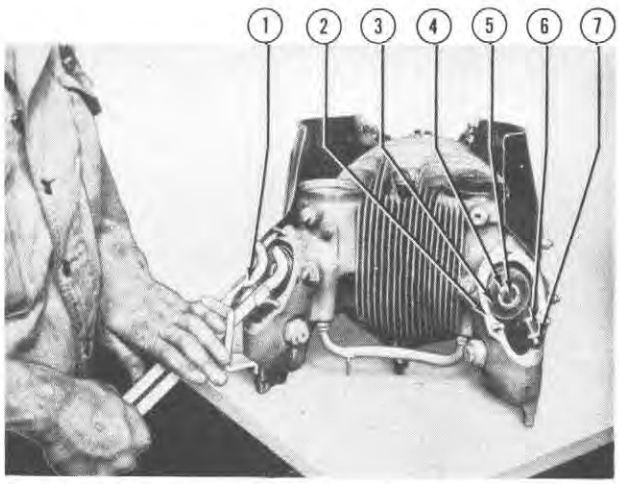
TABLE FOR ADJUSTING VALVE CLEARANCES ON R-2800 ENGINES

TO SET VALVE		SET THIS PISTON ON TOP DEAD CENTER ON THE EXHAUST STROKE	RELIEVE PRESSURE ON THESE TAPPETS	
IN.	EX.	CYLINDER No.	IN.	EX.
1	3	11	7	15
12	14	4	18	8
5	7	15	11	1
16	18	8	4	12
9	11	1	15	5
2	4	12	8	16
13	15	5	1	9
6	8	16	12	2
17	1	9	5	13
10	12	2	16	6
3	5	13	9	17
14	16	6	2	10
7	9	17	13	3
18	2	10	6	14
11	13	3	17	7
4	6	14	10	18
15	17	7	3	11
8	10	18	14	4

Fig. 130—Instructions for Adjustment of Valve Clearances

4. VALVES.

a. DESCRIPTION.—One inlet and one exhaust valve is installed in each cylinder. The exhaust valves are of hollow head and stem design and are sodium cooled with a seating face of stellite. Two concentric valve springs secured to the stems by split cone locks and washers are used at each valve. The "B" series engines have heavy inlet valve springs which are not interchangeable with the exhaust valve springs.



1. Valve Spring Compressor (PWA 459)
2. Rocker Box
3. Valve Spring
4. Valve Split-Lock
5. Valve
6. Rocker Arm
7. Valve Adjusting Screw

Figure 131 — Valve Spring Compressor

b. REMOVAL AND DISASSEMBLY.—This operation *must be done* with the cylinder removed from the engine. (See paragraph 6. *b.* (5) *(c) 3.*, this section.

(1) Place the cylinder over a wooden block which has the same contour as the inside of the cylinder head.

(2) Compress the valve springs with the valve spring compressor. Remove the split locks which hold the outer valve spring washer in position.

(3) Lift out the valve springs and washers.

(4) Remove the cylinder from the block and lift out the valves. Do NOT let the valves fall out and strike the cylinder wall.

(5) Place the valves in a rack or otherwise protect them during overhaul to insure correct reassembly.

c. TOP OVERHAUL.

(1) Check the exhaust valves with the valve radius stretch gage by holding the edge of the gage against the stem of the valve, and the curvature of the gage against the radius of the valve head. A clearance of 1/32 inch between the gage and the valve is cause for valve replacement.

(2) Valves which have creases, or show signs of swelling or drawing where the head joins the stem must be replaced.

(3) Inspect the lock grooves for wear, galling, or burns.

(4) Inspect the valve heads for excessive pitting or erosion.

(5) Examine the valve springs for cracks, rust, or pit marks.

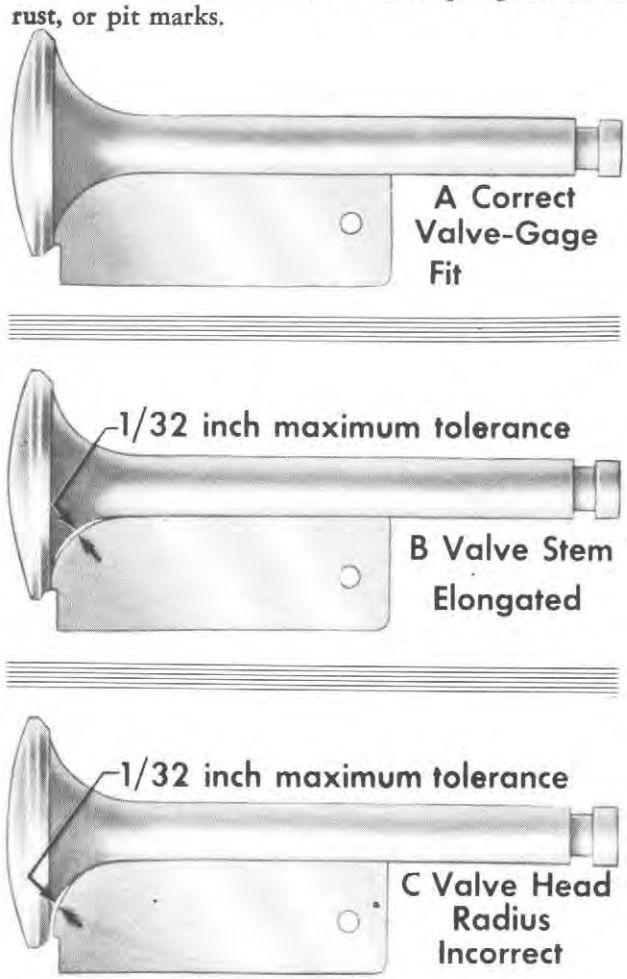


Figure 132—Valve Radius Stretch Gage

d. ASSEMBLY AND INSTALLATION.—This operation must be done with the cylinders removed from the engine.

(1) Clean and oil the valve stems and guides before installing them in the cylinders.

(2) Place each valve in position and set the cylinder over a dome-headed wooden block to hold the valves in place during assembly of the valve springs.

(3) Place the lower valve spring washer, the inner and outer valve springs, and the upper valve

spring washer in position. Compress the valve springs with the valve spring compressor (PWA-459) and install the split cone locks which hold the valve, springs, and washers in place.

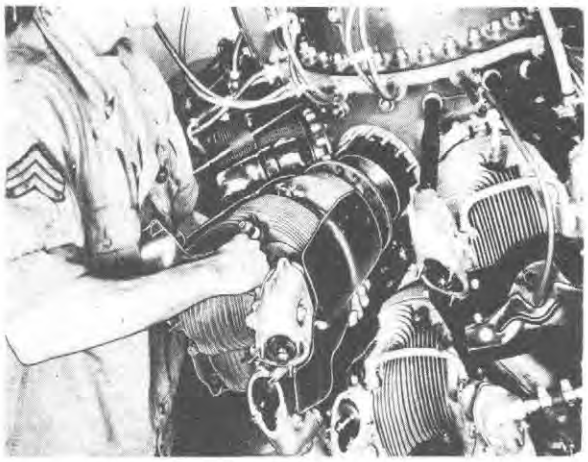
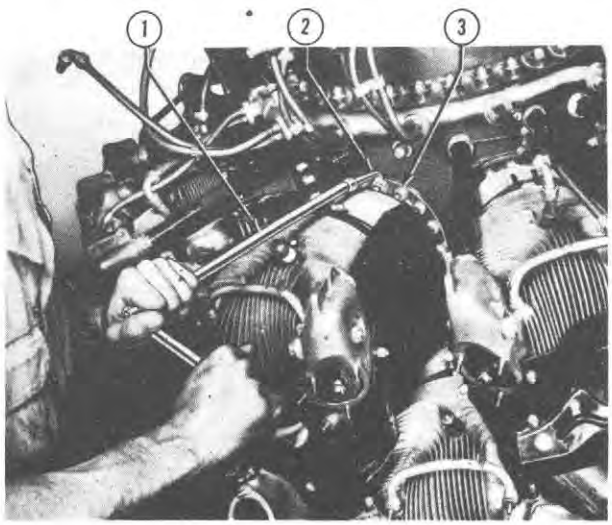


Figure 133—Cylinder Removal

(d) CYLINDERS.

1. DESCRIPTION.—The cylinder barrels are machined from steel forgings and have an aluminum sleeve with deep integral cooling fins shrunk onto the central portion. The heads are machined from aluminum alloy castings, having closely spaced cooling fins and integral rocker housing. Each cylinder has one inlet and one exhaust valve, the inlet valve seating on a bronze insert, and the exhaust on a steel insert. The cylinder-head also incorporates bronze inlet and exhaust valve guides, bronze bushings for two spark plugs, and four steel inserts for supporting the two rocker arm shafts.



1. Extension 2. Hold Down Nut Wrench 3. Hold Down Nut

Figure 134 — Hold Down Nut Removal

2. REMOVAL AND DISASSEMBLY.

a. Remove all anti-drag ring cowling which would interfert with the necessary work on the engine. (See paragraph 6. *b.* (14) *(b)*, this section.)

b. Remove all front spark plug lead elbows from the spark plugs and remove the spark plugs with the spark plug wrench. Remove the rear spark plug elbow and rear spark plug from the cylinder to be removed.

c. Turn the propeller shaft with the propeller shaft turning bar until the piston of the cylinder to be removed is on top center of the compression stroke. Remove No. 8 and 13 master rod cylinders last. Remove the circular clamps which fasten the exhaust piping to the cylinder.

d. Remove the rocker box covers and the rocker arms as instructed in paragraph 6. *b.* (5) *(c)*.

e. Remove all primer lines which are fastened to the intake pipes. Unscrew packing nuts which secure intake pipes to the blower section and unions at the cylinder inlet ports, using intake pipe coupling nut wrench (PWA-1786).

f. Remove the push rods and push rod cover tubes as instructed in paragraph 6. *b.* (5) *(c)* 3. b., this section.

g. Remove the small cap plates from the cylinder head deflector and lift out the braided ignition wire conduit and rubber grommet from the slots in the cylinder head deflector. Remove the elastic stop nuts holding the head deflector and remove the head deflector. Remove the clamps which hold the braided ignition wire conduits to the cylinder. Remove the small deflector baffle plates between adjacent front and rear row inter-cylinder deflectors by unfastening the retaining screws.

CAUTION

If the master rod cylinder is to be removed, to hold the master rod in the center of the crankcase opening so it cannot turn to either side upon removal of the cylinder. This may be done by blocking the master rod. If the master rod is permitted to move sideways, the bottom ring on some of the other pistons will come out of the cylinders and may seriously damage the pistons and skirts of these cylinders.

h. Remove the cylinder hold-down nuts using wrenches PWA-2394, PWA-2396, or PWA-2400 with suitable handles. Remove cylinder.

i. Cover the openings in the crankcase and blower sections to prevent the entrance of foreign material.

Note

If several cylinders are to be removed, the master rod cylinder must be removed last and installed first. The master rod cylinder on the front bank of cylinders is No. 8, and on the rear bank it is No. 13.

3. TOP OVERHAUL.

a. If two or more center head fins are cracked the entire length, the cylinder should be discarded. Small cracks in the head fins are not cause for rejection.

b. Examine the following parts for cracks:

(1) Inside surface of the cylinder head.

(2) Inlet and exhaust ports.

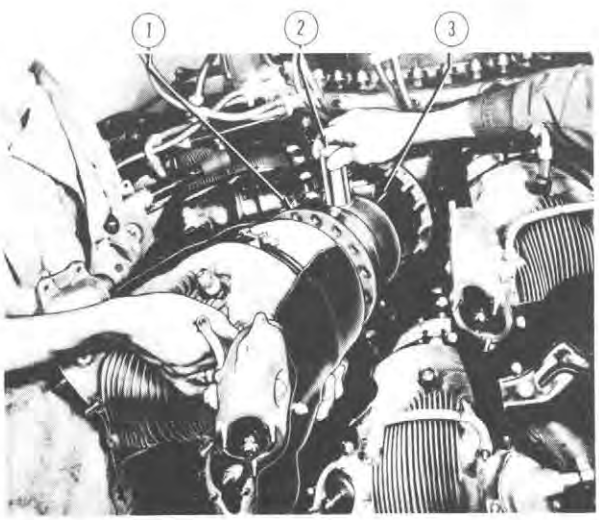
(3) Strengthening rib on the front of the valve housing.

(4) Heavy flange at base of cylinder head.

(5) Inside of rocker box walls for cracks and valve spring chafing.

(6) Cylinder barrel for cracks and scoring.

c. Check the cylinder hold down flange for flatness, squareness, and trueness with the cylinder barrel flange surface plate, using Prussian Blue dye. An uneven seating surface may be corrected by lapping the flange on the cylinder barrel flange lapping fixture, provided the flange is not uneven or distorted more than .005 inch.



1. Cylinder 2. Piston Pin 3. Piston

Figure 135 — Installing Cylinder

4. ASSEMBLY AND INSTALLATION.

a. Install the rocker arms as described in 6. *b.* (5) *3.* c., this section.

b. Install the valves as instructed in paragraph 6. *b.* (5) *4.* d., this section.

c. Install and tighten the cylinder hold-down nuts. The torque indicating handle wrench (PWA-2239) will be used, whenever possible, to tighten the nuts to a torque of 450 in.-lbs.; with PWA-2394, PWA-2396, or PWA-2400 wrenches.

CAUTION

When using a wrench with a plain handle, do not tighten the nuts excessively as the studs may be stretched or broken.

d. Fit the proper seals on each end of the intake pipe and insert the pipe in the blower. Screw the packing nut in the blower loosely, then screw the upper packing nut on the union of the cylinder inlet port, and tighten with PWA-1786 wrench.

e. Depress the valves and install push rods and covers. Apply a torque of 75 in.-lbs. for tightening the cover gland nuts. Each push rod is marked with its position and will be installed according to the markings. The markings are on the tappet ends of the push rods.

Note

The two-piece telescoping push rod cover tubes must be installed so that the smaller diameter tubes are fastened to the rocker boxes of the cylinders above the horizontal centerline of the engine and to the tappet guides for cylinders below the horizontal centerline of the engine.

CAUTION

Be sure the rubber oil seal rings are in the grooves provided at the tappet guide and rocker box connections for each push rod cover tube. Do not tighten these connections excessively because the seal may be cut or damaged, causing leakage.

f. Adjust the valve clearance in accordance with the procedure described in paragraph 6. *b.* (5) *(c) 4. e.,* this section. Install new rocker box cover gaskets. Install the covers in pairs as they were removed. Secure the covers with elastic stop nuts.

g. Install all spark plugs and connect spark plug leads to the spark plus. Install all primer lines, oil pipes, etc.

h. Fasten the exhaust piping to the exhaust port of the cylinder with the circular clamps and replace the anti-drag ring cowling sections.

Note

The preceding installation instructions are based on the assumption that the connecting rod assembly was not moved after cylinder removal and that the piston is on the top dead center of the compression stroke of the cylinder being installed.

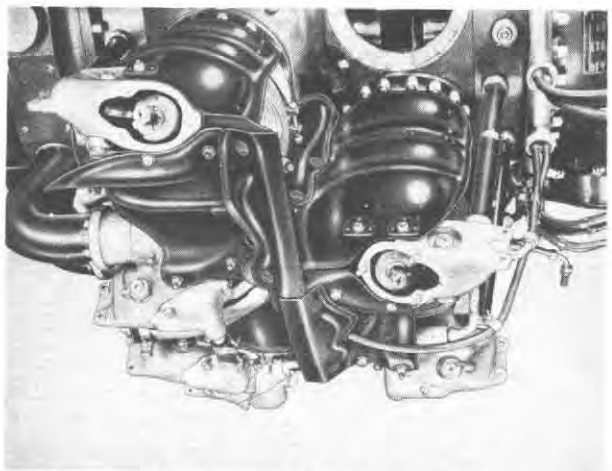


Figure 136—Inter-Cylinder Air Deflectors

(e) COOLING AIR BAFFLES AND DEFLECTORS.

1. DESCRIPTION.–Pressure type air deflectors are installed between the rocker housings on each cylinder head and between adjacent front and rear row cylinders. The baffles have air blast tubes which cool the rear spark plugs and ignition leads on each row of cylinders.

2. REMOVAL AND DISASSEMBLY.

a. Remove the top plate from each cylinder inter-ear air deflector by unfastening the two Dzus fasteners.

b. Lift out the ignition wire conduit and the split grommet from its slot in each deflector.

c. Unscrew the nuts securing the deflectors and lift them from the cylinder heads.

d. Remove the wing nuts and spring fasteners which secure the deflector extension plates to the bottom of each front row deflector.

3. TOP OVERHAUL.

a. Check the inter-cylinder and inter-ear drain pipes for security of attachment. To avoid excessive tightening in order not to crack the cylinder head, see the table of recommended torque values See Section IX.

b. Replace damaged or bent pipes in the following manner:

(1) Cut through the old pipe adjacent to each pipe connector.

(2) Back out the threaded pipe connector with a suitable wrench.

(3) Coat the new connectors with thread lubricant and screw into place.

Note

Rear row connectors must be screwed in until the front face of the connector is ½ inch from the front face of the cylinder head base. Front row connectors must be screwed in until they are seated firmly.

4. ASSEMBLY AND INSTALLATION.–Reverse the REMOVAL AND DISASSEMBLY procedure.

(f) PISTON ASSEMBLY.

1. DESCRIPTION. – The pistons are machined from aluminum alloy forgings and are of the full skirt type. They have a domed head with recesses in the top to provide clearance for the valve heads when the piston is at the top of its stroke. Three compression rings, a dual oil control ring, and an oil scraper ring are installed in the three top grooves, the fourth groove, and the bottom groove in the order mentioned. The master cylinder pistons are the only exception incorporating a straight-sided compression ring in lieu of the scrape ring in the bottom groove, for better lubrication of master cylinder pistons. The compression rings are wedge type and are fitted into grooves correspondingly profiled.

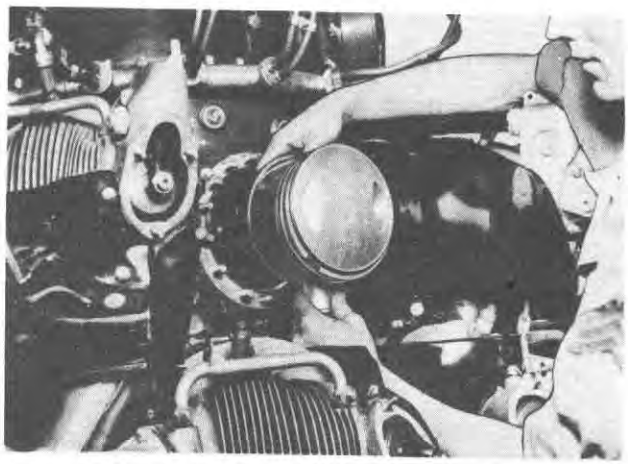


Figure 137—Piston Pin Removal

2. REMOVAL AND DISASSEMBLY.

a. Turn the propeller shaft until the piston in the cylinder to be removed is on dead center.

b. Remove cylinder as instructed in paragraph 6. *b.* (5) *(d) 2.*, in this section.

c. Push the piston pin in and remove the piston.

CAUTION

When the cylinder is being removed, make certain that the piston pin does not fall out.

d. If difficulty is experienced in pushing out piston pin, remove pin with the piston pin pusher (PWA-2302).

e. Place articulated rod support slings over each rod and over the cylinder mounting studs on either side to prevent the articulated rods from striking the crankcase.

CAUTION

Remove master cylinder last and install master cylinder first. The throw of the master rod from its center line to either side of the crank case is sufficient to permit the bottom ring of the opposite piston to drop below the cylinder barrel inside the power section.

f. Remove all piston rings with piston ring expander pliers. Tag the rings to show from which pistons and grooves they have been removed.

3. TOP OVERHAUL.

a. Inspect piston pins for scoring, cracks, excessive wear, and rust pitting.

b. It is permissible to continue the use of chromium plated compression rings in service if the plating is in good condition and there is no evidence

Figure 138—Piston Ring Removal

of appreciable wear or loss of tension. Dual oil control and oil scraper rings which show no appreciable wear or loss of tension may also be continued in service. The unplated compression rings used in the second and third grooves of each piston should be replaced after each overhaul.

4. ASSEMBLY AND INSTALLATION.

a. WITH RING COMPRESSORS.

(1) Install piston rings with the piston ring expanding pliers (see paragraph 6., *b.*, (5), *(f)*, *4.*, a., this section).

(2) An oil scraper ring is installed in

Figure 139—Installing Piston Into Cylinder

the bottom groove of the piston with the beveled side up. (Master cylinder pistons use the straight compression ring in this location.)

(3) Dual oil control rings are installed in the fourth ring groove with the serrated side of *both rings* placed downward.

(4) Install wedge-type compression rings in the three upper grooves, with a chrome-plated ring in the top groove.

(5) Turn the crank shaft with the crankshaft turning bar until the master rod of the rear bank (No. 13) is approximately at its top center position.

(6) Fit the rubber oil seal around the radius under the hold down flange of No. 13 cylinder.

(7) Insert the correct piston pin through No. 13 piston and the bushing in the master rod. The piston pin must be well oiled before insertion.

Note

Each piston and piston pin will bear the same number as that of the cylinder in which they are installed. Each cylinder is numbered on the forward side of the hold down flange; each piston is numbered on one of the piston pin bosses and each piston pin is numbered on one of the plugs at the end of the pin and installed with the number toward the outside of the engine.

(8) Install pistons and piston pins in the same positions from which they were removed.

(9) Coat the cylinder walls, pistons, and rings with a generous amount of oil.

(10) Stagger the ring gaps around the circumference of the piston.

(11) Lock the piston ring clamp over the piston and rings. Slide the cylinder over the piston and into place against its mounting pad.

(12) Fasten the cylinder to the crankcase with several nuts. Install the remaining pistons and cylinders of the rear bank in the same manner.

b. WITHOUT RING COMPRESSOR.

(1) In an emergency, pistons may be installed in a cylinder barrel without the use of a ring compressor. With the cylinder on the bench and the piston rings properly fitted for side and gap clearance and ready for installation, place the cylinder in position by turning it so it will rest on the rocker boxes, front side down.

(2) Turn the piston so that the cylinder number on the bottom edge of the skirt will be toward the nose of the engine. As the front of the cylinder is placed in a down position on the bench, the piston is also held in position with the number down.

(3) Next arrange the spacing of the ring gaps. The ring gaps should be spaced as far apart as possible and not in line with the piston pin hole. A satisfactory arrangement is to place the gap of the top compression ring about twenty degrees from the piston pin hole, the gap on the second ring one hundred eighty from the first and the third at ninety. The gaps of the dual oil control rings, both rings being installed in one groove, should be one hundred eighty degrees apart and out of line with the compression gaps as far as possible.

(4) While installing the piston, the thumbs should be kept inside the piston skirt at all times, one on each side, with the fingers on the outside of the piston. Holding the piston in this position, the rings are installed one at a time. With the fingers, the half of the top compression ring opposite the gap is held in its groove flush with the piston wall. The piston is then placed in a cocked position in the cylinder barrel, with part of the ring being held flush with the piston wall in its groove, inside the cylinder wall. With the thumbs remaining inside the piston skirt, move one hand to the piston ring gap and compress the balance of the ring in the groove by placing one finger on each side of the gap. Now bring the piston to a straight position in the cylinder barrel and the top ring is installed.

(5) The same procedure is used on each ring, cocking the piston for each additional ring the same as on the first, placing fingers on each side of ring gap and straightening piston in cylinder. The dual oil control rings, though both are in the same groove, are installed one at a time.

Note

Caution must be used when moving the fingers around the piston as a severe cut can be suffered if fingers are slid around the piston ring instead of picking them up when moving to another location on the piston.

(6) With the rings installed up to the piston pin hole, the cylinder assembly is then ready to be installed on the engine. The entire assembly is placed in position over the rod, the piston pin inserted and the cylinder pushed down to the scraper ring which can easily be installed by a similar method as used on the others, cocking the piston by letting the cylinder down over one side of the ring, compressing at the gap, pushing cylinder over ring and into position on mounting pad of power section.

(6) ENGINE OIL UNITS.

(a) GENERAL.—Engine oil units include the front oil scavenge pump, the main oil scavenge pump, the engine oil pressure pump, the temperature compensating oil relief valve, the low pressure oil relief valve, the oil screen by-pass valve, the thermostat, and the oil screen and plugs. A description of each component part follows.

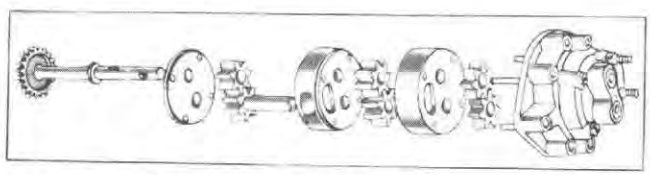


Figure 140—Front Scavenger Pump (Exploded)

1. FRONT OIL SCAVENGE PUMP.

a. DESCRIPTION.—The front oil scavenge pump is a three-section unit located in the bottom of the front nose section. This pump scavenges the front cam compartment drain oil, the reduction gearing drain oil, and the oil collected in the rocker drain sump. The scavenged oil from all three sections is forced through an external pipe connecting with cored passages in the blower and intermediate rear sections which in turn connect through an internal pipe to a passage at the discharge side of the main scavenge pump.

b. REMOVAL AND DISASSEMBLY.

(1) Remove the nuts securing the front oil scavenge pump to the reduction gear housing. Pull the pump from the housing with the oil pump puller (PWA 2151-11).

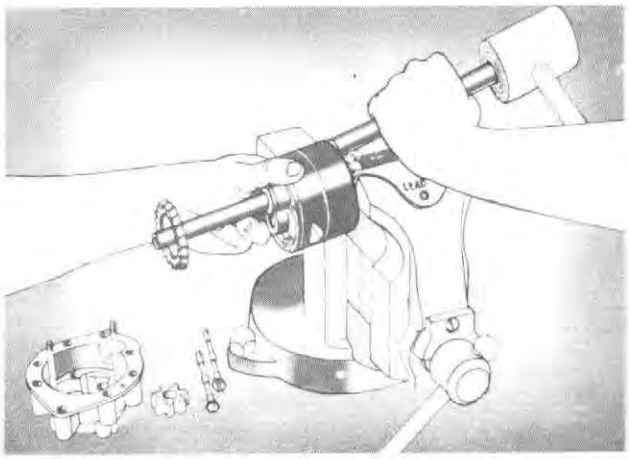


Figure 141—Front Scavenger Oil Pump Assembly

CAUTION

Be sure to turn the propeller shaft so that the oil pump drive gear clears the pinion shafts and pinion cage bolts.

(2) Remove the four bolts holding the various sections of the pump together (two of these bolts are loose—two are dowel type and must be drifted out).

(3) With a light fibre drift, tap the oil pump cover from the pump lower body.

(4) Remove these parts in the following order:

(a) Lower set of gears and key on the drive shaft.

(b) Lower body.

(c) Middle set of gears with key on the drive shaft.

(d) Upper body.

(e) Upper set of gears together with the keys on the drive shaft.

(f) Oil pump plate. If trouble is encountered in removing the gears, grasp the gear on the drive shaft in a lead-jawed vise and tap the bottom of the body gently.

CAUTION

Never tap the lower end of the drive shaft as this may cause the keys to embed in the adjacent section of the pump body.

c. TOP OVERHAUL.

(1) Examine the oil pump bodies for scoring and wear.

(2) Make sure the gears turn freely and smoothly, and show no signs of rubbing.

(3) Inspect the drive and idler shafts for roughness and wear.

(4) Check the fit of all keys in keyways.

d. ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

Figure 142—Rear Scavenger Oil Pump (Exploded)

2. MAIN OIL SCAVENGE PUMP.

a. DESCRIPTION. – A two-section main scavenge pump is located in the right rear face of the rear section to scavenge oil from the main sump and the bottom portion of the rear section. Both sections discharge scavenged oil into the oil outlet passage, which is part of the main scavenge pump.

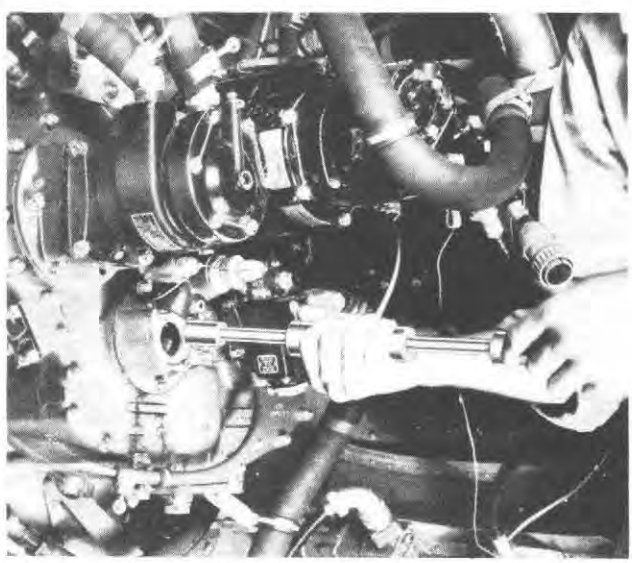


Figure 143—Oil Pressure Pump Removal With Puller

b. REMOVAL AND DISASSEMBLY.

(1) Remove the nuts and washers holding the main oil scavenge pump in place.

(2) Pull out the pump with the oil pump puller (PWA 2151-11).

(3) Remove the drive gear retainer screw located in the side of the rear section of the pump.

(4) Unscrew the nuts and washers from the two tight (dowel) bolts and remove the bolts.

(5) Unscrew the nuts from the two studs that hold the various sections of the pump together. Remove the rear section of the pump.

(6) Disassemble in the following order:

(a) Lower body.

(b) Seal ring.

(c) Lower set of gears.

(d) Key on the drive shaft.

(e) If difficulty is experienced in removing the gear keyed to the drive shaft, use the oil pump gear puller (PWA 2569).

c. TOP OVERHAUL.

(1) Examine the main oil scavenge pump bodies for scoring and wear.

(2) Make sure the gears turn freely and smoothly and show no signs of rubbing.

(3) Inspect the drive and idler shafts for roughness and wear.

(4) Check the fit of all keys in keyways.

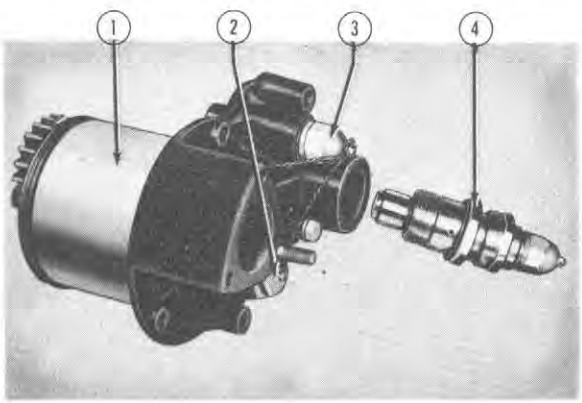
(5) Make sure that the oil seals are properly seated.

(6) Examine the oil return check valve for proper seating. Check the condition of the threads.

d. ASSEMBLY AND INSTALLATION.—Reverse REMOVAL AND DISASSEMBLY procedure.

3. ENGINE OIL PRESSURE PUMP.

a. DESCRIPTION. — Oil is circulated through the engine by a gear type pressure pump located in the left rear face of the rear section. The oil pressure pump provides mounting bosses for the inlet oil connection, the temperature compensating high pressure oil relief valve, the low pressure oil relief valve, the oil screen by-pass valve, and the thermostat, together with their connecting cored passages.



1. Oil Pressure Pump
2. Thermostat
3. Low Pressure Relief Valve
4. High Pressure Relief Valve

Figure 144 — Oil Pressure Pump

b. REMOVAL AND DISASSEMBLY.—Refer to paragraph 6. *b.* (6) *(a) 1.* b. *(1)* through *(5),* this section.

(1) Remove the body, the oil seal rings, and the idler gear in that order.

(2) Clamp the oil pump pressure gear in a soft-jawed vise and remove the pump drive gear retainer screw.

(3) Withdraw the pump drive gear and the end plate.

(4) The idler shaft remains in the end plate.

c. TOP OVERHAUL.—Refer to paragraph 6. *b.* (6) *(a) 1.* c., this section.

d. ASSEMBLY AND INSTALLATION.

(1) Place the two leather oil seals in the drive-shaft and idler shaft recesses of the pump outer cover.

(2) Insert the oil seal in the driveshaft recess of the oil pump and plate.

(3) Insert the oil pump drive shaft and gear in the end plate and place the idler gear on the bronze shaft.

(4) Assemble the pump body in position over the gears and end plate and install the body in the cover plate.

(5) When the gears turn freely and the oil seals are properly seated, insert the through bolts in position and install nuts and washers on all four body bolts.

(6) Tighten and safety uniformly but not excessively.

(7) Install the oil pump drive gear on the end of the drive shaft and secure it.

(8) Assemble the two oil seal rings in the groove on the O.D. of the pump.

e. ADJUSTMENT.—If the oil pressure, after starting, does not register on the gage almost immediately, the engine should be stopped and an investigation made of the cause. With the compensating type of oil pressure relief valve, initial cold starting oil pressures may reach as high as 400 psi. If the oil pressure as the running progresses is less than 50 psi at 1450 rpm or 70 psi at 2150 rpm, the pressure

should be immediately increased. The pressure should be adjusted later on (if necessary), by means of the adjusting screw on the main oil pressure relief valve, to 80-90 psi at 2400 rpm with the inlet temperature at 140°-167°F (66°-75°C). The rear section oil pressure should be adjusted to 25-40 psi by means of the low pressure relief valve adjustment. If the fuel pressure is not within the desired range of 17±-psi at 1000 rpm and above, it should be adjusted by means of the fuel pressure relief valve.

4. TEMPERATURE COMPENSATING OIL RELIEF VALVE (HIGH PRESSURE).

a. DESCRIPTION.—Oil is by-passed to the compensating piston of the high pressure relief valve when its temperature is greater than 104 degrees Fahrenheit. The oil passes over a thermostat which opens up when the proper temperature is reached and sends the oil to this relief valve.

b. REMOVAL AND DISASSEMBLY.

(1) Remove the acorn cap.

(2) Remove the cap which contains the adjusting screw, lock nut, gasket, spring, and piston, using the compensating relief valve cap wrench (PWA 978).

(3) Remove the plunger from the body.

(4) Unscrew the relief valve housing from the rear side of the oil pressure pump using the housing wrench (PWA 977).

(5) Remove the valve body with the body wrench (PWA 1604).

c. TOP OVERHAUL.

(1) Insert the plunger in the relief valve body and check for proper seating by applying Prussian Blue dye.

(2) If necessary, lap the plunger with fine lapping compound.

CAUTION

Do not disturb the setting of the adjusting screw. However, it may be necessary to alter the setting of the screw during the first engine run-in to obtain the desired oil pressure.

d. ASSEMBLY AND INSTALLATION.

(1) Install the gasket and housing on the rear side of the oil pressure pump with the compensating relief valve housing wrench.

(2) Install the piston, spring, gasket, and the cap which contains the adjusting screw, and lock nut in that order, using the compensating relief valve cap wrench (PWA 978).

(3) Install the gasket and the acorn cap on the assembly.

5. LOW PRESSURE OIL RELIEF VALVE.

a. DESCRIPTION.—The low pressure oil relief valve by-passes excessive low pressure oil to the inlet side of the oil pressure pump.

b. REMOVAL AND DISASSEMBLY.

(1) Remove the acorn cap and gasket from the rear section of the oil pressure pump.

(2) Remove the housing, valve, and spring from the forward side of the pump.

(3) Remove the valve from its housing.

c. TOP OVERHAUL

(1) Examine piston for smoothness and proper seating.

(2) Make sure the relief valve spring is free from cracks and burrs and has sufficient pressure.

d. ASSEMBLY AND INSTALLATION.

(1) Reverse the REMOVAL AND DISASSEMBLY procedure.

6. OIL SCREEN BY-PASS VALVE.

a. DESCRIPTION.—The oil screen by-pass valve is provided to allow oil to by-pass the oil screens, thus preventing stoppage of the flow of oil to the engines if the screens should become clogged.

b. REMOVAL AND DISASSEMBLY.—Remove the cover, gasket, spring, and valve, and remove valve and the by-pass body strainer from the rear side of the oil pressure pump.

c. TOP OVERHAUL.

(1) Examine the pistons for smoothness and proper seating.

(2) Make sure the by-pass valve spring is free from cracks and burrs and has pressure of three to four pounds for 1-⅜ inch spring.

d. ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

7. THERMOSTAT.

a. DESCRIPTION.—The thermostat serves to by-pass oil into the temperature compensating high pressure oil relief valve whenever the oil temperature reaches 104 degrees Fahrenheit.

b. REMOVAL AND DISASSEMBLY.—Remove the two fillister head screws from the rear section of the oil pressure pump, and carefully tap out the thermostat.

c. TOP OVERHAUL.—Thermostats will be replaced rather than repaired.

d. ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

8. OIL SCREENS AND PLUGS.

a. DESCRIPTION.—Oil screens which require periodic cleaning and maintenance are the oil pressure screen in the bottom central portion of the rear section and the two oil scavenge screens. Drain sump plugs must also be inspected for the presence of metal chips or any foreign material which would indicate a failure or some unsatisfactory condition in the engine.

b. REMOVAL.

(1) Unscrew the following oil drain plugs:

(a) Rear of the rocker box drain sump.

(b) Bottom rear of main oil sump.

(c) Bottom of oil pressure screen chamber in the rear section.

(2) Remove the two drain plugs on either side of the oil pressure screen chamber on the bottom of the rear section.

(3) Remove the small oil screen from the scavenge chamber above and forward of the right plug.

(4) Unscrew the oil drain plug from the scavenge chamber at the lower left side of the intermediate rear section, and remove the oil scavenge screen assembly.

(5) Remove the nuts which secure the oil pressure screen cover to the bottom of the rear section.

(6) Remove the cover and withdraw the screen assembly.

c. TOP OVERHAUL.

(1) Examine the screen for being out of shape, splits in the solder joints, or other damage.

(2) Check the fit of the screen in the recess in the rear case.

(3) Examine the sump drain plugs, the oil pressure screen and the two oil scavenge screens for the presence of metal chips, or any foreign material which would indicate a failure or some unsatisfactory condition in the engine.

(4) Install a new oil screen cover gasket each time the oil pressure screen cover is removed.

(5) Install new gaskets on oil plugs after each removal.

d. INSTALLATION.

(1) Screw the check valve assembly and gasket in position in the rear section and tighten with the check valve seat wrench (PWA 1600).

(2) Assemble the oil screen cover plate and gasket in position and secure with washers and nuts.

(7) ENGINE-DRIVEN FUEL PUMP.—Refer to paragraph 11., *i.*, this section.

(8) ENGINE-DRIVEN VACUUM PUMP.—Refer to paragraph 13., this section.

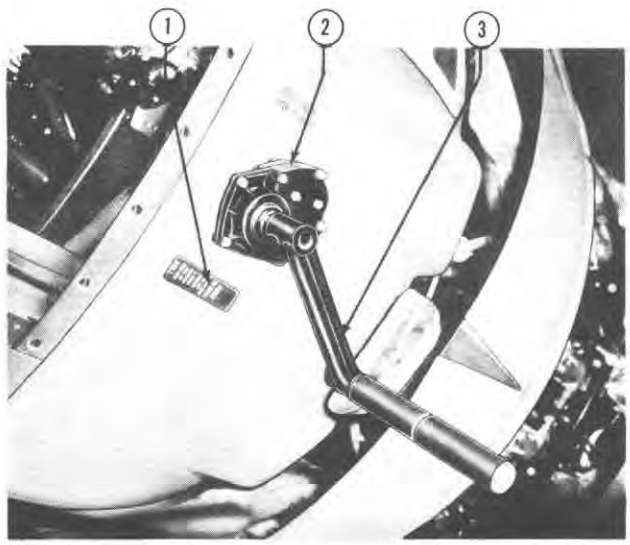
(9) ENGINE-DRIVEN HYDRAULIC PUMP.—Refer to paragraph 14., *b.*, (2), this section.

(10) ENGINE-DRIVEN TACHOMETER GENERATOR.—Refer to paragraph 15., this section.

(11) STARTING SYSTEM.

(a) GENERAL.—The engines may be started electrically or, in emergency, by a handcrank.

1. ENGINE STARTER (ELECTRICAL).—Refer to paragraph 15., this section.



1. Access Door to Starter Cable 2. Gear Box 3. Hand Crank

Figure 145 — Starter Hand Crank

2. STARTER HANDCRANK AND GEAR BOX.—A starter hand crank and gear box are stowed in the outboard side of the left nacelle and are operated through an access hole on the right-hand side of the engine mount. A flexible tube connects the starter with a bracket on the engine mount, into which the hand crank fits. An access door beside the gear box provides a handle which connects by cable to the starter.

(12) PRIMING PLUMBING SYSTEM.

(a) DESCRIPTION.–In order to facilitate engine starting, gasoline is often injected directly (without carburetion) into certain cylinders by means of an electrically operated priming system. Refer to paragraph 11., *n.*, this section and also paragraph 15., this section. Only the following top cylinders are affected: Number 2, 4, 16, and 18 in the front bank and number 1, 3, 15, and 17 in the rear bank.

(b) REMOVAL.–Disconnect all primer lines at the primer distributor and at the cylinders to which they are attached. Unfasten the clamps holding them to the intake pipes and blower section and withdraw each primer line. Remove the primer distributor from No. 1 cylinder intake pipe.

(c) TOP OVERHAUL.–Primer lines will be replaced rather than repaired. See section VIII.

(d) INSTALLATION.–Reverse the REMOVAL procedure.

(13) EXHAUST SYSTEM.

(a) DESCRIPTION.–Exhaust gases are expelled from the engine by nine ejector type stacks. The stacks are attached to the exhaust ports by Pratt & Whitney scissor clamps and cantilever from the engine. No supports are used.

(b) REMOVAL AND DISASSEMBLY.

1. Remove the stacks by disconnecting the scissor clamps at the exhaust ports.

2. Pull the stacks from the engine exhaust ports.

(c) TOP OVERHAUL.

1. Examine the stacks for cracks or excessive burning.

2. Check all clamps for tightness and proper fit.

3. Cover small cracks, holes or other damage by welding.

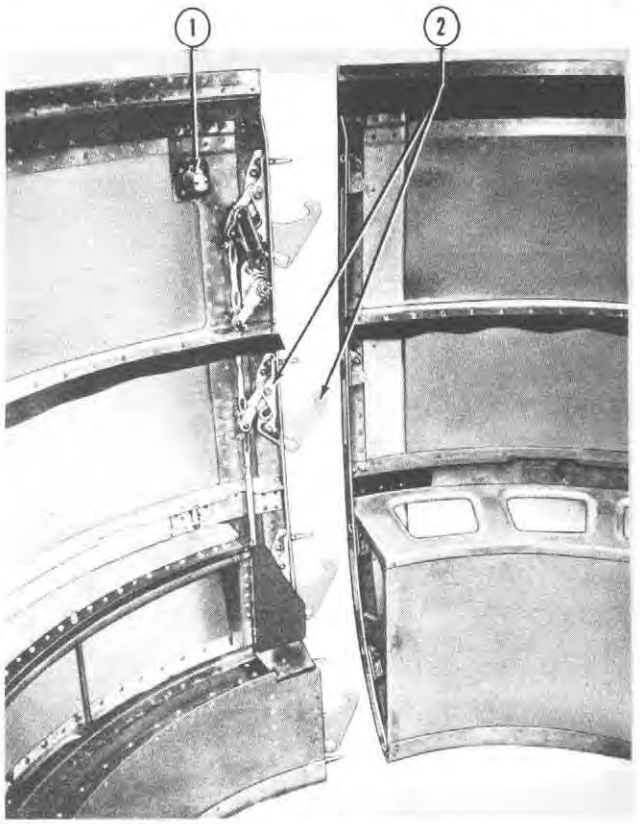
(d) ASSEMBLY AND INSTALLATION.–Reverse the REMOVAL AND DISASSEMBLY procedure.

(14) ANTI-DRAG RING COWLING.

(a) DESCRIPTION.–The anti-drag ring cowling is composed of an upper and a lower segment mounted on "D" shaped anti-drag ring cowl flap bow supports. The upper segment is bolted at the top, forward of the carburetor air duct elbow and latch locks into the lower segment.

(b) REMOVAL AND DISASSEMBLY.–The anti-drag cowling for each engine is interchangeable.

1. Turn the slotted lock socket on the left-hand side of the anti-drag ring cowling with a spark plug wrench to release the latching mechanism. This lock screw head is painted red, and is located near the aft end of the cowling.

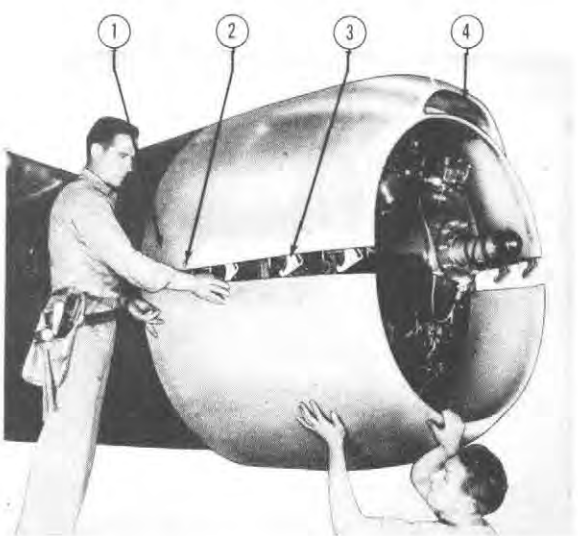


1. Latch Lock 2. Latch Mechanism

Figure 146 — Anti-Drag Ring Latch

Note

The latching mechanism is in locked position when the lock screw slot is parallel to the red line painted on each side of the screw head.



1. Latch Lock Screw
2. Latch Mechanism Operating Nut
3. Latch
4. Ram Scoop

Figure 147 — Anti-Drag Ring Installation

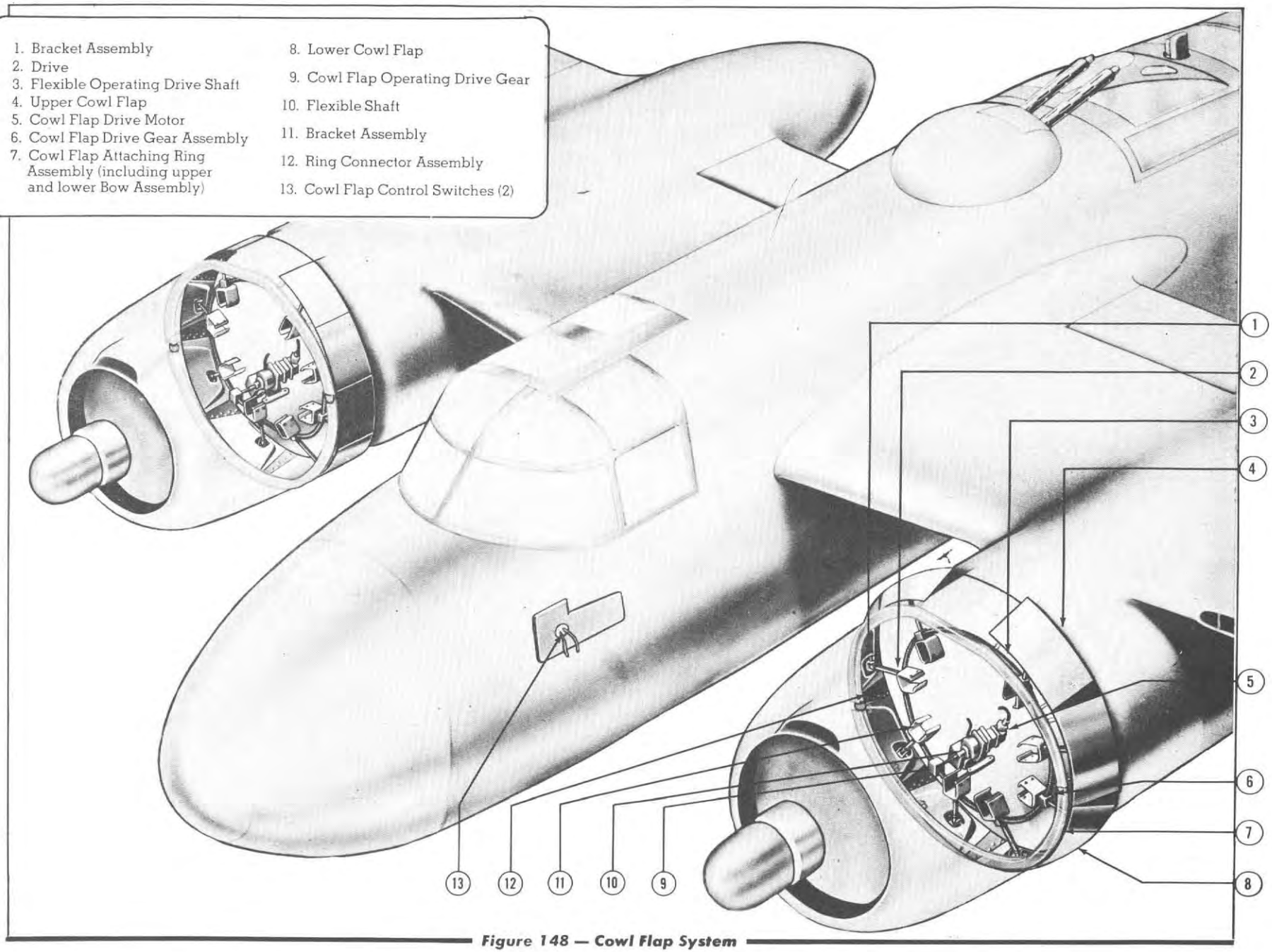


Figure 148 — Cowl Flap System

2. Turn the 7/8-inch hex nut (locking lever) with the cowl flaps closed until the mechanism has reached its full travel.

3. Unlock the right-hand side in the same manner, and remove the lower cowling segment.

4. Open the cowl flaps and disconnect the two toggle bolts which are located at the top of the anti-drag ring cowling, forward of the carburetor air duct elbow.

5. Close the cowl flaps. Unlatch the anti-rotational stop pins which are located above the horizontal center line on the inside of the forward support bow.

6. Remove the upper section of the anti-drag ring cowling.

(c) TOP OVERHAUL.

1. Check for cracks or other damage.

2. Make sure that both cowling sections are fastened securely.

(d) ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

(15) ENGINE COWL FLAPS.

(a) DESCRIPTION.—Eight overlapping cowl flaps are installed for each engine. They are attached by hinges to the aft cowl bow support. The bow support is bolted to the rocker boxes of the engine by brackets. The cowl flaps are designed to operate within thirteen angular degrees with a tolerance of plus or minus one degree. In the closed position the aft edge of the cowl flap must be 1/16 inch from the highest obstruction. In the open position this same dimension should be approximately 5½ inches. An electric drive motor is attached to the lower right-hand side of the engine mount. The motor is connected by a flexible drive shaft to the main operating drive gear box. The operating drive gear box is in turn connected by flexible shafts to eight individual drive gear boxes, each of which moves a flap. The electric motor is operated by the cowl flap switch on the pilot's main electrical control panel. This electric motor is geared for an output of 375 to 415 revolutions per minute. Each thirty revolutions of the output drive shaft will move the flaps one degree of angular travel. Cowl flap load is greatest in the closed position under any flight conditions.

(b) REMOVAL AND DISASSEMBLY.—Reverse the INSTALLATION procedure.

(c) TOP OVERHAUL.

1. Check the assembly for cracks or other damage.

2. Check the installation for tightness and security of mounting.

3. Replace the flexible drive shafts for the individual gear boxes and for the operating drive gear box whenever the serrated ends show excessive wear.

4. Replace the Lord mountings on each of the eight cowl flap drive shaft ends whenever they are excessively worn.

5. When backlash or excessive wear in the gear boxes makes it impossible to adjust the cowl flaps to the specified travel (twelve to fourteen angular degrees, or approximately 3 inches) replace parts as necessary.

6. For maintenance of the electric motor, refer to paragraph 15. *b.* (6), this section.

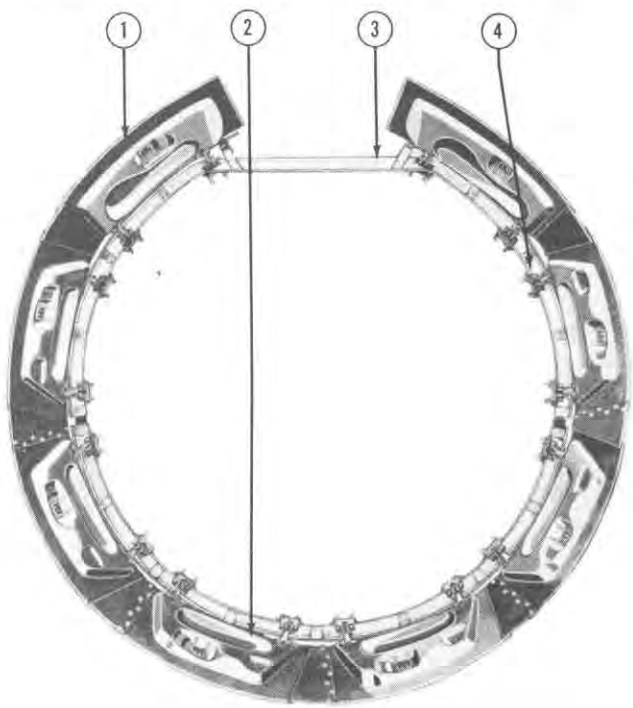
Note

Factory lubrication is intended to last the life of the unit. The gear boxes are packed with approved, low temperature grease.

(d) ASSEMBLY AND INSTALLATION.

1. Bolt the brackets to the rocker boxes.

2. Mount the cowl flap electric drive motor in the lower right hand side of the engine mount.



1. Upper Cowl Flap
2. Lower Cowl Flap
3. Bow Ring Support
4. Hinge Assembly

Figure 149 - Cowl Flap and Bow Ring Support Assembly

3. Mount the cowl flap operating drive gear box onto the bracket provided.

4. Mount each of the eight individual cowl flap drive gear boxes onto the brackets provided. The brackets are bolted onto the Lord engine mounts.

5. Connect all units with the proper flexible drive shafts.

6. Attach the upper bow ring assembly to the engine by bolting the brackets to the rocker boxes.

7. Connect the lower bow ring to the upper bow ring by the bow ring connectors. Attach the lower ring to the engine as described above.

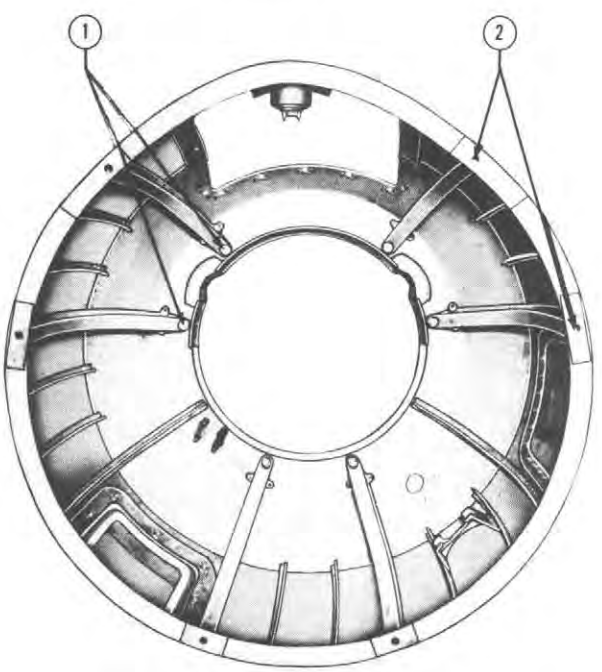
8. Attach the cowl flaps to the bow ring by bolting the hinges to the ring brackets.

9. Connect the jack shafts on the cowl flap drive gear boxes to the bracket provided on the flap.

(e) ADJUSTMENTS.

1. Adjust the individual jackscrews until the trailing edge of the flap is 1/16 inch from the highest obstruction in the closed position and 5½ inches from the highest obstruction in the opened position. The jackscrew is adjusted by turning it to the right to shorten the distance and to the left to lengthen the distance.

2. The three inch travel of the flaps is controlled by a limit switch within the gear box. The switch is not adjustable. The flap travel can be regulated by the jack shafts only.



1. Engine Mount Points 2. Nacelle Mount Points

Figure 150 — Engine Mount

(16) ENGINE MOUNT.

(a) DESCRIPTION.—The engine mount consists of eight forged al. alloy ribs which are stress-covered with a stainless steel skin. The engine is bolted onto the spun aluminum alloy ring at the forward end of the mount through six Lord Company or Pratt & Whitney rubber shock mounts.

(b) REMOVAL AND DISASSEMBLY.

1. Remove the engine as instructed in paragraph 6., *b.*, (2), this section.

2. Disconnect the neoprene sleeve which extends from the carburetor to the air duct elbow, and remove the elbow by disconnecting the Dzus fasteners which hold it to the anti-drag ring cowling.

3. Disconnect the oil lines at the engine, and place covers over the exposed oil ports.

4. Remove the vacuum lines, and plug the vacuum pump ports.

5. Remove and cap all other lines which are connected to the engine.

6. Disconnect the cowl flap flexible actuating shaft from the electric drive motor.

7. Disconnect and remove the propeller auxiliary feathering pump and pump lines.

8. Remove the engine-driven hydraulic pump.

9. Remove the nuts from the studs located at the top of the carburetor and remove the carburetor from the engine. Immediately after removing the carburetor, place a cover plate over the engine carburetor spacer. Extreme care should be taken to prevent any foreign material from falling into the blower section.

10. Disconnect and remove the tachometer cable from the engine.

11. Remove the cotter pins and the three nuts which are located at the end of each forged rib.

12. Remove the bonding from each forged rib and remove the engine mount from the engine. Be careful not to strike any accessory parts.

(c) TOP OVERHAUL.

1. Check the engine mount for damages, cracks, distortions, or other structural defects.

2. Check bolt holes for elongation or other damage.

3. Replace engine mount if repair is necessary.

Note

If it is necessary to replace a Lord shock mount, the entire engine must be removed.

(d) ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure. Follow torque instructions given in section IX.

(17) ENGINE FIRE SEAL.

(a) DESCRIPTION.—The engine fire seal *(figure 151)* is an all metal baffle mounted on the engine blower case, separating the cylinders from the accessory section.

(b) REMOVAL AND DISASSEMBLY.

1. Remove the bolts that secure the seal to the engine.

2. Remove the fireseal.

(c) TOP OVERHAUL.—Damaged fireseals will be replaced whenever possible.

(d) INSTALLATION. – Reverse the DISASSEMBLY procedure.

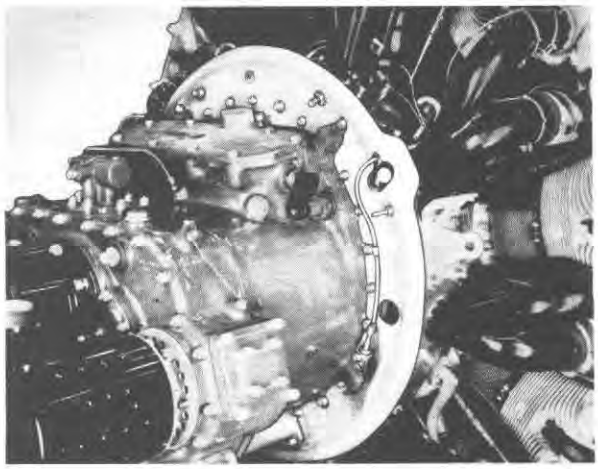


Figure 151—Engine Fire Seal

c. ENGINE SECTION TROUBLE SHOOTING CHART.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Engine fails to start.	*a.* Inadequate fuel supply.	*a.* Check selector valve position and fuel quantity.
	b. Overpriming.	*b.* If overprimed, cut switch and open the throttle full. Turn the propeller in the direction of normal rotation not less than two revolutions.
	c. Underpriming.	*c.* Reprime. If still underprimed, check priming system for leaks.
	d. Incorrect mixture and throttle setting. Idle adjustment too rich or too lean.	*d.* Adjust controls as instructed in paragraph 7. *c.* (4), this section.
	e. Leaking carburetor flange gasket.	*e.* Remove carburetor and replace gasket.
	f. Fuel flow restricted due to presence of water or foreign matter in carburetor strainer.	*f.* Clean the carburetor strainer as instructed in paragraph 7. *c.* (3), this section.
	g. Insufficient fuel pressure.	*g.* See fuel system trouble shooting chart, paragraph 11., this section.
	h. Air leaks from faulty packing or looseness at intake pipe connection.	*h.* Replace packing or tighten gland nut.
	i. Damaged intake pipes.	*i.* Replace pipes.
	j. Water in carburetor.	*j.* Remove drain plug at base of fuel control unit.
	k. Mixture control in idle cut-off.	*k.* See section III, paragraph 3., for starting instructions.
	l. Air in regulator unit.	*l.* Remove vent plug in top of regulator chamber of carburetor and pump until fuel comes out.
	m. Diaphragm failure in carburetor.	*m.* Replace diaphragm as instructed in T.O. No. 03-10BA-3.
	n. Loose electrical connections.	*n.* Tighten connections.
	o. Magneto breaker points which are dirty, pitted or at improper gap when opened or which fail to open.	*o.* Clean points as instructed in paragraph 8. *b.*, this section, and 8. *c.*, this section. Reset gap as instructed in T.O. No. 03-5DA-9 or 03-5DC-1 and -2.
	p. Moisture, oil, or dirt on spark plug terminals or electrodes.	*p.* Remove plugs from engine. Dry, clean and replace.
	q. Burned ignition wires and burned or chafed insulation.	*q.* Replace ignition wiring.

c. ENGINE SECTION TROUBLE SHOOTING CHART.—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
	r. Low electrical output of magnetoes or induction vibrators.	*r.* High tension leads of these units when operated at normal starting speed should be disconnected and held ¼ to ⅜ inch from a grounded surface. If the spark which arcs this gap is weak, the units are functioning improperly. Replace units.
	s. Valves or ignition out of time.	*s.* See paragraph 8. *b.* 3., and 8. *c.* (4), this section, for magneto timing. If vlaves are out of time an engine overhaul will be necessary.
	t. Sticking valves.	*t.* Depress valve several times with PWA valve compressor and lubricate with light lubricating oil (AXS777). This is only a temporary measure and must be followed by a top overhaul in which the sticking valve is cleaned or replaced. See paragraph 6. *b.* (5) *(c)*, this section.
	u. Broken valve springs.	*u.* See paragraph 6. *b.* (5) *(c)*, this section.
	v. Incorrect valve clearance adjustment.	*v.* Adjust clearance as instructed in paragraph 6. *b.* (5) *(c)*, this section.
2. Low engine power.	*a.* Incorrect grade of fuel.	*a.* For correct types of fuel to use in these airplanes refer to stencils on the airplane.
	b. Improper setting or operation of carburetor.	*b.* Adjust carburetor as instructed in paragraph 7. *c.* (4), this section.
	c. Throttle controls out of adjustment.	*c.* Check throttle linkage for freedom of movement to extreme positions.
	d. Inadequate fuel pressure to carburetor.	*d.* See fuel system trouble shooting chart, paragraph 11, this section.
	e. Ice formation on carburetor venturi or air screen.	*e.* Place the carburetor hot air control in the HOT position. Use carburetor anti-icing system.
	f. Air leaks in intake pipes, carburetor mounting flange, or carburetor body gaskets.	*f.* Locate leak. Stop leaks in intake pipes by tightening gland nuts or replace packing. Replace leaking carburetor gaskets.
	g. Faulty ignition.	*g.* Test the ignition by running momentarily on each magneto with the propeller in low pitch position. In switching from both magnetoes to one, the normal drop-off should not exceed 100 rpm at the cruising rpm and manifold pressure. When switching from one magneto to the other the change in rpm should not be more than 30 or 40. **CAUTION** Continued running on one magneto may cause detonation or pre-ignition.
	h. If the drop in speed is in excess of either of the above mentioned limits, investigation should be made for the following conditions:	
	(1) Defective ignition wires or terminal sleeves.	(1) Replace.
	(2) Defective or fouled spark plugs.	(2) Replace.
	(3) Incorrect timing and operation of magnetos.	(3) See item 1. *s.*, above.
	i. Oil on magneto breaker points.	*i.* Clean points as instructed in paragraph 8. *b.*, this section, and paragraph 8. *c.*, this section.
	j. Improperly set valve clearances.	*j.* Reset valves as instructed in paragraph 6. *b.* (5) *(c)*, this section.
	k. Poor compression due to improperly seated valves or defective piston rings.	*k.* Remove valves. If worn unevenly or excessively reface and reseat. Remove pistons and install new rings. See paragraph 6. *b.* (5) *(f)*, this section.
3. Rough running.	*a.* Dirt, water, or foreign matter in the carburetor fuel passages or strainer.	*a.* Flush carburetor with clean gasoline. Do not use carbon tetrachloride or other carbon base solvents.

c. ENGINE SECTION TROUBLE SHOOTING CHART.—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
	b. Improperly operating fuel pump.	*b.* Refer to fuel system trouble shooting chart, paragraph 11., this section.
	c. Air leaks in the air intake system.	*c.* Check intake pipes for damage, and gland nuts for tightness. Inspect carburetor mounting gasket.
	d. Defective or improperly gapped spark plugs.	*d.* Clean, regap, or replace spark plugs as instructed in paragraph 8. *e.* (3), this section.
	e. Oil on magneto breaker points.	*e.* Clean points as instructed in paragraph.
	f. Broken or damaged ignition wires or connections.	*f.* Repair or replace.
	g. Improper timing and operation of magnetos.	*g.* Refer to item 1. *s.*, above
	h. Loose engine mounting bolts.	*h.* Tighten bolts.
	i. Cracked or broken members of the engine mount.	*i.* Replace mount.
	j. Faulty valve action due to improper clearance adjustment.	*j.* Adjust valve clearances as instructed in paragraph 6. *b.* (5) *(c)*, this section.
	k. Bent or worn push rods.	*k.* Straighten if possible, or replace.
	l. Broken valve spring.	*l.* Replace as instructed in paragraph 6. *b.* (5) *(c)*, this section.
	m. Sticking valves.	*m.* Depress valve several times with the PWA valve compressor and lubricate with light oil, (AXS 777). This is only a temporary measure and must be followed by a top overhaul in which the sticking valve is cleaned or replaced. See paragraph 6. *b.* (5) *(c)*, this section.
	n. Unbalance or improper tracking of the propeller.	*n.* Can be caused by nicks or other damage to blades. Replace propellers.
	o. Propeller not tight on propeller shaft.	*o.* Inspect splines for galling. Tighten retaining nut. See paragraph 10, this section.
	p. Propeller thrust nut not tight.	*p.* Examine hub rear cone for galling. Tighten thrust nut as instructed in paragraph 10., this section.
	q. Governor control faulty.	*q.* See paragraph 10., this section.
4. Detonation. (See introduction to trouble-shooting for definition.)	*a.* Excessive cylinder temperature.	*a.* See trouble shooting item No. 27., below.
	b. Low grade or octane of fuel.	*b.* See section III for servicing information.
	c. Mixture too lean.	*c.* Adjust mixture control as instructed in paragraph 7. *c.* (4), this section.
	d. Overspeeding engine.	*d.* Check governor control for malfunction or leakage. See paragraph 10., this section.
	e. Excessive blow-by.	*e.* Replace piston rings as instructed in paragraph 6. *b.* (5) *(f)*, this section.
5. Pre-ignition. (See introduction to trouble-shooting for definition.)	*a.* Prolonged detonation.	*a.* See trouble-shooting item No. 4 above.
	b. Excessively lean mixture.	*b.* Adjust mixture and idle controls as instructed in paragraph 7. *c.* (4), this section.
	c. Excessive cylinder temperature.	*c.* See throuble shooting item No. 27 below.
	d. "Feather-edged" valves or seats.	*d.* Grind valves and reface seats or replace valves.
	e. Excessive carbon deposits.	*e.* Remove and clean valves. See paragraph 6. *b.* (5) *(c)*, this section.
6. Low oil pressure.	*a.* For information regarding troubles to the oil system or any of its units which are not part of the engine, refer to Oil System Trouble Shooting Chart, paragraph 12, this section.	
	b. Clogged oil strainer screen.	*b.* Remove and clean screen. If metal particles are found in the screen or in the drain-plugs of the oil sumps, determine the cause before operating the engine any further.
	c. Improper seating of oil pressure relief valve.	*c.* Examine relief valve for uneven wear or pitting. Check valve stem and compensating piston for scoring or seizing. Wash and clean thoroughly—re-oil with engine oil.
	d. Faulty operation of main oil pump.	*d.* Remove and replace.

c. ENGINE SECTION TROUBLE SHOOTING CHART.–Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
	e. Blow-by resulting from burned or scored pistons or weak piston rings.	*e.* Remove and replace pistons and piston rings as necessary. See paragraph 6. *b.* (5) *(f)*, this section.
	f. Excessively worn bushings or bearings which permit spillage of oil into front section main crankcase or accessory section.	*f.* Requires major overhaul.
7. Oil pressure too high.	*a.* Improperly operating oil pressure relief valve.	*a.* Check valve stem and compensating piston for presence of gum or other matter to prevent the valve from lifting. Wash and clean thoroughly–re-oil with engine oil.
	b. For troubles due to units of the oil system which are not part of the engine refer to Oil System Trouble Shooting Chart, paragraph 10., this section.	
	c. Thermostat control pressure relief valve stuck closed.	*c.* Clean needle valve.
	d. Oil temperature too low.	*d.* See trouble shooting item No. 8.
	e. Oil viscosity too high.	*e.* Warm oil.
8. Oil temperature too high.	*a.* Improper grade oil or insufficient supply.	*a.* See section III for proper grade oil and servicing of oil system.
	b. Oil diluted or dirty.	*b.* If contaminated, drain oil as instructed in paragraph 12. *b.*, this section.
	c. Poor compression caused by burned or scored pistons and weak piston rings.	*c.* Perform top overhaul work as instructed in paragraph 6. *b.* (5) *(f)*, this section.
	d. Excessive cylinder heat temperature.	*d.* See trouble shooting item No. 30 below.
	e. Partial or complete failure of bushings or master rod bearing (Inspect oil screen and drain plug of main oil sump for metal chips which indicate these conditions.)	*e.* Major overhaul required.
	f. Improper valve adjustment.	*f.* Adjust valve clearances as instructed in paragraph 6. *b.* (5) *(c)*, this section.
	g. Improper magneto timing.	*g.* Refer to item 1.
9. No oil pressure.	*a.* Damaged oil pressure line.	*a.* Replace line.
	b. Broken pump shaft.	*b.* Replace pump.
	c. No oil.	*c.* Check tanks and fill system as instructed in paragraph 12. *c.*, this section.
	d. Oil Seal or engine structural part damaged.	*d.* Change engine.
10. Fluctuating oil pressure.	*a.* Oil supply too low.	*a.* Add oil. See paragraph 12. *c.*, this section.
	b. Air leak in oil inlet line.	*b.* Tighten or replace connections or lines. Bleed lines.
	c. Air in oil pressure line or in line to gage.	*c.* Check lines for damage and fittings for looseness. Bleed oil pressure transmitter line and fill with compass fluid.
11. High oil consumption (characterized by excessive blue smoke when engine is hot and idling).	*a.* Burned or scored pistons and worn piston rings.	*a.* Perform top overhaul work as instructed in paragraph 6. *b.* (5) *(f)*, this section.
	b. Worn valve guides.	*b.* Replace.
	c. Viscosity too low.	*c.* See paragraph 12. *b.*, this section.
	d. Oil pressure too high.	*d.* See trouble shooting item, No. 7, above.
	e. Oil temperature too high.	*e.* See trouble shooting item No. 8, above.
	f. Oil leakage anywhere in system.	*f.* Locate leakage. Tighten or replace fittings. Replace damaged line.
	g. Improper scavenge pump operation.	*g.* Repair or replace. See paragraph 6. *b.* (6) *(a)* 1. and 2., this section.

c. ENGINE SECTION TROUBLE SHOOTING CHART.—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
	b. Breather pipes clogged.	*b.* Clean out breather lines.
	i. Accessory drive oil seal leaks.	*i.* Replace oil seal.
12. Excessive vibration.	*a.* Propeller out of balance (not tracking properly) or not mounted correctly.	*a.* See paragraph 10., this section.
	b. Bent crankshaft.	*b.* Change engine. See paragraph 6. *b.* (2), this section.
	c. Engine mount bolts loose.	*c.* See torque chart section IX.
	d. Faulty engine mount bolts.	*d.* See torque chart section IX.
	e. Incorrect valve clearance setting.	*e.* Refer to paragraph 6. *b.* (5) *(c)*, this section.
	f. Mixture too lean or too rich.	*f.* See trouble shooting items No. 17 & 18, below.
	g. Detonation.	*g.* See trouble shooting item No. 4, above.
	h. Pre-ignition.	*h.* See trouble shooting item No. 5, above.
13. Engine fails to develop full power.	*a.* Faulty ignition units, shorting of ignition wires.	*a.* Inspect ignition units including switch, booster coil or induction vibrator, magnetos and spark plugs. Examine all ignition wiring for loose connections or leaks.
	b. Faulty carburetion.	*b.* Check linkage of throttle, mixture, carburetor hot air, and propeller pitch controls. See paragraph 9., this section. Check carburetor and carburetor adjustments as instructed in paragraph 7. *(c)* (4) this section.
	c. Improper valve clearance or ignition timing.	*c.* Refer to item 2., Trouble Shooting Chart.
	d. Air leak in induction system.	*d.* Check intake pipes for cracks or other damage. Check intake pipe packing and packing gland nuts for security.
	e. Fuel pressure too low.	*e.* See Trouble Shooting, paragraph 12, this section.
	f. Air scoop filter clogged.	*f.* Remove obstruction.
	g. Improper lubrication.	*g.* Check operation of pressure and scavenge pumps, oil thermostat and oil pressure relief valve. See paragraph 6. *b.* (6), this section.
	h. Propeller blade angle stop setting rings may be improperly installed.	*h.* Remove dome and check setting rings for proper indexing.
14. Intermittent misfiring.	*a.* Incorrect mixture.	*a.* See trouble shooting items Nos. 17 & 18.
	b. Low grade fuel.	*b.* See Section III, for servicing information.
	c. Water in fuel system.	*c.* Drain water through sumps on fuel tanks, also drain water from carburetor, fuel pump and fuel pressure lines to carburetor.
	d. Air leaks in induction system.	*d.* Check intake pipes for cracks or other damage. Check gland nuts for tightness and packing for general condition.
	e. Improper valve clearance.	*e.* Refer to item 2, Trouble Shooting.
	f. Defective spark plugs.	*f.* Replace faulty plugs.
	g. Defective ignition harness or wires.	*g.* Check wires for loose connections, breaks, burned or chafed areas. Replace if necessary.
	h. Defective magneto.	*h.* See trouble shooting item No. 28, below.
15. Misfiring at high rpm.	*a.* Defective magneto, or induction vibrator.	*a.* Check units as instructed in paragraph 8. b. (1) *(a)* 3., this section. Replace if necessary.
	b. Defective ignition harness or wiring.	*b.* Check wiring for loose connections, breaks, burned or chafed areas. Replace if necessary.
	c. Defective spark plugs.	*c.* Replace defective plugs.
	d. Mixture too lean.	*d.* Adjust mixture control as instructed in paragraph 7. *c.* (4), this section.
	e. Engine operating temperature too low.	*e.* See section III for servicing information.
	f. Restricted fuel flow.	*f.* See paragraph 12., this section.
	g. Engine overheated.	*g.* See trouble shooting item No. 26.
16. Rich mixture.	*a.* Fuel pressure too high.	*a.* See fuel system, paragraph 12, trouble shooting list.
	b. Mixture control setting too rich.	*b.* Adjust mixture control as instructed in paragraph 7. *c.* (4), this section.

c. ENGINE SECTION TROUBLE SHOOTING CHART.—Continued.

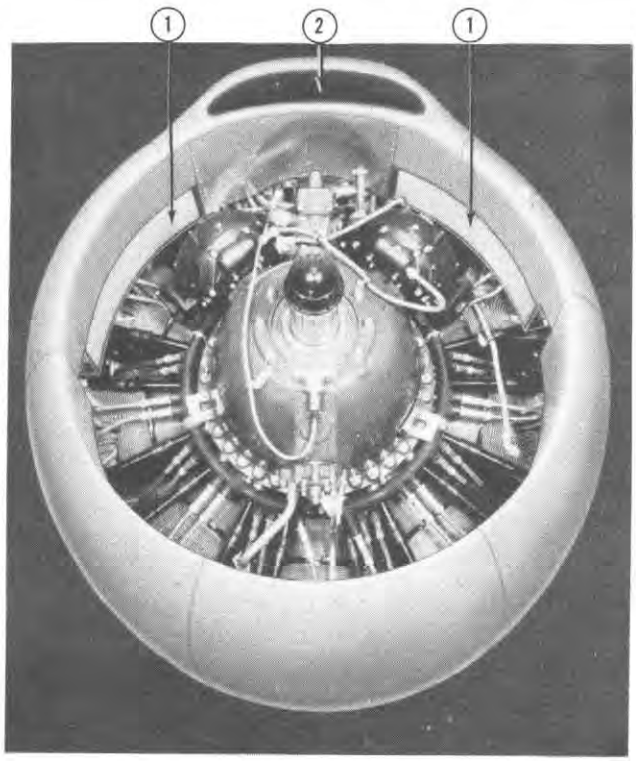
TROUBLE	*PROBABLE CAUSE*	*REMEDY*
	c. Partially clogged filter cartridge.	*c.* Remove obstruction. Remove and clean filter.
	d. Float level too high.	*d.* Replace carburetor. See paragraph 7. *b.*
	e. Jets loose or enlarged.	
	f. Air bleeds clogged.	
	g. Acceleration pump and valve leaking.	
17. Lean mixture.	*a.* Low fuel pressure.	*a.* See paragraph 12, this section.
	b. Mixture control set too lean.	*b.* Adjust mixture control as instructed in paragraph 7. *c.* (4), this section.
	c. Air leak or crack in induction system.	*c.* See trouble shooting item No. 20.
	d. Vapor lock due to overheated line.	*d.* See trouble shooting item No. 19.
	e. Insufficient warm air supply to carburetor.	*e.* Turn on carburetor hot air control.
	f. Jets too small.	*f.* Replace carburetor.
	g. Accelerator pump not operating properly.	*g.* Replace carburetor. See paragraph 7. *c.* (2), this section.
18. Excessive fuel consumption.	*a.* Leaks in lines or loose connections.	*a.* Check fittings and lines.
	b. Fuel pressure too high.	*b.* See paragraph 9, this section.
	c. Mixture control set too rich.	*c.* See trouble shooting item No. 17.
	d. Jets too large or loose in carburetor body.	*d.* Replace carburetor.
	e. Air bleeds clogged.	*e.* Clean out bleed lines.
	f. Float level too high.	*f.* Reset float.
19. Vapor lock.	*a.* Overheated fuel lines.	*a.* Determine cause of heating–see trouble shooting item No. 26. Bleed fuel lines, paragraph 12, this section.
	b. Vertical humps or short bends in lines.	*b.* Straighten out lines.
	Note	
	This trouble is indicated by sudden stoppage of the engine, particularly in hot weather during take-off.	
20. Air leak.	*a.* Cracked induction housing.	*a.* Major overhaul. Replace housing.
	b. Leaking intake pipe flange or gland gaskets.	*b.* Inspect gland nut and packing. Tighten or replace.
	c. Leaking carburetor flange gasket.	*c.* Replace gasket.
	d. Worn throttle shaft or bushings.	*d.* Rework and replace parts as necessary.
21. Engine will not start or continue to run after starting.	*a.* Incorrect starting procedure used.	*a.* See section III, for service information.
	b. Insufficient fuel pressure.	*b.* See paragraph 11., Fuel System Trouble Shooting Chart, item No. 2.
	c. Idle adjustment too low.	*c.* Adjust carburetor as instructed in paragraph 7. *(c)*, (4), this section.
	d. Air in regulator unit.	*d.* Remove vent plug in top of unmetered fuel chamber of regulator unit. Pump fuel until it stands level with plug opening.
	e. Check position of manual mixture control to see that control is not in idle cut-off position.	*e.* If position is wrong, re-rig control linkage.
	f. Main discharge nozzle sticking open.	*f.* Clean unit thoroughly or replace. Nozzles must hold a 3 pound pressure without leaking fuel.
22. Engine runs too rich or too lean at cruising power.	*a.* Fuel pressure low.	*a.* Check fuel pump and fuel pressure gage. Clean carburetor strainer.
	b. Foreign material in cruise jet.	*b.* Clean jet.
	c. Economizer needle leaking or sticking open.	*c.* Replace carburetor.
	d. Check automatic mixture control unit setting and bellows if carburetor is running rich or lean in automatic position at altitude.	*d.* Replace carburetor.

c. ENGINE SECTION TROUBLE SHOOTING CHART.–Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
23. Engine runs too lean at take-off or rated power but satisfactorily at cruising power.	*a.* Insufficient fuel pressure.	*a.* See paragraph 11., this section.
	b. Economizer valve is binding.	*b.* Remove fuel control unit cover body and check mechanism for freedom of movement. Clean parts thoroughly. If necessary, replace unit.
24. Engine runs too lean or too rich at altitude in automatic position, but satisfactorily at sea level.	*a.* Vapor separator float needle stuck in the closed position.	*a.* Remove strainer and inspect float for freedom of movement.
	b. Mixture control valve set in wrong position.	*b.* Check linkage to manual mixture control lever.
	c. Emergency full-rich valve plates open or leaking.	*c.* Remove valve cover on throttle body and see that slots in the plates are open only in full rich position and that plates do not leak. If necessary reface plates on a flat lapping plate.
	d. Automatic mixture control unit set incorrectly or operating faultily.	*d.* Replace carburetor. See paragraph 7. *c.* (2), this section.
25. Engine does not accelerate properly but runs satisfactorily with slow throttle movements.	*a.* Fuel inlet to acceleration pump clogged at the intake restriction, also mixture set too lean.	*a.* Remove pump cover, diaphragm, and examine.
	b. Discharge nozzle leaking.	*b.* Run engine up to high power and retard throttle rapidly several times to remove dirt from under the needle valve seat.
	c. Fuel leak into air chamber of regulator unit.	*c.* Remove air chamber drain plug.
	d. Accelerating pump not adjusted to give required travel.	*d.* Replace carburetor. See paragraph 7. *c.* (2), this section.
26. Overheating of engine.	*a.* Lean mixture.	*a.* See trouble shooting item No. 18.
	b. Viscosity of oil too low.	*b.* See paragraph 12, this section.
	c. Excessive blow-by.	*c.* Replace pistons or piston rings as instructed in paragraph 6. *b.* (5) *(f)*, this section.
	d. Air leak in the induction system.	*d.* See trouble shooting item No. 20, above.
	e. Detonation.	*e.* See trouble shooting item No. 4, above.
	f. Pre-ignition.	*f.* See trouble shooting item No. 5, above.
	g. Excessive manifold pressure.	*g.* See operating instructions, section III, paragraph 6.
27. Failure of dual ignition system.	*a.* Contact points pitted or dirty, also points that fail to open.	*a.* Clean and repair as instructed in paragraph 8. *b.* (1) *(a)* 4., this section.
	b. Loose terminals or other wiring connections.	*b.* Inspect and tighten connections.
	c. Broken accessory drive.	*c.* Replace magneto.
	d. Moisture in ignition harness.	*d.* Dry out harness.
28. Failure of one magneto.	*a.* Broken drive shaft or drive gear.	*a.* Replace magneto.
	b. Defective coil or condenser.	*b.* Replace defective unit.
	c. Dirty or defective breaker points.	*c.* Clean as instructed in paragraph 8. *b.* (1) *(a)* 4., this section, or 8. *c.* (3), this section.
29 Failure of spark plug.	*a.* Plug too hot or too cold for engine. Distortion of plug from improper installation. Tightening plug too tight when installing.	*a.* See paragraph 8 *e.* (3), this section.
	b. Insulator shorted.	*b.* Replace plug.
	c. Electrodes shorted by excessive oil or carbon deposits.	*c.* Clean.
	d. Cracked ceramic.	*d.* Replace plug.
30. Engine does not shut off in idle cut-off position.	*a.* Idle cut-off valve washer on mixture control needle not seating properly.	*a.* Remove plug on side of fuel control unit adjacent to cruise jet to see if washer seats in idle cut-off position. Check control rods for full travel. Check for burrs on metering jet.
	b. Economizer needle not seating properly.	*b.* Remove fuel control unit, cover body and check mechanism for freedom of movement.
	c. Regulator unit functioning improperly.	*c.* Check.

7. CARBURETOR FUEL-AIR INDUCTION SYSTEM.

a. GENERAL. – The carburetor fuel-air induction system consists of the carburetor, and the scoop (also air control gates, electric motor, and filters on some airplanes) installed on the upper portion of the anti-drag ring cowling, which conveys air to the carburetor. Refer to *figure 153.* Air may gain access to the carburetor directly through the scoop (ram-air position); through filters (non-ram air position); or over the engine for the purpose of pre-heating air in cold weather conditions.



1. Filter 2. Ram Scoop

Figure 152 — Ram Air Scoop

b. AIR SCOOPS.

(1) RAM TYPE AIR SCOOP.

(a) DESCRIPTION.—The air induction system consists of a scoop which extends from the leading edge of the anti-drag ring cowling to the carburetor. The first section of the scoop is sheet metal and is integral with the anti-drag ring cowling. The remaining part of the scoop is an elbow-shaped casting. Two flexible connections are used to absorb engine vibration, one between the anti-drag ring cowling and the elbow casting, and the other between the elbow casting and the carburetor. The elbow casting has a door which opens into the engine section through which warm air may enter.

(b) REMOVAL AND DISASSEMBLY.

1. Disconnect the neoprene sleeve which connects the carburetor to the air scoop elbow.

2. Remove the flexible connector between the anti-drag ring cowling and the intake elbow.

3. Remove the control linkage at the side of the elbow.

4. Remove the Dzus fasteners which secure the elbow to the anti-drag ring cowling and remove the elbow.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check the air scoop for security of attachment.

2. Check the control arm for freedom of movement.

3. For cable rigging information refer to *figure 74.*

(d) ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure. See paragraph *(b),* above.

(2) NON-RAM TYPE AIR SCOOP.

(a) DESCRIPTION.—In this type carburetor air induction system, a gate, installed in the aft part of the cowling scoop, prevents the direct passage of air to the carburetor. The air is diverted through the two filters, located at the top of the cowling, before entering the scoop which extends to the carburetor. This system, however, may be used also in the ram position. See paragraph 7. *b.* (1), this section.

(b) REMOVAL AND DISASSEMBLY.

1. The scoop is removed as described in paragraph 7. (1), *(b),* this section.

2. The filters may be removed by releasing the applicable latches and sliding the filters from place.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—When possible replace all carburetor air induction system parts. Small holes in the scoop may be welded if necessary.

(d) INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

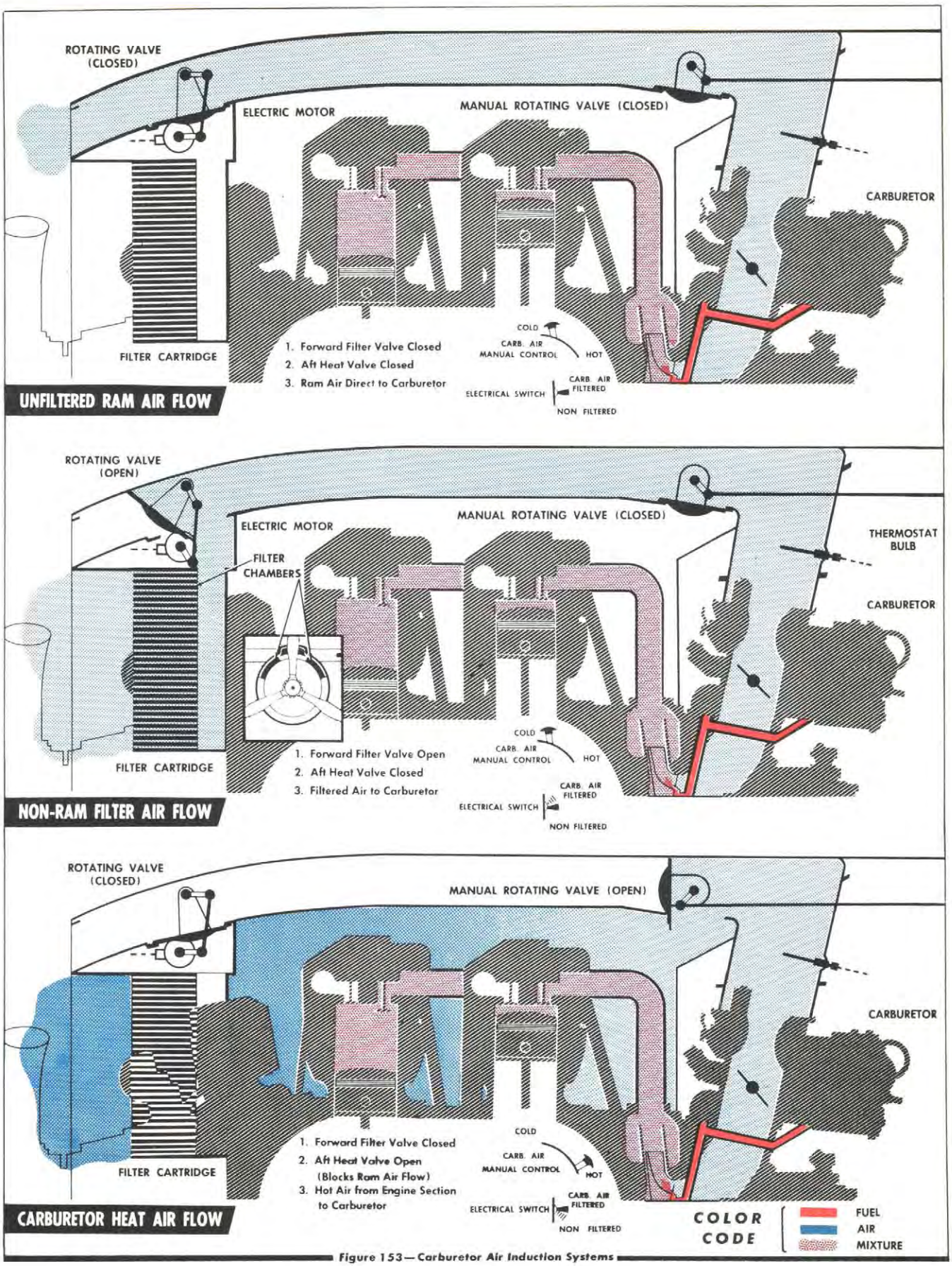
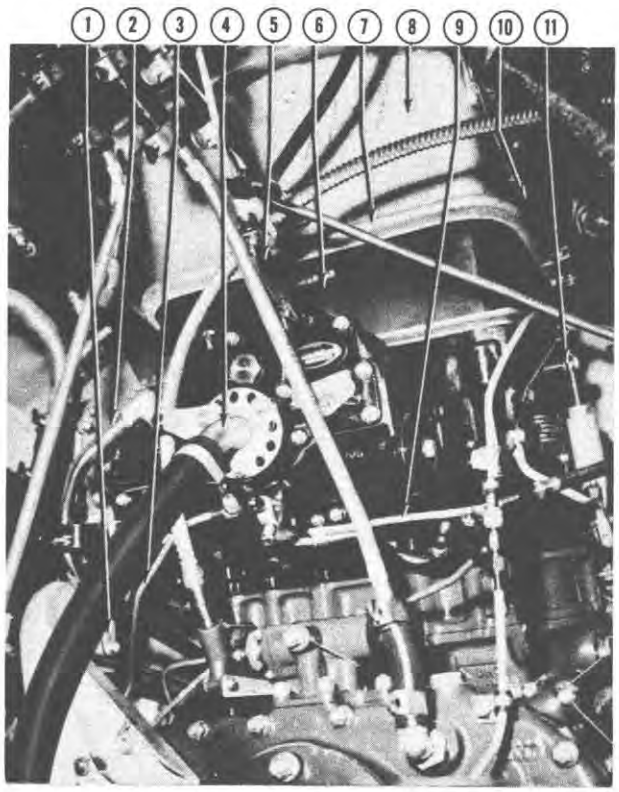


Figure 153—Carburetor Air Induction Systems

c. CARBURETOR.

(1) DESCRIPTION.—These engines are equipped with PT13G1 Bendix-Stromberg downdraft, injection carburetors *(figure 154.)* The carburetor is functionally divided into the following four parts: throttle unit, automatic-mixture-control unit, regulator unit and fuel control unit.

(a) THROTTLE UNIT.—Air is taken in through the air scoop and flows to the three barreled throttle unit. Each barrel contains a large venturi, a boost venturi (tubular restriction), and a group of small impact tubes around the top of the large venturi. The throttle valves control the amount of incoming air. The difference in air pressure between the impact tubes and the boost venturi throat is a measure of the volume of air entering the engine.



1. Carburetor Mixture Control
2. Fuel Line to Discharge Nozzle
3. Fuel Pressure Line
4. Inlet Line from Fuel Pump
5. Vapor Vent Line
6. Neoprene Sleeve
7. Neoprene Sleeve Clamp
8. Air Induction System Elbow Casting
9. Engine Priming Line
10. Clamp Tightening Screws
11. Throttle Control Mechanism

Figure 154 — Carburetor Installed

(b) AUTOMATIC MIXTURE CONTROL.—An automatic mixture control unit is mounted on the side of the throttle body and contains metallic bellows which are sensitive to changes of carburetor air pressure and temperature. The function of the unit is to correct the fuel-air ratio according to existing atmospheric conditions.

(c) REGULATOR UNIT.—The regulator unit has an air chamber and a fuel chamber. Each member is divided into two sections by diaphragms which are installed on the fuel poppet shaft. The incoming air pressure produces an air metering force which acts on the air diaphragm. This force moves the fuel poppet and the fuel diaphragm, permitting the flow of fuel to vary according to the mixture desired and the atmospheric condition of the air being used.

(d) FUEL CONTROL UNIT.—The fuel control unit contains fixed metering jets, the idle valve, the power enrichment valve, and a four position full mixture control selector valve.

(e) ACCELERATION PUMP.—A throttle actuated, piston type acceleration pump is installed on the throttle body. This unit causes the fuel poppet to admit more fuel into the engine blower housing and through the fuel slinger ring on the impeller shaft. This carburetor is also equipped with a throttle balance which reduces the tendency of the throttle valve to creep shut when the vacuum below the throttle valves is high.

(2) REMOVAL AND DISASSEMBLY.

(a) Remove the anti-drag ring cowling as instructed in paragraph 6. *b.* (14) *(b)*, this section.

(b) Disconnect the carburetor air scoop control.

(c) Disconnect the neoprene sleeve which extends from the carburetor to the air duct elbow.

(d) Remove the elbow by unfastening the Dzus fasteners which hold it to the engine mount.

(e) Disconnect the throttle and mixture control rods at the carburetor.

(f) Disconnect the main transfer line which is connected to the blower section.

(g) Disconnect all lines which are connected to the carburetor.

(h) Remove the nuts which secure the carburetor to the studs on the blower housing. Lift the carburetor off the spacer.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—The following maintenance operations can be performed in the field without the use of a flow bench or overhaul equipment. It is not advisable to perform any further work on carburetors between overhaul periods. All work on carburetors will be performed by carburetor specialists.

(a) Remove the fuel strainer bolt, cup, and strainer from the regulator body and clean the parts.

(b) Mixture control and idle linkage joints should be examined occasionally for play. Link bolts should be tightened securely and spring washers in place.

(c) The automatic mixture control unit may be removed for inspection or replacement. While this unit is removed, clean the needle valve. Replacement is necessary approximately every 250 hours.

CAUTION

When the control is removed, particular care must be taken not to change the position of the adjusting screw and lock nut.

(d) Keep the boost venturi clean at all times. Clean the impact tubes with pipe cleaners or a small wire.

(e) When making connections between the fuel pump and the carburetor, be sure to clean all sealing compounds off the ends of the connections. Use the sealing compound lightly on the threaded area only.

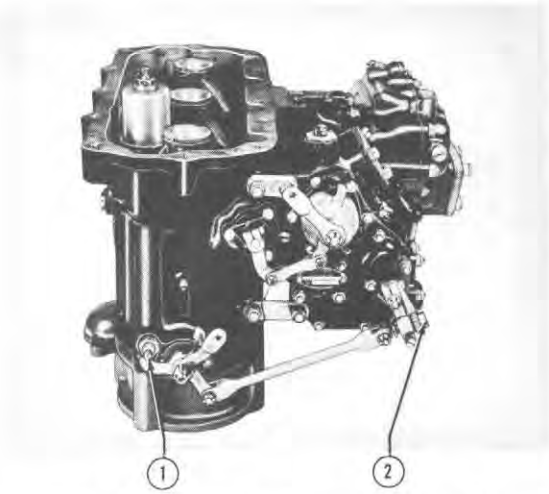
(f) Check for broken lockwires and consequent loosening of nuts and plugs.

(4) ADJUSTMENTS.—All adjustments with the exception of idle adjustment should be made at a major depot where a flow bench is available. Proceed with the idle adjustment as follows:

(a) If the engine is cold, run it at 1000 rpm until the oil inlet temperature reaches 60 degrees C. to 70 degrees C. (140 degrees F. to 158 degrees F.) and the cylinder head temperatures are normal: then run the engine at 2000 rpm long enough to clean the spark plugs. At this time the operation of the plugs should be checked by moving the magneto switch from "BOTH" to "LEFT" and to "RIGHT." If the decrease in rpm is normal, the idling of the engine may then be checked, and adjusted if necessary.

(b) The throttle stop position should first be set so that the engine will idle between 400 and 500 rpm. While the engine is idling, momentarily move the mixture control to "IDLE CUT-OFF" and carefully observe the engine rpm. Move the control back to automatic rich before the engine stops.

(c) If the engine rpm decreased immediately when the mixture control was moved to "IDLE CUT-OFF," turn the knurled adjusting screw one or two notches in a clockwise direction to enrich the mixture and again check the rpm when the control is moved to "IDLE CUT-OFF."



1. Idling Adjustment Screw 2. Throttle Adjustment Screw

Figure 155 — Carburetor (Left Side)

(d) If the engine rpm increased momentarily by more than 5 to 10 (never more than 15 or 20) rpm when the mixture control was moved to "IDLE CUT-OFF" lean the mixture slightly by turning the knurled adjusting screw one or two notches in a counterclockwise direction; then recheck the rpm when the control is moved to "IDLE CUT-OFF."

(e) Each time the adjustment is changed, the engine should be run up to 2000 rpm to clear the spark plugs before proceeding with the rpm check. The above procedure should be repeated until a momentary increase of between 10 and 20 rpm is noted when the mixture control is moved to "IDLE CUT-OFF." When this condition exists, the idling is satisfactorily adjusted. The final idling rpm should be between 500 and 650.

CAUTION

Never attempt to make an adjustment on the automatic units. These adjustments must be made on the flow bench.

(5) ASSEMBLY AND INSTALLATION. — Reverse the REMOVAL AND DISASSEMBLY procedure.

d. TROUBLE SHOOTING CHART. (See paragraph 6. *c.*, this section.)

8. IGNITION SYSTEM.

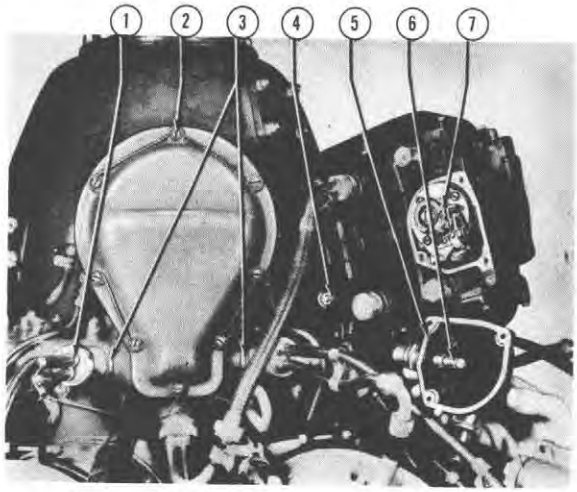
a. GENERAL.—Either Scintilla Magnetos, distributors, and ignition harness or General Electric Magnetos and Ignition Shielding are installed on A-26 engines. The two systems are interchangeable. Engines using the first named system are designated as R-2800-27, engines using the other type ignition system as R-2800-71.

b. SCINTILLA MAGNETOS, DISTRIBUTORS, AND IGNITION HARNESS (Used on R-2800-27 engines).

(1) GENERAL.—The ignition system is the magneto type and is completely independent of the airplane electrical system, except for the induction vibrator circuits. The system is completely shielded and has two major electrical disconnect plugs for each engine: one at each firewall and one at each wing disconnect location. The ignition wires are connected to terminal posts in the ignition junction box, the left and right firewall junction boxes, and the left and right power plant junction boxes. The ignition is furnished by a dual magneto, an induction vibrator, and twin distributors mounted separately on external pads on the front section of the engine housing, and controlled by two ignition switches located on the pilot's main electrical control panel. When the ignition switch is in the "ON" position and the starter is engaged, the current from the battery is supplied to the induction vibrator, causing it to produce a rapidly interrupted current. This current flows through the primary winding of the magneto coil, where, by induction, a high voltage is created in the secondary winding of the magneto coil. This produces a high tension voltage which is supplied to the spark plugs, through the magneto distributor rotor and distributor block electrodes, when the magneto contact points are open. The current causing the initial spark is timed for delivery in advance, and the sparks which follow gradually taper off into retard until the magneto contact points close, and the current by-passes to the ground connection. This action is repeated each time the magneto contact points are separated, sending the interrupted current again through the primary winding of the magneto coil, where the action, outlined above, again occurs. This action continues until the engaging starter is released and the engine is firing under the regular magneto spark.

Note

For wiring diagrams for the component part of the ignition system, refer to the WIRING DIAGRAM SECTION following paragraph 15, this section.



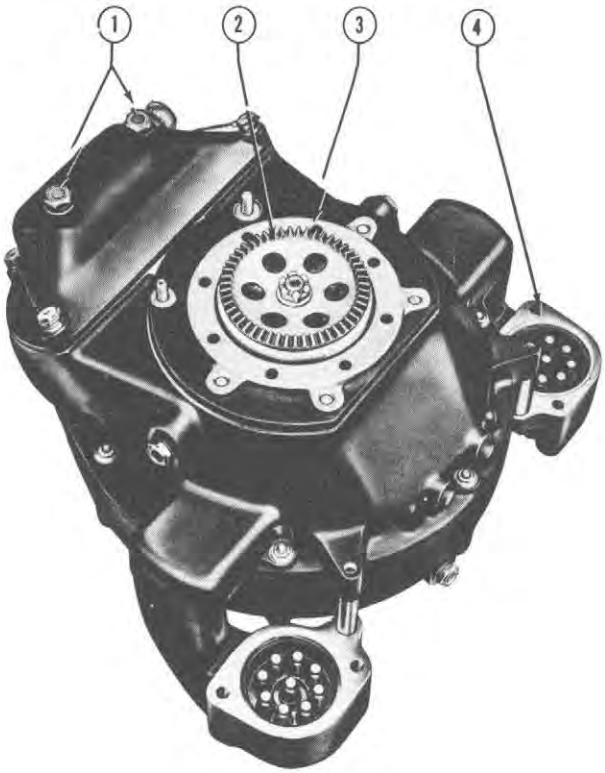
1. Ignition Harness
2. Distributor Cover-Screws
3. Distributor Gland Nuts
4. Magneto Stud Bolts
5. Magneto Breaker Cam Cover
6. Plunger Type Cam Oiler
7. Magneto Breaker Cam

Figure 156 — Magneto and Distributor

(a) MAGNETO AND DISTRIBUTORS.

1. DESCRIPTION.—The type DF18RN Magneto *(7, figure 156)* is a double type, four-bolt flange mounted, eighteen cylinder magneto driven at 1⅛ engine crankshaft speed and mounted one on each engine. The high tension current from each coil within the magneto is conducted through two separate

Figure 157—G. E. Magneto Distributor (Top View)



1. Vent Plugs
2. Gear
3. Adapter Plate
4. Terminal Plug

Figure 158 — G.E. Distributor (Integral with G.E. Magneto, Bottom View)

breaker assemblies by means of an external cable to two separate distributors *(2, figure 156)*, each driven independently of the magneto at one-half engine crankshaft speed. The breaker on the left (Name Plate) side of the magneto is connected to high tension terminals "GR2" and "HT2" and supplies current to the right distributor. The breaker on the right side of the magneto is connected with high tension terminals "GR1" and "HT1" and supplies current to the left distributor. Individual high tension electrical cables then carry the current from the distributors to the spark plugs where discharge or spark occurs for ignition purposes. The left distributor supplies current to the rear spark plugs in all cylinders, and the right distributor supplies current to the front spark plugs. The two distributors and the ignition harness form a completely shielded unit to carry the current to the shielded spark plugs.

2. REMOVAL.

a. Disconnect the distributor connections *(figure 156)* from the magneto, using a pair of leather padded pliers.

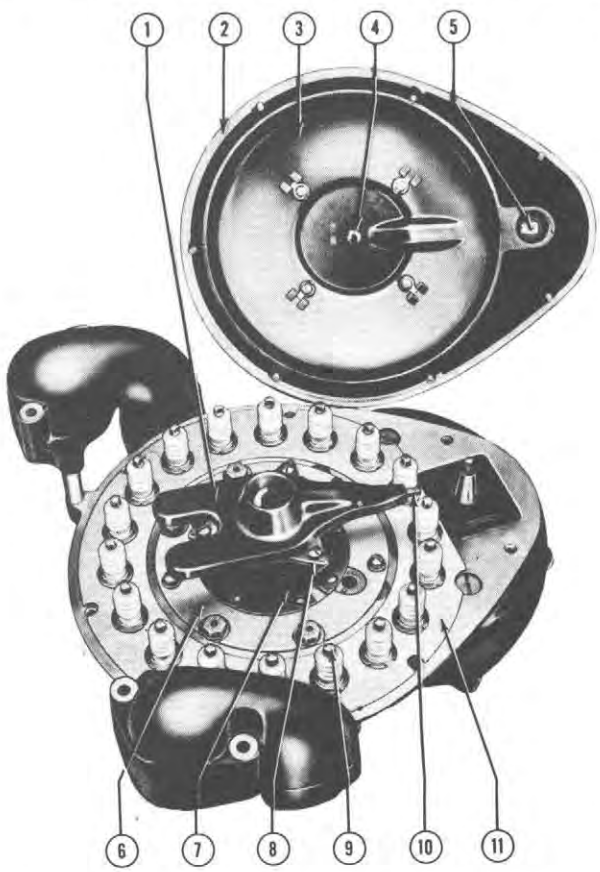
b. Remove the four nuts and washers *(4, figure 156)* holding the magneto in position and lift off the magneto.

c. Remove the distributor blocks as instructed in paragraph 8. *b.* (1) *(a)* 3. a. *(9)*, this section.

3. MAINTENANCE REPAIR OR REPLACEMENT.

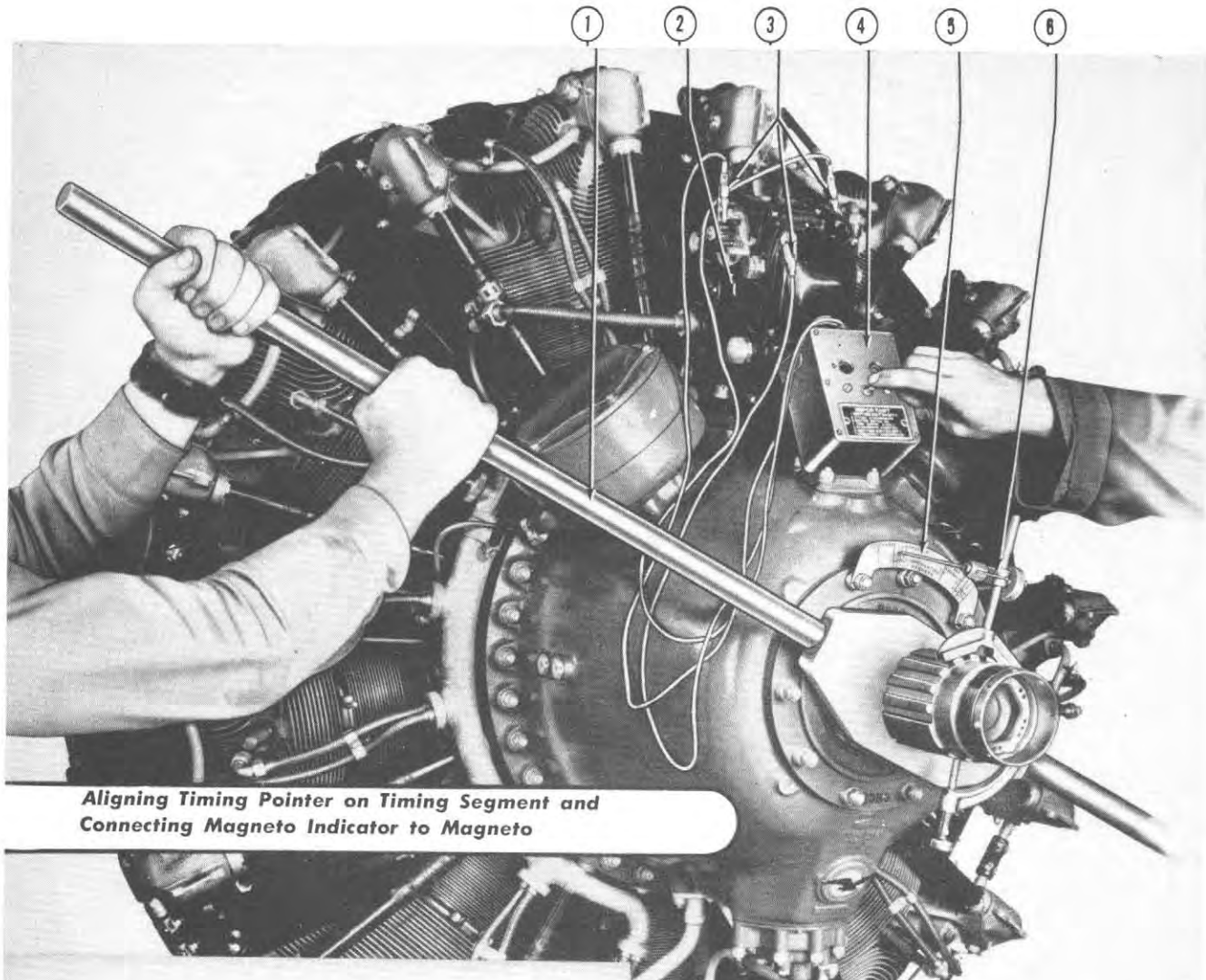
a. CHECKING IGNITION TIMING.—To check the ignition timing completely, the following three checks should be made. First, the magneto should be checked for timing, having its two breakers synchronized with their own timing marks. Second, the magneto should be checked for correct timing with the engine. Third, the distributors should be checked for timing with the engine. Before checking the timing of the ignition, the engine should have the proper timing indicators installed as described in the following paragraphs:

(1) Remove the front spark plugs from all cylinders and install top-center indicators (PWA-



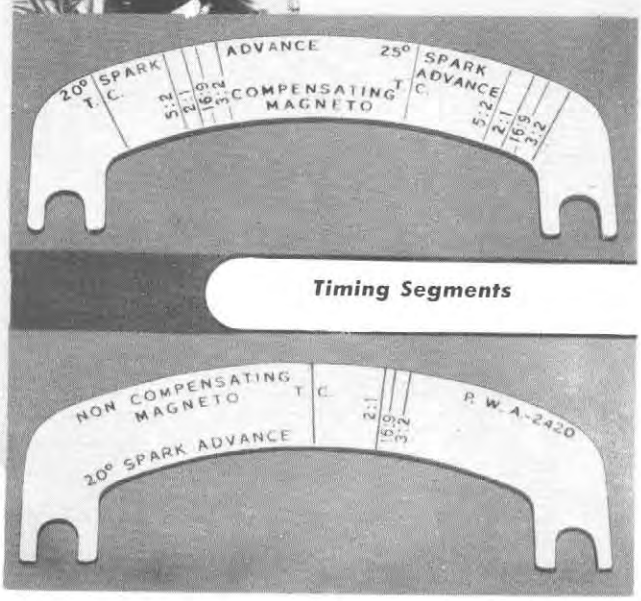
1. Distributor Rotor
2. Cover
3. Electrode Shield Assembly
4. Carbon Button
5. Contract Point
6. Bracket Assembly
7. Eccentric Screws (3)
8. Distributor Rotor Support
9. Electrodes
10. Distributor Rotor Tip
11. Electrode Ring

Figure 159 —G.E. Distributor (Integral with G.E. Magneto, Open View)



Aligning Timing Pointer on Timing Segment and Connecting Magneto Indicator to Magneto

Straight Edge Across Cam Step and in Line with Mark on Timing Post



Timing Segments

1. Propeller Shaft Wrench
2. Magneto
3. Indicator Ground Connections
4. Magneto Indicator
5. Timing Segment
6. Timing Pointer

Figure 160 — Timing and Synchronizing Magneto

2537) in No. 1 cylinder spark plug hole, and locate No. 1 piston at the top center of its compression stroke. Attach the timing segment (PWA-2352) to two of the thrust cover studs and timing pointer (PWA-2353), to the propeller shaft or propeller hub so that the pointer aligns with the top center mark of the segment. Connect the two red wires of magneto indicator (PWA-2417) to the two ground connections of the magneto (GR1 and GR2) and ground the black wire to the engine.

Note

The breaker assembly on the left (Name Plate) side of the magneto connects with the ground and high tension connections "GR2" and "HT2," and the breaker assembly on the right side of the magneto connects with "GR1" and "HT1."

(2) Remove top-center indicator from No. 1 cylinder and the breaker covers on each side of the magneto. Turn the propeller shaft back in clockwise direction (as viewed from the front of the engine) approximately 90°, then forward in the normal direction of rotation, until the timing pointer is aligned with the correct spark advance mark of the timing segment for the R-2800-27 engine.

(3) At this position, a straight edge placed on the step of the breaker cam should align with the timing mark on the post of the breaker plate and both lights of the magneto indicator should go on, indicating the contacts have just opened. *(See figure 160.)*

Note

The contact points must always be adjusted to open at the proper position of the breaker cam in relation to the timing marks on the magneto, and not for any fixed clearance between the contact points.

(4) If the above check shows one or both contact points to be out of adjustment with the magneto timing marks, they should be adjusted as described in paragraph 7. *c.* (4), this section.

(5) When the foregoing is completed, time the magneto to the engine so that both the indicator lights go on when the pointer reaches the correct spark advance mark on the segment for the R-2800-27 engine. This may be done by loosening the four magneto stud nuts and rotating the magneto on its mounting pad, through the range allowed by the slots in its mounting flange *(figure 160)*, until the lights just go on and the pointer is on the correct spark timing mark. The direction of the final rotation of the magneto should, when setting the magneto to the engine, be in a clockwise direction.

Note

When timing the magneto to the engine, it should be noted that No. 1 cam lobe, which is marked with a dot, is opening the contact points.

(6) To check the timing of the distributors to the engine, unfasten the eight fillister head screws from the distributor cover plate and remove the cover plate. Remove the single fillister head screw located behind the distributor block and beneath the ignition wires. Loosen the two gland nuts which fasten the distributor housing to the manifold ring with a distributor gland nut wrench. With the top center indicator, the engine timing segment, and the engine timing pointer installed, rotate the propeller shaft until the piston in No. 1 cylinder is at the proper

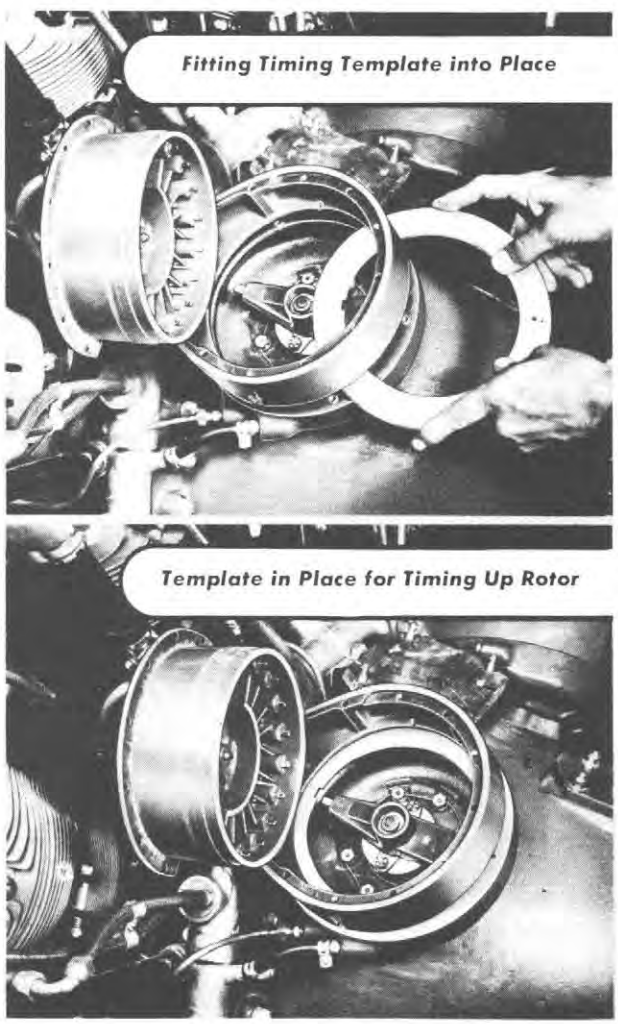


Figure 161 — Aligning the Distributor Rotor

specified advance position on the compression stroke. Pry the distributor body from the adapter sufficiently to reach in with a wire and lift out the rubber seal. NEVER try to remove the distributor body without first removing the seal. Fit the distributor timing template on the top surface of the adapter with the small pin in the rear threaded insert of the adapter face so that the timing projection is nearest the cylinders of the engine. The large electrode on the distributor rotor should align exactly with the timing projection on the template. *(See figure 161.)* Check each distributor separately.

(7) To correct any misalignment of the distributor rotor, loosen the two nuts which fasten it in position on the rotor plate; then rotate the distributor rotor within the range of the slots until the large electrode aligns with the projection on the timing template fitted to the top surface of the distributor adapter. Fasten the distributor rotor in position with the two retaining bolts, using care not to change the position of the rotor. If no timing template is available, merely position the distributor finger so that the TRAILING half of its high tension segment is over the No. 1 distributor head electrode.

(8) A recheck of the ignition timing should be made after any adjustment to the magneto or distributors. This recheck must be made by first reestablishing top-center position of No. 1 piston as previously described, and checking the timing pointer with the top-center mark on the timing segment. The propeller shaft will then be turned back in clockwise direction (as viewed from the front of the engine) approximately 90°, then forward in the normal direction of rotation, until the timing pointer is on the correct spark advance mark of the timing segment. At this position, both lights of the magneto indicator should light, the timing mark on the post of the breaker plate should align with a straight edge placed on the step of the magneto breaker cams, and the large electrode of the distributor finger must align with the projection of the distributor timing template. (This series engine has a spark advance of 20°.)

(9) Remove the four flat head screws holding the retaining plate to the distributor case and slightly lift the block. Reach in under the block with a wire hook and pull out the rubber sealing ring. Never attempt to pull the distributor block off without removing this ring. Pull the ring free of the block before raising the block any further. When the block is free from the case, it may be tilted back, using care not to chip or otherwise damage it. Care must be taken to see that the insulation of the ignition wires is not damaged, or the high tension lead broken.

b. CLEANING CONTACT BREAKER POINTS.—Unless the contact breaker points are oily, dirty, or badly pitted, do not disturb them. If it becomes necessary to clean the contact points, remove the breaker assembly, and clean the points with carbon tetrachloride or unleaded gasoline. Remove high spots with an oil stone or with 400 to 600 "Wet-or-Dry" paper (DO NOT USE EMERY CLOTH).

4. ADJUSTMENT OF CONTACT BREAKER POINTS.—If inspection shows that adjustment of the breaker contacts is necessary, loosen the two screws which fasten the movable contact support to the breaker plate. Adjust the movable contact support by means of the eccentric screw so that the points just begin to open on the No. 1 lobe of the respective cam when a straight edge coincides with the timing mark "M." Tighten the screw when the setting has been made and recheck the adjustment.

Note

The contact points must always be adjusted to open at the proper position of the breaker cam in relation to the timing marks on the magneto and not to any fixed clearance between the contact points.

5. ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

c. GENERAL ELECTRIC IGNITION SYSTEM. (Used on engine model R2800-71.)

(1) GENERAL.—The General Electric Ignition system, consisting of two magnetos (type S18LG-P1) and an ignition shielding assembly (type P18HG-P1), is interchangeable with the Scintilla Magneto, distributor and ignition harness. Each magneto is a single self-contained unit with a built-in distributor assembly so that a separate externally mounted distributor assembly is not required. The magneto operates at one-half the crankshaft speed of the engine and gives 18 sparks per revolution of the magneto. The manifold of the ignition shielding assembly is of circular form. It is made in several sections connected together by ball and socket joints which make it possible to spread the manifold apart slightly for installation in the engine without removing the propeller. A special elastic impregnating gel is forced into the manifold around the conductors to exclude moisture and provide additional insulation. The leads are detachable from the manifold. Each lead comprises high tension ignition cable encased in a flexible braided jacket with appropriate terminals at each end for connection to the manifold and spark plug.

(2) REMOVAL.

(a) SPARK PLUG LEADS.—The removal pro-

cedure for the spark plugs is essentially the reverse of the INSTALLATION procedure.

(b) IGNITION SHIELDING ASSEMBLY.

1. Disconnect the detachable leads from the spark plugs and manifold.

2. Remove the brackets from the engine which fasten the manifold tubes in position.

3. Cut the safety wire and remove the screw holding the center section of the manifold to the bracket.

4. Loosen the four ball and socket joints which fasten the center section and manifold tubes to the manifold castings, using a harness spanner wrench M-8642253-G1. The manifold tubes can now be spread apart and the manifold removed from the engine.

5. Reconnect the detachable spark plug leads to the manifold outlets or pack the leads in a container with the manifold.

(c) REMOVAL OF MAGNETO.

1. Unfasten the six screws which hold the cover to the magneto housing. The cover may now be removed by tapping the lip on the cover with a screw-driver.

2. Remove the ground cable. Close the cable opening in the magneto housing with a piece of cloth to prevent entry of dust and dirt.

3. Remove the four bolts which fasten the magneto to the manifold.

4. Remove the two elastic stop nuts from the studs which project beneath the magneto through the adapter plate.

5. Cut the safety wire on the four bolts which fasten the magneto to the adapter plate and remove the bolts.

6. Remove the magneto from the engine.

7. Remove the gaskets, laminated shim, and adapter plate from the motor nose and fasten them to the magneto using the four hold-down bolts.

8. Replace the cover on the magneto.

9. Repeat steps one to eight, inclusive, for the other magneto.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—In general, damaged ignition systems should be replaced rather than repaired. For other information refer to AN 03-5DD-1.

(4) ADJUSTMENTS.

(a) TIMING MAGNETO WITHOUT TIMING LIGHT.

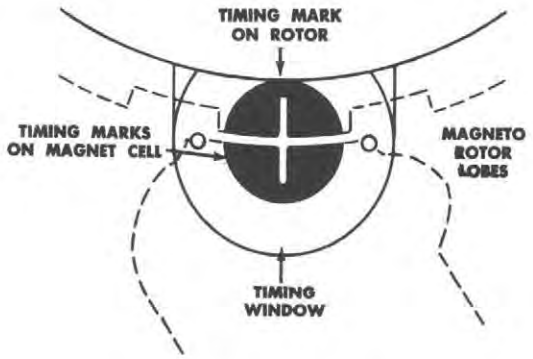


Figure 162 — Timing Marks as Seen Through No. 1 Timing Window

1. Set up the engine at the proper firing point on the *compression stroke of No. 1 cylinder* in accordance with the applicable engine Technical Order.

2. Put the magneto on the engine with the distributor finger as close to the No. 1 electrode as the gear mesh will allow.

3. Look through the No. 1 timing window in the breaker plate assembly. The magneto is correctly timed to the engine if the timing marks on the magneto rotor and magneto cells line up during the 1/32 movement of the magneto rotor allowed by the gear play. *(See figure 162.)*

4. To adjust timing of the magneto, shift the magneto-drive gear on the splined shaft in accordance with the following procedure:

a. The magneto drive gear has 51 teeth and is keyed to the shaft by 13 splines. If this gear

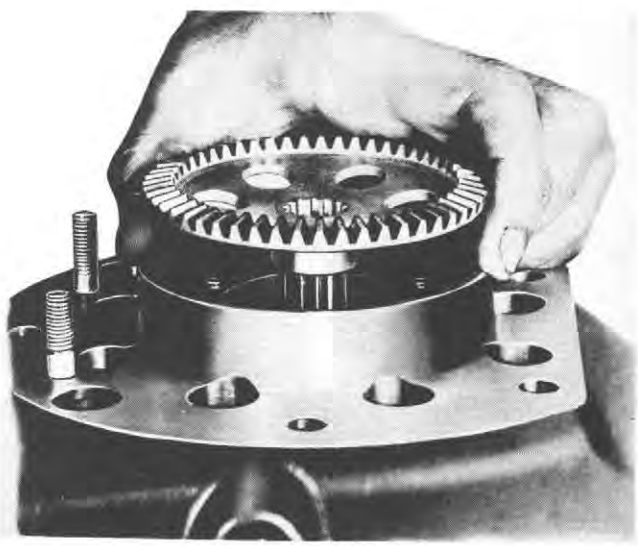


Figure 163 — Moving Gear to Advance Spark

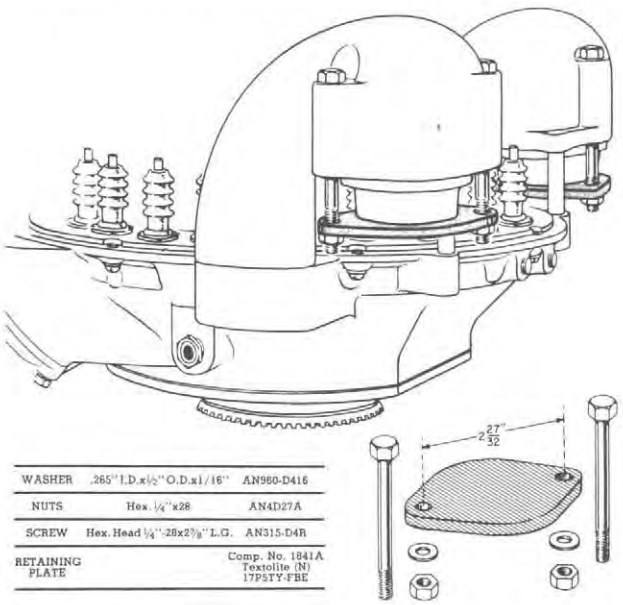
is shifted on the shaft by one spline, the magneto-drive gear and the drive pinion on the engine will not mesh until the magneto shaft is turned slightly. This relation is the basis of timing procedure. Moving the gear one spline "clockwise" (looking at the gear end of the magneto) will retard the magneto by about 1/2 degree of magneto-shaft rotation, or about one degree of engine-crankshaft rotation. Moving the gear "counterclockwise" one spline will advance the magneto timing by the same amount.

b. To retard magneto, remove the drive gear from the shaft and shift the gear one spline in a "clockwise" direction (looking at the gear end of the magneto). To advance magneto, shift in a "counterclockwise" direction. *Figure 163* shows how the gear is moved for advancing or retarding the magneto.

(5) TEST BEFORE INSTALLATION.

(a) INSPECTION AND TESTING OF MAGNETO HOUSING AND MAGNET CELLS.

1. Place a connector plug in each of the magnet terminal plugs and place the connector plugs under pressure by clamping with insulating plate. *(See figure 164.)* Using the Delco Ignition Tester (Model 724420), test between each electrode and the



WASHER	.265" I.D. x ½" O.D. x 1/16"	AN960-D416
NUTS	Hex. ¼"-28	AN4D27A
SCREW	Hex. Head ¼"-28 x 2⅜" L.G.	AN315-D4R
RETAINING PLATE		Comp. No. 1841A Textolite (N) 17P5TY-FBE

Figure 164 — Placing Connector Plugs Under Pressure

magneto housing at 12,000 volts (rms) for one minute. If any electrode fails this test, repeat with a new set of connector plugs to make certain that the magneto and not the plugs caused the failure. If the second test indicates that the magneto has failed, the housing must be discarded and returned to the factory for reworking.

2. Examine each electrode carefully for cracks or damage. If any electrode is defective, the housing must be discarded and returned to the factory for reworking.

1. Cover Bolt
2. Cover
3. Self-Locking Nut
4. Spline Nut

Figure 165 — Removing Cover by Tapping Against Lip

3. Test the magneto as follows:

a. Loosen the bolts *(See figure 165.)* and remove the cover from the magneto. The cover may be raised by tapping against the lip with a screw driver.

b. Mount the magneto on the magneto test stand. Connect the A-C ammeter across both breakers. (One terminal should be connected to the primary connector and the other to the magneto housing.) Place a piece of paper between the points of one breaker to open the circuit through the breakers.

c. Run the magneto at 400 rpm.

d. Read the ammeter. If the reading is less than 1.45 to 1.55 (rms) amperes, it indicates that the magneto needs remagnetizing on the magnet charger.

e. Remove paper between breaker points.

CAUTION

It is imperative that the magnet cells be placed in the charger with the "N" pole of the cell adjacent to proper pole of the charger. The

poles of the magnet cells are shown on *figure 166*. The poles of both magnet cells are the same. Each magnet cell should be magnetized by closing the switch of the charger two or three times, 30 seconds each time. After magnetizing, keep the cells away from metal objects, metal work benches etc., which might act to reduce the magnetic charge.

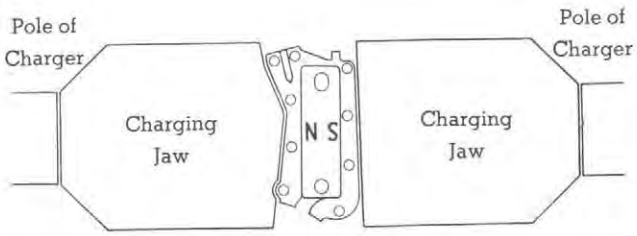


Figure 166 — Poles of Magnet in Relation to Charger

(b) INSPECTION AND TESTING OF ELECTRODE SHIELD.

1. Inspect the button in the center of the electrode shield. *(See figure 4, figure 159.)* If worn within 1/16 inch of its metal base, it must be replaced.

2. Inspect the contact in the electrode shield. If burned or dirty, clean with a piece of emery or crocus cloth held on the flat end of a pencil.

3. Install the electrode shield in the magneto cover and fasten with the four washers and screws. Using the Delco Ignition Tester (Model 7244420), test between the metallic cover and the rotor carbon button at 10,000 volts (rms) for one minute. If the electrode shield fails this test, it must be replaced.

4. If the electrode shield is satisfactory, lockwire the screws to the washers.

(c) INSPECTION AND TESTING OF DISTRIBUTOR ROTOR.

1. Inspect the distributor rotor for cracks or burns. If defective, it must be replaced.

2. Inspect the flat spring contact which engages the carbon button in the electrode shield for burns. Polish the burnished area. If necessary, lift the spring so that it is 3/8 inch high.

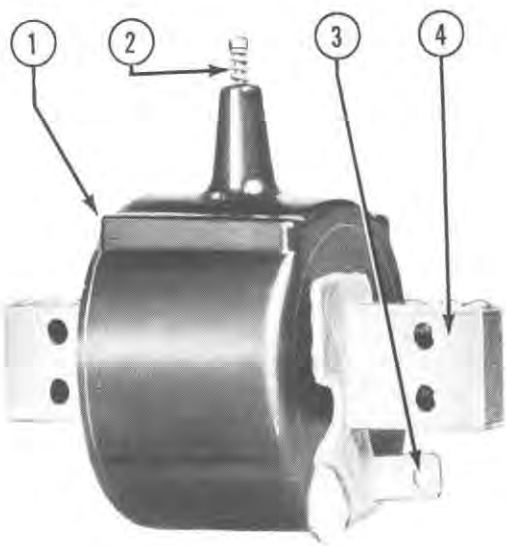
3. Test the distributor rotor at 10,000 volts (rms) between the metal support and the electrode tip. If insulation failure is evident, replace the rotor.

(d) INSPECTION AND TEST OF MAGNETO COIL.

1. Inspect the contact on the coil. If dirty or burned, clean with emery paper.

2. Use a "Supreme" Ohmmeter (model 542), or equivalent, and measure the resistance of the primary coil between the primary connector and the coil core. If the resistance is more than one ohm, the coil must be replaced. *(See figure 167.)*

3. Use a "Supreme" Ohmmeter (model 542), and measure the resistance of the secondary between the coil core and the coil contact. The reading must



1. Coil Assembly
2. Coil Contact
3. Primary Connector
4. Coil Core

Figure 167 — Primary Coil, Showing Primary Connector and Coil Core

be between 15,000 ohms and 30,000 ohms. If the resistance falls outside these limits, the coil must be replaced.

(e) INSPECTION AND TEST OF BREAKER ASSEMBLY.

1. Check the primary condenser with a Biddle Insulation Tester. If the reading is less than ten megohms the condenser is defective and must be replaced.

2. Check the contact points on both the No. 1 and No. 8 breaker assemblies for proper opening. Check that the breaker contacts mate over a substantial portion of their area. Pitting of the contact itself is not detrimental to operation of the magneto as long as substantial areas of the contacts engage. However, if pitting has worn back the contact tips to the metal base, the No. 1 or No. 8 breaker assembly must be replaced.

3. Check the breaker-spring in the breaker arms with a spring scale. If the tension falls outside the 24 and 30 ounce limit, replace the breaker assembly. Unless the breaker tension is sufficient, the breakers may "bounce" or "flutter" at high speed causing improper operation of the magneto.

4. Check that the windows in the breaker plate are not broken or cracked. If so, replace the window by cutting and replacing the two drive pins holding the window in position.

5. Check that a sufficient amount of oil wick projects from the case to engage the cam when assembled. Place one drop of oil, Univis No. 48, (AAF Specification No. 3582) on the wick.

(f) INSPECTION AND TEST OF BALL BEARINGS.

1. Inspect the sealed bearing carried by the breaker plate to see that it turns freely. If bearing is damaged or rotates with difficulty, replace.

2. Inspect the bearing to see that it rotates freely, after the bearing carried by the housing has been washed in solvent. Lubricate the bearing with a small amount of grease to protect it while running test.

Note

Other information pertaining to ignition system tests may be found in AN 03-5DD-1.

Figure 168 —P & W R-2800 Engine Nose, Ready for Installation of Ignition System

(6) ASSEMBLY AND INSTALLATION.

(a) ASSEMBLY.—For information pertaining to assembly of the ignition system refer to AN 03-5DD-1.

(b) INSTALLATION.

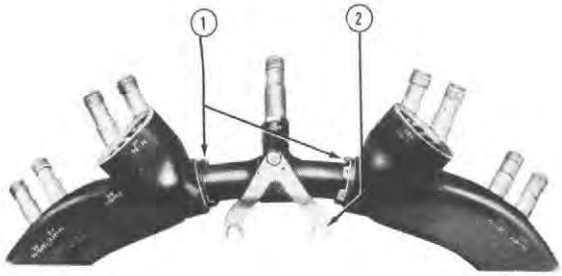
1. PARTIAL INSTALLATION OF MANIFOLD AND DRIVE COVER.

a. Check master-rod location on engine data plate to assure agreement with locations shown on magneto nameplate.

b. Remove the magneto-drive adapter *(See figure 168)* from the center mounting pad on the engine.

c. Place cloths in the three openings for the magneto-drive adapter and distributors to prevent articles from falling into nose.

d. Loosen the four ball and socket joints on opposite sides of the two castings of the manifold, using a harness spanner wrench M-8642253-G1.

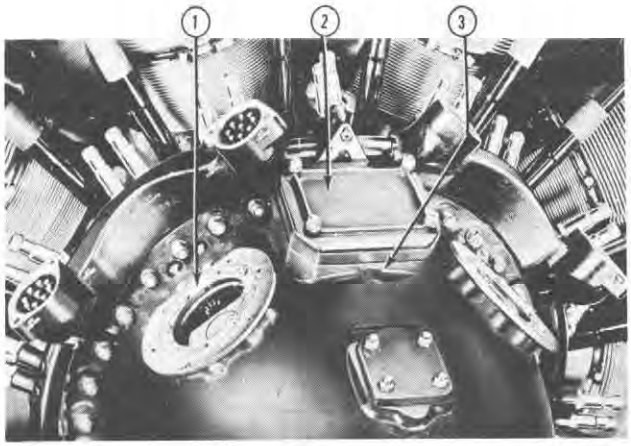


1. Ball and Socket Joints 2. "A" Bracket

Figure 169 — "A" Bracket on Ignition Shielding Assembly

e. Fasten the "A" bracket loosely to the center section of the ignition shielding assembly. *(See figure 169.)*

f. Spread the two halves of the ignition shielding assembly and mount the assembly on the engine nose with the arms of the bracket seated on the two studs back of the magneto mounting pad. It is not necessary to remove the propeller. Tighten the nuts holding the bolt to the engine.



1. Adapter Plate
2. Drive Cover
3. Magneto Drive Adapter

Figure 170 — Adapter Plate and Drive Cover Installed

g. Repiace the double magneto - drive adapter (be sure to replace the gasket under it) and then install the drive-cover gasket and the drive-cover. Both of these are furnished with the ignition shielding assembly.

h. Fasten the drive-cover down with washers and elastic stop nuts on the four studs.

2. INSTALLING ADAPTER PLATE.

a. Remove cover from magneto and also remove the four bolts which hold the adapter plate to the magneto. The adapter plate and adapter plate gasket may now be removed.

b. Place the gasket on the distributor mounting pad on the engine, and install the adapter plate. Fasten the adapter plate with the eight cap screws and lock washers furnished in the installation kit accompanying the magneto and safety wire the screws. The nose will now appear as in *figure 170.*

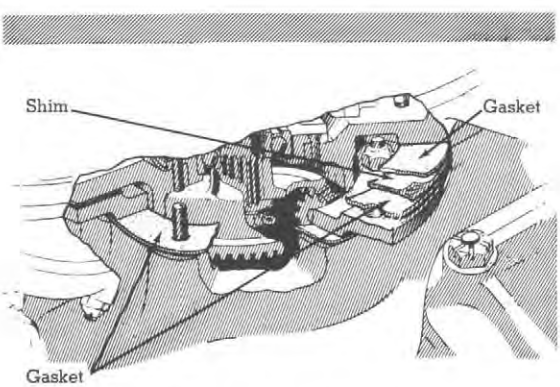


Figure 171 — Laminated Shim Between Two Magneto Gaskets

3. SETTING UP ENGINE.

a. Set up the engine at proper firing point on the *compression stroke of No. 1 cylinder* in accordance with the applicable engine Technical Order.

b. Determine the point of firing from the engine-data plate.

4. SETTING GEAR CLEARANCES.

a. Place the laminated shim between the two magneto gaskets on the magneto flange.

b. Set the magneto on the adapter plate. Make sure gears are in mesh. *(See figure 171.)*

c. Secure the magneto with the two opposite hold-down bolts, and check the gear clearance between the engine-drive pinion and the drive gear on the magneto by moving the distributor-rotor tip. There must be enough play or backlash in the gears to allow the distributor-rotor tip to be moved back and forth about 1/32 inch.

Note

Other information pertaining to installation of the ignition system will be found in the service publication AN 03-5DD-1 describing the 18-cylinder High Tension Ignition System as manufactured by General Electric.

(7) TEST AFTER INSTALLATION.

(a) When the engine has been warmed up, it should be run at 1900 rpm, and the magnet switch turned from "BOTH" to "L" and "R." With the switch at "L," the right-hand magneto is grounded so that the left-hand magneto alone is active in firing the engine. With the switch at "R," only the right-hand magneto is active. The engine should continue to run with the switch at "L" or "R."

(b) The engine speed will drop slightly from 1900 rpm when each magneto is operating alone. The maximum permissible drop in speed is 100 rpm for either magneto with about 70 rpm as the normal speed drop.

(c) If the engine speed drops more than 100 rpm when the magneto switch is turned to either "L" or "R" the timing of the magneto giving the high drop is probably faulty. The timing of the magneto to the engine should be rechecked. If one of the magnetos still gives a high drop, the internal timing of the magneto should be checked.

1. Electrical Connection to Magneto
2. Alternate Electrical Connection
3. Induction Vibrator
4. Radio Noise Filter

Figure 172 — Induction Vibrator and Radio Noise Filter

d. INDUCTION VIBRATORS.

(1) DESCRIPTION.—Two American Bosch type VJR-24B3 or (VJR-24B5, VJR-24B1 or G. E. type 70 G7) induction vibrators *(3, figure 172)* are mounted, one for each engine, on brackets forward of the firewall on the right-hand side of each engine mount. The induction vibrators are designed for use as an auxiliary source of ignition to facilitate starting of aircraft engines. There are two flexible conduits leading from two of the three outlets on the unit: a conduit attached to the "+" outlet, containing a wire leading to the starter switch, and a wire leading to the starter through the starter relay; a conduit attached to the "IGN. SW." outlet, containing a wire leading to the ignition switch, and a wire leading to the magneto. No attachment to the "MAG." outlet is necessary, because the internal contacts for the "IGN. SW." and "MAG." outlets are connected inside the unit. The induction vibrator automatically starts to function when the ignition switch is "ON" and the starter is engaged; it ceases to function when the starter is disengaged.

(2) REMOVAL.

(a) Remove top cover fastening nut with a 7/16 inch socket wrench and lift off cover.

(b) Trip lock spring on "IGN. SW." outlet and unscrew outlet nut. A gentle pull on cable will remove conduit attachment with springs.

(c) Remove terminal clip fastening screw inside the unit. Terminal clip may now be removed through the "+" cable outlet.

Note

If unit is B1 model, the positive cable fastening screw must be loosened and the positive cable removed.

(d) Remove the mounting bolts holding the unit to the bracket and remove the unit.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—Maintenance is limited to minor external and connecting parts. A number of causes of so-called induction vibrator failures may result from faulty spark plugs, a defective switch cable or switch, damaged or incorrect external wiring, or a weak battery, or by having a contact spring that is made from a wire with less than .035 diameter. In order to be sure that the induction vibrator is faulty, leave the unit installed in the airplane, disconnect the conduits as instructed in paragraph 8. *d.* (2), this section, and test as follows: *(See figure 173.)*

(a) Connect a wire from "MAG." outlet to a standard six volt battery ignition coil. Ground the other side of the ignition coil.

(b) Connect a lead from the high tension terminal of the battery ignition coil to a spark gap having sharp points, and set apart at nine mm. Connect the other side of the spark gap to ground.

(c) Connect a wire from the positive side of a fully charged 12-volt storage battery through a single pole, single throw switch, and an ammeter having a range of 0 to 5 amperes, to the positive terminal post in the induction vibrator. Connect the negative side of the storage battery to ground.

Note

The induction vibrator is automatically connected to ground when the mounting bolts are in place.

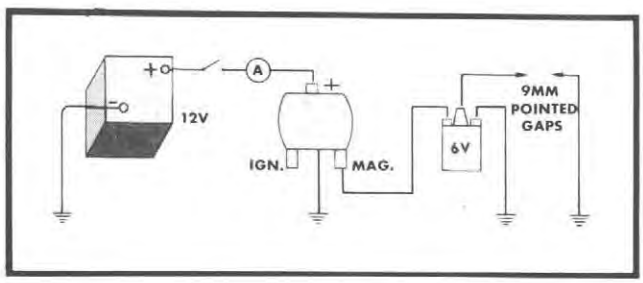


Figure 173 — Induction Vibrator Test

(d) When the switch from the storage battery to the induction vibrator is closed, the unit must supply an electric spark of sufficient intensity to jump the nine mm gap, without missing. The ammeter reading must be from 2.3 to 2.8 amperes.

(e) If the vibrator fails to pass this test, replace it.

Note

No lubrication of any kind is required on this unit.

(4) INSTALLATION. – Reverse removal procedure given in paragraph 8. *d.* (2), this section.

e. SPARK PLUGS.

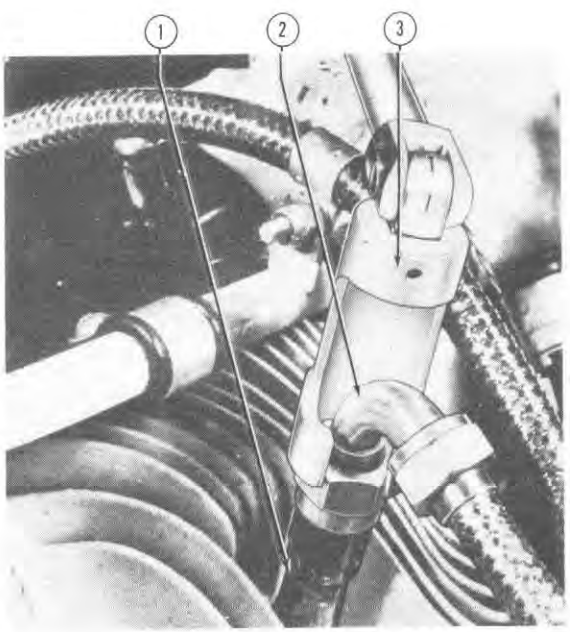
(1) DESCRIPTION.—Type C34S ceramic, long-reach, hot-running spark plugs are installed, two in each of the 18 engine cylinders, which transmit the spark for ignition purposes. Individual high tension cables connect the spark plugs with the distributors.

(2) REMOVAL.—*(See figure 174.)*

(a) Unscrew nuts on spark plug elbows.

(b) Remove ignition wire terminal sleeves from spark plugs.

(c) Remove spark plugs, using spark plug wrench (PWA-2254) and extension handle.



1. Spark Plug (C 34S)
2. Spark Plug Lead Elbow
3. Spark Plug Lead Elbow Wrench

Figure 174 — Spark Plug Lead Elbow Removal

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) CLEANING SPARK PLUGS.—Great care should be taken in handling ceramic spark plugs because rough handling or dropping may crack the ceramic, rendering them useless.

1. Nicks or burrs on the external threads may be chased with an 18 mm die. Do not attempt to disassemble the spark plugs.

2. Clean spark plugs with carbon tetrachloride or an unleaded gasoline. After cleaning, the spark plugs should be inspected for cracked ceramic.

(b) ADJUSTING SPARK PLUG GAPS.—The spark plug electrode gap should be .012 inch (.304mm). Special care should be taken that during this operation no pressure of any kind is exerted on the central electrode of the spark plug.

(4) INSTALLATION.

(a) Before installing spark plugs, fit the split rubber grommets and braided ignition wire conduits in their slots in the cylinder head deflectors; then fasten the braided ignition wire conduits to the inter-rear drain pipe on each cylinder head by means of the necessary clamps.

(b) Apply a small quantity of anti-seize compound, Specification AN-VV-C-566, on the threads of the spark plugs. Do not allow any of the lubricant to collect on the electrodes, because subsequent fouling of the spark plugs may result.

(c) Screw the spark plugs in the cylinder heads, using spark plug wrench (PWA-2254), and tighten to a torque of 350 to 360 in. pounds.

(d) Insert spark plug connectors in the spark plugs and fasten the braided ignition wire conduits to the spark plugs by means of the nuts on the spark plug elbows.

CAUTION

The spark plug connectors must be perfectly clean and dry when they are inserted in the spark plugs.

Note

Extreme care must be exercised to see that the barrel is not rotated with respect to the shell when checking the barrel assembly. All AN type elbows will be checked by using elbow wrenches Nos. 39A5279-1 and 39A-5279-2. Under no condition will the tightness of the elbow be determined by a twisting motion applied to the body of the elbow.

f. IGNITION SHIELDING.

(1) GENERAL.—The following information applies only to engines (R-2800-27) equipped with Scintilla Magnetos, distributors, and harness. General Electric ignition shielding installed on R-2800-71 engines, is discussed in paragraph 8. *c.*, this section.

(a) DESCRIPTION.—The ignition shielding is the Pratt & Whitney type, made up of braided metal conduits to carry the ignition wires from the spark plugs to the manifold ring. The manifold ring is a three-piece assembly and has two distributor adapters which house the distributor blocks. The ignition wires lead to each adapter, where they attach to their respective distributor blocks. Two short conduits, attaching at the manifold ring, carry high tension leads from each side of the magneto to each distributor.

(b) REMOVAL AND DISASSEMBLY.

1. Loosen the gland nuts on each side of both distributors *(3, figure 156)* with a distributor gland nut wrench (PWA-1217).

2. Remove the eight fillister head screws which secure each distributor cover to the body and the body to the adapter, and lift off the cover.

3. Remove the fillister head screw located behind the block and beneath the ignition wires. This screw fastens the body to the adapter.

4. Remove the four nuts securing the ignition harness to the crankcase, and the cap screw securing the manifold to the support bracket directly behind the magneto adapter.

5. Carefully withdraw the ignition harness and distributor blocks.

CAUTION

Extreme care should be taken during this operation not to damage the housing or the distributor blocks.

(c) REPLACEMENT—IGNITION WIRE.

1. If there are indications that an ignition wire is defective, determine which wire is defective by means of a continuity buzzer or other electrical test. When the defective wire is located, examine the spark plug connector for moisture, oil, dirt, cracking, or indications of flashover. If the connector is defective, replace it and recheck the wire; otherwise proceed with the following:

2. Remove the eight fillister head screws from the proper distributor cover plate and remove the cover plate.

3. Unfasten the four flat head screws in the distributor block retaining plate, remove the plate, and carefully lift the distributor block out of its housing.

4. Disconnect the faulty wire from the block.

5. Unscrew the union nut which fastens the electrical conduit carrying the defective ignition wire to the manifold. The defective wire can be manipulated from this opening.

6. Fasten an end of the new wire to the distributor end of the defective wire and pull the old wire out. At the same time, insert the new wire into the manifold, and then into the proper ignition wire conduit.

CAUTION

It is necessary to perform this operation carefully so as not to injure the protective coating on the wire.

7. Dust the new wire with talc or soapstone to prevent it from binding or seizing when being installed in the manifold. Do not use carbon tetrachloride or gasoline for cleaning the ignition harness.

8. When the new wire has been pulled through the manifold far enough, cut it off to the proper length at each end. Fasten the distributor contact insert to the distributor end of the new wire; then insert it in distributor block and fasten in place with locking screw.

9. Place spark plug connector on spark plug end of wire. Fasten manifold union nut in place; then replace distributor block in adapter and fasten in place.

(d) ASSEMBLY AND INSTALLATION.—Reverse REMOVAL AND DISASSEMBLY PROCEDURE.

g. IGNITION SWITCH UNIT.

(1) DESCRIPTION.—A type B-5 ignition switch unit, which incorporates a master ignition "ON-OFF" switch and an ignition switch for each engine, is installed on the pilot's main electrical control panel. The master ignition switch must be "ON" for the ignition switches to operate. Each ignition switch has four positions which control the four circuit conditions, "OFF," "L," "R," and "BOTH." When the switch is on "OFF," the circuits to the magneto are grounded out and are inoperative. When the switch is on "R" (right), current is supplied to the left side of the magneto to the right distributor which fires the front spark plugs in all cylinders. When the switch is on "L" (left), current is supplied to the right side of the magneto to the left distributor which fires the rear spark plugs of all cylinders. When the switch is on "BOTH," current is supplied to the magneto to both distributors, firing all the spark plugs.

(2) REMOVAL.

(a) Remove the screws securing the ignition switch unit to the main electrical control panel within the pilot's compartment.

(b) Remove the screws and lift off the access

door on the upper left-hand side of the fuselage, forward of the pilot's windshield on the outside of the airplane.

(c) Disconnect the ground wire from the ground stud on the bottom of the small panel to the left of the pilot's main electrical control panel.

(d) Pull the ignition switch unit with the conduit attached, through the access door opening to a convenient working position.

(e) Unscrew the conduit union nut, and slide it down on the conduit.

(f) Unscrew the lock nut on the switch side of the union, and slide it down the conduit.

(g) Remove the screws that secure the back-cover of the switch.

(h) Disconnect the wires from the terminals and remove the switch.

CAUTION

Be sure to ground the system when the switch is removed by pulling the ignition plug at either the wing disconnect fitting or the fire-wall disconnect fitting. When the wires are removed from the switch terminals, the magnetos are not grounded, and the engines are subject to starting if the propellers should be moved.

(3) MAINTENANCE REPAIR OR REPLACEMENT.–Replace faulty ignition switch units.

(4) TEST BEFORE INSTALLATION. – Apply test described in paragraph 8. *g.* (3), this section.

(a) Connect two test lamps to the switch.

(b) Connect a battery to both lamps.

(c) Connect one lamp (L) to both "L" terminals of the switch unit; connect the lamp (R) to both "R" terminals of the switch unit.

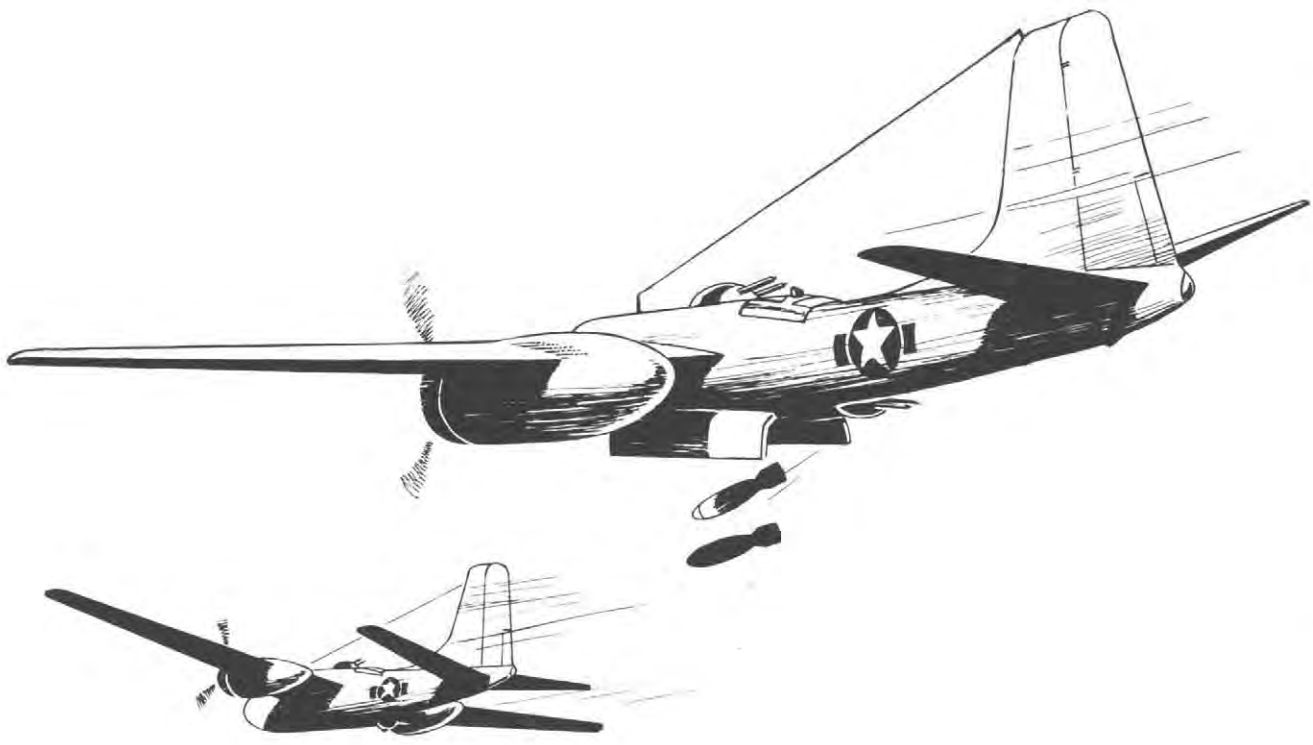
(d) With the master ignition switch in the "ON" position, and the "BOTH" position of the switch not being tested, the lamps should function as shown in the following table:

	Lamps	
Switch Position	*R*	*L*
BOTH	OFF	OFF
L	ON	OFF
R	OFF	ON
OFF	ON	ON

(e) With the switch in the "BOTH" position, push the master ignition switch to the "OFF" position. Both lamps should light.

(5) ASSEMBLY AND INSTALLATION. – Reverse the REMOVAL PROCEDURE, described in paragraph (2), above.

h. TROUBLE SHOOTING CHART.–(Refer to paragraph 6. *c.*, this section.)



9. ENGINE CONTROLS.

a. GENERAL.—The following engine controls are operated from the control pedestal in the pilot's compartment: throttle, fuel-air mixture, two-speed blower, air intake temperature, carburetor air filter, propeller rpm, and the oil cooler exit air door. The first five will be considered in this paragraph, while the propeller controls will be discussed in paragraph 10, this section, and the cooler in paragraph 12, this section. Standard cable controls are used, with the exception of the supercharger and the carburetor air regulator which are operated by Simmonds-Corsey push-pull rods attached to bellcranks in each nacelle. The control levers are arranged in three banks, and left and right engine levers are grouped together to facilitate operations of both engines.

b. THROTTLE.—*(See 2, figure 175.)*

(1) DESCRIPTION.—The throttle levers are in the second or main bank of controls. Increased throttle is obtained by loosening the control lock lever, which is located just to the right of the throttle control levers, and moving the throttle levers forward.

(2) REMOVAL AND DISASSEMBLY.

(a) Disconnect the cable linkage to the carburetor.

(b) Disconnect the cable linkage from the throttle lever.

(c) If complete removal is necessary, remove the pulleys and brackets which connect the cable to the engine section.

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) Check control for freedom of operation.

(b) Check positions of the control, both in the pilot's compartment and at the engine, to insure that they are coinciding properly in the compartment with the placards or marking.

(c) Oil the clevis joints and other bearing parts where this is desirable.

(4) ADJUSTMENTS.

(a) The throttle control is properly adjusted if the control lever on the carburetor strikes the positive stops when the control lever in the pilot's compartment is moved to its full open or full closed positions. If necessary, adjust as follows:

(b) If a major adjustment is necessary, loosen the nut which attaches the control lever to the carburetor throttle shaft.

(c) Place both the pilot's control lever and the carburetor lever in their full open positions.

(d) Tighten the control lever to the carburetor throttle shaft.

(e) To make a minor adjustment, disconnect the rigid control rod from the carburetor actuating arm on the carburetor.

(f) Place both the pilot's control lever and the carburetor lever in the full open position.

(g) If the control rod is found to be too short, loosen the lock nut on the rod end, and loosen the rod end until it can be attached to the control lever on the carburetor.

(h) Adjust the tension of the cables according to the chart shown in paragraph 3., this section.

(5) ASSEMBLY AND INSTALLATION.—Reverse the REMOVAL AND DISASSEMBLY procedure.

c. CARBURETOR MIXTURE CONTROL.

(1) DESCRIPTION.—The carburetor mixture (fuel-air) control levers *(2, figure 176)* are also located in the second or main bank on the pilot's control pedestal. They may be set in any of four positions: IDLE CUT-OFF, AUTO-LEAN, AUTO-RICH, or EMERGENCY RICH. Standard cable controls are installed.

(2) REMOVAL AND DISASSEMBLY.

(a) Disconnect the cable linkage at the mixture control lever on the pilot's control pedestal.

(b) Disconnect the cable linkage at the carburetor.

(c) If necessary, remove the pulleys and brackets which extend the cables from the control lever to the engine section.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—Refer to paragraph 9. *b.* (3), above.

(4) ADJUSTMENTS.

(a) The carburetor mixture control is properly adjusted if the control lever on the carburetor strikes the stops when the control lever in the pilot's compartment is at either extreme of its travel.

(b) If any adjustments are necessary, follow the instructions outlined in paragraph 9. *b.* (4), above.

d. ENGINE BLOWER CONTROL.

(1) DESCRIPTION.—A two-speed, supercharger, blower system is controlled from the front bank of

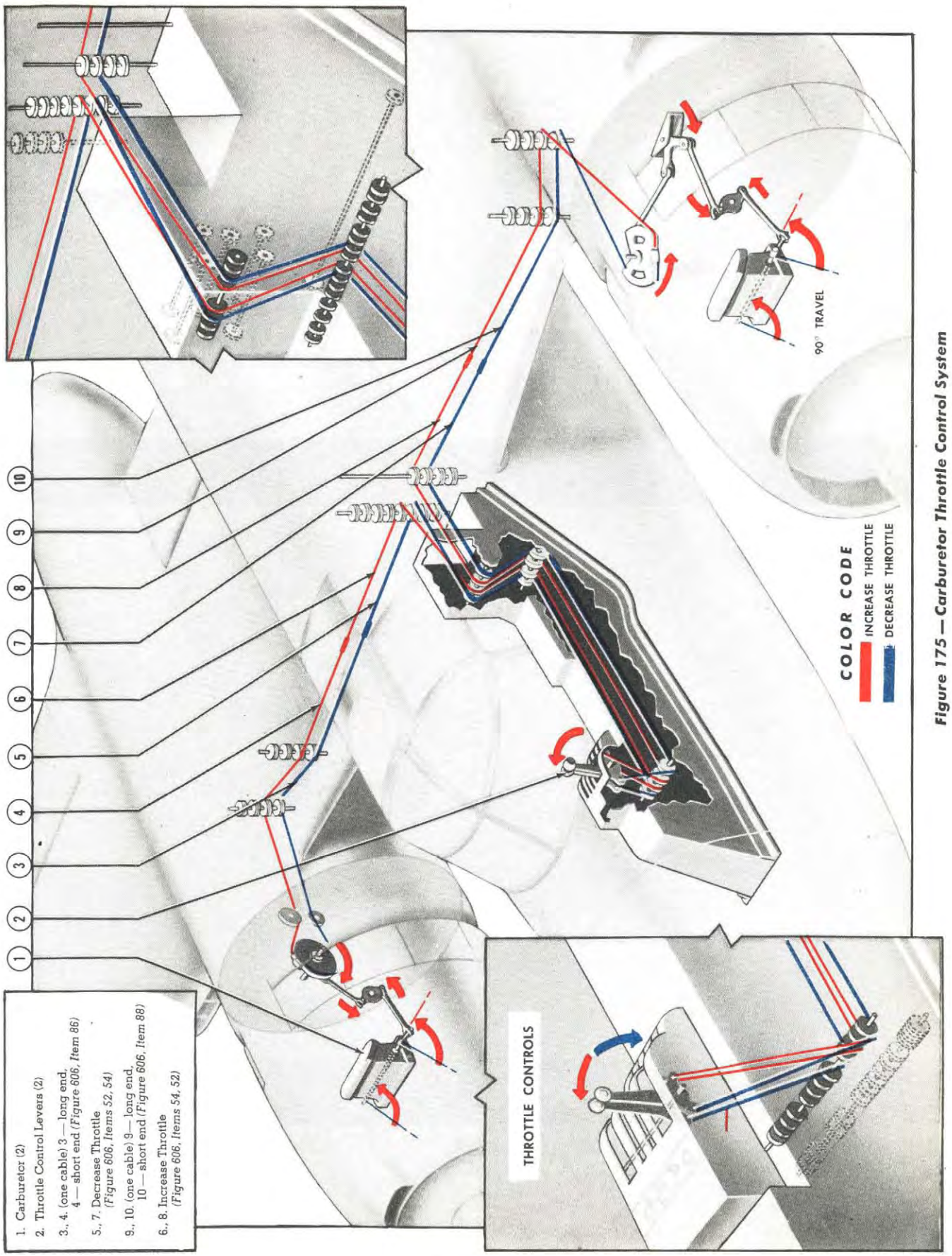


Figure 175 — Carburetor Throttle Control System

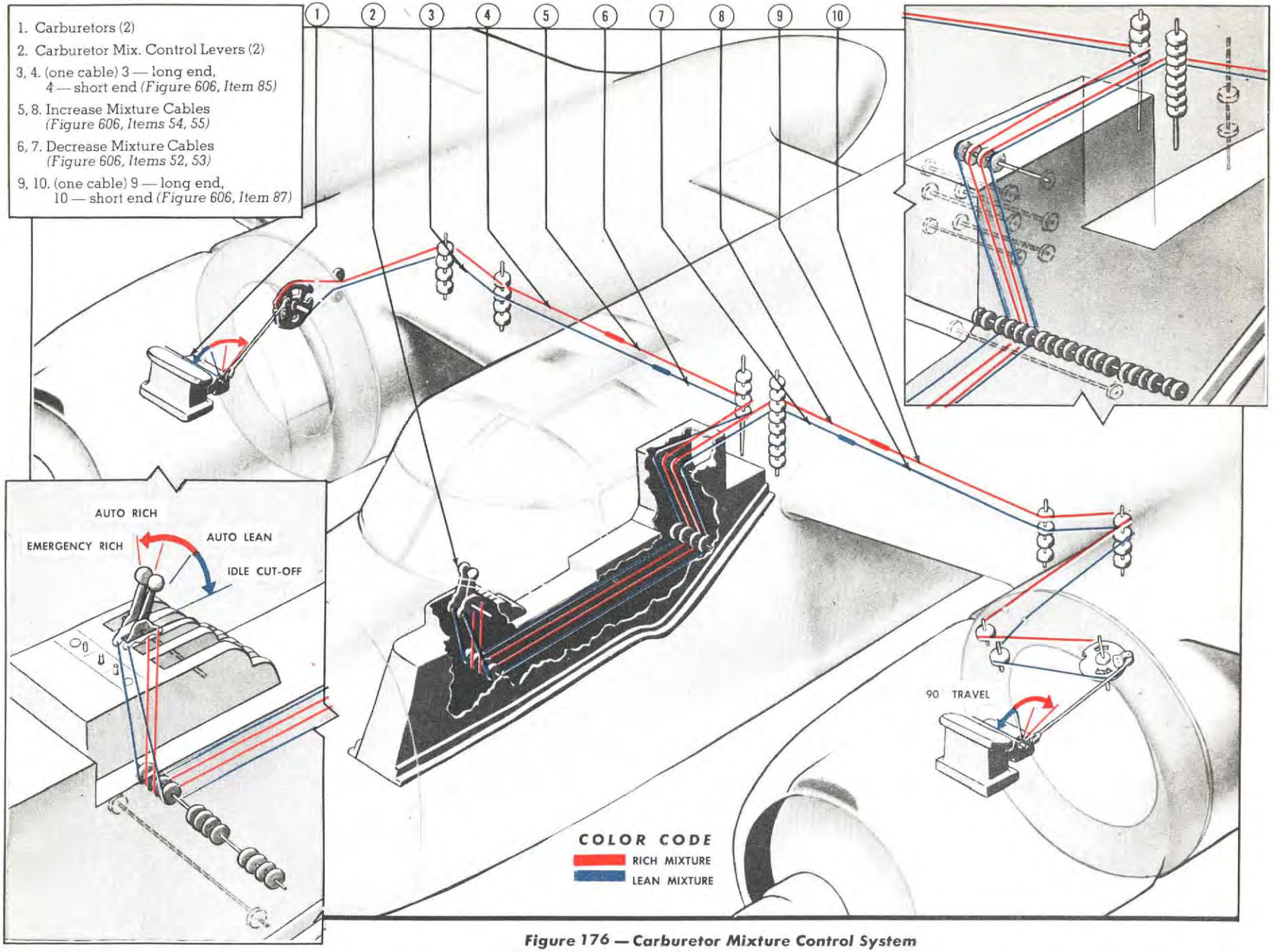


Figure 176 — Carburetor Mixture Control System

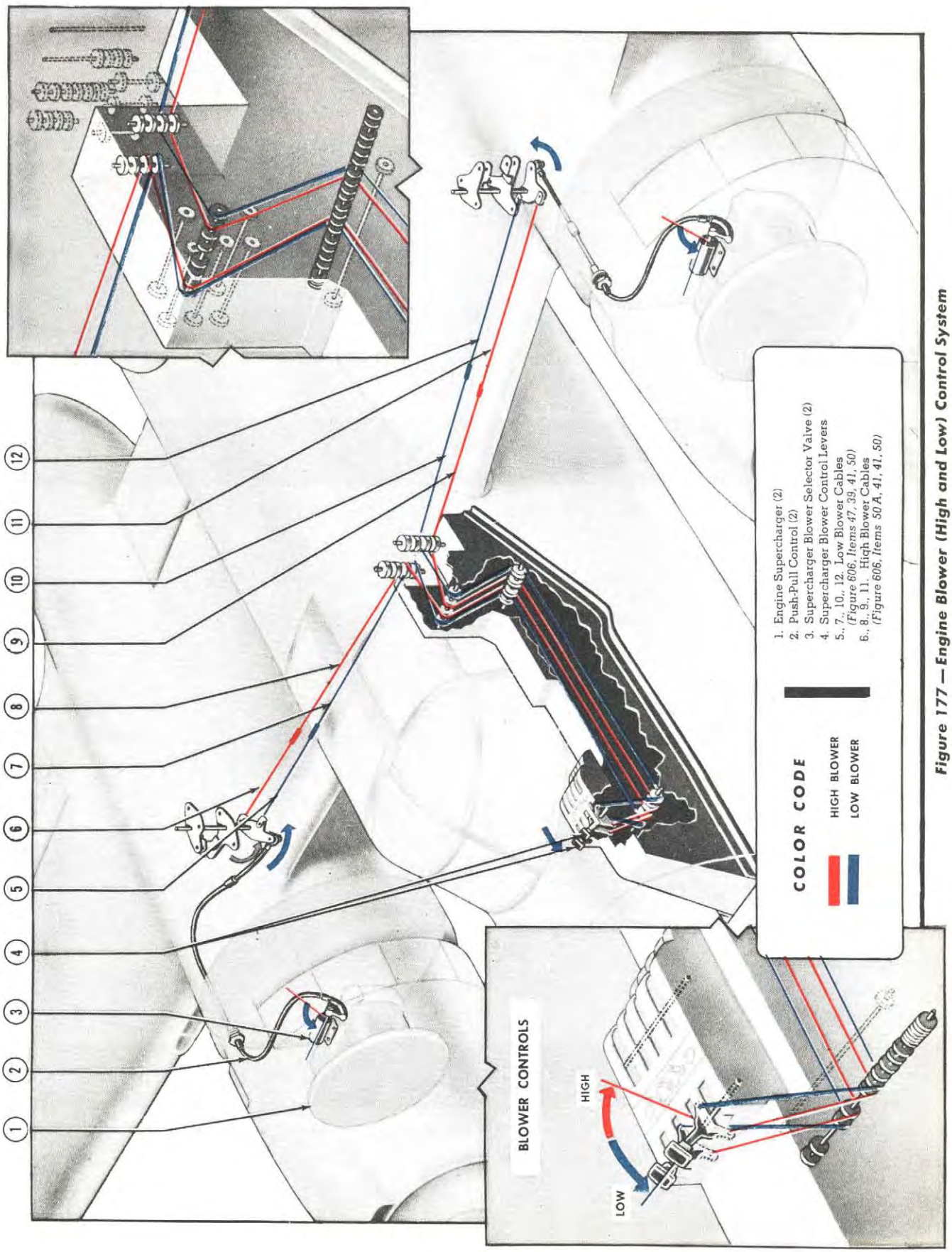


Figure 177 — Engine Blower (High and Low) Control System

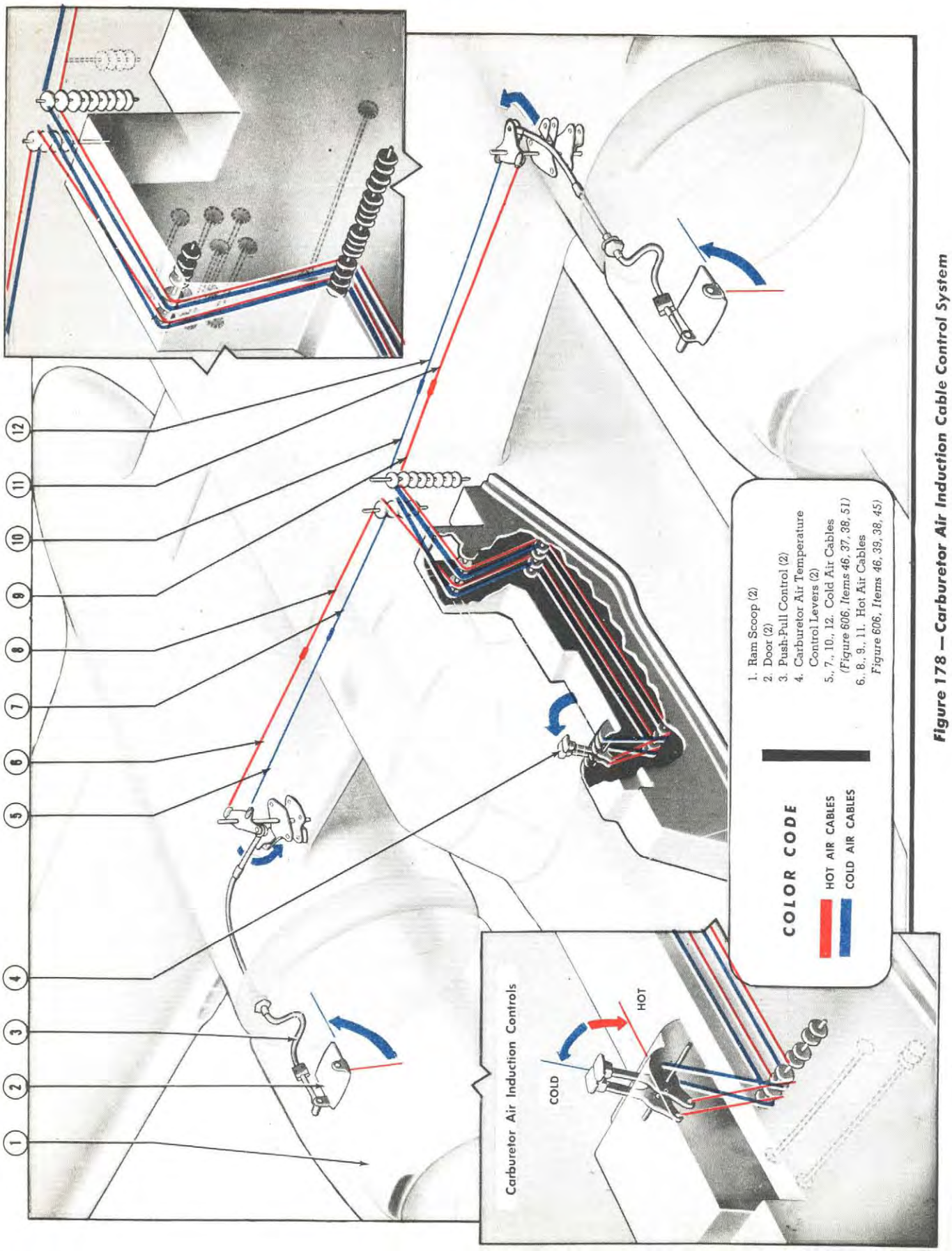


Figure 178 — Carburetor Air Induction Cable Control System

the pilot's control pedestal. When the control levers are full forward, they are in "HIGH BLOWER" position; when they are full aft, they are in "LOW BLOWER" position.

These controls employ Simmonds-Corsey push-pull controls, which consist of flexible tubing enclosing a series of alternating olive shaped and tubular shaped "beads" strung on flexible steel aircraft cable. They form a series of ball and socket joints; the olives and tubelets taking the force of the push stroke, the cable taking the pull force.

(2) MAINTENANCE REPAIR OR REPLACEMENT.—Damaged control members are to be replaced if adjustment as described in paragraph 9. *d.* (3), this section, proves unsatisfactory.

(3) ADJUSTMENTS.

(a) The blower control is properly adjusted if the mechanism on the blower strikes the low stop when the control lever in the pilot's compartment is in its full "LOW" position and the actuating arm of the Simmonds-Corsey control head is fully retracted. If necessary, adjust the control as follows:

(b) Disconnect the two bolts which support the Simmonds-Corsey control head to a bracket just aft of the carburetor.

(c) Disconnect the retaining nut which is on the blower control shaft and remove the control head. This automatically moves the unit to the "LOW BLOWER" position.

(d) Place the pilot's control in the "LOW BLOWER" position. Remove the cover of the control head to see whether the actuating arm is fully retracted.

(e) If the actuating arm in the control head is not fully retracted when the pilot's control lever is in the "LOW" position, disconnect the Simmonds-Corsey control head at the bell crank aft of the firewall and shorten the rod end as much as is necessary.

(f) If the 50-hour inspection, Section X, reveals the Simmonds-Corsey control unit to be in need of adjustment, proceed as follows:

1. Treat the linkage with Beacon M-285 or other lubricant conforming to specification AN-G-3a.

2. Screw the locking barrel along the terminal. Screw the sliding rod tight against the locking barrel.

3. Screw the sliding rod on the non-adjustable end of the linkage and open the inspection hole (under the spring clip) to see that it is screwed all the way on the fixed terminal.

4. Rotate the spring clips to close the inspection hole and finally connect the adjacent members of the control system.

(g) Reinstall the cover and the control head on the serrated blower control shaft, and secure them with the attaching bolts.

(h) Adjust the cable tension as instructed in cable rigging chart *(figure 74)*.

e. CARBURETOR AIR CONTROL.

(1) DESCRIPTION. – The carburetor air control levers are located on the rear bank of the pilot's control pedestal. When the levers are full forward, they are in the "COLD" position. When they are full aft, they are in the "HOT" position.

(2) MAINTENANCE REPAIR OR REPLACEMENT. – Refer to paragraph 9. *d.* (2), this section.

(3) ADJUSTMENTS.

(a) The carburetor air control is properly adjusted if the door in the air scoop elbow strikes the stops when the control lever in the pilot's compartment is moved from its full "HOT" or full "COLD" positions. If necessary, adjust the control as follows:

(b) Remove the four attaching bolts on the Simmonds-Corsey control head and remove the cover.

(c) Remove the actuating arm from the serrated disc with a screw driver.

(d) Place both the pilot's control lever and the carburetor air door in the "HOT" position.

(e) Install the actuating lever with the female serrations on the male serrated disc, and reinstall the cover of the control head.

(f) Adjust for the "COLD" position by turning the adjusting screw which is attached to the control head, just above the rigid control, to the left or right as required.

(g) Adjust the cable tension as instructed in *figure 74*.

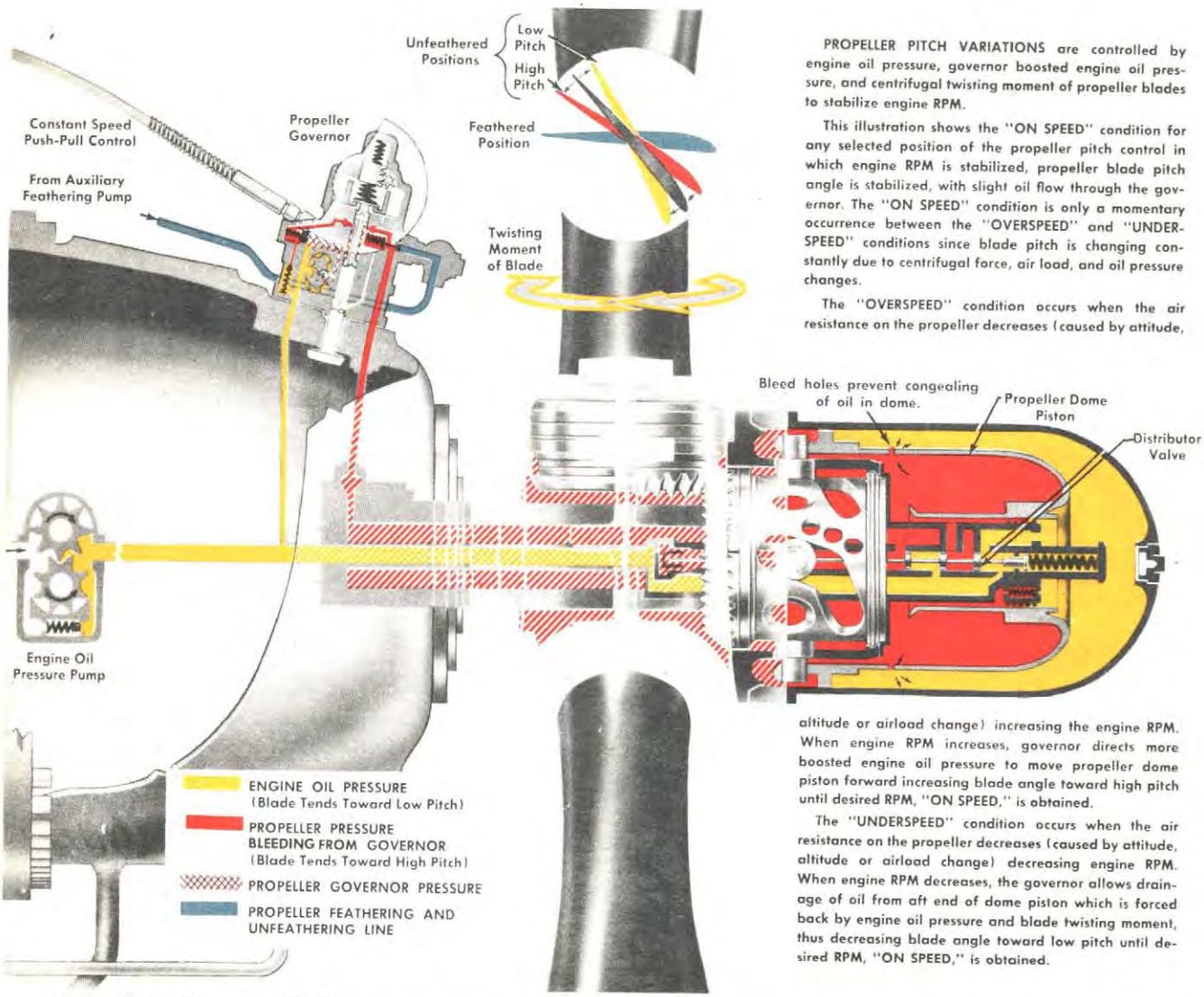
f. CARBURETOR AIR FILTER CONTROL.—Two air filters are installed in the top aft section of the cowling. When the electrical control is energized, a gate installed in the duct extending to the carburetor, prevents further passage of air, which enters through the filters and is by-passed to the carburetor. Refer to paragraph 7., this section. Refer also to paragraph 15., this section.

g. TROUBLE SHOOTING CHART. (See paragraph 6. *c.*, this section.)

10. PROPELLER AND PROPELLER CONTROLS.

a. GENERAL.—A Hamilton Standard Hydromatic propeller *(figure 180)* is mounted on the propeller shaft of each engine. This propeller is the full feathering type, model 23E50-505.

A Hamilton Standard Constant-Speed Control, Model 4G8-G23G or 4G8-G23G-1, is mounted on the propeller governor pad of the front (nose) section of each engine. The constant speed of each engine is maintained automatically by its constant-speed control (engine-driven propeller governor) which causes a continual change in propeller blade angle, through the constant-speed range of 1200 rpm minimum to 2700 rpm maximum, to meet the changing conditions of altitude, attitude and throttle setting. The change in blade angle is accomplished hydraulically by the



PROPELLER PITCH VARIATIONS are controlled by engine oil pressure, governor boosted engine oil pressure, and centrifugal twisting moment of propeller blades to stabilize engine RPM.

This illustration shows the "ON SPEED" condition for any selected position of the propeller pitch control in which engine RPM is stabilized, propeller blade pitch angle is stabilized, with slight oil flow through the governor. The "ON SPEED" condition is only a momentary occurrence between the "OVERSPEED" and "UNDERSPEED" conditions since blade pitch is changing constantly due to centrifugal force, air load, and oil pressure changes.

The "OVERSPEED" condition occurs when the air resistance on the propeller decreases (caused by attitude, altitude or airload change) increasing the engine RPM. When engine RPM increases, governor directs more boosted engine oil pressure to move propeller dome piston forward increasing blade angle toward high pitch until desired RPM, "ON SPEED," is obtained.

The "UNDERSPEED" condition occurs when the air resistance on the propeller decreases (caused by attitude, altitude or airload change) decreasing engine RPM. When engine RPM decreases, the governor allows drainage of oil from aft end of dome piston which is forced back by engine oil pressure and blade twisting moment, thus decreasing blade angle toward low pitch until desired RPM, "ON SPEED," is obtained.

PROPELLER FEATHERING is accomplished by directing engine oil under higher pressure from the propeller feathering pump through an external line through the governor, moving the piston to extreme forward position. This feathers the propeller by rotating the blades to the extreme high pitch angle.

In all oil flow conditions the oil displaced by piston movement is forced into the engine lubrication system either through the governor or the propeller shaft.

UNFEATHERING oil flow to the distributor valve is identical to that of feathering. When dome piston is in extreme forward position, and the auxiliary feathering pump again delivers pressure to the aft end of piston, extreme pressure is developed causing the distributor valve to reverse the oil pressure flow directing the pressure to the forward end moving the piston back. This decreases the blade angle toward low pitch until the constant speed range is reached.

Figure 179 — Propeller Pitch (Engine RPM) Control Forces Diagram

constant-speed control through regulation of the flow of engine oil under pressure to and from the propeller.

Each propeller is equipped with a feathering system, powered with an individual electric motor-driven hydraulic pump *(figure 198)* installed on the mechanic's floor and electrically operated from the pilot's compartment. The feathering pump supplies oil under high pressure, independent of engine oil pressure, directed to the propeller for feathering or unfeathering the blades. Refer to paragraph 10. *d.*, this section. To feather the propeller means to place the blades in the full high pitch position of 90 degrees, measured at the 42 inch station, so that the blades lie directly in line of flight, acting as powerful brakes to stop rotation of the engine and at the same time reducing drag to a minimum.

b. PROPELLER.

(1) DESCRIPTION.—Each of the two Hamilton Standard, hydromatic, constant-speed control, full feathering propellers has the following general characteristics:

Diameter—12 feet 7 inches.
Number of blades—3.
Low pitch—28 degrees at the 42 inch station.
High pitch—90 degrees at the 42 inch station.
Constant speed range of 1200 rpm minimum—2700 rpm maximum.

Propeller reduction gear ratio—2-1.

Three fundamental forces interact to control the blade angle when the propeller is operating in the constant-speed or flight range. They are:

Centrifugal twisting moment of the blades toward low pitch which is utilized to decrease the blade angle.

Engine oil under normal engine-driven pump pressure which supplements the centrifugal twisting moment, thus insuring adequate control force toward low pitch at low propeller speeds.

Engine oil under boosted pressure from the propeller governor which moves the blades toward high pitch. Refer to paragraph 10. *c.* (1), this section, for a description of the constant-speed control governor.

(2) REMOVAL AND DISASSEMBLY.—The following procedure for removing the propeller from the propeller shaft is, in general, the reverse of the installation procedure.

(a) DOME ASSEMBLY REMOVAL.

1. Remove the dome breather hole nut lock wire and the dome breather hole nut; drain the oil from within the dome.

CAUTION

The dome is usually filled with engine oil. Some provision should be made to take care of this oil both at the removal of the dome breather hole nut and when the dome assembly is removed from the hub assembly.

2. Install the dome lifting handle in the dome breather hole. Take out the dome retaining nut lock screw cotter pin and remove the retaining nut lock screw.

3. Back off the dome retaining nut. This nut is attached to the dome and acts as a puller when the nut is unscrewed from the hub. Lift off the dome assembly using care not to damage the distributor valve assembly.

4. Remove the propeller retaining nut lock wire.

CAUTION

It is imperative that this lockwire be removed before unscrewing the distributor valve from the propeller shaft in order to prevent shearing of the distributor valve housing locking splines.

5. Back off the propeller retaining nut two or three turns to relieve any compressive effect on the propeller shaft, then, using the composite wrench and adapter, remove the distributor valve from the propeller shaft.

(b) HUB AND BLADES ASSEMBLY REMOVAL.

1. Install the propeller sling. *(2, figure 180.)*

2. Unscrew the propeller retaining nut.

Note

The propeller hub snap ring, front split cone, and propeller retaining nut are so arranged inside the spider that, as the propeller retaining nut is backed off the propeller shaft, the forward edge of the front split cone will contact the hub snap ring and force the propeller hub and blades assembly off the rear cone.

3. Cover the propeller shaft with a thread protector cap.

4. Remove the hub and blades assembly from the propeller shaft.

5. Cover the propeller shaft until installation of the propeller.

(c) DISASSEMBLY.—Disassembly of propellers other than the accessory disassembly incidental to removal is to be done only at a repair depot.

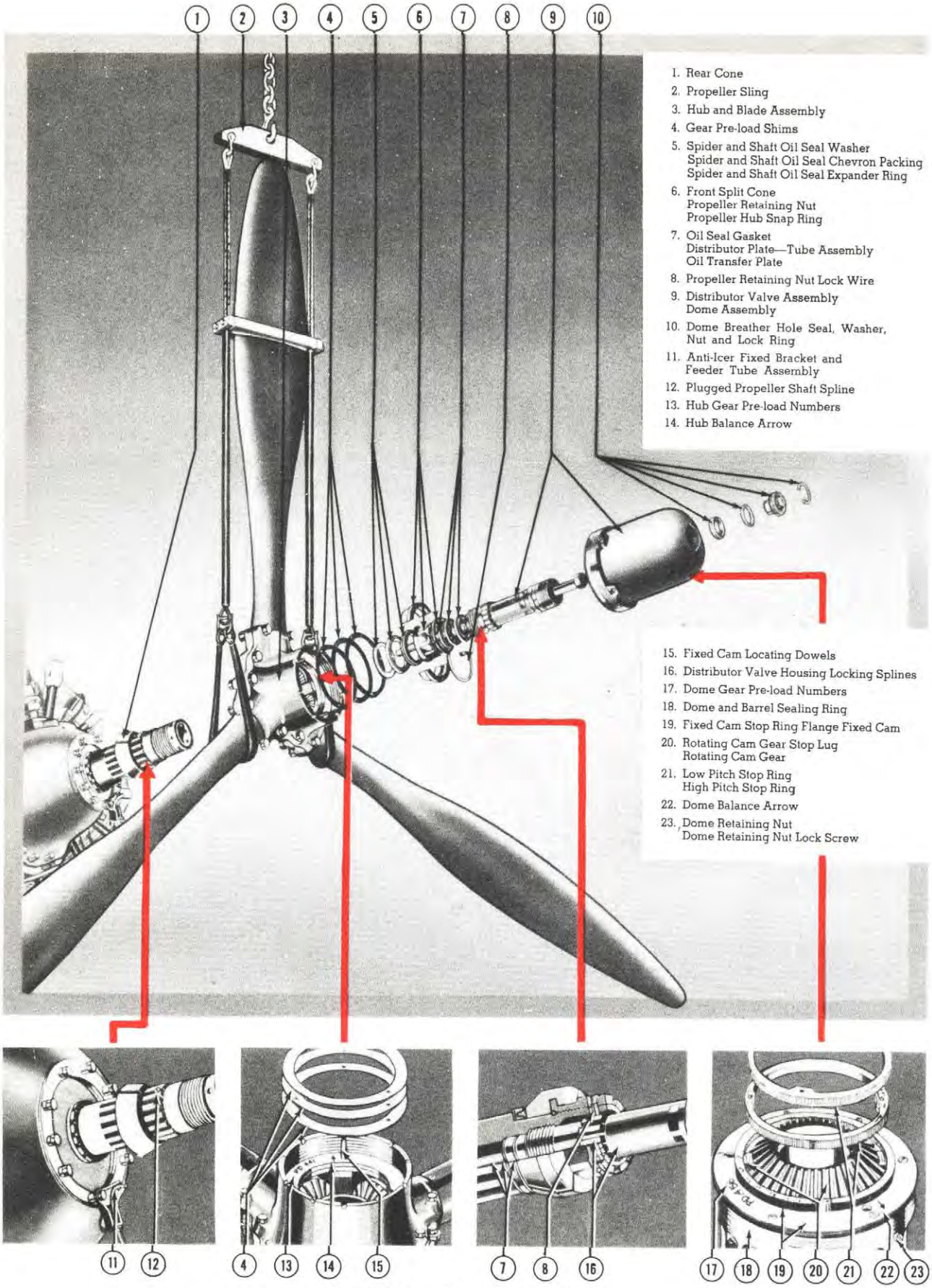


Figure 180 — Propeller Installation

CAUTION

Any operation pertaining to propeller maintenance is to be performed only by trained personnel.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—All propeller maintenance repair or replacement is to be done at a repair depot by trained personnel.

(4) ADJUSTMENT.—All propeller maintenance adjustment is to be done at a repair depot by trained personnel.

(5) TEST BEFORE INSTALLATION.—The test before installation of propellers or propeller parts is to be done at a repair depot by trained personnel.

(6) ASSEMBLY AND INSTALLATION.

(a) ASSEMBLY.—Assembly of propellers other than the necessary assembly incidental to installation is to be done only at a repair depot.

(b) INSTALLATION.

1. GENERAL.

a. Hydromatic propellers as prepared for installation on the A-26B engine propeller shaft, consist of three sub-assemblies: the hub and blades assembly, the dome assembly, and the distributor valve assembly.

b. Certain smaller attaching parts are also included with the hub and blades assembly at installation. These parts are the rear cone, the spider and shaft oil seal assembly, the front split cone, the propeller retaining nut lockwire.

c. The attaching parts included with the dome assembly are the dome breather hole nut and the dome breather hole nut lock wire. The dome assembly is locked in the hub assembly by the dome retaining nut lock screw and cotter pin.

d. The attaching parts which are used at the installation of the distributor valve assembly include the valve housing and oil transfer plate gasket, the valve housing oil transfer plate, and the oil transfer plate and shaft gasket.

e. To insure proper balance, the sub-assemblies of any one propeller will be kept together as a complete propeller unit.

f. The distributor valve assemblies of the same types are interchangeable.

g. Dome assemblies are interchangeable, if previously checked with the hub assembly for balance and gear preload.

2. PREPARATION.

a. Before installing a propeller, all parts which are accessible without disassembling the unit will be examined for defects or damage, and checked for proper fittings. All corrosion and all raised points, nicks, burrs, galls, and scores on joining surfaces of attaching parts, will be carefully dressed off and the parts thoroughly cleaned prior to propeller installation.

CAUTION

Remove all small metal particles after any stoning or dressing of propeller parts. Use carbon tetrachloride or straight-run gasoline in order to protect the neoprene seals and packings. Do not use aromatic gasoline for cleaning a propeller.

b. Inspect the propeller shaft and threads for nicks, burrs, or defects. Dress down defects with a fine stone and polish with crocus cloth. Wash the shaft with gasoline and allow to dry thoroughly. Then apply a light film of clean engine oil to both the inside and outside of the propeller shafts.

c. The propeller hub splines, front split cone and cone seat will be coated with clean engine oil to provide lubrication and prevent corrosion. Rear cone and rear cone seat will be installed dry. Cup grease or semi-fluid oils will not be used for this purpose.

3. INSTALLATION PROCEDURE.

a. INSTALLATION OF ANTI-ICING EQUIPMENT.

(1) Remove the two bottom nuts and washers on the thrust bearing cover plate of the engine's front section. Install the anti-icer fixed bracket and feeder tube assembly *(11, figure 180)* onto the two engine studs against the spacers. Replace nuts (but not washers) by hand, leaving bracket loose enough for final clearance adjustment with installation of propeller slinger ring mounted on hub and blades assembly.

(2) Connect the anti-icing fluid supply pipe to the feeder tube assembly.

(3) After complete installation of the propeller on the engine, check to see that the feeder tube assembly will direct the flow of anti-icing fluid to the anti-icing slinger ring.

b. HUB AND BLADES INSTALLATION.

(1) On new engines, the propeller shaft wide spline is usually in the top dead-center position. Do not rotate the propeller shaft prior to propeller installation because this changes the position of the engine pistons in the cylinders. In case the engine is allowed to stand idle before the initial ground run-up, the portion of the cylinders wiped clean of protective coating by moving the pistons may begin to corrode.

(2) Install the rear cone on the shaft, moving it back until it contacts the propeller shaft thrust bearing nut. Keep the outside surfaces of the rear cone dry and free from oil. To prevent seizure of the propeller retaining nut or the distributor valve on the propeller shaft, apply a thin film of a recommended thread lubricant to the shaft threads.

(3) Cover the propeller shaft threads

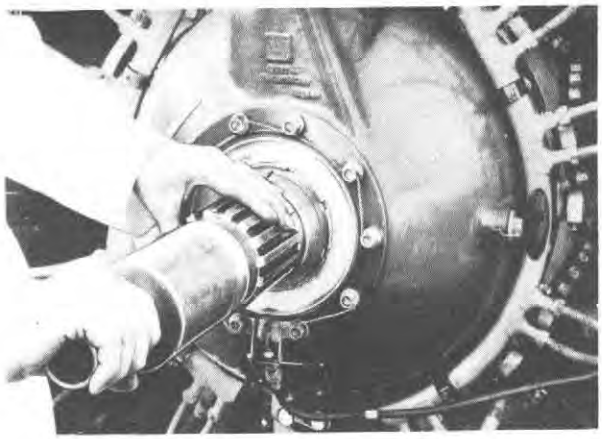


Figure 181—Installing Thread Protector

with a thread protector. Hoist the propeller hub and blades assembly, with the propeller blade up that is adjacent to the blank spline in the propeller spider. This will insure that the propeller blank spline is in line with the wide spline on the engine shaft, and that propeller blade clearance is provided for the work stand. Install the hub and blades assembly on the propeller shaft. While sliding the propeller assembly back on the shaft, tilt the feeder tube assembly to permit the feeder tube to clear the slinger ring attached to the rear of the propeller barrel.

Note

The threads of the propeller shaft may be easily damaged during installation of propeller hub and blade assembly. Care should be used during this operation; if available use a thread protection cap of the type that will allow the propeller hub to slide over it. After installing propeller hub and blade assembly on propeller shaft, remove thread protection cap.

(4) The spider and shaft oil seal rings *(5, figure 180)* consists of the spider and shaft oil seal

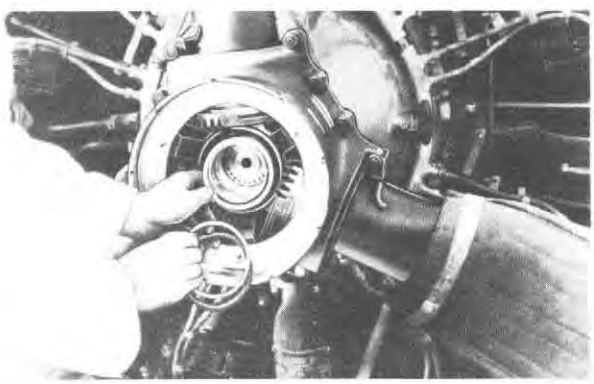


Figure 182—Installation of Spider and Shaft Oil Seal, Oil Seal Washer, and Oil Seal Expander Ring

washer, the spider and shaft oil seal, and the spider and shaft oil seal expander ring. These pieces are installed over the propeller shaft in that order to fit forward of the propeller spider splines. The spider and shaft oil seal (chevron type packing) is installed with "V" edge facing aft against the washer and groove wings facing forward. Use some blunt instrument which will not harm the seals to aid in properly seating this assembly.

(5) Apply a thin film of a recommended thread lubricant to the threads on the inner diameter of the propeller retaining nut. Keep the front split cone outside surface dry and free from oil. Then install the front split cone, consisting of two beveled half rings, on the propeller retaining nut. These parts are

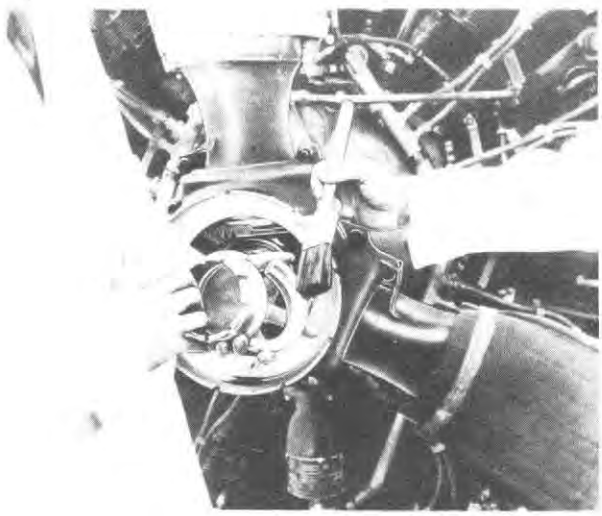


Figure 183—Application of Lubricant to the Retaining Nut and Front Cone

machined so that the annular groove incorporated inside the front split cone matches with the ledge at the base of the retaining nut. Turn the blades into reverse pitch so that the teeth position of the blade gear segments moves down into the hub. This will provide the necessary clearance to permit installation of the propeller retaining nut and the attached front cone halves.

Start the propeller retaining nut and the attached front cone onto the propeller shaft threads by hand.

CAUTION

The propeller retaining nut should advance on the threads without binding or catching. If it does not, recheck both the retaining nut and the propeller shaft threads for burrs, nicks, etc.

Tighten the propeller retaining nut on the shaft using the combination installation wrench in conjunction

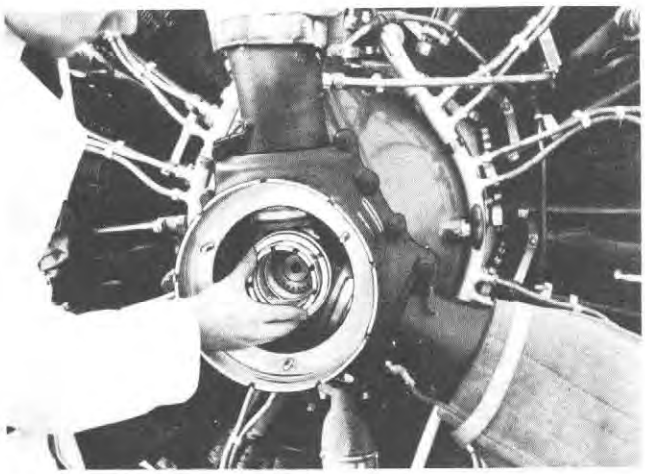


Figure 184—Installation of Propeller Retaining Nut—Start by Hand

with a bar 3 feet long. The required torque for this operation is 720 ft. lbs. which can be obtained by applying a force of approximately 180 pounds at the end of the 3 foot bar.

Note

The distance from the center of the wrench to the end of a 3 foot bar makes approximately the required 4 feet.

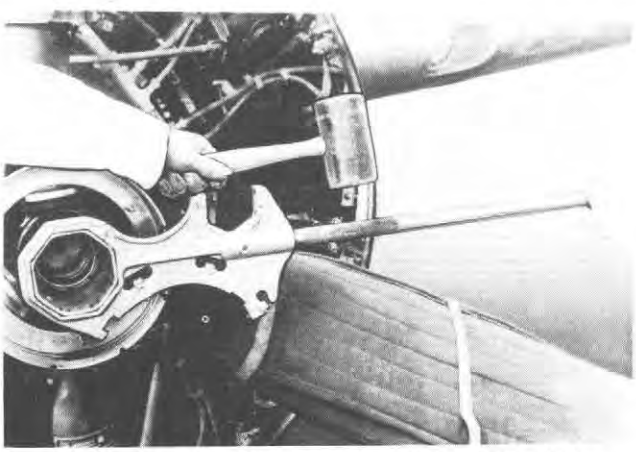


Figure 185—Tightening Retaining Nut With Composite Wrench, Adapter and Handle

In order to fully tighten the nut on the shaft, strike the bar close to the wrench with a hammer weighing about 2½ pounds while this force is being applied. Determine if one of the locking slots in the retaining nut is in alignment with one of the holes in the propeller shaft. If not, repeat the tightening operation until one slot and hole are in alignment. Spacing of the slots in the propeller retaining nut with respect to the holes in the propeller shaft is such that alignment of a slot and hole will occur at each 5 of rotation.

(6) Compress the hub snap ring and install it in the spider hub snap ring groove.

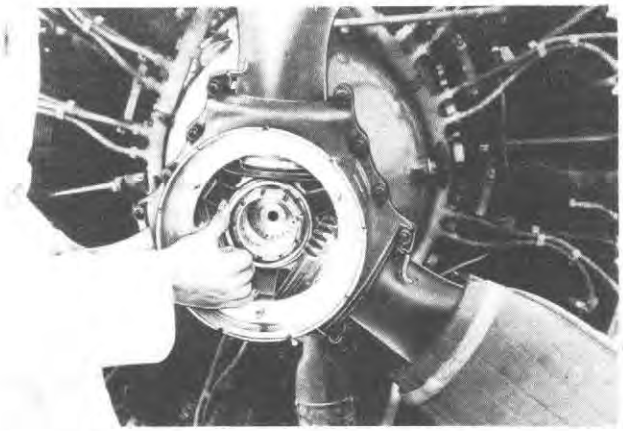


Figure 186—Installation of Hub Snap Ring Into the Spider Hub Snap Ring Groove

c. DISTRIBUTOR VALVE INSTALLATION.

(1) Check to be sure that the copper gasket (distributor plate to engine shaft oil seal) and the distributor plate engine parts *(7, figure 180)* are in place against the adapter flange inside the propeller shaft.

Note

Before installing the distributor valve on a new engine, remove the gasket and distributor plate inside the propeller shaft. Wash these two engine parts clean, coat with engine oil and install them in the shaft. The oil seal gasket fits against the adapter flange. The distributor plate is installed with its rear shoulder in the central hole of the gasket.

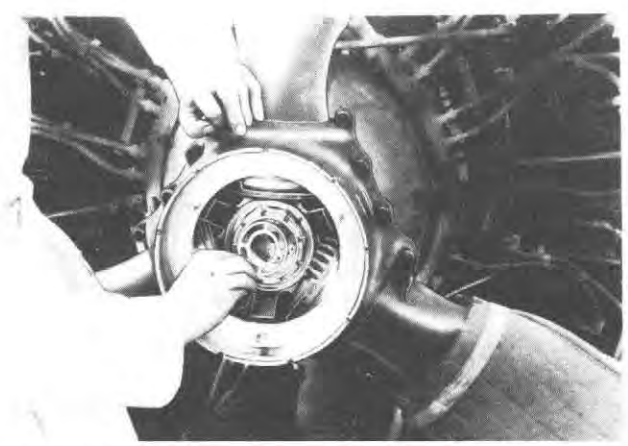


Figure 187—Installation of Oil Transfer Plate and Shaft Oil Seal Gasket—Engine Furnished Parts Previously Installed

(2) Install the oil transfer plate and shaft oil seal gasket *(7, figure 180)*. this gasket fits over the raised central shoulder and onto the smooth face of the distributor plate (engine part). This 1/32 inch copper gasket is furnished by the propeller manufacturer while another is furnished by the engine manufacturer as a spare.

(3) Check the valve housing oil transfer plate on the base of the distributor valve to be sure that it is the solid center type, and that the copper gasket is included between the oil transfer plate and the housing. These parts are installed with a snap fit onto dowels in the rear end of the valve housing.

(4) Apply a thin film of a recommended thread lubricant to the threads on the base of the distributor valve. Screw the valve into the propeller shaft by hand.

CAUTION

The valve should advance into the propeller shaft smoothly and easily. If binding is noticed, remove the valve and check the threads of the propeller shaft and the housing for burrs, damaged threads, etc.

(5) Tighten the distributor valve into the propeller shaft using the composite wrench, using adapter 41B1862. The use of this adapter will permit equal application of torque force on all sides of the valve housing and will prevent the crushing effect encountered when using only the composite wrench. Apply a force of approximately 100 pounds at the end of the one foot bar and, while this force is being maintained, strike the bar near the wrench one light blow with a hammer weighing not more than 2½ pounds. Repeat this tightening operation until one of the slots on the distributor valve housing is in alignment with the same hole in the propeller shaft to which a slot in the propeller retaining nut was previously lined up.

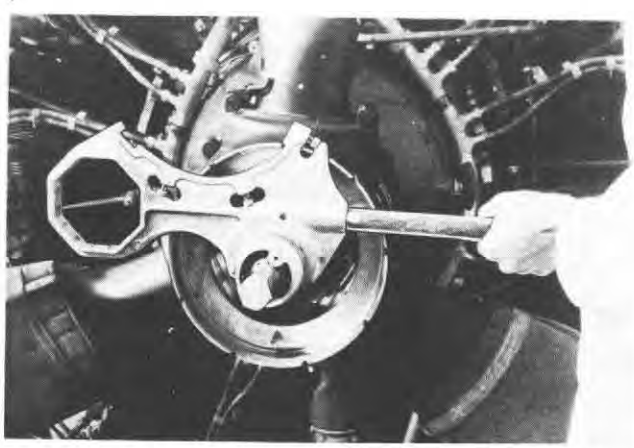


Figure 188—Tightening Distributor Valve by Using Composite Wrench

CAUTION

Under no conditions should the valve housing be backed off even slightly in order to obtain slot and hole alignment. If this alignment cannot be obtained without exceeding the specified torque, remove the distributor valve and reinstall it using either a new oil transfer plate and shaft gasket, or reduce the thickness of the first gasket by lapping it slightly. This caution applies as well to the installation procedure.

(6) Install the propeller retaining nut lock wire with its head placed through the retaining nut slot, propeller shaft hole, and into the distributor valve housing slot (spline groove). Pin head of lockwire should lead in direction of rotation of propeller shaft, while tail end of lockwire should trail. Snap this lockwire AS ILLUSTRATED into position in the lockwire groove provided for it in the retaining nut.

Figure 189—Installation of Retaining Nut Lockwire —Tail to Follow Direction of Finger

(7) Turn each propeller blade by hand to the high pitch angle position (90° or full feathering) against the stop pins. This will place all blade gear segments in proper position for alignment with rotating cam gear in propeller dome.

d. DOME ASSEMBLY INSTALLATION.

CAUTION

When installing the dome assembly, it is ABSOLUTELY ESSENTIAL that the rotating cam gear in the dome be meshed with the blade gear segments in the proper angular relationship, and the following steps should be carried out to insure correct meshing.

Prior to dome installation; check the low and high pitch stop rings in the base of the fixed cam to make certain the dome operating range is correctly set for the installation. To reset these rings, lift out the uppermost stop ring which is the high angle stop ring and

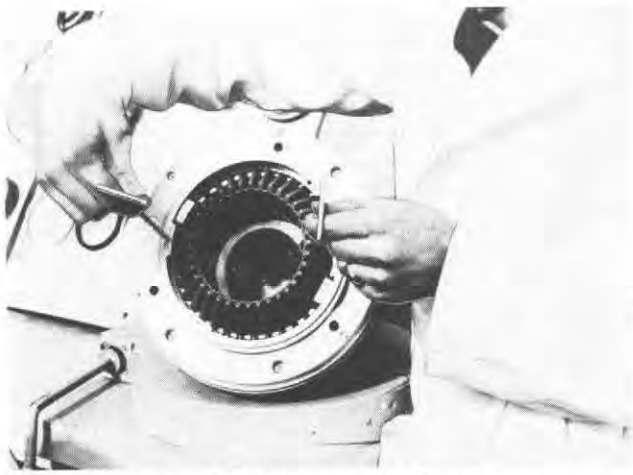


Figure 190—Lifting Out Stop Rings

marked "SET TO HIGH PITCH" on one lug, and "ASSEMBLE THIS STOP LAST" on the other lug. Then lift out the lower stop ring which is the low angle stop ring and marked "SET TO LOW PITCH" on one lug, and "ASSEMBLE THIS STOP FIRST" on the other lug. These rings can best be taken out by inserting 10-24 screws in the tapped holes which are incorporated in the stop lug portion of each ring. In order to insure that the stop rings will not fall out of the dome during installation, it is permissible to "SPRING" the stop rings to a slightly out of round shape so as to provide sufficient friction to hold them against their own weight. Such "SPRINGING" shall not be greater than will permit installation of the rings by hands alone.

Reinstall low pitch stop ring *(lower 21, figure 180)* to full low angle limit by inserting it so that the arrow on the stop ring coincides with the 28 degree mark (indicating the degrees of blade angle at the 42-inch reference station) stamped on the fixed cam stop ring flange. To insert the low pitch stop ring, it may be necessary to rotate the cam gear *(20, figure 180)* a small amount in a counterclockwise direction to permit inserting the stop ring without interfering with the stop lugs on the gear. It will be noticed that this rotation causes the piston in the dome assembly to move forward.

Reinstall the high pitch stop ring to the full high angle limit by inserting it on top of the low pitch ring so that the arrow on the high pitch stop ring coincides with the 90° mark on the fixed cam stop ring flange.

The stop lug on the rotating cam gear marked "SET WITHIN GRADUATIONS," must lie within the graduated arc of the stop ring flange on the base of the fixed cam after the stop rings have been installed.

(1) Install the required number of preload shims over the fixed cam locating dowels in the hub assembly.

(2) Move the rotating cam gear in the dome assembly until the cam stop lugs contact the high pitch stop ring; in this position, the dome piston will be moved into the extreme forward position.

(3) Install the dome lifting handle in the dome breather hole at the extreme forward end of the dome assembly.

Figure 191—Installing Dome Lifting Handle in Breather Hole

(4) The dome assembly is initially installed in the hub assembly with the correct number of pre-load shims in place BUT WITHOUT THE DOME AND BARREL SEAL. Lift the dome assembly into position and install it over the fixed cam locating dowels in the hub assembly. Make certain that the balance arrow etched on the base of the fixed cam coincides at installation with the arrow stamped on the dome and barrel shelf of the outboard barrel half. Extend the arrow with a pencil mark to a point directly outward on the retaining shoulder of the barrel so as to insure proper installation, if gear preload shims cover the arrow on the hub. Lift the dome assembly into position and align it to match the dome hole arrow to the hub dowel arrow; in this position the rotating cam gear and the blade gear segments are now in proper alignment to mesh correctly.

Note

If there are no arrows marked, the propeller is so balanced that the dome may be installed in any position, being perfectly balanced in both hub and dome assemblies.

(5) Install the propeller dome assembly by sliding it straight on over the end of the distributor valve assembly. Make sure that the oil seal rings on the valve assembly properly enter into the sleeve inside the piston.

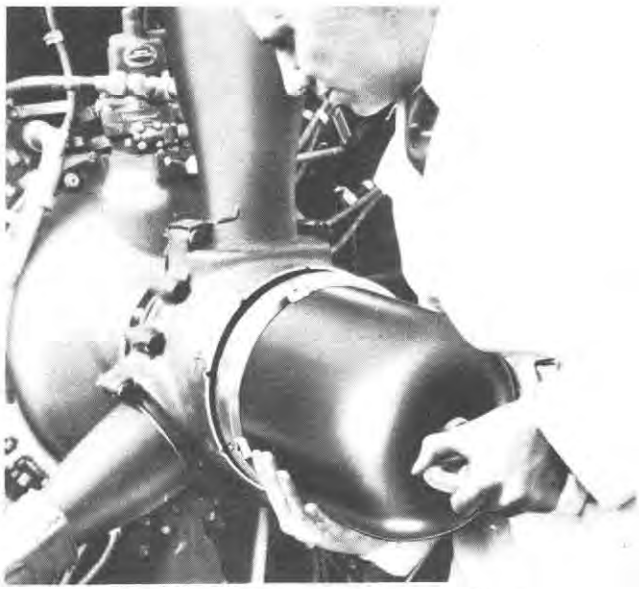


Figure 192—Starting Propeller Dome Assembly

(6) While installing, rotate the dome assembly in a counterclockwise direction until the fixed cam locating dowels in the barrel dome shelf enter the correct dowel holes in the fixed cam.

CAUTION

Do not rotate the dome assembly in a clockwise direction to align dowels and holes, because if the gear teeth should engage, this will tend to move the stop lugs on the rotating cam gear AWAY FROM THE FULL HIGH PITCH ANGLE POSITION, thus allowing the gears to mesh incorrectly.

(7) Start the dome retaining nut into the hub assembly by hand-turning the dome retaining nut, and then attach the composite wrench and insert a wrench bar. Remove the dome lifting handle. Tighten the dome retaining nut using a maximum torque of 720 ft. lb. (180 pounds at 4 feet radius). While this force is being applied, strike the bar near the wrench with a hammer weighing approximately 2 1/2 pounds. Continue this tightening operation until the dome assembly seats on the dome-barrel shelf and one of the lock screw lugs on the dome retaining nut is in line with a half circle groove in the barrel retaining shoulder. Mark the position of the dome retaining nut with respect to the barrel by drawing a pencil line through the center of the aligning lock screw lug and half circle groove.

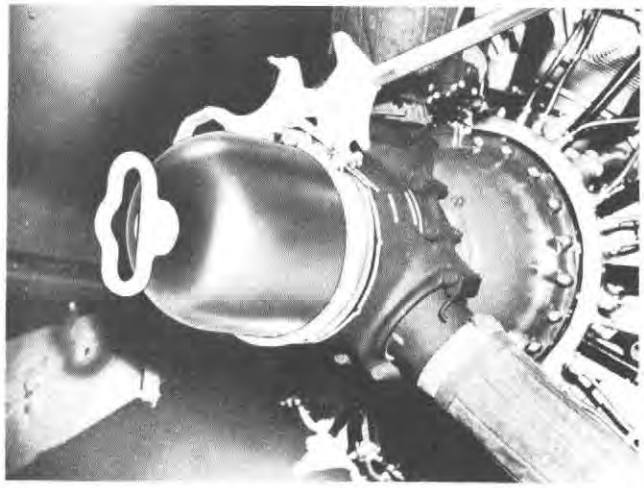


Figure 193—Tightening Dome Retaining Nut with Composite Wrench—3 Ft. Handle

Note

With the dome assembly properly seated in the barrel, the front face of the dome retaining nut will be approximately flush with the front edge of the barrel retaining shoulder. Tightening of the dome reteaining nut, in addition to the fastening the dome unit to the hub, serves to apply the preloading force to the gears, and to compres the dome and barrel seal. Failure to tighten the dome unit securely in the hub will result in elongation or failure of the dome shell retaining screws, and oil leakage around the dome retaining nut.

(8) Remove the dome assembly. Install the dome and barrel seal on the outer perimeter of the fixed cam base just aft of the dome retaining nut. This seal is installed with the tapered end facing away from the dome retaining nut. Reinstall the dome assembly as before and apply sufficient torque force to the dome retaining nut to bring it to the position previously marked.

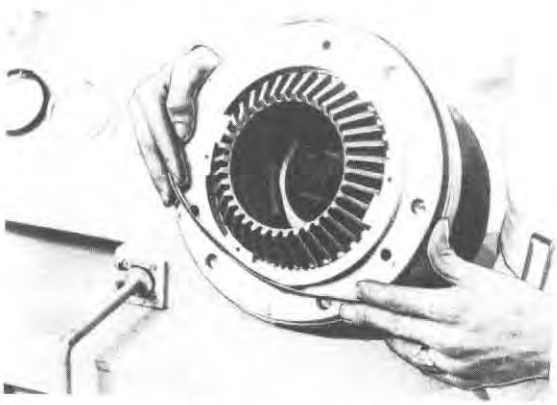


Figure 194—Installation of Dome and Barrel Seal

(9) Install the dome retaining nut lock screw in the dome retaining nut and safety this screw with a 1/16″ x 1/2″ steel cotter pin.

(10) Install the dome breather hole seal in the dome breather hole at the outboard end of the dome assembly. This seal is inserted with the tapered portion facing into the dome. Next insert the dome breather hole washer over the seal.

Figure 195—Installation of Dome Retaining Nut Lock Screw

(11) Install the spinner dome breather hole nut in the dome breather hole and tighten it with a torque force of approximately 40 foot pounds. Continue this tightening operation until one of the holes in the spinner dome breather hole nut is aligned with a slot in the dome shell.

(12) Snap the dome breather hole nut lockwire into the dome shell groove.

(13) Check propeller installation by inspection of blade angles as follows:

(a) Using suitable blade turning levers, shift the propeller blades first into the full low pitch position and then into the full high pitch position and check the blade angles either by the index line on the shank of the blades and the graduation on the barrel blade bore, or by a protractor at the reference station. These angles should be the same as the low and high pitch settings of the stop rings. This check will insure that the correct relationship between the blade gear segments and the cam gear has been obtained.

(b) If this check for correct blade angles reveals any blade incorrectly positioned, remove the dome assembly. Twist each blade by hand into

Figure 196—Changing Blade Pitch

full high pitch position against the stop pins. Check the position of the two stop rings in the dome assembly. Turn the rotating cam gear in the dome to full high pitch stop. Reinstall the dome assembly as described, and recheck the blade angles.

(7) TEST AFTER INSTALLATION.

(a) Prior to feathering and unfeathering a propeller for test after installation, the engine should be started and the propeller operated under constant-speed control as described in paragraph *c.* (7), below. CONSTANT SPEED CONTROL—TEST AFTER INSTALLATION. This will insure that the dome and barrel are filled with engine oil and that all parts of the propeller are fully lubricated.

(b) FEATHERING AND UNFEATHERING TESTS.

1. Complete the ground test of governing action. With the engine operating at approximately 1500 rpm and 22″ Hg. manifold pressure, depress the propeller feathering control switch push-button. When the propeller has reached the full-feathered position, the control switch will release automatically, and the engine speed will have decreased to approximately 500 rpm.

2. After the feathering test has been satisfactorily completed, again depress the propeller feathering control switch, and hold it down while the propeller is being unfeathered until the engine speed increases to approximately 1000 rpm.

3. Release the propeller feathering control switch push-button. The engine will return to the control of the governor.

CAUTION

To avoid overloading the engine sump, do not

repeat the feathering and unfeathering test until the engine has run for at least two minutes at approximately 1000 rpm.

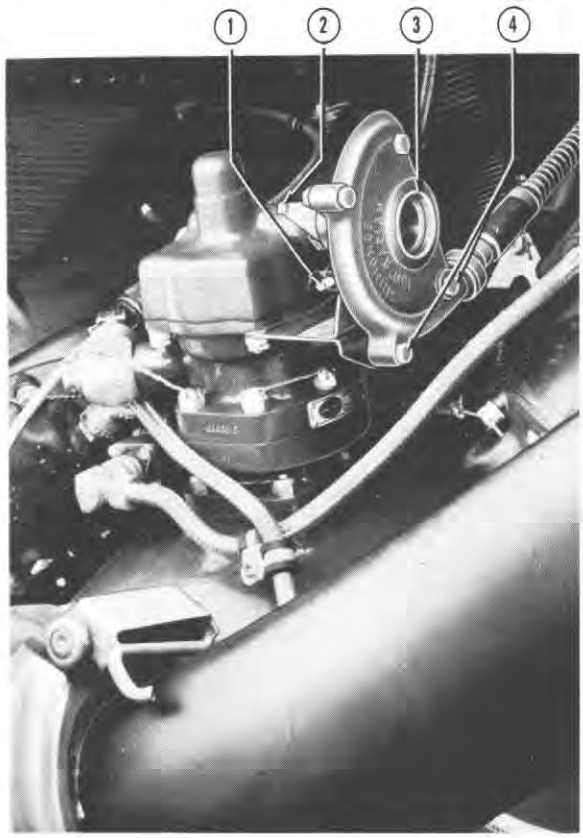
4. The above method of testing the feathering operation with the engine running has several important advantages not attainable when feathering is carried out with the engine stationary. They are: (1) It is not necessary to drain the engine sump after each feathering cycle in order to avoid loading the engine with oil since the engine scavenge pump returns the excess oil to the container. (2) The oil is hot and the propeller feathers and unfeathers faster and on a lower pump pressure, thereby reducing the load on the electrical system. (3) The hot oil and rotating engine parts allow a lower engine back pressure during feathering and unfeathering. (This back pressure is caused by the displacement of approximately three quarts of propeller oil into the engine lubricating system when the propeller is feathered or unfeathered.) (4) The feathering test is made with oil of relatively lower viscosity which approaches more closely the conditions under which the propeller would be feathered in flight.

c. CONSTANT-SPEED CONTROL UNIT (PROPELLER GOVERNOR).

(1) DESCRIPTION.

In conjunction with the hydromatic propeller, the constant-speed control is an automatic device used to maintain the engine rpm constant at any engine speed selected by the pilot within the governing range. Driven by the engine, the constant-speed control functions to regulate the flow of oil to the propeller, changing the blade angle to hold the engine speed constant for each new set of flight conditions. Thus, the engine speed is set and controlled independently of engine power; engine speed being governed by the constant-speed control, while engine power is governed by the throttle. With the hydromatic propeller, the constant-speed control will permit the engine to develop any selected power at any selected engine speed. The engine power and speed will be maintained until the throttle and the propeller governor control levers are readjusted to a new operating rpm.

A Hamilton Standard Constant-Speed Control is mounted on the propeller governor pad of the front (nose) section of the engine. This unit is a double capacity hydromatic propeller governor of the flyball type and is engine-driven. Once set, this governor automatically maintains constant engine rpm by controlling the propeller blade angle within the constant-speed range of 1200 rpm minimum to 2700 rpm for take-off, to meet varying conditions of altitude, attitude and throttle setting. The minimum rpm at which the governor will control the propeller blade angles is set at 1200 rpm by an adjusting screw in the head of the governor. The maximum rpm of the governing range is set at 2700 rpm by an external high rpm



1. HIGH RPM Stop Screw
2. HIGH RPM Stop Arm
3. Serrated Radian Bushing
4. Radian Mounting Bolts

Figure 197 — Constant Speed Control (Propeller Governor) Flexible Shaft Attachment

stop arm on the control head. Adjustment of the two governors, to control rpm of the engines, is made from the engine rpm controls (propeller governor controls) installed on the forward upper structure of the pilot's control pedestal *(figure 199)*. The controls are marked, in the extreme rear position "DECREASE" (signifying minimum rpm or constant-speed high pitch limit range) and in the extreme forward position "INCREASE" (high rpm or low pitch range).

The governor boosts engine oil pressure to the pressure required for moving the blades toward high pitch. Also the governor meters to or drains from the aft end of the propeller piston the quantity of oil required to set and maintain the proper blade angle as necessary to allow the engine to run at constant rpm regardless of the altitude of the airplane.

The functions performed by the constant-speed control are governed by the various component parts within the housing. The speeder spring, located in the head of the governor acts as an adjustable tension

balance for the engine-driven flyballs, balancing or counteracting the centrifugal force exerted by these flyballs at varying engine speeds. Flyball centrifugal force actuates a pilot valve, lifting the pilot valve against the speeder spring. As the speeder spring and flyball forces balance, or one overrides the other, so the pilot valve meters the oil flow through suitable ports in the drive gear shaft to or from the aft end of the propeller piston.

Engine oil pressure is received and boosted by a small engine-driven gear type booster pump within the constant-speed control. This pump furnishes sufficient oil pressure to the aft end of the propeller piston to move the propeller toward the high pitch limit of the constant-speed range. The booster pump is not used to move the blades toward low pitch; this movement is accomplished by normal engine oil pressure and centrifugal twisting moment of the blades. The governor drive gear shaft is splined at one end to fit the engine drive coupling in the engine pad. This hollow shaft drives both the booster pump and the flyball assembly, while the pilot valve fits inside the shaft.

A low pressure relief valve responds to pump pressure and pilot valve positions and all oil, not actually required to shift the propeller blades, is returned to the inlet side of the pump. A high pressure (dump) relief valve is permanently set to limit the booster pump delivery from 330 to 350 psi oil pressure above engine oil pressure. Within the governor body, a high pressure transfer valve in the feathering oil pressure passage acts as a shuttle valve to disconnect the governor booster pump oil flow to the propeller feathering and unfeathering operations.

On the base, a differential pressure cut-out switch is connected to the governor oil pressure outlet passage to the propeller. Upon completion of the feathering operation, 500 psi oil pressure developed by the feathering pump actuates a plunger within the switch. The automatic plunger movement breaks the feathering electrical circuit to stop the pump. For further information on the electrical function of this switch, refer to paragraph 15., this section.

(2) REMOVAL AND DISASSEMBLY.

(a) REMOVAL.

1. Remove anti-drag ring cowling described in paragraph 6. *b.* (14) *(b)*, this section.

2. Mark the relationship between the serrated bushing on the governor shaft and the index mark on the end of the governor shaft, and between the bushings and the serrated disk carrying the stop arm, in order that the control may be reassembled in the same manner to avoid unnecessary adjustment.

3. Disconnect the control head.

4. Disconnect the feathering pump high pressure connection in the body of the governor unit.

5. Disconnect the electrical control wire from the pressure cut-out switch on the base of the governor.

6. Unscrew the mounting stud nuts which secure the governor unit to the engine pad, and remove the governor.

(b) DISASSEMBLY.—The constant-speed control governor is to be disassembled only at a repair depot.

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) MAINTENANCE REPAIR.—The constant-speed control governor is to be repaired only at a repair depot.

(b) REPLACEMENT.—Replace all faulty governors.

(4) ADJUSTMENTS.—Any internal adjustment of the constant speed control governor is to be made at a regular depot. For instructions regarding adjustment of maximum rpm, see paragraph 10. *e.* (2) *(d)*, this section.

(5) INSPECTION BEFORE INSTALLATION.

(a) Check that the oil control plugs in the governor body and base are installed in B-B holes, as the governor drive on the engine rotates in a clockwise direction. The plug hole in the body may be seen through the hole in the base.

(b) Make certain that the governor drive gear shaft turns freely before it is assembled on its drive coupling on the engine.

(6) ASSEMBLY AND INSTALLATION.

(a) ASSEMBLY. – Assembly of the constant-speed control governor is to be done at a repair depot.

(b) INSTALLATION.

1. Install the governor on the engine pad and place the nuts on the mounting studs fingertight. Remove the governor head from the body and check the drive gear shaft for backlash and freedom of movement while tightening. It is essential that these nuts be evenly tightened. The securing nuts should not be drawn down excessively, because to do so may cause the displacement of the gasket in the vicinity of the mounting studs and result in warping the governor base.

Note

For installation and adjustment of the governor control, see paragraph 10. *e.* (2) *(b)* & *(f)*, this section.

CAUTION

Make certain that the governor drive gear shaft turns freely before it is assembled on its drive coupling on the engine.

2. Install Simmonds-Corsey head as follows:

a. Place the RPM control lever in the extreme "DECREASE" position.

b. Turn the constant speed control governor shaft to the low rpm position.

c. Install the Simmonds - Corsey control head on the governor shaft by fitting serrations over serrations of corresponding attaching bushing. If adjustment is necessary refer to paragraph 10. *e.* (2) *(d)*, this section.

(7) TEST AFTER INSTALLATION.

(a) Before testing the constant-speed control, the propeller should be inspected to check the correct blade angles. This test is necessary to insure the correct relationship between rotating cam gear and blade gear segments. This test will usually be performed after the installation of the propeller.

Note

Do not use the feathering pump to move the blades to low pitch position in order to check the blade angles. If oil pressure is used for this purpose before checking the blade angles, serious damage may result to the mechanism due to improper installation.

(b) Set the engine RPM (propeller governor) control *(figure 199)* in the pilot's compartment to the "INCREASE" (Maximum rpm, low pitch) position, and then start the engine and warm it up in accordance with the engine operating instructions. When the engine is started, the forward end of the propeller dome cylinder will fill with engine oil at normal engine-pump pressure. This pressure, in conjunction with the blade centrifugal twisting moment, will hold the blades against the low pitch stops.

With the propeller blades in full low pitch, and the actual engine rpm lower than that for which the propeller governor is set, the engine rpm will vary directly with engine horsepower output.

Note

Horsepower varies with rpm and manifold pressure. Rpm is controlled by the propeller governor through change of blade pitch; manifold pressure is controlled by the throttle. In the condition stated above, with the blades in full low pitch, the propeller acts as a fixed pitch propeller and engine horsepower is governed by the throttle which in this case controls rpm as well as manifold pressure.

(c) After completing the engine warm - up period, advance the throttle to some intermediate engine speed, for example, 1500 rpm. Move the engine rpm control to the extreme "DECREASE" position. At this control setting, the engine will turn faster than the speed for which the governor is set, and the governor will supply oil pressure to the aft end of the propeller piston. In 35 to 45 seconds, when the aft end of the dome cylinder has been filled with oil, the propeller blades will move toward a higher pitch and the engine rpm will drop down to the minimum propeller governor setting.

(d) After the forward and aft ends of the dome cylinder have been filled with oil according to the procedures outlined above, move the engine rpm control several times between the "DECREASE" and the intermediate settings to eliminate trapped air from the propeller system.

d. AUXILIARY FEATHERING PUMP ASSEMBLY.

(1) DESCRIPTION.—When it is necessary to stop engine rotation in flight, in case of engine failure or testing conditions, the powerful braking effect of the propeller in the feathered conditions is employed. Feathering the blades to the full high pitch position of 90 degrees at the 42 inch station so that the blades lie in the direction of flight prevents windmilling and reduces drag to a minimum. Since the engine-driven oil pump and the engine-driven governor are inoperative when the engine stops, an auxiliary source of power is provided for feathering and unfeathering the propeller.

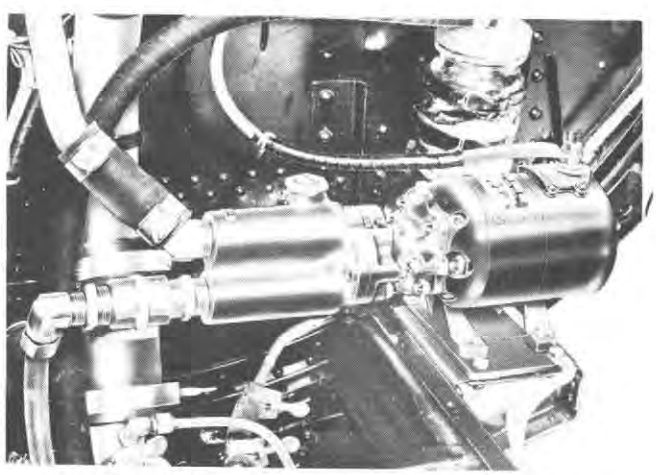


Figure 198—Propeller Feathering Pump and Motor

This power unit is an individual electric motor-driven hydraulic pump assembly *(figure 198)*, one for each propeller, mounted below the oil tank in the nacelle. The electric drive motor is controlled by the propeller feathering control switch button in the pilot's compartment. The electric motor is described in paragraph 15., this section. The auxiliary feathering pump takes oil supplied from the oil container and pumps this oil under high pressure to the propeller

governor housing where this pressure actuates the high pressure transfer valve to disconnect the propeller governor from the system. The transfer valve is actuated to allow high pressure oil from the feathering pump to flow through the governor base and through the passage in the front (nose) section to the propeller shaft and then through the distributor valve to the propeller dome cylinder. This route from the governor to the propeller dome is the same as that used to conduct oil from the governor booster pump during constant speed operation.

Feathering is started by depressing the propeller feathering control switch push-button which holds in automatically. During the feathering operation, high pressure oil is pumped to the aft end of the propeller piston, moving the piston forward to feather the blades while forcing the engine oil forward of the piston to drain into the engine crankshaft, just as in constant-speed operation. When the piston has reached its full forward travel, feathering the blades to 90 degrees, the accumulated oil pressure within the feathering pump lines and the aft end of the dome cylinder reaches 500 psi and actuates the differential pressure cut-off switch on the base of the governor; this action opens the propeller feathering circuit and stops the pump.

Considerably greater oil pressure is required for the unfeathering operation than for the feathering, in order to open the distributor valve in the propeller shaft to redirect the oil flow within the dome cylinder. The only movement of the distributor valve is produced during unfeathering operation by the high pressure of 600 psi or more. However, at 500 psi, the pressure cut-out switch is actuated and breaks the feathering electrical circuit, automatically releasing the feathering control switch in the pilot's compartment which stops the feathering pump motor. For this reason, the feathering control switch must be HELD DOWN MANUALLY to produce sufficient pressure for unfeathering.

During the unfeathering operation in flight with engine dead, high pressure oil from the feathering pump at first flows to the aft end of the propeller piston. When the pressure builds up to 600 psi it actuates the distributor valve which redirects the pump pressure into the forward end of the dome cylinder while oil in the aft end is now directed into the engine crankshaft for drainage. Pressure in the forward end of the propeller dome forces the piston aft, unfeathering the blades. In flight, the blades immediately windmill and crank the engine. When the engine reaches the desired speed for starting, approximately 1000 rpm, the feathering control switch must be released to stop the feathering pump. The distributor valve returns to its normal position and the transfer valve in the governor closes to shut off the feathering pump line thus permitting the governor to resume its normal automatic control of engine speed when the engine is now started.

The pump is a fixed clearance type with a positive displacement of .141 cu. inches. The total weight including motor is approximately 11 pounds. The pump itself consists essentially of a pair of closely meshed steel gears contained within a housing, mounted on the end of a 24-volt motor. The housing is made up of a heat treated aluminum alloy body. The body contains 2 removable lead bronze bushings. Two removable bushings are also located in the cover. The parts are accurately machined to provide the proper clearance for the gears to turn freely with a minimum of fluid pressure loss.

The intake port and discharge port are located in the cover. A pair of small drilled holes provide communication between the intake port, gear shafts, and seal chamber in order to relieve pressure at the end of the shafts and in the seal chamber. The oil pressure relief valve, set at 1200 psi, is located in the cover. It is arranged to by-pass fluids from the discharge port back to the intake port when the discharge pressure exceeds the pressure adjustment.

A seal is provided to keep the fluid within the pump, to prevent air being drawn into the pump.

(2) REMOVAL.

(a) Remove the access doors from the left-hand side of the nacelle. *(See 3, figure 9.)*

(b) Drain the oil from the engine system through the "Y" oil drain valve which is accessible through a cover plate *(27, figure 6)* in the bottom of the nacelle.

(c) Drain the 1½ gallons of reserve oil from the oil tank through the plug beneath the tank sump.

(d) Remove the oil lines from the pump and drain them into the container.

(e) Disconnect the electric plug from the motor.

(f) Disengage the bolts which secure the motor to the mechanics floor.

(3) DISASSEMBLY. — The feathering pump should be disassembled only at a repair depot.

(4) MAINTENANCE REPAIR OR REPLACEMENT.

(a) MAINTENANCE REPAIR.—The hydraulic feathering pump and electric motor assembly is to be repaired only at a repair depot.

(b) REPLACEMENT.—Replace all damaged or worn pump and electric motor assemblies.

(5) ADJUSTMENTS.—Any adjustment of the hydraulic feathering pump and electric motor assembly is to be made at a repair depot.

(6) TEST BEFORE INSTALLATION.—The hydraulic feathering pump and electric motor assembly is tested before being shipped from the factory. Consequently, a test before installation is not necessary.

(7) ASSEMBLY AND INSTALLATION.

(a) ASSEMBLY.—The feathering pump should be assembled only at a repair depot.

(b) INSTALLATION.—Reverse of REMOVAL AND DISASSEMBLY procedure.

(8) TEST AFTER INSTALLATION.—For complete procedure, refer to paragraph *b.* (7), this section, PROPELLER, TEST AFTER INSTALLATION.

e. PROPELLER CONTROLS.

(1) PROPELLER FEATHERING CONTROL SWITCH.—A push-button control switch *(figure 352)* is provided for each propeller feathering system. These switches are installed on the forward upper structure of the pilot's control pedestal. Further description of these switches will be found in paragraph 15. *d.* (11) *(c)*, this section.

(2) ENGINE RPM CONTROLS (PROPELLER GOVERNOR CONTROLS).

(a) DESCRIPTION.—Each of the two constant-speed control units (propeller governors) can be manually adjusted from the pilot's compartment. Adjustments are made with the engine RPM controls installed on the forward upper structure of the pilot's control pedestal. The purpose of these controls is to control the engine speed within the constant-speed range of 1200 rpm minimum to 2700 rpm take-off speed. The function of these controls is to adjust the propeller governor, i. e., to increase or decrease the compression applied to the speeder spring within the governor head, thus regulating the flow of oil from the governor to the propeller to affect a change of blade angle, in this way constant-speed control governing only the engine RPM.

It should be clearly borne in mind that with the constant-speed control, governing only the engine RPM controls (propeller governor controls) can regulate engine speed. These controls do not regulate blade pitch. The abbreviation "RPM" designates these controls and their extreme positions are marked as follows: the forward control position is "INCREASE" signifying high rpm or low pitch range; the aft control position is "DECREASE" signifying low rpm or constant-speed high limit range. The control system incorporates pulleys and cables from the control pedestal to the bellcrank in each nacelle. A push-pull control mechanism connects each bellcrank to the respective propeller governor.

The push-pull control mechanism consists of two main parts: the casing and the core. The casing in each nacelle is rigid from the bellcrank to the firewall, flexible from the firewall to the governor. The casing sections are connected by couplings at the firewall. The core consists of an arrangement of olives and tubelets, threaded on a cable. In the "PULL" operation, tension is borne by the cable; in the "PUSH" operation, compression is borne by the linkage of olives and tubelets. At the governor, this mechanism ends in a control head mounted on the serrated disc of the propeller governor shaft. An external high rpm stop arm, attached to the control head, limits the movement within the control head when the stop arm strikes the high rpm adjustable stop bolt threaded through a boss in the governor head. This stop arm is set to limit the high rpm developed by the engine while controlled by the propeller governor. The stop arm functions to limit the amount of compression that can be applied to the speeder spring by the engine RPM control.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.—Disconnect control linkages *(figure 197)* at the propeller governor and at the engine RPM control in the pilot's compartment. Remove in an orderly manner.

2. DISASSEMBLY.—The propeller controls are disassembled when removed.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Faulty control parts should be replaced rather than repaired.

(d) ADJUSTMENTS.

1. When installing the control on a replacement governor, install the serrated bushing on the governor shaft in the same relationship to the index mark on the end of the governor shaft as existed on the governor removed. Also adjust the stop arm disc in the previous relationship to the serrated bushing on the governor shaft. This will avoid unnecessary adjustment of the controls.

2. To obtain small changes in the maximum rpm setting, turn the stop screw on the governor head clockwise to decrease rpm, or counterclockwise to increase rpm.

3. To obtain larger changes in the maximum rpm setting, loosen the nut on the end of the governor shaft and shift the disc carrying the stop arm to a serration placing the stop arm farther away from the stop screw on the governor head to increase rpm, or nearer the stop screw to decrease rpm. As each serration on the stop arm disc changes the setting of the arm by 15 degrees, this results in a change of approximately 114 rpm in the governor setting.

CAUTION

If the engine fails to develop take-off rpm at take-off manifold pressure and with the propeller control in full increase rpm position, check whether the engine rpm drops slightly when the manifold pressure is slightly reduced. If the rpm does not change, the governor is controlling the propeller, but the governor is not set for take-off rpm due to

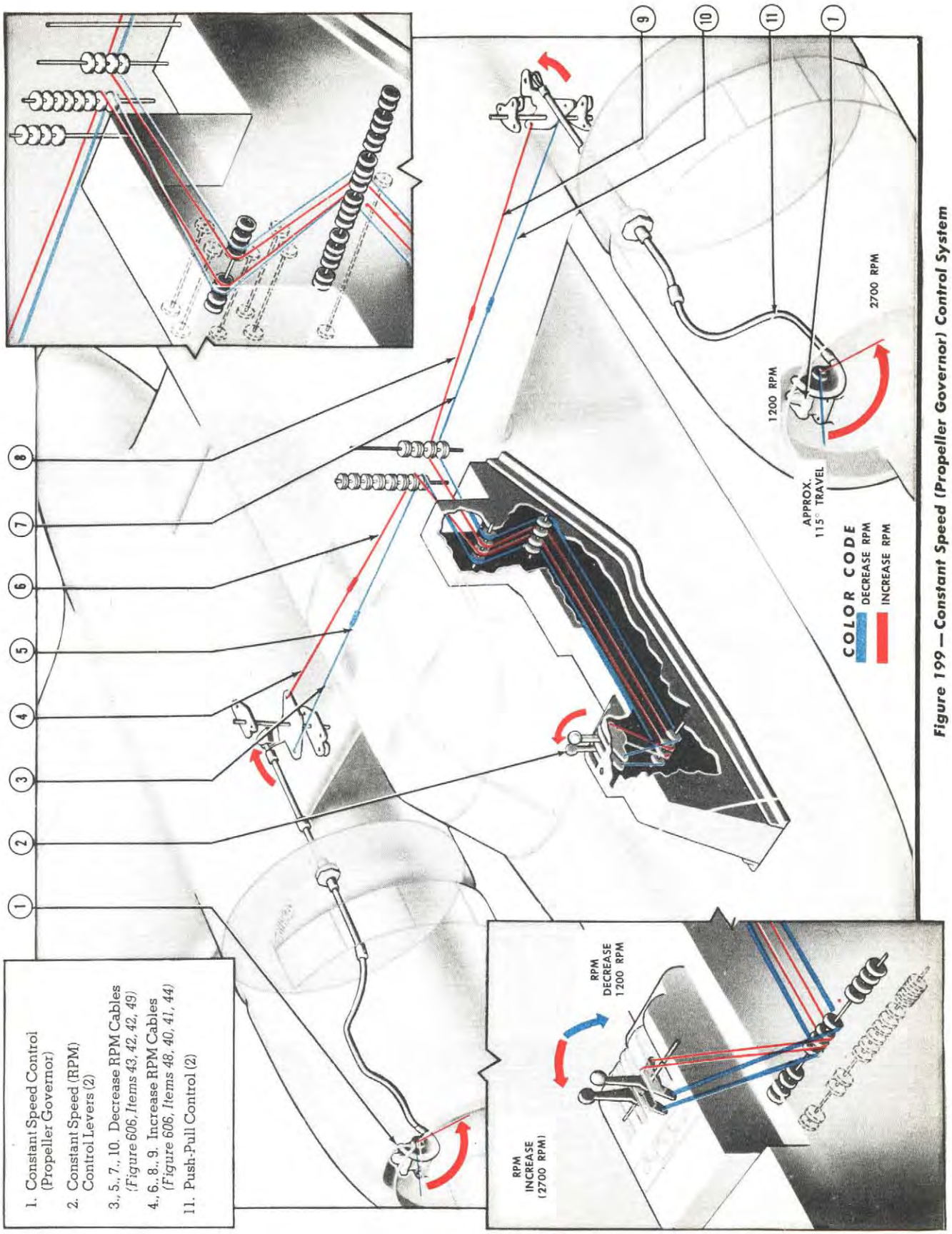


Figure 199 — Constant Speed (Propeller Governor) Control System

improper adjustment of the high rpm stop on the control, or improper operation or rigging of the controls. If the engine rpm drops when the manifold pressure is slightly decreased, the governor is in the underspeed condition but the blades are against the low pitch stops and cannot go to a lower angle. DO NOT ATTEMPT TO INCREASE THE RPM BY ADJUSTING THE GOVERNOR MAXIMUM RPM STOP UNDER THESE CONDITIONS, AS THIS WILL NOT INCREASE THE RPM ON THE GROUND AND CAN CAUSE DANGEROUS OVERSPEEDING IN FLIGHT. Check the engine for any condition causing loss of power, and check the minimum blade angle.

4. The propeller control lever in the cockpit should be adjusted so that when the stop arm on the control is against the stop screw on the governor, the cockpit lever is ⅛ inch from its full forward position. To obtain this adjustment, change the relationship between the serrations on the bushings on the governor shaft and the outer part of the control required.

CAUTION

When making this adjustment, take care not to loosen the nut on the governor shaft allowing the relationship between the radial serrations on the bushings on the governor shaft and the disc carrying the stop arm to change. This would result in changing the rpm setting of the governor.

5. If it is necessary to install a replacement governor without information on the previous adjustment of the controls, proceed as follows:

a. Place the propeller control in the cockpit in full decrease rpm position.

b. Install the disc carrying the stop arm and the serrated bushing on the governor shaft. Turn the governor shaft clockwise to the full extent of its travel. Set the stop arm so that the arm is approximately 110 degrees away from the stop screw when the draft is in its full clockwise position.

c. Install the outer part of the control head over the serrated bushing on the governor shaft, keeping the governor shaft turned fully clockwise.

d. The above procedure gives a trial setting. Run the engine and adjust the stop screw on the governor head and the stop arm on the control described above to set the stop for take-off rpm.

e. Adjust the control as described above so that the cockpit lever is ⅛ inch from its full forward position when the stop arm on the control is against the stop screw.

(e) TEST BEFORE INSTALLATION. – The control parts are not tested before installation.

(f) ASSEMBLY AND INSTALLATION.–Reverse the REMOVAL AND DISASSEMBLY PROCEDURES.

(g) TEST AFTER INSTALLATION.–The engine RPM control (lever and cable linkage) is tested in conjunction with the test of the constant-speed control unit. Refer to paragraph 10. *c.* (7), this section. The propeller feathering control switch push-button is tested in conjunction with the test of the hydraulic feathering pump and electric drive motor assembly.

f. PROPELLER AND CONTROLS TROUBLE SHOOTING LIST.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Inability to attain take-off rpm on the blocks.	*a.* Wrong setting of governor and incorrect rigging of control system.	*a.* Reset governor and rerig system.
	b. Improper adjustment of low pitch stop ring in propeller dome assembly.	*b.* Reset stop ring.
	c. Low engine power.	*c.* See engine manual.
	d. Erroneous reading on tachometers, manifold pressure gage.	*d.* Calibrate instruments.
2. Overspeeding on take-off.	*a.* Wrong setting on governor control.	*a.* Reset and rerig.
	b. Insufficient exercise of propeller mechanism prior to take-off.	*b.* Move engine rpm control through constant-speed range with engine running.
	c. Backlash in engine rpm control.	*c.* Rerig control system.
	d. Too rapid throttle opening.	*d.* Advance throttle slowly.

f. PROPELLER AND CONTROLS TROUBLE SHOOTING LIST.—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
	e. Poor or incorrect gaskets between distributor valve and propeller shaft; and between governor base and engine mounting pad.	*e.* Install new gaskets.
	f. Sticky governor pilot or relief valve.	*f.* Remove governor and forward to overhaul depot.
	g. High engine transfer ring leakage.	*g.* Remove engine and forward to overhaul depot.
	h. Erroneous reading tachometers, manifold pressure gage.	*h.* Replace defective instrument.
3. Poor synchronization.	*a.* Ignition trouble.	*a.* Check with ignition tester or megger.
	b. Poor carburetion.	*b.* Consult engine carburetor manual.
	c. Backlash in governor control system.	*c.* Rerig control system.
	d. Sluggish pilot valve.	*d.* Remove governor and forward to overhaul depot.
	e. Sluggish governor relief valve.	*e.* Remove governor and forward to overhaul depot.
	f. Sticky piston action in propeller dome assembly.	*f.* Remove dome shell. Clean and lubricate piston gasket. If piston contact area of dome is scored, polish with wet and dry 300 emery.
	g. Loose piston gasket.	*g.* Tighten piston gasket nut.
	h. Variation in engine transfer ring leakage.	*h.* Replace defective instrument.
4. Leakage.	*a.* At crankshaft breather.	
	(1) Incomplete engine scavening or excessive blow-by.	(1) Consult engine manual.
	(2) Loose distributor valve.	(2) Tighten distributor valve or engine shaft extension.
	(3) Leaky gaskets.	(3) Replace gaskets.
	b. Dome Breather Hole.	
	(1) Damaged seal.	(1) Replace seal.
	(2) Loose dome breather hole nut.	(2) Tighten nut.
	(3) Washer missing.	(3) Install washer.
	c. Interference between breather pipe in propeller shaft and distributor valve oil transfer plate fillet.	*c.* Rework fillet.
	d. Dome Retaining Nut.	
	(1) Damaged seal.	(1) Replace seal.
	(2) Loose nut.	(2) Tighten nut.
	e. Blades.	
	(1) Damaged packing or molded chafing ring.	(1) Replace packing and molded chafing ring by split type chafing ring.
	f. Barrel Half Seals.	
	(1) Damaged seals.	(1) Replace seals.
	(2) improper closure of barrel half.	(2) Remove burrs from parting surfaces of barrel half.
	g. Barrel Spider Packing.	
	(1) Damaged packing.	(1) Replace packing.
	h. Rear Cone.	
	(1) Damaged spider shaft oil seal.	(1) Replace seal.
	(2) Spider shaft oil seal washer installed improperly.	(2) Install in proper sequence–washer, seal, ring.
	(3) Spider shaft oil seal washer missing.	(3) Install washer.
	i. General.	
	(1) Engine thrust plate seal.	(1) Consult engine manual.

f. PROPELLER AND CONTROLS TROUBLE SHOOTING LIST.–Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
5. Roughness.	*a.* Spark plugs or ignition.	*a.* Replace spark plugs–check wiring.
	b. Propeller unbalance.	*b.* Check balance (effects will be greater at high rpm).
	c. Blade angles vary.	*c.* Correct angles–(effects will be greater at high rpm).
6. Failure to Feather.	*a.* Batteries low.	*a.* Recharge batteries.
	b. Faulty electrical system.	*b.* Check power and control circuits of feathering pump.
	c. Failure of pushbutton to remain engaged.	*c.* Check wiring or low pressure setting of cutout switch.
	d. Failure to remain unfeathered. (1) Pushbutton fails to disengage.	*d.* Reset cutout switch.
	e. Incorrect high pitch stop ring settings.	*e.* Reset stop ring.
	f. Sheared coupling in feathering pump.	*f.* Replace coupling.
	g. Restricted oil supply to feathering pump.	*g.* Check feathering pump inlet lines for foreign material, and bleed line.
	h. Excessive leakage.	
	(1) Improper distributor valve installation.	(1) Check for tightness or interference.
	(2) Poor or incorrect gaskets between distributor valve and propeller shaft and between governor base engine mounting pad.	(2) Install new gaskets.
	(3) Engine transfer rings.	(3) Replace defective engine.
	i. Defective feathering pump.	*i.* Replace pump.
7. Failure to Unfeather.	*a.* Batteries low.	*a.* Recharge batteries.
	b. Faulty electrical system.	*b.* Check power and control circuits of feathering pump.
	c. Excessive leakage.	
	(1) Engine transfer rings.	(1) Replace defective engine.
	(2) Improper distributor valve installation.	(2) Check tightness or interference.
	(3) Poor or incorrect gaskets between distributor valve and propeller shaft and between governor base engine mounting pad.	(3) Install new gaskets.
	d. Sheared coupling in feathering pump.	*d.* Replace coupling.
	e. Restricted oil supply to feathering pump.	*e.* Check feathering pump inlet lines for foreign material and bleed line.
	f. Defective feathering pump.	*f.* Replace pump.

11. FUEL SYSTEM.

a. GENERAL. *(See figure 200.)*—The fuel system includes five self-sealing fuel cells, an engine-driven fuel pump mounted on each engine, electrically operated fuel booster pumps on each fuel tank, fuel level transmitters in each tank with fuel quantity indicators in the pilot's compartment, two cable controlled fuel tank selector valves, one cable-controlled cross-feed and bomb bay fuel tank(s) selector valve, two fuel strainers, two fuel pressure transmitters and a dual fuel pressure indicator, drain cocks, engine priming and oil dilution solenoid valves, and the necessary lines and fittings. Provisions are made for the installation of a non-self-sealing long range tank in the bomb bay. The normal fuel system capacity is 925 U. S. gallons (771 Imperial gallons) which is increased by 675 U. S. gallons (562 Imperial gallons) by installation of the long range tank. Normal fuel pressure is 17 $\pm$ 1 psi with the engines operating at 2000 rpm.

b. FILLING THE FUEL SYSTEM.

(1) All fuel delivery hose must be metal-lined or bonded between the nozzle and the fittings on the opposite end. In addition, one end of a flexible bonding wire or cable shall be attached permanently to the discharge nozzle. When a fuel tank is filled, attach the free end of the bonding wire to a convenient, uninsulated metallic part of the airplane to insure an electrical bond between the tank and the delivery hose. DO NOT attach the bonding wire near the filler neck of the tank. A standard test clip may be used on the free end of the bonding wire for conveniently attaching or removing the wire. The bonding wire must be attached before removing the tank filler cap and must not be disconnected until the filler cap has been reinstalled.

CAUTION

Filling of the fuel tanks should be accomplished in the open air and care must be taken to avoid spilling fuel. All precautions against fire must be observed. Fuel trucks must be equipped with a suitable static ground chain.

(2) Care must be taken while filling the fuel cells to prevent damage to the tank filler necks. The discharge nozzle must be held and must not be placed in the filler neck without support.

(3) The main (nacelle) fuel cells are located in each nacelle and have a capacity of 300 U. S. gallons 249.8 Imperial gallons). The filler wells are located on the aft outboard corner of each tank and are accessible from the top side of the nacelle. *(See 6, 14, & 22, figure 7.)* An overflow drain line at the filler well allows excess fuel to be discharged to the ground.

(4) The auxiliary (wing) fuel cells are located in the wing between the nacelles and fuselage and have a capacity of 100 U. S. gallons (83.3 Imperial gallons). The filler wells are located immediately inboard of each nacelle and are accessible from the top side of the wing. An overflow drain line at the filler well allows excess fuel to be discharged to the ground.

(5) The auxiliary (bomb bay) fuel cell is installed in the top forward section of the bomb bay and has a capacity of 125 U. S. gallons (104.1 Imperial gallons). The filler well is located at the top, left-hand side of the fuselage. An overflow drain line at the filler well permits excess fuel to be discharged to the ground. When the long range tank is installed in the bomb bay the combined capacity of the auxiliary (bomb bay) cell and long range tank is 800 U. S. gallons (666.4 Imperial gallons). The same filler well is used for filling either the auxiliary (bomb bay) cell alone or the bomb bay cell and long range tank combined. *(See 6, figure 7.)*

c. DRAINING THE FUEL SYSTEM.

(1) GENERAL.—Drain cocks are installed in all fuel cells, both fuel strainers, and booster pumps, and a drain plug is installed in the long range tank to facilitate complete drainage of the fuel system or drainage of accumulated moisture from the fuel container sumps. *(See figure 202.)*

(2) DRAINING THE COMPLETE SYSTEM.

(a) Open the deflector plating at the bottom of both nacelles by releasing the fasteners.

(b) Place a suitable container beneath the drain elbows in the fuel strainers.

(c) Place the cross feed and bomb bay tank(s) selector valve in the "OFF" position.

(d) Place both fuel tank selector valve controls in the "MAIN ON" positions.

(e) Place the corresponding booster pump switches in the "HIGH BOOST" position.

(f) Place the booster pump switches and selector valve controls in the "OFF" position, after the main cells and lines have been drained.

(g) Open the drain cock on the bottom of each main cell and allow the residual fuel to drain into a container. Close the drain cock after the fuel has drained.

(h) Place both fuel tank selector valve controls in the "AUXILIARY ON" positions.

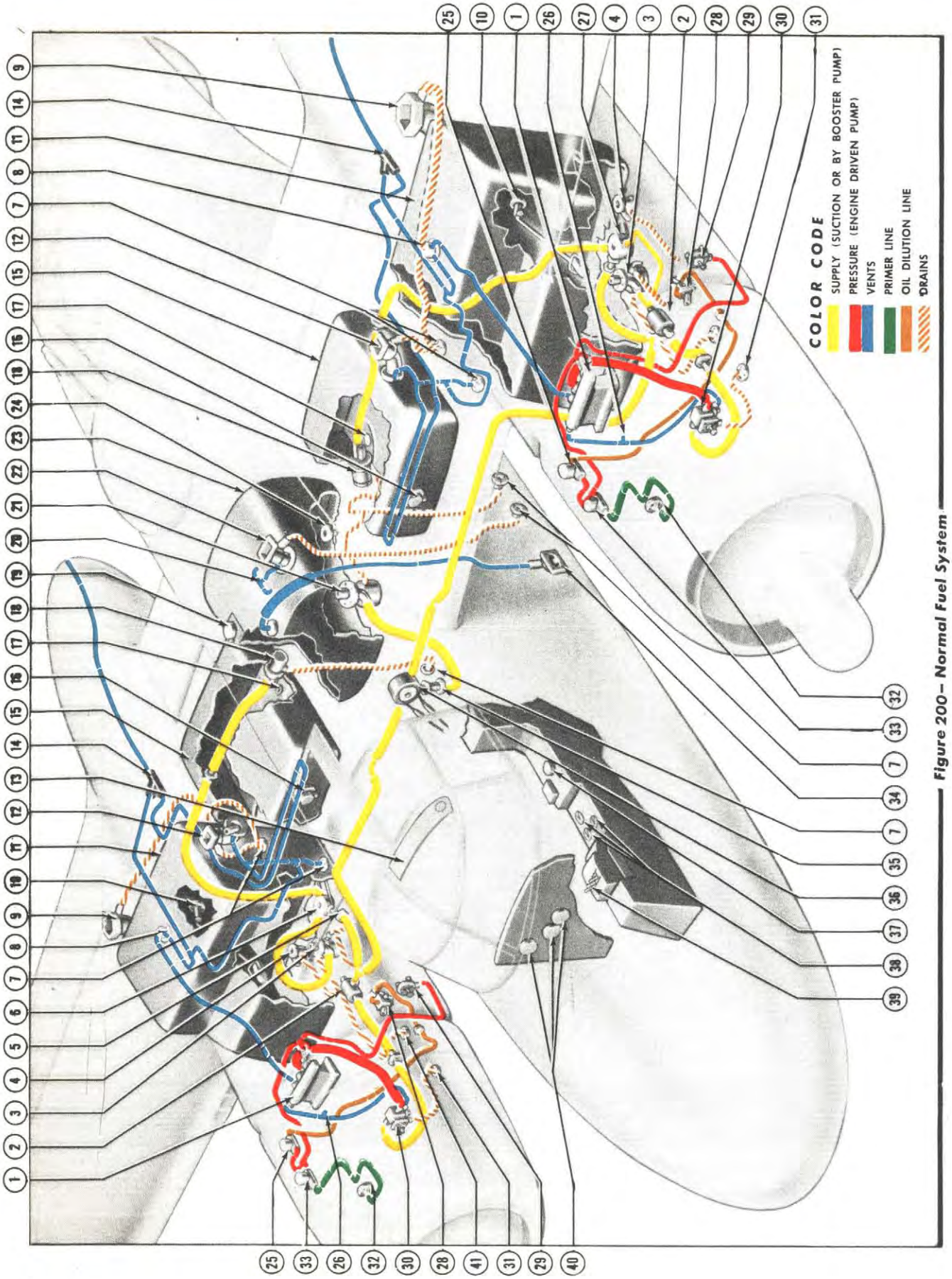


Figure 200– Normal Fuel System

KEY TO FIGURE 200

1. Carburetor
2. Fuel Strainer *(Figure 222)*
3. Main (Nacelle) Fuel Cell Booster Pump
4. Main Fuel Cell Drain Cock
5. Coupling (Check Valve on Some Airplanes)
6. Right Hand Fuel Tanks Selector Valve
7. Flanges
8. 2126545 Vent and Vapor Return Fitting, 1128968 Gasket
9. Main (Nacelle) Fuel Cell Filler Wells
10. Fuel Level Transmitters (Main Fuel Cells)
11. Main (Nacelle) Fuel Cells *(Figures 206 & 207)*
12. Auxiliary (Wing) Fuel Cell Filler Wells
13. Engine Primer and Oil Dilution Control Switches *(Figure 205)*
14. Manifold Fitting
15. Auxiliary (Wing) Fuel Cells
16. Fuel Level Transmitters (Wing Fuel Cells)
17. Auxiliary (Wing) Fuel Cell Draink Cocks
18. Auxiliary (Wing) Fuel Cell Booster Pumps
19. Fuel Level Transmitter Bomb Bay Cell (Located on Bottom of Cell on Some Airplanes)
20. Vent Fitting (Tee must be Capped when Long Range Tank is Not Installed)
21. Bomb Bay Cell Fuel Booster Pump
22. Bomb Bay Fuel Cell Filler Well
23. Auxiliary (Bomb Bay) Fuel Cell *(Figures 211 & 212)*
24. Bomb Bay Fuel Cell Drain Cock
25. Oil Dilution Solenoid Valve
26. Fuel Pressure Gage Vent Line Connection
27. Left Hand Fuel Tanks Selector Valve
28. Oil System "Y" Drain Cock
29. Fuel Pressure Transmitter *(Figure 241)*
30. Type G9 Engine Driven Fuel Pump
31. 1202421 Flange
32. Engine Primer Distributor (On Engine)
33. Engine Primer Solenoid Valve
34. 5150303 Vent Fitting
35. 2206737 Coupling (Check Valve on Some Airplanes)
36. Cross-Feed and Bomb Bay Tank(s) Selector Valve *(Figure 221)*
37. Long Range Tank Fuel Indicator *(Figure 205)*
38. Fuel Tank Selector Valve Controls *(Figure 205)*
39. Fuel Booster Pump Selector Switches *(Figure 205)*
40. Fuel Pressure Gage and Fuel Level Indicators *(Figure 205)*
41. 2193628 Flange
    1193826 Gasket

(i) Place the corresponding booster pump switches in the "HIGH BOOST" positions.

(j) Place the booster pump switches and selector valve controls in the "OFF" positions, after the auxiliary (wing) cells and lines have drained.

(k) Open the drain cocks on the auxiliary (wing) cells *(7, figure 202)* and allow the residual fuel to drain into a container. Close the drain cocks after the fuel has drained.

(l) Be sure the cross-feed and bomb bay tank(s) selector valve still is in the "OFF" position.

(m) Place containers beneath the bomb bay cell drain cocks on the booster pump and bottom of the cell *(9 & 10, figure 202)*.

(n) Open the drain cocks and allow the bomb bay cell to drain. Close the drain cocks after the fuel has drained.

(o) If the long range tank is installed both the bomb bay cell and long range tank may be drained by removing the drain plug in the long range tank and opening the drain cock on the booster pump. Replace the drain plug and close the drain cock after the fuel has drained into suitable containers.

(3) DRAINING ACCUMULATED MOISTURE.

(a) Open the drain cocks on the fuel cells, booster pumps, and fuel strainers, and remove the drain plug from the long range tank. *(See 5, figure 215.)* When the water has been drained from the tanks, close all drain cocks, replace the drain plug in the long range tank, and replace all lock wire.

(b) Accumulated moisture must be drained from the fuel tanks before and after each flight and at frequent intervals when the airplane is inactive. Frequent draining of water from the fuel tanks aids in preventing water from being drawn into the fuel lines or freezing during cold weather operations. Local stoppage of fuel lines caused by ice particles may be eliminated by heating the lines with a heater that does not employ an open flame.

(c) The fuel tanks should be serviced at the end of each flight to eliminate air spaces in the tanks in which condensation of moisture can occur.

d. FUEL SYSTEM CONTROLS AND INSTRUMENTS. *(See figure 205.)*

(1) CONTROLS.

(a) FUEL TANK SELECTOR CONTROLS.—The fuel tank selector controls are located on the pedestal in the pilot's compartment *(figure 205)* and operate the tank selector valves and cross-feed and bomb bay tank(s) selector valve by means of cables. One tank selector valve controls the left hand main and auxiliary tanks and one controls the right hand main and auxiliary tanks. The cross-feed and bomb bay tank(s) selector valve controls fuel cross feed and selection of fuel from the bomb bay cell alone or in combination with the long range tank. For complete information about the selector valves and controls refer to paragraph 11. *k.*, this section.

(b) FUEL BOOSTER PUMP SELECTOR SWITCHES.—Three switches are installed on the control pedestal, one for the booster pumps in each wing fuel system and one for the bomb bay tank booster pump. Each switch has two positions "LOW BOOST" and "HIGH BOOST." The "LOW BOOST" position sets up the circuit for normal operation of the booster pump while "HIGH BOOST" position sets up the circuit for increased booster pump operation, which is controlled by the booster pump rheostats. For complete information about the fuel booster pump selector switches refer to paragraph 15. *d.* (5), this section.

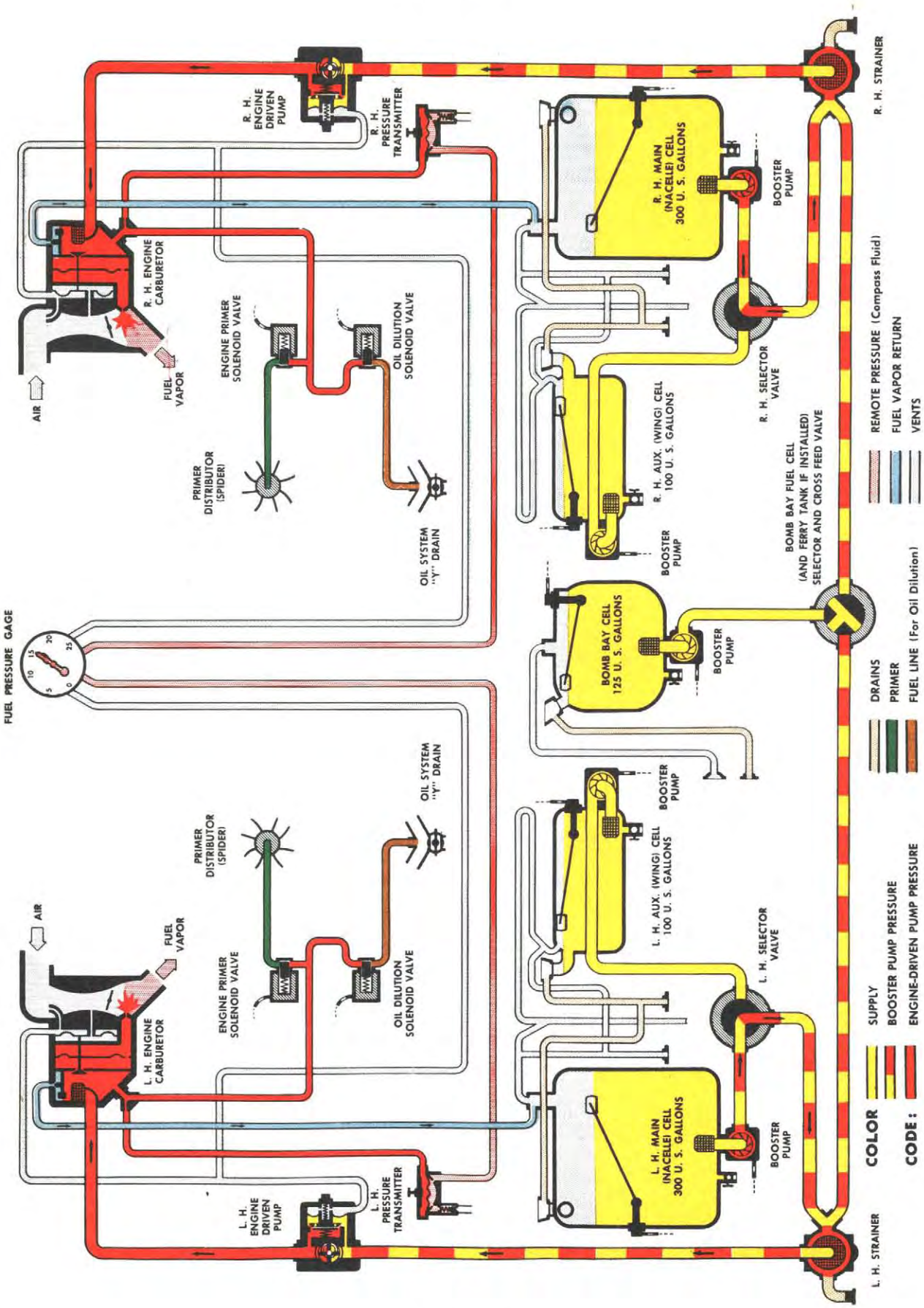
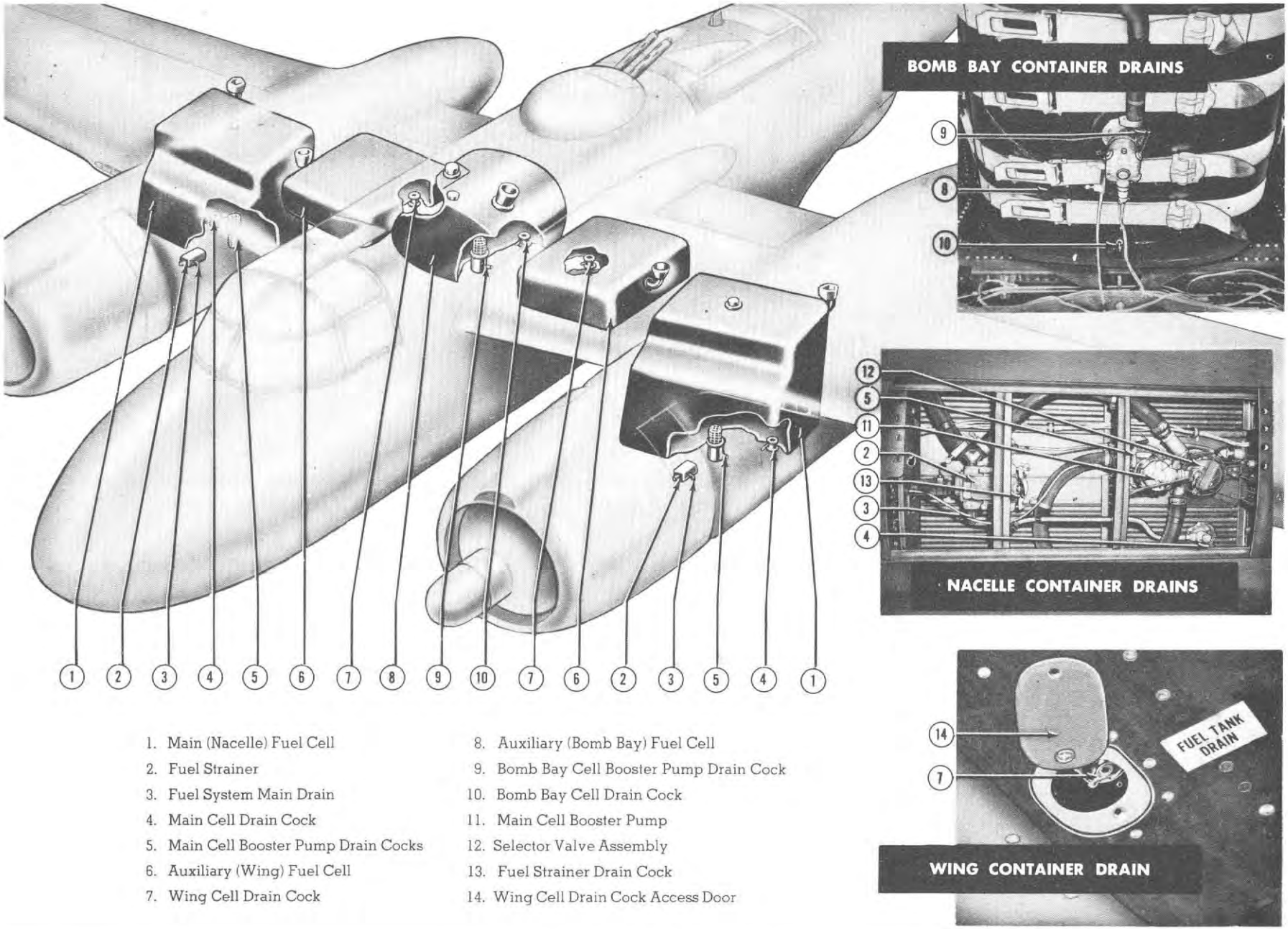
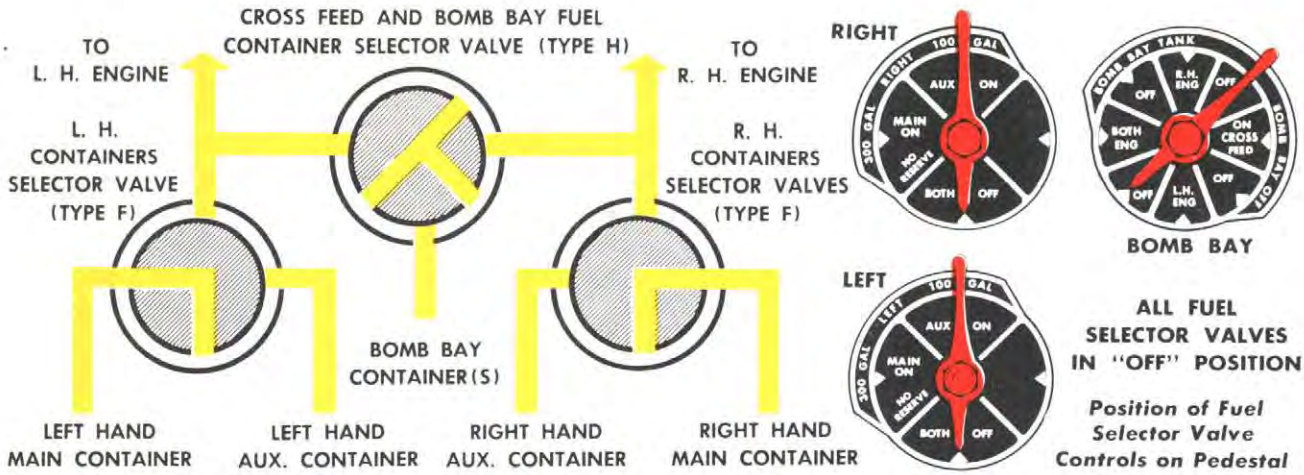


Figure 201 — Fuel System Flow Diagram



1. Main (Nacelle) Fuel Cell
2. Fuel Strainer
3. Fuel System Main Drain
4. Main Cell Drain Cock
5. Main Cell Booster Pump Drain Cocks
6. Auxiliary (Wing) Fuel Cell
7. Wing Cell Drain Cock
8. Auxiliary (Bomb Bay) Fuel Cell
9. Bomb Bay Cell Booster Pump Drain Cock
10. Bomb Bay Cell Drain Cock
11. Main Cell Booster Pump
12. Selector Valve Assembly
13. Fuel Strainer Drain Cock
14. Wing Cell Drain Cock Access Door

Figure 202—Fuel System Drains



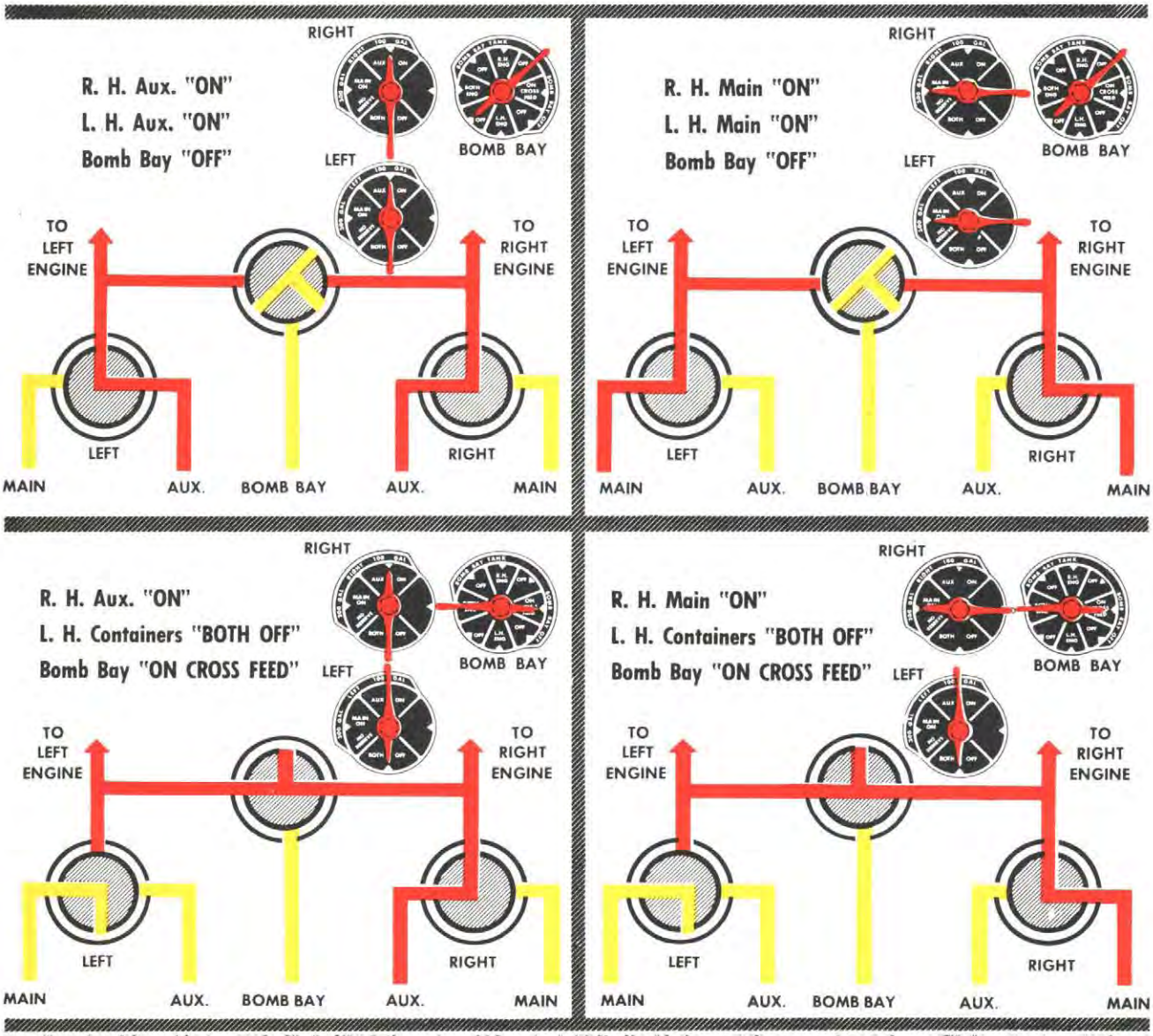


Figure 203(Sheet 1 of 2) — Alternate Positions of Fuel Container Selector Valves

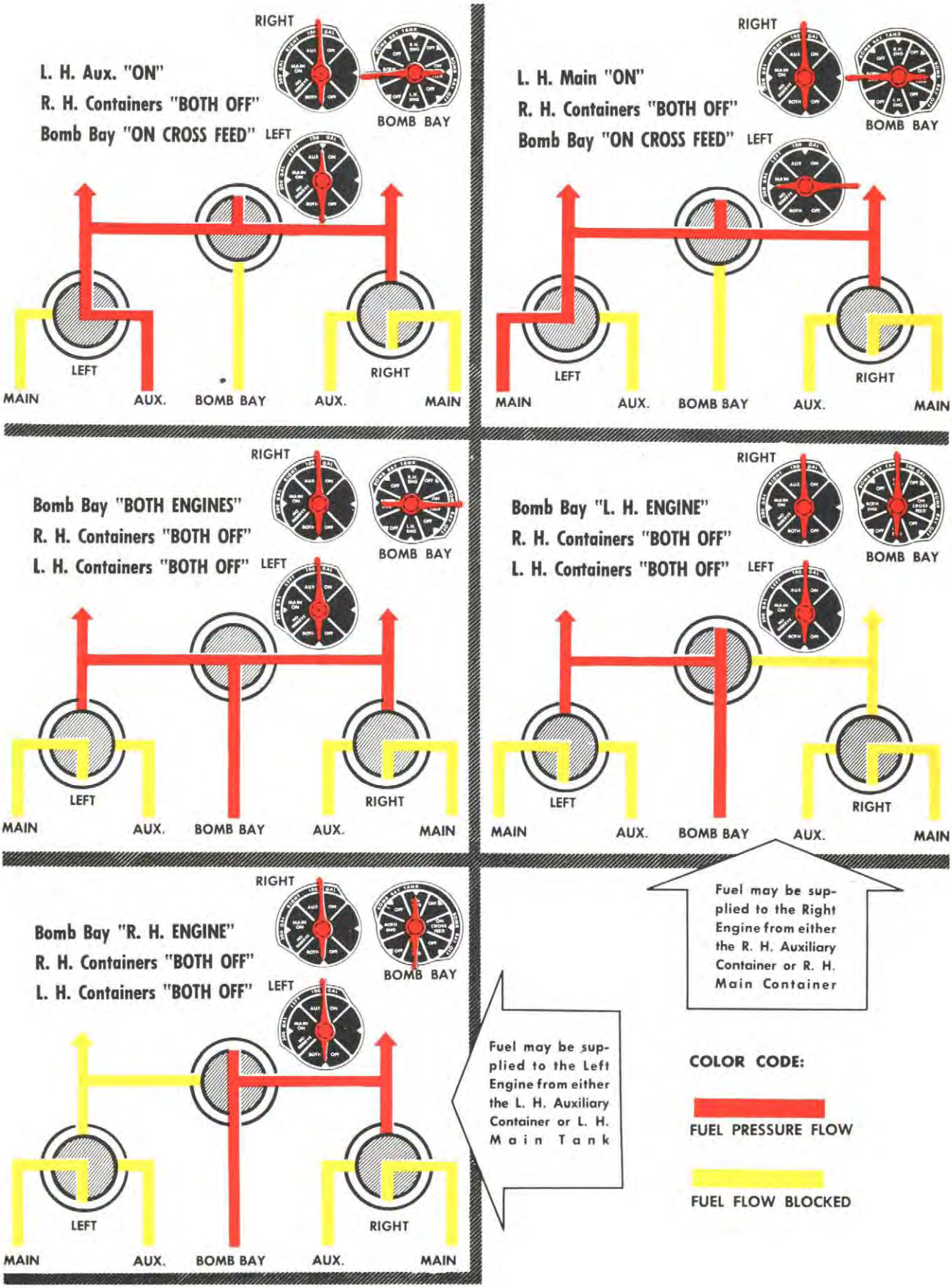


Figure 203(Sheet 2 of 2) — Alternate Positions of Fuel Container Selector Valves

FUEL TANK SELECTOR VALVE CONTROLS — FUEL BOOSTER PUMP SELECTOR SWITCHES

	Desired Transfer	L.H. Selector Control Position	R.H. Selector Control Position	Cross Feed Bomb Bay Control Position	L. H. Booster Pumps Switch	R. H. Booster Pumps Switch	Bomb Bay Booster Pump Switch
1.	L.H. Main to R.H. Main	MAIN ON	MAIN ON	ON CROSS FEED	HIGH BOOST	OFF	OFF
2.	L.H. Main to R.H. Auxiliary	MAIN ON	AUX. ON	ON CROSS FEED	HIGH BOOST	OFF	OFF
3.	L.H. Main to Bomb Bay	MAIN ON	BOTH OFF	L.H. ENG.	HIGH BOOST	OFF	OFF
4.	L.H. Main to L.H. Auxiliary	FOLLOW PROCEDURES 1 AND 6, OR 2 AND 8, OR 3 AND 10.					
5.	R.H. Main to L.H. Main	MAIN ON	MAIN ON	ON CROSS FEED	OFF	HIGH BOOST	OFF
6.	R.H. Main to L.H. Auxiliary	AUX. ON	MAIN ON	ON CROSS FEED	OFF	HIGH BOOST	OFF
7.	R.H. Main to Bomb Bay	BOTH OFF	MAIN ON	R.H. ENG.	OFF	HIGH BOOST	OFF
8.	R.H. Main to R.H. Auxiliary	FOLLOW PROCEDURES 5 AND 2, OR 6 AND 14, OR 7 AND 12.					
9.	Bomb Bay to L.H. Main	MAIN ON	BOTH OFF	L.H. ENG.	OFF	OFF	HIGH BOOST
10.	Bomb Bay to L.H. Auxiliary	AUX. ON	BOTH OFF	L.H. ENG.	OFF	OFF	HIGH BOOST
11.	Bomb Bay to R.H. Main	BOTH OFF	MAIN ON	R.H. ENG.	OFF	OFF	HIGH BOOST
12.	Bomb Bay to R.H. Auxiliary	BOTH OFF	AUX. ON	R.H. ENG.	OFF	OFF	HIGH BOOST
13.	L.H. Auxiliary to R.H. Main	AUX. ON	MAIN ON	ON CROSS FEED	HIGH BOOST	OFF	OFF
14.	L.H. Auxiliary to R.H. Auxiliary	AUX. ON	AUX. ON	ON CROSS FEED	HIGH BOOST	OFF	OFF
15.	L.H. Auxiliary to Bomb Bay	AUX. ON	BOTH OFF	L.H. ENG.	HIGH BOOST	OFF	OFF
16.	L.H. Auxiliary to L.H. Main	FOLLOW PROCEDURES 13 AND 5, OR 14 AND 17, OR 15 AND 9.					
17.	R.H. Auxiliary to L.H. Main	MAIN ON	AUX. ON	ON CROSS FEED	OFF	HIGH BOOST	OFF
18.	R.H. Auxiliary to L.H. Auxiliary	AUX. ON	AUX. ON	ON CROSS FEED	OFF	HIGH BOOST	OFF
19.	R.H. Auxiliary to Bomb Bay	BOTH OFF	AUX. ON	R.H. ENG.	OFF	HIGH BOOST	OFF
20.	R.H. Auxiliary to R.H. Main	FOLLOW PROCEDURES 17 AND 1, OR 18 AND 13, OR 19 AND 11.					

CAUTION—Fuel transfer is to be accomplished only when the airplane is on the ground and when the engines are not operating. Observe fuel quantity indicators closely to prevent overflow of fuel.

Figure 204 — Fuel Transfer Chart

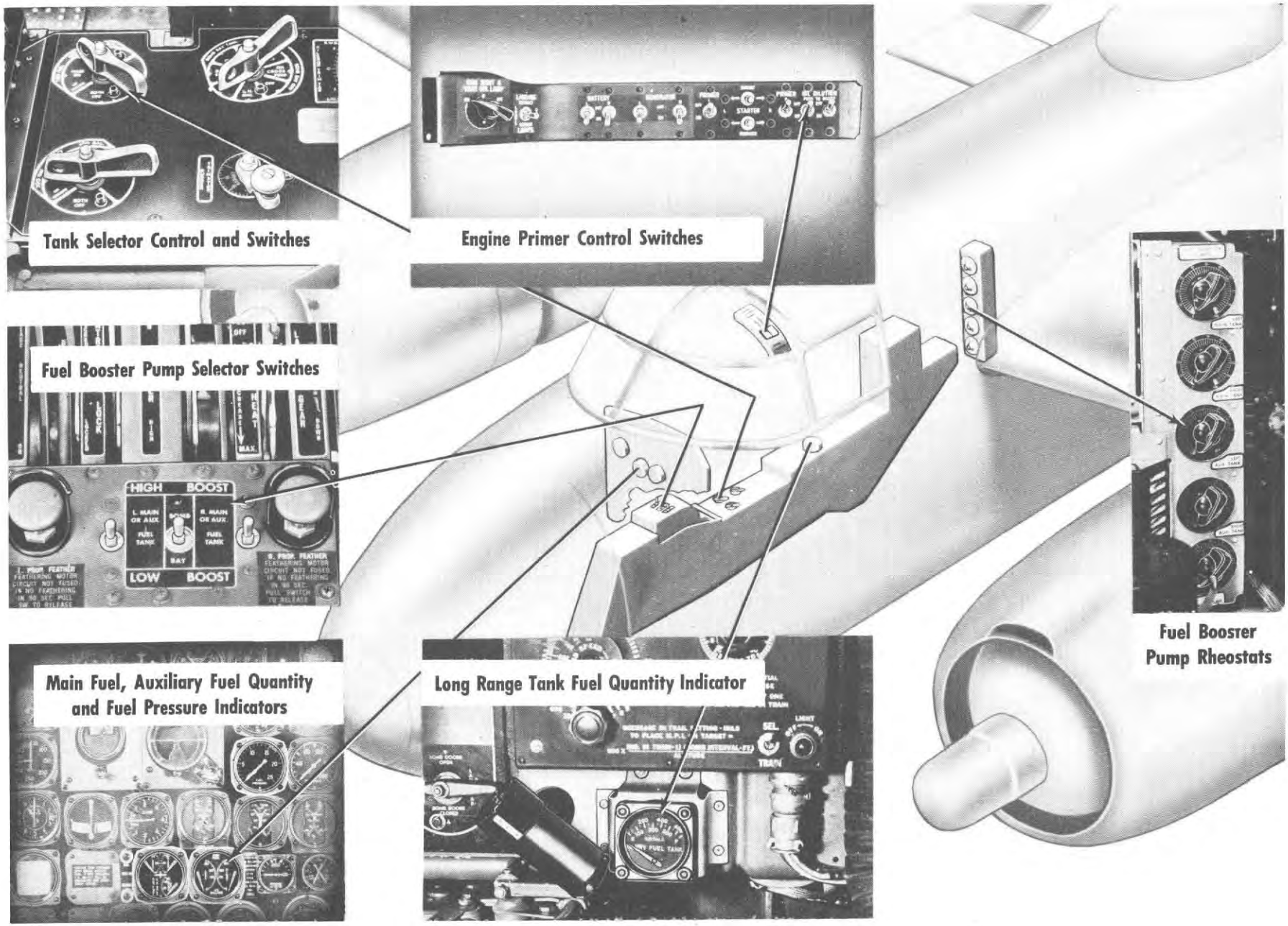


Figure 205 — Fuel System Instruments and Controls

(c) FUEL SELECTOR SWITCHES. – Two rotary type fuel selector switches are installed on the control pedestal. A lever is attached to the fuel tank selector valve control shaft and rotates with the shaft in conjunction with the three positions of the selector valve control, "MAIN ON," "AUX ON," and "BOTH OFF." Each fuel selector switch is wired to the corresponding booster pump selector switch. When the booster pump selector switch is in either the "LOW BOOST" or "HIGH BOOST" position, the booster pumps in the wing fuel system are operated automatically by the selector valve control. The bomb bay tank(s) booster pump has no fuel selector switch and is controlled directly by the booster pump selector switch on the pedestal, independently of the setting of the cross feed and bomb bay tank(s) selector valve control. For complete information about the fuel selector switches refer to paragraph 15. *d.* (5) *(d).*

(d) FUEL BOOSTER PUMP RHEOSTATS.– Five rheostats are installed on the control pedestal behind the pilot's seat and regulate the speed of the booster pumps in the "HIGH BOOST" position. For complete information about the fuel booster pump rheostats refer to paragraph 15. *d.* (5), *(d)*, this section.

(e) ENGINE PRIMER AND OIL DILUTION SWITCHES.–Priming of the engines and dilution of the engine oil are controlled by electrical switches located on the pilot's overhead electrical panel. For complete information about these switches refer to paragraph 15. *d.* (2) *(c)*, and 15. *d.* (7), this section.

(2) INSTRUMENTS.

(a) FUEL PRESSURE INDICATOR.–A dual fuel pressure indicator is installed on the pilot's main instrument panel to indicate the fuel pressure at each carburetor. Normal fuel pressure is 17 ± 1 psi. A fuel pressure transmitter is installed on each firewall. For complete information about the fuel pressure indicating system refer to paragraph 13. *f.* (6), this section, and *figure 241.*

(b) FUEL LEVEL TRANSMITTERS. – A fuel level transmitter is installed in each fuel tank and consists of a float arm, gears, adjusting screw, and electrical receptacle. Each transmitter is wired to the proper fuel quantity indicator in the pilot's compartment. For complete information about the fuel level transmitters refer to paragraph 15. *d.* (12) *(f)*, this section.

(c) FUEL QUANTITY INDICATORS.–Three fuel quantity indicators are installed in the pilot's compartment. A dual indicator, located on the main instrument panel, indicates the fuel quantities in the left and right main (nacelle) cells. The auxiliary fuel quantity indicator, also located on the main instrument panel, indicates the fuel quantities in the auxiliary (wing and bomb bay) cells. The long range tank (ferry fuel) fuel quantity indicator is located on the control pedestal.

e. FUEL TANK SELECTION.–Refer to *figure 203* for schematic diagrams of fuel flow to the engines and combinations of alternate fuel tank selector valve control settings.

f. FUEL SYSTEM ADJUSTMENTS.

(1) FUEL PRESSURE.–Refer to paragraph 11. *i.* (5), this section.

(2) FUEL BOOSTER PUMP RHEOSTATS.–Refer to paragraph 15. *d.* (5) *(b)*, this section.

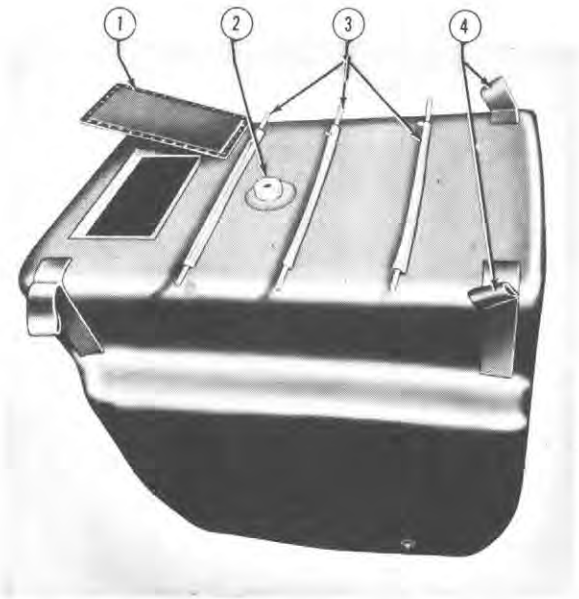
(3) FUEL QUANTITY TRANSMITTERS AND INDICATORS.–Refer to paragraph 15. *d.* (12), this section.

g. FUEL TRANSFER.–Check valves were installed in the fuel lines *(figure 200)* on some airplanes and transfer of fuel from one tank to another is not possible. On other airplanes the check valves were removed from the fuel system and transfer of fuel is possible if the engines are not running. To transfer fuel from tank to tank observe the procedures given in *figure 204.*

h. FUEL CELLS AND TANKS.

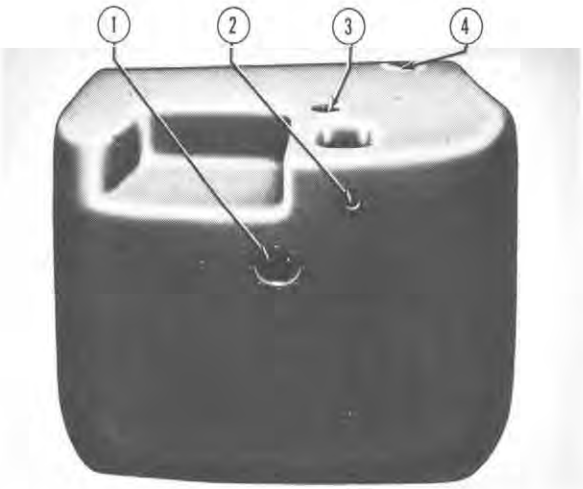
(1) MAIN (NACELLE) FUEL CELLS.
(See figures 206 & 207.)

(a) DESCRIPTION.–The self-sealing main fuel cells are installed in each nacelle between the wing spars and have a fuel capacity of 300 U. S. gallons (249.8 Imperial gallons). The filler well is located at the aft outboard corner of the cell and may be reached through an access hole on the top of the wing. A fuel level transmitter is installed on the aft side of the cell.



1. Access Cover
2. Vent and Carburetor Vapor
3. External Stiffeners
4. Hoisting Straps

Figure 206 — Main (Nacelle) Fuel Cell (Top View)



1. Opening for Fuel Booster Pump
2. Opening for Drain Cock
3. Opening for Fuel Level Transmitter
4. Opening for Filler Well

Figure 207 — Main (Nacelle) Fuel Cell (Bottom View)

A fuel booster pump and drain valve are installed on the bottom of the cell. The carburetor vapor vent line is connected to the fitting at the top of the cell and the vapor return flow from each carburetor to the corresponding main fuel cell may reach a maximum of 10 gallons an hour. Drain and vent lines are provided on each main cell. Internal and external stiffeners aid in maintaining the proper contour of the cell. Rubber padding and fabric panels are installed on the surrounding wing structure to protect the cell against chafing.

(b) REMOVAL.

1. Drain all fuel from the main cell as instructed in paragraph 11. *c.*, this section.

2. Remove the lower half of the engine cowl as instructed in paragraph 6. *b.* (14) *(b)*, this section.

3. Install a jack and support stand under the rocker arm boxes in the forward bank of engine cylinders *(figure 27)*. It is necessary to support the engine because the wing is weakened when the large stress panel is removed.

4. Remove the oil tank filler well access cover and remove the screws that attach the filler well to the oil tank nacelle fairing. Remove the screws along the outer edges of the oil tank fairing and remove the fairing.

5. Remove the nuts and bolts that secure the forward portion of the nacelle fairing to the brackets on the wing front spar.

6. Remove the wing hoisting hook access cover on the top of the nacelle *(figure 11)*. From the nacelle wheel well use a socket wrench and extension to remove the bolts that attach the nacelle fairing to the stress panel.

7. Remove the screws that attach the nacelle fairing to the filler well and filler well retainer. Remove the screws at the outer edges of the nacelle fairing and remove the fairing.

8. Remove the access cover from the stress panel. Remove the bolts that attach the brackets on the stress panel to the fuel cell. Remove the fuel cell cover.

Note

The bolts with the heads painted red attach the fuel cells to the stress panel brackets. The bolts with unpainted heads attach the fuel cell cover to the cell.

9. Disconnect the vent lines at the wing front and rear spars. Disconnect the vent lines from the fitting on the stress panel. Remove the screws that attach the flange assembly and gasket to the stress panel and remove the flange assembly.

10. Remove the screws at the outer edges of the stress panel and remove the stress panel.

11. Disconnect the drain line from the synthetic rubber filler well. Disconnect the grounding jack. Remove the screws that attach the filler well to the filler neck and remove the filler well.

12. Remove the screws that attach the filler neck and mounting ring to the fuel cell. Hold the mounting ring through the access hole in the cell while removing the screws. Remove the filler neck and mounting ring.

13. Disconnect the electrical wiring from the fuel level transmitter at the forward end of the main landing gear wheel well. Remove the screws that attach the fuel level transmitter to the mounting flange and carefully remove the transmitter.

CAUTION

Care must be observed to prevent damage to the float arm and float when the transmitter is removed from the fuel cell.

14. Remove the screws that attach the fuel level transmitter mounting ring to the support flange and remove the mounting ring through the cell access hole.

15. Remove the fuel cell drain valve from the bottom of the cell by removing the attaching screws.

16. Disconnect the electrical wiring at the disconnect plug on the fuel booster pump. Remove the screws and nut that attach the booster pump to the support casting and remove the booster pump. Remove the screws from the booster pump mounting ring and remove the mounting ring through the fuel cell access hole.

17. Remove the screws that attach the plugged heater outlet fitting on the front wall of the fuel cell (right-hand cell only) and remove the fitting.

18. Open the slide fasteners and remove the external stiffeners from the top of the cell. Carefully loosen the sides of the fuel cell from the surrounding nacelle structure and lift the cell from the nacelle by means of the hoisting straps.

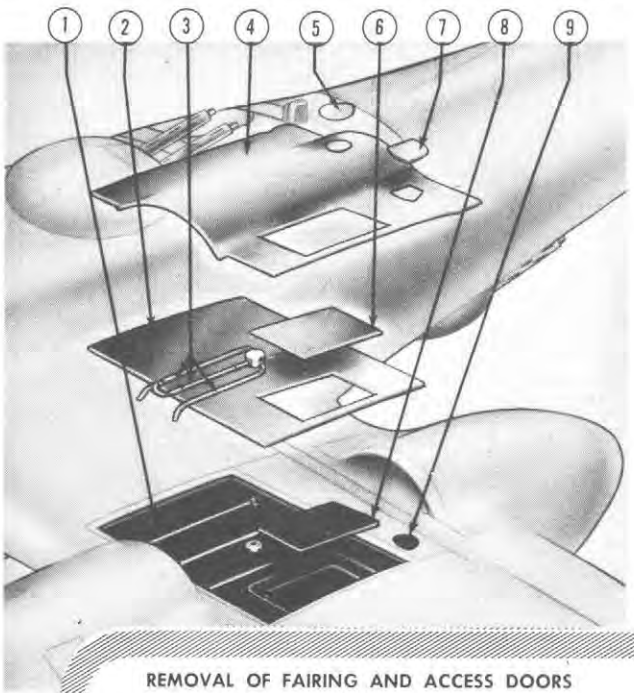
(c) MAINTENANCE REPAIR OR REPLACEMENT.—The majority of all self-sealing fuel cell damage can be attributed to improper installation, that is, structural damage to the cell itself; damaged or torn inner liner; separation of plies; damaged or loosened fittings; excessive scuffing of either interior or exterior ply of the cell; high torque on the attaching bolts or screws, or the action of deteriorating solvents. Inner liner failure will permit gasoline to come into contact with the sealant material causing localized swelling. The same condition will result if the exterior of the cell is exposed to gasoline for a prolonged period of time. Fitting failure is followed by the loss of fuel, frequently resulting in swollen spots. All fitting failures or damage require immediate corrective action. Further information on fittings may be found in T.O. No. 03-10J-4.

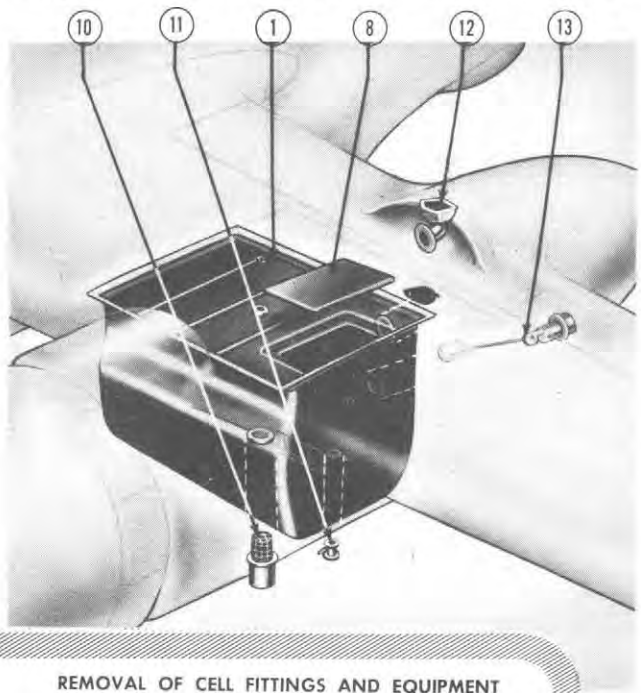
1. INSPECTION OF REPAIRABLE CELLS.

a. Inspect the interior of the cell for loose areas between the plies of material, blistered areas, or spots where cements have failed (loss of adhesion). Be especially careful to note any raised areas or looseness around the bases of fittings.

b. Inspect for breaks in the outside covering, especially on the binding strips around the edges of the cell. A scuffed area will permit spilled gasoline to penetrate the retainer and cause swelling of the sealant layer.

c. Check all protruding fittings by GENTLY FLEXING them in all directions to reveal any cracks or torn places. Check metal inserts or washers to determine damage caused by pressure or excessive torque. Check threads in metal inserted fittings to see





REMOVAL OF FAIRING AND ACCESS DOORS

1. Main (Nacelle) Fuel Cell
2. Stress Panel
3. Vent and Carburetor Vapor Return Lines
4. Nacelle Fairing
5. Wing Hoist Fitting Access Door
6. Stress Panel Access Door
7. Filler Well Access Door
8. Cell Access Cover

REMOVAL OF CELL FITTINGS AND EQUIPMENT

9. Filler Well Access Hole
10. Fuel Booster Pump
11. Cell Drain Cock
12. Filler Well and Filler Neck Casting
13. Fuel Level Transmitter

NOTE—Disconnect fuel lines and electrical wiring before removing cell. Hoist cell by means of hoisting straps on cell.

Figure 208 — Removal of Main (Nacelle) Fuel Cell

that they are not stripped or damaged. Insure that the tapped hole is not filled with anything that will cause bolts or screws to bottom prematurely.

d. Examine the interior of the cell with a vaporproof light. If gasoline has penetrated the lining, a swollen or soft area will be the first indication. The hole in the lining may be so small as to be almost invisible, but the swelling will be quite prominent if the hole has been of long standing.

WARNING

Gasoline vapors are toxic and should not be inhaled for a prolonged period of time.

e. A loose area, whether raised or flat, between the inner liner and the first ply of the sealant, is not harmful if it does not exceed one inch in diameter. Such an area or blister is generally a manufacturing imperfection caused by trapped air, solvent, or moisture during the manufacture of the cell.

f. Examine, with a mirror if necessary, all sides of the cell for cracks or folds. It is difficult to determine whether an apparent defect is actually a harmful crack or a harmless fold in the inner liner. If in doubt close all fitting openings in the cell and fill it with gasoline. It is imperative that the cell is placed in a temporary crate of appropriate size and shape. Drain the cell after 48 hours and look for swollen areas directly behind the doubtful fold. If no swollen area is present, the fold may be considered harmless and the cell may be used if no other defects are found.

2. INSPECTION OF CELLS INSTALLED IN THE AIRPLANE.

a. Obviously, a detailed inspection as outlined above is not practical for cells installed in the airplane, and frequent inspections requiring the removal of the cells are not desirable. However, during preflight inspection as many as possible of the above items should be observed through the available access openings.

b. At 30 day intervals, or in connection with every second 100-hour inspection, whichever is first, the following inspections are to be made:

(1) Drain the self-sealing fuel cells as instructed in paragraph 11 *c.*, this section, and drain the oil tanks as instructed in paragraph 12. *d.*, this section. Prior to placing the airplane back in service, refill the cells and compare the quantity of fuel or oil required to fill each cell to the normal capacity with the original capacity as stencilled on the filler caps or covers. If the capacity of the cell is less than 95 percent of the original capacity, the cells must be inspected to determine the cause of the reduced capacity.

Note

This inspection may be made conveniently by conducting it at the end of a flight and before the fuel cells or oil tanks are serviced.

(2) Visually inspect cells, fittings, and connections through the access holes as much as possible without actually removing the cells from the airplane.

c. TWELVE MONTH INSPECTION.—At the end of each 12 month service, inspect thoroughly the interior of the cells for any indication of failure such as those listed in paragraph 11. *b. (c)*, this section. This will be accomplished through access holes, or if necessary, by the removal of the cells from the airplane. If evidence of deterioration is found, the cells will be repaired or replaced in accordance with the instructions contained in the No. 03-10J-series Technical Orders. Serviceable cells may be reinstalled.

3. DISPOSITION OF CELLS.

a. Repair of self-sealing cells in which the self-sealing layers are swollen excessively will not be attempted. In all instances where the swollen area is larger than 25 square inches, replace the cell.

b. Cells damaged mechanically by shell fragments or gunfire, cells leaking at seams and cells having swollen or deteriorated areas may be repaired in accordance with the instructions contained in No. 03-10J-series Technical Orders. The defective cells removed, if considered repairable, will be forwarded to Air Service Commands, air bases, sub-depots, depot groups, or depots, for repair, and will be tagged with a "Repairable Part Routing Tag," AAF Form 50. Swollen areas should be outlined on the exterior with a light colored paint and sufficient wording used to indicate the nature of the damage or failure. This is necessary because repairmen have difficulty finding the damage after the swollen area dries out and the cell returns to normal size.

c. Prior to installation of replacement cells, a thorough inspection will be made for any damage to the cell because of sabotage or mishandling in transit.

(d) INSTALLATION.—To install the main (nacelle) fuel cells reverse the REMOVAL procedure given in paragraph 11. *b. (b)*, this section.

Note

Screws holding fittings to the self-sealing cell are to be tightened to 20-30 inch-pounds torque and screws are not to be tightened after initial installation.

(e) TESTS AFTER INSTALLATION.—Fill the main (nacelle) fuel cell with fuel as instructed in paragraph 11. *b.*, this section. Check the entire installation for fluid leaks. Check the operation of the fuel booster pump and fuel quantity indicator.

(2) AUXILIARY (WING) FUEL CELLS.
(See figure 209.)

(a) DESCRIPTION. – The auxiliary (wing) self-sealing fuel cells are installed in each wing between the two wing spars and between the main (nacelle) fuel cell and the fuselage. Each wing fuel cell has a fluid capacity of 100 U.S. gallons (83.3 Imperial gallons). The filler wells are located on the outboard sides of the cells and are accessible from the top of the wing. The wing cells fuel booster pumps are installed on the inboard sides of the cells. An internal line conducts fuel from the booster pump to the outlet fitting on the outboard side of the cell. A fuel level transmitter is installed on the front of the cell. Condensed moisture may be drained from the cell by means of a drain cock on the bottom of the cell *(7, figure 202)*. Overflow drain lines and vent lines *(figure 200)* are provided for the cell.

(b) REMOVAL.

1. Drain the auxiliary wing fuel cell as instructed in paragraph 11. *c.*, this section.

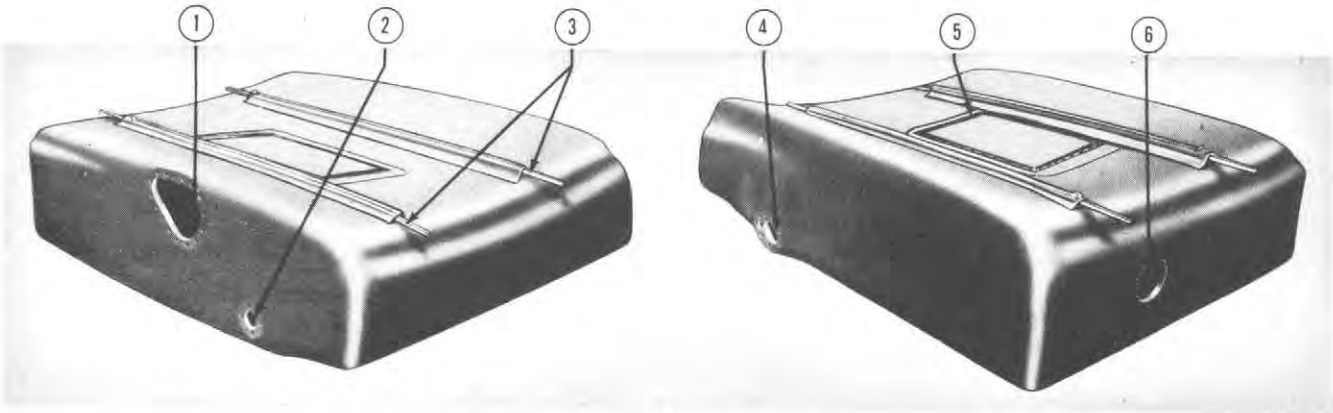
2. Remove the lower half of the engine cowl as instructed in paragraph 6. *b.* (14) *(b)*, this section.

3. Place a support stand and jack under the rocker arm boxes in the forward row of cylinders *(figure 27)* to support the engine. Removal of the wing stress panel weakens the wing and the engine must be supported.

4. Remove the wing nose upper section inboard of the nacelle by removing the attaching screws.

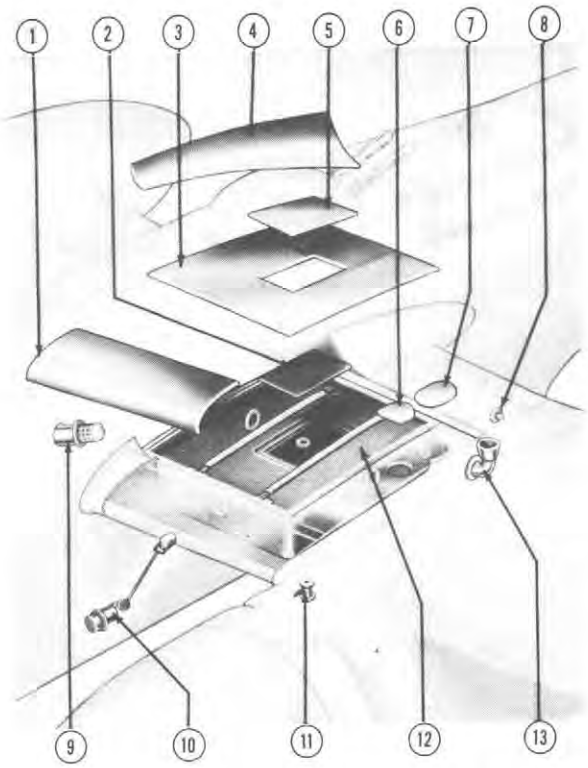
5. Remove the stress panel access cover by removing the attaching screws.

6. Remove the bolts that attach the stress panel brackets to the wing fuel cell. Remove the wing fuel cell access cover.



1. Opening for Filler Well
2. Opening for Internal Line
3. External Stiffeners
4. Opening for Fuel Booster Pump and Internal Line
5. Access Cover
6. Opening for Fuel Level Transmitter

Figure 209 — Auxiliary (Wing) Fuel Cell (Top View)



1. Wing Removable Nose Section
2. Cell Access Cover
3. Stress Panel
4. Fairing
5. Stress Panel Access Door
6. Filler Well Access Door
7. Access Door
8. Cell Internal Outlet Fitting
9. Fuel Booster Pump
10. Fuel Level Transmitter
11. Drain Cock
12. Auxiliary (Wing) Fuel Cell
13. Filler Well and Filler Neck Casting

NOTE—Disconnect fuel lines and electrical wiring before removing cell. Hoist cell by means of hoisting straps on cell.

Figure 210 — Removal of Auxiliary (Wing) Fuel Cell

Note

The bolts with heads painted red attach the stress panel brackets to the wing fuel cell. The bolts with unpainted heads attach the access cover to the fuel cell.

7. Remove the screws along the outer edges of the stress panel and remove the stress panel.

8. Remove the filler well access cover and the access cover immediately aft of the filler well. Disconnect the filler well overflow drain line. Remove the screws that attach the filler well to the filler neck and wing structure and remove the filler well.

9. Disconnect the vent line from the filler neck fitting. Remove the filler cap and grounding jack. Remove the screws from the filler neck and remove the filler neck through the wing cell access hole.

10. Disconnect the internal line fittings inside the wing cell and remove the line. Disconnect the outlet fitting on the outside of the cell. Remove the screws that attach the fitting to the cell and remove the fitting through the wing cell access hole.

11. Disconnect the electrical wires and fuel lines from the fuel booster pump inside the bomb bay.

12. Remove the screws that attach the fuel booster to the mounting ring inside the cell. Remove the booster pump and gasket. Remove the mounting ring through the fuel cell access hole.

13. Disconnect the electrical wiring from the fuel level transmitter. Remove the screws that attach the transmitter to the mounting flange and remove the transmitter and gasket. Remove the screws from the mounting flange and remove the flange through the fuel cell access hole.

14. Remove the wing cell drain cock access door on the under side of the wing. Unscrew the drain cock from the wing cell.

15. Open the slide fasteners and remove the stiffeners from the top of the wing fuel cell.

16. Loosen carefully the wing fuel cell from the surrounding structure and lift the cell from the wing by means of the hoisting straps.

(c) MAINTENANCE REPAIR.—See paragraph 11. *b.* (1) *(c)*, this section.

(d) INSTALLATION.—Reverse the REMOVAL procedure.

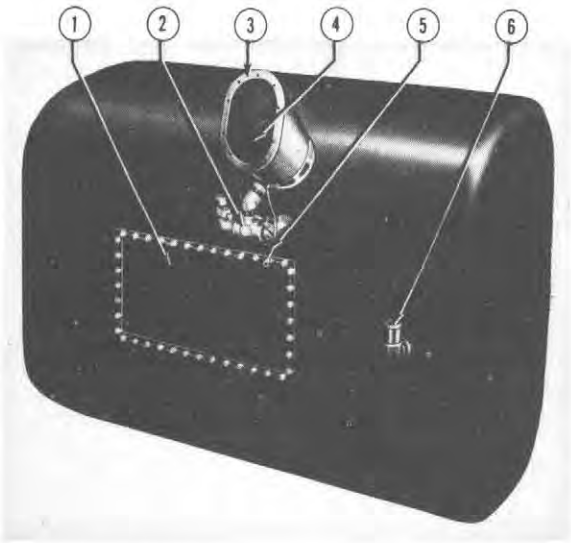
Note

Screws holding fittings to self-sealing cells are to be tightened to 20-30 inch-pounds torque, and the screws are not to be tightened after initial installation.

(e) TESTS AFTER INSTALLATION.—Fill the wing cell with fuel. Check the operation of the fuel booster pump. Check the fuel quantity indicator for proper operation. Check the entire wing fuel cell installation for evidence of fluid leakage.

(3) AUXILIARY (BOMB BAY) FUEL CELL. *(See figure 211 & 212.)*

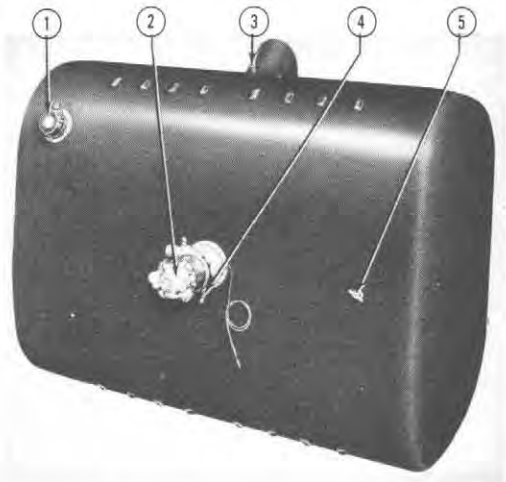
(a) DESCRIPTION. — A self-sealing fuel cell with a usable capacity of 125 U. S. gallons (104.1 Imperial gallons) is installed in the upper forward end of the bomb bay. The bomb bay cell filler well is accessible on the top, left-hand side of the fuselage. The bomb bay cell is hung from chocks in the bomb bay by four strap assemblies. One strap assembly at the forward end of the cell and one at the aft end of the cell prevent swaying of the bomb bay cell. A fuel booster pump and a fuel drain cock are installed on the bottom of the cell. The fuel supply line from the



1. Access Cover
2. Tee (Connector for Long Range Tank Vent Lines)
3. Filler Well
4. Filler Cap
5. Grounding Jack
6. Vent Fitting

Figure 211 — Auxiliary (Bomb Bay) Fuel Cell (Top View).

booster pump is connected to the cross-feed and bomb bay fuel tank(s) selector valve, which is located above the pilot's compartment slanting floor at the forward end of the bomb bay. The fuel level transmitter is installed at the top of the bomb bay cell on some airplanes and at the bottom of the cell on other airplanes. Drain and vent lines are provided on the cell *(figure 200.)* The bomb bay fuel cell does not interfere with the carrying of 500 or 1000 pound bombs, or torpedoes.

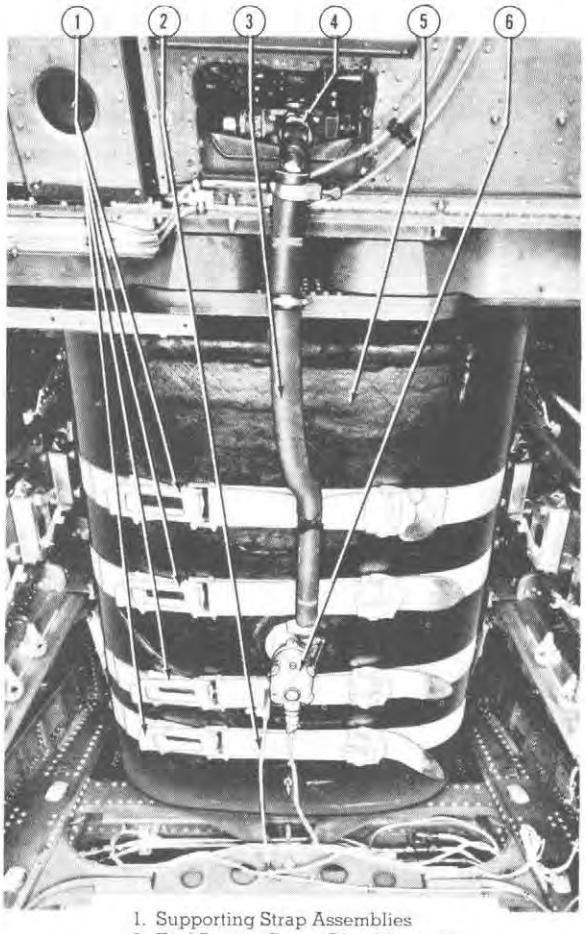


1. Fuel Level Transmitter (Located on top of Cell on Some Airplanes)
2. Fuel Booster Pump
3. Connection for Overflow Drain Line
4. Elbow (Top Connect Gland Drain Line)
5. Drain Cock

Figure 212 — Auxiliary (Bomb Bay) Fuel Cell (Bottom View)

(b) REMOVAL.

1. Drain the bomb bay cell as instructed in paragraph 11. *c.*, this section. Disconnect the hose from the cross feed and bomb bay tank(s) selector valve and drain the fuel in the hose.



1. Supporting Strap Assemblies
2. Fuel Booster Pump Gland Drain Line
3. Fuel Supply Line
4. Cross Feed and Bomb Bay Tank(s) Selector Valve
5. Bomb Bay Fuel Cell
6. Fuel Booster Pump

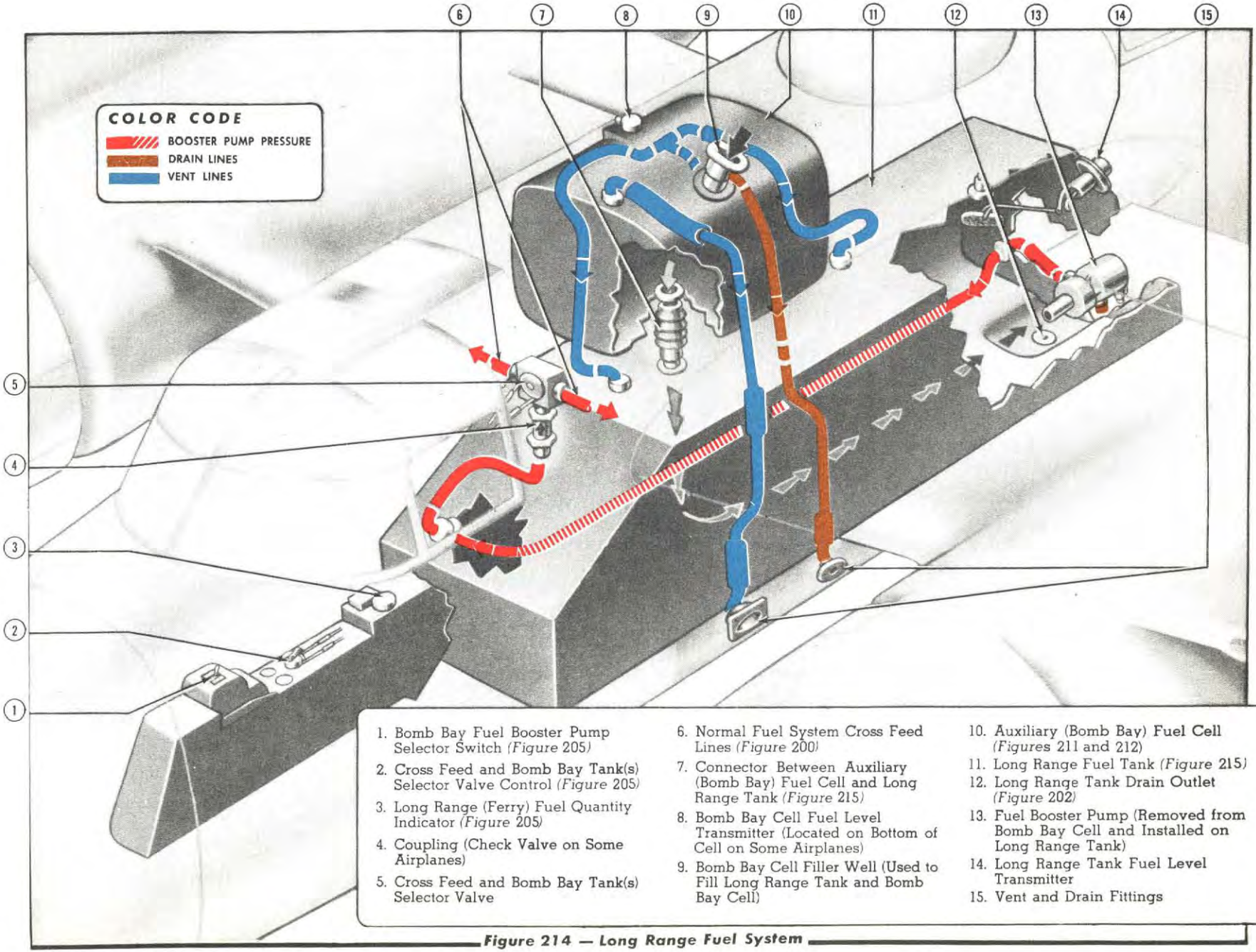
Figure 213 — Auxiliary (Bomb Bay) Fuel Cell Installed (Looking Aft)

Note

Make certain that the cross feed and bomb bay tank(s) selector valve control in the pilot's compartment is in the "OFF" position.

2. Disconnect the fuel supply line from the booster pump and cross feed and bomb tank(s) selector valve and remove the hose.

3. Disconnect the booster pump gland drain line at the pump and at the elbow on the wing rear spar.



1. Bomb Bay Fuel Booster Pump Selector Switch *(Figure 205)*
2. Cross Feed and Bomb Bay Tank(s) Selector Valve Control *(Figure 205)*
3. Long Range (Ferry) Fuel Quantity Indicator *(Figure 205)*
4. Coupling (Check Valve on Some Airplanes)
5. Cross Feed and Bomb Bay Tank(s) Selector Valve
6. Normal Fuel System Cross Feed Lines *(Figure 200)*
7. Connector Between Auxiliary (Bomb Bay) Fuel Cell and Long Range Tank *(Figure 215)*
8. Bomb Bay Cell Fuel Level Transmitter (Located on Bottom of Cell on Some Airplanes)
9. Bomb Bay Cell Filler Well (Used to Fill Long Range Tank and Bomb Bay Cell)
10. Auxiliary (Bomb Bay) Fuel Cell *(Figures 211 and 212)*
11. Long Range Fuel Tank *(Figure 215)*
12. Long Range Tank Drain Outlet *(Figure 202)*
13. Fuel Booster Pump (Removed from Bomb Bay Cell and Installed on Long Range Tank)
14. Long Range Tank Fuel Level Transmitter
15. Vent and Drain Fittings

Figure 214 — Long Range Fuel System

4. Remove the filler well access cover on the top of the fuselage. Disconnect the filler well overflow drain line. Remove the filler cap. Remove the screws that attach the filler well and remove the filler well. Disconnect the grounding jack.

5. Disconnect the vent hose from the vent line through the access hole in the top of the fuselage.

6. Disconnect the electrical wiring from the fuel level transmitter and fuel booster pump.

7. Remove the cotter keys on the bomb bay cell aft strap buckles. Open the buckles and free the straps from the cell.

8. Remove the cotter keys from the bomb bay cell cradle strap buckles. Support the cell and open the buckles to free the straps from the cell. Carefully remove the bomb bay fuel cell from the bomb bay.

(c) INSTALLATION.—To install the bomb bay cell reverse the removal procedure.

(d) TESTS AFTER INSTALLATION.—Fill the bomb bay cell with fuel as instructed in paragraph 11. *b*. Check the entire installation for fluid leaks. Check the operation of the fuel booster pump and fuel level transmitter and fuel quantity indicator.

(4) LONG RANGE (FERRY) TANK.

(a) DESCRIPTION.—The long range tank is constructed of welded steel and is not self-sealing. The tank is installed in the bomb bay and has a capacity of 675 U.S. gallons (562 Imperial gallons). When the long range tank is installed, the booster pump is removed from the auxiliary (bomb bay) cell and installed on the long range tank. A flexible connector is installed on the pump outlet of the bomb bay cell and inlet of the long range tank. The same hose that connected the bomb bay cell booster pump to the cross feed and bomb bay tank(s) selector valve is used to connect the long range tank outlet to the valve. The long range tank is hung in the bomb bay by means of shock mounts bolted to supports on the tank and in the bomb bay. The fuel booster pump is mounted on the aft end of the tank and the fuel is supplied to the tank outlet through a removable internal line in the tank. The long range tank is filled by means of the bomb bay cell filler well. Fuel is supplied to the engines from the combination of long range tank and bomb bay auxiliary cell in exactly the same manner as from the auxiliary (bomb bay) cell alone. *(See figure 203.)*

(b) REMOVAL.

1. Open the bomb bay doors as instructed in paragraph 14. *d*. (10), this section, and install safety stops in the bomb bay doors operating linkage *(figure 269)*.

2. Drain the fuel from the bomb bay tanks as instructed in paragraph 11. *c*., this section.

3. Remove the bomb bay filler well and filler cap through the hole in the top of the fuselage.

4. Disconnect the long range tank vent hoses from the tee fitting at the auxiliary (bomb bay) cell inlet fitting. Cap the open ends of the tee fitting with rubber caps and hose clamps.

CAUTION

Make certain that the tee fitting is capped if the airplane is to be operated without the long range tank. If the tee fitting is left open, fuel will be discharged into the bomb bay and create a serious fire hazard.

5. Disconnect the hose from the long range tank outlet.

6. Disconnect the electrical wiring from the fuel level transmitter and fuel booster pump at the disconnect plugs.

7. Remove the access cover from the bottom of the long range tank. Reach through the access hole and remove the nuts and washers from the bolts of the connector collar at the tank inlet.

8. Support the long range tank and remove the bolts from the shock mounts. Remove the long range tank from the airplane.

9. If the airplane is to be operated without the long range tank, observe the following instructions:

a. Remove the flexible connector, sleeve, collar, clamps, and gasket from the bomb bay auxiliary cell booster pump outlet by removing the attaching screws.

b. Remove the fuel booster pump from the long range tank. Remove the gland drain from the booster pump and install plug in the opening.

c. Install booster pump on the bomb bay auxiliary cell and install elbow and booster pump gland drain line as shown in *(2, figure 213)*.

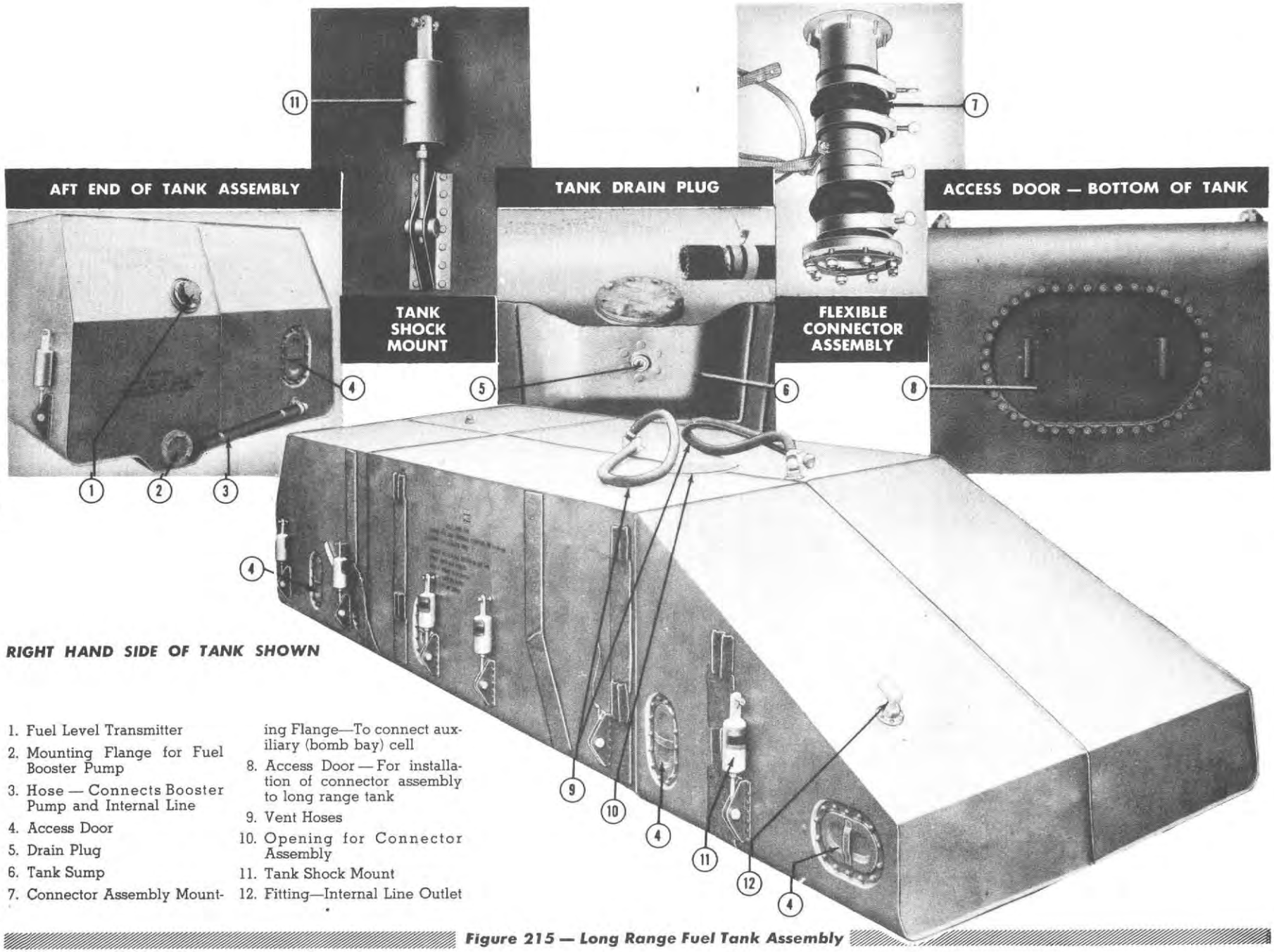
d. Connect the hose to the cross-feed and bomb bay tank(s) selector valve to the outlet port of the fuel booster pump.

e. Install the auxiliary (bomb bay) cell filler well and filler cap.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Repairs may be made to the tank by approved welding procedures.

CAUTION

The tank must be free from gasoline fumes



RIGHT HAND SIDE OF TANK SHOWN

1. Fuel Level Transmitter
2. Mounting Flange for Fuel Booster Pump
3. Hose — Connects Booster Pump and Internal Line
4. Access Door
5. Drain Plug
6. Tank Sump
7. Connector Assembly Mounting Flange—To connect auxiliary (bomb bay) cell
8. Access Door — For installation of connector assembly to long range tank
9. Vent Hoses
10. Opening for Connector Assembly
11. Tank Shock Mount
12. Fitting—Internal Line Outlet

Figure 215 — Long Range Fuel Tank Assembly

to eliminate the fire hazard while welding. To make certain that all gas-vapor is out of the tank, let it remain open in a cool dry open area for several days. At about 24 hour intervals check with an Explosive Vapor Tester. When the tester indicates no explosive vapor, welding may be accomplished. As a further precaution against explosion, close all tank outlets but one and force carbon dioxide gas into the tank to approximately 2 psi pressure. Keep the gas in the tank while welding.

(d) INSTALLATION.

1. Douglas drawing 5202252, Installation of the Bomb Bay Ferry Tank, is stowed in a box containing the publications that accompany the airplane. Refer to this drawing when installing the long range tank.

2. Drain the bomb bay auxiliary fuel cell as instructed in paragraph 11. *c.,* this section.

3. Disconnect the gland drain line and elbow from the bomb bay cell booster pump. Disconnect the gland drain line from the left-hand auxiliary (wing) cell booster pump drain line at the tee. Cap or plug the open end of the tee.

4. Disconnect the hose at the booster pump outlet and remove the booster pump from the bomb bay cell.

5. Install the fuel booster pump in the long range tank. Install the line that connects the booster pump and internal line in the tank. Install the fuel level transmitter. Install the elbow in the tank outlet fitting. Connect the vent hoses and elbows to the tank.

6. Install the connector, sleeve, collar assembly, clamps and gasket on the bomb bay cell booster pump outlet.

7. Remove the bomb bay cell filler well and filler cap through the hole in the top of the fuselage.

8. Before the long range tank is raised into position, lower cords or ropes through the hole in the top of the fuselage to each of the vent hoses.

9. Fasten the ropes to the vent hoses. Pull the hoses into place as the tank is raised into position in the bomb bay. Remove the caps from the tee fitting at the bomb bay cell inlet fitting and install the vent hoses.

10. When the long range tank is in the proper position, there is adequate clearance between the tank and the bomb bay doors when the bomb bay doors are closed.

11. Install the shock mount units to the hooks on the fuselage and supports on the long range tank.

12. Install the gland drain line on the fuel booster pump and stow the plug and elbow taken from the pump. When the bomb bay doors are closed, the gland drain line should extend ½ inch below the bottom of the door.

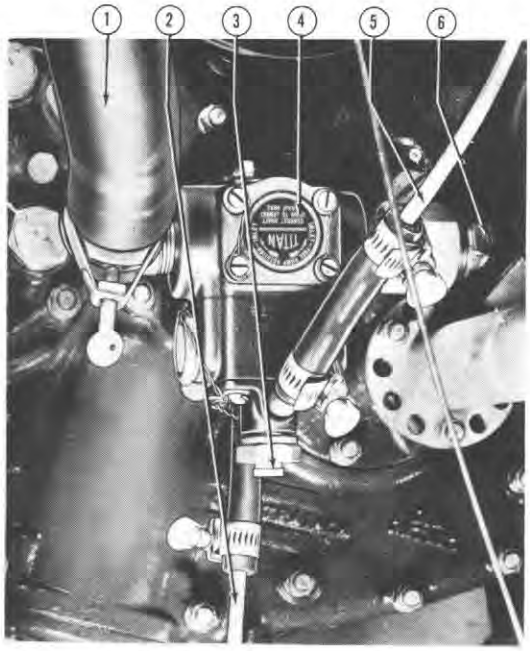
13. Install the bomb bay cell filler well and filler cap.

14. Connect the electrical wiring to the long range tank fuel level transmitter and fuel booster pump.

(e) TEST AFTER INSTALLATION.—Fill the long range tank and bomb bay cell with fuel as instructed in paragraph 11. *b.,* this section. Check the booster pump for proper operation. Check the long range fuel quantity indicator *(figure 205)* for proper indication. Check all lines and fittings on the long range tank for evidence of fluid leakage.

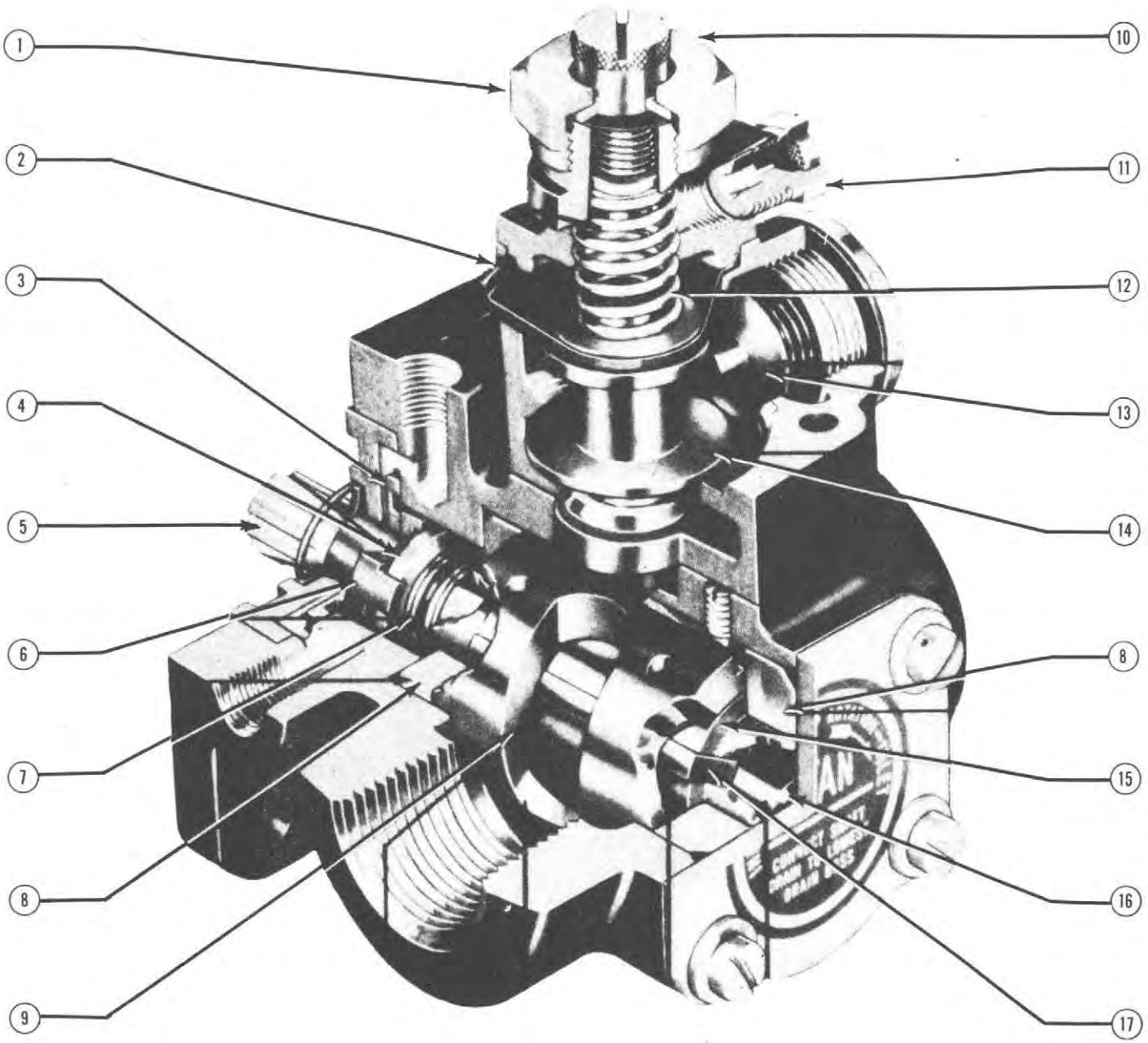
i. ENGINE-DRIVEN FUEL PUMP.
(See figures 216 & 217.)

(1) DESCRIPTION.—Any type G-9 engine-driven fuel pump may be installed on the accessory drive section of each engine to furnish fuel under pressure to the carburetors. The pumps are of the rotary vane, positive displacement type. The rotor and vanes revolve inside a cylindrical pumping chamber bored in



1. Fuel Pressure Line (Pump to Carburetor)
2. Pump Drain Line
3. Fuel Pressure Adjusting Screw
4. Type G-9 Engine-Driven Fuel Pump
5. Vent Line (Pump to Carburetor)
6. Fuel Supply Line to Pump

Figure 216—Engine-driven Fuel Pump Installed



1. Lock Nut
2. Diaphragm
3. Rear Bearing Seal
4. Packing
5. Drive Shaft
6. Rotating Metal Seal
7. Spring
8. Rotor Bearings
9. Liner
10. Pressure Adjusting Screw
11. Vent Plug (Removed when Vent Line to Carburetor is Installed)
12. Relief Valve Spring
13. By Pass Valve
14. Relief Valve
15. Rotor
16. Pin
17. Vanes

Figure 217 — Typical Type G-9 Engine-Driven Fuel Pump (Candler-Hill)

the liner. The rotor is mounted eccentrically to the liner bore in such a manner that the rotor almost touches the liner at one point. Thus there is a crescent shaped space between the rotor and the liner bore, and as the vanes sweep this space they create a pumping action which draws fuel in through the intake port and forces it out through the discharge port. The pumps will operate equally well in either direction of rotation, but reversing the rotation reverses the fuel flow and necessitates turning the relief valve housing 180 degrees. The function of the relief valve is to regulate the discharge pressure. The relief valve is held closed by a spring which can be set at the desired tension by the pressure adjusting screw to obtain 17±1 psi discharge pressure. Since the pump usually is pumping more fuel than can be used, the relief valve allows the excess fuel to flow to the intake side of the pump and maintain the proper discharge pressure. The bypass valve allows fuel to bypass the pumping mechanism when the engine-driven pump is inoperative and the fuel booster pumps are operating. The diaphragm in the engine-driven pump is vented to the carburetor to maintain the relative relationship of the air pressure and fuel pressure in the carburetor. The drive coupling of the pump has a safety shear section to protect the engine in the event of jamming of the pump. *(See figure 218.)*

(2) REMOVAL.

(a) Place the fuel booster pump selector switches in the "OFF" positions.

(b) Place the fuel tank selector valve controls in the "BOTH OFF" position. Place the cross-feed and bomb bay tank(s) selector valve in the "OFF" position.

(c) Open the deflector plating at the bottom of each nacelle.

(d) Remove the drain plug from the elbow in the fuel strainer to allow the fuel in the supply line to the engine-driven fuel pump to drain.

(e) Remove the large access panels from the lower sides of the nacelles *(3, figure 9)* and remove the center section of the firewall.

(f) Disconnect the two main fuel lines, the diaphragm vent line and drain line from the engine-driven fuel pump.

(g) Remove the safety wire and nuts and remove the engine-driven pump from the mounting pad on the engine.

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) Inspect the pump and fittings at each 25-hour inspection for evidence of leaks. Be certain that the pump mounting nuts are tight and properly safetied.

(b) The most probable cause of faulty pressure regulation is foreign matter lodged under the relief valve. Remove the relief valve housing and carefully wash the relief valve assembly in a suitable cleaning fluid. Reinstall the valve assembly on the pump. Make certain there is no stoppage in the diaphragm vent line to the carburetor.

(c) If the safety shear section of the pump drive coupling is sheared, install a new or serviceable pump. If the pump is damaged or is not functioning properly, install a new or serviceable pump.

Note

Fuel pumps are removed for overhaul at the time engines are removed for overhaul. Fuel

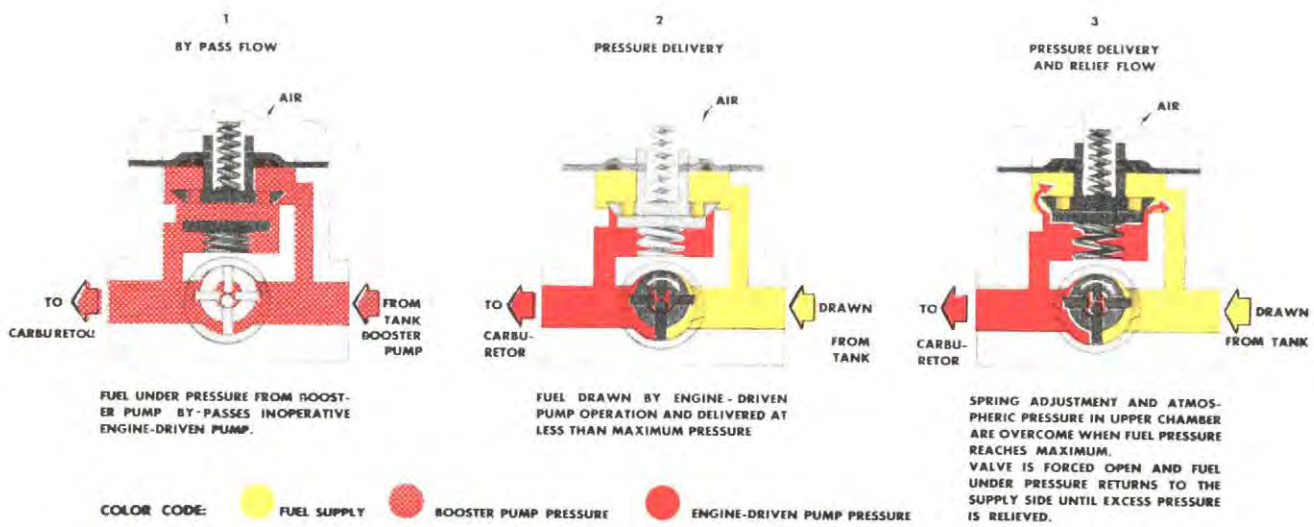


Figure 218—Engine-Driven Fuel Pump Operation

pumps that have been operated less than 100 hours since their last overhaul may be reinstalled. Pumps removed for overhaul will be forwarded to the control depot.

(4) INSTALLATION.

(a) Determine the direction of rotation of the pump drive coupling and be sure the relief valve assembly is installed on the pump correctly as instructed by the name plate.

(b) Test the pump for freedom of operation by turning the drive coupling with the fingers. If the drive shaft does not turn freely, wash the pump thoroughly with clear gasoline to remove any foreign material.

(c) See that the mounting pad on the engine is clean and smooth and that the gasket between the pad and pump mounting flange is in good condition.

(d) Place the gasket and the pump mounting flange over the mounting studs. Be sure the drive shaft registers perfectly with the engine driver. The pump flange should go down against the mounting pad freely by hand. Support the pump and tighten the nuts uniformly, then safety with lock wire.

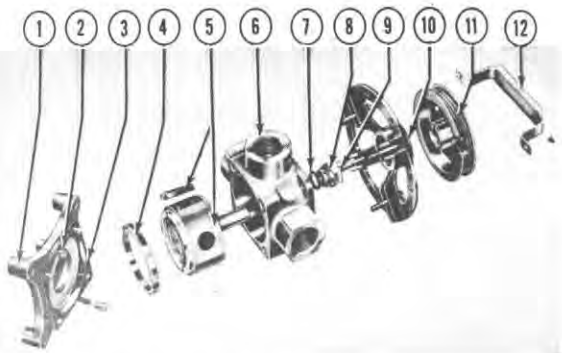
(e) Install fittings and lines to the proper ports and check for any leakage. Replace the drain plug in the fuel strainer.

(f) Install access covers and panels.

(5) ADJUSTMENTS.–If it is necessary to adjust the fuel pressure, loosen the lock nut enough to allow the adjusting screw *(3, figure 216)* to turn. Turn the adjusting screw clockwise to increase pressure, or counterclockwise to decrease pressure. When the lock nut is tightened and a fuel pressure indication of 17±1 psi is obtained, safety the lock nut with safety wire.

j. FUEL BOOSTER PUMPS.
(See figure 342)

(1) DESCRIPTION.–A fuel booster pump is installed on each of the five self-sealing fuel cells. When the long range tank is installed, the booster pump is removed from the bomb bay cell and installed on the long range tank to serve both bomb bay cell and the long range tank. The booster pumps are electric motor driven centrifugal type pumps and provide boosting (pumping of vapor free fuel under pressure to the engine-driven fuel pumps at high altitude to prevent fuel system failure because of vapor lock), fuel system pressure for priming and engine starting, an emergency fuel pump in the event of engine-driven pump failure, and provide a means of fuel transfer from tank to tank for ground operations. Three fuel booster pump selector switches *(figure 205)* are located on the control pedestal. When the main or auxiliary booster pump selector switches are in the "LOW BOOST" or "HIGH BOOST" position, operation of the booster pumps is controlled automatically by the fuel selector



1. Valve Mounting Base
2. Indexing Roller
3. Gasket
4. Ring
5. Valve Plug and Seal Assembly
6. Valve Body
7. Packing
8. Nut
9. Pin
10. Support and Bearing Assembly
11. Drum Assembly (Cable Removed)
12. Guard

Figure 219—Typical Fuel Selector Valve

switches, which are operated by the fuel tank selector valve controls on the pedestal. The bomb bay tank(s) fuel booster pump is controlled directly by the selector switch *(figure 205)*, independently of the setting of the cross-feed and bomb bay tank(s) selector valve control on the pedestal. Five rheostats *(figure 205)* control the speed of the booster pumps in the "HIGH BOOST" position. These rheostats are pre-set on the ground and MUST NOT be adjusted in flight. When the booster pumps are not operating, fuel is drawn through the booster pumps by the engine-driven fuel pumps.

(2) REMOVAL.–Refer to paragraph 15. *d.* (5) *(b) 3.*, this section.

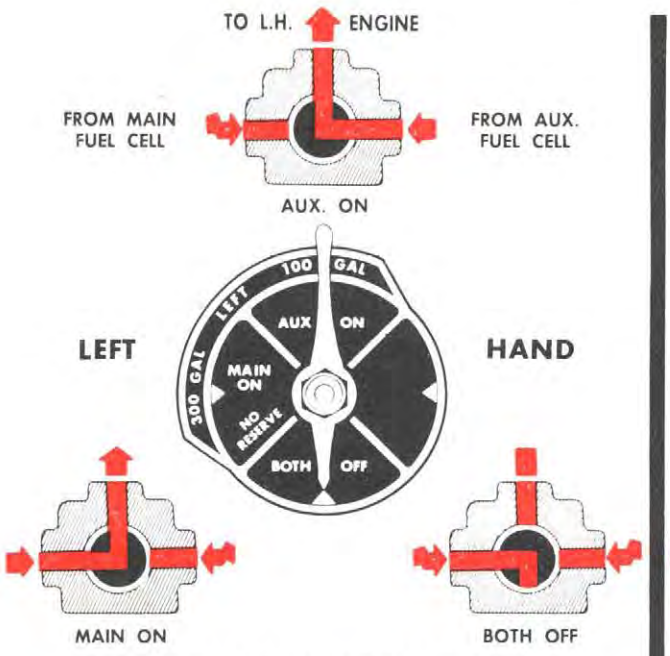
(3) MAINTENANCE REPAIR OR REPLACEMENT.–Refer to paragraph 15. *d.* (b) *4.*, this section, for maintenance repair instructions.

(4) ADJUSTMENTS.–To adjust the fuel booster pump rheostats refer to paragraph 15. *d.* (2) *2.*, this section.

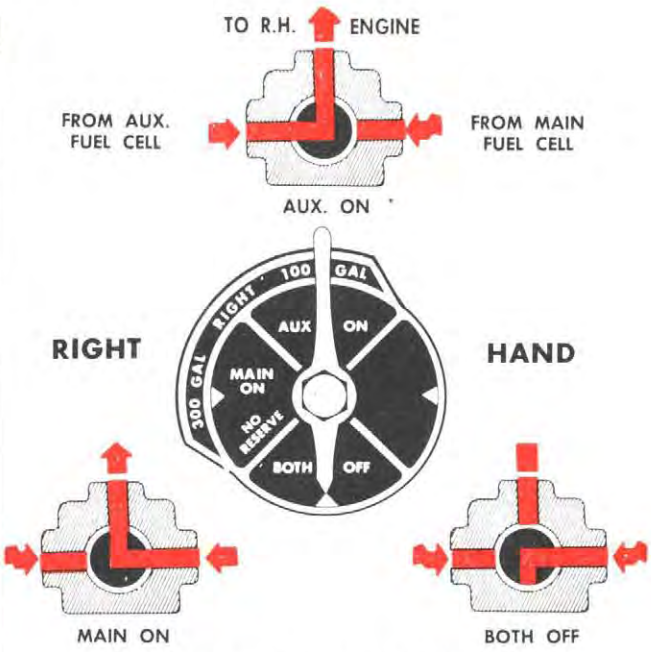
(5) INSTALLATION.–Refer to paragraph 15. *d.* *(b) 6.*, this section.

k. FUEL SELECTOR VALVES AND CONTROLS.

(1) DESCRIPTION.–Three cable-controlled fuel selector valves are installed on the airplane to select fuel from the fuel system tanks. The selector valve controls are located on the control pedestal in the pilot's compartment *figures 220 & 221*. The right-hand main (nacelle) and auxiliary (wing) fuel cells are selected by means of the right-hand fuel tank selector valve, located on the bottom of the right-hand nacelle *(figure 220)*. The left-hand main (nacelle) and auxiliary (wing) cells are selected by means of the left-hand fuel tank selector valve, located on the bottom of the



RELATION OF PEDESTAL CONTROL TO LEFT HAND SELECTOR VALVE PORTS



RELATION OF PEDESTAL CONTROL TO RIGHT HAND SELECTOR VALVE PORTS

NOTES: 1. Rig cables and pedestal controls in "MAIN ON" position and make certain the valve ports are aligned as shown in all positions of the pedestal control.

2. Access to cable turnbuckles is obtained by removing upper panels of the wing removable nose sections between the fuselage and nacelles.

3. Refer to *figure 74.* to obtain the proper cable tension.

1. R.H. Selector Valve
2. R.H. Drum and Cable Assembly *(Figure 606, Item 23)*
3. R.H. Control Handle, Drum and Cable Assembly *(Figure 606, Item 19)*
4. L.H. Control Handle with Drum and Cable Assembly *(Figure 606, Item 18)*
5. Cable Turnbuckles
6. L.H. Selector Valve
7. L.H. Drum and Cable Assembly *(Figure 606, Item 24)*

COLOR CODE
ON CABLES
OFF CABLES

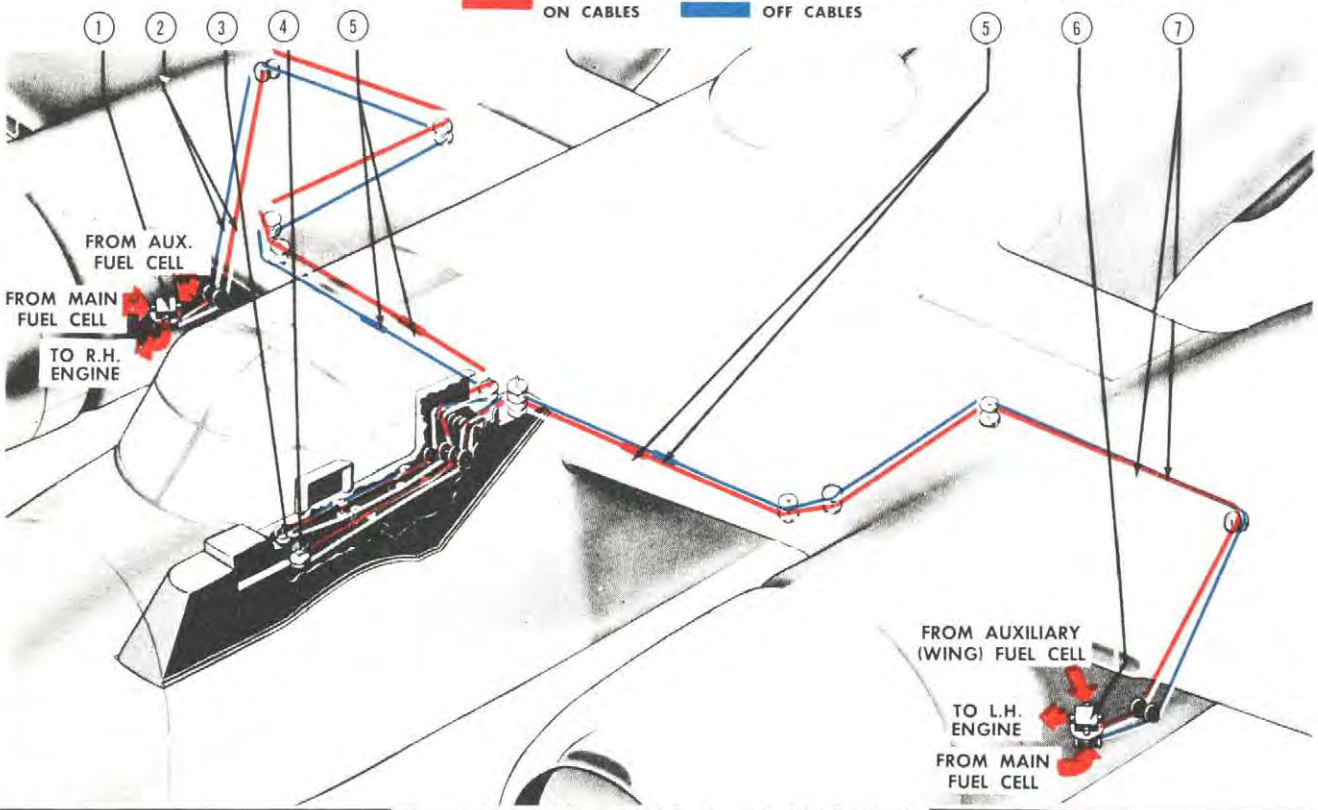
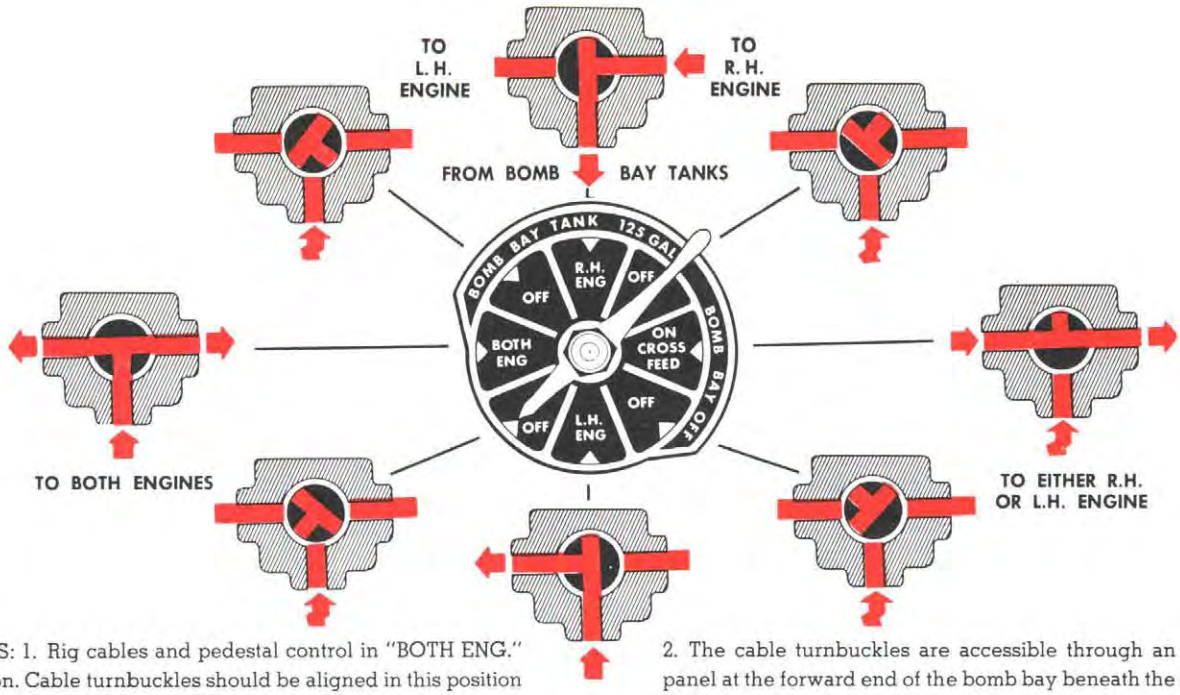


Figure 220 — Wing Fuel System Cable Controls



NOTES: 1. Rig cables and pedestal control in "BOTH ENG." position. Cable turnbuckles should be aligned in this position within 7/8 ± 1/8 inch. Make certain the valve ports are aligned as shown in all positions of the pedestal control.

2. The cable turnbuckles are accessible through an access panel at the forward end of the bomb bay beneath the aft end of the control pedestal.

3. Refer to figure 74 to obtain the proper cable tension.

1. Control Handle 2. Drum and Cable Assembly *(Figure 606, Item 12)* 3. Cross Feed and Bomb Bay Tank(s) Selector Valve
4. Drum and Cable Assembly — On Selector Valve *(Figure 606, Item 15)* 5. Cable Turnbuckles

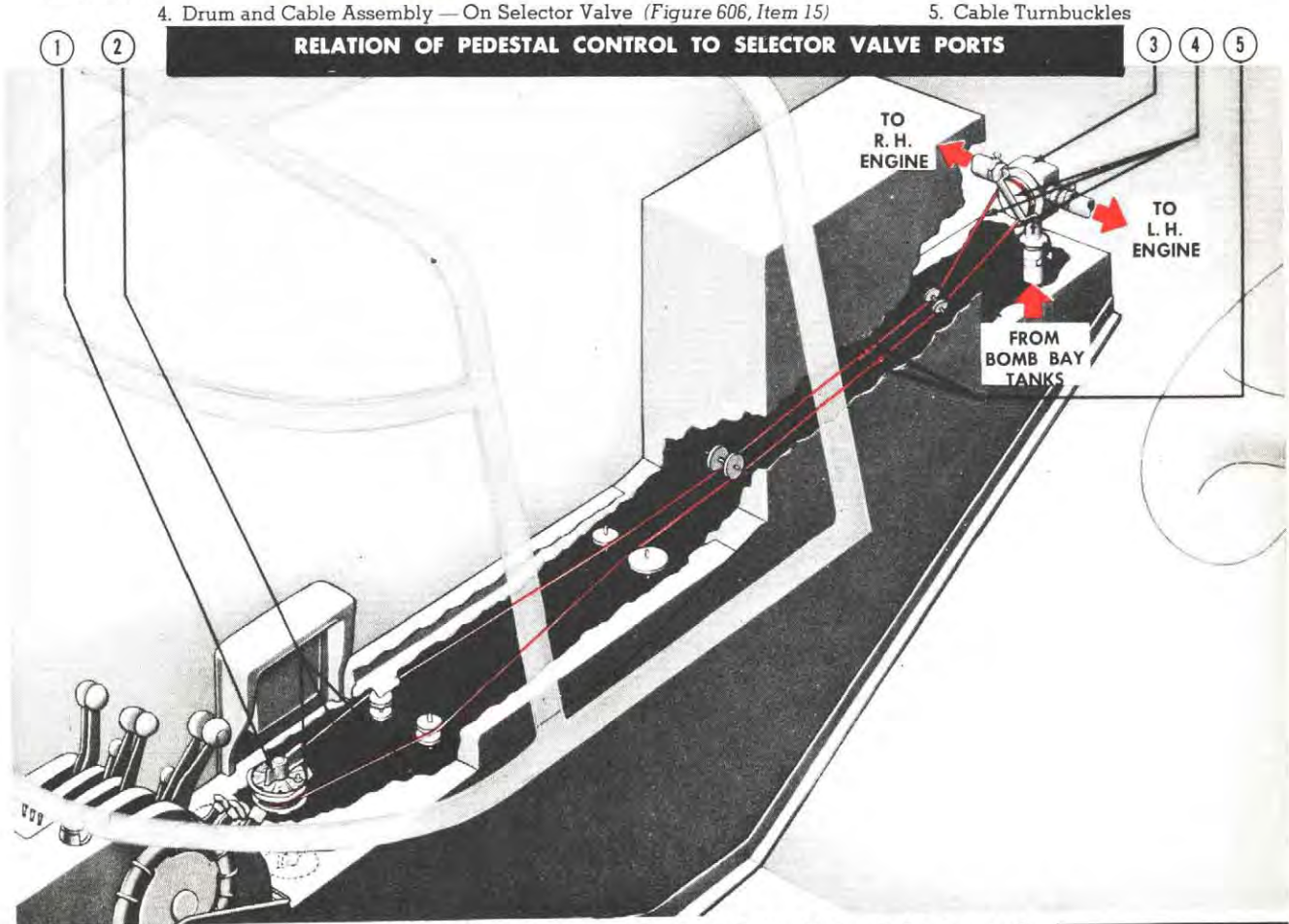


Figure 221 — Cross Feed and Bomb Bay Tanks Selector Valve Cable Controls

left-hand nacelle. The cross-feed and bomb bay tank(s) selector valve, located at the aft end of the control pedestal, controls the cross-feeding of fuel or selection of fuel from the auxiliary (bomb bay) cell alone or combined bomb bay cell and long range tank. *(See figure 221.)* For alternate settings of the fuel tank selector valve controls and schematic diagrams of fuel flow to the engines refer to *figure 203*. The fuel tank selector valves are type "F" valves with two ports in the valve plug. The cross-feed and bomb bay tank(s) selector valve is a type "H" valve with three ports in the valve plug. The three valves are of similar construction *(figure 219)* with the exception of the valve porting arrangement.

Note

When setting the fuel tank selector valve controls always make the setting by "click" or "feel" and not solely by the markings on the valve control indicator plate. Because of wear in the cables and operating mechanism, the selector valves may not always have the ports fully open or closed when the control handle is turned to the proper "ON" and "OFF" positions marked on the indicator plate. When the spring loaded indexing plate in the valve engages the friction release mechanism, the valve ports are properly aligned. A decided "click" can be heard when the plate engages when the engines are not operating or can be felt through the control handle when the engines are operating.

(2) REMOVAL.

(a) RIGHT OR LEFT-HAND FUEL TANK SELECTOR VALVE.

1. Drain the main (nacelle) and auxiliary (wing) fuel cells as instructed in paragraph 11. c., this section.

2. Remove the pulley guard by removing the attaching bolts.

3. Remove the pin that secures the valve shaft to the drum and cable assembly. Remove the drum from the valve shaft, loosening the cable turnbuckles *(5, figure 220 & 5, figure 221)* if necessary.

4. Remove the nuts and bolts that attach the support assembly to the valve and remove the support assembly.

5. Disconnect the fuel lines from the valve assembly.

6. Remove the bolts that attach the valve assembly to the support and remove the valve assembly.

(b) REMOVAL OF CROSS-FEED AND BOMB BAY TANK(S) SELECTOR VALVE.

1. Place both right and left-hand fuel tank selector controls in the "BOTH OFF" positions. Place the cross-feed and bomb bay tank(s) selector valve control in the "BOTH ENG." position.

2. Drain the bomb bay tank(s) as instructed in paragraph 11. *c.*, this section.

3. Disconnect the supply hose to the bomb bay cell from the coupling or check valve in the cross feed valve and allow the fuel in the cross-feed lines to drain.

4. Remove the screws from the access doors to the selector valve at the forward end of the bomb bay.

5. Disconnect the cross-feed lines from the selector valve.

6. Loosen the cable turnbuckles *(5, figure 221)*. Remove the bolts that attach the valve assembly to the mounting bracket and remove the valve and drum and cable assembly from the airplane.

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) The fuel selector valves, controls and cables must be inspected periodically for any binding and dragging, which if found must be eliminated by inspecting the alignment of pulleys, cables and valve assemblies.

(b) If any of the fuel selector valves are damaged or not functioning properly, new parts must be installed.

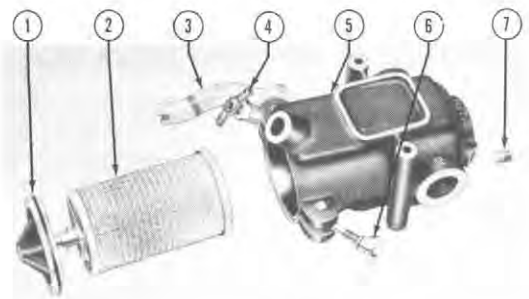
CAUTION

Whenever fuel selector valves are removed or replaced, the reassembly and installation of parts must be checked carefully to insure that the valve ports open to the tank positions indicated by the control handle on the pedestal. *(See figure 221.)*

(4) INSTALLATION.—Reverse the REMOVAL procedure and refer to *figures 220 and 221* for correct alignment of the selector valves with the controls on the pedestal.

l. FUEL STRAINERS.
(See figure 222.)

(1) DESCRIPTION.—A wire mesh type fuel strainer *(figure 222)* is installed in each fuel supply line between the engine-driven fuel pump and tank selector valve and is located on the bottom of the nacelle, immediately forward of the main (nacelle) cell booster pump *(2, figure 202)*. The fuel strainer filters foreign material from the fuel before the fuel enters the engine-driven fuel pump. A drain cock is installed on the bottom of each strainer to facilitate the drainage of condensed moisture from the strainer. A drain plug in



1. Cap
2. Strainer Assembly
3. Clamp Assembly
4. Drain Cock
5. Body
6. Nut, Bolt, and Washer
7. Plug

Figure 222 — Fuel Strainer Assembly

an elbow in the strainer is removable for complete drainage of the main (nacelle) and auxiliary (wing) cells. Refer to paragraph 11. *c.*, this section, for draining instructions.

(2) REMOVAL AND DISASSEMBLY.

(a) REMOVAL.

1. Place the booster pump selector switches on the pedestal in the "OFF" position.

2. Place the fuel tank selector valve controls in the "BOTH OFF" positions and the cross-feed and bomb bay tank(s) selector valve control in the "OFF" position.

3. Open the deflector plating at the bottom of the nacelles.

4. Remove the drain plugs from the fuel strainer elbows and drain the fuel from the strainers and fuel supply lines.

5. Disconnect the fuel lines from the fuel strainers.

6. Remove the bolts that attach the fuel strainers to the support brackets and remove the strainers from the airplane.

(b) DISASSEMBLY.—The fuel strainer is disassembled by unscrewing the wing nut, swinging back the hinged arm, and removing the cover and screen assembly. *(See figure 222.)*

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) The screens in the strainers must be cleaned periodically in a suitable cleaning fluid. Inspect the screens for damage and replace with new parts if necessary.

(b) Examine the top cover gasket and be sure it is in good condition. If in doubt, install a new gasket.

(c) Check the drain cock and drain cock outlet for damage or corrosion. Badly corroded parts must be replaced with new parts.

(d) If the fuel strainer assembly is cracked or otherwise damaged, install a new part.

(4) ASSEMBLY AND INSTALLATION.

(a) ASSEMBLY.—To assemble the fuel strainer refer to *figure 222* and reverse the DISASSEMBLY procedure.

(b) INSTALLATION.—To install the fuel strainer refer to *(2, figure 202)* and reverse the REMOVAL procedure.

(5) TEST AFTER INSTALLATION.—Inspect the fuel strainers for fluid leakage with normal pressure in the fuel system.

m. CARBURETORS. — Down draft, injection carburetors are installed on each engine. The carburetors are discussed fully as an engine accessory and for complete information about the carburetors refer to paragraph 7., this section.

n. ENGINE PRIMING AND OIL DILUTION SOLENOID VALVES.

(1) DESCRIPTION.—Two electrically operated solenoid valves *(figure 200)* are installed on the right side of each engine mount to control the flow of gasoline to the engine priming distributors, and to the oil system "Y" drains for dilution of the engine oil. The engine priming and oil dilution solenoid valves are controlled by momentary contact switches on the pilot's overhead electrical panel. Normally the valves are in the closed position, with the valve plunger held against the valve seat by the valve spring. When the control switch is placed in the "ON" position, the valve solenoid is energized, lifting the plunger and allowing fuel from the fuel pressure gage line to flow through the valve either to the priming distributor or oil "Y" drain. When the control switch is released, the valve solenoid is deenergized and the spring returns the plunger to the closed position.

Note

When priming the engines, the fuel booster pumps must be operating to supply fuel pressure to the solenoid valves. For correct priming procedure refer to section III. The engines must be operating to accomplish dilution of the engine oil. Refer to section III, 3. *g.* (2), for correct oil dilution procedures.

(2) REMOVAL.

(a) Place the booster pump selector switches on the control pedestal in the "OFF" position.

(b) Place the fuel tank selector valve controls

on the pedestal in the "BOTH OFF" position Place the cross feed and bomb bay fuel tank(s) selector valve in the "OFF" position.

(c) Remove the access panel *(3, figure 9)* from the lower right-hand side of the nacelle.

(d) Remove the center section of the firewall.

(e) Disconnect the lines leading to the engine priming and oil dilution solenoid valves.

(f) Disconnect the electrical wiring from the solenoid valves.

(g) Remove the bolts that attach the solenoid valves to the support brackets and remove the valves.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—Inspect the oil dilution solenoid valves for leakage every 25 hours by observing the following procedure:

(a) Remove the access panel *(3, figure 9)* on the lower right-hand side of the nacelle. Remove the center section of the firewall.

(b) Remove the plug that fits in the bottom of the dilution solenoid valve.

(c) Start the engine as instructed in section III, 3. *f.*

(d) If leakage through the plug hole is less than 10 drops a minute, the solenoid valve is operating satisfactorily. Stop the engine as instructed in section III, and reinstall the plug.

(e) If leakage through the valve is more than 10 drops a minute, stop the engine, and reinstall the plug. Start the engine and place the proper oil dilution switch in the "ON" and "OFF" positions for 10 five second periods. Stop engine and remove the valve plug. Start the engine and if leakage through the valve is less than 10 drops a minute, the valve is operating satisfactorily. If leakage still is greater than 10 drops a minute, proceed with the following instructions:

(f) Using a steel rod or finger, raise the valve plunger several times, allowing the plunger to spring back on the valve seat. This will produce better seating of the plunger on the seat.

(g) Start the engine. If leakage through the valve still exceeds 10 drops a minute, replace the valve assembly with a new part and forward the defective valve to the control depot. If leakage is less than 10 drops a minute, reinstall the plug in the valve. Install the firewall center section and access panel.

(h) Overhaul and special inspection of the solenoid valves is to be performed yearly or as necessary according to the instructions in T.O. No. 03-15-11.

(4) INSTALLATION. – To install the engine priming or oil dilution solenoid valves reverse the REMOVAL procedure.

o. FUEL SYSTEM CHECK VALVES.

(1) DESCRIPTION.—Check valves were installed in the fuel tank and cross-feed selector valves on some airplanes to prevent back flow of fuel into the fuel tanks and leakage in the fuel tank selector valves. In airplanes with check valves installed, fuel transfer between tanks was not possible. The check valves were removed from the fuel system on other airplanes and on these airplanes fuel transfer between tanks is possible for ground operations. Refer to *figure 204* for fuel transfer procedures.

(2) REMOVAL.

(a) Place the fuel booster pump selector switches in the "OFF" position.

(b) Place the fuel tank selector valve controls in the "BOTH OFF" positions and the cross-feed and bomb bay tank(s) selector valve control in the "OFF" position.

(c) Open the deflector plating at the bottom of the nacelles.

(d) Remove the drain plug from the fuel strainers elbows and drain the fuel in the lines.

(e) Disconnect the hoses from the check valves and unscrew the check valves from the fuel tank and cross-feed selector valves.

(3) MAINTENANCE REPAIR OR REPLACEMENT. – A damaged or defective check valve should be replaced with a new check valve or the check valve may be replaced with a suitable coupling. Check valves with a red "O" have been modified into couplings by removing the poppet, hinge pin and spring.

p. FUEL SYSTEM LINES AND FITTINGS.

(1) DESCRIPTION.—Self-sealing hose and metallic lines are used in the fuel system. Metal, threaded unions, and hoses and hose clamps are utilized to join the fuel lines. The color banding of fuel lines is red.

(2) REMOVAL.

(a) Drain the fuel from the lines before removal.

(b) Disconnect hose clamps on hose connections or unscrew nuts from metal unions. Remove the lines.

(3) MAINTENANCE REPAIR OR REPLACEMENT.

(a) All fuel system lines and fittings should be inspected frequently to detect fluid leaks, cracks in tubes or hoses, damaged fittings, and security of line supports.

(b) Any lines or hoses with cracks, deep scratches and other defects must be replaced with new parts. Refer to section VIII for tubing fabrication information.

(c) Replace defective hose clamps or other fittings with new parts.

(4) INSTALLATION.—To install lines or hoses reverse the REMOVAL procedure. Check for fluid leaks after the line is installed.

---

q. FUEL SYSTEM TROUBLE SHOOTING CHART.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. No fuel pressure indication when starting engines.	*a.* Booster pump selector switches and fuel tank selector valves controls not in proper position.	*a.* Refer to section III.
	b. Booster pumps fail to operate.	
	(1) Wiring connected improperly.	(1) Connect wiring properly. Refer to wiring diagram index which follows paragraph 15.
	(2) Loose or high resistance in booster pump connections.	(2) Clean and tighten connections.
	(3) Dirty commutator.	(3) Clean and smooth commutator as instructed in paragraph 15. *d.* (5) *(b)* 4., this section.
	(4) Brushes binding in brush holders.	(4) Remove and clean as instructed in paragraph 15. *d.* (5) *(b)* 4., this section.
	(5) Damaged booster pump.	(5) Replace pump.
2. No fuel pressure indication.	*a.* Lack of fuel in tanks.	*a.* Fill the fuel tanks.
	b. Defective fuel pressure indicator.	*b.* Check fuel pressure indicator as instructed in paragraph 13. *f.* (3), this section.
	c. Fuel selector valve controls not in proper position.	*c.* Place controls in proper position.
	d. Broken, damaged, or disconnected fuel lines or fittings.	*d.* Check all fuel lines and fittings for leaks. Make necessary replacements.
	e. Clogged fuel strainers.	*e.* Remove and clean strainers as instructed in paragraph 11. *l.* (2), this section.
	f. Engine-driven fuel pump fails to pump.	
	(1) Foreign matter holding the relief and bypass valves open.	(1) Remove and clean valve assembly as instructed in paragraph 11. *i.* (2) & (3), this section.
	(2) Drive coupling sheared.	(2) Replace engine-driven fuel pump.
	(3) Leak in intake lines to engine-driven pump.	(3) Examine intake lines for leaks and repair lines and fittings as necessary.
	(4) Relief valve diaphragm ruptured.	(4) Replace engine-driven fuel pump.
3. Low fuel pressure.	*a.* See 1. *b.* above.	
	b. See 1. *d.* above.	
	c. See 1. *e.* above.	
	d. See 1. *f.* above.	
	e. Leaking or damaged fuel selector valves.	*e.* Replace defective selector valves.
	f. Improper adjustment of engine-driven fuel pump relief valve.	*f.* Adjust the relief valve as instructed in paragraph 11. *i.* (5), this section.
4. High fuel pressure.	*a.* Improper adjustment of engine-driven fuel relief valve.	*a.* Adjust the relief valve as instructed in paragraph 11. *i.* (5), this section.
	b. Defective fuel pressure indicator.	*b.* Check fuel pressure indicator as instructed in paragraph 13. *f.* (4) *(b)*, this section.
5. Fluctuating fuel pressure indication.	*a.* Engine-driven fuel pump relief valve sticking.	*a.* Remove and clean relief valve assembly as instructed in paragraph 11. *i.* (2) & (3), this section.
	b. Obstruction in intake lines to engine-driven fuel pump or clogged fuel strainer.	*b.* Check intake lines and remove any obstructions. Clean strainer as instructed in paragraph 11. *l.* (2), this section.
	c. Vent line from engine-driven fuel pump to carburetor clogged.	*c.* Remove and clean line.
	d. Fuel tank vent lines obstructed.	*d.* Clean lines by blowing out with compressed air.

12. OIL SYSTEM.

a. GENERAL.—Two independent engine oil systems *(figure 223)* are installed on the airplane to supply oil for the necessary lubrication of the internal parts of each engine. The oil tank also supplies oil to the propeller feathering pump. Oil from the self-sealing oil tank is supplied by gravity through the oil inlet line to the gear-type oil pressure pump, located in the engine rear section, and the oil pressure pump forces the oil through the engine to the moving engine parts. The engine drain oil is scavenged by two separate, gear-type pumps and returned to the oil temperature regulator, then to the temperature accelerating well (hopper) in the oil tank. The oil tank has two vent lines connected to the rear engine section and an overflow drain line from the filler well. Oil temperature is regulated by means of the electrically controlled exit flap (oil cooler door). The normal oil inlet temperature is 60 degrees to 75 degrees C (140 degrees to 153 degrees F) with limits of 40 degrees to 100 degrees C (104 degrees to 212 degrees F) permissible. Normal oil pressure is 75 psi with operating limits of 60-100 psi permissible. Minimum permissible oil pressure when the engine is idling is 25 psi. An oil dilution system is provided to prevent congealing of the engine oil during airplane layovers in cold weather and to facilitate cold engine starting.

b. OIL SYSTEM INSTRUMENTS AND CONTROLS. *(See figure 225.)*

(1) OIL PRESSURE INDICATOR.—A dual oil pressure indicator is installed on the main instrument panel in the pilot's compartment. An oil pressure transmitter is installed on the firewall and is connected to the engine rear section and the oil pressure indicator. Refer to paragraph 13. *f.* (5), this section, and *figure 242* for complete information about the oil pressure indicating system.

(2) OIL TEMPERATURE INDICATOR.—A dual oil temperature indicator is installed on the pilot's main instrument panel. An oil temperature bulb is installed in each oil container sump and each oil temperature bulb is wired to the oil temperature indicator. For complete information about the oil temperature indicator, refer to paragraph 13. *e.* (4), this section.

(3) OIL COOLER DOOR SWITCHES.—The oil cooler doors are controlled by two electrical switches installed on the forward side of the step on the control pedestal in the pilot's compartment (located on the pilot's main electrical control panel on earlier airplanes). The switches have three positions: "OPEN," "CLOSE," and "OFF."

(4) OIL COOLER DOORS POSITION INDICATOR.—An electrically operated dual oil cooler doors position indicator is installed on the pilot's main instrument panel. A transmitter is installed adjacent to each oil cooler door and the transmitters are wired to the indicator so that changes in the positions of the oil cooler doors are registered by the position indicator. For complete information about the oil cooler door switches and position indicator refer to paragraph 13. *e.* (14), this section.

(5) OIL DILUTION SWITCHES.—The oil dilution solenoid valves are controlled by two momentary contact switches located on the pilot's overhead electrical panel. For complete information about the oil dilution switches refer to paragraph 15. *d.* (7), this section.

c. FILLING THE OIL SYSTEM.

(1) The oil container filler well access door is located at the top of the nacelle aft of the leading edge of the wing. Remove the cover by releasing the Dzus fasteners. *(See 3, figure7.)*

(2) The filler well is designed so that a funnel is not needed when the oil container is serviced. Open the filler cap.

(3) The normal capacity of the oil container is 30 U.S. gallons (25 Imperial gallons) as indicated by the "N" mark on the measuring stick, located in the filler fitting.

(4) Use oil Specification AN-VV-O-446, Grade 1120 to fill the container for normal operation. For cold weather operation use oil Specification AN-VV-O-446, Grade 1100A.

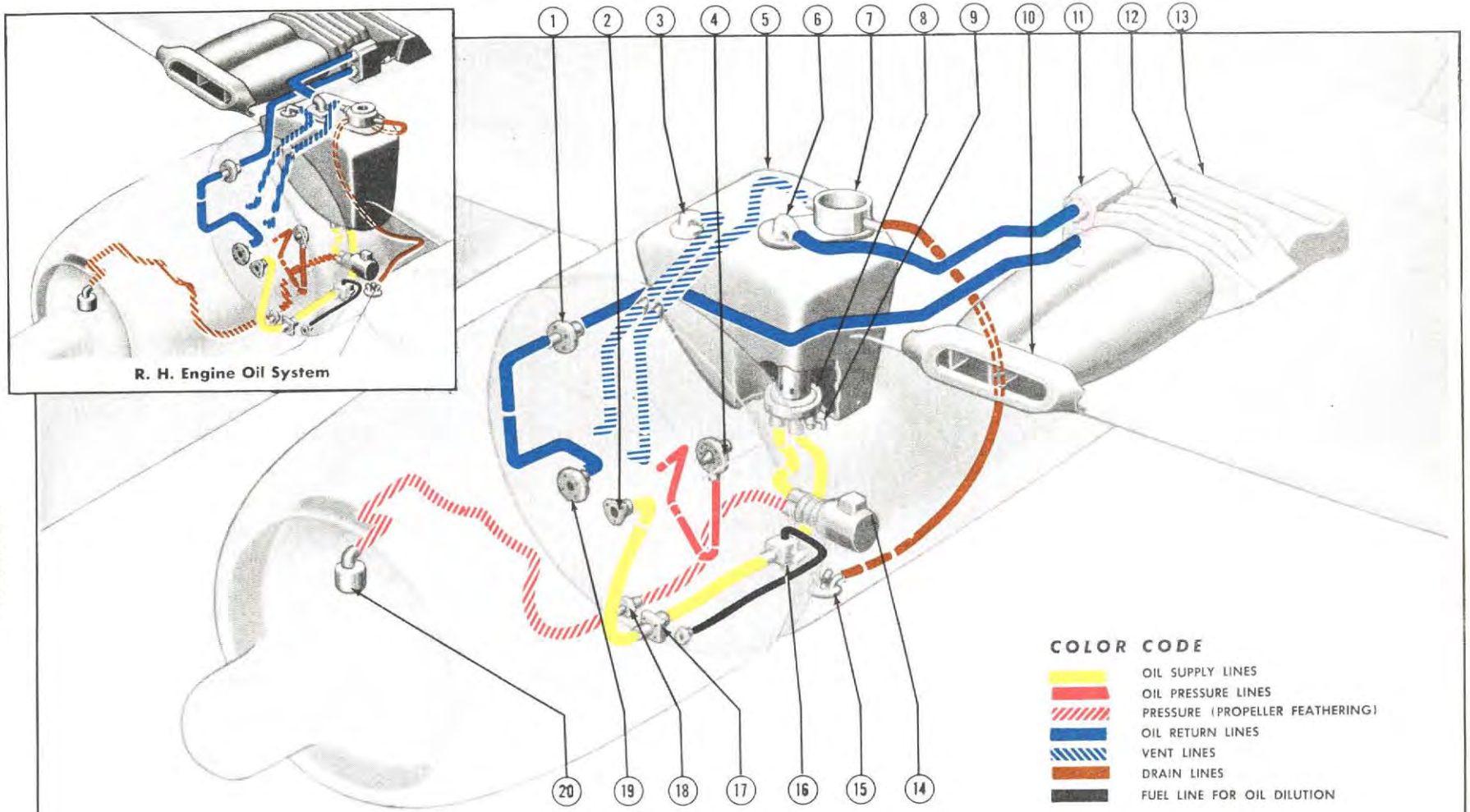
(5) Move the propeller manually five or six complete revolutions to draw oil into the inlet line and engine. Check the oil level and add oil if necessary to increase the level to the "N" mark on the measuring stick.

(6) Secure the filler cap and install the filler well access cover.

CAUTION

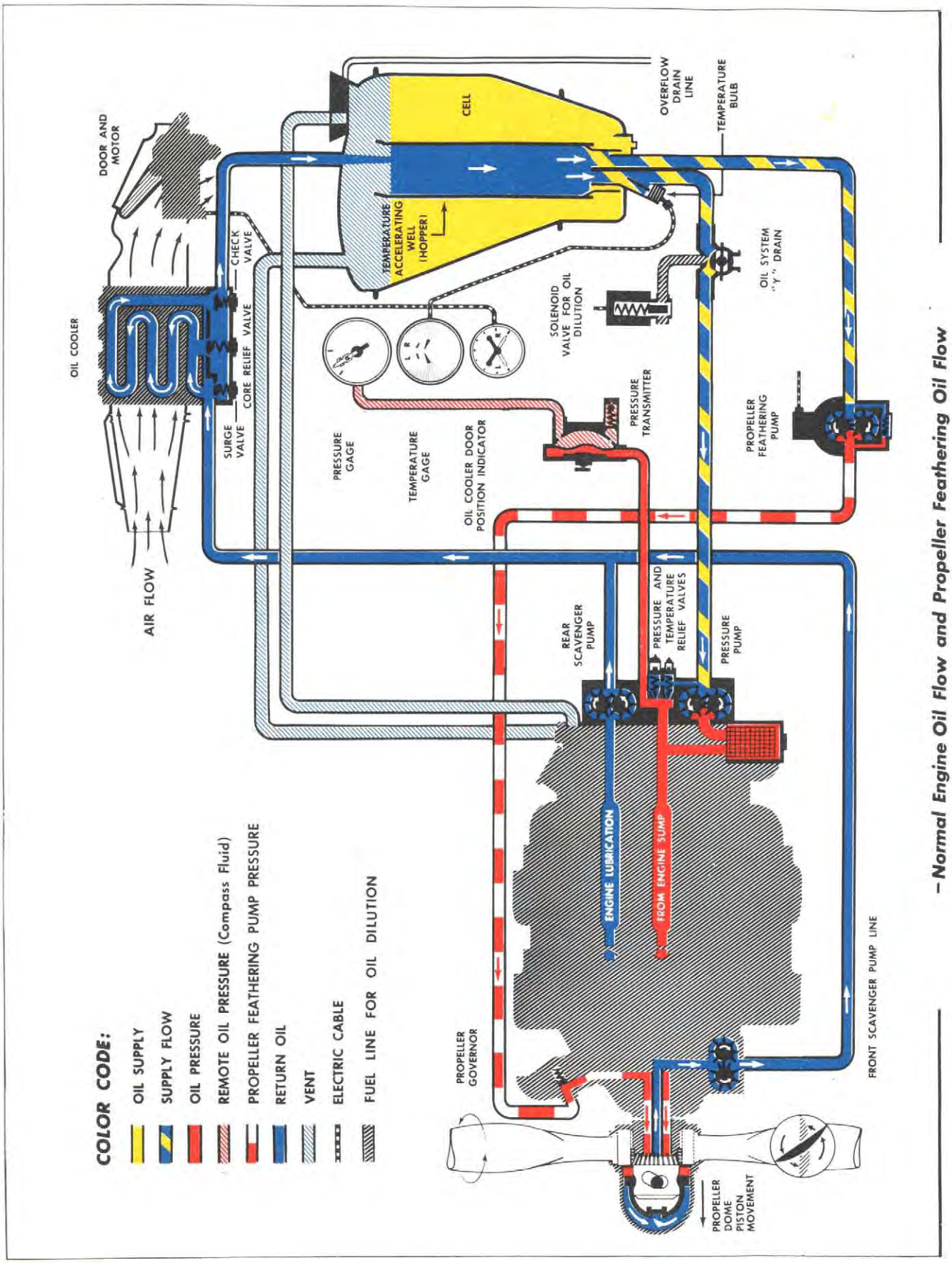
Care must be exercised to prevent the entrance of foreign material into the oil container during the filling operation to avoid damage to the engine parts.

d. DRAINING THE OIL SYSTEM.—Each oil system may be drained by means of two drain cocks and a drain plug *(figure 227)*. The "Y" drain cock is installed in the oil supply line aft of the firewall. The



1. Connector on Fire Wall
2. 2123201 Elbow (Oil Inlet)
3. Vent Fitting on Oil Tank
4. Oil Pressure Transmitter
5. Oil Tank Assembly
6. 4192860 Oil Tank Inlet Fitting—L.H.
   4123739 Oil Tank Inlet Fitting—R.H.
   1125908 Gasket
7. Oil Tank Filler Well
8. Oil Temperature Accelerating Well (Hopper)
9. Oil Tank Sump Drain Cock
10. Oil Cooler Air Scoop
11. Core Relief and Surge Protection Valve
12. Oil Cooler Assembly
13. Oil Cooler Door (Inside Aft Air Duct)
14. Propeller Feathering Pump
15. 2193628 Drain Fitting
16. "Y" Drain Cock
17. 2205648 Connector
18. Union
19. 2105060 Fitting (Oil Outlet)
20. Propeller Governor

Figure 223 — Engine Oil System



–Normal Engine Oil Flow and Propeller Feathering Oil Flow

"Y" drain cock, which is auto-locking and does not require the use of lock wire, may be reached by means of an access panel on the lower side of the nacelle forward of the deflector plating and stencilled "OIL Y DRAIN." All oil, except that in the oil container sump and oil cooler may be drained through the "Y" drain. The oil container sump is drained by means of a drain cock installed in the tank outlet fitting. This drain cock is accessible through the panel on the left side of the nacelle. Drain plugs are installed on the bottom of the oil coolers and are accessible through a cover stencilled "OIL COOLER DRAIN."

Note

Prior to engine starting during cold weather, the oil tank sump drain and "Y" drain should be operated and checked for the presence of ice or congealed oil. If ice or congealed oil is present, which will be shown by no flow of oil at these drains, thawing may be accomplished by using a "heat gun" or other heater without an open flame. Close the drains as soon as water is drained or oil begins to flow. Drain condensed moisture from the oil tank

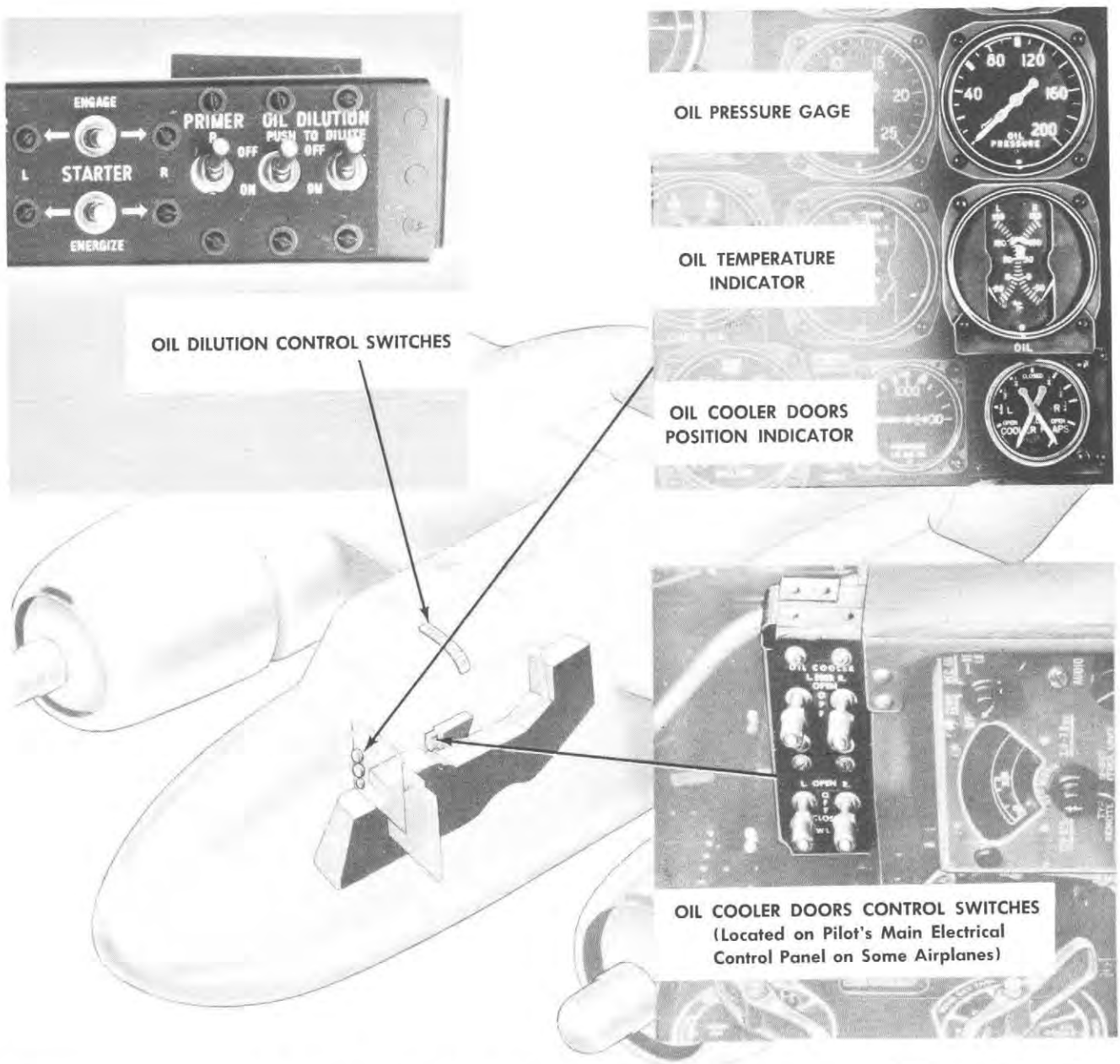


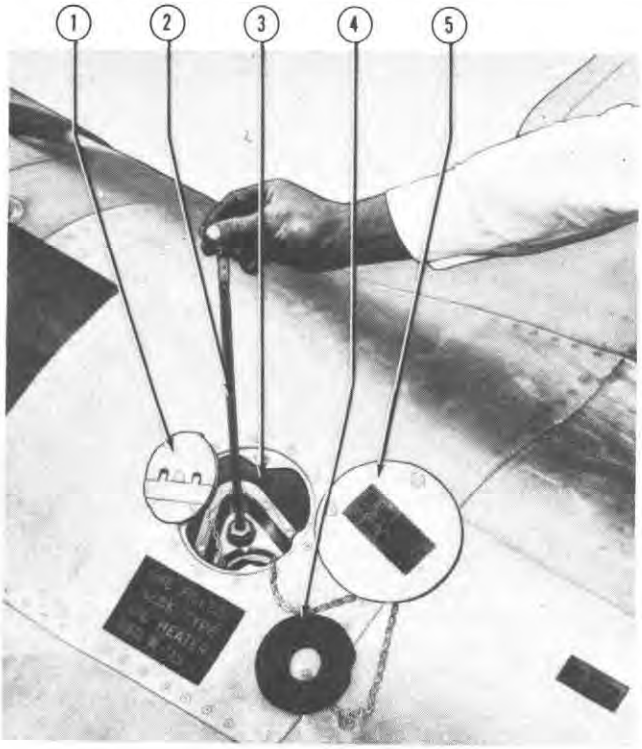
Figure 225—Engine Oil System Instruments and Controls

sump drain and "Y" drain after every flight in cold weather. The drain plugs in the oil coolers will be replaced with drain cocks in Modification Centers on northbound airplanes.

(1) The time of inspection of oil tank sumps for possible accumulation of water will depend greatly upon local ground temperatures and operating conditions. In areas where ground temperatures are at or below the freezing point 0 degrees C (32 degrees F) or may drop to or below that point during the time an airplane on flying status is to remain inactive for more than one hour, open the oil tank sump drain cock to drain off any accumulation of water approximately one hour AFTER the last flight has been made.

Note

This time is important since the greatest condensation of moisture takes place during the cooling period of the oil tank. If no water or oil runs out of the sump drain cock, make an immedate inspection of the tank to determine the reason and take the necessary corrective action prior to the next flight of the airplane.



1. Filler Cap
2. Measuring Stick Assembly
3. Filler Well
4. Immersion Heater Adapter
5. Filler Well Access Cover

Figure 226 — Measuring Oil Level in Oil Tank

(2) In areas where it is known that ground temperatures will remain constantly above the freezing point 0 degrees C (32 degrees F) inspect the oil tank sump for accumulated water at each 25-hour inspection or once each seven days, whichever is first.

e. OIL SYSTEM ADJUSTMENTS.

(1) To adjust the oil system pressure refer to paragraph 12. *b.* (1), this section.

(2) To adjust the oil cooler door mechanism refer to paragraph 12. *b.* (4) *(e)*, this section.

f. CLEANING THE OIL SYSTEM.—To prevent contamination of the oil systems with dirt, metal particles, and other foreign materials, drain and thoroughly flush and clean the oil lines and oil tanks after each engine change as follows:

(1) Disconnect the oil lines, remove the hose connections and inspect for any trapped debris. Thoroughly flush and clean each oil system with kerosene, Specification No. VV-K-211.

(2) During the flushing operation disconnect the oil outlets at the bottom of the oil tank hoppers and pour kerosene through the tank until all traces of dirt and debris have been eliminated.

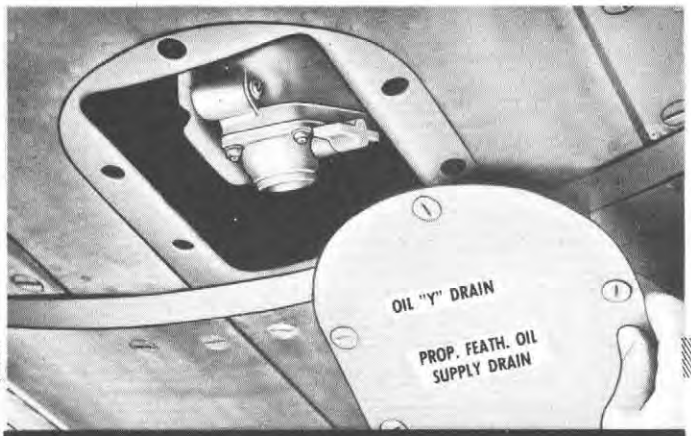
(3) At each fourth engine change or at the discretion of the local engineering officer at any intermediate engine change and at all changes made necessary by an internal engine failure of such an extent that metal particles are circulated through the oil system, remove the oil tanks as instructed in paragraph 12. *g.* (8), this section. Clean and flush the tank with hot kerosene and shake the tank violently during the cleaning operation.

CAUTION

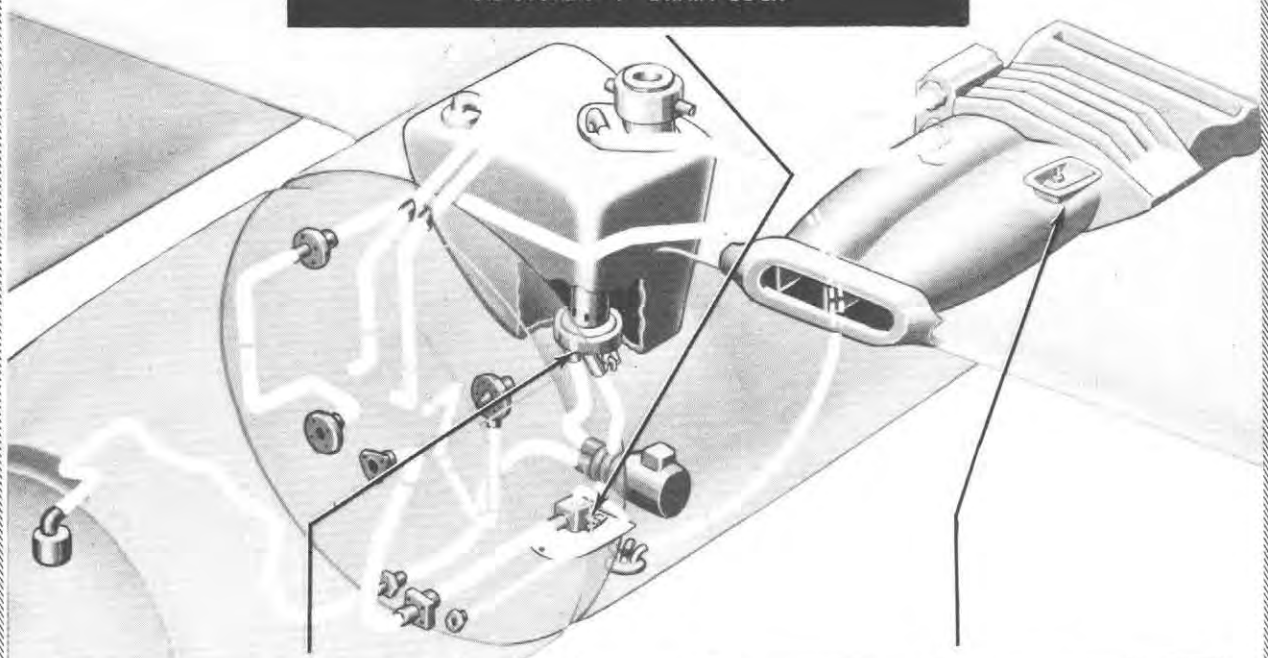
When using kerosene in the cleaning operation, precautions against fire must be observed.

g. OIL TANK. *(See figures 228 & 229.)*

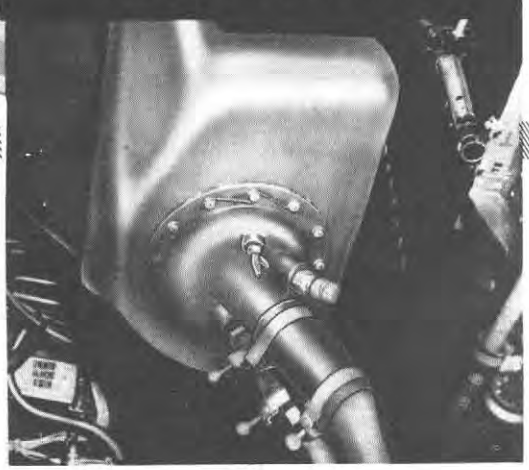
(1) GENERAL.—Each oil tank, installed between the firewall and wing front spar in each nacelle, consists of a self-sealing cell in a metal shell, oil temperature accelerating well (hopper), the necessary inlet and outlet fittings, oil level measuring stick, and filler cap. The oil tank has a total capacity of 39 U. S. gallons (32.5 Imperial gallons) with 30 U. S. gallons (25 Imperial gallons) as the useable oil capacity as indicated by the "N" mark on the measuring stick. A 1.25 U. S. gallons (1.04 Imperial gallons) quantity of reserve oil is maintained by a standpipe in the oil tank sump to supply the propeller feathering pump during an emergency when the engine has been stopped because of a depleted supply of oil. The remaining space in the oil tank is for expansion of the oil.



OIL SYSTEM "Y" DRAIN COCK



OIL TANK SUMP DRAIN COCK



OIL COOLER DRAIN PLUG
(Drain Cock Installed on North Bound Airplanes)

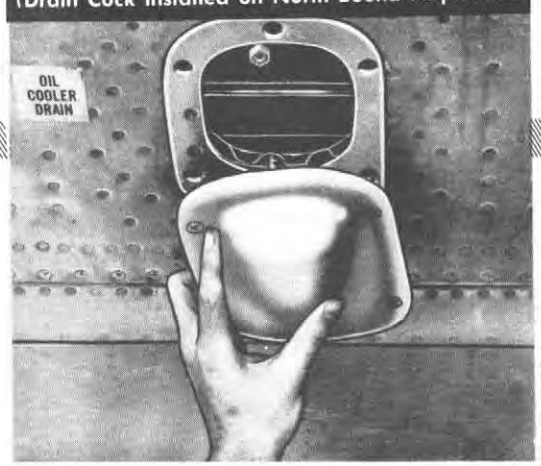


Figure 227—Engine Oil System Drains

(2) SELF-SEALING CELL.—The oil tank self-sealing cell is constructed of an inner liner of oil resistant snythetic rubber, an inner liner of sealing material, and an outside covering or retainer. When the cell is punctured, the sealant comes into contact with the oil and swells to several times its original size. This swelling action, plus a mechanical closing action due to the construction characteristics of the cell, seals the injury and prevents leakage. The cell includes a vent elbow to connect the forward vent line.

(3) OIL TANK SHELL.—The oil tank shell is constructed of aluminum alloy and consists of two parts which are bolted together.

(4) OIL TEMPERATURE ACCELERATING WELL (HOPPER).—The hopper is a metallic tube installed in the oil tank to partially isolate a small quantity of the oil supply. The smaller quantity of oil within the hopper flows to the engine, and oil returning from the engine is introduced into the hopper and immediately flows again to the engine. With the hopper type tank the engine oil is warmed quickly, since the entire oil supply is not being drawn into the engine. The bulk oil in the tank flows into the hopper gradually through holes at the top and bottom of the hopper.

(5) INLET FITTING.—The inlet fitting, located at the top of the oil tank, is a casting that receives the filler cap and provides bosses for the return line elbow, rear vent line connection, overflow drain line connection, and oil level measuring stick, which screws into a tube assembly. The synthetic rubber filler well is attached to the inlet fitting and the oil tank fairing.

(6) OUTLET FITTING.—The outlet fitting, located on the bottom of the tank, provides outlets to the oil supply line and propeller feathering line, and bosses for installation of a drain cock and oil temperature bulb. The outlet fitting is designed with a standpipe to provide a reserve supply of oil available only to the propeller feathering pump.

(7) USE OF OIL IMMERSION HEATERS.—The oil tank filler cap permits the use of oil immersion heaters and a wooden adapter ring is provided to hold the flexible lead of the heater and to provide a seal against the entrance of foreign material into the oil tank. The adapter ring is stowed on the under side of the oil tank filler well access cover. Oil immersion heaters provide a means of heating the oil in the tanks during airplane layovers when low temperatures are encountered and heated hangar space is not available. Normally immersion heaters are not necessary when the oil is properly diluted. The use of immersion heaters will not assist in starting a cold engine or in providing fluid oil in the inlet lines to the engines. If it is necessary to use immersion heaters observe the following procedure:

(a) Use 250 watts—115 volts heaters.

(b) Remove the filler well access cover and filler cap. Place the adapter ring in the filler opening.

(c) Wipe off the heater assembly to prevent foreign material from getting into the oil tank.

(d) Place the heater in the tank and adjust the adapter on the heater lead so that the heating element is approximately two inches from the bottom of the tank. Be sure the heater is covered with oil. Install the heaters after the engines have been stopped and before the oil has cooled.

(e) Plug the heater lead into an external 110 volt circuit. Never connect the heaters to the airplane batteries or use a higher voltage than 110 volts.

(f) It is not necessary to operate the heaters continuously to maintain fluid oil in the tanks. Prior to starting the engines, remove the heaters and install the filler caps and access covers.

Note

Keep clean the space between the heating element and the perforated shield. Prevent the heater from touching the ground.

(8) REMOVAL AND DISASSEMBLY.

(a) REMOVAL.

1. Remove the access panels on the lower side of the nacelle *(3, figure 9)*.

2. Remove the oil "Y" drain cock access door and drain the main oil supply into a clean container after opening the "Y" drain cock. After the oil has drained, close the "Y" drain.

3. Drain the oil in the oil tank sump into a clean container by opening the sump drain cock. Close the drain after the oil has been drained.

4. Disconnect the oil supply line and propeller feathering supply line from the oil tank by loosening the hose clamps.

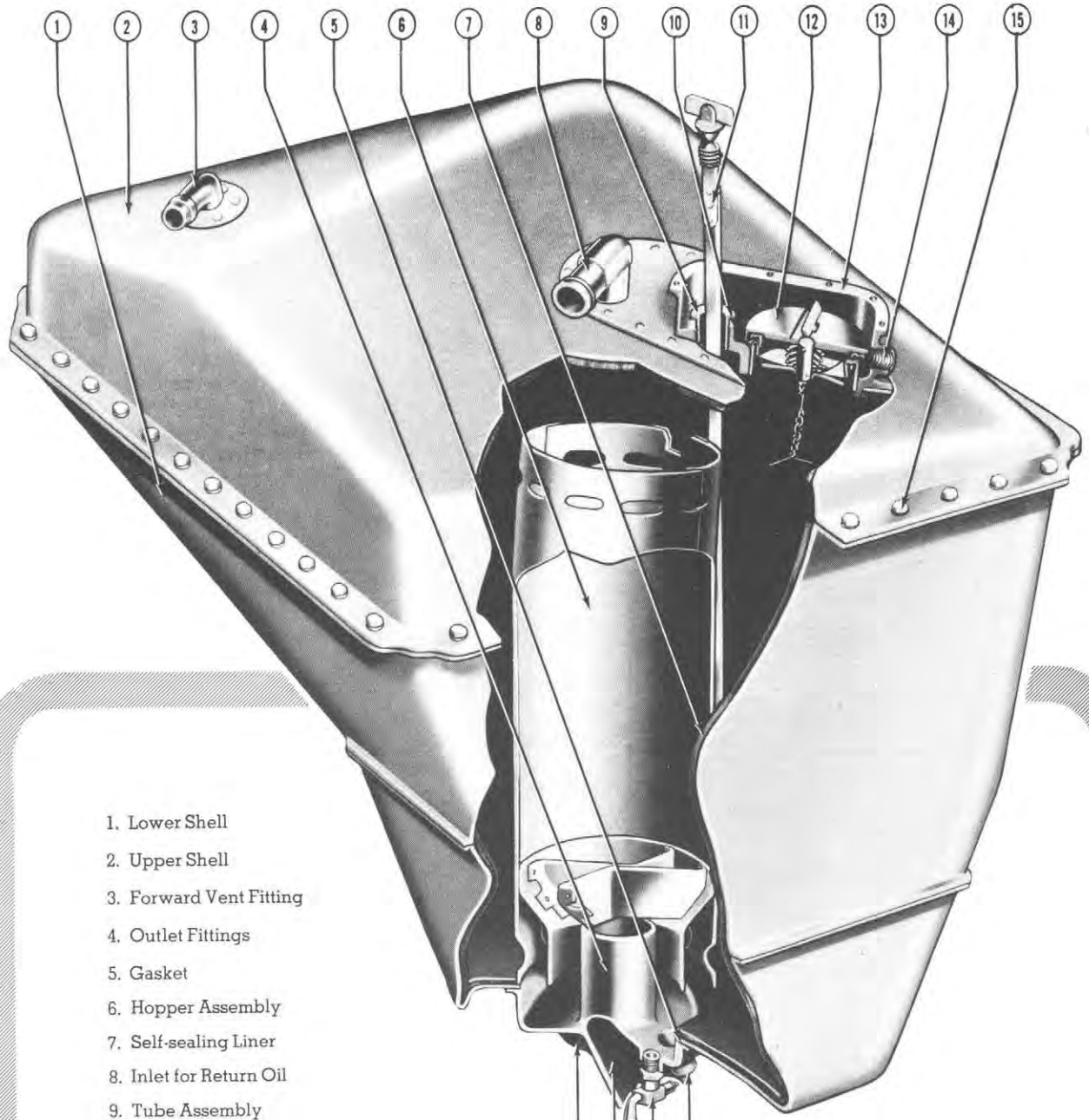
5. Disconnect the electrical wiring from the oil temperature bulb.

6. Remove the oil tank filler well access door on the top of the nacelle by releasing the Dzus fasteners. Remove the screws that attach the filler well to the oil tank fairing. Remove the oil tank fairing.

7. Disconnect the oil return line, the two vent lines, and the overflow drain line.

8. Remove the bolts that attach the oil tank forward and aft flanges to the firewall and to the wing front spar.

9. Lift the oil tank by the inboard and outboard flanges and remove the tank carefully from the nacelle.



1. Lower Shell
2. Upper Shell
3. Forward Vent Fitting
4. Outlet Fittings
5. Gasket
6. Hopper Assembly
7. Self-sealing Liner
8. Inlet for Return Oil
9. Tube Assembly
10. AN900-14 Gasket
11. Measuring Stick Assembly
12. Filler Cap
13. Inlet and Vent Fitting
14. Overflow Drain Line Opening
15. Bolt, Washer, and Nut

Note: Screws holding fittings to self-sealing cell are to be tightened to 20 to 30 inch-pounds. Screws are not to be tightened after initial installation.

Figure 228 — Oil Tank Assembly

CAUTION

Do not lift the oil tank by its fittings.

(b) DISASSEMBLY.

1. Remove the inlet fitting and filler well from the top of the oil tank.

2. Remove the hopper through the filler opening.

3. Remove the outlet fitting from the bottom of the oil tank.

4. Remove the bolts that attach the upper and lower sections of the oil tank shell and remove the upper section.

5. Remove the self-sealing cell from the lower section of the shell.

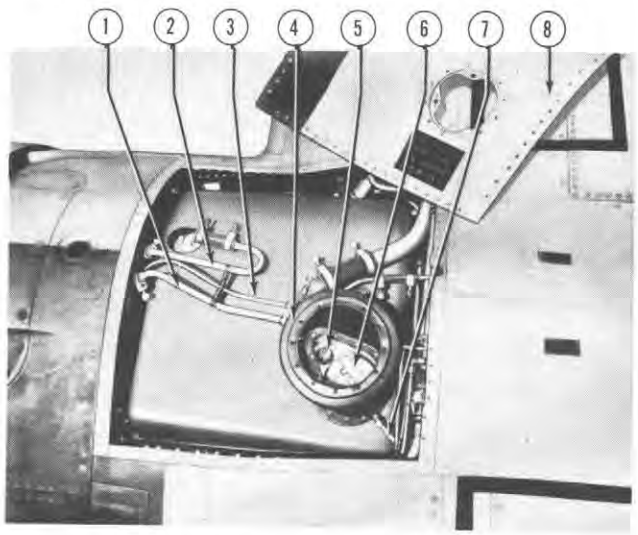
CAUTION

Observe care in removing the self-sealing cell if the metallic shell is damaged to prevent tearing the cell on sharp metal edges of the shell injury.

(9) MAINTENANCE REPAIR OR REPLACEMENT.

(a) CLEANING.—Clean the oil tank at each fourth engine change as instructed in paragraph 12. *f.*, this section.

(b) SELF-SEALING CELL.—Refer to paragraph 12. *g.* (2), this section.



1. Oil Tank Rear Vent Line
2. Oil Tank Forward Vent Line
3. Carburetor Vapor Return Line (Fuel System)
4. Oil Tank Filler Well
5. Measuring Stick Assembly
6. Filler Cap
7. Overflow Drain Line
8. Fairing

Figure 229 — Oil Tank Installed (Nacelle Fairing Removed)

(c) OIL TANK SHELL.—If the oil tank shell or hopper is damaged, install new parts. If the inlet and outlet fittings and gaskets are damaged, replace with new parts.

(10) ASSEMBLY AND INSTALLATION.

(a) ASSEMBLY.—To assemble the oil tank refer to *figure 228* and reverse the disassembly procedure given in paragraph 12. *g.* (8), this section.

Note

Screws holding fittings to the self-sealing cell are to be tightened to 20-30 inch-pounds torque and the screws are not to be tightened after the initial installation.

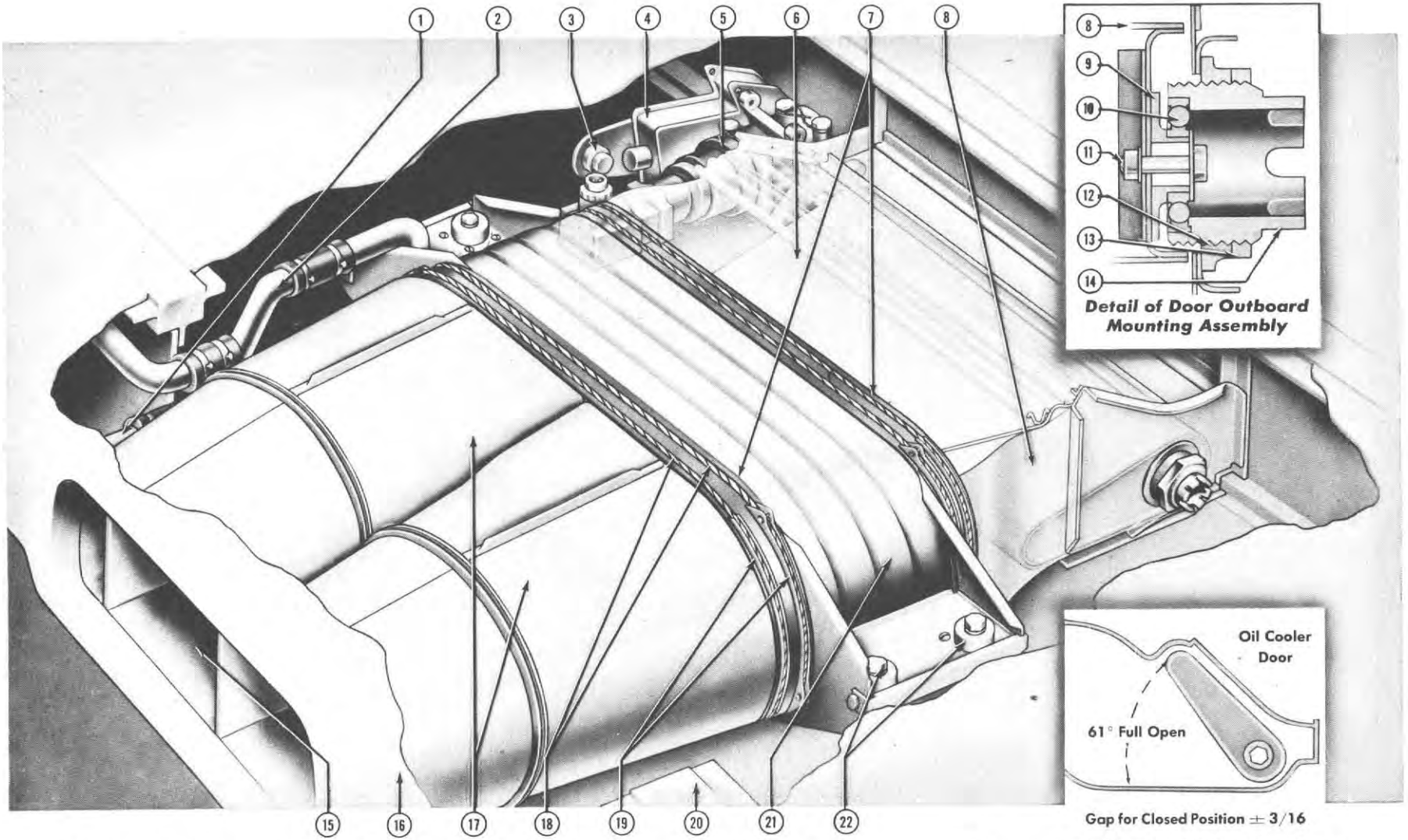
(b) INSTALLATION.—To install the oil tank reverse the removal procedure given in paragraph 12. *g.* (8), this section.

h. OIL TEMPERATURE REGULATOR. *(See figure 230.)*

(1) GENERAL.—The oil temperature regulator installation consists of the oil cooler, control valves, air ducts, and the oil cooler door operating mechanism. The oil temperature regulator functions to maintain the oil supply at the temperature most desirable for engine operation. The oil cooler is installed in the wing outboard of the nacelle. The air intake scoop is installed in the wing leading edge and two ducts are located forward of the cooler. A single aft duct terminates on the under surface of the wing. An oil cooler door (exit flap) is installed in the aft duct and is actuated by an electric motor to control the flow of air through the oil cooler. The hot oil returning from the engine is introduced into the oil cooler and the oil temperature is reduced by the flow of air through the cooler before the oil returns to the oil tank. However, if the oil is cold and the oil pressure is high, the control valves allow the oil to by-pass the cooler and return directly to the oil tank. Oil temperature is regulated by observing the oil temperature indicator *(figure 225)* and operating the oil cooler door by means of the oil cooler door switch, to the position necessary to maintain the proper oil temperature. The oil cooler doors position indicator and oil cooler door switches are located in the pilot's compartment *(figure 225)*. Each oil cooler door switch has three positions "OPEN," "CLOSE," and "OFF."

(2) OIL COOLER.

(a) DESCRIPTION.—The oil cooler for each engine oil system is installed in the wing between the front and rear spars outboard of the nacelle. *(See figure 230)*. The cooler consists of a shell and outer warming jacket and control valve mounting flange, fabricated as an integral unit, and the core assembly. The core, honey-comb-like in external appearance, is a bundle of copper tubes arranged in such a uniform manner that oil can pass over the outside wall of each



1. Oil Line to Cooler
2. Oil Line from Cooler
3. Oil Cooler Door Position Transmitter
4. Actuator Follow-up Unit
5. Oil Cooler Door Actuator
6. Aft Air Duct
7. Seal and Channel
8. Oil Cooler Door
9. Collar Assembly
10. Bearing
11. Bolt and Washer
12. Collar
13. Lock Nut
14. Retainer Assembly
15. Oil Cooler Air Scoop
16. Air Scoop Nose Structure
17. Forward Air Ducts
18. Cables
19. Clamps
20. Front Wing Spar
21. Oil Cooler Assembly
22. Shock Mounts

Adjustment of Oil Cooler Door

Set mechanism stops in drive unit for full travel of 63°, starting with the above minus tolerance of no gap. Set limit switches follow-up actuator unit for full travel to 61°, starting with the above minus tolerance of no gap. Set for full travel to 60°, starting with nominal gap dimension of 3/16 inch.

Figure 230 Oil Temperature Regulator Installation (L.H. Wing)

tube while cold air is flowing along the inside wall. Hot oil flowing around the tubes continually transfers heat to the air flowing through the tube. Because the hexagonal ends of the tubes are bonded together with solder, the core of the cooler actually becomes a leakproof container through which air (through tubes) and oil (surrounding the tubes) circulates freely. This cooling action lowers the temperature of the oil to a degree suitable for normal engine operation. To prevent a channeling of the oil from one end of the core to the other, with consequent partial cooling of oil, a series of baffles divide the core bundle into compartments with openings at alternate ends. Thus the oil is forced to traverse all the tubes in one compartment before passing into the next. The baffles also furnish strength to withstand thermal stresses and hydraulic pressures in the core. The "free-flow" warm-up of oil in the core is accomplished by spacing the tubes and baffles so that low pressure flow paths are set up for the oil.

(b) REMOVAL.

1. Remove the stressed panel, located on the under surface of the wing and stencilled "OIL COOLER ACCESS."

2. Remove the drain plug, or open the drain cock if installed, and drain the oil in the cooler into a clean container.

3. Remove cables and clamps that clamp the rubber seals to the oil cooler and the air ducts. Move the seals so that they will not interfere with the removal of the cooler.

4. Disconnect the hoses leading to the control valve assembly by loosening the hose clamps.

5. Remove the four bolts and washers that attach the cooler to the wing and carefully remove the cooler from the airplane.

6. Remove the shock mounts and brackets from the cooler.

7. Remove the screws that attach the control valve assembly to the cooler and remove the control valve assembly.

8. The cooler is constructed as an integral unit and is not to be disassembled.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check the hose connections at the inlet and outlet lines of the cooler. Replace damaged or deteriorated hoses.

2. Check for oil leakage around the control valve and base casting. Check for leakage where the core joins the shell and base casting.

3. Check mounting straps and clamps for correct tension.

4. Check core tubes for obstructions to air flow. If the core is dirty, blow out with compressed air. If the dirt cannot be removed with an air blast the cooler must be removed and cleaned according to instructions in T. O. No. 03-15-17.

5. Check for collapsed tubes in core by looking through core face. Check core face for surface leaks and outlet ducts for oil splatter from damaged tubes. If the core tubes are damaged or leaking, install a new or serviceable cooler, or the tubes may be replaced according to instructions in T. O. No. 03-15-17.

6. Check the air ducts, inlet scoop, and exit for obstructions and any damage.

7. Clean the oil cooler at each normal engine change or prior to making any solder repairs. In the event of an engine change resulting from an engine failure that releases metal particles into the oil system, the oil cooler must be rebuilt if it is to be used for future engine operation. Remove the oil cooler and tag with AAF form No. 50 marked "METAL-REBUILD" and forward to the control depot. Refer to T. O. No. 03-15-17 for proper cleaning and repair procedures.

(d) TESTS BEFORE INSTALLATION.

1. Attach an air hose to the inlet connection of cooler. Plug all other openings in the cooler.

2. Submerge cooler in a water tank with water covering the core face. Apply 100 to 105 psi air pressure and check for any air bubbling from the cooler core face indicating leaky tubes in cooler.

(e) INSTALLATION.

1. Before installing the oil cooler, make certain that the shock mounts are in good condition. Replace any damaged or deteriorated mounts with new parts.

2. Installation is the reverse of the REMOVAL procedure given in paragraph 12. *b.* (2) *(b)*, this section. Also refer to *figure 230.*

(3) CONTROL VALVE ASSEMBLY.
(See figure 231.)

(a) DESCRIPTION.—The control valve assembly contains a core relief and surge protection valve, external warming jacket relief valve, and core check valve to protect the oil cooler from excessive oil pressures resulting from cold oil. The core protection valve has its opening to the inlet port of the cooler, and has a small atmospheric vent in the cap. The external warming jacket relief valve is under the center of the valve assembly. The core check valve is at the outlet port of the cooler. The entire valve assembly is attached to the cooler by means of screws. In normal operation the oil returning from the engine flows into the lower chamber of the inlet port, then

KEY TO FIGURE 231

1. Guide Nuts
2. Gaskets
3. Warming Jacket Relief Valve Spring
4. Check Valve Spring
5. Warming Jacket Relief Valve Poppet
6. Check Valve Poppet
7. Valve Seats
8. Valve Housing Assembly
9. Outlet Port
10. Inlet Port
11. Gasket
12. Surge Protection and Core Relief Valve Poppet
13. Valve Guide
14. Spacer
15. Packing
16. Packing Retainer
17. Nut
18. Surge Protection and Core Relief Valve Spring
19. Vented Guide Nut
20. Mounting Screw

into the common inlet of the external warming jacket and the core of the cooler, through the core under the check valve, and then to the outlet port. If tne pressure drop in the core exceeds 30 psi, the external warming jacket relief valve is lifted and the oil bypasses around the jacket of the cooler. If the pressure in the system exceeds 45 psi, the core relief valve is lifted to allow the oil to bypass directly from the inlet to the outlet port of the valve. If the system pressure becomes even greater, the guided valve is moved higher, pulling up the core protection valve which finally closes off the oil cooler from the remainder of the system. The core check valve prevents back flow of oil into the core when the surge valve has lifted, bypassing the oil over the check valve into the outlet port of the control valve assembly.

(b) REMOVAL.

1. To remove the control valve assembly refer to paragraph 12. *b.* (2) *(b),* this section.

2. If emergency disassembly of the valve is attempted refer to *figure 231.*

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check for leaks around control valve and oil cooler base casting. Leakage may be caused by a damaged gasket or loosened attaching screws. Check the oil line hose connections.

2. If the control valve assembly is damaged or is not operating properly, replace the valve with a new or serviceable part.

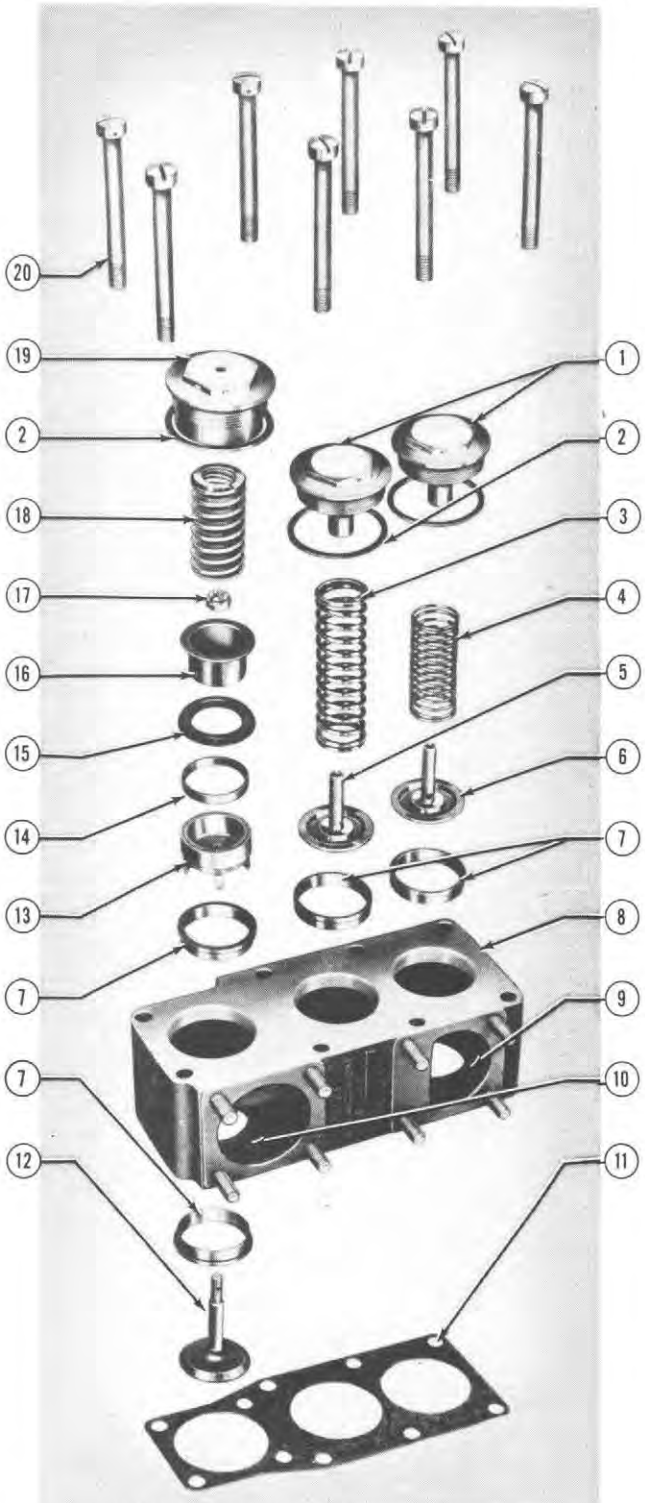


Figure 231—Oil Temperature Regulator Control Valve (Disassembled)

(d) INSTALLATION.—Installation is the reverse of the removal procedure as given in paragraph 12. *b.* (2) *(b)*, this section.

(4) OIL COOLER DOOR AND OPERATING MECHANISM. *(See figure 230.)*

(a) DESCRIPTION.—The oil cooler door (oil cooler duct exit flap) controls the flow of air through the oil cooler and air duct installation. The oil cooler door actuator consists of a gear box with torque drive and electric motor with magnetic brake on which is mounted the automatic follow-up and limit switch box unit, and the oil cooler door position transmitter. The motor provides power to open and close the oil cooler door. The follow-up switch allows the motor to operate until the oil cooler door reaches the desired position: the limit switches stop the motor when the oil cooler door is in the extreme open or closed position. The drive shaft of the actuator fits into a splined collar on the oil cooler door which is supported on the opposite side by a collar which fits into a bearing assembly. The cooler door is controlled by a switch in the pilot's compartment *(figure 225)*. The switch has three positions, "OPEN," "CLOSE," and "OFF." For further description of the oil cooler door actuator and switch box refer to paragraph 15. *d.*(8) *(c)*, this section.

(b) REMOVAL.

1. Remove the access panel on the upper surface of the wing outboard of the nacelle and stencilled, "OIL COOLER DOOR CONTROLS."

2. Disconnect the electrical connections at the oil cooler door actuator and switch box.

3. Remove the bolts that attach the actuator and switch box assembly to the wing structure. Remove the actuator by sliding the drive shaft out of the splined collar on the oil cooler door.

4. Remove the bolt and washer that secure the oil cooler door outboard collar in the retainer and bearing assembly.

5. Cut the lockwire, loosen the lock nut, and unscrew the retainer and bearing assembly until the door outboard collar is free.

Note

It is not necessary to remove the retainer and bearing assembly.

6. Remove the oil cooler door through the oil cooler duct exit by tilting the door and sliding it through the opening.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. For repairs to the oil cooler actuator and switch box refer to paragraph 15. *d.* (8) *(b)*, this section.

2. Check the oil cooler door mechanism for tightness and security of mounting bolts every 50 hours.

3. Check the oil cooler door bearing collars, spacers, and outboard bearing for evidence of wear. Replace damaged parts with new parts.

4. If the oil cooler door is damaged, replace with a new part.

5. Excessive end play in the oil cooler door may be eliminated by tightening the outboard retainer and bearing assembly.

(d) INSTALLATION.—Refer to *figure 230* and reverse the REMOVAL procedure given in paragraph 12. *b.* (4) *(b)*, this section. When installing the oil cooler door, make certain the door has end clearance in its full range of movement.

(e) ADJUSTMENTS.—To adjust the oil cooler door and actuator refer to *figure 230* and paragraph 15. *d.* (8) *(b) 4*, this section.

i. OIL DILUTION SYSTEM — DESCRIPTION. — An oil dilution system is provided for each engine oil system to dilute the engine oil with gasoline to prevent congealing of the oil when the airplane is inactive during cold weather. An oil dilution valve is installed on the right side of each engine mount *(figure 200)* and is controlled by an electrical switch in the pilot's compartment *(figure 225)*. When the dilution switch is placed in the "ON" position the solenoid valve is opened and fuel under pressure from the fuel pressure line *(figure 200)* is injected into the oil inlet line at the "Y" drain valve *(figure 200)*. The diluted oil is circulated through the engine and is returned to the hopper in the oil tank. The dilution switch returns to the "OFF" position when released. When it is necessary to dilute the oil in anticipation of a cold engine start (temperature below 5 degrees C—41 degrees F) observe the procedure given in section III. For other information about the oil dilution solenoid valve refer to paragraph 15. *d.* (7) *(b)*, this section.

j. PROPELLER FEATHERING SYSTEM.—The oil tank supplies oil to the propeller feathering pump, which furnished oil under high pressure to the propeller governor for feathering of the propeller. The propeller feathering pump is mounted beneath the oil tank in the nacelle *(figure 223)*. The propeller feathering supply line is connected to the outlet fitting of the oil tank. A 1.25 U. S. gallons (1.04 Imperial gallons) reserve supply of oil in the oil tank sump is available only to the propeller feathering pump when the engine has been stopped because of a depleted supply of oil. For complete information about the propeller feathering system refer to paragraph 10. *e.* (1), this section.

k. OIL SYSTEM LINES.
(See figure 223.)

(1) DESCRIPTION.—Most of the rigid lines in the oil system are made of aluminum alloy. Hoses and hose clamps are used to connect the lines. Bronze tubing and metal fittings are utilized in the propeller feathering system. Color banding of oil lines is yellow. For general tubing fabrication information refer to section VIII.

(2) REMOVAL.—Removal of oil system lines is accomplished either by loosening the hose clamps or by unscrewing nuts on the tubing collars when metal lines and fittings are used.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—Check the oil system lines and connections frequently for evidence of oil leakage. Replace lines that are damaged. Replace damaged or deteriorated hoses and hose clamps with new parts.

(4) INSTALLATION. — For tubing fabrication and installation information refer to section VIII.

l. OIL SYSTEM TROUBLE SHOOTING CHART.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Low Oil Pressure.	*a.* High oil temperature	*a.* See item No. 2
	b. Excessive oil foaming	*b.* Check oil in tank. If excessive foaming is evident, drain system and fill with new oil.
	(1) High altitude operation	
	(2) Excessively hot oil	
	(3) Oil supply depleted	
	c. Leak, congealed oil, or air in oil pressure gage line; leak or air in oil pressure transmitter line.	*c.* Inspect lines and fittings for leaks. Bleed air from lines or thaw congealed oil. Refill pressure gage line with compass fluid.
	d. Leaking oil dilution solenoid valve.	*d.* Refer to paragraph 15. *d.* (7), this section.
	e. Faulty engine parts or operation	*e.* See engine section trouble shooting chart in paragraph 6. *c.*, this section.
	(1) Oil pressure pump	
	(2) Screens	
	(3) Oil pressure relief valve	
	(4) Excessive engine operating clearness.	
2. High Oil Temperature	*a.* Operating at excessively high manifold pressure.	*a.* Operate engines at recommended manifold pressure.
	b. Insufficient oil supply	*b.* Check oil level in tanks. If supply is abnormally low, check lines and fittings for leaks.
	c. Oil cooler doors not operating properly.	*c.* Check operation of oil cooler doors.
	d. Damaged or restricted oil cooler core.	*d.* Replace cooler if damaged. Restrictions in the core may be removed by use of compressed air, or by removing and cleaning with solvent.
	e. Congealed oil in coolers.	*e.* Close oil cooler doors until core thaws and normal oil flow resumes.
	f. Defective core relief and surge protection valve.	*f.* Replace valve with new port.
	g. Diluted or dirty oil.	*g.* Check oil at tank or at drain cock. If oil is dirty, drain system and fill with fresh oil. If oil is *diluted,* check dilution solenoid valve as instructed in item 1. *d.*
3. Loss of Oil (High Oil Consumption)	*a.* Oil temperature too high	*a.* See item No. 2.
	b. Oil pressure too high	*b.* See item No. 4.
	c. Leaks in system	*c.* Check lines and fittings for leaks.
	d. Oil viscosity too low	*d.* Check dilution solenoid valve as instructed in item No 1. *d.*
	e. Faulty engine parts or operation	*e.* See engine trouble shooting chart in paragraph 6. *e.*, this section.
	f. Clogged breather lines from engine blower case.	*f.* Clean out breather lines.

l. OIL SYSTEM TROUBLE SHOOTING CHART—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
4. High Oil Pressure	a. Low air temperature (Oil too viscous)	*a.* Warm oil supply with ground heaters
	b. Defective gage or pressure transmitter.	*b.* Refer to 13. *f.* (4) *(b)*, this section.
	c. Improper operation of oil pressure relief valve.	*c.* Refer to engine section trouble shooting chart in paragraph 6.
5. No Oil Pressure	*a.* Defective gage or pressure transmitter.	*a.* Refer to 13. *f.* (4) *(b)*, this section.
	b. Damaged oil inlet lines or gage lines.	*b.* Inspect lines and fittings for damage, causing leakage.
	c. Defective oil pressure pump.	*c.* See engine trouble shooting chart in paragraph 6.
	d. Air lock in oil inlet line.	*d.* Prime line pre-oil engine.
6. Delay in Oil Pressure Indication (Stop engine if no oil pressure is indicated within 30 seconds)	*a.* Loose or leaking connections.	*a.* Check connections for tightness.
	b. Excessive viscosity (Pump forcing air into oil system)	*b.* Warm oil supply with ground heater.
7. Fluctuating Oil Pressure Indication	*a.* Insufficient oil supply	*a.* Check oil level in tanks. If supply is abnormally low, check lines and fittings for leaks. If supply is normal, check operation of oil pump. See engine trouble shooting chart in paragraph 6. *c.*
	b. Air in pressure gage or pressure transmitter lines.	*b.* Bleed air from lines. Refill pressure gage lines with compass fluid.
	c. Oil viscosity too high.	*c.* Warm oil supply with ground heater.

13. INSTRUMENTS

a. GENERAL.—Most of the instruments used on this airplane are installed on a shock-mounted panel located in the pilot's compartment forward of the control column. The instrument panel is illuminated by two fluorescent lamps attached to the instrument panel shield. On airplanes equipped with the bombardier nose (A-26C) a small instrument panel is provided for the bombardier. Engine instruments are the dual indicating type, actuated by remote electrical transmitters, low pressure fluid transmitters, or by direct reading. Instruments which indicate altitude, airspeed and rate of climb operate from direct atmospheric pressures supplied through the pitot-static tube, located on the tip of the vertical stabilizer. Flight instruments of the gyroscopic type are vacuum-actuated, operating by suction furnished by either one of two engine-driven vacuum pumps. The majority of the engine and position indicators are actuated electrically. Two exceptions are the fuel and oil pressure indicators operated by means of pressure transmitters located in the engine sections. A third exception is the engine manifold pressure gage, which provides a direct indication. All indications are transmitted either by means of aluminum alloy tubing and flexible hoses, or by electrical wiring. An auxiliary airspeed line, not connected to any equipment, is installed in the fuselage aft section and the vertical stabilizer on some airplanes. The line was provided for possible future installation of a wing flap maneuvering control.

b. INSTRUMENT PANEL.

(1) DESCRIPTION. – A shock-mounted instrument panel is installed in the pilot's compartment and in the bombardier nose if installed. These panels are attached to the airplane structure by means of six Lord vibration absorbers installed in four places.

(2) REMOVAL.

(a) Disengage the electrical cables and flexible lines from the instruments.

(b) Label all the instrument connections to facilitate replacement.

(c) Remove the panel by disengaging the bolts from the vibration absorbers which secure the panel in position.

(d) Cap all lines and instruments so that dirt cannot enter.

(3) MAINTENANCE REPAIR OR REPLACEMENT.—A cracked or broken instrument panel shall be replaced.

(4) INSTALLATION.

(a) Support the panel in place while inserting the bolts through the vibration absorbers. Tighten the bolts evenly.

(b) Remove the caps from the lines and apply a coat of thread lubricant compound to the threads. Then connect the lines to the respective instruments according to the labels. Use short-handled line wrenches and do not put excessive strain on the fittings. Make certain that the panel rides clear of all surrounding structure.

(c) Connect the electrical plugs on the back of the instruments.

(5) TEST AFTER INSTALLATION.—Check panel vibration, which should not exceed an .004 inch amplitude.

c. PITOT-STATIC INSTRUMENTS AND EQUIPMENT. *(See figure 234.)*

(1) GENERAL.—The pitot-static instruments and equipment consist of the airspeed indicator, the altimeter, the rate of climb indicator, the pitot-static tube and the connecting lines.

(2) OPERATIONAL TESTS.

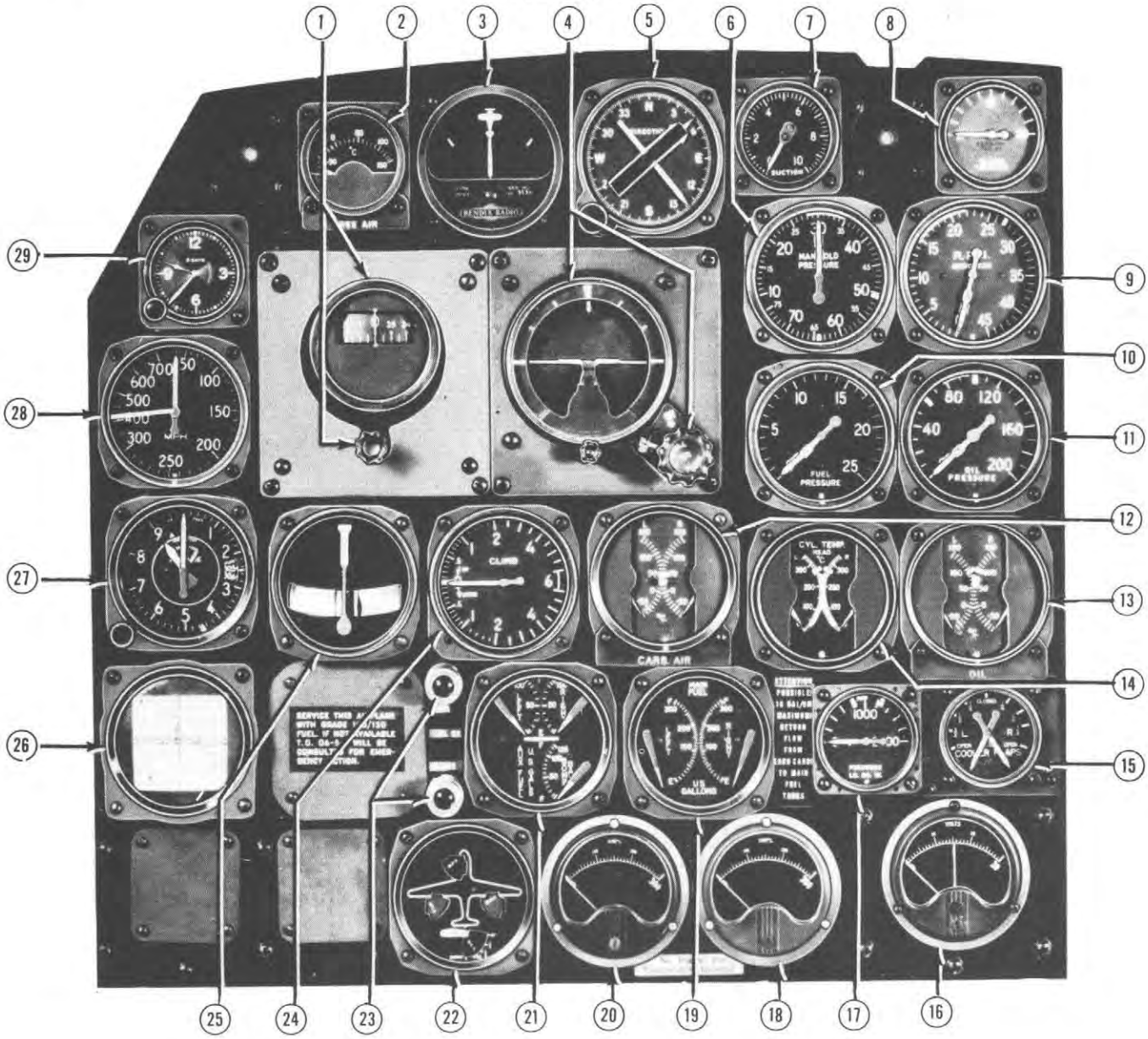
(a) PITOT-STATIC INSTRUMENTS. – Improper operation of a pitot-static instrument may be due to (1) a faulty mechanism, (2) a leaking case, (3) a leaking line or connection, or (4) foreign material in the pitot-static tube or connecting lines.

(b) If the pointer of the airspeed indicator, the altimeter or the rate of climb indicator fails to respond, the source of the trouble frequently may be traced to a stoppage in the pitot-static tube or the connecting lines. Disconnect the instruments involved and clean the lines and tubes by applying air pressure at the panel ends of the lines. If this fails to overcome the trouble, install a new instrument.

(c) If the pointer of the airspeed indicator or the rate of climb indicator oscillate, or if the altimeter reading is too high, the source of the trouble frequently may be traced to leakage of air in the instrument cases or connecting lines. If tests show that an instrument case is leaking, remove the instrument and install a new one. If tests show that the instrument itself functions properly, test the lines and connections for leaks.

CAUTION

These tests should be made only by persons familiar with the delicate nature of the instruments. Test pressures must be applied and released slowly and gently to avoid damaging the instruments.



1. Directional Gyro (Turn) Indicator and Setting Knob.
2. Outside (Free) Air Temperature Indicator
3. Radio Compass Left-Right Indicator
4. Gyro Horizon (Flight) Indicator and Caging Knob
5. Remote Magnetic Compass Indicator
6. Manifold Pressure Gage (Dual)
7. Suction Gage
8. De-Icer System Pressure Gage
9. Tachometer Indicator (Dual)
10. Fuel Pressure Gage (Dual)
11. Oil Pressure Indicator (Dual)
12. Carburetor Air Temperature Indicator (Dual)
13. Oil Temperature Indicator (Dual)
14. Cylinder Head Temperature Indicator (Dual)
15. Oil Cooler Door Position Indicator (Dual)
16. Voltmeter
17. Hydraulic Pressure Gage
18. R. H. Engine Ammeter.
19. Main Fuel Quantity Gage
20. L. H. Engine Ammeter
21. Auxiliary Fuel Quantity Gage
22. Landing Gear and Wing Flap Indicator
23. Landing Gear Warning Lamps
24. Rate of Climb Indicator
25. Bank and Turn Indicator
26. Tell-Tale Indicator
27. Altimeter
28. Airspeed Indicator
29. Clock

Figure 232—Instrument Panel

1. AIRSPEED INDICATOR CASE LEAK TEST.

a. Disconnect the STATIC line as close to the indicator as possible and attach a rubber tubing to the instrument end.

b. Put the other end of the tubing in the mouth and softly take in breath until the pointer reaches 200 mph. Then pinch off the tube.

c. If the pointer descends faster than five mph, a leak in the instrument case is indicated and the instrument must be replaced. If no case leak is indicated, test the connecting lines for leaks.

2. PITOT PRESSURE (AIRSPEED) LINE LEAK TEST.

a. Seal the pitot pressure drain holes in the pitot-static tube with tape.

b. Attach a rubber tube to the pitot pressure (airspeed) opening at the end of the pitot static tube, making sure that the connection is air tight.

c. Blow GENTLY into the tube until the airspeed indicator is caused to read 150 mph. Then pinch off the source of pressure.

CAUTION

Do not apply suction to the pitot-pressure (airspeed) opening of the pitot static tube.

d. During a one minute period the indicator pointer should not change appreciably from the 150 mph reading. The indicator case must be tapped with the fingers during the test to overcome the effects of friction on the pointer.

e. If the pointer indication varies by more than 10 mph, check the lines for cracks or faulty connections.

3. ALTIMETER CASE LEAK TEST.

a. Disconnect the line (static pressure) from the altimeter.

b. Connect a length of rubber tubing to the altimeter vent and by blowing gently, decrease the altitude indication by only 500 feet.

c. Pinch off the tube and watch the pointer for 10 seconds. Tap the indicator case to eliminate friction. The indication should not change by more than 20 feet.

d. If the change is more than 20 feet during the 10 second period, a case leak is indicated and the altimeter must be replaced.

4. RATE OF CLIMB INDICATOR CASE LEAK TEST.

a. Set the indicator pointer to zero by means of the adjusting knob on the face of the instrument.

b. Disconnect the static line from the instrument and attach a rubber tubing to the inlet on the instrument case.

c. GENTLY AND SLOWLY apply a suction which will cause the pointer to read 2,000 feet per minute ascent, and then pinch the tube. The pointer then should return to zero and stay there as long as the tube is pinched off.

d. If the pointer rotates past zero, an air leak in the instrument is indicated and another instrument should be installed. Be sure to tap the instrument case while making the test to overcome friction in the pointer shaft.

5. STATIC PRESSURE LINE LEAK TEST.

a. Connect a mild source of suction to the static opening of the pitot static tube. (A rubber tube may be used by splitting one end and binding it to the pitot-static tube.)

b. Set the altimeter pointers to zero.

c. Slowly apply SUCTION to the static line until the altimeter pointers indicate an altitude of 1,000 feet. Then pinch off the tube and tap the instrument case to overcome friction in the pointer.

d. In one minute the indication of the altimeter pointers should not change by more than 150 feet.

e. If the change in the position of the altimeter pointers exceeds 150 feet, check the lines for cracks or loose connections.

CAUTION

Do not apply air pressure to the static pressure lines when the instruments are connected.

(3) REMOVAL OF INSTRUMENTS.

(a) Remove the access door *(7, figure 7)* to the instruments, located on the upper left-hand side of the fuselage, forward of the windshield.

(b) Remove the individual instruments from the back of the panel by disengaging the flexible lines and removing the four bolts which secure each instrument to the panel. The bolts are of various lengths and should be kept with the instruments.

(c) Label the instrument connections for location if more than one instrument is removed.

(d) Cap the lines.

(4) MAINTENANCE REPAIR OR REPLACEMENT.—Damaged or faulty instruments shall be

replaced. Before removing an instrument which is believed to be defective, it should be subjected to a test to make certain that the difficulty lies in the instrument, and is not due to leaky or clogged lines, or a damaged pitot tube. Refer to Operational Test paragraph 13. *c.* (2), this section.

(5) ASSEMBLY AND INSTALLATION OF INSTRUMENTS.

(a) Reverse the REMOVAL procedure.

(b) Apply a coat of thread lubricant compound to the threads before connecting the lines to the instruments.

(c) Check the flexible connecting hoses, and replace them if they have hardened or deteriorated.

(6) AIRSPEED INDICATOR.—The airspeed indicator, one on pilot's instrument panel and one on bombardier's instrument panel (if installed), records the speed of the airplane as it travels through the air. The instrument is actuated by impact and static pressures supplied by the pitot-static tube, the difference between the pressures being the means of measurement. Scale range on the dial is from 0 to 700 miles per hour. The instrument is automatic in operation and no external adjustments are provided.

(7) ALTIMETER.

(a) The altimeters (one on the pilot's instrument panel and one on the bombardier's instrument panel, if installed), compute the altitude of the aircraft in reference to a preselected location on the ground, and also the altitude above sea level. The altimeter is connected to the static line of the pitot-static tube and is operated by changes in the existing atmospheric pressure. Devices on the dial consist of an altitude scale, a barometric scale with an index marker, two reference markers, and three pointers. A knob on the front of the instrument is used prior to take-off to set the pointers to zero, or to a pressure specified by the pilot.

(b) ADJUSTMENT. – The altimeter pointers may be set to zero or the existing barometric pressure by means of a setting knob which protrudes from the front of the instrument. This adjustment is made by the pilot.

(8) RATE OF CLIMB INDICATOR.

(a) DESCRIPTION.—The rate of climb indicator is used to indicate a gain or loss in the altitude of the airplane while it is in flight. In level flight, the pointer is horizontal. In rate of climb, the pointer rotates upward from the zero position; in rate of descent, the pointer rotates downward from the zero position. A zero setting screw protrudes from the front of the instrument. The instrument consists principally of an indicator, a thermos chamber and a diaphragm. It is actuated by the differential between the atmospheric static pressure, supplied by a line from the pitot-static tube, and the pressure within the thermos chamber.

(b) ADJUSTMENT.—When the rate of climb indicator does not properly indicate zero, the pointer may be adjusted by means of a screw located on the front of the instrument. Tap the instrument with the finger while making the adjustment.

(9) PITOT-STATIC TUBE. *(See figure 233.)*

(a) DESCRIPTION.—The pitot-static tube provides the means of actuation for airspeed indicator, the altimeter, and the rate of climb indicator. The tube is installed on the leading edge of the vertical stabilizer, at the top. Two connecting lines extend through the fuselage to the instrument panel. An electrical heater, controlled from the pilot's main electrical control panel, is used to prevent icing of the pitot-static tube. Designed to be used only when freezing conditions are encountered in flight, the heater may be turned on momentarily for checking purposes while the airplane is on the ground. For further information on the heater refer to paragraph 15. *d.* (9) *(b)*, this section.

(b) REMOVAL.

1. Disconnect and cap the two pitot-static tube lines through the access hole located just below the tube.

2. Remove the neoprene fillet cemented to the stabilizer plating and the pitot-static tube by applying non-leaded gasoline to the base of the fillet and working the fillet loose.

Figure 233– Pitot Static Tube

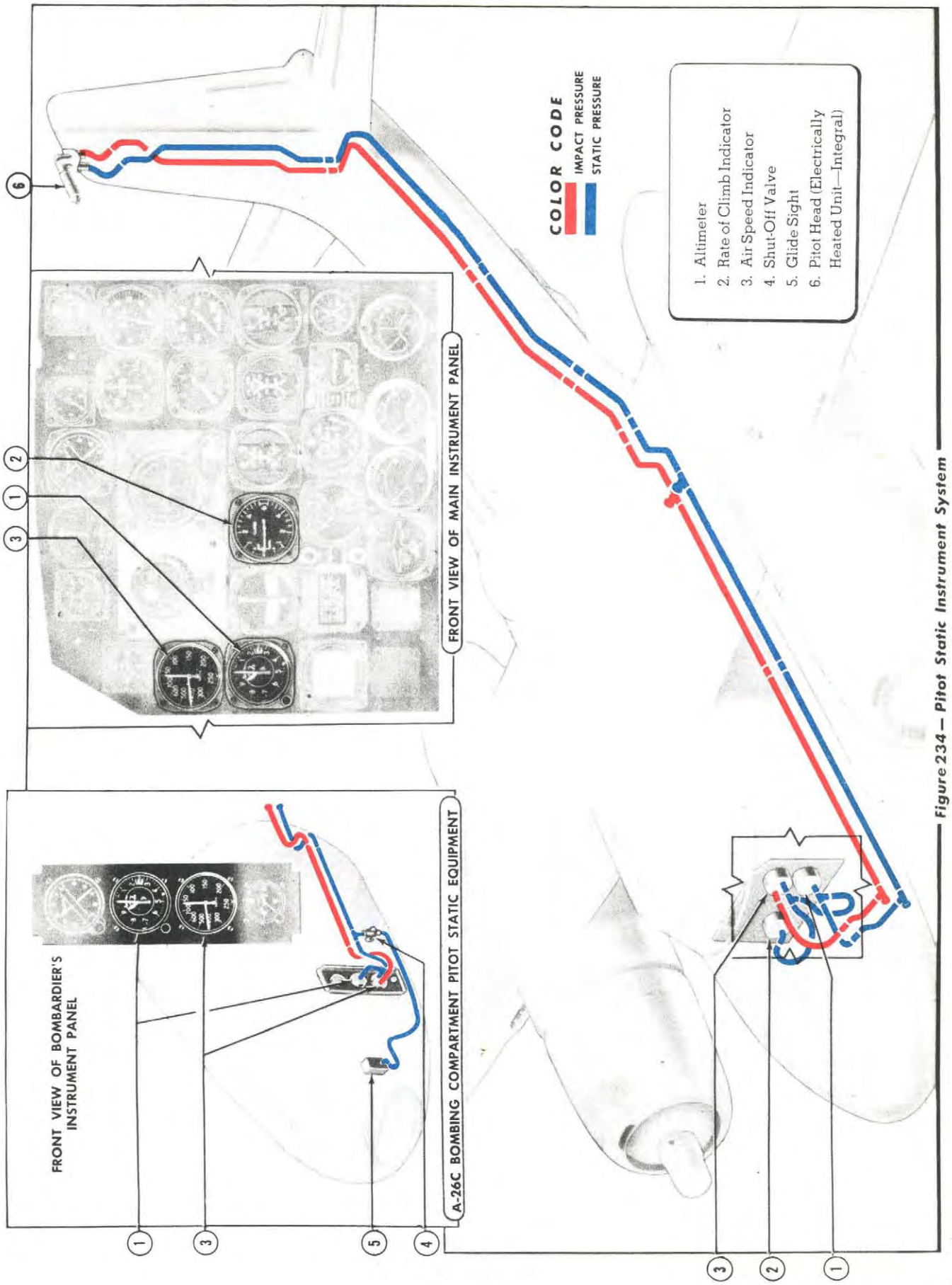


Figure 234 — Pitot Static Instrument System

3. Remove the two screws and disconnect the heater element wires from the base of the pitot-static tube. Lift the tube from the tip until the lines are clear.

(c) MAINTENANCE REPAIR. – A damaged pitot-static tube, or a tube with a burned out heating unit, shall be replaced.

(d) INSTALLATION.

1. Place the tube in position; remove the caps from the lines, apply a thread lubricant compound to the threads, and connect the lines to the pitot-static tube.

2. Insert the screws which secure the tube to the bracket and tighten them.

3. Connect the heating element wires.

4. Cement the neoprene filler to the stabilizer plating with neoprene cement, preferably DuPont Fairprene No. 1 or 4. Apply a thin, even coat to both surfaces and allow to dry from 20 to 45 minutes (or until the solvent odor and the sheen are gone). A better bond will be obtained if the metal surface is first primed with cement primer, preferably 624 N, manufactured by B and D Chemical Co., or equivalent.

(10) LINES. *(See figure 234.)* – Aluminum alloy tubing is used to carry static and dynamic air pressures from the pitot-static tube to the pitot-static instruments. The tubing is held in place at definite points by means of clips and clamps which reduce vibration. The actual connection to the instruments is made with short lengths of flexible composition hose, installed to reduce instrument panel vibration. Drain tees *(figure 234)* are provided in each line. Lines repair and replacement instructions may be found in Section VIII.

d. VACUUM-ACTUATED INSTRUMENTS AND EQUIPMENT. *(See figure 235.)*

(1) GENERAL.–The vacuum operated instruments installed in the airplane, and associated equipment, consist of a bank and turn indicator, a gyro horizon indicator, a directional gyro indicator, a suction gage, two engine-driven vacuum pumps, two suction relief valves, a vacuum pump selector valve, an air filter and connecting lines. The terms "vacuum" and "suction" are used interchangeably to signify reduced air pressure.

(2) REMOVAL OF INSTRUMENTS.

(a) Remove the access door to the instruments, located on the upper left-hand side of the fuselage, forward of the windshield.

(b) Remove the individual instruments from the panel by disengaging the flexible lines and removing the four bolts which secure each instrument to the panel. As the bolts are of various lengths they should be kept with the instruments to which they belong.

(c) Label the instrument connections for location if more than one instrument is removed.

(d) Cap the lines.

(3) ADJUSTMENT.–See adjustment of the suction relief valve below.

(4) MAINTENANCE REPAIR OR REPLACEMENT.–Damaged or defective vacuum instruments shall be replaced. Improper operation of the gyro instruments usually is caused by excessive vibration, or an improper supply of vacuum and these possibilities should be checked before the instrument is removed from the airplane. Following are system tests which should be made before a supposedly defective vacuum instrument is removed from the airplane.

(5) BANK AND TURN INDICATOR.

(a) DESCRIPTION.–The bank and turn indicator is a "two-in-one" instrument, used principally during conditions of poor visibility. It helps the pilot to keep the airplane laterally level while flying straight, and to bank at the proper angle when turning. The instrument consists of a gyro-actuated indicator and a simple form of pendulum.

(b) MAINTENANCE REPAIR.

1. Check the vacuum being supplied to the instrument by attaching a portable suction gage to the inlet on the bottom of the case. The desired vacuum at the inlet is 1.9 inches of mercury. Minimum vacuum required for operation is 1.08 inches of mercury and the maximum is 2.05.

2. If the vacuum is below minimum or above maximum, check the adjustment of the control valve located on the vacuum instrument manifold. This valve functions to restrict the suction supplied to the bank and turn indicator. If the control valve is dirty, it should be removed and cleaned with solvent.

3. If insufficient vacuum is being supplied to the control valve, check the vacuum pump for proper operation and the vacuum lines for air leaks.

(c) TEST AFTER INSTALLATION. – The pointer must set at zero, with a tolerance of $\pm$ 1/64 inch, when the gyro is not spinning. When the airplane is in the normal horizontal position, the bell should rest at the zero position with a tolerance of $\pm$ .008 inch if the instrument is tapped gently.

(6) GYRO HORIZON INDICATOR.

(a) DESCRIPTION.–The gyro horizon (flight) indicator establishes an artificial horizon by means of a gyro-actuated horizon bar and a fixed miniature airplane. A pointer attached to the dial also indicates the degree of bank. A caging knob is provided on the front of the instrument so that it can be made inoperative during violent maneuvers.

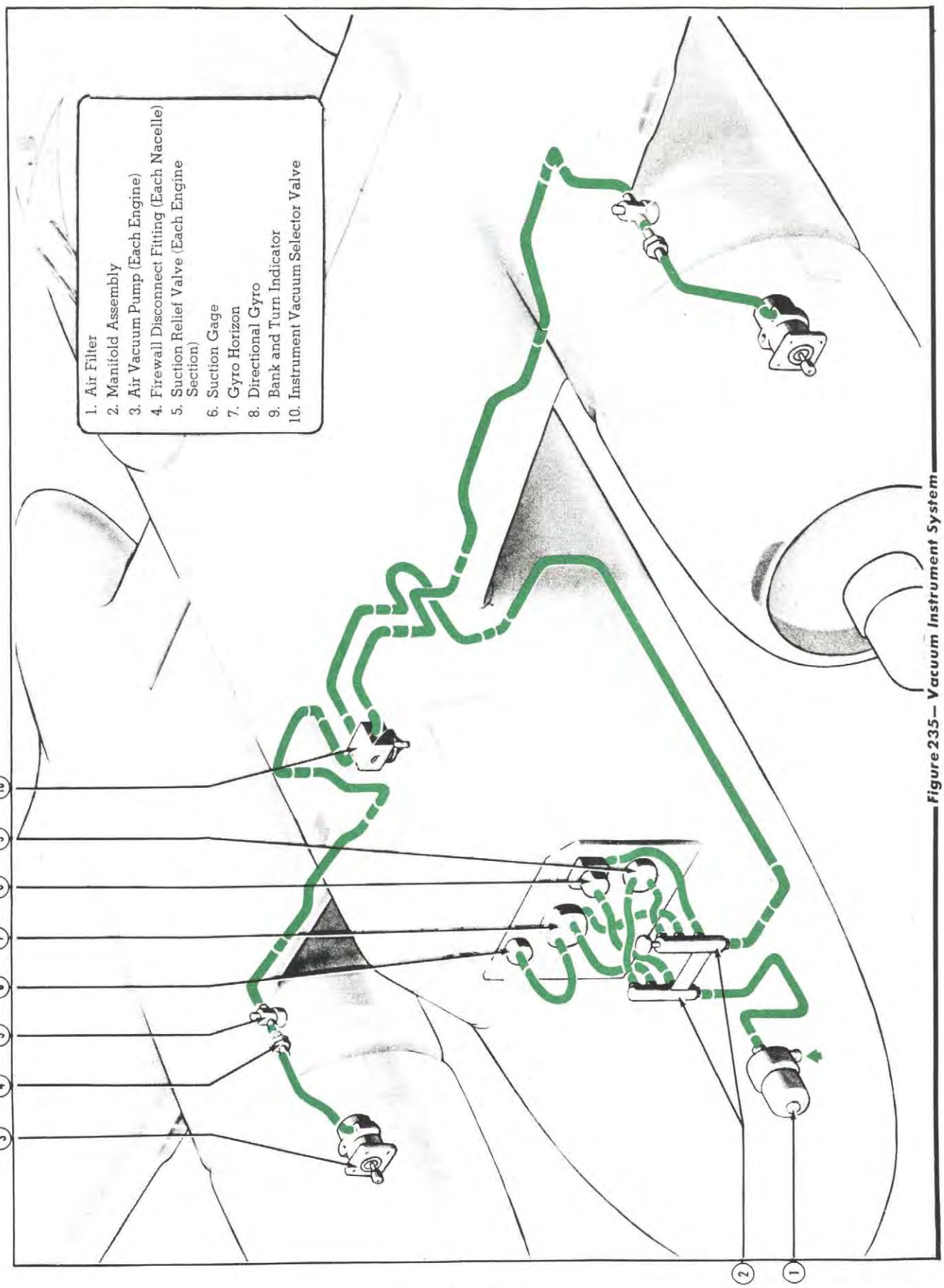


Figure 235– Vacuum Instrument System

(b) MAINTENANCE REPAIR.

1. Check the vacuum being supplied to the instrument concerned by connecting a portable suction gage to the alternate connection on the instrument. The vacuum required is from 3.5 to 4.2 inches of mercury.

2. If abnormal or subnormal vacuum is being provided, check the suction relief valve *(figure 239)* for proper adjustment and operation. The relief valve, located in the nacelle forward of the firewall, is used to regulate the vacuum supplied by the vacuum pump, as well as to supply air to the pump if a line becomes clogged.

3. If sufficient pressure is being supplied to the suction relief valve, check the vacuum pump for proper operation and the lines for air leaks.

(c) TEST AFTER INSTALLATION. – After the engines have been running for 10 minutes or more, and the suction is shut off, the gyro in the gyro horizon indicator should coast at least eight minutes but not more than sixteen minutes. The gyro rotations can be detected by placing the ear to the cover glass. When the engines are running, the horizon bar should hold steady after one and one-half minutes.

(7) DIRECTIONAL GYRO INDICATOR.

(a) DESCRIPTION.–The directional gyro (turn) indicator establishes a fixed reference on flight direction. It consists of a gyroscope, a graduated circular card on which the relative movement of the airplane is shown, and a caging knob used to set the gyro assembly on the desired heading.

(b) MAINTENANCE REPAIR.–See paragraph *(b)* above.

(c) TEST AFTER INSTALLATION.

1. The test given for the gyro horizon indicator (paragraph 13. *d.* (6)), also is applicable for the directional gyro indicator.

2. Improper operation of the directional gyro indicator frequently is caused by excessive vibration or improper vacuum, and these factors should be checked before the instrument is removed from the airplane. Instrument panel vibration should not exceed .004 inch amplitude.

(8) SUCTION GAGE.

(a) DESCRIPTION.–The suction gage, which is connected by a line to the gyro horizon indicator, shows the amount of suction supplied to the vacuum operated instruments. It consists mainly of a pressure-sensitive diaphragm, a dial calibrated in inches of mercury, and a pointer. Desired amount of suction is four inches of mercury.

(b) TEST AFTER INSTALLATION.–Check the suction gage for proper operation while the engines are running.

(9) AIR FILTER. *(See figure 236.)*

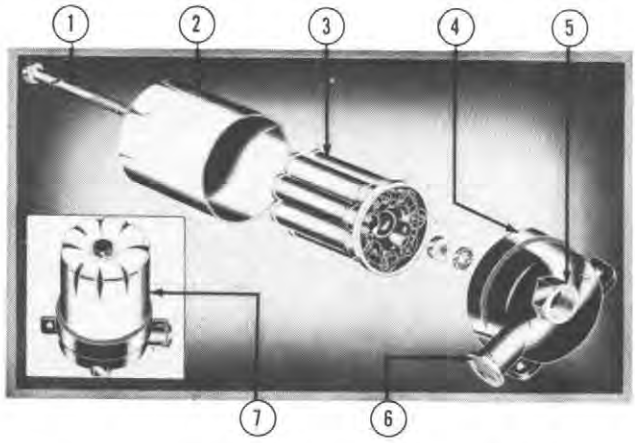
(a) DESCRIPTION.–The air filter is connected to the air intake port of the vacuum system, and is designed to remove from the air all the foreign substances which might damage the sensitive instruments. The filter is installed on the forward end of the control pedestal in the pilot's compartment and can be serviced without removing the outer case from the mounting bracket. The air filter is supplied in more than one shape and design, but operation is the same and maintenance requirements are similar. The air filter illustrated in *figure 236* contains a cylindrical diffusing screen and seven tubular elements through which the air must pass before it reaches the vacuum-operated instruments.

(b) REMOVAL.–Disconnect the line at the fitting and remove the two attaching bolts. Cap the line. For disassembly of the air filter, refer to the following maintenance repair instructions.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Damaged or defective air filters shall be replaced. Cleaning of the air filter, or replacement of the filtering elements is required after 25 hours of operation. To disassemble and clean the filter proceed as follows:

1. Disconnect the flexible hose from the filter outlet.

2. Cap the hose.



1. Disassembly Bolt
2. Filter Case
3. Filtering Elements (Diffusing Screen Not Shown)
4. Filter Head
5. Outlet Port
6. Inlet Screen
7. AN5822-1 Air Filter

Figure 236 — Air Filter

3. Loosen the bolt on the bottom of the filter and remove the filter head.

4. Remove the lock nut and nut from the bolt and pull out the filter assembly.

5. Slide off the cylindrical diffusing screen which covers the filter elements.

6. Apply low pressure compressed air to the open ends of the filter elements to loosen dirt deposits. Also direct the air along the filaments from each end. Do not apply the air pressure at right angle to the filter.

7. Using a clean cloth, wipe off any remaining dust on the elements and in the case. Also wipe the head, especially the outlet port and the inlet screen.

8. After the diffuser and elements have been reassembled in the case, the puller nut should be installed loosely by hand and then locked in place with lock nut.

(10) ENGINE - DRIVEN VACUUM PUMPS. *(See figure 237.)*

(a) DESCRIPTION.—Two engine-driven vacuum pumps supply the suction required to operate the gyroscopic instruments, and the air pressure required to operate the wing and tail de-icing system. The pumps, installed on the lower left-hand side of each engine, are of the rotary, four vane, positive displacement type. Each pump consists essentially of a cast aluminum housing containing a tempered sleeve in which an offset rotor with four moving vanes is driven by means of a spring coupling mated with the engine drive gear. Rated capacity is 17 cubic feet of free air per minute at 2250 rpm with 4.2 inches of mercury inlet suction, and 16 inches of mercury outlet pressure. Ratio of the pump rpm to the engine rpm is 5 to 3. Both pumps operate continuously with the engines. They are automatically lubricated.

Figure 237 — Typical Vacuum Pump

(b) REMOVAL.

1. Remove the left-hand access door on the nacelle, or the removable center section of the firewall.

2. Loosen the clamps and remove the two flexible hoses attached to the pump.

3. Remove the four safety-wired nuts which attach the pump to the engine.

4. Pull the pump away from the engine.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Damaged or defective engine-driven vacuum pumps shall be replaced. For emergency repair see *figure 237.*

(d) TEST AFTER INSTALLATION.—Check vacuum provided by the pumps. The vacuum recorded on the suction gage should be 4.2 inches of mercury.

(11) VACUUM PUMP SELECTOR VALVE. *(See figure 238.)*

(a) DESCRIPTION.—While the two vacuum pumps run continuously with the engines, suction from only one of the pumps is utilized to operate the vacuum-actuated instruments. The vacuum pump selector valve, installed in the pilot's compartment aft of the pilot's seat, makes it possible for the pilot to switch the source of suction from one pump to the other in event of an engine failure. Under normal operation, the suction from the alternate pump is used to draw air from the de-icer system so that the de-icer boots will "hug" the wings and the stabilizers. When the de-icer system is operating, the same source of suction helps to deflate the boots.

(b) REMOVAL.

1. Disconnect the four vacuum lines and cap them.

2. Remove the four bolts which secure the valve to the bracket. Remove the valve.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—A damaged or defective vacuum pump selector valve shall be replaced. For emergency repairs see *figure 238.*

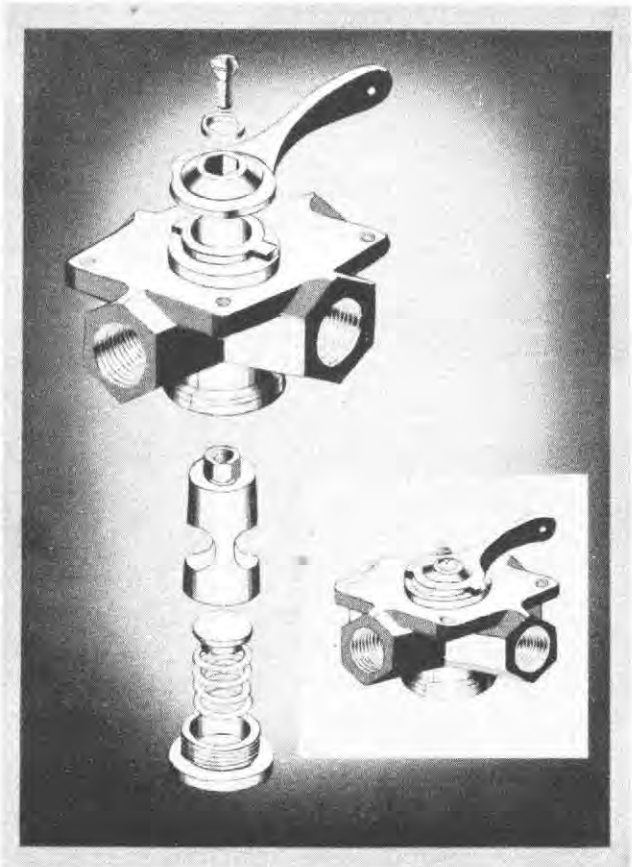


Figure 238—Vacuum Pump Selector Valve

(12) VACUUM MANIFOLD ASSEMBLY. *(See figure 235.)*

(a) DESCRIPTION. – The vacuum manifold assembly, mounted on a bracket in the pilot's compartment forward of the instrument panel, provides a simple means of distribution of vacuum to and from the vacuum-actuated instruments. The manifold assembly is a casting consisting of two leak-proof chambers, each containing four ports. An adjustable needle-valve is mounted on the casting, and is connected into the line which extends to the bank and turn indicator. The valve is used to restrict the vacuum from four inches of mercury to two inches.

(b) REMOVAL.

1. Remove the instrument panel access door on the top of the fuselage.

2. Disconnect the lines and the two bolts which attach the assembly to the bracket.

3. Remove the assembly.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–A damaged or leaking vacuum manifold assembly shall be replaced.

(13) SUCTION RELIEF VALVE. *(See figure 239.)*

(a) DESCRIPTION.–A suction relief valve is installed in each of two lines extending from the vacuum pumps to the selector valve. Located in each nacelle forward of the firewall, the relief valves provide a means of controlling the amount of suction supplied. Each valve automatically supplies air to the vacuum pump in event that a line becomes clogged. The suction relief valve is the spring-loaded, disc type and has an adjustment screw.

(b) REMOVAL.

1. Remove access door from left-hand side of the engine mount.

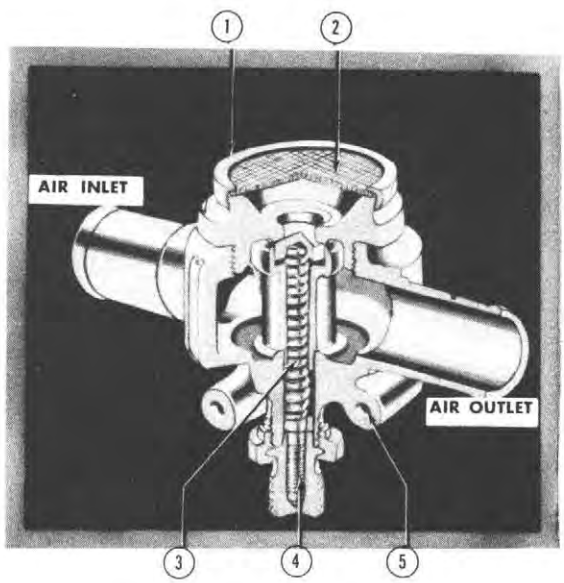
2. Disconnect the lines and cap them.

3. Remove the clamps from the two hose connections to the valve.

4. Slide off the hose and remove the valve.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. At regular engine overhaul periods, remove the valve seat from the valve body *(figure 239)* and take out the bakelite disc. Inspect the disc and correct any slight wear by passing it lightly over a flat oil stone. If the wear is excessive, replace the disc.



1. Type B-8 (3V-216-B) Suction Relief Valve
2. Valve Screen
3. Spring
4. Adjustment Screw
5. Mounting Lugs

Figure 239—Suction Relief Valve

2. When reassembling the valve, note condition of the gaskets and replace them if necessary. Make certain that the valve seat and the lock nut are fastened with safety wire.

(d) ADJUSTMENTS.–To increase the suction supplied to the vacuum instruments, loosen the lock nut on the suction relief valve and turn the adjusting nut clockwise. To decrease the suction, turn the nut counter-clockwise. The relief valve should be adjusted to supply a vacuum of 4.2 inches of mercury to the instruments.

(14) LINES. *(See figure 235.)*–Aluminum alloy tubing is used in the vacuum instrument system. The tubing is held in place at certain points by means of clips and clamps which reduce vibration. The actual connection to the instruments is made with short lengths of composition hose, installed to reduce instrument panel vibration. For replacement and maintenance of lines see Section VIII.

e. ELECTRICALLY OPERATED INSTRUMENTS.

(1) GENERAL.–The electrically operated instruments consist of the cylinder temperature indicator (thermocouple thermometer), the tachometer, the oil temperature indicator, the oil cooler door position indicator, the carburetor air temperature indicator, the fuel level gages, the tell-tale indicator, the remote magnetic compass indicator, the landing gear and flap position indicator, the radio compass left-right indicator, the outside air temperature indicator, the ammeters and the voltmeter. Because these instruments and related equipment are electrical in nature, all information other than a general description will be found in paragraph 15, this section. An exception is the radio compass left-right indicator, described in paragraph 15. *b.* (12) *(j)*, this section.

(2) CYLINDER HEAD TEMPERATURE INDICATOR (THERMOCOUPLE THERMOMETER). *(See 14, figure 232.)*–The dual cylinder head temperature indicator records the temperature of each of the air cooled engines. The instrument is actuated by electrical impulses set up in iron-constantan thermocouples located at the number 14 cylinders. Two zero-setting screws are provided on the front of the instrument for temperature adjustments.

(3) TACHOMETER. *(See 9, figure 232.)* – The tachometer measures the speed of the engine crank shafts in revolutions per minute. The dual indicator is actuated by an electrical generator attached to the tachometer drive of each engine.

(4) OIL TEMPERATURE INDICATOR. *(See 13, figure 232.)*–The dual oil temperature indicator records the temperature of the lubricating oil used in each engine. The indicator is connected electrically to sensitive resistor bulbs located in the oil container sumps.

(5) CARBURETOR AIR TEMPERATURE INDICATOR. *(See 12, figure 232.)*–The dual carburetor air temperature indicator shows the temperature which exists in the throat of the carburetor on each engine. The indicator is connected electrically to a resistor bulb installed in the intake duct of each carburetor.

(6) FUEL LEVEL GAGES. *(See 19 & 21, figure 232.)*–The fuel level gages indicate the quantity of fuel contained in each of the five containers normally installed in the airplane, and for the bomb bay ferry tank when installed. One dual indicator, installed on the instrument panel, shows the quantity in each of the main fuel containers installed in the nacelles. Another multiple indicator on the instrument panel shows the quantity in each of the two auxiliary fuel containers installed in the wings, and for the bomb bay (fuselage) container. A third indicator mounted on the control pedestal in the pilot's compartment shows the fuel quantity in the ferry tank when it is installed in the bomb bay. Each indicator is actuated electrically by means of float arms installed in each fuel container, and remote indication transmitters.

(7) TELL-TALE INDICATOR. *(See 26, figure 232.)*–The Douglas tell-tale indicator, located on the instrument panel and remotely controlled by the gunner at the sighting station, is installed to inform the pilot of the direction which the turret guns face in relation to the empennage; the outline of the empennage from a view looking aft is described on the dial of the instrument. When the turret AC power is turned on by the gunner a green dot appears on the dial. When the turrets are operated the green dot indicates the direction the guns face in relation to the tail section. A cathode ray tube is the source of the green dot.

(8) REMOTE MAGNETIC COMPASS INDICATOR. *(See 5, figure 232.)*–The remote magnetic compass indicator shows the direction the airplane is heading with reference to the earth's magnetic field. A rotating reference marker and setting knob are provided to help keep the airplane on a pre-selected course. The indicator is connected electrically to the magnetic compass transmitter, mounted on the vertical stabilizer.

(9) LANDING GEAR AND WING FLAP POSITION INDICATOR. *(See 22, figure 232.)* – The landing gear and wing flap position indicator keeps the pilot informed on the position of the main landing wheels, the nose wheel and the wing flaps. Red warning spots appear on the indicator when any part of the landing gear is not locked in the "UP" or the "DOWN" position. The wing flap position indicator is calibrated to show the ¼, ½, ¾ or "DOWN" position of the flaps. The instrument is actuated electrically by remote indication transmitters mounted near the units.

(10) RADIO COMPASS LEFT-RIGHT INDICATOR. *(See 3, figure 232.)*—The radio compass left-right indicator operates in conjunction with the radio compass to show the direction of an incoming radio signal in relation to the course of the airplane. The indicator is connected electrically to the radio compass, which is installed in the fuselage aft of this lower turret.

(11) OUTSIDE (FREE) AIR TEMPERATURE INDICATOR. *(See 2, figure 232.)*—The outside air temperature indicator records the temperature which exists outside the airplane. The indicator is connected electrically to a resistor bulb located in a well on the lower left-hand side of the fuselage near the junction of the nose section.

(12) AMMETERS. *(See 18 & 20, figure 232.)*—Two ammeters are installed on the pilot's instrument panel. The instruments measure the direct current produced by the generators installed on each engine. For all other information concerning this instrument refer to paragraph 15. *d.* (12), this section.

(1) VOLTMETER. *(See 16, figure 232.)*—A voltmeter is installed on the pilot's instrument panel. The instrument measures hte voltage produced by the electrical generators installed on each engine. For all other information concerning this instrument refer to paragraph 15. *d.* (12), this section.

(14) OIL COOLER DOORS POSITION INDICATOR. *(See 15, figure 232.)*—A dual oil cooler door position indicator is installed on the pilot's instrument panel. The indicator is actuated by electrical transmitters linked to the electrical drive unit of each oil cooler door. Door positions indicated on the dial of the indicator are open, closed and three intermediate points.

f. PRESSURE INSTRUMENTS.

(1) GENERAL.—The pressure-type instruments and associated equipment consist of a dual fuel pressure indicator, a dual oil pressure indicator, fuel and oil pressure transmitters, an engine manifold pressure gage, an engine manifold pressure gage line drain control, a hydraulic fluid pressure gage, a de-icer air pressure gage, an air pressure gage, and the pressure lines.

(2) REMOVAL.—The removal procedure is the same as for all other instruments located on the instrument panel. See paragraph 13. *c.* (3), this section.

CAUTION

When removing or installing a fuel or oil pressure transmitter, do not remove or loosen the flange screws used in the assembly of the transmitter. These screws have been set to a definite torque (25 to 30 inch-pounds) and may leak if disturbed.

(3) FILLING FUEL, OIL PRESSURE INSTRUMENT LINES. *(See figure 240.)*—To replace the compass fluid (Spec. AN-VV-C-551) in the fuel and oil pressure instrument lines and transmitters proceed as follows, using a portable filling gun or the master gage unit from the C-1 instrument field set:

(a) Center the diaphragm within the transmitter by loosening the lock nut which secures the thumbscrew on the front of the instrument, and gently pushing in on the thumb-screw until the pressure plate rests against the diaphragm; then turn the thumbscrew clockwise with the fingers until the pin engages in the slot.

(b) Remove the cap from the lower check valve on the back of the transmitter (the valve is black and marked "F"), and connect the filling gun.

(c) Remove the cap from check valve "B" near the indicator and connect a bleed line, venting it into a suitable vessel.

(d) Using a maximum pressure of 25 pounds per square inch, slowly force the compass fluid into the system, continuing until bubbles no longer come through the bleed line. (The end of the bleed line must be immersed in the fluid in the vessel so that the bubbles will show.)

(e) Remove the filling and bleed lines and replace the caps. Loosen the thumbscrew on the transmitter, pull the thumbscrew outward as far as it will go, and then tighten thumbscrew locknut. Connect the fuel or oil pressure line to the fitting on the base of the instrument. Check the indicator for zero setting. If there is an indication on the gage, with no pressure being applied at the transmitter, reset the pointer to zero by means of the setting screw located inside the case of the indicator.

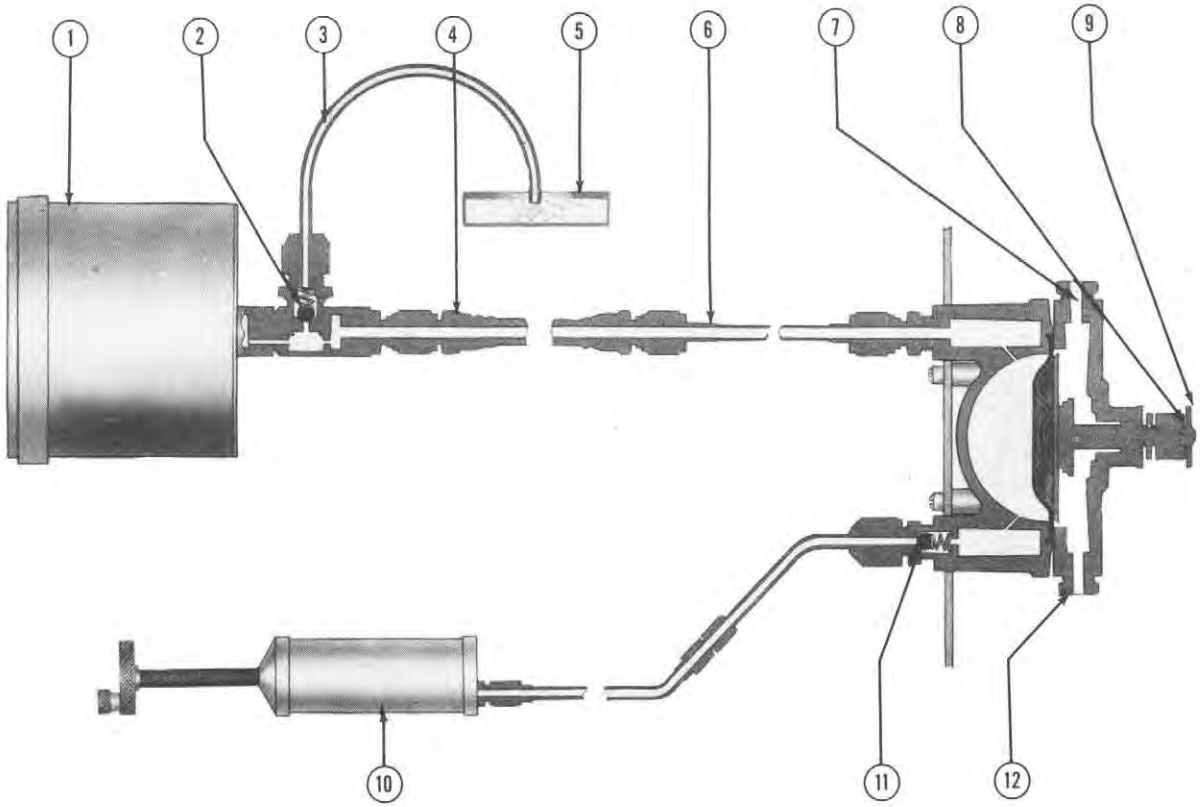
(4) FUEL PRESSURE INDICATOR.
(See 10, figure 232.)

(a) DESCRIPTION.—The dual fuel pressure indicator shows the fuel pressure which exists at the carburetor inlet of each engine. The indicator, which contains a metal bellows assembly, is actuated by compass fluid pressure which is transmitted through lines from the fuel pressure transmitters *(figure 241)* mounted in each engine section.

(b) MAINTENANCE REPAIR OR REPLACEMENT.

1. LOW OR ABSENT PRESSURE INDICATION.

a. If the oil pressure indication is low or absent, the trouble ordinarily may be traced to compass fluid leaks in the connecting lines or to a faulty



1. OIL PRESSURE GAGE
2. BLEED CHECK VALVE (STAMPED "B")
3. BLEED LINE
4. FLEXIBLE CONNECTOR
5. DISCHARGE VESSEL
6. SYSTEM 1/8 INCH TUBING
7. PORT USED IN COLD WEATHER MAINTENANCE
8. LOCKNUT
9. THUMBSCREW
10. PORTABLE FILLING GUN
11. FILLING CHECK VALVE (STAMPED "F")
12. CONNECTION TO ENGINE

Figure 240 — Filling Procedure for Oil and Fuel Pressure Indicator Systems

indicator. Make a careful visual inspection of the lines and connections. If a leaking connection is discovered, drain the remaining compass fluid from the line. Take the leaky connection apart and inspect the flaring on the tube for cracks, distortions or dirt. Correct all cracks or distortions immediately.

b. If there is no leakage visible to the eye, make the following air pressure test for gradual leakage in the lines or indicator case:

(1) Drain the compass fluid from the lines.

(2) With the oil pressure indicator properly connected, disconnect the instrument line at the transmitter.

(3) Install a suitable air valve at the transmitter end of the instrument line. (A Schrader valve is recommended.)

(4) Attach to the valve an air pressure source equipped with a pressure regulator.

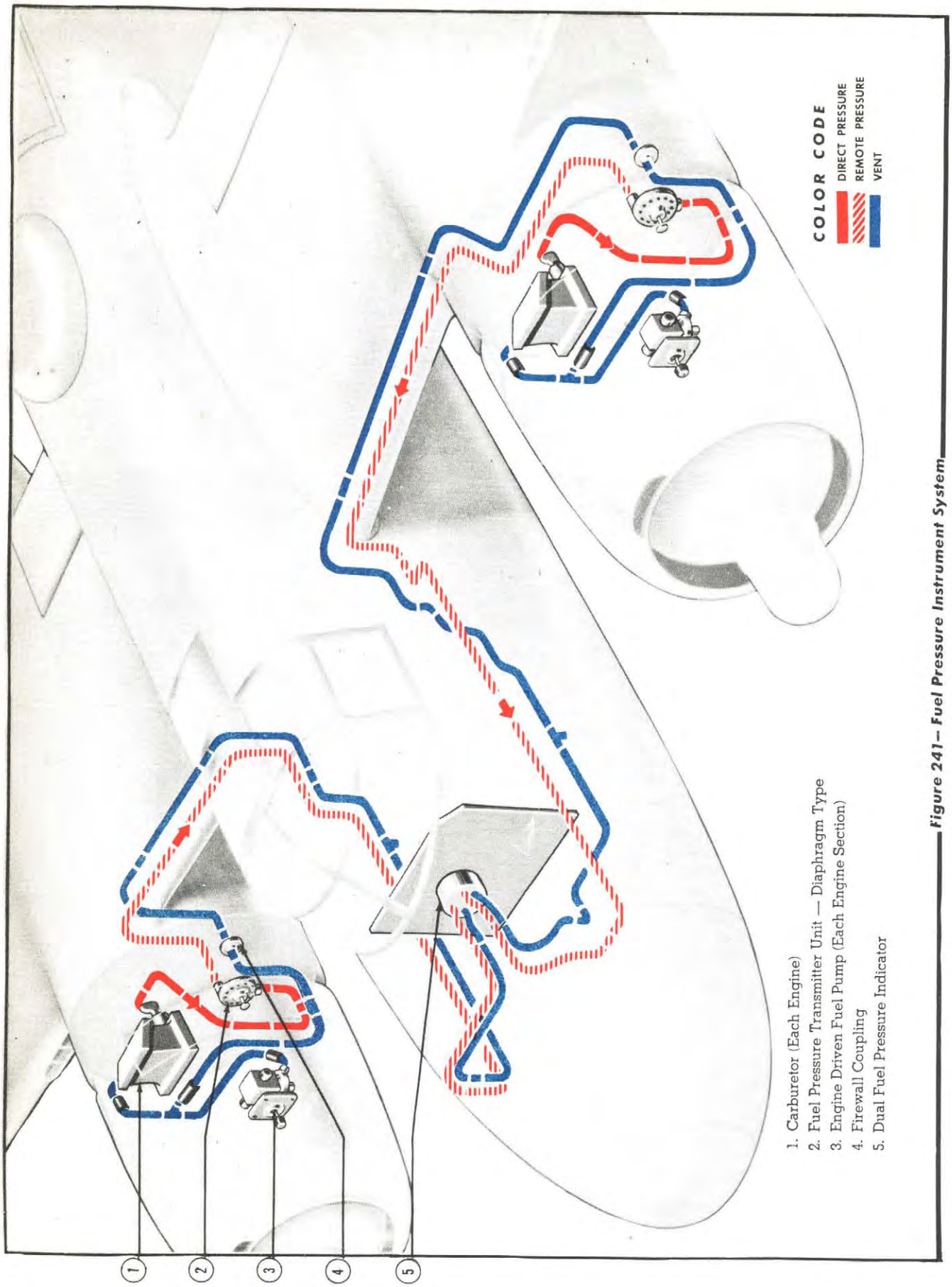
(5) Apply an air pressure of 160 pounds psi as indicated on the oil pressure indicator. Do not exceed 160 pounds.

(6) Maintain the air pressure for one-half hour. If the indicator shows a pressure drop, check lines and connections for leaks, using a brush and soap suds.

c. If no leaks can be found in the lines, it may be assumed that the oil pressure indicator is defective. Install a new indicator.

2. SLUGGISH INDICATION.

a. If the indicator pointer responds very slowly to the engine oil pressure, the difficulty frequently may be traced to a broken diaphragm in the



1. Carburetor (Each Engine)
2. Fuel Pressure Transmitter Unit — Diaphragm Type
3. Engine Driven Fuel Pump (Each Engine Section)
4. Firewall Coupling
5. Dual Fuel Pressure Indicator

Figure 241 – Fuel Pressure Instrument System

transmitter. Damage of this kind will allow the engine oil to enter the compass fluid lines. To overcome the difficulty it will be necessary to drain the compass fluid and oil from the indicator end of the line and install a new transmitter. Then refill the system with compass fluid as described below.

b. A sluggish indication occuring in extremely cold weather (below 14 degrees F.) may be caused by the congealing of engine oil in the line which extends from the engine to the transmitter. To overcome the difficulty, proceed as follows every 25 hours, or after four flights:

(1) Remove the cap from the top of the oil pressure transmitter.

(2) Connect a filling gun containing hydraulic fluid (Specification AN-VV-O-366) to the transmitter and fill the transmitter and the line to the engine with the fluid.

(3) Replace the cap on the top of the transmitter.

(c) TEST AFTER INSTALLATION.–Disconnect the pressure line at the corresponding transmitter, apply an air pressure to the line which will give at least one-half of the scale reading on the indicator, and then close the source of the pressure at a point within two inches of the connection. During a period of one minute, the pressure indication of the pointer should not change. If a change in the indication occurs, and it is not due to a leakage in the lines, fittings or transmitter, remove the indicator and replace it with a serviceable instrument.

(5) OIL PRESSURE INDICATOR.
(See 11, figure 232.)

(a) DESCRIPTION.–The dual oil pressure indicator shows the pressure at which the lubricant is being forced to the engine bearings and the various other points of the lubricating system. The indicator, which contains a bourdon tube, is actuated by compass fluid pressure which is transmitted through lines from the oil pressure transmitters mounted in each engine section.

(b) MAINTENANCE REPAIR.–See paragraph 13. *f.* (4) *(b),* above.

(c) TEST AFTER INSTALLATION.–See paragraph 13. *f.* (4) *(c),* above.

(6) FUEL AND OIL PRESSURE TRANSMITTERS.–*(See figures 241 & 242.)*

(a) DESCRIPTION.–The fuel and oil pressure transmitters are manufactured to the same specification. Each transmitter consists of two chambers separated by a flexible synthetic rubber diaphragm. One side of the diaphragm is subjected to the fuel or oil pressure, as the case may be, and the other side transmits the pressure to the indicator through the medium of the compass fluid within lines. The oil and fuel pressure transmitters are mounted on the outboard side of the firewall in each nacelle.

(b) REMOVAL.

1. FUEL PRESSURE TRANSMITTER.

a. Remove the access door located on the left hand side of the engine mount.

b. Remove the connecting lines on the forward and aft sides of the firewall.

c. Remove the four bolts which attach the transmitter to the forward side of the firewall.

d. Remove the transmitter.

2. OIL PRESSURE TRANSMITTER.

a. Remove the access door located on the right-hand side of the engine mount.

b. Remove the line connected to the engine accessory case.

c. Disconnect the four bolts which secure the transmitter to the mounting bracket.

d. Remove the transmitter.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Damaged or defective fuel and oil pressure transmitters shall be replaced.

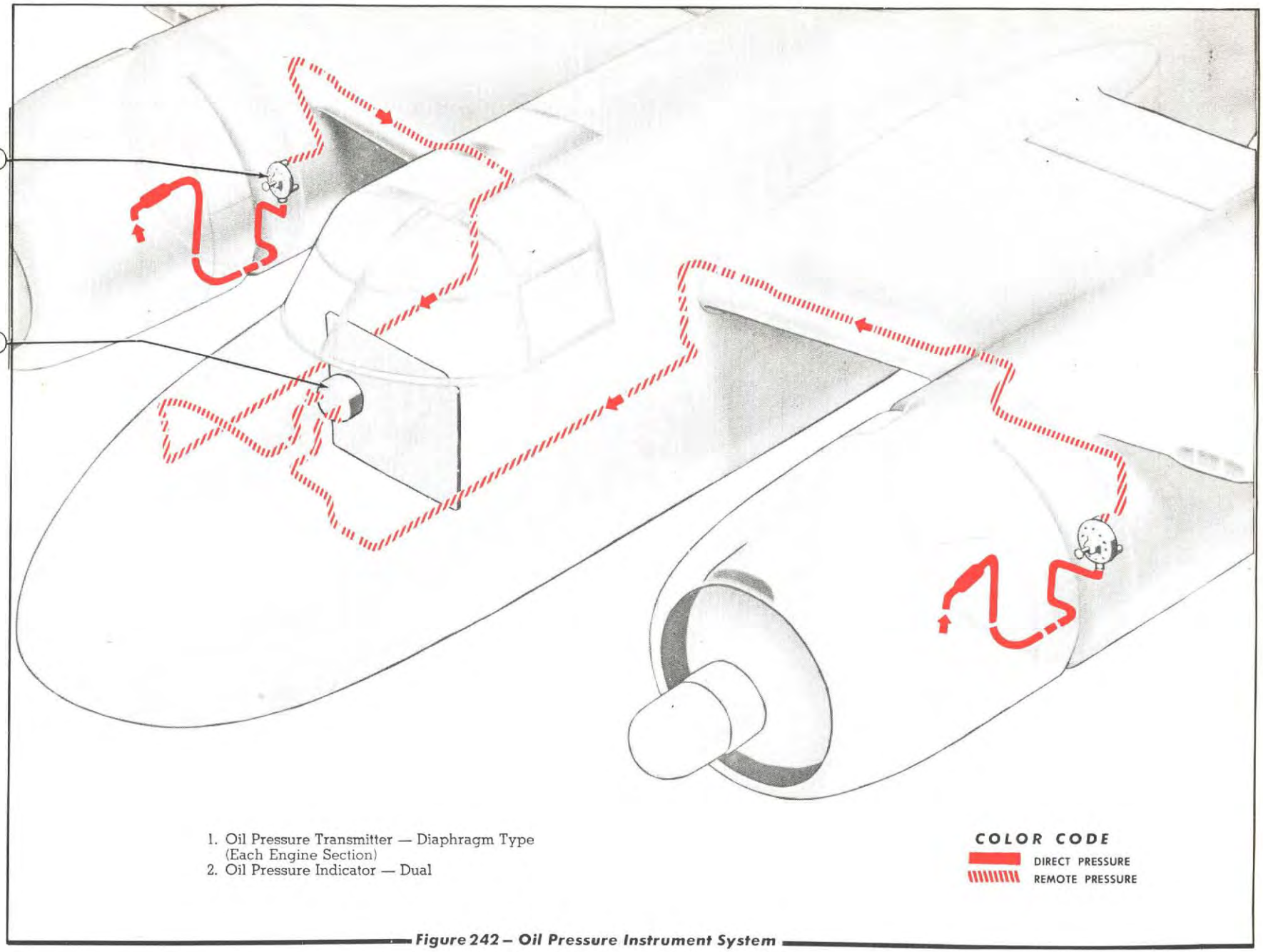
(d) ADJUSTMENTS.–No adjustments are provided on the fuel and oil pressure transmitters other than a means of setting the diaphragms when the pressure systems are being refilled with compass fluid. See paragraph 13.

(e) TEST AFTER INSTALLATION.–After the line to the instrument has been refilled with compass fluid, the transmitter and system may be tested for proper operation by disconnecting the engine pressure line at the transmitter and installing an air valve on the engine side of the transmitter. Apply suitable air pressure through a pressure regulator to give at least one-half scale indication on the instrument panel gage. If no pressure drop can be detected on the indicator within 30 minutes, the system is satisfactory for operation. If air leakage occurs, check connections and retest.

CAUTION

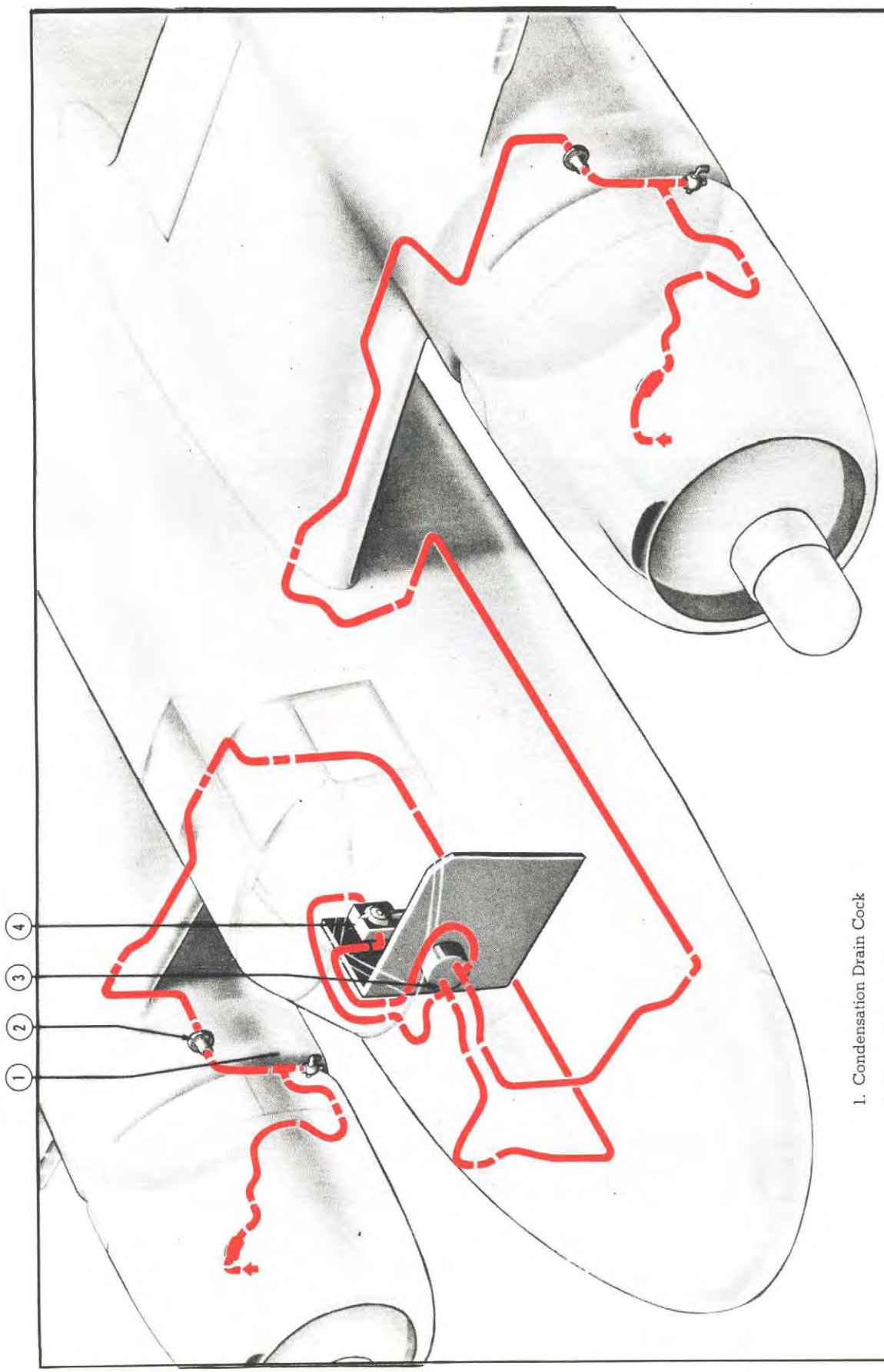
Never apply air pressure to the transmitter when the transmitter and the line are empty of compass fluid.

(7) ENGINE MANIFOLD PRESSURE GAGE.
(See 6, figure 232.)



1. Oil Pressure Transmitter — Diaphragm Type (Each Engine Section)
2. Oil Pressure Indicator — Dual

Figure 242 – Oil Pressure Instrument System



1. Condensation Drain Cock
2. Firewall Connection
3. Manifold Pressure Gage — Dual
4. Manifold Pressure Gage Drain Control

Figure 243 — Manifold Pressure Instrument System

(a) DESCRIPTION.—The dual manifold pressure gage is connected to the intake manifold of each engine and guides the pilot in his use of the supercharger. Lines extend directly from each engine to the gage, which contains two bellows assemblies. When the engines are inoperative, the gage indication should correspond with the local barometric pressure. The dial is calibrated in inches of mercury.

(b) MAINTENANCE REPAIR OR REPLACEMENT.

1. A damaged or defective engine manifold pressure gage shall be replaced.

2. To test the engine manifold pressure gage for case air leaks, disconnect the manifold pressure line at the gage and apply an air pressure which will give a scale reading of 50 inches of mercury. If the pressure indication drops in a one minute period, the instrument shall be. replaced.

(c) TEST AFTER INSTALLATION.

1. The engine manifold pressure gage may be tested for case leaks by first disconnecting the line to the gage at the engine end, and then applying air pressure until the indicator shows 50 inches of mercury. Maintain the air pressure for at least a minute, during which time there should be no change in the reading.

2. The damping adjustment in the instrument is checked by suddenly releasing the air pressure after the gage reaches 50 inches of mercury. The indicator should reach 32 inches of mercury in not less than one second, or more than two seconds.

(8) ENGINE MANIFOLD PRESSURE GAGE LINE DRAIN CONTROL. *(See figure 243.)*—This control is used to clear moisture from the engine manifold gage lines prior to takeoff. The control, which is a simple valve and lever assembly, is mounted on the instrument panel glare shield and is connected to the pressure lines extending from the manifold at each engine. The control is so arranged that when the valve is opened, air is permitted to enter the lines and the moisture is sucked back into the engine manifold. In order that the moisture will not be blown into the pilot's compartment, the engine should always be idling at 800 rpm or less when draining the lines. The valve is opened for a period of approximately 30 seconds.

(9) HYDRAULIC FLUID PRESSURE GAGE. *(See 17, figure 232.)*—The hydraulic fluid pressure gage records the pressure which exists in the hydraulic system. The gage is located on the pilot's left-hand control panel and is connected to the left-hand brake pressure supply line. For all other information on the instrument, refer to paragraph 14., this section.

(10) DE-ICER AIR PRESSURE GAGE. *(See figure 232.)*—The de-icer air pressure gage measures the air pressure delivered to the de-icing system from the exhaust of the engine-operated vacuum pumps. The gage is located on the pilot's left-hand control panel. For all other information on the instrument, refer to paragraph 20., this section.

(11) AIR PRESSURE GAGE. *(See figure 288.)*—The air pressure gage, which is connected to the air bottle in the pilot's compartment, indicates the air pressure which is available for emergency application of the brakes. The gage is located near the top of the pilot's enclosure, aft and right of the pilot's seat. For all other information concerning the gage, refer to paragraph 14., this section.

(12) LINES. (See Section VIII.)—Aluminum alloy tubing is used in the fuel, oil and manifold pressure instrument systems. The tubing is held in place at certain points by means of clips and clamps which reduce vibration. Actual connection with the instruments is made with short lengths of flexible hose. Drain tees are provided in the fuel pressure vent line. Drain cocks are installed in the manifold pressure lines at the firewall, on some airplanes. When the airplane is parked in a cold area, the drain cocks should be opened to permit drainage of moisture which condenses in the line after the engines have cooled. Close the drain cock before starting the engines.

g. CLOCK.
(See 29, figure 232.)

(1) GENERAL.—A clock is mounted on each of the pilot's and bombardier's (when installed) instrument panels in the same manner as the instruments. The clock consists of an aluminum case containing an eight-day movement. A winding and setting knob is provided on the front of the clock, and a rate adjustment is provided on the back.

Figure 244—Driftmeter

(2) REMOVAL. – Remove the four bolts which attach the clock to the instrument panel and remove the clock.

(3) MAINTENANCE REPAIR OR REPLACEMENT.–A damaged or defective clock shall be replaced.

(4) ADJUSTMENT.–The clock shall be set to correspond with the master clock in the control tower.

h. DRIFT METER. *(See figure 244.)*–A Type B-5 drift meter is installed on the right wall of the pilot's compartment on some airplanes. The drift meter is used by the navigator (gun loader) to measure the angle between the navigational heading of the airplane and its actual path over the ground. The drift meter also may be used to determine ground speed.

i. ASTRO-COMPASS.–A type A-1 astro compass is mounted on the under side of the entrance latch of the pilot's compartment on certain airplanes. The instrument is used to provide the navigator with a true heading of the airplane, and to swing the magnetic compass and correct its reading during flight.

j. INSTRUMENT TROUBLE SHOOTING LIST.

BANK AND TURN INDICATOR

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Pointer fails to respond.	*a.* Leaky or clogged line.	*a.* Repair, clean, or replace line. See section VIII.
	b. Clogged air filter.	*b.* Clean filter. See paragraph 13. *d.* (9) *(c)*, this section.
	c. Oil thickened by cold.	*c.* Replace instrument.
	d. Valve at manifold clogged.	*d.* Clean valve.
	e. Vacuum pump selector valve not fully open.	*e.* Open vacuum pump selector valve.
	f. Dirt in mechanism.	*f.* Replace instrument.
2. Incorrect sensitivity.	*a.* Too much or too little vacuum.	*a.* See remedies above. Readjust the control valve on manifold.
	b. Air filter clogged.	*b.* Clean filter. See paragraph 13. *d.* (9) *(c)*, this section.
3. Pointer vibrates.	*a.* Excessive vibration in instrument panel.	*a.* Check mounting of panel. Replace rubber shock absorbers if worn or deteriorated.
	b. Damping screw misadjustment.	*b.* Replace instrument.
	c. Lack of oil.	*c.* Lubricate at 100 hour Inspection.
	d. Defective mechanism.	*d.* Replace instrument.
4. Pointer does not set at zero.	*a.* Defective mechanism.	*a.* Replace instrument.
	b. Pointer sits incorrectly on staff.	*b.* Replace instrument.
	c. Sensitivity spring adjustment pulls pointer off zero.	*c.* Replace instrument.

DIRECTIONAL GYRO INDICATOR

1. Excessive drift in card.	*a.* Excessive vibration.	*a.* Check panel shock mountings and replace if necessary.
	b. Improper suction.	*b.* Adjust suction relief valve. See paragraph 13. *d.* (13) *(d)*, this section.
	c. Engine-driven vacuum pump failure.	*c.* Replace pump. See paragraph 13. *d.* (10), this section.
	d. Air filter clogged.	*d.* Clean air filter. See paragraph 13. *d.* (9) *(c)*, this section.
	e. Leak in vacuum line.	*e.* Locate leak and repair line. See Section VIII.
	f. Vacuum pump selector valve not fully open.	*f.* Open vacuum pump selector valve.
	g. Defective mechanism (worn or dirty pivots and bearings).	*g.* Replace instrument.

j. INSTRUMENT TROUBLE SHOOTING LIST.–Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
2. Caging mechanism works hard.	*a.* Lack of oil.	*a.* Lubricate external part of shaft with instrument oil.
3. Pendulum ball doesn't center.	*a.* Instrument out of alignment on panel.	*a.* Correct the alignment.

GYRO HORIZON INDICATOR

1. Horizon bar fails to respond.	*a.* Instrument caged.	*a.* Uncage instrument.
	b. Air filter dirty.	*b.* Clean filter. See paragraph 13. *d.* (9) *(c)*, this section.
	c. Vacuum below required 3.5 inches Hg.	*c.* Adjust suction relief valve. See paragraph 13. *d.* (13) *(d)*, this section.
	d. Air leak in vacuum line or connection.	*d.* Locate and repair leak. See section VIII.
	e. Vacuum pump selector valve not fully open.	*e.* Open vacuum pump selector valve.
	f. Failure of engine-driven vacuum pump.	*f.* Replace engine-driven vacuum pump. See paragraph 13. *d.* (10) *(c)*, this section.
2. Horizon bar fails to settle.	*a.* Excessive vibration.	*a.* Check panel mountings and replace if defective.
	b. Insufficient vacuum.	*b.* Adjust suction relief valve. See paragraph 13. *d.* (13) *(d)*, this section.
	c. Defective mechanism.	*c.* Replace instrument.
3. Horizon bar oscillates.	*a.* Gyro not completely uncaged.	*a.* Uncage gyro.
	b. Air filter dirty.	*b.* Clean filter. See paragraph 13. *d.* (9) *(c)*, this section.
	c. Excessive vacuum.	*c.* Adjust suction relief valve. See paragraph 13. *d.* (13) *(d)*, this section.
	d. Excessive vibration.	*d.* Check panel mountings and replace if necessary.

SUCTION GAGE

1. Excessive error at zero.	*a.* Loose pointer.	*a.* Replace gage.
	b. Seasoning of diaphragm.	*b.* Replace gage.
2. Scale error excessive.	*a.* Improper calibration.	*a.* Replace gage.
3. Pointer calibration excessive.	*a.* Rough seat in suction relief valve.	*a.* Adjust or replace suction relief valve.

FUEL, OIL PRESSURE INDICATORS

1. Excessive pointer oscillation.	*a.* Defective mechanism.	*a.* Replace instrument.
2. Jerky movement of pointer.	*a.* Defective mechanism.	*a.* Replace instrument.
3. Sluggish operation of pointer.	*a.* Foreign material in connecting lines.	*a.* Clean connecting lines.
	b. Oil congealed in line to engine due to extreme cold.	*b.* Fill line with low viscosity fluid. See paragraph 13. *f.* (3), this section.

j. INSTRUMENT TROUBLE SHOOTING LIST.—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
4. Limited or no pointer movement.	*a.* Leak in lines or connections.	*a.* Locate and repair leak. See section VIII.
	b. Insufficient compass fluid.	*b.* Refill lines with fluid. See paragraph 13. *f.* (3), this section.
	c. Defective instrument.	*c.* Replace instrument.
	d. Defective transmitter.	*d.* Replace transmitter.
5. High reading.	*a.* Faulty instrument.	*a.* Replace instrument.

ENGINE MANIFOLD PRESSURE GAGE

1. Excessive pointer oscillation.	*a.* Instrument needs adjustment.	*a.* Replace instrument.
2. Jerky movement of pointer.	*a.* Trouble in instrument.	*a.* Replace instrument.
3. Sluggish pointer.	*a.* Foreign material in connecting lines.	*a.* Clean lines by means of manifold pressure gage line drain. See paragraph 13. *f.* (8), this section.
4. Limited pointer movement.	*a.* Loose pointer. *b.* Leak in line or connections.	*a.* Replace instrument. *b.* Locate leak and repair line. See section VIII.
5. High or low reading.	*a.* Instrument needs adjustment.	*a.* Replace instrument.
6. Excessive error at existing barometric pressure.	*a.* Pointer shifted.	*a.* Replace instrument.

ALTIMETER

1. Instrument fails to function.	*a.* Clogged static line connection.	*a.* Disconnect all instruments from static connection line and blow through tubing.
	b. Defective mechanism.	*b.* Replace instrument.
2. Rough operation, excessive friction.	*a.* Dirty or defective mechanism.	*a.* Replace instrument.
3. Reading high.	*a.* Static line leaks.	*a.* Check static line for leak. See section VIII and make necessary repairs.
	b. Pitot tube out of alignment.	*b.* Line up pitot tube.

RATE OF CLIMB INDICATOR

1. Pointer off zero.	*a.* Shift in mechanisms.	*a.* Reset pointer by means of adjustment screw. Tap lightly while making adjustment.
2. Pointer cannot be reset to zero.	*a.* Broken pivot.	*a.* Replace instrument.
3. Pointer fails to respond.	*a.* Obstruction in static line.	*a.* Disconnect all instruments connected to static line, open line drain plug, and blow line clear.
4. Indication incorrect.	*a.* Case air leak.	*a.* Replace instrument.
	b. Friction due to dirty pivots and jewels.	*b.* Replace instrument.
	c. Pitot tube damaged.	*c.* Replace tube. See paragraph 13. *c.* (8), this section.
5. Pointer oscillates.	*a.* Air leak in static line.	*a.* Disconnect all instruments from line, check lines and instruments for leaks. See section VIII.

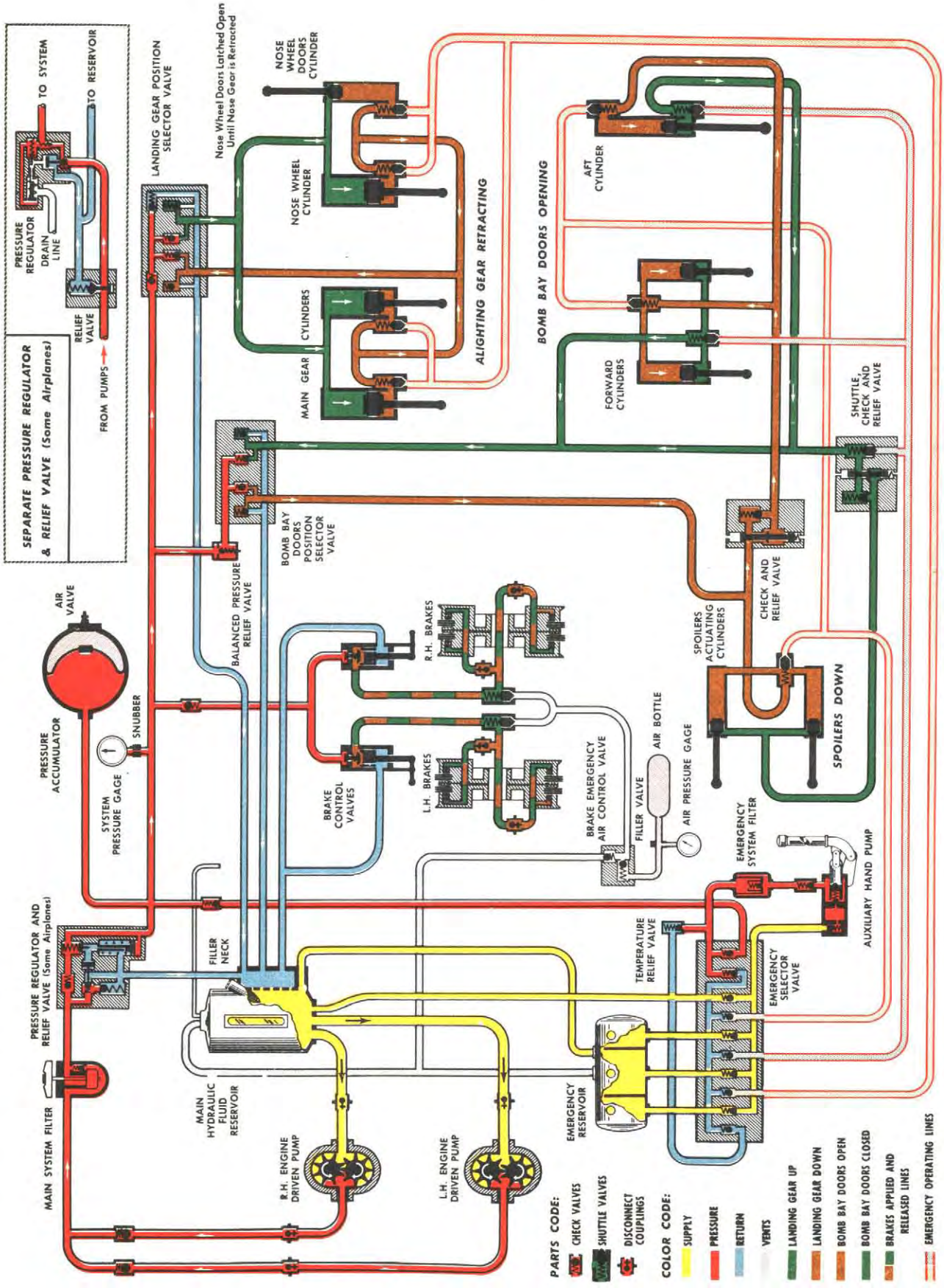


Figure 245 — Hydraulic Fluid Flow System

14. HYDRAULICS

a. GENERAL. – A pressure-accumulator type hydraulic system *(figure 245)* is installed in the airplane to operate the retractable tricycle alighting gear, the brakes, and the bomb bay doors and bomb bay spoilers. The entire hydraulic system contains approximately eight U.S. gallons (6.66 Imperial gallons) of hydraulic fluid, Specification AN-VV-O-366. During normal operation fluid pressure is supplied by two engine-driven hydraulic pumps. An emergency hydraulic system is installed to extend the alighting gear, and to open and close the bomb bay doors and spoilers. A pressure bottle type brake emergency air system is installed to operate the brakes if the main hydraulic system is not functioning.

b. SUPPLY, PRESSURE, AND RETURN HYDRAULIC SYSTEM. *(See figure 246.)*

(1) GENERAL.—The main hydraulic system fluid reservoir *(10, figure 246)* which has a capacity of 1.75 U.S. gallons (1.46 Imperial gallons), supplies fluid by gravity to the two engine-driven hydraulic pumps *(2, figure 246)*. The fluid under pressure from the engine-driven pumps flows through disconnect couplings *(3, figure 246)* and check valves *(8, figure 246)* into a filter *(9, figure 246)* and then to the hydraulic system pressure regulator *(12, figure 246)* which is set to maintain a system operating pressure of 850 to 1000 psi. Check valves prevent the back flow of hydraulic fluid from the system to the engine-driven pumps should the engines fail. From the pressure regulator, the fluid flows to the hydraulic system pressure accumulator *(14, figure 246)* and then to the systems. If the pressure regulator fails to operate properly and the system pressure exceeds 1250 ± 25 psi, the system pressure relief valve by-passes the excess fluid to the main hydraulic system reservoir. The entire system operating pressure may be relieved by applying toe pressure to and releasing the rudder-brake pedals *(figure 247)* until the hydraulic system pressure gage indicates zero. The operating pressure is indicated on the hydraulic system pressure gage *(5, figure 246)* located on the left side of the instrument panel in the pilot's compartment on some airplanes, and on the main instrument panel on other airplanes.

CAUTION

As long as the hydraulic units are operating properly they should not be removed from the airplane, regardless of the period of service. Disassembly of any of the units should be undertaken only when absolutely necessary. It is a safe rule that if a hydraulic unit is operating satisfactorily, LET IT ALONE. If damage to a unit is suspected, test it in the airplane before removing it for disassembly.

(2) ENGINE-DRIVEN HYDRAULIC PUMPS. *(See figures 248 and 249.)*

(a) DESCRIPTION.—One gear-type engine-driven, pressure-loaded pump is mounted on the accessory drive section of each engine. The pump will operate in either direction of rotation. The pumping action is accomplished by the rotation of a pair of closely meshed precision steel gears supported on bronze bearings within a closely fitted housing. When the gear teeth separate on one side, the resultant tooth space is filled by hydraulic fluid drawn from the inlet port. The fluid is carried around to the opposite side where the teeth mesh again, and then displaced into the pressure port. This action produces a positive flow of fluid under pressure into the outlet port of the pump. The pump cover is provided with four spring-loaded, ball-type check valves. Working in combination, one set of two check valves operates to provide suitable lubrication throughout the pump, and the other set provides a means of pressure loading the cover bearings to compensate for wear on the bearings and to provide more efficient operation in cold weather. The drive gear of the pump is turned by a drive shaft which engages the engine accessory drive. The drive shaft is provided with a safety shear section to protect the engine accessory drive if pump failure is caused by excessive load or jamming of parts. Each pump supplies sufficient pressure to operate the hydraulic system, but the actuation of the hydraulic units will be slower if only one engine-driven pump is operative.

(b) REMOVAL.

1. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

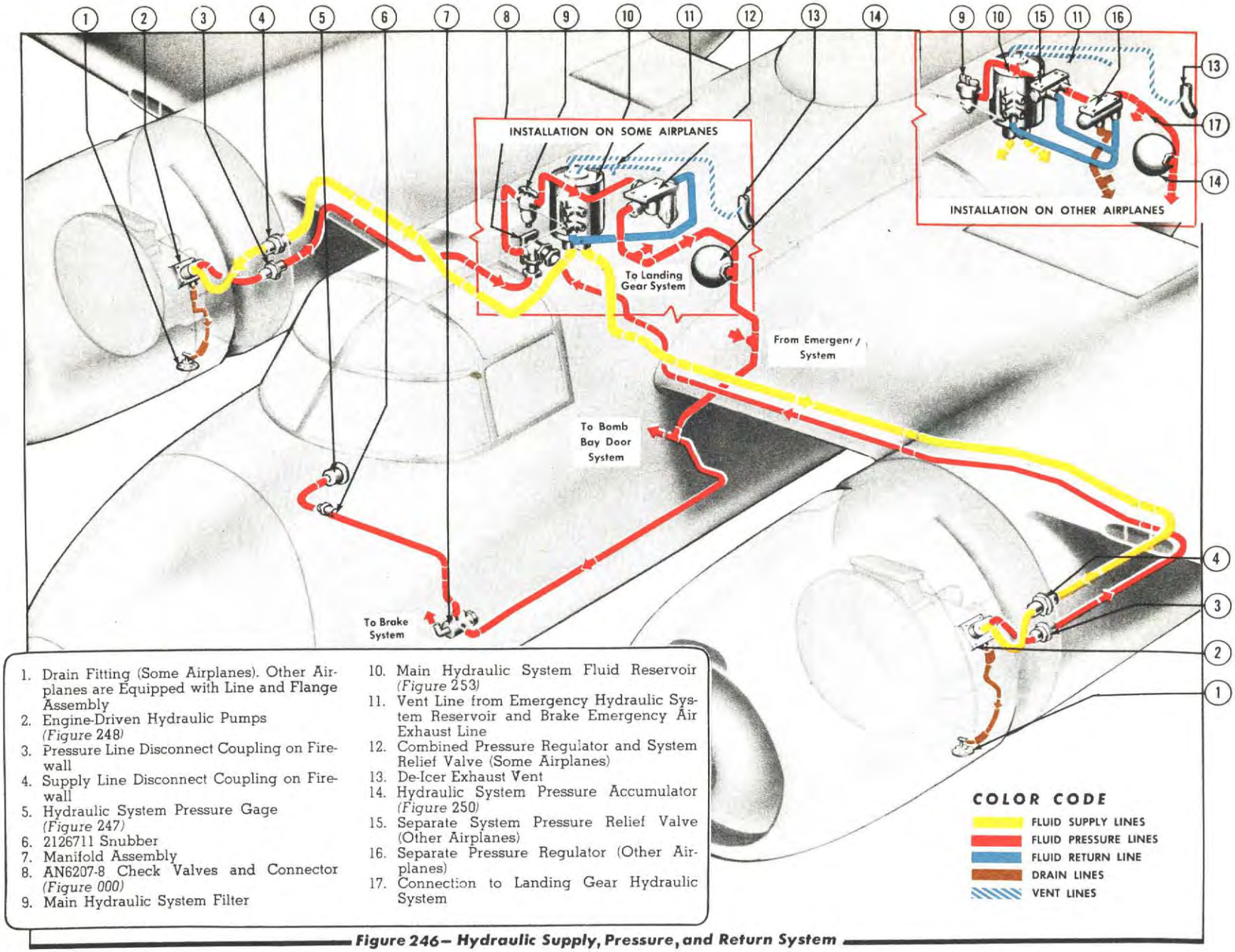
2. Remove the access door *(3, figure 9)* on the outboard side of the left nacelle and the inboard side of the right nacelle.

3. Disconnect and cap the hydraulic hoses at each pump. Disconnect the engine-driven pump drain line.

4. Cut the safety wire, remove the nuts that attach each pump to the engine mounting pad studs and then remove the pump and gasket from the mounting pad.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. The fluid circulating through the pump during normal operation provides ample lubrication for all requirements; therefore, no special lubrication is required.



1. Drain Fitting (Some Airplanes). Other Airplanes are Equipped with Line and Flange Assembly
2. Engine-Driven Hydraulic Pumps *(Figure 248)*
3. Pressure Line Disconnect Coupling on Firewall
4. Supply Line Disconnect Coupling on Firewall
5. Hydraulic System Pressure Gage *(Figure 247)*
6. 2126711 Snubber
7. Manifold Assembly
8. AN6207-8 Check Valves and Connector *(Figure 000)*
9. Main Hydraulic System Filter
10. Main Hydraulic System Fluid Reservoir *(Figure 253)*
11. Vent Line from Emergency Hydraulic System Reservoir and Brake Emergency Air Exhaust Line
12. Combined Pressure Regulator and System Relief Valve (Some Airplanes)
13. De-Icer Exhaust Vent
14. Hydraulic System Pressure Accumulator *(Figure 250)*
15. Separate System Pressure Relief Valve (Other Airplanes)
16. Separate Pressure Regulator (Other Airplanes)
17. Connection to Landing Gear Hydraulic System

Figure 246– Hydraulic Supply, Pressure, and Return System

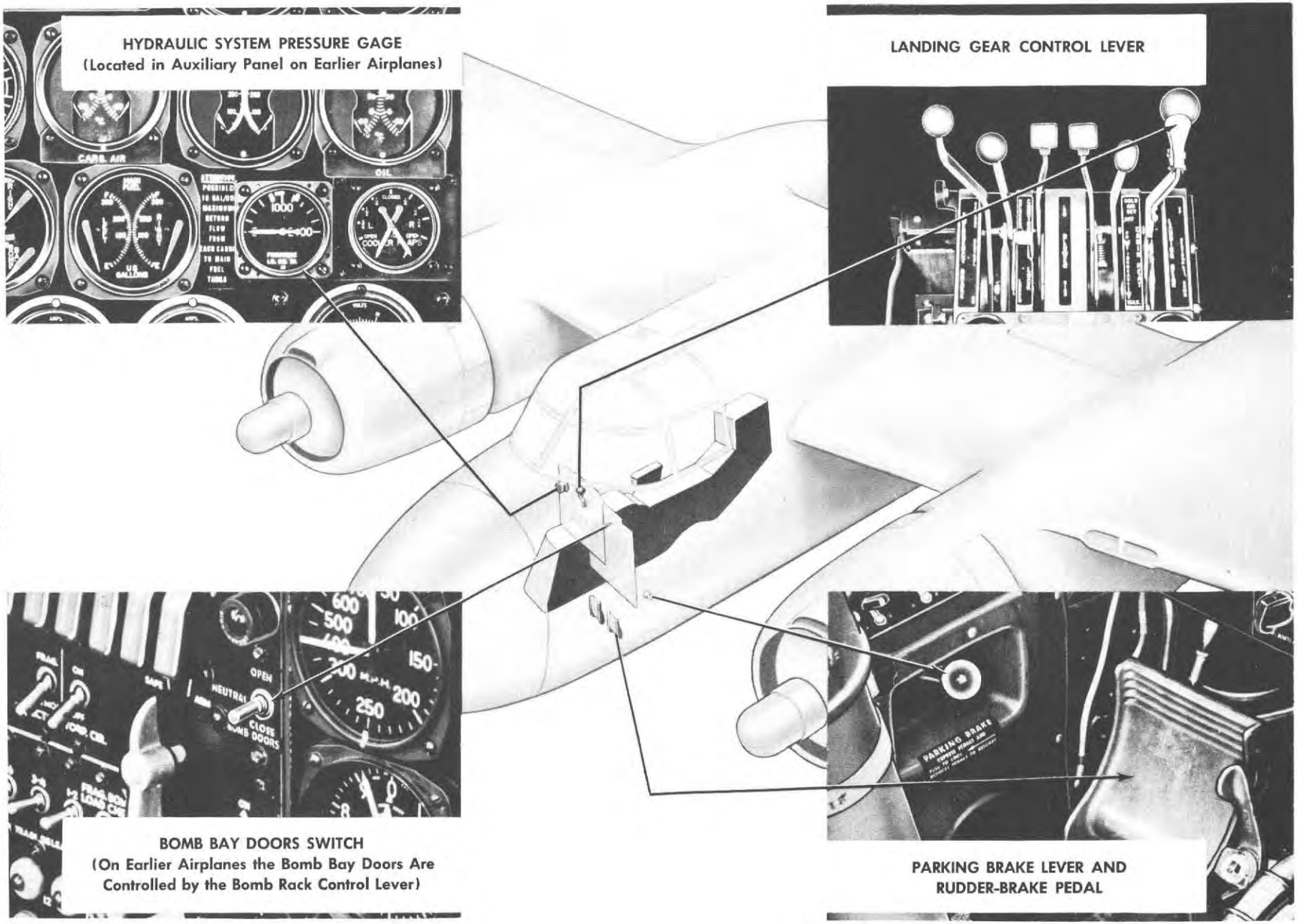
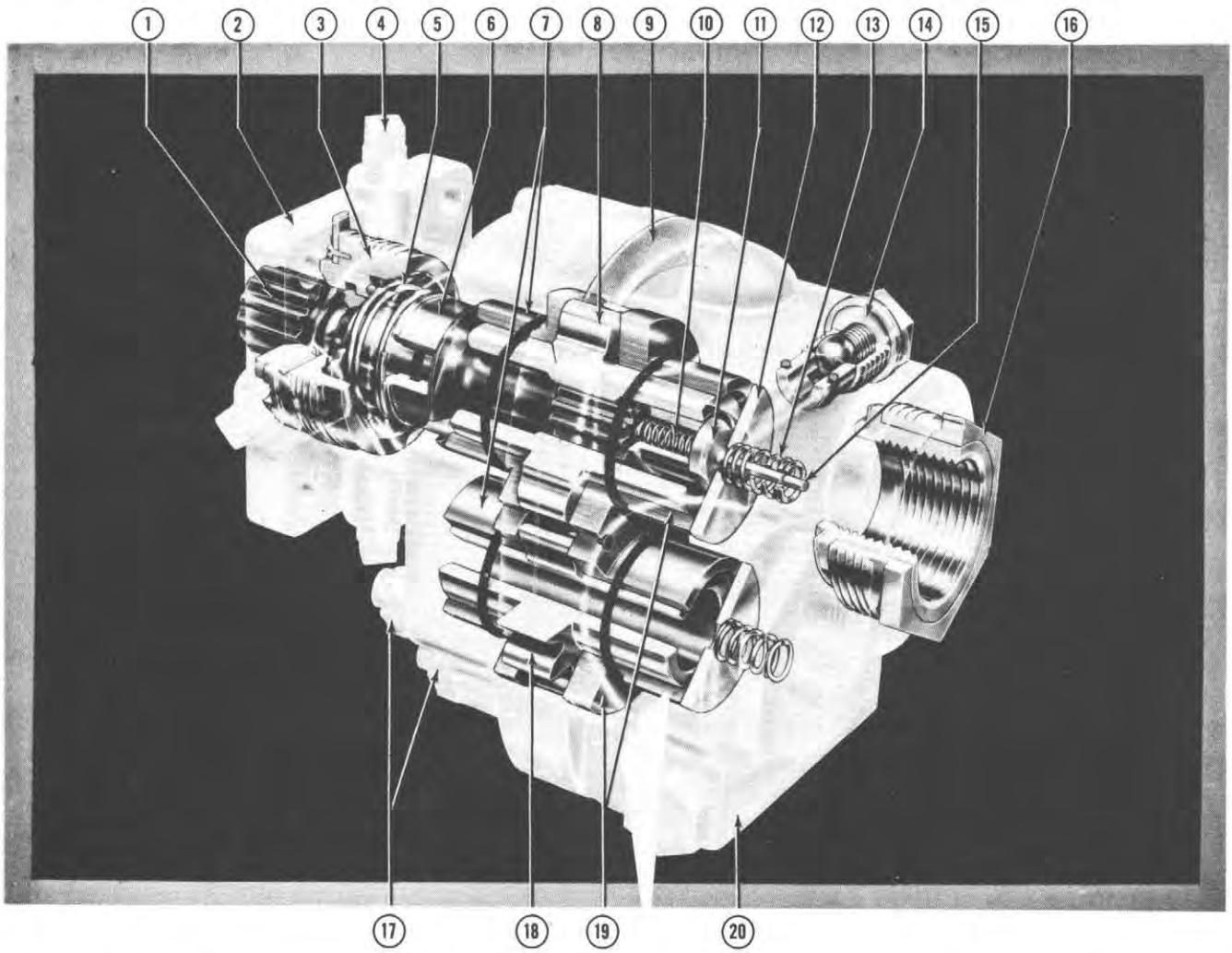


Figure 247—Hydraulic System Controls and Instruments

2. Loss in pump capacity may be caused by foreign material becoming lodged under the ball check valves. The ball check valves should be removed by removing the valve retainers from the cover. Wash the ball checks in clear gasoline and reassemble the ball check valves.

3. The pump will not function properly if there is any air in the system. Bleed the lines to ensure that they are free from entrapped air. The lines may be bled by operating all units to the full extent. Bleed the brakes according to the procedure outlined in paragraph 14. *e.* (2) *(d) 1,* this section.

4. Loss of capacity may also be caused by air being drawn through the seal into the pump. The mating spline of the engine accessory drive may be slightly burred or rusted or have an accumulation of grease which prevents the spline on the pump coupling drive from entering the engine drive spline to full depth. This will force the bronze seal disc away from the seal surface of the drive shaft and allow air to be drawn into the pump. Before the pump is mounted, the engine mounting pad and drive should be carefully checked to be certain they are clean. A small portion of clean grease should be placed on the pump drive spline before it is installed on the engine.



1. Drive Coupling
2. Pump Body and Mounting Flange
3. Drive Coupling Seal Assembly
4. Plug
5. Spring
6. Seal Cup
7. Body Bushings
8. Drive Gear
9. Cover Gasket
10. Drive Coupling Spring
11. Spring Guide
12. Spacer
13. Spacer Spring
14. Check Valve Assembly
15. Pin
16. Nut and Adapter
17. Studs and Nuts
18. Driven Gear
19. Cover Bushings
20. Pump Cover

Figure 248—Typical Engine-driven Hydraulic Pump (Pesco)

5. Leakage exceeding the maximum limit of five drops per minute from the drain port requires examination of the seal rings or seal surfaces for damage, or for particles of dirt which may be embedded in them. If the seal surfaces are rough or scored, or if the seal rings are swollen or torn, replace them with new parts.

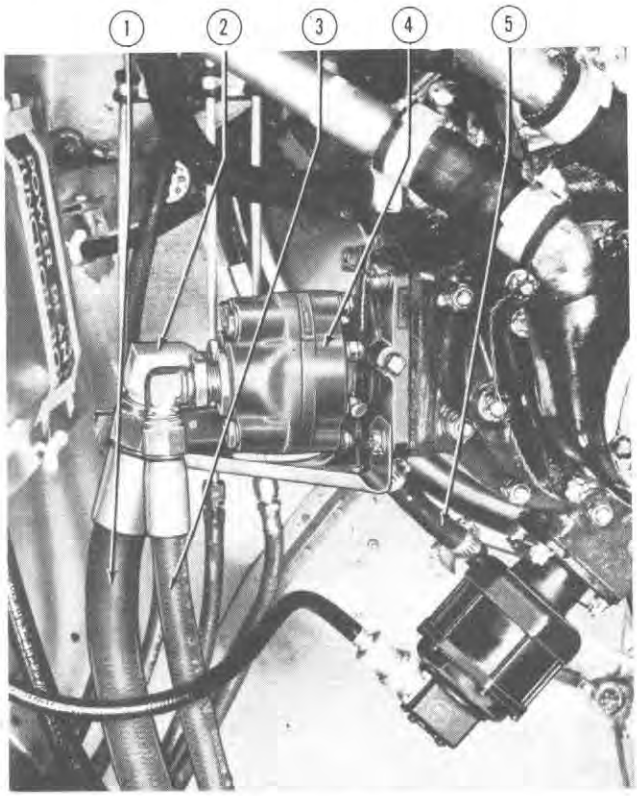
6. Sheared pump drive coupling or damaged pump requires replacement. Disassembly and major repair of the engine-driven pumps should be undertaken only at depots where adequate tools and testing facilities are available.

(d) INSTALLATION.

1. Before installing a new pump, flush the pump with hydraulic fluid (Spec. AN-VV-O-366).

2. Clean the engine mounting pad. Check the engine drive to see that the spline is free from nicks, burrs, rust, or accumulated grease.

3. Turn the pump coupling with the fingers to test for freedom of operation.



1. Hose Assembly (Supply)
2. 2126774 Elbow
3. Hose Assembly (Pressure)
4. Engine-Driven Hydraulic Pump
5. Pump Drain Line

Figure 249—Engine-driven Hydraulic Pump Installed

Note

The coupling tension springs of the bushings cause a close fit of the gears. Do not reject a pump merely because it appears to be too tight.

4. Apply a thin coating of lubricant, Specification AN-G3, to the splines of the pump drive coupling. Also apply a thin coating of the same lubricant to all male pipe threads, taking care to keep first (leading) thread free from grease.

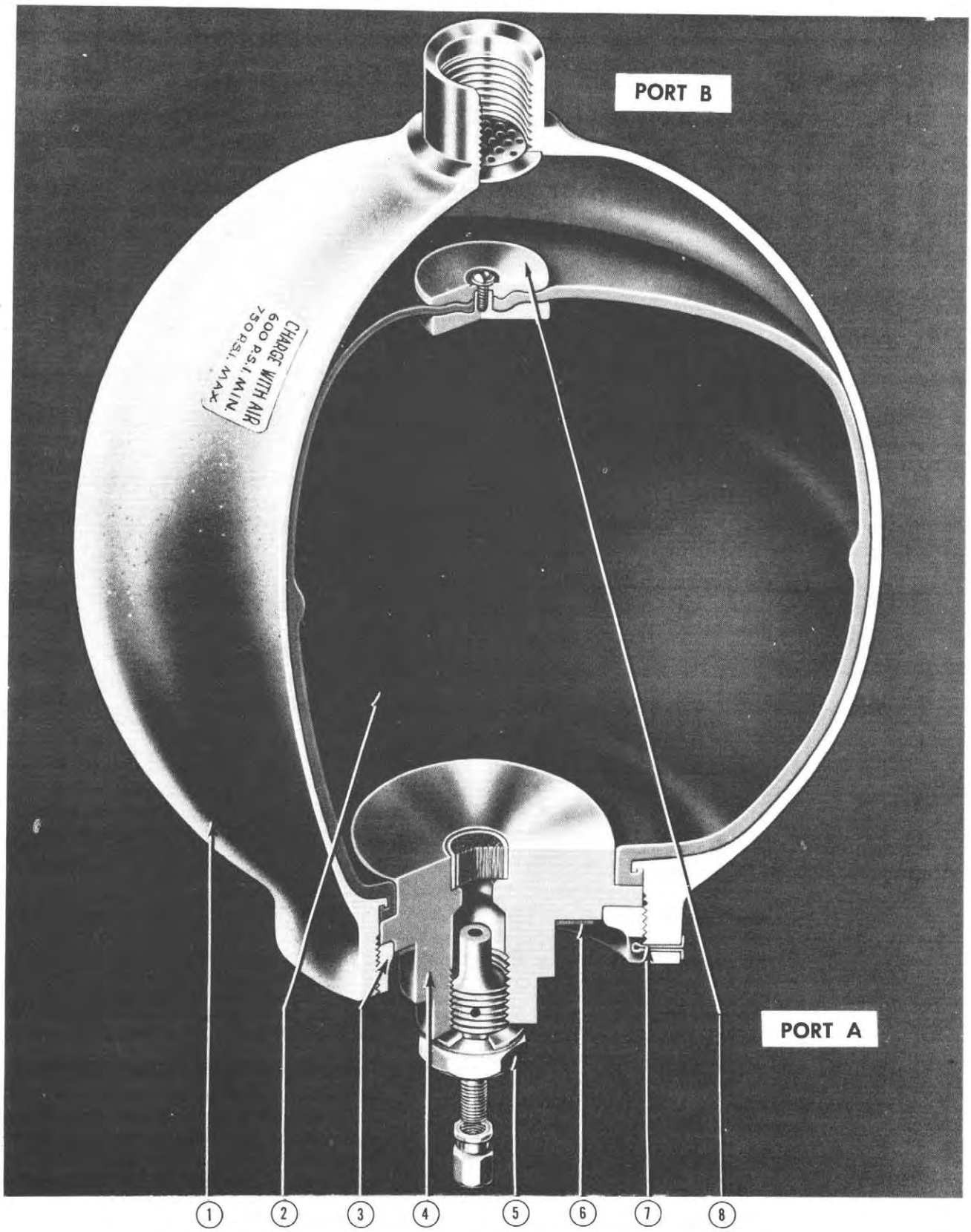
5. Reverse the procedure outlined in REMOVAL to install the pump on the engine mounting pads.

6. Test the pump suction lines and fittings from the reservoir for leaks. Tighten all connections and eliminate air leaks so that a suction of 20 inches (50.8 cm) Hg can be maintained for at least five minutes. Make certain that all flexible hoses are installed without twisting and are properly supported.

7. After installation of the engine-driven pumps is complete, bleed the entire hydraulic system. Use the hand pump to fill the hydraulic lines and units before the system is put in operation. Bleeding must be done thoroughly to eliminate air in the hydraulic system.

(3) HYDRAULIC SYSTEM PRESSURE ACCUMULATOR. *(See figure 250.)*

(a) DESCRIPTION. – The hydraulic system pressure accumulator is a spherical welded steel container that is used essentially to store energy to provide an instantaneous supply of high pressure fluid when actuation of hydraulic units cause fluid demands beyond the capacity of the engine-driven hydraulic pumps. The accumulator also acts as a surge chamber or shock absorber for excessive loads thrown on the hydraulic system. The accumulator is supported by two brackets, located on the canopy in the pilot's compartment *(12, figure 252)*. When the accumulator is charged initially with dry, clean air at a pressure of 600-750 psi, the flexible synthetic rubber bladder, which separates the air and hydraulic fluid in the accumulator, is fully extended against the walls of the accumulator shell. As hydraulic fluid from the hydraulic system pressure regulator flows into the accumulator, the bladder is forced down compressing the air in the bladder. When the accumulator is fully charged with hydraulic fluid, the bladder is in the shape of a "U." When actuation of hydraulic units lowers the system pressure, the compressed air forces the bladder outward which expells the hydraulic fluid from the accumulator, supplying an instantaneous supply of high pressure fluid to the hydraulic system. The total volume of the accumulator is 200 cubic inches. However, with 750 psi air charge and hydraulic system pressure at the lower limit (850 psi) only 24 cubic inches of fluid is available in the accumulator.



1. Shell Assembly
2. Bladder
3. Retainer
4. Cap Assembly
5. Air Valve Assembly (Tighten cap with small wrench to torque of 15-25 inch-pound
6. Nameplate
7. Cotter
8. Stop Assembly

Figure 250 — Hydraulic System Pressure Accumulator

HYDRAULIC SYSTEM PRESSURE ACCUMULATOR

Douglas Drawing No. 4123727 Bendix Aviation Ltd. No. 403714

TEST PROCEDURE		
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE
750 psi air press.–Port A	None	Observe leakage by gage in 10 min. None allowed
1250 psi oil press.–Port B 750 psi air press.–Port A	None	External – None

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines at the tee fitting in the accumulator.

c. Remove the screws and collars that attach the pressure accumulator to the mounting brackets and remove the accumulator.

2. DISASSEMBLY.

a. Release the air pressure in the accumulator by backing off the air valve with a box wrench. DO NOT release the air pressure by depressing the air valve core.

b. Remove the retainer ring and cap assembly with service tool K33601. Hold the accumulator shell with a strap wrench when removing the retainer ring.

c. Remove the bladder by collapsing it to the inside with a smooth piece of wood. Grasp the fold of the bladder firmly and pull outward, twisting at the same time. DO NOT attempt to pry out the bladder with a sharp instrument or tool or the bladder may be punctured.

d. It is not necessary to remove the stop and washer on the bottom of the bladder unless the bladder has been damaged, necessitating replacement, or unless there is evidence of oil leakage through the stop and washer to the inside of the bladder.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check the air charge in the pressure accumulator every 25 hours by observing the following procedure:

a. Obtain system pressure (850-1000 psi) with the engines operating or by operating the hydraulic hand pump with the emergency hydraulic system selector valve in the "SYSTEM" position.

b. Slowly relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals. The last hydraulic system pressure gage indication before a sudden drop to zero is the accumulator air charge and should be 600-750 psi.

2. If the pressure accumulator is damaged, leaking or is not functioning properly, install a new or serviceable part.

(d) TESTS BEFORE INSTALLATION.–Refer to *figure 250* for leak tests of the pressure accumulator

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.

(See figure 250.)

a. Install the washer and stop on the bottom of the bladder. Make certain the screw is in tight to prevent air leaking from inside the bladder. Stake the screw lightly in two places.

b. Install the bladder assembly in the shell. Make certain the bladder is fitted all around the inside of the shell and that the lip on the top of the bladder is over the shoulder on the inside of the shell.

c. Place the cap assembly in the top of the accumulator, making certain that the lip of the bladder is not pushed down inside or distorted in any way. Push the cap against the bladder, and seat with a slight rocking motion.

d. Screw in the retainer ring, holding the cap in place. The retainer ring should be turned until it bottoms against the cap and then tightened with service tool K33601. When sufficiently tight, the top of the ring should be approximately 1/16 inch below the rim of the shell assembly.

Note

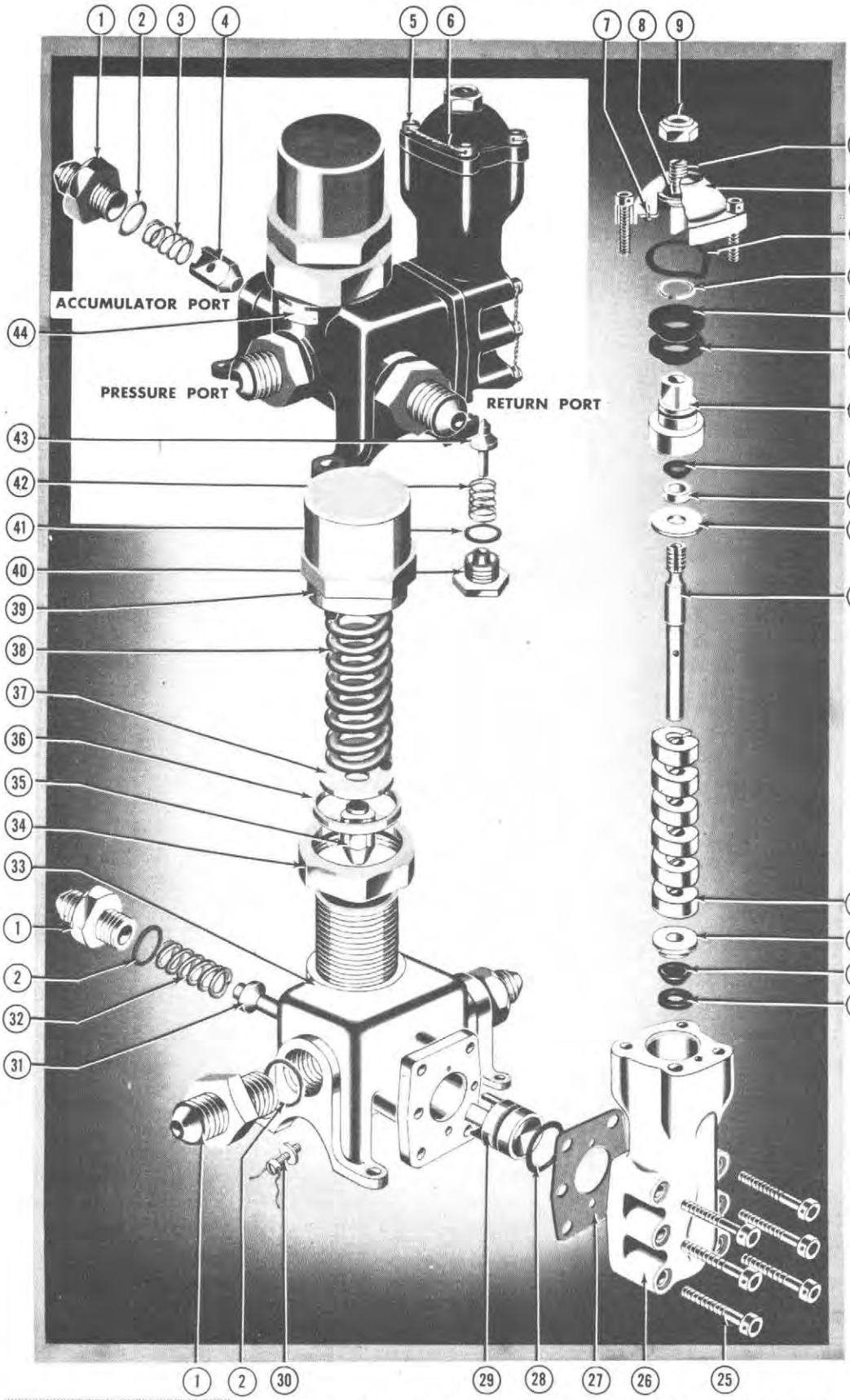
In cold weather tighten the ring an additional ¼ turn.

e. Install the air valve assembly, making certain that the gasket is in good condition. Tighten the valve cap with a small wrench to a torque of 15-25 inch-pounds. Finger tightness of the cap will not hold pressure consistently.

2. INSTALLATION.–To install the pressure accumulator refer to *12, figure 252* and reverse the removal procedure given in paragraph 14. *b.* (3) *(b) 1,* this section.

(f) MAJOR OVERHAUL.

1. Remove and disassemble the pressure accumulator as instructed in this paragraph 14. *b.* (3) *(b) 1,* this section.



1. Coupling
2. AN6227-13 Packing
3. Check Valve Spring
4. Check Valve Poppet
5. Cap Screw
6. Lock Wire
7. Plate and Screws
8. AN6227-6 Packing
9. Nut
10. Pin-Driver
11. Pilot Cap
12. AN6227-21 Packing
13. Snap Ring
14. Adapter
15. Leather Packing
16. Piston
17. AN6227-5 Packing
18. Washer
19. Washer
20. Piston Rod
21. Spring
22. Retainer
23. Packing
24. Adapter
25. Screw
26. Housing —Pilot Valve
27. Gasket
28. AN6227-12 Packing
29. Piston
30. Screw, Washer, and Lock Wire
31. Poppet
32. Spring
33. Valve Body
34. Lock Nut
35. Relief Valve Poppet
36. Seal
37. Spring Stop
38. Spring—Relief Valve
39. Cap—Relief Valve
40. Guide
41. AN902-5 Gasket
42. Spring
43. Pilot Poppet
44. Nameplate

Douglas Drawing
No. 5122202
Bendix Aviation Ltd.
No. 401507

Figure 251—Hydraulic System Pressure Regulator and Relief Valve (Some Airplanes)

HYDRAULIC SYSTEM PRESSURE REGULATOR AND RELIEF VALVE (SOME AIRPLANES)

Douglas Drawing No. 5122202 Bendix Aviation Ltd. No. 401507

TEST PROCEDURE			
TEST PRESSURE	PORTS PLUGGED	MAXIMUM LEAKAGE	
		INTERNAL	EXTERNAL
1000 psi–Accumulator Port	Pressure Port	1 drop/min. at Return Port	None
1000 psi–Pressure Port	Accumulator Port	1 drop/min. at Return Port	None
1000 psi–Return Port	Press. & Accum. Ports		None
Relief valve must relieve 6 gals./min. at 1250 ± 25 psi max.			

2. Clean the inside of the shell thoroughly with solvent or clean hydraulic fluid to remove any foreign material that might be discharged into the hydraulic system.

3. Inspect the bladder thoroughly for evidence of rupture, cracking, holes, which necessitate replacement.

4. Examine the shell for cracks at the welds, or evidence of wear. Check the threads in the shell for wear. A damaged shell must be replaced.

5. Examine the air valve assembly and replace any damaged parts with new parts.

6. Reassemble the pressure accumulator as instructed in paragraph 14. *b.* (3) *(b) 1.*, this section, and test for leaks as instructed in *figure 250.*

(4) HYDRAULIC SYSTEM PRESSURE REGULATION.

(a) GENERAL.–Two types of hydraulic system pressure regulators are used on this airplane. On some airplanes the hydraulic system pressure regulator and system pressure relief valve are combined in one integral unit. On other airplanes the pressure regulator and system relief valve are separate units. The differences in the line routing of the two installations are shown in *figure 246.*

(b) COMBINED PRESSURE REGULATOR AND SYSTEM RELIEF VALVE.
(See figure 251.)

1. DESCRIPTION.–The pressure regulator and system relief valve is installed on the pilot's compartment canopy inboard and above the main hydraulic system reservoir. The pressure regulator and relief valve functions to maintain the hydraulic system pressure between 850-1000 ± 20 psi and to by-pass fluid to the reservoir when the upper limit is reached, thereby relieving the load on the engine-driven hydraulic pump, which operates continuously. This is accomplished by means of the pilot valve assembly, which may be adjusted to operate at the desired cut-in and cut-out pressure. As pressure increases from the pressure port to the accumulator port, the pressure is exerted on the back of a piston in the pilot valve. When the pressure increases to 1000 ± 20 psi, a poppet in the bottom of the pilot valve is forced open by action of the piston and piston rod and the fluid is by-passed to the return port to the reservoir, relieving the load on the engine-driven hydraulic pump. When the pressure in the pressure accumulator decreases to 850 ± 20 psi by actuation of any of the hydraulic system units, the regulator, by means of closing of the internal poppets, allows the engine-driven pumps to recharge the system pressure. An integral check valve prevents flow of fluid from the accumulator port to the return port. The relief valve on the top of the valve body contains a spring-loaded poppet which is adjusted to open at 1100 psi and to allow full flow to the reservoir at 1250 ± 25 psi maximum.

2. REMOVAL AND DISASSEMBLY.

a. REMOVAL.

(1) Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

(2) Disconnect and cap the hydraulic lines leading to the pressure regulator and relief valve asssembly.

(3) Remove the screws that attach the regulator assembly to the mounting bracket and remove the regulator.

b. DISASSEMBLY.–When disassembly of the pressure regulator and relief valve assembly is attempted refer to *figure 251.* Disassembly of the regulator should be done only where adequate repair and testing facilities are available.

3. MAINTENANCE REPAIR OR REPLACEMENT.

a. At the 25-hour inspection period check the pressure regulator for evidence of external fluid leakage, especially at the couplings, the pilot valve cap, the relief valve cap, and the gasket between the

pilot valve housing and valve body. Also check the cut-in and cut-out pressure of the regulator.

b. If the pressure regulator and relief valve assembly is damaged or is not operating properly it should be replaced with a new or serviceable part.

4. ADJUSTMENTS.

a. Adjustment for cut-out pressure is the only one necessary as this adjustment also regulates the cut-in pressure. With the engines operating the hydraulic system pressure should remain at 850-1000 ± 20 psi. If the system pressure is not within these limits, relieve the hydraulic system pressure and adjust the driver pin screw in the pilot valve to obtain the desired pressure range.

Note

It is preferable to adjust the driver pin screw when there is no pressure on the regulator to avoid damage to the screw-driver head of the pin.

b. The relief valve is adjusted by means of the large cap. Tightening the cap increases the hydraulic system relief pressure setting; unscrewing the cap decreases the relief pressure setting. The relief valve should be adjusted to open at 1100 psi and allow full flow to the reservoir at 1250 ± 25 psi.

5. ASSEMBLY AND INSTALLATION.

a. ASSEMBLY.—To assemble the pressure regulator and relief valve assembly refer to *figure 251.*

Note

Make certain the drive on the bottom of the driver pin is engaged in the slot in the top of the piston rod. To facilitate replacing the cap on the pilot valve, the piston rod should be screwed into the piston until almost flush with the top of the piston.

b. INSTALLATION.—To install the pressure regulator and relief valve assembly reverse the REMOVAL procedure.

6. TESTS AFTER INSTALLATION.—Refer to *figure 251* for fluid leak tests of the pressure regulator and relief valve assembly.

7. MAJOR OVERHAUL.

a. Remove and disassemble the pressure regulator and relief valve assembly as instructed in 2., above.

b. Inspect the packing on the couplings. If there is any evidence of wear or leakage, replacement is necessary.

c. Carefully inspect all the poppets for evidence of wear or leakage. If leakage is apparent, the poppet may be reseated by placing a soft brass punch against the back of the poppet when it is on the seat and tapping LIGHTLY with a small hammer. If the poppet is badly worn or grooved and leakage persists, replacement is necessary.

CAUTION

Under no circumstances should these poppets be lapped into the seats.

d. Inspect all springs. If any springs are broken, replacement is necessary.

e. Inspect the threads on the driver pin, the piston rod, piston, and the nut of the pilot valve. If threads are stripped or too worn to allow adjustment of the pilot valve, replacement is necessary.

f. Inspect the piston and packing for scoring and scratching. Replace worn or scored packing.

g. Check the honed cylinder surface for scores or scratches. If the cylinder wall is scored deeply, allowing fluid leakage, replacement is necessary.

h. Inspect the retainer and packing in the pilot valve for wear. Inspect the piston and seal in the valve body for evidence of wear. If the seal is worn or scored, replacement is necessary.

i. When repairs have been completed, assemble and test the pressure regulator and relief valve assembly as instructed in *figure 251.*

(c) SEPARATE PRESSURE REGULATOR.

1. DESCRIPTION.—An AN 6206-1 pressure regulator and AN 6200-8AB relief valve are installed on some airplanes. The separate pressure regulator is similar to the pilot valve of the pressure regulator and relief valve assembly and is set to cut in at 800 $^{+50}_{-0}$ psi and to cut out at 1000 $^{+50}_{-0}$ psi. The separate pressure regulator has four ports, a pressure inlet port, a port to the pressure accumulator, a return port to the reservoir, and a drain port as shown. The separate pressure regulator is located on the pilot's compartment canopy *(16, figure 246.)*

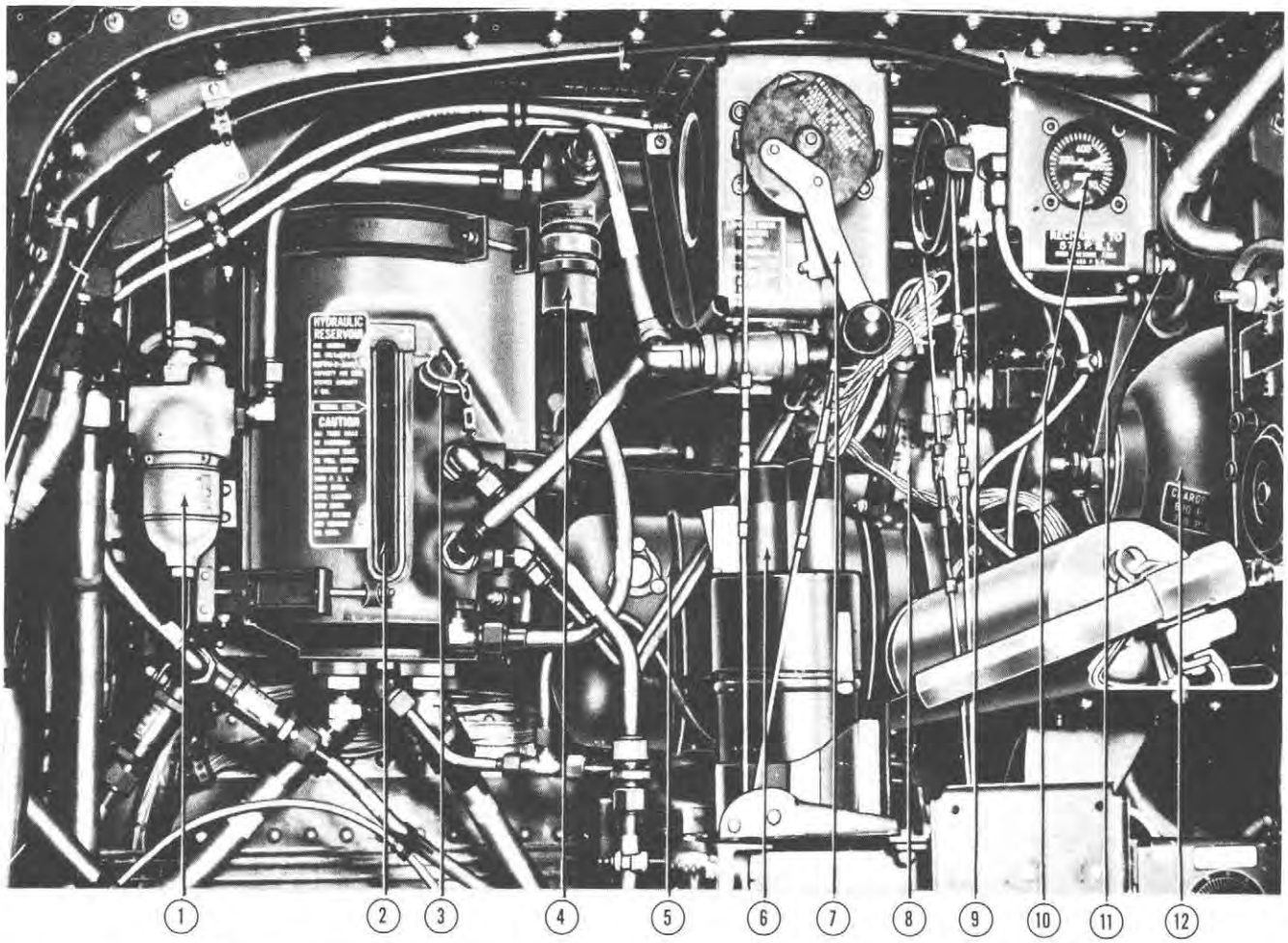
2. REMOVAL AND DISASSEMBLY.

a. REMOVAL.

(1) Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder brake pedals until the hydraulic system pressure gage indicates zero.

(2) Disconnect and cap the hydraulic lines leading to the pressure regulator.

(3) Remove the screws that attach the pressure regulator to the mounting bracket and remove the pressure regulator.



1. Main Hydraulic System Filter
2. Sight Gage—Main Hydraulic System Reservoir
3. Filler Neck—Main Hydraulic System Reservoir
4. Hydraulic System Pressure Regulator and Relief Valve (Some Airplanes)
5 Emergency Hydraulic System Fluid Reservoir
6 Solenoid Operated Bomb Bay Doors Position Selector Valve
7. Landing Gear Position Selector Valve Auxiliary Control Lever
8. Brake Emergency Air Bottle
9. Brake Emergency Air Control Valve
10. Brake Emergency Air Pressure Gage
11. Brake Emergency Air Filler Valve
12. Hydraulic System Pressure Accumulator

Figure 252—Hydraulic System Equipment Installed in Pilot's Compartment (Looking Aft)

b. DISASSEMBLY. – Disassembly of the pressure regulator should not be attempted in the field.

3. MAINTENANCE REPAIR OR REPLACEMENT.–Check the pressure regulator at the 25-hour inspection period for evidence of fluid leakage. Also check the cut-in and cut-out adjustment of the pressure regulator. If the pressure regulator is damaged or is not operating properly, replacement is necessary.

4. ADJUSTMENTS.–The cut-out pressure of the pressure regulator is made by means of a screw head driver in one end of the pressure regulator. If the hydraulic system pressure range is not 800 to 1000 + 50psi, relieve the system pressure and adjust the — 0 regulator by turning the screw-head driver either in or out. When the proper adjustment is obtained, tighten the lock nut on the screw-head driver.

5. INSTALLATION.–To install the pressure regulator, reverse the REMOVAL procedure.

(d) SEPARATE PRESSURE RELIEF VALVE.

1. DESCRIPTION.–The AN 6200-8AB pressure relief valve is installed in conjunction with the AN 6206-1 pressure regulator on some airplanes. The separate pressure relief valve is installed in the engine-driven hydraulic pump pressure line between the main hydraulic system filter and the pressure regulator, and is located on the pilot's compartment canopy. The

pressure relief valve has three ports, a pressure inlet, an outlet to the pressure regulator, and an outlet to the main hydraulic system reservoir. The spring loaded poppet in the pressure relief valve is adjusted to open at 1125 psi minimum and allow full flow to the reservoir at 1250 psi maximum. *(See 15, figure 246.)*

2. REMOVAL AND DISASSEMBLY.

a. REMOVAL.

(1) Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

(2) Disconnect and cap the hydraulic lines leading to the pressure relief valve.

(3) Remove the screws that attach the valve to the mounting bracket and remove the pressure relief valve from the airplane.

b. DISASSEMBLY. – Disassembly of the pressure relief valve should not be attempted in the field.

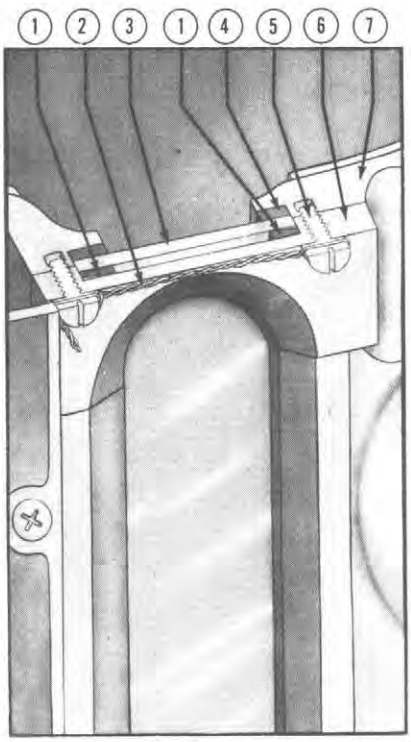
3. MAINTENANCE REPAIR OR REPLACEMENT.

a. Inspect the pressure relief valve for evidence of fluid leakage at the 25-hour inspection period.

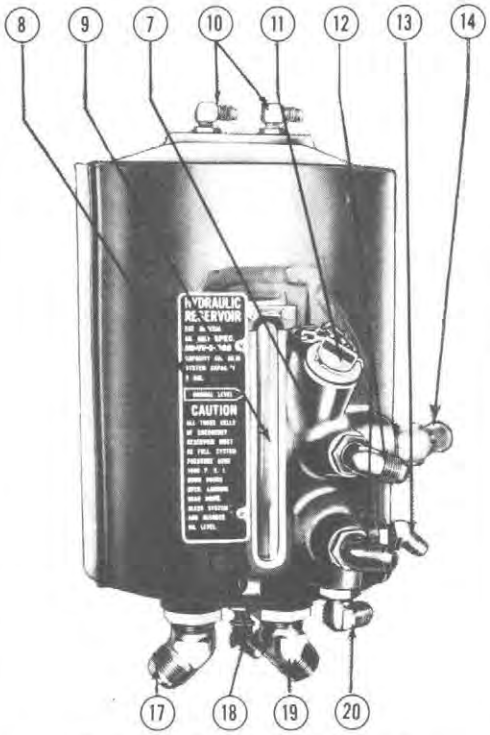
b. If the pressure relief valve is damaged or is not functioning properly, replacement is necessary.

4. ADJUSTMENTS.–Adjustment of the pressure relief valve is made by tightening or loosening the end cap. Tightening the cap increases the system pressure relief setting; loosening the cap decreases the system pressure relief setting. Adjust the valve to open at 1125 psi minimum and to allow full flow to the reservoir at 1250 psi maximum.

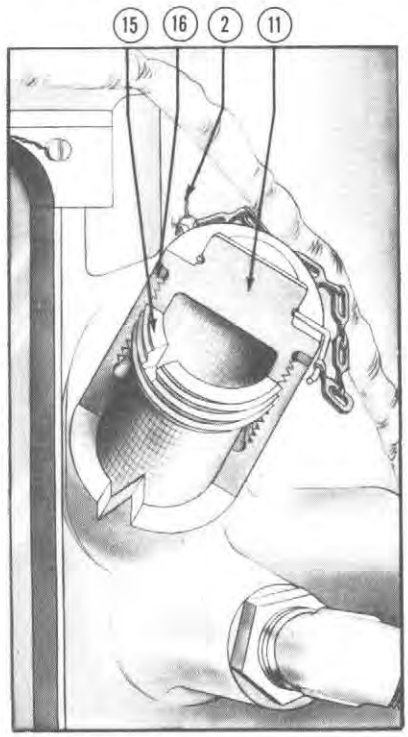
5. INSTALLATION.–To install the pressure relief valve reverse the REMOVAL procedure.



Detail of Sight Gage Assembly



Complete Reservoir Assembly



Detail of Filler Neck Assembly

1. Wedge
2. Lock Wire
3. Transparent Panel
4. Gasket
5. Screw
6. Sight Gage Cap
7. Segment
8. Instruction Plate
9. Sight Gage Assembly
10. Vent Fittings
11. Filler Cap and Chain Assembly
12. Fitting (Brake or Landing Gear Return)
13. Fitting (Bomb Bay Door Return)
14. Fitting (Emergency Reservoir Supply)
15. Strainer Assembly
16. Gasket
17. Fitting (R. H. Engine-Driven Pump Supply)
18. Fitting (Hand Pump Supply)
19. Fitting (L. H. Engine-Driven Pump Supply)
20. Fitting (Pressure Regulator Return)

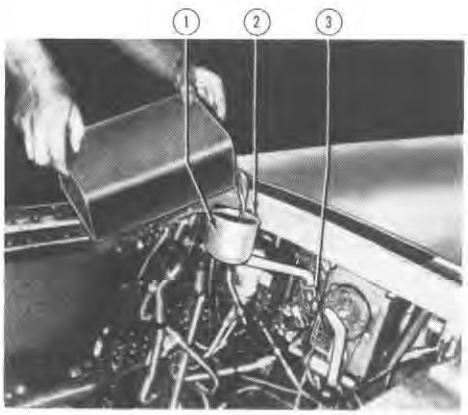
Douglas Drawing No. 5122204

Figure 253 — Main Hydraulic System Fluid Reservoir

(5) MAIN HYDRAULIC SYSTEM FLUID RESERVOIR. *(See figure 253.)*

(a) DESCRIPTION.—The main hydraulic system fluid reservoir is a welded aluminum container supported by straps at the rear of the pilot's compartment and has a fluid capacity of 1.75 U.S. gallons (1.46 Imperial gallons). The main reservoir supplies fluid to the main system and to the emergency hydraulic fluid reservoir *(figure 287)*, and incorporates a sight gage *(9, figure 253)* for determining the fluid level. An instruction plate for filling the fluid reservoir is attached to the reservoir beside the sight gage.

1. FILLING THE RESERVOIR.—Use hydraulic fluid (Specification AN-VV-O-366) only and observe the following procedure:



1. Funnel Assembly
2. Hole for Hook on Filler Funnel
3. Reservoir Filler Neck

Figure 254—Filling The Hydraulic System Reservoirs

a. Remove the reservoir filler cap and use the hydraulic reservoir funnel *(figure 254)* to pour the fluid into the main reservoir at the filler opening until all three cells of the emergency hydraulic system reservoir *(figure 290)* are filled, and the fluid approaches the normal level mark on the main reservoir. Make certain all foreign material is removed from the top of the supply container before hydraulic fluid is poured into the filler funnel.

Note

The hydraulic reservoir funnel is attached to clips on the radio equipment shelf aft support, located behind the pilot's seat. To use the funnel, place the spout into the filler opening. Hook the funnel into the hole provided in the canopy support. It is not necessary to hold the funnel while pouring hydraulic fluid into the reservoir.

b. Either attach a hydraulic test stand or operate the engines to maintain 1000 psi system operating pressure. The test stand should be connected at the firewall self-sealing disconnect couplings.

c. With the landing gear down and the bomb bay doors open, bleed the system and recheck the fluid level. Add more fluid if necessary and then replace the filler cap.

CAUTION

Every precaution must be observed in the handling of hydraulic fluid to prevent contamination. The storage containers must be kept sealed; all handling equipment must be kept clean and should be used for hydraulic fluid only. Leakage, poor functioning of hydraulic units, and excessive wear of parts are often caused by contaminated fluid. Do not mix different types of hydraulic fluid because the resulting mixture may cause the packing to seize, deteriorate, and clog the actuating cylinders so that they will fail to operate. Do not expose hydraulic fluid to the air any more than is absolutely necessary. The fluid will absorb dust and grit from the air and this becomes a serious menace. Fluid that has been exposed to dust contamination, or which has been used previously, should be filtered before using. Filtering will remove the sludge from used fluid, as well as all metal flakes and grit. Hydraulic fluid may be strained effectively by using fine wire mesh as a strainer. The filtered fluid should be placed in clean containers, properly marked to identify the contents, then sealed until required for use.

(b) REMOVAL.

1. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

2. Disconnect and cap all hydraulic lines at the reservoir.

3. Remove the bolts, bend back the straps and remove the main hydraulic system reservoir.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Small holes or cracks in the reservoir may be welded by approved welding procedures.

2. Fluid leaks may develop at the outlets of the reservoir. If moderate tightening of the elbow nuts will not stop the fluid leakage, install new gaskets or fittings.

3. Leakage of fluid around the sight gage may require replacement of the gasket or the panel. Procedure follows:

a. Cut the lockwire and remove the screws which attach the sight gage cap to the reservoir; then remove the cap.

b. Remove the four wedges which press the plexiglas panel against the gasket.

c. Remove the panel and gasket and replace them with new parts if defects are discovered.

d. To reassemble the sight gage panel, first install the gasket. Slide in the plexiglas panel. Install the four wedges to seal the panel. Reinstall the sight gage cap and safety the screws.

4. Clean the reservoir strainer assembly by the following procedure:

a. Unscrew the filler neck cap.

b. Unscrew the strainer assembly in the filler neck with a piece of strap iron of the proper width and thickness to fit into the slots in the strainer assembly.

c. Clean the strainer with clear gasoline. Small holes or tears in the brass screen may be soldered.

d. After thoroughly cleaning the strainer, install the strainer assembly and filler cap. Install a new filler cap gasket if the original gasket shows evidence of deterioration.

5. If the reservoir is damaged badly, replace it with a new reservoir assembly.

(d) TEST BEFORE INSTALLATION.—Apply 10 psi with all outlets plugged to test for fluid leaks. No fluid leaks are permissible.

(e) INSTALLATION.—Installation of the main hydraulic system reservoir is the reverse of the REMOVAL procedure.

(6) MAIN HYDRAULIC SYSTEM FILTER.

(a). DESCRIPTION.—A Purolator unit *(figure 255)* is employed to filter the fluid in the main hydraulic system. The filter is located at the right of the main hydraulic system fluid reservoir in the rear of the pilot's compartment *(1, figure 252).* Cleaning of the fluid is accomplished by a metal edge filter element. Cleaning of the filter element is accomplished without disassembly by rotating the cleaning handle at the top of the filter four or five times in a clockwise direction. the filter four or five times in a clockwise direction. A drainable sump is located at the bottom of the filter to catch foreign particles. The filter has a capacity of 12 gallons per minute and incorporates two fluid pressure relief valves set at 28 to 30 psi differential to bypass the fluid if the filter element clogs. The filter operates during cleaning unless the sump is being drained.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the system operating pressure by applying toe pressure and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines at the filter.

c. Remove the attaching screws and remove the filter from the airplane.

2. DISASSEMBLY.

(See figure 255.)

a. Clamp the filter upside down in a vise, using the square boss on top the head of the filter.

b. Unscrew the case from the head. Remove the cleaning handle by removing the handle lock nut.

c. Use a wide bit screw driver to remove the relief valve seats from the filter head.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. The filter should be thoroughly cleaned every 100 hours by observing the following instructions:

a. Relieve the system operating pressure by applying toe pressure to and releasing the rudder brake pedals until the hydraulic system pressure gage indicates zero.

b. Turn the cleaning handle *(1, figure 255)* four or five times in a clockwise direction. This turns the filtering element against stationary blades, and foreign particles are scraped into the drainable sump.

c. Remove the drain plug from the filter and allow dirt and hydraulic fluid to drain out into a container.

d. Install a new gasket and insert drain plug.

e. Increase the fluid pressure in the system, and inspect the drain plug for fluid leaks. If no fluid leakage is observed, replace drain plug safety wire.

f. Clean the emergency system filter when the main system filter is cleaned.

2. This self-cleaning filter requires no maintenance other than periodic draining of the sump. However, the filtering element may become clogged with foreign materials, and it may be necessary to disassemble the filter and clean the element.

3. To disassemble the filter, refer to paragraph 14. *b.* (6) *(b) 2.,* this section. To clean the filtering element, submerge the element in clear gasoline or fuel oil, and wash with a soft, lint-free cloth or a soft hair brush. DO NOT USE WIRE BRUSH OR SCRAPER. Wash out the inside of the head and case

by submerging in clear gasoline or fuel oil, and using a soft, lint-free cloth or soft hair brush.

Note

It is extremely important that the filter is functioning efficiently. Dirty fluid will cause operating troubles in the hydraulic system and excessive wear of parts in the hydraulic units.

4. A damaged filter should be replaced with a new or serviceable part.

(d) TESTS BEFORE INSTALLATION.–Refer to *figure 255* for leak tests.

(e) ASSEMBLY AND INSTALLATION.

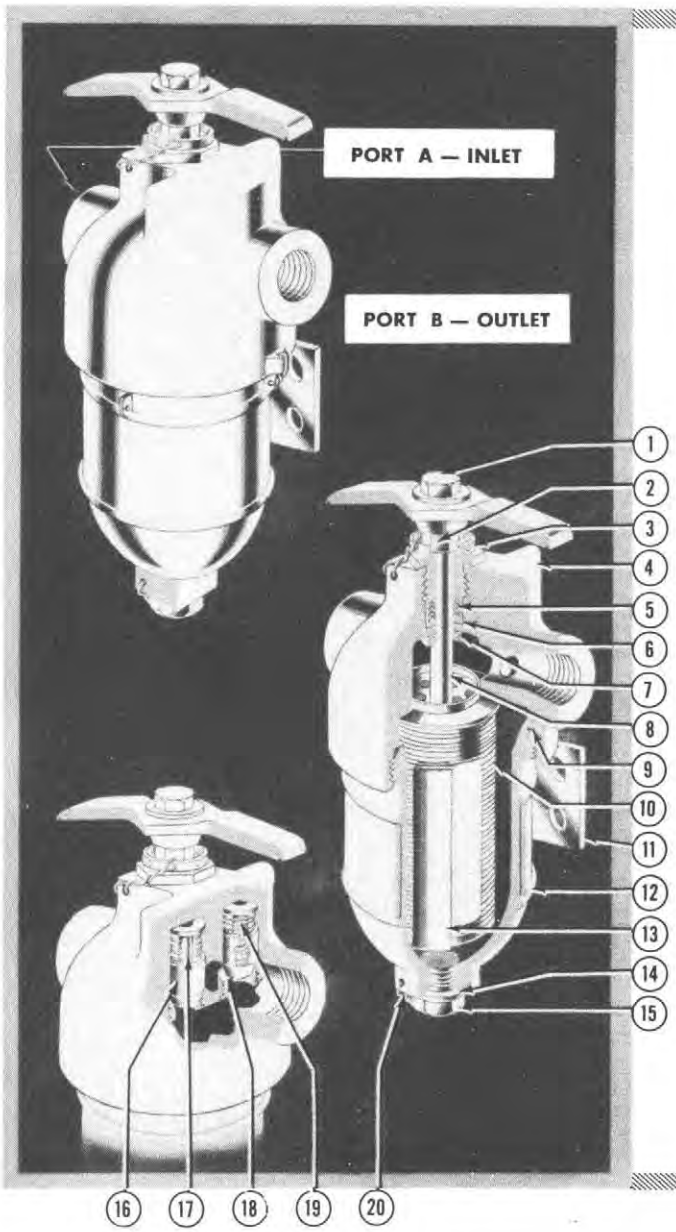
1. ASSEMBLY.–To assemble the filter, refer to *figure 255.*

2. INSTALLATION.–To install the filter, reverse the REMOVAL procedure.

(f) MAJOR OVERHAUL.

1. Remove and disassemble the main hydraulic system filter as instructed in paragraph 14. *b.* (6) *(b) 2.*, this section.

2. Inspect relief valve spring guides for evidence of wear which may cause the spring to stick. Inspect the springs for breaks. Check the relief valve pistons for wear on the seats which may cause leakage or wear on the sides of the pistons which might cause sticking.



1. Cleaning Handle Assembly
2. Nut
3. Packing Plug
4. Head
5. AN-6225-3 Packing
6. Packing Support
7. Retainer Cap
8. Drive Shaft Retainer
9. AN-6230-6 Case Packing
10. Filter Element
11. Bracket and Nameplate
12. Case
13. Knife and Frame Assembly
14. Drain Plug Gasket
15. Drain Plug
16. Relief Valve Piston
17. Spring Guide
18. Relief Valve Seat
19. Relief Valve Spring
20. Lock Wire (3 Places)

TEST PROCEDURE		
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE
1500 psi– Port A	Port B	2 drops in 12 hrs.–External
Relief valves should open at 28-30 psi pressure differential if element clogs.		

Douglas Drawing No. 4123160
Purolator Products Type G-159 J-11

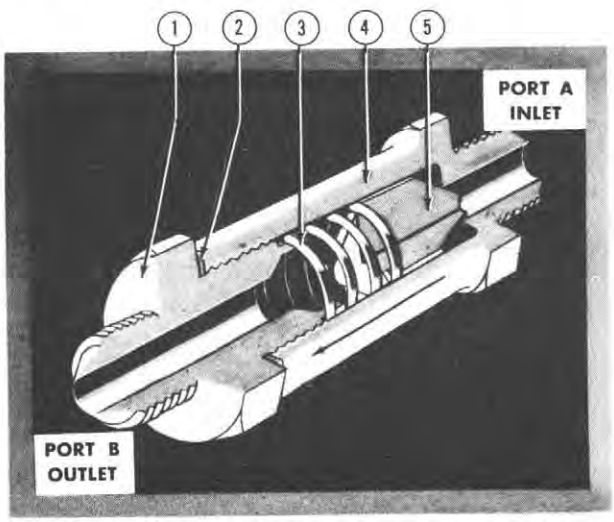
Figure 255—Main Hydraulic System Filter

3. Inspect the edges of the cleaning knives for wear that will prevent proper cleaning of the element. Inspect the filtering screen on the element assembly for wear caused by the cleaning knives as this wear will allow dirt to pass through the filtering screen.

4. Clean the filtering element, head, and case thoroughly by submerging in clear gasoline or fuel oil, and washing with soft, lint-free cloth. DO NOT USE WIRE BRUSH OR SCRAPER.

5. Install new packing and gaskets.

6. When the repairs to the filter are completed, assemble the filter and test for leaks as instructed in *figure 255*.



1. Connector
2. Gasket
3. Spring
4. Valve Body
5. Poppet

NOTE
Arrow on valve body indicates direction of fluid flow through the check valve.

TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE	
		INTERNAL	EXTERNAL
1500 psi–Port B	None	None	None
5 psi–Port B	None	1 drop in 2 min.	None

Figure 256—Typical Fluid Check Valve

(7) HYDRAULIC FLUID CHECK VALVES.

(a) DESCRIPTION. – Hydraulic fluid check valves are incorporated in the main hydraulic system to maintain the flow of fluid in one direction only in critical lines. *(See figures 246 and 282.)* The check valve consists of spring-loaded plastic poppet with a conical end which seats on the aluminum alloy valve body and a connector that retains the poppet spring. The check valve allows free flow of fluid in one direction but no flow in the opposite direction. An arrow on the side of the valve body indicates the direction of flow. Fluid flow through the poppet end of the valve unseats the poppet. Flow in the opposite direction immediately seats the poppet and prevents any further back flow.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines at the check valve.

c. Unscrew attaching clip (if any) and remove the check valve.

2. DISASSEMBLY.—Refer to *figure 256* if disassembly of the check valves is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Inspect the line connections and connector end of the valve body for leakage. No other maintenance or lubrication is necessary.

2. The check valve should be replaced if it is damaged or not functioning properly.

(d) TEST BEFORE INSTALLATION.—Refer to *figure 256*, for fluid leak tests of the check valves.

(e) INSTALLATION.—To install a check valve, reverse the REMOVAL procedure.

(8) HYDRAULIC SYSTEM PRESSURE GAGE. *(See figure 247.)*

(a) DESCRIPTION.—The Bourdon-tube type hydraulic system pressure gage is located on the left side of the instrument panel in the pilot's compartment on some airplanes and on the main instrument panel on other airplanes, and indicates pressure from 0 to 2000 psi. The gage is connected to the brake pressure line. The line to the gage includes a snubber which prevents damage to the gage by fluid surges in the hydraulic system.

(b) REMOVAL.

1. Remove the instrument panel access door *(7, figure 7)*.

2. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

3. Disconnect and cap the hydraulic line or hose leading to the gage.

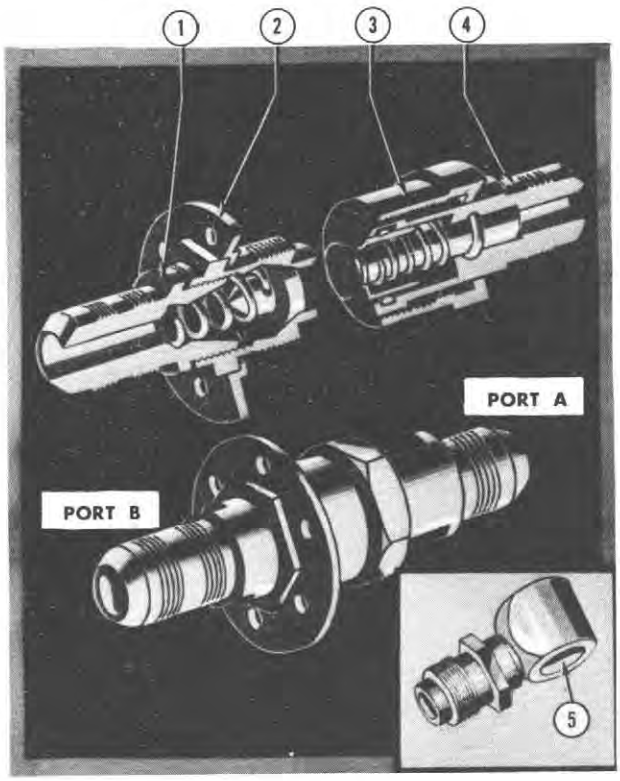
4. Remove the screws attaching the gage to the instrument panel and remove the gage.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–If a gage is damaged or is not functioning properly, a new or serviceable gage will be installed. Repair of the gage should be made only at depots by qualified personnel.

(d) INSTALLATION.–To install the hydraulic system pressure gage reverse the REMOVAL procedure.

(9) SELF-SEALING DISCONNECT COUPLINGS.

(a) DESCRIPTION. – Self-sealing disconnect couplings *(figure 257)* to facilitate service and maintenance are provided at the hydraulic connections on the firewall and at the brake units. The couplings consist of two parts connected by a union nut. When the union nut is unscrewed, the coupling valves are seated by springs to prevent the loss of hydraulic fluid and the introduction of air into the lines. When the union nut is tightened, the valves allow free flow of the hydraulic fluid. The firewall couplings are provided with a mounting flange, while the brake couplings are attached to the brake units with hollow bolts.



1. Bulkhead Fitting End Half
2. Mounting Flange
3. Nut
4. Coupling Half Gasket Seal Fitting End
5. Brake Coupling Half 15 Banio Swivel End

TEST PROCEDURE	
TEST PRESSURE	MAX. LEAKAGE
5 psi—Port A—Valve Disconnected	10 drops / hr.
5 psi—Port B—Valve Disconnected	10 drops / hr.
1500 psi—Port A—Port B Plugged	External—None

Figure 257—Typical Self-sealing Disconnect Coupling

(b) REMOVAL.

1. Relieve the system operating pressure by applying toe pressure and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

2. Disconnect and cap the hydraulic lines leading to the couplings.

3. To remove the firewall couplings, remove the attaching screws. To remove the brake couplings, remove the attaching hollow bolts.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–A damaged coupling should be replaced with a new or serviceable part.

(d) TEST BEFORE INSTALLATION.–Refer to *figure 257* for leak tests.

(e) INSTALLATION.–To install the self-sealing couplings, reverse the REMOVAL procedure.

Note

When installing the brake disconnect couplings, preload the attaching bolts to 540 inch-pounds wrench torque. If this torque does not give a satisfactory seal, install new seal washers.

c. LANDING GEAR HYDRAULIC SYSTEM. *(See figure 258.)*

(1) GENERAL.–The landing gear hydraulic system consists of the hydraulic units necessary to operate the main landing gear, nose wheel gear, and nose wheel doors. The operation of this system is controlled by the landing gear position selector valve *(9, figure 258)* located on the canopy in the pilot's compartment. The landing gear control lever is located on the forward right-hand side of the pilot's control pedestal and actuates the landing gear position selector valve and nose wheel door "UP" latches by means of cables.When the control lever is moved to the "UP" position, the selector valve directs fluid pressure to the main landing gear, nose wheel gear, and nose wheel door actuating cylinders. The main landing gear and nose wheel gear actuating cylinder pistons extend, and the nose wheel door actuating cylinder piston retracts. The displaced fluid is returned to the fluid reservoir through the landing gear DOWN lines and selector valve as the

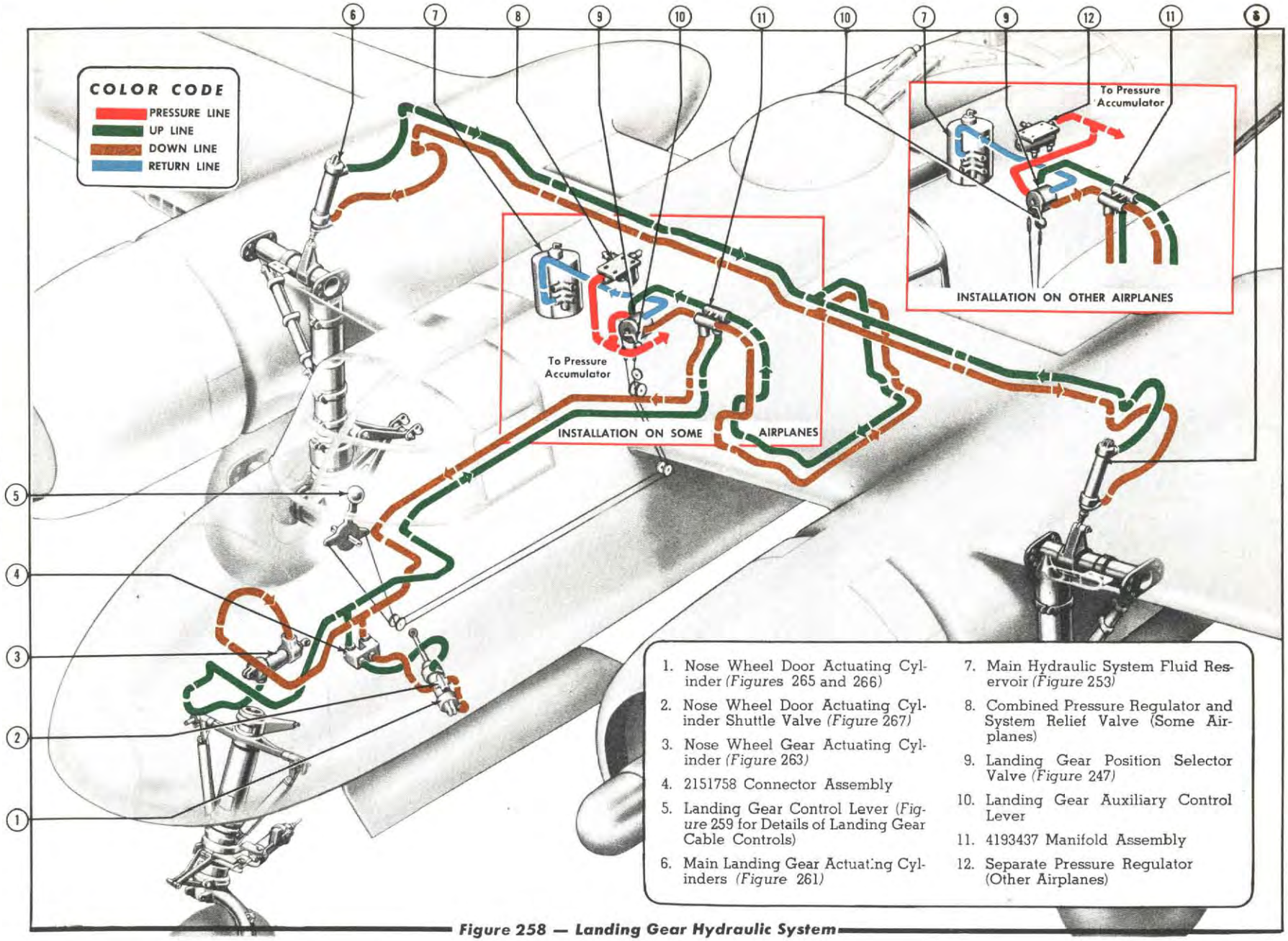
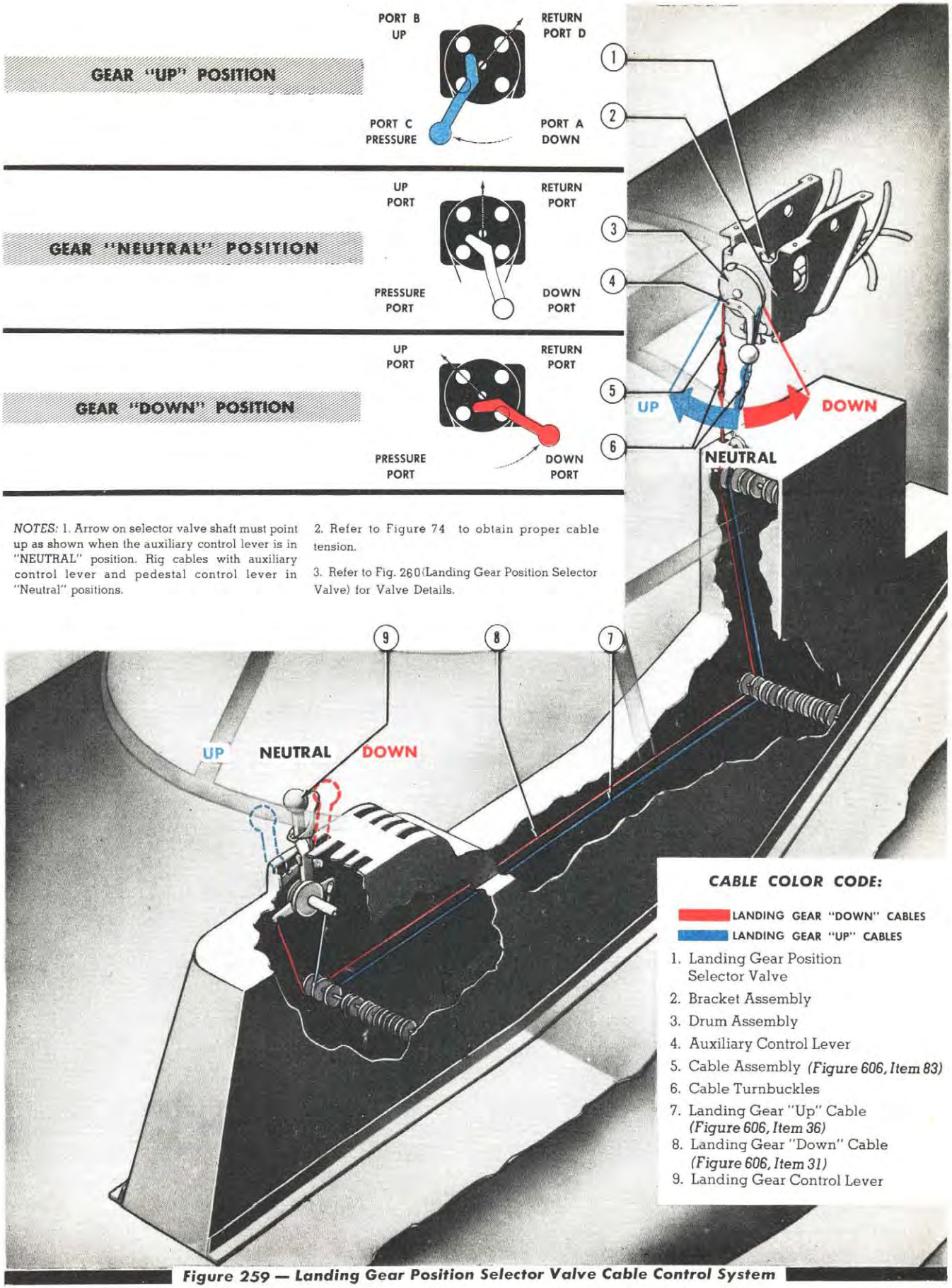


Figure 258 — Landing Gear Hydraulic System

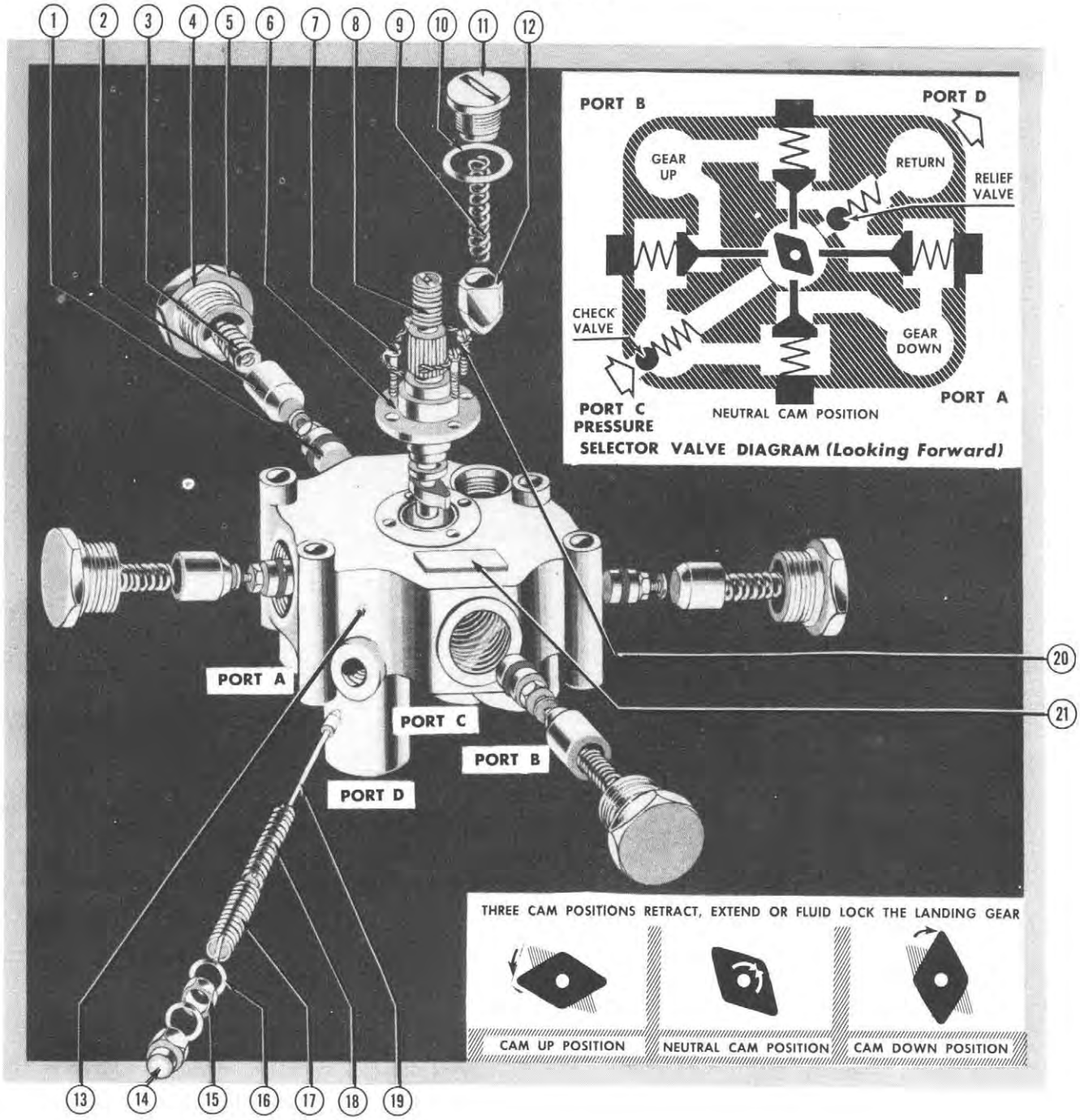


NOTES: 1. Arrow on selector valve shaft must point up as shown when the auxiliary control lever is in "NEUTRAL" position. Rig cables with auxiliary control lever and pedestal control lever in "Neutral" positions.

2. Refer to Figure 74 to obtain proper cable tension.

3. Refer to Fig. 260 (Landing Gear Position Selector Valve) for Valve Details.

Figure 259 — Landing Gear Position Selector Valve Cable Control System



1. Piston Assembly
2. Poppet
3. Spring
4. AN900-12 Gasket
5. Cap
6. Bearing
7. Screw
8. Control Shaft
9. Spring
10. Packing
11. Plug
12. Check Valve
13. Body Assembly
14. Cap
15. Lock Nut
16. AN900-5 Gasket
17. Set Screw
18. Spring
19. Needle
20. Lock Wire
21. Nameplate

Douglas Drawing No. 4196938

Figure 260—Landing Gear Position Selector Valve

LANDING GEAR POSITION SELECTOR VALVE

Douglas Drawing No. 4127438 Bendix Aviation Ltd. No. 401481

TEST PROCEDURE					
TEST	TEST PRESSURE	PORTS PLUGGED	HDLE. POS.	MAX. LEAKAGE INTERNAL	MAX. LEAKAGE EXTERNAL
1	1500 psi–Port C	A, B, and D	3		None
2	1300 psi–Port C	A and B	2	Relief valve must relieve at 1250 ± 50 psi	None
	WARNING: Do not exceed 4 drops / sec. flow through relief valve.				
3	1000 psi–Port C		2	10 drops / hr. each at Ports A and B. 10 drops / hr. at Port D	None
4	1000 psi–Port A		1	Leakage found at Port D in Test 3 plus 10 drops / hr.	None
5	1000 psi–Port B		3	Leakage found at Port D in Test 3 plus 10 drops / hr.	None
6	100 psi–Port B	D and A	3	10 drops / hr.	None

landing gear retracts. When the landing gear is extended, the flow of fluid and direction of piston action is reversed. After the landing gear has been retracted, the control lever should be moved from the "UP" position to the "NEUTRAL" position. For complete information about the mechanical operation of the landing gear refer to paragraph 5. *b.*, this section. When the airplane is on the ground, a solenoid detent pin prevents the landing gear position selector valve handle from being moved from the "DOWN" position to the "UP" position. The retraction release switch is installed on the left main landing gear shock strut cylinder above the torque arm. A cam on the torque arm opens the switch when the torque arm is compressed; that is, when the landing gear is bearing the weight of the airplane. Opening the switch opens the circuit to the selector valve solenoid, de-energizing the solenoid pin which springs forward and prevents movement of the landing gear control lever to the "UP" position. Refer to paragraph 15. *d.* (13) *(e)*, this section for complete information about the solenoid detent pin assembly and the landing gear signal system.

Note

When extending the landing gear, move the control lever on the pedestal from the "NEUTRAL" to the "DOWN" position in a continuous movement taking no longer than two seconds to move the lever. DO NOT actuate the control lever by a series of light taps.

(2) LANDING GEAR POSITION SELECTOR VALVE AND CABLE CONTROLS.

(See figures 259 and 260.)

(a) DESCRIPTION.—The landing gear position selector valve is attached to a bracket on the canopy in the pilot's compartment *(figure 259)*. This poppet type valve has four ports; a pressure port, return port, an UP port and a DOWN port. When the control lever is moved to the "DOWN" position, a cam assembly on the valve shaft opens two of the poppet valves, one connecting the pressure port to the DOWN line and the other connecting the return port to the UP line. When the control lever is moved to the "UP" position, the other two poppet valves are opened, one connecting the pressure port to the UP line and the return port to the DOWN line. When the lever is in the "NEUTRAL" position, all four poppet valves are closed. The valve unit has an integral check valve to prevent flow of fluid from the cylinder ports to the system pressure port, and an integral fluid pressure relief valve which by-passes fluid to the reservoir when pressure in the landing gear hydraulic system increases to 1250 ± 50 psi. The cable controls consist of a drum and cable assembly installed on the valve shaft with cables connecting to the control lever on the pedestal. Another cable is attached to the control lever to release the nose wheel door up latches when the control is moved to the "DOWN" position on some airplanes.

(b) REMOVAL AND DISASSEMBLY.

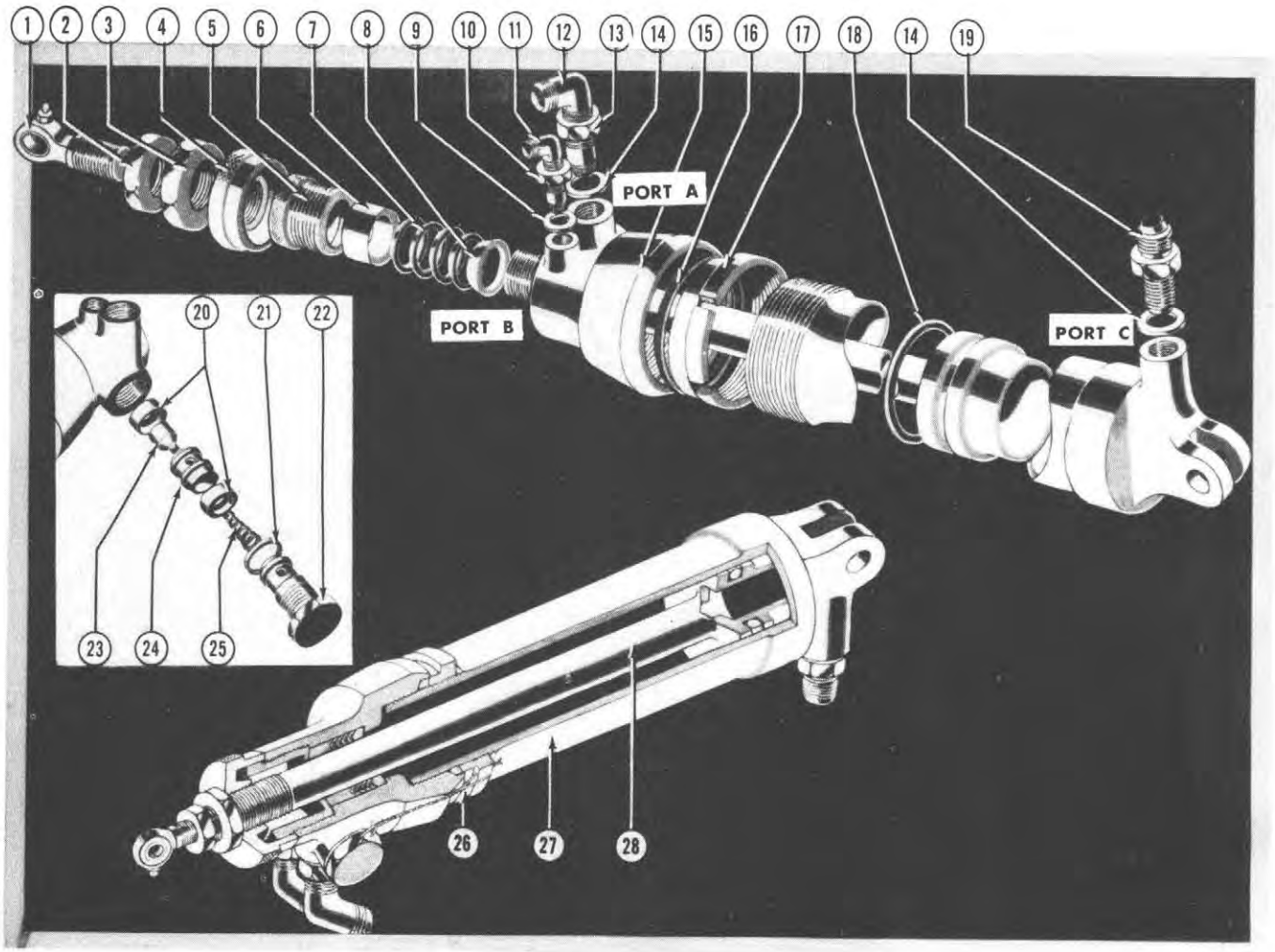
1. REMOVAL.

a. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the four hydraulic lines leading to the landing gear position selector valve.

c. Loosen the cable turnbuckles *(figure 259)* and remove the pulley with cable attached from the valve shaft.

d. Remove the screws attaching the valve to the bracket and remove the valve.



1. Rod End Assembly (Includes 116500-9A-028G Bushing)
2. Nut
3. Nut
4. Stop Nut
5. Packing Nut
6. Ring
7. AN6225-22 Packing (4 Required)
8. Ring
9. AN902-4 Gasket
10. Lock Nut
11. Elbow
12. Elbow
13. Lock Nut
14. AN902-8 Gasket
15. Cylinder End
16. Gasket
17. Nut
18. AN6227-38 Packing
19. Union
20. Seats—Shuttle Valve (Emergency Substitute Part may be made from AN6226-9)
21. Washer
22. Plug—Shuttle Valve
23. Cone—Shuttle Valve
24. Spacer—Shuttle Valve
25. Spring—Shuttle Valve
26. Lock Wire
27. Barrel Assembly
28. Piston Assembly

TEST PROCEDURE

TEST PRESS.	PISTON POS.	MAX. LEAKAGE	
		EXTERNAL	INTERNAL
1500 psi–Port A	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port B	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port C	Extended	2 drops in 12 hrs.	10 drops / hr.
Friction Pressure – 25 psi max.			

Douglas Dwg. No. 5122377

Figure 261—Main Landing Gear Actuating Cylinder

2. DISASSEMBLY.—Refer to *figure 260* if disassembly of the landing gear position selector valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—If the landing gear position selector valve is damaged or is not functioning properly, replace it with a new or serviceable part.

(d) ADJUSTMENTS.

1. If the valve has been disassembled, the flat head screws *(1, figure 260)* on the pistons must be adjusted so that the control shaft *(8, figure 260)* may rotate 20 degrees in the "NEUTRAL" position—that is, between the closing of one pair of poppets and the opening of the opposite pair. Install the valve pulley so that as much of the 20 degrees as possible is usable in extending the gear.

2. The relief valve is set to by-pass fluid to the reservoir at 1250 ± 50 psi. Place the emergency hydraulic system selector valve in the "SYSTEM" position and operate the hydraulic hand pump until the hydraulic system pressure gage indicates 1250 ± 50 psi.

a. If the hydraulic pressure gage indicates more than 1250 ± 50 psi, the set screw *(17, figure 260)* located under the return port should be turned out.

b. If the gage indicates less than 1250 ± 50 psi, turn the adjusting screw in.

(e) To adjust the cable controls refer to *figure 259.*

(e) TESTS BEFORE INSTALLATION.—Refer to *figure 260* for leak tests.

(f) INSTALLATION.—To install the valve, reverse the REMOVAL procedure. Adjust the cable controls as shown on *figure 259.*

(3) MAIN LANDING GEAR ACTUATING CYLINDERS.
(See figure 261.)

(a) DESCRIPTION.—Each main landing gear actuating cylinder is attached at the cylinder end to the landing gear retracting link support, and at the piston end to the main landing gear strut retracting arm. When the landing gear is retracted, fluid is forced into the cylinder upper port *(figure 258),* extending the piston and retracting the gear. As the piston is actuated, the excess fluid is forced out of the cylinder lower port *(figure 258),* and then back to the fluid reservoir through the landing gear DOWN line and position selector valve. When the landing gear is extended, the fluid flow and piston actuation is reversed. The main landing gear cylinders have integral shuttle valves *(23, figure 261)* which close the main hydraulic fluid ports when the emergency DOWN lines are being used.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Install ground safety pins on the two main landing gear assemblies and on the nose gear. *(See figure 91.)*

b. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

c. Disconnect and cap the three hydraulic hoses leading to the main landing gear actuating cylinder.

d. Remove the bolt attaching the piston rod eyebolt to the retracting link support and remove the cylinder.

e. Remove the bolt that attaches the cylinder head to the retracting link support and remove the main landing gear actuating cylinder.

2. DISASSEMBLY.

a. A suitable clamp must be used to prevent distorting the cylinder barrel when this part is clamped in a vise during disassembly. Great care must be exercised in clamping the cylinder barrel because the thin barrel walls are easily dented or distorted. A clamp may be made of two pieces of hardwood with the two halves encircling the entire length of the barrel. Use of this type of clamp assures that the clamping pressure is evenly distributed over the entire outside barrel surface. Place the cylinder barrel with clamp in a vise and tighten the vise until the cylinder is held securely.

b. To disassemble the main landing gear actuating cylinder, refer to *figure 261* and observe the following precautions:

(1) Use a spanner wrench (service tool K27705) to loosen the cylinder head packing retainer nut.

(2) Use a strap wrench to loosen the knurled nuts on the piston rod and cylinder.

(3) DO NOT GRIP the piston rod with a pair of pliers, because the rod will be scratched and damaged, and cause damage to the piston rod packing.

(4) DO NOT USE a screw driver or other sharp pointed tool to pry out the piston rod packing.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Very little maintenance is required of the actuating cylinders during normal operation, other than occasional tightening or replacement of packing. If the actuating cylinders are not functioning properly, and disassembly is necessary, observe the following instructions:

1. After the cylinder has been disassembled, wash all parts of the cylinder in clean hydraulic fluid.

2. If moderate tightening of the packing nuts *(figure 261)* does not stop external fluid leakage, new packing *(figure 261)* must be installed. Attempts to stop fluid leakage by excessive tightening of the packing results in rapid wear of the packing.

3. Internal leakage should be remedied by installing a new packing *(18, figure 261)* on the piston.

4. Inspect all wearing surfaces on the piston, piston rod and cylinder walls for evidence of scratches and abraded areas. Light scratches and abrasions should be buffed out carefully. Long deep scratches may cause considerable fluid leakage, and parts with such damage should be replaced.

5. All packing removed during disassembly must be replaced with new packing, although fluid leakage has not been observed. Packing in service for some time, takes a permanent "set" to surrounding parts and will not seal properly when removed and reinstalled.

CAUTION

When new packing is installed, make certain that the rings are of the approved type and same part number as originally used, and they should be thoroughly inspected. Soak the packing in hydraulic fluid (Specification AN-VV-O-366) or equivalent for approximately 24 hours before installation. Packing should not be installed if swelling occurs after it has been soaked in hydraulic fluid because swelling indicates that the ring is not made of oil resistant synthetic rubber. Great care must be observed when installing packing rings over and through threaded surfaces in order to avoid shearing or scraping the edges of the rings. Place a cap over the end of the threaded piston rod, or tube, slightly larger than the packing rings in the threaded opening in the cylinder head. Install one ring at a time. Push the rings together with a suitable blunt tool. DO NOT USE a screw driver or other sharp tool to press packing rings into position.

6. Inspect the integral shuttle valve *(figure 261)* to determine if the steel cone is properly seated. If the cone or seats are pitted, scored, or worn excessively, new parts should be installed. Check the spacer, spring, plug, and gasket for evidence of excessive wear. Install new parts if necessary.

7. Inspect the general condition of all remaining parts of the cylinder, and install new parts if inspection reveals defects. Check bushings or bearings for evidence of excessive wear.

(d) ADJUSTMENTS. – To adjust the main landing gear actuating cylinders with the landing gear retracting mechanism, refer to paragraph 5. *b.* (2) *(e).*, this section.

(e) TESTS BEFORE INSTALLATION.–Refer to *figure 261* for fluid leak tests.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.–To assemble the cylinder, refer to *figure 261.*

Note

Install all packing rings with care to avoid damaging the edges of the rings.

2. INSTALLATION.–To install the main landing gear cylinders, reverse the REMOVAL procedure.

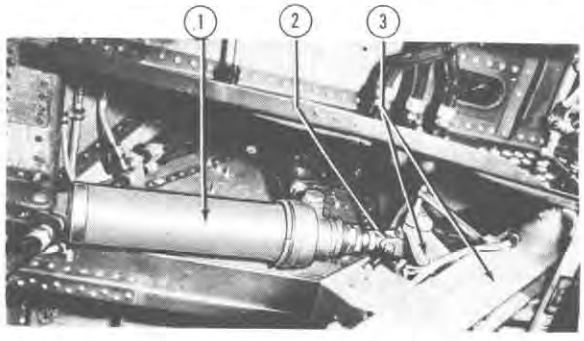
Note

The locknut on the main landing gear actuating cylinder should be tightened to a torque of 1300-1500 inch pounds.

(g) MAJOR OVERHAUL.–Follow the same procedure as given in MAINTENANCE REPAIR OR REPLACEMENT.

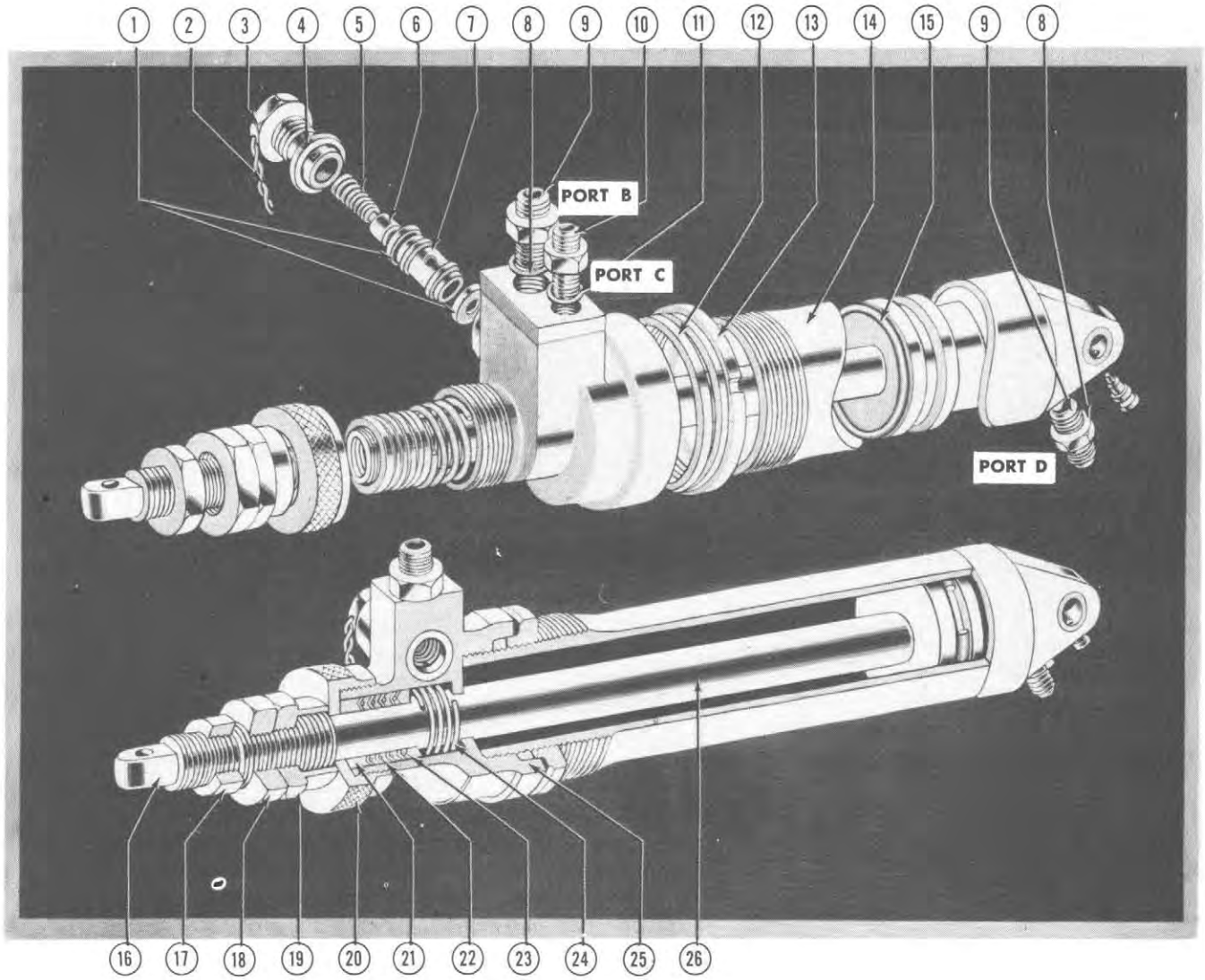
(4) NOSE WHEEL GEAR ACTUATING CYLINDER.
(See figures 262 and 263.)

(a) DESCRIPTION. – The nose wheel gear actuating cylinder is located in the center of the forward section of the nose wheel well. The cylinder end is attached to a bracket in the forward section of the nose wheel well. The piston end is attached to a lever on the upper shaft assembly of the nose wheel gear retracting link. When the nose wheel gear is extended or retracted, the action of the hydraulic fluid is identical to, and simultaneous with that of the main landing gear actuating cylinder. A mechanical latch *(figure 109)* holds the nose wheel gear in the retracted position until the nose wheel doors reach the fully opened position. At this point, the link assembly, which connects the nose wheel door mechanism, releases the



1. Nose Wheel Gear Actuating Cylinder
2. Clevis
3. Nose Wheel Gear Retracting Mechanism

Figure 262—Nose Wheel Gear Actuating Cylinder Installed



1. Seat (Emergency Substitute Part may be made from AN6226-4)
2. Lock Wire
3. Plug—Shuttle Valve
4. Gasket
5. Spring—Shuttle Valve
6. Cone—Shuttle Valve
7. Spacer—Shuttle Valve
8. AN902-6 Gasket
9. Union
10. Union
11. AN902-4 Gasket
12. Gasket
13. Nut
14. Barrel Assembly (Includes 116500-9A-024G Bushing)
15. AN6227-35 Packing
16. Bolt
17. Nut
18. Lock Nut
19. Stop Nut
20. Packing Nut
21. Ring
22. AN6225-22 Packing (4 Required)
23. Ring
24. Spring
25. Cylinder Head
26. Piston Assembly

TEST PROCEDURE			
TEST PRESSURE	PISTON POS.	MAX. LEAKAGE	
		EXTERNAL	INTERNAL
1500 psi—Port B	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi—Port C	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi—Port D	Extended	2 drops in 12 hrs.	10 drops / hr.
Friction Pressure – 25 psi max.			

Fig. 263—Nose Wheel Gear Actuating Cylinder

mechanical latch, thus allowing the nose wheel gear to extend. When the nose wheel is retracted, a mechanical latch *(figure 264)* is provided to prevent the nose wheel doors from closing until the nose wheel is fully retracted. When the nose wheel gear reaches the fully retracted position, it releases the latching mechanism, allowing the doors to close. The nose wheel gear actuating cylinder has an integral shuttle valve *(figure 263)* that closes the main hydraulic fluid port when the emergency DOWN line is being used. For complete information about the nose gear and nose wheel doors operating mechanism refer to paragraph 5. *c.*, this section.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Install ground safety pins *(figure 91)* on the nose wheel gear and main landing gear.

b. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

c. Disconnect and cap the three hydraulic lines leading to the cylinder.

d. Remove the bolt which attaches the piston rod eyebolt to the link between the retracting arms.

e. Remove the bolt which attaches the cylinder head to the support on the floor of the pilot's compartment.

f. Remove the nose wheel gear actuating cylinder.

2. DISASSEMBLY.–Refer to *figure 263* for disassembly procedure.

CAUTION

Do not clamp the cylinder barrel in a vise, but provide a suitable clamp as instructed in paragraph 14. *c.* (3) *(c)*, this section.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Refer to maintenance repair instructions for main landing gear cylinders paragraph 5. *c.* (3) *(c)*, this section.

(d) ADJUSTMENTS.–Refer to paragraph 5. *c.* (1) *(e)*, this section, to adjust the nose wheel gear actuating cylinder with the nose wheel gear operating mechanism.

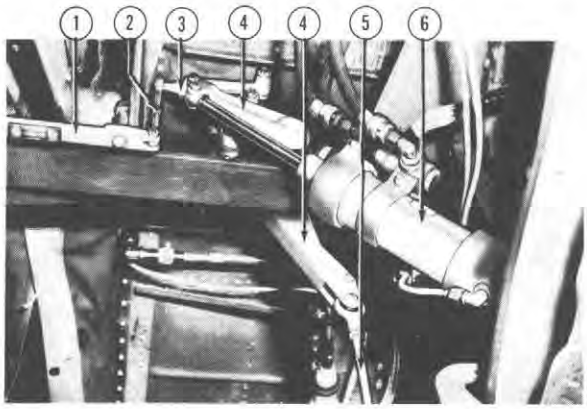
(e) TESTS BEFORE INSTALLATION.–Refer to *figure 263* for fluid leaks.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.–To assemble the nose wheel gear actuating cylinder refer to *figure 263*.

CAUTION

Use great care in installing the packing in the cylinder. Refer to paragraph 14. *c.* (3) *(f)* 2., this section.



1. Nose Wheel Doors DOWN Latch Operating Lever
2. Nose Wheel Doors DOWN Latch Actuating Rod
3. Nose Wheel Doors DOWN Latch
4. Nose Wheel Doors Operating Arms
5. Nose Wheel Door Actuating Rod
6. Nose Wheel Doors Actuating Cylinder and Shuttle Valve Assembly (See Figures 265and 266)

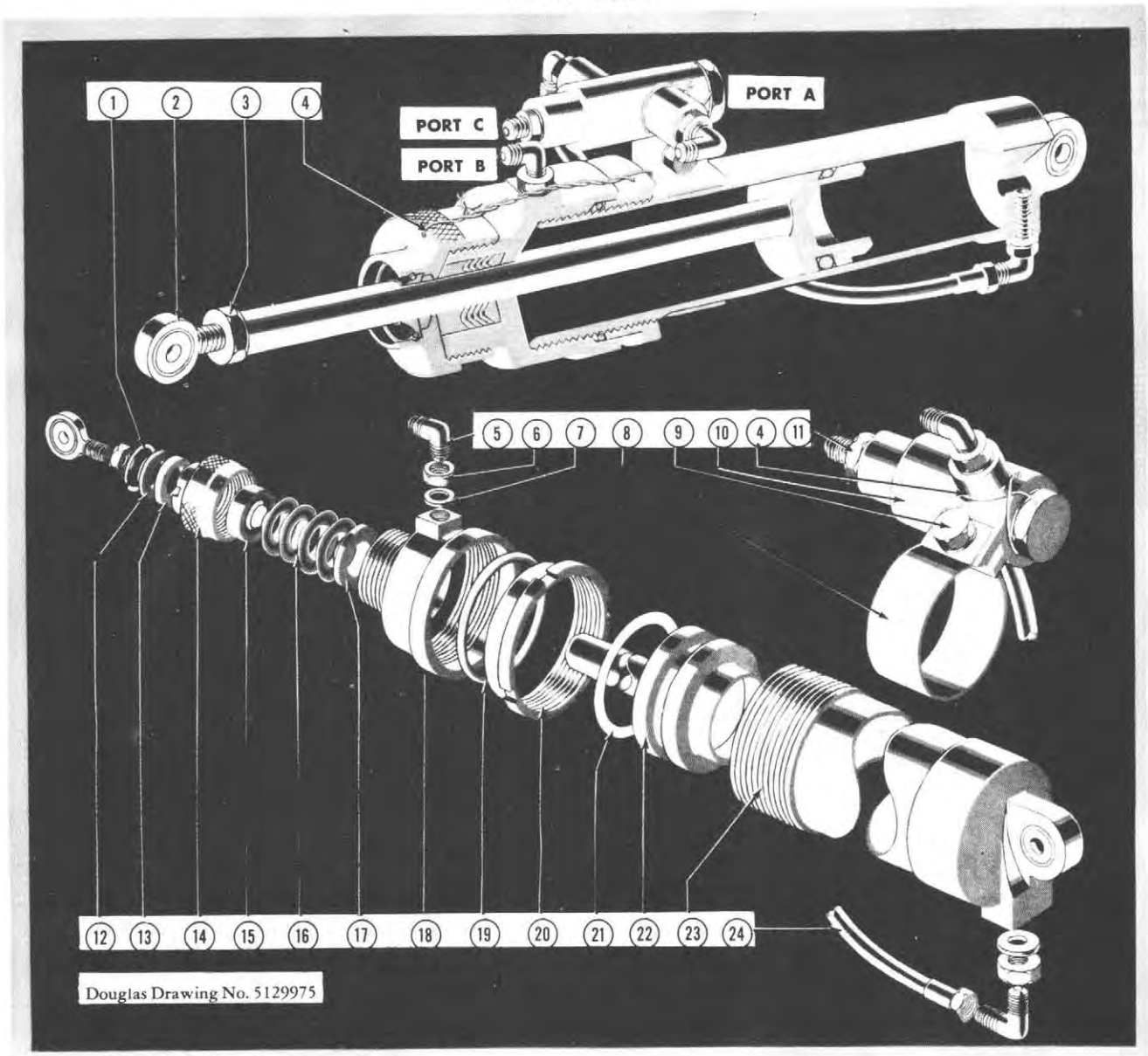
Figure 264—Nose Wheel Door Actuating Cylinder Installed

2. INSTALLATION.–To install the nose gear actuating cylinder reverse the REMOVAL procedure. The locknut on the nose wheel actuating cylinder should be tightened with a torque of 1300-1500 inch-pounds.

(g) MAJOR OVERHAUL.–Follow the same procedure as given in MAINTENANCE REPAIR OR REPLACEMENT.

(5) NOSE WHEEL DOOR ACTUATING CYLINDER.
(See figure 264.)

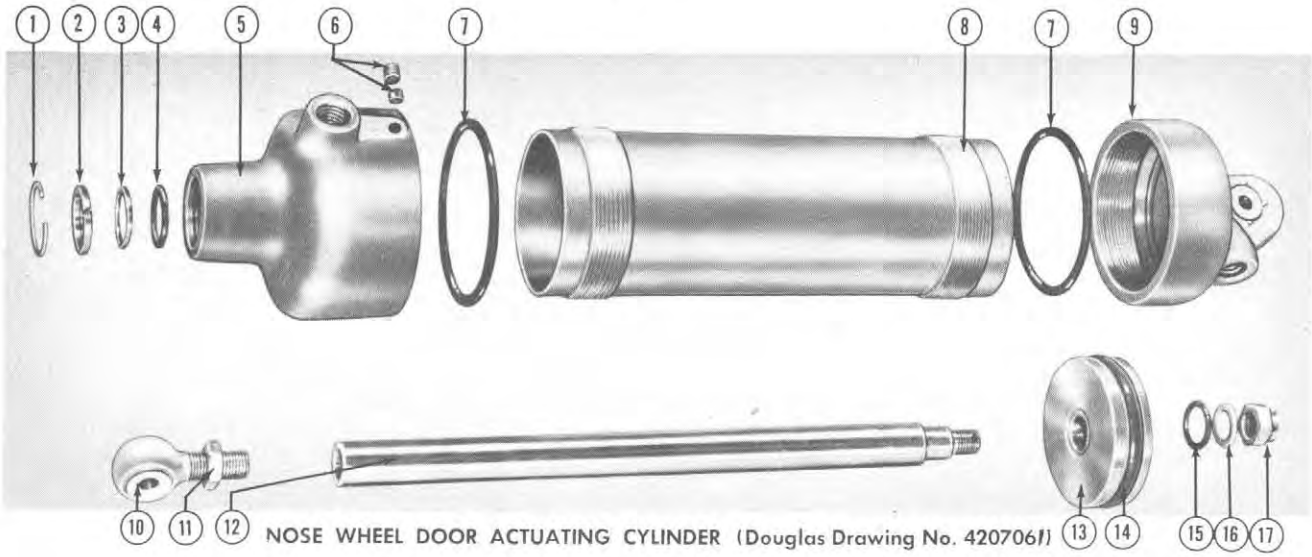
(a) DESCRIPTION.–The nose wheel door actuating cylinder is located on the left side of the nose wheel well. It is attached to a support at the cylinder end, and to an actuating lever at the piston end. The actuating cylinder piston extends and opens the nose wheel doors after the nose wheel gear is extended. The piston retracts to close the doors after the nose wheel gear has been retracted. A mechanical latch system permits the nose wheel gear to extend only after the nose wheel doors have opened completely, and the doors to close only after the nose wheel gear is fully retracted. Two types of nose wheel door actuating cylinders have been used on the airplane, one cylinder being larger than the other. The differences in the two cylinders may be seen by comparing *figure 265* and *figure 266*. For complete information about the nose wheel door operating mechanism refer to paragraph 5. *c.* (6), this section.



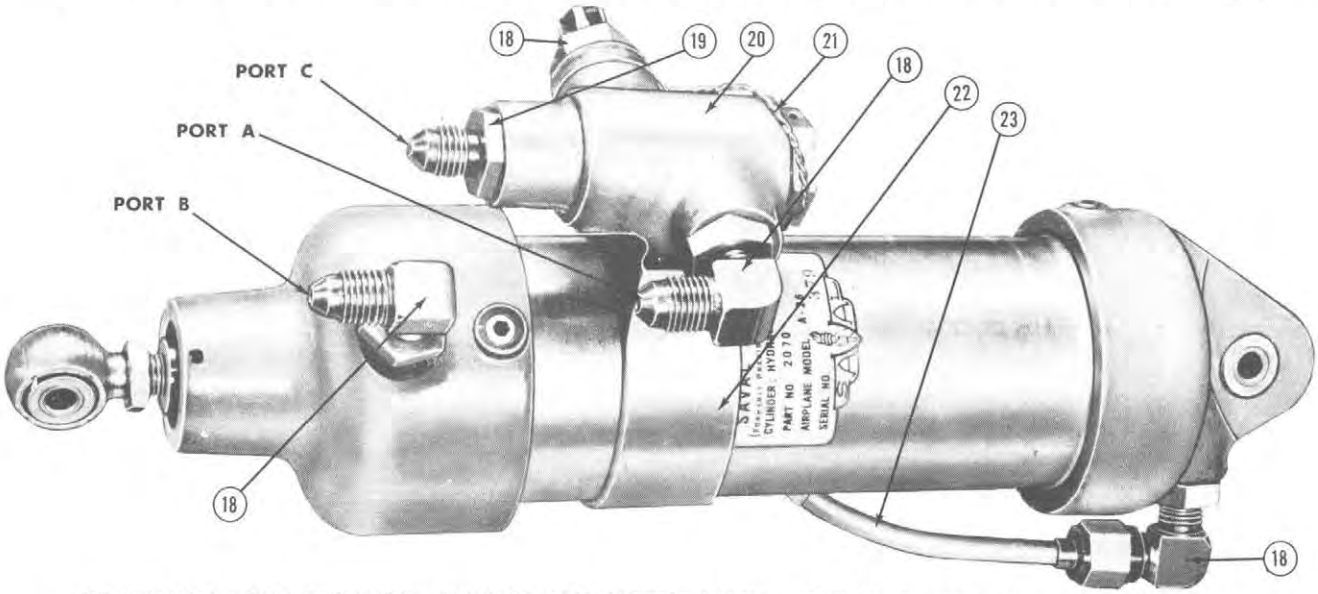
1. Lock Ring
2. Bolt Assembly
3. Lock Nut
4. Lock Wire
5. Elbow (3 Required)
6. Nut (3 Required)
7. AN902-4 Gasket (4 Required)
8. Clamp
9. Bolt, Nut, and Washers
10. Shuttle Valve *(See figure 267.)*
11. Union and Gasket
12. Wiper
13. Felt
14. Packing Nut
15. Ring
16. AN6225-14 Packing (4 Required)
17. Ring
18. Cylinder Head
19. Gasket
20. Nut
21. AN6227-27 Packing
22. Piston Assembly
23. Barrel Assembly
24. Tube Assembly

TEST PROCEDURE			
		MAX. LEAKAGE	
TEST PRESSURE	PISTON POS.	EXTERNAL	INTERNAL
1500 psi–Port A	Extended	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port B	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port C	Extended	2 drops in 12 hrs.	10 drops / hr.
Friction Pressure – 25 psi max.			

Figure 265—Nose Wheel Door Actuating Cylinder (Some Airplanes)



NOSE WHEEL DOOR ACTUATING CYLINDER (Douglas Drawing No. 420706I)



NOSE WHEEL DOOR ACTUATING CYLINDER AND SHUTTLE VALVE ASSEMBLY (Douglas Drawing No. 420709I)

1. Lock Ring
2. AN6231-3 Wiper
3. Spacer
4. AN6227-12 Piston Rod Packing
5. Cylinder Head
6. Lock Screw and Plug
7. AN6230-6 Packing
8. Cylinder Barrel
9. Cylinder End
10. Piston Rod End
11. Check Nut
12. Piston Rod
13. Piston
14. AN6227-30 Packing
15. AN6227-10 Packing
16. Washer
17. Nut and Cotter
18. Elbow, Nut and Gasket
19. Union, Nut and Gasket
20. Shuttle Valve *(Figure 267)*
21. Lock Wire
22. Clamp
23. Tube Assembly

TEST PROCEDURE		
TEST PRESSURE	PISTON POSITION	MAXIMUM LEAKAGE
1500 psi at Port A	Extended	2 drops in 12 hours – external 10 drops an hour – internal
1500 psi at Port B	Retracted	2 drops in 12 hours – external 10 drops in an hour – internal
Packing Friction Pressure – 25 psi maximum		

Figure 266—Nose Wheel Door Actuating Cylinder Assembly (Some Airplanes)

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Install ground safety pins on the nose wheel gear and main landing gear. *(See figure 91.)*

b. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

c. Disconnect and cap the three hydraulic lines leading to the nose wheel door actuating cylinder.

d. Remove the bolt attaching the piston rod eyebolt to the connecting arms.

e. Remove the bolt attaching the actuating cylinder to the left side of the nose wheel well. wheel well.

f. Remove the actuating cylinder from the airplane.

2. DISASSEMBLY—Refer to *figures 265 & 266* for disassembly procedure. Use service tool K26419 to loosen the lock nut on the smaller nose wheel door actuating cylinder on some airplanes.

c. MAINTENANCE REPAIR OR REPLACEMENT.—Refer to maintenance repair instructions for the main landing gear cylinders in paragraph 14. *c.* (3) *(c)*, this section. These instructions all apply with the exception of the repair on the integral shuttle valve. The nose wheel door actuating cylinder does not include an integral shuttle valve.

(d) ADJUSTMENTS.—Refer to paragraph 5. *c.* (1) *(d)*, this section, for adjustment of the nose wheel doors and operating mechanism with the nose wheel door actuating cylinder.

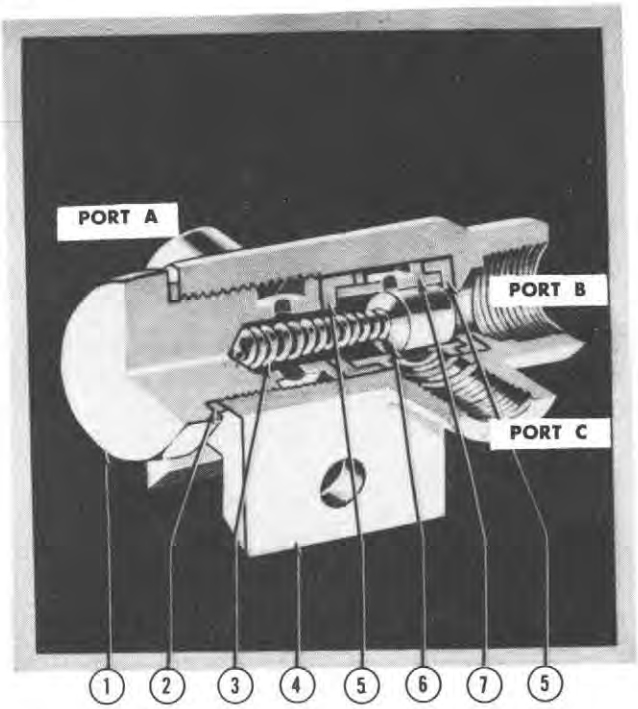
(e) TESTS BEFORE INSTALLATION.—Refer to *figures 265 and 266* for fluid leak tests of the nose wheel door actuating cylinder.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—To assemble the nose wheel door actuating cylinder, refer to *figures 265 and 266*. Apply 95-100 inch-pounds wrench torque when tightening the lock nut on the piston rod of the nose wheel door actuating cylinder.

2. INSTALLATION.—To install the nose wheel door actuating cylinder reverse the REMOVAL procedure.

(g) MAJOR OVERHAUL.—Follow the same procedure as given in MAINTENANCE REPAIR OR REPLACEMENT, *(c)*, above.



1. Plug
2. Washer
3. Spring
4. Body
5. Seat (Emergency Substitute Part may be made from AN6226-2)
6. Cone
7. Spacer

TEST PROCEDURE			
PORT PLUGGED	TEST PRESS.	MAX. LEAKAGE IN-TERNAL	MAX. LEAKAGE EX-TERNAL
Port C	1500 psi–Port A	None–Port B	None
Port C	1500 psi–Port B	None–Port A	None

Douglas Drawing No. 4129449

Figure 267—Nose Wheel Door Actuating Cylinder Shuttle Valve

(6) NOSE WHEEL DOOR ACTUATING CYLINDER SHUTTLE VALVE.
(See figure 267.)

(a) DESCRIPTION.—A shuttle valve is clamped to the nose wheel door actuating cylinder, and functions to close the emergency hydraulic system DOWN line during normal operation of the main hydraulic system. The spring-seated cone in the shuttle closes the main DOWN line port when the emergency hydraulic system is used.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve system operating pressure by applying toe pressure and releasing rudder-brake pedals until pressure gage indicates zero.

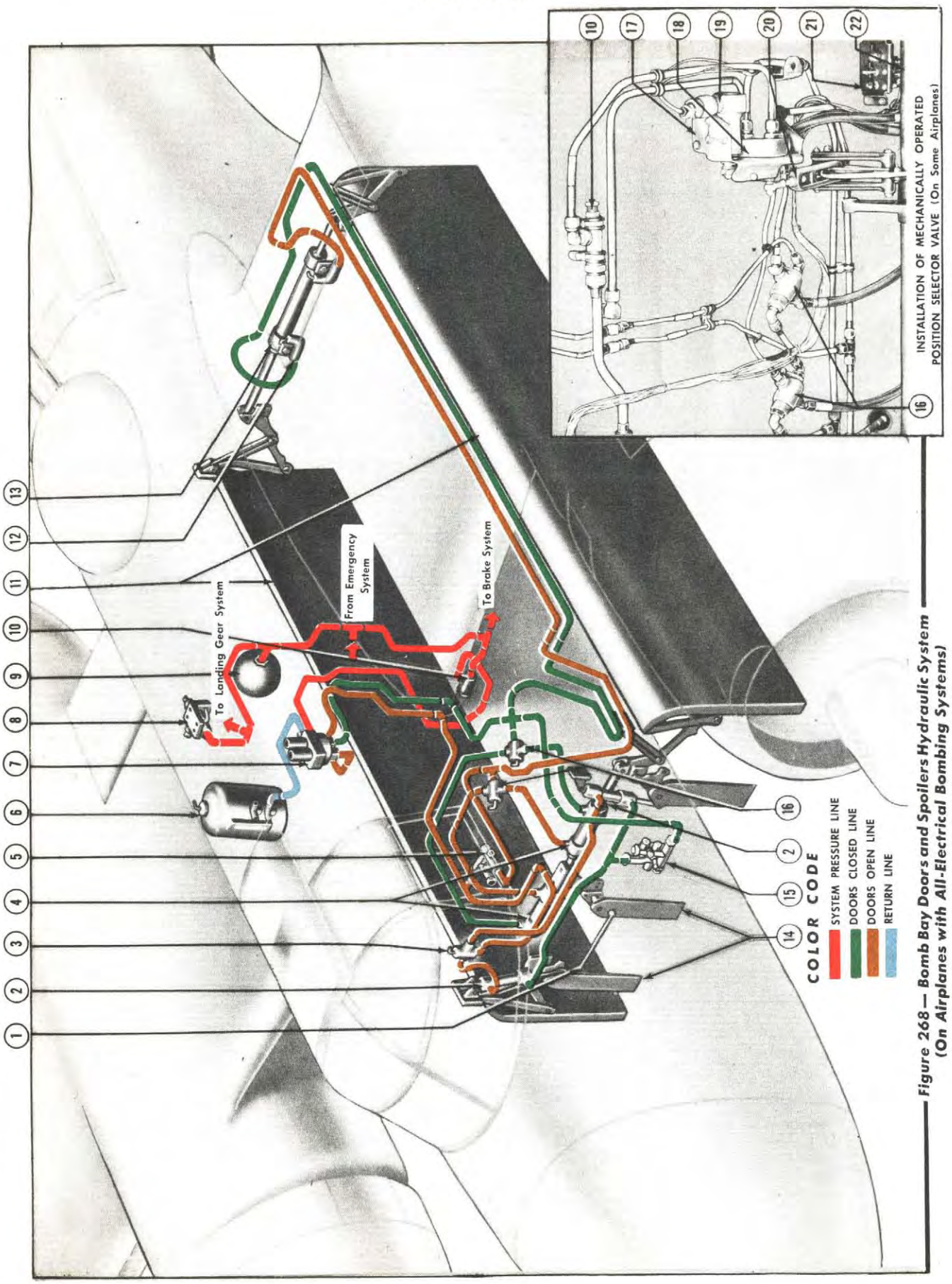


Figure 268 — Bomb Bay Doors and Spoilers Hydraulic System (On Airplanes with All-Electrical Bombing Systems)

KEY TO FIGURE 268

1. Center Spoiler Plate Actuating Rod
2. Bomb Bay Spoilers Actuating Cylinders
3. Bomb Bay Spoilers Actuating Cylinders Shuttle Valve
4. Bomb Bay Door Forward Actuating Cylinders *(Figure 273)*
5. Combination Check and Pressure Relief Valve
   Check Valve Opens at 3 to 7 psi
   Relief Valve opens at 625 ± psi Minimum
   Reseats at 525 psi Minimum
6. Main Hydraulic System Fluid Reservoir *(Figure 253)*
7. Bomb Bay Doors and Spoilers Position Selector Valve
8. Hydraulic System Pressure Regulator *(Figure 251)*
9. Hydraulic System Pressure Accumulator *(Figure 250)*
10. Balanced Pressure Relief Valve *(Figure 280)*
11. Bomb Bay Doors *(Figure 281 for Details of Bomb Bay Doors Operating Mechanism)*
12. Bomb Bay Doors Aft Actuating Cylinder Shuttle Valves *(Figure 276)*
13. Bomb Bay Doors Aft Actuating Cylinder *(Figure 275)*
14. Bomb Bay Spoiler Plates
15. 2207679 Restrictor Union
    Combination Shuttle, Check, and Pressure Relief Valve
    Shuttle Valve Opens at 25 to 30 psi
    Check Valve Opens at 3 to 7 psi
    Relief Valve Opens at 825 ± 25 psi Minimum
    Relief Valve Reseats at 700 psi Minimum
16. Bomb Bay Doors Forward Actuating Cylinders Shuttle Valves *(Figure 274)*
17. Mounting Bracket
18. Mechanically Operated Bomb Bay Doors Position Selector Valve *(Figure 272)*
19. Solenoid Assembly—Bomb Bay Doors Locking
20. Valve Operating Levers
21. Bomb Bay Doors Lock Control Switch
22. Torque

b. Disconnect the hydraulic lines leading to the shuttle valve.

c. Unbolt the attaching clamp.

d. Remove the shuttle valve from the airplane.

2. DISASSEMBLY.–Refer to *figure 267* when disassembly of the shuttle valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–The only maintenance necessary with this valve will be to prevent external fluid leaks at the plug and internal fluid leaks of the spring seated cone. Internal fluid leaks will cause sluggish operation of the actuating cylinder.

1. If moderate tightening fails to stop leakage at the plug, replace the gasket or plug.

2. Check the steel cone for corrosion, roughness or pitting, and install a new cone if defects are apparent. Replace the valve seats if worn or scored.

3. Replace worn or fatigued spring with a new spring.

(d) TESTS BEFORE INSTALLATION.–Refer to *figure 267* for leak tests of the shuttle valve.

(e) ASSEMBLY AND INSTALLATION.

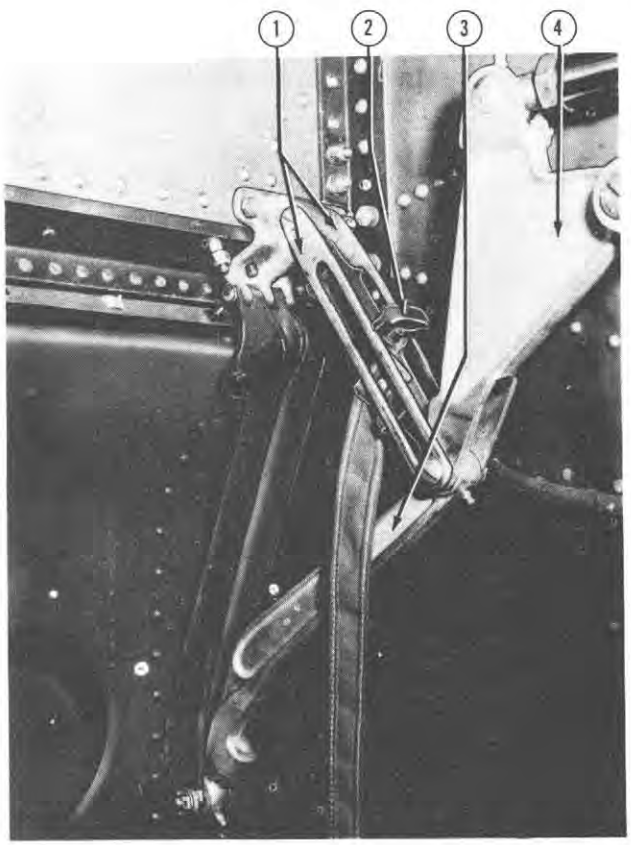
1. ASSEMBLY. – To assemble the shuttle valve reverse the DISASSEMBLY procedure and refer to *figure 267*.

2. INSTALLATION.–To install the shuttle valve reverse the REMOVAL procedure.

(f) MAJOR OVERHAUL. – Follow the same procedure as given in MAINTENANCE REPAIR OR REPLACEMENT, *(c)*, above.

d. BOMB BAY DOORS AND SPOILERS
(See figure 268.)

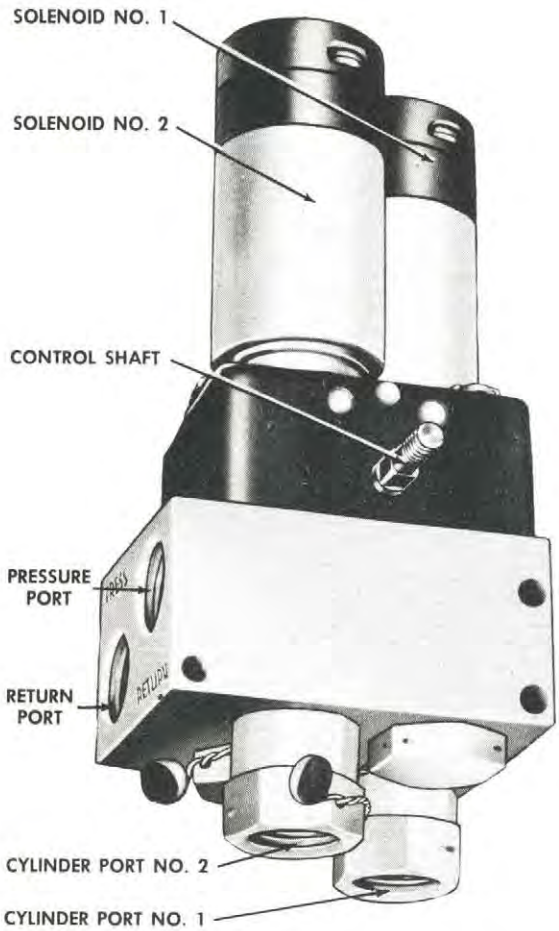
(1) GENERAL.–The opening and closing of the bomb bay doors and the extension and retraction of



1. Sliding Stop Links
2. Safety Stop and Streamer Assembly
3. Bomb Bay Door Actuating Arm
4. Bellcrank

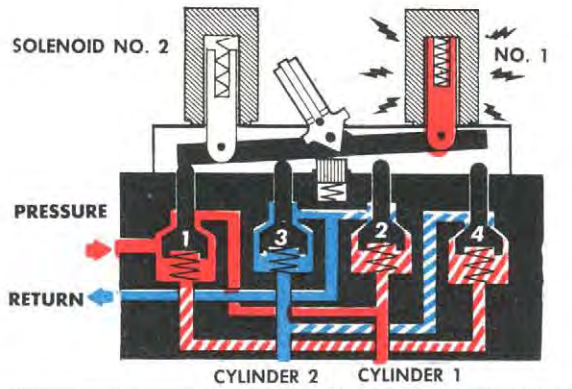
Figure 269—Bomb Bay Door Safety Stop Installed

Douglas Drawing No. 4204376 — D11735 Adel Precision Products Inc.—4V4032 The Aerodraulics Co.

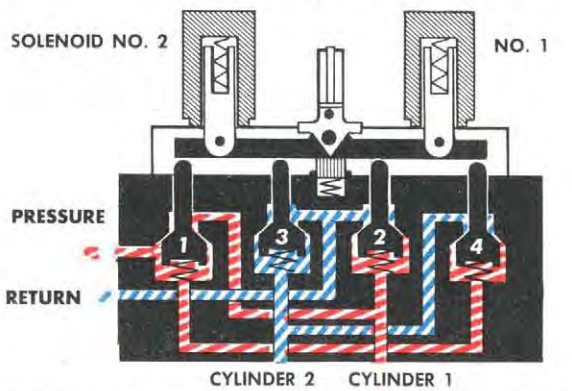


Cylinder Port No. 1 open to pressure and Cylinder Port No. 2 open to return when Solenoid No. 1 is energized

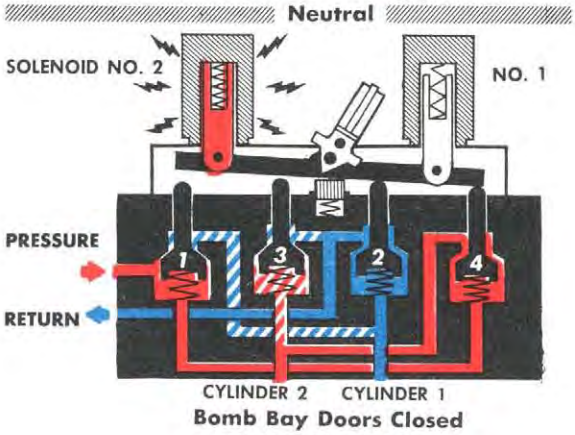
Cylinder Port No. 2 open to pressure and Cylinder Port No. 1 open to return when Solenoid No. 2 is energized



Bomb Bay Doors Open



Neutral



Bomb Bay Doors Closed

VALVE DIAGRAMS

TEST PROCEDURE				
Solenoid Energized	*Test Pressure*	*Ports Plugged*	*Allowable Internal Leakage*	*Remarks*
None	1000 psi at Pressure Port	None	10 Drops an Hour at Cylinder No. 1 and Cylinder No. 2 Ports	Test Poppets 1 and 4
No. 1	1000 psi at Pressure Port	Cyl. No. 1 and Cyl. No. 2	Leakage from Cylinder No. 1 in First Test Plus 10 Drops per Hour at Return Port	Test Poppet 3
No. 2	1000 psi at Pressure Port	Cyl. No. 1 and Cyl. No. 2	Leakage from Cylinder No. 2 in First Test Plus 10 Drops per Hour at Return Port	Test Poppet 2

Figure 270 — Solenoid Operated Bomb Bay Doors Position Selector Valve (Some Airplanes)

the bomb bay spoilers is accomplished by actuation of hydraulic cylinders. Two pressure relief valve assemblies are installed to obtain the proper operating sequence of the spoilers and the bomb bay doors. One pressure relief and check valve assembly is installed in the bomb bay door OPEN line to prevent flow of fluid to the bomb bay doors actuating cylinders until the spoilers have been extended completely. The other pressure relief, shuttle, and check valve assembly is installed in the bomb bay doors CLOSED line to prevent flow of fluid to the spoilers actuating cylinders until the bomb bay doors have closed. Another pressure relief valve is installed in the pressure line to the bomb bay doors position selector valve to prevent the reduction of pressure to the brakes when the bomb bay doors are operated. Two types of selector valves have been used. On airplanes with electrical bomb release and mechanical salvo system the bomb bay doors position selector valve is installed on the underside of the slanting floor of the pilot's compartment at the forward end of the bomb bay. On these airplanes the selector valve is controlled by means of levers and cables by the bomb rack control lever *(figure 523)*. On airplanes with the all electrical bombing system the solenoid operated selector valve is installed on the aft end of the control pedestal and controlled by a switch on the main electrical control panel in the pilot's compartment. *(See figures 247 and 288.)*

Note

On airplanes with electrical bomb release and mechanical salvo the bomb bay doors can be locked in the closed position by a solenoid assembly *(19, figure 268)* on the position selector valve so that crew members may walk safely across the bomb bay doors when the airplane is in flight. This solenoid is controlled by toggle switches *(21, figure 268)*, in the forward bomb bay near the access door to the pilot's compartment and in the aft bomb bay near the gunner's access door.

(2) BOMB BAY DOORS POSITION SELECTOR VALVE.

(a) GENERAL.—Two types of bomb bay door position selector valves have been used in the airplane. One selector valve is controlled mechanically and is installed on airplanes with electrical bomb release and mechanical salvo systems. The other selector valve is controlled electrically and operated by means of solenoids and is installed on airplanes with all electrical bombing systems.

(b) ELECTRICALLY OPERATED BOMB BAY DOORS POSITION SELECTOR VALVE.
(See figure 270.)

1. DESCRIPTION.—Two solenoids are installed on this poppet-type selector valve to operate the valve. The solenoids are controlled by an electrical switch on the pilot's main electrical control panel *(figure 247)*. The valve has four ports; a pressure port, a return port, and two ports connected to the bomb bay doors and spoilers actuating cylinders. When the control switch is moved to the bomb bay doors "OPEN" position, one of the solenoids is energized and opens the poppets which connect the pressure port to the bomb bay doors OPEN line and the return port to the bomb bay doors CLOSED line. When the switch is moved to the bomb bay doors "CLOSE" position, the other solenoid is energized and it opens the poppets which connect the pressure port to the bomb bay doors CLOSED and the return port to the bomb bay doors OPEN line. The valve is installed on the aft end of the control pedestal and includes a handle on the valve shaft to operate the valve manually in the event of an electrical failure.

2. REMOVAL.

a. Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines leading to the valve. Disconnect the electrical wiring.

c. Remove the bolts that attach the valve to the mounting bracket and remove the valve assembly.

d. Disassembly of the valve should not be attempted in the field.

3. MAINTENANCE REPAIR OR REPLACEMENT.—If the bomb bay doors position selector valve is damaged or is not functioning properly, it should be replaced with a new or serviceable part.

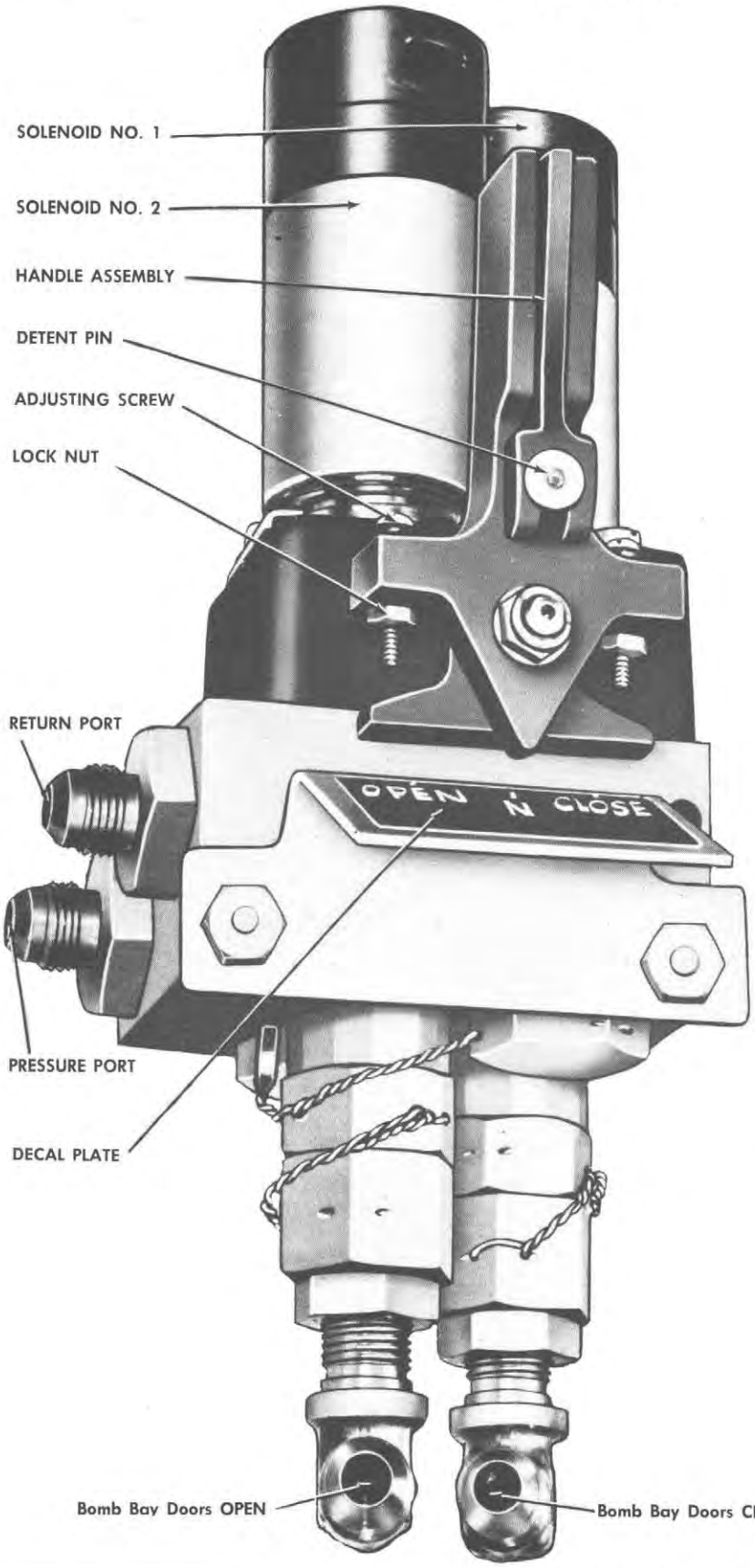
4. TESTS BEFORE INSTALLATION.—Refer to *figure 270* for fluid leak tests of the selector valve.

5. ADJUSTMENTS.—To adjust the handle on the valve assembly refer to *figure 271.*

6. INSTALLATION.—To install solenoid operated selector valve, reverse the REMOVAL procedure as given in *2* above.

(c) MECHANICALLY OPERATED BOMB BAY DOORS POSITION SELECTOR VALVE.
(See figure 272.)

1. DESCRIPTION.—This four way, poppet type selector valve is located on the under side of the slanting floor at the forward end of the bomb bay. When the bomb rack control lever is moved to the "DOORS OPEN" position, two of the poppet valves are opened; one connecting the pressure port to the bomb bay doors OPEN line and the return port to the



HANDLE ADJUSTMENT PROCEDURE

1. *OPEN POSITION*

   a. Energize Solenoid No. 2.

   b. Place handle in OPEN position with detent pin engaged.

   c. Adjust right hand screw to obtain .002 clearance between screw and clutch.

   d. Tighten lock nut.

2. *CLOSE POSITION*

   a. Energize Solenoid No. 1.

   b. Place handle in CLOSE position with detent pin engaged.

   c. Adjust left hand screw to obtain .002 clearance between screw and clutch.

   d. Tighten lock nut.

Figure 271 — Adjustment of Auxiliary Manual Control on Solenoid Operated Bomb Bay Doors Position Selector Valve

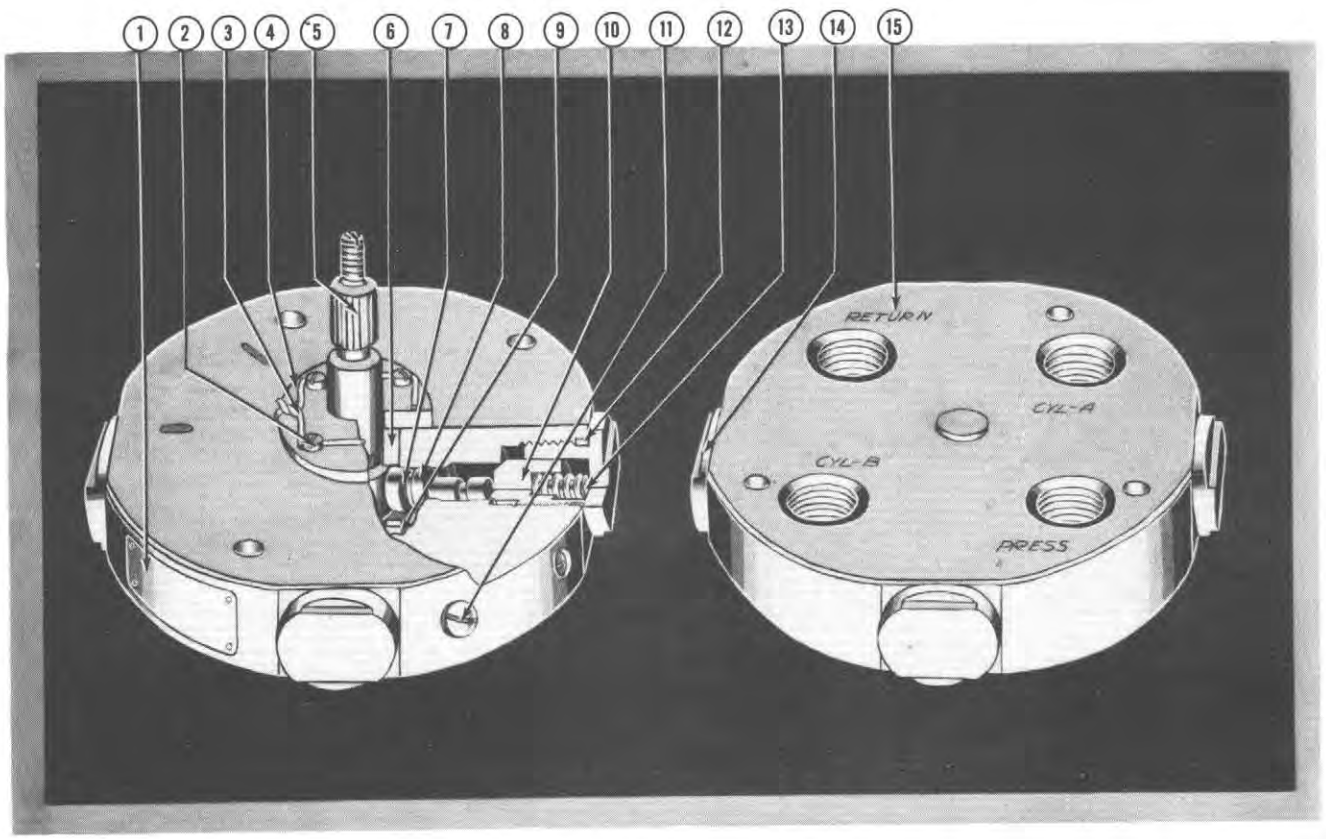
bomb bay doors CLOSED line. The displaced fluid is returned to the fluid reservoir through the position selector valve. When the bomb rack control lever is moved to the "DOORS CLOSE" position, the action described above is reversed. The valve mechanism consists of four identical spring loaded plastic poppet assemblies actuated by a camshaft. The poppets are arranged radially about the camshaft in the aluminum alloy valve body. The valve unit is connected by linkage and cables to the bomb rack control lever. When the valve is in the neutral position, all four poppets are closed. *(See 18, figure 268.)*

2. REMOVAL.

a. Be certain that the landing gear control lever in the pilot's compartment is in the "DOWN" position.

b. Check the emergency selector valve control handle on the pilot's control pedestal to see that it is in the "SYSTEM" position.

c. Place the bomb rack control lever or bomb bay doors switch located in the pilot's compartment in the "DOORS OPEN" position.

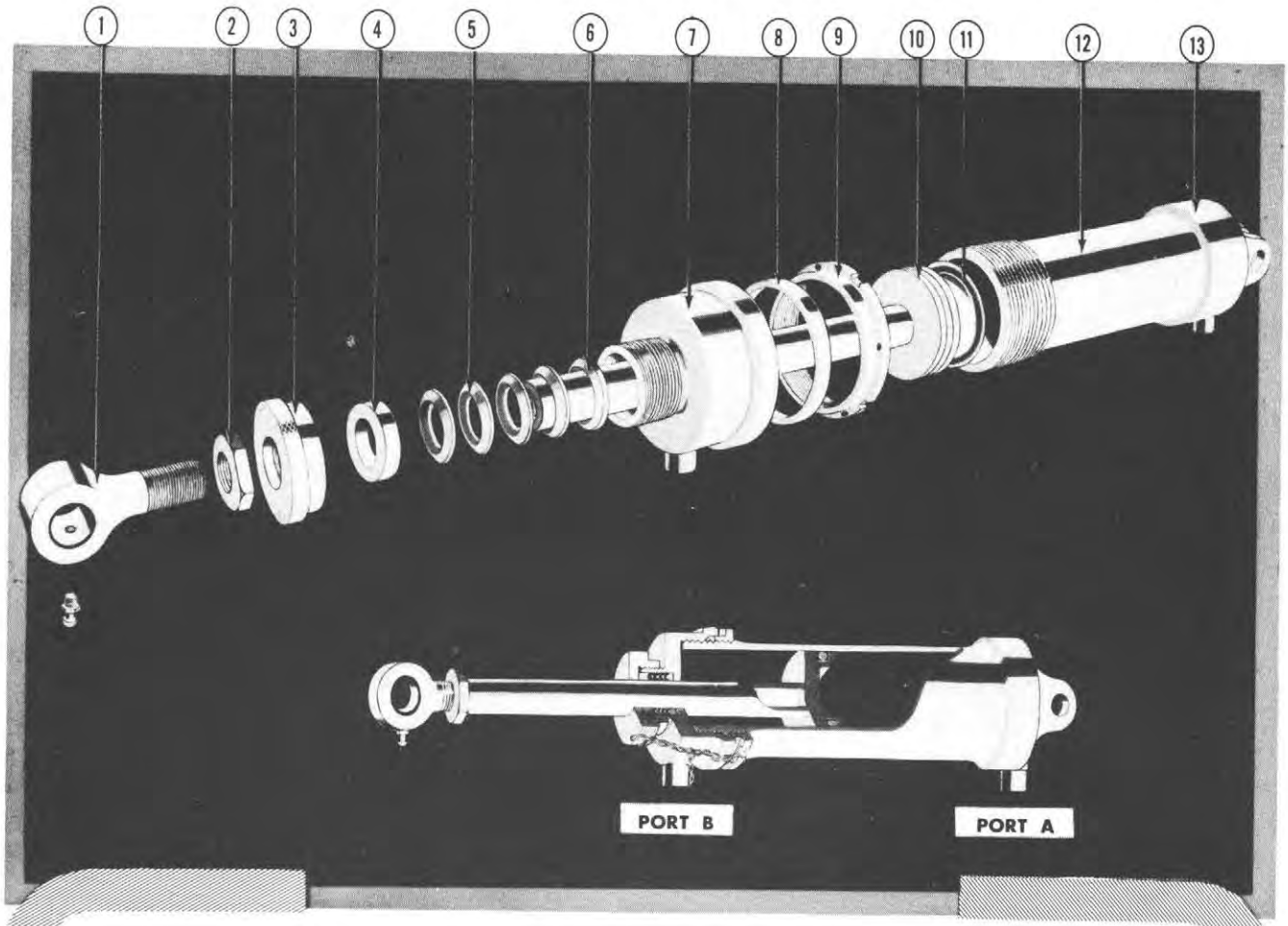


AN6213-1 SELECTOR VALVE

1. Nameplate
2. Screw
3. Lock Wire
4. Plate
5. Camshaft
6. Bearing
7. AN6227-4 Packing
8. Piston
9. Washer
10. Poppet
11. Pipe Plug
12. AN902-8 Gasket
13. Spring
14. Cap
15. Body

Figure 272—Mechanically Operated Bomb Bay Doors Position Selector Valve (Some Airplanes)

TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	HANDLE POSITION	MAX. LEAKAGE
1500 psi–Cyl. A Port	Press., Return, and Cyl. B Ports	Any Position	External–None



1. Bolt Assembly (Includes 116500-9A-24G Bushing)
2. Lock Nut
3. Packing Nut
4. Ring
5. AN6225-20 Packing (4 Required)
6. Ring
7. Cylinder End
8. Gasket
9. Packing Nut
10. Piston Assembly
11. AN6227-32 Packing
12. Barrel
13. Cylinder Head

TEST PROCEDURE			
TEST PRESS.	PISTON POS.	MAX. LEAKAGE	
		EXTERNAL	INTERNAL
1500 psi–Port B	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port A	Extended	2 drops in 12 hrs.	10 drops / hr.
Friction Pressure – 25 psi max.			

Douglas Drawing No. 5122207

Figure 273—Bomb Bay Doors Forward Actuating Cylinder

d. If the bomb bay doors do not open fully, operate the hydraulic hand pump *(figure 288)* until the doors are opened completely.

CAUTION

To prevent the possibility of the bomb bay doors closing, four safety stops *(figure 269)* should be fitted in the sliding links at the door connections. These safety stops are located in the miscellaneous equipment roll *(figure 585)* on the outboard side of the left nacelle.

e. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

f. Remove the armor plate at the forward end of the bomb bay.

g. Disconnect and cap the hydraulic lines at the bomb bay door position selector valve.

h. Unfasten the operating levers from the valve control shaft.

i. Remove the bolts that attach the valve to the valve bracket. Remove the valve.

j. If disassembly of the valve is attempted refer to *figure 272*.

3. MAINTENANCE REPAIR OR REPLACEMENT.–If the bomb bay doors position valve is damaged or is not functioning properly, it should be replaced with a new or serviceable part.

4. TESTS BEFORE INSTALLATION.–Refer to *figure 272* for fluid leak tests.

5. INSTALLATION.–To install the valve, reverse the REMOVAL procedure, given in *2.*, above.

(3) BOMB BAY DOOR FORWARD ACTUATING CYLINDERS.
(See figure 273.)

(a) DESCRIPTION.–The two bomb bay door forward actuating cylinders are located at the forward end of the bomb bay. Each cylinder is attached to a bracket assembly at the cylinder end and to the bomb door operating linkage at the piston end. To open the bomb bay doors, fluid pressure is applied at the inboard ports *(figure 268)* of each cylinder. The pistons extend, and the displaced fluid flows back to the fluid reservoir through the bomb bay door position selector valve. The action is reversed when the bomb bay doors are closed.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

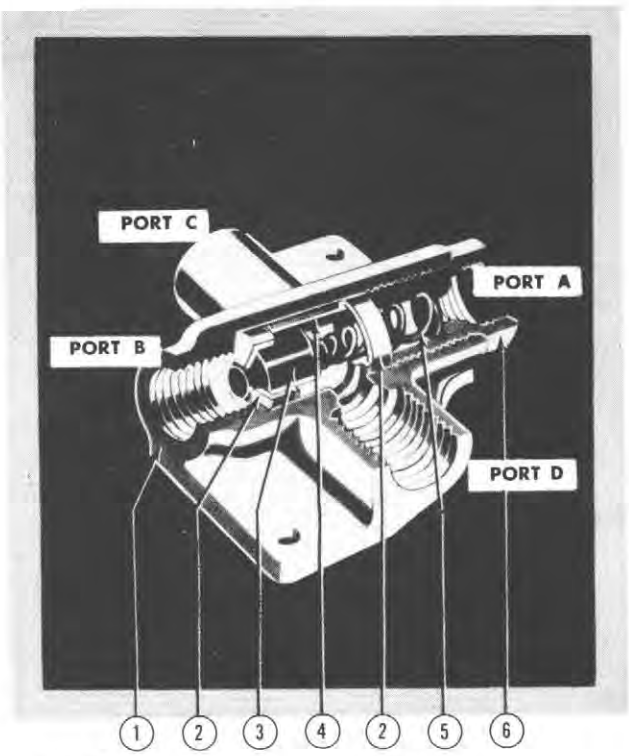
a. Follow the same procedure as outlined in BOMB BAY DOOR POSITION SELECTOR VALVE, paragraph 14. *d.* (2) *(b) 2.*, this section, and in addition:

b. Disconnect and cap the hydraulic hoses at each actuating cylinder.

c. Remove the bolts attaching the cylinders to the brackets and the bomb bay door linkage. Remove the cylinders.

2. DISASSEMBLY.–Refer to *figure 273* for disassembly procedure.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Refer to instructions on main landing gear cylinders, except for instructions for integral shuttle

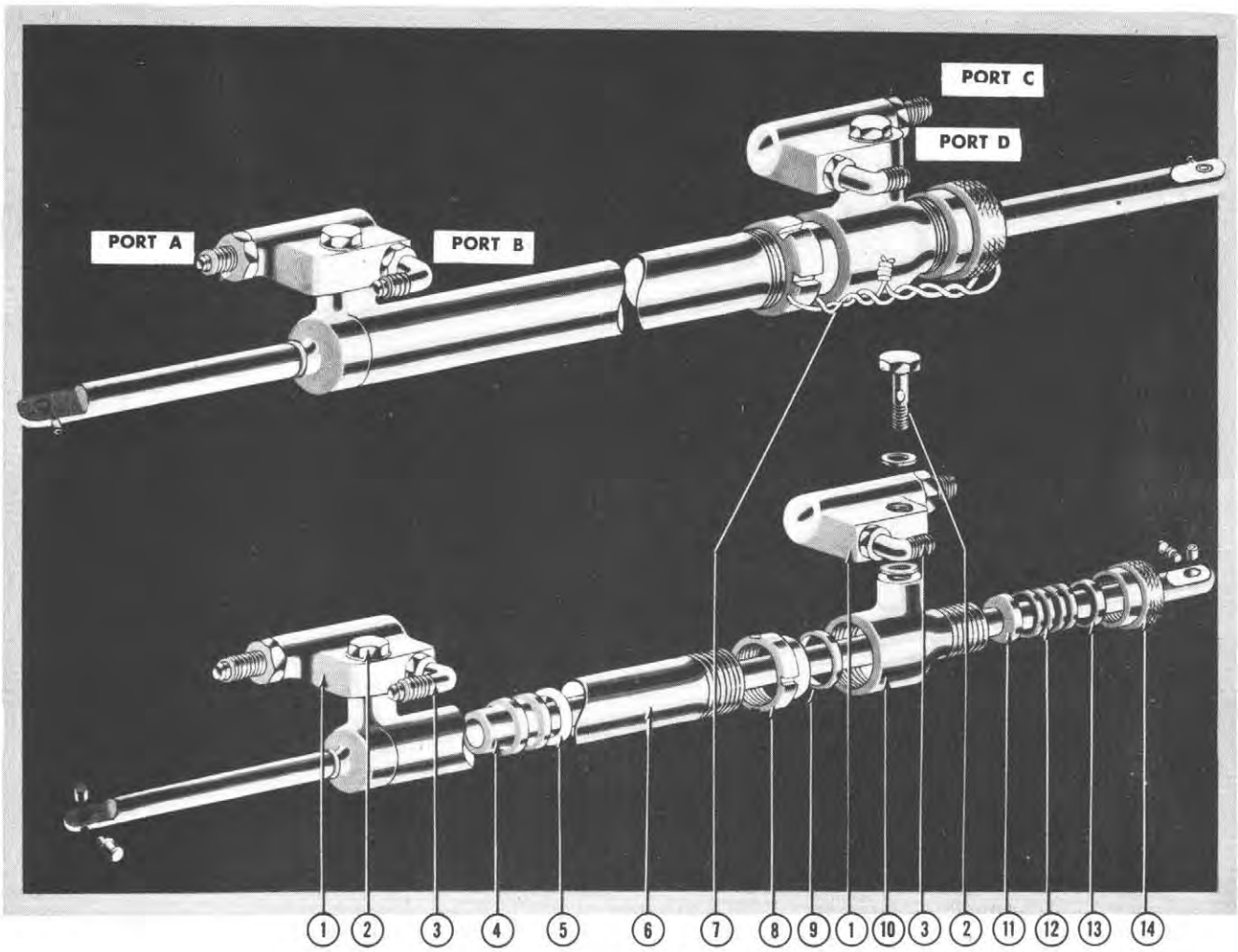


1. Body
2. Seat (Emergency Substitute Part may be made from AN6226-4)
3. Cone
4. Spacer
5. Spring
6. End Fitting (Apply 420 inch-pounds Torque Preload)

TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE	
		INTERNAL	EXTERNAL
1500 psi–Port A	Ports C and D	None	None
5 psi–Port A	Ports C and D	2 drops in 12 hrs.	None
1500 psi–Port B	Ports C and D	None	None

Douglas Drawing No. 2150744

Figure 274—Bomb Bay Doors Forward Actuating Cylinder and Spoilers Actuating Cylinder Shuttle Valve



1. Shuttle Valve Assembly *(See figure 276.)*
2. Bolt and AN901-6C Gaskets
3. Elbow, Lock Nut, and AN902-4 Gasket
4. Piston Assembly (Includes 116500-6B-23G Bushing)
5. AN6227-25 Packing
6. Barrel Assembly (Includes 116500-6B-23G Bushing)
7. Lock Wire
8. Packing Nut
9. Gasket
10. Cylinder End
11. Ring
12. AN6225-20 Packing (4 Required)
13. Ring
14. Packing Nut

TEST PROCEDURE			
TEST PRESS.	PISTON POS.	MAX. LEAKAGE	
		EXTERNAL	INTERNAL
1500 psi–Port A	Extended	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port B	Extended	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port C	Retracted	2 drops in 12 hrs.	10 drops / hr.
1500 psi–Port D	Retracted	2 drops in 12 hrs.	10 drops / hr.
	Friction Pressure – 25 psi max.		

Douglas Drawing No. 5122208

Figure 275—Bomb Bay Doors Aft Actuating Cylinder

valve repair. The bomb bay door forward actuating cylinders do not have integral shuttle valves.

(d) ADJUSTMENTS.–Refer to BOMB BAY DOOR ADJUSTMENTS, paragraph 14. *d.* (11) *(d)*, this section, for adjustment of the bomb bay door forward actuating cylinders with the bomb bay door mechanism.

(e) TEST BEFORE INSTALLATION.–Refer to *figure 273* for fluid leak tests of the bomb bay door forward actuating cylinders.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.–To assemble the forward bomb bay door actuating cylinders, refer to *figure 273*.

CAUTION

Use care when installing the packing rings in the actuating cylinder to avoid damage to the rings.

2. INSTALLATION. – To install the cylinders reverse the REMOVAL procedure and refer to *figure 281*.

(g) MAJOR OVERHAUL. – Follow the same procedure as given in MAINTENANCE REPAIR OR REPLACEMENT above.

(4) BOMB BAY DOORS AFT ACTUATING CYLINDER.
(See figure 275.)

(a) DESCRIPTION.–The bomb bay doors aft actuating cylinder, located at the rear of the bomb bay, is attached at each end to the bomb bay door linkage. Since the cylinder is movable, it functions in conjunction with either or both of the forward actuating cylinders. When the bomb bay doors are opened, hydraulic pressure is applied at the cylinder end, extending the piston. The excess fluid is returned to the fluid reservoir through the bomb bay doors CLOSED line and bomb bay door position selector valve. When the doors are closed, the fluid flow and piston movement is reversed.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Follow the same procedure as outlined under BOMB BAY DOOR POSITION SELECTOR VALVE, paragraph 5. *d.* (13) *(e)*, this section.

b. Cap the four hydraulic hoses at the cylinder.

c. Remove the bolts attaching the cylinder to the bomb bay door linkage. Remove the cylinder.

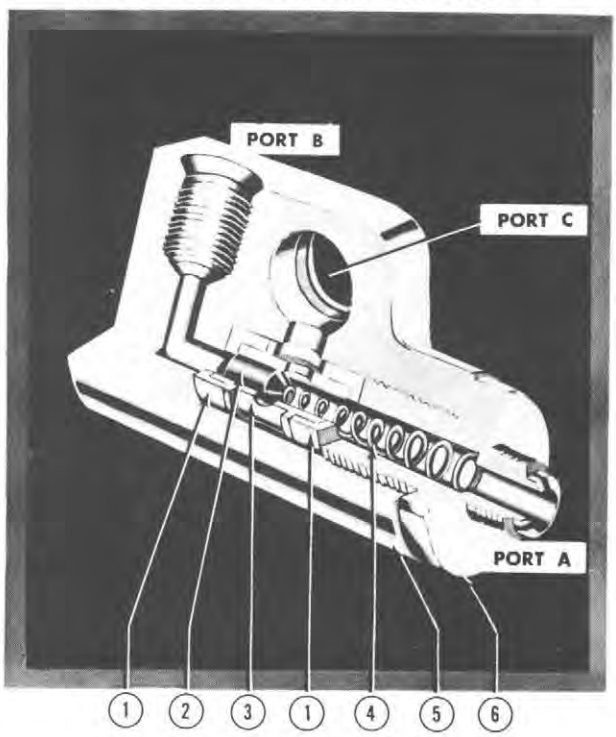
2. DISASSEMBLY.–Refer to *figure 275* for disassembly procedure.

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Refer to instructions MAIN LANDING GEAR ACTUATING CYLINDER, paragraph 14. *c.* (3) *(c)*, this section, except for procedure concerning the integral shuttle valve. The bomb bay door aft actuating cylinder does not have an integral shuttle.

(d) ADJUSTMENTS.–Refer to paragraph 14. *d.* (10) *(e)*, this section for adjustment of the bomb bay door aft actuating cylinder with the bomb bay door operating mechanism.

(e) TESTS BEFORE INSTALLATION.–Refer to *figure 275* for fluid leak tests of the bomb bay door aft actuating cylinder.

(f) ASSEMBLY AND INSTALLATION.

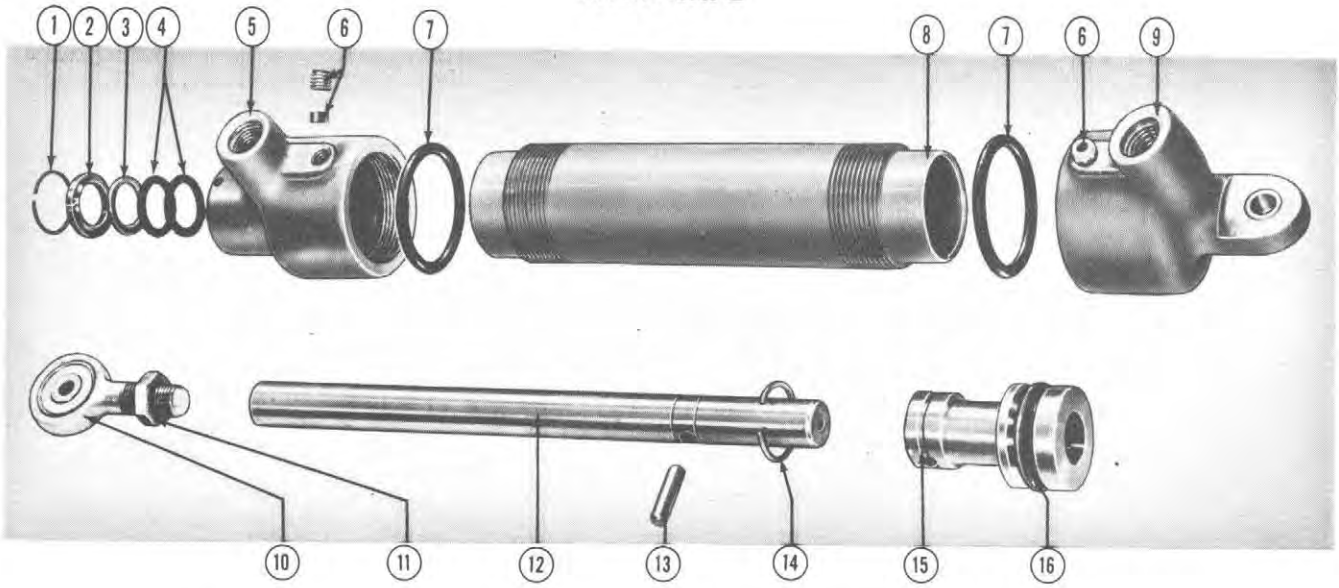


1. Seat
2. Cone
3. Spacer
4. Spring
5. Body
6. Connector (Apply 420 inch-pound Torque Preload)

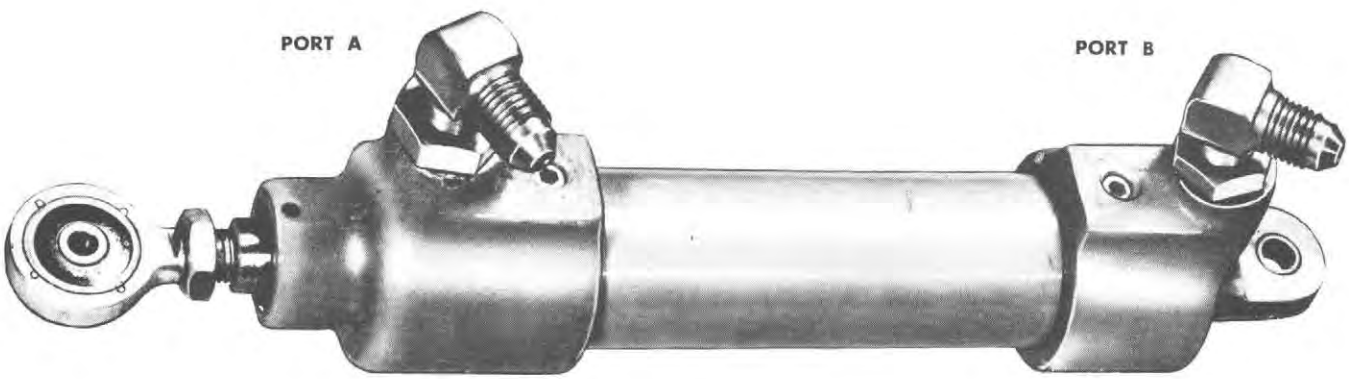
TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE	
		INTERNAL	EXTERNAL
1500 psi–Port B	Port C	None at Port A	None
1500 psi–Port A	Port C	None at Port B	None
5 psi–Port A	Port C	2 drops in 12 hrs at Port B	None

Douglas Drawing No. 2129383

Figure 276–Bomb Bay Doors Aft Actuating Cylinder Shuttle Valve



1. Lock Ring
2. Wiper
3. Spacer
4. Piston Rod Packing
5. Cylinder Head
6. Lock Screw and Plug
7. Cylinder Head or End Packing
8. Cylinder Barrel
9. Cylinder End
10. Piston Rod End
11. Lock Nut
12. Piston Rod
13. Pin
14. Lock Ring
15. Piston
16. Piston Packing



TEST PROCEDURE		
TEST PRESSURE	PISTON POSITION	MAXIMUM LEAKAGE
1500 psi at Port A	Extended	2 drops in 12 hours – external 10 drops an hour – internal
1500 psi at Port B	Retracted	2 drops in 12 hours – external 10 drops in an hour – internal
Packing Friction Pressure – 25 psi maximum		

Douglas Drawing No. 4206319

Figure 277—Bomb Bay Spoilers Actuating Cylinder

1. ASSEMBLY.—To assemble the bomb bay doors aft actuating cylinder refer to *figure 275.*

CAUTION

Use care in installing the packing rings in the cylinder.

2. To install the bomb bay doors aft actuating cylinder, reverse the REMOVAL procedure.

(5) BOMB BAY SPOILERS ACTUATING CYLINDERS.
(See figure 277.)

(a) DESCRIPTION.—The bomb bay spoilers are actuated by two small cylinders, located in the aft section of the nose wheel well. The cylinder assemblies are attached at the cylinder ends to brackets in the nose wheel well and at the piston ends to the spoiler plates. When the actuating cylinder pistons extend, they force the spoiler plates into the airstream. When the actuating cylinder pistons retract, they pull the spoiler plates up into a slot in the bottom of the fuselage between the nose wheel well and the bomb bay.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines leading to the bomb bay spoilers actuating cylinder.

c. Remove the attaching bolts and nuts and remove the actuating cylinders.

2. DISASSEMBLY.—If disassembly of the spoilers actuating cylinder is attempted, refer to *figure 277.*

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Refer to paragraph 14. *c.* (3) *(c),* this section.

(d) TESTS BEFORE INSTALLATION.—Refer to *figure 277* for fluid leak tests of the spoilers actuating cylinder.

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—To assemble the cylinders refer to *figure 277.*

2. INSTALLATION.—To install the spoilers actuating cylinders reverse the REMOVAL procedure.

(6) COMBINATION PRESSURE RELIEF AND CHECK VALVE.
(See figure 279.)

(a) DESCRIPTION.—The combination pressure relief and check valve assembly is installed in the bomb bay doors and spoilers OPEN line to obtain the proper opening sequence of the spoilers and bomb bay doors. The valve is located on the pilot's compartment slanting floor at the forward end of the bomb bay. When the bomb bay doors are opened, fluid under pressure flows to the spoilers actuating cylinders but is prevented from flowing to the doors actuating cylinders by the pressure relief valve. When the spoilers actuating cylinders have extended the spoilers, the fluid pressure increases in the doors OPEN line until the pressure relief valve opens and allows fluid to flow to the doors actuating cylinders, which open the bomb bay doors. The check valve is provided in the valve assembly so that fluid returning to the reservoir may by-pass the pressure relief valve when the bomb bay doors and spoilers are closed. The pressure relief valve is adjusted to open at 625 ± 25 psi and to reseat at 525 psi. The check valve opens at 3 to 7 psi.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Follow the procedure outlined in paragraph 14. *d.* (10) *(b),* this section.

b. Disconnect and cap the hydraulic lines leading to the valve assembly.

c. Remove the screws that attach the valve assembly to the slanting floor and remove the valve from the airplane.

2. DISASSEMBLY.—Refer to *figure 279* if disassembly of the combination pressure relief and check valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—If the valve assembly is damaged or is not functioning properly, replace it with a new or serviceable part.

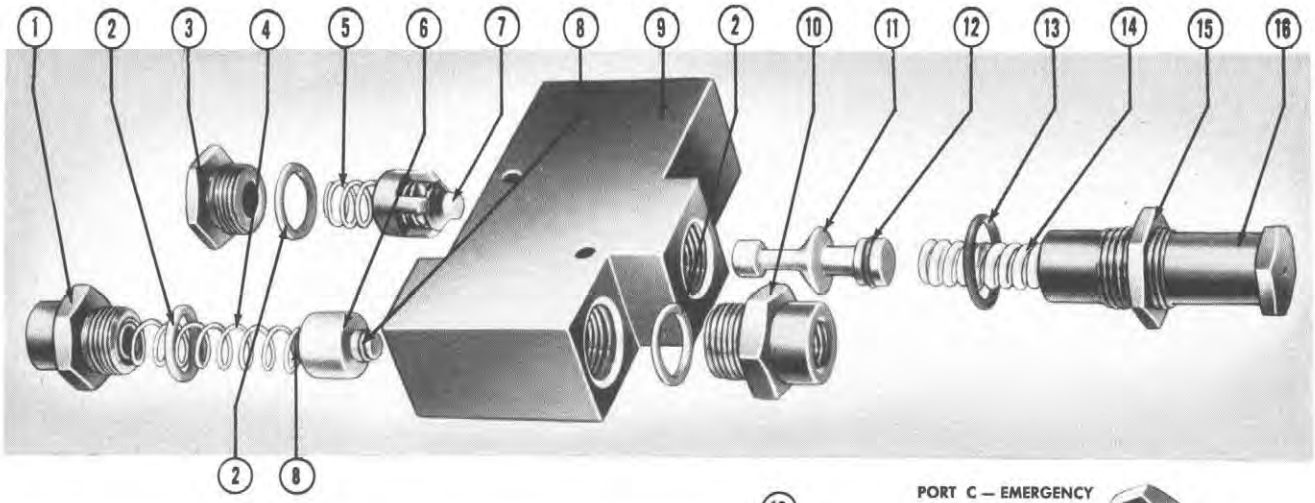
(d) ADJUSTMENTS.—The pressure relief valve is adjusted by means of the adjusting cap *(11, figure 279).* Tighten the cap to increase the pressure relief setting or loosen the cap to decrease the pressure relief setting. Adjust the pressure relief valve to open at 625 ± 25 psi and to rseat at 525 psi. When the proper adjustment is obtained, tighten the lock nut on the adjusting cap.

(e) TESTS BEFORE INSTALLATION.—Refer to *figure 279* for fluid leak tests of the combination pressure relief and check valve.

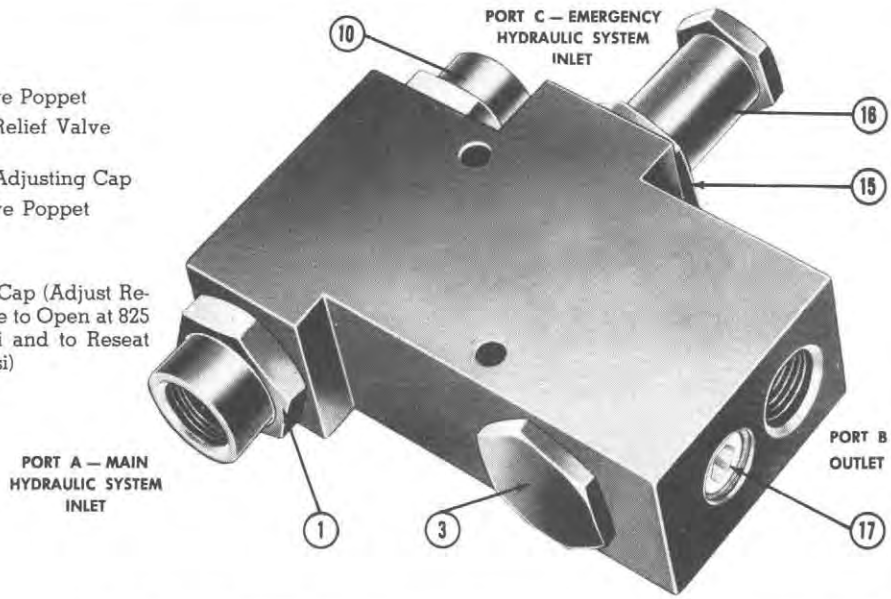
(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—To assemble the valve refer to *figure 279.*

2. INSTALLATION.—To install the valve reverse the REMOVAL procedure.



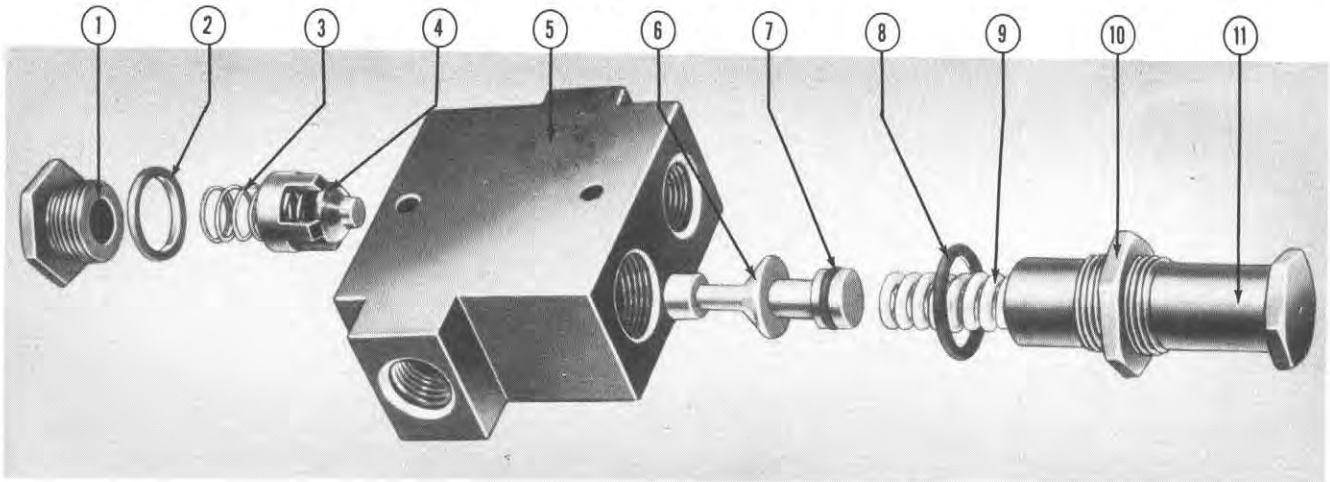
1. Fitting (Main Hydraulic System Port)
2. Gasket
3. Plug—Check Valve
4. Shuttle Valve Spring
5. Check Valve Spring
6. Shuttle Valve Poppet
7. Check Valve Poppet
8. Packing—Shuttle Valve Poppet
9. Valve Body
10. Fitting (Emergency Hydraulic System Port)
11. Relief Valve Poppet
12. Packing—Relief Valve Poppet
13. Packing—Adjusting Cap
14. Relief Valve Poppet Spring
15. Lock Nut
16. Adjusting Cap (Adjust Relief Valve to Open at 825 ± 25 psi and to Reseat at 700 psi)
17. Plug



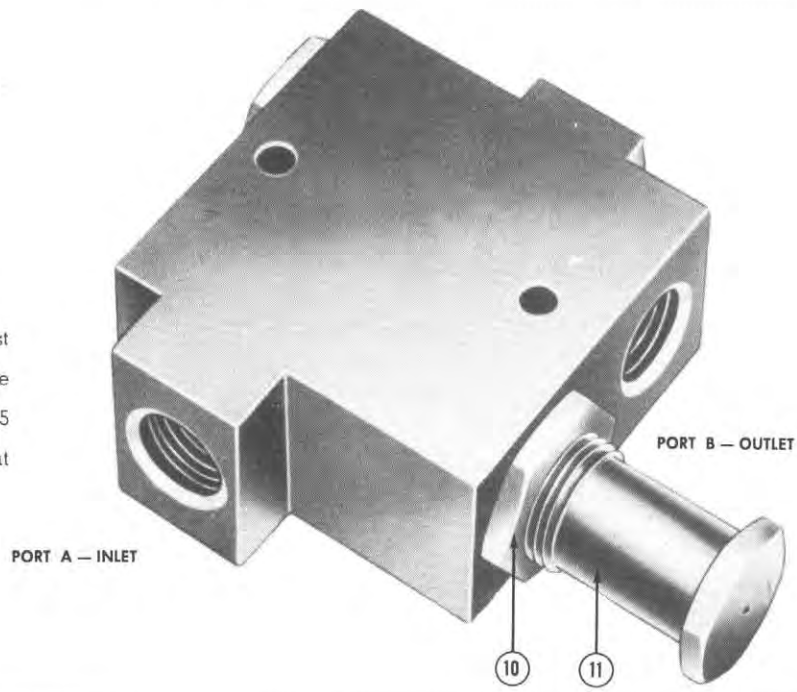
TEST PROCEDURE				
TEST PRESSURE	PORTS PLUGGED	MAXIMUM LEAKAGE		PURPOSE OF TEST
		Internal	External	
1500 psi at Port A	Ports B and C	None	2 Drops in 12 Hours	Proof Pressure
775 psi at Port A	None	None	2 Drops in 12 Hours	Seal of Poppets (Relief and Check)
Drop Pressure from 900 to 700 psi at Port A	None	None after 1 Minute	2 Drops in 12 Hours	Reseat Pressure (Relief Valve)
5 psi at Port A	None	1 Drop in 2 Minutes at Port B	2 Drops in 12 Hours	Static Test (Check Valve)
3 to 7 psi at Port B	None	Fluid Should Relieve at Port A	2 Drops in 12 Hours	Opening Pressure (Check Valve)
5 psi at Port A	Port B	1 Drop an Hour at Port C	2 Drops in 12 Hours	Static Test (Shuttle Valve)
1500 psi at Port A	Port B	None	2 Drops in 12 Hours	Seat of Shuttle Valve at Port C
Manually unseat shuttle poppet and apply 6 psi at Port C	Port B	1 Drop an Hour at Port A	2 Drops in 12 Hours	Static Test (Shuttle Valve)
1500 psi at Port C	Port B	None	2 Drops in 12 Hours	Seal of Shuttle Valve at Port A

Douglas Drawing No. 4207096

Figure 278—Combination Pressure Relief, Check, and Shuttle Valve



1. Plug
2. Plug Gasket
3. Check Valve Spring
4. Check Valve Poppet
5. Valve Body
6. Poppet—Pressure Relief
7. Poppet Packing
8. Adjusting Cap Packing
9. Pressure Relief Valve Spring
10. Lock Nut
11. Adjusting Cap (Adjust Pressure Relief Valve to Open at 625 ± 25 psi and to Reseat at 600 psi)



TEST PROCEDURE				
TEST PRESSURE	PORTS PLUGGED	MAXIMUM LEAKAGE		PURPOSE OF TEST
		Internal	External	
1500 psi at Port A	Port B	None	2 Drops in 12 Hours	Proof Pressure
575 psi at Port A	None	None	2 Drops in 12 Hours	Seal of Poppets (Relief and Check)
Drop Pressure from 700 to 525 psi at Port A	None	None After 1 Minute	2 Drops in 12 Hours	Reseat Pressure (Relief Valve)
5 psi at Port A	None	1 Drop in 2 Minutes	2 Drops in 12 Hours	Static Test (Check Valve)
3 to 7 psi at Port B	None	Fluid Should Relieve at Port A	2 Drops in 12 Hours	Opening Pressure (Check Valve)

Douglas Drawing No. 4207095

Figure 279 — Combination Pressure Relief and Check Valve

(7) COMBINATION PRESSURE RELIEF, CHECK, AND SHUTTLE VALVE.
(See figure 278.)

(a) DESCRIPTION.—The combination pressure relief, check, and shuttle valve is installed in the bomb bay doors CLOSED line to obtain the proper closing sequence of the bomb bay doors and spoilers. This valve is similar to the combination pressure relief and check valve except that it includes a shuttle valve for the emergency hydraulic system connection. This valve is installed in the nose wheel well. When the bomb bay doors are closed the pressure relief valve prevents the flow of fluid to the spoilers actuating cylinders until after the bomb bay doors have closed and the bomb bay door actuating cylinders have bottomed. The check valve is provided so that fluid returning to the reservoir can by-pass the pressure relief valve when the bomb bay doors are opened. The shuttle valve closes the emergency hydraulic system port when the main hydraulic system is used and closes the main hydraulic system port when the emergency hydraulic system is used. The pressure relief valve opens at 825 ± 25 psi and reseats at 700 psi. The check valve opens at 3 to 7 psi and the shuttle valve operates at 25 to 30 psi.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines leading to the valve assembly, located in the nose wheel well.

c. Remove the screws that attach the valve to the bracket and remove the valve from the airplane.

2. DISASSEMBLY.—If disassembly of the valve is attempted refer to *figure 278.*

(c) MAINTENANCE REPAIR OR REPLACEMENT.—If the combination pressure relief, check and shuttle valve is damaged or is not functioning properly, replace it with a new or serviceable part.

(d) ADJUSTMENTS.—Adjustment of the pressure relief valve assembly is made by means of the adjusting cap *(16, figure 278).* Tightening the cap increases the pressure relief setting; loosening the cap decreases the pressure relief setting. The relief valve must be adjusted to open at 825 ± 25 psi and to reseat at 700 psi. When the correct adjustment is obtained, tighten the lock nut on the adjusting cap.

(e) TESTS BEFORE INSTALLATION.—Refer to *figure 278* for fluid leak tests of the combination pressure relief, check, and shuttle valve.

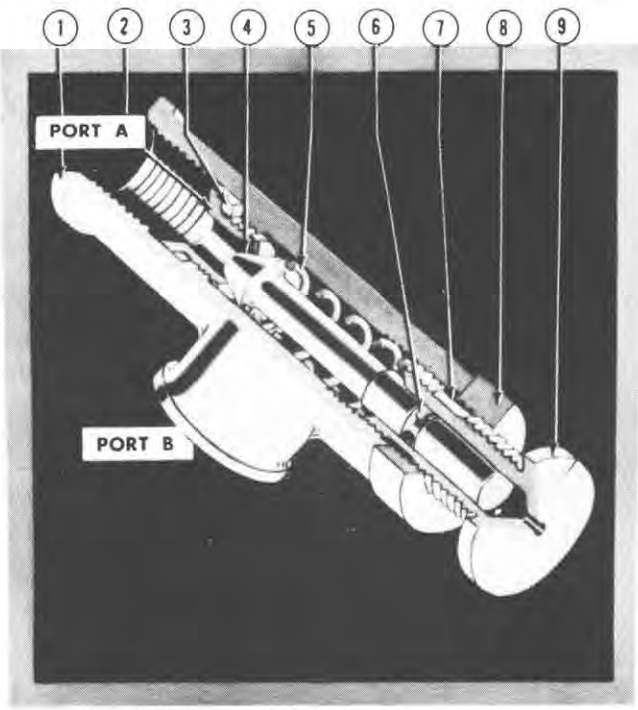
(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—Refer to *figure 278* to assemble the valve.

2. INSTALLATION.—To install the valve reverse the REMOVAL procedure.

(8) BALANCED PRESSURE RELIEF VALVE.
(See figure 280.)

(a) DESCRIPTION. — The balanced pressure relief valve, which prevents the reduction of fluid pressure to the brakes when the bomb bay doors are operated, is installed in the pressure line to the bomb



1. Valve Body
2. Poppet Seat
3. Washer
4. Piston—Poppet
5. Spring
6. AN6227-1 Packing
7. AN902-6 Gasket
8. Lock Nut
9. Adjusting Retainer

TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE INTERNAL	MAX. LEAKAGE EXTERNAL
1500 psi–Port A	Port B		2 drops in 12 hrs.
500 psi–Port A	None	.25 to .50 gals. /min. at Port B	2 drops in 12 hrs.
Drop press. from 750 psi to 400 psi at Port A	None	.25 to .50 gals. /min. at Port B	2 drops in 12 hrs.

Douglas Drawing No. 4196938
Interstate Aircraft and Engineering Corp. No. B13-300

Figure 280—Balanced Pressure Relief Valve

bay doors position selector valve and is located on the slanting bulkhead in the forward end of the bomb bay. The valve consists of a poppet-piston held against a steel seat by a spring and adjustable adapter. The valve is adjusted to open at 600 psi and to reseat at 570 psi. The valve will relieve three gallons of hydraulic fluid a minute with 750 psi at the inlet port. A small hole is drilled through one wall of the steel seat to provide a passage for expansion of the hydraulic fluid. This hole allows passage of 1/4 to 1/2 gallon per minute of hydraulic fluid when the poppet is seated. THIS SEEPAGE OF OIL SHOULD NOT BE REGARDED AS MALFUNCTION OF THE VALVE.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Follow the same procedure as outlined in paragraph 14. *d.* (2) *(c) 2.*, this section.

b. Disconnect and cap the hydraulic lines leading to the valve.

c. Remove the clips attaching the valve to the slanting floor and remove the valve from the airplane.

2. DISASSEMBLY.—Refer to *figure 280* if disassembly of the balanced pressure relief valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—If the balanced pressure relief valve is damaged or is not functioning properly, it should be replaced with a new or serviceable part.

(d) ADJUSTMENTS.—This valve is adjusted and tested at the factory and should not require further adjustment. However, if adjustment is required, proceed with the following instructions: Loosen the lock nut with a 3/4 inch crescent type wrench. To increase the pressure required to open the poppet, tighten the adjustable retainer *(9, figure 280)*; to decrease the required pressure, loosen the retainer. Adjust the valve to open at 600 psi and to reseat at 570 psi. When the proper adjustment has been obtained, tighten the lock nut on the adjustable retainer.

(e) TESTS BEFORE INSTALLATION.—Refer to *figure 280* for fluid leak tests of the balanced pressure relief valve.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—Refer to *figure 280* to assemble the valve.

CAUTION

When assembling the valve, do not tighten the elbow too tightly in the outlet port. A maximum of one-half of the gasket groove width of the elbow should be installed below the face of the outlet. Tightening the elbow to below the recommended depth will cause interference with the working parts of the valve.

2. INSTALLATION.—To install the balanced pressure relief valve, reverse the REMOVAL procedure, paragraph 14. *d.* (8) *(b)*, this section.

(9) SHUTTLE VALVES.
(See figures 274 and 276.)

(a) DESCRIPTION. — Five shuttle valves are installed in the bomb bay doors and spoilers hydraulic system, two for the bomb bay door forward actuating cylinders, two for the bomb bay aft actuating cylinder, and one for the bomb bay spoilers actuating cylinders. The bomb bay door forward actuating cylinders and bomb bay spoilers actuating cylinders shuttle valves are identical and have four ports, one for the main hydraulic system line, one for the emergency hydraulic system, and two ports to the lines to the actuating cylinders. The bomb bay door aft actuating cylinders have three ports, one for the main hydraulic system line, one for the emergency hydraulic system line, and one to the actuating cylinder. The bomb bay door aft actuating cylinder shuttle valves are attached to the cylinder ports by hollow bolts, which provide the passage into the cylinder. The bomb bay door forward actuating cylinder shuttle valves are located on the slanting floor at the forward end of the bomb bay. The shuttle valve mechanism consists of a spring-loaded cone that slides within a spacer and seats against synthetic rubber seats. Normally the spring-loaded cone closes the emergency hydraulic system port. When the emergency hydraulic system is used, the shuttle valve closes the main hydraulic system port.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines leading to the shuttle valve.

c. Remove the attaching screws or bolt and remove the shuttle valve.

2. DISASSEMBLY.—The shuttle valve may be disassembled by unscrewing the connector and removing the spring, cone, spacer, and seats.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Internal fluid leaks because of improper seating of the steel cone, will cause sluggish operation of the actuating cylinder. If disassembly and repair of a shuttle valve is attempted observe the following procedure:

1. Inspect cone and seats for scoring or wear. New parts must be installed when an inspection reveals defects in the cone and seats.

2. Inspect the spring for evidence of wear or fatigue. Install new spring if necessary.

3. Inspect the remaining valve parts for wear, cracks, or other defects, installing new parts when and where necessary.

4. Install new gaskets, if there is evidence of external leakage.

(d) TESTS BEFORE INSTALLATION.—Refer to *figures 274 and 276* for leak tests of the shuttle valves.

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY. — To assemble the shuttle valves refer to *figures 274 and 276* and reverse the DISASSEMBLY procedure.

Note

Apply wrench torque of 420 inch-pounds (maximum) when installing the connector which retains the spring-loaded cone, seats, and spacer.

2. INSTALLATION.—To install the shuttle valves reverse the REMOVAL procedure.

(f) MAJOR OVERHAUL.—Follow the same procedure as given in MAINTENANCE REPAIR OR REPLACEMENT, *(c)* above.

(10) BOMB BAY DOORS AND OPERATING MECHANISM.
(See figure 281.)

(a) DESCRIPTION.—The bomb bay doors are riveted aluminum alloy structures which form the lower surface of the center portion of the fuselage when closed. The doors are supported at each end by the bellcranks and actuating arms, and by five hinges along the bomb bay structure. Power to operate the bomb bay doors is obtained from the two forward hydraulic actuating cylinders and the aft actuating cylinder. The movement of the actuating cylinder pistons is transmitted through bellcranks to the operating arms, which are attached to the bomb bay doors. Sliding links provide stops to limit the travel of the doors and operating mechanism. The two forward actuating cylinders are attached to the bomb bay structure. The aft actuating cylinder is attached at both ends to the aft operating mechanism and is not attached to the bomb bay structure.

(b) REMOVAL.

1. With the bomb bay door control and the emergency hydraulic system selector valve control in the DOORS OPEN position, operate the hydraulic hand pump to open the bomb bay doors.

2. When the bomb bay doors have been opened completely, install safety blocks in the sliding links as shown in *figure 269*.

3. Remove the bolts that attach the actuating arms, bellcranks, and sliding links.

4. Remove the bolts from the bomb bay door hinges and remove the doors.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Inspect the bellcranks, actuating arms, sliding links, and hinges for wear, cracks, and other defects. Damaged parts must be replaced with new or serviceable parts.

2. For repair to the bomb bay doors refer to AN 01-40 AJ-3.

(d) INSTALLATION. — To install the bomb bay doors and operating mechanism reverse the REMOVAL procedure.

(e) ADJUSTMENTS.—The bomb bay doors are properly adjusted in the CLOSED position when they press tightly and evenly against the rubber seal around the edge of bomb bay. To properly adjust the doors, proceed as follows:

1. With the bomb bay doors open, disconnect the actuating arms from each door.

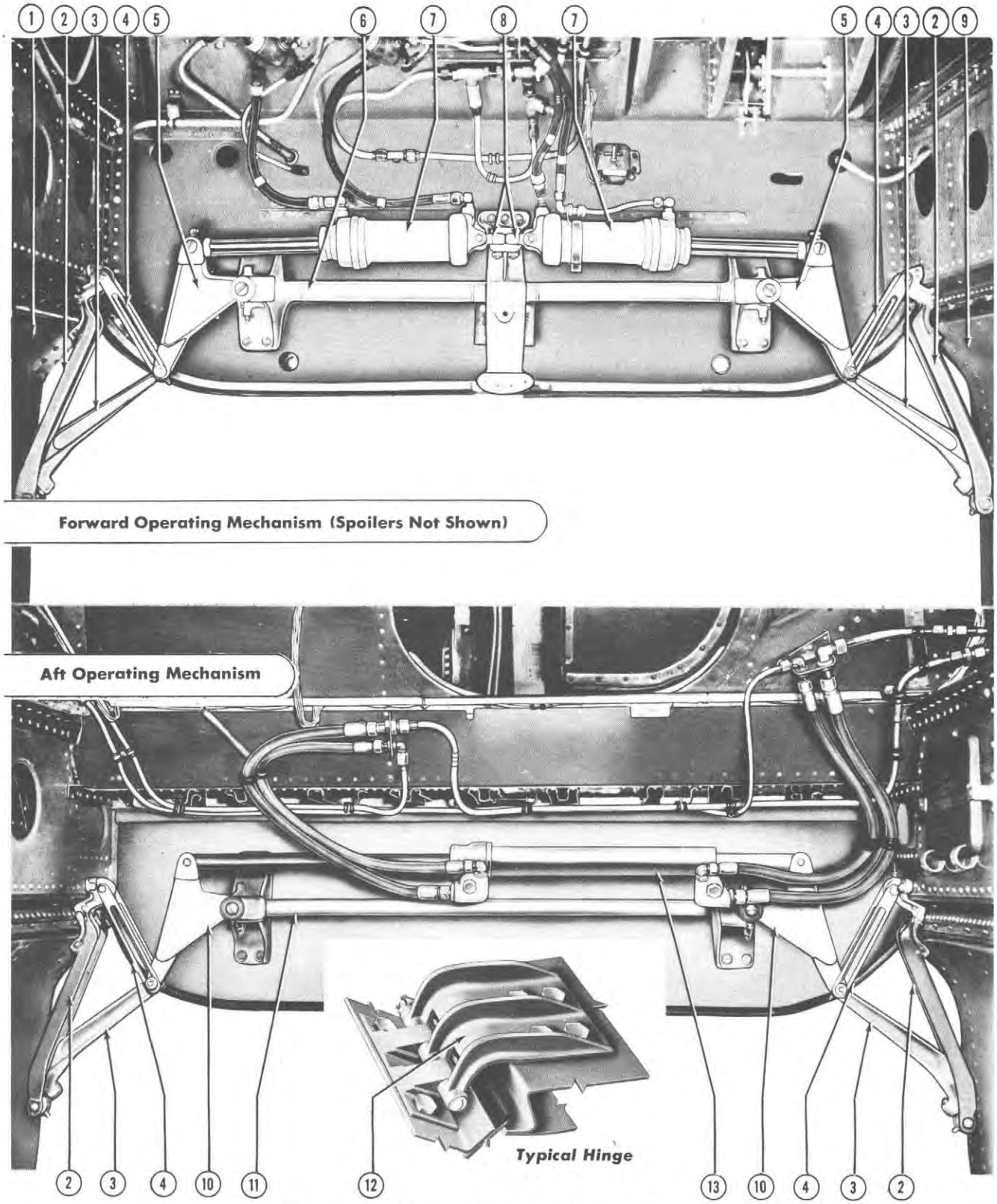
2. Adjust each forward actuating cylinder eyebolt to bring the bellcranks against the sliding link stops at both open and closed extreme positions.

3. If the actuating cylinder positions retract fully before they are stopped by the sliding links, proceed as follows: disconnect the piston rods at the bellcranks, loosen the locknuts, and shorten the piston rods until the sliding links strike the stops.

4. Check the travel of the aft actuating cylinder to make certain that the bellcranks are stopped at both ends of travel by the sliding link stops.

5. While the actuating mechanism remains in the CLOSED position, raise and adjust one bomb bay door at a time. The eyebolts which are screwed into the ends of each actuating arm, are adjusted (either in or out) to permit the bomb bay door to press tightly against the rubber seal about the edge of the bomb bay when the doors are closed.

6. After the actuating arms have been properly adjusted, pre-load the eyebolt check nut on the bomb bay door forward actuating cylinders with 1212 inch-pounds wrench torque. Operate the actuating cylinders to the OPEN position and connect the actuating arms to the doors with the attaching bolts.



1. L. H. Door Assembly
2. Hinge
3. Actuating Arm
4. Sliding Stop Links
5. Forward Bellcranks
6. Bracket Assembly
7. Forward Actuating Cylinders
8. Link Assemblies
9. R. H. Door Assembly
10. Aft Bellcranks
11. Bracket Assembly
12. Hinge (10 Required)
13. Aft Actuating Cylinder

Figure 281—Bomb Bay Doors Operating Mechanism

(11) BOMB BAY DOOR SPOILERS AND OPERATING MECHANISM.
(See figure 268.)

(a) DESCRIPTION.—The bomb bay spoilers are mounted in a slot in the bottom of the fuselage between the nose wheel well and the bomb bay. Three plate assemblies are provided to extend into the air stream and break up the air stream into the bomb bay when the bomb bay doors are open. Two pressure relief and check valve assemblies are installed in the bomb bay doors and spoilers hydraulic lines to obtain the proper operating sequence of the spoilers and doors. The spoilers extend completely before the bomb bay doors open, and the bomb bay doors close completely before the spoilers retract. The right and left hand spoiler plates are actuated directly by the bomb bay spoilers actuating cylinders, located in the aft end of the nose wheel well. The center spoiler plate is actuated by means of a rod assembly that links the center plate to the right hand spoiler plate. The operation of the bomb bay doors and spoilers is controlled by the bomb bay doors control.

(b) REMOVAL.

1. Open the bomb bay doors.

2. Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

3. Remove the bolts that attach the bomb bay spoilers actuating cylinders to the right and left hand spoiler plates.

4. Remove the rod that links the center and right hand spoiler plates.

5. Remove the bolts that attach the spoiler plates to the mounts and remove the spoiler plates.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Inspect the spoiler plates and mounts periodically for wear, and general condition and security. Replace any damaged parts with new or serviceable parts.

(d) ADJUSTMENTS.—The bomb bay spoiler plates should be adjusted to be flush with the bottom of the fuselage in the retracted position and to open 90 ± 1 degrees.

(e) INSTALLATION.—To install the bomb bay spoilers reverse the REMOVAL procedure.

e. BRAKE HYDRAULIC SYSTEM.
(See figure 282.)

(1) GENERAL.—Multiple-disc brake units, actuated hydraulically, are employed on this airplane. Two brake units are installed in each main landing gear wheel. Each wheel may be braked separately. Application of toe pressure on the rudder-brake control pedals opens the pressure ports of each power brake control valve. Hydraulic fluid under pressure flows directly to the brake actuating cylinders (integral with the brake) to produce the necessary braking effect. The brake control valves *(1, figure 282)* admit pressure to the brake actuating cylinders in direct proportion to the force applied to the rudder-brake pedals. When the brake pedals are released, the fluid returns to the reservoir through the brake lines and power brake valves. A check valve *(6, figure 282)* is installed near the left-hand brake control valve to maintain pressure in the brake control valves in the event of leaks in the brake pressure line. Self-sealing disconnect couplings are provided at the wheels to facilitate removal of the brake units or the wheels. A parking brake is provided and is operated by depressing the rudder-brake pedals fully, and by pulling back the parking brake lever *(figure 247)* located on the lower left side of the pilot's compartment.

(2) POWER BRAKE CONTROL VALVES.
(See figure 283.)

(a) DESCRIPTION.—The two power brake control valves are bolted to supports, located immediately forward of the rudder-brake pedals. The power brake control valve consists of a body that has a pressure port, a brake port and a return port; an extension lever that operates the piston in the valve body; the piston assembly which is sealed at both ends by synthetic rubber packing cups; an upper valve that controls the flow of fluid from the pressure port to the brake port, and a lower valve that controls the flow of fluid from the brake port to the return port. The power brake valve is designed to allow a pressure flow of fluid to the brakes when toe pressure is applied to the rudder-brake pedals. When the brakes are applied, the extension lever raises the piston in the valve body, closing the lower valve and opening the upper valve; and fluid flows from the pressure port to the brake port, actuating the brakes. Pressure increases in the brake port and on the head of the piston and the piston is forced downward. This pressure on the piston deflects the extension lever giving a "load feel" on the rudder-brake pedals. When toe pressure on the rudder-brake pedals is released, the valve piston returns to its normal position, closing the upper valve and opening the lower valve, which permits the fluid to flow from the brake port to the return port, releasing the main wheel brakes.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Remove the instrument panel access door *(7, figure 7)*.

b. Relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

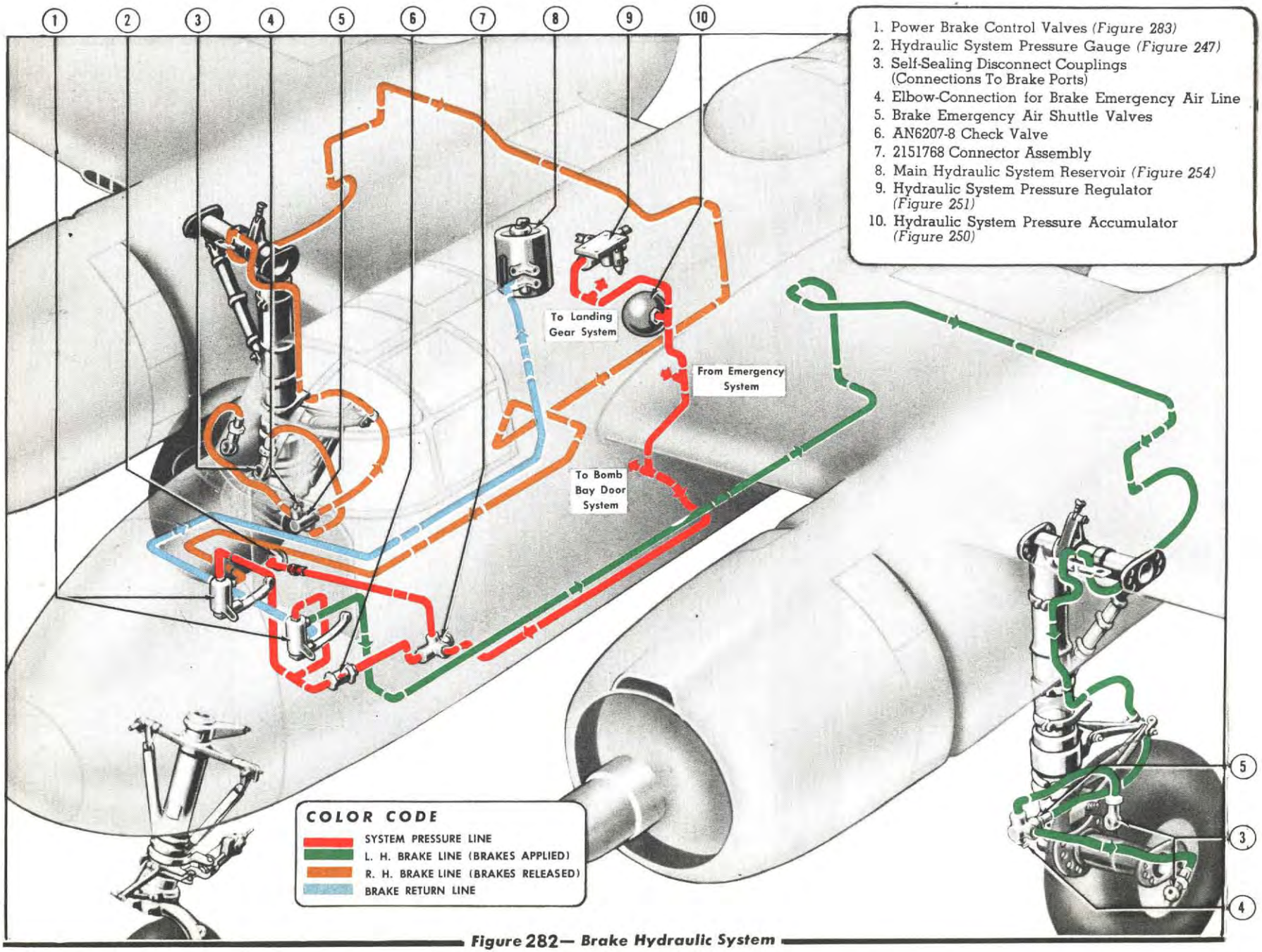
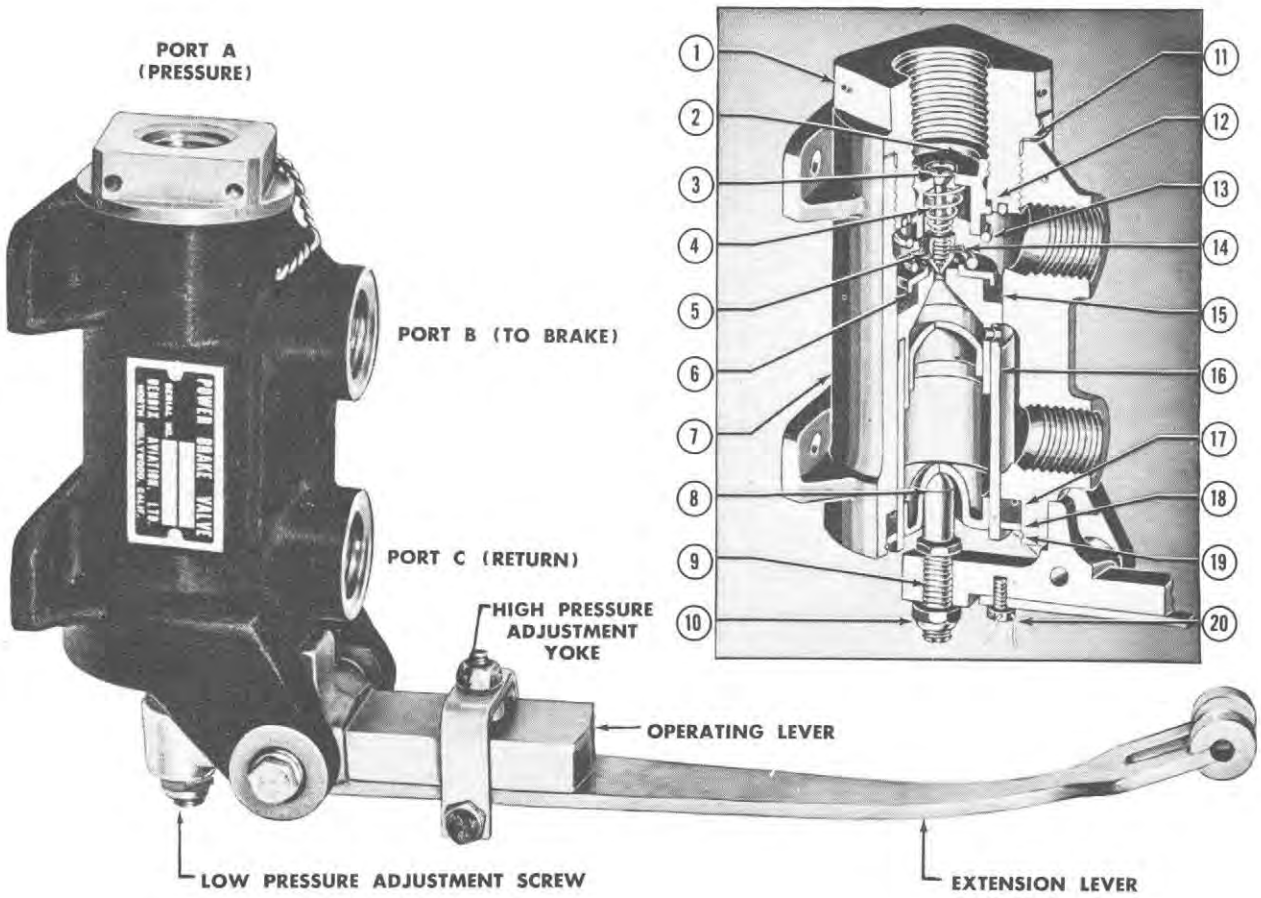


Figure 282— Brake Hydraulic System



1. Adapter
2. Upper Valve Seat
3. Upper Valve
4. Spring
5. Lower Valve
6. Packing Cup Retainer
7. Valve Body
8. Push Rod
9. Screw
10. Lock Nut
11. Gasket
12. Packing
13. Spring
14. Cotter
15. Piston Packing Cup
16. Piston Assembly
17. Cylinder Packing Cup
18. Packing Cup Support
19. Lock Ring
20. Bolt, Washer and Lock Wire

TEST PROCEDURE

TEST PRESSURE	PORTS PLUGGED	MAX. LEAKAGE	
		INTERNAL	EXTERNAL
1500 psi–Port A	None	1 drop in 15 min. at Ports B or C	None
450 psi–Port B with piston held in open position by screwing in bottom adjusting screw	Port A	1 drop in 15 min. at Port C	None
100 psi at Port C with piston actuated 25 times	Ports A and B		None

Douglas Dwg. No. 5123539

Bendix Aviation Ltd. No. 401332

Figure 283—Power Brake Control Valve

c. Disconnect and cap the hydraulic lines leading to each brake valve.

d. Remove the bolt that attaches the brake valve extension lever to the rudder-brake pedal mechanism.

e. Remove the bolts that attach the brake valves to the supports and remove the valves.

2. DISASSEMBLY.—Refer to *figure 283* when disassembly of the brake valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Inspect the power brake valves for evidence of fluid leakage at the valve ports and around the end of the piston at the 25-hour inspection period.

2. If the power brake valve is damaged or is not functioning properly, replace it with a new or serviceable part.

(d) ADJUSTMENTS.

1. TO BLEED THE BRAKES.—Both sides of each wheel must be bled, making a total of four bleeding operations that must be performed. Observe the following procedure for each of the bleeding operations:

a. Remove the cap screw *(figure 284)* and washer from the bleeder port in the brake. Insert bleeder hose *(figure 284)*. Place the free end of the hose in a clean receptacle.

b. With the emergency hydraulic system selector valve in the "SYSTEM" position, operate the hydraulic hand pump until the hydraulic system pressure gage indication is approximately 800 psi.

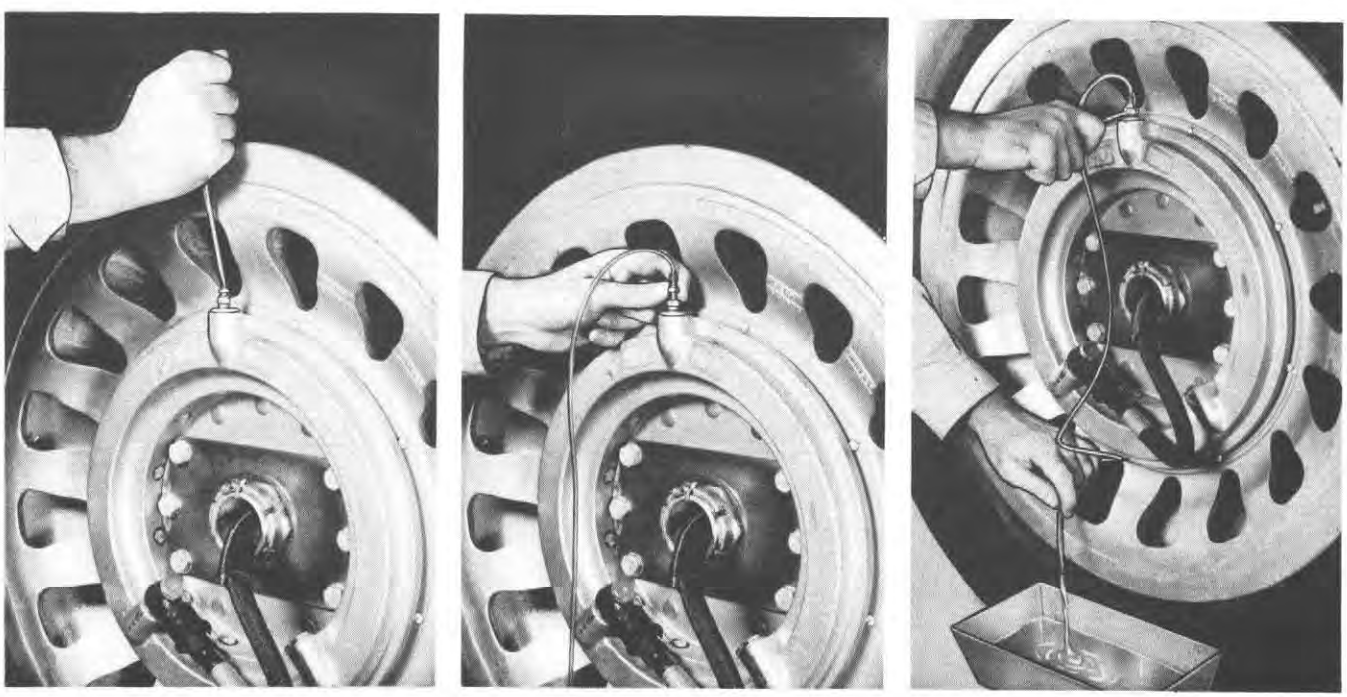
c. Set the parking brake by applying toe pressure on the rudder-brake pedals and pulling back the parking brake lever *(figure 247)*. Open the bleeder valve *(figure 284)*.

d. Allow hydraulic fluid to flow from the bleeder hose until clear, bubble-free fluid is observed.

e. Close and lock the bleeder valve. Remove the bleeder hose and replace the cap screw and washer. Release the parking brake by applying toe pressure to the rudder-brake pedals.

CAUTION

Maintain an ample supply of hydraulic fluid in the reservoir during the bleeding operation. If any hydraulic fluid spills on the tires, wipe it off immediately.



1. With 850-1000 psi in hydraulic system set the parking brake. Remove cap screw and washer from brake bleeder valve.

2. Install standard bleeder hose in brake bleeder valve.

3. Open bleeder valve and allow hydraulic fluid to flow until clear, bubble free fluid is obtained. Close bleeder valve, remove bleeder hose, and reinstall cap screw and washer.

Figure 284 —Brake Bleeding Procedure

2. TO ADJUST THE CONTROL VALVES.—Bleed all four brakes as instructed above. Each brake valve must be adjusted separately with 850-1000 psi pressure in the hydraulic system, by the following procedure:

a. Install an extension line and 500 psi pressure at the bleeder port of each inboard brake. *(See figure 285.)*

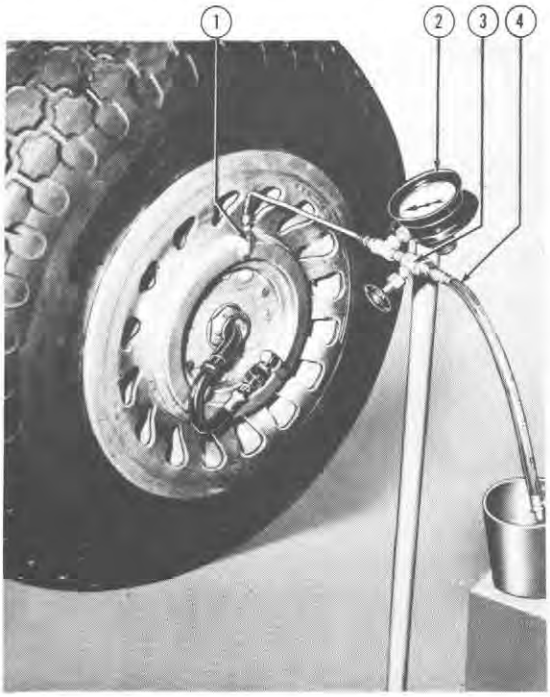
b. With the brakes released, tighten the low pressure adjusting screw *(figure 283)* directly under the valve body until the pressure gage indicates 60-80 psi.

c. Back off the adjusting screw until the gage pressure stops dropping. Back off an additional half turn. Lock the screw with the jam nut.

Note

The gage will not drop to zero because of static pressure of the fluid in the lines. Probably there will be five to eight psi pressure indicated on the gage.

d. Depress the rudder-brake pedals fully with the rudder pedals locked in their neutral position. Observe the pressure indication on the gage. The correct reading should be 300 ± 20 psi with the brakes in the FULL ON position. If the pressure is low, move the operating lever adjustment yoke *(figure 283)* away from the valve, tighten the yoke, and depress the brake pedals again. If the pressure is high, move the yoke toward the valve to decrease the pressure at the brakes.



1. Brake Bleeder Valve
2. Hydraulic Fluid Pressure Gage
3. Shut-Off Valve
4. Bleeder Hose

Figure 285—Installation of Pressure Gage for Adjustment of Power Brake Control Valve

CAUTION

The brakes must be applied to the FULL ON position. The parking brake cannot be substituted for the above as the yoke must be tight when testing for pressure.

e. Repeat the above high pressure adjustment procedure until the correct pressure is indicated on the gage.

f. With the parking brakes ON, the brake pressure should be 225 ± 25 psi. There should be no interference or external leakage of fluid.

(e) TEST BEFORE INSTALLATION.—Refer to *figure 283* for leak tests of the power brake valves.

(f) INSTALLATION.—To install the power brake valves, reverse the REMOVAL procedure.

(g) MAJOR OVERHAUL.

1. Remove and disassemble the power brake valve as instructed in paragraph 14. *e.* (2) *(b)*, this section.

2. Inspect the piston packing cups for scoring or other evidence of leakage. If they are scratched or scored, install new packing cups.

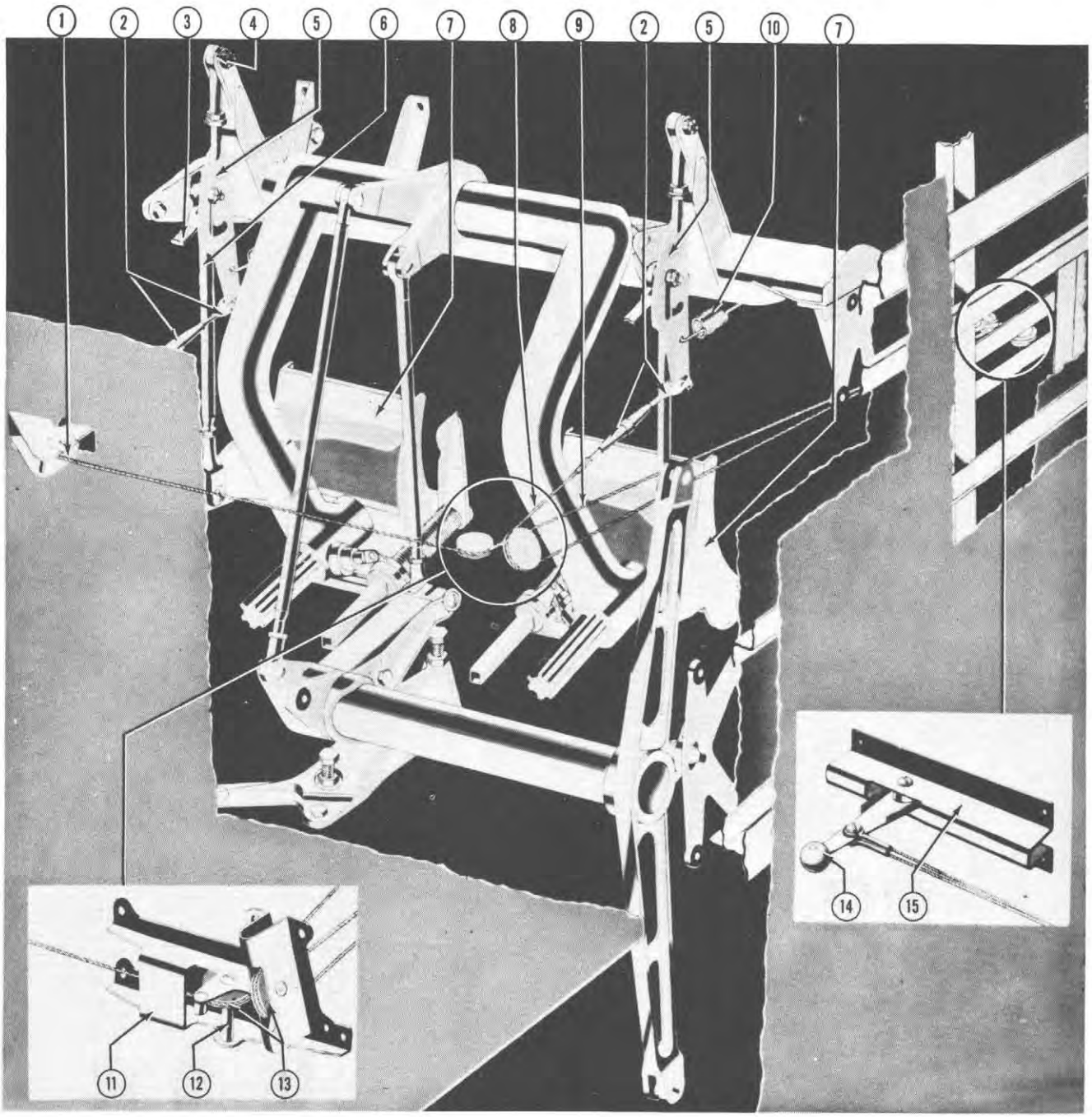
3. Inspect the valve seat, the upper and lower valves, and the valve seat on the piston assembly. If these valves are leaking, they may be reseated by lapping with a fine lapping compound as follows:

a. Apply lapping compound to the valves and seats. The piston assembly should be placed in the valve body and the valves assembled in the valve seat. Thread the valve seat into the adapter and screw the adapter into the body.

b. Lap the upper valve by turning with a screw driver while the valve is on the seat. The lower valve may be lapped by depressing the extension lever until the upper valve is lifted off seat approximately .010 inch. The lower valve then is seated on the piston assembly. Hold the extension lever in this position and turn the upper valve from the outside with a screwdriver to lap in the lower valve.

c. After lapping the valves, disassemble the unit and wash all parts thoroughly in clear gasoline to remove all traces of lapping compound.

4. Reassemble the power brake valve and test for leaks as instructed in *figure 283*.



1. Bracket and Pulley Assembly
2. Turnbuckle and Fork
3. Brake Valve Extension Lever
4. Bearing
5. Locking Plate
6. Rod Assembly
7. Rudder-Brake Pedals
8. L. H. Parking Brake Cable *(Figure 606, Item 14)*
9. R. H. Parking Brake Cable *(Figure 606, Item 30)*
10. Spring
11. Bracket Assembly
12. Spacer
13. Pulleys
14. Parking Brake Control Lever
15. Bracket

Figure 286—Parking Brake Mechanism

(3) BRAKE ACTUATING CYLINDERS.
(See figure 99.)

(a) DESCRIPTION. – Each wheel brake has two annular ring pistons, backed up by two synthetic rubber seals. Toe pressure applied on the rudder-brake pedals permits hydraulic fluid pressure to act on the rubber seals which in turn force the annular ring pistons against the brake discs. This pressure results in friction between the rotary and the stationary discs *(figure 99)* in the brake unit, producing effective braking of the airplane. When the brakes are relieved by releasing the rudder-brake pedals, the pistons are forced back to their normal position by leaf springs *(figure 99)* and the hydraulic fluid returns to the reservoir through the brake control valves and brake lines.

(b) REMOVAL AND DISASSEMBLY.
(Refer to figures 97 and 98.)

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Refer to paragraph 5. *b.* (4) *(c)*, this section.

(d) ADJUSTMENTS.–Refer to paragraph 5. *b.* (4) *2. (d)*, this section.

(e) ASSEMBLY AND INSTALLATION.–Refer to paragraph 5. *b.* (4) *(2) (e)*, this section.

(4) SELF-SEALING DISCONNECT COUPLINGS.
(See figure 257.)

(a) DESCRIPTION. – Self-sealing disconnect couplings are provided on the inboard and outboard side of each brake unit to facilitate removal of the wheels or brakes. No fluid leakage occurs when connecting or disconnecting these couplings. For all other information about these couplings, refer to paragraph 14. *b.*, this section.

(5) PARKING BRAKE.
(See figure 286.)

(a) DESCRIPTION.–A parking brake is installed in the airplane to lock the brakes when the airplane is parked. To operate the parking brake, the rudder-brake pedals are depressed fully by toe pressure, and the parking brake control lever *(figure 247)*, located on the left side of the pilot's compartment forward of the bomb rack control lever, is pulled back. Release the pedals before releasing the control lever. The rudder-brake pedals and power brake control valves are held in the "ON" position by a slotted plate, which is controlled by cables to the parking brake control lever. Apply toe pressure on the rudder-brake pedals to release the parking brake.

(b) REMOVAL.–To remove the parking brake cables, control lever, and locking plate remove the attaching bolts. *(See figure 286.)*

(c) MAINTENANCE REPAIR OR REPLACEMENT.–Inspect the parking brake installation periodically for condition and security. Check for any binding of the cables and pulleys. Replace any worn or damaged parts with new parts. To adjust the cable tension refer to *figure 74*.

(d) INSTALLATION.–To install the parking brake refer to *figure 286*.

KEY TO FIGURE 287

1. Emergency Hydraulic System Filter and Check Valve
2. Nose Wheel Door Actuating Cylinder *(Figures 265 and 266)*
3. Nose Wheel Door Actuating Cylinder Shuttle Valve
4. Nose Wheel Gear Actuating Cylinder *(Figure 261)*
5. Hydraulic Hand Pump *(Figure 289)*
6. Emergency Hydraulic System Temperature Relief Valve *(Figure 294)*
7. Emergency Hydraulic System Selector Valve *(Figure 288 for Details of Cable Controls)*
8. Main Landing Gear Actuating Cylinders
9. AN6207-4 Check Valve
10. Main Hydraulic System Fluid Reservoir *(Figure 253)*
11. Tee (Connection for Brake Emergency Air Exhaust Line)
12. Emergency Hydraulic System Fluid Reservoir *(Figure 290)*
13. De-Icer Exhaust Vent
14. Bomb Bay Door Forward Actuating Cylinder Shuttle Valves *(Figure 274)*
15. Bomb Bay Spoilers Actuating Cylinders Shuttle Valve *(Figure 274)*
16. Combined Check, Shuttle, and Pressure Relief Valve Assembly *(Figure 278)*
17. Bomb Bay Door Aft Actuating Cylinder Shuttle Valves *(Figure 276)*
18. Bomb Bay Door Aft Actuating Cylinder *(Figure 275)*
19. Landing Gear DOWN Supply Line From Emergency Reservoir
20. Bomb Bay Doors and Spoilers OPEN
21. Bomb Bay Doors CLOSED Supply Line
22. Bomb Bay Doors OPEN Supply Line
23. Bomb Bay Doors and Spoilers CLOSED Operating Line
24. Supply Line from Main Hydraulic System Reservoir
25. Landing Gear DOWN Operating Line
26. Hand Pump Pressure Line
27. Drum and Cable Assembly
28. Pressure Line to Main Hydraulic System
29. Hand Pump Supply Line
30. Return Line
31. Mounting Bracket

f. EMERGENCY HYDRAULIC SYSTEM.
(See figure 287.)

(1) GENERAL.–The emergency hydraulic system is installed in the airplane to extend the landing gear and open and close the bomb bay doors and spoilers when the main hydraulic system is inoperative. The emergency hydraulic system reservoir furnishes fluid to the hydraulic hand pump, which furnishes pressure for the system. Fluid under pressure from the hand pump flows to the emergency hydraulic system filter and check valve assembly to the emergency hydraulic system selector valve which has four positions. A relief valve is included in the system to relieve excess fluid pressure caused by thermal expansion.

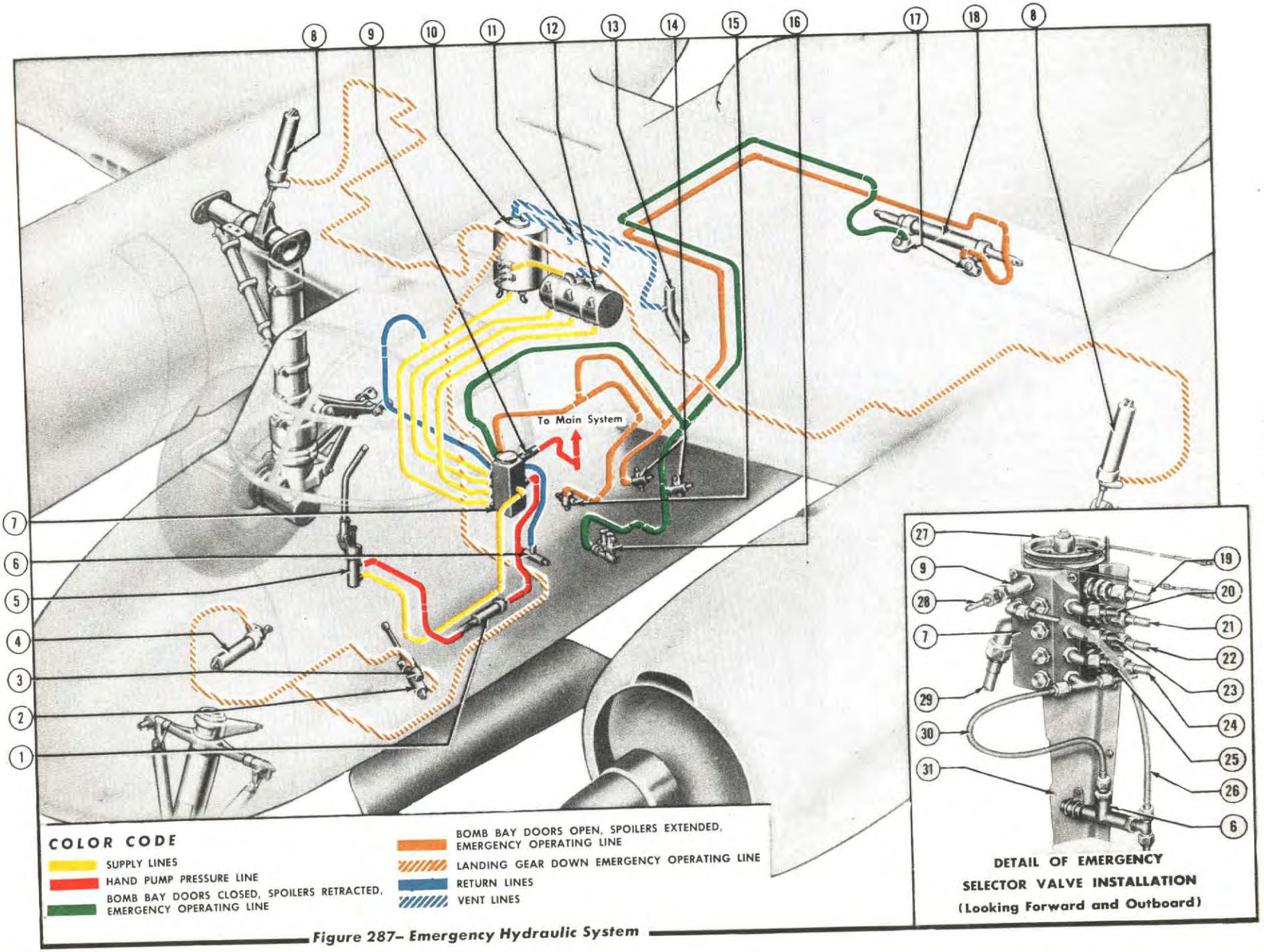


Figure 287– Emergency Hydraulic System

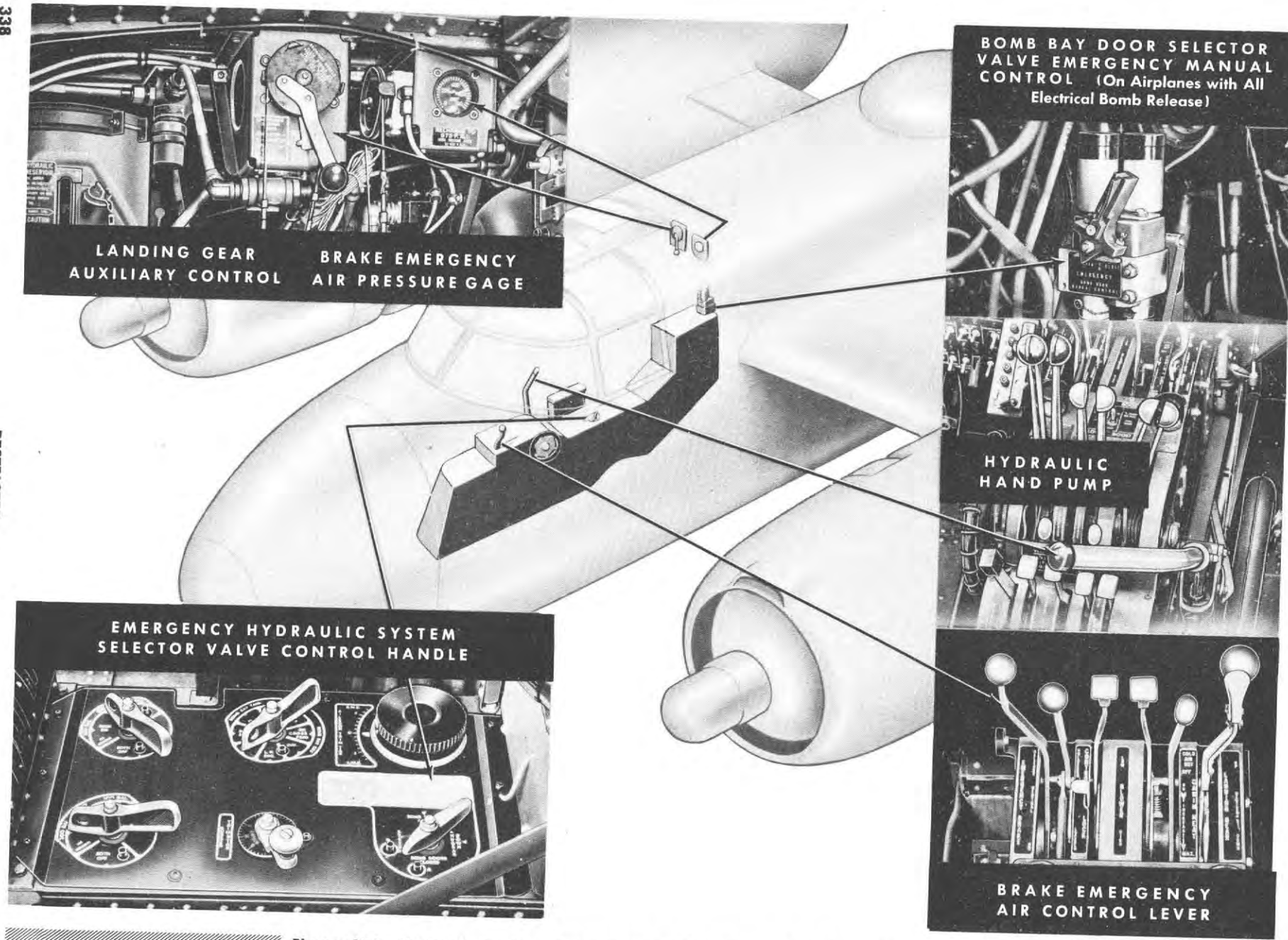


Figure 288—Hydraulic System—Emergency and Auxiliary Controls and Instruments

Note

The corresponding main hydraulic system selector valve first must be set for the desired operation; then, the emergency position selector valve must be set to actuate the desired mechanism. Because the emergency system utilizes main hydraulic lines as return lines, the corresponding main position selector valves must be set for the same operations as the emergency position selector valve; otherwise the excess fluid could not return to the reservoir and emergency operation would be impossible. When an emergency hydraulic system operation is completed, return the emergency system selector valve control handle to the "SYSTEM" position. In the "SYSTEM" position fluid is supplied to the hydraulic hand pump from the main hydraulic system reservoir and fluid under pressure from the hand pump is utilized to increase pressure in the main hydraulic system pressure accumulator.

(2) HYDRAULIC HAND PUMP.
(See figure 289.)

(a) DESCRIPTION.—The double-acting piston-type hydraulic hand pump is mounted on the right side of the pilot's control pedestal. *(See figure 288.)* The hand pump serves two functions: (1) to supply pressure for the main hydraulic system when it is not convenient to operate the engine-driven hydraulic pumps, (2) to supply pressure for the emergency hydraulic system in opening or closing the bomb bay doors and spoilers, and extending the landing gear. The pump has a capacity of 1.25 cubic inches per cycle minute. When the pump is operated, hydraulic fluid is sucked in on only one stroke, but is displaced under pressure on both strokes because of the check valve and accompanying passages contained within the piston head. Handle movement is limited to approximately 65 degrees.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the two hydraulic lines leading to the hand pump.

c. Remove the two bolts attaching the brackets to the pump assembly and remove the pump assembly.

2. DISASSEMBLY. — If disassembly of the hand pump is attempted, refer to *figure 289.*

(c) MAINTENANCE OR REPLACEMENT.

1. The pump requires no internal lubrication because all working parts operate in oil. Occasional lubrication of the link pivots is required. Refer to the lubrication chart in Section III. Inspect the hand pump tube connections periodically for evidence of fluid leakage.

2. If the hydraulic hand pump is damaged or is not operating properly, it should be replaced with a new or serviceable part.

(d) TESTS BEFORE INSTALLATION.—Refer to *figure 289* for fluid leak tests.

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—To assemble the hydraulic hand pump refer to *figure 289.*

2. INSTALLATION. — To install the hydraulic hand pump, reverse the REMOVAL procedure.

(3) EMERGENCY HYDRAULIC SYSTEM FLUID RESERVOIR.
(See figure 290.)

(a) DESCRIPTION.—The emergency hydraulic system fluid reservoir is a welded aluminum container located inboard of and below the main hydraulic system fluid reservoir, which supplies fluid to the emergency system reservoir. The emergency fluid reservoir is divided into three separate cells, with each cell having a bullseye inspection window. The fluid in the emergency fluid reservoir cannot be drawn out by the engine-driven pumps so that a fluid supply is available to the hydraulic hand pump, should the main system reservoir be damaged. One cell of the emergency system fluid reservoir supplies fluid to open the bomb bay doors, the second cell supplies fluid to extend the landing gear, and the third cell supplies fluid to close the bomb bay doors. Openings at the top of the emergency system reservoir cell partitions permit filling of the reservoir.

(b) REMOVAL.

1. Relieve the system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

2. Disconnect and cap all the hydraulic lines at the emergency reservoir.

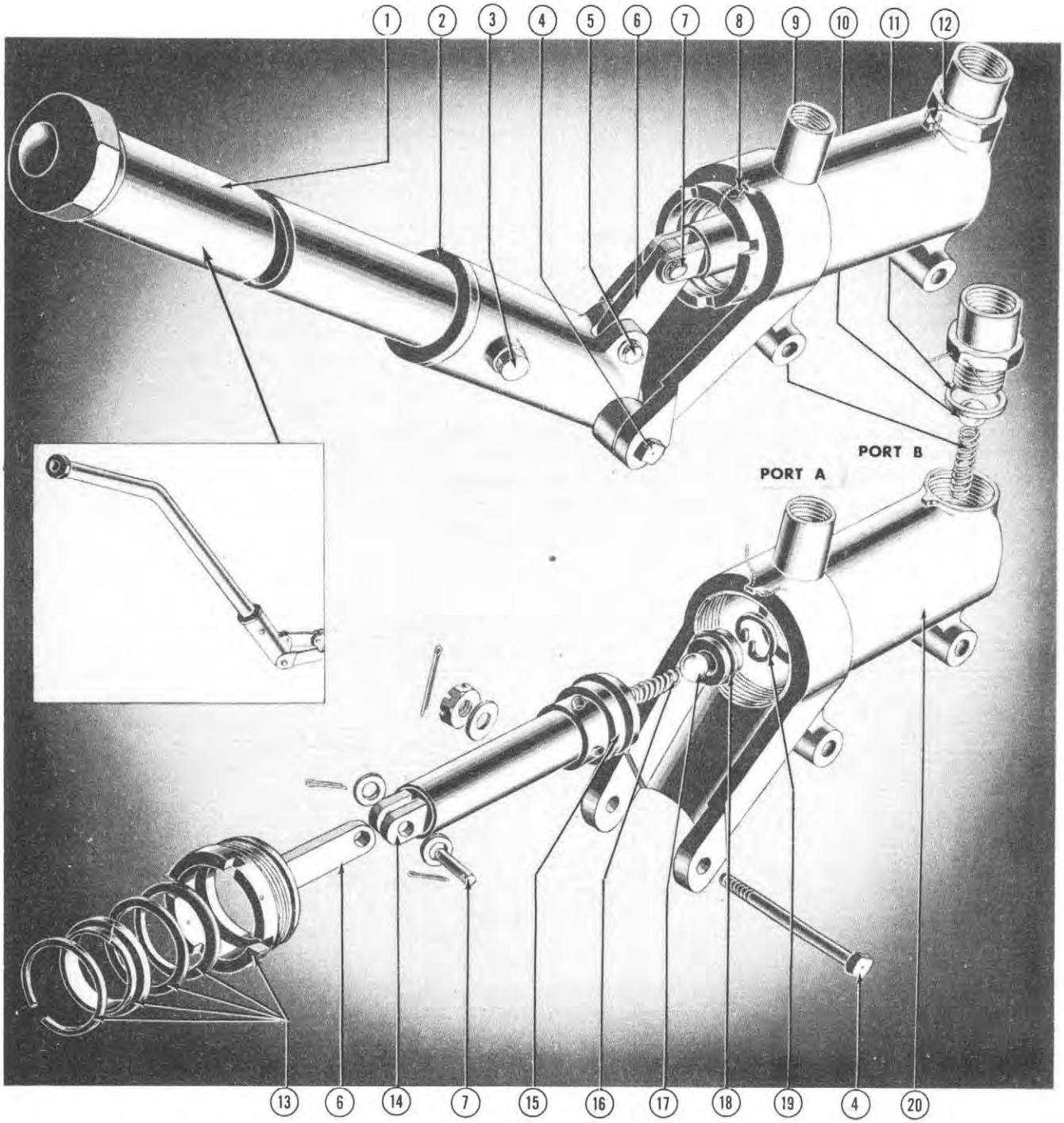
3. Remove the bolts, bend back the straps, and remove the reservoir.

4. The reservoir cannot be disassembled.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Small holes or cracks in the emergency hydraulic system reservoir can be welded.

2. If moderate tightening will not stop fluid



1. Handle Assembly
2. Handle Socket
3. Bolt, Nut, and Washer
4. Bolt or Shaft, Washer, and Cotter
5. Pin, Washers, and Cotters
6. Link
7. Pin, Washers, and Cotters
8. Lock Wire
9. Spring
10. Ball
11. AN902-8 Gasket
12. Fitting
13. Gland Assembly (Includes AN6227-17 Packing)
14. Piston Assembly
15. AN6227-16 Packing
16. Spring
17. Ball
18. AN6227-9 Packing
19. Lock Ring
20. Pump Body

Douglas Drawing No. 5123561

Adel Precision Products Inc. D10007-4

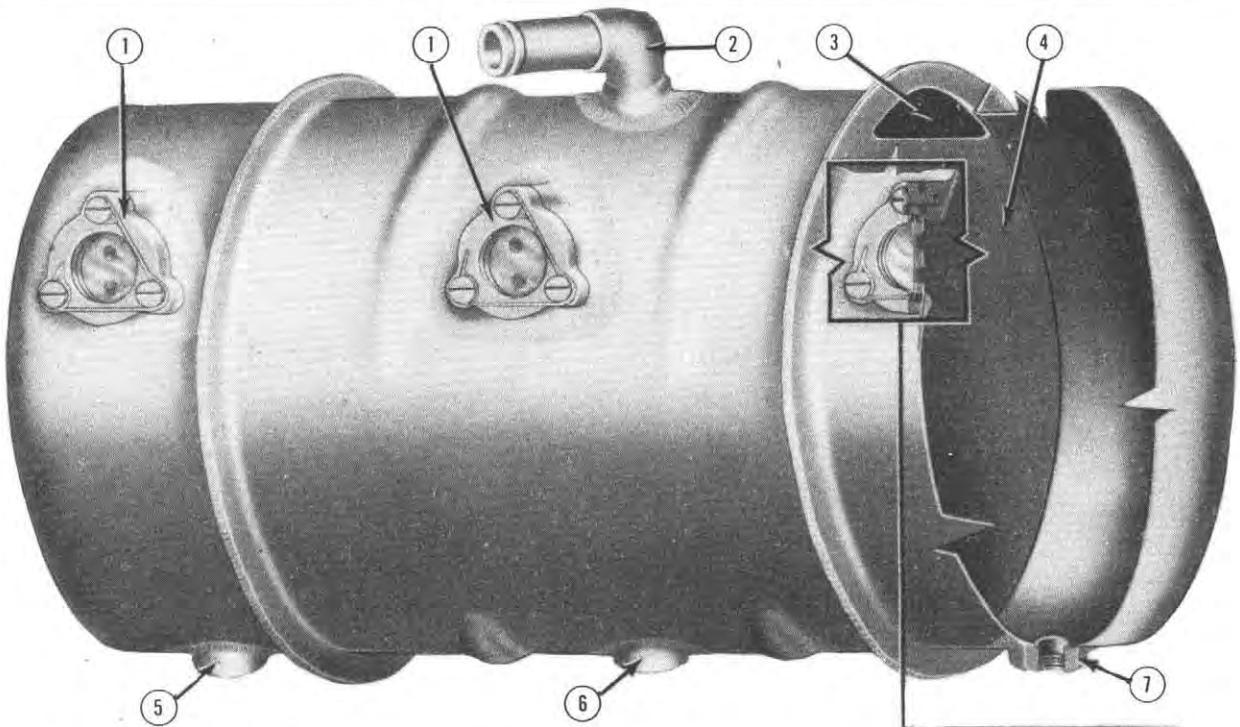
Figure 289—Hydraulic Hand Pump

HYDRAULIC HAND PUMP

Douglas Drawing No. 5123561

Adel Precision Products Inc. D10007-4

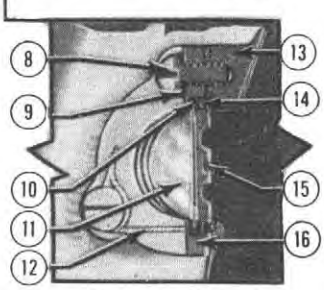
TEST PROCEDURE					
PORT A	PORT B	POSITION	LOAD APPLIED 18" HANDLE	EXTERNAL LEAKAGE	MAX. HANDLE CREEP
Pump Against Relief Valve Set at 1250 psi	Connect To Reservoir	Operate Slowly	1080 in.-lbs.		
Plugged	Connect To Reservoir	Piston Extending	1080 in.-lbs.	2 drops / hr.	1½ in. / hr.
Plugged	Connect To Reservoir	Piston Retracting	1080 in.-lbs.	2 drops / hr.	1½ in. / hr.



1. Bullseye Window Assembly
2. Vent and Inlet Fitting
3. Opening in Bulkhead to Permit Filling of Cell
4. Bulkhead
5. Outlet Boss (Bomb Bay Doors Closed)
6. Outlet Boss (Landing Gear Down)
7. Outlet Boss (Bomb Bay Doors Open)
8. Screw
9. Washer
10. Bullseye Gasket
11. Bullseye Window
12. Lock Wire
13. Bullseye Boss
14. AN6227-15 Packing
15. Bullseye Disc
16. Bullseve Cover

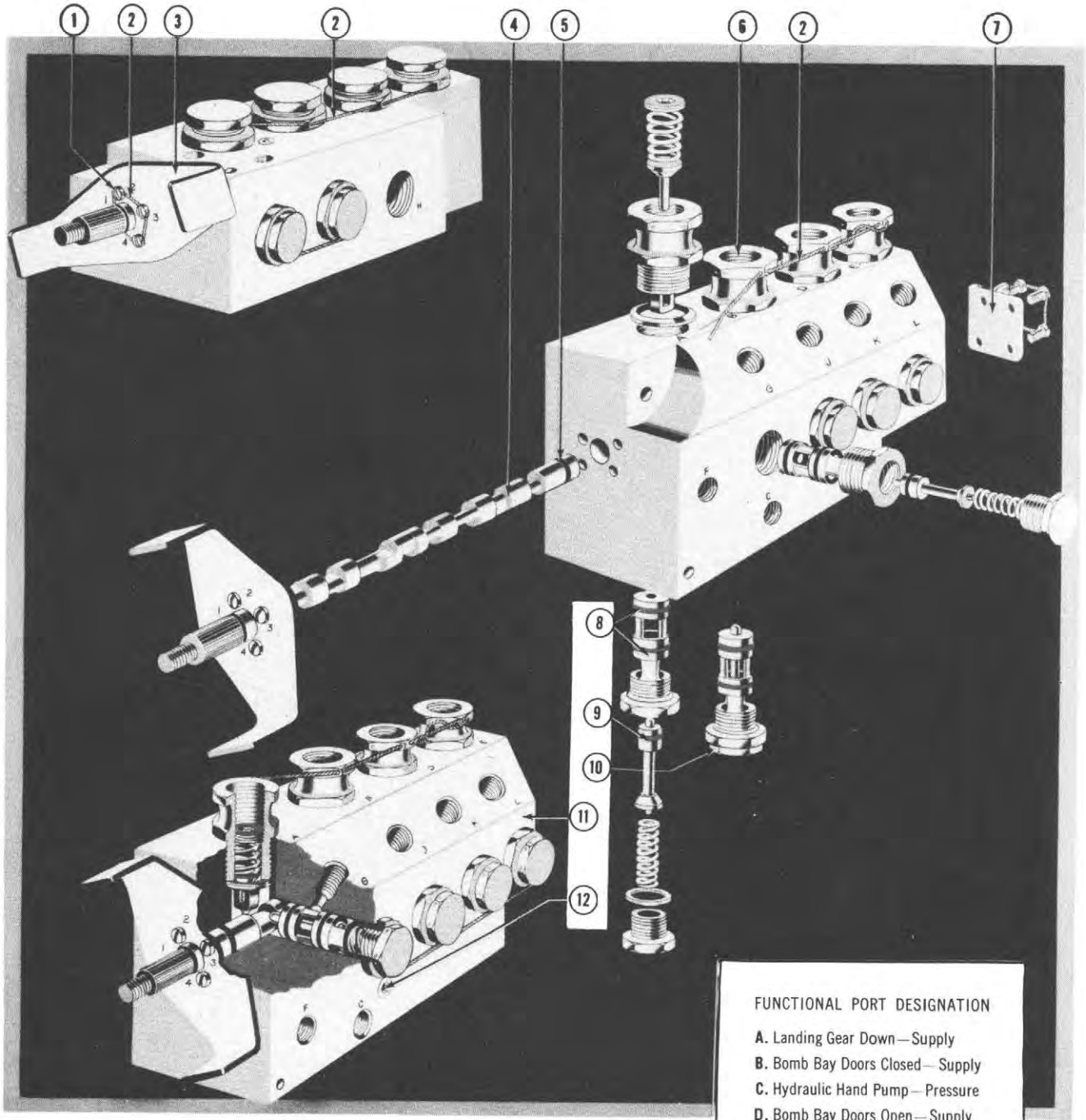
NOTE — Some window assemblies include cover gasket and spacer instead of AN6227-15 Packing

Douglas Drawing No. 5128374



DETAIL OF WINDOW ASSEMBLY

Figure 290 — Emergency Hydraulic System Fluid Reservoir



1. Screws
2. Lock Wire
3. Pulley Guard
4. Cam Shaft
5. AN6227-7 Packing
6. Cartridge Assembly
7. Bracket
8. AN6227-9 Packing
9. AN6227-1 Packing
10. Cartridge Assembly
11. Valve Body
12. Plug

FUNCTIONAL PORT DESIGNATION

- **A.** Landing Gear Down—Supply
- **B.** Bomb Bay Doors Closed—Supply
- **C.** Hydraulic Hand Pump—Pressure
- **D.** Bomb Bay Doors Open—Supply
- **E.** System—Reservoir Supply
- **F.** To System
- **G.** Bomb Bay Doors Open—Pressure
- **H.** Hydraulic Hand Pump—Supply
- **J.** Bomb Bay Doors Closed—Pressure
- **K.** Landing Gear Down—Pressure
- **L.** Vent

Douglas Drawing No. 5128486
Adel Precision Products Corp. D10005

Figure 291—Emergency Hydraulic System Selector Valve

EMERGENCY HYDRAULIC SYSTEM SELECTOR VALVE

Douglas Drawing No. 5128486 Adel Precision Products Inc. D10005

TEST PROCEDURE				
TEST PRESSURE	PORTS PLUGGED	HANDLE POS.	MAX. LEAKAGE	
			INTERNAL–2 DROPS / MIN.	EXTERNAL
1500 psi–Port B	H	1	At Port A	None
1500 psi–Port D	H	1	At Port A	None
1500 psi–Port E	H	1	At Port A	None
1500 psi–Port A	H	2	At Port B	None
1500 psi–Port C	J	2	At Each Port F, J, K, and L	None
1500 psi–Port C	G	4	Total At Ports F, J, K, and L	None
1500 psi–Port C	F	3	At Port J	None

leaks at the outlet connections, replace gaskets or fittings.

3. Fluid leaks may develop at the bullseye inspection windows, observe the following procedure:

a. Cut the lockwire; remove the screws and washers attaching the bullseye cover to the bullseye boss. Replace worn washers.

b. Inspect the molded neoprene gasket for deterioration, and install new gasket if necessary.

c. Inspect the bullseye plexiglas window and replace it if it is damaged.

4. If the emergency fluid reservoir is badly damaged, it should be replaced with a new or serviceable part.

(d) TESTS BEFORE INSTALLATION.–Apply 10 psi with all outlets plugged to test for leaks. No leakage is permissible.

(e) INSTALLATION. – To install the emergency hydraulic system reservoir reverse the REMOVAL procedure.

(4) EMERGENCY HYDRAULIC SYSTEM SELECTOR VALVE AND CABLE CONTROLS. *(See figures 291 and 292.)*

(a) DESCRIPTION. – This poppet-type valve is located in the left-hand aft section of the pilot's compartment. It is controlled by cables which are connected to a handle on the control pedestal. The emergency hydraulic system selector valve controls the opening and closing of the bomb bay doors, extending of the landing gear, and increasing pressure in the accumulator. To operate any of the emergency systems, the main hydraulic system selector valves first must be set for the same operation as the emergency selector valve. During normal operation when the main hydraulic system is functioning, the emergency hydraulic system selector valve should remain in the "SYSTEM" position.

Note

When changing the emergency selector valve from "BOMB DOORS OPEN" to "BOMB DOORS CLOSED," the valve should remain in the "SYSTEM" position for approximately five seconds to allow pressure in the bomb bay doors and spoilers system to be dissipated.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

b. Loosen the cable turnbuckle, remove the two bolts, and remove the pulley with the cable in place.

c. Disconnect and cap all hydraulic lines leading to the valve.

d. Remove the three bolts which attach the valve to the bracket and remove the valve.

2. DISASSEMBLY.–Refer to *figure 291* if disassembly of the emergency hydraulic system selector valve is attempted.

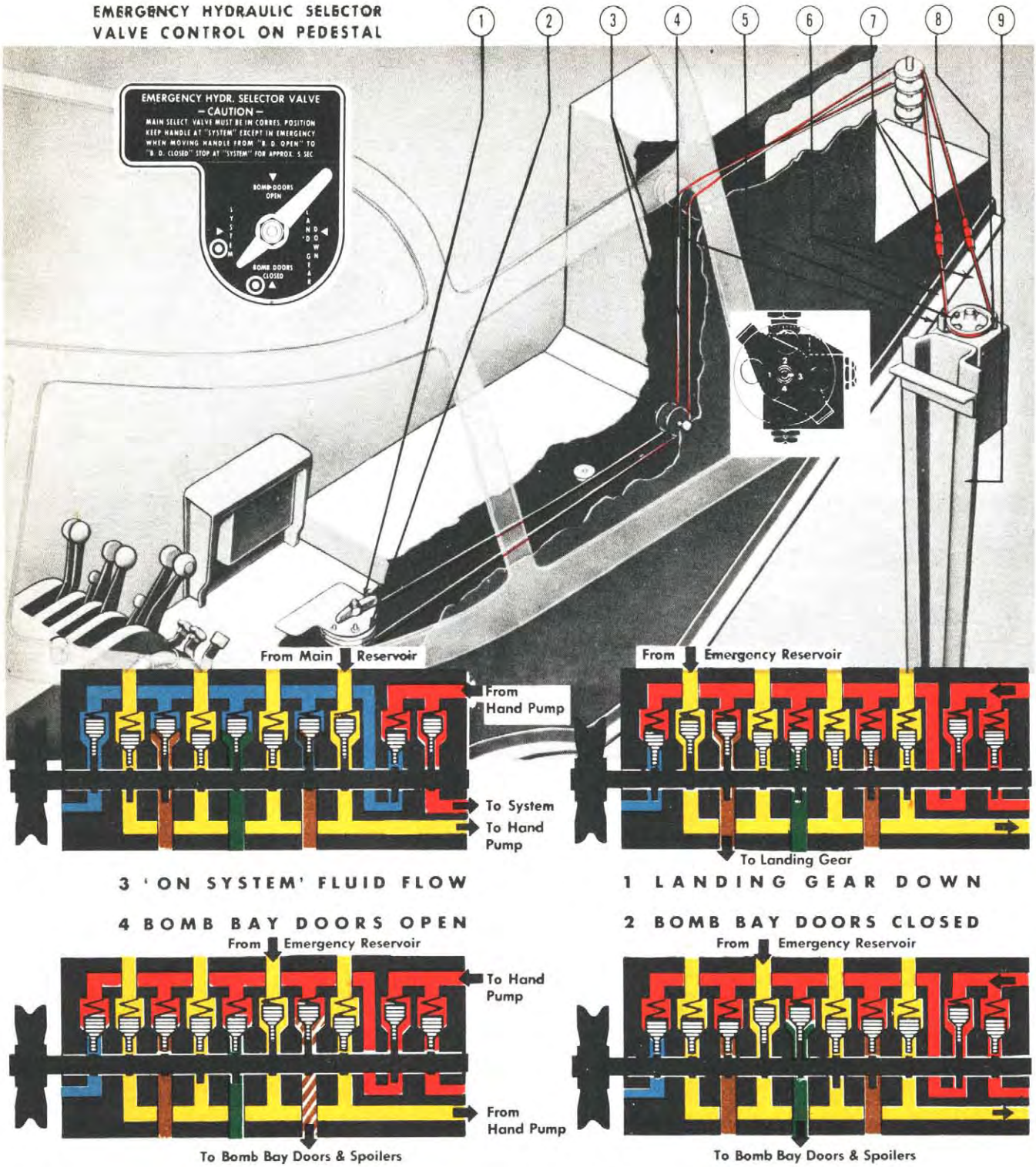
(c) MAINTENANCE REPAIR OR REPLACEMENT.–If the emergency hydraulic system selector valve is damaged or is not operating properly, replace it with a new or serviceable part.

(d) ADJUSTMENTS. – To adjust the valve, cables and cable control refer to *figure 292.*

(e) TEST BEFORE INSTALLATION.–Refer to *figure 291* for fluid leak tests.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.–Refer to *figure 291* for assembly procedure.



NOTES:

1. Rig cables with the pedestal control in "ON SYSTEM" position and mark on selector valve shaft pointing aft at No. 3 on pulley guard as shown.

2. Refer to Figure 74 to obtain correct cable tension.

1. Pedestal Control
2. Pedestal Control Pulley
3. Pedestal Cable Assembly *(Figure 606, Item 13)*
4. Pulley Guard
5. Selector Valve Pulley
6. Valve Cable Assembly *(Figure 606, Item 16)*
7. Cable Turnbuckles
8. Emergency Hydraulic Selector Valve
9. Bracket Assembly

SUPPLY PRESSURE RETURN LANDING GEAR DOWN BOMB BAY DOORS OPEN BOMB BAY DOORS CLOSED

Figure 292—Emergency Hydraulic Selector Valve Cable Control System

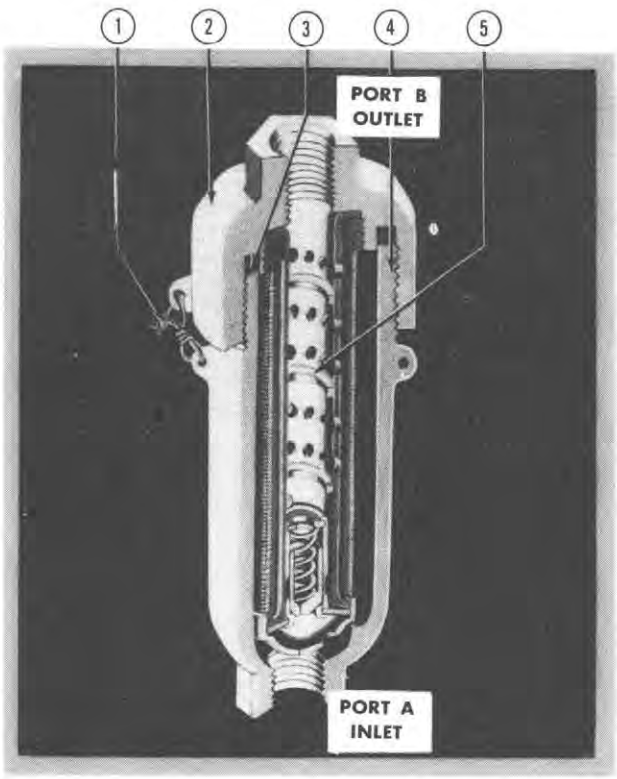
2. INSTALLATION.–To install the emergency hydraulic system selector valve, reverse the REMOVAL procedure.

(5) EMERGENCY HYDRAULIC SYSTEM FILTER. *(See figure 293.)*

(a) DESCRIPTION.–This filter is located in the emergency hand pump pressure line on the left side of the nose-wheel well. The unit filters the supply of emergency hydraulic system fluid and must be disassembled to be cleaned. A pressure relief valve is incorporated in the metal-edge type filter element, and is set at 28 to 30 psi pressure differential to bypass the fluid if the filter clogs. The filter has a capacity of 1.5 gallons a minute at a maximum pressure differential of 10 psi.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.



1. Lock Wire
2. Head
3. Case Packing
4. Case
5. Element Assembly (Includes Relief Valve Assembly)

TEST PROCEDURE		
TEST PRESSURE	PORTS PLUGGED	MAX. LEAKAGE
1500 psi–Port A	Port B	External–None
Relief valve must open at 28-30 psi to bypass fluid if element clogs		

Douglas Drawing No. 2123260
Purolator Products Type G-160 M-5

Figure 293—Emergency Hydraulic System Filter

a. Relieve the system operating pressure by applying toe pressure to and releasing the rudder brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines leading to the filter and check valve assembly.

c. Remove the screw and clip which attach the filter to the side of the nose-wheel well. Remove filter. Remove the check valve from the inlet port of the filter.

2. DISASSEMBLY.–Refer to *figure 293* for disassembly procedure.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. CLEANING.–Remove and disassemble the filter as instructed above. Unscrew the filter element from the head. Clean the filter element with a soft bristle brush (DO NOT USE METAL BRUSH) and wash it in solvent. Blow air through reverse side of filter element. The filter should be disassembled and cleaned every 100 hours.

Note

This filter should be cleaned at the same time as the main hydraulic system filter.

2. Install new case packing if there is evidence of external leakage.

3. If the emergency hydraulic system filter is damaged, it should be replaced with a new or serviceable part.

(d) TEST BEFORE INSTALLATION.–Refer to *figure 293* for leak tests of the emergency hydraulic system filter.

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.–To assemble the emergency hydraulic system filter refer to *figure 293.*

2. INSTALLATION.–To install the filter, reverse the REMOVAL procedure.

(6) HYDRAULIC FLUID CHECK VALVES. *(See figure 256.)*

(a) DESCRIPTION. – Hydraulic fluid check valves are installed in the emergency hydraulic system to prevent the fluid from reversing its normal direction of flow in certain lines. One check valve *(figure 287)* is located in the hand pump pressure line at the inlet port of the emergency system filter, while one is located at the emergency selector valve in the connecting line from the valve to the line to the main hydraulic system pressure accumulator. A check valve and pressure relief valve assembly is installed in the bomb bay doors OPEN line. The check valves consist of spring-loaded plastic poppets seating on the aluminum alloy valve body.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic pressure gage indicates zero.

b. Remove valves from the airplane after disconnecting and capping hydraulic lines at the valves.

2. DISASSEMBLY.—Refer to *figure 256* for disassembly procedure.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—If a check valve is damaged or is not functioning properly, replace it with a new or serviceable part.

(d) TEST BEFORE INSTALLATION.—Refer to *figure 256* for leak tests.

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—Refer to *figure 256* for assembly procedure.

2. INSTALLATION.—Installation is the reverse of REMOVAL above.

(7) EMERGENCY HYDRAULIC SYSTEM TEMPERATURE RELIEF VALVE.
(See figure 294.)

(a) DESCRIPTION.—This valve is located on the same bracket that supports the emergency selector valve in the pilot's compartment, and functions to relieve fluid pressure in the emergency hydraulic system caused by thermal expansion. The valve is installed in the pressure line from the hydraulic hand pump to the emergency hydraulic selector valve with excess fluid being returned to the reservoir. The valve relieves fluid at the rate of three cubic inches a minute at a maximum pressure of 1300 psi. The valve consists essentially of a spring-loaded steel ball resting upon a hardened steel valve seat in an aluminum alloy body.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve system operating pressure by applying toe pressure to and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

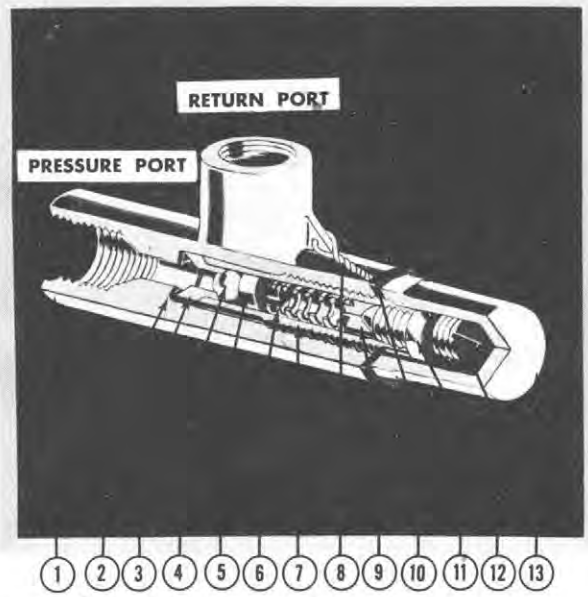
b. Disconnect and cap the hydraulic lines at the valve.

c. Remove the clip and screw which attach the valve assembly to the bracket and remove the valve assembly.

2. DISASSEMBLY.—Refer to *figure 294* if disassembly of the valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—Leaks may develop because of faulty seating or the valve ball because of wear or by foreign particles lodging under the ball. Foreign particles may be dislodged by the following procedure:

1. Raise the system pressure by operating the hydraulic hand pump and continue the pumping to force a considerable volume of fluid to flow through the valve. This fluid flow should dislodge any particles holding the valve open, particularly if the valve body is lightly tapped at the same time with a rubber hammer. If this fails to remedy the trouble, the valve must be removed from the airplane and disassembled and cleaned.



1. Valve Body
2. Crush Washer
3. Ball Seat
4. Ball
5. Spring Seat (Ball End)
6. Spring
7. Bushing
8. Lock Wire
9. Spring Seat (Adjusting End)
10. Crush Washer
11. Lock Nut
12. Adjusting Screw
13. Cap

NOTE

Valve opens at 1170 psi minimum and reseats at 1100 psi. Valve allows flow at rate of 3 cubic inches a minute at maximum pressure of 1300 psi.

TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE	
		INTERNAL	EXTERNAL
1160 psi–Pressure Port	None	None at Return Port	None
1500 psi–Pressure Port	Return Port		None

Douglas Drawing No. 4193465 Aircraft Accessories Corp. No. 31023

Figure 294—Emergency Hydraulic System Temperature Relief Valve

2. If the temperature relief valve is not functioning properly or is damaged, it should be replaced with a new or serviceable part.

(d) ADJUSTMENTS.

1. MINOR ADJUSTMENT. – Remove cap *(13, figure 294)*, loosen lock nut *(11, figure 294)* and turn the adjusting screw *(12, figure 294)* IN to increase the pressure, and OUT to decrease the pressure. Tighten the lock nut after adjustment; replace dust cap and safety wire.

2. MAJOR ADJUSTMENT.–If the correct position of the adjusting screw has been lost, as in disassembly, the valve can be adjusted by turning the adjusting screw in until the spring is almost completely compressed. Then increase the system pressure to 1300 psi with the hydraulic hand pump. Turn the adjusting screw out until the temperature relief valve opens, as indicated by a pressure drop. Tighten the locknut, raise the system pressure again as a check, and make final minor adjustment as may be required.

(e) TESTS BEFORE INSTALLATION.–Refer to *figure 294* for leak tests.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY. – To assemble the temperature relief valve refer to *figure 294*.

2. INSTALLATION.–To install the temperature relief valve, reverse the REMOVAL procedure.

(g) MAJOR OVERHAUL.

1. Remove and disassemble the temperature relief valve as instructed in paragraph 14. *f.* (7) *(b)*, this section.

2. Thoroughly wash all parts in clean hydraulic fluid.

3. Inspect the valve ball for roughness or corroded surfaces. Replace the ball if there is evidence of roughness or corrosion.

4. Check the condition of valve seat. A valve seat that is slightly worn can be reconditioned by carefully lapping with extra-fine grinding compound. Select a short length of steel tubing that has an inside diameter slightly smaller than the valve ball outside diameter. Force a ball firmly into the end of this tube so that slightly more than one-half of the ball extends from the tube. Lap the ball to the seat, using a combined tapping and rotary motion to avoid "ringing" the valve seat. After a smooth, true seat is obtained, the seat and valve body should be carefully washed in clear gasoline to remove every trace of grinding compound.

Note

The ball used for grinding MUST NOT be used in the valve, and a new ball must be installed when reassembling the valve.

5. If the valve seat cannot be satisfactorily reconditioned by lapping, it should be replaced. Both valve seat and valve ball should be replaced at the same time, because it is impossible to obtain a satisfactory seal when a new seat is used with an old ball, or when a new ball is installed without first lapping the old seat to a true surface.

6. Inspect all remaining parts for wear and make necessary replacements. Assemble the valve and tests for fluid leaks as instructed in *figure 294*.

g. BRAKE EMERGENCY AIR SYSTEM.
(See figure 295.)

(1) GENERAL. – An independently operated brake emergency air system consisting of an air bottle *(11, figure 295)*, pressure gage *(8, figure 295)*, control valve *(6, figure 295)*, shuttle valves *(2, figure 295)*, and necessary fittings, provides a means of applying the brakes when the hydraulic system is not functioning. Air pressure is directed to the brakes without using the rudder-brake pedals. The air bottle contains sufficient air under pressure for three applications of the brakes. The brake emergency air system shuttle valves *(2, figure 295)* close the brake hydraulic system lines when the air system is utilized. The pressure gage is attached to a bracket at the left of the landing gear position selector valve on the canopy in the pilot's compartment. The brake air control valve also is attached to the bracket and is controlled by cables attached to a control lever on the pilot's control pedestal *(3, figure 295)*. The control lever has three positions, "NEUTRAL," "ON," and "RELEASE."

CAUTION

The brakes must be bled (see paragraph 14. *e.* (2) *(d) 1.*, this section) after each use of the air system as the brake hydraulic system will not operate properly when air is entrapped in the hydraulic lines.

(2) BRAKE AIR BOTTLE.
(See 11, figure 295.)

(a) DESCRIPTION.–The cylindrical steel air bottle, located aft of the emergency hydraulic system fluid reservoir, contains 67 cubic inches of compressed air at an initial pressure of 575 psi. The bottle is connected to a manifold block which also is the connection for the brake air control valve, air pressure gage, and air filler valve for charging the bottle. To charge the air bottle, use a booster pump, high pressure air pump, or large air bottle and charge the bottle until the pressure gage indicates 575 psi. Charge the bottle at the air valve in the manifold block to the left of the air pressure gage. *(See 10, figure 295.)* The air bottle should be recharged when the pressure decreases to 450 psi.

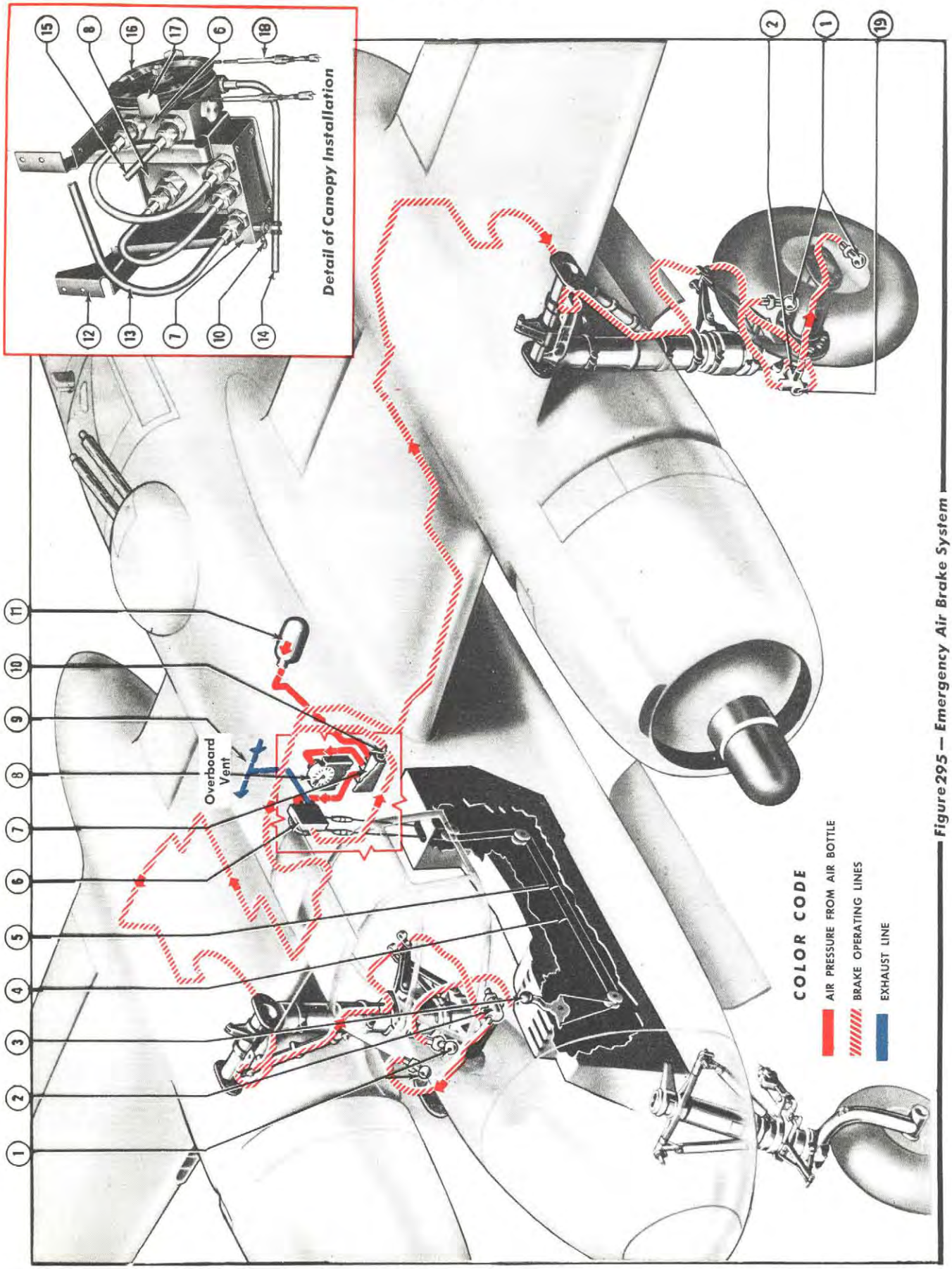


Figure 295 — Emergency Air Brake System

KEY TO FIGURE 295

1. Self Sealing Disconnect Couplings
2. Brake Emergency Air Shuttle Valve
3. Brake Emergency Air Control Lever (*Figure 288*)
4. Brake Emergency Air Cable
5. Brake Emergency Air Cable
6. Brake Air Control Valve (*Figure 296*)
7. 4151285 Manifold Assembly
8. Brake Air Pressure Gage
9. Tee in Vent Line from Emergency System Reservoir to Main System Reservoir. (On Some Airplanes the Brake Air Exhaust Line Is Connected to the Vent Line From the Main System Reservoir to the De-Icer Exhaust Vent)
10. Air Bottle Filler Valve Assembly
11. Brake Air Bottle (Recharge to 575 psi when the Air Pressure Decreases to 450 psi)
12. Mounting Bracket Assembly
13. Pressure Line From Air Bottle
14. Brake Operating Line
15. Exhaust Line
16. Pulley
17. Pulley Guard
18. Brake Air Control Valve Pulley Cable
19. Connection for Brake Hydraulic Line (*Figure 282*)

(b) REMOVAL.

1. Relieve the pressure in the air bottle by backing off the air valve in the manifold block.

2. Disconnect the line to the bottle.

3. Unbolt the strap assembly holding the bottle, and remove the bottle.

4. The only disassembly possible is to remove nut, connector and gasket.

(c) MAINTENANCE REPAIR OR REPLACEMENT.

1. Check for leaking connections by applying a thin neutral soap solution to the air bottle connection. If tightening fails to stop the air leak, replace the connection and gasket.

2. If the bottle is damaged or inspection reveals deep scratches, cracks or serious defects, a new bottle should be installed.

(d) TEST BEFORE INSTALLATION.–Apply 675 psi pressure at inlet. There should be no external leakage.

(e) INSTALLATION.–To install the air bottle, reverse the REMOVAL procedure.

(3) BRAKE AIR CONTROL VALVE AND CABLE CONTROLS.
(See figures 296 and 297.)

(a) DESCRIPTION. – This two-way valve, mounted on a bracket to the left of the landing gear position selector valve on the canopy of the pilot's compartment, controls the air pressure to apply the brakes. The valve has three ports, one to the brake operating line, one to the exhaust line, and one to the air pressure supply line. Two poppets, actuated by a cam assembly, control the flow of air through the valve. The valve is controlled by cables attached to a lever on the pilot's control pedestal *(figure 288)*.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve the air pressure by backing off the air valve in the manifold block.

b. Disconnect the three lines leading to the brake air control valve.

c. Remove the drum and cable assembly from the control shaft of the valve.

d. Remove the screws that attach the valve to the bracket and remove the valve.

2. DISASSEMBLY.–Refer to *figure 296* if disassembly of the brake air control valve is attempted.

(c) MAINTENANCE REPAIR.–If the valve is damaged or not functioning properly, it should be replaced with a new or serviceable part. Inspect the cable controls periodically for general condition and security. Replace damaged parts with new parts.

(d) ADJUSTMENTS.–If the valve has been disassembled, the set screws in the piston assemblies should be adjusted to obtain a minimum poppet lift of .032 inches, and a shaft rotation of four to nine degrees on each side of the neutral position of the control shaft before the poppets are opened. Refer to *figure 297* for proper rigging of the cable controls.

(e) TESTS BEFORE INSTALLATION.–Refer to *figure 296* for leak tests.

(f) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.–To assemble the brake air control valve refer to *figure 296*.

2. INSTALLATION.–To install the brake air control valve, reverse the REMOVAL procedure.

(4) BRAKE AIR PRESSURE GAGE.
(See figure 288.)

(a) DESCRIPTION.—The brake air pressure gage, attached to a bracket on the canopy in the pilot's compartment, indicates pressure from zero to 750 psi, and indicates the air pressure available in the air bottle to apply the brakes in an emergency.

(b) REMOVAL.

1. Relieve the air pressure by backing off the air valve in the manifold block.

2. Disconnect the line to the air pressure gage.

3. Remove the attaching screws and remove the valve.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—If the air gage is damaged or is not functioning properly, replace with a new or serviceable gage. Repairs to the air gage will be accomplished only at depots by qualified personnel.

(d) INSTALLATION.—To install the air pressure gage, reverse the REMOVAL procedure.

(5) BRAKE EMERGENCY AIR SHUTTLE VALVES.
(See figure 298.)

(a) DESCRIPTION.—The brake emergency air shuttle valves are attached to the inboard end of each main landing gear axle, and close the brake hydraulic lines when the brake emergency air system is being used. The spring-seated steel cone within the valve normally closes the air pressure port when the brake hydraulic system is being operated.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.

a. Relieve hydraulic system pressure by applying and releasing the rudder-brake pedals until the hydraulic system pressure gage indicates zero.

b. Disconnect and cap the hydraulic lines leading to the shuttle valve.

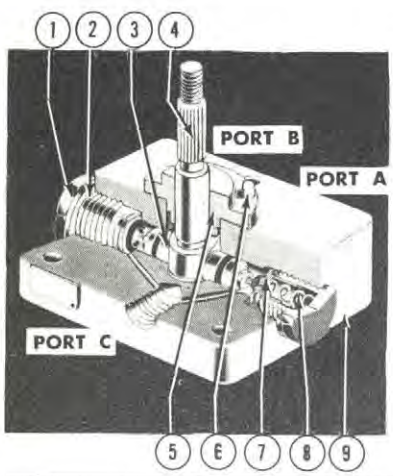
c. Remove the bolts attaching the valve support to the main landing gear axle.

d. Disconnect the union from the shuttle valve.

e. Remove the three screws attaching the shuttle valve to the valve support, and remove the valve.

2. DISASSEMBLY.—Refer to *figure 298* when disassembly of the shuttle valve is attempted.

(c) MAINTENANCE REPAIR OR REPLACEMENT.—To prevent internal leaks and consequent



1. Cap
2. AN900-11 Gasket
3. Piston Assembly (Includes AN6227-4 Packing)
4. Control Shaft
5. Bearing
6. Screws and Lock Wire
7. Poppet
8. Spring
9. Valve Body

Douglas Drawing No. 4128185
Bendix Aviation Ltd. No. 402246

TEST PROCEDURE				
TEST PRESS.	HDLE. POS.	PORTS PLUGGED	MAX. LEAKAGE	
			INTERNAL	EXTERNAL
650 psi air press. at Port A	#3	C	None at Port B	None
650 psi air press. at Port A	#2		None at Port C	None

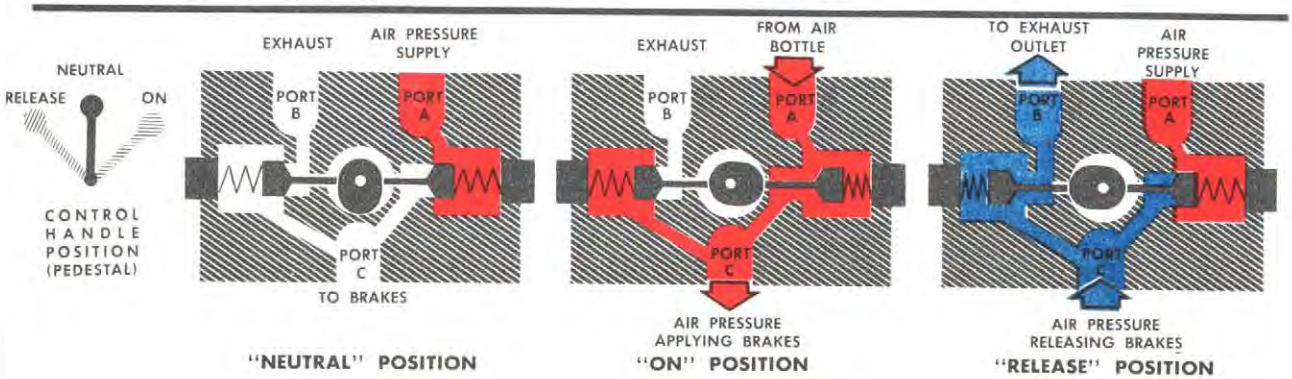
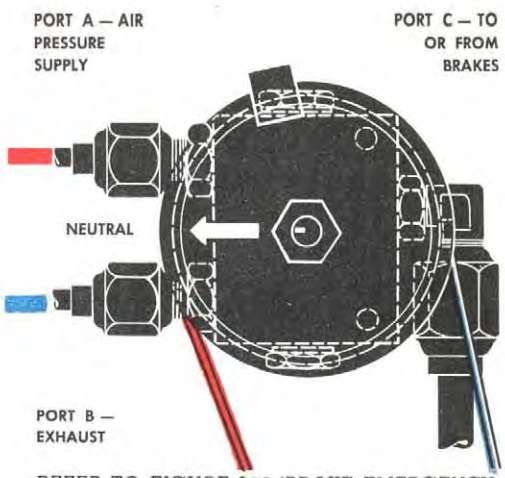


Figure 296 — Brake Emergency Air Control Valve

BRAKES "ON" POSITION

BRAKES "NEUTRAL" POSITION

BRAKES "RELEASED" POSITION



REFER TO FIGURE 296 (BRAKE EMERGENCY AIR CONTROL VALVE) FOR VALVE DETAILS

1. Brake Emergency Air Control Lever
2. Brakes "ON" Cable *(Figure 606, Item 35)*
3. Brakes "RELEASE" Cable *(Figure 606, Item 35)*
4. Pulley
5. Pulley Guard
6. Brake Air Control Valve
7. Valve Pulley Cable Assembly *(Figure 606, Item 84)*
8. Bracket Assembly
9. Air Pressure Gage
10. Air Filler Valve Assembly
11. Manifold Assembly
12. Turnbuckles

—*NOTES*—

a. Reg. cables with brake emergency air control lever in "Neutral" position and mark on brake air control valve shaft pointing directly aft as shown.

b. Refer to Figure 74 to obtain proper cable tension.

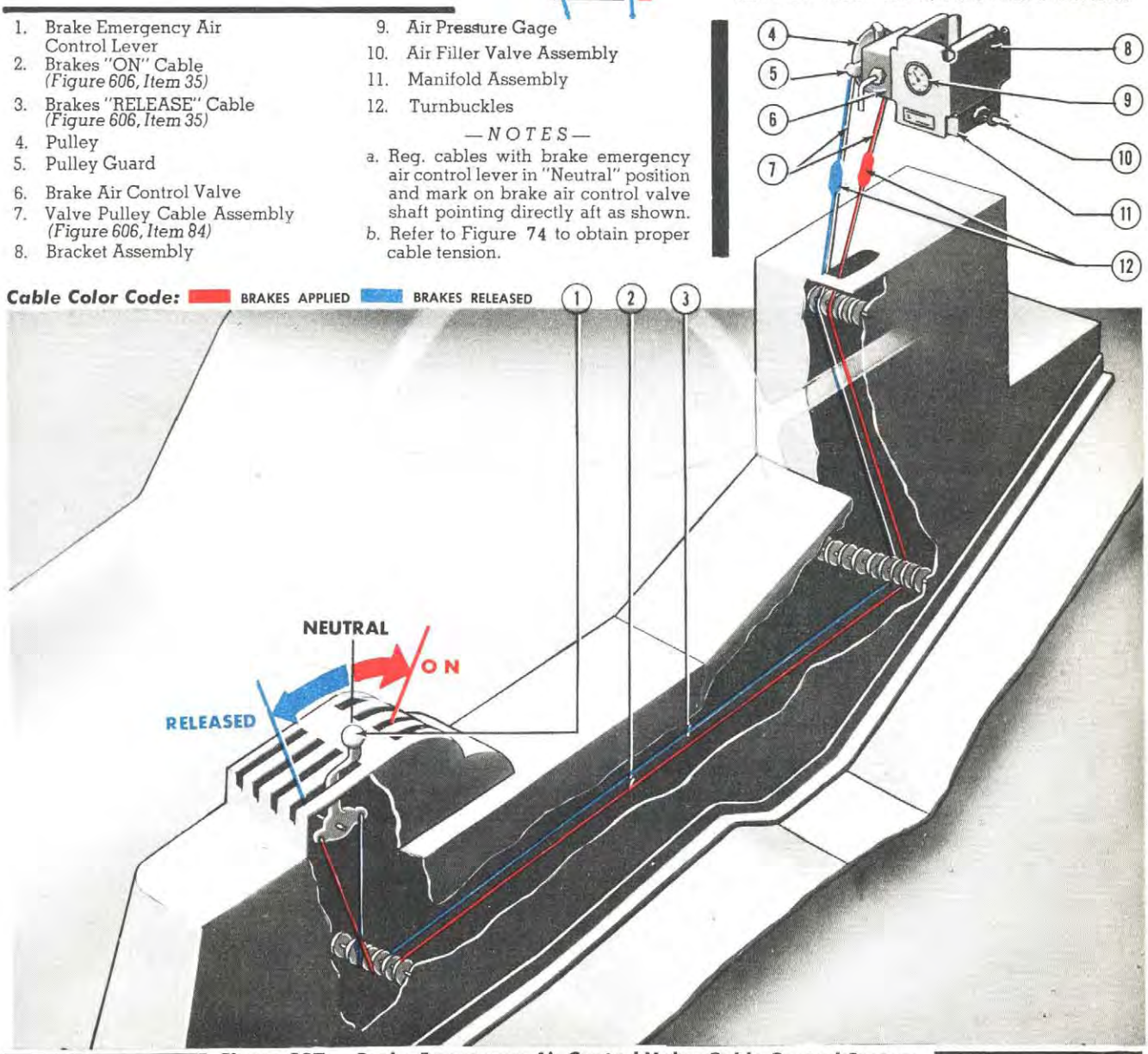


Figure 297 — Brake Emergency Air Control Valve Cable Control System

sluggish or spongy action of the brakes will be the primary maintenance problem in connection with the shuttle valve.

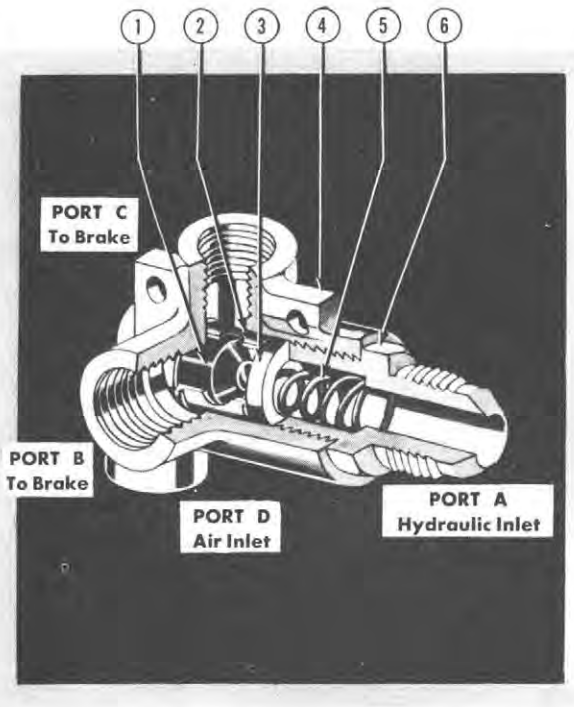
1. After disassembly of the valve, wash all parts in clean hydraulic fluid.

2. Inspect the steel cone and seats for evidences of pitting, corrosion, and other defects. New seats and cone should be installed if inspection reveals excessive wear.

3. Check the spring for evidence of fatigue or wear, and install new spring if necessary.

4. Inspect the remaining parts for wear, cracks, and other defects and make necessary replacements.

(d) TESTS BEFORE INSTALLATION.—Refer to *figure 298* for leak tests of the shuttle valve.



1. Cone
2. Spacer
3. Seat—2 Required (Emergency Substitute Part may be made from AN6226-9)
4. Body
5. Spring
6. Connector (Apply 420 inch-pounds Torque Maximum) and Lock Wire

TEST PROCEDURE			
TEST PRESS.	PORTS PLUGGED	MAX. LEAKAGE	
		INTERNAL	EXTERNAL
700 psi–Port A	Ports C and D	None at Port B	None
700 psi–Port B	Ports C and D	None at Port A	None

Douglas Drawing No. 4127548

Figure 298—Brake Emergency Air Shuttle Valve

(e) ASSEMBLY AND INSTALLATION.

1. ASSEMBLY.—To assemble the shuttle valve refer to *figure 298.*

2. INSTALLATION.—To install the shuttle valve, reverse the REMOVAL procedure.

(6) TEST OF THE BRAKE EMERGENCY AIR SYSTEM.

(a) By means of a booster pump, a high pressure air pump, or a large air bottle, fill the brake emergency air bottle until the air pressure gage indicates 575 psi.

(b) With the foot brakes off, apply the brakes by placing the brake air control lever in the "ON" position. Keep the lever in the "ON" position for 15 minutes.

(c) After an initial pressure drop to 375 ± 25 psi the air pressure should remain constant.

(d) The wheels should be locked. Check them by attempting to roll the airplane forward or backward.

(e) After the initial pressure drop, any definite decrease from the constant pressure indicates an air leak in the system.

(f) If an air leak is present, locate it by applying a thin, neutral soap solution to all connections in the brake air system.

(g) Tighten any leaking connections, and test again with soap solution. If a connection still leaks air, replace it with a new connection.

(h) Relieve the air pressure on the brakes by placing the control lever in the "RELEASE" position. Air pressure in the emergency line will be exhausted to the atmosphere. Return the control lever to the "NEUTRAL" position and recharge the air bottle to 575 psi.

(i) The brakes now must be bled in accordance with the instructions in paragraph 14. *e.* (2) *(d),* this section.

h. TUBING AND FLEXIBLE HOSES.

(1) TUBING.—52SO aluminum alloy tubing is used throughout the hydraulic system in this airplane. AN-type end fittings are used on the hydraulic lines.

(a) REMOVAL OF LINES.—All hydraulic lines in the airplane may be removed by first relieving the system operating pressure and unscrewing the fittings at the ends of the lines. Attaching clips or clamps also must be removed. The ends of exposed lines must be capped to prevent dust and grit from entering the hydraulic fluid. Do not use rubber plugs to seal exposed lines. Rubber plugs may be shredded by the threads, and rubber particles will be circulated through the hydraulic system.

(b) INSTALLATION.—Before installation all lines and fittings should be blown out with clean, dry air. Apply thread lubricant sparingly. Great care must be observed in properly tightening the nuts. Overtightening may completely cut off or severely damage the tube flare. The line will blow out if the nut is not tightened sufficiently. Carefully observe the wrench-torques given in Section VIII.

(c) FABRICATION.—Refer to Section VIII for general information on the fabrication of tubing.

(2) FLEXIBLE HOSES.—Approved, winterized, flexible hoses are installed on the movable parts in the hydraulic system.

CAUTION

Hydraulic actuating cylinders should not be handled by the hoses, or allowed to hang loosely from these hoses. Flexible hose should not be bent to a radius less than nine times its outside diameter. Do not install a flexible hose so that it is subjected to a twisting load. On all flexible hoses, there is a stripe running the entire length of the hose to determine any twisting after installation. A hose should not be stretched tightly between two fittings. About 5 to 8 percent of the total length of the hose must be allowed for slack to prevent the hose from being pulled out of the fittings when it is subjected to pressure. Hose must be protected against chafing, where necessary, by a suitable cover or boot.

i. CLIPS, CLAMPS, AND MISCELLANEOUS FITTINGS.

(1) CLIPS AND CLAMPS.—The hydraulic lines are held in place by clips and clamps which are placed at definite intervals to reduce line vibrations. The cushion clips and clamps are tightened sufficiently to hold the lines firmly. These line supports are bonded to the airplane in order that there shall be no vibrations and subsequent static electric charges generated that will interfere with the airplane's radio. These supports provide a vibration-absorbing cushion for the lines to eliminate fatigue and mechanical damage at the attachment point.

Note

It usually is desirable to slightly tighten the clips after a few hundred hours of service to compensate for initial displacement or cold flow of the cushioning material. When this service is not done, it is possible under adverse conditions for moisture to condense or otherwise reach the bonding material with attendant corrosive action and high resistance.

(2) MISCELLANEOUS FITTINGS.—Several types of multiple connectors are used in this airplane. Since these connectors have no moving parts, they require little maintenance except occasional tightening of unions or replacing of gaskets to prevent fluid leakage.

j. COMPLETE HYDRAULIC SYSTEM TEST.

(1) GENERAL.

(a) Support the airplane on wing and nose stands in flying attitude according to the instructions in Section III.

(b) With zero pressure in the hydraulic system, charge the pressure accumulator to 600-750 psi air pressure.

Note

When charging the accumulator with air, the air pressure should not indicate on the hydraulic system pressure gage. If pressure is indicated on the hydraulic pressure gage *(figure 247)*, relieve the hydraulic system pressure by applying toe pressure to and releasing the rudder-brake pedals.

(c) Fill the hydraulic reservoir *(figure 254)* with hydraulic fluid (Specification AN-VV-O-366). Use filler funnel. The hydraulic reservoir sight gage should indicate FULL according to the instruction plate on the reservoir.

(d) Connect a motor-driven hydraulic test stand pump to the firewall disconnect couplings at either the right or left nacelle firewalls. The test stand pump should deliver five gallons a minute at 1000 psi, in order to operate the hydraulic units at their correct speeds.

(e) Operate all hydraulic units repeatedly to their full extent until all air is driven from the hydraulic system. Operate units slowly to prevent overflowing of the reservoir by foamy oil. If necessary, refill the fluid reservoir according to the instruction plate on the reservoir.

(2) HYDRAULIC SYSTEM PRESSURE REGULATOR.—Check operation of the hydraulic fluid pressure regulator. The regulator should "cut-in" at 850 $\pm$ 20 psi and "cut-out" at 1000 $\pm$ 20 psi.

(3) HYDRAULIC SYSTEM PRESSURE CHECK.

(a) Check all fluid reservoir to engine-driven pump line connections individually for loose fittings.

(b) Place the landing gear control lever in the "DOWN" position. Place the bomb bay doors control in the "DOORS OPEN" position. Operate the hydraulic hand pump to raise the system pressure to 1100 psi. The system pressure should not drop below 1000 psi in five minutes.

(c) With ground safety pins installed on the main landing gear and nose gear, place the landing

gear control lever in the "UP" position. Place the bomb bay doors control in the "CLOSED" position. Operate the hydraulic hand pump to raise the system pressure to 1100 psi. The system pressure should not drop below 1000 psi in five minutes.

(4) LANDING GEAR.

(a) Adjust the main landing gear according to the instructions outlined in paragraph 5. *b.* (1) *(d)*, this section.

(b) Adjust the nacelle doors according to the instructions given in paragraph 5. *b.* (6) *(d)*, this section.

(c) Adjust the nose wheel and nose wheel doors according to the instructions in paragraph 5. *c.* (6) *(d)*, this section.

(d) Place the left and right battery switches *(figure 323)* "ON." Depress the retraction release switch *(figure 364)* on the left hand main landing gear shock strut. The solenoid plunger detent pin at the landing gear position selector valve should not permit movement of the position selector valve auxiliary handle to the "UP" position. With the landing gear latched down, and the landing gear position selector valve in the "DOWN" or the "NEUTRAL" position, the instrument panel indicator should show all three gears in the DOWN position.

(e) Retract the landing gear to the latched "UP" position. The landing gear should retract and lock in 12 seconds maximum. The nacelle doors should close completely and fair (fit flush) with the fuselage. There should be no interference. The landing gear and flap position indicator or indicator lamps should show all three gears in the "UP" position. A red lamp *(figure 232)* on the pilot's instrument panel should light when the throttle is "CLOSED."

(f) Place the landing gear control lever in the "DOWN" position. The landing gear should extend and lock in 12 seconds maximum. A green lamp on the pilot's instrument panel should light.

(g) External fluid leakage in the landing gear actuating cylinders should not exceed one drop in five pressure applications.

(h) The nose wheel shock strut and the main landing gear shock struts should be filled with hydraulic fluid and inflated with air in accordance with the instruction plate on the shock strut. Refer to paragraph 5. *c.* (3) *(c) 2. and 3.*, this section.

(i) The nose wheel snubber reservoir should be full of hydraulic fluid (Specification AN-VV-O-366) according to the instructions in paragraph 5. *c.* (5) *(e)*, this section.

(5) BOMB BAY DOORS.

(a) With the bomb racks empty, place the bomb bay doors control *(figure 247)* in the "DOORS OPEN" position. The bomb bay doors should open completely in four seconds maximum. A red lamp *(figure 232)* in the pilot's compartment should light. There should be no interference, and external fluid leakage of any cylinder should not exceed one drop in five pressure applications.

(b) Place the bomb bay doors control in the "DOORS CLOSED" position. The bomb bay doors should close completely in four seconds maximum. The red lamp in the pilot's compartment no longer should be lighted. There should be no interference or external leakage.

(c) With the bomb bay doors control lever (on some airplanes) in the "NEUTRAL" position, place the bomb bay door lock switch (on some airplanes) located in the forward end of the bomb bay in the "LOCKED" position. Check switch in the aft end of the bomb bay the same way. It should be impossible to move the bomb bay door selector valve in either direction. A red lamp on the switch panel should light when either of the lock switches is in the "LOCKED" position.

(6) WHEEL BRAKES (HYDRAULIC PRESSURE).

(a) Adjust the brakes in accordance with paragraph 5. *b.* (4) *(d)*, this section.

(b) Adjust the power brake control valves in accordance with the instructions given in paragraph 5. *e.* (2) *(d)*, this section.

(7) EMERGENCY HYDRAULIC SYSTEM. *(See figure 287.)*

(a) Place the emergency hydraulic system selector valve control handle and bomb bay doors control in the "BOMB DOORS OPEN" position. Operate the hydraulic hand pump to raise the pressure to 1100 psi. The bomb bay doors should open with approximately 60 strokes of the hydraulic hand pump. The pressure should not drop below 1000 psi in five minutes. There should be no interference or external fluid leaks.

(b) Place the emergency hydraulic system selector valve control handle and bomb bay doors control in the "BOMB DOORS CLOSED" position. Operate the hydraulic hand pump to raise the pressure to 1100 psi. The bomb bay doors should close with approximately 50 strokes with the hand pump. The pressure should not drop below 1000 psi in five minutes. There should be no interference or external fluid leaks.

(c) Place the emergency selector valve control handle in the "LANDING GEAR DOWN" position

and landing gear control lever in the "DOWN" position. Operate the hydraulic hand pump to raise the pressure to 1100 psi. The landing gear should extend with approximately 170 strokes with the hand pump, and the pressure should not drop below 1000 psi in five minutes. There should be no interference or external fluid leaks.

(8) WHEEL BRAKES (EMERGENCY AIR PRESSURE).

(a) With an initial air charge of 575 psi in the brake emergency air bottle, place the brake emergency air control lever in the "ON" position. The air pressure gage should indicate 375 ± 25 psi. There should be no external leakage of air.

(b) Place the emergency brake control lever in the "RELEASE" position. The air pressure on the brakes will exhaust to the atmosphere. There should be no external leakage of air. When the test is completed, return the brake emergency air control lever to "NEUTRAL" position.

(c) Bleed the brakes in accordance with instructions outlined in paragraph 14. *e.* (2) *(d)* 1., this section. Recharge the brake emergency air bottle to 575 psi.

k. HYDRAULIC SYSTEM TROUBLE SHOOTING CHART.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
1. Engine-driven pumps fail to deliver normal pressure.	*a.* Loose or faulty connections at the pumps.	*a.* Tighten loose connections or install new connections if necessary.
2. Engine-driven pumps fail to deliver fluid.	*a.* Loose or faulty connections at the pumps.	*a.* Tighten loose connections or install new connections if necessary.
	b. Incorrect direction of rotation.	*b.* Mount the pump correctly on the engine drive according to instructions outlined in paragraph 14. *b.* (2) *(d)*, this section.
	c. Pump drive shaft sheared by overloading.	*c.* Install new pump.
	d. Air lock in pump.	*d.* Bleed system.
3. Oil leakage at pressure accumulator cap.	*a.* Retainer insufficiently tightened.	*a.* Tighten retainer.
	b. Damaged bladder.	*b.* Install new bladder.
4. Line hammer.	*a.* Loss of air pressure in pressure accumulator.	*a.* Check for air leaks and damaged bladder.
	b. Low air pressure in accumulator.	*b.* Charge accumulator to correct pressure (600-750 psi) and check air valve for leakage.
	c. High air pressure in accumulator.	*c.* Bleed air valve to obtain correct pressure (600-750 psi).
5. Frequent loading and unloading of pressure regulator.	*a. See* 4. *a.* through *c.*, above.	*a. See* 4. *a.* through *c.*, above.
6. Sudden pressure drop when system is operated.	*a.* See 4. *a.* through *c.*, above.	*a. See* 4. *a.* through *c.*, above.
7. Loss of air pressure in pressure accumulator.	*a.* Leaks at accumulator air valve.	*a.* Install new air valve core, gasket, or both.
	b. Punctured or torn bladder.	*b.* Install new bladder in pressure accumulator.
8. Sluggish response of pressure accumulator.	*a.* Oil screen in accumulator clogged.	*a.* Clean the oil screen with a soft bristle brush.
9. Fluid leaks at packing nut of hydraulic hand pump.	*a.* Packing nut insufficiently tightened.	*a.* Tighten packing nut.
	b. Pump packing rings sheared during assembly, or packings are worn or deteriorated.	*b.* Install new packing rings with care.

k. HYDRAULIC SYSTEM TROUBLE SHOOTING CHART.—Continued.

TROUBLE	*PROBABLE CAUSE*	*REMEDY*
10. Hydraulic hand pump fails to deliver pressure.	*a.* Piston head packings leaking because of shearing during assembly or deterioration and excessive wear.	*a.* Install new packings with care.
	b. Ball in piston head check valve does not seat properly.	*b.* Reseat the ball. If ball cannot be properly seated because of condition of seat and ball, lap seat with extra fine grinding compound. Install new ball.
11. Actuating cylinder operates sluggishly.	*a.* Internal fluid leaks because of worn piston sealing ring.	*a.* Install new sealing ring.
	b. Internal fluid leaks of shuttle valve.	*b.* Check cone in shuttle valve for proper seating. Replace cone or seats if damaged. and replace cone or seats.
12. Actuating cylinder leak at piston rod or at cylinder head joint.	*a.* Packing retaining nut insufficiently tightened.	*a.* Tighten packing retaining nut moderately.
	b. Packing rings worn or deteriorated.	*b.* Install new packing rings with care.
13. Emergency air brake handle applied, but brakes are not applied and air pressure is unchanged.	*a.* Mechanical failure in the cable system from pilot's emergency brake control handle to air control valve.	*a.* Inspect system for mechanical failure or maladjustment. Repair, replace, or readjust mechanical parts where necessary.
14. Emergency air brakes respond, but indicated air pressure continues to drop as long as brake handle is held in the "ON" position.	*a.* External fluid leaks in emergency air brake system.	*a.* Repair or replace parts and fittings where leakage occurs.
	b. Air leaks through the hydraulic system at the shuttle valves.	*b.* Inspect shuttle valves for proper seating of cone, and repair if necessary.
15. No pressure is indicated by the emergency brake air pressure gage.	*a.* No air pressure in the air bottle.	*a.* Charge bottle to 575 psi and observe air pressure gage for evidence of leaks in air control valve. If valve is leaking, remove, disassemble, and repair.