AN 01-60JE-2

# *ERECTION AND MAINTENANCE INSTRUCTIONS*

*FOR*

ARMY MODELS

# P-51D-5, -10, -15, -20, -25
# P-51K-1, -5, -10, -15

BRITISH MODEL

# MUSTANG IV

AIRPLANES

The pink pages in this handbook are temporary revision pages prepared by the Contractor to incorporate the latest available information. These temporary pages will be superseded by official revision pages supplied by the A.A.F. Upon receipt of such official revisions, the pink temporary pages should be removed.

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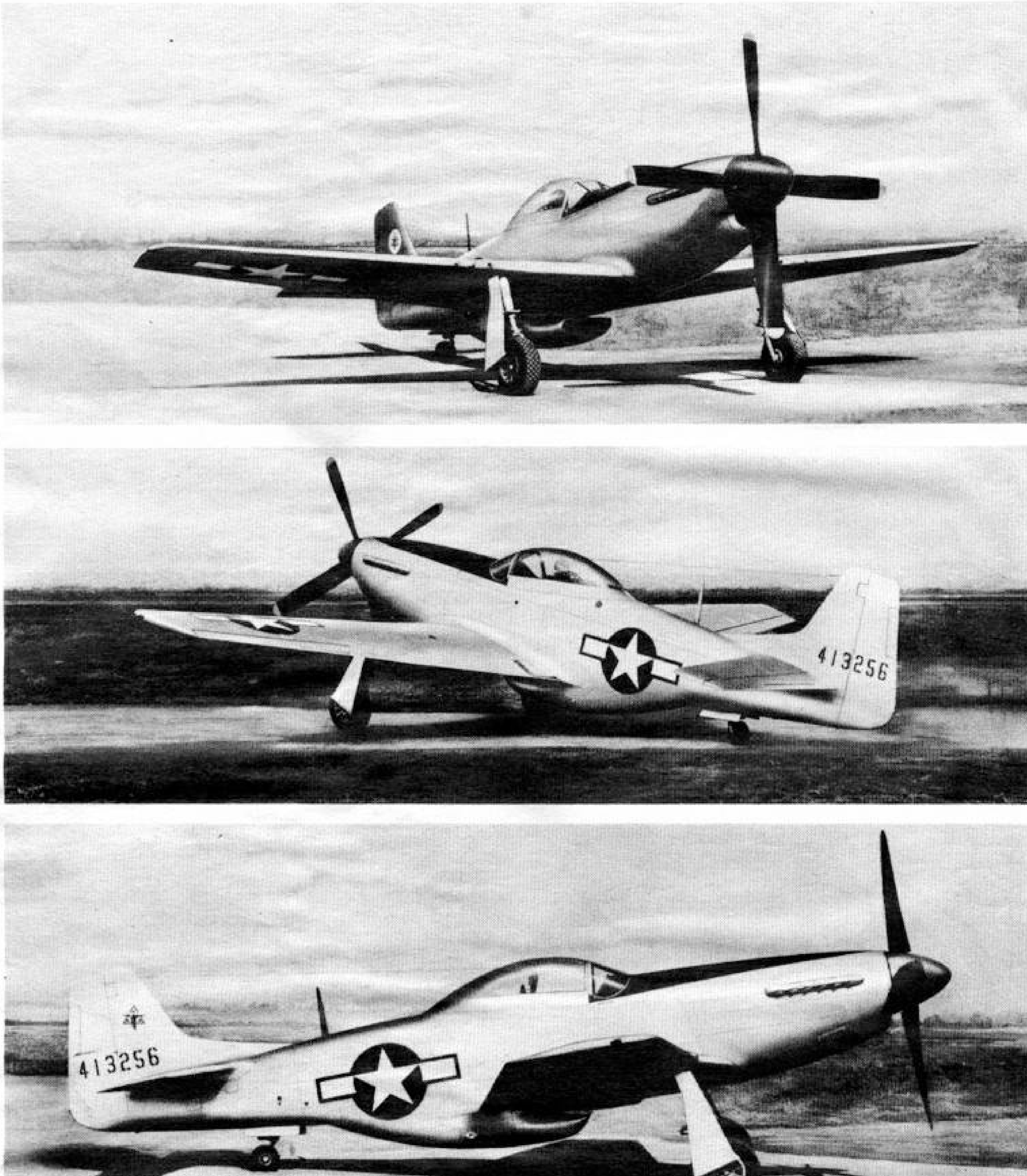


*Three Views of Airplane*

# Appendix I

## UNITED STATES-BRITISH GLOSSARY OF AERONAUTICAL NOMENCLATURE

| UNITED STATES | BRITISH EQUIVALENTS |
|---|---|
| Accumulator | Accumulator or Pressure Reservoir |
| Air Controls or Cable Controls | Flying Controls |
| Air Duct | Interconnecting Sleeve or Trousers |
| Air Filter | Air Cleaner |
| Airplane | Aeroplane |
| Airplane Tail, Empennage, or Tail Group | Empennage or Tail Unit |
| Airport, Airfield, or Airdrome | Aerodrome |
| Airspeed Head or Pitot Tube | Pressure Head |
| Anchor Lights | Riding Lights or Mooring Lights |
| Antenna | Aerial |
| Artificial Horizon or Gyro Horizon | Artificial Horizon |
| Automatic Pilot, Gyro Pilot, Mechanical Pilot, or Robot Pilot | Automatic Pilot, Automatic Control, or George |
| Battery, Storage | Storage Battery or Accumulator |
| Binding Post | Terminal |
| Bulletproof Glass | Armour Glass |
| Cable Controls or Air Controls | Flight Controls |
| Calibrated Speed | Indicated Air Speed (A.S.I.) |
| Ceiling | Cloud Height |
| Center Section or Center Wing Panel | Centre Section or Centre Plane |
| Check Valve | Check Valve or Non-return Valve |
| Chord | Chord Line |
| Clevis | Clevis, Fork Joint, or Knuckle Joint End |
| Command Set | Pilot Controller Set |
| Cone, Split | Collet |
| Cone, Union | Nipple |
| Control Stick | Control Column |
| Controls, Air, or Cable Controls | Flying Controls |
| Converter | Converter or Motor Generator (A.C. to D.C.) |
| Cotter Pin | Split Pin |
| Driftmeter or Drift Indicator | Drift Sight |
| Empennage, Airplane Tail, or Tail Group | Empennage or Tail Unit |
| Engine Section (complete) | Power Plant |
| Feathering | Feathering or Differential Pitch-control |
| Filter, Air | Air Cleaner |
| Filter, Screen, or Oil Strainer | Filter |
| Firewall | Fireproof Bulkhead |
| Flare, Signal | Signal Projectile or Signal Star |
| Fuel Gage or Fuel Level Gage | Fuel-contents Gauge or Fuel Level Indicator |
| Fuel, Gasoline, or Gas | Fuel or Petrol |
| Gasket | Gasket, Joint, or Washer |
| Gasoline Capacity or Fuel Capacity | Fuel Volume or Petrol Volume |
| Gasoline, Gas, or Fuel | Fuel or Petrol |
| Generator | Generator or Dynamo |
| Glass, Armor, or Bulletproof Glass | Armour Glass |
| Gyro Horizon or Artificial Horizon | Artificial Horizon |
| Hardware | Ironmongery |
| Horizontal Stabilizer or Stabilizer | Tail Plane |
| Hydraulic Cylinder or Hydraulic Strut | Jack |
| Indicated Airspeed (IAS) | Air-Speed-Indicator Reading |
| Inspection Window | Inspection Port |

| UNITED STATES | BRITISH EQUIVALENTS |
|---|---|
| Interphone | Intercommunication or Intercom |
| Inverter | Motor Generator (D.C. to A.C.) |
| Landing Gear or Undercarriage | Alighting Gear, Undercarriage or Chassis |
| Leading Edge Airfoil or Slat | Slat |
| Left | Port |
| Liaison Set | General Purpose Set |
| Life Raft | Dinghy |
| Lights, Anchor | Riding Lights or Mooring Lights |
| Lockring or Snap Ring | Circlip |
| Lock Washer | Spring Washer |
| Loop Antenna or Radio Loop | Loop Aerial |
| Manifold Pressure | Boost Pressure or Boost |
| Manifold Pressure Regulator | Boost Control Unit or Automatic Boost Control Unit |
| Manometer Pressure or Superpressure | Super-pressure |
| Meter, Drift, or Drift Indicator | Drift Sight |
| Meter, Frequency | Wavemeter |
| Monkey Wrench | Screw-spanner |
| Mooring Rings or Mooring Lugs | Picketing Rings |
| Mooring Spindle or Mooring Cone Outrigger | Mooring Spindle |
| Nut, Spanner | Ring Nut |
| Oil Cooler or Oil Radiator | Oil Cooler |
| Oil Strainer or Screen Filter | Filter |
| Outer Wing Panel or Outboard Panel | Outer Plane or Outer Main Plane |
| P-51D | Mustang IV |
| Pad | Accessory Mounting Face |
| Palnut | Locknut (type of) |
| Panel, Center Wing, or Center Section | Centre Section or Centre Plane |
| Panel, Outboard, or Outer Wing Panel | Outer Plane or Outer Main Plane |
| Pilot, Automatic,-Gyro Pilot, Mechanical Pilot or, Robot Pilot | Automatic Pilot, Automatic Control, or George |
| Pin, Cotter | Split Pin |
| Pitot Tube or Airspeed Head | Pressure Head |
| Post, Binding | Terminal |
| Radio | Wireless |
| Radio Loop or Loop Antenna | Loop Aerial |
| Radio operator | Wireless Operator |
| Raft, Life | Dinghy |
| Rib, Former, or False Rib | Nose Rib |
| Right | Starboard |
| Ring, Lock, or Snap Ring | Circlip |
| Rings, Mooring, or Mooring Lugs | Picketing Rings |
| Screen Filter or Oil Strainer | Filter |
| Screw, Cap | Set Screw |
| Screw, Fillister | Cheese-headed Screw |
| Screw, Flathead | Countersunk-head Screw |
| Seal, Valve | Jam Pot Cover |
| Setscrew or Headless Setscrew | Grub Screw |
| Shield or Screen (ignition) | Ignition Harness or Screening |
| Signal Flare | Signal Projectile or Signal Star |
| Slat or Leading Edge Airfoil | Slat |
| Snap Ring or Lockring | Circlip |
| Socket Wrench | Box Spanner |
| Spanner Nut | Ring Nut |
| Speed, Calibrated | Indicated Air-speed (A.S.I.) |
| Speed, Indicated Air (IAS) | Air-Speed-Indicator Reading |
| Split Cone | Collet |
| Stabilizer or Horizontal Stabilizer | Tail Plane |
| Stabilizer, Vertical, or Tail Fin | Fin |
| Stack | Pipe (single) |

| UNITED STATES | BRITISH EQUIVALENTS |
|---|---|
| Static Tube | Static-pressure Tube |
| Stick, Control | Control Column |
| Storage Battery | Storage Battery or Accumulator |
| Strut, Oleo, or Air-Oil Strut | Compression Leg, Shock Absorber Leg, or Oleo Leg |
| Supercharger, Reciprocating-type | Piston-type Supercharger |
| Superpressure or Manometer Pressure | Super-pressure |
| Tachometer | Tachometer, Engine Speed Indicator, Revolution Indicator or Rev. Counter |
| Tail Fin or Vertical Stabilizer | Fin |
| Tail Group, Airplane Tail, or Empennage | Empennage or Tail Unit |
| Traffic Control Projector | Traffic-control Light |
| Tube (radio) | Valve |
| Tube, Static | Static-pressure Tube |
| Union Cone | Nipple |
| Valve | Valve or Cock |
| Valve, Jettison, Dump Valve or Emergency Fuel-release Valve | Jettison Valve |
| Valve Seal | Jam Pot Cover |
| Vent | Vent-pipe |
| Vertical Stabilizer or Tail Fin | Fin |
| Washer, Lock | Spring Washer |
| Weight, Empty, or Dead Load | Tare Weight or Tare |
| Weight, Fixed Power Plant | Gross Dry-weight |
| Weight, Gross, or Full Load | Gross Weight or All-up Weight |
| Window, Inspection | Inspection Port |
| Windshield | Windscreen |
| Wing | Main Plane |
| Wires, Fairing | Circumferential Outer-cover Wires |
| Wrench, Monkey | Screw-Spanner |
| Wrench, Socket | Box Spanner |

# Appendix I

## UNITED STATES-BRITISH GLOSSARY OF AERONAUTICAL NOMENCLATURE

| BRITISH EQUIVALENTS | UNITED STATES |
|---|---|
| Accessory Mounting Face | Pad |
| Accumulator or Pressure Reservoir | Accumulator |
| Aerial | Antenna |
| Aerodrome | Airport, Airfield, or Airdrome |
| Aeroplane | Airplane |
| Air Cleaner | Air Filter |
| Air-Speed-Indicator Reading | Indicated Airspeed (IAS) |
| Alighting Gear, Undercarriage or Chassis | Landing Gear or Undercarriage |
| Armour Glass | Bulletproof Glass |
| Artificial Horizon | Artificial Horizon or Gyro Horizon |
| Automatic Pilot, Automatic Control or George | Automatic Pilot, Gyro Pilot, Mechanical Pilot or Robot Pilot |
| Boost Control Unit or Automatic Boost Control Unit | Manifold Pressure Regulator |
| Boost Pressure or Boost | Manifold Pressure |
| Box Spanner | Socket Wrench |
| Centre Section or Centre Plane | Center Section or Center Wing Panel |
| Centre Section or Centre Plane | Panel, Center Wing, or Center Section |
| Check Valve or Non-return Valve | Check Valve |
| Cheese-headed Screw | Screw, Fillister |
| Chord Line | Chord |
| Circlip | Snap Ring or Lockring |
| Circumferential Outer-cover Wires | Wires, Fairing |
| Clevis, Fork Joint or Knuckle Joint End | Clevis |
| Cloud Height | Ceiling |
| Collet | Split Cone |
| Compression Leg, Shock Absorber Leg, or Oleo Leg | Strut, Oleo, or Air-Oil Strut |
| Control Column | Control Stick |
| Converter or Motor Generator (A.C. to D.C.) | Converter |
| Countersunk-head Screw | Screw, Flat Head |
| Dinghy | Life Raft |
| Drift Sight | Driftmeter or Drift Indicator |
| Empennage or Tail Unit | Empennage, Airplane Tail, or Tail Group |
| Feathering or Differential Pitch-control | Feathering |
| Filter | Oil Strainer or Screen Filter |
| Fin | Vertical Stabilizer or Tail Fin |
| Fireproof Bulkhead | Firewall |
| Flying Controls | Air Controls or Cable Controls |
| Fuel-contents gauge or Fuel Level Indicator | Fuel Gage or Fuel Level Gage |
| Fuel or Petrol | Fuel, Gasoline, or Gas |
| Gasket, Joint, or Washer | Gasket |
| General Purpose Set | Liaison Set |
| Generator or Dynamo | Generator |
| Gross Dry-weight | Weight, Fixed Power Plant |
| Gross Weight or All-up Weight | Weight, Gross, or Full Load |
| Grub Screw | Setscrew or Headless Setscrew |
| Ignition Harness or Screening | Shield or Screen (ignition) |
| Indicated Air Speed (A.S.I.) | Calibrated Speed |
| Inspection Port | Inspection Window |
| Intercommunication or Intercom | Interphone |
| Interconnecting Sleeve or Trousers | Air Duct |
| Jack | Hydraulic Cylinder or Hydraulic Strut |
| Jam Pot Cover | Valve Seal |

| BRITISH EQUIVALENTS | UNITED STATES |
|---|---|
| Jettison Valve | Valve, Jettison, Dump Valve, or Emergency Fuel Release Valve |
| Locknut | Palnut |
| Loop Aerial | Loop Antenna or Radio Loop |
| Main Plane | Wing |
| Mooring Spindle | Mooring Spindle or Mooring Cone Outrigger |
| Motor Generator (D.C. to A.C.) | Inverter |
| Mustang IV | P-51D |
| Nipple | Union Cone |
| Nose Rib | Rib, Former, or False Rib |
| Oil Cooler | Oil Cooler or Oil Radiator |
| Outer Plane or Outer Main Plane | Outer Wing Panel or Outboard Panel |
| Picketing Rings | Mooring Rings or Mooring Lugs |
| Pilot Controller Set | Command Set |
| Pipe (single) | Stack |
| Piston-type Supercharger | Suprcharger, Reciprocating-type |
| Pressure Head | Airspeed Head or Pitot Tube |
| Port | Left |
| Power Plant | Engine Section (complete) |
| Riding Lights or Mooring Lights | Anchor Lights |
| Ring Nut | Spanner Nut |
| Screw-Spanner | Monkey Wrench |
| Set Screw | Screw, Cap |
| Signal Projectile or Signal Star | Signal Flare |
| Slat | Leading Edge Airfoil or Slat |
| Split Pin | Cotter Pin |
| Spring Washer | Lock Washer |
| Starboard | Right |
| Static-pressure Tube | Static Tube |
| Storage Battery or Accumulator | Storage Battery |
| Super-pressure | Manometer Pressure or Superpressure |
| Tachometer, Engine Speed Indicator, Revolution Indicator, or Rev. Counter | Tachometer |
| Tail Plane | Horizontal Stabilizer or Stabilizer |
| Tare Weight or Tare | Weight, Empty, or Dead Load |
| Terminal | Binding Post |
| Valve | Tube (radio) |
| Valve or Cock | Valve |
| Vent-pipe | Vent |
| Wavemeter | Meter, Frequency |
| Windscreen | Windshield |
| Wireless | Radio |

# ALPHABETICAL INDEX



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# Section I

# DESCRIPTION, DIMENSIONS, AND LEADING PARTICULARS

## 1. GENERAL DESCRIPTION.

The Model P-51D and P-51K Series Airplanes, powered with a Packard-built Rolls Royce V-1650-7 engine incorporating a two-stage two-speed supercharger, are single-place, low-wing fighters employing an NACA low-drag airfoil. The high speed and fuel capacity of these airplanes make them especially valuable for reconnaissance flights and long-range escort-fighter missions. The armament includes six machine guns, and two wing racks which can be used for bombs, depth charges, or chemical tanks. Droppable combat tanks may be substituted for bombs on long-range missions.

**Note**

The P-51D and P-51K Series Airplanes are identical except for the propeller installation and the propeller control system. The P-51D Airplanes are equipped with the Hamilton Standard propeller, and the P-51K Airplanes are equipped with the Aeroproducts propeller. Information on both types of propellers, as applicable to these airplanes, is included herein. As all other information in this handbook applies equally to both the P-51D and the P-51K Airplanes, only the designation P-51D is used for convenience sake.

### PRINCIPAL DIMENSIONS

(Aircraft in level flight position unless otherwise stated)

**General**

| | |
|---|---|
| Span | 37 ft. 5/16 in. |
| Length (over-all) | 32 ft. 3 5/16 in. |
| Height | 12 ft. 2 1/16 in. |
| Height (approx. height tail wheel on ground, propeller blade vertical) | 13 ft. 4½ in. |

**Wing**

| | |
|---|---|
| Airfoil section | NAA-NACA LOW DRAG AIRFOIL |
| Chord at root | 8 ft. 8 in. |
| Chord near tip (215 inches from fuselage centerline) | 4 ft. 2 in. |
| Incidence (variable) approximate | 1 degree |
| Dihedral (at 25% line) | 5 degrees |
| Sweepback (leading edge) | 3 degrees 35 min. 32 sec. |

**Stabilizer**

| | |
|---|---|
| Span | 13 ft. 2⅛ in. |
| Maximum chord | 2 ft. 6 in. |
| Incidence | 2 degrees |
| Dihedral | None |

**Fuselage**

| | |
|---|---|
| Width (maximum) | 2 ft. 11 in. |
| Height (maximum) | 6 ft. 9¼ in. |
| Length (without engine mount) (from firewall to end of fuselage without rudder) | 20 ft. 11½ in. |
| Length (with engine mount) | 27 ft. 10⅞ in. |

### AREAS

| | |
|---|---|
| Wings (less ailerons) | 227.33 sq. ft. |
| Ailerons (total) | 12.73 sq. ft. |
| Flaps (total) | 32.22 sq. ft. |
| Horizontal stabilizers | 27.98 sq. ft. |
| Elevators (including tabs) | 13.05 sq. ft. |
| Elevator trim tabs (total) | 1.92 sq. ft. |
| Vertical stabilizer | 9.61 sq. ft. |
| Rudder (including tabs) | 10.41 sq. ft. |
| Rudder trim tab (total) | .81 sq. ft. |

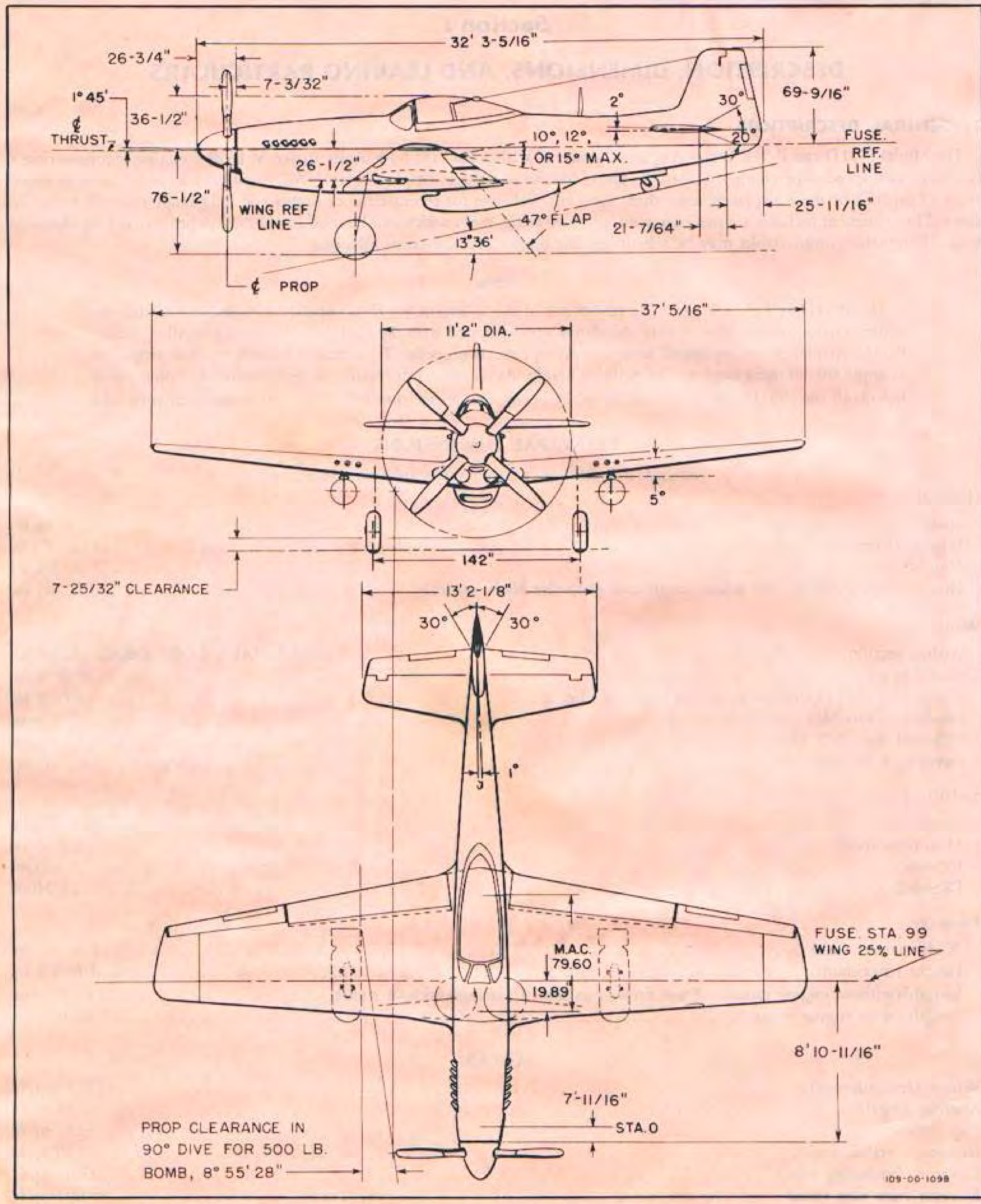



*Figure 1—Three-view Diagram*

## SETTINGS AND RANGES OF MOVEMENT OF CONTROL SURFACES

(Movements measured in degrees and inches)

| | DEGREES | INCHES (Maximum Chord) |
|---|---|---|
| Stabilizer (incidence) | 2 positive | |
| Fin, offset (measured from fuselage centerline) | 1 left | |
| Ailerons—up (from neutral) | *10, 12, or 15 | 2¼<br>2⅝<br>3⅜ |
| Ailerons—down (from neutral) | *10, 12, or 15 | 2¼<br>2⅝<br>3⅜ |
| Flaps (total) | 47 | 18⅞ |
| Elevators—up (from streamline with stabilizer) | 30 | 8¾ |
| —down (from streamline with stabilizer) | 20 | 5¾ |
| Rudder—right (from streamline with fin) | 30 | 13 |
| —left (from streamline with fin) | 30 | 13 |
| Trim tabs | | |
| Elevator—up (from elevator trailing edge) | 10 | ¾ |
| —down (from elevator trailing edge) | 25 | 1⅞ |
| Rudder—right (from rudder trailing edge) | 10 | 15/16 |
| —left (from rudder trailing edge) | 10 | 15/16 |
| Aileron—up (from aileron trailing edge) | 10 | ¾ |
| —down (from aileron trailing edge) | 10 | ¾ |

*Tolerance on control surface movements ½ degrees, ⅛ inch*

*See section IV, paragraph 4. *h.* (4) for alternate control settings of ailerons.

## LANDING GEAR

Wheel-type Landing Gear
- Type ........ Hydraulically retractable
- Tread (width from center of tire to center of tire) ........ 11 ft. 10 in.
- Shock struts (main)
  - Type ........ Air-oil combination
  - Manufacturer and Part No. ........ Bendix 67270 & 67271
  - Fluid required
    - Trade name identification ........ Intava Servo Fluid
    - AAF Specification No. ........ 3580
    - British equivalent ........ DTD 44C
  - Approximate maximum air pressure ........ 300 lbs./sq. in.

Wheels (main)
- Type ........ Smooth-contour 27-in. Goodyear No. 530441
- Tire ........ (Spec. AN-C-5) Smooth-contour 27-in. tread, all-weather
- Tire pressure ........ Fill to inflation rib, approx. 45 lbs./sq. in.

**Brakes**
- Type ........ Hydraulic multiple-disc Brake Goodyear No. 511124

Tail Wheel Unit
- Type ........ Hydraulically retractable
- Shock strut
  - Type ........ Air-oil combination
  - Manufacturer and Part No. ........ NA 97-34101
  - Fluid required
    - Trade name identification ........ Intava Servo Fluid
    - AAF Specification No. ........ 3580
    - British equivalent ........ DTD 44C
  - Approximate maximum air pressure ........ 300 lbs./sq. in.
- Wheel (tail)
  - Type (G.F.E.) ........ Channel-tread 12.50 x 4½ Goodyear No. 95-978
  - Tire (G.F.E.) ........ Channel-tread 12.50 x 4½
  - Tire pressure ........ Approx. 70 lbs./sq.

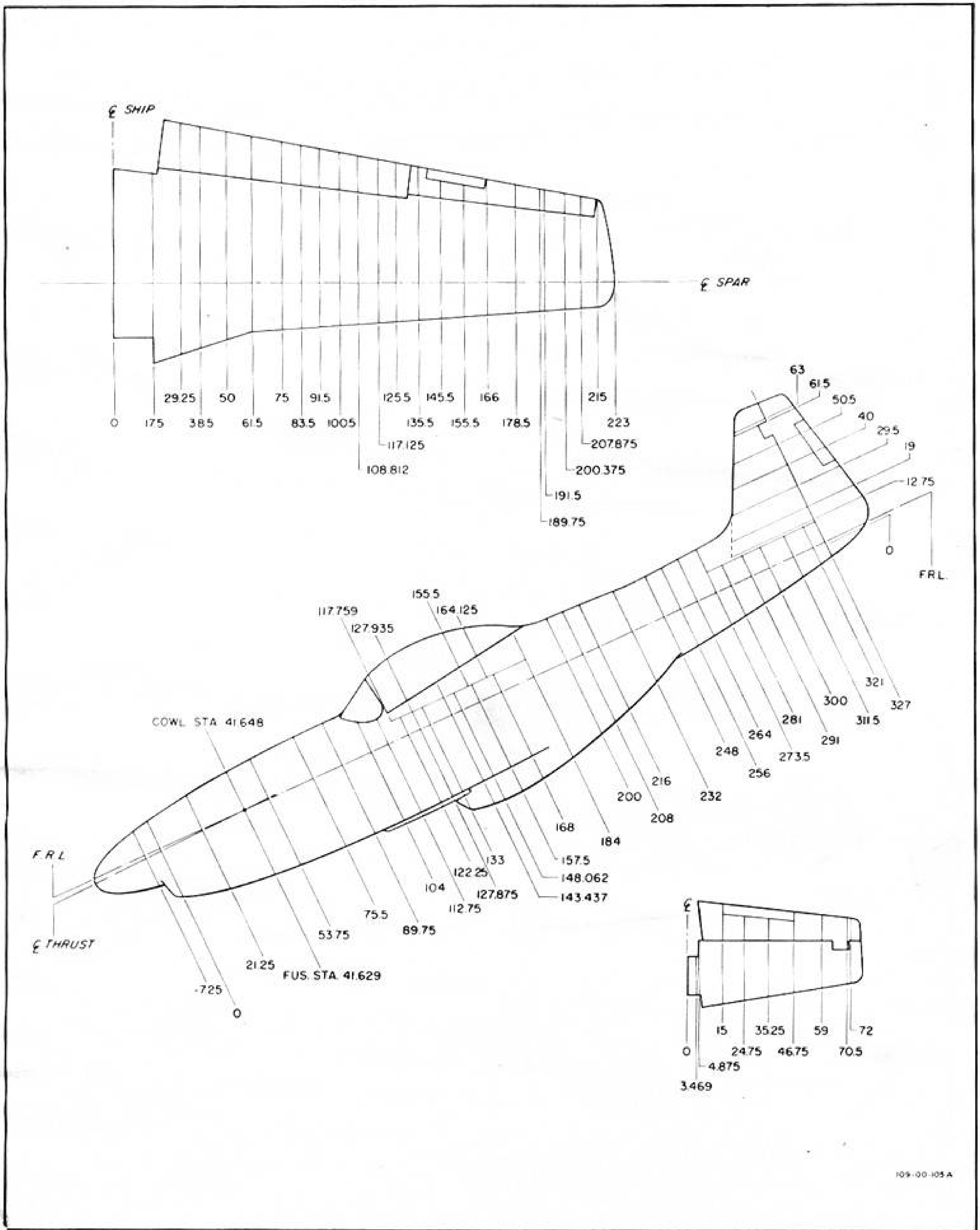



*Figure 2—Stations Diagram*

## ENGINES

### Engines

| | |
|---|---|
| Number | 1 |
| Designation | V-1650-7 |
| Gear ratio | .479:1 |
| Fuel | Spec. AN-F-28 Grade 100/130 |
| Oil | Spec. AN-O-5 Grade 1100p |
| Coolant | Winter (below −12°C (10°F))—Spec. AN-E-2 with NaMBT added. Type "C"<br>Summer—Spec. AN-E-2 with NaMBT added. Type "D" |

## PROPELLER

### Propeller (P-51D Airplanes)

| | |
|---|---|
| Manufacturer | Hamilton Standard |
| Type (4 blades) | Hydromatic |
| Hub No. | 24D50-65 |
| Blade No. | J6523A-24 |
| Diameter | 11 ft. 2 in. |
| Pitch setting | |
| Low (fine) | 23 degrees |
| High (coarse) | 65 degrees |

### Propeller (P-51K Airplanes)

| | |
|---|---|
| Manufacturer | Aeroproducts |
| Type (4 blades) | Hydromatic |
| Hub No. | A-542A-1 |
| Blade No. | A-20-156-24M |
| Diameter | 11 ft. |
| Pitch setting | |
| Low (fine) | 22.8 |
| High (coarse) | 57.8 |

## TANK CAPACITIES

| | Gallons (each) | |
|---|---|---|
| **Fuel** | | |
| Wing tanks (2) | 92 US | (76.5 Imp.) |
| Fuselage tank (1) | 85 US | (70.7 Imp.) |
| Droppable combat tanks (2) | 75 US | (62.4 Imp.) |
| Total fuel (wing tanks) | 184 US | (153.2 Imp.) |
| Total fuel (wing and fuselage tanks) | 269 US | (224.1 Imp.) |
| Total fuel (wing, fuselage, and combat tanks) | 419 US | (348.2 Imp.) |
| **Oil** | | |
| Tank capacity | 13.8 US | (11.5 Imp.) |
| Expansion space | 1.3 US | (1.1 Imp.) |
| Total oil (tank only) | 12.5 US | (10.4 Imp.) |
| Total system capacity (including tank) | 21.2 US | (17.7 Imp.) |
| **Coolant** | | |
| Engine cooling system | | |
| Tank capacity | 5.2 US | (4.4 Imp.) |
| Expansion space | 2.0 US | (1.67 Imp.) |
| Total system (including tank) | 16.7 US | (13.9 Imp.) |
| Aftercooling system | | |
| Tank capacity | 0.5 US | (0.4 Imp.) |
| Expansion space (system) | 0.5 US | (0.4 Imp.) |
| Total system (including tank) | 4.8 US | (4.0 Imp.) |

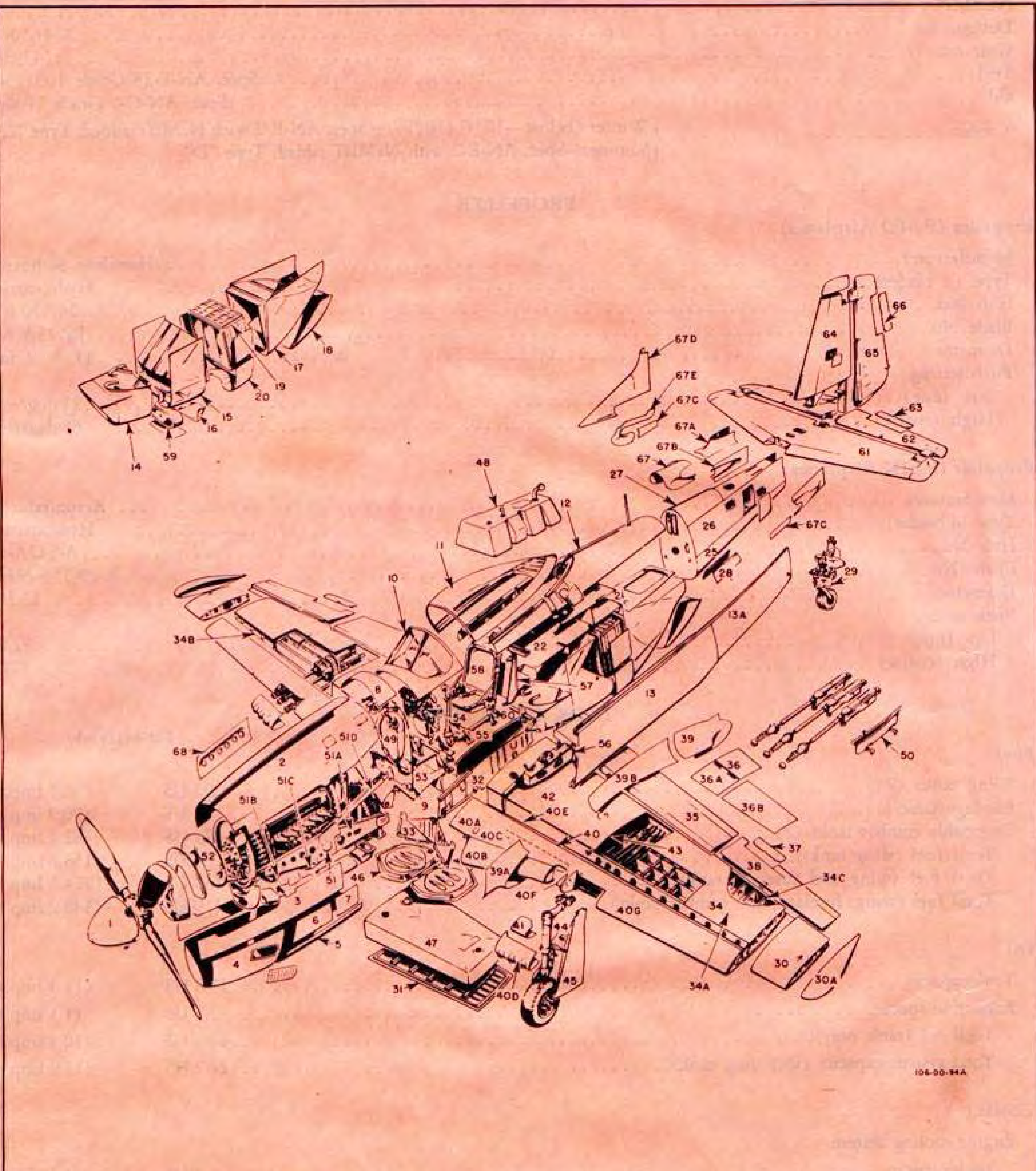



*Figure 3—Exploded View of Airplane*

## ENGINEERING ITEM BREAKDOWN

| REF. NO. | PART NO. | TITLE | REF. NO. | PART NO. | TITLE |
|---|---|---|---|---|---|
| 1 | 104-44002 | Spinner Assembly (P-51D Airplanes) | 39A | 106-10005 | Wing Fillet, Fwd. |
| | 109-44002 | Spinner Assembly (P-51K Airplanes) | 39B | 106-10006 | Wing Fillet, Interm. |
| 2 | 106-31573 | Engine Top Cowl | 40 | 106-14030 | Wing Leading Edge |
| 3 | 102-31071 | Engine Inter. Cowl | 40A | 106-14033 | Top Fwd. Inboard Skin |
| 4 | 104-310285 | Engine Bottom Cowl, Fwd. | 40B | 106-14031 | Auxiliary Nose Assembly |
| 5 | 106-31598 | Engine Bottom Cowl, Aft | 40C | 106-14036 | Lower Fwd. Inboard Skin |
| 6 | 106-31555 | Engine Inter. Cowl, Center | 40D | 106-14029 | Gun Nose Assembly |
| 7 | 106-31599 | Engine Inter. Cowl, Rear | 40E | 106-14004 | Front Spar |
| 8 | 106-310127 | Cover, Firewall to Windshield | 40F | 91-33106-10 & -11 | Landing Gear Support |
| 9 | 106-31102 | Firewall Assembly | | | |
| 10 | 106-318226 | Windshield Assembly | 40G | 106-14040 | Upper Outboard Nose Assembly |
| 11 | 106-318251 | Canopy | 41 | 106-14032 | Landing Gear Access Door |
| 12 | 106-31128 | Fuselage Top Deck | 42 | 102-14034-100 & -101 | Upper Interm. Inboard Skin |
| 13 | 106-31107-52 & -53 | Fuselage Side Panel, Fwd. | 43 | 106-14802 | Wing Sta. 75 Rib Assembly |
| 13A | 106-31107-50 & -51 | Fuselage Side Panel, Aft | 44 | 73-33102-10 & -11 | Landing Gear Strut |
| 14 | 106-310119 | Radiator Air Scoop, Fwd. | 45 | 106-33302 | Strut Fairing |
| 15 | 102-31016 | Radiator Air Duct, Fwd. | 46 | 106-33301 | Wheel Fairing Doors |
| 16 | 102-31023 | Air Cooler Outlet Door | 47 | 102-48003 | Fuel Cell (Wing) |
| 17 | 102-31079 | Aft Air Duct | 48 | 106-48005 | Fuel Cell (Fuselage) |
| 18 | 102-31025 | Radiator Outlet Door | 49 | 102-47002-15 | Oil Tank |
| 19 | 102-46005 | Radiator Assembly | 50 | 97-63002-5 | Wing Bomb Rack |
| 20 | 102-310106 | Radiator Bottom Cover | 51 | 102-31901 | Engine Mount Assembly |
| 21 | 102-31202 | Fuselage Aft Shear Web | 51A | 102-31902 | Main Beam |
| 22 | 106-31205 | Fixed Radio Shelf | 51B | 102-31909 | Front Frame |
| 23 | | | 51C | 102-31996 | Canted Frame |
| 24 | 106-31137 | Fixed Instrument Panel | 51D | 102-31948 | Brace |
| 25 | 73-31110-200 | Fuselage Rear Section, Lower | 52 | 104-46008 | Coolant Header Tank |
| 26 | 97-31026 | Fus. Rear Section Side Panel, L.H. | 53 | 99-52403-10 | Rudder Pedal Assembly |
| 26A | 97-31027 | Fus. Rear Section Side Panel, R.H. | 54 | 106-51005 | Instrument Panel |
| 27 | 106-31116 | Fus. Rear Section Top Deck | 55 | 102-52111-2 | Control Column |
| 28 | 73-31066 | Tail Wheel Doors | 56 | 106-52506 | Pedestal Assembly |
| 29 | 97-34101 | Tail Wheel Assembly | 57 | 106-73520 | Rear Armor Plate |
| 30 | 106-14014 | Wing Tip Assembly, Inner | 58 | 106-53009 | Seat Assembly |
| 30A | 106-14018 | Wing Tip Assembly, Outer | 59 | 102-47006 | Oil Cooler |
| 31 | 102-14060 | Fuel Tank Door | 60 | 104-52608-2 | Flap Torque Tube |
| 32 | 106-14300 | Wing Rib, Sta. 0 | 61 | 73-21001-100 | Horizontal Stabilizer |
| 33 | 106-10015 | Wing Center Bulkhead | 62 | 73-22001 | Elevator |
| 34 | 106-14701 | Wing Trailing Edge Assembly | 63 | 97-22003 | Elevator Trim Tab |
| 34A | 106-14035 | Upper Inter. Outboard Skin | 64 | 73-23001 | Vertical Stabilizer |
| 34B | 106-14038 | Lower Inter. Outboard Skin | 65 | 73-24001-40 | Rudder |
| 34C | 106-14005 | Wing Rear Spar | 66 | 97-24003 | Rudder Trim Tab |
| 35 | 73-18001 | Wing Flap | 67 | 106-20012 | Empennage Fillet, Fwd. |
| 36 | 106-14052 | Gun Bay Door, Rear | †67A | 106-20013 | Fin Fillet, Fwd. |
| 36A | 106-14050 | Gun Bay Door, Fwd. | †67B | 106-20015 | Stabilizer Fillet, Rear |
| 36B | 106-14051 | Ammunition Bay Door | 67C | 106-20014 | Empennage Fillet, Lower |
| 37 | 97-16003 | Aileron Trim Tab Assembly | *67D | 109-25001 | Fairing |
| 38 | 104-16001 | Aileron Assembly | *67E | 109-20012 & -1 | Fairing |
| 39 | 106-10007 | Wing Fillet, Rear | 68 | 102-42023 | Stack Fairing |

† On Early Airplanes
* On Later Airplanes

NOTE: FOR INSTALLATION DWG. NOS. REFER TO NA DWG. 106-900002

***KEY TO FIGURE 3***

# Section II

## SHIPMENT AND ERECTION PROCEDURE

### 1. PREPARATION OF AIRPLANE FOR "ON-DECK" SHIPMENT.

As the type of vessel upon which the airplane is to be shipped is unknown, these procedures are designed to facilitate the loading of the airplane on a "meccano" (steel girder structure) deck, a hatch cover, or a carrier deck, so as to utilize a minimum of space.

*a.* PROCESSING AND ACCESSORY MATERIALS.– There are three general types of preservatives: the type used on the outside of the airplane, the type used on the engine, and the type used in a sealed chamber. Any of the various covering materials for sealing openings is satisfactory if it is properly applied, but proper application is not always possible.

(1) OUTSIDE PRESERVATIVES.

*(a)* PAR-AL-KETONE.—The outside preservative is known as Par-al-ketone and may be Type I, Type II (Grade A), or Type II (Grade B). Alternate compounds conforming to Specification No. AN-C-52 may be substituted for Par-al-ketone.

*1.* AN-C-52, Type I, a cold application material made from oxidized hydrocarbons, is an all-purpose rust preventive for both ferrous and nonferrous metals which is satisfactory for coating parts subject to direct weather exposure. The material must be applied between 4° and 35°C (40° and 95°F) by dip, spray, or brush application. The solvent in this material will evaporate completely in 24 hours after application. At least 12 hours should elapse before handling sprayed assemblies.

**CAUTION**

As the flash point of this material is 38°C (100°F), it must not be heated over an open flame, must never be heated above 34°C (95°F), and every effort should be made to apply it at room temperature.

*2.* Type II, Grade A, Par-al-ketone is satisfactory for use on parts not subject to direct weather exposure. Type II, Grade B, Par-al-ketone is satisfactory for use on parts subject to direct weather exposure and where a hard, covering film is desired. Type II Par-al-ketone, Grade A or Grade B, should be applied by a hot dip method. If the hot dip application is not practical, the material should be sprayed or brushed on hot.

*3.* Adding solvent to Par-al-ketone to provide easier handling is not recommended, as the solvent will seriously impair the corrosion-resistance properties of the preservative. If it is necessary to use a solvent, one of the following must be used:

| | |
|---|---|
| Specification No. AN-N-3 | Aliphatic Petroleum Naphtha |
| Specification No. AN-VV-N-96 | Aromatic Petroleum Naphtha |
| Specification No. P-S-661 | Dry cleaning fluid, commercially known as Stoddard solvent |

Other solvents conforming to Specification No. AN-C-52

*4.* In addition to these solvents, kerosene, Specification No. V-K-211a, and white gas, Specification No. AN-VV-F-22, may be used to remove any type of Par-al-ketone.

*5.* Care should be taken to free surfaces from absorbed moisture, grease, dirt, fingerprints, and other contamination prior to application of this Par-al-ketone.

*6.* Do not allow Par-al-ketone to come in contact with rubber sleeves or connectors, synthetic or plastic materials, electrical conduit, or cable insulation. Do not use Par-al-ketone where it may be harmful to a lubrication system. Do not use Par-al-ketone where it can not be readily removed by washing or by other satisfactory methods.

*(b)* PLASTIPHANE.—Plastiphane, which is an approved alternate for Par-al-ketone, can be sprayed on any surface or assembly to form a tough, noninflammable covering that is impervious to moisture, dirt, gasoline, oil, and grease. Plastiphane will remain consistently pliable in temperatures ranging from −34.4°C to +51.7°C (−30°F to +125°F).

There is no applicable specification covering this material. It may be procured, through local purchase orders, from the Aviation Packaging Company, 50 Broadway, New York, N. Y. Twenty-five to thirty gallons of Plastiphane are required to process this airplane.

*1.* Plastiphane may be applied with standard AAF paint and dope spraying equipment, used only with nozzle, air cap, and ring No. AV640.

*2.* The air pressure of the spray tank will be maintained at 50-55 pounds and the fluid pressure at the nozzle at 5-15 pounds.

*3.* A maximum of two spray coats is sufficient except where there is a possibility of abrasion. Such places should be protected by four coats of Plastiphane.

(2) ENGINE PRESERVATIVE.—The engine preservative is composed of one part of corrosion-preventive compound, Specification No. AN-VV-C-576-A (British Specification No. DTD-587), and three parts of engine oil, Specification No. AN-VV-O-446, Grade 1120. The corrosion-preventive compound is designed specifically for use on aircraft engines and is a satisfactory lubricant for an aircraft

engine operating at not over 50 percent rated power. The material is thoroughly soluble in, and will mix with, the specified lubricating oil, above 10°C (50°F).

**CAUTION**

In all cases, dry air only must be used for spraying.

(3) SEALED CHAMBER DEHYDRATOR.—The sealed chamber dehydrating agent (silica gel) conforms to Specification No. AN-D-6. Agents covered by this specification will absorb moisture and other condensable vapors in the air. Silica gel is available in the following types:

| | |
|---|---|
| Type I | Large particle size |
| Type II | Large particle size with humidity indicator |
| Type III | Medium particle size |
| Type IV | Medium particle size with humidity indicator |
| Type V | Ungraded |

*(a)* Types I, III, and V are white. Types II and IV are placed in transparent containers, and the material is blue when it is activated. This blue material is used in conjunction with a color analysis chart (AN7514). The chart is graduated according to color so that by matching the color of the dehydrating material with the nearest color on the chart, a direct reading of the percentage of moisture content can be made. When there is 20 percent moisture content, the material turns pink and should be replaced with new material. Neither rust nor corrosion can take place if the relative humidity stays below 30 percent.

*(b)* Silica gel can be completely rejuvenated by heating it at 160°C (320°F).

*(c)* Silica gel should be used at the rate of ½ pound per cubic foot of volume (under the most humid conditions). The space must be sealed against the outside atmosphere. In a large space such as the cockpit or the radio compartment, the seal should be as tight as possible and a large surplus of silica gel provided.

*(d)* If the moisture is removed from one instrument, and another instrument is connected to it by means of a tube, the moisture content will tend to become the same in both instruments. However, the smaller the opening connecting them and the greater the distance to the dehydrating agent, the longer the time required.

**Note**

Do not use silica gel where it cannot be sealed within a chamber.

(4) MATERIALS FOR CLOSING OPENINGS.

*(a)* Wherever practical, cover parts with waterproof paper, oilcloth, tape, or waterproof canvas. Oilcloth can be used alone on a dry surface, such as the radio or electrical system, with or without silica gel. For extremely rough usage, use waterproof canvas.

*(b)* Greaseproof wrapping paper conforming to Specification No. AN-P-12 should be used where it will not be subjected to any rough or exposed treatment. This specification covers the general requirements for two types of wrapping paper:

Grade A—greaseproof and acid free
Grade B—greaseproof

*(c)* Use waterproof tape (Specification No. AN-T-12) exclusively for all wrapping. To get the best adhesion, clean the surface with a rag moistened in solvent. Make sure that no section of the tape is unattached. Do not use tape on plexiglas, as a chemical reaction is set up between the adhesive and the plastic which will impair the transparency of the plastic.

*b.* CARE OF THE AIRPLANE AWAITING PROCESSING.—See section III, paragraph 4, for storage procedures.

*c.* PROCESSING AIRPLANE FOR SHIPMENT.

(1) PREPARING ENGINE AND ACCESSORIES.

*(a)* PREPARING AIRPLANE FOR ENGINE RUN-UP.

*1.* Make sure all obstacles are clear of the airplane.

*2.* Check hydraulic fluid level with dip stick. Level must reach full mark on stick. *(See section III, paragraph 2. b. (4) (e), for filling procedure.)*

*3.* Check oil level. If the oil is visible, there is sufficient oil for the run-up. *(See section III, paragraph 2. b. (2) (c), for filling procedure.)*

*4.* Check coolant level in aftercooler. This chamber should be full. *(See section III, paragraph 2. b. (3) (c), for filling procedure.)*

*5.* Check coolant in main engine header coolant tank. This chamber should be full. *(See section III, paragraph 2. b. (3) (c), for filling procedure.)*

*6.* Head the airplane into the wind.

**Note**

Maximum cooling is necessary. Use the slipstream from one airplane to help cool another.


***Figure 4—Placing Template Over the Oil Radiator Opening***

*7.* Apply and set the parking brakes.

*8.* With the operator inside, close and lock the cockpit enclosure.

*9.* Place chocks in front of wheels.

*10.* Ground the airplane and pour 10 gallons of unleaded gasoline, Specification No. AN-F-22 (Grade 62), into each wing fuel tank. *(See section III, paragraph 2. b. (1) (c), for filling procedure.)*

*11.* During the winter, close the oil radiator openings, using a template. *(See figure 4.) Do not close the air scoop above the radiator.*

*12.* When summer temperatures prevail, the first run-up may be omitted.

*(b)* MAKING THE FIRST ENGINE RUN-UP (Preheating of Engine Oil in Winter).

*1.* Check the cockpit for broken or loose parts and the instrument panel for broken glass.

*2.* Tie the landing gear control handle "DOWN" with safety wire.

*3.* Be sure the ignition and battery-disconnect switches are "OFF."

*4.* Unlock the control stick.

*5.* Turn the propeller 4 or 5 complete turns by hand.

*6.* Station a man with a fire extinguisher on each side of the engine.

**Note**

A 10-pound carbon dioxide cylinder should be used. If carbon tetrachloride is employed, use the 2-quart size.

*7.* Insert the battery cart plug into the external power receptacle.

*8.* Pump the flaps to the full "UP" position with the hydraulic hand-pump.

**Figure 5—Tying Control Stick Back With Safety Belt**

*9.* Pull the carburetor air control to "RAM AIR."

*10.* Hold coolant radiator air control switch in the "OPEN" position until air exit door on scoop is in full open or down position.

**Note**

The ground crew member should signal the man in the cockpit when air exit door is in the full open position.

*11.* Tie the stick back with the safety belt. *(See figure 5.)*

*12.* Turn all trim tab controls to zero.

*13.* Push the propeller pitch control to full "INCREASE RPM."

*14.* Pull the fuel mixture control back to "IDLE CUT OFF."

*15.* Crack the throttle. (Move it forward approximately ¾ to one inch, or the equivalent of 800 to 1000 rpm.)

*16.* Check the emergency boost control valve to be sure it is safetied in the "IN" position.

*17.* Cage the gyros by turning each knob in the direction indicated by the arrow.

*18.* Turn all switches "OFF."

*19.* Turn radio "OFF."

*20.* Turn fuel selector valve to "LEFT MAIN TANK."

*21.* Turn generator-disconnect switch "ON."

*22.* Turn battery-disconnect switch "ON."

*23.* Turn booster pump to "NORMAL."

*24.* Be sure that the gage registers 8 to 10 pounds fuel pressure.

*25.* Prime 4 strokes for summer conditions, 8 for winter conditions.

*26.* Wait for the "all clear" signal from the ground crew.

*27.* Turn the ignition (magneto) switch to "BOTH."

*28.* Engage the starter until the engine starts.

*29.* When engine fires, push the mixture control to "AUTO RICH." Keep priming until the mixture takes over.

**Note**

In case the engine starts and then stops, pull the mixture control back to "IDLE CUT OFF" and repeat the starting procedure.

*30.* Check the oil pressure. If no pressure is shown within 3 to 5 seconds, cut the engine by pulling mixture control to "IDLE CUT OFF" position and slowly advancing the throttle to full "OPEN" position after engine has ceased firing. Determine the reason for lack of oil pressure before proceeding further.

*31.* After the engine is running, signal for the battery cart to be removed.

*32.* The engine speed should not exceed 800 to 1000 rpm until the oil and coolant temperature gages begin to rise.

*33.* Cage the starter switch.

*34.* Turn off the booster pump switch.

*35.* While the engine is warming up, check the instruments to be sure they read within the "GREEN" limits but not in the "RED." Check the gages to make sure they register within the proper limits, as follows:

a. OIL PRESSURE GAGE.—The oil pressure gage should read from 70 to 90 pounds per square inch with the engine cold. As the oil temperature rises, the pressure will drop to approximately 50 to 60 pounds at 1000 rpm.

b. COOLANT GAGE.—The normal operating temperature is 100° to 110°C (212° to 230°F) on *unleaded fuel run-up.*

**CAUTION**

If coolant temperature reaches 121°C (250°F), cut the engine immediately. Check steps *3.*, *4.*, and *5.* of paragraph 1. *c.* (1) *(a)* in this section before proceeding.

c. OIL TEMPERATURE GAGE.—Maximum 90°C (194°F).

*36.* "First run-up" oil temperature should reach 50° to 60°C (122° to 140°F) at 1000 to 1200 rpm.

*37.* Increase the speed of the engine to 1500 rpm in preparation for shutting it off.

*38.* Pull mixture control back to "IDLE CUT OFF" to cut the engine.

*39.* When engine ceases firing, push the throttle slowly all the way forward to the full "OPEN" position. This gives the engine a clean "cutoff."

*40.* When the propeller has ceased rotating, turn "OFF" the magneto ignition, battery-disconnect, and the generator-disconnect switches, and the fuel selector valve.

**WARNING**

Double check this carefully. If these switches were left on and the propellers were turned accidentally, serious injury or death might result to personnel. *Stay clear of propeller at all times.*

*41.* Lock the control stick in place.

*42.* Cut the safety wire and remove the oil drain plug.

*43.* Drain the oil into a drum. The oil must be drained while warm or engine must be run again.

*(c)* MAKING THE SECOND ENGINE RUN-UP.

*1.* Fill the oil tank (at least 12 gallons; 15 gallons if cooler was drained) with the following mixture: one part corrosion-preventive oil, Specification No. AN-VV-C-576, and three parts of engine lubricating oil, Specification No. AN-VV-O-446.

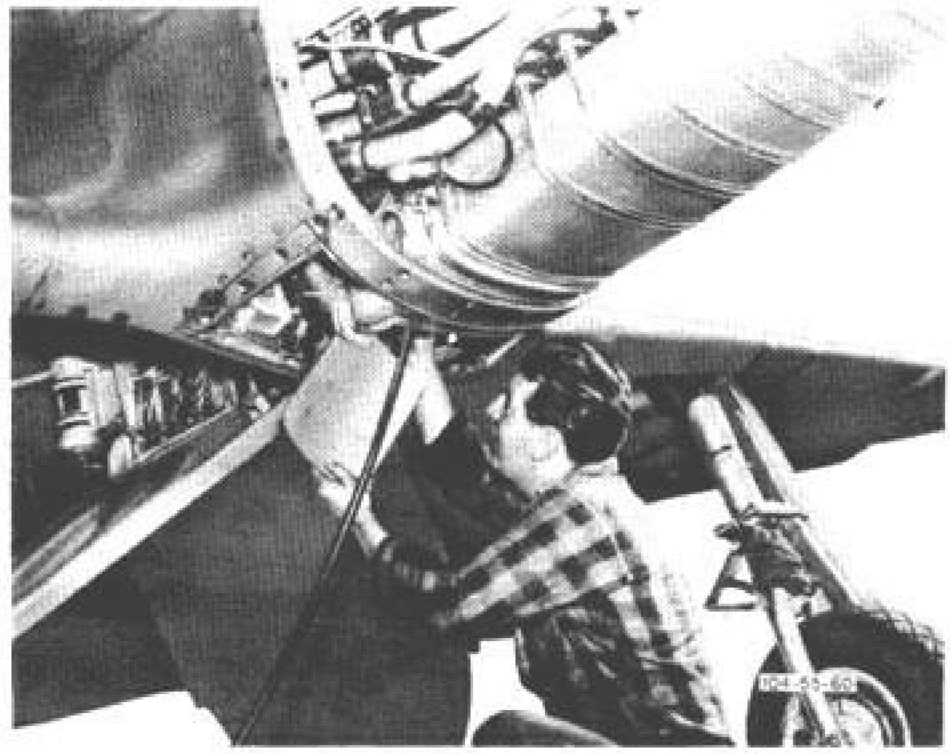


**Figure 6—Induction of Corrosion Preventive During Engine Run-up**

*2.* Repeat steps *1.* through *35.*, paragraph 1. *c.* (1) *(a)* in this section.

*3.* Run the engine at 1500 rpm until the oil temperature reaches 85°C (185°F).

*4.* Insert the atomizer nozzle of the mixture-induction apparatus through the carburetor air scoop *(figure 6)* and the carburetor until atomizer contacts the throttle butterfly valve. At 1500 rpm, start spraying corrosion-preventive mixture into the supercharger. Cut engine immediately as outlined in steps *37.* through *40.*, paragraph 1. *c.* (1) *(a)* in this section.

*5.* Operate the corrosion-preventive mixture pump (hand or electric) until the propeller stops turning. This ensures the complete coating of parts after combustion has ceased. At least one quart of mixture should be inducted.

**Note**

Electrically operated induction apparatus should be used where possible to ensure proper control of the amount of mixture inducted. Be sure the corrosion-preventive mixture is heated to a free flowing temperature.

*6.* Turn all switches off. Check this carefully.

*7.* Lock the control stick.

*8.* Attach a hose to each of the four fuel tank petcocks, open them, and direct the flow to a container.

*9.* Break the safety wire and remove the oil drain plug. The oil should be drained while warm. Otherwise the engine must be run again.

**Note**

The corrosion-preventive mixture drained from the engine may be used for the run-up of 10 engines. For this reason, clean containers are to be used.

*10.* Further processing of the engine should be started within 20 minutes of the second engine run-up.

*(d)* PROCESSING THE ENGINE.

*1.* Immediately upon the airplane's arrival at the hangar after final run-up, remove all engine cowling, spark plugs, and cylinder head covers. Place the serial number of the airplane on all cowlings and on all other parts removed.

**Note**

It is imperative that these parts be removed while the engine is still hot, to prevent condensation of vapors.

*2.* Place protectors over the wheels so that oil will not splash on the tires.

*3.* Cover the starter and generator with oilcloth and tape to protect them from oil and gasoline.

*4.* Place a pan under the engine to catch the oil and gasoline that will be drained.

*5.* Drain the oil from the engine and the oil tank by removing the oil screens *(figure 7)* and the sump plug from the engine, and the drain plugs from the oil tank.

**Note**

Drain the oil while the engine is hot, as hot oil has a low viscosity.

*6.* Reinstall and safety the screens and drain plugs.

*7.* Remove the timing inspection plug from the crankcase and attach it to the engine with safety wire. Install a dehydrator plug.


***Figure 7—Removing the Crankcase Oil Screen***

*8.* Remove the Cuno oil filter and inspect it for metal particles. If foreign matter of any kind is found, notify the proper authority. Wash the oil filter thoroughly in white gasoline, and dip it in corrosion-preventive mixture.

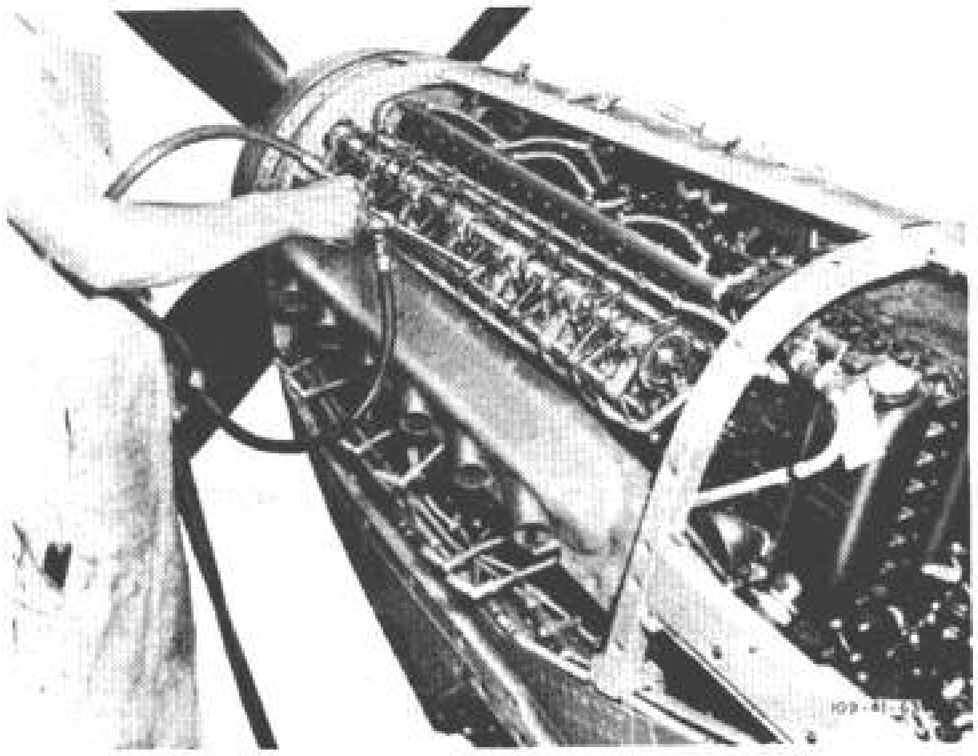


***Figure 8—Spraying the Valve Mechanism***

*9.* Remove the plug from the oil filter housing and wash out the inside of the housing with unleaded gasoline. Spray the housing internally with corrosion-preventive mixture. Reinstall and safety the oil filter and the plug.

**CAUTION**

The Cuno should never be rotated manually while it is out of its housing.

*10.* Spray the intake and exhaust valves of all cylinders with corrosion-preventive mixture. Turn the propeller, and spray each valve as it opens so as to thoroughly cover the valve seats and stems. Observe the firing order of the cylinders, and spray in that order.

*11.* While rotating the crankshaft, thoroughly spray all parts of the camshaft, drive gear, rocker arms, valve stems and springs *(figure 8)* with corrosion-preventive mixture.

*12.* Spray each cylinder with corrosion-preventive mixture through both the spark plug ports *(figure 9)* when the piston is at the bottom of its stroke. A fine spray of oil, directed so that it will reach all parts of the cylinder, will be sufficient.

**Note**

The cylinder will be in the bottom position when the exhaust valve is beginning to open. Avoid excessive turning of the propeller by following the firing order of the cylinders.

*13.* Clean and spray corrosion-preventive mixture on the inside of the cylinder head covers. *(See figure 10.)* Reinstall the cover, tightening the nuts to 65 inch-pounds by drawing them down on alternate sides of the covers.

*14.* Without rotating the propeller, spray each cylinder again for one to three seconds, regardless of the position of the piston.

*4.* Spray the bomb rack control bracket, lever, and sector with Par-al-ketone (Specification No. AN-C-52, Type I). These items are accessible through the center gun aperture in the front spar of the wing.

*5.* Field strip, and clean the guns.

*6.* Coat the operating parts with rust-preventive compound (US Specification No. 2-84B light, or Specification No. AXS-673), and reassemble the guns.

*7.* Dip the guns in a bath of rust-preventive compound (US Specification No. 2-84B or Specification No. AXS-674) maintained at a minimum temperature of 82.2°C (180°F).

*8.* Reinstall the gun solenoid, wrap in wax paper, and tape in its entirety.

*9.* Reinstall the guns.

**CAUTION**

When treating the guns, wear gloves to prevent hand perspiration getting into the gun and its components.

*10.* Preserve the gun bays in the following manner:

a. Cover the gun solenoid Cannon plugs with wax paper and tape securely.

b. If gun heater wiring is installed, cover the Cannon plugs with wax paper, and tape securely.

c. Tape the junction box.

d. Tape the terminal box.

*11.* Stow the miscellaneous equipment in the ammunition boxes and gun bays.

*12.* Reinstall the ammunition bay access doors and the gun bay access doors.

(6) PROCESSING FUSELAGE INTERIOR.

*(a)* Remove the oxygen filler valve access door and tape over the oxygen filler valve. Reinstall the access door.

*(b)* On airplanes equipped with a remote indicating compass, remove the upper and lower access cover, wrap the compass with wax paper, and then tape oilcloth over the wax paper. Replace the upper and lower access cover.

*(c)* Cover all equipment in the cockpit and on the radio shelf with wax paper and oilcloth, and then tape.

**CAUTION**

Do not allow the tape adhesive to come in contact with the oxygen regulator diaphragm or diaphragm knob. Distortion of the diaphragm will seriously affect the functioning of the regulator.

*(d)* Tape the generator control box and the oxygen pressure signal assembly located between the instrument panel and the firewall.

*(e)* Tape all the electrical box assemblies in the wheel wells.

*(f)* Securely lash or tape all parts that may move.

*(g)* Lash the landing gear control in the down position.

*(h)* Lash the flap control handle up.

*(i)* Lash the safety belt and shoulder harness to the pilot's seat.

*(j)* Tape the emergency fairing door control knob down.

*(k)* Secure the oxygen mask-to-regulator hose.

*(l)* Secure the cockpit canopy lever in the locked position. Close and lock the cockpit hatch.

**Note**

Before locking canopy closed, lower the flap and spray the flap hinge castings, the flap control valve lever, and the flap steel rubbing strip with Par-al-ketone (Specification No. AN-C-52, Type I). Then raise the flap to the full up position.

*(m)* Cover the glass and plexiglas as follows:

*1.* Thoroughly clean the glass.

*2.* Cover the glass with a clean, soft kraft paper.

**CAUTION**

Do not place the tape adhesive upon the glass, as a chemical reaction of the adhesive compound used in the tape will cause serious crazing of the glass surfaces. Secure the paper with narrow strips of tape attached to the metal frames.

*3.* Install a sheet of single-face corrugated paper over the kraft paper. The corrugations should be facing away from the glass.

*4.* Cover the corrugated paper with a 30-85-30 reinforced waterproof paper (Fibreen, Specification No. UU-P-271, Type L-4 or D-1), and tape in its entirety with waterproof tape.

(7) PROCESSING THE EXTERIOR OF THE FUSELAGE AND WING.—Spray all the items listed, especially the magnesium castings, with Par-al-ketone (Specification No. AN-C-52, Type I). This may best be accomplished by the use of a spray gun with a long spout. Use rapid, sudden bursts of spray, not a continuous spray, and make sure the corrosion preventive covers the castings completely. Mask off the areas immediately surrounding the castings with a cardboard held by hand.

**Note**

Magnesium castings may be easily recognized by a distinct dark yellow-green prime coating.

*(a)* WHEEL WELL AREA.—Spray the following castings with Par-al-ketone (Specification No. AN-C-52, Type I):

Fairing door hinge brackets
Torque tube bellcranks
Torque tube bellcrank lock
Retracted position lock fitting
Lock mechanism control rod bellcrank
Landing gear lock mechanism bellcrank
Landing gear fairing door lock bellcrank
Landing gear pivot support
Fairing attaching links

*(b)* CARBURETOR AIR DUCT AREA.—Spray these castings with Par-al-ketone (Specification No. AN-C-52, Type I):

Carburetor air duct bellcranks
Carburetor air duct leading edge

*(c)* WING TRAILING EDGE AREA.—Spray these castings with Par-al-ketone (Specification No. AN-C-52, Type I):

Aileron inboard, center, and outboard hinge brackets and fittings
Wing flap inboard, center, and outboard hinge brackets and fittings
Wing flap control valve lever

**Note**

The last two items listed in *(c)* preceding must be sprayed before the flap control is tied down and the cockpit sealed.

(8) SEALING AIRPLANE FOR SHIPMENT.

*(a)* INSTALLING SILICA GEL.—Tie bags of silica gel in the airplane as follows:

Radiator air scoop—2 pounds
Oxygen tank compartment—3 pounds
Radio compartment—6 pounds
Forward of instrument panel—2 pounds
Cockpit—8 pounds
Dynamotor compartment—2 pounds
Wheel wells—4 pounds each
Ammunition bays—2 pounds each
Gun compartments—2 pounds each
Camera—½ pound

*(b)* SEALING GUN CAMERA.

*1.* Place bag of silica gel on camera, and wrap in greaseproof paper.

*2.* Wrap camera in oilcloth, and tape.

*3.* Replace camera in wing, and tape the openings closed.

*4.* Cover camera window with corrugated cardboard, and tape completely.

*(c)* INSTALLING PLYWOOD SHIELDS.

*1.* TRAILING EDGE OF WING.

a. Cut two cleats from 1 x 2-inch stock to fit between projections on lips of aileron butt.

b. Drill two holes through blocks and thread approximately 12 inches of wire through them.

c. Cut a shield of ¼-inch plywood to cover opening, leaving holes for aileron hinges to project, and leaving approximately 3 inches overlap at the outboard end to clear the projecting fiber wing tip guides.

d. Slide cleats in place near each end of aileron opening.

e. Place shield over opening, thread wire through holes in shield, and twist wire with pliers until shield is tight. Cut off excess wire and bend twisted ends flat against shield. *(See figure 18.)*

*2.* WING PANEL ENDS.

a. Cut three cleats from 1 x 2-inch stock to fit in wing tip butt between rib and screws, evenly spaced along opening.

b. Cut shield of ¼-inch plywood to fit over opening, leaving space for the projecting fiber wing tip guides.

c. Wedge cleats in position in opening.

d. Place shield in position over opening and fasten with one ¾-inch screw to each cleat.

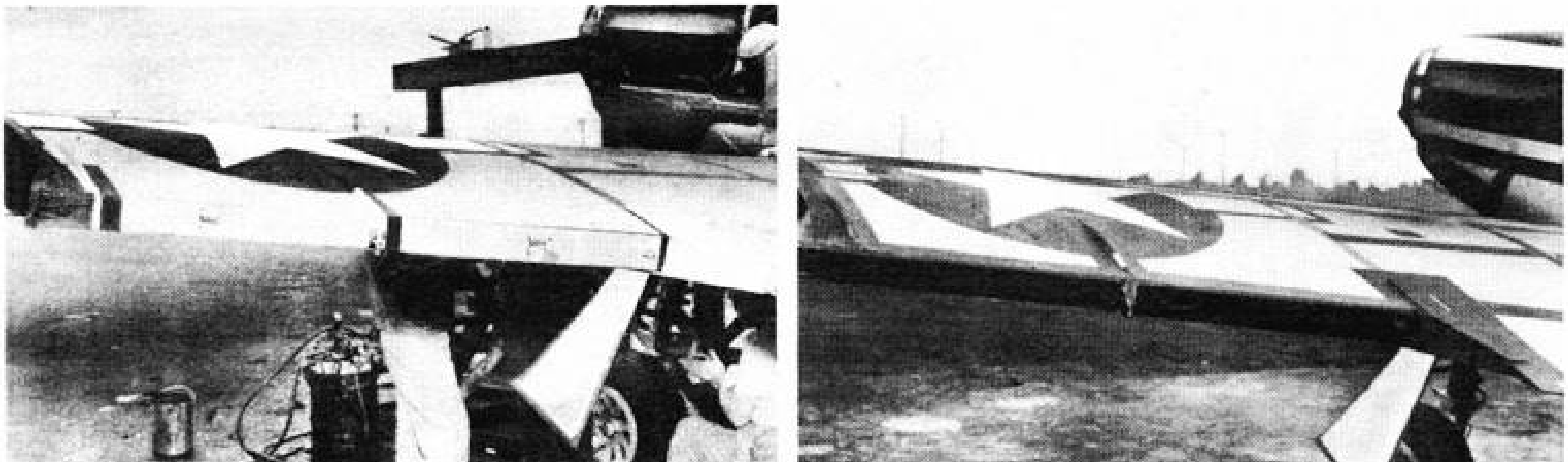


*Figure 18—Sealing Trailing Edge of Wing*

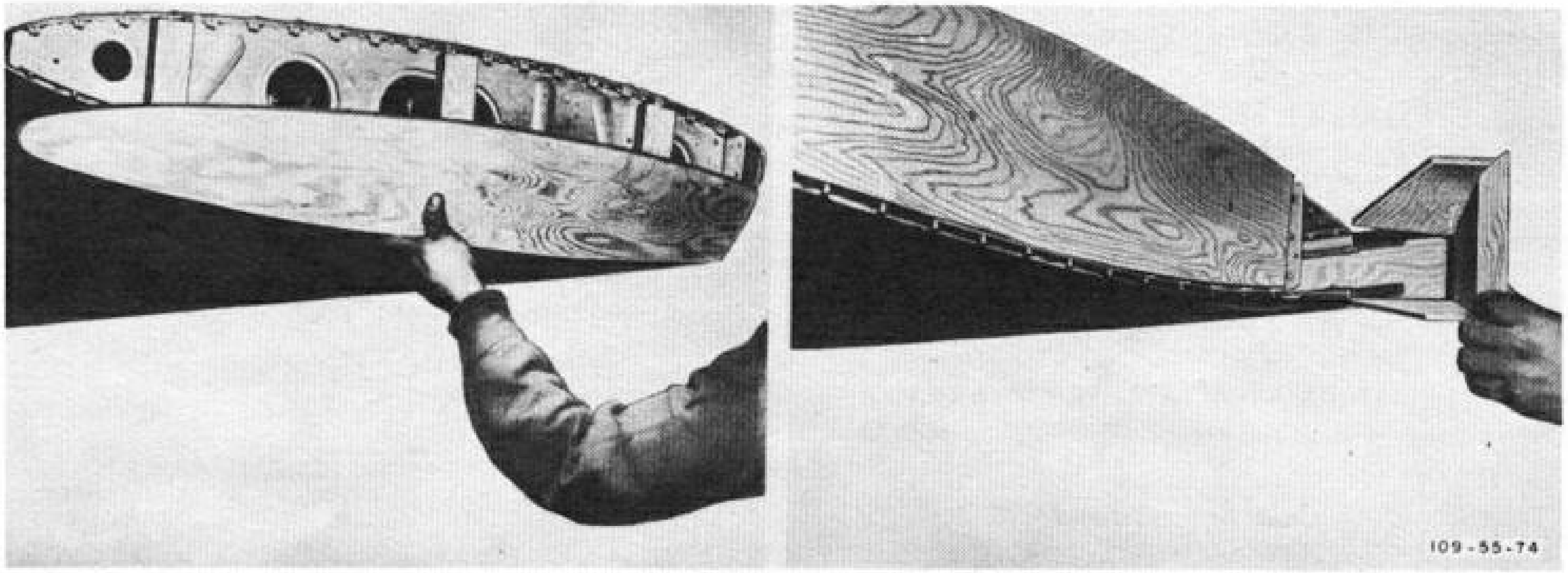



**Figure 19—Installing Wing Panel End Shield**

e. Cut a piece of 1 x 6-inch stock to fit from end of aileron to wing tip butt shield, clearing wing tip guides.

f. Cut ¼-inch plywood panels to fit between 1 x 6-inch piece and wing tip butt, and fasten to upper and lower edge of the 1 x 6-inch piece with 4-penny nails.

g. Fasten this piece to aileron shield and wing tip butt shield with 4-penny nails. *(See figure 19.)*

3. FUSELAGE REAR SECTION.

a. Cut shield of ¼-inch plywood to cover rear deck of fuselage. *(See figure 20.)*

b. Cut a piece of 1 x 4-inch stock to cover aft end of fuselage. *(See figure 20.)*

c. Pass an 18-inch length of wire through two holes near the bottom of rear bulkhead. Drill holes in shield at proper places to receive wire.

d. Place a block of 1 x 2-inch stock in bottom of tail opening against bulkhead to keep shield from being pulled into hole.

e. Place shield over hole, pass ends of wire through holes in shield, and twist wire until shield is tight. Cut off excess wire and bend twisted ends against shield.

4. RADIATOR AIR INLET SCOOP SHIELD.

a. Cut a piece of ¼-inch plywood to cover front of scoop.

b. Cut pieces of ¼-inch plywood to cover spaces above scoop on each side. Fasten the three pieces together with 1 x 2-inch corner blocks and 4-penny nails.

c. Drill two holes about 2 inches apart halfway back on side pieces, and pass a length of wire through them.

d. Drill two holes about 2 inches apart in front section of shield, and pass a length of wire through them and around wire between two side sections, letting the ends extend out of the front section.

e. Pass a length of wire around center brace of scoop, place shield assembly in position, and pass wire through two holes in scoop shield. *(See figure 21.)* Twist

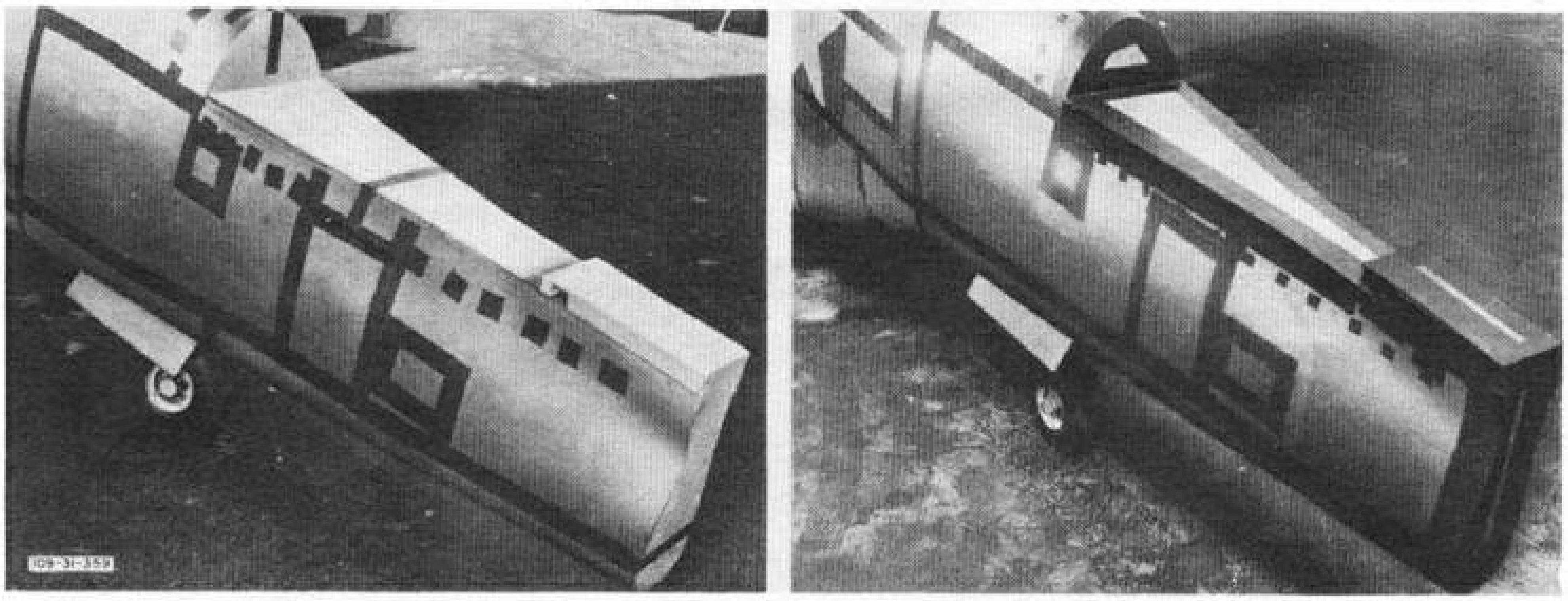



**Figure 20—Fuselage Rear Section Plywood Section**

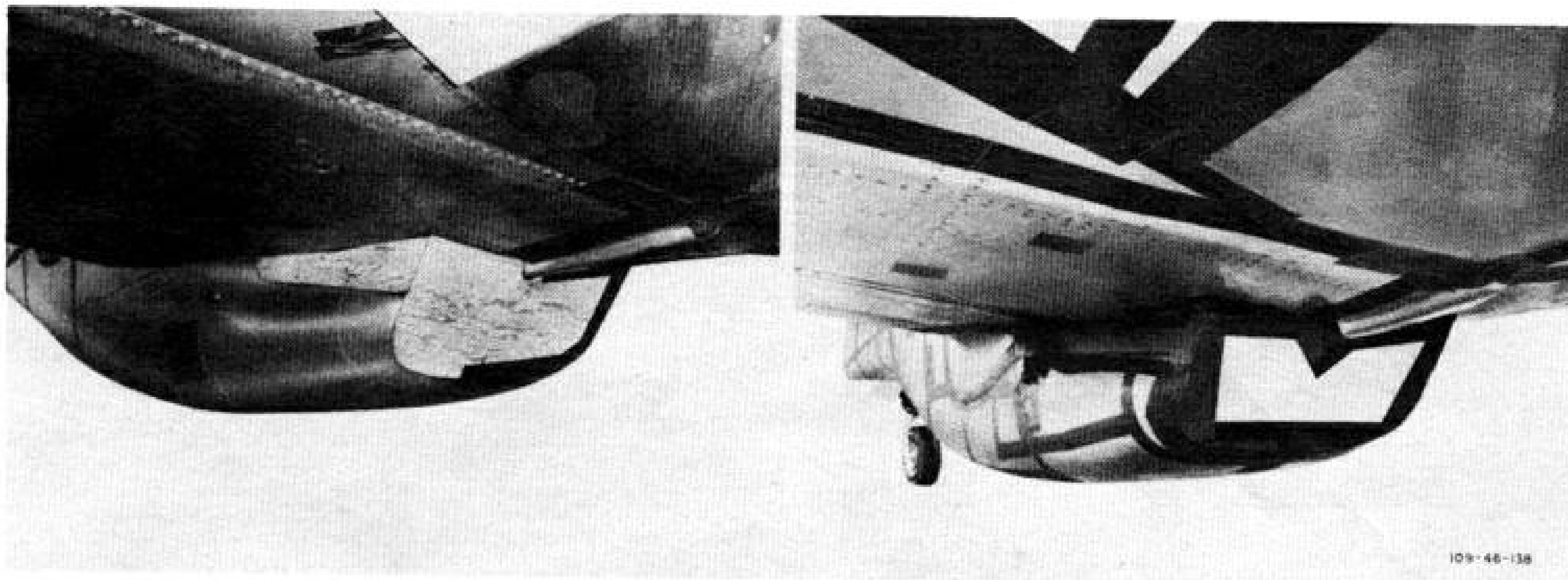


*Figure 21—Radiator Air Scoop Forward Shield*

wire tight. Cut off excess, and bend twisted ends flat against shield.

f. Tighten wire connecting two side pieces until sides are snug. Cut off excess.

g. Tighten wire connecting front top panel to wire connecting side panels. Cut off excess.

5. COOLANT RADIATOR AIR OUTLET FLAP SHIELD.

a. Cut a piece of ¼-inch plywood to cover coolant radiator air outlet flap. *(See figure 22.)*

b. Tape shield in place.

6. WHEEL WELLS.

a. Cut a cleat from 1 x 2-inch stock approximately 10 inches long to fit across wheel well opening near the strut.

b. Cut a cleat from 2 x 3-inch stock to fit the inboard end of the narrow part of the wheel well opening.

c. Cut braces of 1 x 2-inch stock to reach from the two horizontal cleats to the top panel of the wing.

d. Place cleats in position, resting them on lip of wheel well opening. Wedge braces in to keep cleats from moving.

e. Close inboard wheel well door and prop it closed with a stick of wood padded on the end so as not to scratch or dent the skin.

f. Cut a shield of ¼-inch plywood to cover the part of the wheel well remaining open. Allow it to overlap closed wheel well door at least one inch.

g. Place shield in position and fasten with three 1¾-inch screws and ½-inch washers to 2 x 3-inch cleat, and two 1½-inch screws to 1 x 2-inch cleat. *(See figure 23.)* The overlap of the shield will keep the inboard door closed.

(9) PROCESSING WHEELS AND STRUTS.

*(a)* Spray both sides of wheel with Par-al-ketone (Specification No. AN-C-52), being sure tire is properly protected with masking compound.

*(b)* Cut two blocks of 1 x 2-inch stock, set a ⅜ x 2½-inch bolt through each, and wedge them in the hub so that the bolts extend on the outboard side.

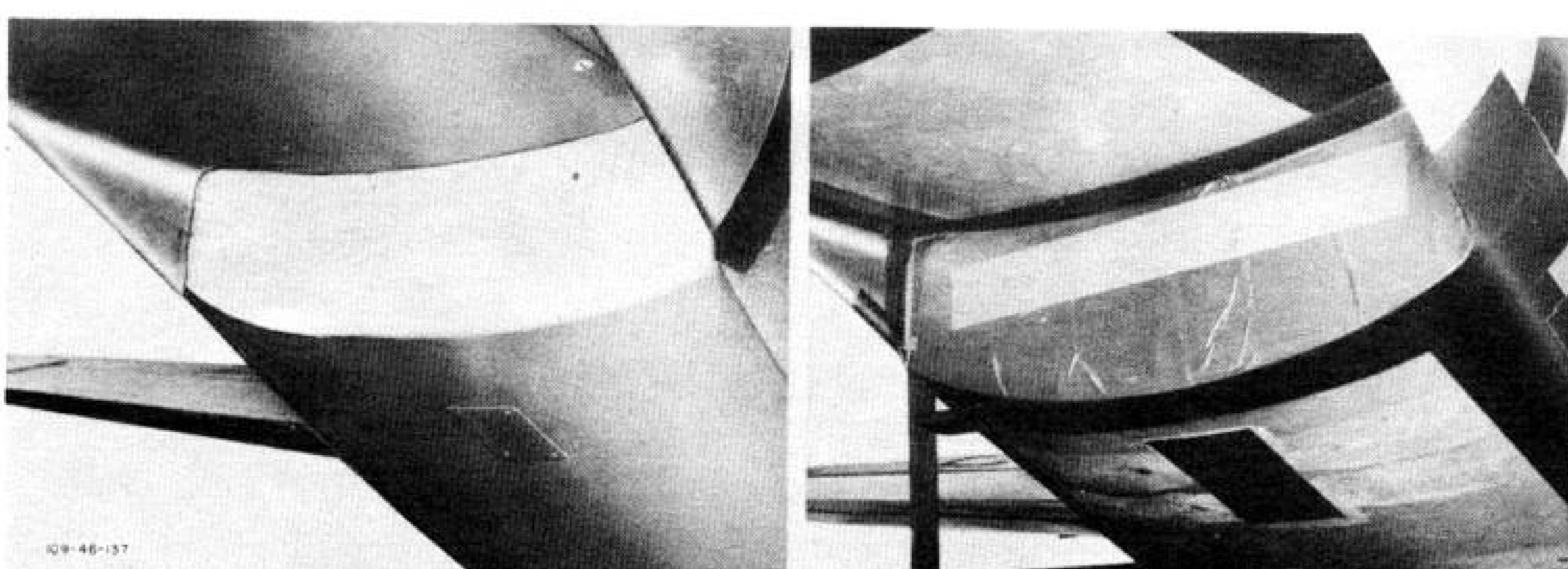


*Figure 22—Coolant Radiator Air Outlet Flap Shield*

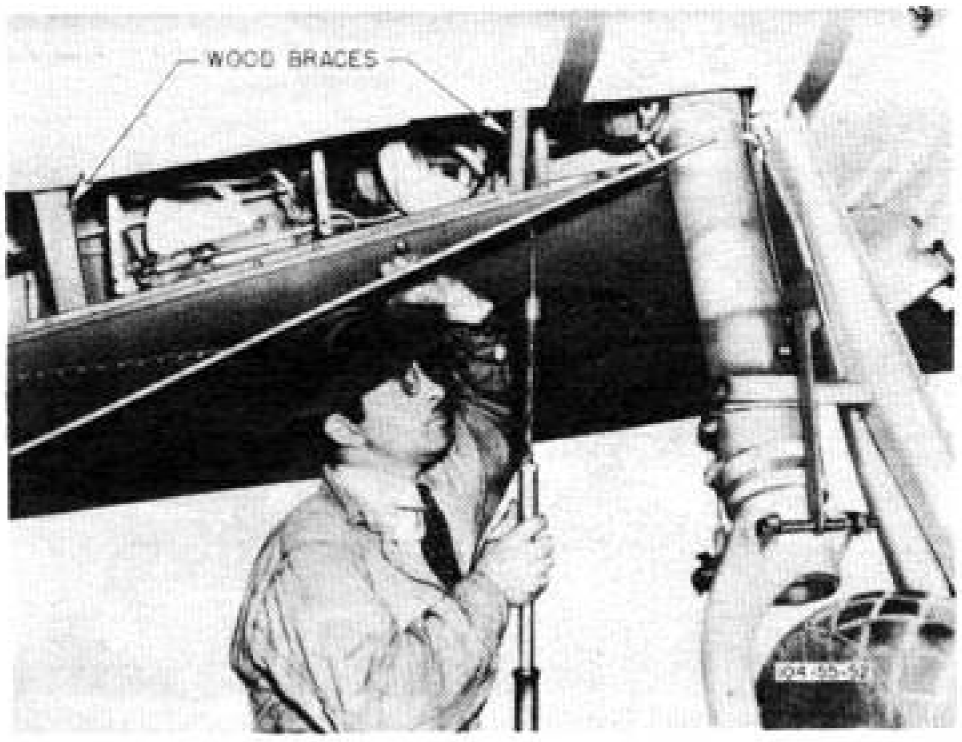



*Figure 23—Wheel Well Plywood Cover*

(*c*) Cut a disc of ¼-inch plywood to cover the hub, and drill two holes for the bolts.

(*d*) Place plywood disc over hub and fasten with nuts on bolts. (*See figure 24.*)

(*e*) Tape over edge of plywood disc.

**Note**

Nothing need be done to the tail wheel other than spraying with Par-al-ketone (Specification No. AN-C-52). Before spraying the hub, paint tire with rubber masking compound, as Par-al-ketone (Specification No. AN-C-52) will damage rubber. If Par-al-ketone (Specification No. AN-C-52) drips on exposed rubber, clean it off with naphtha.

(*f*) Brush Par-al-ketone (Specification No. AN-C-52) on strut cylinder.

(*g*) Place a 2½-inch collar around the strut cylinder, and let the air out of the strut until it comes down to the collar. (*See figure 24.*)

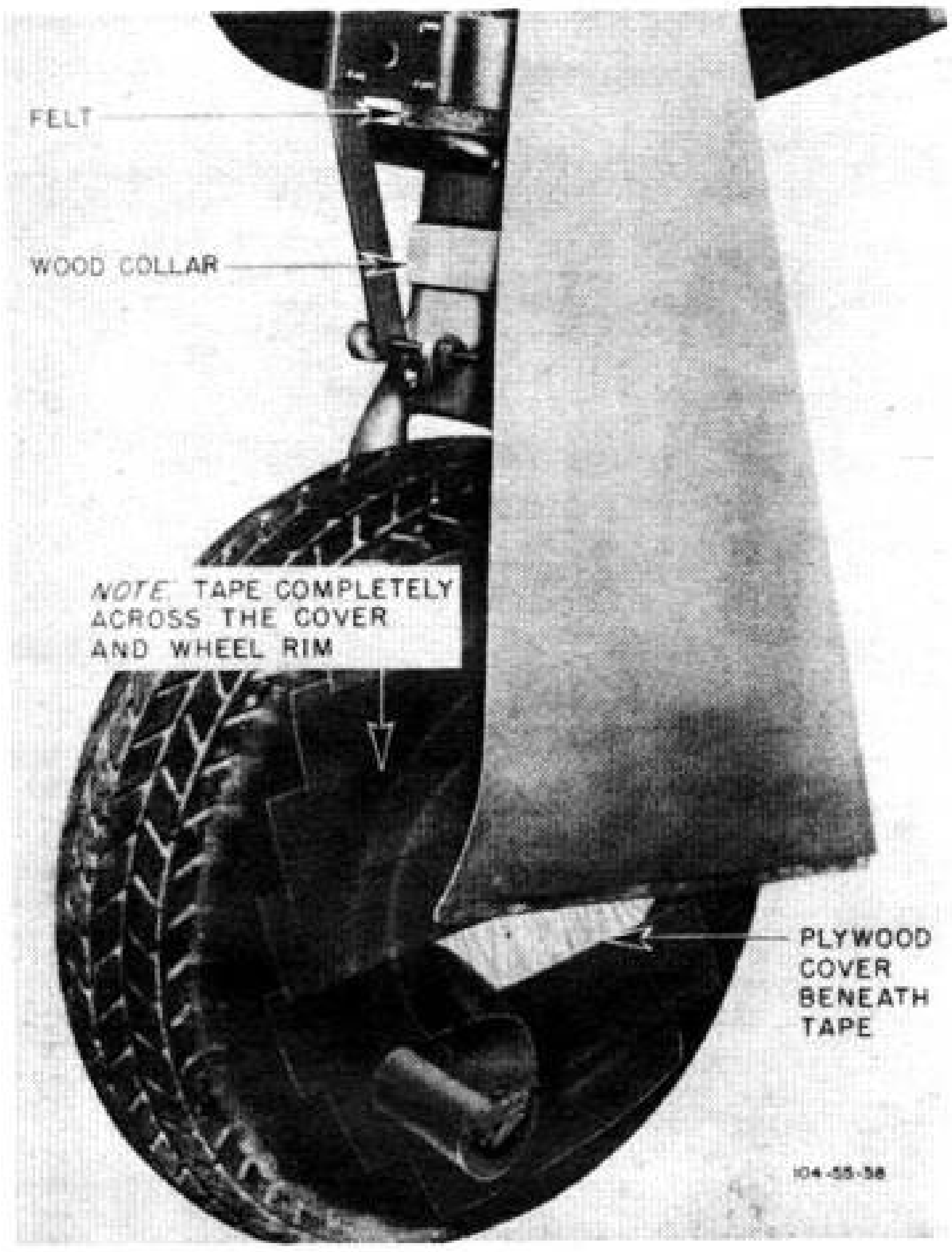



*Figure 24—Main Wheel Cover and Strut Lashing Collar*

(*h*) When wheel well shield and top of strut are taped closed, carry tape down strut about 10 inches.

(10) COVERING OTHER OPENINGS.

(*a*) Cover engine nose with plywood and tape. (*See figure 25.*)

(*b*) Cover exhaust stacks with oilcloth. (*See figure 25.*)

(*c*) Cover carburetor air filters with oilcloth and tape.

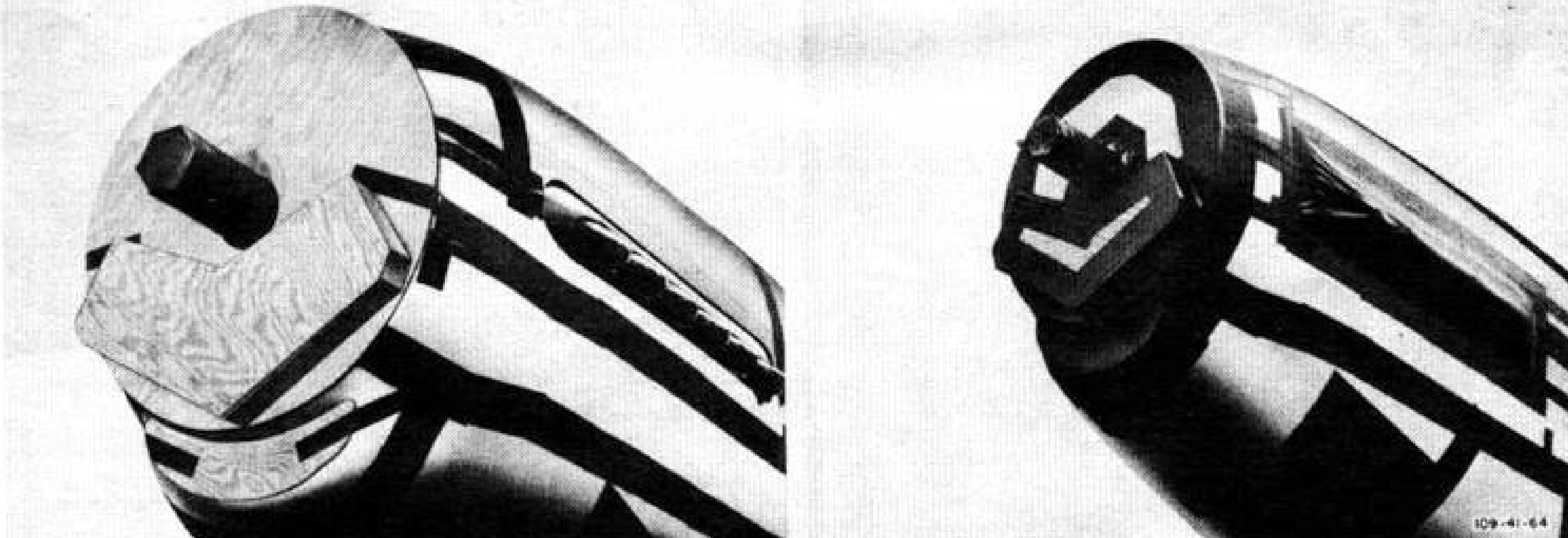



*Figure 25—Engine Nose Plywood Cover*

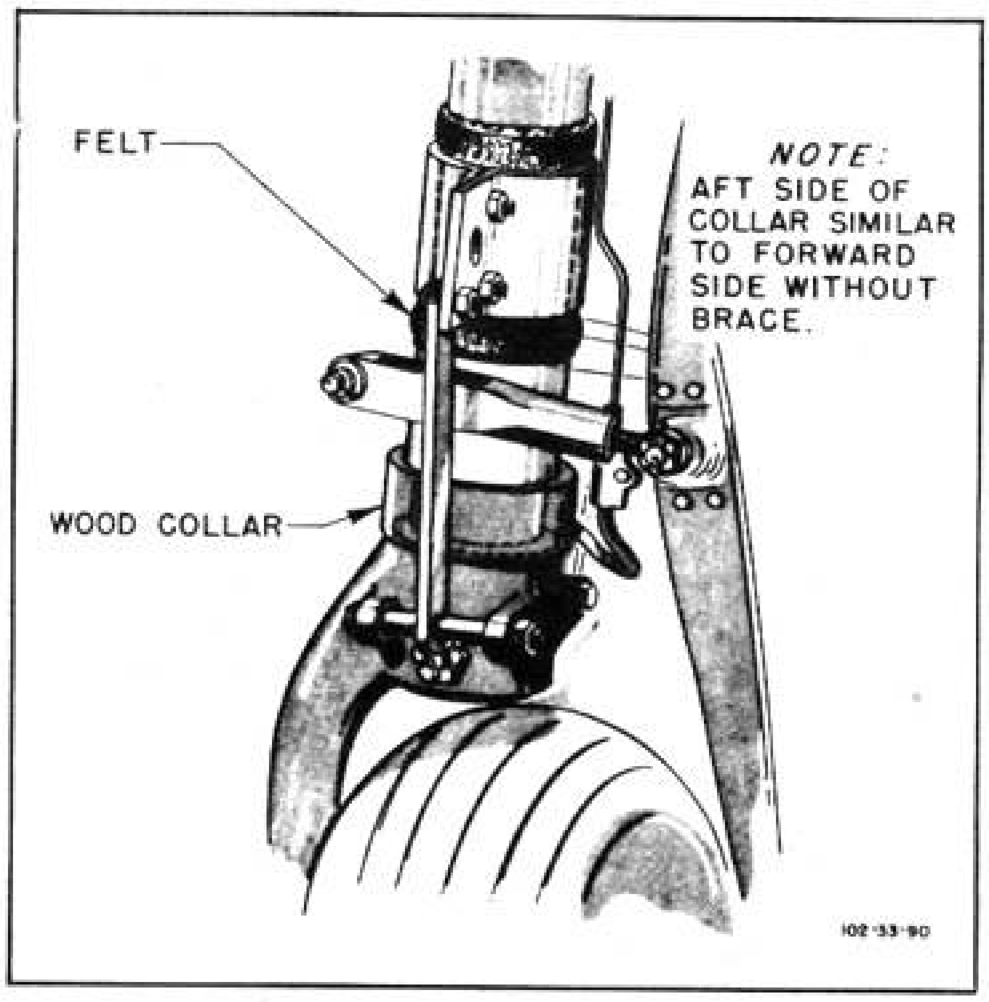



**Figure 26—Main Gear Lashing Collar**

*(d)* Cover gun ports with greaseproof paper, waterproof paper, and oilcloth taped in place.

*(e)* Cut a spoiler strip of ¾-inch half-round stock to reach from the fuselage to the end of the wing, and tape it in place on the high point of the wing.

*(f)* Cover all other cracks, holes, and joints with tape. *(See figure 28.)*

(11) INSTALLING TIE-DOWN IRONS.

*(a)* Clamp tie-down irons to landing gear struts above fairing brace. *(See figure 26.)*

*(b)* Fasten leg of tie-down iron to a bolt passed through tow bracket below cylinder.

*(c)* Install solid lift bar coated with Par-al-ketone (Specification No. AN-C-52) through lift tube at rear of fuselage. Slip collars of plywood covered on inboard side with felt and greaseproof paper over ends of bar, and screw on lift ring nuts.


**Figure 28—Airplane Completely Sealed**

(12) SPRAYING AIRPLANE WITH PAR-AL-KETONE.

*(a)* Spray entire airplane including struts and wheel covers with Par-al-ketone (Specification No. AN-C-52, Type I). *(See figure 27.)*

*(b)* After spray has dried, cover nose section with oilcloth and then with a canvas engine cover. *(See figure 30.)*

*(c)* Cover tail section with a canvas cover that reaches to the forward end of the tail wheel door, and lash in place. *(See figure 29.)*

*(d)* Spray over covers with Par-al-ketone (Specification No. AN-C-52, Type I).

*(e)* Stencil shipping data on both sides of fuselage slightly to the rear of the trailing edge of the wing.

*(f)* Stencil "GLASS" on cockpit enclosure windows.

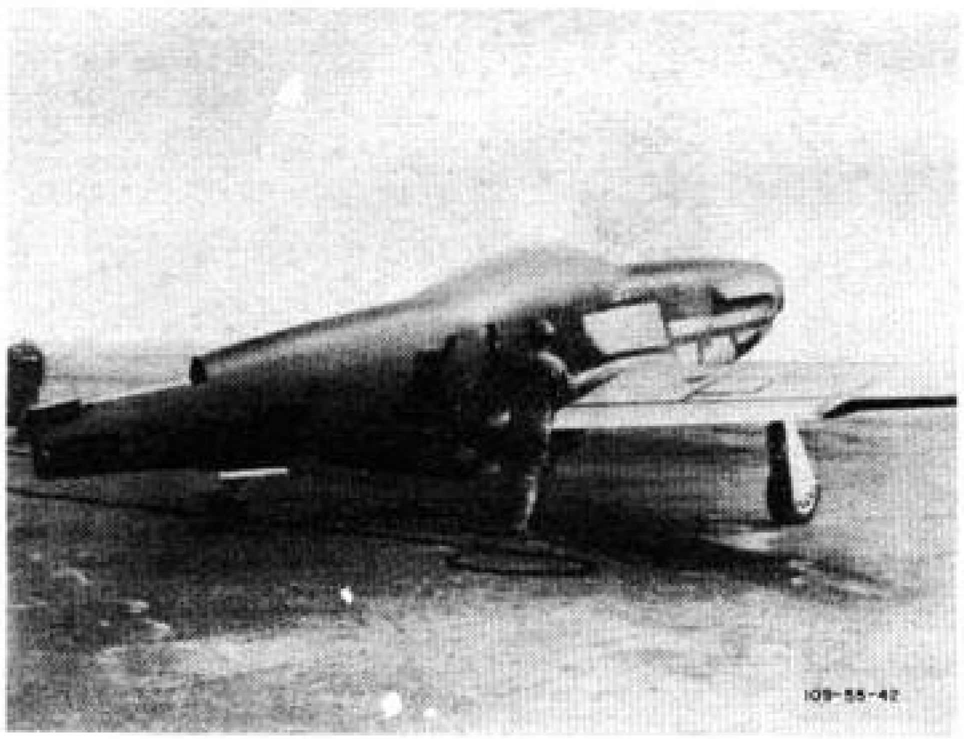



**Figure 27—Spraying Complete Airplane**


**Figure 29—Canvas Cover Installation—Tail Section**

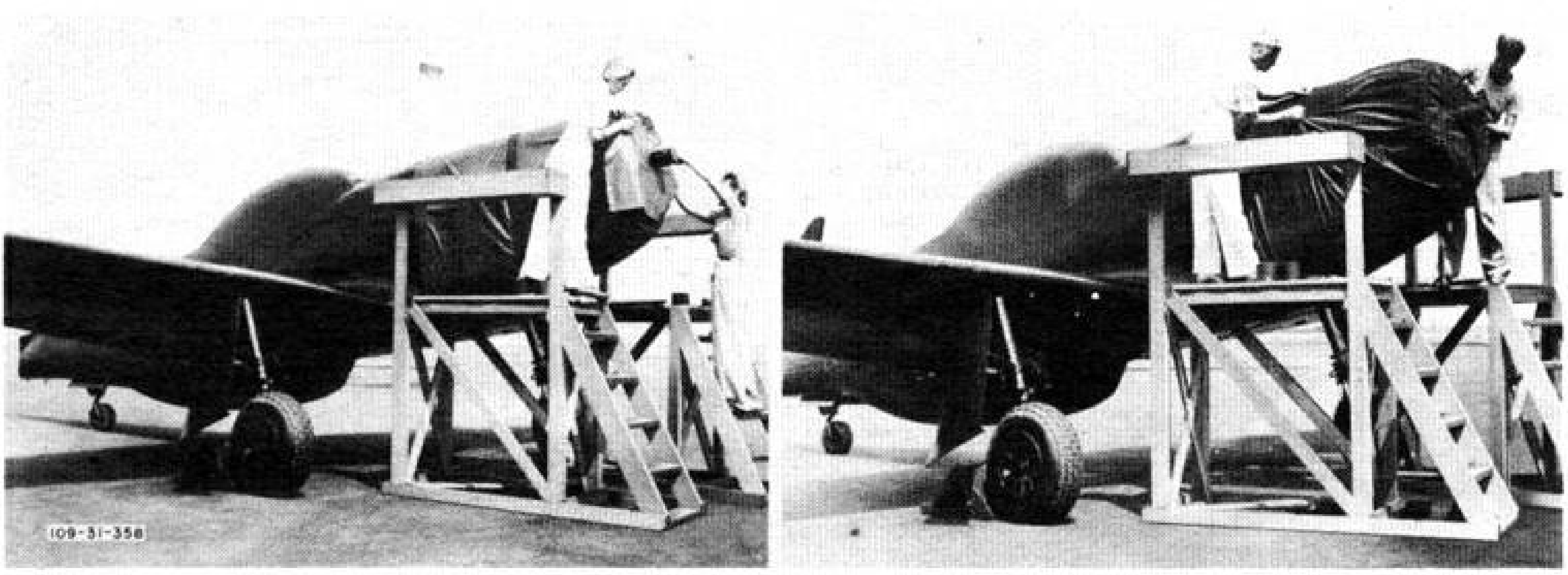


*Figure 30—Covering Nose Section After Spraying*

(13) PACKING AND CRATING OF ON-DECK SHIPPING CRATE.

*(a)* Build the crate components as shown in figure 33. The reference numbers given in the following procedures are also given in figure 33.

*(b)* Place crate bottom on dollies and lag end chucks (1-2) at each end, running down lag screws with nut runner.

*(c)* Place propeller rack about 3½ inches closer to one end than the other. Be sure the tips of the blades clear the sides by at least 1½ inches. The propeller rack will consist of members 8-1, 8-2, 8-3, and 8-4, which are bolted to supports (6-1) with eight machine bolts (H-4). These bolts are run from the underside of supports (6-1) with the holes countersunk so that the supports will fit flush with the bottom. Lag each support to the two center bottom skids with two lag screws each. *(See figure 31.)*

*(d)* Place propeller hub and blade assembly in felt-padded collar and install upper collar members (8-2 and 8-4), which will be diagonally braced at each corner with braces (6-3). *(See figure 32.)* Bore five 1½-inch drainage holes in the crate bottom and cover with ¼-inch mesh wire.

*(e)* Place front spinner on blocks up against end chuck on lower left-hand side of crate bottom. Secure spinner in place by cross-webbing over jiffy pads and blocking the ends of the webbing to the bottom. Attach waterproof tape over the webbing to prevent it slipping off the spinner.

*(f)* Place wing tips, one at each end of the bottom, on padded blocks. The butt end of the wing tips will be outward with the corrugated paper covered navigation lights upward. Secure each wing tip in place with two strips of webbing over jiffy pads, and block the webbing ends. Brace three sides of each wing tip with triangular-shaped padded blocks.

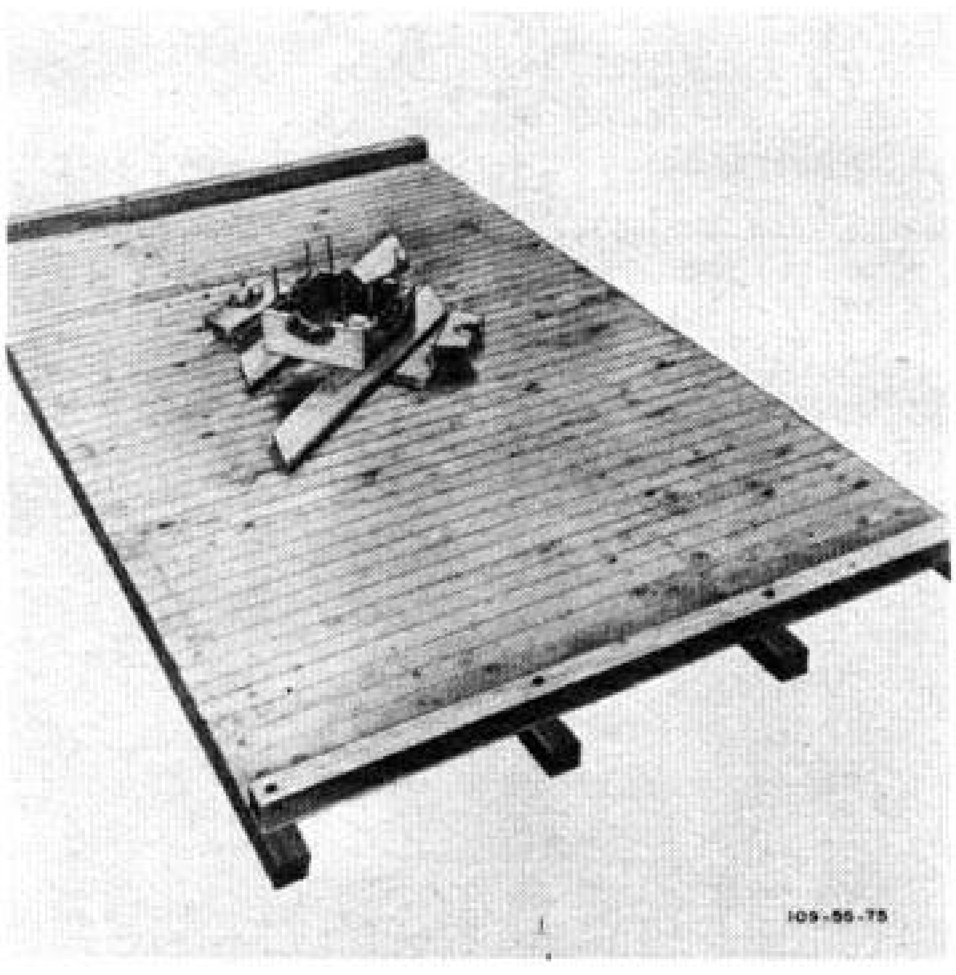


*Figure 31—On-Deck Shipping Crate Bottom With Propeller Collar in Place*

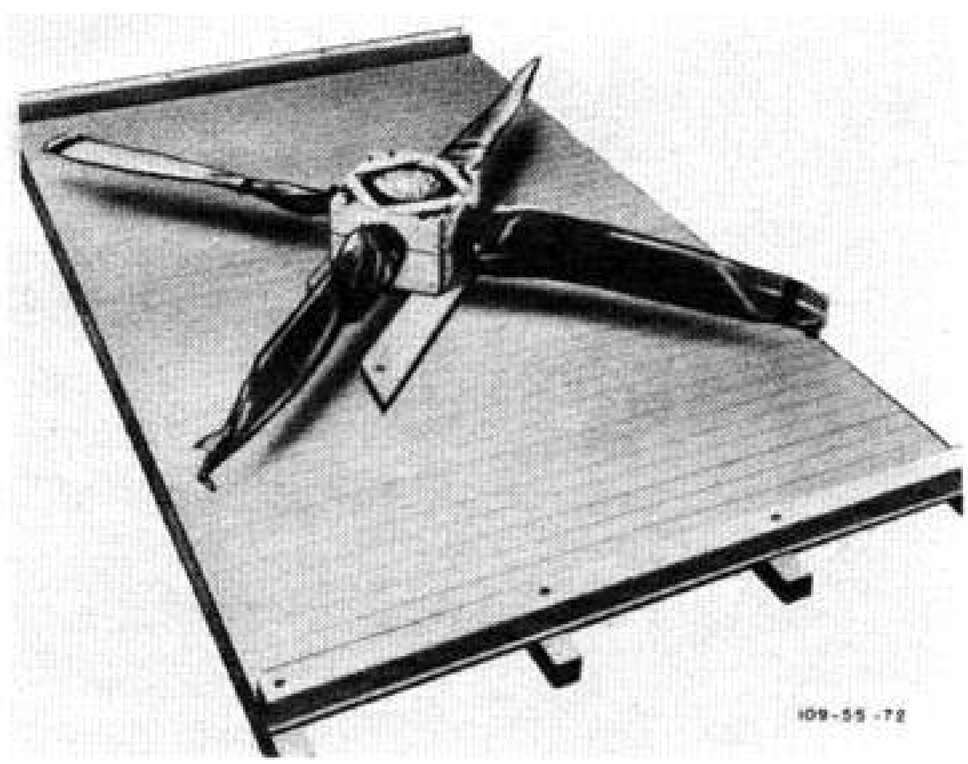
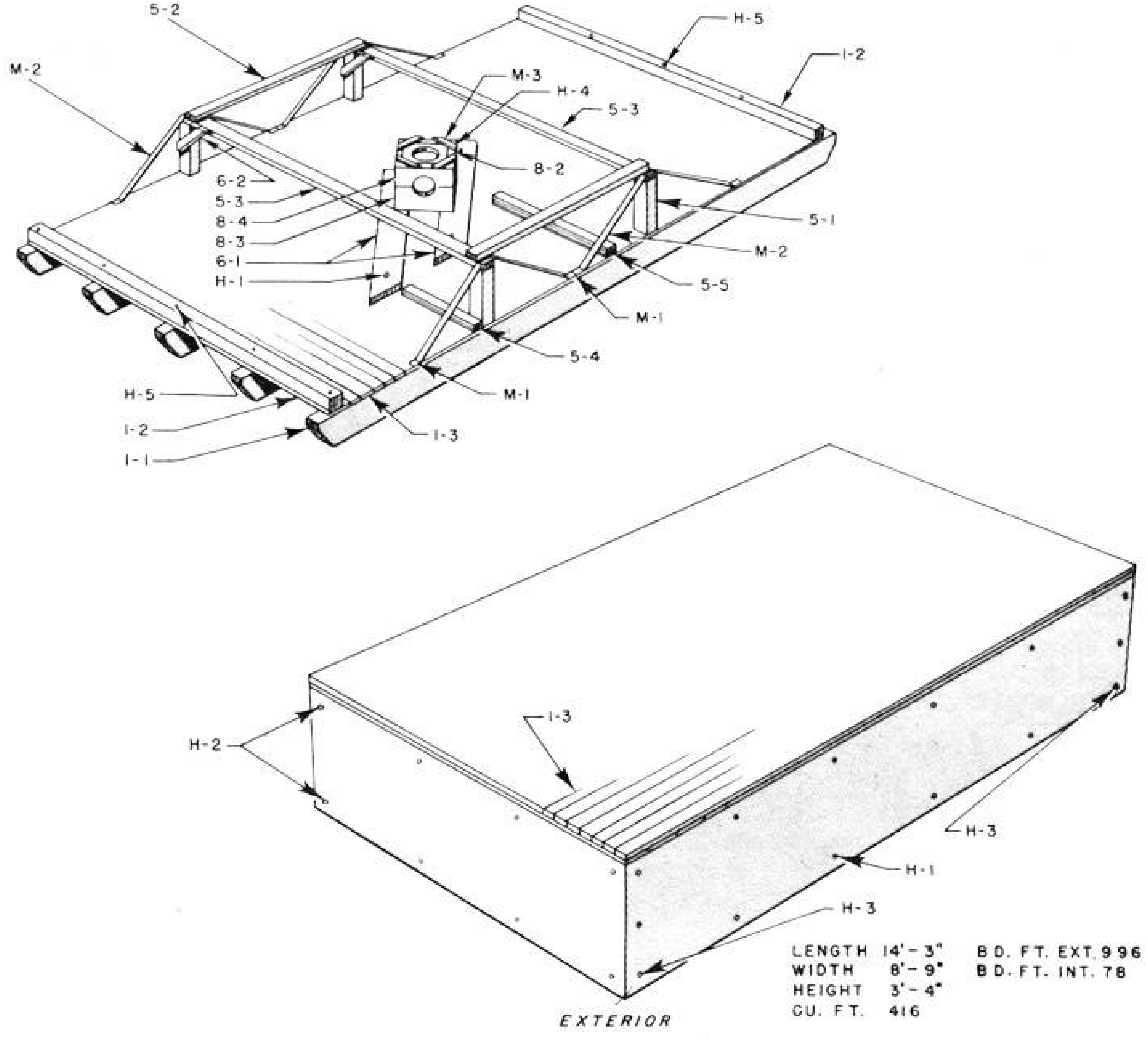


*Figure 32—Propeller Secured in Crate*




| | REQ | SIZE | DESCRIPTION | | REQ | SIZE | DESCRIPTION | | REQ | SIZE | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8-4 | 2 | 2"X6"X18" | PROP. COLLAR | 5-3 | 2 | 2"X4"X8'-4" | CROSS PIECE | 2-4 | 20 | 2"X4"X2'-5-2/5 | SIDE SPACER |
| 8-3 | 2 | 2"X8"X18" | PROP. COLLAR | 5-2 | 2 | 2"X2"X5'-3" | BRACE | 2-3 | 4 | 2"X4"X12'-0" | SIDE HORIZONTAL |
| 8-2 | 2 | 2"X6"X14-1/2" | PROP. COLLAR | 5-1 | 4 | 2"X4"X14'-1/4" | UPRIGHT | 2-2 | 6 | 2"X4"X3'-1-1/4" | SIDE VERTICAL |
| 8-1 | 2 | 2"X8"X14-1/2" | PROP. COLLAR | 4-2 | 6 | 4"X4"X8'-0-1/2" | TOP CROSS | 2-1 | 10 | 2"X4"X3'-4" | SIDE DIAGONAL |
| 6-2 | 4 | 1"X2"X1'-0" | BRACE | 4-1 | 2 | 2"X4"X13'-6" | TOP LONG | 1-3 | | 581 SQ.FT.3/4" | TBG SHEATHING |
| 6-1 | 2 | 2"X8"X5'-0" | PROP. SUPPORT | 3-3 | 4 | 4"X4"X8'-4" | END HORIZONTAL | 1-2 | 2 | 4"X4"X8'-4" | END CHOCKS |
| 5-6 | 26 | 2"X4" VARY | BASES | 3-2 | 8 | 4"X4"X2'-0-1/2" | END VERTICAL | 1-1 | 4 | 4"X6"X14'-3" | SKIDS |
| 5-5 | 3 | 1"X3"X3'-2" | RUDDER SUPPORT | 3-1 | 4 | 2"X4"X3'-1" | END DIAGONAL | | 60 | 2"X3"X3/4" | PLYWOOD |
| 5-4 | 2 | 1"X3"X2' | RUDDER SUPPORT | 2-5 | 4 | 2"X4"X1'-6-1/8" | SIDE DIAGONAL | | | 1"X2"X72'-0" | STRIPS |

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*Figure 33 (Sheet 1 of 3 Sheets)—On-Deck Shipping Crate*

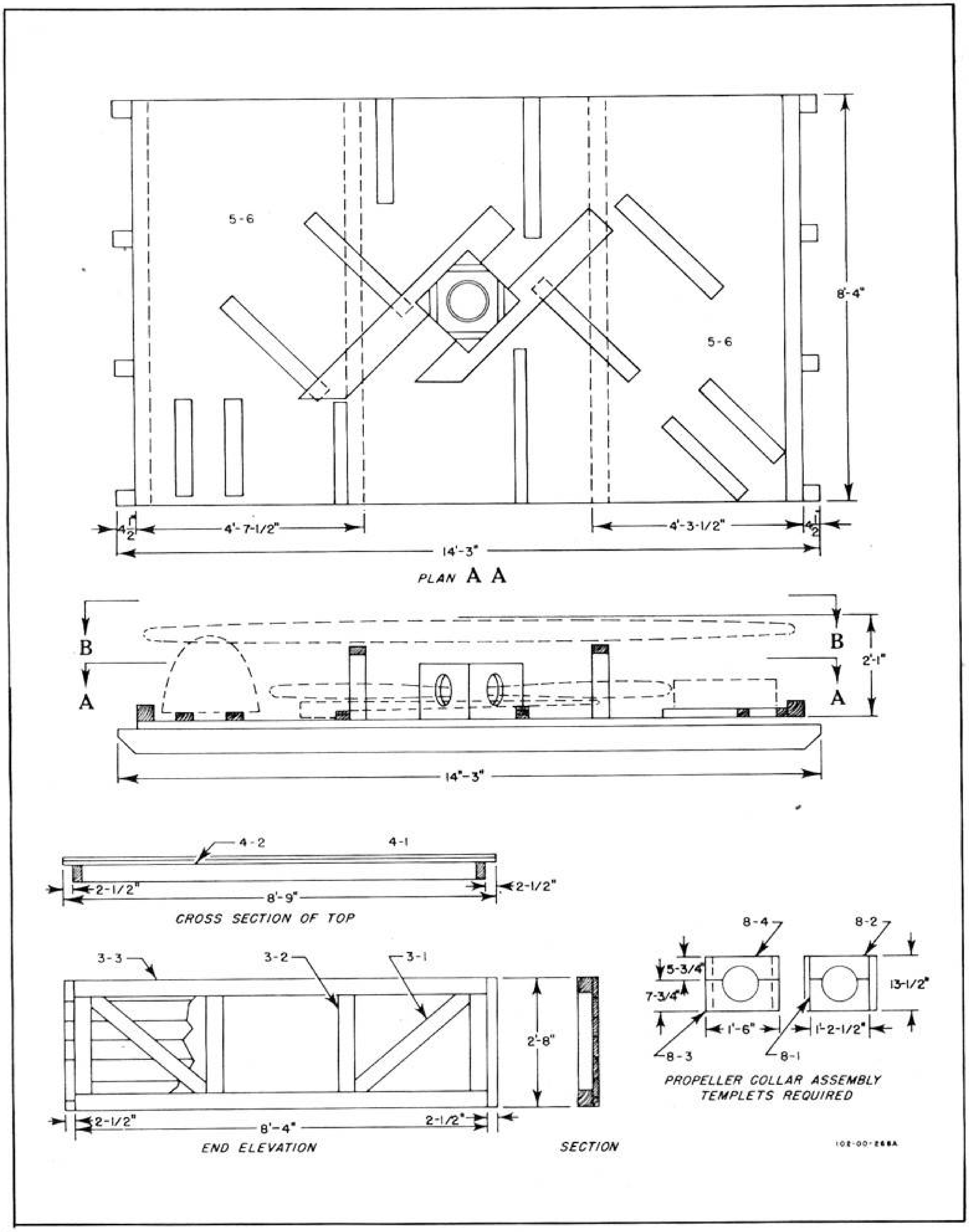
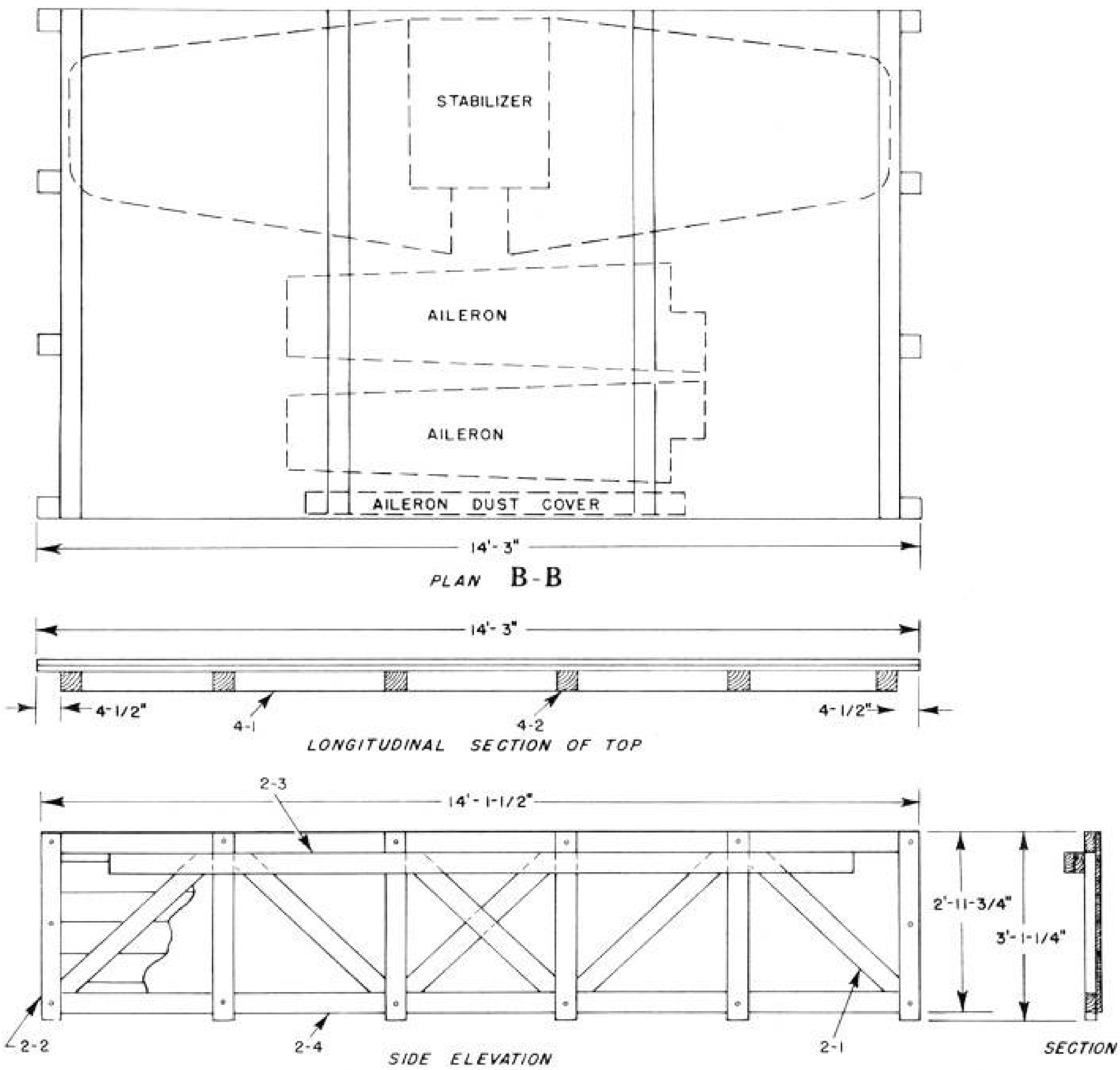



*Figure 33 (Sheet 2 of 3 Sheets)—On-Deck Shipping Crate*




| | REQ | SIZE | DESCRIPTION |
|---|---|---|---|
| H-5 | 8 | 1/2"X 11" | CARBTR BOLT |
| H-4 | 8 | 1/2"X 15" | MACH. BOLTS |
| H-3 | 4 | 1/2"X 7" | MACH. BOLTS |
| H-2 | 24 | 1/2"X 8" | LAG SCREWS |
| H-1 | 36 | 1/2"X 5" | LAG SCREWS |
| M-3 | 4 | 1/8"X1-1/2"X8" | BRACING |
| M-2 | 24 | 1-1/4" | BANDING |
| M-1 | 8 | 1-1/4"X 4" | ANCHOR PLATES |

| |
|---|
| 138 SQ. FT. FIBERENE PAPER |
| 130 SQ. FT. NANKEE PAPER |
| 135 SQ. FT. ROOFING |
| 5 GALLONS ASPHALT |
| 30'- 1-1/4" IRON BANDING |
| 48' METAL EDGING |
| 1 SQ. FT. WIRE MESH |
| 2# 20 D NAILS |
| 12# 8 D NAILS |
| 5# 7 D NAILS |

| MATERIALS FOR SEALING FUSELAGE |
|---|
| 48 SQ. FT. 1/4" PLYWOOD |
| 2"X4"X9" WHEEL BLOCKING |
| 4"X4"X6" WHEEL BLOCKING |
| 4"X6"X2" WHEEL BLOCKING |

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*Figure 33 (Sheet 3 of 3 Sheets)—On-Deck Shipping Crate*

*(g)* Place rudder (leading edge out) on padded blocks on right-hand side of crate bottom, and secure in place with two strips of webbing over jiffy pads. Place padded blocks at each end of the rudder, and plywood blocks over the ends of the webbing.

*(h)* Place vertical stabilizer on padded blocks on left side of crate bottom, with the blocking at the butt end higher than the tip end.

**Note**

Nail webbing to the crate bottom on the inside before positioning stabilizer, as it cannot be reached afterward.

*(i)* Secure stabilizer by crisscrossing the webbing at the large end and fitting the webbing into recess in stabilizer at small end. Block all ends of webbing.

*(j)* Place prewrapped airtight plugs on blocks in lower left corner of crate bottom, and secure with one strip of webbing lengthwise of the package and two strips of webbing sidewise.

*(k)* Place accessory box and power unit box in upper right corner of crate bottom against end chuck, and secure each box with ¾-inch metal banding once lengthwise and twice sidewise. Block boxes in with blocks at end and on the side.

*(l)* Place rear spinner on block between propeller rack and accessory box. Place two thicknesses of jiffy padding on the blocks and the top edges of the spinner. Secure with webbing crossed at top. Block the ends of the webbing. *(See figure 34.)*

*(m)* Place two one-gallon cans of ethylene glycol and a one-gallon can of hydraulic fluid on blocks against accessory box, and secure in place with webbing over jiffy padding. The webbing will extend sidewise over each individual can and over all three cans lengthwise. Block webbing at ends.

*(n)* Attach short and long fairings to greaseproof paper coated 2 x 4-inch blocks with washers and wood screws. Screws and washers will be given a coating of Paral-ketone (Specification No. AN-C-52, Type I) where they come in contact with the fairings. Place the short fairing in the lower center of the crate bottom and the long fairing in front of the accessory box, and nail to the bottom.

*(o)* Place uprights (5-1) and attach crosspieces (5-3) as indicated on figure 35. Then attach cross braces (5-2) and diagonal corner braces (6-4). Secure uprights (5-1) to bottom by diagonal banding (M-2). Nail contour wedges on the two crosspieces (5-3), 3 inches from the left edge. Nail two other wedges to these crosspieces a sufficient distance from the first two to fit the stabilizer when it is placed on the crosspieces. Lay a strip of jiffy padding over the crosspieces (5-3) and the contour wedges, and install stabilizer. Lay another strip of jiffy padding over the top of the stabilizer and webbing, applied crosswise and diagonally. Block all ends of webbing.

*(p)* Lay ailerons separately on padded crosspieces (5-3). Fill in space between ailerons and crosspieces with

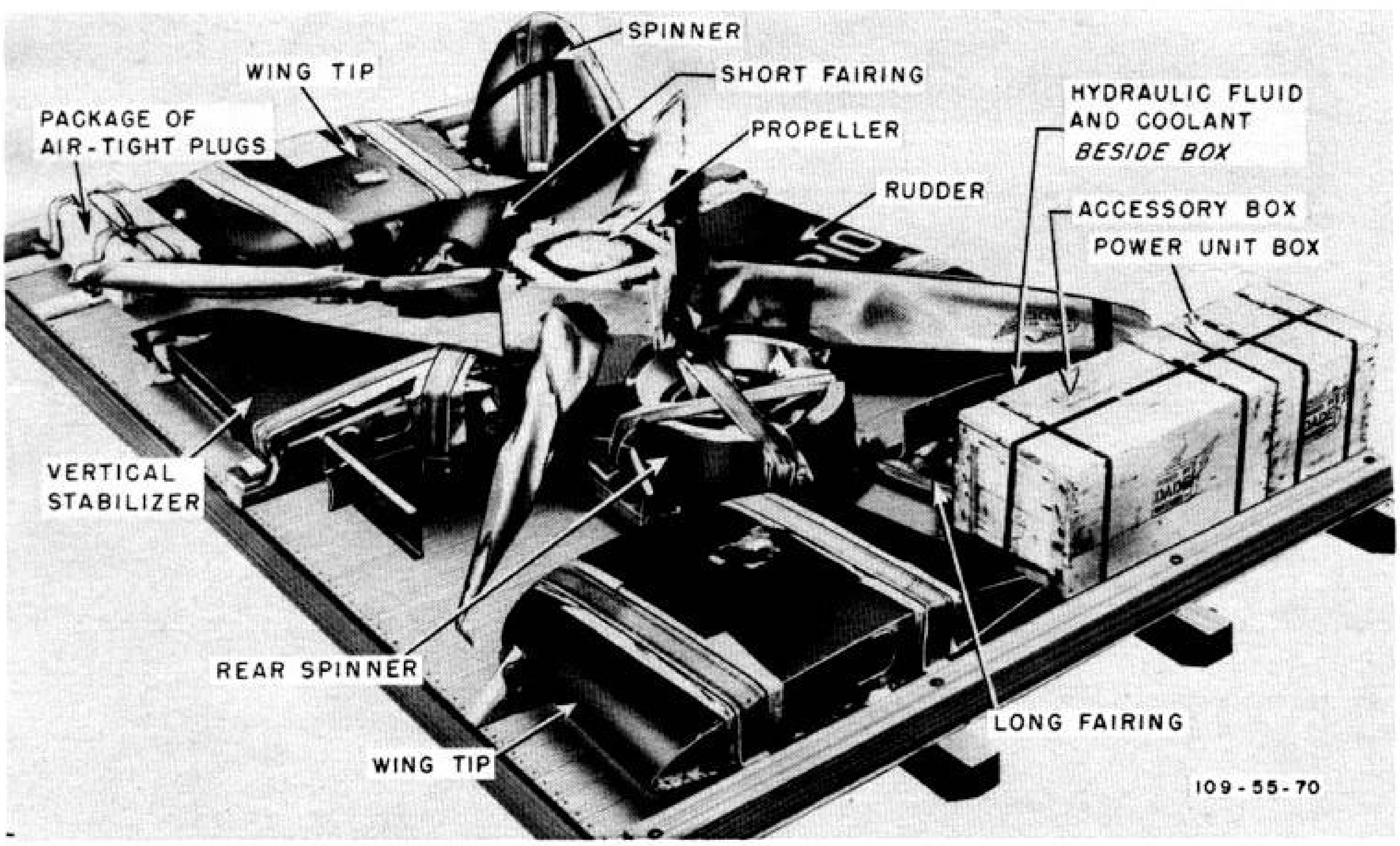



***Figure 34—Layout of On-Deck Shipping Crate Lower Level***

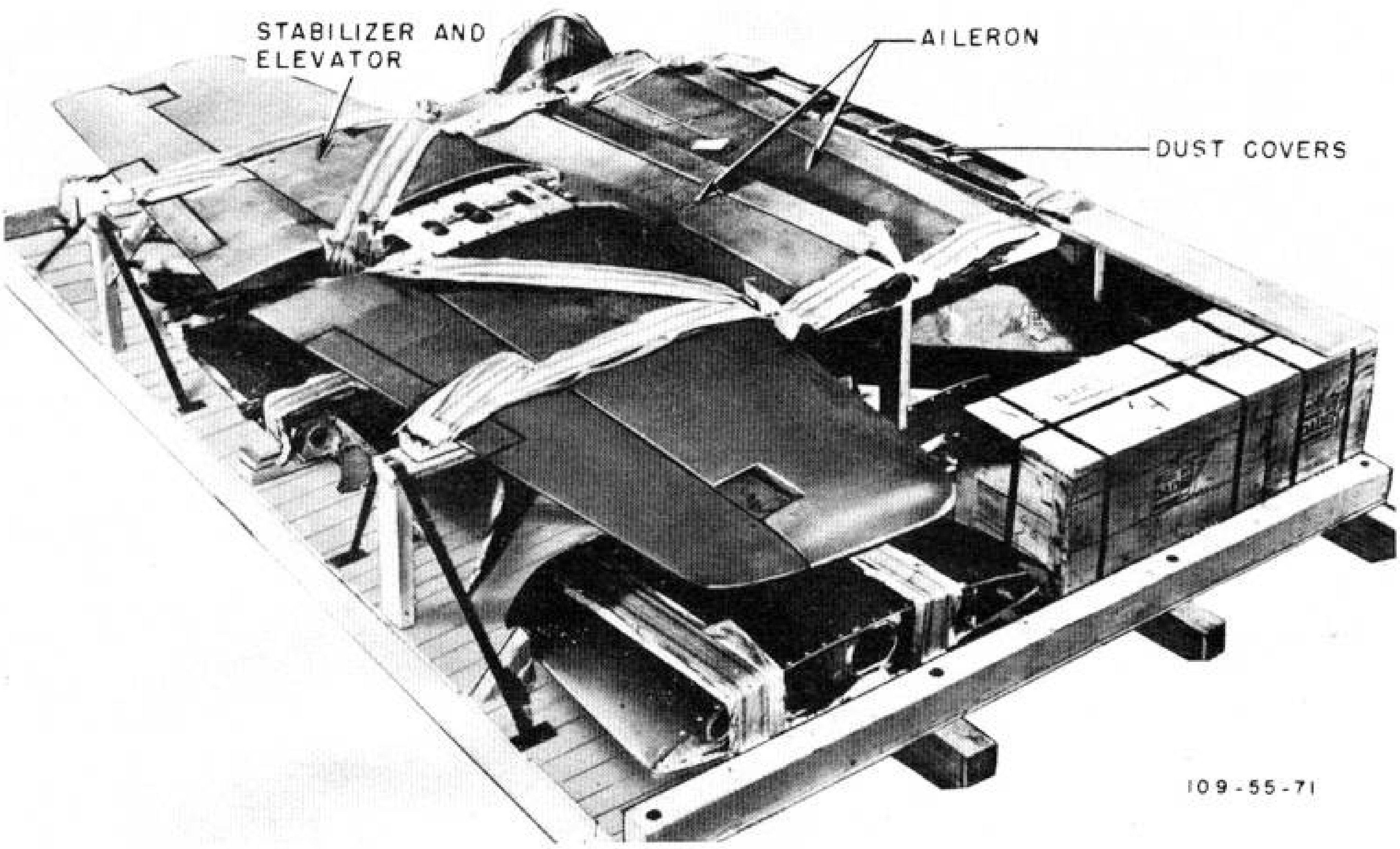



*Figure 35—Layout of On-Deck Shipping Crate Upper Level*

padded wedges. Secure each aileron in place with webbing over jiffy pads. Place a padded block at upper end of first aileron to keep it from slipping and a padded block at lower end of second aileron.

*(q)* Place a 1 x 8-inch sheathing across the two crosspieces (5-3) with one end resting on the power unit box. Lay the dust covers on this board and secure in place with webbing over jiffy pads.

*(r)* Clean all refuse from case and check to see if all drain holes are clear. Check to see if all parts are of the same serial number as that of the airplane for which they are packed, and that packing is complete in accordance with packing list.

*(s)* Attach preconstructed end sections in position and secure with four lag screws (H-2). Position side sections and secure each to base with five lag screws (H-1) and two machine bolts (H-3) as indicated on drawing. Fasten each corner with one lag screw (H-1).

*(t)* Place top in position and fasten through each side section with seven lag screws (H-1). Fasten top through each end section with four lag screws (H-2). Coat top with roofing mastic and roofing paper as in other airplanes.

*(u)* Paint sides and end of the case with nonspecular gray paint. Place packing list of the parts packed in the

*Figure 36—Installing Main Wheel Cover*

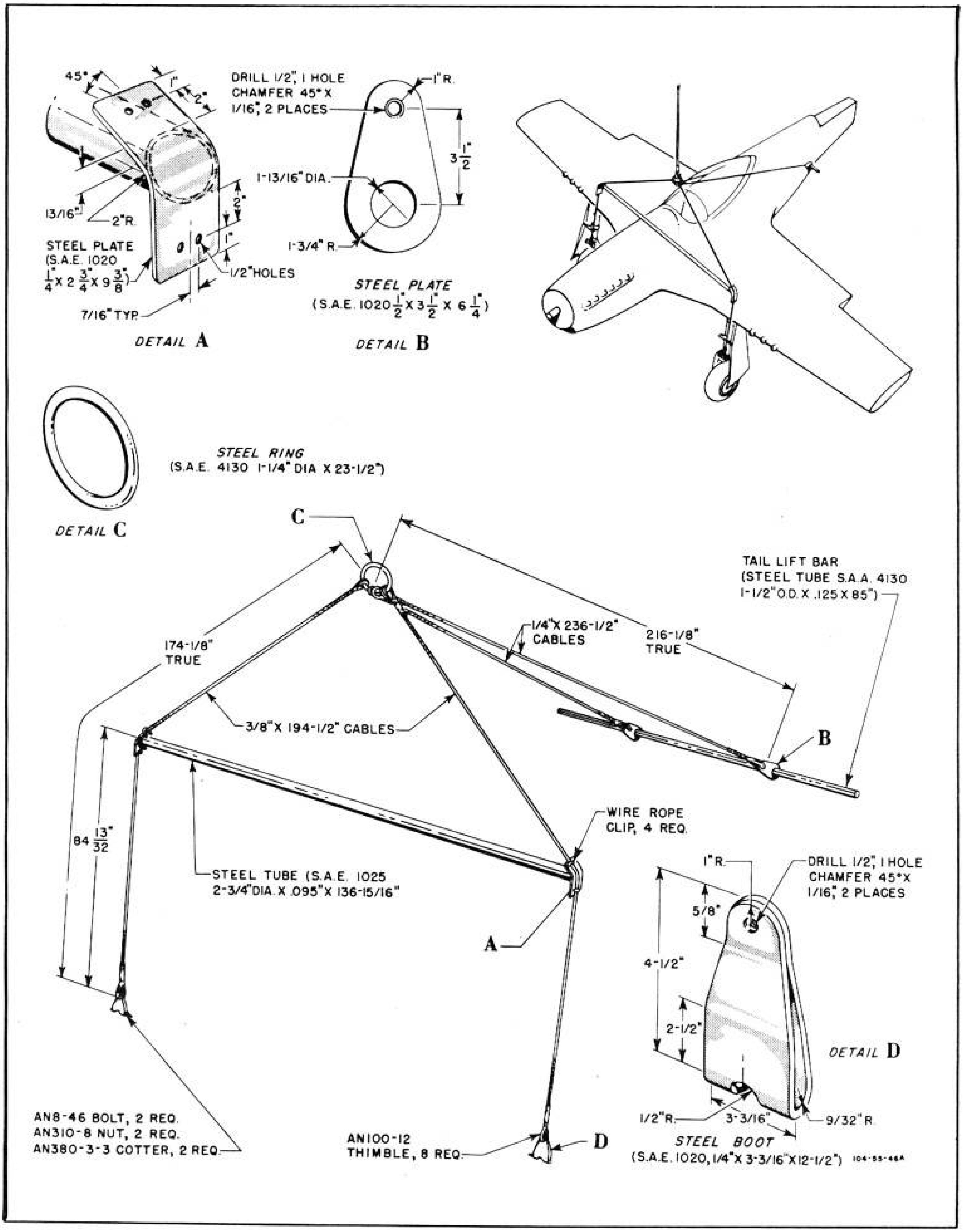



*Figure 37—Special Hoisting Sling*

*Figure 38—Installing Tail Wheel Cover*

case in a waterproof envelope, with the serial number of the airplane clearly marked upon it, fasten envelope to case, and cover with a piece of 22-gage sheet metal.

*(v)* Stencil all necessary markings on the crate or case according to Specification No. 94-40645-A.

(14) LOADING THE PROCESSED P-51.

*(a)* Perform the following operations on the dock:

*1.* Insert the solid tail tube in the tail.

*2.* Attach the special sling *(figure 37)* to each main gear and to tail tube.

*3.* Lift the airplane about 2 feet off the ground.

*4.* Install the wheel covers. *(See figure 36.)*

*5.* Install the tail wheel bag. *(See figure 38.)*

*6.* Lift the airplane onto the ship.

*(b)* Perform the following operations on the ship:

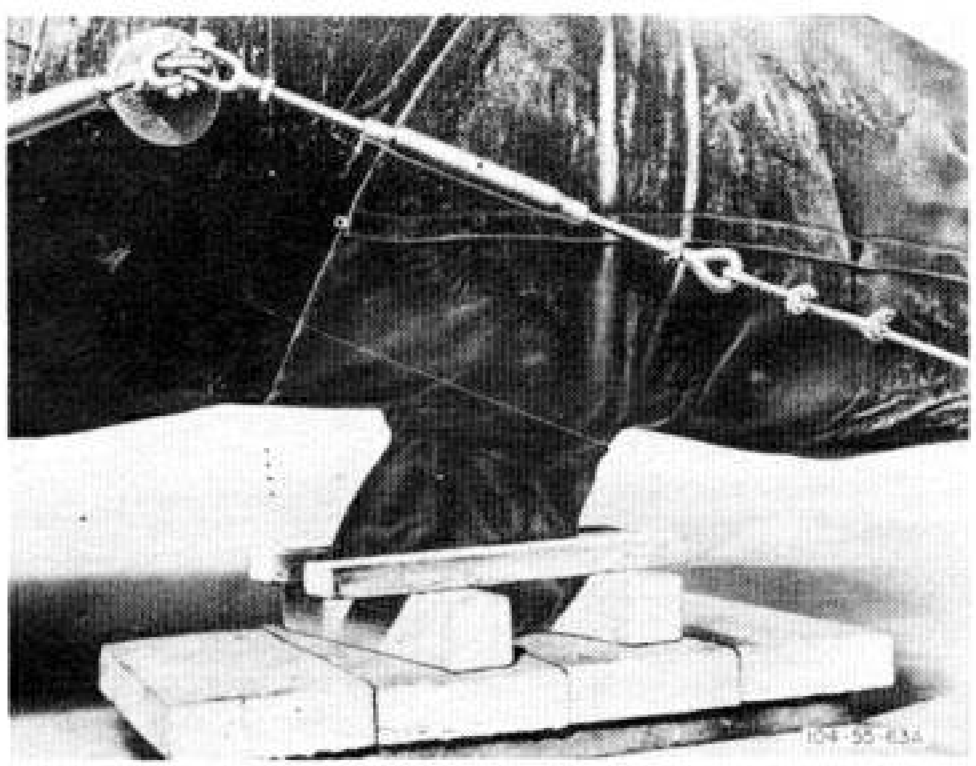


*Figure 39—Lashing at Tail Section*

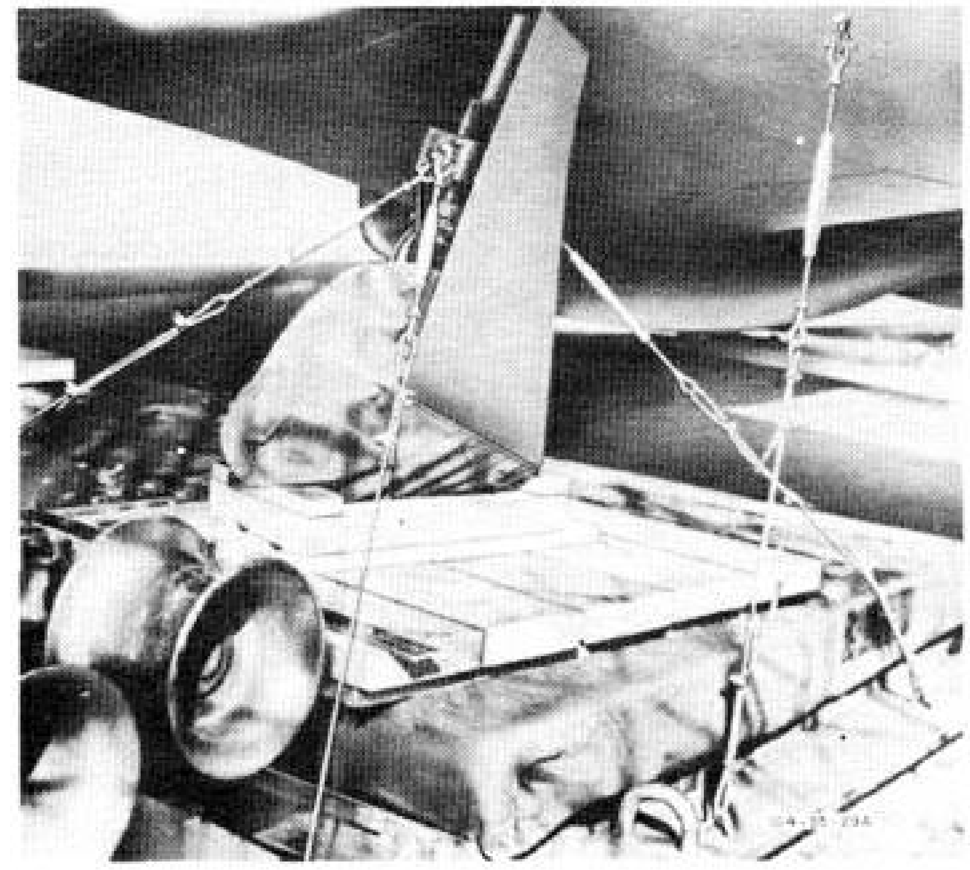


*Figure 40—Lashing at Main Gear and Wing*

*1.* Chock the wheels.

*2.* Seal the tops of the wheel bags with tape. Slit bottom of bag to permit water to drain out.

*3.* Remove the lifting sling.

*4.* Block the tail wheel in place and seal the tail wheel bag. Slit bottom of bag to permit water to drain out.

*5.* Lash the tail wheel to the deck. *(See figure 39.)*

*6.* Lash the main wheels to the deck. *(See figure 40.)*

*7.* Lash the wing to the deck. *(See figure 40.)*

**Note**

Use mooring cable protectors on all sharp corners. *(See figure 41.)*

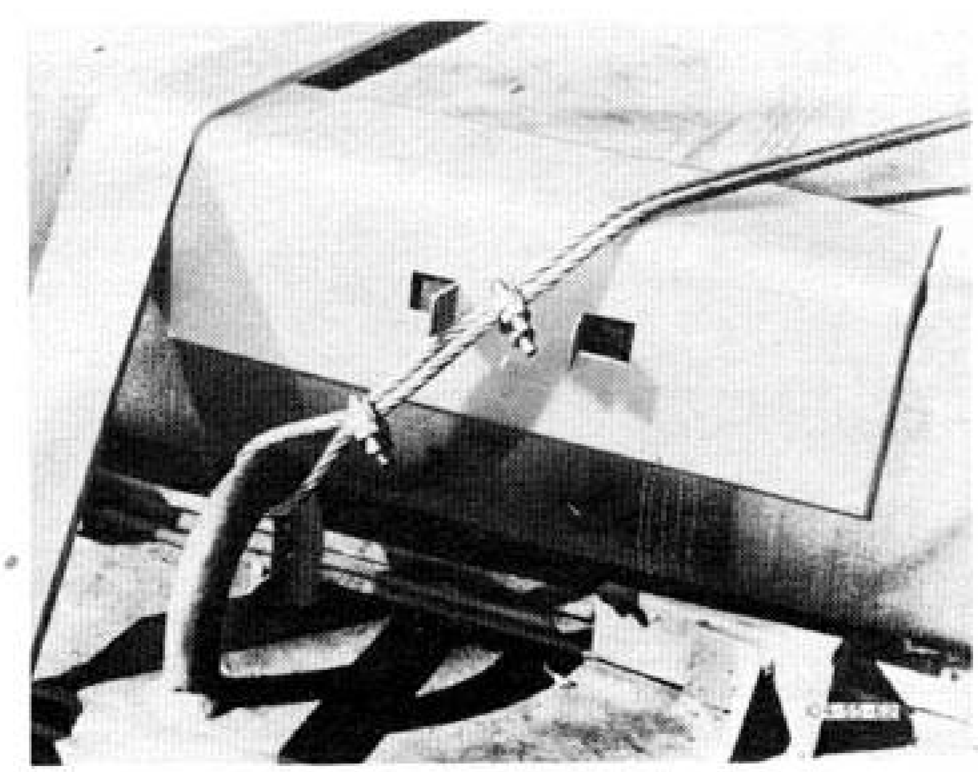


*Figure 41—Mooring Cable Protector*

(15) INSPECTION CHART FOR AIRPLANES PROCESSED FOR ON-DECK SHIPMENT.

| ITEMS TO BE INSPECTED | CORRECTIVE MEASURES TO BE TAKEN |
|---|---|
| *Corrosion.* — Destruction action of salt water and salt air on unprotected metal surfaces. On metal parts where the protective coating has been rubbed off, corrosion may appear as a white or red rust. | Clean and thoroughly wash with fresh water any surface on which corrosive action has begun. Dry and then coat with Par-al-ketone. |
| *Loose Tape.*—Tape peeling, blistering, or bubbling. | Trim off loose tape; clean surface with kerosene or low octane gasoline. Apply new tape and rub well.<br>**CAUTION**<br>Do not stretch tape. After application of new tape, brush with Par-al-ketone. |
| *Par-al-ketone.* — The protective coating which is applied to the exterior of the fuselage and exposed metal surfaces for protection against the elements. | Where this material has been worn off or scratched, surface should be cleaned and brushed with Par-al-ketone. |
| *Lashings.*—Include main wheel strut clamps, tail lift tubes, cables, and turnbuckles. | Main wheel strut clamp bolts should be drawn tight. In the event of failure of the tail lift tube, cable may be threaded through hollow tube.<br>**CAUTION**<br>Do not remove broken tail lift tube.<br>Place padding on sides of fuselage to prevent chafing. To secure airplane firmly against shifting, and to preclude the possibility of any structural strain to the airplane, cables should be tight but not taut. Adjustments in tension may be made by use of turnbuckles. |
| *Chocking.*—Main wheel and tail wheel chocks designed to steady the airplane and prevent movement. | If chock padding is worn or torn away, replace with new padding or some substitute. If chock is split or broken, repairs should be made by the ship's carpenter. |
| *Chafing.* — The rubbing action of wheels against wheel chocks. This action removes the Par-al-ketone from the wheel, making it highly susceptible to corrosion. | All places from which Par-al-ketone has been rubbed off should be cleaned with fresh water and brushed with Par-al-ketone. To prevent further chafing, place spacer between the wheel chock and tire. |
| *Wheel Boots.* — Waterproof covers on wheels, brakes, and lower struts should be examined for any evidence of entrapped water, tears, or loose tape. | If entrapped water is found in wheel boot, open boot, remove dust cover on main landing wheel, and examine wheel for evidence of corrosion. If corrosion has begun, treat as described before; then reinstall wheel boot, tape, and seal. |
| *Tail Cover.*—Waterproof cover on disassembled fuselage should be examined for evidence of entrapped water due to tears or breaks in cover. | Drain entrapped water, remove cover, and examine fuselage for signs of corrosion. Treatment same as described before. |
| *Supercharger.*—Should be examined for presence of water. | Drain entrapped water, and examine supercharger and cover for signs of corrosion. Treatment is same as described before. |
| *Flat Tires.*—Tires should be constantly checked for signs of slow deflation. | The chock is designed to support the weight of the airplane in the event of a flat tire. Lashing and turnbuckles should be tightened to prevent movement, and chocks should be carefully examined. |
| *Engine Covers.*—Waterproof covers on engine and nose of fuselage should be examined for evidence of entrapped water. Examine rope lashing to see that shrinkage does not tear eyelets from cover. | Make necessary adjustments to lashing. Drain entrapped water, remove cover, and examine for signs of corrosion. Treatment as described before. |
| *Cockpit Enclosure.*—Should be thoroughly sealed at all times with tape and Par-al-ketone. | If seal is broken by tape becoming loose or waterproof paper being torn, correct as described before. |
| *Loose Insignia Covers.*—Waterproof paper placed over insignia to prevent disclosure of identity. | Should paper become torn or loose, replace and tape. |
| *Flaps Down.*—Loss of hydraulic pressure will let flaps hang loosely. | To correct this condition, support flaps by a wooden clamp made with two strips of wood extending approximately 12 inches past the leading edge and trailing edge of the wing.<br>These strips should be padded, one placed on the lower and one on the upper surface of the wing, and bolted or lashed together at their extremities. This will hold the flaps in normal "UP" position. |
| *Plywood.*—Plywood is additional protection given to fabric surfaces or exposed disassembled surfaces of metal. | Upon discovery of broken plywood or loose bolts, have the ship's carpenter make necessary repairs. After repairs, seal all seams and joints with tape and Par-al-ketone. |
| *Damage to Airplane.* — The entire airplane should be closely examined for any evidence of breaks, dents, or scratches that may occur in transit. | Any breaks in skin or cockpit glass or other part of the airplane should be tightly sealed to prevent entrance of salt water which would cause interior corrosion. Dents and scratches should be washed and Par-al-ketoned. |

## 2. PREPARATION OF AIRPLANE FOR "CRATED" SHIPMENT.

In handling, processing, and packing the airplane for "crated" overseas shipment, all components are in a single crate.

*a.* PROCESSING AND ACCESSORY MATERIALS. *(See paragraph 1. a.)*

*b.* CARE OF AIRPLANE AWAITING PROCESSING.—See section III, paragraph 4, for storage procedures.

*c.* PREPARING AIRPLANE FOR SHIPMENT.

(1) PREPARING ENGINE.

*(a)* ENGINE RUN-UP.—See paragraph 1. *c.* (1) in this section.

*(b)* PROCESSING THE ENGINE.—See paragraph 1. *c.* (1) *(b)* in this section.

*(c)* PROCESSING THE FUEL SYSTEM.—See paragraph 1. *c.* (1) *(g)* in this section.

(2) PROCESSING THE PROPELLER COMPONENTS.—See paragraph 1. *c.* (2) in this section.

(3) PROCESSING MISCELLANEOUS ITEMS.—See paragraph 1. *c.* (3) in this section.

**Note**

Do not reinstall the battery in the fuselage.

(4) PROCESSING THE EMPENNAGE.—See paragraph 1. *c.* (4) in this section.

(5) PROCESSING THE WING.

*(a)* Remove the fuselage from the wing. *(See section IV, paragraph 1. b.)*

*(b)* Cap all lines on both wing and fuselage.

*(c)* Remove and process the two bomb racks. *(See paragraph 1. c. (5) (d) 4. in this section.)*

*(d)* Remove and process the wing subassemblies. *(See paragraph 1. c. (5) in this section.)* Leave pitot assembly on wing.

**Note**

If Saran-packed guns are available, remove installed guns and stow Saran-packed guns in crate. *(See figure 43.)*

*(e)* Remove wing flaps. *(See section IV, paragraph 1. b. (2).)* Spray exterior surface of flaps with Par-al-ketone (Specification No. AN-C-52) and wrap with 20-20-20 paper.

*(f)* Remove pilot's seat and armor plate.

*d.* SHIPPING CRATE.—Build the shipping crate. *(See figure 44.)*

*e.* INSTALLING AND SEALING ASSEMBLIES IN CRATE.

(1) INSTALLING FUSELAGE IN CRATE.

*(a)* Place a fiber block on each of the forward fuselage support stand attaching bolts. Place a Pliofilm patch *(figure 45, detail A)* on top of each block.

*(b)* Hoist fuselage in level flight position and guide the wing attaching holes in the lower longeron onto the forward fuselage stand attaching bolts.

*(c)* Place a temporary stand under the propeller shaft as a precaution against nosing over when sling is removed.

*(d)* Support the tail of the fuselage at the jacking point. Remove the hoisting sling and lift-tube bar.

*(e)* Place an F-2 wrap *(figures 42 and 45)* on the fuselage, cut holes in the wrap for the lift-tube bar, install rubber bumpers between the fuselage and the support stand, and then install the lift-tube bar that is to be shipped with the airplane.

*(f)* PROTECTIVE MEASURES PRIOR TO HERMETICALLY SEALING FUSELAGE.

*1.* Install a dry charged battery; then tie on the instrument panel a conspicuous warning tab stating: "WARNING! BATTERY IS DRY CHARGED."

*2.* Seal and secure the wing electrical disconnect plugs to the fuselage.

*3.* Plug in the radio flexes; on early airplanes, lock radio shelf forward.

*4.* Lash down hydraulic hand-pump handle.

*5.* Lash rudder control pedals.

*6.* Tie the landing gear control handle in the up position and attach a conspicuous warning tag.

(2) HERMETICALLY SEALING FUSELAGE.

*(a)* Blunt all protrusions on fuselage with masking tape and padding.

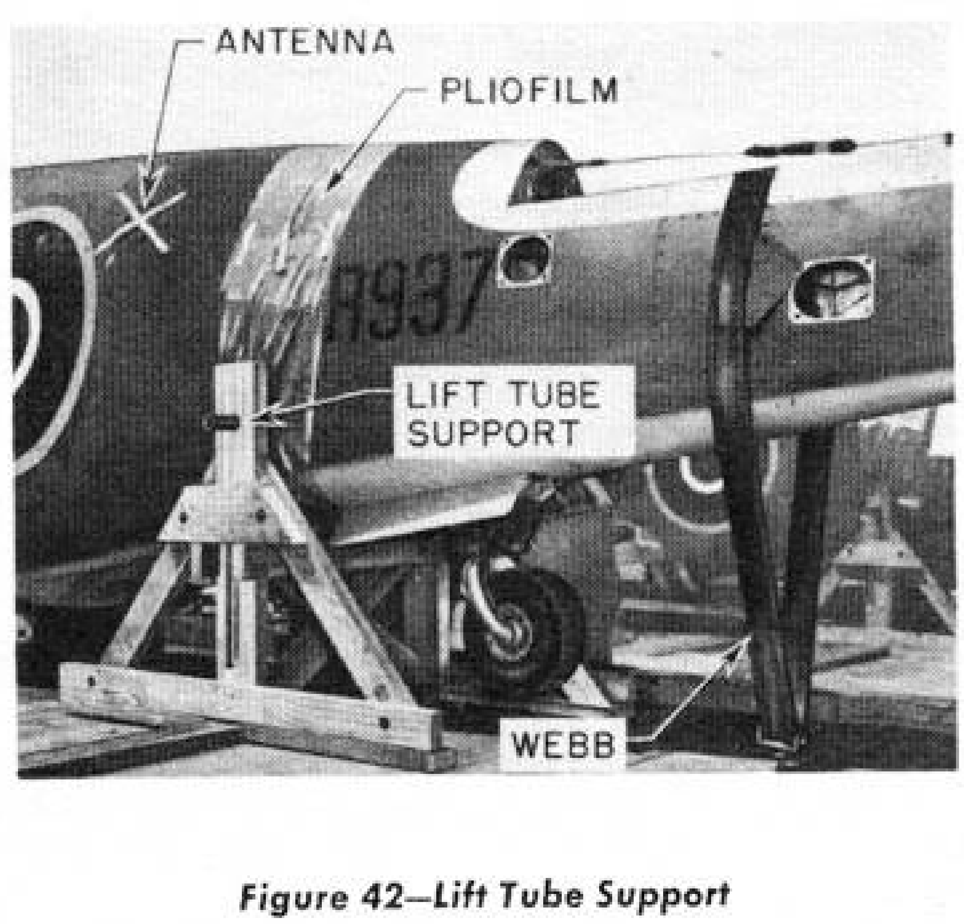
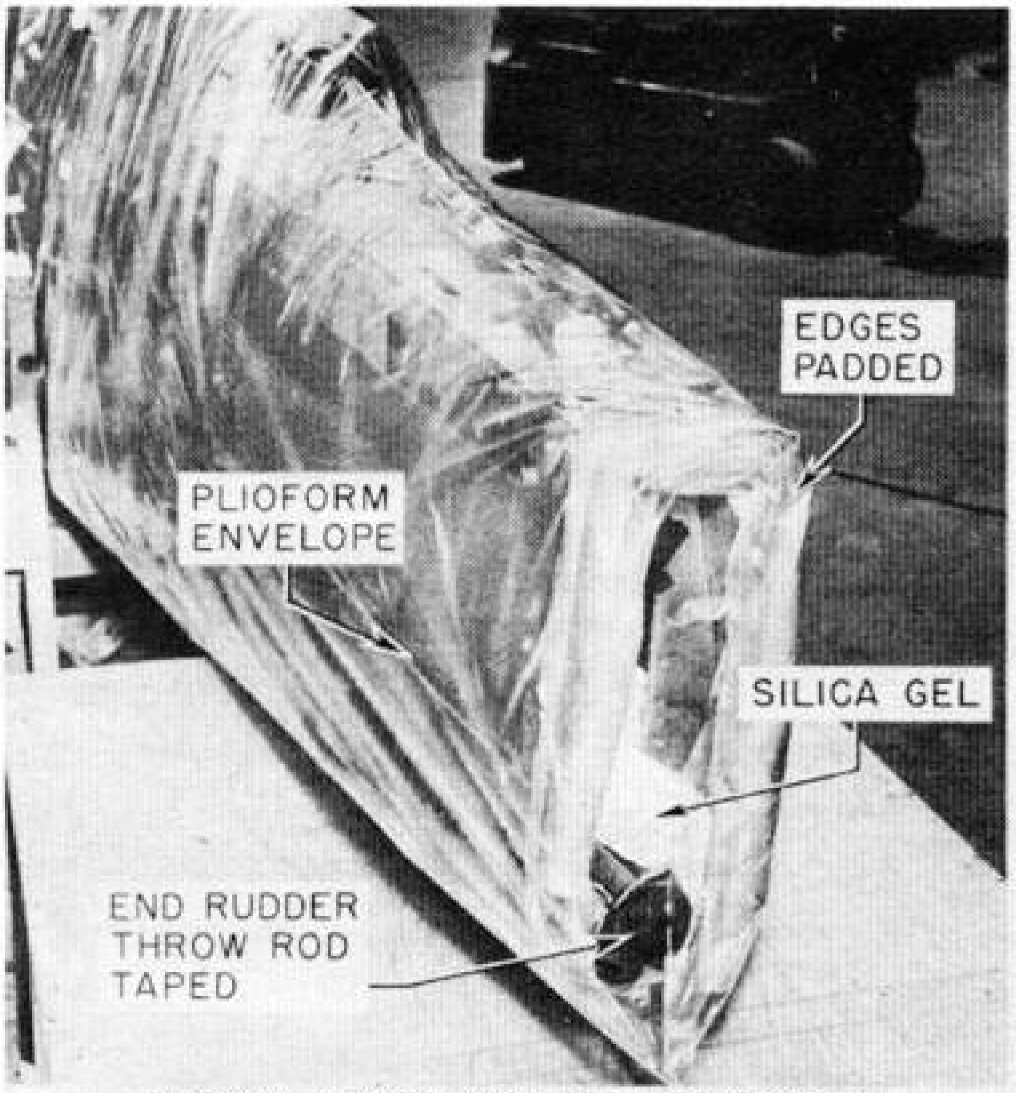


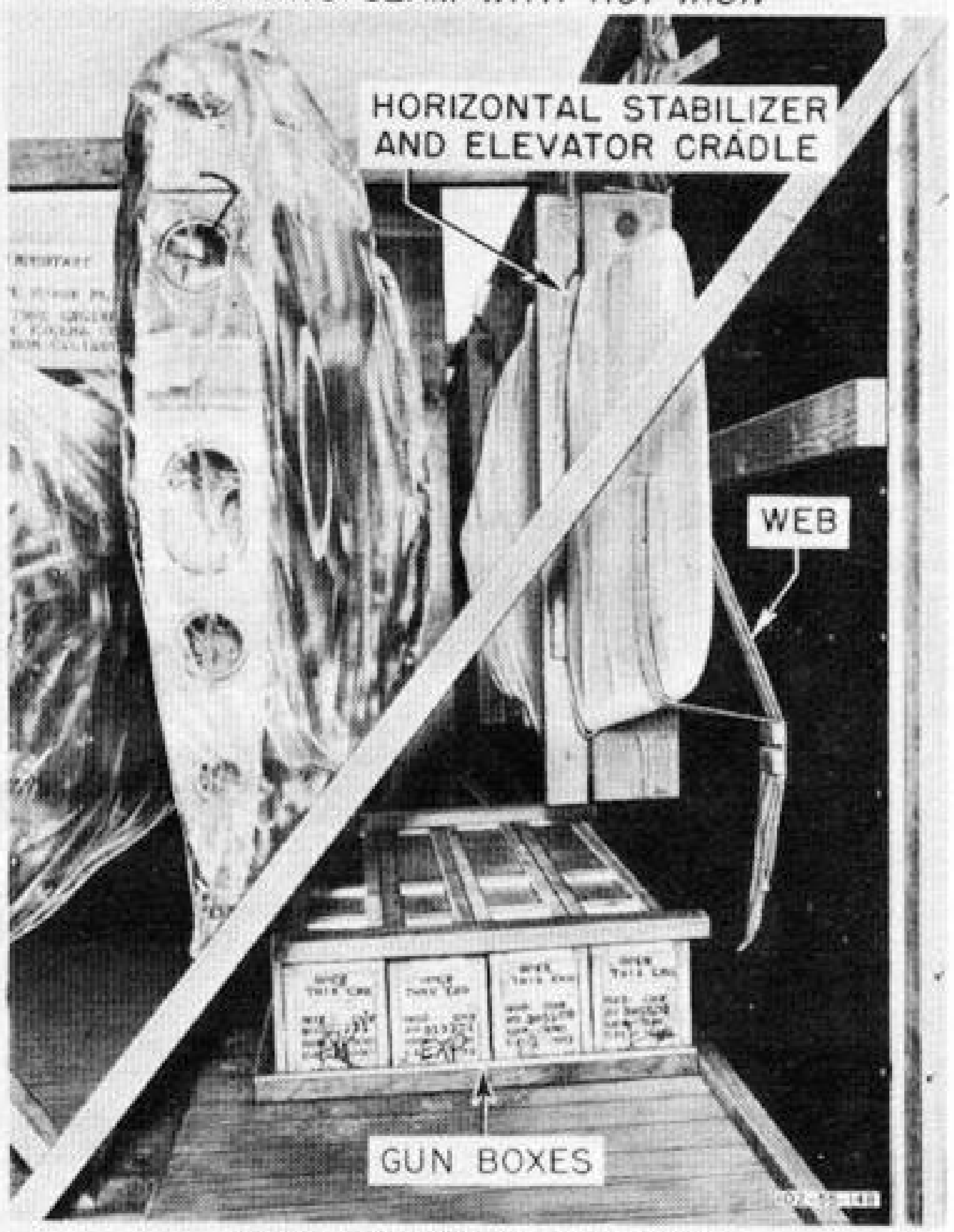

***Figure 42—Lift Tube Support***




*RUDDER THROW ROD DISCONNECTED*

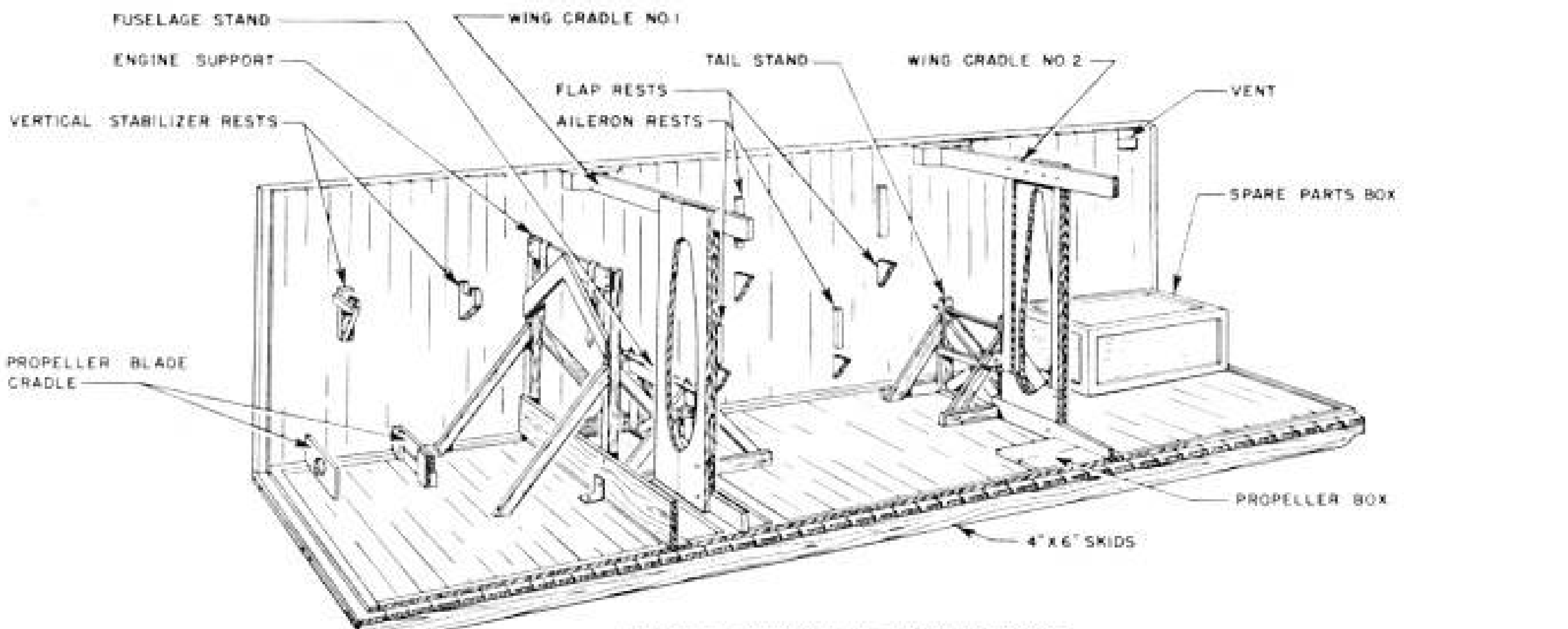

*JOINING SEAM WITH HOT IRON*


*SILICA GEL BAGS INSTALLED*




*SECURING PARTS IN CRATE*

***Figure 43—Sealing and Stowing Parts in Crate***




INTERIOR PERSPECTIVE VIEW OF CRATE

109-00-144

| PCS. | SIZE (IN INCHES) | LENGTH (IN INCHES) | CUT LENGTH | DESCRIPTION |
|---|---|---|---|---|
| 5 | 1 x 4 | 14 | | S4S Cleats, Braces, etc. |
| 10 | 1 x 2 | 14 | | S4S Cleats & Framing for Boxes, etc. |
| 3 | 48 x 3/8 | 8 | | S2S Plywood Miscellaneous Boxes |
| 2 | 24 x 3/8 | 6 | | S2S Plywood Spare Parts Box |
| 2 | 24 x 3/8 | 4 | | S2S Plywood Spare Parts Box |
| 2 | 40 x 3/8 | 6 | | S2S Plywood Spare Parts Box |
| 8 | 2 x 4 | | 2' 8" | S4S Tank Cradles |
| 8 | 1 x 6 | | 2' 8" | S4S Tank Cradles |
| 16 | 1 x 6 | | 3' 5" | S4S Tank Cradles |
| 4 | 1 x 12 | | 2' 8" | S4S Tank Cradles |
| 2 | 2 x 12 | | 3' 0" | S4S Prop. Base |
| 6 | 2 x 6 | | 1' 11" | S4S Propeller Cradles |
| 2 | 2 x 4 | | 2' 8 3/8" | S4S Beams, Tail Stand |
| 2 | 2 x 4 | | 4' 6" | S4S Spreaders, Tail Stand |
| 2 | 2 x 6 | | 3' 0" | S4S Uprights, Tail Stand |
| 6 | 2 x 6 | 8 | | S4S Cleats, etc. |
| 2 | 2 x 4 | | 2' 2 3/8" | S4S Sills, Fuselage Stand |
| 2 | 2 x 4 | | 2' 8 1/8" | S4S Sills, Fuselage Stand |
| 1 | 4 x 4 | | 3' 8" | S4S Beam, Fuselage Stand |
| 1 | 2 x 8 | | 3' 6" | S4S Beam, Wing Cradles |
| 3 | 2 x 6 | | 3' 6" | S4S Beams, etc. Wing Cradles |
| 4 | 2 x 4 | | 6' 5 1/4" | S4S Doublers, Wing Cradles |
| 2 | 2 x 12 | | 1' 11" | S4S Ties, Wing Cradles |
| 4 | 2 x 12 | | 7' 10" | S4S Uprights, Wing Cradles |
| 1 | 2 x 12 | | 7' 2" | S4S Beam, Engine Support |
| 2 | 4 x 4 | | 5' 10 1/4" | S4S Posts, Engine Support |
| 1 | 1 x 4 | 10 | | S4S Braces |
| 10 | 2 x 6 | | 7' 2" | S4S Sills, Ties, etc. |
| 1 | 2 x 6 | | 3' 10" | S4S Beam, Engine Support |
| 4 | 1 x 6 | 16 | | S1S1E Facing Around Top, etc. |
| 2 | 1 x 6 | 18 | | S1S1E Facing Around Top |
| 78 | 1 x 6 | | 7' 7" | S2S Shiplap Covering (or 58 pcs. 1 x 8-7' 7") |
| 14 | 2 x 4 | 9 | | S4S Braces, of Top, etc. |
| 14 | 2 x 4 | 10 | | S4S Center Members of Top, etc. |
| 9 | 2 x 4 | | 7' 3 1/2" | S4S Cross Members of Top & Ends |
| 2 | 2 x 4 | 34 | | S1S1E Side Members of Top |
| 72 | 1 x 12 | | 8' 0" | S1S1E Upright Outside Covering |
| 193 | 1 x 6 | | 8' 0" | S2S Shiplap Uprights (or 116 pcs. 1 x 8-8' 0") |

| PCS. | SIZE (IN INCHES) | LENGTH (IN INCHES) | CUT LENGTH | DESCRIPTION |
|---|---|---|---|---|
| | 2 x 2 | 190 lin | | S1S1E Purlins, Floor Stops, etc. |
| 18 | 2 x 4 | 8 | | S1S1E Studs (Including End) |
| 20 | 2 x 4 | 9 | | S1S1E Braces (Side Walls, etc.) |
| 4 | 2 x 4 | 34 | | S1S1E Side Wall Members |
| 2 | 2 x 4 | | 4' 6" | S1S1E Floor Cleats |
| 3 | 2 x 4 | | 5' 4" | S4S Cleats & Fuselage Stand Spreader |
| 78 | 1 x 6 | | 7' 7" | S2S Shiplap Flooring (or 58 pcs. 1 x 8-7' 7") |
| 4 | 2 x 4 | 14 | | S1S1E Spacers, etc. |
| 2 | 1 x 12 | 14 | | S1S1E Reinforcement, etc. |
| 3 | 4 x 6 | 34 | | Rough (Floor Beams or Skids) |
| 1 | 4 | | | Safety Hasp |
| 1 pr. | 5 | | | Strap Hinges |
| 34 | 3/8 x 5 | | | Lag Screws (Ends of Crate & Straps) |
| 72 | 3/8 x 8 | | | Lag Screws (Sides & Top of Crate, etc.) |
| 3 | 3/8 x 10 | | | Lag Screws (Prop. Cradle) |
| 2 | 1/2 x 6 | | | Lag Screws |
| 1 | 1/2 x 5 | | | Lag Screw (Engine Support) |
| 250 | 3/8 | | | Req. Washers |
| 10 | 1/2 | | | Req. Washers |
| 24 | 3/8 x 3 1/4 | | | Square Head Bolts |
| 54 | 3/8 x 4 1/2 | | | Square Head Bolts |
| 2 | 3/8 x 6 1/2 | | | Square Head Bolts |
| 2 | 3/8 x 9 | | | Square Head Bolts |
| 3 | 3/8 x 13 | | | Square Head Bolts (Prop. Cradles) |
| 2 | 3/8 x 13 1/2 | | | Square Head Bolts (Tail Stand) |
| 7 | 1/2 x 5 | | | Square Head Bolts |
| 1 | 1/2 x 6 | | | Square Head Bolt |
| 8 | 1 x 1/8 | 16 | | Steel Strap (See Detail) |
| 4 | 1 x 1/8 | 20 | | Steel Strap (See Detail) |
| 2 | | | | 24ST Al. Alloy Bushing (See Detail -5) |
| 4 | AN960-816 | | | Washers (See Detail -5) |
| 2 | AC365-820 | | | Nuts (See Detail -5) |
| 2 | AN8 x 3 1/2 | | | Bolts (See Detail -5) |
| 2 | | | | Cast Iron Fittings (Fuselage Stand) |
| 1 | 4 x 3 x 3/8 | | 3 3/4" | Clip Angle (Engine Support) |
| 2 | 2 x 3/16 | | 46 3/16" | Steel Strap Hangers (Engine Support) |
| 2 | 5 x 5 x 1 | | | Rubber Pads 1 1/2 Dia. Hole in Center (Tail Stand) |
| 1 | 1 1/2 O.D. x 1/8 | | 36" | Pipe Drilled as Per Detail (See Tail Stand) |

*Figure 44 (Sheet 1 of 7 Sheets)—Complete Airplane Shipping Crate*

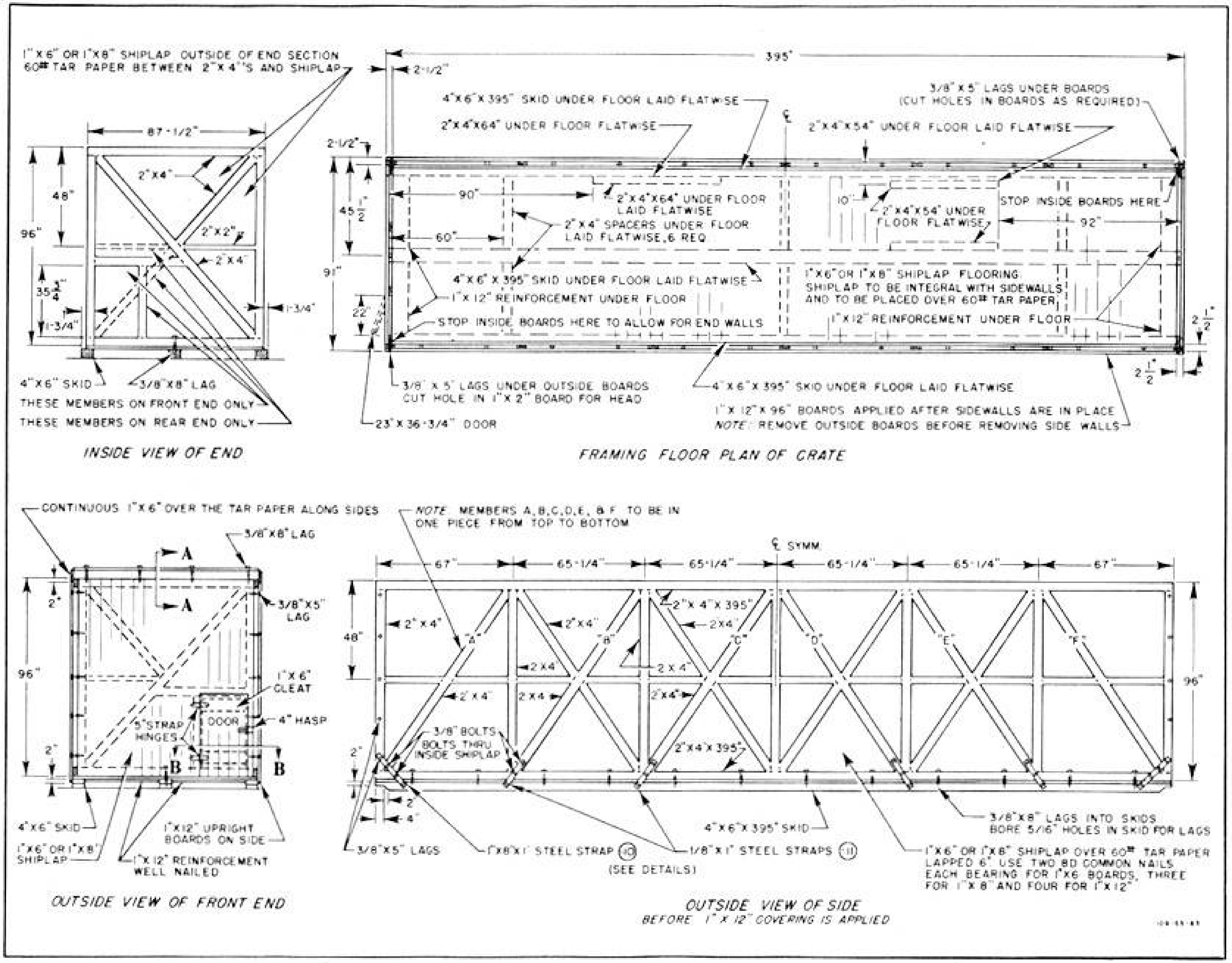
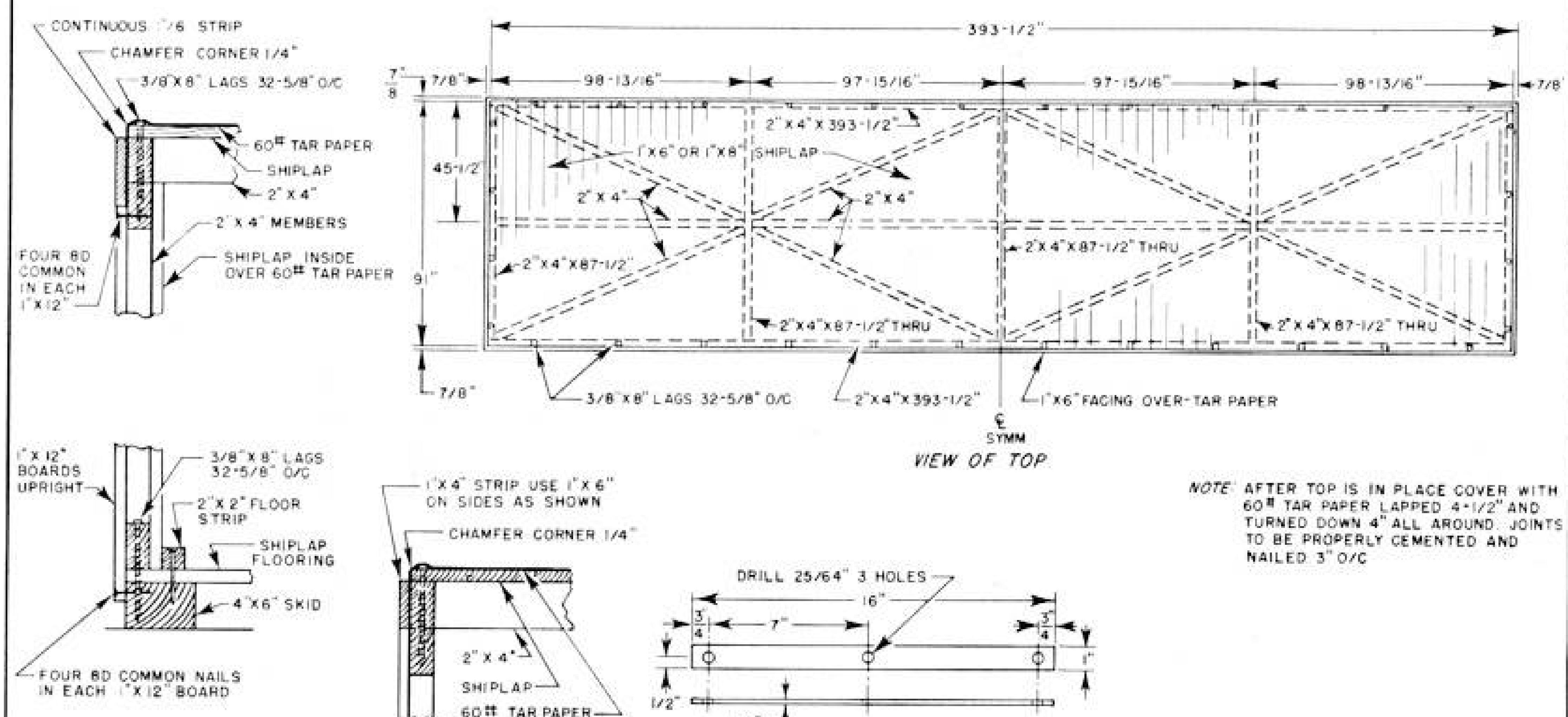
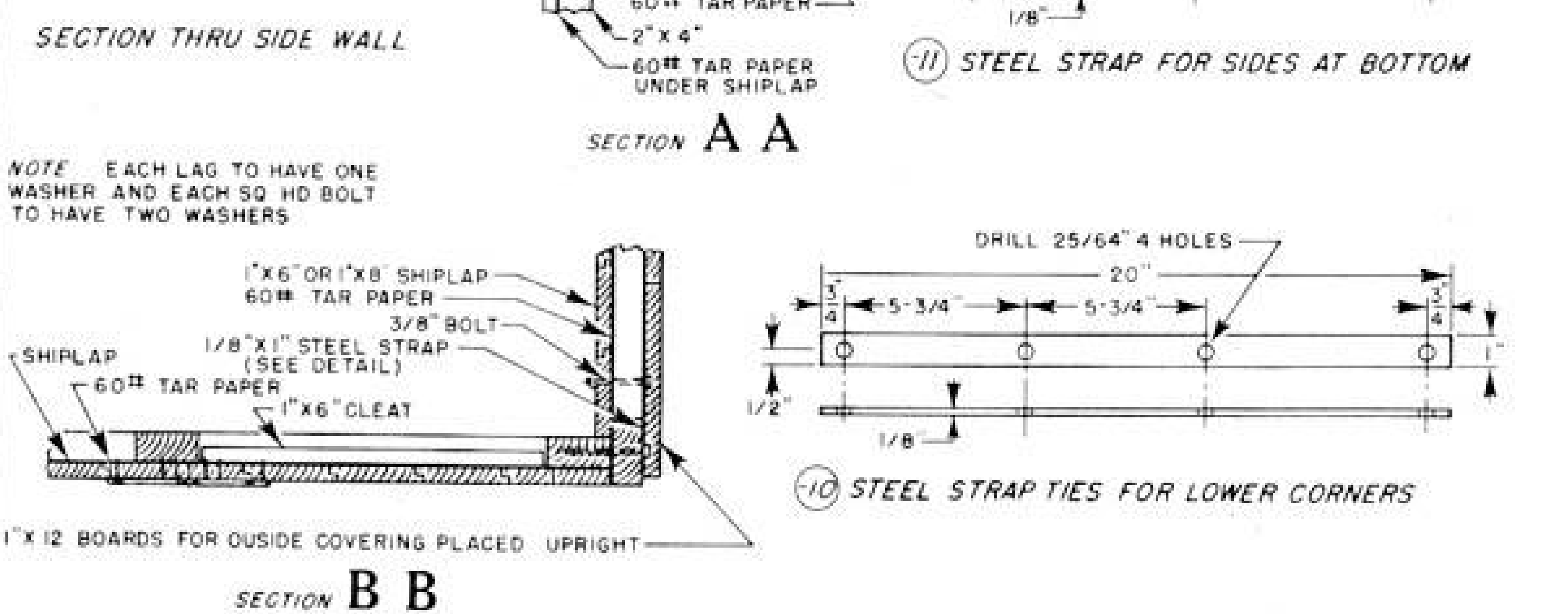



Figure 44 (Sheet 2 of 7 Sheets)—Complete Airplane Shipping Crate




*FUSELAGE STAND PARTS LIST*

| PCS | SIZE | LENGTH | CUT LENGTH | DESCRIPTION |
|---|---|---|---|---|
| 1 | 4"X 4" | | 3' - 8" | BEAM |
| 2 | 2"X 4" | | 5' - 4" | SPREADERS |
| 2 | 2"X 4" | | 2'-8-1/8" | SILLS |
| 2 | 2"X 4" | | 2'-2-3/8" | SILLS |
| 3 | 2"X 4" | 6' | | BRACES |
| 1 | 2"X 6" | 4' | | TIE |
| 1 | 2"X 6" | | 7' - 2" | SILL |
| 6 | 1/2"X5" | | | SQ. HD. BOLTS |
| 9 | 3/8"X4 1/2" | | | SQ. HD. BOLTS |
| 2 | 3/8"X 8" | | | SQ. HD. BOLTS |
| 2 | 3/8"X 8" | | | LAGS |
| 2 | 1/2"X 6" | | | LAGS |
| 24 | 3/8" | | | REQ WASHERS |
| 6 | 1/2 | | | REQ WASHERS |

Figure 44 (Sheet 3 of 7 Sheets)—Complete Airplane Shipping Crate

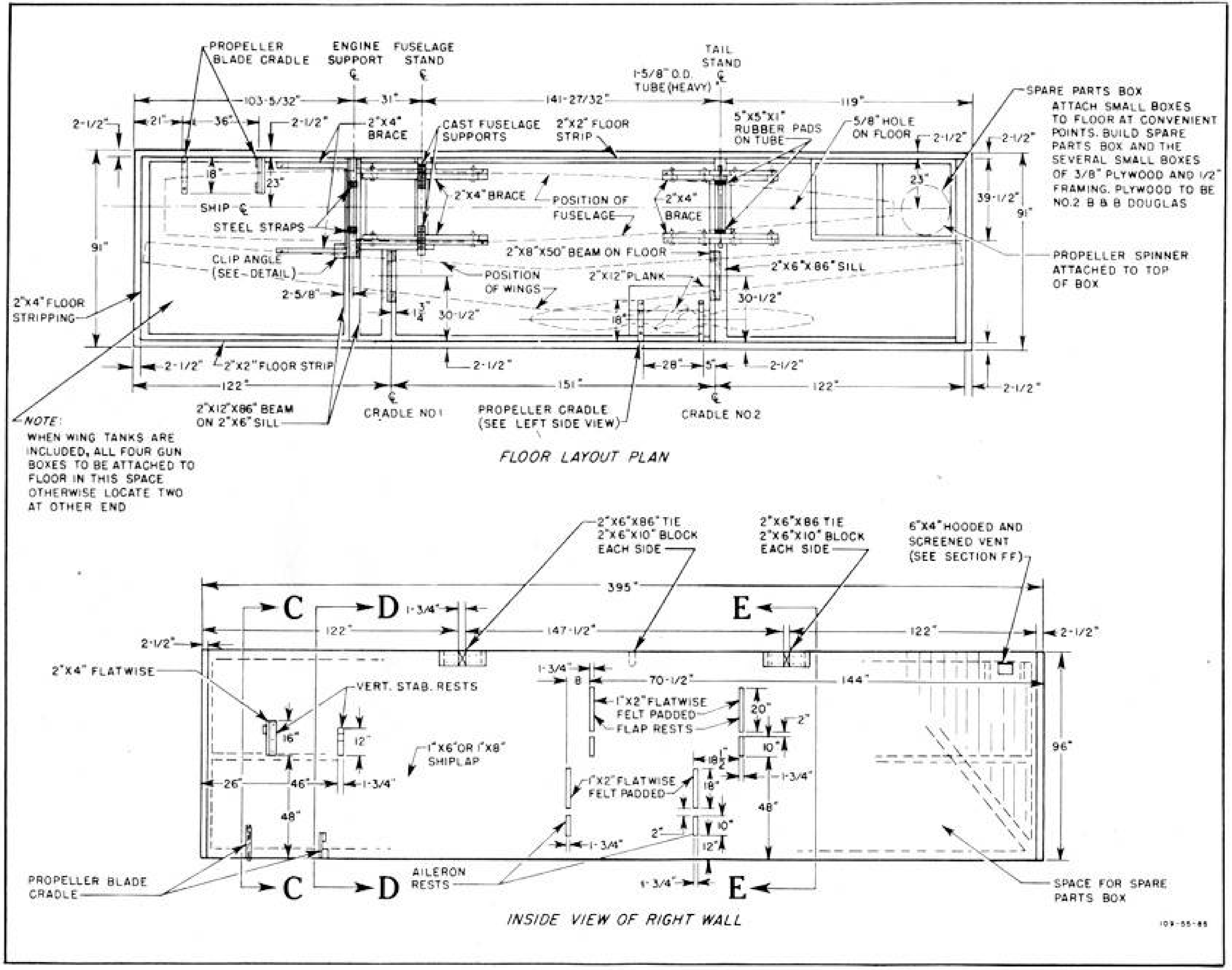



Figure 44 (Sheet 4 of 7 Sheets)—Complete Airplane Shipping Crate

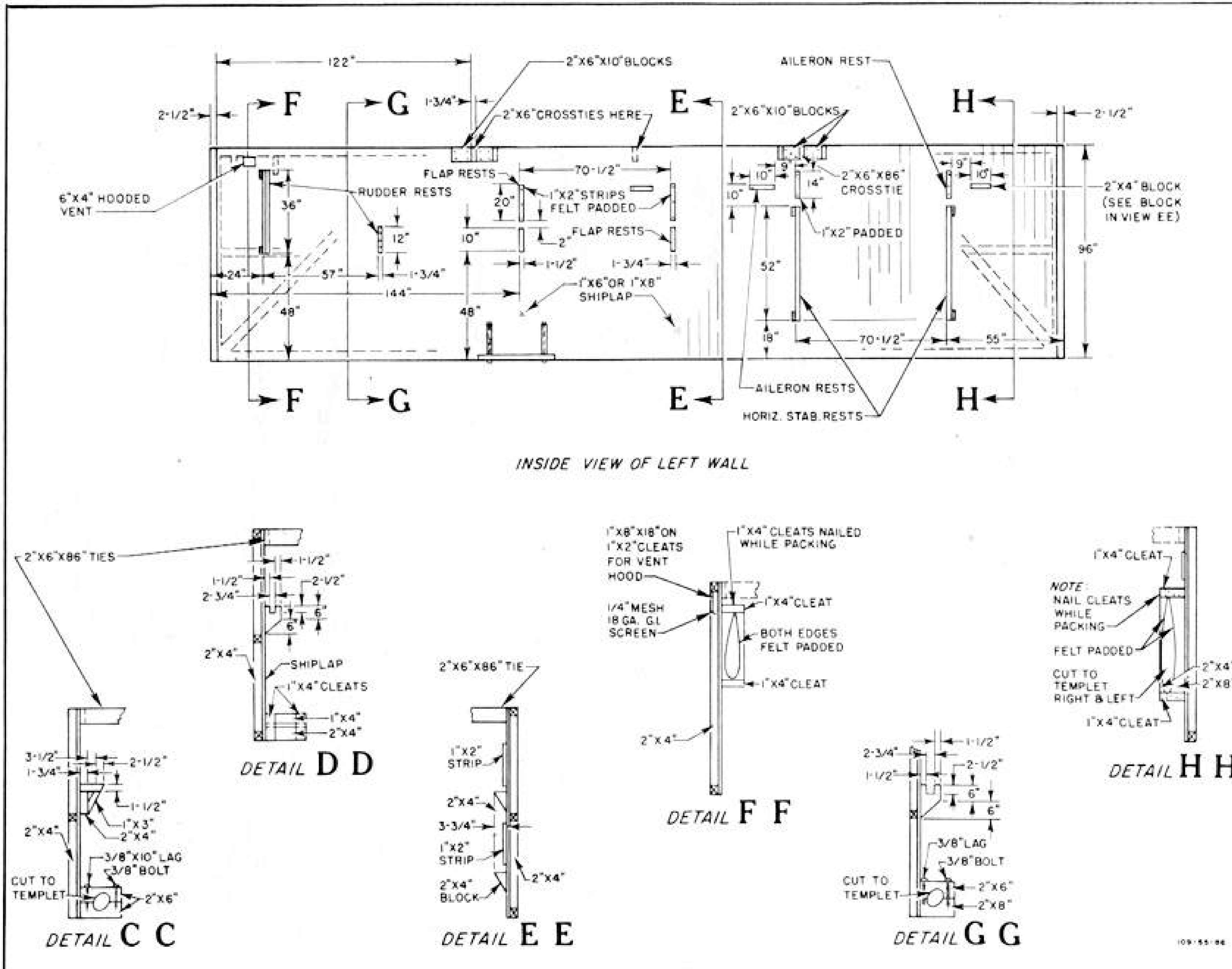
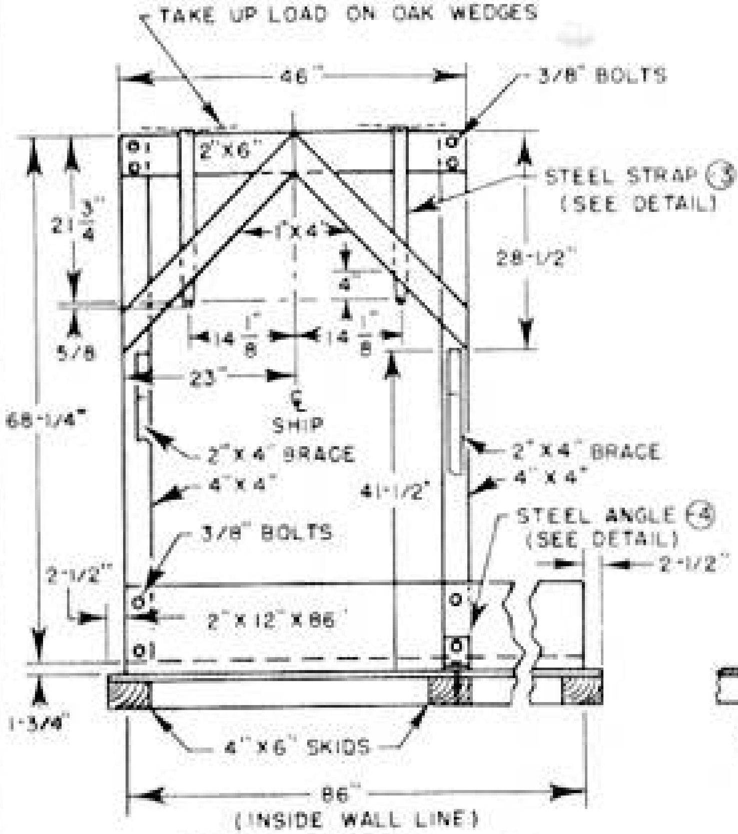
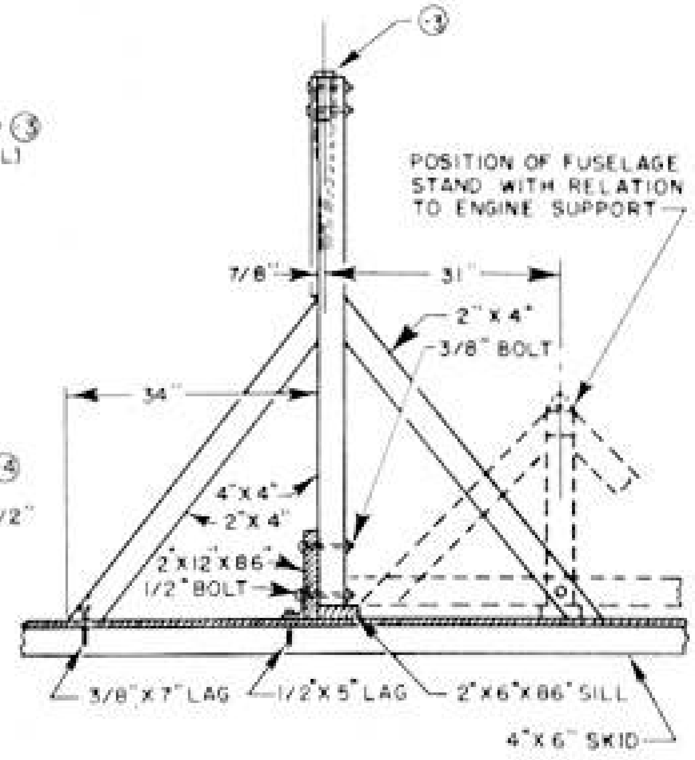



Figure 44 (Sheet 5 of 7 Sheets)—Complete Airplane Shipping Crate

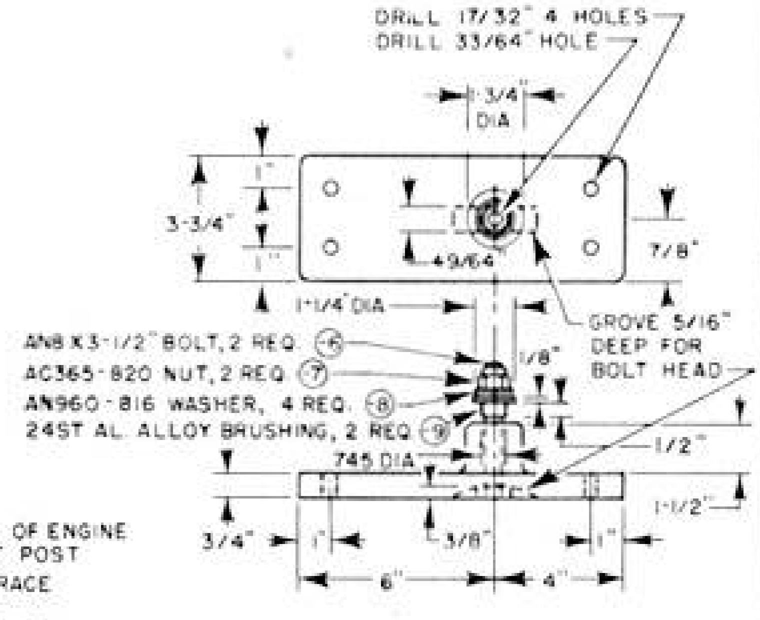



ENGINE SUPPORT



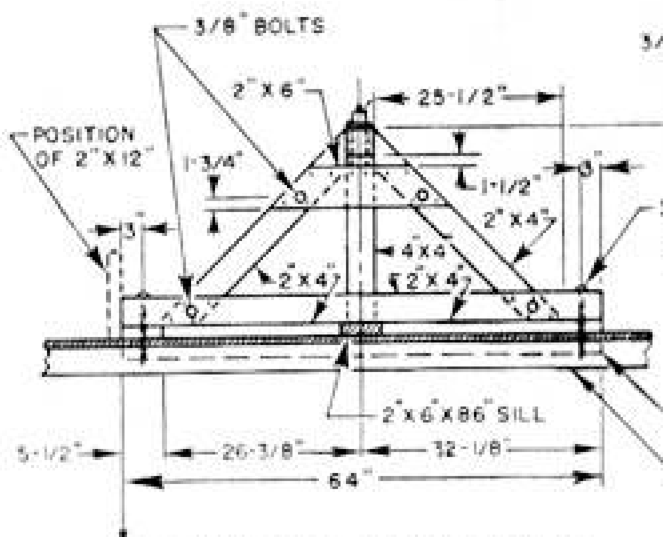

END VIEW OF ENGINE SUPPORT

| PCS | SIZE | LENGTH | CUT LENGTH | DESCRIPTION |
|---|---|---|---|---|
| 1 | 2"X6" | | 3'-10 | BEAM |
| 1 | 2"X6" | | 7'-2" | SILL |
| 1 | 1"X4" | 6" | | BRACES |
| 2 | 4"X4" | | 5'-10-1/4 | POSTS |
| 2 | 2"X4" | 9" | | BRACES |
| 1 | 2"X12" | | 7"X 2" | BEAM |
| 4" | 7/8X1-3/4" | | 8" | WEDGES |
| 7 | 3/8"X4½" | | | SQ. HD. BOLTS |
| 2 | 3/8X8" | | | SQ. HD. BOLTS |
| 1 | 1/2"X6½" | | | SQ. HD. BOLT |
| 1 | 1/2"X5" | | | LAG |
| 2 | 3/8"X7" | | | LAGS |
| 22 | 3/8" | | | REQ. WASHERS |
| 2 | 1/2" | | | REQ. WASHERS |

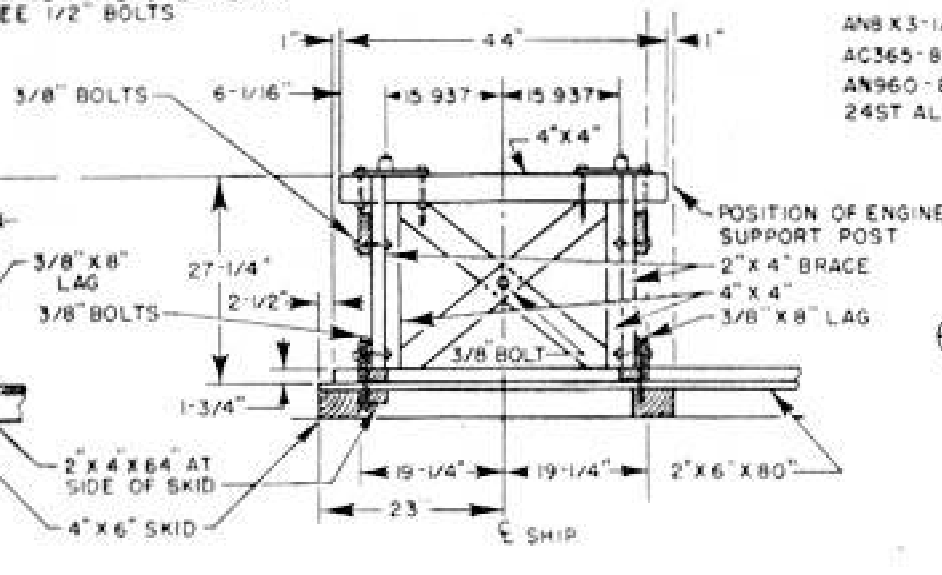



(5) CAST IRON FITTING FOR FUSELAGE STAND

CAST FITTING, 2 REQ. (5) (SEE DETAIL)
CAST FITTINGS TO BE SET TO A STEEL TEMPLET. EACH TO HAVE ONE 1/2" X 6" LAG AND THREE 1/2" BOLTS

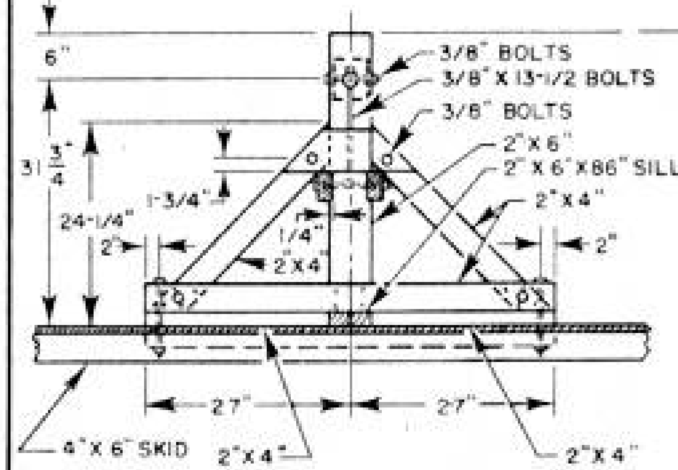



END VIEW OF FUSELAGE STAND

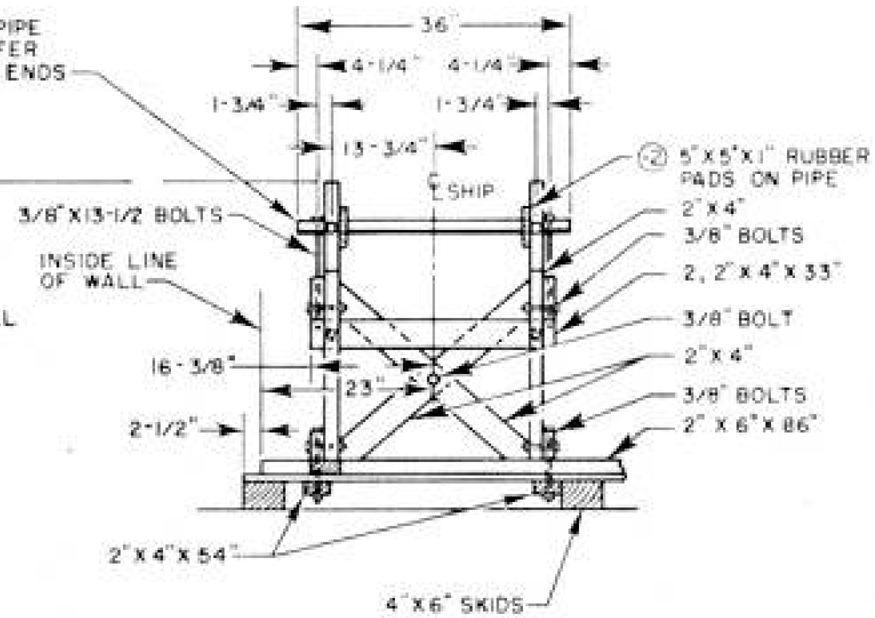



FUSELAGE STAND

Figure 44 (Sheet 6 of 7 Sheets)—Complete Airplane Shipping Crate



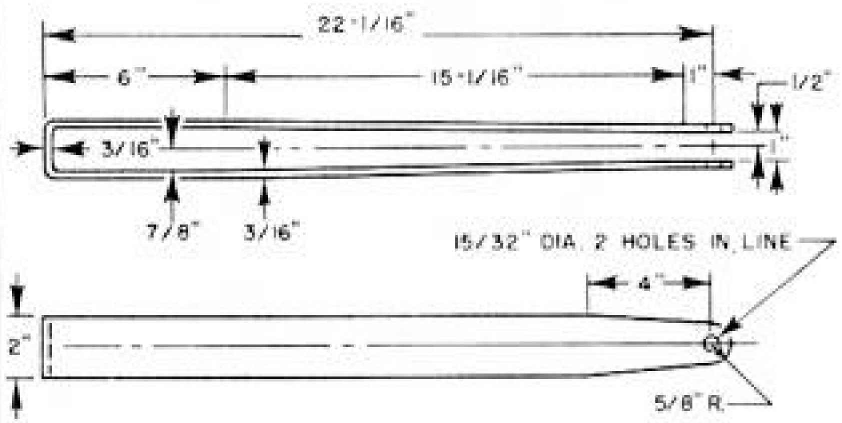

END VIEW OF TAIL STAND




NOTE: DO NOT BOLT TAIL STAND TO FLOOR UNTIL SHIP IS SET

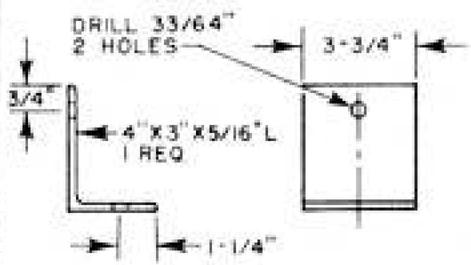
TAIL STAND

| PCS | SIZE | LENGTH | CUT LENGTH | DESCRIPTION |
|---|---|---|---|---|
| 2 | 2"x6" | | 3'-0" | UPRIGHTS |
| 1 | 2"x6" | 4 | | TIES |
| 2 | 2"x4" | | 4'-6" | SPREADERS |
| 2 | 2"x4" | | 2'-8-3/4" | BEAMS |
| 2 | 2"x4" | 10 | | BRACES & SILLS |
| 1 | 1-1/2"OD x 1/8" | | 3'-0" | STEEL PIPE |
| 2 | 5"x5"x1" | | | RUBBER PADS |
| 2 | 3/8"x13-1/2" | | | SQ HD BOLTS |
| 4 | 3/8"x8" | | | SQ HD BOLTS |
| 2 | 3/8"x6-1/2" | | | SQ HD BOLTS |
| 2 | 3/8"x9" | | | SQ HD BOLTS |
| 11 | 3/8"x4-1/2" | | | SQ HD BOLTS |
| 40 | 3/8" | | | REQ WASHERS |

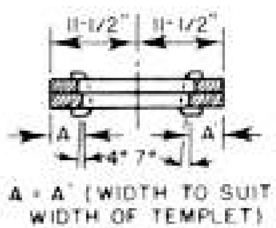



(-3) DETAILS OF STEEL STRAPS FOR ENGINE SUPPORT

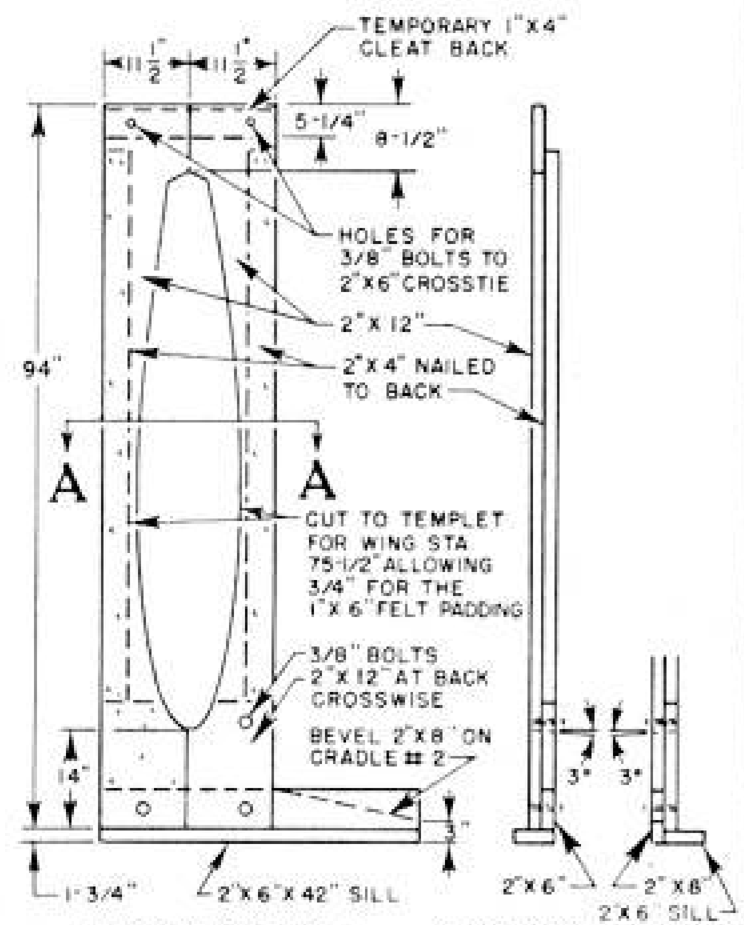
| PCS | SIZE | LENGTH | CUT LENGTH | DESCRIPTION |
|---|---|---|---|---|
| 4 | 2"x12" | | 7'-10" | UPRIGTHS |
| 2 | 2"x12" | | 1'-11" | TIE |
| 4 | 2"x4" | | 6'-5-1/4" | DOUBLERS |
| 3 | 2"x6" | | 3'-6" | BEAM & SILLS |
| 1 | 2"x8" | | 3'-6" | BEAM |
| 1 | 1"x4" | 4' | | |
| 3 | 2"x6" | | 7'-2" | CROSS TIES |
| 10 | 3/8"x4-1/2" | | | SQ HD BOLTS |
| 20 | 3/8 | | | REQ WASHERS |




(-4) CLIP ANGLE FOR ENGINE SUPPORT




SECTION A A
ANGLES REVERSED FOR #2




WING CRADLE NO. 1
SAME FOR WING CRADLE #2 REVERSED

END VIEW NO. 1

END VIEW NO. 2

Figure 44 (Sheet 7 of 7 Sheets)—Complete Airplane Shipping Crate

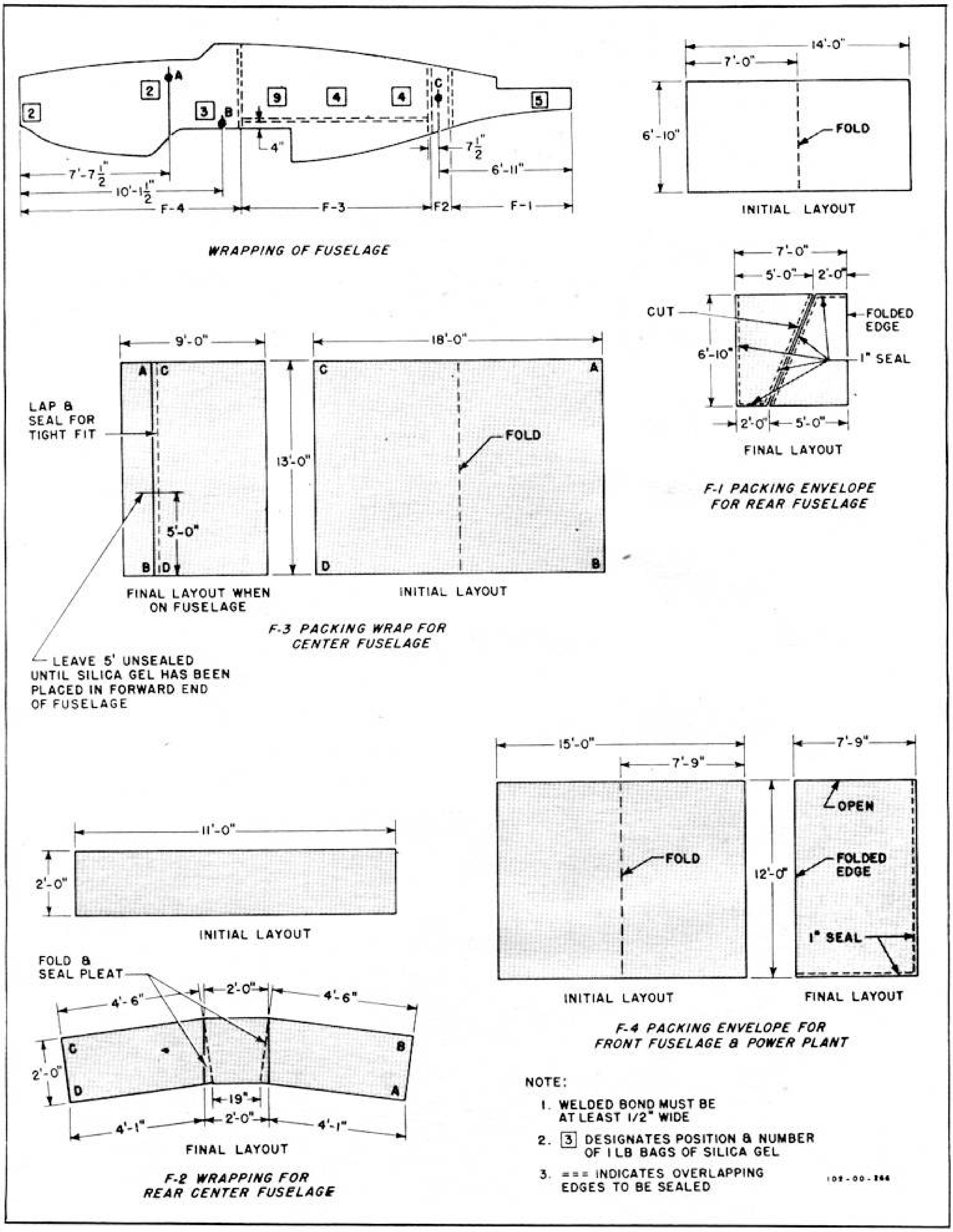



*Figure 45 (Sheet 1 of 2 Sheets)—Pliofilm Wrap Details*

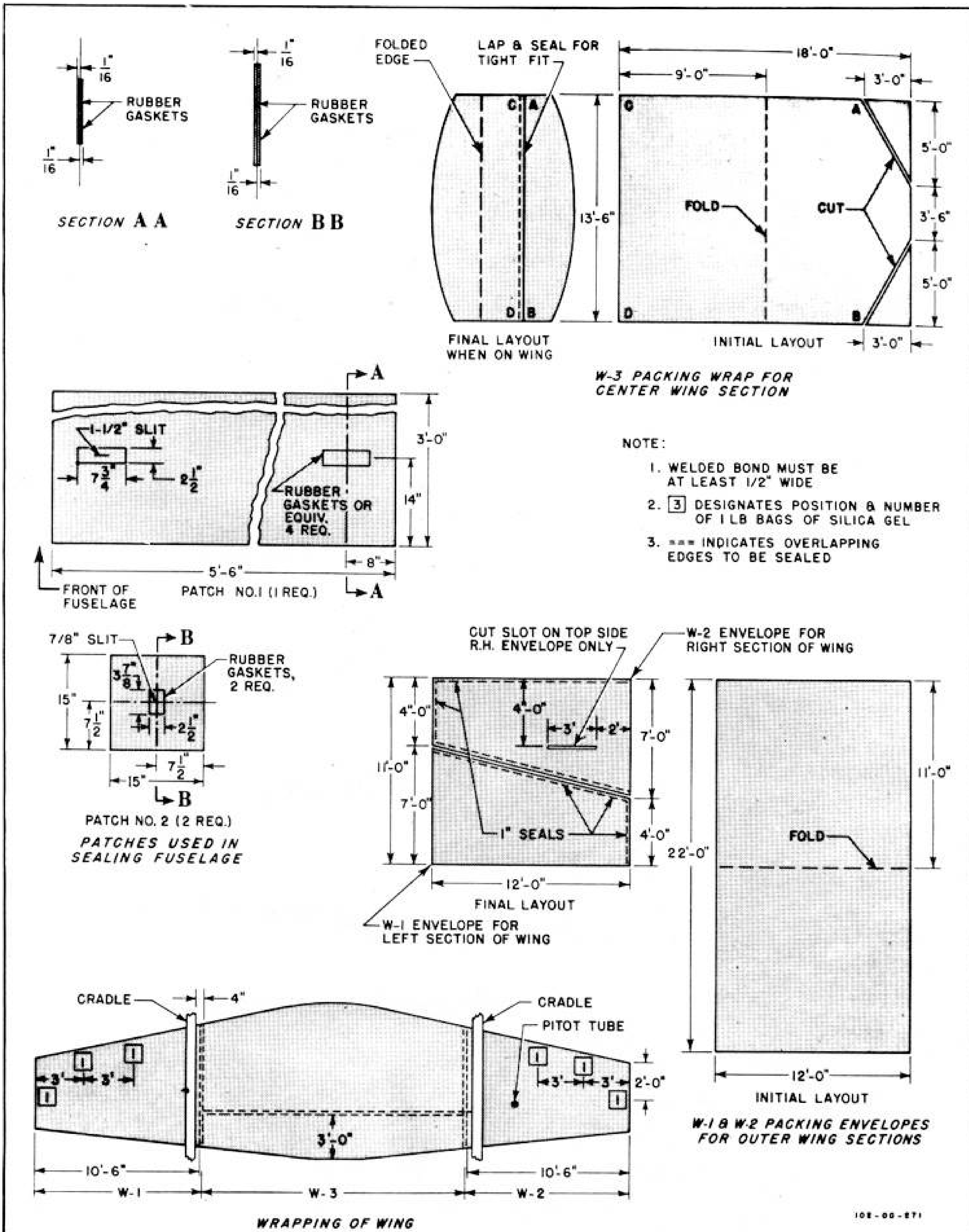



*Figure 45 (Sheet 2 of 2 Sheets)—Pliofilm Wrap Details*

*(b)* Place one-pound bags of silica gel (Specification No. AN-D-6) in the following positions. Fasten each bag in place with strong cord tied around the center of the bag.

| POSITION | NO. OF BAGS |
|---|---|
| Rear fuselage | 5 |
| Cockpit | 9 |
| Radio compartment | 8 |
| Front section of engine | 2 |
| Rear section of engine | 2 |
| Forward of instrument panel | 3 |

**CAUTION**

Silica gel absorbs water rapidly; when being installed, a minimum of time should elapse between removing it from the airtight can and sealing the fuselage. If more than ½ hour elapses before the fuselage is sealed, cut the Pliofilm and install new bags of silica gel.

*(c)* Heat-seal wrap F-1 and wrap F-2. *(See figure 45.)*

*(d)* Place F-3 wrap *(figure 45)* on fuselage. Heat-seal the horizontal joint and then heat-seal wrap F-3 to wrap F-2.

*(e)* Check silica gel spark plugs in power plant for moisture content.

*(f)* Place F-4 wrap *(figure 45)* on fuselage. Heat-seal F-4 wrap to F-3 wrap.

*(g)* At point where the vertical braces attach to engine mount, glue two 3 x 1½ x ⅛-inch rubber gaskets to the envelope.

*(h)* Install the top of the fuselage forward support frame and attach the steel supporting straps to the engine mount lifting lugs.

*(i)* Drive wooden wedges under the steel straps where they cross the top of the forward support. When the straps are tight, nail wedges in place.

*(j)* Remove temporary propeller shaft stand.

(3) INSTALLING WING IN CRATE.

*(a)* Spray the outboard edge and the trailing edge of the wing with Par-al-ketone (Specification No. AN-C-52, Type I).

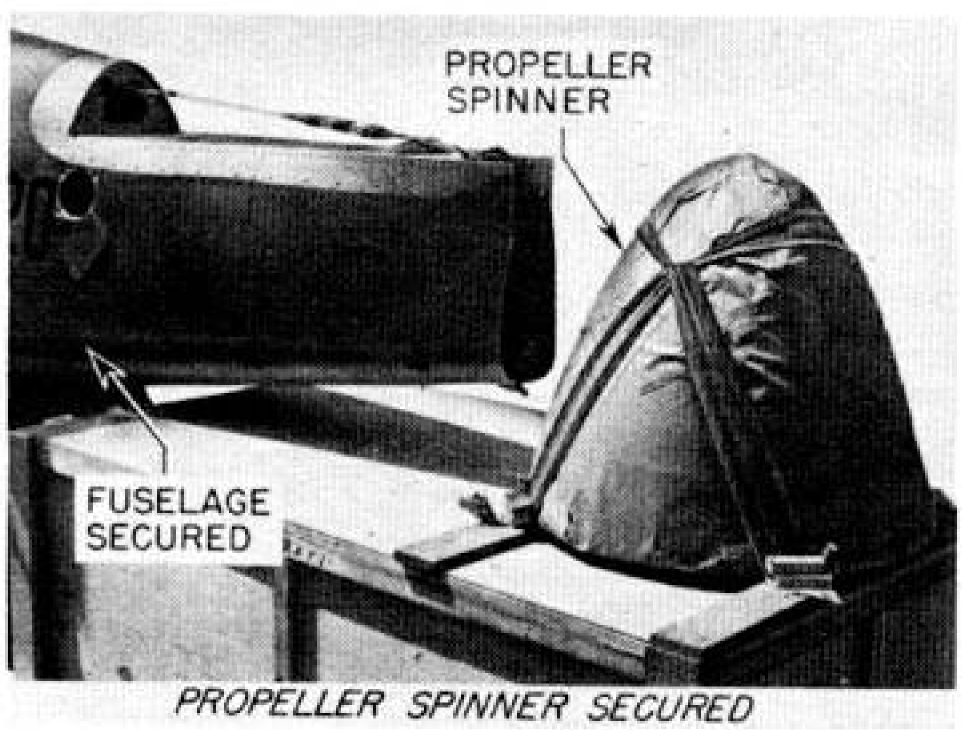



**Figure 46—Propeller Spinner Secured**

*(b)* After the Par-al-ketone has dried, install one-pound bags of silica gel (Specification No. AN-D-6) in the following positions:

| POSITION | NO. OF BAGS |
|---|---|
| Wing outboard edge (1 each side) | 2 |
| Trailing edge (2 each wing section) | 4 |

*(c)* Cover the outboard and trailing edges with greaseproof paper (Specification No. AN-P-12), and tape to wing.

*(d)* Place wrap W-1 and W-2 *(figure 45)* on the wing.

*1.* The pliofilm envelopes should extend at least four inches beyond the inner edge of the cradles.

*2.* Securely tape open edges to wing.

*3.* Heat-seal a patch over the opening made in W-2 wrap for pitot tube.

*(e)* Attach a wing hoist *(section III, paragraph 2. a. (4))* to the wing.

*(f)* With the slack taken up in the hoisting cable, remove the support stand from the wing.

*(g)* Hoist the wing into the cradles so that each cradle barely clears the inboard gun port.

*(h)* Secure the wing in place by installing the outboard half of each wing cradle. Peen all bolts.

(4) HERMETICALLY SEALING WING.

*(a)* Lash the landing gear in the retracted position.

*(b)* Place the W-3 wrap *(figure 45)* on the wing. Move the horizontal seal to a convenient height.

*(c)* Heat-seal wrap W-3 to wrap W-1 and W-2. *(See figure 45.)*

*(d)* Heat-seal horizontal seam of wrap W-3.

**CAUTION**

As silica gel absorbs water rapidly, allow only a minimum of time to elapse between removing it from the airtight can and sealing up the wing. If more than ½ hour elapses before the wing is sealed, cut the Plioform and install new bags of silica gel.

(5) FINAL CHECK OF SEALED UNITS.

*(a)* Check the covering and seal any holes or weak points with Pliofilm.

*(b)* Seal any holes which cannot be patched with Scotch tape.

*(c)* Paste a tag marked "ONE BAG OF SILICA GEL HERE" on the Pliofilm covering as close as possible to the location of each silica gel bag.

(6) INSTALLING MISCELLANEOUS ITEMS IN CRATE.

*(a)* Pack radiator air inlet scoop, all fillets, the pilot's seat, armor plate, cowling, loose equipment, etc., into a single

box, and secure the box under the tail of the fuselage in the right rear corner of the crate.

*(b)* If Saran-packed guns are shipped, place the gun boxes in the left forward section.

**CAUTION**

Be certain that all boxes are made fast to the bottom of the crate.

*(c)* Secure the propeller spinner on top of the loose equipment box. *(See figure 46.)*

*(d)* Place all parts of the propeller hub in a box and then secure the box to the crate floor.

*(e)* Secure the propeller hub and three blades to the crate floor. *(See figures 44 and 47.)*

*(f)* Secure the single propeller blade to the floor of the crate in the forward right corner. *(See figures 44 and 47.)*

*(g)* Secure the empennage units, the ailerons, and the flaps to the sides of the crates. *(See figures 44 and 48.)*

*(h)* Store approximately 50 percent surplus of bolts, nuts, washers, screws, cotters, bushings hose, spacers, and clamps in the crate to cover damage and loss.

*(i)* Stow 20 gallons of engine oil, 21 gallons of coolant, 5½ gallons of hydraulic fluid, and one gallon of shock strut fluid in crate. *(See section III, paragraph 2.* ***b.*** *for correct fluid specifications.)*

*f.* CLOSING THE CRATE.

(1) Move the two sides into place and secure them to the floor. *(See figures 44 and 49.)*

(2) Inspect the entire crate. If all items are stowed satisfactorily, move the crate ends into place and secure them to the floor and to each side. *(See figure 44.)*

(3) Install the top of the crate. *(See figure 44.)*

(4) Install 1 x 12-inch siding around outside of crate. *(See figure 44.)*

(5) Mark the crate as per current specification.

**3. ERECTION PROCEDURE.**

***a.*** UNCRATING COMPLETE AIRPLANE.

(1) Remove the 1 x 12-inch siding.

(2) Remove all lag screws and remove the crate top.

(3) Remove each end of the crate. Support the crate sides by means of temporary diagonal bracing.

(4) Remove the sides of the crates.

**CAUTION**

Lower the sides of the crate carefully so that the components lashed on each side will not be damaged.

(5) Attach a wing hoisting sling *(section III, paragraph 2.* ***a.*** *(4))* to the wing and apply a strain on the hoisting

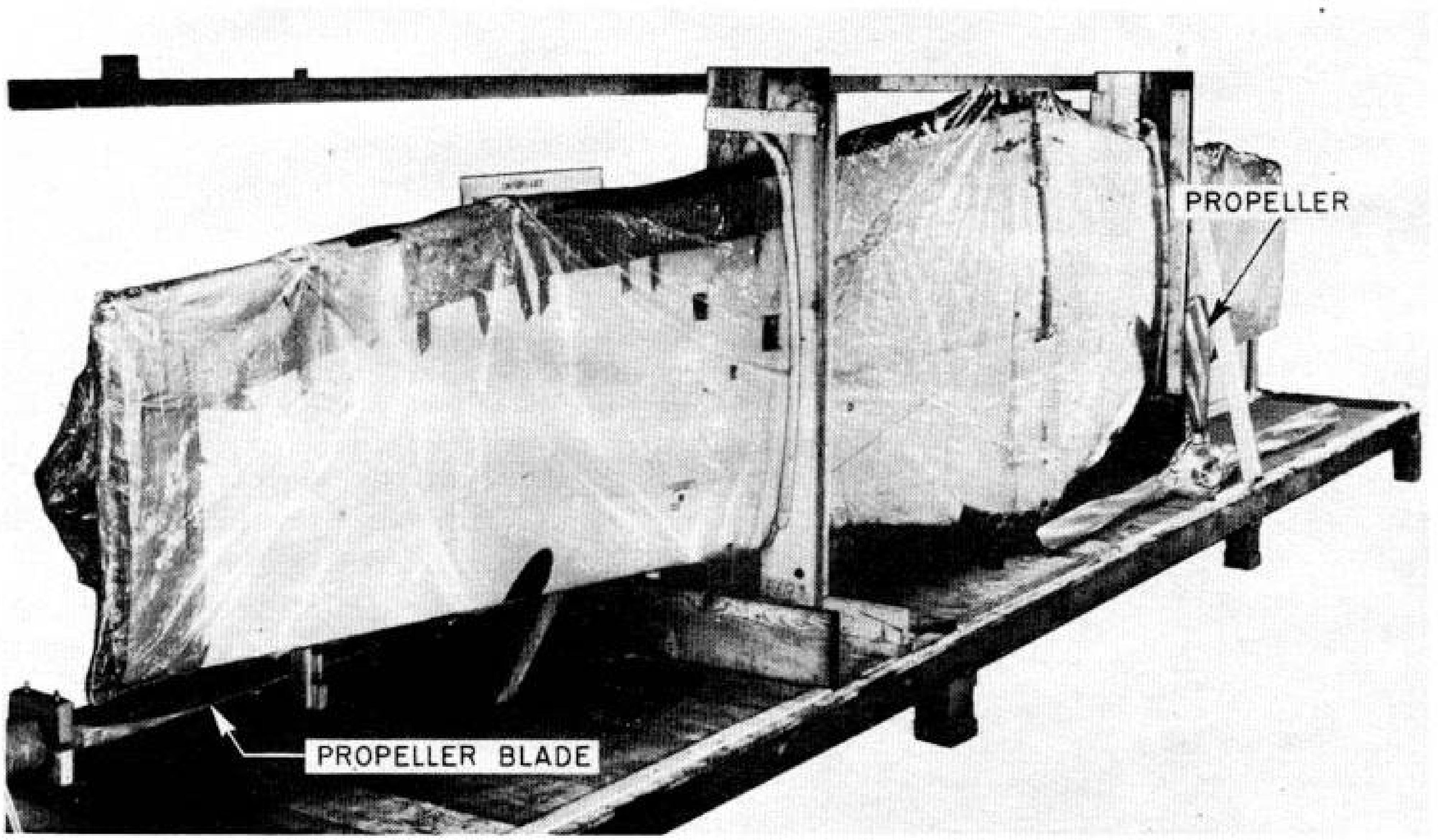



***Figure 47—Crating Wing***

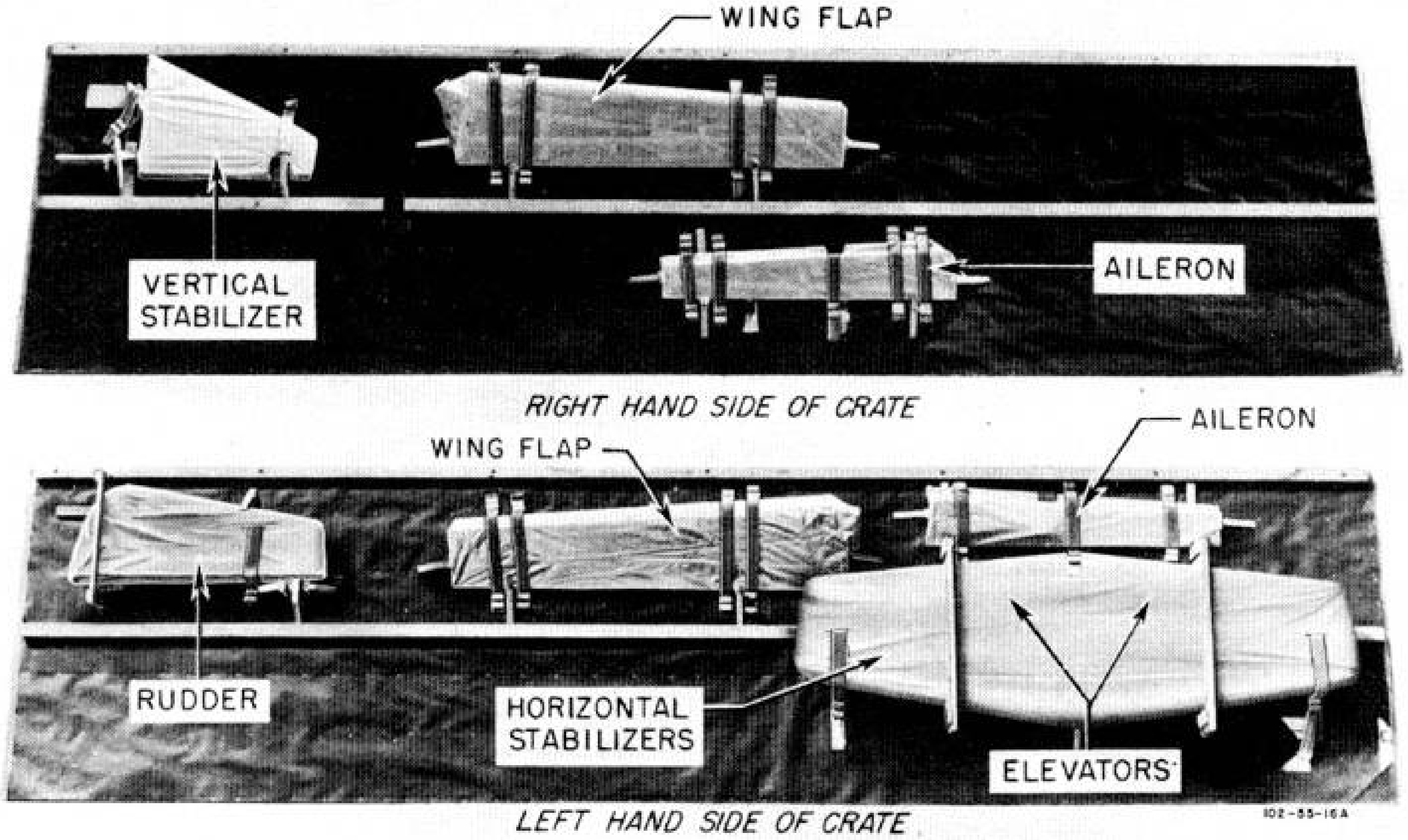



**Figure 48—Parts Mounted on Crate Sides**

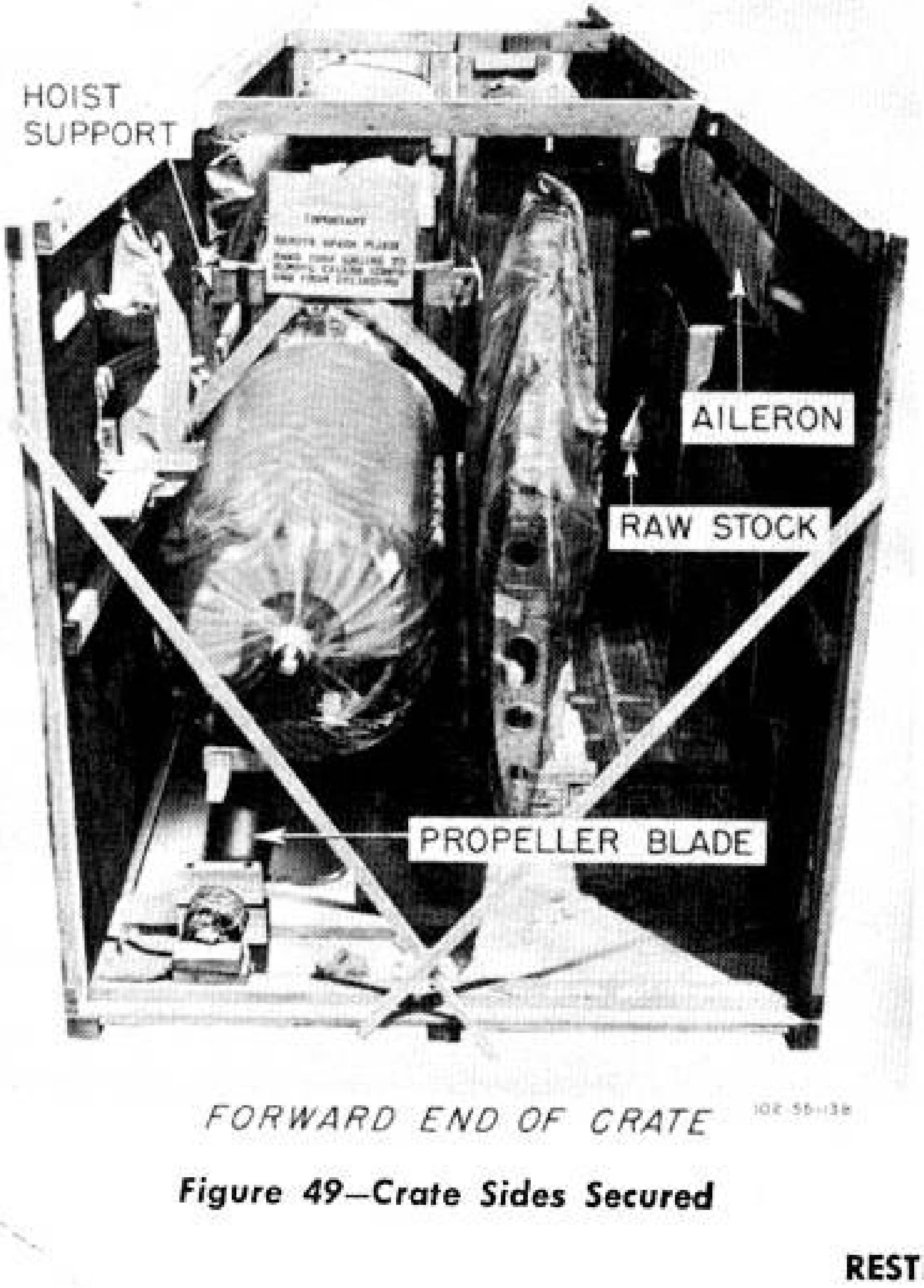



**Figure 49—Crate Sides Secured**

cable to prevent wing from falling when the cradles are loosened.

(6) At the point where the wing cradles are drawn together and bolted, saw through the center.

(7) Remove the bolts at the bottom of the outboard side of each cradle. Remove the outboard side of the cradle.

(8) Hoist the wing out of the crate.

(9) Remove all of the boxes so as to have working room around the fuselage.

(10) The fuselage is now ready to be removed. This can be accomplished either with or without the fuselage support stands in the crate as follows:

*(a)* HOISTING FUSELAGE WITH THE CRATE SUPPORT STANDS.

*1.* Hook a fuselage hoisting sling *(section III, paragraph 2. **a.** (3) (**b**))* to the fuselage.

*2.* Remove all bolts and lag screws which secure the fuselage support stands to the crate floor.

*3.* Hoist fuselage and stands out of crate.

*4.* If the fuselage is to be left on the support stands, place sandbags on the tail section to prevent the fuselage from nosing over.

*(b)* HOISTING FUSELAGE WITHOUT SUPPORT STANDS.

*1.* Place a support stand under the propeller shaft to prevent fuselage from nosing over.

*2.* Jack the fuselage at the tail jacking point to relieve weight on tail lift tube.

*3.* Pull the tail lift-tube bar from the tail stand.

*4.* Jack the airplane so that the lift-tube bar can be inserted again clear of the stand.

*5.* Hook a fuselage hoist sling *(section III, paragraph 2.* ***a.*** *(3)* ***(b)****)* to the fuselage and hoist the fuselage clear of the crate.

*b.* ASSEMBLING AIRPLANE.

(1) Remove tape, paper, silica gel, and lashings from all assemblies.

(2) Remove corrosion preventive from all portions of the airplane with hot Stoddard solvent (Federal Specification No. P-S-661) or equivalent.

**CAUTION**

The bomb racks must be removed and cleaned. Corrosion preventive in the mechanism will cause malfunctioning.

(3) Install the fuselage on the wing. *(See section IV, paragraph 1. c.)*

(4) Install the wing tips, ailerons, and flaps on the wing. *(See section IV, paragraph 1.* ***e.*** *(2).)*

(5) Install pitot tube on the wing. *(See section IV, paragraph 18.* ***e.*** *(2)* ***(b)*** *3.)*

(6) Install horizontal stabilizer and elevator assembly, the vertical stabilizer, and the rudder on the fuselage. *(See section IV, paragraph 2.)*

(7) Hook up radio antenna equipment.

(8) Install propeller. *(See section IV, paragraph 10. c.)*

(9) Remove the dehydrating agents from the engine and replace the spark plugs.

(10) Preoil the engine. *(See section IV, paragraph 8. g. (1) (b).)*

# Section III

# HANDLING AND GENERAL MAINTENANCE INSTRUCTIONS

## 1. ACCESS AND INSPECTION PROVISIONS.

The access provisions for inspection and maintenance are identified in figure 50. A dzus fastener tool *(figure 51)* facilitates the work of opening and closing dzus-fastened coverplates.

## 2. GROUND HANDLING.

All handling facilities are marked and identified on the airplane. A flush-type handhold and a step are located on the left side of the fuselage; wing-to-fuselage fillets constitute walkways.

*a.* HOISTING.—A lift tube to accommodate a bar up to 1⅝ inches in diameter in the tail of the fuselage, a hoisting lug in each wing panel, and a hoisting lug on each side of the engine mount constitute the hoisting facilities on this airplane. *(See figures 52 through 57.)* The wing hoisting fittings are stowed in the tool kit furnished with the airplane. *(See figure 76.)* When not in use, the wing hoisting lugs are fitted with flush plugs. The upper aft engine cowling must be removed to gain access to the engine mount hoisting lugs.

(1) HOISTING COMPLETE AIRPLANE.—There are two methods of hoisting the completely assembled airplane, which weighs approximately 7000 pounds (dry).

*(a)* ONE-POINT LIFT.—The complete airplane can be hoisted with a single hoisting cable if an E750 hoisting sling *(figure 52)* is used. The sling fastens to the engine mount hoisting lugs, and to each end of an E727 lift-tube bar. *(See figure 53.)*

1. Rudder Lower Hinge Access
2. Vertical Stabilizer Aft Right-hand
3. Vertical Stabilizer Forward
4. Fuselage to Horizontal Stabilizer
5. Aft Wing to Fuselage
6. Oxygen Filler Valve Access
7. Hydraulic Reservoir Access
8. Oxygen Lines and Instruments
9. Engine Access Upper Cowlings
10. Engine Access Side Cowlings
11. Engine Crank Access
12. Engine Heating Access
13. Engine Access Lower Forward Cowling
14. Engine Access Lower Intermediate Cowling
15. Engine Access Lower Aft Cowling
16. Wing to Fuselage Forward Fairing
17. Wing to Fuselage Intermediate Fairing
18. Main Landing Gear Pivot Shaft Access
19. Running Light Access
20. Ammunition Bay Access
21. Gun Bay Access Door
22. Aileron Cable Turnbuckle Inspection Cover
23. Wing Fuel Tank Filler Cap
24. Front Scoop Attachment Bolt Access
25. Oil Radiator Line Access
26. Aftercooler Line Hose Access
27. External Power Plug Access
28. Radiator Cover Bolts Access
29. Radiator Cover Attachment Bolts Access
30. Radiator Cover Assembly
31. Tail Gear Down-lock Access
32. Tail Gear-Up-latch Access
33. Elevator Trim Tab Actuating Drum Access
34. Coolant Tank Filler Neck Access
35. Aftercooler Tank Access
36. Oil Tank Filler Neck Access
37. Engine Controls and Instrument Access
38. Horizontal Stabilizer Forward Access
39. Elevator Trim Tab Cable Access
40. Rudder Trim Tab Actuating Cable Drum Access Door
41. Vertical Stabilizer Aft Left-hand Fairing
42. Rudder Bellcrank Access Door
43. Tail Gear Up-latch and Actuating Strut Access Door
44. Remote-reading Compass Access Door
45. Propeller Governor Access Door
46. Aileron Center Hinge Access Door
47. Aileron Trim Tab Actuating Drum Access Door
48. Fuel Tank Doors
49. Fuel Booster Pump Access Doors
50. Fuel Tank Drain Cock Access
51. Oil Radiator Access Door
52. Oil Radiator Rear Scoop Actuating Rod Access Plate
53. Coolant Drain Access Door
54. Rear Scoop Hinge Access Door
55. Rear Scoop Actuating Rod Access Plate
56. Control Cable and Oxygen Cylinder Access Door
57. Aftercooler Drain Access Door
58. Aileron Boost Tab Actuating Fitting Door
59. Remote Contactor Mast Access Door
60. Recognition Lights and Access
61. Wheel Well Fairing Doors

***KEY TO FIGURE 50***

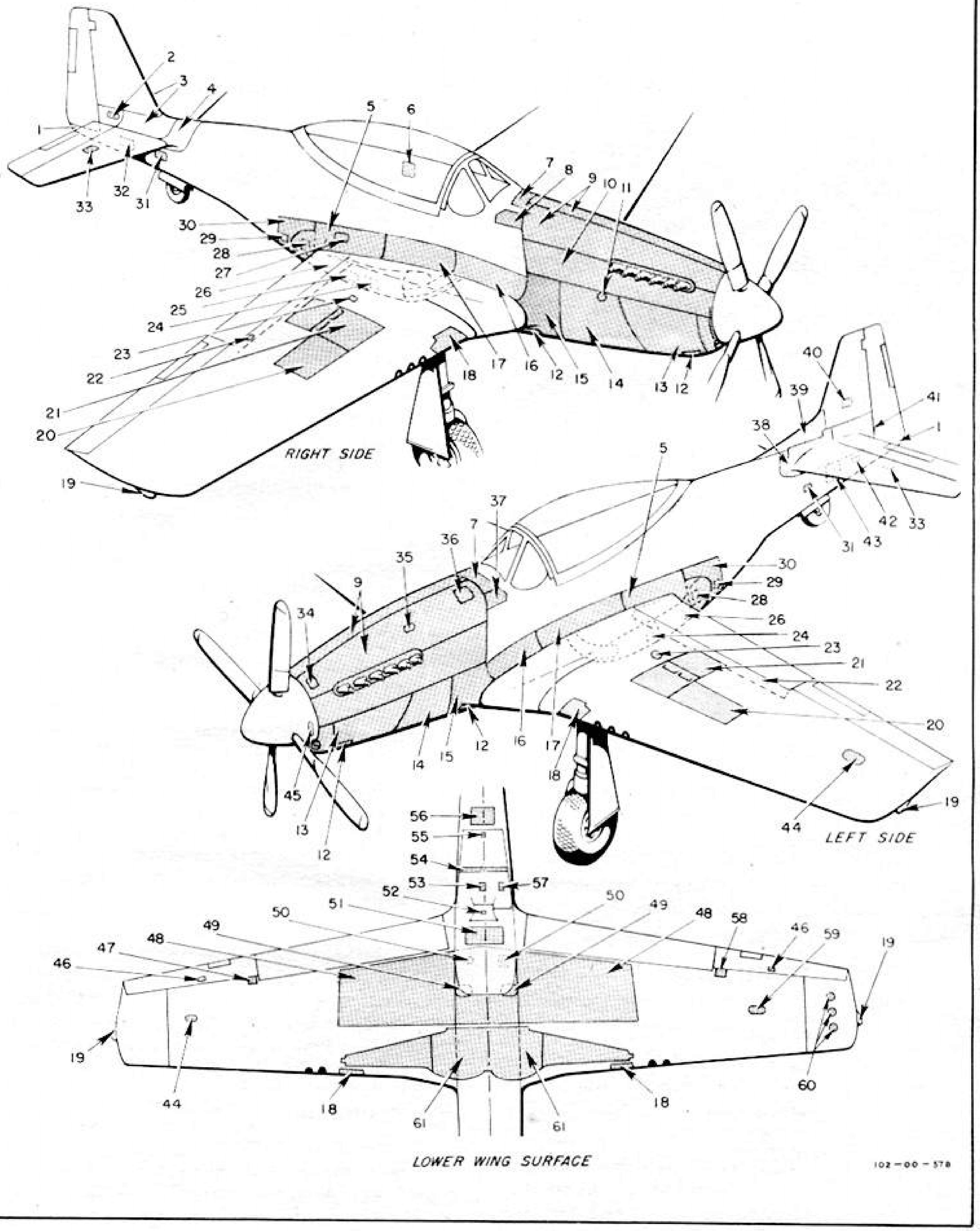



**Figure 50—Access and Inspection Provisions**

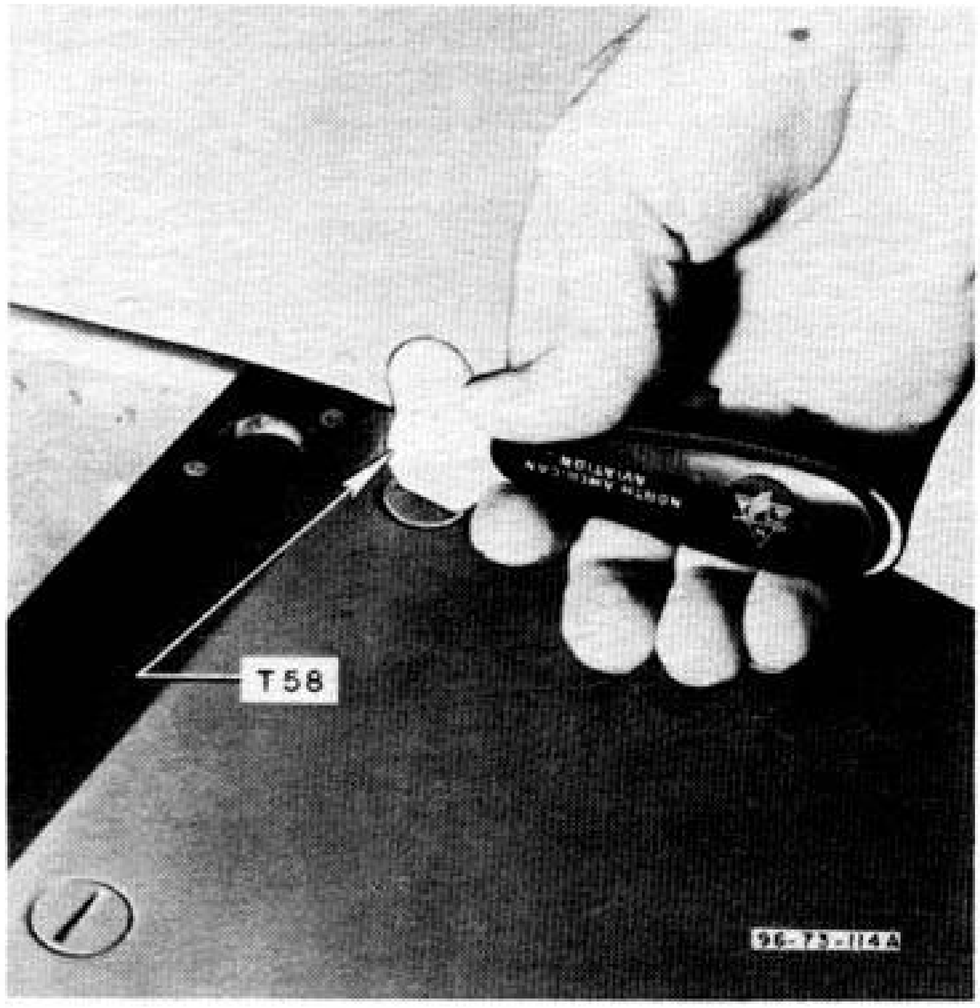



**Figure 51—Dzus Fastener Tool**

*(b)* THREE-POINT LIFT.—The complete airplane can be hoisted by means of a hoisting cable connected to an E717 hoisting sling *(figure 53)*, and two hoisting cables connected to the wing hoisting fittings. Since the center of gravity of the airplane is located just aft of the wing hoisting lugs, a 200-pound weight should be suspended from the fuselage lift tube before the engine is hoisted.

**CAUTION**

Do not permit the lifting cables connected to the wing hoisting fittings to exceed a 30-degree departure from the vertical position. Do not lift at the wing hoisting fittings if the fuel compartment doors are not installed.

(2) HOISTING TAIL OF AIRPLANE.—The tail of the airplane, complete with empennage, can be hoisted with an E717 hoisting sling. *(See figure 53.)* The airplane weighs approximately 1600 pounds at the lift tube.

**WARNING**

Do not lift the tail of the airplane by means of the horizontal stabilizer.

(3) HOISTING THE FUSELAGE.—The fuselage can be hoisted with or without the engine installed. The fuselage weighs approximately 4100 pounds with the engine and 2100 pounds without the engine.

*(a)* FUSELAGE WITHOUT ENGINE.—The fuselage without the engine can be hoisted with a single hoisting cable if an E718 hoisting sling *(figure 54)* is used. The sling fastens to a bar bolted to the upper engine mount attachment lugs, and to each end of an E727 lift-tube bar. *(See figure 53.)*

*(b)* FUSELAGE WITH ENGINE.—The fuselage with the engine can be hoisted with a single hoisting cable if an E750 hoisting sling *(figure 52)* is used. The sling fastens to the engine mount hoisting lugs, and to each end of an E727 lift-tube bar. *(See figure 53.)*

(4) HOISTING THE WING.—The wing can be hoisted with a single hoisting cable if an E719 hoisting sling *(figure 55)* is used. The sling bolts to the four wing-to-fuselage attachment mounts. By connecting the sling cables to the different holes in the sling frame, the wing can be hoisted horizontally or with the leading edge down. The wing weighs approximately 2500 pounds.

(5) HOISTING THE EMPENNAGE.—The empennage is installed in three units: the horizontal stabilizer and elevators assembled, the vertical stabilizer, and the rudder. Any one of the assemblies is light enough to be handled without a hoisting sling.

(6) HOISTING THE ENGINE.—The engine can be hoisted with or without the engine mount installed. The engine drained, with accessories, weighs approximately 2000 pounds with mount and 1800 pounds without mount.

*(a)* ENGINE WITHOUT MOUNT.—The engine without the mount can be hoisted with an E729 hoisting sling. *(See figure 56.)* The sling attaches to the lifting eye on the crankcase half of the reduction gear casing and to the lifting lugs of the mounting feet on each side of the crankcase supercharger.

*(b)* ENGINE WITH MOUNT.—The engine with the engine mount can be hoisted with an E724 hoisting sling. *(See figure 57.)* The sling attaches to the hoisting lugs on the aft end of the engine mount and to the propeller shaft.

*b.* JACKING.—Two jack pad fittings in each wing panel, a jack pad fitting in the center of the wing, a jack pad fitting in the tail of the fuselage, and a jacking lug on each main landing gear strut constitute the jacking facilities for this airplane. *(See figure 58.)* The necessary jack pads are provided in the tool kit furnished with the airplane. *(See figure 76.)*

(1) WING PANEL JACKING POINTS.—The wing panel jack pad fittings are located just outboard of the bomb rack on each wing panel. Install E752 jack pads in the fittings. These jacking points are used to jack the airplane when changing the main landing wheels or main landing gear, in combination with the center jacking point when removing the tank doors, and in combination with the tail jack pad fitting or a tail stand when checking the hydraulic system operation.

(2) WING CENTER JACKING POINT.—The wing center jack pad fitting is located on the center rib of the wing between the forward spar and the leading edge of the wing. Install an E732 jack pad in the fitting. This jacking point is used when removing the fuel tank doors.

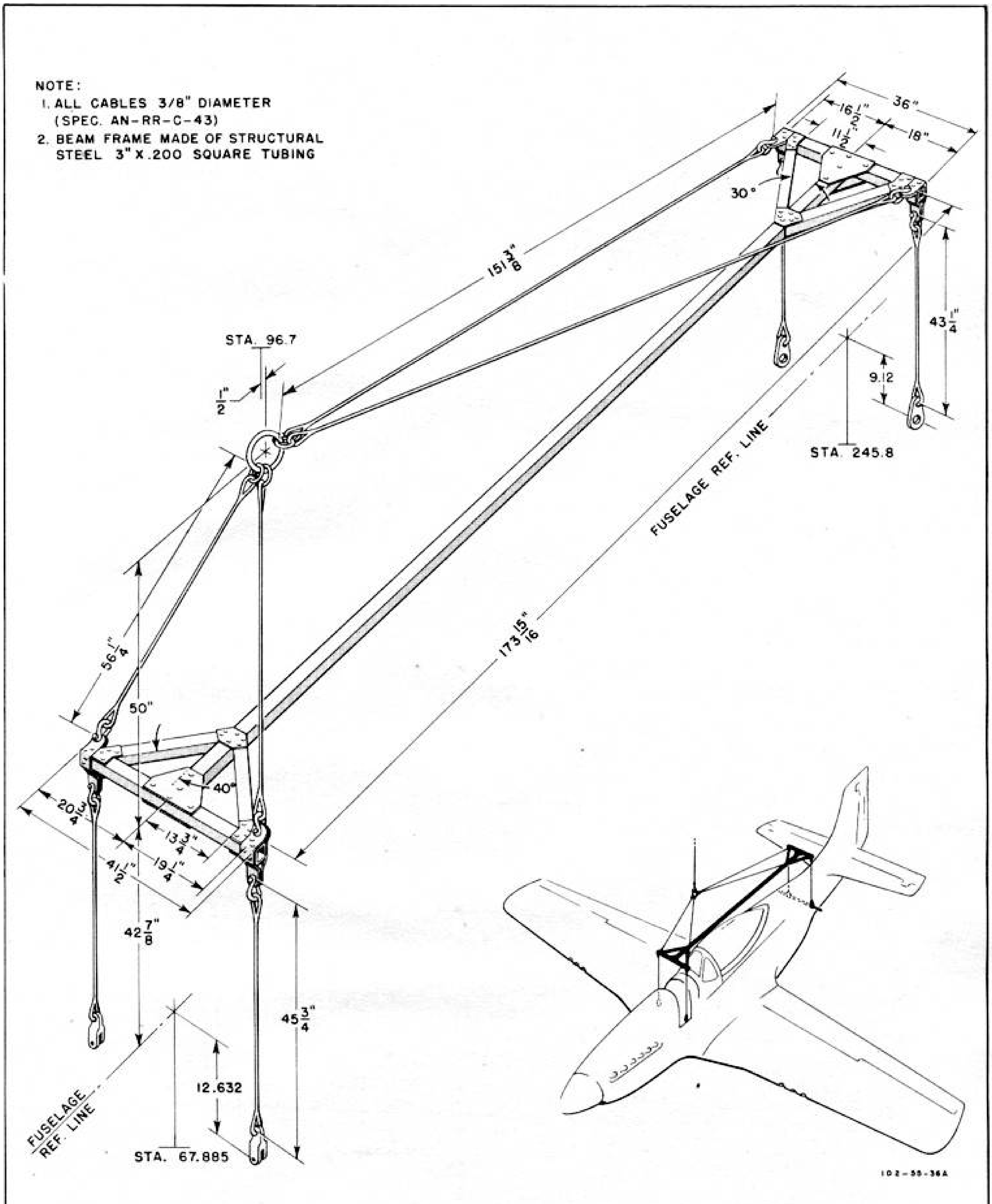



*Figure 52—Complete Airplane Hoisting Sling*

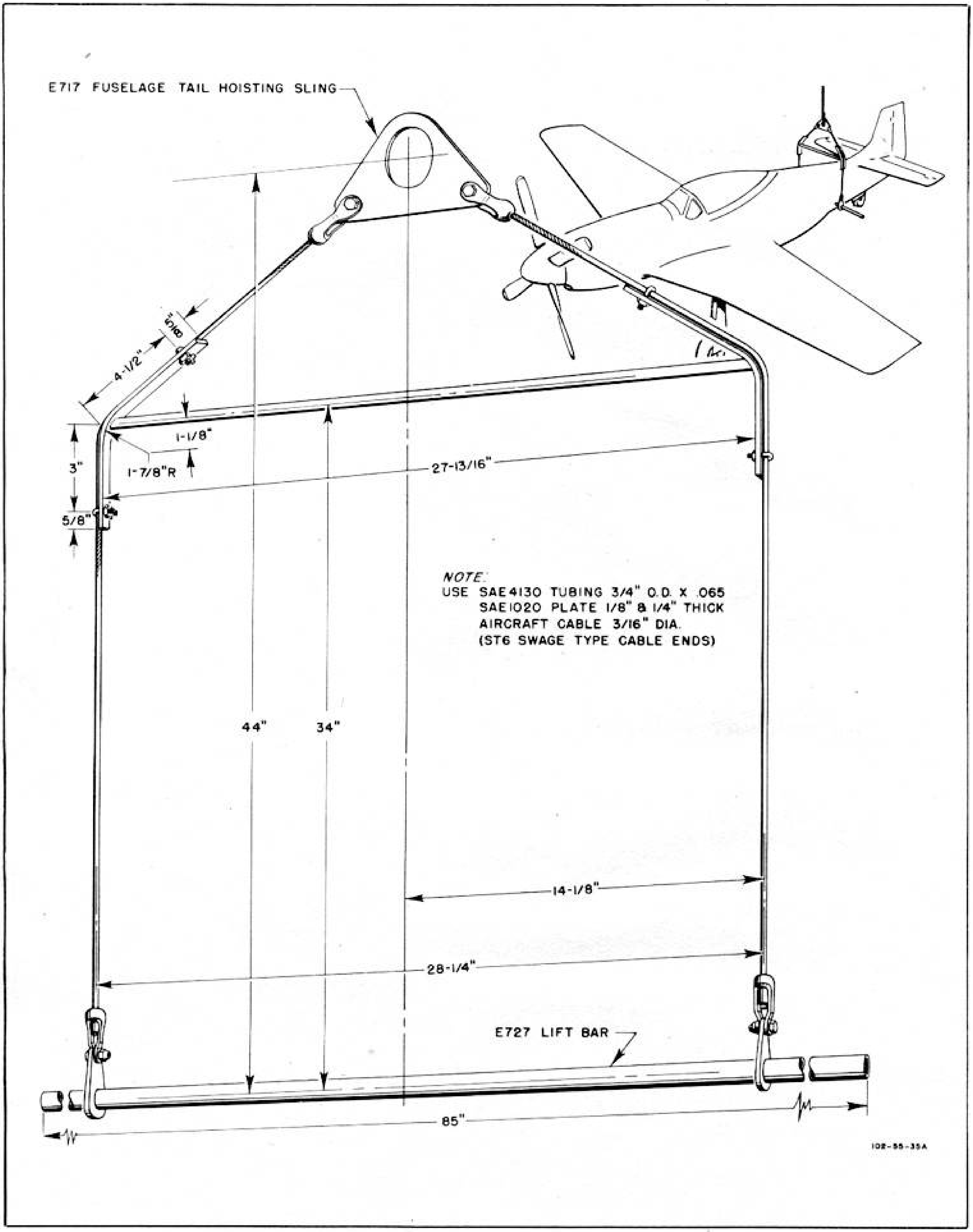



*Figure 53—Fuselage Tail Hoisting Sling and Lift Tube Bar*

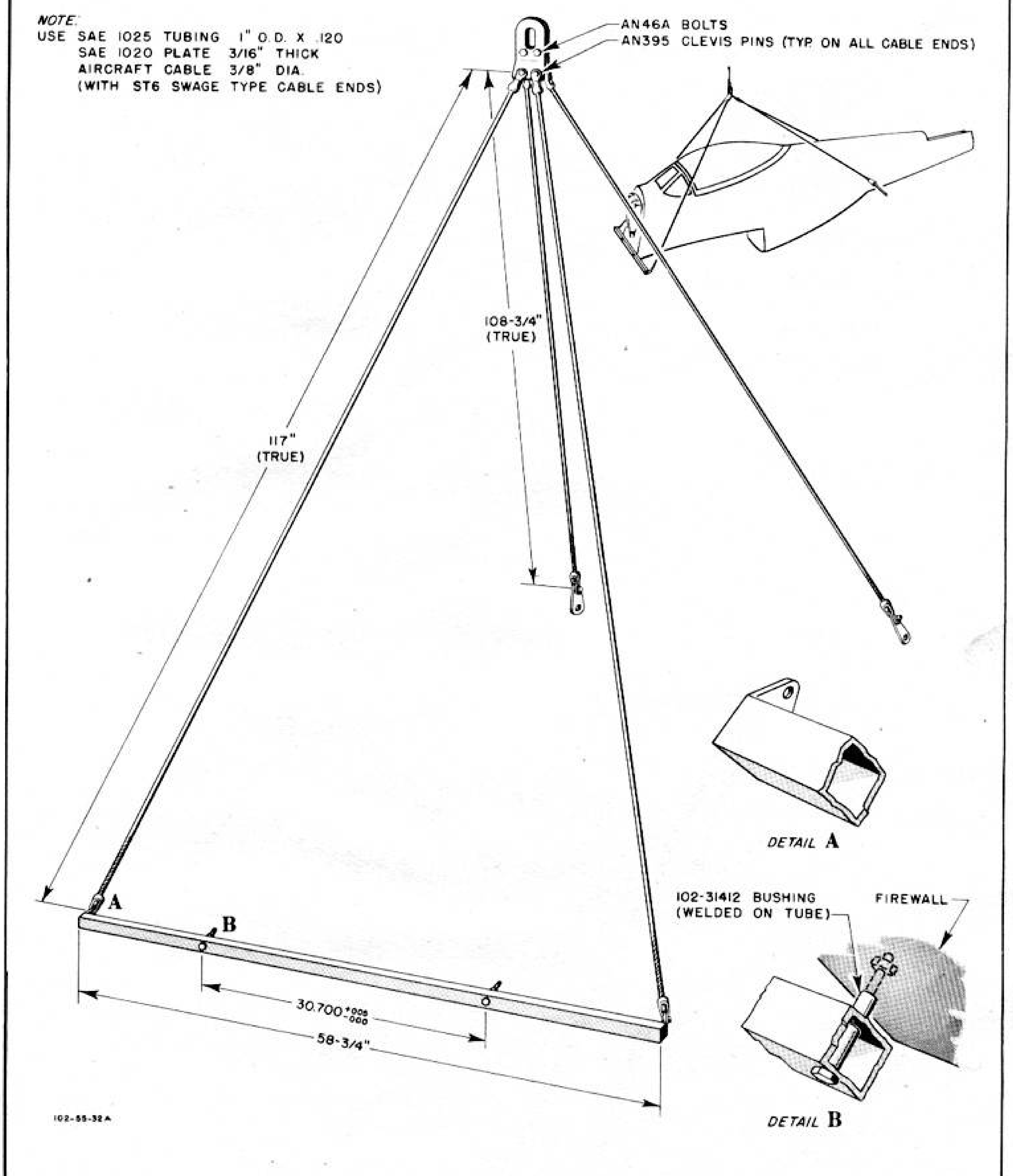



*Figure 54—Fuselage (Without Engine Mount) Hoisting Sling*

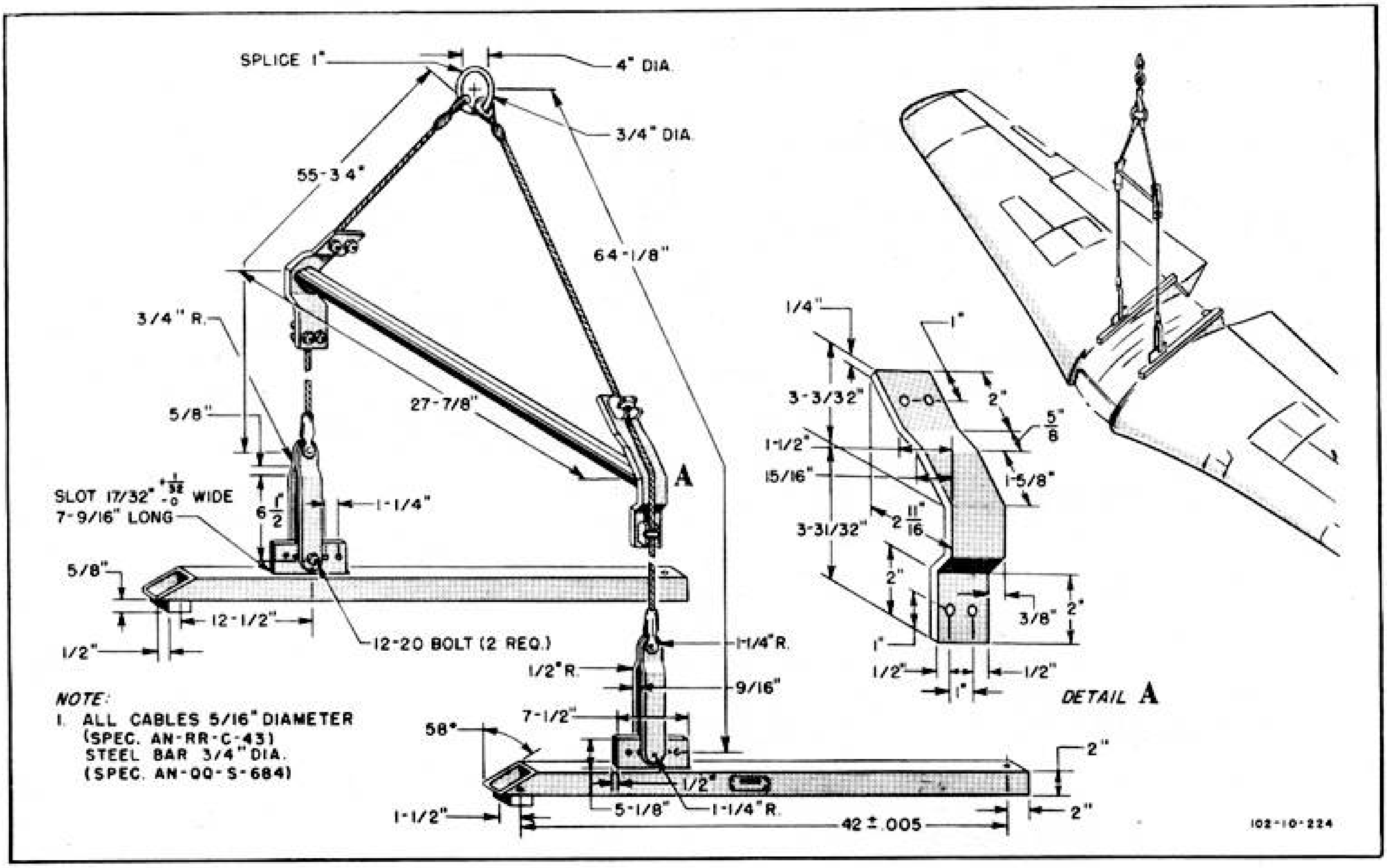



*Figure 55—Wing Hoisting Sling*

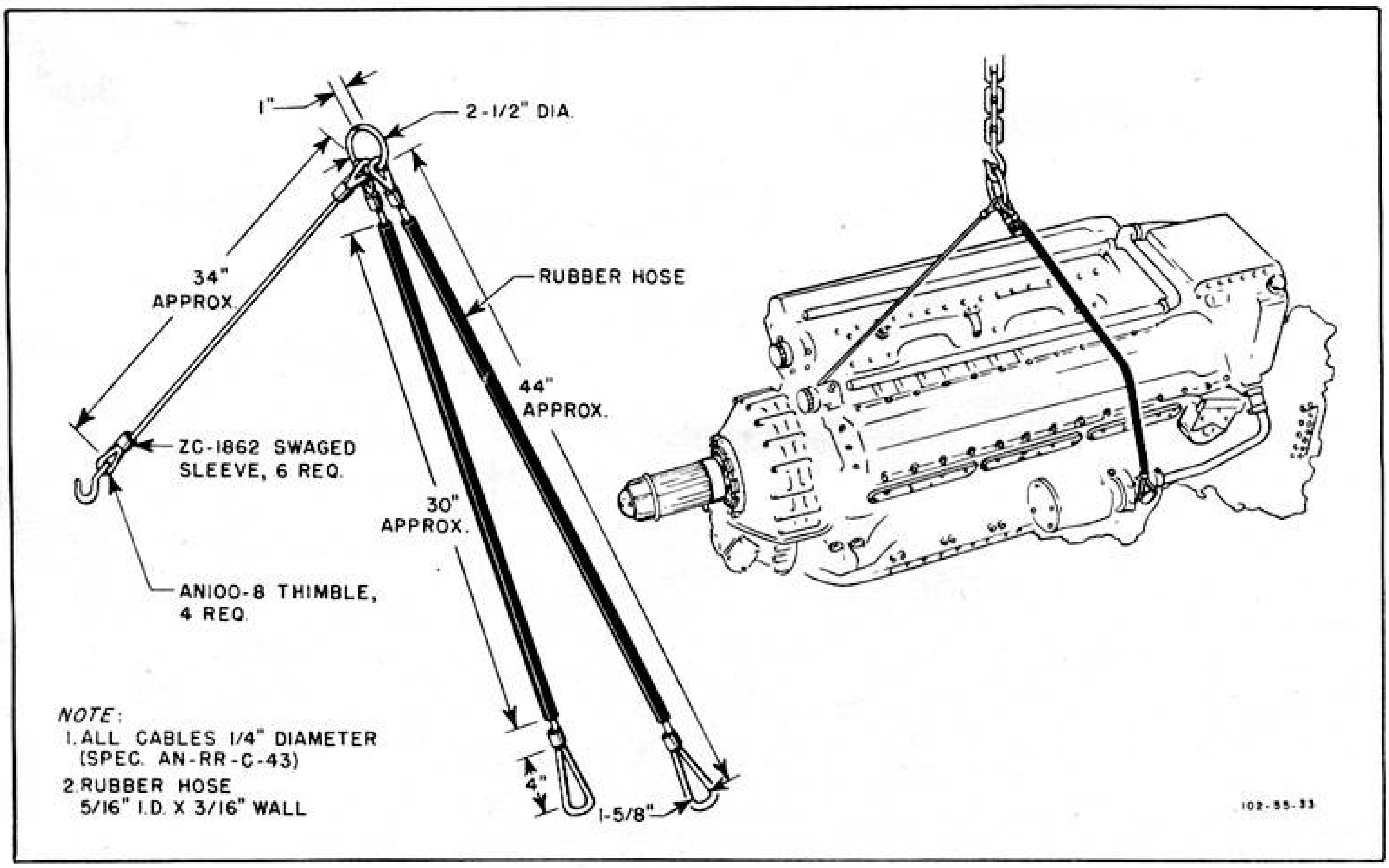



*Figure 56—Engine (Without Mount) Hoisting Sling*

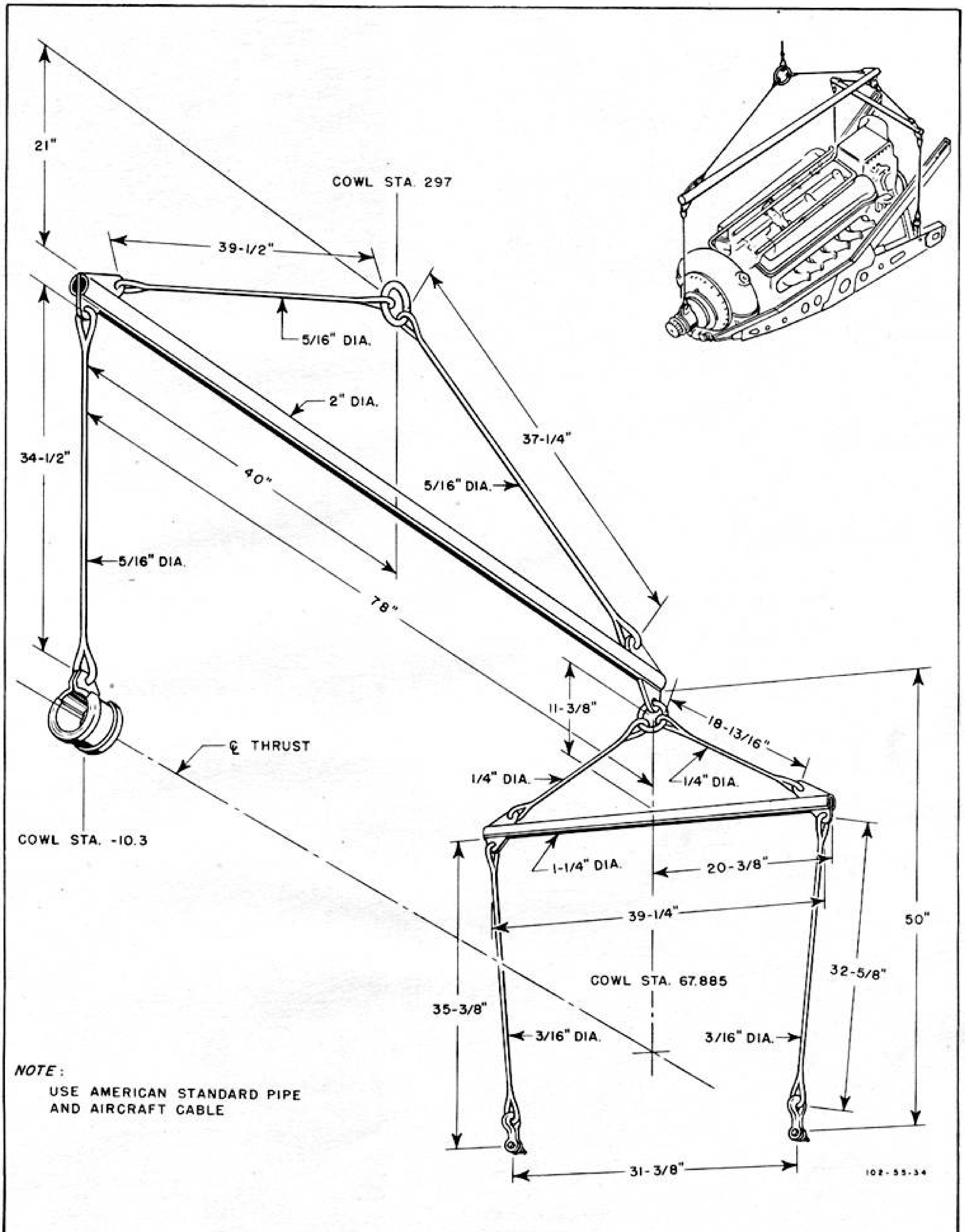



*Figure 57—Engine (With Mount) Hoisting Sling*

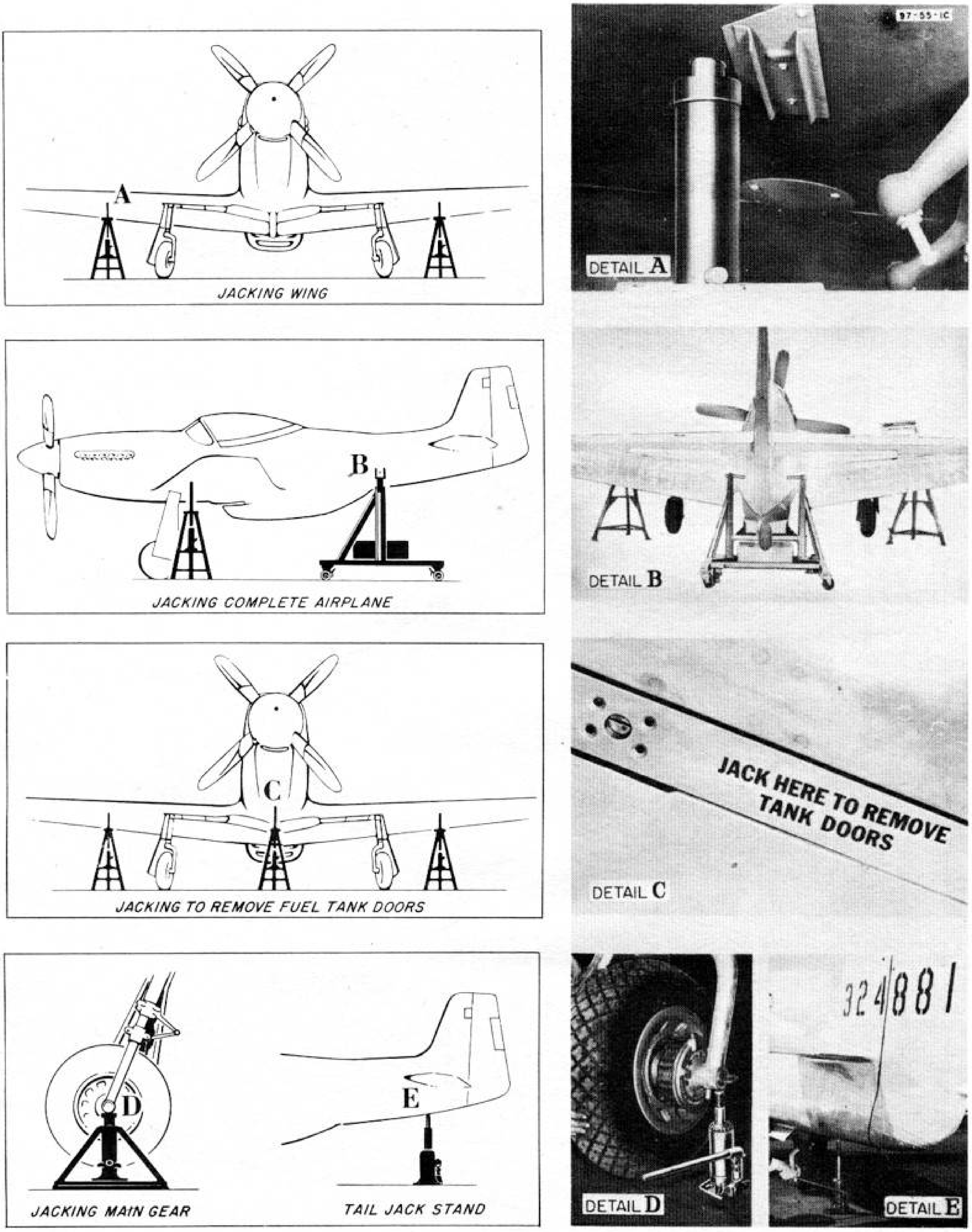



*Figure 58—Jacking the Airplane*

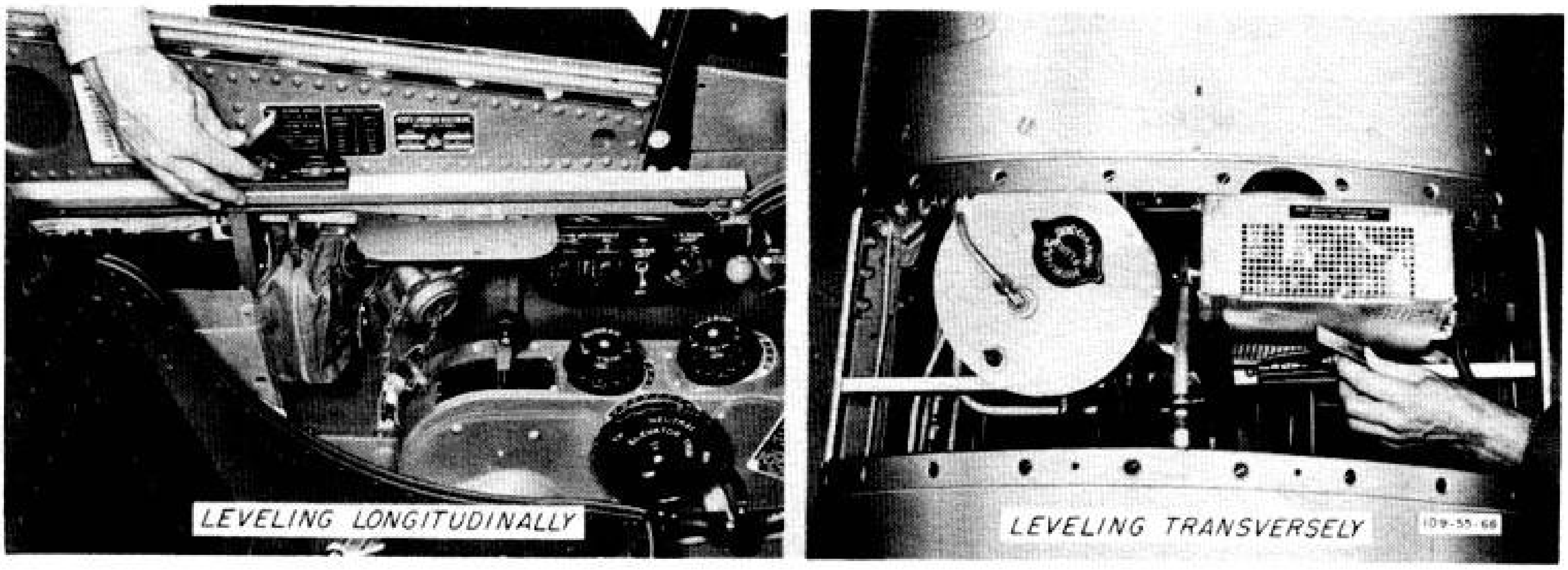



**Figure 59—Leveling the Airplane**

## WARNING

Do not leave the airplane jacked for long periods of time with the fuel tank doors off. Install the doors at least partially so that wings will not be twisted in case one jack slips or settles.

(3) FUSELAGE TAIL JACKING POINT.—The fuselage tail jack pad fitting is located in the lower skin of the fuselage directly below the horizontal stabilizer. Install an E772 jack pad in the fitting. When jacking the airplane to the level flight position, suspend a 200-pound weight from the fuselage lift tube to prevent the airplane's nosing over. This jacking point is used to jack the airplane when removing the tail wheel, to raise the airplane to the level flight position for firing or bore sighting the guns, and in combination with the wing panel jacking points when checking the hydraulic system operation. After the tail section has been raised, an E748 tail stand may be used to support the tail at the fuselage lift tube. This stand incorporates a 200-pound weight for balancing the airplane and is especially valuable when test-firing the guns.

(4) MAIN LANDING GEAR JACKING LUGS.—The main landing gear jacking lugs are located below the inboard end of the main wheel axles. These jacking points are used when removing the main wheels and main wheel brakes if the wing panel jacking points cannot be used.

**CAUTION**

A bolt and spacer are located directly forward of each main gear jacking lug. Do not jack the airplane at these points.

*c.* LEVELING.—The leveling lugs are located aft of the pilot's seat on the upper longerons.

(1) TRANSVERSELY. *(See figure 59.)*

*(a)* Lay a straight bar across the fuselage from either of the leveling lugs on the upper right longeron to the one lug on the upper left longeron.

*(b)* Place a leveling protractor on the bar, and then raise or lower one wing as required.

(2) LONGITUDINALLY. *(See figure 59.)*

*(a)* Lay a straight bar across the two leveling lugs on the upper right longeron.

*(b)* Place a leveling protractor on the bar, and then raise or lower the tail of the fuselage as required to position the airplane in the predetermined attitude of flight.

*d.* DATUM POINTS.—Two datum points are located on the lower surface of the airplane. *(See figure 60.)* One point is on the center rib of the wing at station 99 just forward of the wing spar, and the other is just forward of the tail wheel well at station 250.375. The points are well marked with red circles and are provided with AC366-F1032 nut plates for attaching plumb bobs.

*e.* PARKING BRAKES AND SURFACE CONTROL LOCK.

(1) PARKING BRAKES.—The parking brake control handle is centrally located below the instrument panel. To apply the parking brakes, proceed as follows:

*(a)* Pull the control handle part way back.

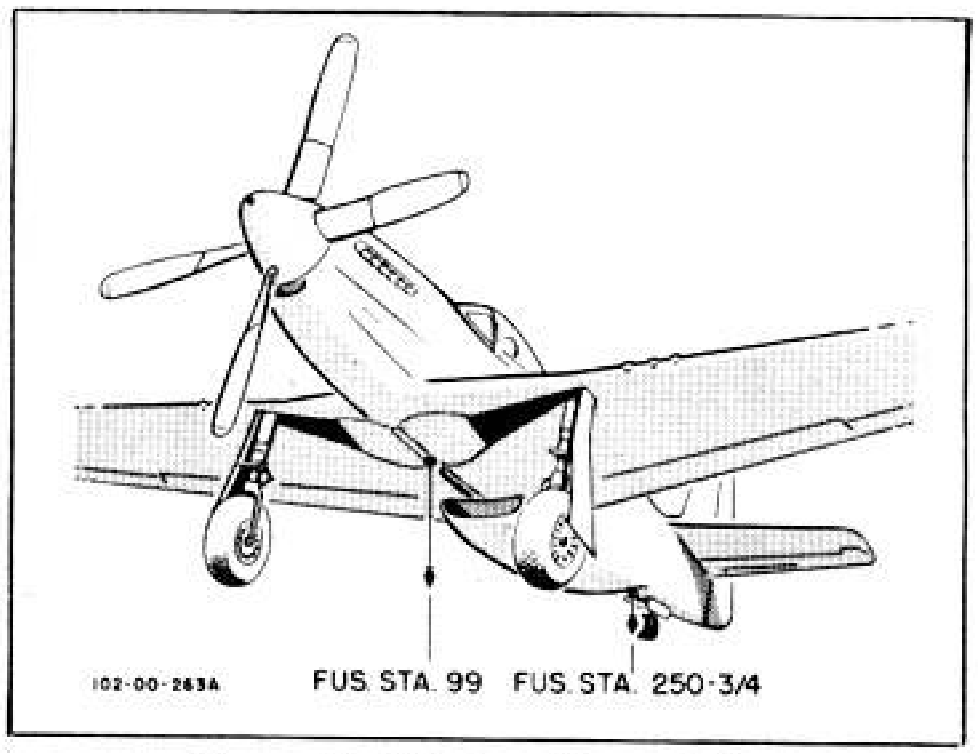



**Figure 60—Airplane Datum Points**

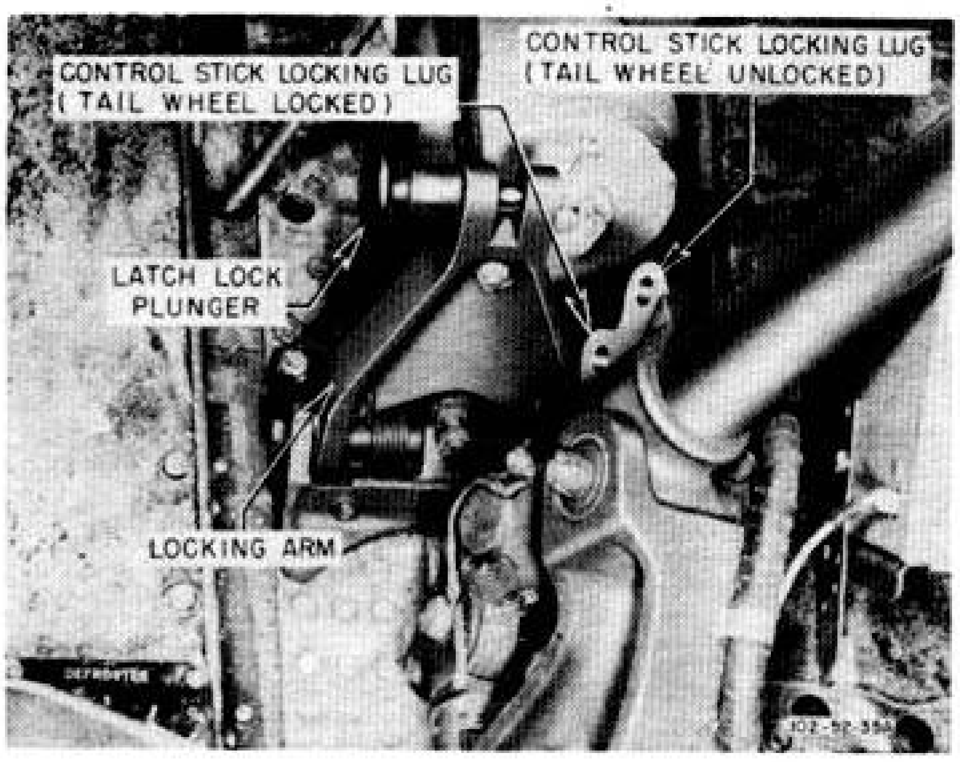



*Figure 61—Surface Control Lock*

(*b*) Press both brake pedals to their full extent.

(*c*) Pull the control handle back as far as it will go.

(*d*) Release the brake pedals.

(*e*) Release the control handle.

**Note**

To release the parking brakes, depress both brake pedals.

(2) SURFACE CONTROL LOCK.—The surface control locking gear (*figure 61*), located forward of the pilot's control stick, is operated as follows:

(*a*) Grasp the locking arm with the left hand and pull the lock plunger outboard.

(*b*) Center the control stick, pull the locking gear aft until the lock arm engages the desired locking lug on the control stick, and then release the plunger.

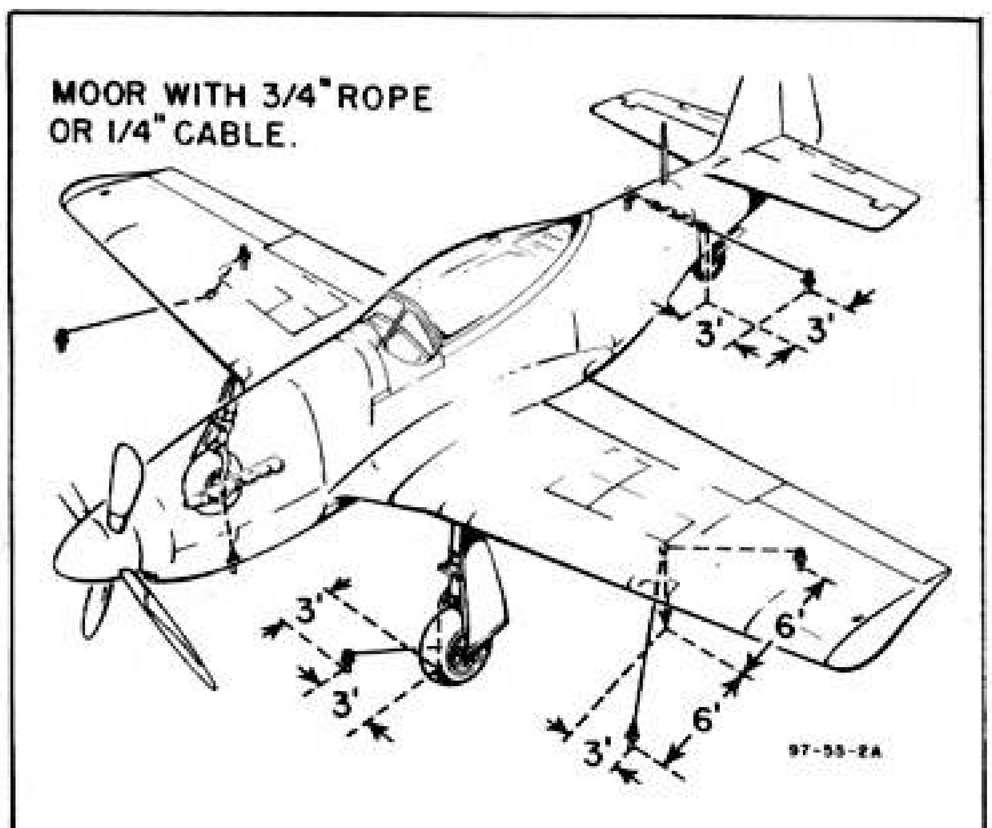



*Figure 62—Mooring the Airplane*

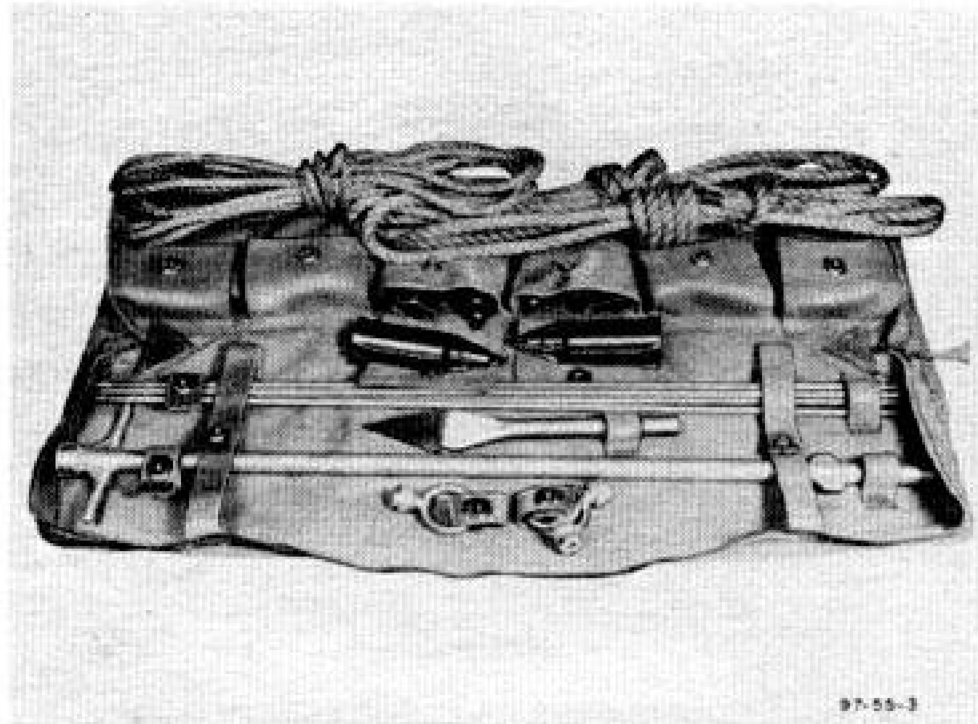


*Figure 63—Mooring Kit*

**Note**

The upper locking lug on the control stick positions the stick so that the tail wheel is unlocked, and the lower lug positions the stick so that the tail wheel is locked. (*See figure 61.*)

(*c*) Move the rudder control pedals until the rudder lock engages; the rudder pedals will only lock in the neutral position.

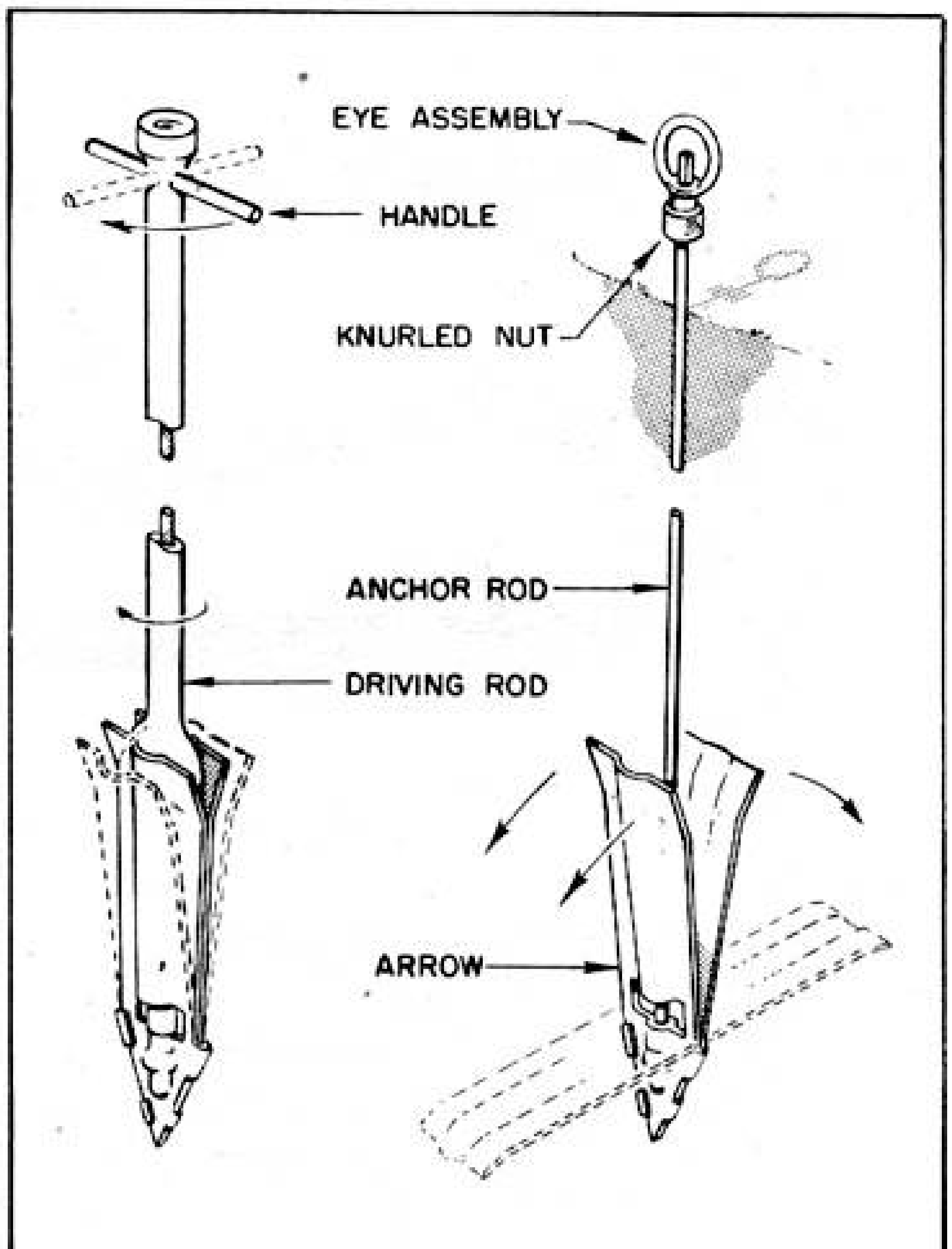



*Figure 64—Mooring Stakes*

*f.* MOORING.

(1) MOORING PROVISIONS.

*(a)* WING.—A mooring ring is provided on the lower surface of each wing panel approximately in line with the outboard end of the wing flap. *(See figure 62.)* The rings retract flush into the wing surface when not in use. Pry at the inboard part of the rings to disengage them from the stowed position.

*(b)* MAIN LANDING GEAR.—A mooring ring is on the inboard end of each main landing gear axle. *(See figure 62.)*

*(c)* FUSELAGE.—The lift tube in the fuselage just aft of and below the insignia provides a means of mooring the tail of the airplane. *(See figure 62.)*

*(d)* MOORING KIT.—A standard mooring kit, Type D-1 *(figure 63)*, is stowed inside the fuselage near the oxygen cylinders.

(2) MOORING INSTRUCTIONS.—The following mooring instructions represent minimum precautions:

*(a)* Head the airplane into the wind.

*(b)* Lock the surface controls at the lower locking lug and neutralize the rudder pedals so that the rudder controls lock. With the stick in this position, the tail wheel is locked. *(See figure 61.)*

*(c)* Moor the airplane with ¾-inch ropes or ¼-inch cable. *(See figure 62.)* If mooring facilities are not available, use mooring kit as instructed in paragraph (3), following.

**CAUTION**

When warning of storms or high winds is received, install felt-padded wooden clamps to lock all movable control surfaces securely. These clamps should be used in addition to the surface control locks.

(3) USE OF MOORING KIT. *(See figure 64.)*

*(a)* Screw the anchor rod into the arrow, and then slip the driving rod over the anchor rod into the socket of

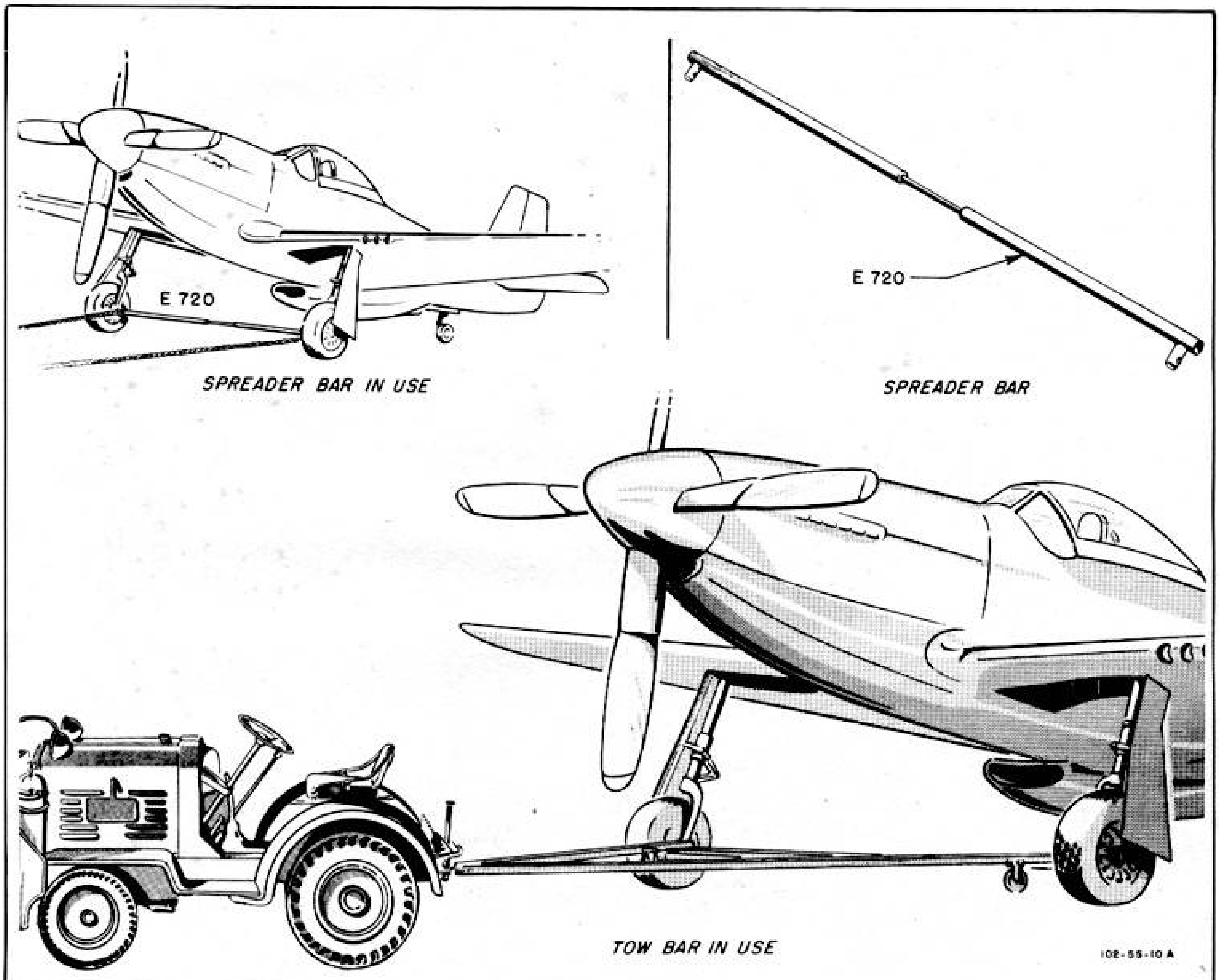



**Figure 65—Towing the Airplane**

the arrow. The cam on the driving rod must be turned so that the prongs of the arrow will not spread when the arrow is driven into the ground. If the ground is hard, the surface may be broken with a ground-breaking pin.

*(b)* Align the rod with the mooring point on the airplane, and then drive the arrow down until the driving rod handle is within approximately 3 inches of the ground.

*(c)* Rotate the handle 90 degrees and strike the driving rod a sharp blow to spread the prongs of the arrow, return the handle to the driving position, and then pull the driving rod from the ground.

*(d)* Align the squared socket of the "eye" assembly with the square end of the anchor rod, fit the "eye" on the rod, and then tighten down the knurled nut.

*(e)* To withdraw the anchor rods, detach the mooring ropes and unscrew the rods. Leave the arrows in the ground and replace the expanded arrows as soon as possible so as to keep the mooring kit complete.

*g.* TOWING.—A towing ring is at the inboard end of each main landing wheel axle. The use of an E715 tow bar will facilitate towing the airplane within an area limited by ground equipment or other aircraft. *(See figure 65.)* If tow ropes are used, an E720 spreader bar or some similar bar arrangement will prevent the landing gear from collapsing should the landing gear control handle be inadvertently moved. Release the parking brakes and unlock the tail wheel before attempting to move the airplane. When the airplane is being towed near other equipment, station one man in the cockpit to operate the brakes, and assign a man to each wing tip. Whenever towing is being done by ropes or cables, station a man in the cockpit to operate the brakes so that the airplane will not run down the towing equipment.

*h.* SERVICING INSTRUCTIONS.

(1) FUEL SYSTEM.

*(a)* FUEL.—100 octane fuel, Specification No. AN-F-28, Grade 130.

*(b)* TANK CAPACITIES.

*1.* WING TANKS (2).—92 US (76.5 Imperial) gallons each.

*2.* FUSELAGE TANK (1).—85 US (70.7 Imperial) gallons.

*3.* COMBAT TANKS (2).—75 US (62.4 Imperial) or 110 US (92 Imperial) gallons each.

*(c)* FILLING MAIN FUEL TANKS.—The main tanks are filled individually through filler necks on the upper surface of the respective wing panels. *(See figure 66.)* The ground jacks are located just forward and inboard of each filler neck. When filling the tanks, observe the following precautions:

*1.* Before filling the tanks, examine the fuel system for leaks, ground the airplane, and drain a small amount of fuel from the two drain cocks at the forward end of the radiator scoop and from the fuel strainer at the base of the firewall in order to eliminate accumulated water and foreign matter.

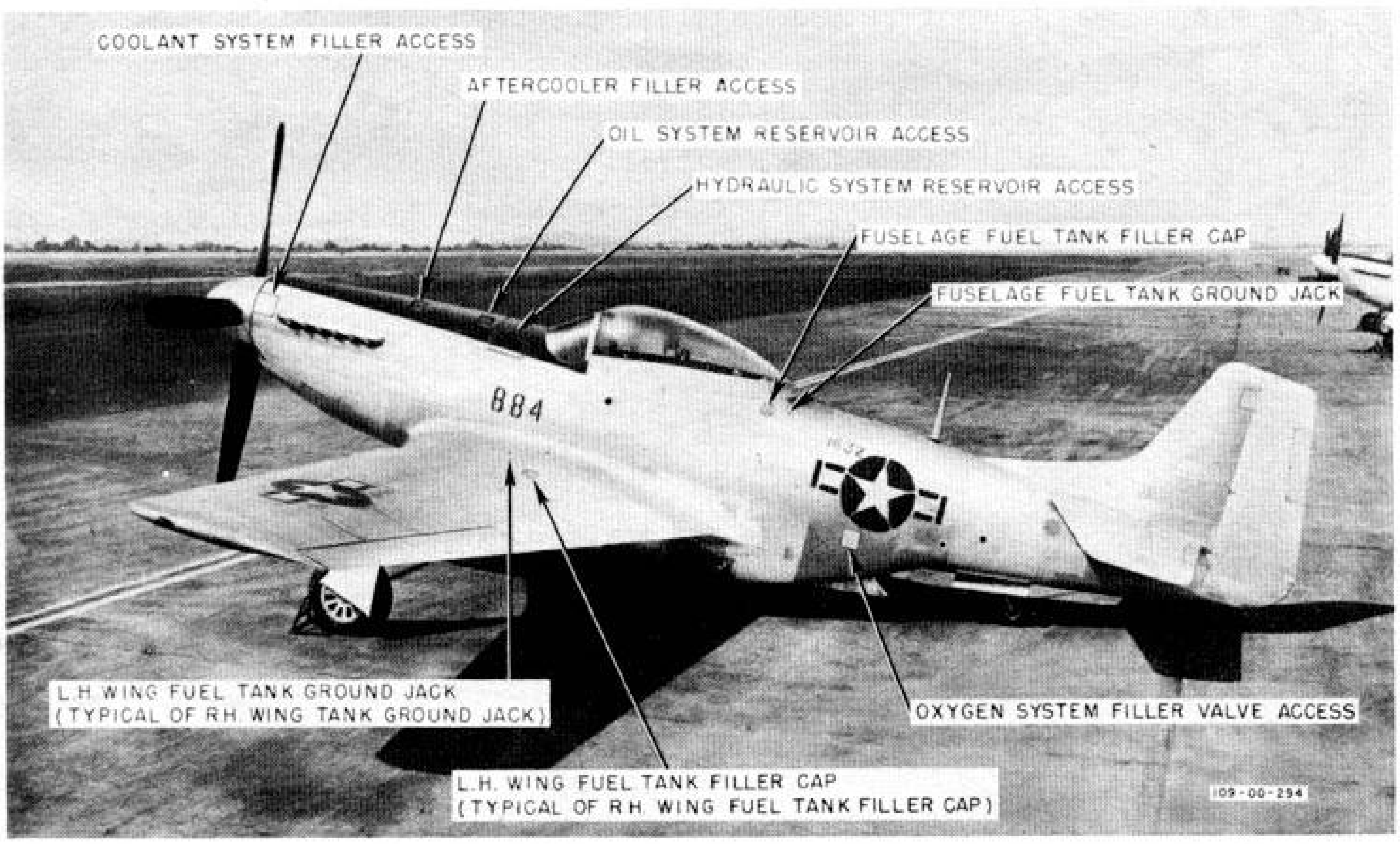



**Figure 66—Servicing Provisions**

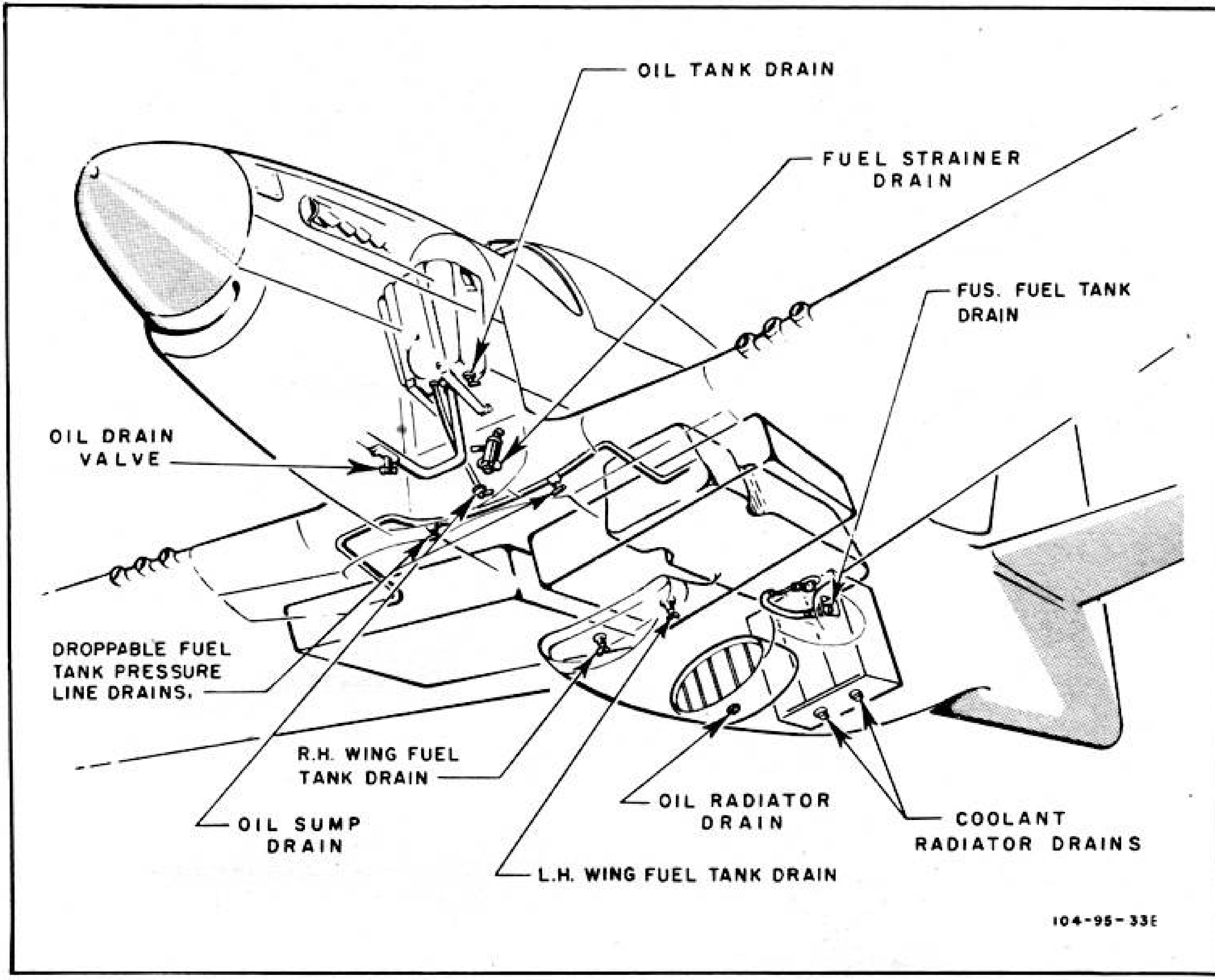



***Figure 67—Fuel, Oil, and Coolant Drains***

*2.* Avoid filling the tanks to overflowing, as there are no filler neck drain lines.

*3.* After filling the tanks, check the filler caps for security, and wipe any spilled fuel from the surface of the wing.

*(d)* DRAINING MAIN FUEL TANKS.

*1.* Ground the airplane at the ground jacks just forward and inboard of each main tank filler cap. *(See figure 66.)*

*2.* Place suitable container near booster pump on tank to be drained.

*3.* Remove booster pump access door.

*4.* Remove Allen head drain plug in booster pump discharge nipple. Obtain a funnel or devise some method of directing the fuel from the pump nipple to the container. A hose attached to a fitting which will screw into the pump nipple is very satisfactory.

*5.* Turn "OFF" fuel shut-off valve, place the fuel selector control handle in proper position for the tank being drained, and set booster pump switch in "ON" position.

*6.* Either plug in external power supply, or turn "ON" the battery-disconnect switch.

*7.* Drain any fuel which has settled in aft end of tanks by opening the drain cocks on the aft inboard end of each tank. *(See figure 67.)*

*8.* Replace Allen head drain plugs in booster pump discharge nipples, and safety drain cocks.

*(e)* FILLING FUSELAGE FUEL TANK.—Before filling the fuselage tank, ground the airplane at the ground jack located just below the fuselage tank filler neck, and then drain a small amount of fuel from the drain cock, which is accessible through a dzus-fastened door on the left underside of the fuselage; this will eliminate accumulated water and foreign matter. Fill the tank through the filler neck on the left side of the fuselage just aft of the canopy. *(See figure 66.)*

*(f)* DRAINING FUSELAGE FUEL TANK.—Ground the airplane at the ground jack just aft of the fuselage tank filler cap *(figure 66)*, and then open the drain cock which is accessible through a dzus-fastened door on the left

underside of the fuselage. *(See figure 67.)* After draining the tank, tighten and safety the drain cock.

*(g)* FILLING COMBAT FUEL TANKS.—Ground the airplane at either of the ground jacks just forward and inboard of the wing tank filler caps, and then fill the combat tanks to overflowing at the filler neck on the upper forward end of each tank. No gages are provided. If the tanks are permitted to stand for several hours after filling, drain out a small amount of fuel through the drain plug on the bottom of each tank, replace and safety drain plug, and refill the tanks with fuel. This removes any moisture or foreign matter which may accumulate in the tanks.

*(h)* DRAINING COMBAT FUEL TANKS.—Place a suitable container beneath the drain plug at the bottom of the tank to be drained, and then remove the plug. After draining, install and safety the drain plugs.

(2) OIL SYSTEM.

*(a)* OIL.—Specification No. AN-O-5, Grade 1100p, or AN-VV-O-446, Grade 1120 and Grade 1100. The Specification No. AN-VV-O-446, Grade 1100 oil is for summer use only.

*(b)* SYSTEM CAPACITY.—21 US (17.5 Imperial) gallons.

*(c)* FILLING OIL SYSTEM.—The oil filler neck is accessible through a small dzus-fastened door on the left side of the upper engine cowling. *(See figure 66.)* If foam is present when replenishing the tank, be careful to get a proper reading of the oil level.

*1.* Fill the oil tank to the level of the filler neck. This will require approximately 12 gallons if the tank is empty.

*2.* Run the engine for one or two minutes between 800 and 1000 rpm. These figures should be closely adhered to, as running the engine above the specified time or speed may cause serious internal damage to the engine.

*3.* Stop the engine and again fill the tank to the level of the filler neck.

*4.* Run the engine as instructed in (2) *(c) 2.*

*5.* Check the oil level, add oil if necessary, and then install and safety the filler cap.

*6.* Wipe off any spilled oil and fasten the access door.

*(d)* DRAINING OIL SYSTEM.

*1.* Remove the drain plug from the oil drain casting in the lower right side of the engine accessory compartment. For access to the oil drain casting, remove the lower right-hand engine cowling. Drain oil cooler radiator by removing the drain plug on the bottom of the cooler, accessible through an access door in the bottom of the fuselage.

*2.* Remove the filter caps from the lower left end of the crankcase, just forward of the coolant pump. Access to the filter caps is gained by removing the left-hand lower engine cowling and removing the center carburetor air duct. If the filter screens do not drop out when the caps are removed, take them out by hand.

*3.* Inspect the filter screens. If an abnormal collection of metal particles is present, investigate immediately.

*4.* After the oil has drained out of the system, wipe and clean the inside of the filter screen casings thoroughly with a lint-free cloth moistened with unleaded gasoline.

*5.* Clean the filter screens with naphtha or unleaded gasoline. Do not use a cloth when cleaning the screens.

*6.* Reinstall the filters, making sure that the gaskets are in good condition and that all joint surfaces are clean.

## WARNING

Excessive tightening of cap nut will result in damage to filter screen housing and loss of proper scavenging action.

(3) ENGINE COOLING AND AFTERCOOLING SYSTEMS.

*(a)* COOLANT.—Winter below −12°C (10°F), Type C. Summer above −12°C (10°F), Type D.

*(b)* SYSTEM CAPACITIES.

*1.* ENGINE COOLING SYSTEM.—16.7 US (13.9 Imperial) gallons.

*2.* AFTERCOOLING SYSTEM.—4.8 US (4 Imperial) gallons.

*(c)* FILLING COOLING SYSTEMS.—The header tank filler cap is accessible through the dzus-fastened door at the forward end of the upper left engine cowling just aft of the propeller spinner. *(See figure 66.)* The aftercooler expansion tank is accessible through the door on the top left engine cowling just forward of the oil tank filler cap access door. Because the pressure-type cooling systems require closed circuits, air traps are likely to occur when filling the system. Therefore, sealed vent lines are provided to bleed off the air when the system is being filled. The vents for both systems are located just inside the left wing rear fillet.

*1.* Remove the two vent line caps inside left rear wing fillet.

*2.* Fill the header tank and the aftercooler expansion tank until coolant overflows the respective vent lines.

*3.* Quickly install and safety the vent line caps.

*4.* Continue filling each system until the tanks overflow; then install the filler caps.

*5.* Run the engine at 800 rpm from one to two minutes. Stop the engine and inspect both tanks for coolant level. Fill coolant tanks. Install and safety the filler caps. Repeat this procedure as often as necessary to completely fill the system.

*(d)* DRAINING ENGINE COOLING SYSTEM.

*1.* Remove the drain plugs from the coolant pump and engine cooling section of the radiator. *(See figure 67.)* The pump drain plug is accessible through the lower left engine cowling. A door beneath the coolant radiator provides access to the engine cooling system drain plug located on the left-hand side of the radiator.

*2.* Remove the header tank filler cap to allow air to enter the system as the coolant drains. The filler cap is accessible through the dzus-fastened door at the forward end of the upper left engine cowling just aft of the propeller spinner. *(See figure 66.)*

*(e)* DRAINING AFTERCOOLER SYSTEM.

*1.* Remove the drain plug from the aftercooling section of the radiator. *(See figure 67.)* A door beneath the coolant radiator provides access to the aftercooling system drain plug on the right-hand side of the radiator.

*2.* Remove the aftercooler expansion tank filler cap to allow air to enter the system as the coolant drains. The filler cap is accessible through the door of the top left engine cowling just forward of the oil tank filler cap access door. *(See figure 67.)*

**Note**

Collect the coolant liquid drained from the cooling systems and test it for proper percentage of water and glycol with a glycol hydrometer. If the liquid is not contaminated, it may be strained and used again.

(4) HYDRAULIC SYSTEM.

*(a)* FLUID.—Specification No. AN-VV-O-366.

*(b)* SYSTEM CAPACITY.—3.5 US (2.9 Imperial) gallons.

*(c)* RESERVOIR CAPACITY.—Early airplanes, 1.86 US (1.45 Imperial) gallons. Later airplanes, 1.21 US (1 Imperial) gallons.

*(d)* EXHAUSTING HYDRAULIC SYSTEM PRESSURE.—The hydraulic system is exhausted by operating the wing flaps or by pulling the emergency release knob on the instrument subpanel and opening the controllable check valve. The hydraulic pressure gage on the lower right-hand side of instrument subpanel should read zero. The hydraulic system pressure should be exhausted before:

*1.* Replenishing the hydraulic reservoir or checking the fluid level.

*2.* Draining and filling the complete hydraulic system.

*3.* Checking the air pressure in the accumulator.

*4.* Disconnecting any hydraulic lines or removing any hydraulic unit.

**CAUTION**

Be sure to push in the emergency lowering knob as soon as the refilling is accomplished.

*(e)* REPLENISHING HYDRAULIC RESERVOIR FLUID.—When filling the reservoir, it is recommended that a suitable receptacle be placed under the reservoir drain line which bottoms at the left side of the lower firewall. On later airplanes, this drain line has been removed. Clean the reservoir filler neck strainer at each refilling and make sure the filler cap and dip stick are correctly secured in place. Fill the reservoir as follows:

*1.* Exhaust the system pressure.

*2.* Fill the reservoir to overflowing. The reservoir dip stick is calibrated to show when one quart or two quarts of fluid need to be added.

**CAUTION**

Do not fill the reservoir through the dip-stick hole.

*(f)* FILLING THE HYDRAULIC SYSTEM WITH TEST STAND.—The hydraulic test stand should be used when filling the complete hydraulic system. Before filling the complete hydraulic system, place the airplane on jacks to permit operation of the landing gear. It is also necessary to inflate the accumulator to 400 ($\pm$ 25) pounds per square inch. The system has a total fluid capacity of approximately 3.5 US (2.9 Imperial) gallons. Hydraulic fluid must be absolutely clean. Filter the fluid before putting it in the system. Avoid working on the hydraulic system out of doors where units are subject to contamination.

*1.* Connect the test stand lines to the firewall disconnect couplings. A return line must be run from the vent connection at the top of the reservoir to the test stand reservoir, leaving the airplane reservoir filler cap tight.

*2.* Circulate fluid through the system thoroughly, and then operate each unit several times to purge the system of as much air as possible. If necessary, loosen the B nuts on the lines at units such as the tail wheel operating strut, the hydraulic pressure gage, and the fairing door operating strut to relieve trapped air. After bleeding, be sure to tighten and safety where required. Units will bleed automatically when the system is operating.

*3.* Operate each unit several times. The pressure gage reading should return to 1000-1100 pounds per square inch after each operation.

*4.* Stop the test stand pump and disconnect the test stand from the airplane.

*5.* Connect the engine-driven pump suction and pressure lines to the disconnect couplings at the firewall.

*6.* Make sure the landing gear control handle is in the down position, take the airplane off the jacks, start the engine, and then test the engine-driven pump by operating the wing flaps.

*7.* Carefully inspect the lines and equipment for leaks, and replenish the reservoir if necessary.

*(g)* FILLING HYDRAULIC SYSTEM WITH HAND-PUMP.—Complete filling of the hydraulic system by means of the hand-pump entails a great amount of labor. Use this method only when no other means is available. Use the applicable instructions in paragraph 2. ***b.*** (4) ***(f)***, and keep filling the reservoir as fluid is used.

*(h)* DRAINING HYDRAULIC SYSTEM.—Disconnect system return line at landing gear selector valve to

drain system. To drain reservoir, disconnect any brake line in the wing.

(5) OXYGEN SYSTEM.

*(a)* OPERATING PRESSURE.—400 pounds per square inch.

*(b)* FILLING OXYGEN SYSTEM.—A suitable oxygen cylinder recharger designed in accordance with AAF Dwg. 41G5917 and Specification No. 2198A should be used in filling the oxygen cylinders. The oxygen filler valve is accessible through the access door on the left side of the fuselage, just below the insignia. *(See figure 66.)*

*1.* Turn the supply equipment regulator adjusting screw all the way open; then very slowly open the valves on the supply cylinders.

*2.* Close the adjusting screw until the supply pressure gage reads 425 pounds per square inch.

## WARNING

The use of high-pressure recharging cylinders without pressure reducer regulators will burst the oxygen cylinders in the airplane.

*3.* Remove the filler valve plug by turning the handle.

*4.* Insert the nozzle on the end of the supply hose into the filler valve, pushing it into the opening until the catch snaps. An adapter to fit the valve for British recharging equipment is located in the spring clip on top of the filler valve assembly.

*5.* Open the shut-off valve on the supply equipment and allow oxygen to flow into the system until the oxygen pressure gage on the instrument panel reads 425 pounds per square inch, at which point the flow of oxygen should be stopped. The charging of the cylinders generates heat. After servicing, the cylinders will cool with a resultant drop in pressure of approximately 25 pounds per square inch. The pressure gage will then read approximately 400 pounds per square inch.


***Figure 68—Checking Specific Gravity of the Battery***

*6.* Turn off the supply valve and disconnect the filler hose by turning the filler valve handle ⅛ turn.

## WARNING

Hold the filler hose firmly while turning the handle, as the oxygen pressure may throw it with considerable force.

*7.* Snap the plug into the filler valve opening.

*(c)* DRAINING OXYGEN SYSTEM.—The oxygen system can be drained by turning the red emergency knob on the oxygen regulator. This allows the oxygen to by-pass the regulator and flow from the system.

### CAUTION

Make certain that the mask-to-regulator hose is not blocked; otherwise the regulator diaphragm will rupture.

(6) TESTING BATTERY SPECIFIC GRAVITY.—Since gravity varies with temperature as well as with the percentage of acid (increasing temperature lowers it; decreasing temperature raises it), it is necessary to correct for temperature in accurately determining the condition of charge of the battery. AAF hydrometers are calibrated to read correctly at 26.7°C (80°F). In taking readings, make the temperature correction indicated by the thermometer on the hydrometer by adding or subtracting the correct number of points to the float reading. For example, if the hydrometer reading is 1.250 and the thermometer reading is —1.1°C (30°F), the correction shown on temperature scale is "subtract 20 points." Thus, the true specific gravity of the battery would be 1.250 minus 20, or 1.230. Replace the battery as soon as practicable if its specific gravity, corrected for temperature, is below 1.240 *(figure 68)* or above 1.310. The following specific gravity table is for new batteries at 26.7°C (80°F) with the electrolyte level ⅜ inch above the top of the protector:

| STATE OF CHARGE | SPECIFIC GRAVITY |
|---|---|
| Fully charged. | 1.275 to 1.300 |
| ⅓ discharged. Replace with fully charged battery if below this reading. | 1.240 |
| ⅔ discharged. Not sufficient capacity for satisfactory operation. | 1.200 |
| Completely discharged. | 1.150 |

In cold weather, it is especially important not to allow the specific gravity of the electrolyte to fall too low. The temperatures at which electrolyte will freeze are as follows:

| SPECIFIC GRAVITY | FREEZING POINT |
|---|---|
| 1.300 | −71°C (−95°F) |
| 1.275 | −62°C (−80°F) |
| 1.250 | −52°C (−62°F) |
| 1.225 | −37.2°C (−35°F) |
| 1.200 | −26.6°C (−16°F) |
| 1.175 | −20.0°C (− 4°F) |
| 1.150 | −15.0°C ( 5°F) |
| 1.125 | −10.6°C ( 13°F) |
| 1.100 | − 7.2°C ( 19°F) |

In these cases, it is almost always necessary to replace the battery; however, if a battery is only partially frozen, thawing in a warm room may save it.

## 3. GROUND OPERATING INSTRUCTIONS.

*a.* STARTING ENGINE.

(1) See that ignition switch is "OFF."

(2) Move mixture control to "IDLE CUT OFF."

(3) Have ground personnel turn the propeller several revolutions.

(4) Turn "ON" generator-disconnect switch. If external power supply is not used, turn "ON" battery-disconnect switch. These switches are on the right-hand switch panel.

(5) Open throttle one inch (early airplanes) or to "START" position (late airplanes).

(6) Move propeller control to full "INCREASE."

(7) On early airplanes, make certain boost control, at lower left side of instrument panel, is in "AUTOMATIC." On late airplanes, see that throttle gate is safety wired.

(8) See that supercharger blower switch on pilot's switch panel is in "AUTO."

(9) Turn oil and coolant radiator air control switches at left side of cockpit to "AUTOMATIC."

(10) Move carburetor air control, at aft end of control pedestal, to "RAM AIR." ("UNRAMMED FILTERED AIR," if required.)

(11) Turn "ON" fuel shut-off control, adjacent to the fuel selector; place booster pump switch in "ON" or "NORMAL," and turn fuel selector to "FUS. TANK," or "MAIN TANK L.H." if fuselage tank is not serviced.

(12) Check fuel pressure gage for 12 to 14 pounds per square inch with booster pump switch "ON" (late airplanes) or for 8 to 12 pounds per square inch with booster pump switch in "NORMAL" (early airplanes).

(13) *Electric prime:* three to four seconds when cold, one when hot (late airplanes). *Hand prime:* three to four strokes when cold, one when hot (early airplanes).

(14) Make sure propeller is clear.

(15) Turn ignition switch to "BOTH."

(16) Lift guard on starter switch, on front switch panel, and press switch to "START."

**Note**

Whenever possible, use an external power supply to start the engine. If external power is not available, use handcrank. Use airplane's battery in an emergency only.

(17) As engine starts, move mixture control to "AUTO RICH" or "RUN." If engine does not start after several turns, continue priming by hand.

**WARNING**

When engine is not firing, mixture control should be in "IDLE CUT OFF."

(18) Check oil pressure. If pressure is not up to 50 pounds within 30 seconds, stop engine and investigate.

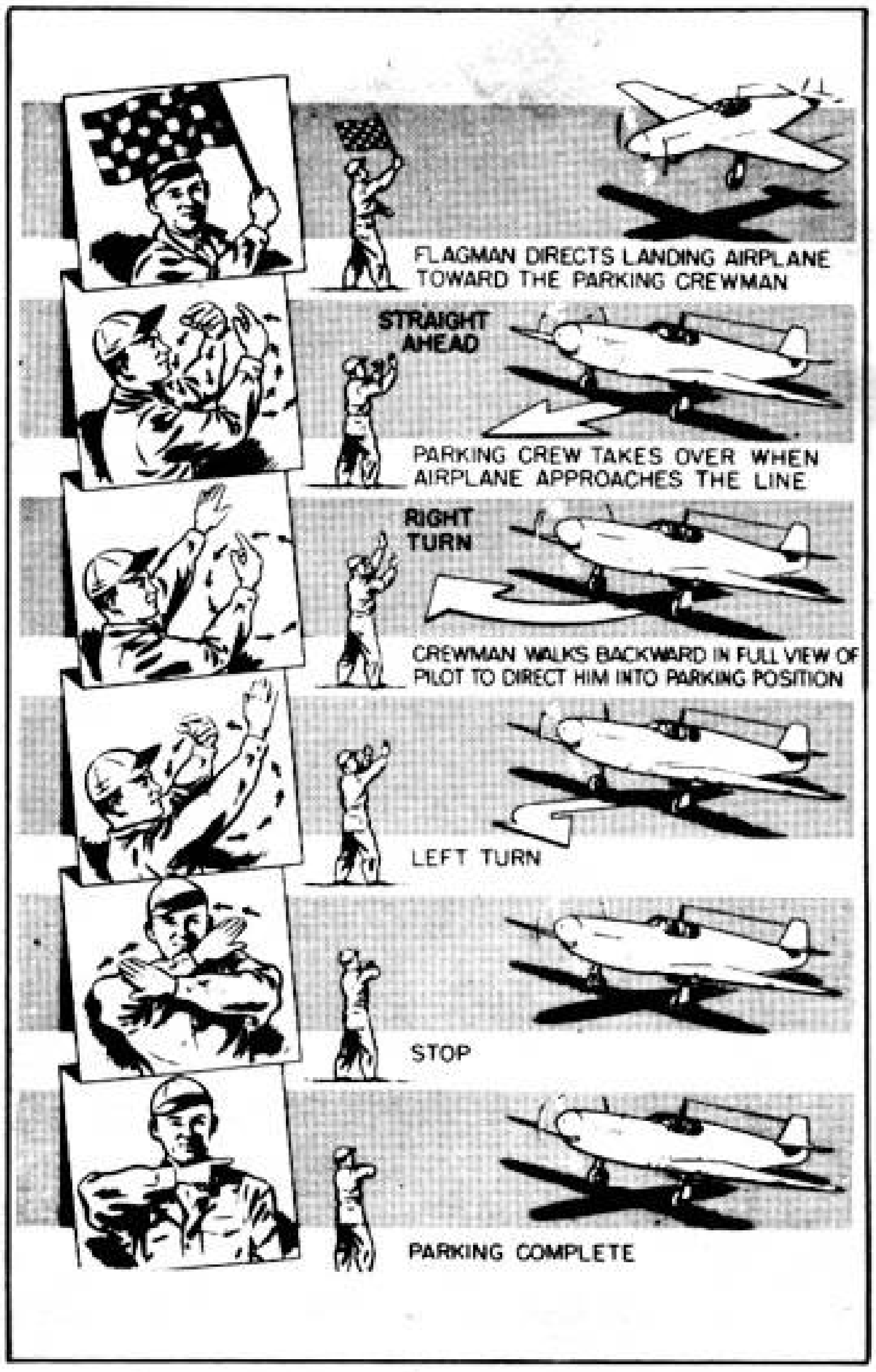



*Figure 69—Ground Crew Taxiing Signals*

*b.* ENGINE WARM-UP.

(1) Warm up the engine at 1300 rpm until the oil temperature shows a definite increase and the oil pressure remains steady when the throttle is opened. The desired oil and coolant temperatures will be maintained by having the radiator air controls in "AUTOMATIC."

| | DESIRED | MAXIMUM |
|---|---|---|
| Oil temperature | 70°- 80°C (158°-176°F) | 90°C (194°F) |
| Coolant temperature | 100°-110°C (212°-230°F) | 121°C (250° F) |

If coolant and oil temperatures exceed limits with controls in "AUTOMATIC," shut engine off and investigate.

*c.* STOPPING ENGINE.

(1) Turn "OFF" booster pump switch.

(2) If a cold weather start is anticipated, hold "ON" oil dilution switch, on pilot's switch panel (2 minutes maximum).

(3) Run engine to 1500 rpm, set mixture control in "IDLE CUT OFF," and move throttle fully open. Leave mixture control in "IDLE CUT OFF" as a precaution against accidental starting.

(4) Turn "OFF" ignition switch after the engine ceases firing.

(5) Turn "OFF" fuel shut-off valve.

## 4. STORAGE.

*a.* TEMPORARY STORAGE (Less Than Seven Days). —Airplanes to be processed within seven days after the last flight should be handled as follows:

(1) Upon arrival at the field, bring airplane log up to date.

(2) Park the airplane in a safe and convenient location.

(3) Moor the airplane *(paragraph* 2. *f.)* and chock the wheels. A standard mooring kit (Type D-1) is furnished with each airplane.

(4) Set the parking brakes.

(5) Shut off all ignition switches.

(6) Correct all mechanical defects, check the airplane for shortages, and service as required.

(7) Lock the surface controls.

(8) Shut the cockpit hatch.

(9) Cover the pitot tube head.

(10) Cover the radiator air scoop with the dust cover provided with the airplane, and tape the carburetor air scoop casting.

(11) In bad weather, install the engine and cockpit covers.

(12) Each day, pull the engine through 4 complete revolutions.

(13) Every other day, roll the airplane so as to change the position of the tires.

*b.* STORAGE OVER SEVEN DAYS.—When the airplane is not to be processed within seven days but will be processed within thirty days, the engine should be treated as follows:

(1) Remove the exhaust spark plugs from all cylinders.

WARNING

DO NOT TURN ENGINE OVER UNTIL ALL DEHYDRATING MATERIALS HAVE BEEN REMOVED FROM THE ENGINE

*Figure 70—Crankshaft Warning Card*

(2) Rotate the crankshaft; as each exhaust valve reaches the fully open position, spray it with corrosion-preventive mixture (Specification No. AN-VV-C-576) through the spark plug holes.

(3) Rotate the crankshaft at least 4 revolutions to thoroughly work the corrosion-preventive mixture into the exhaust valve guides.

(4) While the piston is at the bottom of the stroke, spray corrosion-preventive mixture (Specification No. AN-VV-C-576) into each cylinder; cover all interior surfaces.

(5) Set the propeller so that one blade stands straight down, and again spray corrosion-preventive mixture (Specification No. AN-VV-C-576) into all the cylinders. After this treatment, the crankshaft should not be rotated again until the engine is about to be run; if it is rotated, each cylinder must be sprayed again.

(6) Install cylinder dehydrator (Protek) plugs (AN7511-13) in all exhaust spark plug holes.

**Note**

Dehydrator plugs must indicate less than 20 percent relative humidity when compared with the humidity indicator card AN7511.

(7) Place and anchor a one-pound bag of dehydrating agent (Specification No. AN-D-6), bearing a plainly marked tag, in the carburetor air intake scoop, and seal the opening securely.

(8) Install a 2-ounce bag of dehydrating agent (Specification No. AN-D-6) in each exhaust stack and close the end of the stack with securely taped Pliofilm. Bags of dehydrating agent should bear an identifying tag attached by a 3-inch string, and the bags must be installed so that the tags remain outside the stack.

(9) Cover all other openings and breathers in the engine with moistureproof tape (Specification No. AN-T-12) or suitable moistureproof plugs.

(10) Place a warning tag *(figure 70)* on the propeller and another on the control stick in the cockpit.

(11) Inspect cylinder dehydrator plugs weekly and replace when the humidity indicated reaches 20 percent. At this time, also replace the dehydrating agent in the carburetor air intake and in the exhaust stacks.

## 5. LUBRICATION REQUIREMENTS.

Specific lubrication points are illustrated in figure 74. A 2-man lubrication team can be employed, one man to clean and lubricate and another man to inspect and clean the lubricated parts.

*a.* LUBRICATION PROCEDURE.—The following is to be carried out in conjunction with the check chart:

(1) Wipe zerk or mechanism with a clean rag. If necessary, moisten the rag with cleaning solvent.

(2) Lubricate zerk or mechanism with the lubricant specified.

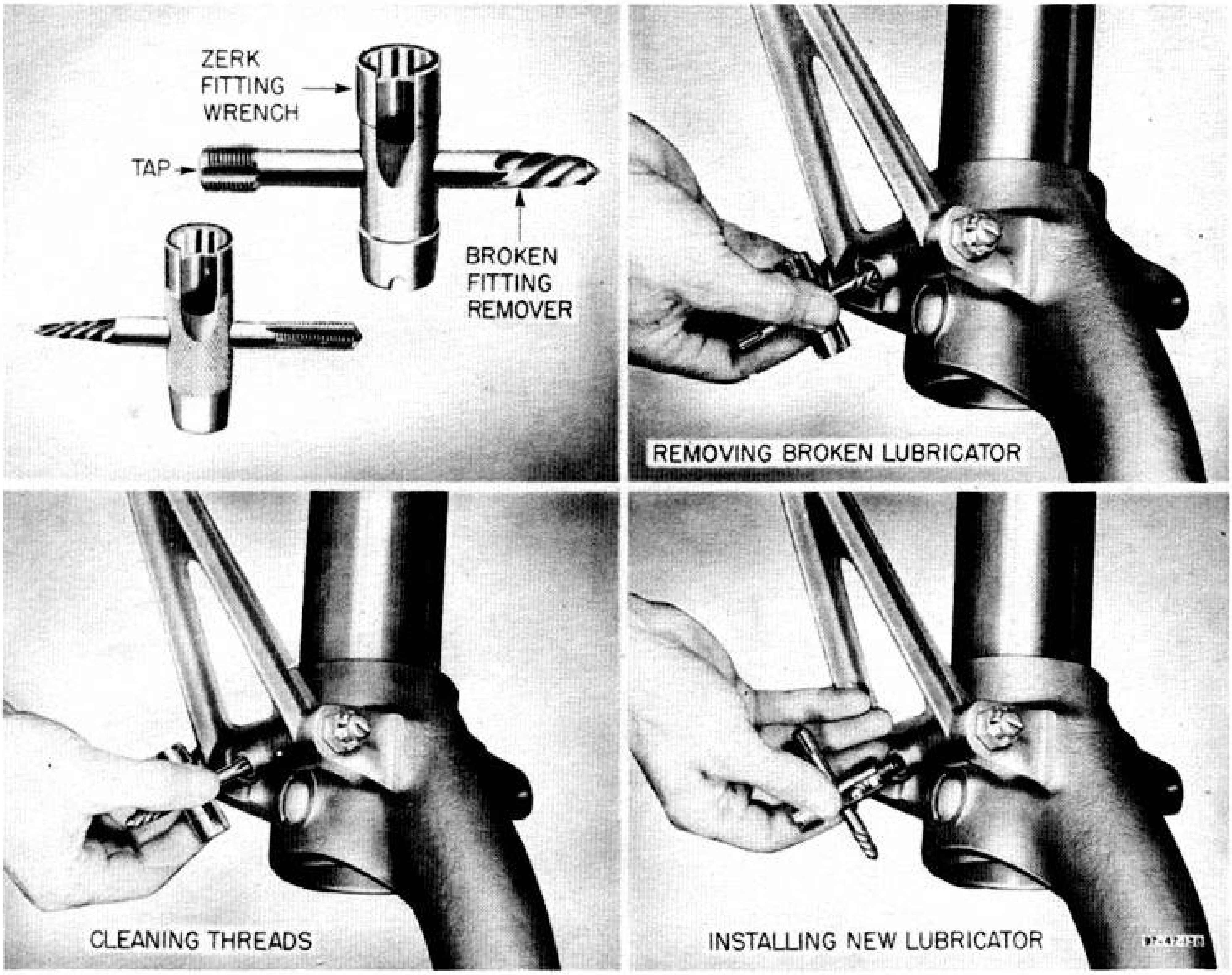



*Figure 71—Lubricator Fitting Tool*

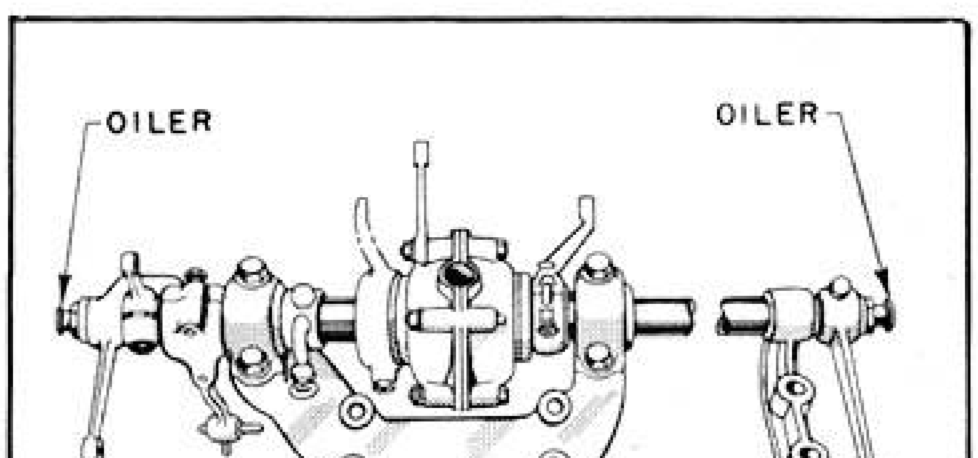



*Figure 72—Engine Control Shaft Lubrication*

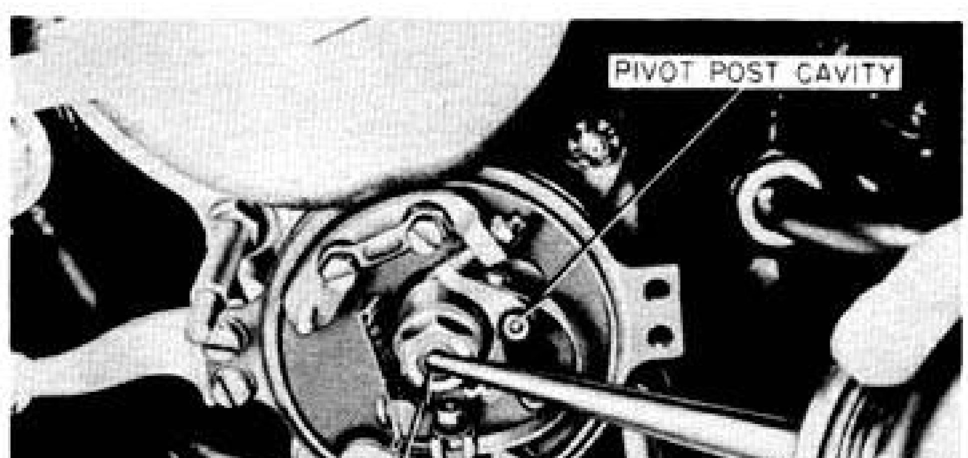



*Figure 73—Magneto Breaker Lubrication*

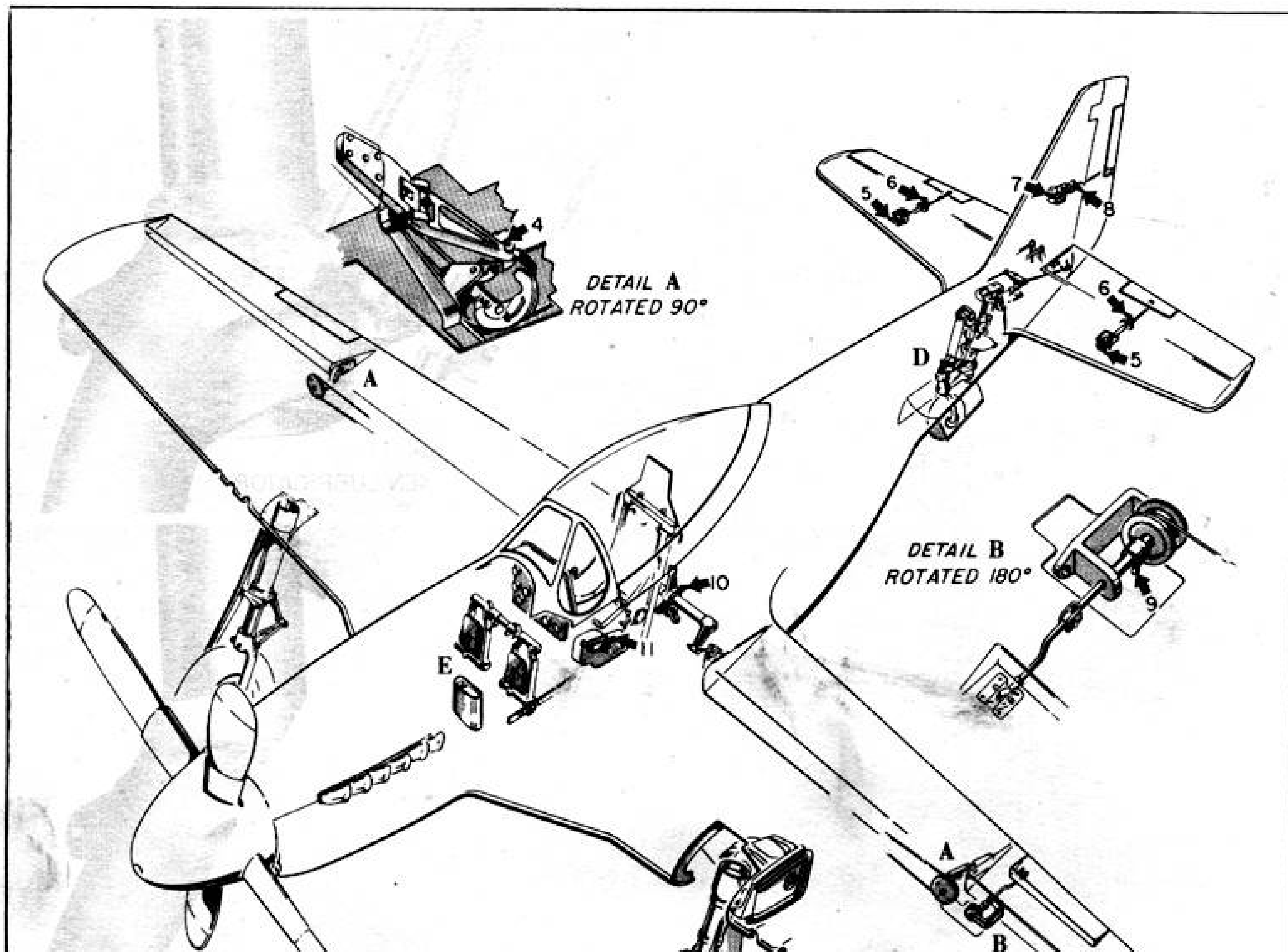



**Figure 74—Lubrication Chart**

(3) Inspect zerk or mechanism for proper lubrication.

(4) Remove excess lubricant.

*b.* GENERAL LUBRICATION NOTES.

(1) BEARING SURFACES.—Excessive lubrication of bearing surfaces will attract dirt and grit. These items must be inspected and cleaned after lubrication.

(2) ZERK FITTINGS.—All zerk fittings, painted orange for identification, should be lubricated with a pressure gun. Broken zerk fittings can be removed with a special tool. *(See figure 71.)*

(3) SEALED BEARINGS.—Bearings used in pulleys, bellcranks, hinge points, rod ends, etc., are of the sealed type packed with lubricant at assembly, and require no lubrication between major overhaul periods.

(4) LANDING WHEELS.—The landing wheel bearings must be removed, cleaned, and lubricated with high melting point grease, Specification No. 3560E, medium grade, at least every fourth 50-hour inspection period.

(5) ENGINE CONTROL SHAFT. *(See figure 72.)*—Fill control shaft on engine at oilers located at each end of this shaft with machine gun oil, Specification No. AN-O-6, every 25-hour inspection.

**LUBRICATION REQUIREMENTS DURING DAILY INSPECTION**

| NO. | ITEM | LUBRICANT | CLEANED & LUBRICATED | INSPECTED & CLEANED |
|---|---|---|---|---|
| 1 | Main Gear Shock Strut Filler Plug | AAF3580 | | |
| 2 | Hydraulic System | AN-VV-O-366 | | |
| 3 | Tail Gear Shock Strut Filler Plug | AAF3580 | | |
| | **LUBRICATION REQUIREMENTS DURING 25-HOUR INSPECTION** | | | |
| 4 | Aileron Outboard Control Sectors | AN-G-3 | | |
| 5 | Elevator Trim Tab Actuating Drums | AN-G-3 | | |
| 6 | Elevator Trim Tab Actuating Mechanism | AN-G-3 | | |
| 7 | Rudder Trim Tab Actuating Drum | AN-G-3 | | |
| 8 | Rudder Trim Tab Actuating Mechanism | AN-G-3 | | |
| 9 | Aileron Trim Tab Actuating Drum (L.H. only) | AN-G-3 | | |
| 10 | Elevator Bellcrank | AN-G-3 | | |
| 11 | Landing Gear Control Handle | AN-G-3 | | |
| 12 | Landing Gear Fairing Door Actuating Linkage | AN-G-3 | | |
| 13 | Main Landing Gear Pivot Shaft | AN-G-3 | | |
| 14 | Main Landing Gear Torque Link | AN-G-3 | | |
| 15 | Main Landing Gear Torque Link | AN-G-3 | | |
| 16 | Main Landing Gear Torque Link | AN-G-3 | | |
| 17 | Main Landing Gear Torque Link | AN-G-3 | | |
| 18 | Tail Gear Down-lock | AN-G-3 | | |
| 19 | Tail Gear Trunnion | AN-G-3 | | |
| 20 | Tail Gear Trunnion | AN-G-3 | | |
| 21 | Tail Wheel Steering Mechanism | AN-G-3 | | |
| 22 | Tail Wheel Steering Mechanism | AN-G-3 | | |
| 23 | Brake Master Cylinder Actuating Bellcrank | AN-G-3 | | |
| 24 | Brake Master Cylinder Actuating Bellcrank | AN-G-3 | | |
| 25 | Rudder Pedal | AN-G-3 | | |
| 26 | Rudder Pedal | AN-G-3 | | |
| 27 | Brake Pedal | AN-G-3 | | |
| 28 | Brake Pedal | AN-G-3 | | |
| | **LUBRICATION REQUIREMENTS DURING 50-HOUR INSPECTION** | | | |
| 29 | Main Gear Wheel Bearings | 3650 Med. Grade | | |
| 30 | Tail Wheel Bearings | 3650 Med. Grade | | |

*KEY TO FIGURE 74*

(6) MAGNETO BREAKER. *(See figure 73.)*

*(a)* BREAKER BASE BEARING.—Coat lightly with machine gun oil, Specification No. AN-O-6, every 100-hour inspection.

*(b)* PIVOT POST CAVITY.—Fill with Lubrico No. M-31 or Intava No. 682 grease every 50-hour inspection.

(7) COOLANT PUMP.—Lubricate coolant pump with high melting point grease, Specification No. AN-G-5 (AAF3560), every 25-hour inspection.

(8) MANIFOLD PRESSURE REGULATOR. *(See figure 75.)*—Lubricate the manifold pressure regulator with engine oil, Specification No. AN-VV-O-446, Grade 1100, at the following points every 50-hour inspection:

*(a)* Cam housing bakelite ring—coat lightly.

*(b)* Adjusting screw—two drops.

(9) DYNAMOTORS.—Lubricate the dynamotors *(section IV, paragraph 21)* as follows every 500-hour inspection period, if necessary.

*(a)* Apply three drops of SAE 20 oil to the small hole in the top of each bearing housing.

*(b)* Through the same hole in the bearing housing, add approximately 0.05 cubic inch (⅜-inch cube) of ball-bearing grease to each bearing.

*(c)* After disassembly for cleaning with carbon tetrachloride, US Specification No. 4-503-110, repack with ball-bearing grease.

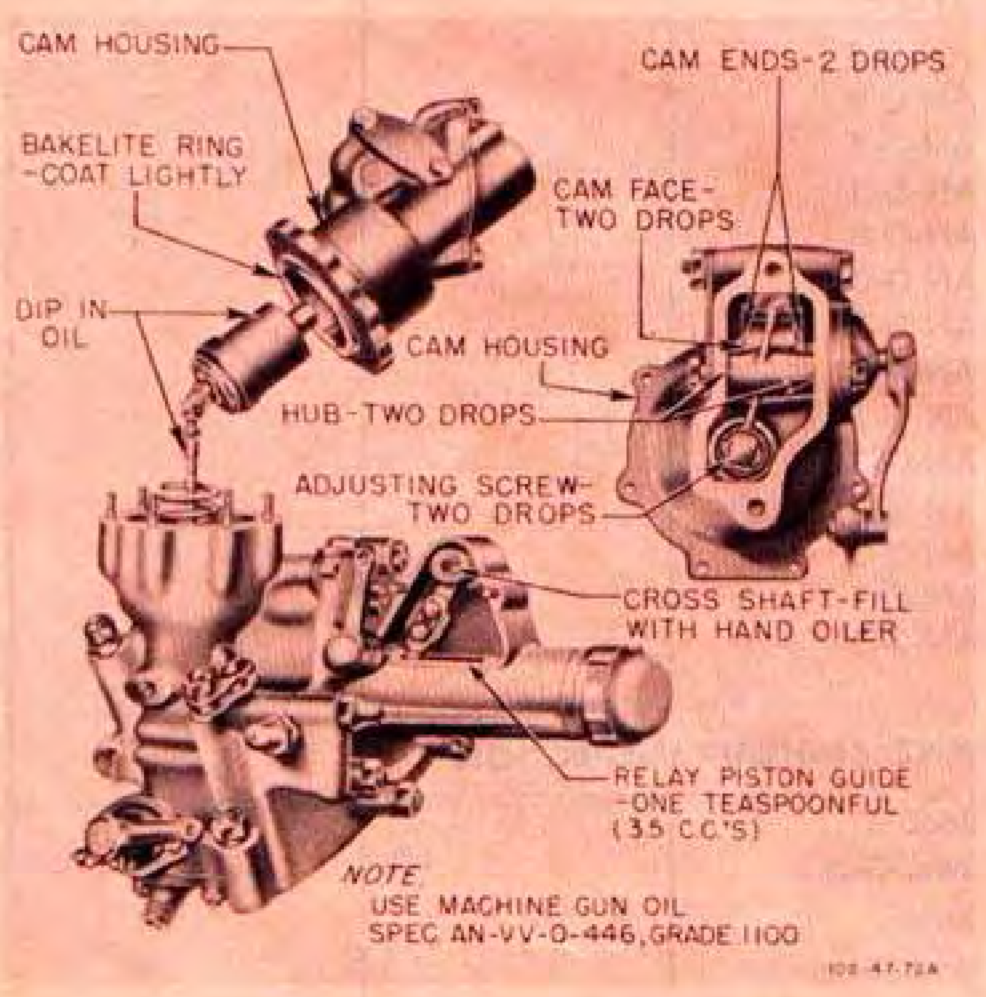
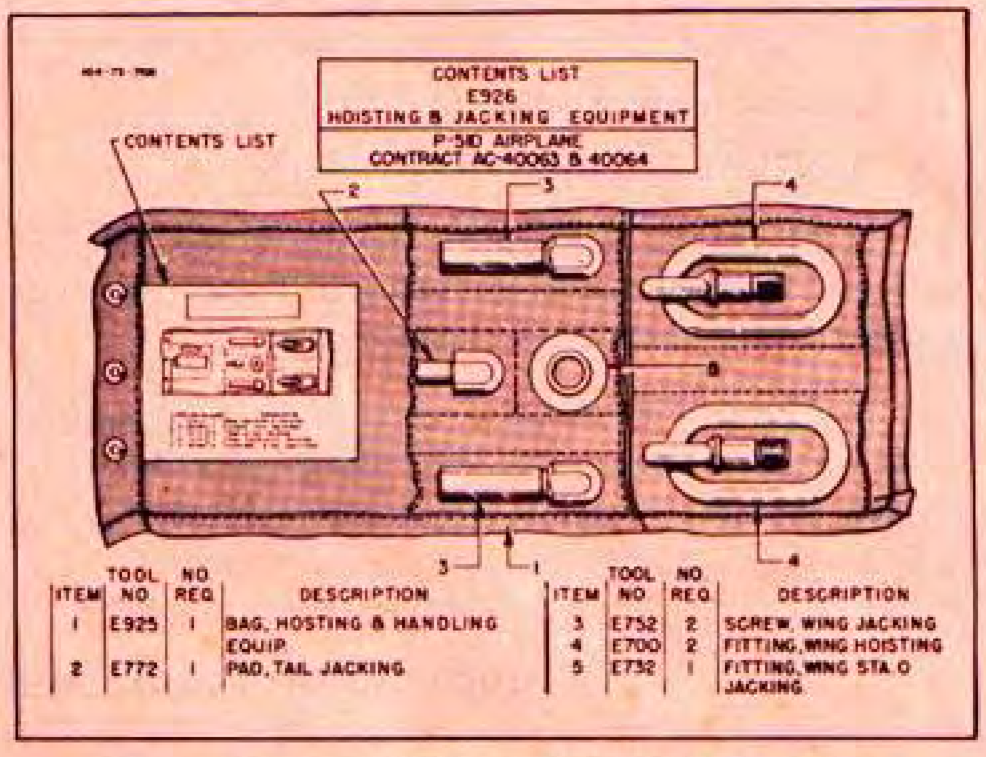



Figure 75—Manifold Pressure Regulator Lubrication




| ITEM | TOOL NO | NO REQ | DESCRIPTION |
|---|---|---|---|
| 1 | E925 | 1 | BAG, HOSTING & HANDLING EQUIP |
| 2 | E772 | 1 | PAD, TAIL JACKING |
| 3 | E752 | 2 | SCREW, WING JACKING |
| 4 | E700 | 2 | FITTING, WING HOISTING |
| 5 | E732 | 1 | FITTING, WING STA O JACKING |

Figure 76—Tool Kit Furnished With Airplane

## 6. SPECIAL TOOLS AND EQUIPMENT.

*a.* TOOL KITS.

(1) AIRPLANE TOOL KIT.—An E926 tool kit is furnished. *(See figure 76.)*

(2) ENGINE TOOL KIT.—An AT-9212 Packard engine tool kit is provided. *(See figure 77.)*

(3) PROPELLER TOOLS.—Special propeller tools illustrated in figure 80 *(or figure 80A)* are supplied as miscellaneous items in odd-numbered airplanes.

(4) ARMORER'S TOOL KIT.—An armorer's tool kit is furnished with each airplane.

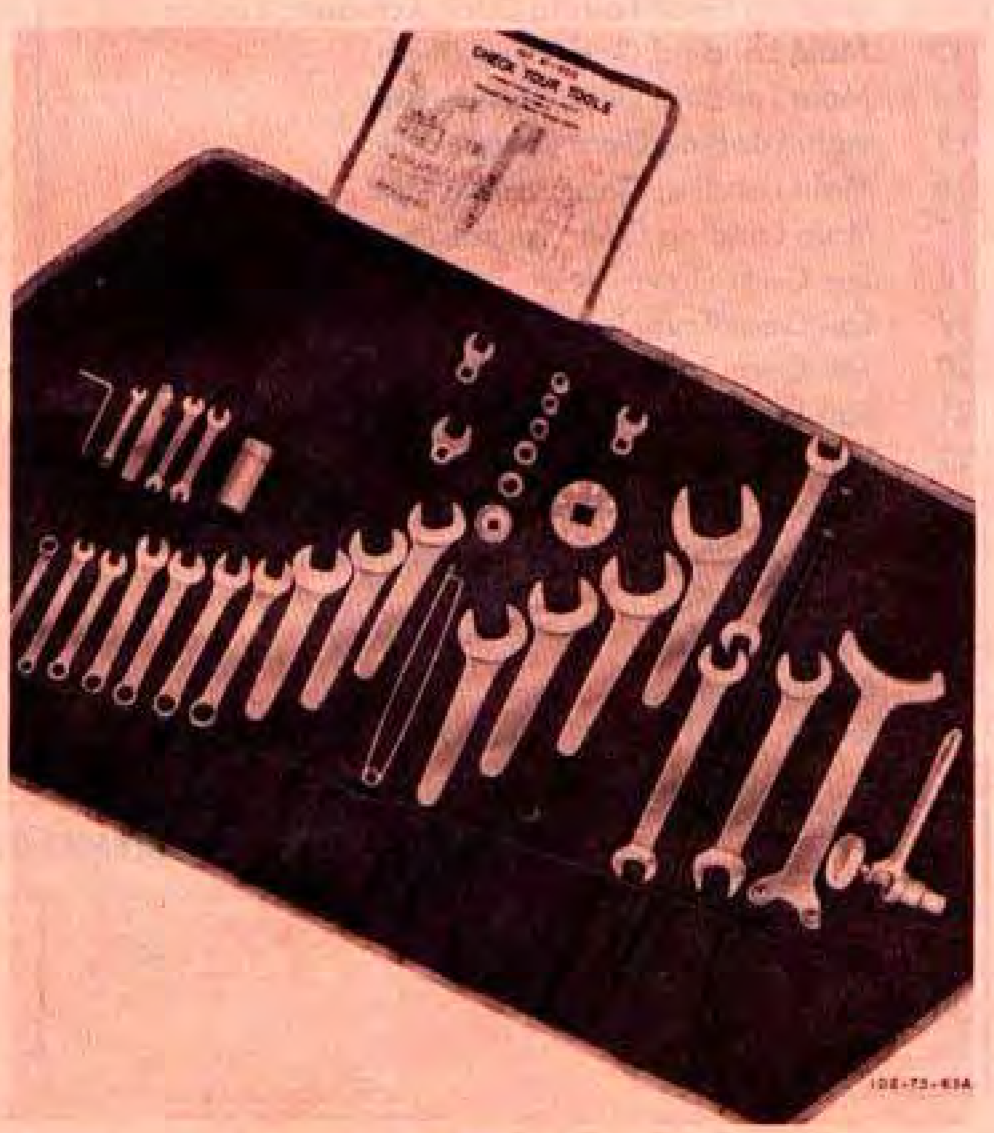
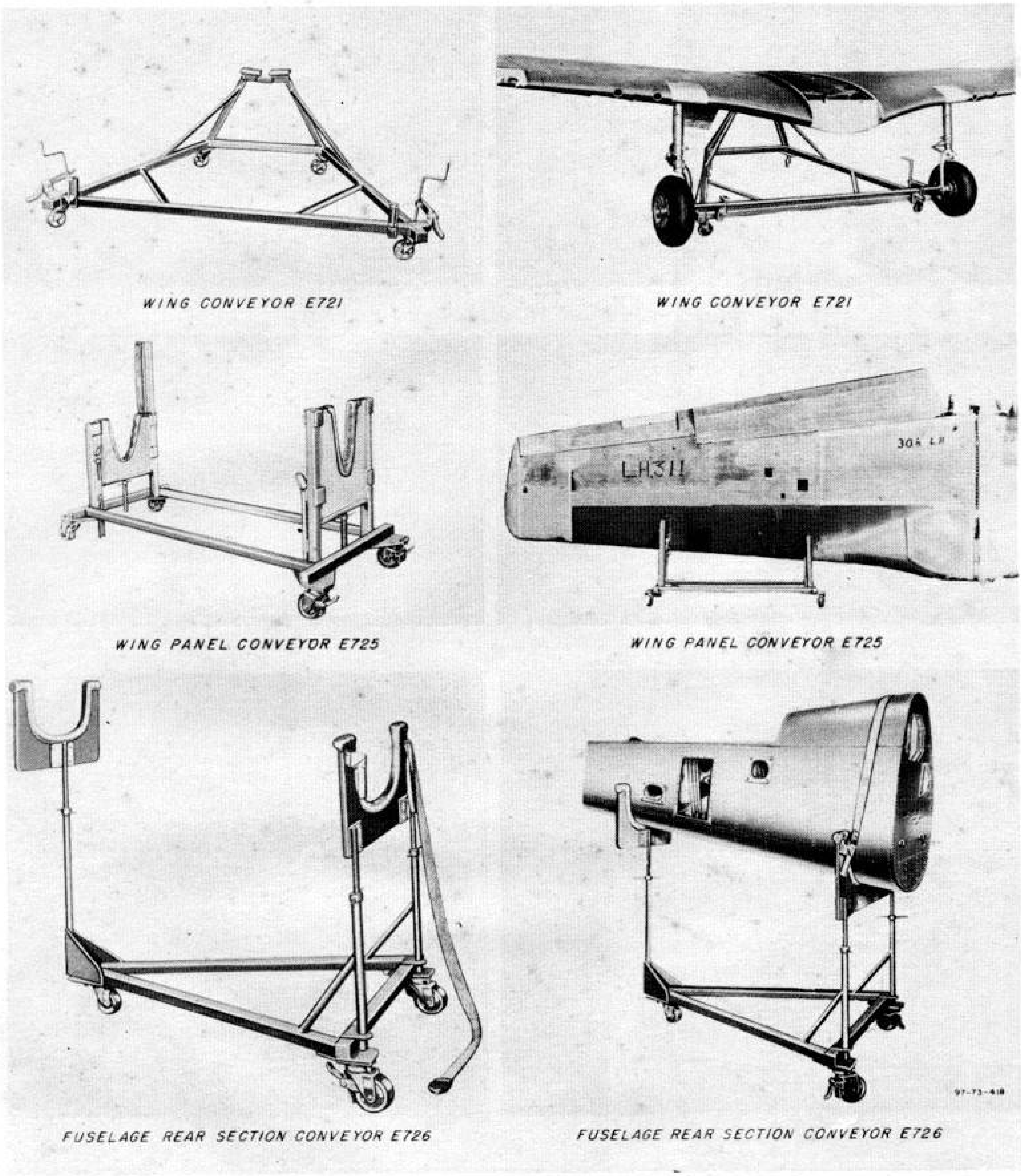



Figure 77—Engine Tool Kit



WING CONVEYOR E721 — WING CONVEYOR E721

WING PANEL CONVEYOR E725 — WING PANEL CONVEYOR E725

FUSELAGE REAR SECTION CONVEYOR E726 — FUSELAGE REAR SECTION CONVEYOR E726

*Figure 78—Special Handling Jigs*

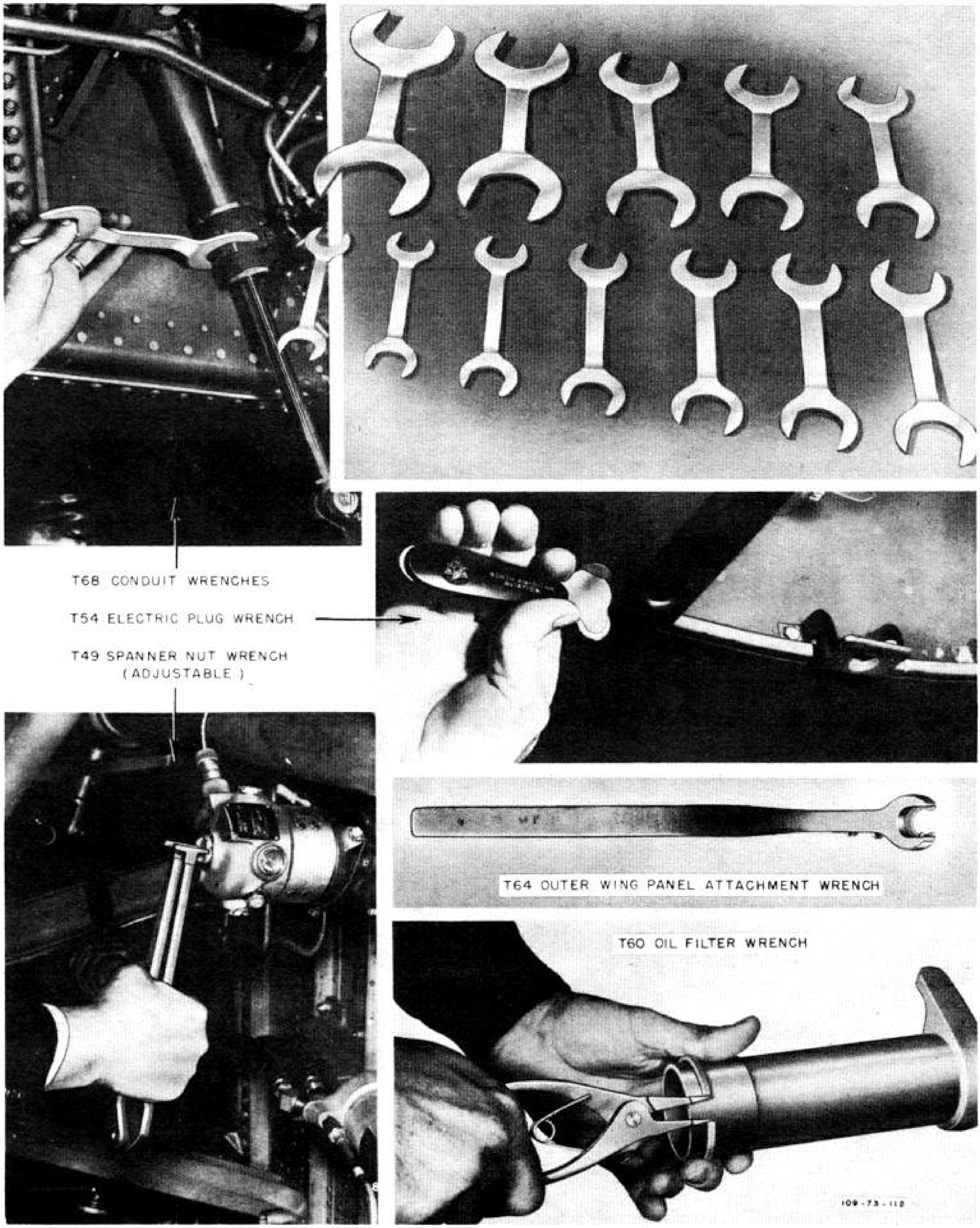



*Figure 79 (Sheet 1 of 4 Sheets)—Special Tools*

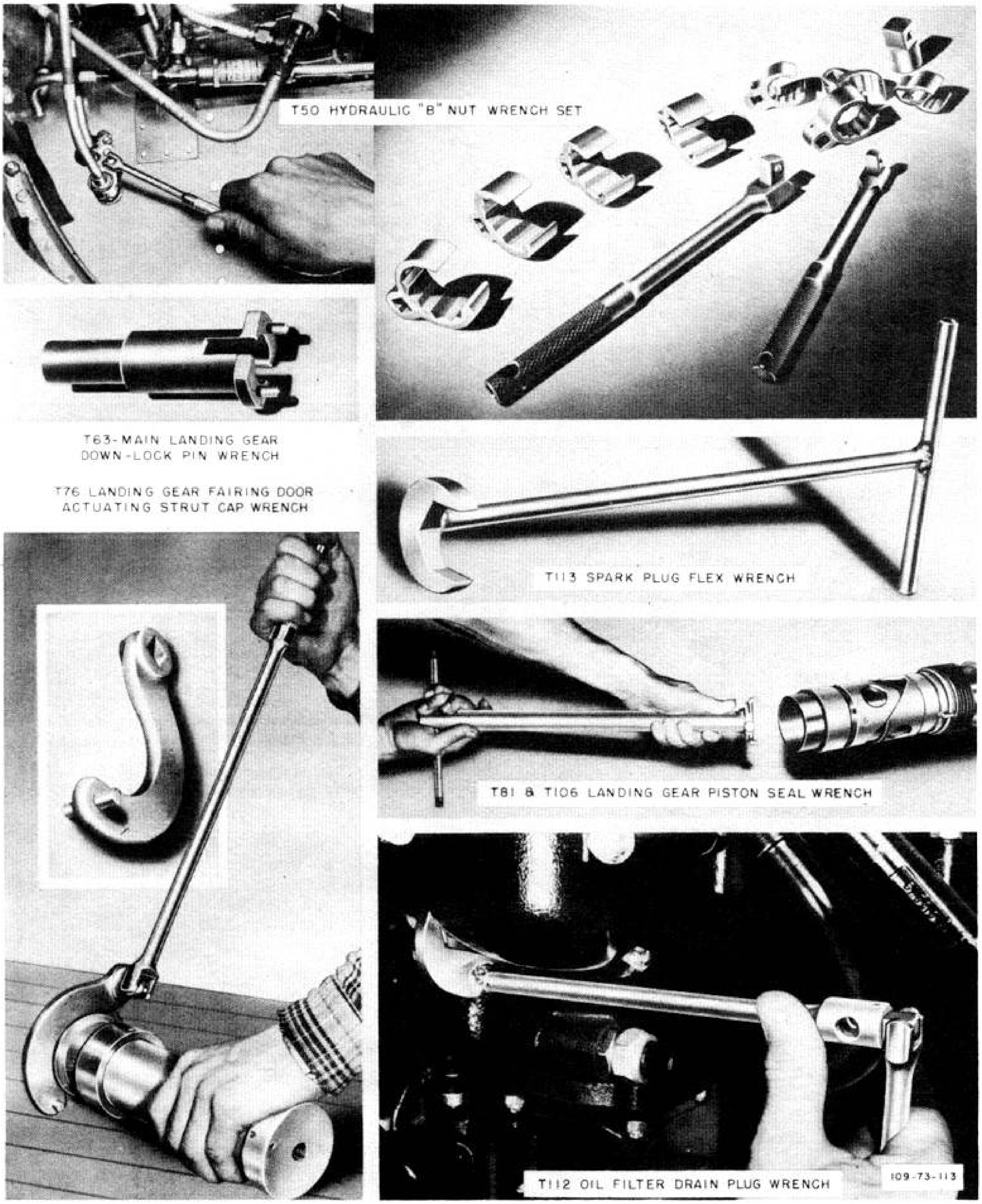



*Figure 79 (Sheet 2 of 4 Sheets)—Special Tools*

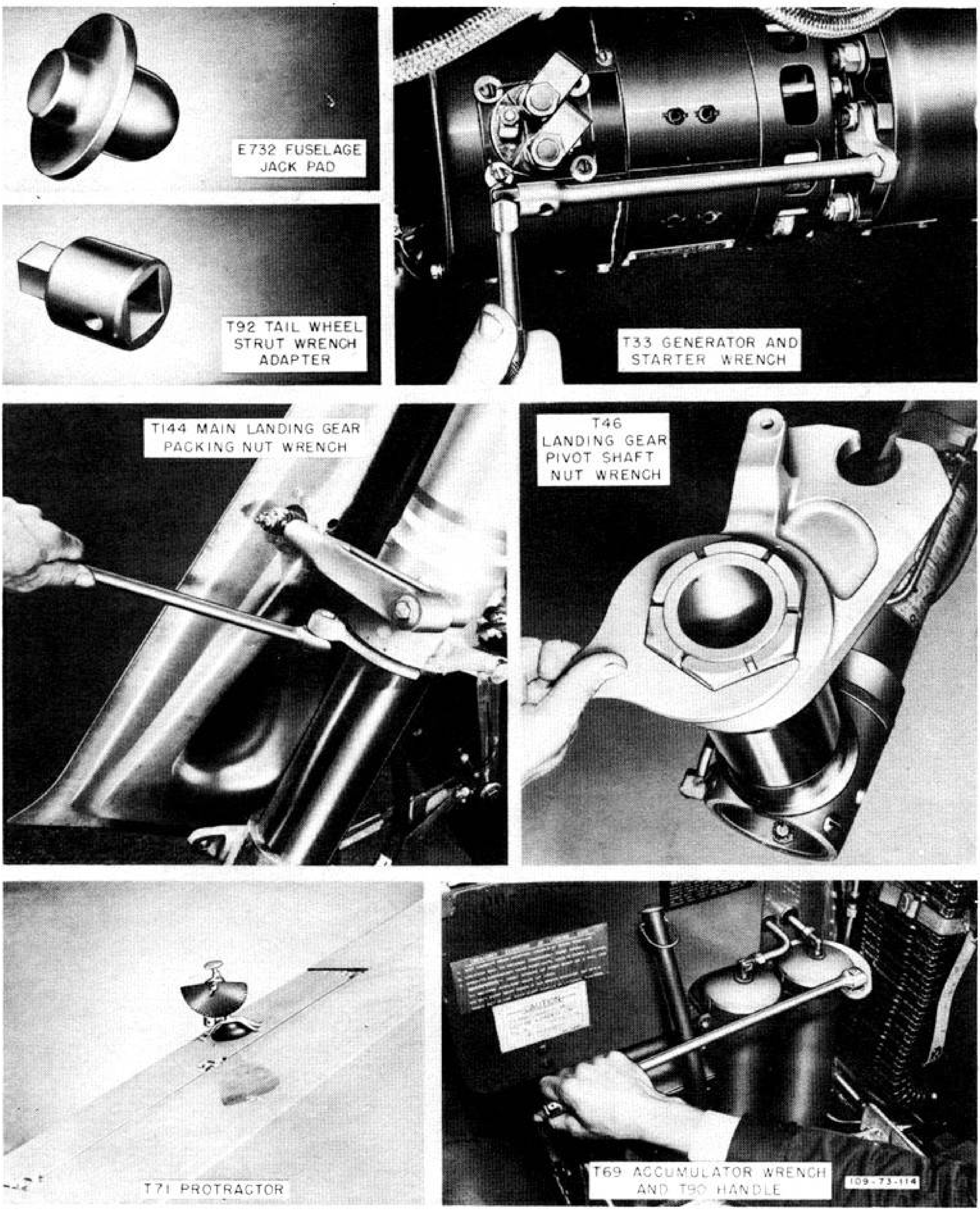
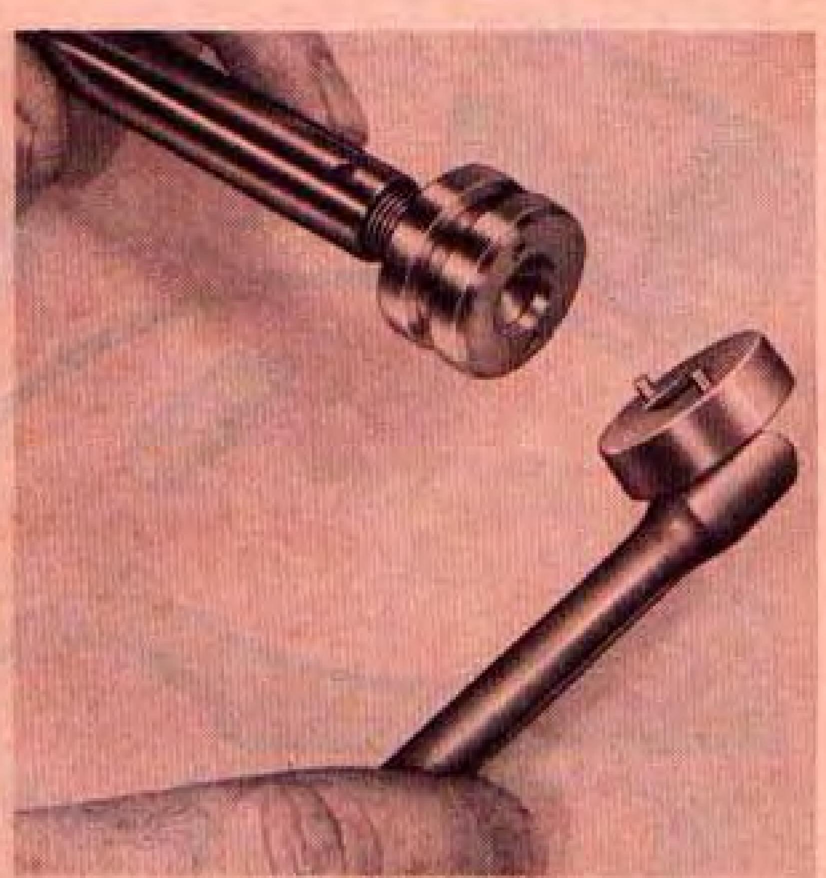



*Figure 79 (Sheet 3 of 4 Sheets)—Special Tools*

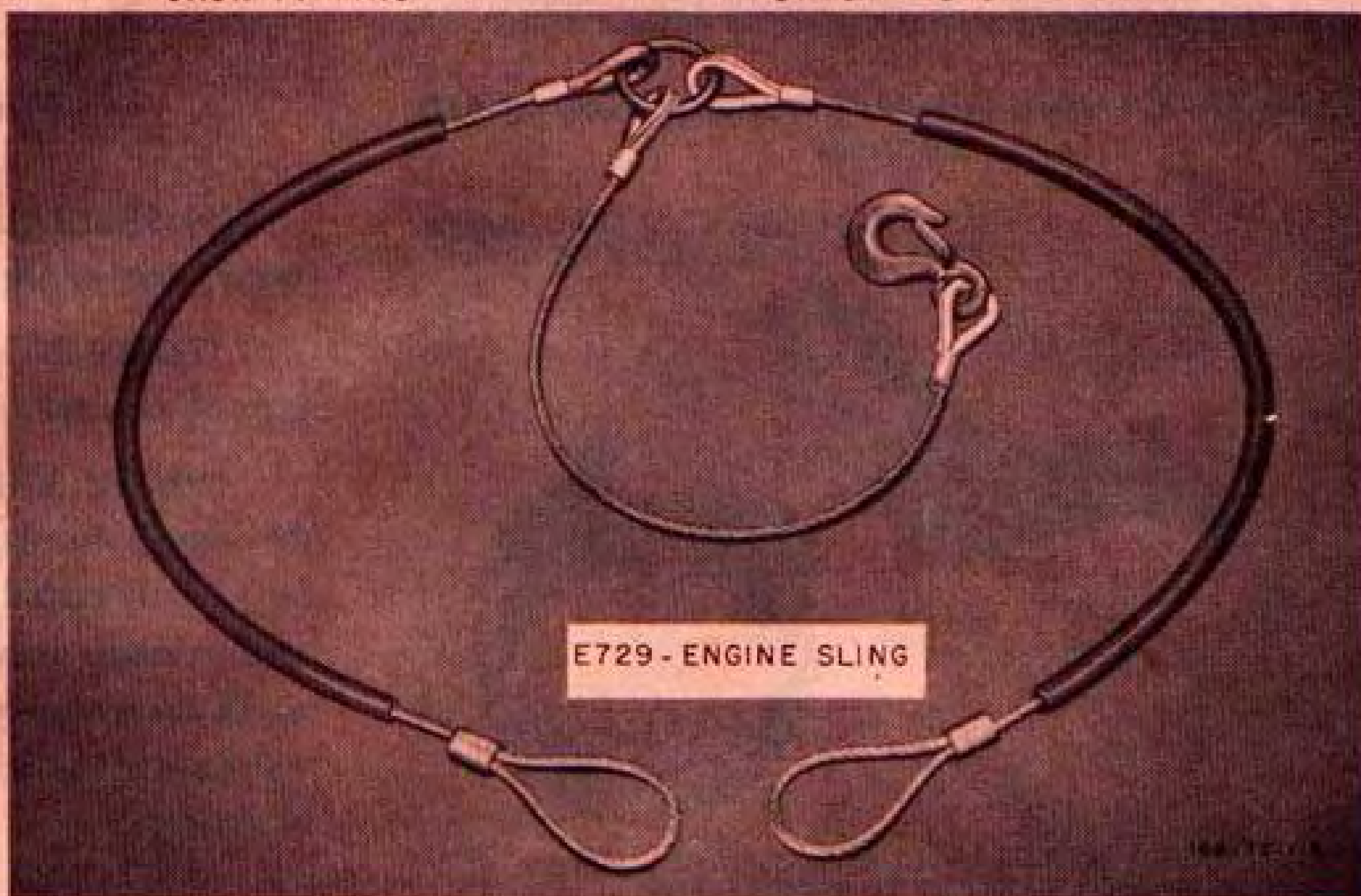
T52-TURNBUCKLE WRENCH

E729 WING OUTER JACK FITTING



T70 TAIL WHEEL STRUT PISTON WRENCH

T6-FUEL TANK INSTALLATION CHAIN



E729-ENGINE SLING

T56 EMERGENCY CABLE SPLICE

T67 CONDUIT STRAP WRENCH

*THE FOLLOWING SPECIAL TOOLS ARE IN ADDITION TO THOSE ILLUSTRATED*

| | |
|---|---|
| E772 | TAIL JACKING PAD |
| E752 | WING JACKING PIN |
| E718 | REAR FUSELAGE SELECTION SLING |
| E794 | FUSELAGE AND ENGINE SLING |
| E748 | TAIL JACKING STAND |
| E719 | WING HOISTING SLING |
| T116 | TAIL GEAR PISTON RING PLIERS |
| T117 | TAIL GEAR PISTON INNER PLUG WRENCH |
| T145 | TAIL GEAR PISTON OUTER PLUG WRENCH |
| T125 | HI-SHEAR RIVET TOOL KIT |

***Figure 79 (Sheet 4 of 4 Sheets)—Special Tools***

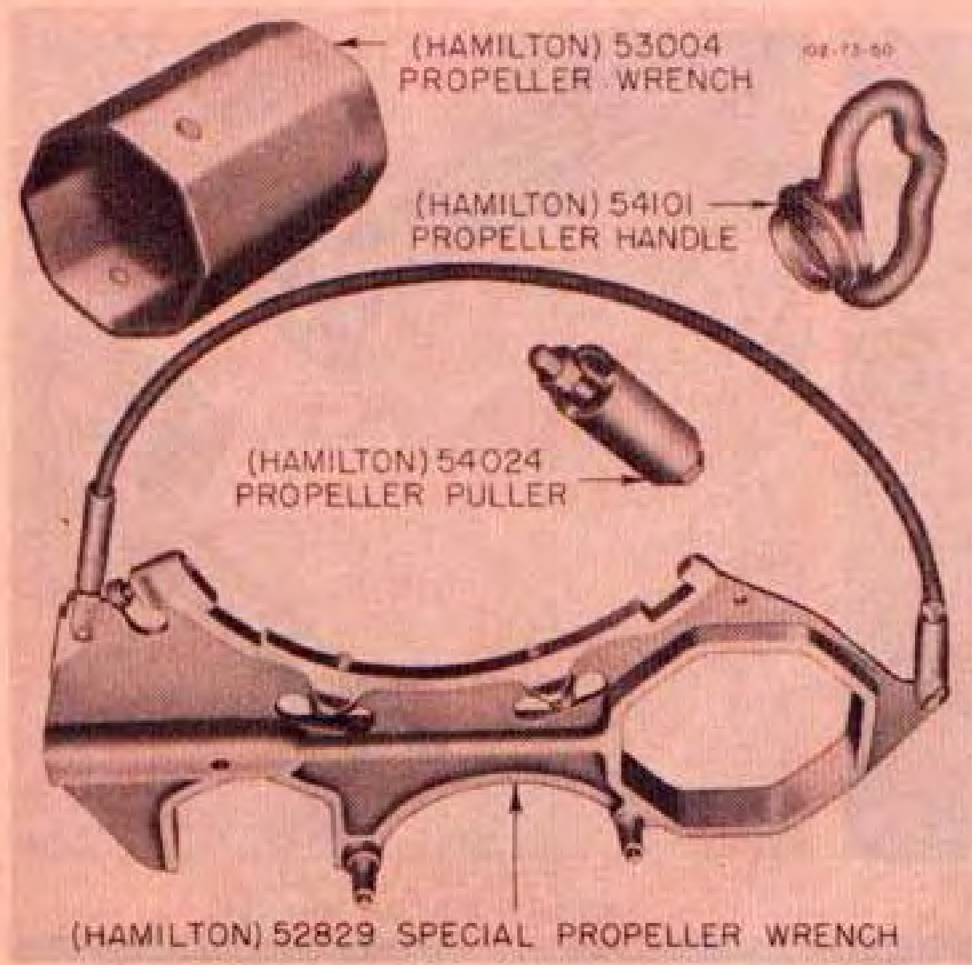



***Figure 80—Hamilton Standard Propeller Tools—P-51D Airplane***

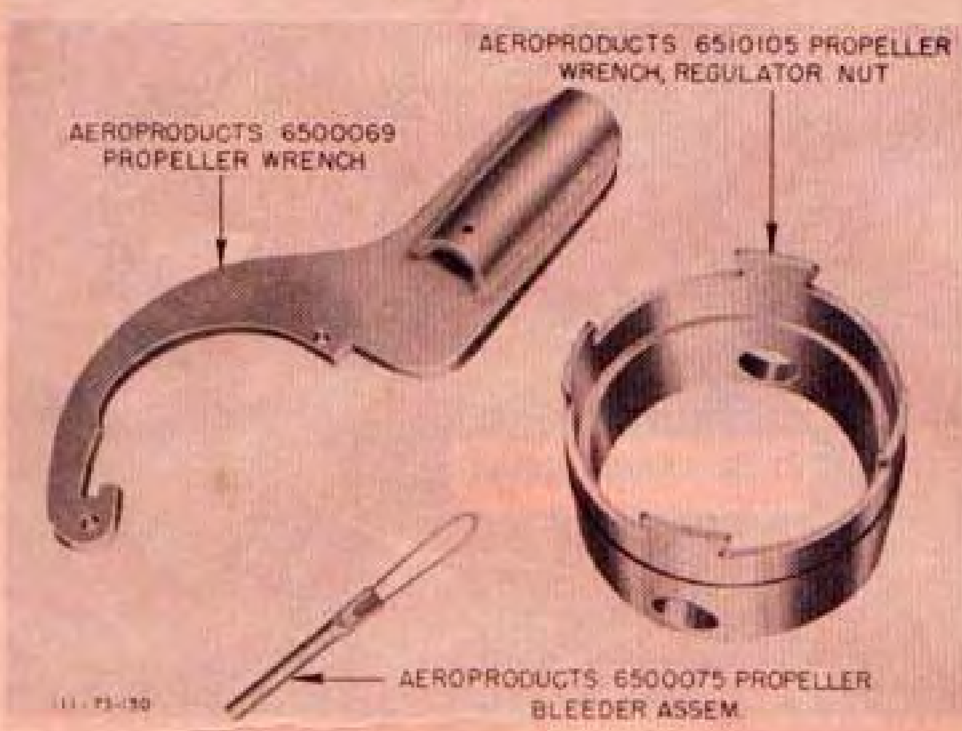
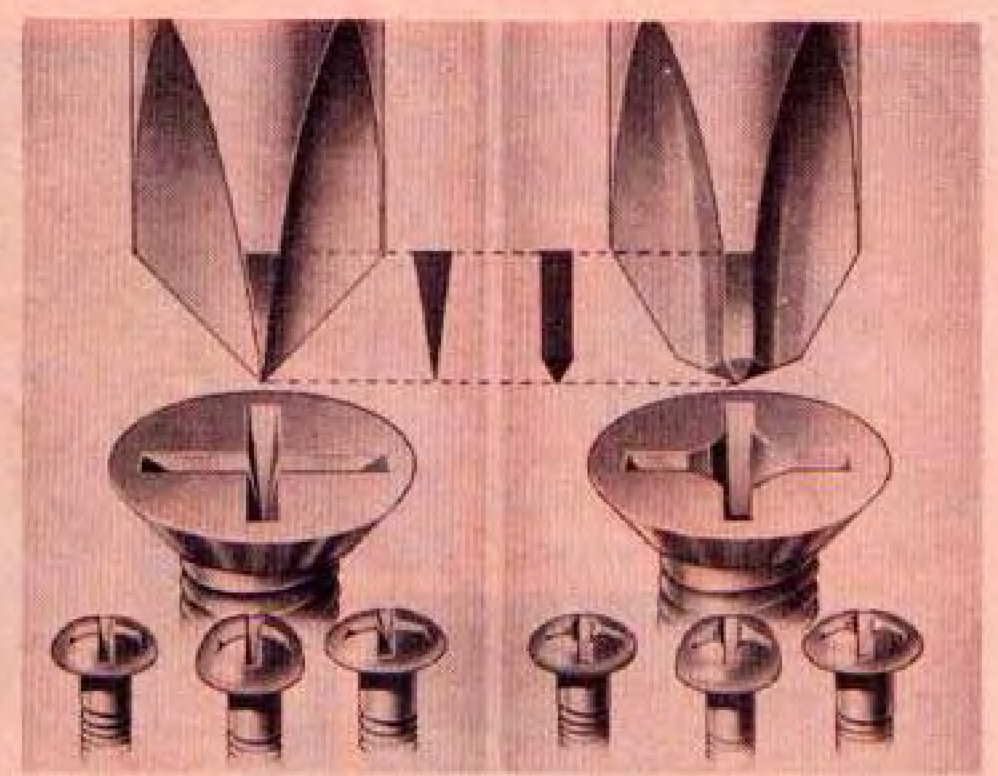



***Figure 80A—Aeroproducts Propeller Tools—P-51K Airplane***



**Reed and Prince Recessed Head Screws and Reed and Prince Recessed Head Driver.**

**Phillips Recessed Head Screws and Phillips Four Winged Driver.**

102-00-44

***Figure 81—Special Screws***

(5) SPECIAL TOOLS.—Special tools used in the maintenance of airplane are illustrated in figure 79.

*b.* HANDLING JIGS.—Jigs for handling the component parts of the airplane are illustrated in figure 78.

*c.* SPECIAL SCREWS.—The Phillips head screws used in the original structure of the airplane should not be mistaken for similarly shaped Reed and Prince screws which might be used on repair or modified assemblies. *(See figure 81.)* The use of the wrong type of screwdriver on either type screw will damage the screw head, necessitating the replacement of the screw.

# Section IV

## MAJOR COMPONENT PARTS AND INSTALLATIONS

### 1. WING.

*a.* GENERAL DESCRIPTION. *(See figure 84.)*—The wing is a full-cantilever, stressed-skin structure, consisting essentially of a right and left wing panel with removable tips, ailerons, and wing flaps.

*b.* REMOVING FUSELAGE FROM WING. *(See figures 82 and 83.)*

*c.* INSTALLING FUSELAGE ON WING. *(See figures 82 and 83.)*

**Note**

Before installing cockpit floorboards and engine cowling, connecting wing flaps, and securing wing-to-fuselage fairing, make all necessary adjustments, settings, and inspections.

References: Hydraulics—paragraph 19.
Landing Gear—paragraph 5.
Fuel System—paragraph 15.
Surface Controls—paragraph 3.

*d.* WING PANELS.

(1) DESCRIPTION. *(See figure 84.)*—The two main panels of the wing consist of a main spar, an aft spar, pressed ribs, and stringers covered with alclad. A tank bay at the inboard end of each wing panel provides space for a self-sealing fuel tank. A structural door is provided in the undersurface of each wing section to facilitate fuel cell installation and removal. Three .50-caliber machine guns are mounted in a gun bay in each wing panel. A hinged door and two cover-plates on the upper side of each wing panel provide access to the guns and ammunition cases. There is a wheel bay in the inboard leading edge of each wing panel into which the landing gear retracts. A landing light is installed in the left wheel bay. Fairing doors enclose the retracted gear completely, presenting a smooth contour to the airflow in flight. A bomb rack is installed on the lower surface of each wing panel just outboard of the landing gear. Each panel is finished at the leading edge with fast-drying red putty and gray surfacer. The wing panels are bolted together so that the inboard rib of the left panel becomes the center rib of the wing.

(2) SEPARATING AND JOINING WING PANELS. *(See figure 83.)*

**Note**

Before fuselage is installed on complete wing assembly, make all necessary adjustments, inspections, and settings.

References: Hydraulics—paragraph 19.
Landing Gear—paragraph 5.
Fuel System—paragraph 15.
Surface Controls—paragraph 3.

(3) FUEL TANK DOORS.

*(a)* DESCRIPTION. *(See figure 84.)*—A flush-type aluminum alloy structural door is located on the underside of each wing panel between the main and rear spar, and adjacent to the wing center rib. The tank doors are arranged to hold the fuel tanks in position, and also serve to facilitate fuel tank installation and removal.

*(b)* REMOVING AND INSTALLING FUEL TANK DOORS. *(See figure 86.)*

(4) LANDING GEAR ACCESS DOORS.

*(a)* DESCRIPTION. *(See figure 84.)*—Metal access doors constructed in two sections, located on the wing leading edge directly forward of landing gear shock strut, are provided to facilitate removal of the main landing gear with pivot shaft.

*(b)* REMOVING AND INSTALLING LANDING GEAR ACCESS DOORS. *(See figure 89.)*

(5) LANDING GEAR FAIRING DOORS. *(See figure 84.)*—Hydraulically operated landing gear fairing doors are hinged to castings installed on the center rib of the wing. The doors close flush with the lower skin of the wing when the gear is fully extended or retracted. The hydraulic system is timed so that the fairing doors open to permit the landing gear to pass as it extends or retracts.

*e.* WING TIPS.

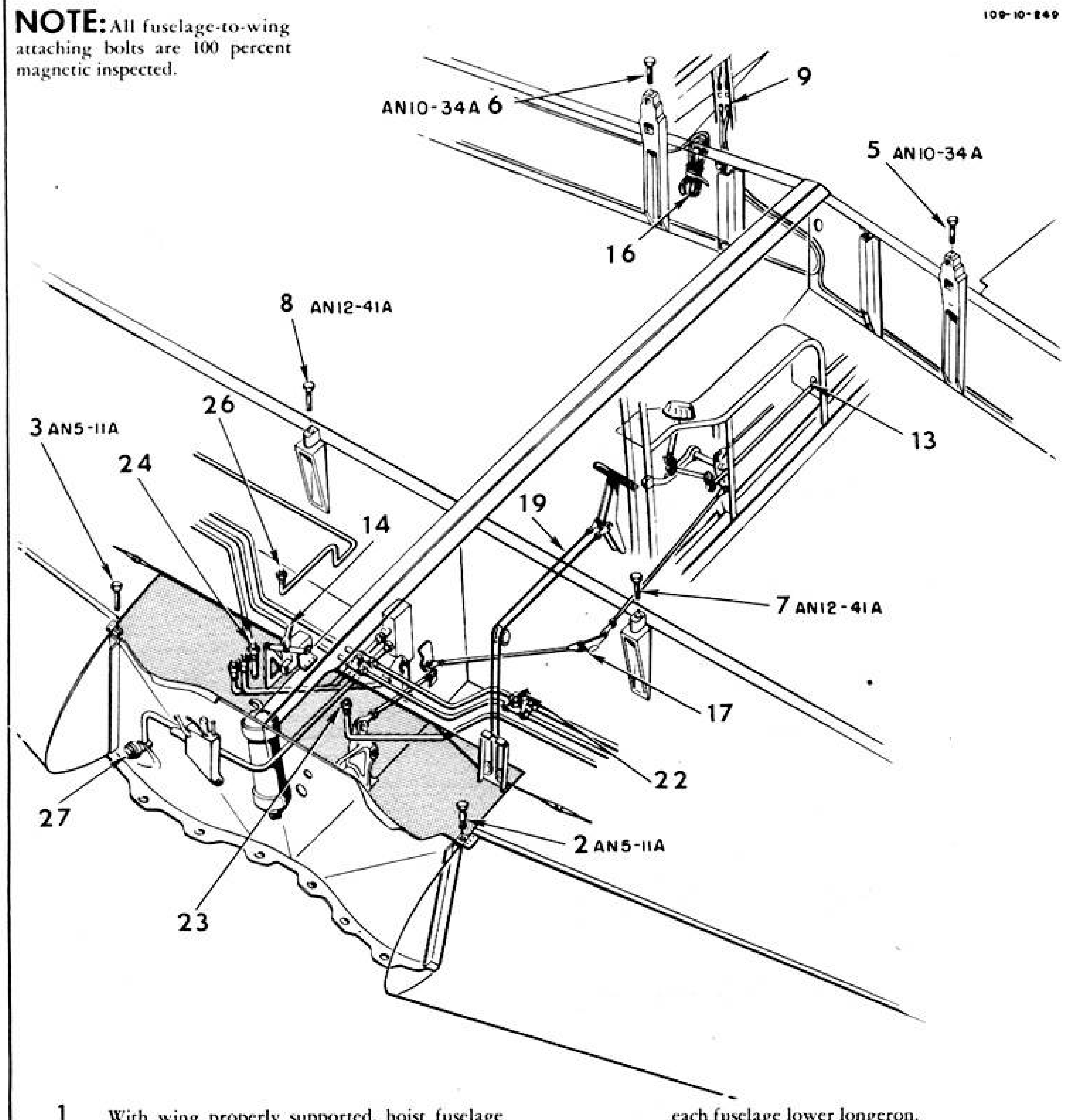
(1) DESCRIPTION. *(See figure 84.)*—A detachable wing tip is secured to each wing panel by screws and bolts. A navigation light is installed on the outboard end of each wing tip, and three recognition lights are on the lower surface of the right wing tip only.

(2) REMOVING AND INSTALLING WING TIPS. *(See figure 85.)*

*f.* AILERONS.

(1) DESCRIPTION. *(See figure 84.)*—A metal-covered, internally sealed, aerodynamically balanced aileron is installed on the trailing edge of each wing panel, immediately inboard of each wing tip. Adequate dynamic balance and static balance are obtained by disposition of the structure, and the addition of a lead strip forward of the aileron hinge line. Three aileron hinge brackets bolted to the forward spar provide bearing attachment points. The aileron hinges on three sealed bearings. A controllable trim tab is fitted into the trailing edge of the left aileron, and a fixed trim tab is fitted into the right aileron.

**NOTE:** All fuselage-to-wing attaching bolts are 100 percent magnetic inspected.




1 With wing properly supported, hoist fuselage over wing. As fuselage is being lowered, attach fuselage tank fuel line to fuel selector valve and primer line to connection on wing.

2, 3 Install bolts through left and right firewall attaching angles.

4 Install bolts through wing center bulkhead fitting.

5, 6 Install bolts through wing aft attaching holes in each fuselage lower longeron.

7, 8 Install bolts through wing forward attaching holes in each fuselage lower longeron.

9, Connect gun bay electrical wires.

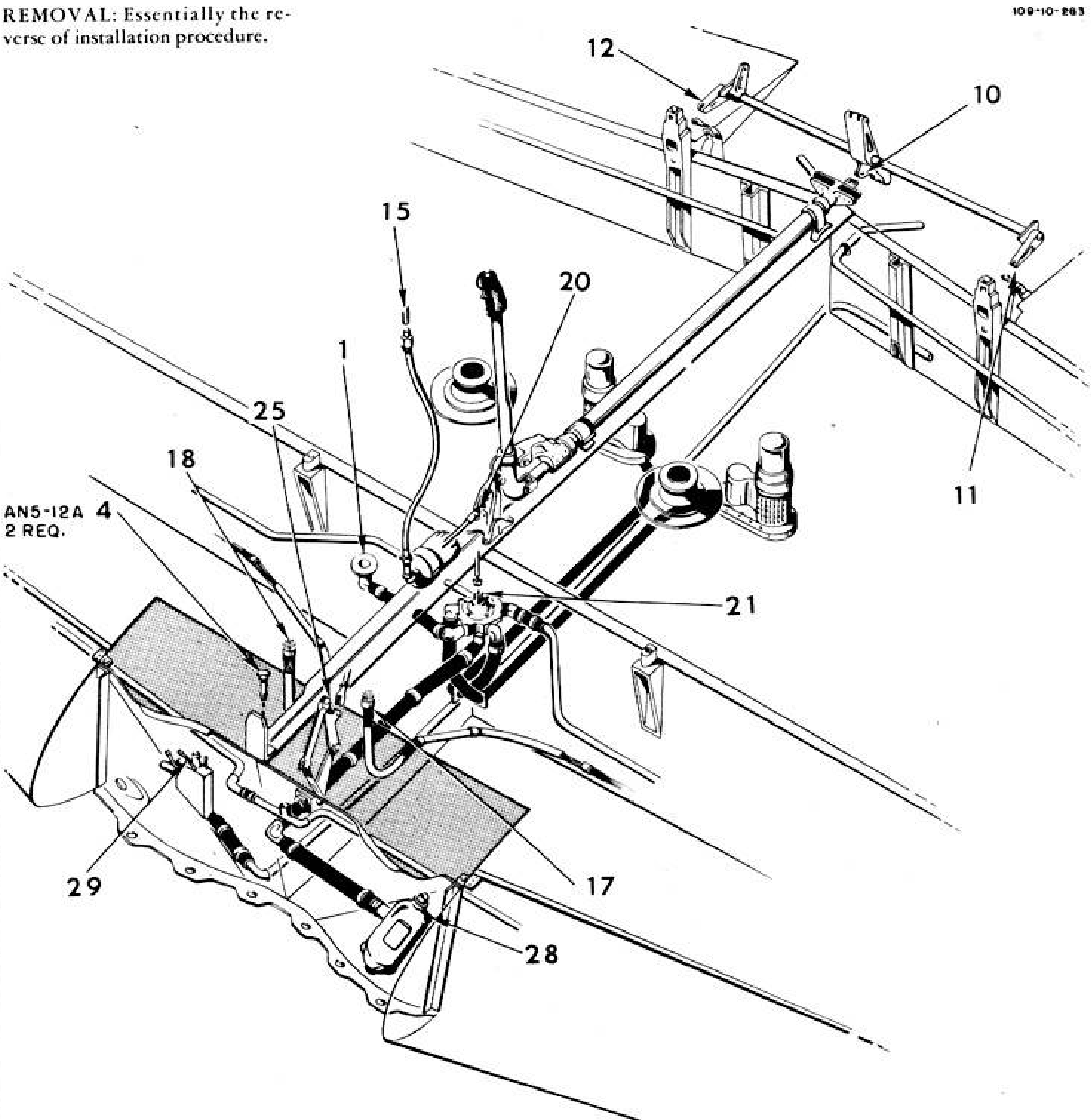
10 Connect elevator push rod.

11, 12 Connect wing flap link.

13 Connect aileron trim tab control.

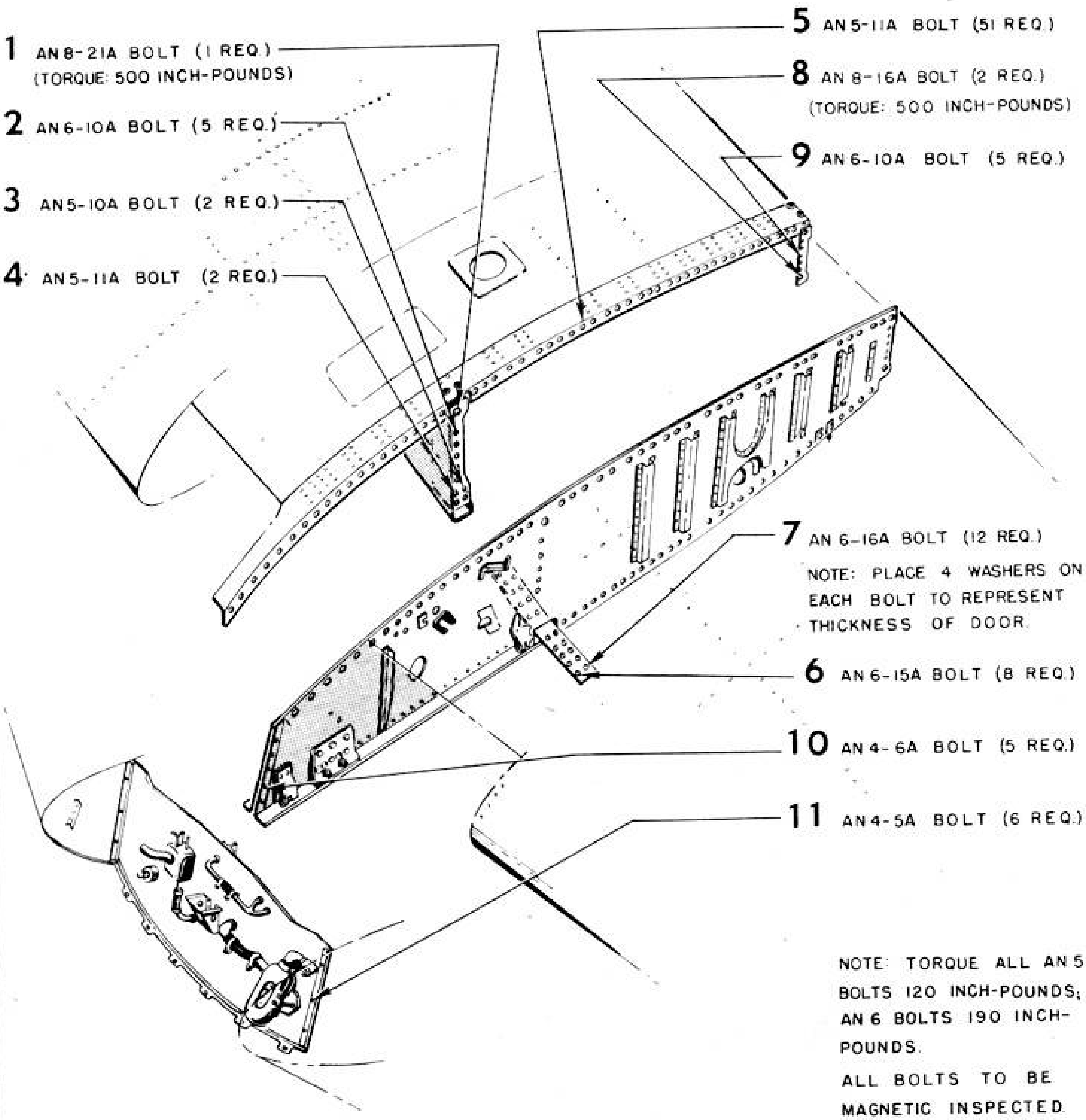
14 Connect fairing door emergency control valve link rod.

*Figure 82 (Sheet 1 of 2 Sheets)—Installing Fuselage on Wing*




15, 16 Insert IFF right wing antenna cable into receptacle on radio and make vacuum air filter line connection.
17 Connect landing gear control handle linkage.
18 Insert (2) wing electrical plugs in receptacles.
19 Connect bomb rack control cables.
20 Connect surface control lock rod.
21 In left wheel well, connect fuel tank selector valve linkage.
22 Connect tail gear hydraulic lines in left wheel well.
23, 24 Connect brake supply hydraulic lines.
25 Connect fuel shut-off valve linkage.
26 In right wheel well, connect pressure line.
27 On wing center bulkhead, connect hydraulic line.
28 Connect engine pump fuel supply line.
29 Connect drain lines.
30 Attach combat tank pressurization lines.

*Figure 82 (Sheet 2 of 2 Sheets)—Installing Fuselage on Wing*




**1–5** Position wing panels, using drift pins, so that centers are together with splice bar between; align splice plate, using drift pins, and ream holes to correspond with holes in main spar; then install bolts along bolting angles.

**6, 7** Install bolts securing splice plate.

**8, 9** Install and secure bolts through rear spar bolting angle.

**10, 11** Install and secure wing bulkhead assembly.

**Removal:** Essentially the reverse of the installation procedure.

109-10-248

*Figure 83—Joining Wing Panels*

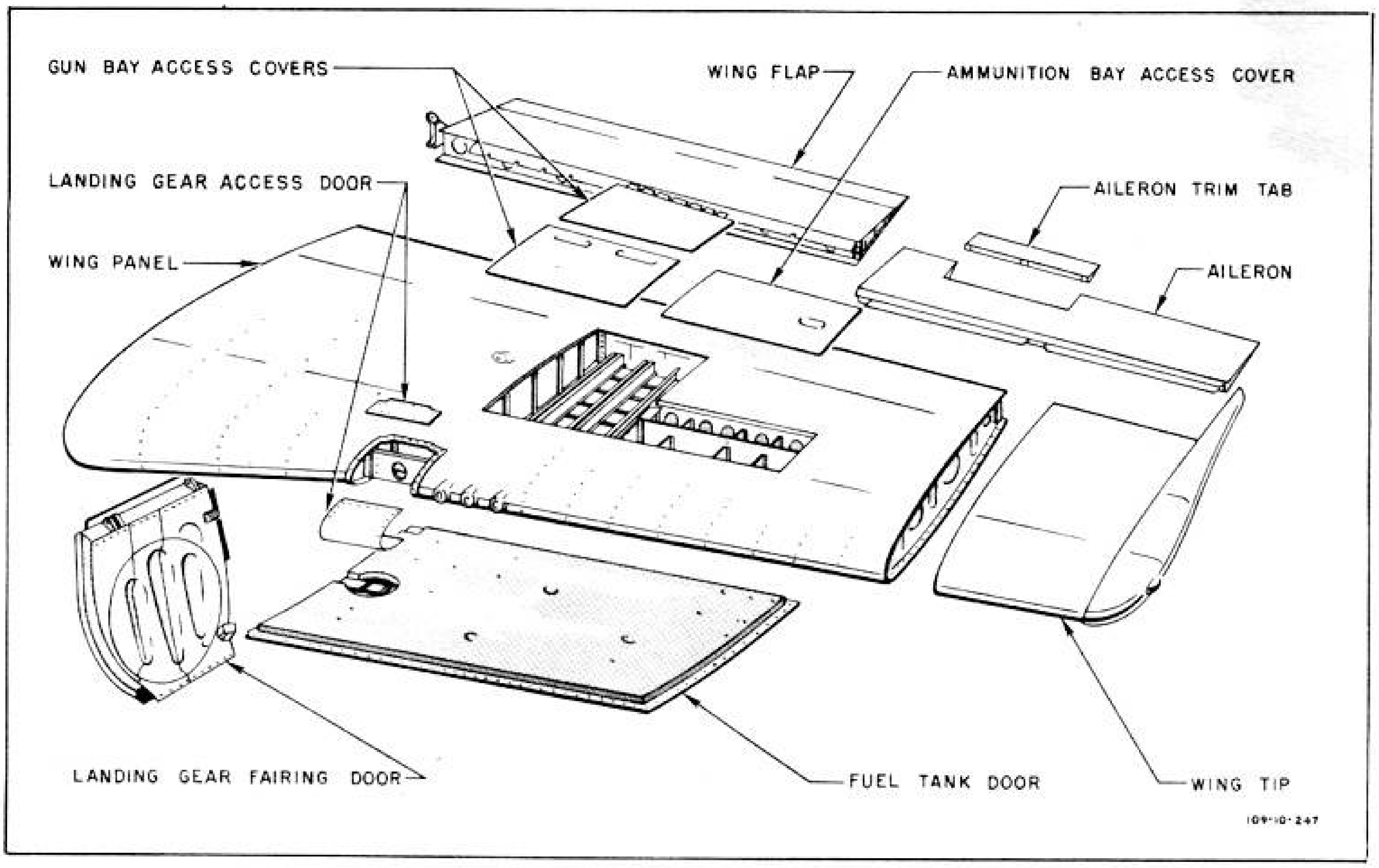
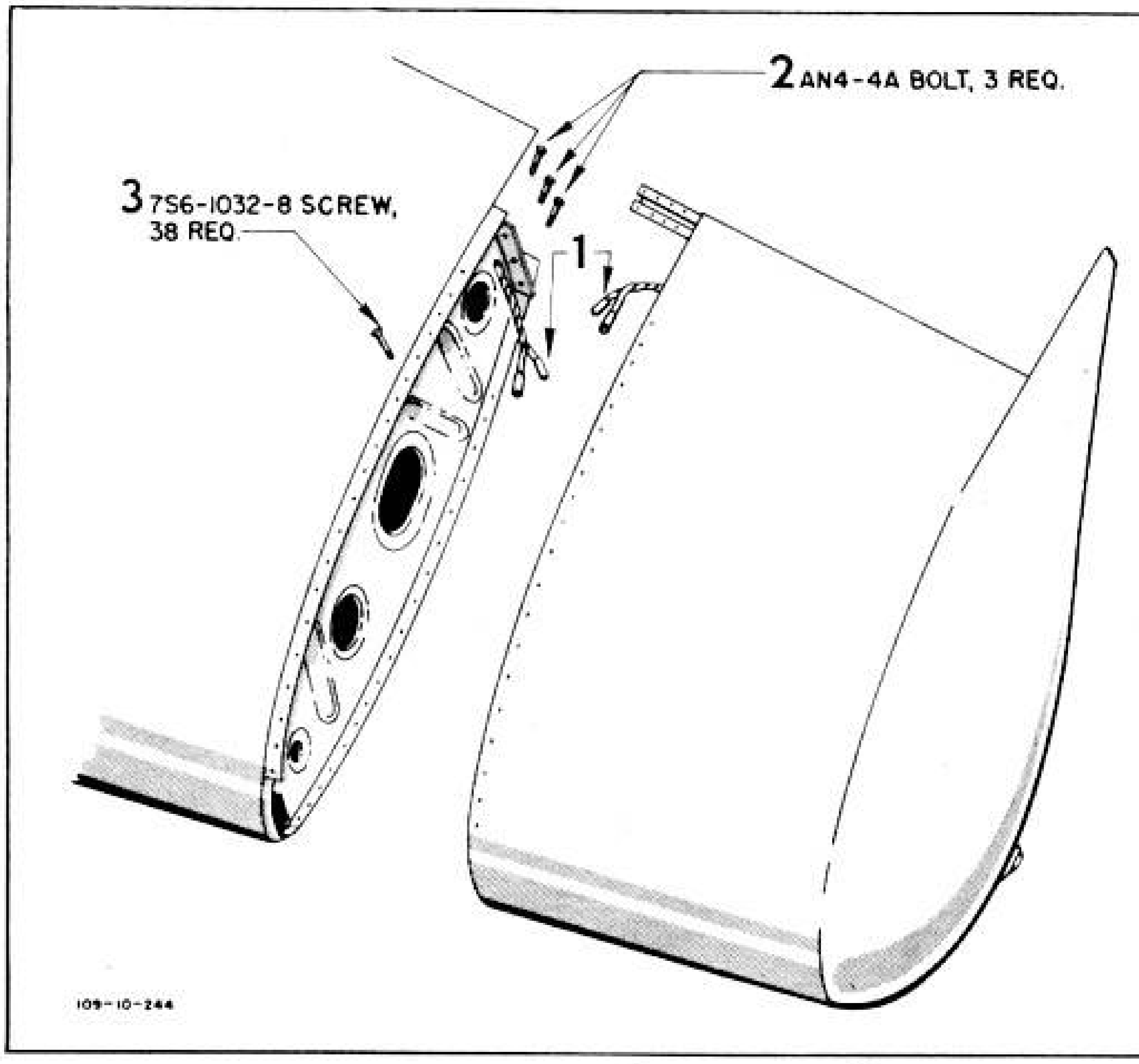



*Figure 84—Wing Panel Assembly*




**1** Position wing tip to wing panel, and make electrical connection.

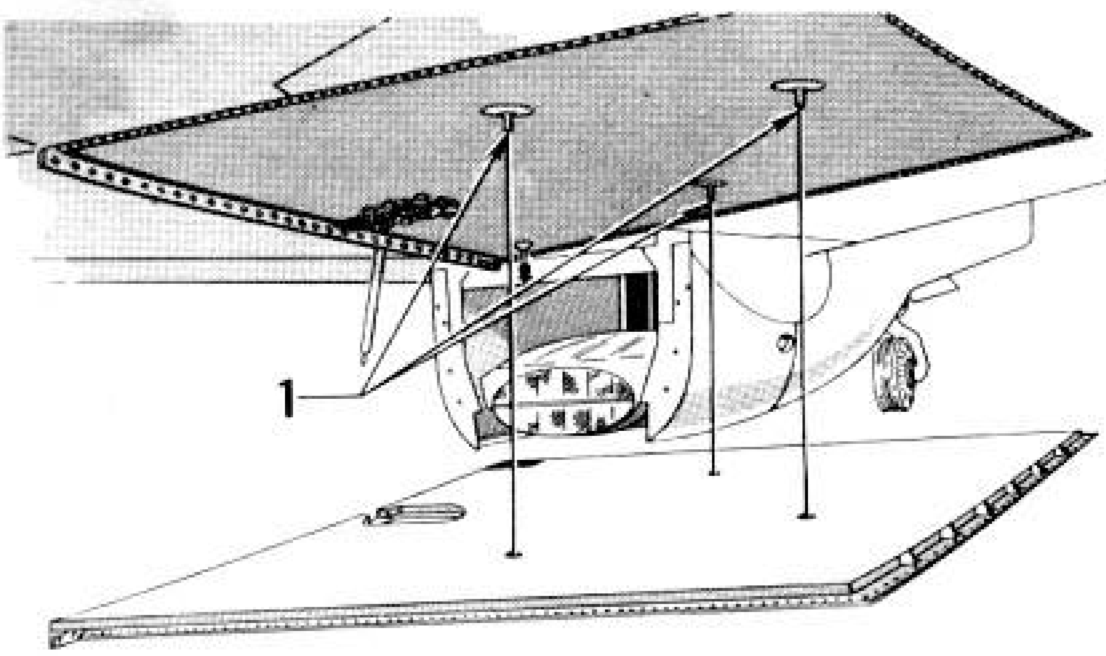
**2** Install bolts through holes of wing tip rear spar.

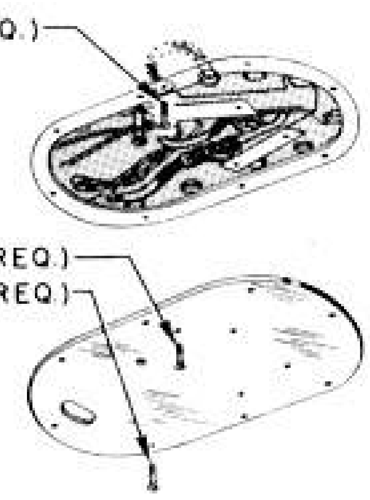
**3** Install attaching screws through upper and lower wing tip surfaces.

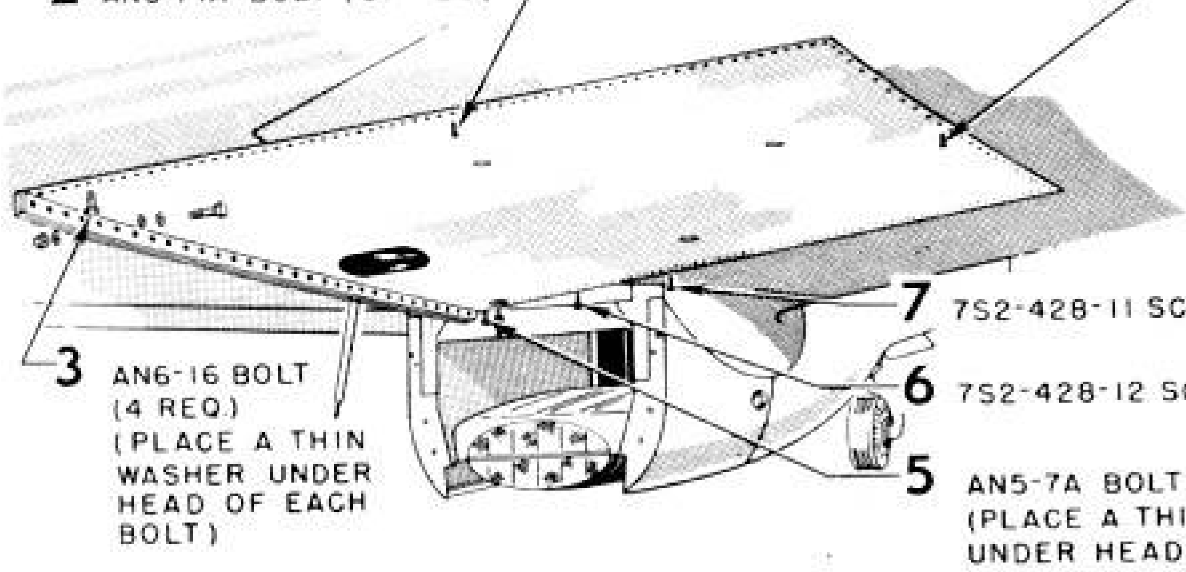
**Removal:** Essentially the reverse of installation procedure, with the following exception:

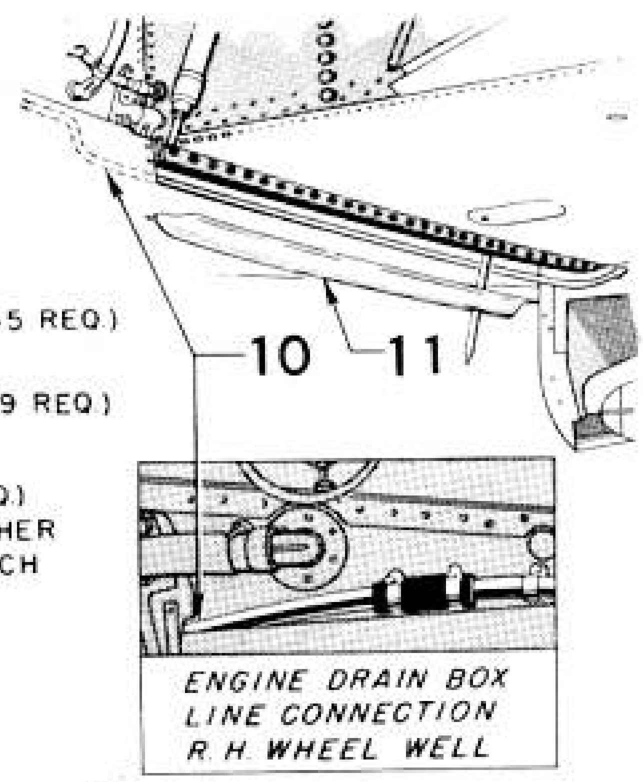
Prior to removing wing tip, it is necessary to remove aileron.

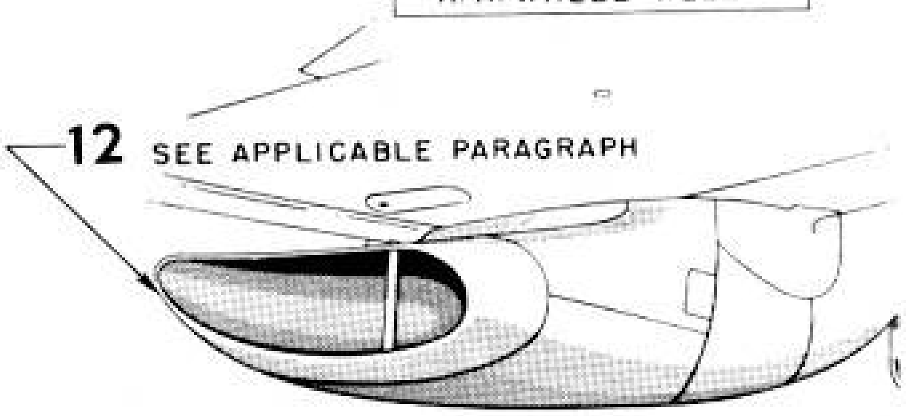
*Figure 85—Installing Wing Tips*




**1** Install washers on tank lower stud fittings, and attach separate wires of suitable strength and length to the stud fittings.

Place tank door on ground in line with tank compartment, and thread wires through holes provided in door for stud connections.

Raise and guide door into position, keeping stud connections in alignment.

**2** Support tank door, and install bolts along center rib attachment angle.

**3-7** Install remaining screws and bolts along forward, aft, and outboard edges of tank door.

**8** Connect bonding braid from booster pump to tank door.

**9** Install booster pump access door.

**10** Install engine drain box drain line.

**11** Install fairing over lower wing center bolting angle.

**12** Install radiator air inlet scoop.

REMOVAL: Essentially the reverse of installation procedure, with the following exceptions:

Prior to removing fuel tank doors, jack airplane, using wing jacking points at lower surface of each wing section immediately outboard of bomb racks, and jacking point on wing center rib.

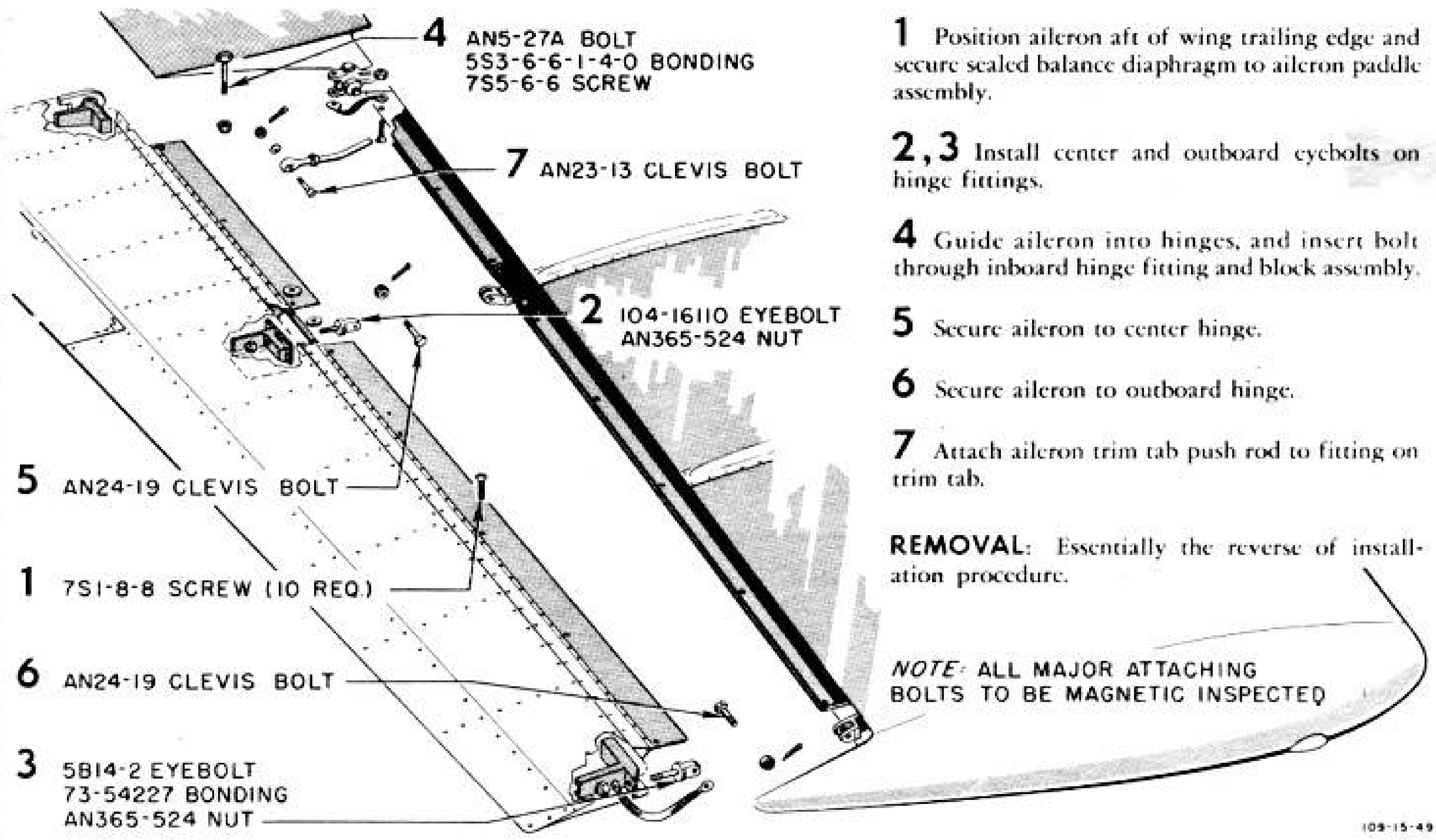
Weight of airplane must be supported at center jacking point, with outer jacking points being used for balance only.

CAUTION

The foregoing jacking procedure should be closely followed, as the fuel tank doors form a structural part of the wing. Distortion and misalignment may result from improper support. To prevent sinking when jacking on soft surface, place suitable platform beneath jacking stand.

109 10-246

*Figure 86—Installing Fuel Tank Doors*




**1** Position aileron aft of wing trailing edge and secure sealed balance diaphragm to aileron paddle assembly.

**2, 3** Install center and outboard eyebolts on hinge fittings.

**4** Guide aileron into hinges, and insert bolt through inboard hinge fitting and block assembly.

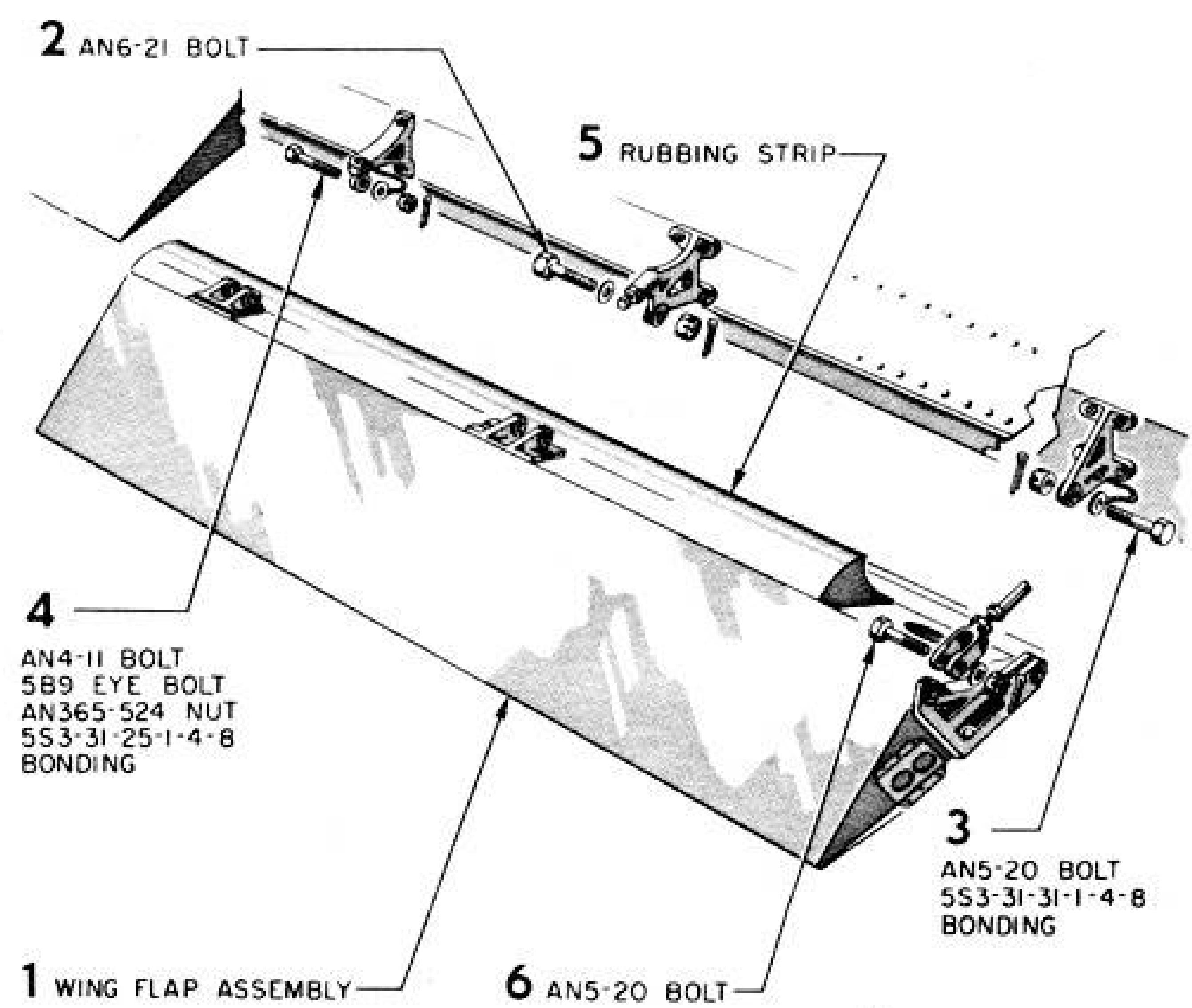
**5** Secure aileron to center hinge.

**6** Secure aileron to outboard hinge.

**7** Attach aileron trim tab push rod to fitting on trim tab.

**REMOVAL:** Essentially the reverse of installation procedure.

*Figure 87—Installing Ailerons*




**NOTE:** The following procedure requires the services of two men.

**1, 2,** Hoist flap assembly into position, and insert attaching bolt through center hinge bracket.

**3, 4** Attach bolts and bonding to inboard and outboard hinges.

**5** Manually raise flap and guide rubbing strip under trailing edge of wing skin.

**6** Secure flap torque tube link to flap.

**REMOVAL:** Essentially the reverse of installation procedure.

*Figure 88—Installing Wing Flaps*

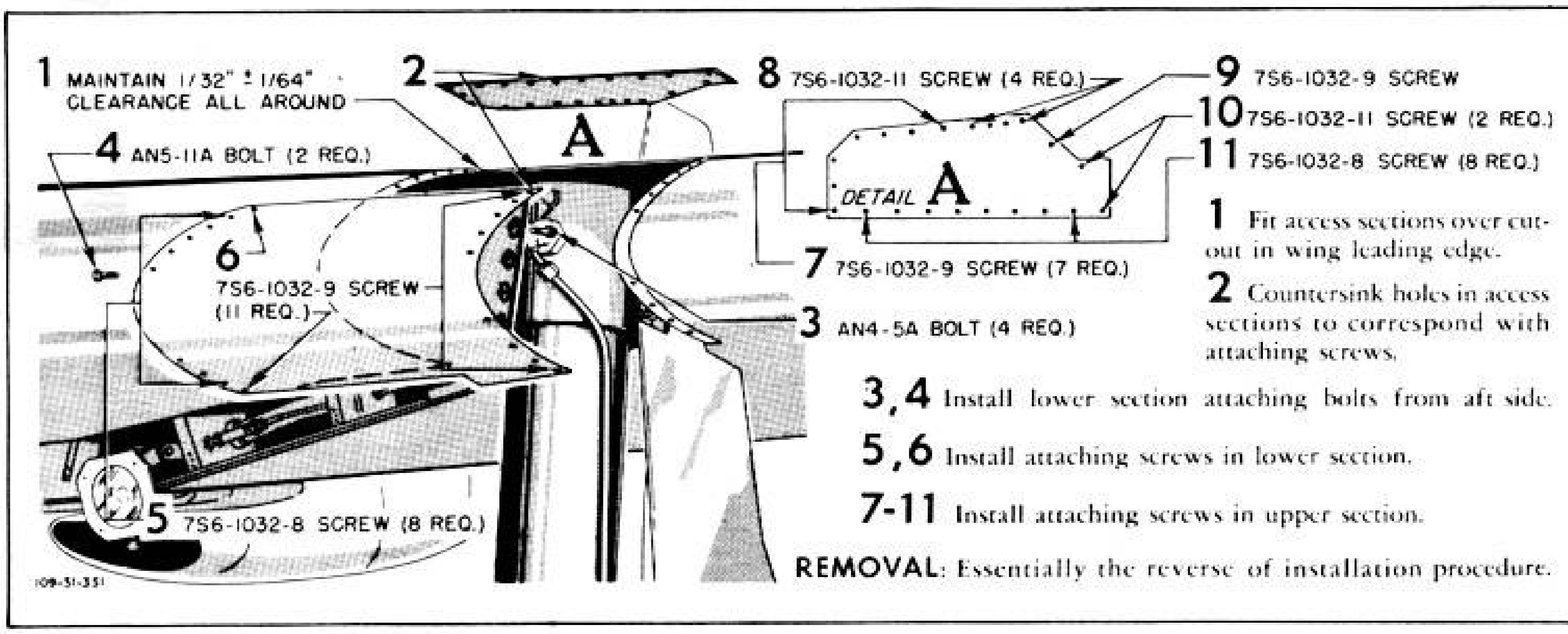



*Figure 89—Installing Landing Gear Access Doors*

(2) REMOVING AND INSTALLING AILERONS. *(See figure 87.)*

*g.* AILERON TRIM TABS.

(1) DESCRIPTION. *(See figure 84.)*—A phenol fiber trim tab is installed on the trailing edge of each aileron. A metal bracket on each tab provides an attachment point for the trim tab actuating rod. Each trim tab is hinged to its respective aileron by three hinge bearings attached at the cutouts provided in the leading edges of the tabs. There is a special spacer inside each trim tab hinge, and a special tension washer between hinge and bracket. The left trim tab is controllable from the cockpit; the right trim tab is fixed. Right and left trim tabs can be made interchangeable by moving the trim tab actuating bracket from one end of the tab to the other end.

(2) REMOVING AND INSTALLING AILERON TRIM TABS. *(See figure 90.)*

*h.* WING FLAPS.

(1) DESCRIPTION. *(See figure 84.)*—A metal-covered, sealed-aileron type wing flap is installed on the trailing edge of each wing panel, between the fuselage and the aileron. A stainless steel rubbing strip curves forward and down on the leading edge of the flap. The wing flaps hinge on three sealed-type bearings.

(2) REMOVING AND INSTALLING WING FLAPS. *(See figure 88.)*

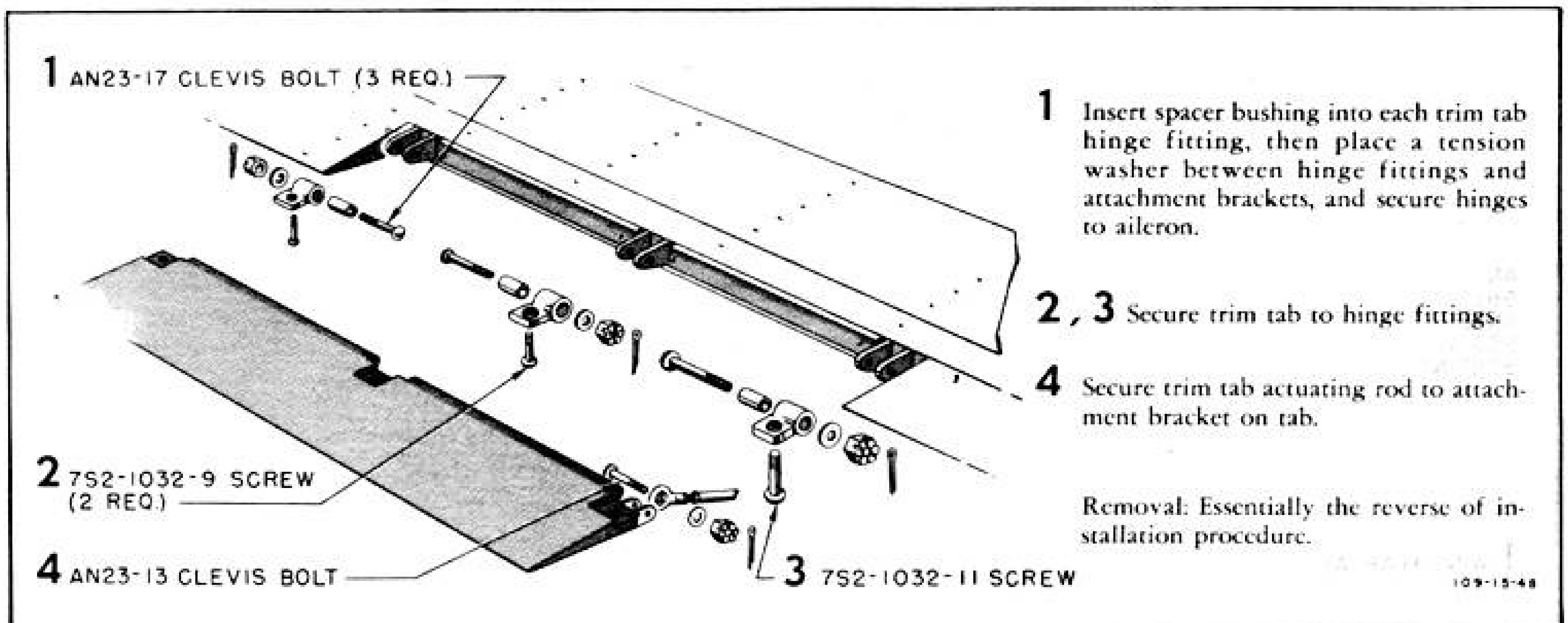



*Figure 90—Installing Aileron Trim Tabs*

**2. EMPENNAGE.**

*a.* GENERAL DESCRIPTION.—The empennage consists of a horizontal stabilizer, a vertical stabilizer, a rudder, and two elevators. Fuselage-to-empennage fairings streamline the empennage installation. On later airplanes, a dorsal fin is installed between fuselage and vertical stabilizer.

*b.* VERTICAL STABILIZER.

(1) DESCRIPTION. *(See figure 92.)*—The vertical stabilizer is a metal-covered, full-cantilever, semimonocoque structure consisting of a forward and rear spar, flanged ribs, and extruded stringers covered with alclad sheet. The tip, formed about two supporting ribs, is not detachable.

(2) REMOVING AND INSTALLING VERTICAL STABILIZER. *(See figure 92.)*

*c.* RUDDER.

(1) DESCRIPTION. *(See figure 91.)*—A fabric-covered rudder, with trim tab, is hinged to the trailing edge of the vertical stabilizer with three sealed-type hinge bearings. The rudder actuating rod attachment fitting is an integral part of the lower hinge fitting. A formed aluminum cap is placed over the bottom part of the rudder after installation. The rudder attains adequate dynamic balance by means of weights attached to the leading edge.

(2) REMOVING AND INSTALLING RUDDER. *(See figure 91.)*

*d.* HORIZONTAL STABILIZER.

(1) DESCRIPTION. *(See figure 93.)*—The horizontal stabilizer is a full-cantilever, all-metal structure with detachable tips.

(2) REMOVING AND INSTALLING HORIZONTAL STABILIZER. *(See figure 93.)*

*e.* HORIZONTAL STABILIZER TIPS.

(1) DESCRIPTION. *(See figure 93.)*—Metal tips are attached to main panel of horizontal stabilizer with screws.

(2) REMOVING AND INSTALLING HORIZONTAL STABILIZER TIPS. *(See figure 93.)*

*f.* ELEVATORS.

(1) DESCRIPTION. *(See figure 94.)*—Fabric-covered elevators, with trim tabs, are hinged to the trailing edge of the horizontal stabilizer by five sealed-type bearings: one at each outboard end, one at center of each elevator, and one at the horn assembly. A weight attached to the outboard end of the leading edge of each elevator provides for adequate dynamic and static balance.

(2) REMOVING AND INSTALLING ELEVATORS. *(See figure 94.)*

*g.* ELEVATOR AND RUDDER TRIM TABS.

(1) DESCRIPTION. *(See figure 95.)*—Phenol fiber trim tabs are installed on the elevators and rudder. A metal bracket on each trim tab provides an attachment point for the trim tab actuating rod. Each tab is hinged to the respective movable surface by three hinge bearings attached at cutouts provided in leading edge of tab.

(2) REMOVING AND INSTALLING ELEVATOR AND RUDDER TRIM TABS. *(See figure 95.)*

**Note**

Rudder trim tabs on airplanes with dorsal fin installation have reverse boost linkage.

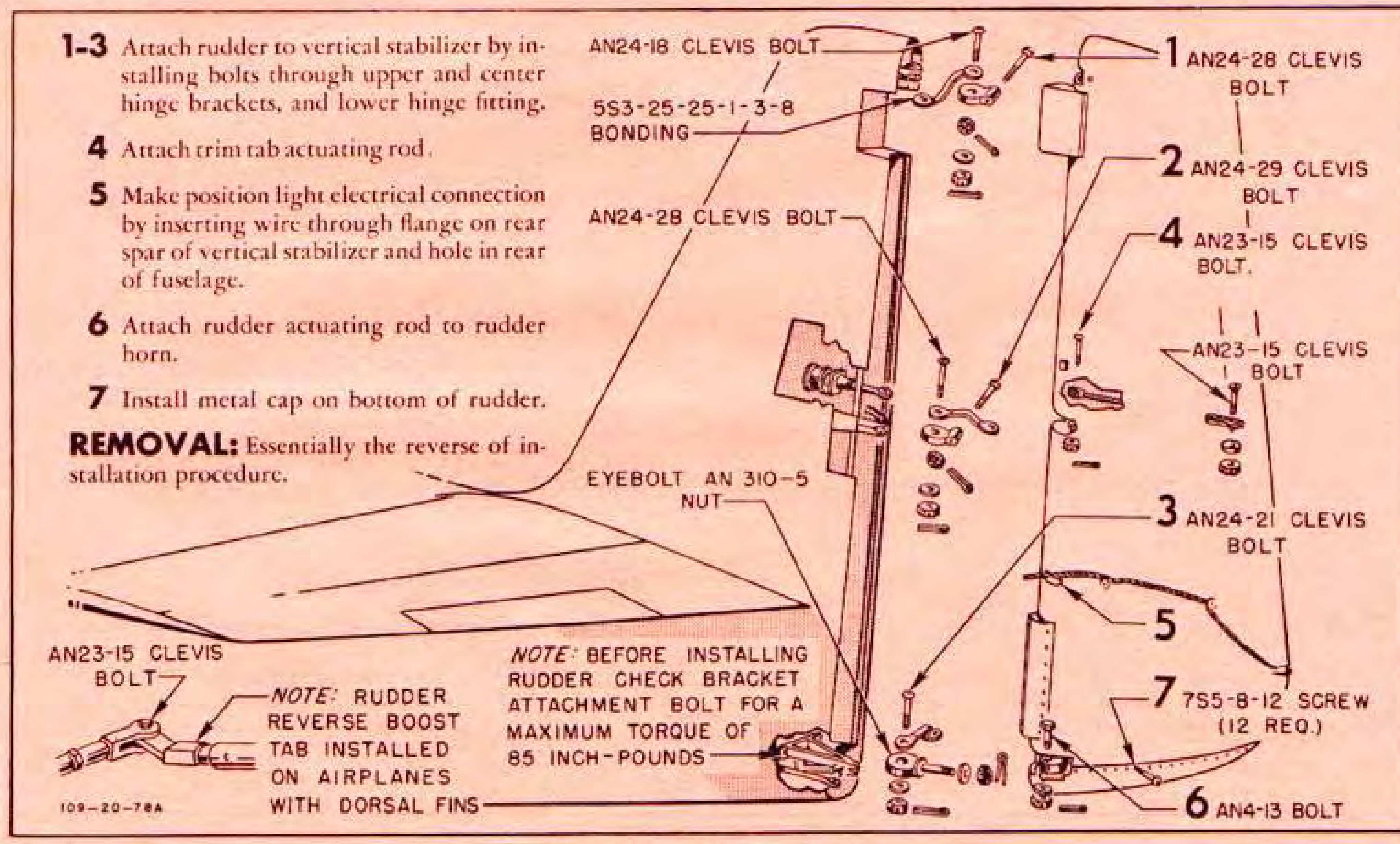
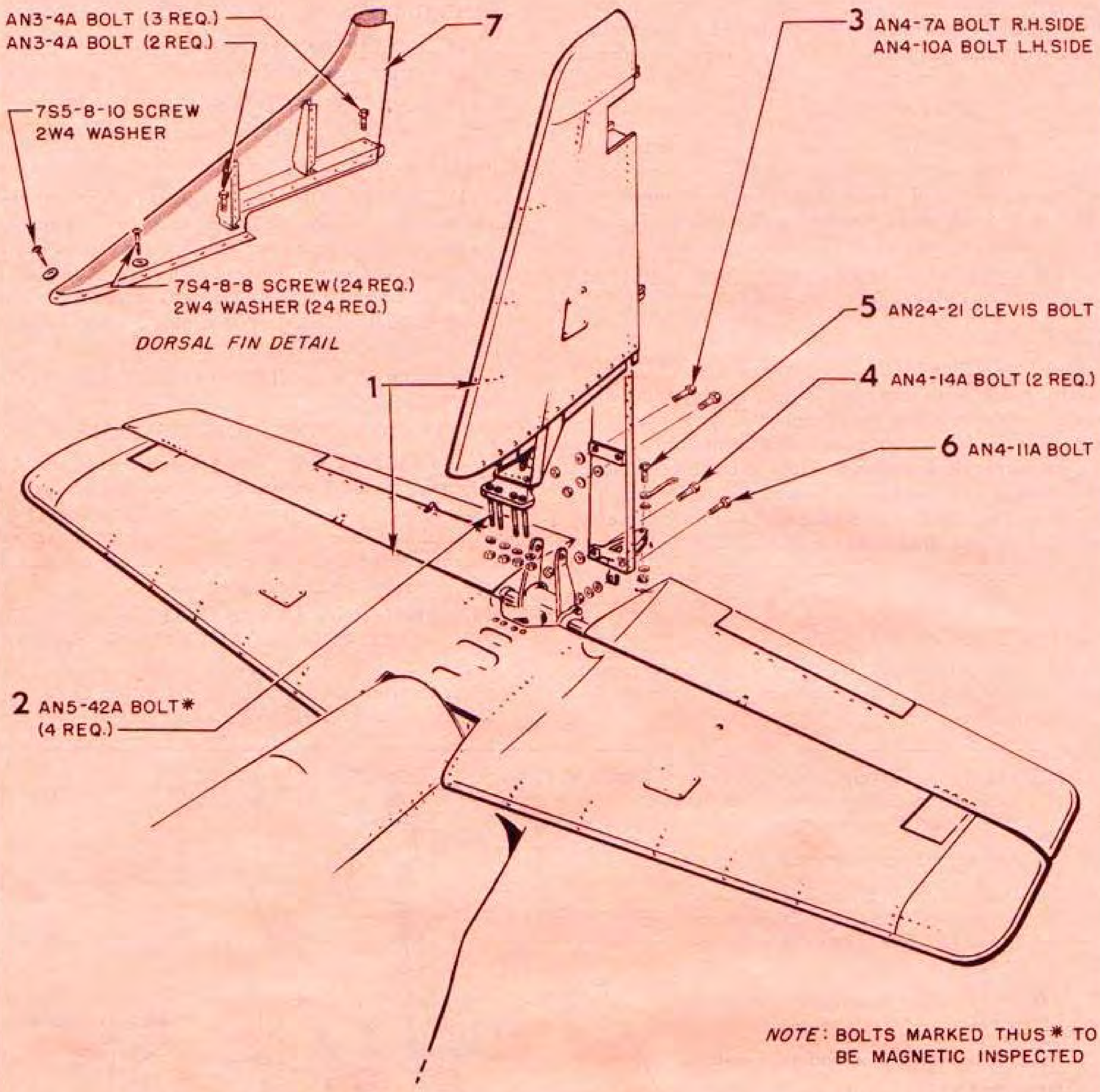



*Figure 91—Installing Rudder*




**1** Position vertical stabilizer on horizontal stabilizer.

**2** Install bolts securing vertical stabilizer to horizontal stabilizer.

**3-6** Install bolts securing vertical stabilizer to aft end of fuselage.

**7** On later airplanes, install dorsal fin.

**REMOVAL:** Essentially the reverse of installation procedure, with following exceptions:

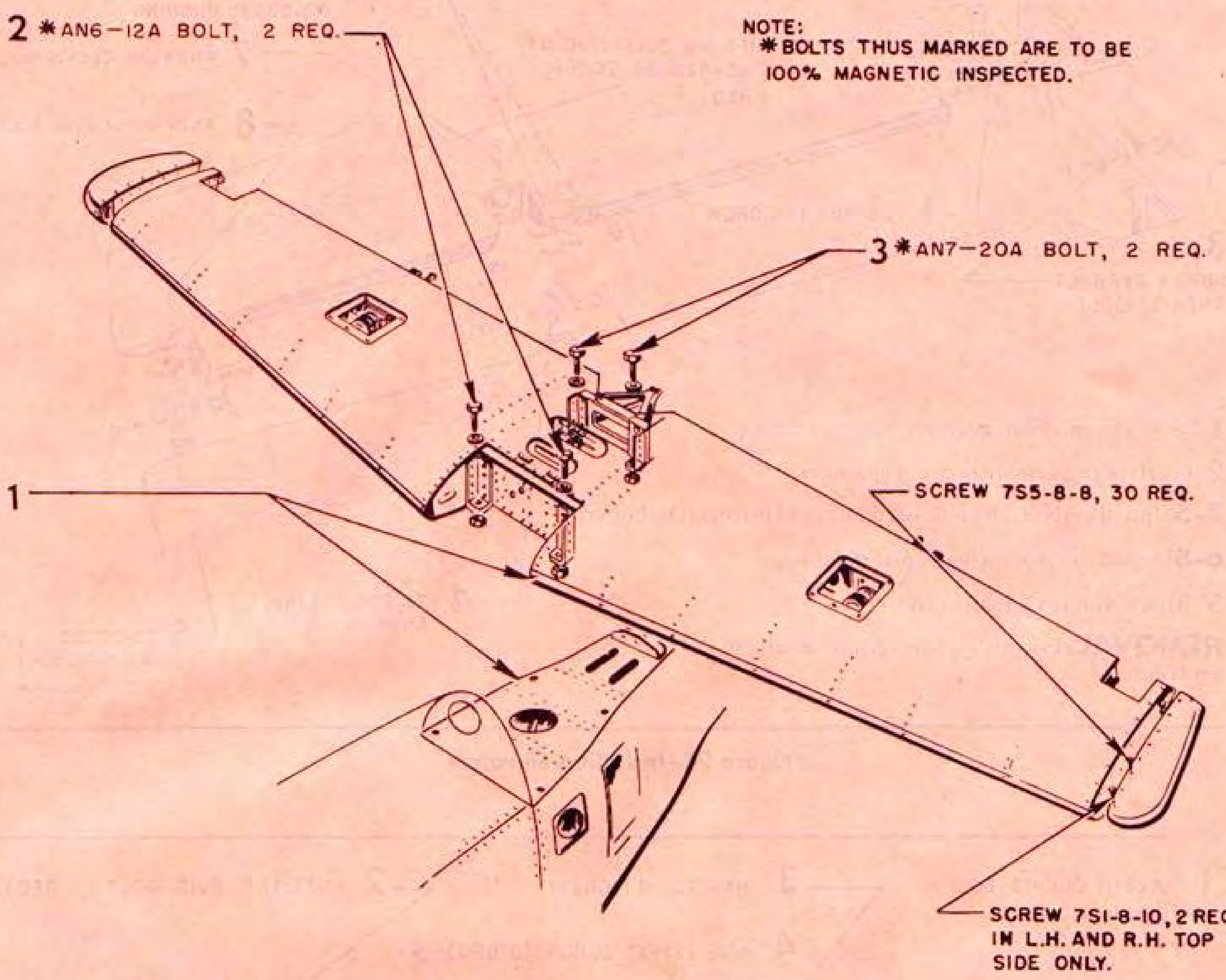
Prior to removing vertical stabilizer, it is necessary to remove rudder, and rudder trim tab drum.

Disconnect transmitter antenna at top of vertical stabilizer.

Tape rudder trim tab cables to drums in vertical stabilizer and in cockpit to facilitate reinstallation.

109-23-95

*Figure 92—Installing Vertical Stabilizer*




**1** Place horizontal stabilizer on fuselage.

**2** Attach front spar of horizontal stabilizer to fuselage.

**3** Attach aft spar of horizontal stabilizer to fuselage.

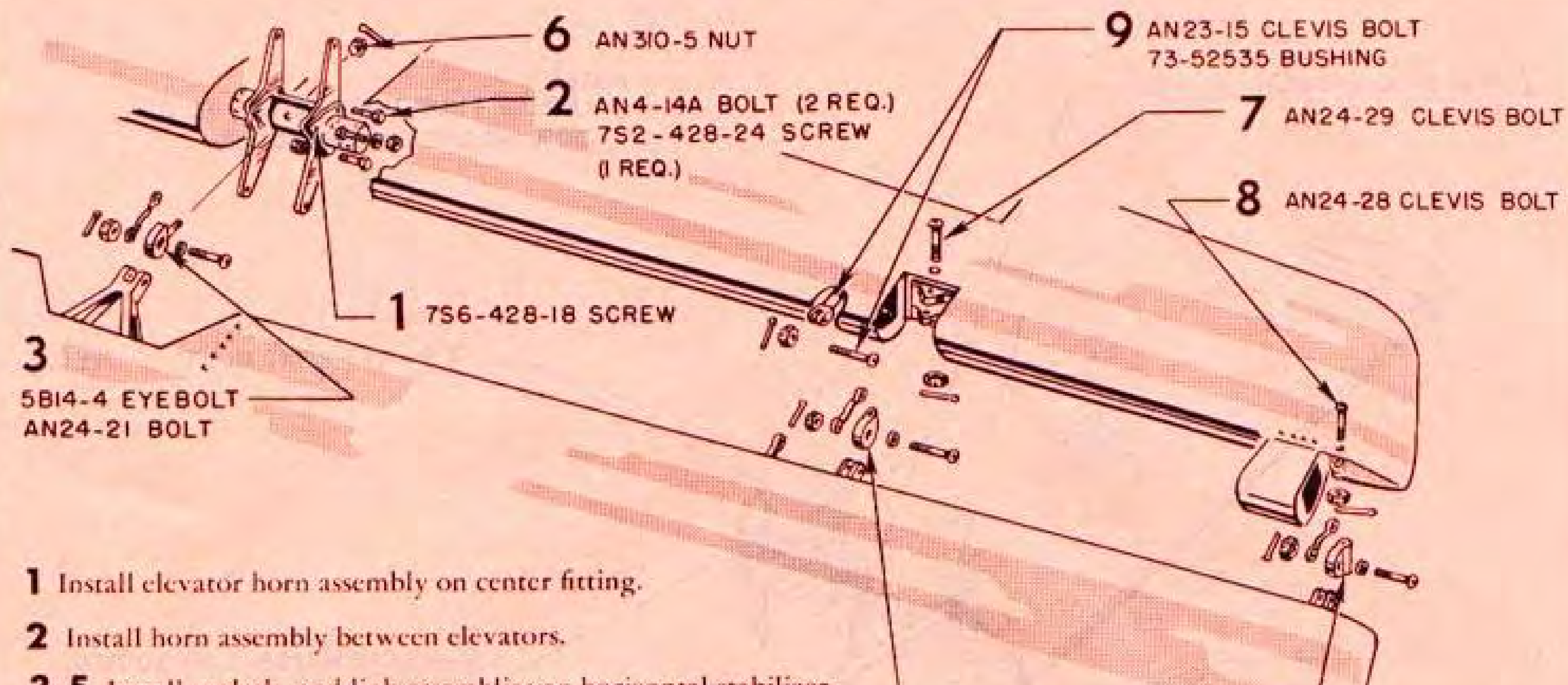
## REMOVAL

**Removal:** Essentially the reverse of installation procedure.

When removing horizontal stabilizer,either one of two procedures may be followed: Remove rudder, vertical stabilizer, and then horizontal stabilizer and elevators as a unit, or disconnect elevator and elevator horn, and slide horizontal stabilizer from under vertical stabilizer. Both methods require disconnecting elevator cables and elevator trim tab cables.

109-20-51A

*Figure 93—Installing Horizontal Stabilizer*




**1** Install elevator horn assembly on center fitting.

**2** Install horn assembly between elevators.

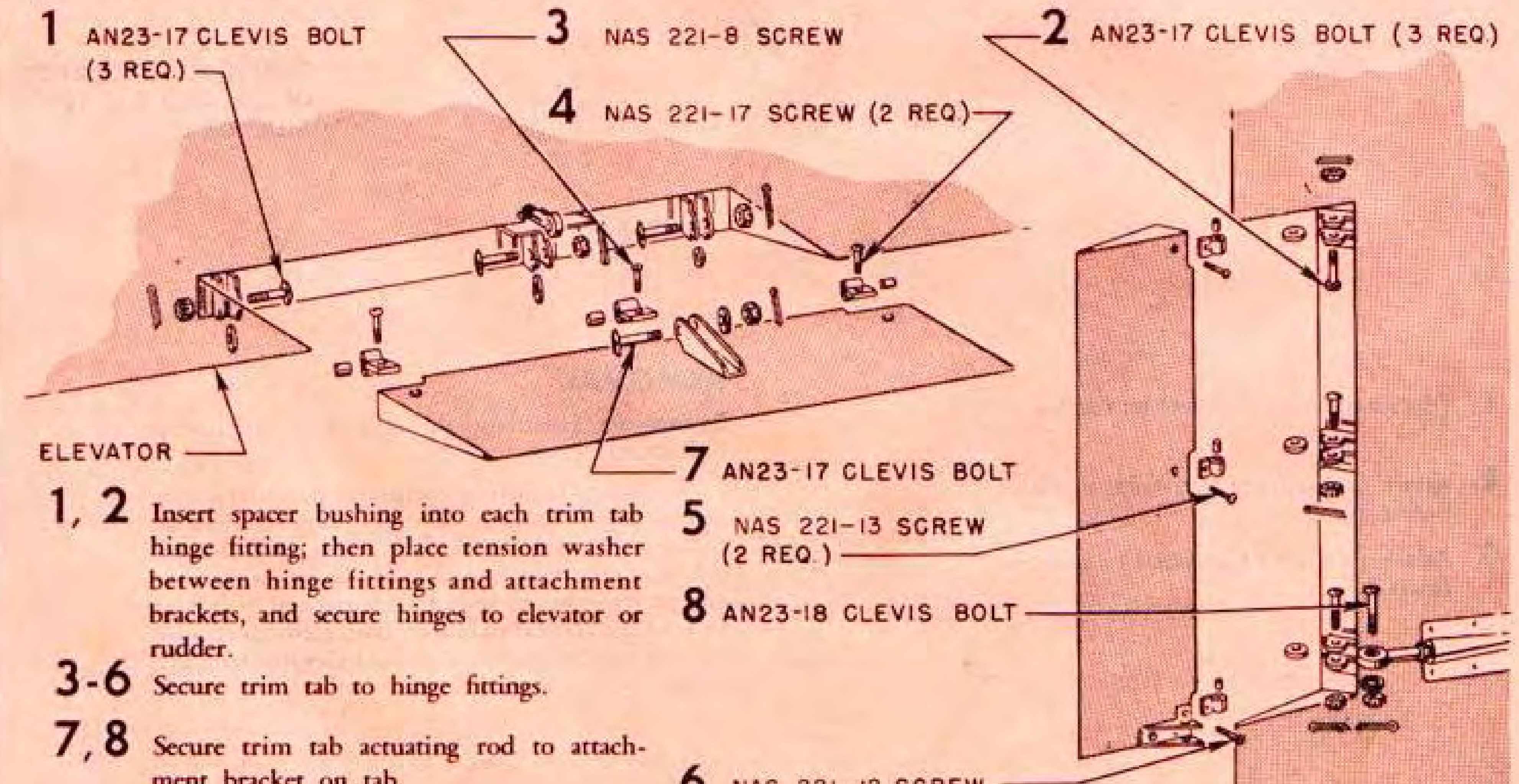
**3-5** Install eyebolt, and link assemblies on horizontal stabilizer.

**6-8** Install elevator on horizontal stabilizer.

**9** Attach trim tab actuating rod.

**REMOVAL:** Essentially the reverse of installation procedure.

*Figure 94—Installing Elevators*




**1, 2** Insert spacer bushing into each trim tab hinge fitting; then place tension washer between hinge fittings and attachment brackets, and secure hinges to elevator or rudder.

**3-6** Secure trim tab to hinge fittings.

**7, 8** Secure trim tab actuating rod to attachment bracket on tab.

**Removal:** Essentially the reverse of installation procedure.

*Figure 95—Installing Elevator and Rudder Trim Tabs*

### 3. SURFACE CONTROLS.

*a.* GENERAL DESCRIPTION.—The ailerons and elevators are conventionally controlled by the pilot's control stick and the rudder by hanging-type pedals. All primary control surfaces, except right aileron, are equipped with adjustable trim tabs operated from the cockpit. The tab on the right aileron is adjustable only on the ground and is used to correct wing heaviness. Tinned steel cables connect the control stick, rudder pedals, and trim tab controls to their respective control surfaces. Turnbuckles are incorporated in each system to facilitate installing and rigging of the cables. The wing flaps are hydraulically actuated and selectively positioned by a control handle in the cockpit.

*b.* SURFACE CONTROL TROUBLE SHOOTING CHART.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Binding or rubbing.** | Pulley bracket out of line.<br>Insufficient lubrication.<br>Cables incorrectly routed.<br>Equipment interfering.<br>Cable off pulley. | Straighten or replace pulley bracket.<br>Lubricate.<br>Correct.<br>Adjust equipment to provide clearances.<br>Replace pulley, if worn. Check alignment of pulley. Check cable guards. |
| **Obstructed full movement.** | Control surface or control stick stops incorrectly set.<br>Foreign objects or icing condition. | Adjust stops.<br>Clear openings between fixed and movable surfaces. |
| **Surfaces move in excess of limits.** | Control stick stops set incorrectly. | Adjust stops. |
| **Surfaces refuse to move.** | Cable off pulley.<br>Insufficient lubrication.<br>Incorrect rigging.<br>Equipment interfering.<br>Icing conditions. | Replace pulley, if worn. Check alignment of pulley. Check cable guards.<br>Lubricate.<br>Rig correctly.<br>Adjust equipment to provide clearances.<br>Remove ice from between surfaces. |
| **Trim tab indicators do not respond.** | Gears stripped or damaged.<br>Indicator bent.<br>Incorrect rigging. | Replace gears.<br>Adjust indicator.<br>Rig tab control system. |
| | **WING FLAPS** | |
| **Spongy flaps.** | Flaps not adjusted with a preload. | Adjust flap linkage. |
| | **AILERONS** | |
| **Aileron flutter.** | Play in control sectors.<br>Incorrect rigging. | Replace outboard sector; change clevis bolts at inboard sectors.<br>Rig control system. |
| | **ELEVATORS AND RUDDER** | |
| **Elevators or rudder flutter.** | Worn clevis bolts at hinges.<br>Hinges out of line with hinge brackets.<br>Incorrect rigging. | Replace clevis bolts.<br>Replace hinge or bracket as required.<br>Rig control system. |
| | **TRIM TABS** | |
| **Trim tab flutter.** | Worn clevis bolts through hinges. | Replace clevis bolts. |

*c.* RIGGING NOTES.—The following notes and cautions conform to Army-Navy standards and should be thoroughly understood by the mechanic.

(1) GENERAL.

*(a)* Establish the exact neutral position of each control system, work from that position, and the results will be more effective.

*(b)* When setting tensions, tighten all cables to about 25 pounds above normal, operate the control thoroughly, and then rig the cables to the normal tensions. This will eliminate the loss of tension due to stretch, cables seating in pulleys, etc.

*(c)* Operate the control surfaces through the complete range of travel while checking the components for clearance. This particularly applies to actuating rods and links.

*(d)* Always tape trim tab cables to the cable drums before releasing the cable tensions. Otherwise, the cables will unwind, causing unnecessary work and trouble.

*(e)* Set the cable guards so that the clearance between the guard and the cable equals one third the diameter of the cable ± 1/64 inch. If the clearance is greater than this, the cable can twist off the pulley.

*(f)* When removing a cable, obtain a cord that is at least as long as the cable, tie the cord to the link or attachment to which the cable was fastened, and then draw the cable and cord through the system. This procedure will provide a positive means of routing another cable correctly.

(2) RIGGING TOLERANCES.

*(a)* CONTROL SURFACE TRAVEL.—Maintain the control surface throws within 1/2 degree of the correct angular travel.

*(b)* CONTROL SURFACE PLAY.—The maximum control surface play allows only 1/8-inch travel at the trailing edge of the respective main control surface, and only 1/16-inch travel at the trailing edge of the respective trim tabs.

*(c)* CONTROL CABLE TENSIONS.—Maintain the cable tensions within 5 pounds of the correct tension.

(3) TURNBUCKLE SAFETY REQUIREMENTS.

*(a)* TURNBUCKLE ADJUSTMENT TOLERANCE.—A maximum of three threads on the clevis or swaged fitting may be exposed outside the turnbuckle barrel.

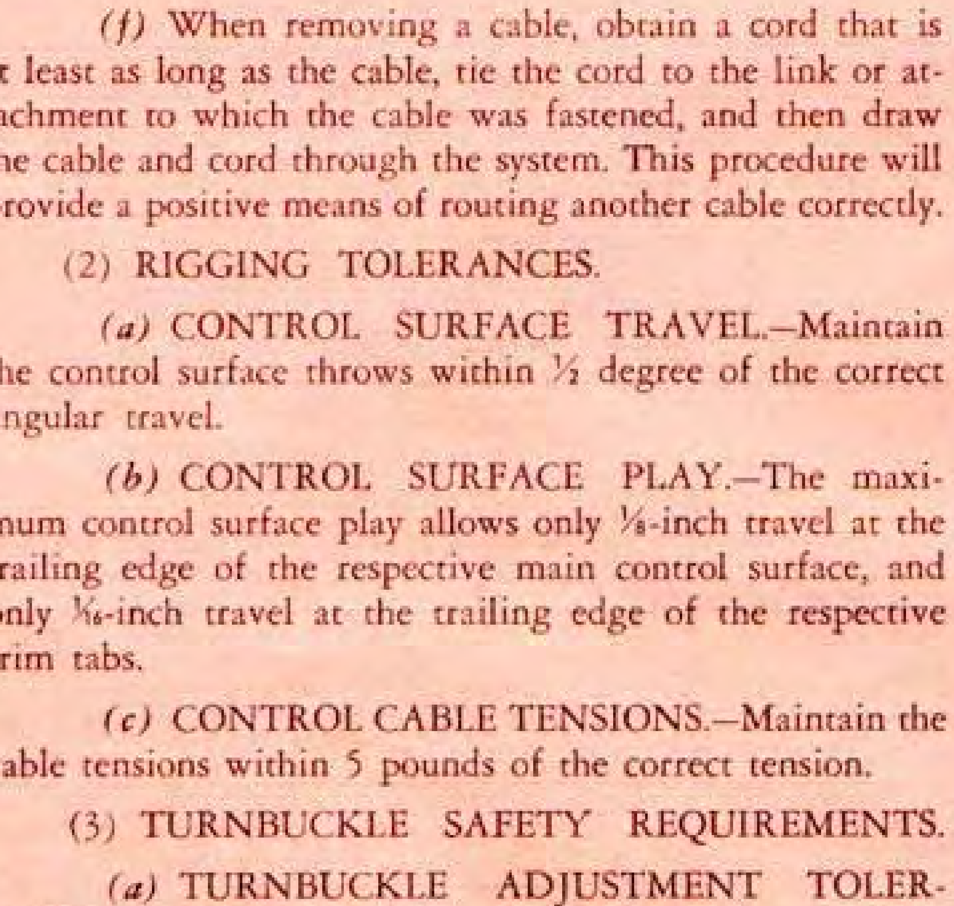



***Figure 96—Turnbuckle Safety Requirements***

*(b)* TURNBUCKLE SAFETY WIRE.—Safety turnbuckles on cable up to 1/8 inch in diameter with .032 wire. Safety turnbuckles on cable larger than 1/8 inch in diameter with .040 wire. Use brass or stainless steel wire. Tie the .032 wire with 5 to 6 wraps at each end of the turnbuckle barrel *(figure 96)*, and the .040 wire with 6 to 8 wraps.

(4) PUSH-PULL ROD SAFETY REQUIREMENTS. —All push-pull rods must be adjusted so that the threaded rod is visible through the inspection hole provided in the bearing or clevis end, and so that at least one thread is visible beyond the jam nut.

(5) DRILLED-HEAD BOLT SAFETY REQUIREMENTS.—Safety 3/8-inch and 5/16-inch drilled-head bolts with .051 wire, and safety No. 10 and 1/4 inch drilled-head bolts with .040 wire.

(6) GENERAL CAUTIONS.

*(a) Do not* use long-nose pliers with rough jaws when pulling or twisting safety wire. Rough jaws will scar and weaken the wire.

*(b) Do not* tighten one end of a turnbuckle before the other. If available, use some type of turnbuckle wrench.

*(c) Do not* twist the cable to shorten or lengthen it. This could result in the cable breaking the turnbuckle safety and becoming slack in flight. If the cable is too long or too short, *replace it.*

*(d) Do not* force turnbuckle on cable swages or clevis ends. If the turnbuckle binds, it is usually because the swage was not clean or was scarred and nicked at the threads.

*(e) Do not* adjust a turnbuckle without first breaking the safety wire.

*(f) Do not* use pliers on control bolts, turnbuckles, rods, etc. Use a good wrench that fits.

*(g) Never* use a cotter key twice.

**WARNING**

Failure to install a cotter key or safety wire may cost human lives.

*d.* SURFACE CONTROL CABLES.

(1) DESCRIPTION.—The control cables are fabricated of preformed tinned steel cable. The main control cable terminals are of the die-swaged friction type. The remaining cables are either sweat-soldered into tinned terminals or woven-spliced.

(2) CONTROL CABLE TENSIONS.—Cable adjustments should not be made with the airplane in the direct sun if any other location is available. The air temperature

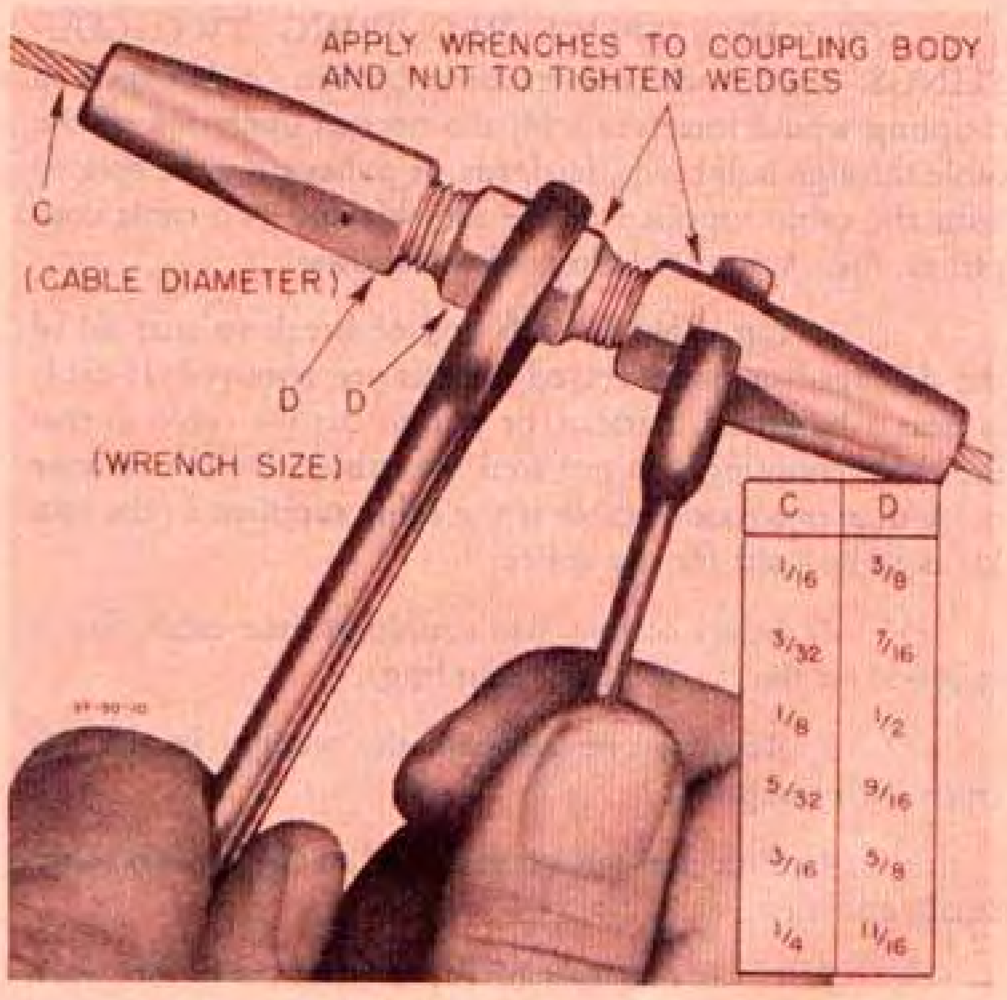



*Figure 97—Tightening Coupling Nuts*

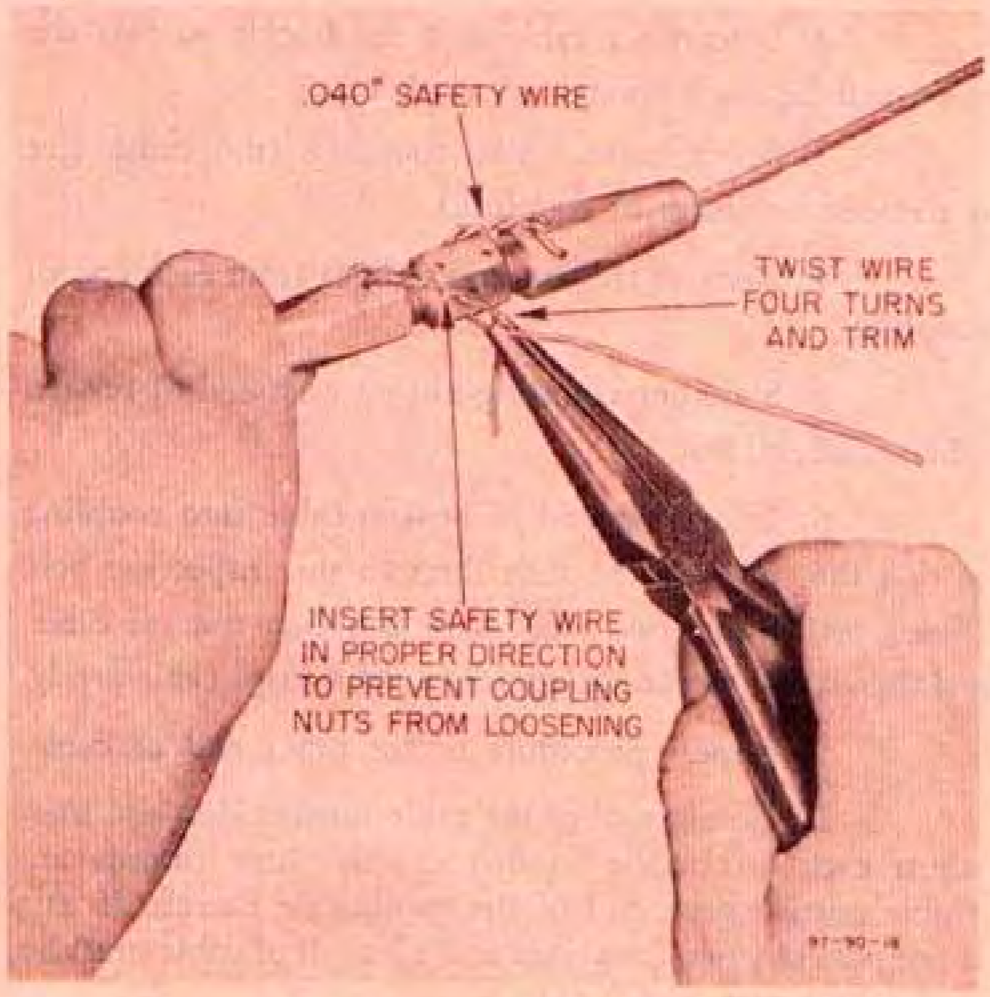



*Figure 97A—Safetying Cable Coupling*

around the airplane should be 21°C ± 3°C (70°F ± 5°F), if possible, because the aluminum alloy fuselage and the tinned steel cables do not expand and contract proportionately.

(3) CABLE MAINTENANCE SPLICE.—Cable splices may be made in minimum time by the use of a T56 cable coupling. This tool is especially valuable for use at a first or second echelon because it makes it unnecessary to remove the cables before splicing.

*(a)* CABLE COUPLING.—The coupling consists of a pair of chucks fitted on a single spindle. One chuck clamps on each end of the broken cable in such a way that the spindle bridges the broken section of the cable. *(See figure 98.)* As each end of the spindle has a right-hand thread, the coupling must be securely safetied to prevent the coupling nuts from loosening. When the coupling is in use, the cable should be bottomed in each spindle. An inspection hole in each end of the spindle shank makes it possible to determine an unsafe condition of the cable splice. Holes drilled through the corners of each nut and through each side of the spindle shank provide a means of safetying the coupling with brass or steel safety wire.

*(b)* CABLE SPLICE REQUIRING ONE COUPLING.—Cables which have been broken or damaged so that a very short length of cable is lost can be spliced with one coupling unless the coupling will interfere with the normal operation of the cable at a bulkhead, fairlead, or pulley. Install the cable coupling as follows:

*1.* Cut cable at each end of break so that all of the damaged or badly frayed strands are removed.

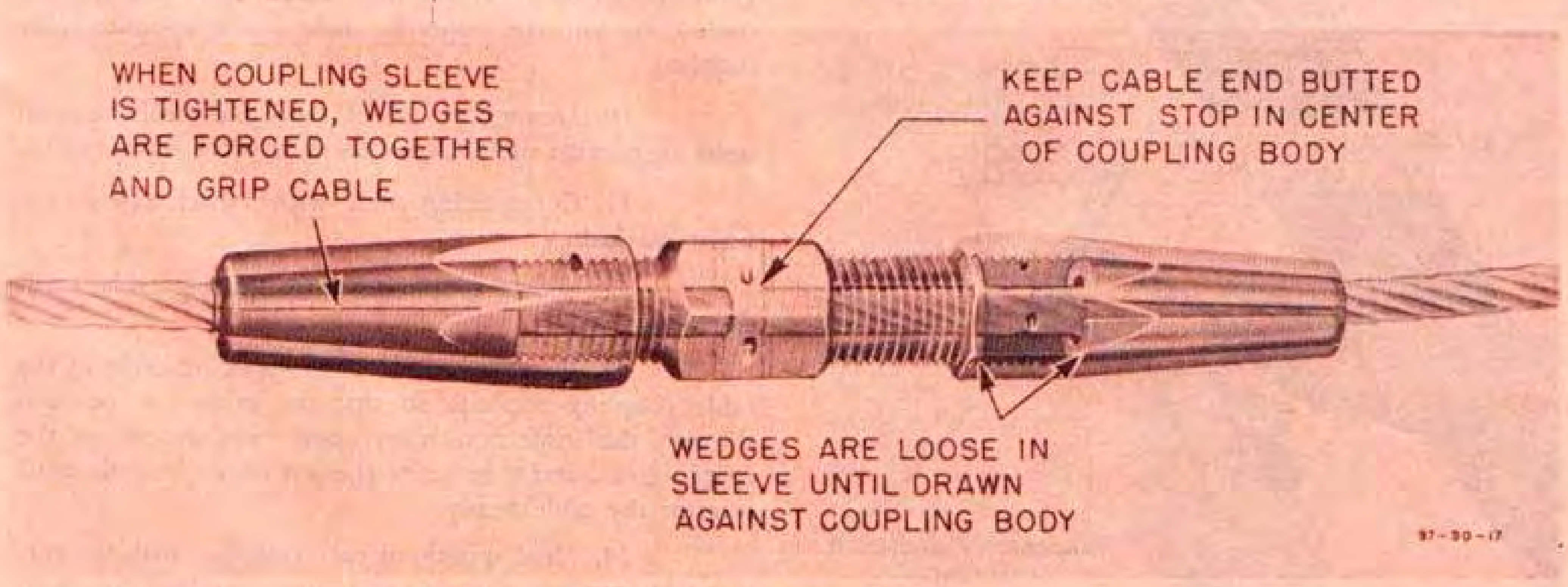



*Figure 98—Cable Coupling Detail*

*2.* Disconnect cable at a turnbuckle so that the cable will be slack enough to work on.

*3.* Select correct size coupling (the cable size is stamped on shank of coupling).

*4.* Remove the nut and wedges from each end of coupling.

*5.* Slide one coupling nut on each end of broken cable, small end first.

*6.* Insert one end of broken cable into coupling so that the cable can be seen through the inspection hole *(figure 98)*, insert two wedges in coupling nut on cable, and then screw nut on the spindle until it grips cable firmly.

*7.* Repeat procedure *6.* for other end of cable.

*8.* Connect all of the cable turnbuckles, and then adjust each turnbuckle so that exactly three threads are visible outside each end of the turnbuckle barrels. If this is not possible, two couplings and a length of cable must be used. *(See paragraph* (4) *(c).)*

*9.* Hold spindle of coupling with the correct size open-end wrench, and turn each coupling nut tight with another wrench. The nut is tight when the wedges are fully flush with the end of the nut.

*10.* Safety each coupling nut to coupling shank with .040 safety wire.

*11.* Rig the cable system.

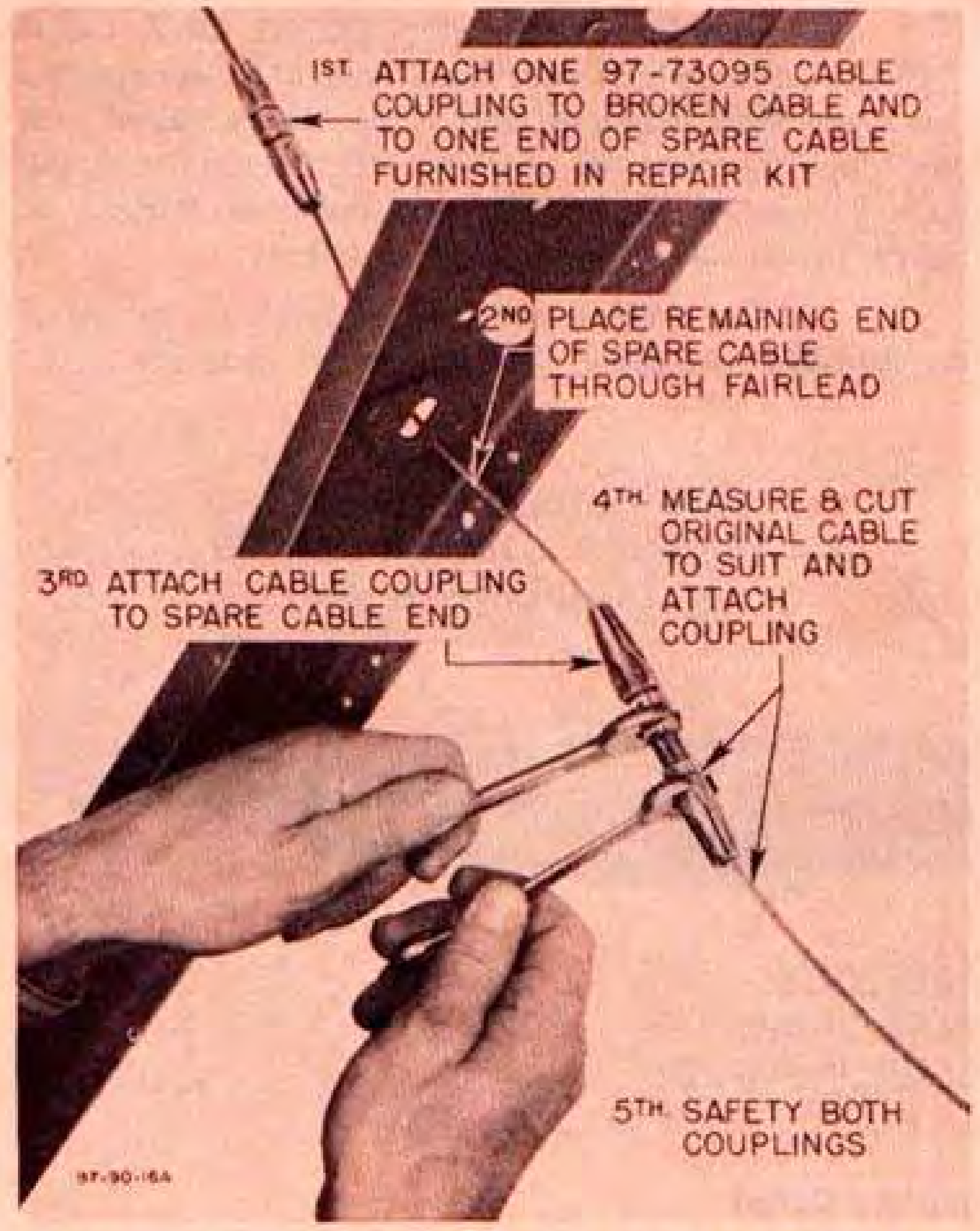



***Figure 99—Attaching Coupling Near a Fairlead***

*(c)* CABLE SPLICE REQUIRING TWO COUPLINGS.—Cables which have been broken or damaged so coupling would interfere with the normal operation of the cable through bulkheads, fairleads, or pulleys, may be spliced with the cable supplied in the tool kit and two cable couplings. *(See figure 99.)* Proceed as follows:

*1.* Cut cable at each end of break so that all of the damaged or badly frayed strands are removed. If cable is near a bulkhead, fairlead, or pulley, cut the cable so that the cable coupling will not foul the cables. Do not remove more than one foot of cable if the cable supplied in the tool kit is to be used for the splice.

*2.* Select correct size couplings (the cable size is stamped on the shank of the coupling).

*3.* Remove one nut and the wedges in the nut from each coupling.

*4.* Slide one nut on each end of the broken cable, small end first.

*5.* Insert one end of the broken cable into each coupling so that the cable can be seen through the inspection hole *(figure 98)*, insert two wedges in each coupling nut, and then screw the nut on spindle until it grips the cable firmly.

*6.* Cut the splicing cable so that all badly frayed strands are removed.

*7.* Insert one end of the splicing cable in one of the couplings (already attached to the broken cable) so that the cable can be seen through the inspection hole, slide the coupling nut on the cable, insert two wedges in the nut, and then screw the nut on spindle until it grips cable firmly.

*8.* Loosen all the turnbuckles on the cable until exactly three threads are visible at each end of the turnbuckle barrels.

*9.* Pull each end of the cable tight; then using a grease pencil or a wet indelible pencil, mark the splicing cable even with the inspection hole in the opposite cable coupling.

*10.* Disconnect one of the cable turnbuckles in order to provide the slack necessary to work on the cable.

*11.* Cut splicing cable with a hack saw at the point marked.

*12.* Slide a coupling nut on splicing cable, small end first.

*13.* Insert loose end of the splicing cable in the cable coupling opposite so that the cable can be seen through the inspection hole, insert two wedges in the coupling nut, and then screw the nut on the spindle until it grips the cable firmly.

*14.* Hold spindle of each coupling with the correct size open-end wrench and tighten coupling nuts with another wrench. The nut is tight when the wedges are fully flush with the end of the nut.

*15.* Safety each coupling nut to the respective coupling shank with .040 safety wire.

*16.* Connect all of the cable turnbuckles and rig the cable system.

*e.* CONTROL STICK.

(1) DESCRIPTION.—The control stick is a swaged tube of aluminum alloy, the upper end of which is fitted with a plastic pistol-type grip. The lower end of the tube is fitted into a socket which is mounted in a trunnion-like manner on a fitting integral with the aileron torque tube. The aileron torque tube has stops to limit the movement of the ailerons. *(See figure 101.)*

*f.* SURFACE CONTROL LOCK.

(1) DESCRIPTION.—The surface control locking mechanism is installed forward of the base of the control column. *(See figure 101.)* The lock is an inverted V-shaped bracket, slotted at the top and fitted with a spring-loaded plunger which will engage either of two holes in the locking flange on the control stick. Engaging the lock in the upper hole locks the ailerons and rudder in the neutral position and the elevators in the down position. Engaging the plunger in the lower hole locks all the control surfaces in the neutral position.

**Note**

The position of the control stick also controls the tail wheel lock.

*g.* INSTALLATION, REMOVAL, AND ADJUSTMENT OF CONTROL STICK AND SURFACE CONTROL LOCK ASSEMBLY. *(See figures 100 and 101.)*

*h.* AILERON CONTROL SYSTEM.

(1) DESCRIPTION.—The movement of the ailerons is controlled by the lateral movement of the stick. The ailerons are not differentially controlled. Movement of the control stick simultaneously imparts movement to both ailerons from a V-shaped bellcrank on the aft end of the control stick torque tube. Linkage attaches the aileron bellcrank to the inboard cable sectors, fastened to the rear spar, and by means of cable imparts the movement of the control stick to the outboard cable sectors. *(See figure 102.)* The outboard sectors impart the movement to a fork and block assembly integral with the aileron. *(See figure 104, detail A.)* The aileron bellcrank has three link attachment holes on each arm. By attaching the link at the desired hole, aileron travel of 10, 12, or 15 degrees up and down can be obtained. Aileron travel is limited by adjustment bolts located at the base of the control stick. Access to the aileron cables is gained by removing the aft wing-to-fuselage fairing and disconnecting the flap actuating linkage.

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF THE AILERON CONTROL SYSTEM. *(See figure 104.)*

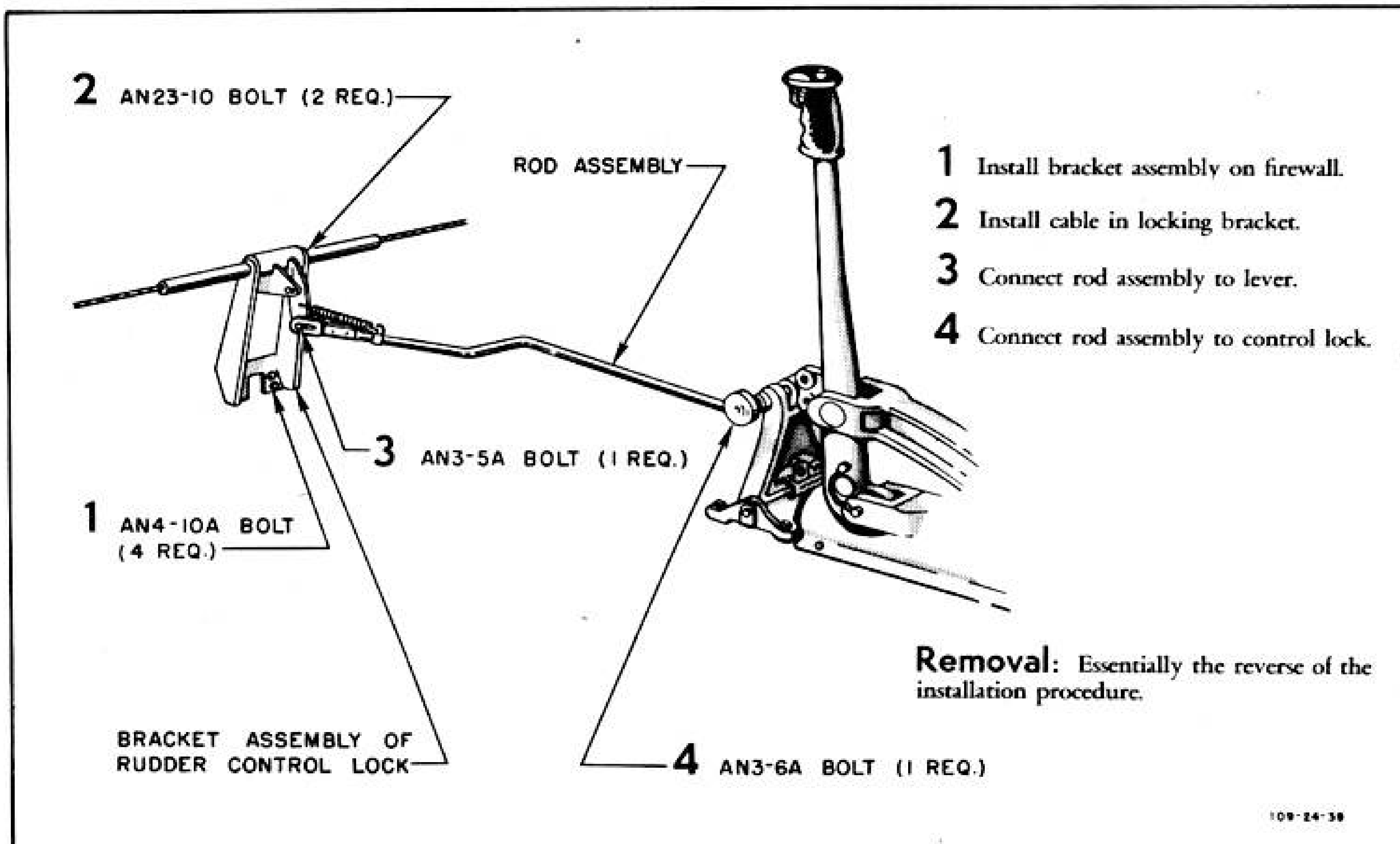
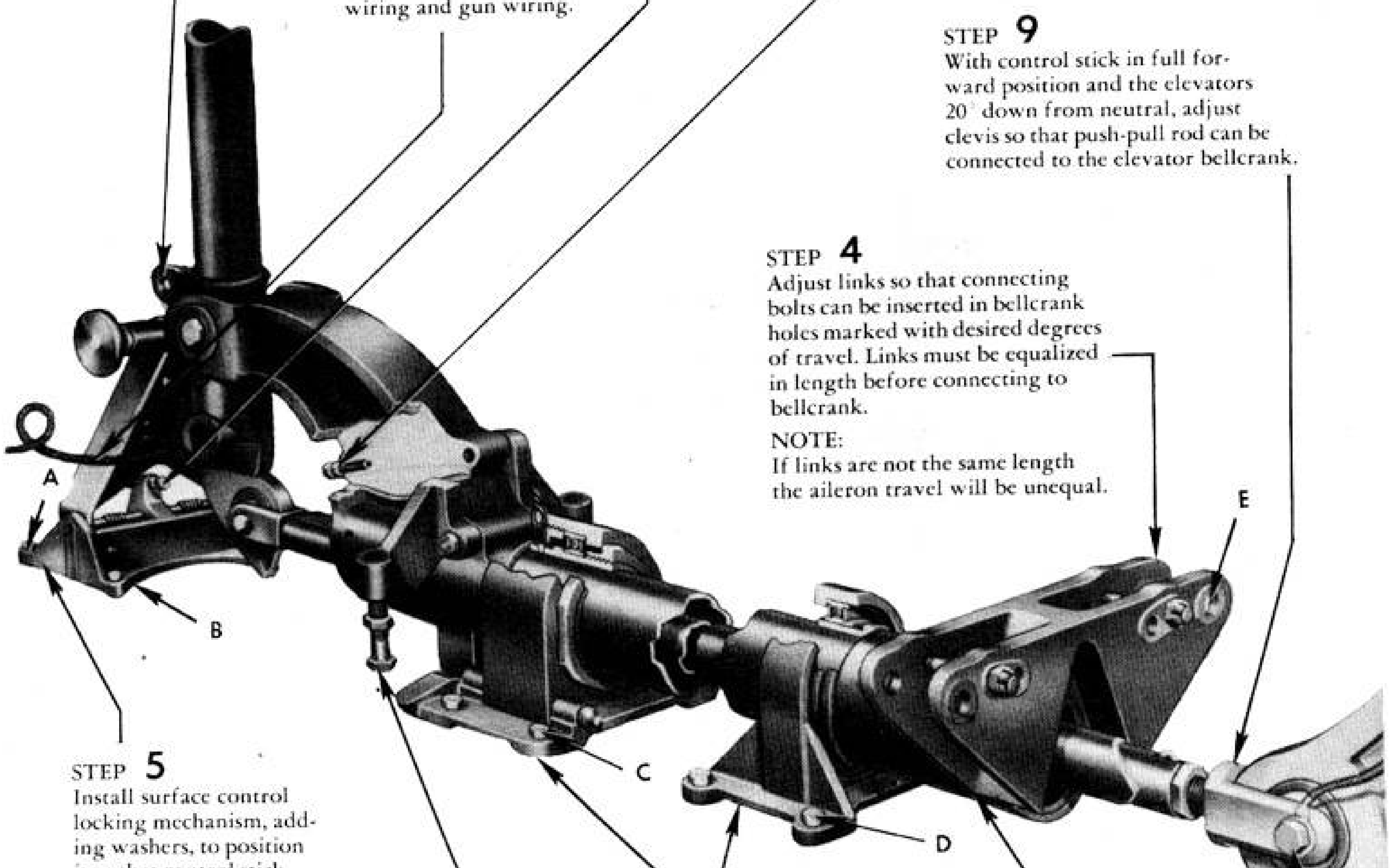



*Figure 100—Rudder Locking Mechanism*




A AN5-17A bolt (2 req.)
B AN4-7A bolt (2 req.)
C AN4-7A bolt (4 req.)
D AN4-7A bolt (4 req.)
E AN5-16 bolt (2 req.)
F AN25-22 bolt (1 req.)

**REMOVAL:** Essentially the reverse of installation procedure with following exception: *To gain access to control stick assembly remove seat and armor plate, control stick shroud, and cockpit floor boards.*

104-52-84A

***Figure 101—Installing Control Stick and Locking Mechanism***

(3) CHECKING AILERONS FOR WARP. *(See figure 103.)*

*i.* AILERON TRIM TAB CONTROL SYSTEM.

(1) DESCRIPTION.—The trim tab on the right aileron is a fixed tab and adjustable on the ground only. The trim tab on the left aileron is controllable from the cockpit. *(See figure 106.)* The aileron trim tab control knob on the control pedestal is connected to the inboard cable drum by a chain. Cables from the inboard cable drum extend to the outboard cable drum which is mounted in a housing secured to the rear spar of the wing at the inboard end of the aileron. The tab is limited to a travel of 10 degrees up and down from neutral by cable stops just inboard of the aileron. To gain access to the cables, remove the wing trailing edge to fuselage fairing, disconnect the flap hinge link to lower the flap, and remove the aileron.

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF AILERON TRIM TAB CONTROL SYSTEM. *(See figure 105.)*

(3) ADJUSTING FIXED TAB LINKAGE ON RIGHT-HAND AILERON.

*(a)* Engage the surface control lock.

*(b)* Adjust the link which secures the tab in neutral so that the tab is in direct alignment with the aileron trailing edge.

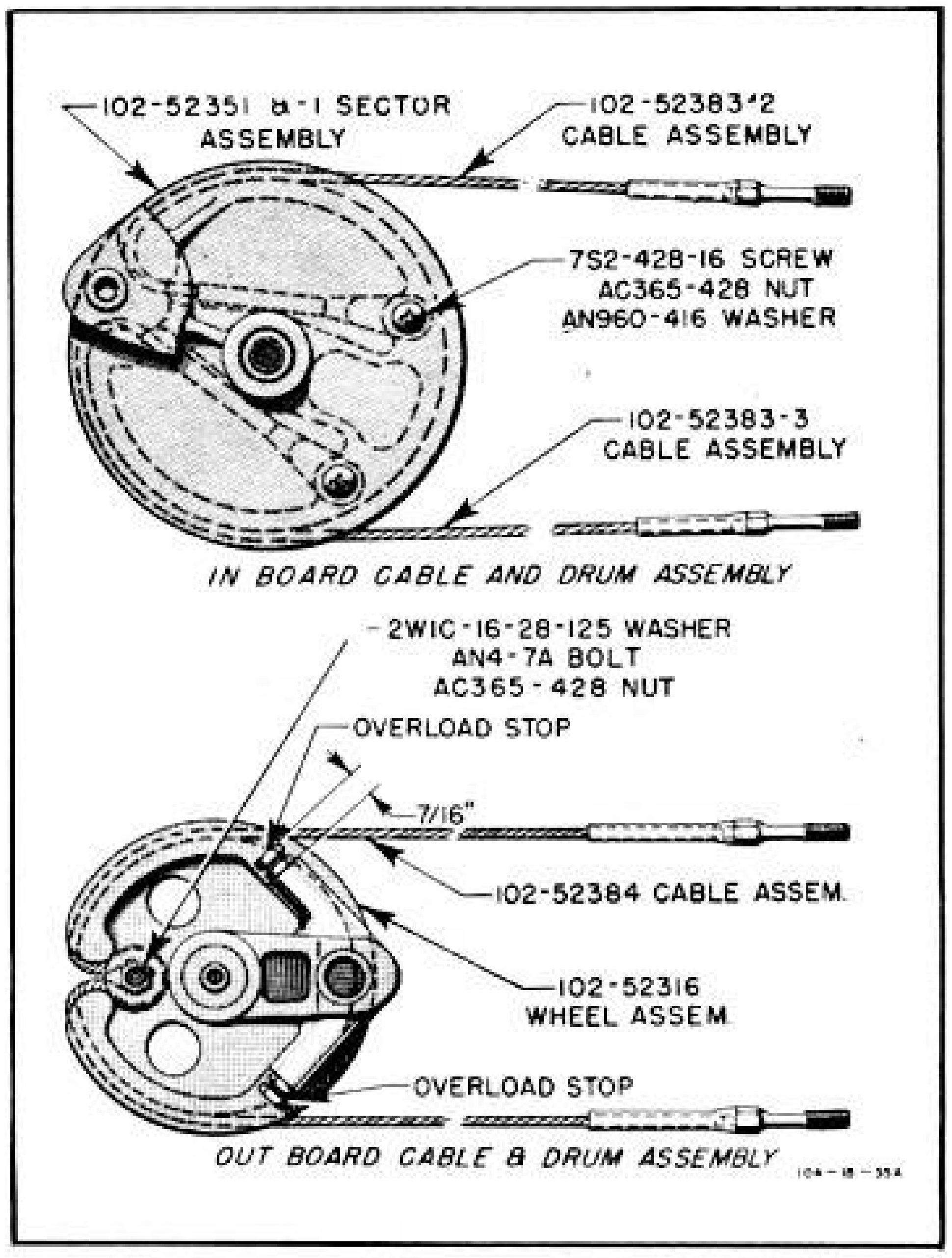



**Figure 102—Aileron Cable Sectors**

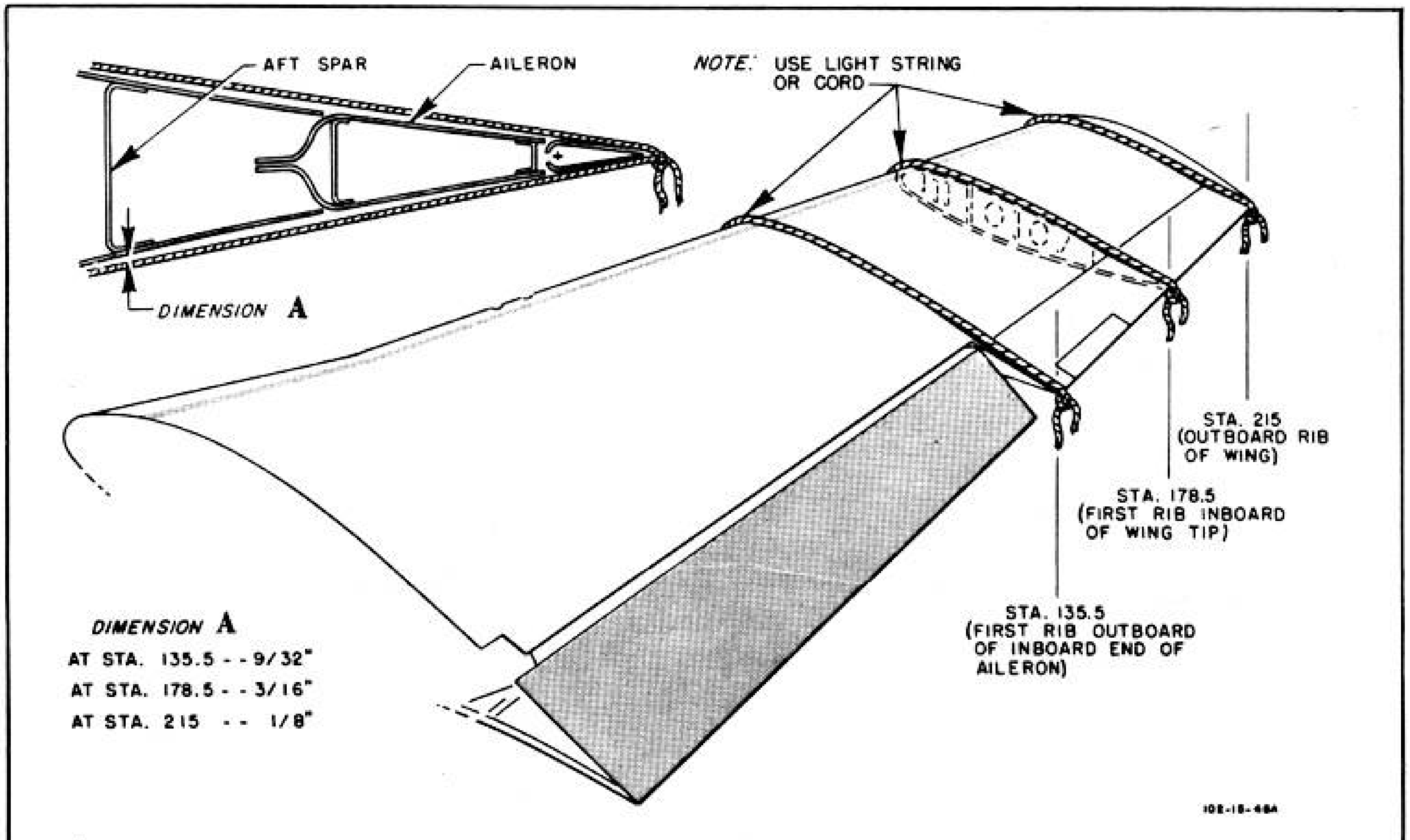
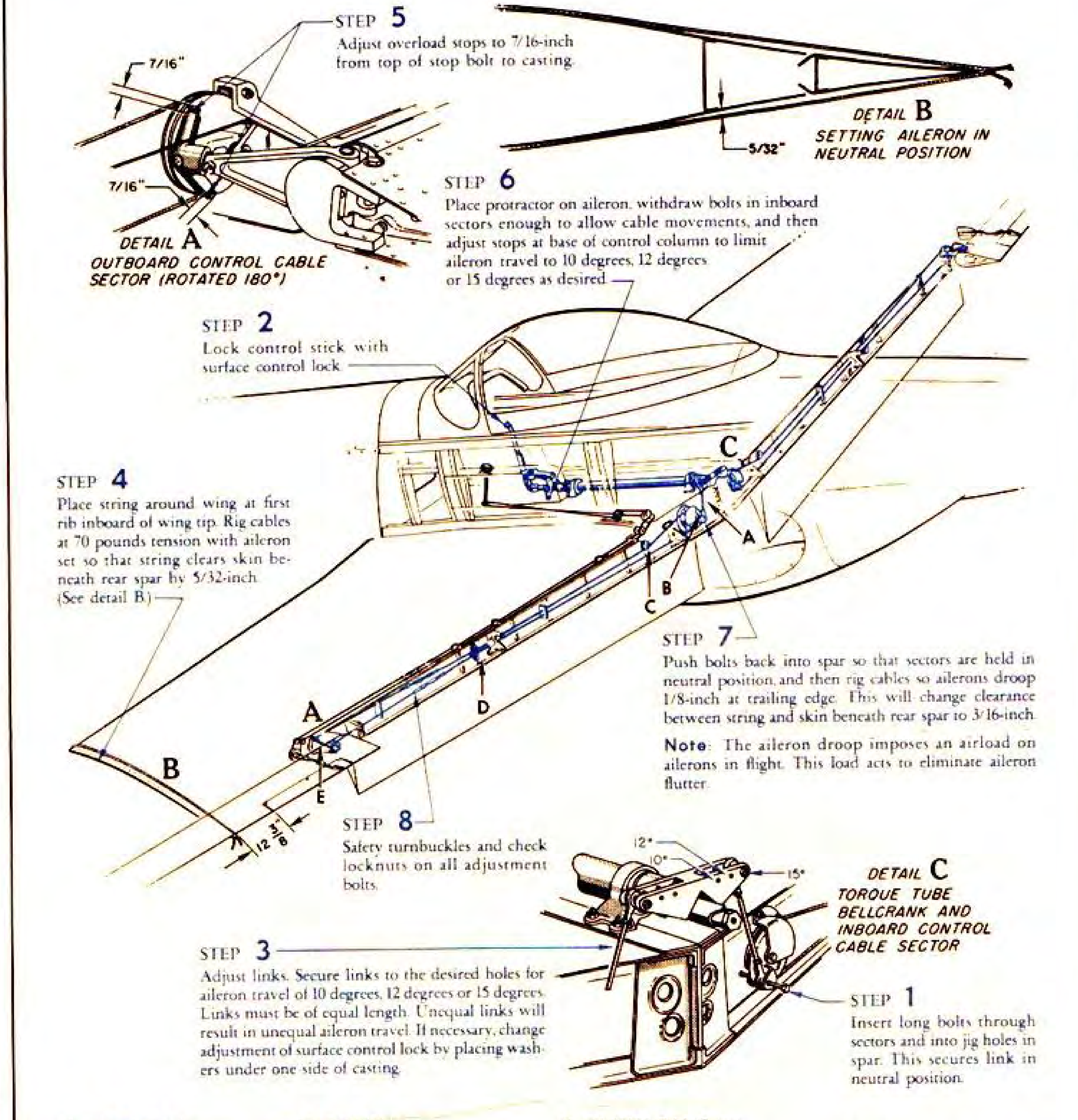



**Figure 103—Checking Aileron for Warp**




**A** 102-52364 Link
AN5-16 Bolt

**B** 102-52393 Cable Sector
102-52387 Bushing
AN6-30A D.H. Bolt

**C** 4B2-R36 Spacer
AN210-3A Pulley

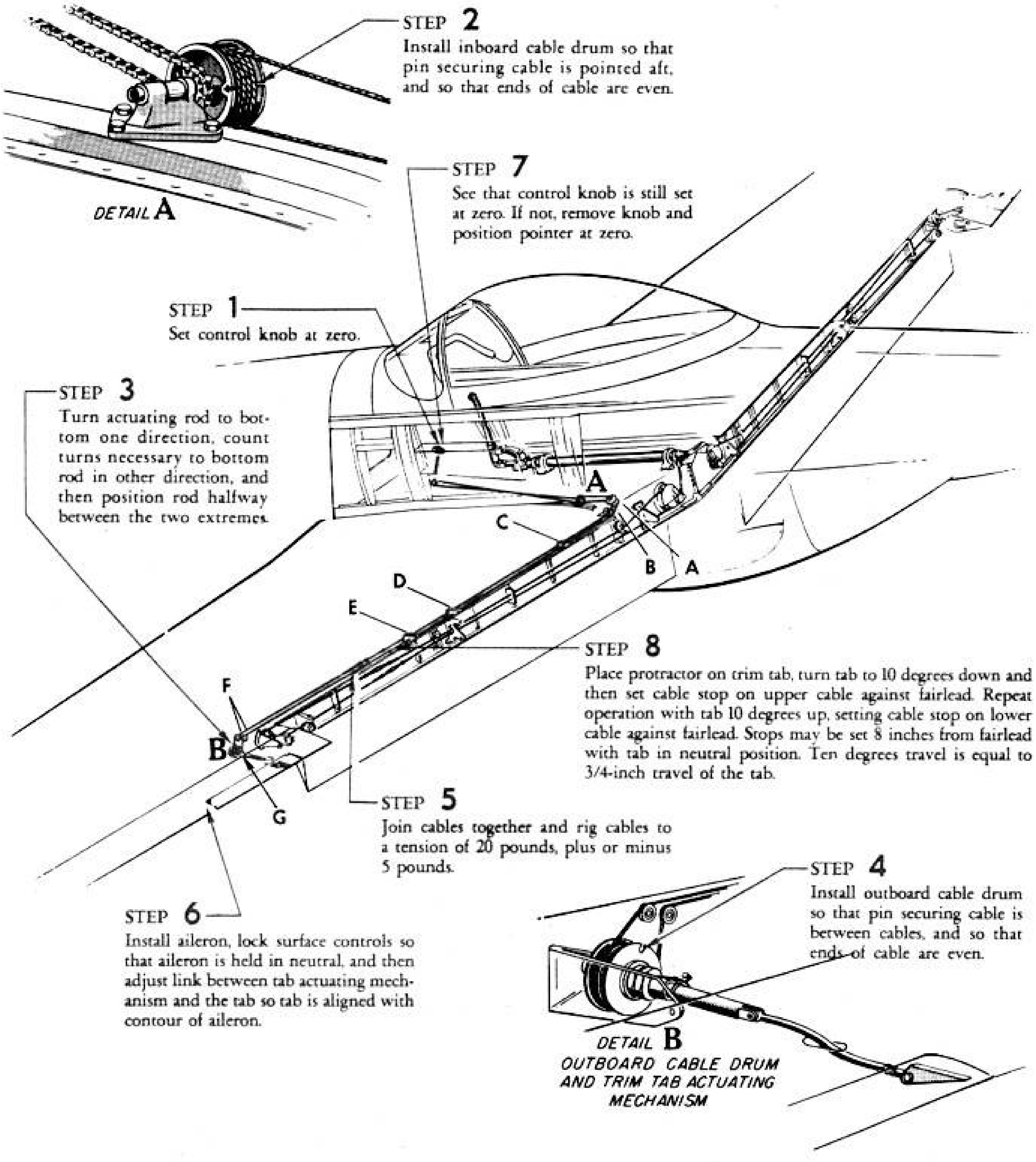
**D** AN210-3A Pulley (2 Req.)
AN4-20 Bolt (2 Req.)

**E** 102-52394 Cable Sector
AN4-34A D.H. Bolt
73-52317 Fork Assembly
73-52379 Block
AN5-20 Bolt

**NOTE:** R.H. aileron cable installation similar to L.H.

103-52-95

*Figure 104—Aileron Control System*




| | | | | | |
|---|---|---|---|---|---|
| A | AN210-2A Pulley (2 Req.)<br>AN3-10 Bolt (2 Req.)<br>7S2-1032-11 Screw (3 Req.) | C | 73-525101 Fairlead<br>7S2-832-7 Screw | F | 102-16018 Pulley (2 Req.)<br>AN3-14 Bolt<br>(Install AN380-3-5 cotter as guard pin) |
| | | D | 102-52147 Fairlead<br>AC530-8-6 Screw | | |
| B | AN210-1A Pulley (2 Req.)<br>AN3-11 Bolt (1 Req.)<br>7S2-1032-9 Screw (2 Req.) | E | 102-525143 Fairlead<br>7S2-832-11 Screw | G | 106-52584 Tab Actuating Mechanism<br>AN3-5A Bolt (4 Req.) |

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*Figure 105—Aileron Trim Tab Control System*

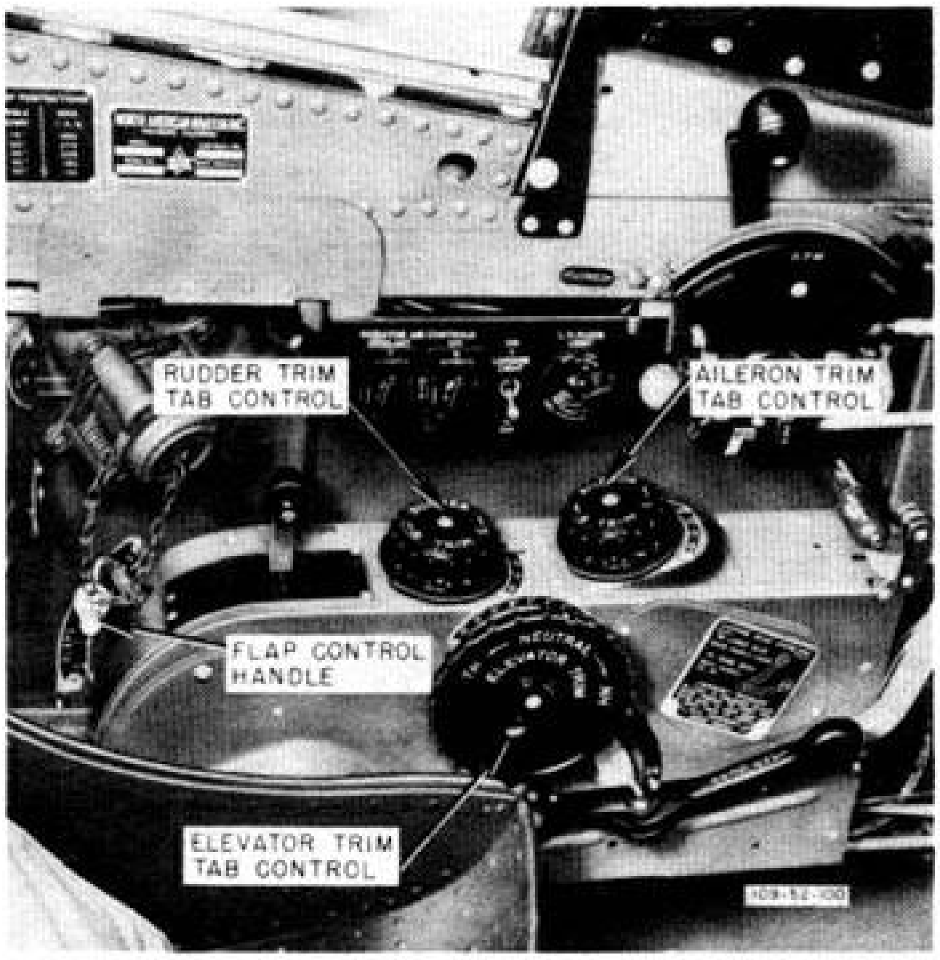



***Figure 106—Cockpit Pedestal Controls***

(4) AILERON TRIM TAB ACTUATING MECHANISM.—The aileron trim tab actuating mechanism consists of a housing bolted to the wing trailing edge structure, a cable drum assembly, and actuating shaft. The actuating shaft engages the threads in the cable drum. When the cable drum is rotated, the actuating shaft is threaded either fore or aft, as the actuating shaft is prevented from turning by a setscrew in the aft end of the housing. The fore-and-aft movement of the actuating shaft moves the tab up or down through an adjustable link. *(See figure 107.)*

*j.* ELEVATOR CONTROL SYSTEM.

(1) DESCRIPTION.—The elevators are controlled by the fore-and-aft movement of the control stick. A push-pull rod connects the control stick to the elevator bellcrank mounted on the flap torque tube. *(See figure 108.)* A dual set of cables extends aft from the bellcrank to the elevator horn assembly which is pivoted on a bracket in the horizontal stabilizer. *(See figure 108.)* Elevator travel is limited to 30 degrees up and 20 degrees down by adjustment bolts on the base of the control stick and surface control lock. *(See figure 101.)* To gain access to the elevator cables, remove the dzus-fastened dome at the aft end of the radiator air scoop, and the fairing attached to the dorsal fin, the horizontal stabilizer, and the vertical stabilizer; also remove the access door below the horizontal stabilizer and the wing trailing edge to fuselage fairing.

**Note**

An elevator bobweight of approximately 20 pounds is fastened to the upper arm of the elevator bellcrank on later airplanes.

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF THE ELEVATOR CONTROL SYSTEM. *(See figure 108.)*

*k.* ELEVATOR TRIM TAB CONTROL SYSTEM.

(1) DESCRIPTION.—A controllable trim tab is installed on each elevator. The tabs are operated by a wheel on the pilot's control pedestal. *(See figure 106.)* Control cables extend aft from a cable drum connected to the control wheel, through the fuselage to the center of the horizontal stabilizer, and then outboard to a cable drum in each side of the stabilizer. *(See figure 109.)* The actuating screw is threaded into the cable drum and moves fore and aft as the cable drum is rotated. Linkage connects the actuating screw to the tab and the fore-and-aft movement of the actuating screw moves the tab up and down. The movement of the tabs is limited to 10 degrees up and 25 degrees down, by cable stops just forward of the horizontal stabilizer. *(See figure 109.)*

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF THE ELEVATOR TRIM TAB CONTROLS. *(See figure 109.)*

*l.* RUDDER PEDAL ASSEMBLY.

(1) DESCRIPTION.—A hanging-type rudder pedal assembly is suspended by two blocks bolted to brackets on each side of the fuselage. The pedals are adjustable for leg length by means of a spring-loaded release on the inboard side of each pedal.

(2) INSTALLATION AND REMOVAL OF RUDDER PEDAL ASSEMBLY. *(See figure 110.)*

*m.* RUDDER CONTROL SYSTEM.

(1) DESCRIPTION.—The rudder control cables extend aft from each pedal to a bellcrank in the aft end of the fuselage. *(See figure 111.)* A rudder pedal balance cable, extending forward from one pedal, across the fuselage,

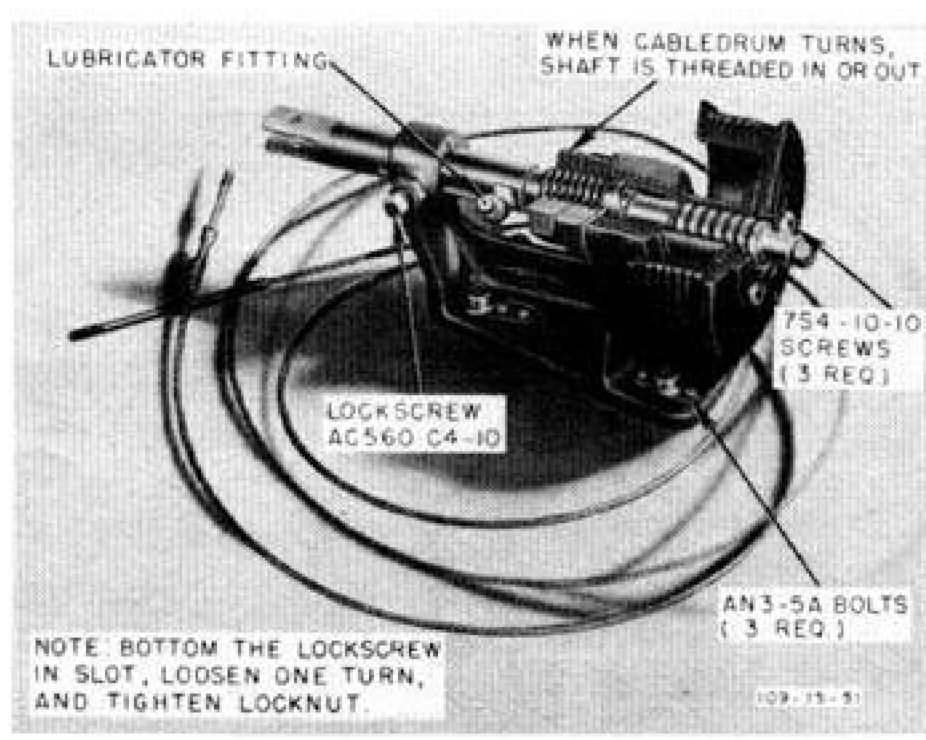



***Figure 107—Aileron Trim Tab Actuating Mechanism***

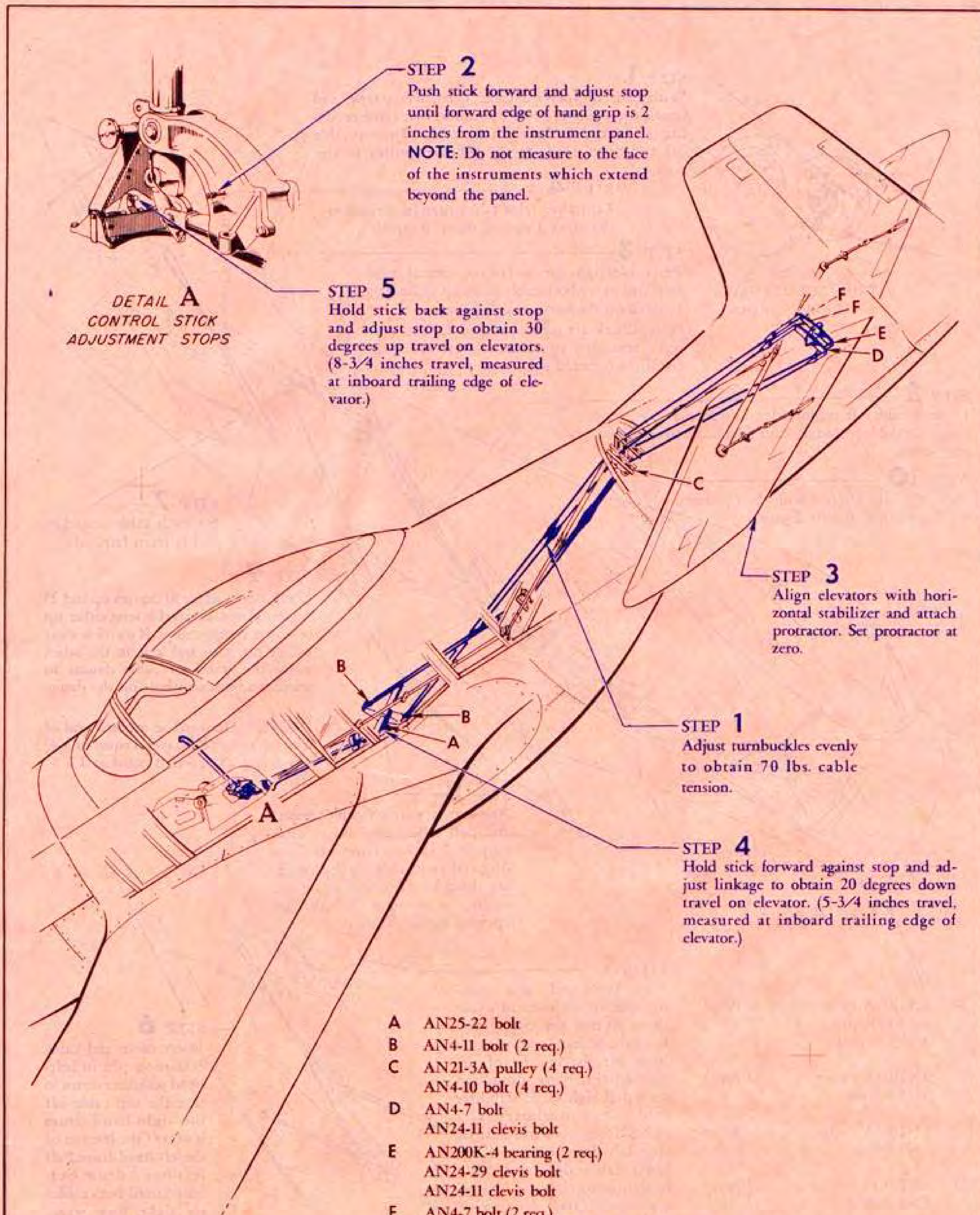



*Figure 108—Elevator Control System*

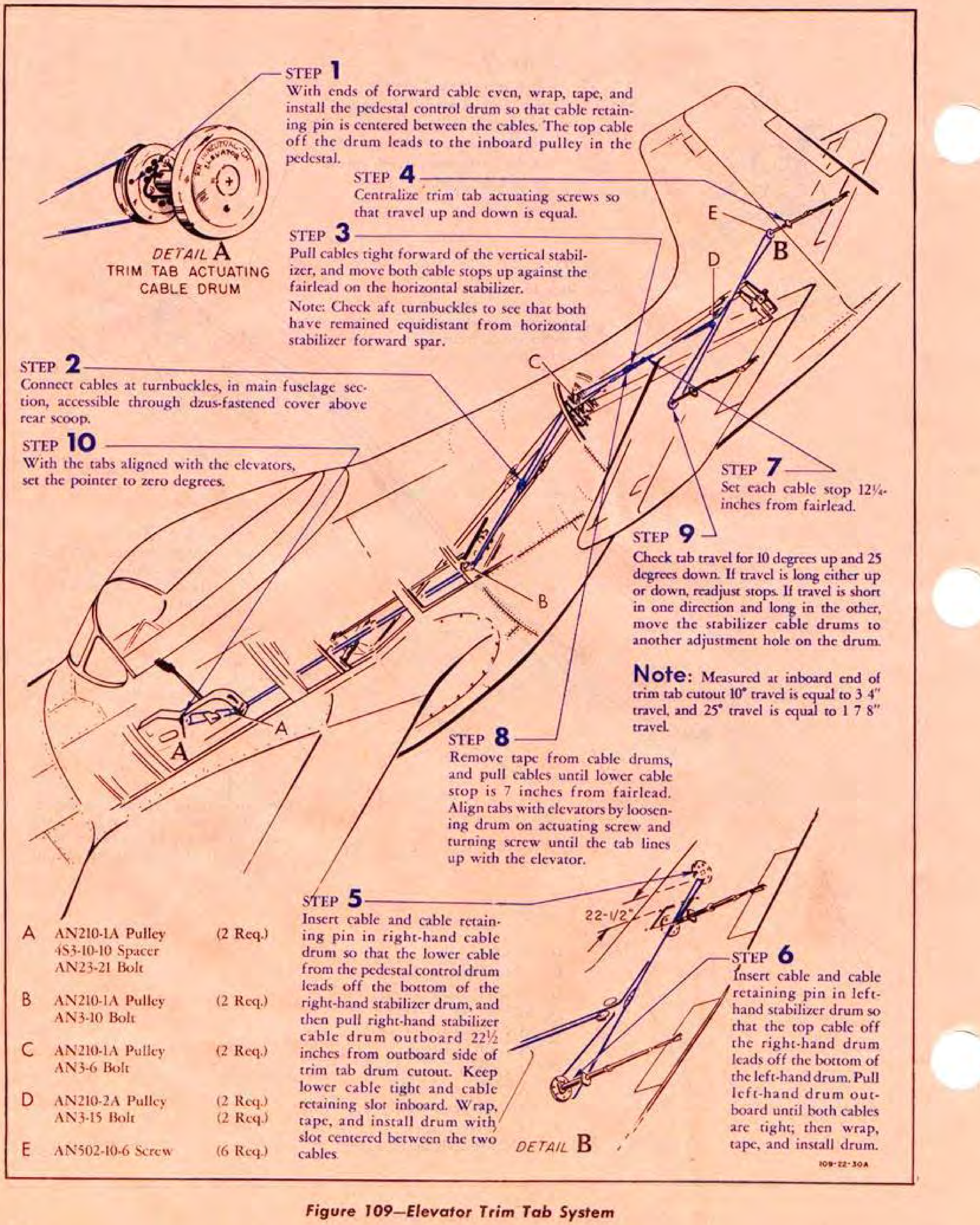
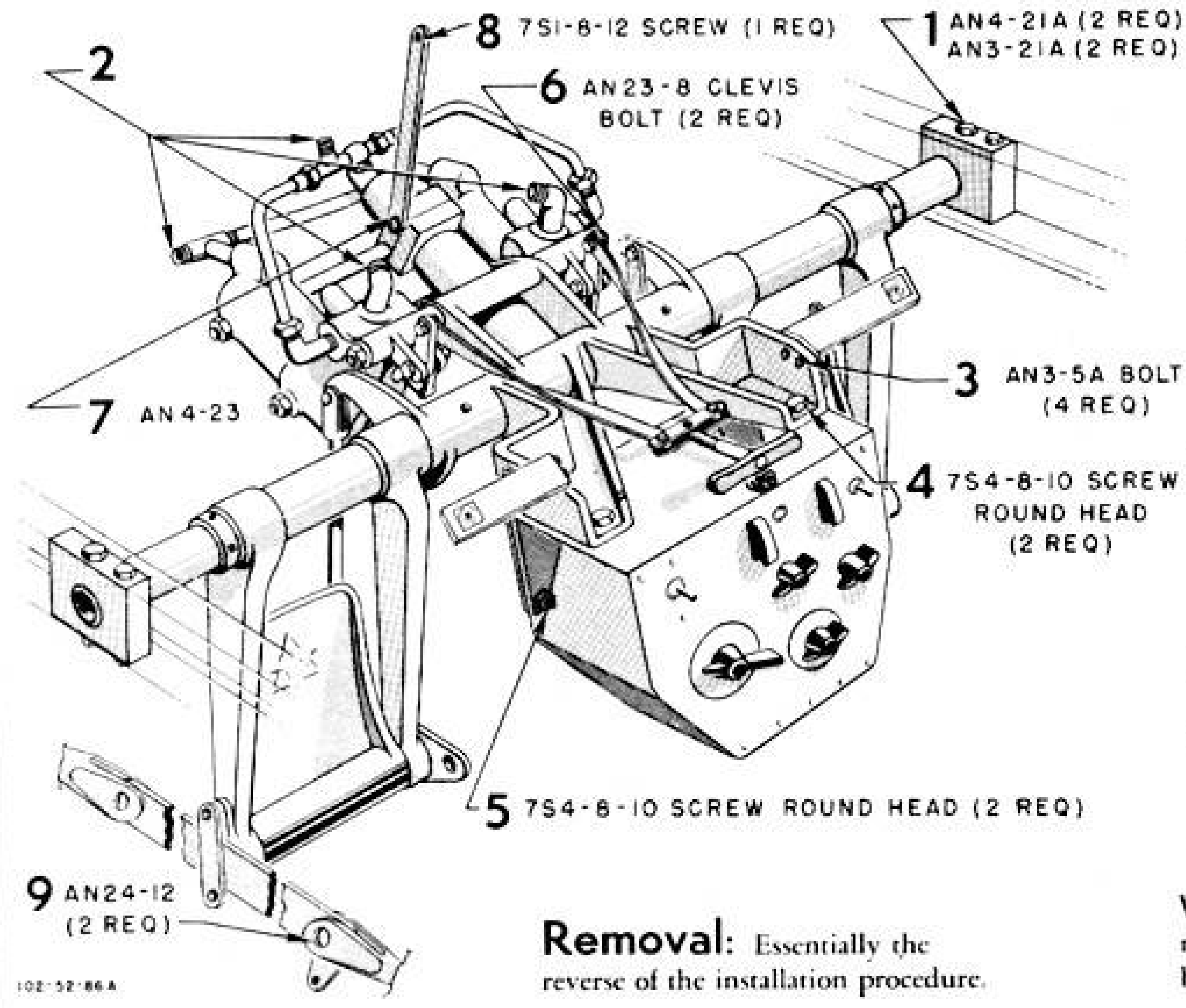



*Figure 109—Elevator Trim Tab System*




**Removal:** Essentially the reverse of the installation procedure.

**1** Insert rudder pedal assembly through opening forward of windshield, and maneuver rudder suspension bar into brackets on sides of fuselage. Install bolts through brackets and blocks.

**2** Connect hydraulic lines.

**3** Install bolts attaching bracket to Lord mounts.

**4** Install screws attaching bracket to front switch panel.

**5** Install screws attaching lower bracket to front switch panel.

**6** Connect parking brake lever.

**7,8** Connect brace to brake compensator valve and to generator control box.

**9** Install rudder cables.

**WARNING:** If possible, repair without removal, as the proximity of other assemblies renders removal difficult.

***Figure 110—Installing Rudder Pedal Assembly***

and then aft to the other pedal, maintains a constant tension forward on each pedal. A push-pull rod connects the rudder bellcrank to the rudder actuating horn; the horn is an integral part of the rudder lower hinge casting. Rudder travel is limited to 30 degrees each side of the neutral position by stops on the rudder bellcrank assembly. *(See figure 111, detail B.)* To gain access to the rudder cables, remove the dzus-fastened dome at the aft end of the radiator air scoop, the access covers on the right side of the fuselage below the horizontal stabilizer, and the aft wing-to-fuselage fairing.

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF THE RUDDER CABLE SYSTEM. *(See figure 111.)*

*n.* RUDDER TRIM TAB CONTROL SYSTEM.

(1) DESCRIPTION.—A controllable trim tab is installed on the rudder. The trim tab is operated by a control knob on the pilot's control pedestal. Reverse boost is imparted to the tab by the link rod. Control cables from the cable drum connected to the control knob extend aft through the fuselage to a point aft of the tail wheel installation, and then up to the cable drum in the vertical stabilizer. *(See figure 112.)* The actuating mechanism is similar to that of the aileron tab. *(See figure 107.)* The tab is limited to an angular travel of 10 degrees each side of neutral by cable stops forward of the rear section bulkhead. To gain access to the rudder trim tab cables, remove the dzus-fastened dome at the aft end of the radiator air scoop, remove access covers on left side of fuselage, remove access cover below the horizontal stabilizer, and remove the access cover on the left side of the vertical stabilizer.

**Note**

On early P-51D Airplanes, without the dorsal fin installation, the rudder trim tab is not set to boost.

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF RUDDER TRIM TAB SYSTEM. *(See figure 112.)*

*o.* WING FLAP CONTROL SYSTEM.

(1) DESCRIPTION.—The wing flaps are operated by a hydraulically actuated strut located on the right-hand side of the fuselage above the radiator air scoop. The strut piston is connected to a bellcrank integral with the flap torque tube, and the torque tube is connected to the flap hinge casting by a short adjustable link. *(See figure 113.)* The flaps have a movement of 47 degrees down from the neutral position, and are selectively controlled by a control handle on the aft end of the control pedestal. *(See figure 106.)* The sector of the control handle is slotted in the positions

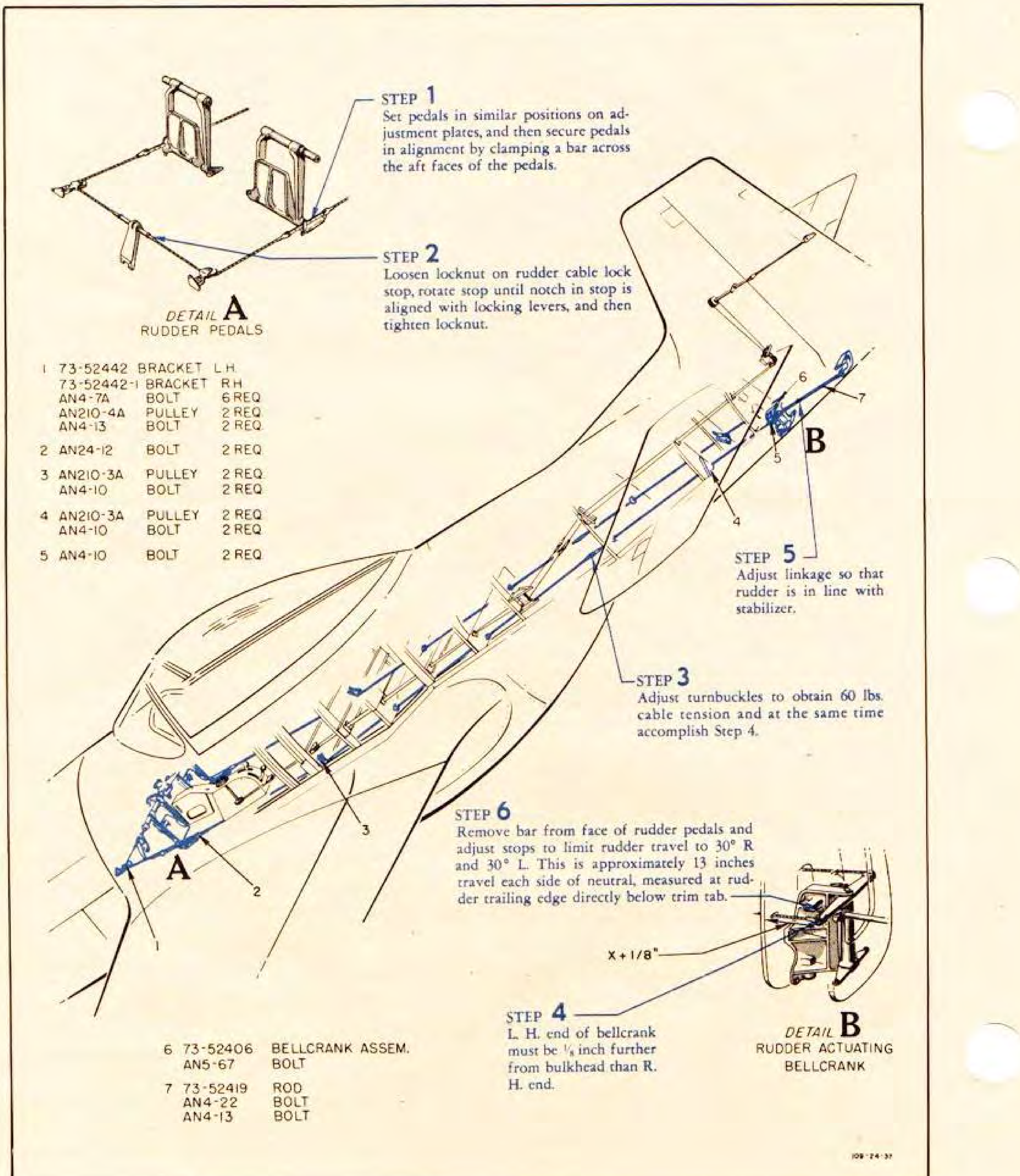



*Figure 111—Rudder Control System*

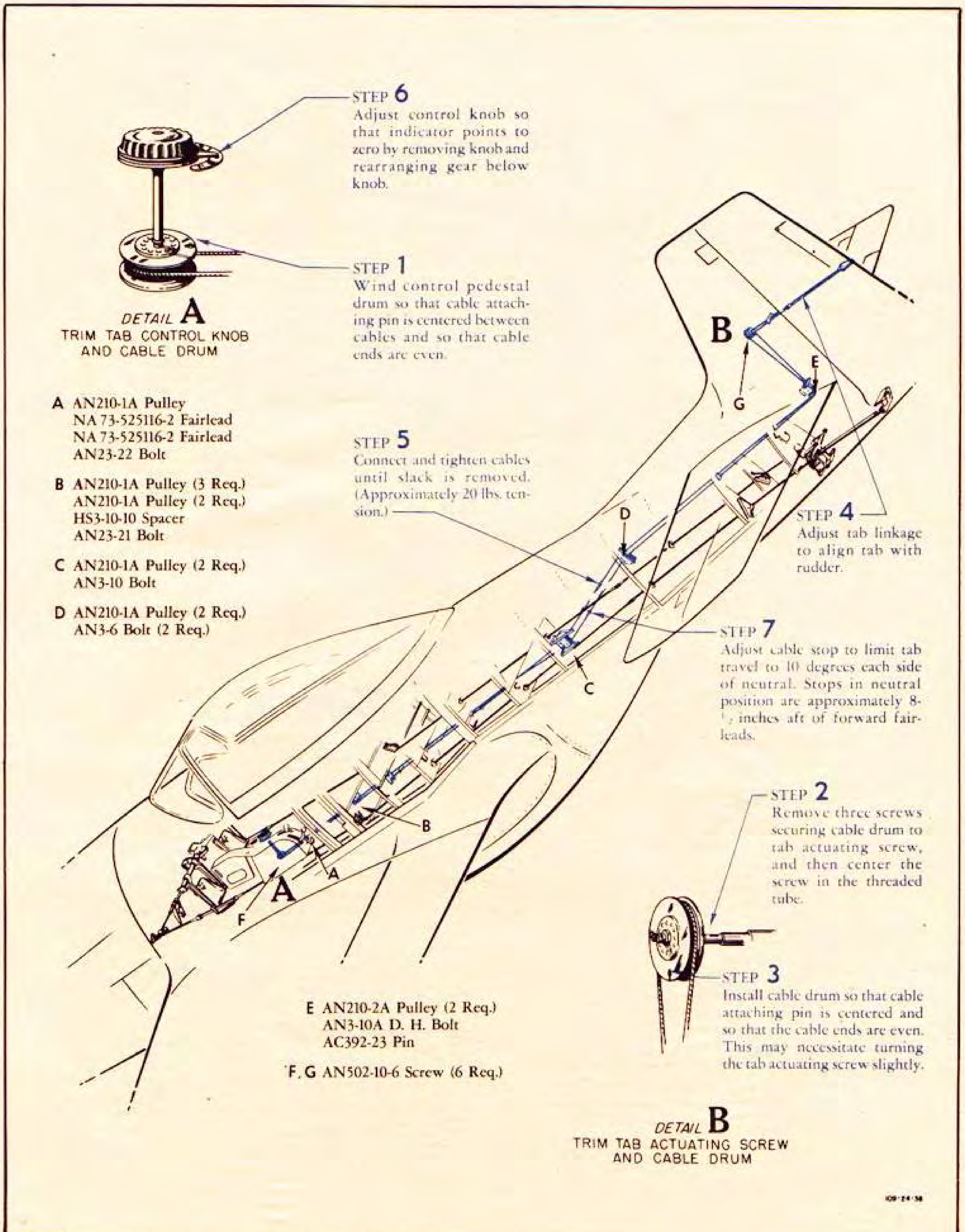



*Figure 112—Rudder Trim Tab Control System*

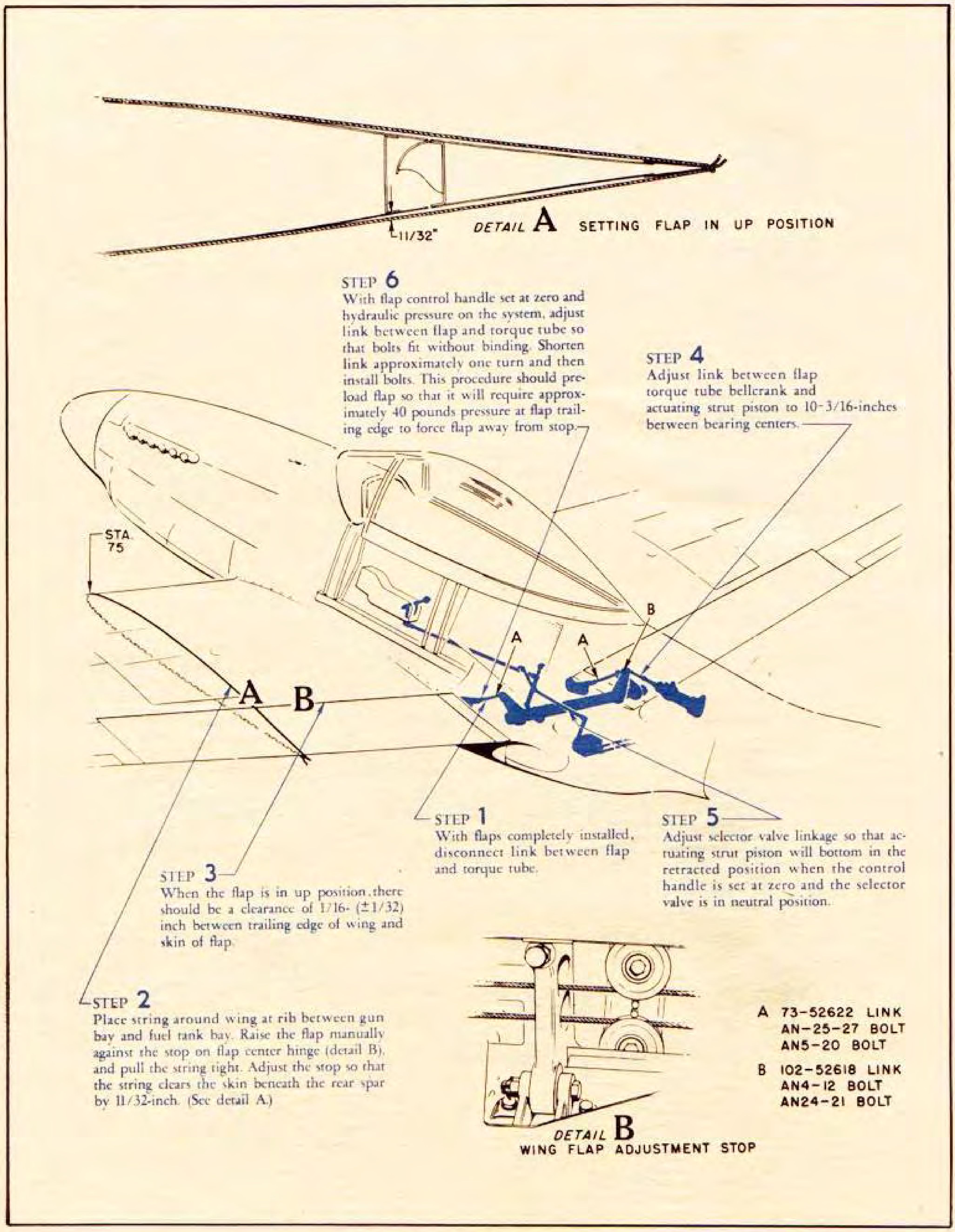



*Figure 113—Flap Control System*

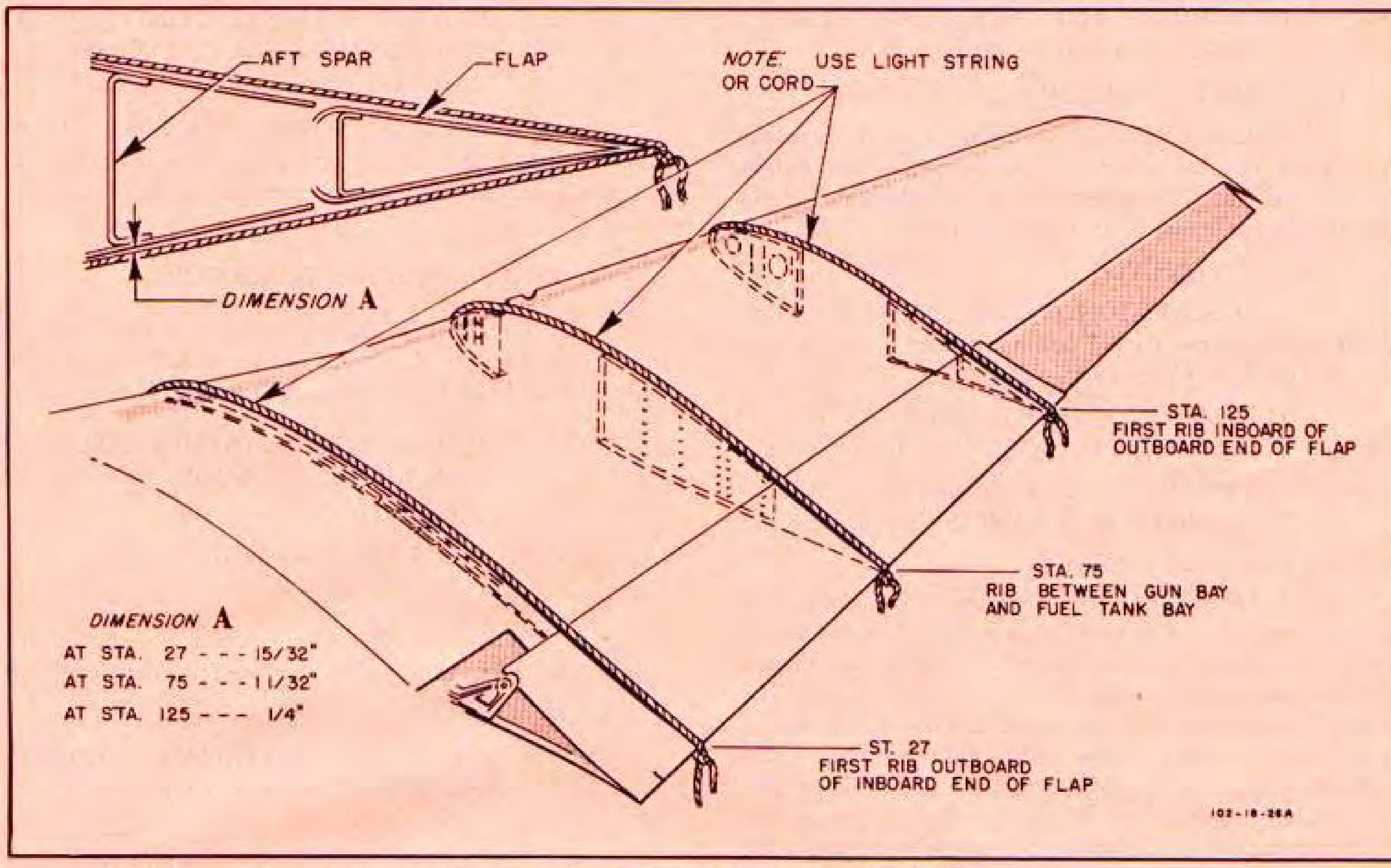



***Figure 114—Checking Wing Flaps for Warp***

which indicate each 10 degrees of flap movement. The control handle may be placed in any one of the slotted positions and hydraulic pressure will move the flap to the indicated angular position.

(2) INSTALLATION, REMOVAL, AND ADJUSTMENT OF THE WING FLAP SYSTEM. *(See figure 113.)* —The adjustment procedure for the flap preselector linkage is given in section IV, paragraph 19. *i.* (2).

(3) CHECKING FLAPS FOR WARP. *(See figure 114.)*

**4. FUSELAGE.**

*a.* GENERAL DESCRIPTION. *(See figure 115.)*—The fuselage is semimonocoque in design and, with exception of the armor plate firewall and armor plate aft of the pilot's seat, is fabricated of aluminum alloy. The fuselage is made up of three sections: engine mount *(paragraph 7)*, main section, and rear section, bolted together.

*b.* REMOVING AND INSTALLING FUSELAGE. *(See paragraph* 1. *b. and c.)*

*c.* FUSELAGE MAIN SECTION.

(1) DESCRIPTION. *(See figure 115.)*—The fuselage main section is constructed around four longerons. The upper longerons, extruded H sections, extend aft from the firewall, and terminate in a tapered form extended full length of the section. The lower longerons, formed by an H section and a rolled U channel bolted together, extend full length of the section. The fuselage is covered with aluminum alloy sheet stock.

(2) FIREWALL.

*(a)* DESCRIPTION. *(See figure 115.)*—The firewall is bolted to the forward end of the fuselage main section. The outer rim of the firewall is steel armor plate, and the center is stainless steel sheet formed to provide space for installation of the oil tank.

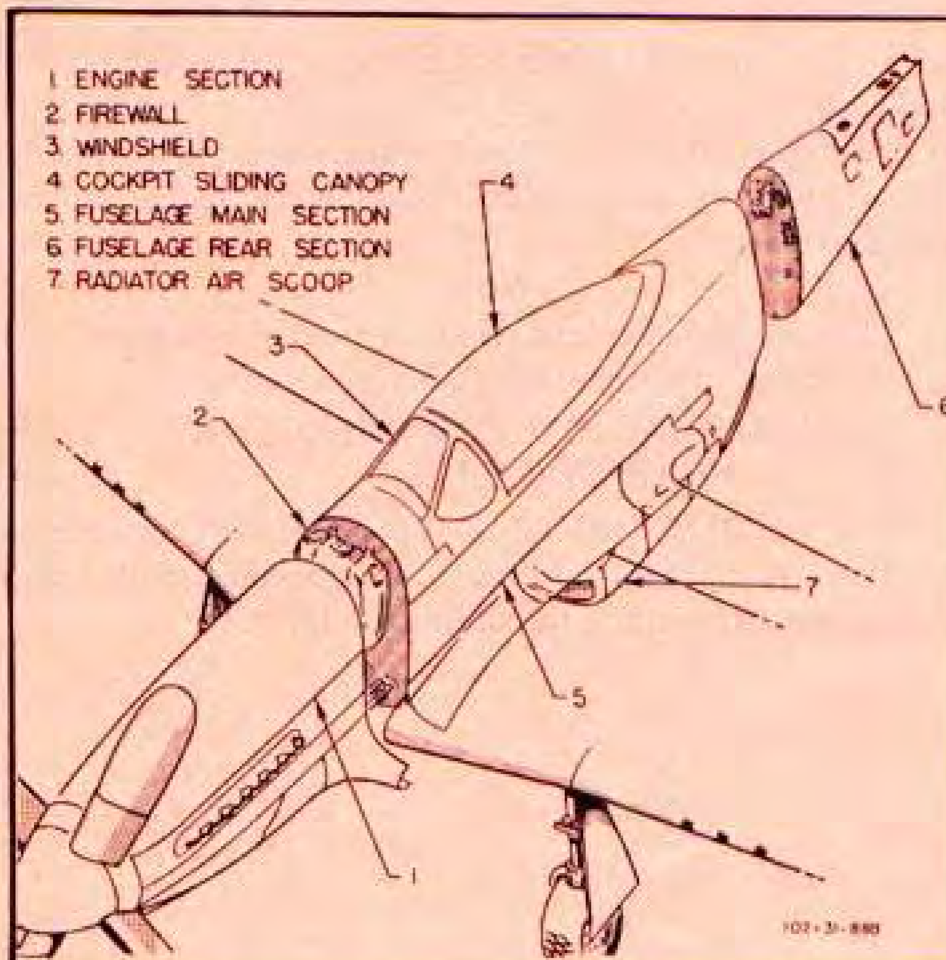



***Figure 115—Fuselage Assembly Sections***

*(b)* REMOVING AND INSTALLING FIRE-WALL. *(See figure 116.)*

(3) COCKPIT ENCLOSURE.

*(a)* DESCRIPTION. *(See figure 115.)*—The cockpit is enclosed by a half teardrop-type canopy, constructed in two sections. The forward section is the windshield, and the rear section is a transparent, sliding enclosure.

*(b)* WINDSHIELD.

*1.* DESCRIPTION. *(See figure 115.)*—The windshield consists of two curved, laminated plate glass side panels, and a flat front plate of armor glass.

*2.* REMOVING AND INSTALLING WIND-SHIELD FRONT PANEL. *(See figure 118.)*

*3.* REMOVING AND INSTALLING WIND-SHIELD SIDE PANELS. *(See figure 118.)*

*(c)* SLIDING CANOPY.

*1.* DESCRIPTION. *(See figure 115.)*—The sliding rear section of the cockpit enclosure is formed from a single sheet of transparent acrylate resin plastic, affording sufficient strength qualities to obviate the use of inner bracing. The design offers maximum unobstructed rear vision. The section is mounted on three trucks which slide on three tracks installed within the fuselage contour lines. Opening and closing the sliding canopy is accomplished by means of a cable and crank assembly operated from the right side of the cockpit. The section locks to each of the three trucks by means of a pin and latch. An emergency release handle is installed in the right forward side of the cockpit, making it possible to jettison the sliding section in any position between closed and full open. An outside emergency release handle is provided on the right side just below the windshield side panel.

*2.* REMOVING SLIDING CANOPY.—Pull emergency release handle, located on right forward side of cockpit, and lift off canopy.

*3.* INSTALLING SLIDING CANOPY.—Position canopy over cockpit and pull emergency release handle so that locking pins and latches in the three trucks engage, and red indicator at each side of cockpit and at rear of canopy *does not show.*

**Note**

The services of at least two men are required when handling and installing the sliding canopy.

*(d)* SLIDING CANOPY EMERGENCY RELEASE CABLES.

*1.* DESCRIPTION.—When the emergency release handle at the right forward side of the cockpit is pulled, two cables operate to release the sliding canopy.

*2.* REMOVING AND INSTALLING SLIDING CANOPY EMERGENCY RELEASE CABLES. *(See figure 119.)*

*3.* ADJUSTING SLIDING CANOPY EMERGENCY RELEASE.—Place emergency release handle in "CLOSED" position, and adjust emergency slides flush with track.

(4) RADIATOR AIR INLET SCOOP.

*(a)* DESCRIPTION. *(See figure 121.)*—A fixed air inlet scoop is mounted forward of the oil and coolant radiators to provide air supply for both radiators.

*(b)* REMOVING AND INSTALLING RADIATOR AIR INLET SCOOP. *(See figure 121.)*

(5) COOLANT RADIATOR ADJUSTABLE AIR OUTLET FLAP.

*(a)* DESCRIPTION. *(See figure 120.)*—An adjustable air outlet flap is hinged to the fuselage immediately aft of the coolant radiator.

*(b)* REMOVING AND INSTALLING COOLANT RADIATOR AIR OUTLET FLAP. *(See figure 120.)*

*(c)* ADJUSTING COOLANT RADIATOR AIR OUTLET FLAP. *(See figure 120.)*

(6) OIL RADIATOR ADJUSTABLE AIR OUTLET FLAP.

*(a)* DESCRIPTION. *(See figure 117.)*—An adjustable oil radiator air outlet flap is hinged to the fuselage just aft of the oil radiator.

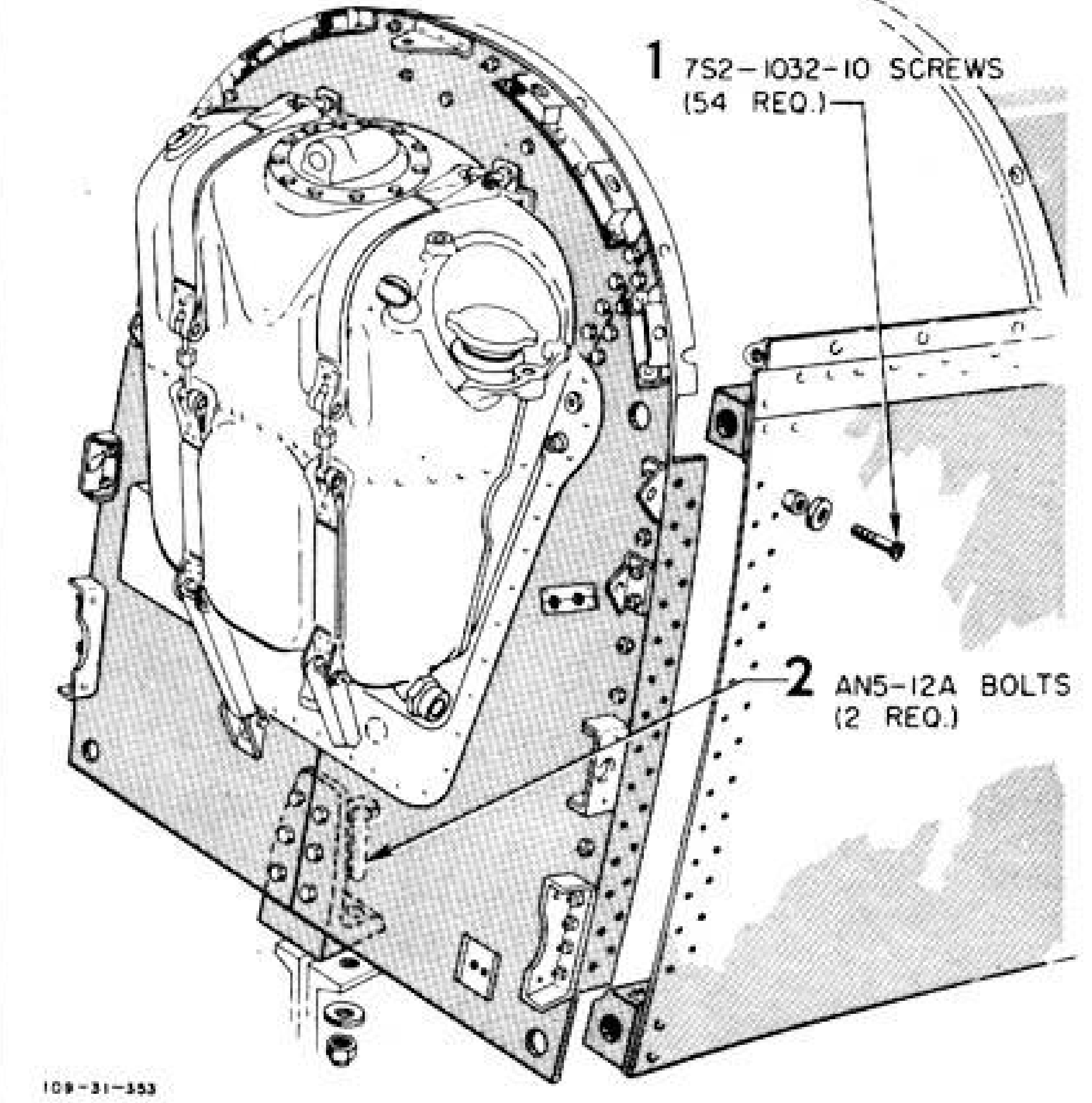
*(b)* REMOVING AND INSTALLING OIL RADIATOR AIR OUTLET FLAP. *(See figure 117.)*

*(c)* ADJUSTING OIL RADIATOR AIR OUTLET FLAP. *(See figure 117.)*

(7) FUSELAGE REAR SECTION.

*(a)* DESCRIPTION. *(See figure 115.)*—The rear section of the fuselage is bolted to the main section just aft of the fuselage lift tube. A solid bulkhead is located at the fuselage rear section to main section attachment station. Provisions are incorporated in the rear section structure for the installation of tail gear and empennage.

*(b)* REMOVING AND INSTALLING FUSELAGE REAR SECTION. *(See figure 122.)*




**1** Fit firewall to fuselage, and insert screws through left and right attachment angles.

**2** Secure attaching bolts.

**Removal:** Essentially the reverse of installation procedure, with following exceptions:

Prior to removing firewall, drain coolant system and oil system, and remove engine and engine mount.

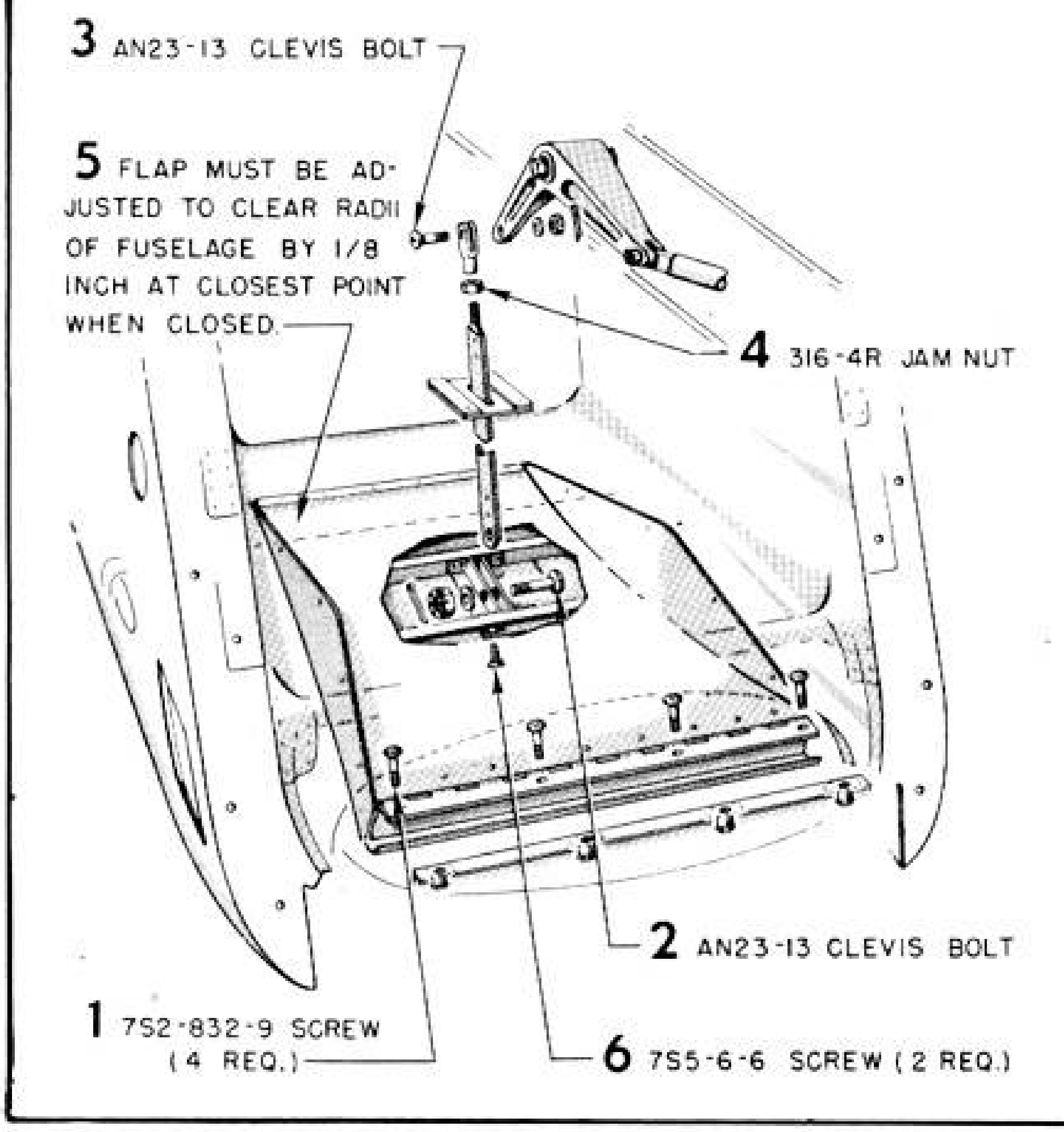
Disconnect all lines, wires, and other equipment between firewall and fuselage, and between firewall and wing.

Temporarily install top engine mount bolts; then remove all firewall-to-fuselage attachment screws.

Remove top engine mount bolts, and with firewall properly supported, remove firewall.

**Note:** As firewall is difficult to handle, at least two men should help support it when last bolts are removed.

***Figure 116—Installing Firewall***




**1** With flap in place, install screws through attaching hinge.

**2** Connect actuating rod to bottom of flap.

**3** Remove rear wing-to-fuselage fairing on one side of airplane; then remove clevis bolt securing actuating rod to bellcrank.

**4** Loosen jam nut below clevis, and rotate clevis to right or left to obtain desired length of actuating rod.

**5** Reinstall clevis bolt, washer, nut, and cotter key, and tighten jam nut against clevis; then check flap for proper clearance at fuselage radii.

**6** Reinstall wing-to-fuselage fairing, and install access cover on bottom of flap.

**REMOVAL:** Essentially the reverse of installation procedure.

109-46-131

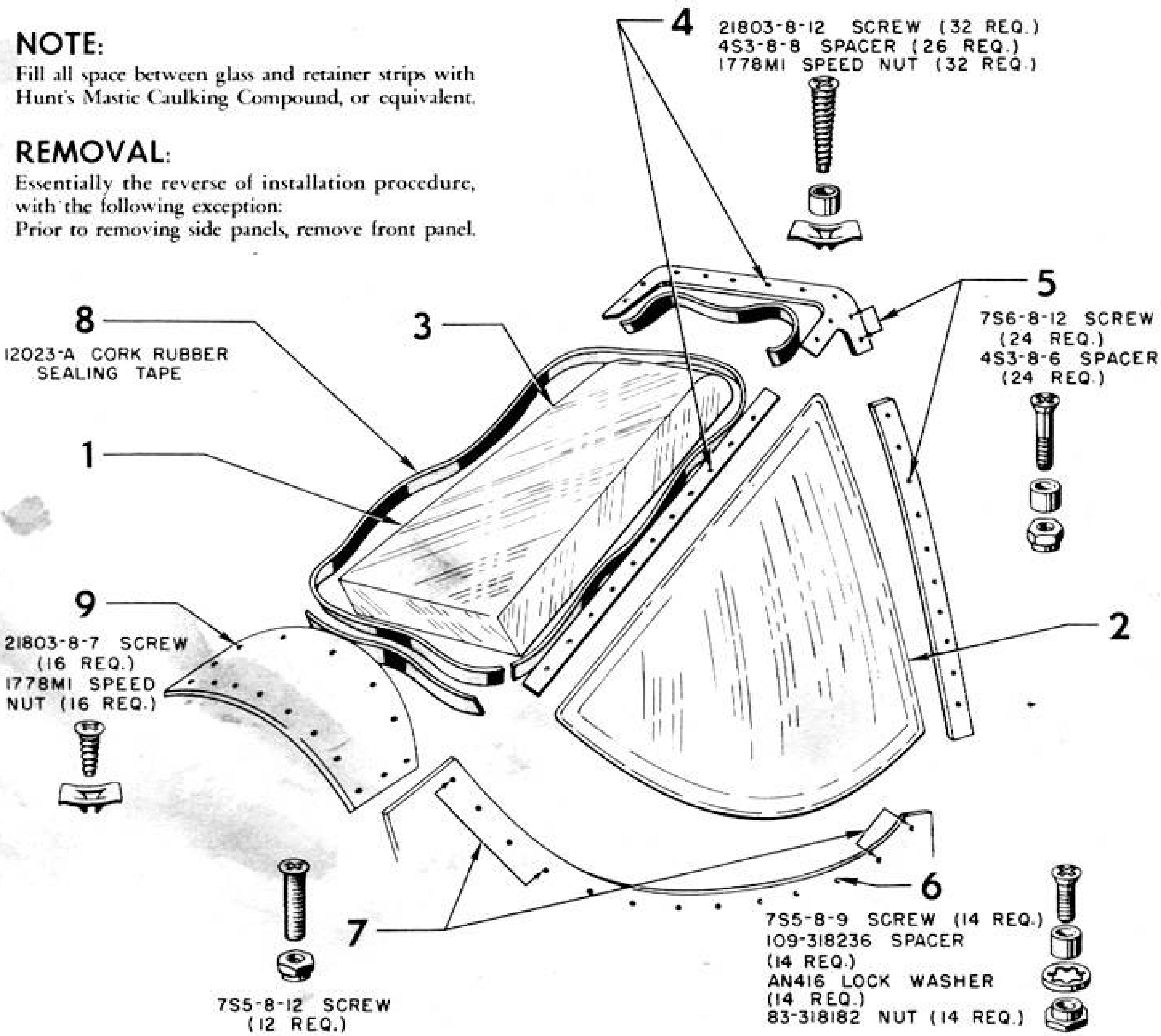
***Figure 117—Installing and Adjusting Oil Radiator Outlet Flap***

## NOTE:

Fill all space between glass and retainer strips with Hunt's Mastic Caulking Compound, or equivalent.

## REMOVAL:

Essentially the reverse of installation procedure, with the following exception:
Prior to removing side panels, remove front panel.




## INSTALLING SIDE PANELS:

**1**

Remove front panel if installed.

**2**

Position side panel in frame assembly.

**3**

Reinstall front panel. (See 8 and 9)

**4-7**

Secure retainer strips, and install screws in lower windshield cowling.

## INSTALLING FRONT PANEL:

**8**

Install cork-rubber sealing tape in frame assembly.

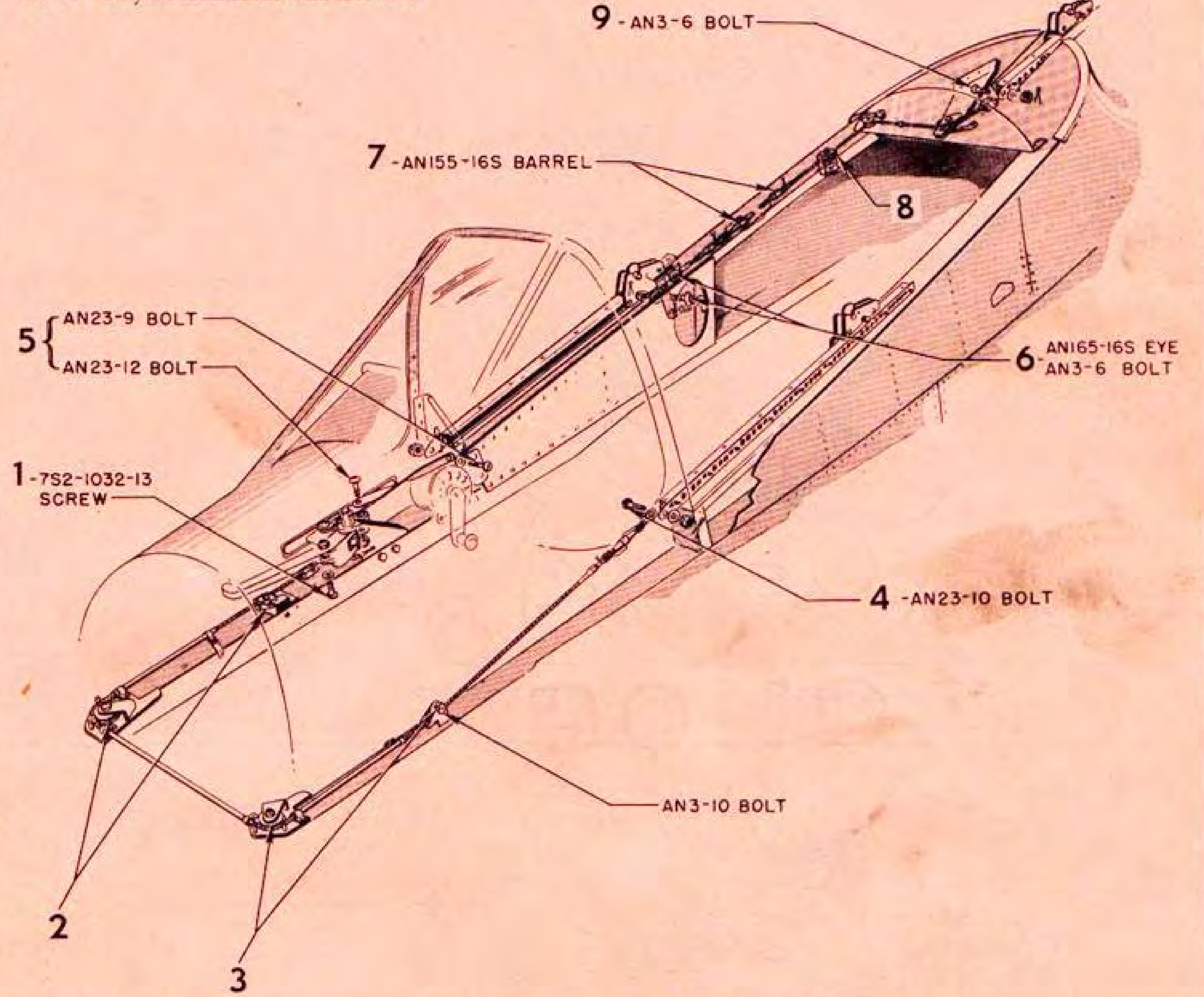
**9**

Slide top of glass into frame, and lower bottom part into place; then install fairing at bottom of panel.

109-31-354

*Figure 118—Installing Windshield Panels*

NOTE: Safety all turnbuckles with .040 wire.




1 Attach clevis end of cable assembly to emergency release handle.

2 Pass cable over outboard side of pulley immediately forward of release handle, and string cable forward over pulley at right corner of firewall.

3 Continue cable across firewall and over pulley at left side; then run cable aft and under pulley adjacent to instrument panel.

4 Attach turnbuckle end of cable to left side emergency release slide.

5 Connect link to emergency release handle and attach aft end of link to right side emergency release slide.

6 Attach eye to fitting extending downward from right side emergency release slide.

7 Screw barrel onto eye; and screw terminal of aft release cable into barrel.

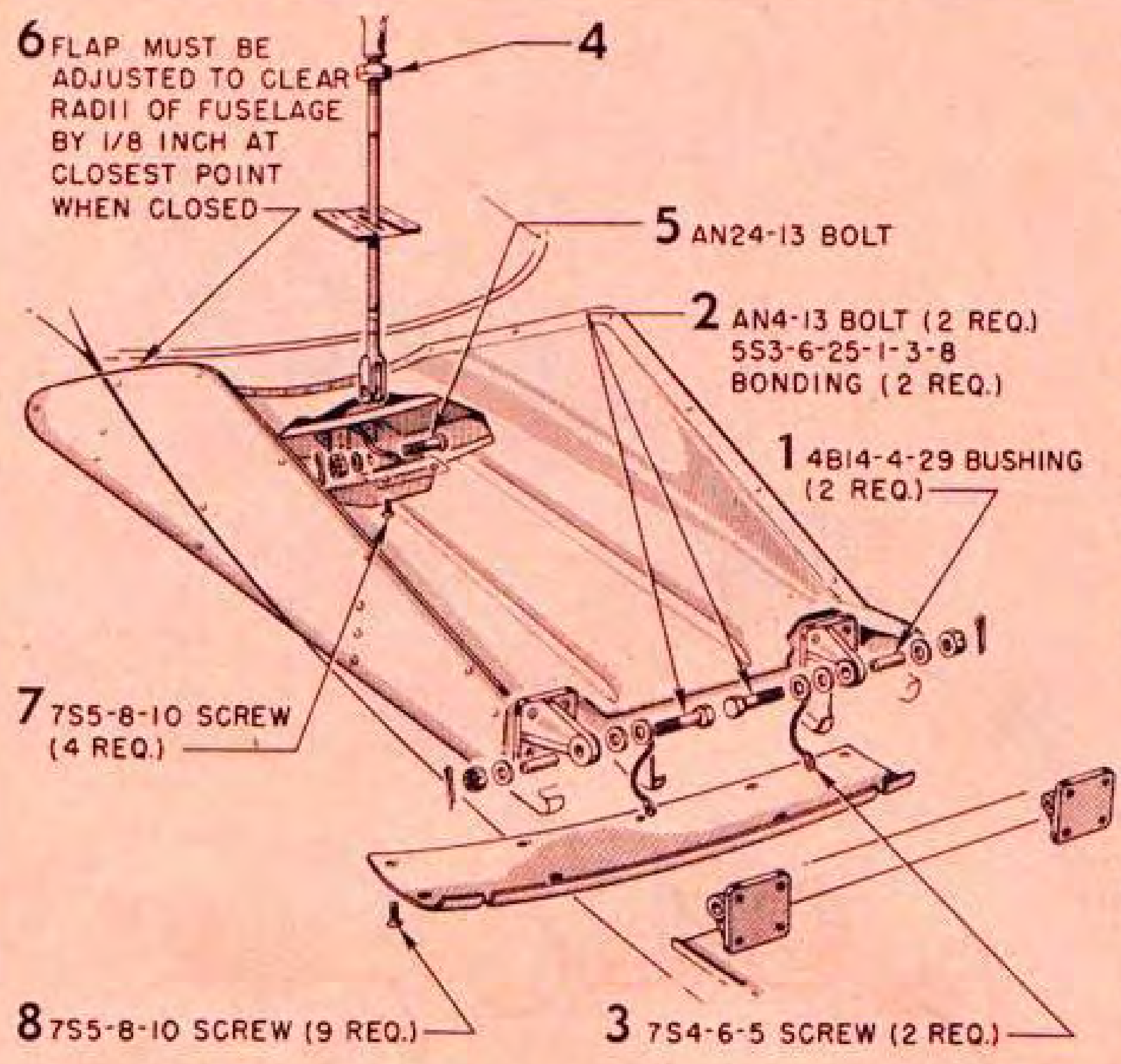
8 String cable aft and over outboard side of two pulleys aft of pilot's seat, and continue cable inboard to center pulley.

9 Run cable aft and connect to aft release slide.

REMOVAL: Disconnect cables at attaching points and draw out.

109-31-356A

*Figure 119—Installing Sliding Canopy Emergency Release Cables*




**1** Position coolant radiator air outlet flap and insert a bushing in each hinge.

**2** Insert bolt through each hinge with bonding under head of each bolt.

**3** Secure bondings to fuselage.

**4** Loosen jam nut at top of actuating rod, and screw rod in or out to desired length.

**5** Connect actuating rod to flap.

**6** With flap fully closed, check for proper clearance at fuselage radii, and tighten jam nut at top of actuating rod.

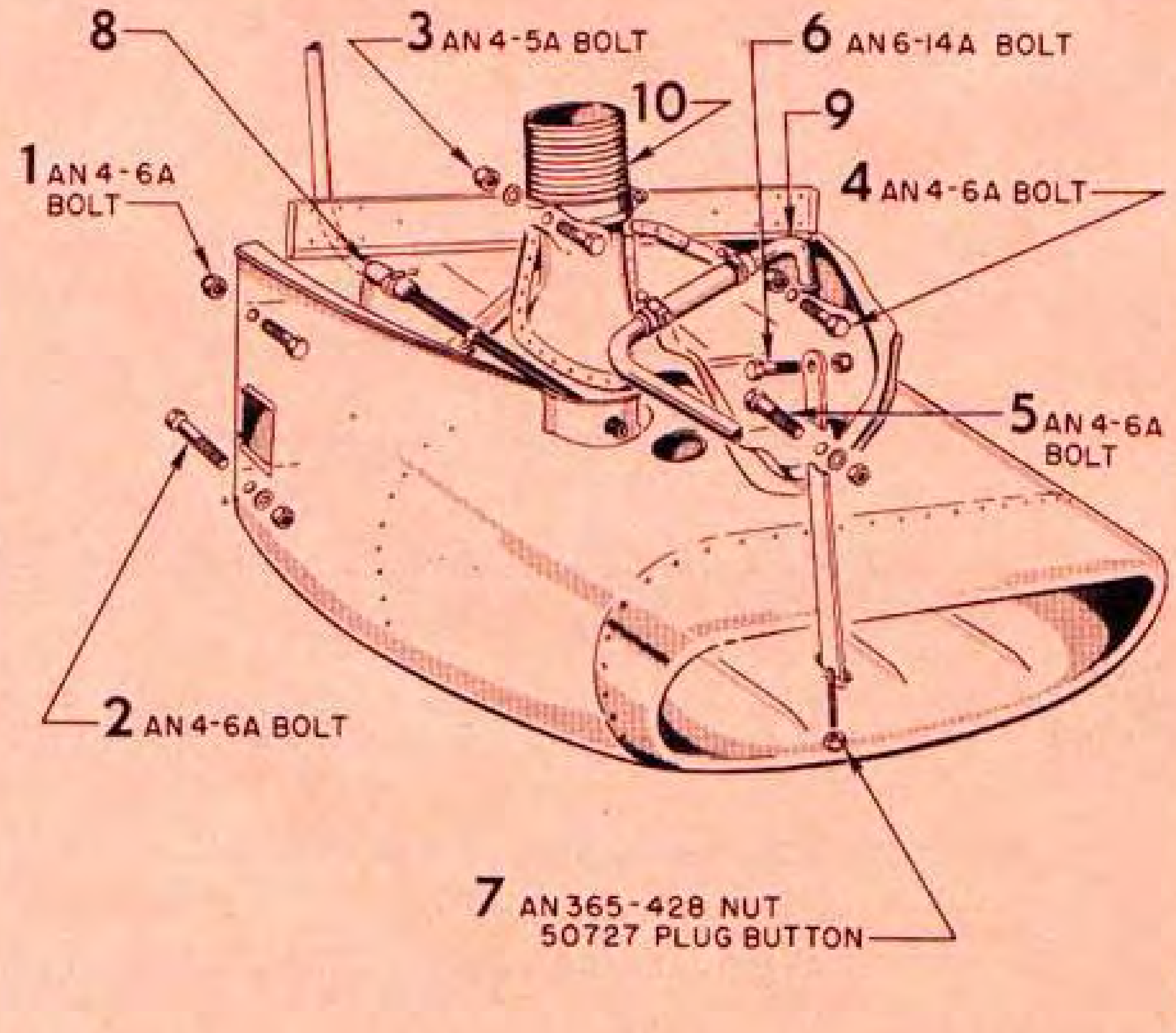
**7** Install access cover on bottom of flap.

**8** Install access cover at forward edge of flap.

**REMOVAL:** Essentially the reverse of installation procedure.

109-46-132

***Figure 120—Installing and Adjusting Coolant Radiator Air Outlet Flap***




**1-5** Place scoop in position and secure attaching bolts.

**6-7** Connect scoop support rod.

**8** Connect battery vent tube.

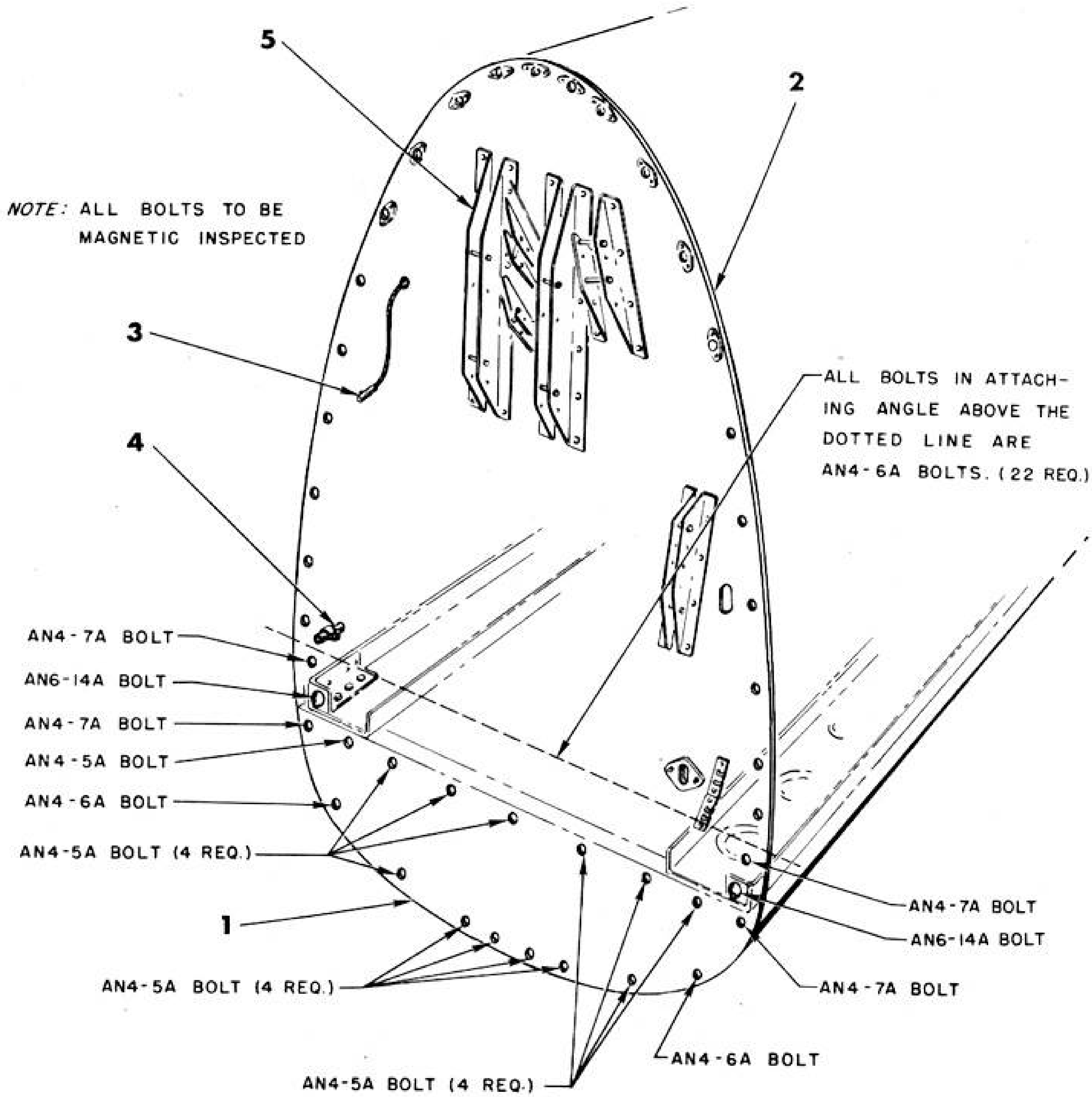
**9** Connect main drain sump vent line.

**10** Connect cockpit cold air inlet flex tube.

**REMOVAL:** Essentially the reverse of installation procedure.

109-53-34

***Figure 121—Installing Radiator Air Inlet Scoop***




**1** Secure lower attaching angle at bottom of tail section.

**2** Fit rear section to main fuselage attaching angle.

**3** Connect electric-disconnect plug on forward side of rear section bulkhead.

**4** Connect pilot's relief tube forward of rear section.

**5** Connect empennage control cables. (See applicable paragraph.)

REMOVAL: Essentially the reverse of installation procedure.

109-31-356

***Figure 122—Installing Fuselage Rear Section***

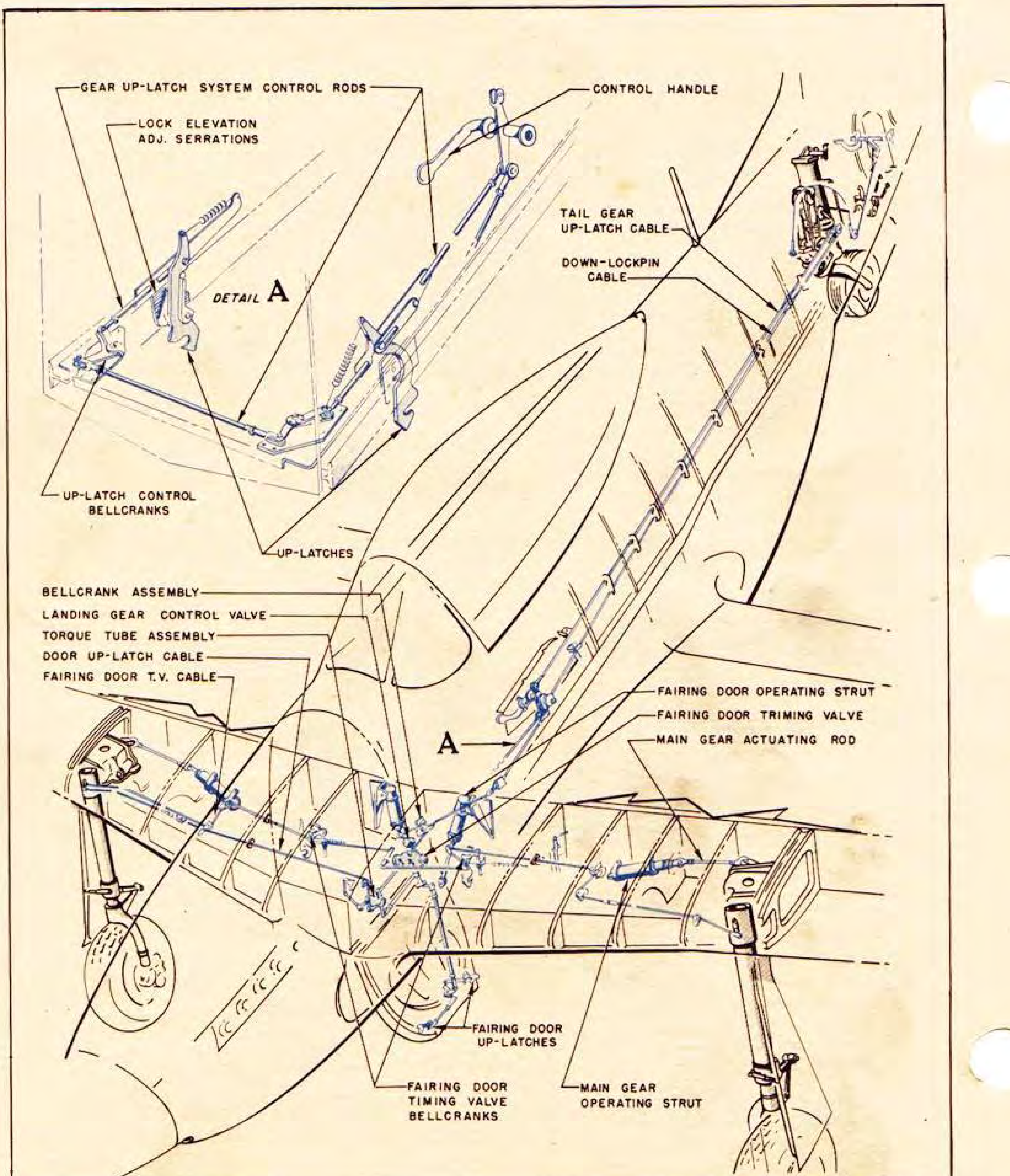



*Figure 123—Landing Gear Control System*

## 5. LANDING GEAR.

*a.* GENERAL DESCRIPTION.—The landing gear installation embodies a retractable main gear assembly in each wing panel and a retractable tail gear assembly in the fuselage, each assembly being completely enclosed in the retracted position. All shock struts employ the air-oil combination for cushioning. The positioning of all three landing gear assemblies is controlled simultaneously by one lever on the lower left side of the cockpit. The tail wheel is selectively steerable or free swiveling. *(See figure 123.)*

*b.* LANDING GEAR TROUBLE SHOOTING CHART.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Main gear fails to down-lock.** | Broken down-lockpin spring. | Replace spring. |
| | Lack of lubricant, or dirt in lockpin seat. | Remove pin, clean, lubricate, and replace. |
| | Gear actuating strut bottomed before gear was fully down. | Shorten linkage between strut and torque arm. |
| **Main gear moves down too slowly.** | Controllable check valve not opening. | Turn in adjustment screw on valve. |
| | Hydraulic control valve not fully positioned. | Adjust valve control linkage. |
| **Main gear fails to start down (fairing doors open).** | Up-latches remain locked. | Shorten up-latch linkage to control handle. |
| **Main gear fails to move up (fairing doors open).** | Down-lockpin not fully pulled. | Shorten hydraulic strut actuating arm. |
| | Lockpin actuating strut not fully retracted because of short linkage or frozen pin. | Lengthen linkage, or remove, clean, and lubricate lockpin assembly. |
| | Check valve in down-lockpin hydraulic strut leaking. | Reseat valve. |
| **Main gear fails to up-latch.** | Strut roller jamming behind up-latches. | Screw out adjustable latch stops. |
| | Roller fails to seat in hook because of interference in wheel well. | Lower latches on ratchet base. Check tire for oversize. Check proper positioning of hydraulic lines. |
| | Broken latch spring. | Replace spring. |
| | Latch control linkage too short. | Lengthen linkage. |
| | Latch stops over extended. | Screw in adjustable latch stop. |
| | Shock strut fairing is restricting gear. | Lengthen linkage between fairing and gear. |
| **Main gear drops before up-latching.** | Controllable check valve not closing. | Retract adjustable screw on valve. |
| **Fairing doors fail to open. (Main gear is up.)** | Door up-latches locked. | Adjust door lock control linkage. |
| | Malfunction of fairing door timing valve. | Check operation of valve and/or adjust linkage. |
| **Fairing doors fail to close. (Main gear is up.)** | Timing valve bellcrank pins bent or jammed. | Replace pins; correct cause. (Overlength adjustment of cables to shock struts sometimes causes jammed pins in earlier airplanes.) |
| | Timing valve cables from shock strut caught or jammed. | Remedy cause and replace pulleys and/or cable. |
| | Malfunction of timing valve. | Readjust positioning linkage; check valve operation. |
| **Fairing doors fail to close. (Main gear is down.)** | Timing valve cable from shock strut broken, detached, or misadjusted. | Replace, attach or adjust cable; check condition of pulleys. |
| | Rod linkage from bellcranks to timing valve out of adjustment. | Adjust linkage. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Fairing doors fail to open. (Main gear is down.)** | Door latch cable from right shock strut overlength or broken.<br>Defective or broken linkage in doors.<br>Malfunction of hydraulic control valve. | Readjust or replace cable.<br>Readjust or replace linkage, or replace door.<br>Check valve and control linkage. |
| **Tail gear fails to come down.** | Up-latch cable detached or broken.<br>Up-latch cable overlength. | Attach or replace. Inspect pulleys for damage.<br>Shorten cable. |
| **Tail gear fails to go up.** | Down-lock cable detached or broken.<br>Down-lock cable overlength. | Attach or replace. Inspect lockpin for condition.<br>Shorten cable. |
| **Tail gear fails to down-lock.** | Broken lock spring.<br>Control cable underlength or jammed. | Replace spring.<br>Adjust cable; inspect pulleys. |
| **Tail gear fails to up-lock.** | Broken lock spring.<br>Control cable underlength or jammed. | Replace spring.<br>Adjust cable; inspect pulleys. |
| **Tail gear fails to declutch.** | Cable broken or detached.<br>Cable overlength. | Replace or attach cable.<br>Shorten cable; inspect pulley. |
| **Airplane bounces excessively on landing.** | Struts normally extended; indicates too little fluid.<br>Struts overextended; indicates too much air. | Add fluid.<br>Bleed out air. |
| **Airplane lands heavily.** | Insufficient air. | Add air. Bleed out fluid if strut overfilled. |

*c.* LANDING GEAR CONTROL SYSTEM.

(1) DESCRIPTION.—Linkage from the landing gear control handle to the landing gear hydraulic selector valve controls the hydraulically actuated landing gear assemblies. The landing gear control handle also positions the main gear and tail gear up-locks, the main gear fairing door up-latches, and the tail gear down-lock through rod and cable linkage. *(See figure 123.)* For description and maintenance of the landing gear hydraulic system, refer to paragraph 19. ***e.***

(2) PRELIMINARY PROCEDURE FOR MAINTENANCE AND ADJUSTMENT OF THE LANDING GEAR CONTROL SYSTEM.

***(a)*** Jack the airplane. *(See paragraph 2.* ***b.*** *of section III.)*

***(b)*** Connect hydraulic test stand. *(See paragraph 19.* ***b.*** *(4)* ***(b)*** *in this section.)*

***(c)*** Disconnect the main gear fairing doors and main gear shock strut fairing.

***(d)*** Disconnect one end of the landing gear control safety stop spring. *(See paragraph 5.* ***c.*** *(4) and figure 125.)*

**CAUTION**

Never place landing gear control handle in the up position unless the airplane is jacked.

(3) LANDING GEAR HYDRAULIC SELECTOR VALVE LINKAGE.

***(a)*** DESCRIPTION.—Rod linkage from the landing gear control handle bellcrank positions the hydraulic selector valve. This valve is located in the aft inboard corner of the right-hand wheel well. *(See figure 124.)*

***(b)*** ADJUSTING THE LANDING GEAR HYDRAULIC SELECTOR VALVE LINKAGE. *(See figure 124.)*

(4) LANDING GEAR CONTROL SAFETY STOP.

***(a)*** DESCRIPTION.—The landing gear control safety stop is a part of the torque tube assembly on the left side of the wing center rib. The safety stop prevents the landing gear control handle from being moved from "DOWN" to "UP" unless the left main gear fairing door is closed, thus preventing main landing gear from retracting on to the fairing doors before they have completed the gear down cycle of operation. The safety stop is a spring-loaded hinged stop that blocks the inner bellcrank of the torque tube assembly from moving to the up position. A bracket on the left fairing door depresses a pedal on the safety stop when the fairing door moves up. This permits free travel of the inboard torque tube bellcrank. *(See figure 125.)*

***(b)*** DISCONNECTING LANDING GEAR CONTROL SYSTEM SAFETY STOP SPRING.—When landing gear system adjustments require unrestricted travel of the control linkage, disconnect tension spring on the safety stop. While stop is inoperative, be careful to complete the main landing gear operating cycles before repositioning the control handle. Reconnect the safety stop spring when adjustments are completed. *(See figure 125.)*

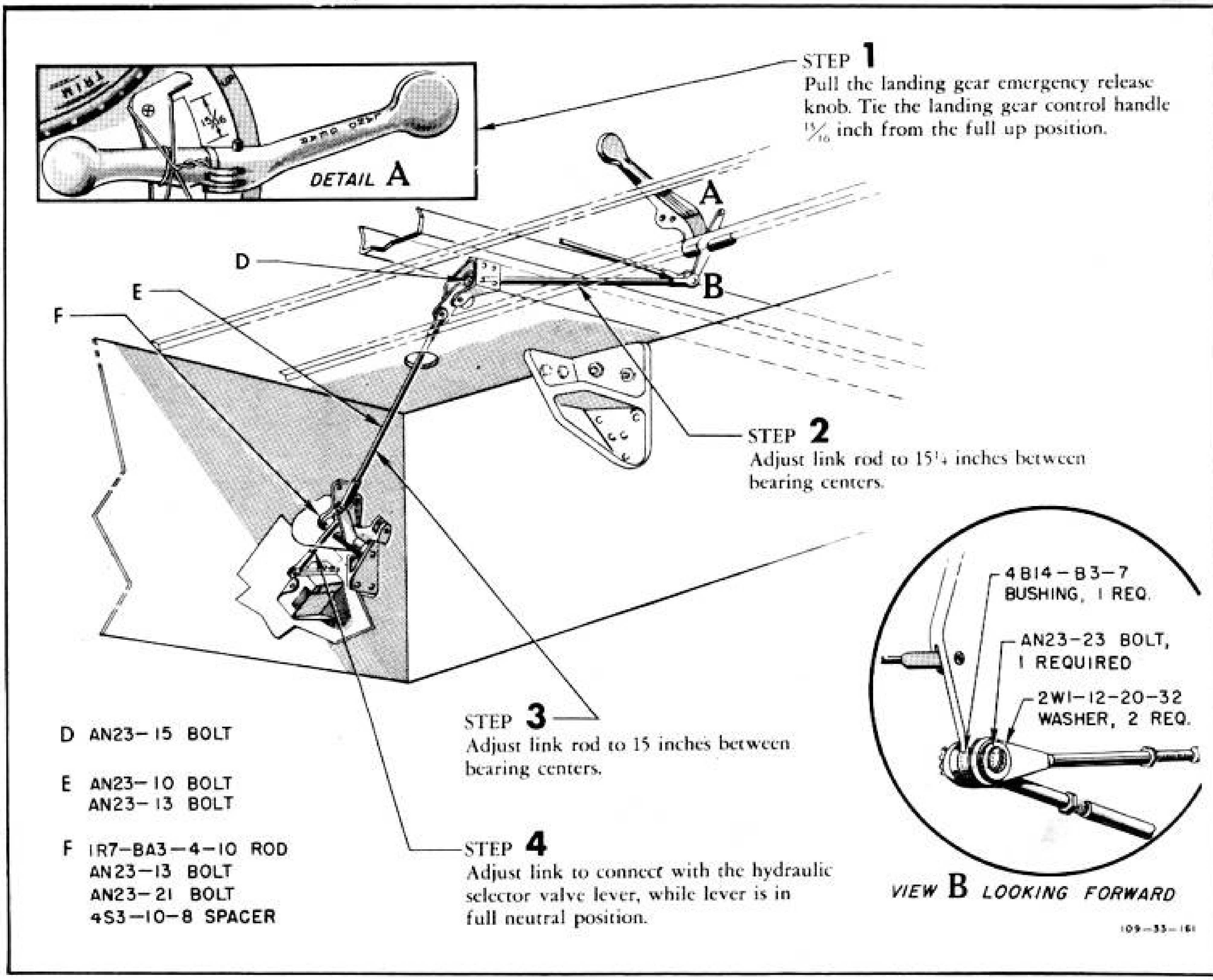



***Figure 124—Adjusting Landing Gear Hydraulic Selector Valve Linkage***

(5) LANDING GEAR EMERGENCY RELEASE SYSTEM.

*(a)* DESCRIPTION.—A red knob (described as "emergency down knob" in landing gear maintenance instructions) below the pilot's panel connects by rod linkage to a hydraulic pressure release valve, and to a torque tube bellcrank in right wheel well. Pulling this knob exhausts all pressure in the landing gear hydraulic system, and also retracts the fairing door up-latch hooks by actuating the landing gear control torque tube.

*(b)* ADJUSTING LANDING GEAR EMERGENCY RELEASE VALVE AND LINKAGE. *(See paragraph* 19. *e.* (8).)

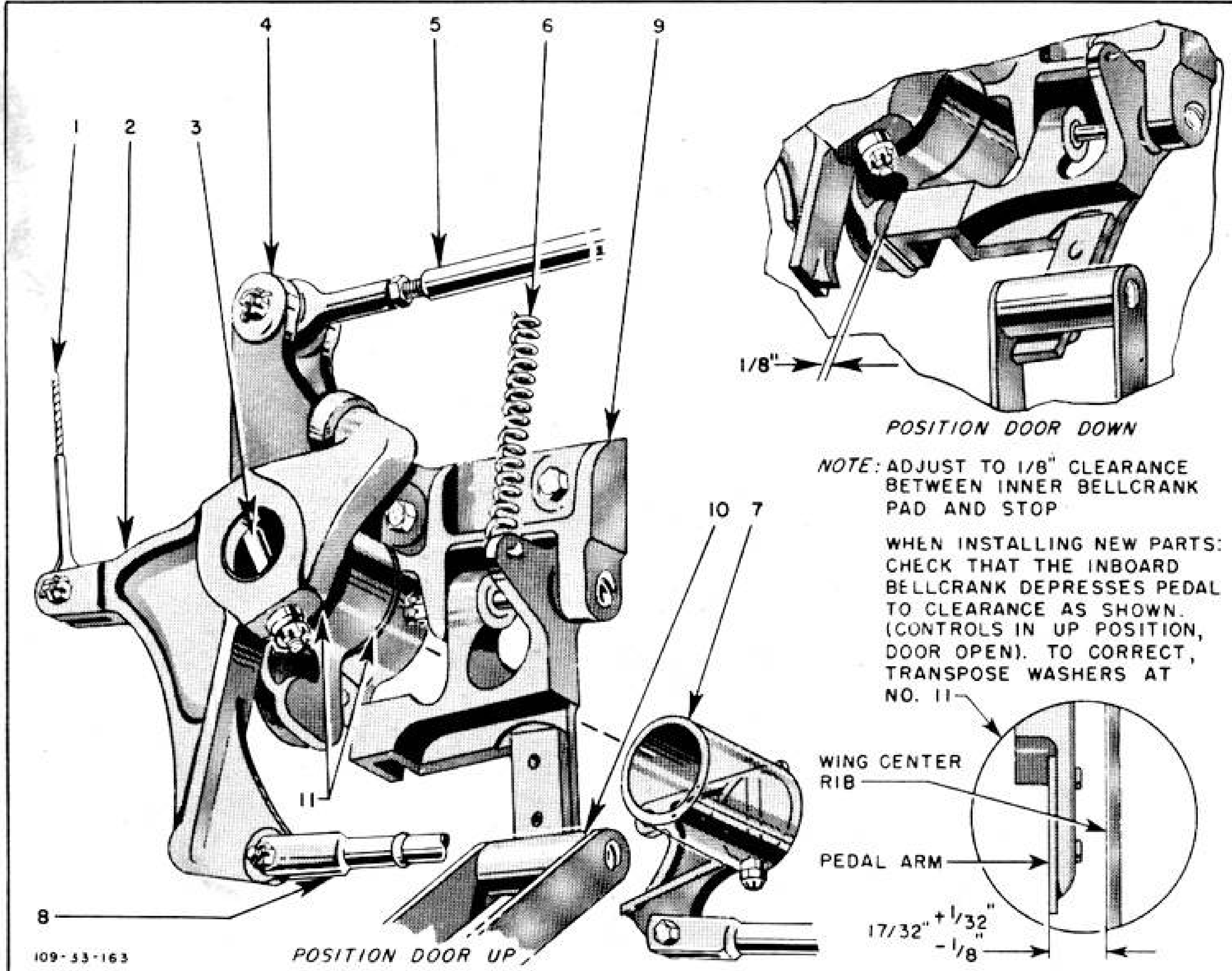
(6) OPERATIONAL CHECK OF LANDING GEAR CONTROLS.

*(a)* Operate gear, with normal hydraulic pressure. With main fairing doors and safety stop spring disconnected and control handle and gear in up position, check clearances between wheel assembly and units in the wheel well.

*(b)* Make sure that fairing door latch cable from right shock strut is not restricting the up-latches, and that the latch links are the required amount above dead center. See that there is clearance between end of slot in the emergency down link rod and stud on bellcrank. Observe tightness and fit of shock strut fairing doors.

*(c)* Remove the wheels, put grease on up-latch roller on wheel fork (to indicate striking point on up-latch hook), and test operation of main gear up-latches. Inspect for correct clearance between latch hook and adjustable stop. Position gear down, exhaust hydraulic pressure, open fairing doors manually, and move control handle to "UP." Then turn the control handle to "DOWN," and observe that the up-latch control link rod moves ⅛ (± 1/16) inch before it begins to actuate the up-latch hook. With both gear and control handle in up position, check for clearance between pads of the inboard and outboard torque tube bellcranks.

*(d)* With wheels installed, hydraulic pressure on, fairing doors connected, control stop spring connected, and shock strut fairing disconnected, move control handle to gear up position. Make sure that the fairing door up-latches have




1. Fairing Door Latch Cable
2. Outboard Bellcrank
3. AC386-1-10 Taper Pin
4. Inboard Bellcrank
5. Torque Tube Actuating Link Rod
6. Safety Stop Tension Spring
7. Emergency Down Bellcrank
   2W2S-48-40-63 Washer
   AC386-1-10 Taper Pin
8. Fairing Door Actuating Link Rod
9. Landing Gear Control Safety Stop AN23-32 Bolt
10. Fairing Door Safety Stop Roller Bracket
11. 2W2S-48-40-31 Washer (2 Req.)

***Figure 125—Landing Gear Control Torque Tube and Safety Stop Assembly***

required clearance, and that they overlap in relation to the latch rollers. Check for minimum clearance between doors and wheels. Observe tightness and fit of fairing doors. Move gear down and check each gear for proper down-locking.

*(e)* With fuselage access doors (below stabilizer) removed, observe tail gear for proper up-locking, down-locking, alignment of wheel with rudder, proper clutching and declutching, and fit of fairing doors.

*(f)* With gear up, shut off hydraulic test stand, and test emergency down release operation by pulling knob. Fairing doors should be unlocked and operable by hand pressure. Put control handle down; gears should drop by own weight. While doors are open, measure clearance between inboard bellcrank and control safety stop pads. Move fairing doors manually and observe clearance between retracted latch tips and up-latch rollers, and clearance between extended latch tips and wings. Observe fairing doors for designed warp, and apply weight test if warp is insufficient.

*(g)* Connect shock strut fairing, and make sure it is not restricting the movement of the fairing doors. Operate the landing gear system 3 or 4 times through its complete cycle, and make sure operation is smooth and synchronized.

*d.* LANDING GEAR POSITION INDICATORS (Earlier Airplanes).—A red landing gear position warning

## WITH PIVOT SHAFT

1 Remove access doors above and forward of support casting. Clean support casting and pivot shaft bearings.

2 Place torque arm on down-lockpin, with bevel side down and forward. Insert pivot shaft part way into support casting. While supporting torque arm, horizontal and flush with support casting, push pivot shaft gently into bearing until shaft end engages torque arm. Swing the gear slightly to align splines, and work pivot shaft in sufficiently to permit starting the pivot shaft retaining nut.

3 Tighten nut by hand and T-46 wrench. Allow a clearance from .006 to .017 inch between forward pivot shaft shoulder and support casting.

4 Install pivot shaft nut safety bolt. Grease pivot shaft bearing through zerk fitting on support casting.

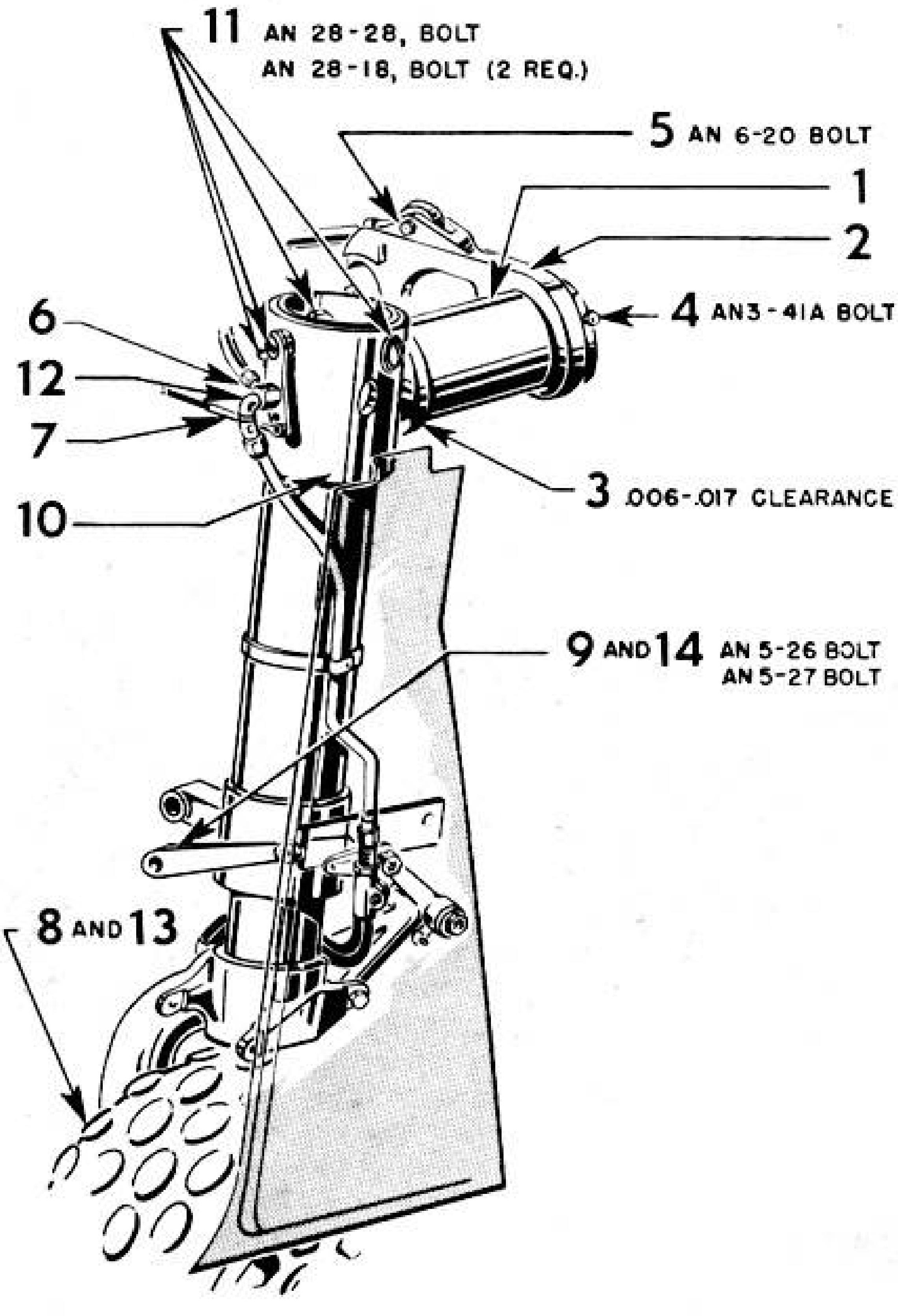
5 Connect pivot shaft torque arm actuating link.

6 Connect brake line to inboard side of junction block.

7 Connect fairing door timing valve cable.

8 Install wheel and access doors in wing.

9 Connect shock strut fairing door.




## WITHOUT PIVOT SHAFT

10 Clean inside of pivot shaft casting and top of shock strut thoroughly. Insert shock strut up into the pivot shaft casting.

11 Install the three pivot shaft casting clevis bolts and filler plug.

12 Connect brake line to forward side of junction block.

13 Install wheel.

14 Connect shock strut fairing door.

**REMOVAL:** Essentially the reverse of installation procedure. —— Weights of the main gear assembly are approximately as follows: with wheel, tire, and pivot shaft—200 pounds; without wheel—150 pounds; without pivot shaft—130 pounds.

109-55-162

*Figure 126—Removing and Installing Main Landing Gear*

light at the left of the instrument panel illuminates whenever the engine throttle control handle is retarded unless the main landing gear is extended and locked. For description and maintenance of the landing gear position warning system, refer to paragraph 20. *i.* in this section.

*e.* LANDING GEAR POSITION INDICATORS (Later Airplanes).—A red landing gear position warning light at the left of the instrument panel illuminates at the start of a main landing gear operation cycle, and remains lit until the operation has been properly completed. If the engine throttle control handle is retarded while the main landing gear is locked in the retracted position, the red warning light will also illuminate. A green landing gear position indicator light adjacent to the red warning light illuminates whenever both main landing gear are in the extended and *locked* position. A switch-controlled landing gear position warning horn sounds whenever the engine throttle control handle is retarded while the main landing gear is in a retracted and locked position. For description and maintenance of the landing gear position warning system, refer to paragraph 20. *j.* in this section.

*f.* MAIN LANDING GEAR.

(1) DESCRIPTION.—The main landing gear assemblies are supported by castings installed on the forward side of the front spar in each wing panel, at the outboard end of the wheel well. *(See figure 123.)* The support castings are bolted to the front spar of the wing and to the lower and upper skin of the wing in order to dissipate the landing gear thrust throughout the entire wing structure. Each main landing gear is a full-cantilever shock strut with a half fork and axle bolted to the shock strut piston, and a pivot shaft bolted to the upper end of the shock strut cylinder. A scissor-type torque link attached to the top of the half fork and to the lower end of the shock strut cylinder transmits the torque load applied on the axle and fork to the shock strut cylinder. The landing gear assemblies are secured to the landing gear support castings by the shock strut pivot shafts, which permit the gear to pivot laterally.

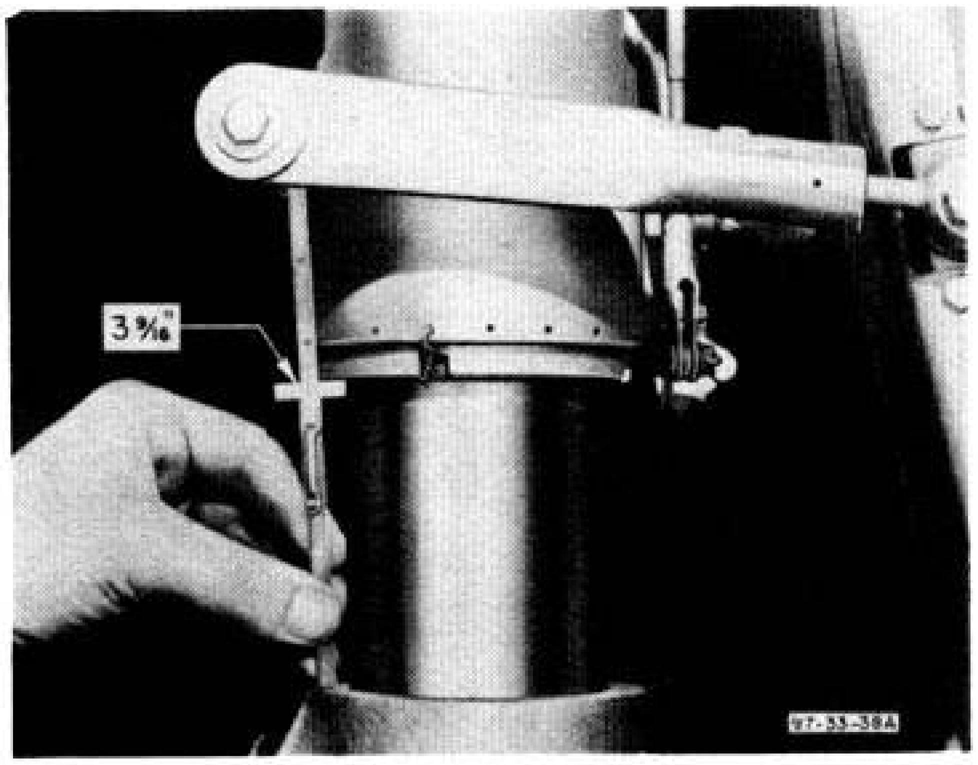



***Figure 127—Inspecting Main Gear Shock Strut for Correct Inflation***

(2) SERVICING MAIN LANDING GEAR SHOCK STRUTS.

*(a)* SHOCK STRUT FLUID.—A mineral base fluid, Specification No. AN-VV-O-366 (AC3580), is used in all three landing gear shock struts. As the strut is designed for this type and viscosity of fluid, any other type of fluid may cause the shock strut to fail in service.

*(b)* FILLING MAIN GEAR SHOCK STRUTS.

*1.* Jack airplane so that landing gear is off the ground.

*2.* Release air by loosening the filler plug one turn.

*3.* Remove filler plug and fully compress the strut.

*4.* Fill compressed strut to overflowing with hydraulic fluid.

*5.* Replace filler plug loosely; extend and compress strut several times to eliminate any trapped air in the strut.

*6.* Remove filler plug and add more fluid if necessary.

*7.* Replace filler plug and tighten it securely.

*(c)* ALTERNATE METHOD OF FILLING MAIN GEAR SHOCK STRUTS.

*1.* Obtain a hose with a fitting which will screw onto the air valve stem of the strut filler plug. A hose from an ordinary tire pump is good.

*2.* Remove valve core from valve stem and attach the hose.

*3.* Compress strut completely.

*4.* Place free end of the hose in a bucket of hydraulic fluid and then extend the strut approximately halfway.

*5.* Remove the hose from the hydraulic fluid and then extend strut.

*6.* Place hose back in the fluid can, and completely compress the strut. If some of the fluid is forced out when the strut is compressed, the fluid level is correct. If not, repeat the foregoing procedure.

*(d)* INFLATING MAIN GEAR SHOCK STRUTS.—Because of the small quantity of air in the shock strut and the relatively high pressure, it is not advisable to attempt to measure the pressure with a gage. Inflate the shock struts with the airplane fully loaded, in the following manner *(see paragraph 5. **d.** (2) (f) before proceeding):*

*1.* Inflate the strut until 3⁵⁄₁₆ inches of polished piston are visible between the packing nut and the shock strut piston shoulder. *(See figure 127.)*

*2.* Replace the hex cap, which is a secondary seal, and tighten it lightly with a wrench. *Excessive tightening of the cap will result in the seat of the cap being forced inward and depressing the valve core.*

*(e)* CLEANING SHOCK STRUTS.—If it is necessary to clean the shock strut piston and cylinder while the

packing is being changed, wash the metal parts thoroughly with kerosene or solvent, Specification No. P-S-661. Dry the parts with a lint-free rag or compressed air. Wipe the packing rings clean with a lint-free rag.

*(f)* SHOCK STRUT AIR VALVES.—The air valves are similar in design and function to those used in automobile tires; however, they are specially designed for use in air-oil shock absorbers and hydraulic systems. The valves should be checked and operated in the following ways:

*1.* After inflation, test the valve, the valve core, and the filler plug carefully for leaks by using soapy water. Usually leaks around the filler plug, valve, or other parts will be evident by a seepage of fluid.

*2.* Small amounts of air can be removed from the strut by slightly opening the filler plug and then rapidly tightening it again. *Do not depress the valve core to correct overinflation.*

*3.* Do not damage the filler plug and air valve assembly by excessive tightening of the air-hose connection, by improper use of tools, or by using the filler plug as a stop for a hoist attachment or hitch. When using the pump, if leakage at the hose connection to the air valve cannot be stopped by hand tightening, replace the fitting gasket. Do not use wrenches or pliers

**CAUTION**

When inflating shock struts from high-pressure air bottles or pumps, meter the air in slowly. A sudden rush of air may blow a portion of the air valve into the shock strut, necessitating a complete disassembly of the strut. Upon removal, check all leaky valves for missing parts that may have fallen into the strut assembly. When a valve core has been removed, do not reinstall the same core, but put in a new core.

*(g)* SHOCK STRUT PACKING.—In case of leakage at the packing gland, noticeable by fluid seepage or by air bubbles when soapy water is applied, tighten the packing nut firmly. Exert hand pressure only on the spanner. Before tightening, however, release the air pressure from the strut; the packing cannot be tightened properly under pressure. If normal tightening by this method will not stop the leakage, replace the packing. In this case, inspect the piston tube for excessive scoring, roughness, or an out-of-round or bent condition.

*1.* When replacing the packing, be careful to avoid roughening or tearing the featheredged lip of the packing ring. Whenever possible, this work should be done by a depot or service squadron. The replacement procedure is as follows:

a. Be certain that all the air pressure is released from the strut.

b. Remove filler plug and drain oil.

c. Before disassembly, consult the diagram of the strut packing. *(See figure 128.)*

d. Remove the packing nut safety wire and unscrew packing nut.

e. Pull out piston tube assembly, using a slight bumping action. If necessary, bump slightly to loosen the packing.

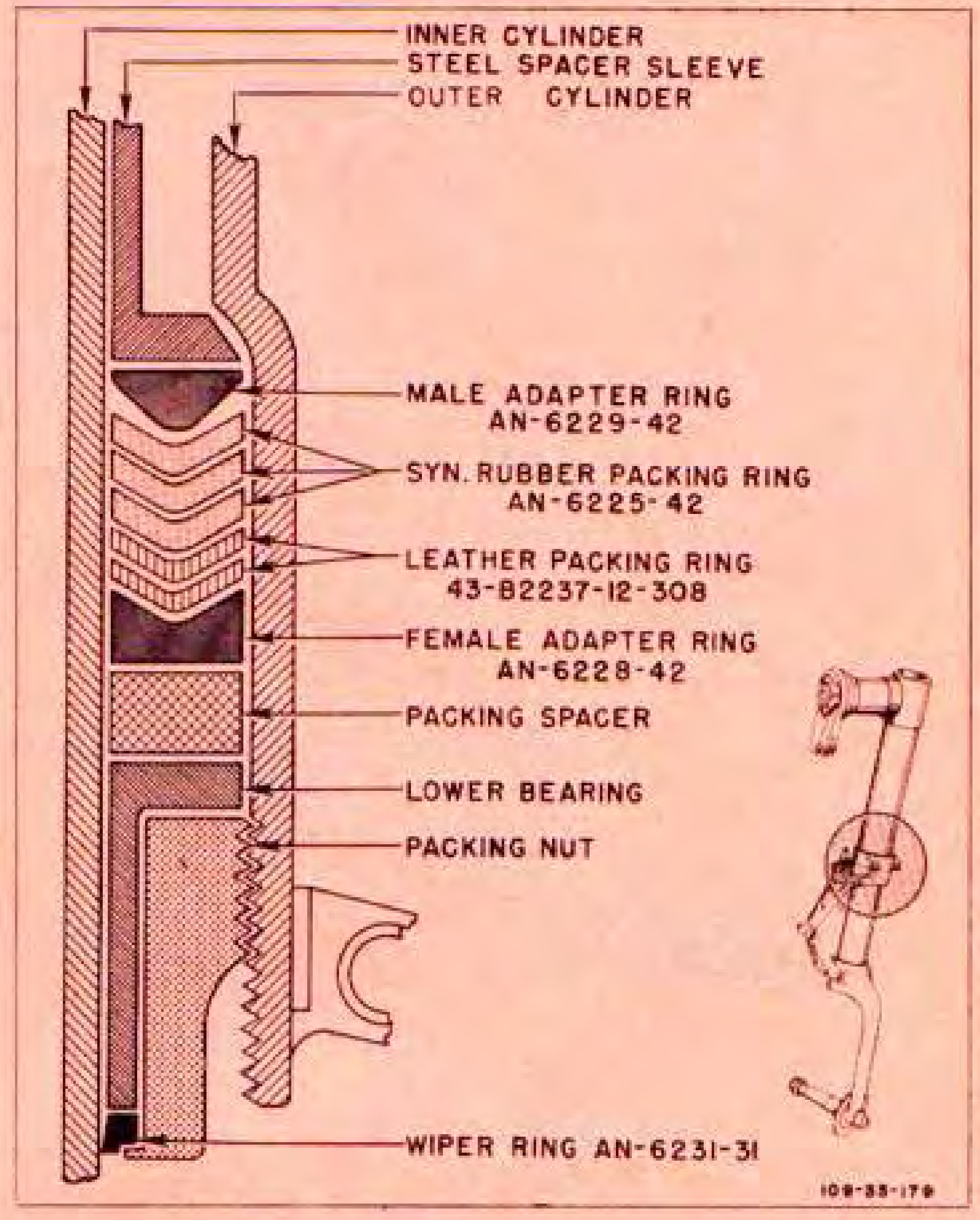



***Figure 128—Main Gear Shock Strut Cylinder Packing***

f. Coat the new packing rings with a grease mixture consisting of 95 percent (by volume) of Specification No. AN-G-3 grease and 5 percent of graphite No. 2-64. If the shock strut is to be used immediately, wet the packing rings with hydraulic fluid, Specification No. AN-VV-O-366.

g. If means are available, "run in" the strut after replacing the packing. This should be done on a machine which will move the piston in and out through at least half of its total travel, a minimum of 500 cycles. The strut should be fully serviced with oil and air before it is "run in."

(3) REMOVING AND INSTALLING MAIN LANDING GEAR.

*(a)* REMOVING AND INSTALLING MAIN GEAR WITH PIVOT SHAFT. *(See figure 126.)*

*(b)* REMOVING AND INSTALLING MAIN GEAR WITHOUT PIVOT SHAFT. *(See figure 126.)*

(3a) REPLACING MAIN GEAR PIVOT SHAFT BUSHINGS.

*(a)* PREPARATION FOR REBORING MAIN GEAR PIVOT SHAFT SUPPORT CASTING. *(See figure 130A.)*

*(b)* REBORING MAIN GEAR PIVOT SHAFT SUPPORT CASTING. *(See figure 130B.)*

*(c)* INSTALLING OVERSIZE MAIN GEAR PIVOT SHAFT BUSHINGS. *(See figure 130C.)*

(4) MAIN GEAR ACTUATING LINKAGE. *(See figure 129.)*

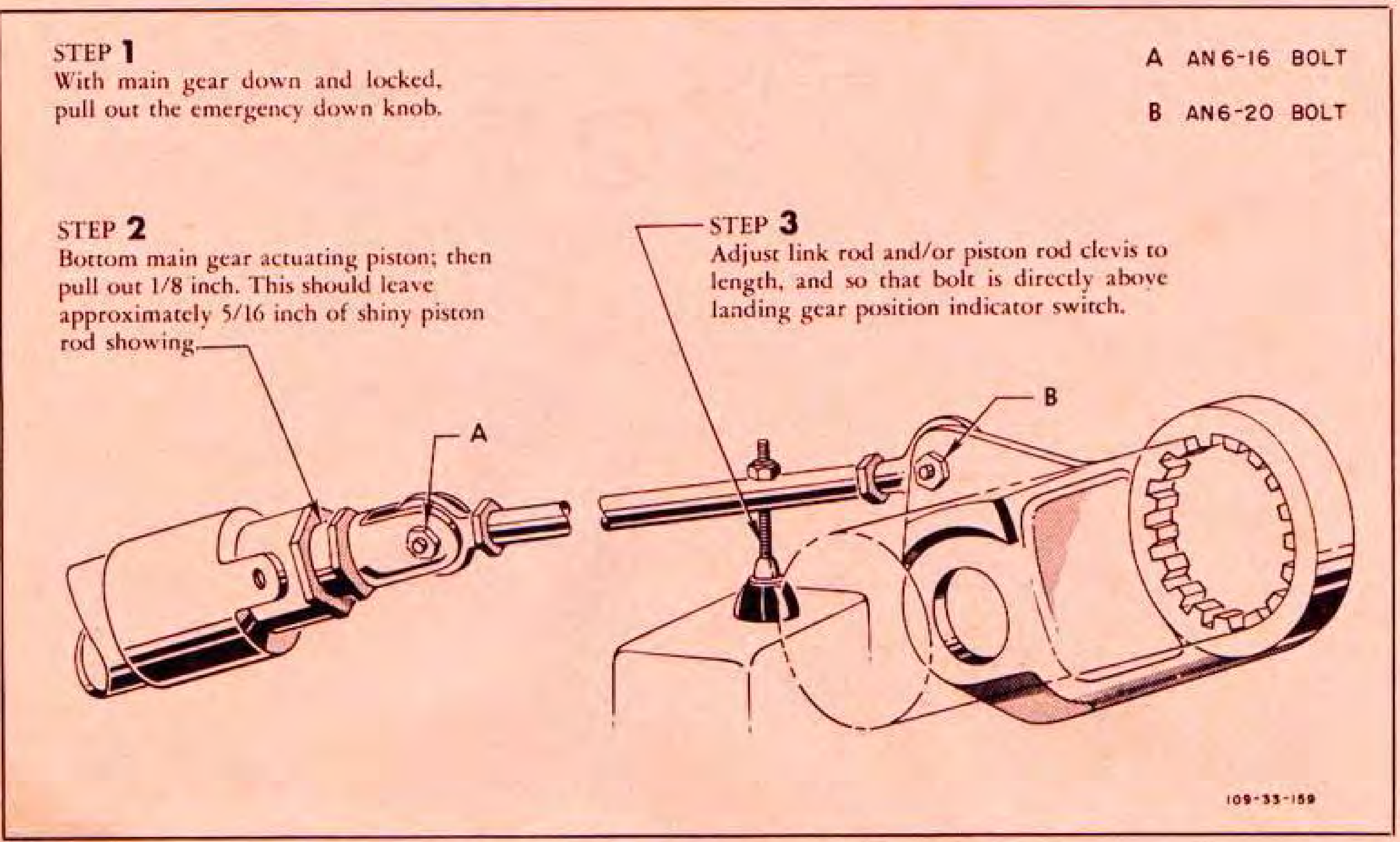



*Figure 129—Adjusting Main Landing Gear Actuating Linkage*

(5) MAIN GEAR DOWN-LOCKPINS.

*(a)* DESCRIPTION.—A main landing gear down-lockpin is located on the inboard side of each main gear. The pin is spring-loaded in the locked position, and seats into and locks the pivot shaft torque arm when the main gear is in the extended position. This pin is retracted by the lockpin hydraulic actuating strut whenever the landing gear control handle is placed in the up position. The strut also acts as a timing valve for the main gear hydraulic actuating strut, preventing hydraulic power from reaching strut before the torque arm is unlocked. *(See figure 131.)*

*(b)* REMOVING AND INSTALLING THE MAIN GEAR DOWN-LOCKPINS. *(See figure 131.)*

*(c)* ADJUSTING MAIN GEAR DOWN-LOCKPINS. *(See figure 132.)*

(6) MAIN GEAR UP-LATCHES.

*(a)* DESCRIPTION.—An up-latch mounted on each lower longeron extends into the wheel well. With the gear retracted, these hook-shaped latches engage rollers mounted on the lower end of each wheel fork. The latches are spring-loaded in the engaged position and are retracted through rod linkage when the landing gear control handle is placed in the gear down position. Serrated mounting permits vertical adjustment of the latches. *(See figures 123 and 133.)*

*(b)* REMOVING, INSTALLING, AND ADJUSTING MAIN GEAR UP-LATCHES. *(See figure 133.)*


*Figure 130—Adjusting Main Gear Shock Strut Fairing*

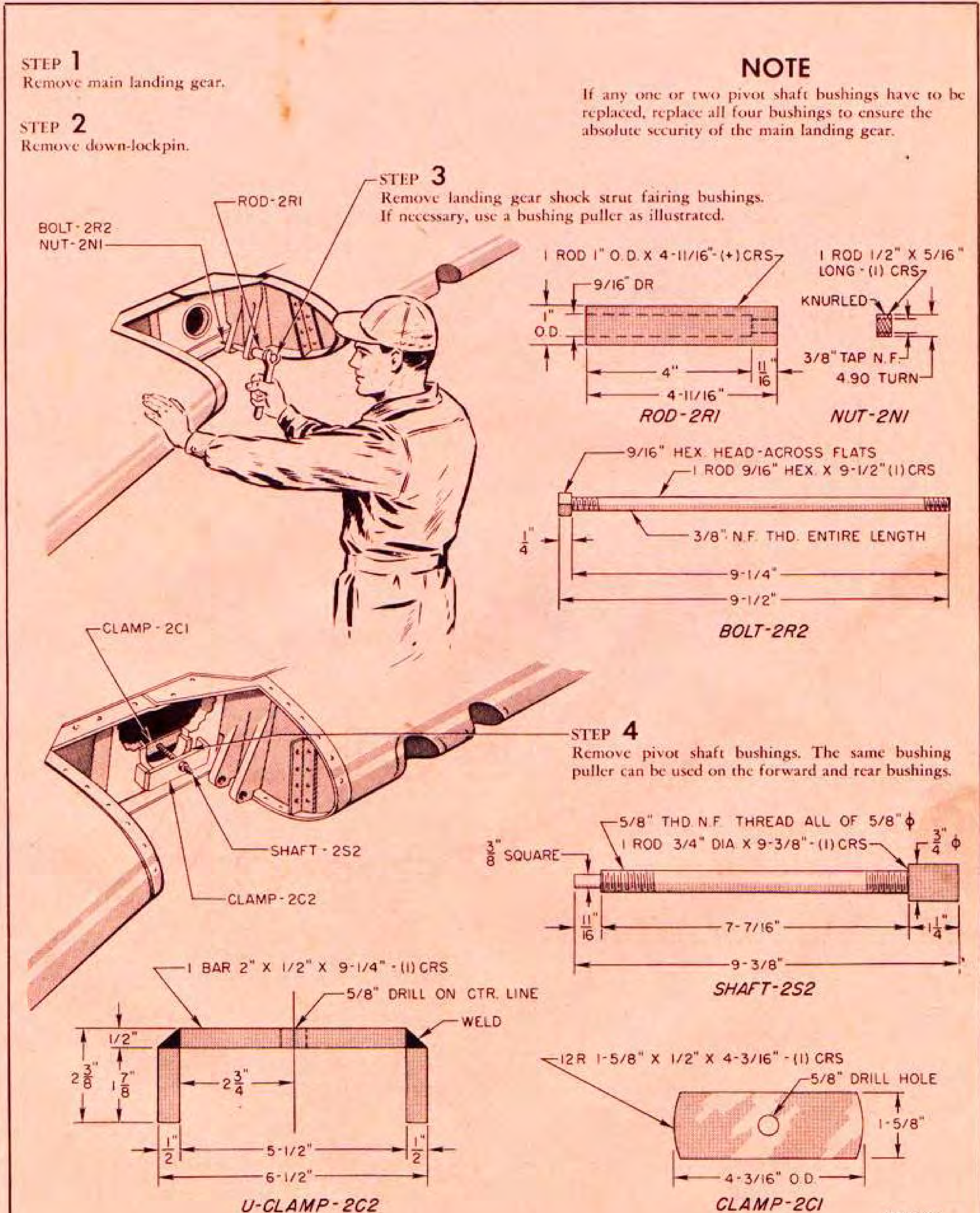
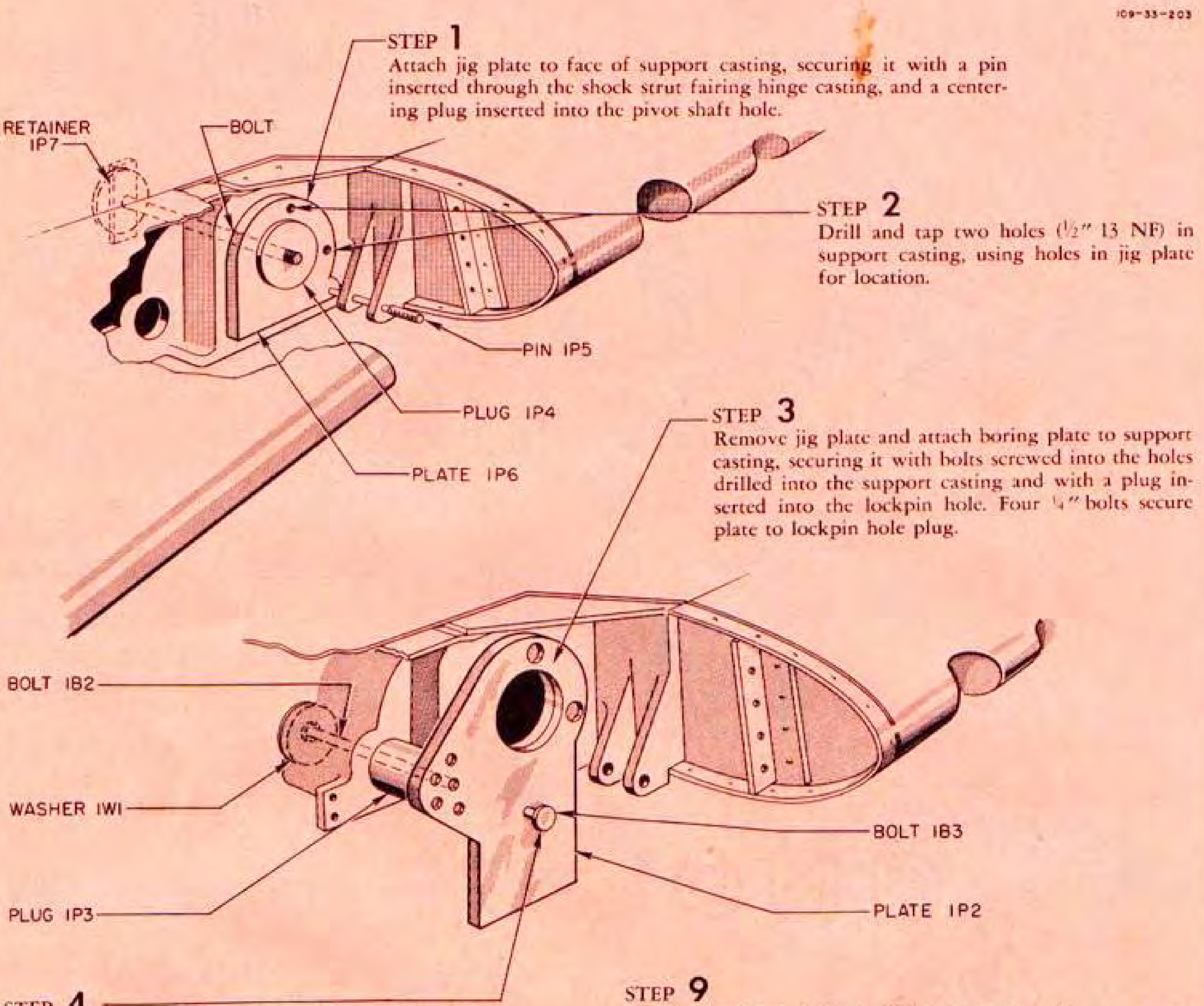



*Figure 130A—Preparation for Reboring Main Gear Pivot Shaft Support Casting*




STEP **4**
Install bolt in plate.

STEP **5**
Suspend the boring bar from a hoist, preferably one that can be moved in any direction, so that weight of boring bar is not supported by jig plate.

STEP **6**
Clamp boring bar to lower edge of boring plate. Be sure that boring bar is absolutely secure.

STEP **7**
Set boring bar in alignment with original hole in casting and adjust bar so that .050 inch will be removed at first cut.

STEP **8**
After first cut, set bar for finishing cut of .011 inch. Finished hole should be 4.3110 $^{.0005}_{.0000}$.

STEP **9**
Remove boring equipment and apply the Dow Treatment solution to the bare metal.

STEP **10**
Allow Dow Treatment solution to remain on metal for 1½ minutes, and then clean the surface with a wet cloth.
Solution (Specification No. AN-M-12) for treating magnesium casting:

| | |
|---|---|
| a. Sodium dichromate | 1.5 lbs. / gal. |
| b. Nitric acid (Sp. Gr. 1.42) | 1.5 pints / gal. |
| c. Magnesium sulfate | 0.2 lbs. / gal. |

d. Add enough water to make a gallon of solution.

With a cloth or sponge, apply the above solution to the bare metal where the oversize hole was bored. (This will increase the size of the bored hole to 4.3120.)

**CAUTION:** Allow to set for 1½ minutes, and then rinse clean with a wet cloth.

*Figure 130B (Sheet 1 of 2 Sheets)—Reboring Main Gear Pivot Shaft Support Casting*

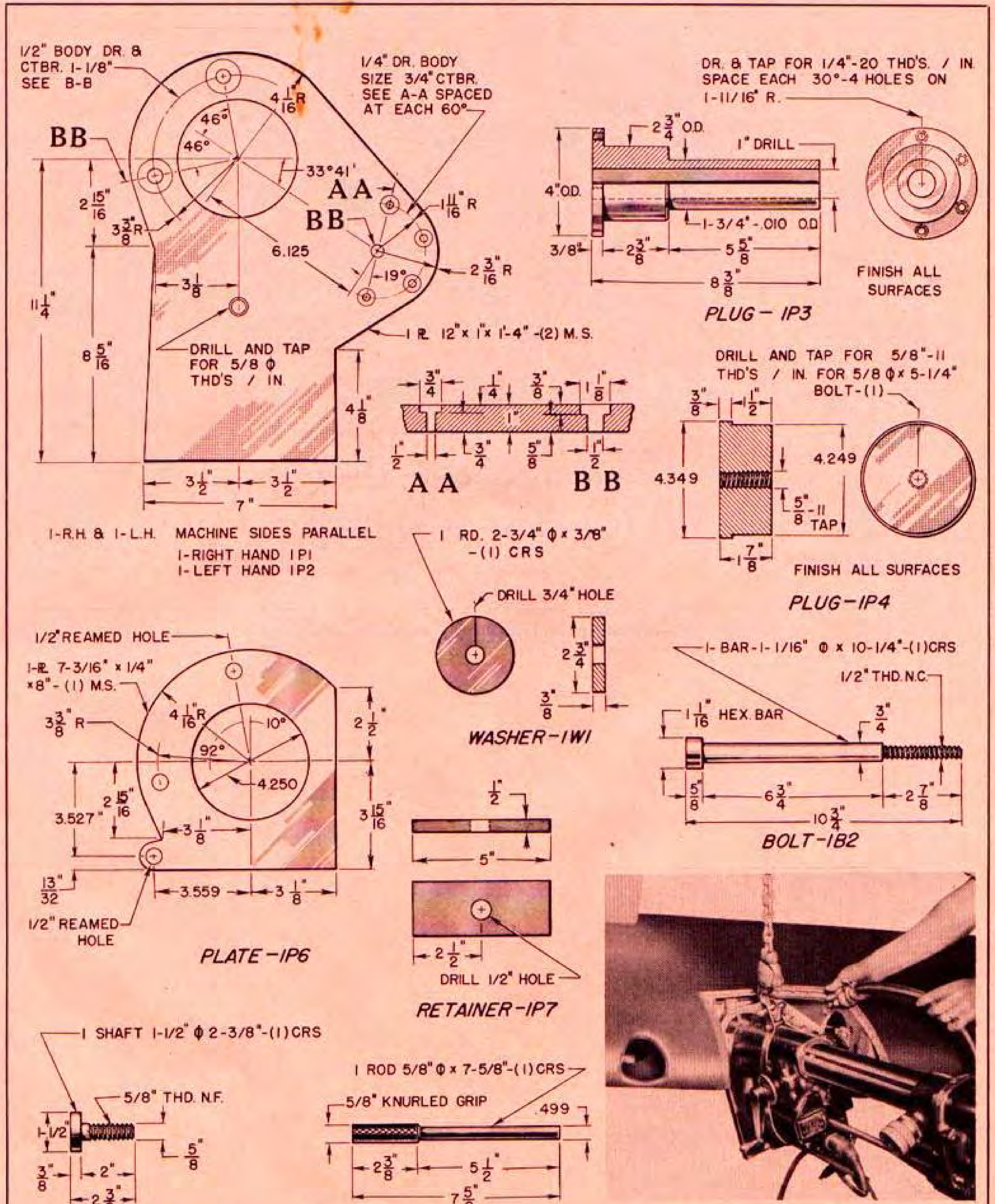



***Figure 130B (Sheet 2 of 2 Sheets)—Reboring Main Gear Pivot Shaft Support Casting***

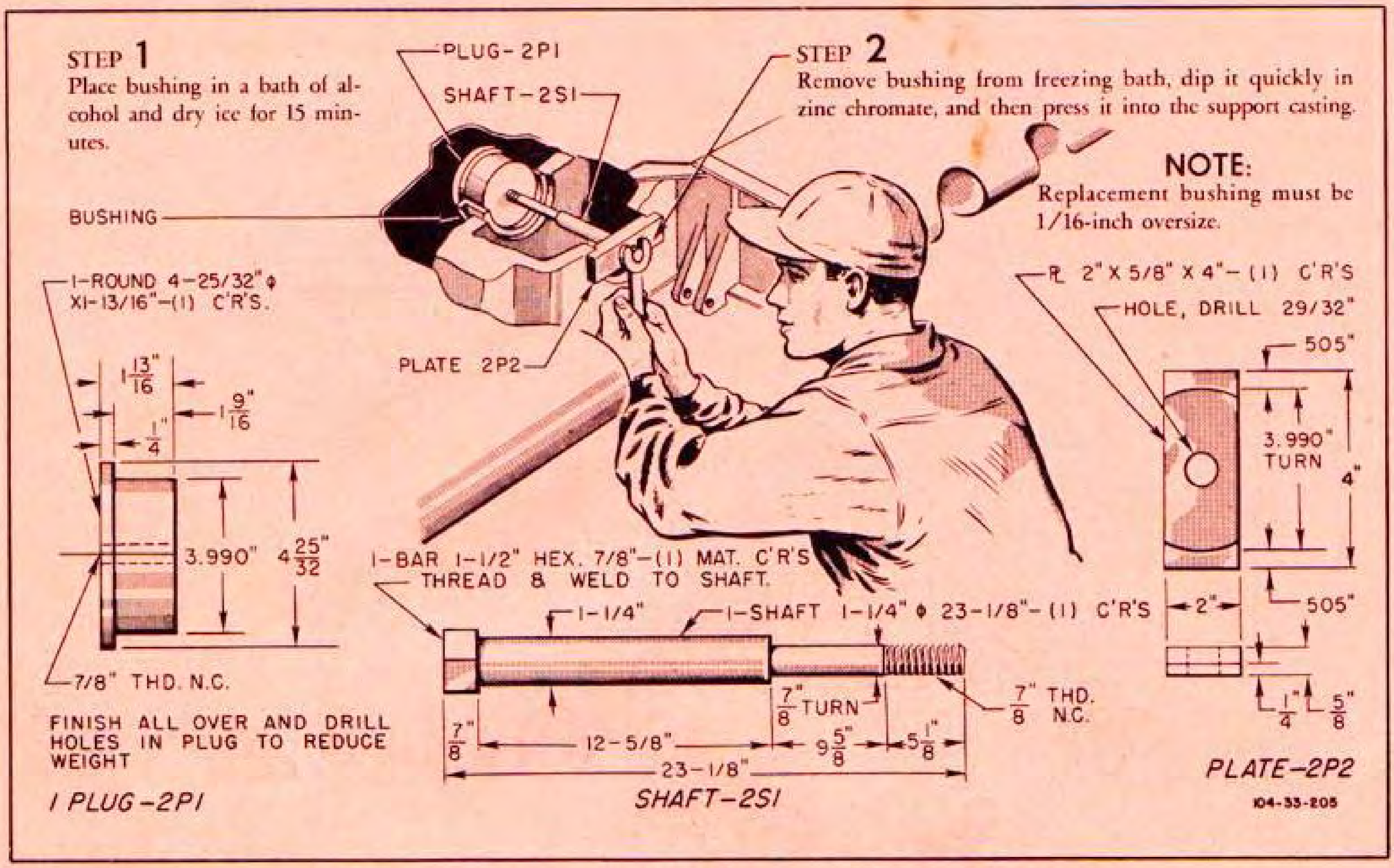
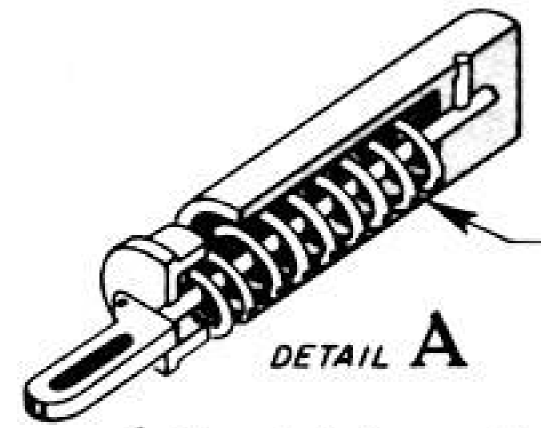
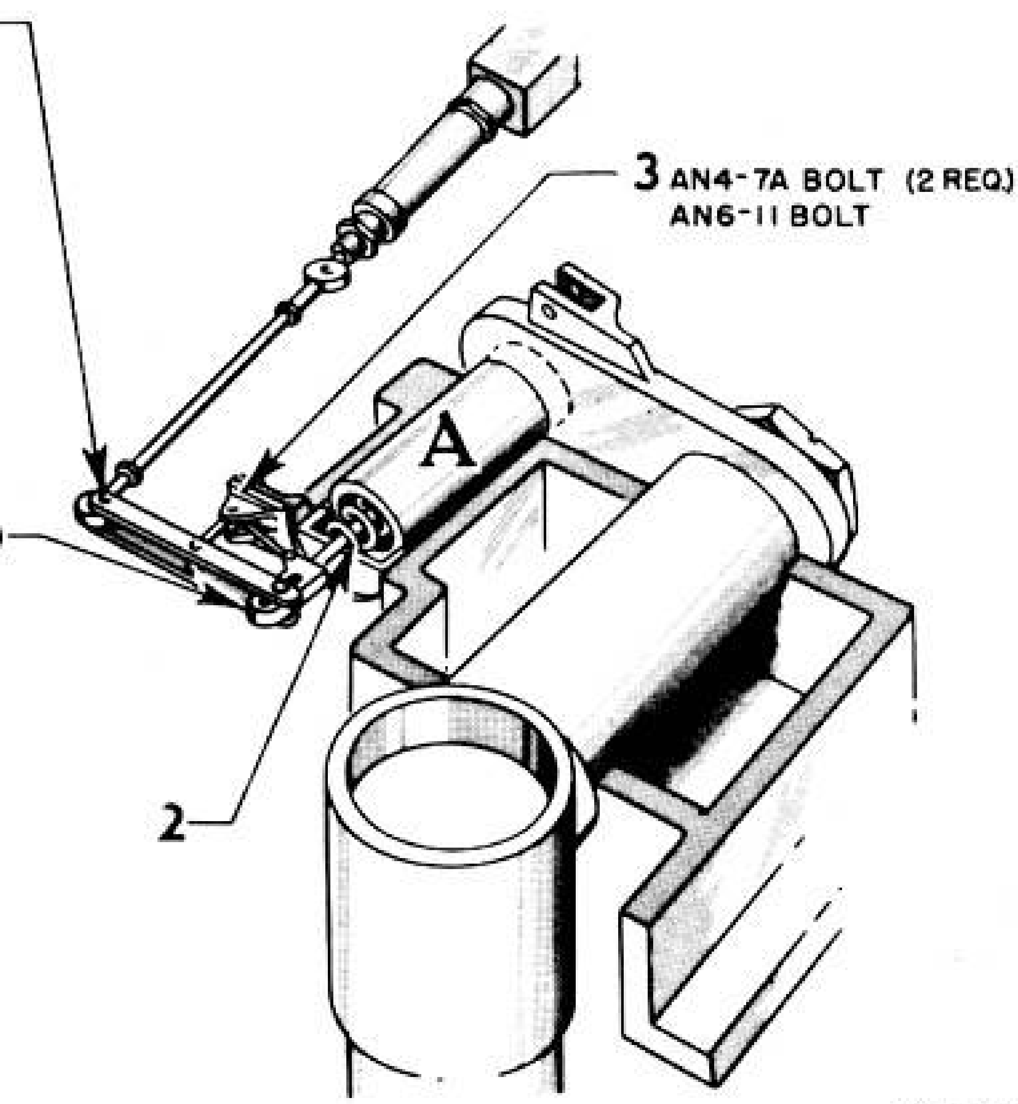



**Figure 130C—Installing Oversize Main Gear Pivot Shaft Bushings**

REMOVAL: Essentially the reverse of installation procedure.




1 Clean lockpin assembly. Grease pin and spring thoroughly, as this cannot be done after installation.

2 Insert lockpin into main gear support casting. Screw lockpin retaining cap in until there is no clearance between cap flange and countersunk seat on casting. Use T63 wrench, or insert two bolts in cap holes, and use screwdriver, inserted crosswise between bolts, as a lever.

3 Install bracket and lever assembly.

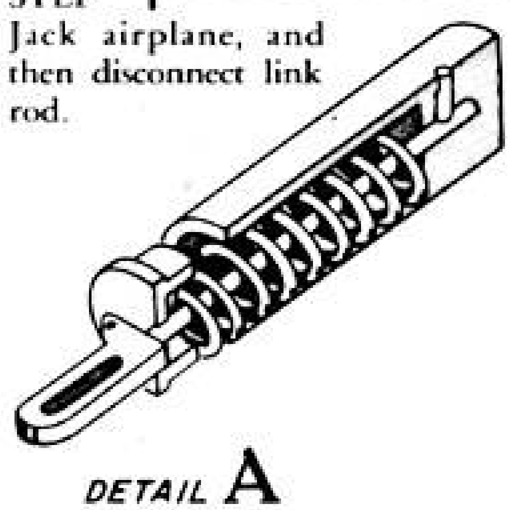
4 and 5 Connect lever to link rod and lockpin.

***Figure 131—Installing Main Gear Down-lockpin***

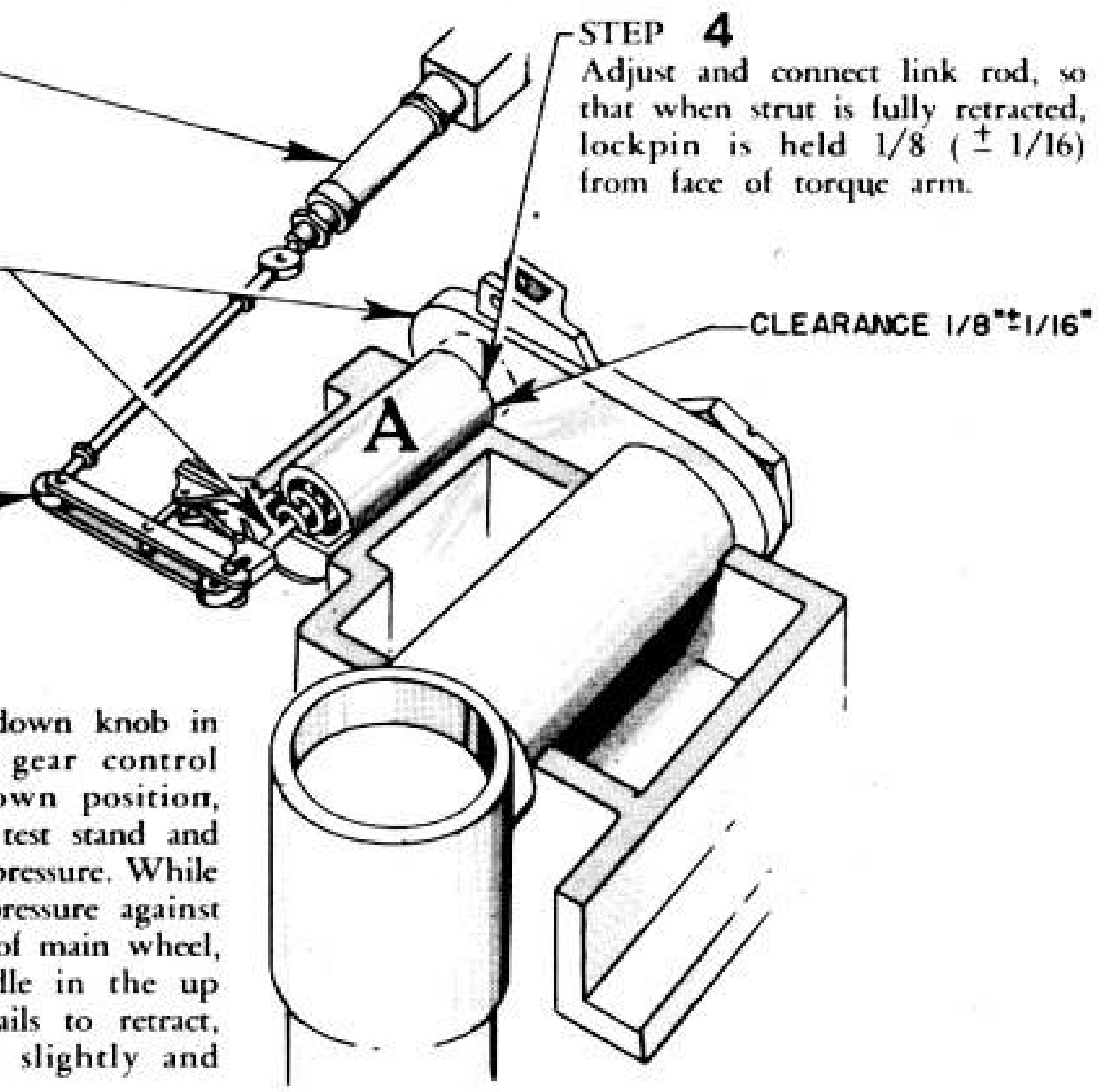
STEP 2
Place landing gear control handle in up position, and operate hydraulic hand-pump until piston is fully retracted.

STEP 3
Pull landing gear emergency down knob, hold lockpin out manually, push main gear slightly inboard, and then release lockpin. This procedure will leave lockpin resting against face of torque arm and not in locking hole.

STEP 1
Jack airplane, and then disconnect link rod.




STEP 4
Adjust and connect link rod, so that when strut is fully retracted, lockpin is held 1/8 (± 1/16) from face of torque arm.




STEP 5
With emergency down knob in and the landing gear control handle in the down position, connect hydraulic test stand and build up 1000 lbs. pressure. While exerting 35 lbs. pressure against the outboard side of main wheel, place control handle in the up position. If gear fails to retract, shorten link rod slightly and repeat test.

***Figure 132—Adjusting Main Gear Down-lockpin***

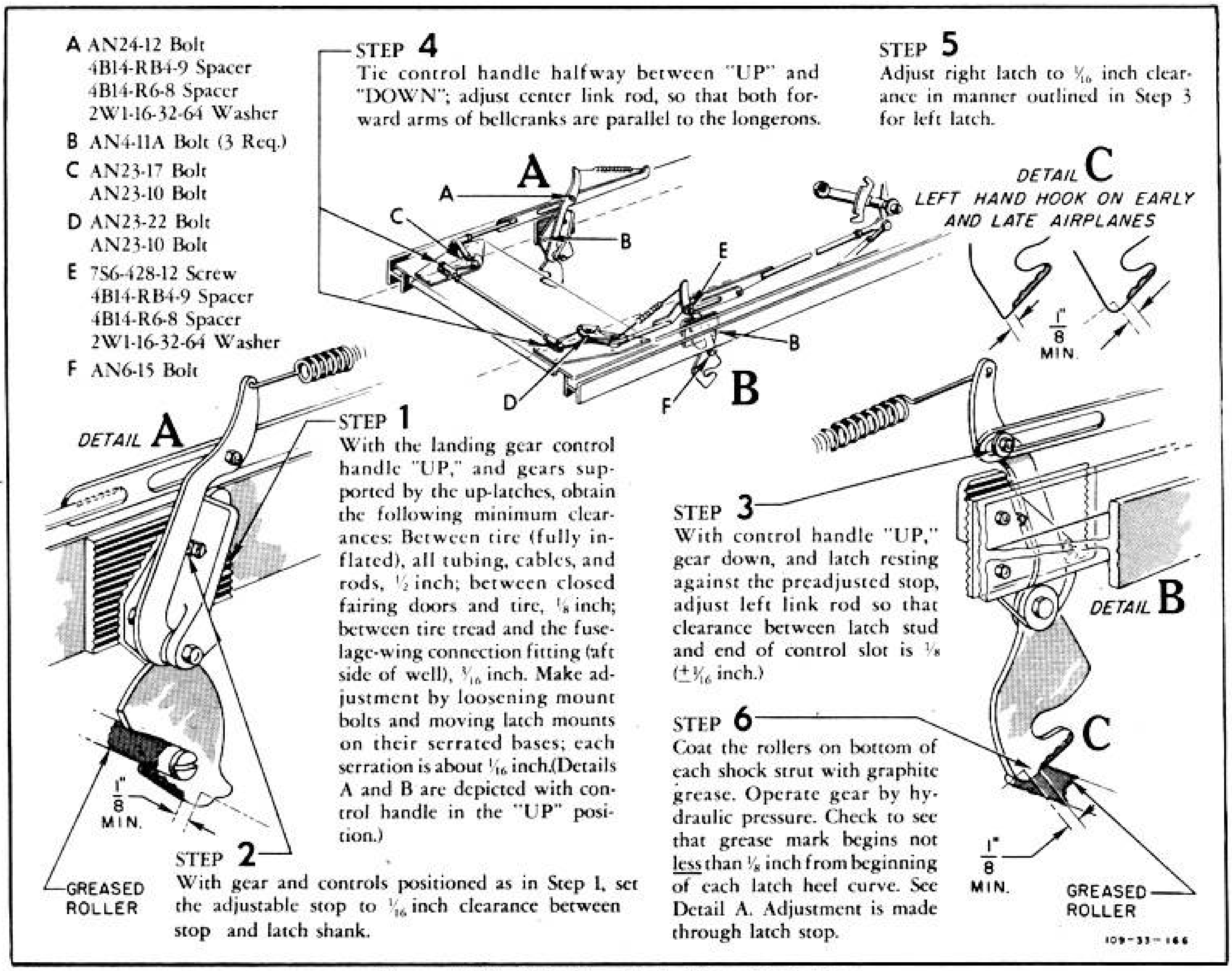



*Figure 133—Adjusting Main Gear Up-latches*

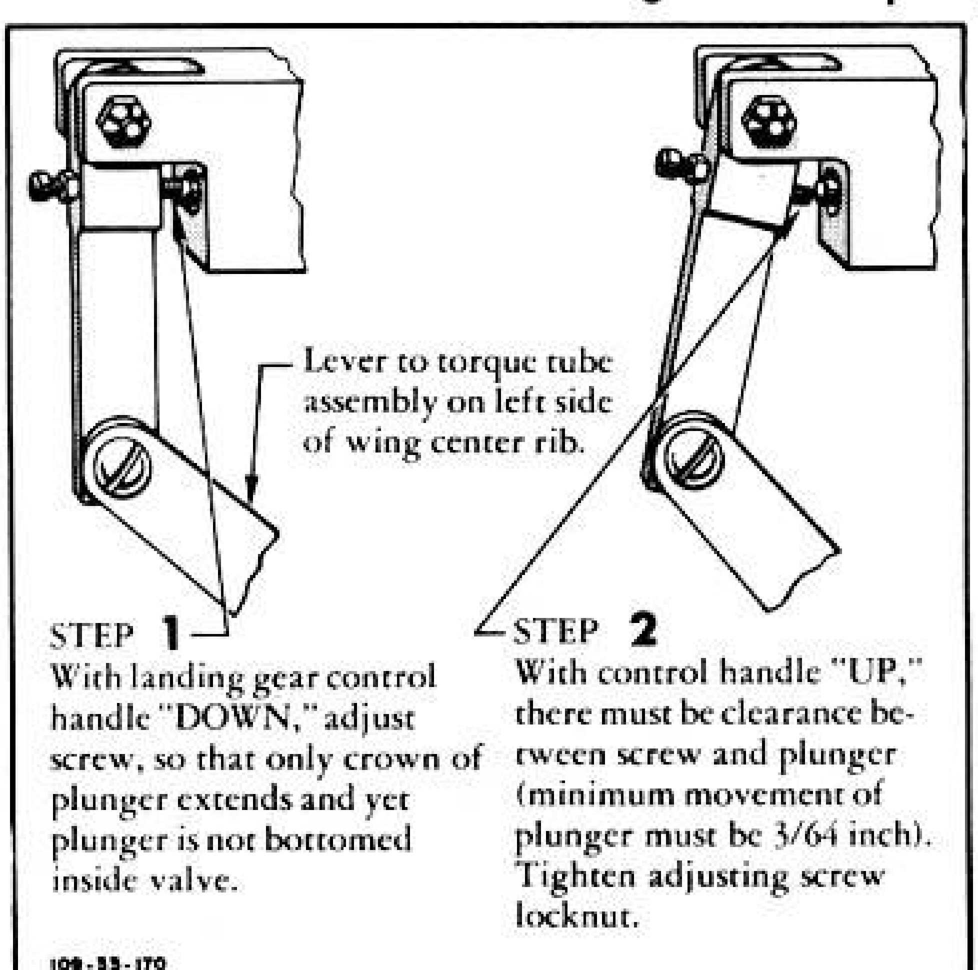



*Figure 134—Adjusting Main Gear Controllable Check Valve*

(7) MAIN GEAR CONTROLLABLE CHECK VALVE.

(*a*) DESCRIPTION.—The controllable check valve, on the left side of the wing center rib, is positioned by a lever connected to the torque tube assembly. The valve is closed when the landing gear controls are in the "UP" position, and thus locks the hydraulic fluid in the main gear actuating struts so that the gear will not drop suddenly in event hydraulic pressure decreases. For further information, refer to paragraph 10. *e.* (8) in this section.

(*b*) ADJUSTING MAIN GEAR CONTROLLABLE CHECK VALVE. *(See figure 134.)*

(8) MAIN GEAR SHOCK STRUT FAIRING.

(*a*) DESCRIPTION.—Shock strut fairings for the main gear are hinged to the wings outboard of the struts. The fairings are connected to the struts by adjustable rods. When the gear is retracted, the fairings move up with the gear and fit flush with the wing skin. *(See figure 130.)*

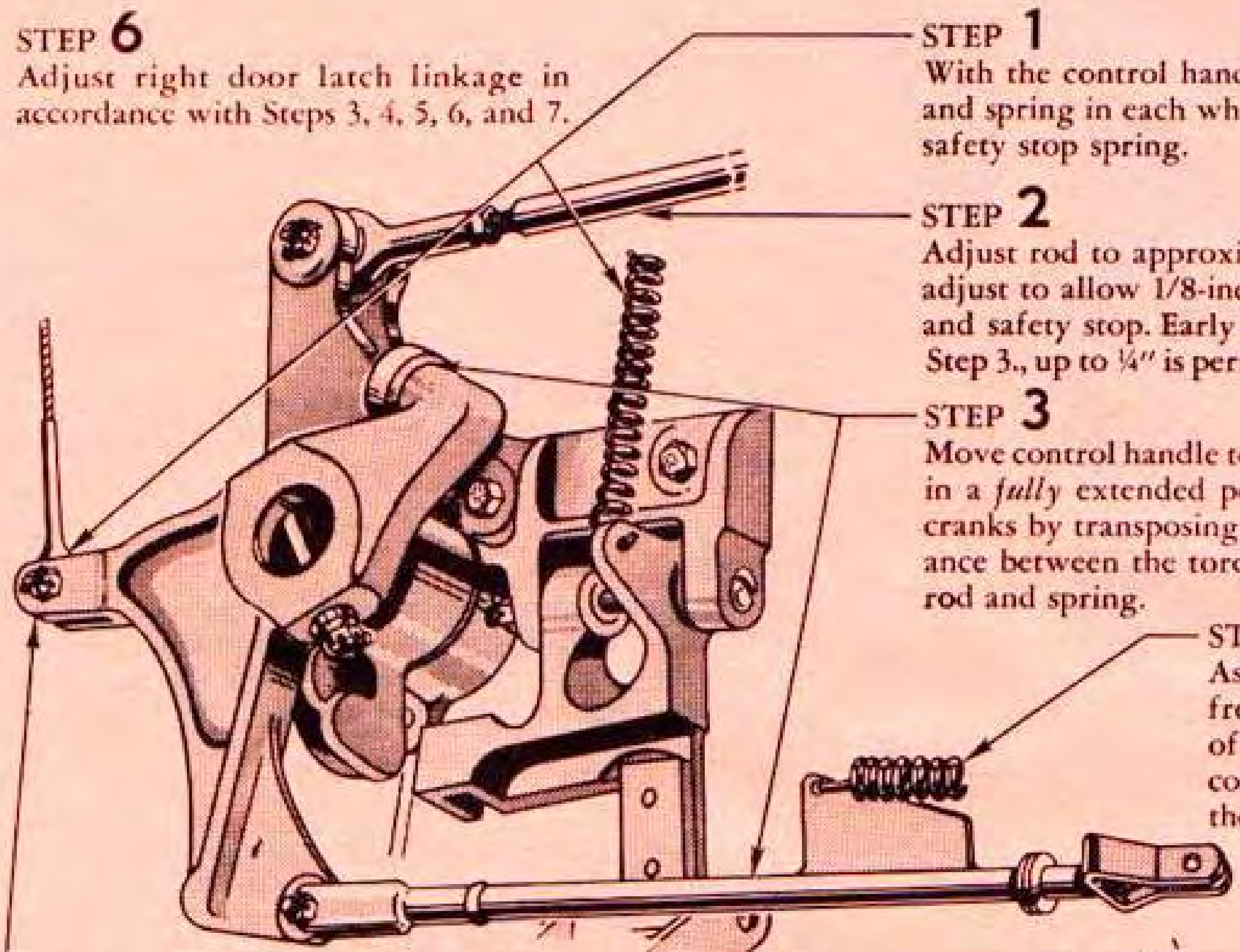
(*b*) REMOVING, INSTALLING, AND ADJUSTING MAIN GEAR SHOCK STRUT FAIRING. *(See figure 130.)*

STEP **6**
Adjust right door latch linkage in accordance with Steps 3, 4, 5, 6, and 7.

STEP **1**
With the control handle "DOWN," disconnect the hinge rod and spring in each wheel well. Disconnect the latch cable and safety stop spring.

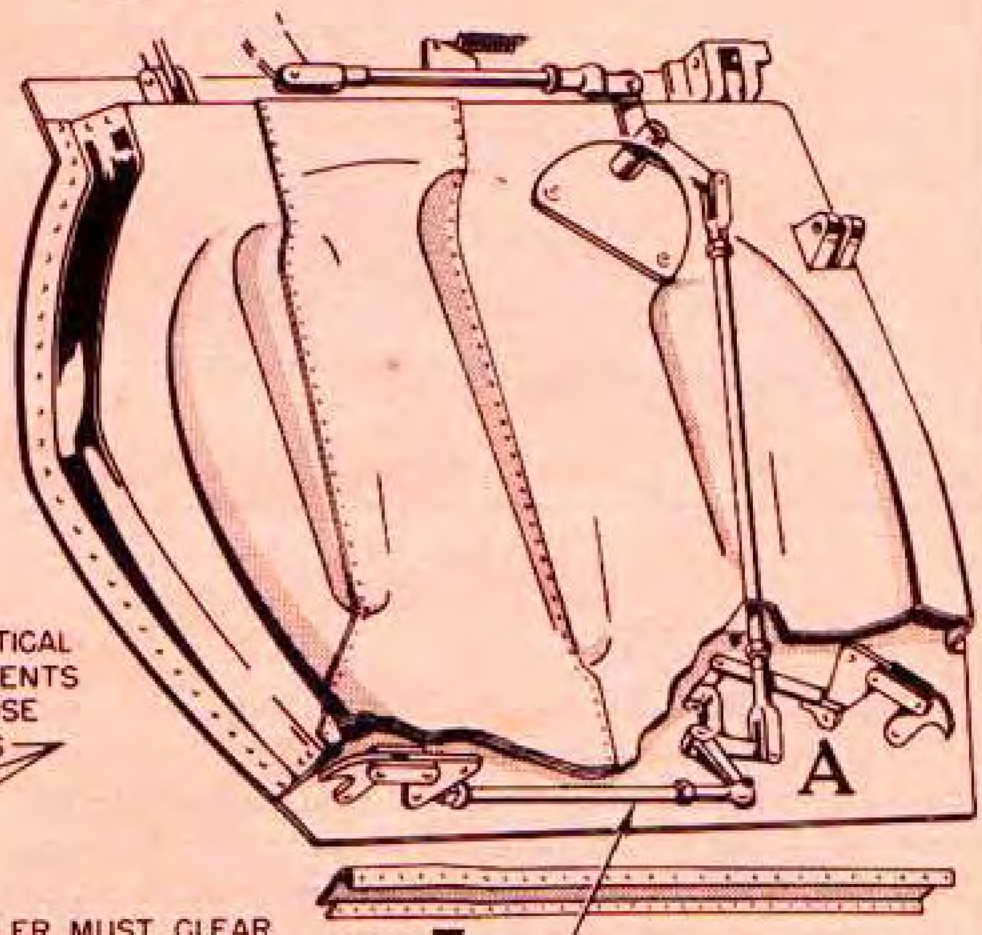
STEP **2**
Adjust rod to approximate length of 11-11/16 inches. Further adjust to allow 1/8-inch clearance between inboard bellcrank and safety stop. Early Airplanes *Only:* If required to complete Step 3., up to ¼" is permitted.

STEP **3**
Move control handle to "UP," and place the fairing door hooks in a *fully* extended position. Adjust rod to fit between bellcranks by transposing washers. Adjustment must allow clearance between the torque tube bellcrank pads. Connect hinge rod and spring.



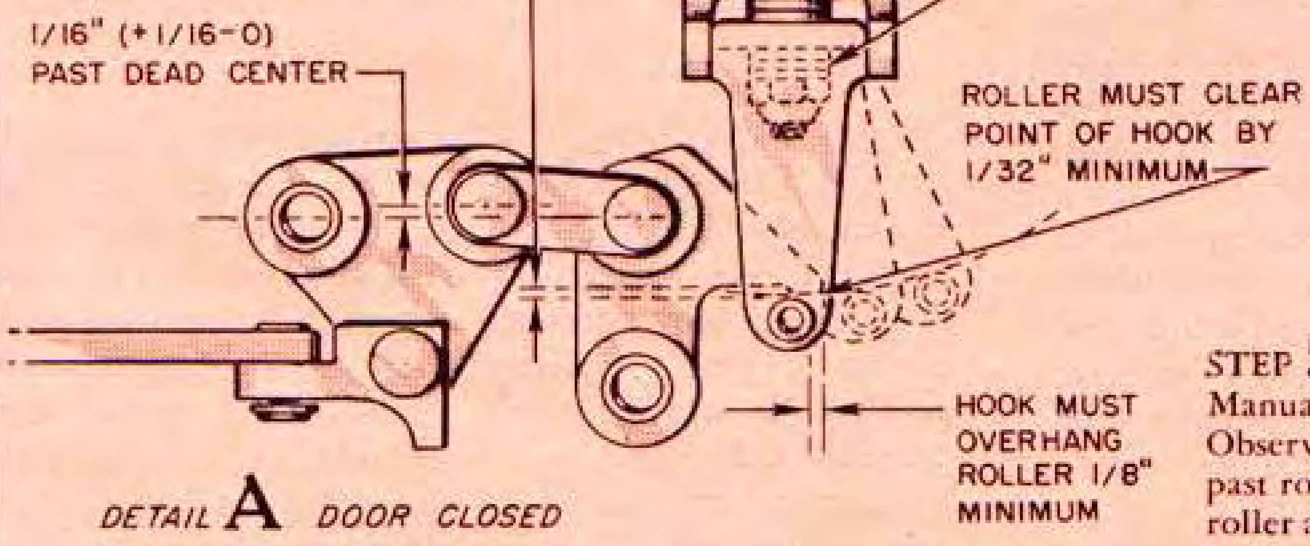
STEP **9**
Ascertain that the torque tube moves freely, by temporarily disconnecting one of the hinge rod springs and then move the control handle; one spring should actuate the hooks on both doors.

STEP **8**
Move control handle to "DOWN." Close door manually and see that hook tip clears roller.




STEP **10**
Connect fairing door latch cable. (Adjustment of this cable has been covered in applicable paragraph.) Test system by repeated operation of landing gear by hydraulic pressure.

STEP **4**
Look into the hook openings to ascertain that the links have passed 1/16 (+1/16 —0) inch past dead center. *This is a mandatory requirement.*




STEP **7**
See that the action of both hooks in the door is exactly synchronized, and adjust rod if necessary. (As door linkage is adjusted at the factory, further adjustment is seldom needed.)

STEP **5**
Manually close fairing door to locked position. Observe that hook extends a minimum of 1/8-inch past roller. While firmly holding door closed, swing roller assembly in its arc and see that the roller passes under tip of hook with 1/32-inch clearance.

109-33-172A

***Figure 135—Adjusting Main Gear Fairing Door Up-latch Linkage***

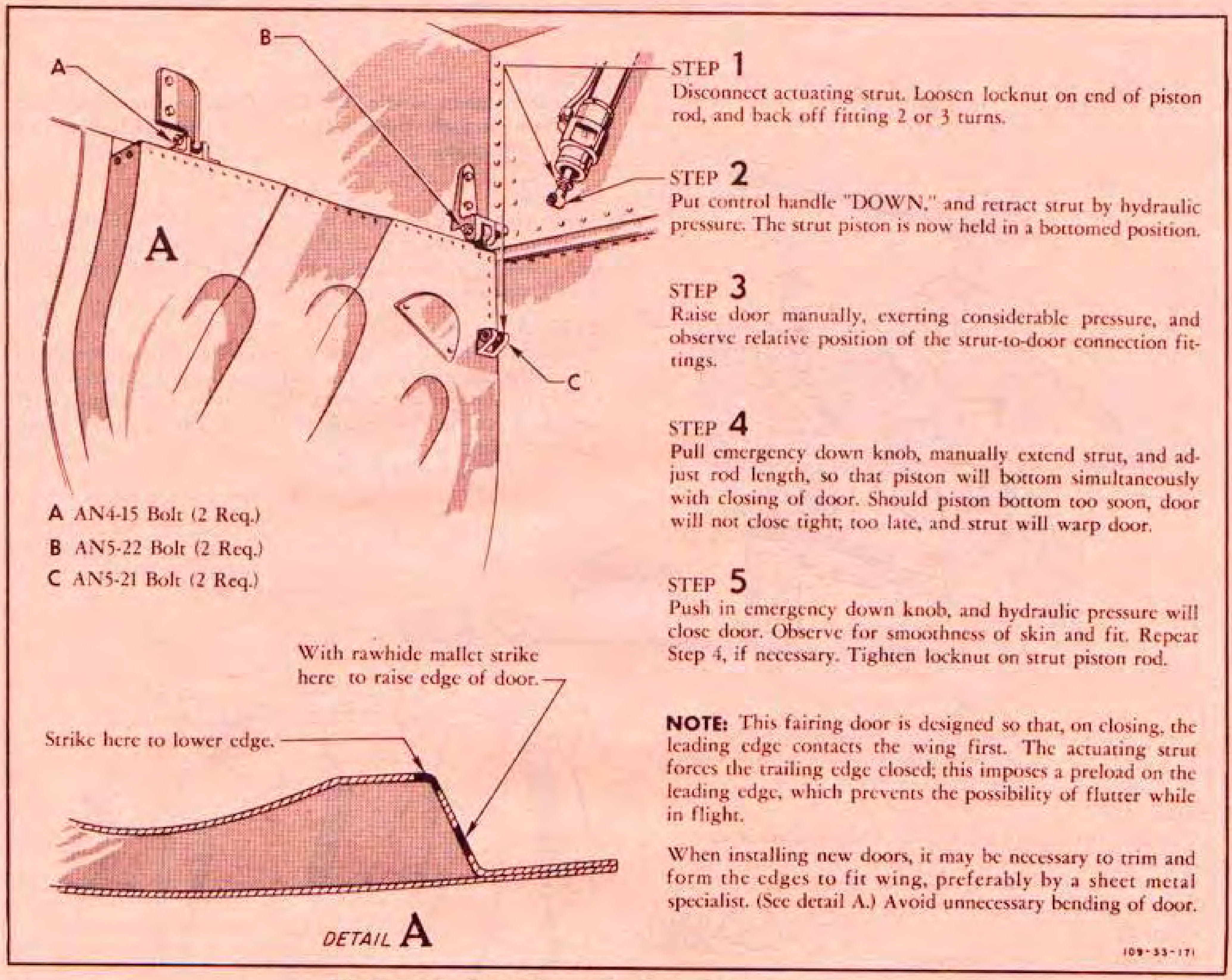



***Figure 136—Adjusting Main Gear Fairing Doors***

(9) MAIN GEAR FAIRING DOORS.

*(a)* DESCRIPTION.—Hydraulically operated fairing doors are hinged on the wing center rib. *(See figure 136.)* The doors are actuated by hydraulic struts connecting between the aft side of each door and the wing. The doors are closed flush with the lower skin of the wing at all times, except when the main gears are in process of extending and retracting. The operation of the fairing doors is timed through a hydraulic valve. *(See figure 137.)* When the main gear is retracted, the doors are locked closed by up-latch hooks, located on the forward and aft side of the doors. These latches are operated by rod linkage from the landing gear torque tube assembly. When the main gear is extended, cable linkage from the right shock strut to the torque tube assembly holds the latch hooks in an unlocked position.

*(b)* REMOVING, INSTALLING, AND ADJUSTING MAIN GEAR FAIRING DOORS. *(See figure 136.)*

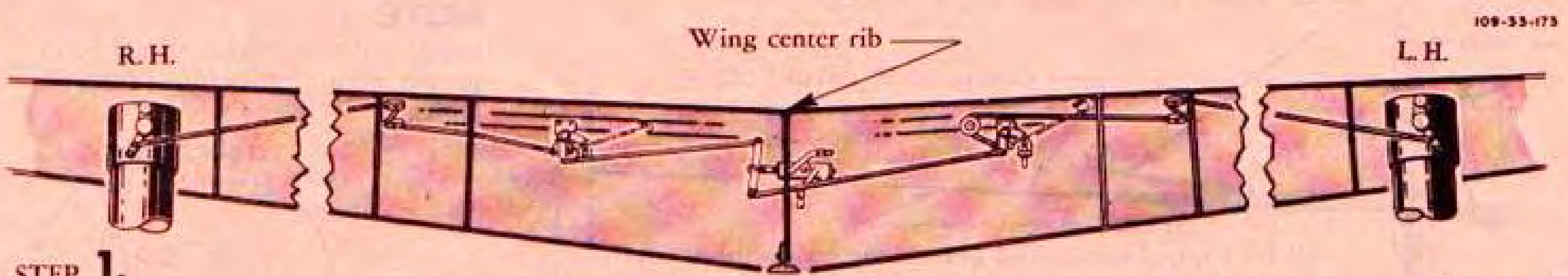
*(c)* ADJUSTING MAIN GEAR FAIRING DOOR TIMING VALVE LINKAGE. *(See figure 137.)*

*(d)* ADJUSTING MAIN GEAR FAIRING DOOR UP-LATCH LINKAGE. *(See figure 135.)*

*(e)* ADJUSTING MAIN GEAR FAIRING DOOR UP-LATCH CABLE. *(See figure 138.)*

*g.* TAIL GEAR.

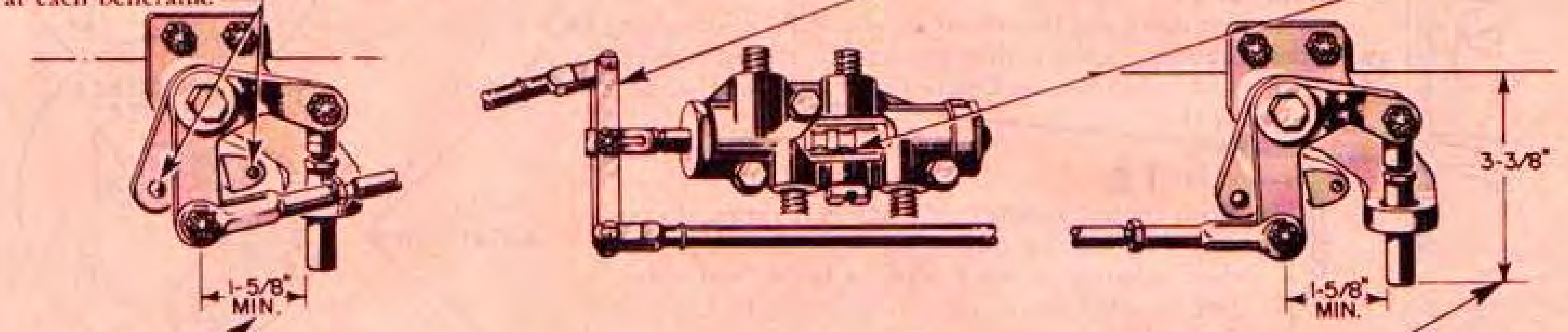
(1) DESCRIPTION.—The auxiliary tail gear is fully retractable, free swiveling, and steerable. The gear is installed in a trunnion-like manner to a single support casting bolted to the two lower longerons. The tail wheel, which is retracted hydraulically, moves forward and up, and the fairing doors enclose the gear completely within the fuselage. The tail gear shock strut assembly consists of a shock strut cylinder and piston, a torque tube, a post assembly housing, and a post assembly which supports the tail wheel axle. A filler plug with an air valve is provided at the top of the shock strut. The torque tube connected to the post assembly housing prevents the shock strut piston from turning in the shock strut cylinder. A roller on top of the shock strut assembly engages the up-latch when the gear is retracted, and a lug on top of the shock strut assembly




STEP **1.**
With gear down and emergency down knob pulled, disconnect cables and springs at each bellcrank.

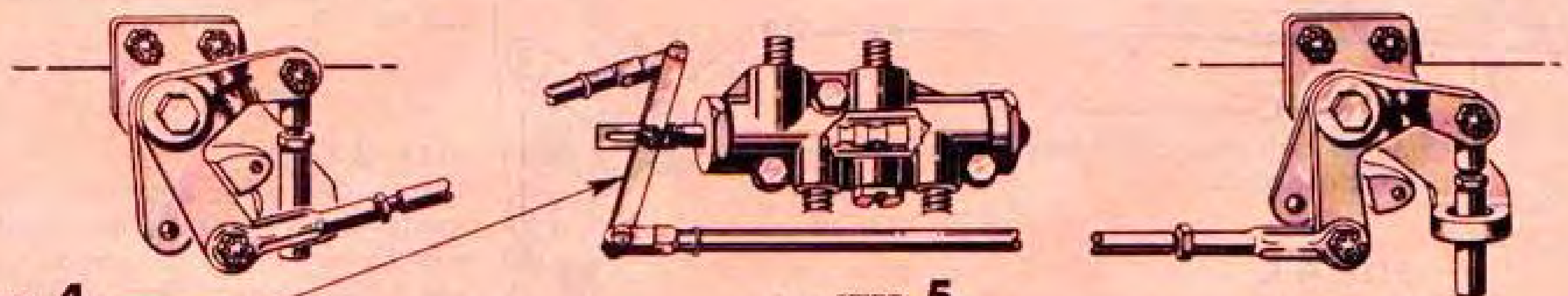
Position crossbar at end of slot and at a 90-degree angle to valve.

Extend valve plunger until internal positioning ball seats.



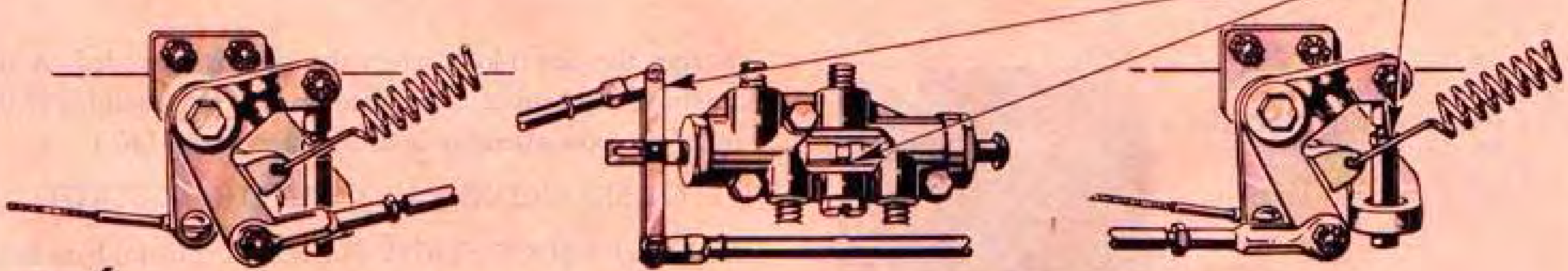

STEP **2.**
Position both bellcranks so that distance from center of lower arm to side of striker pin is 1-5/8 inch minimum.

STEP **3.**
Adjust both striker pins to a temporary length of 3-3/8 inches, measured from end of pin to lowest point of nearest stringer.



STEP **4.**
Place control handle "UP," and manually raise right (or left) gear to an up-locked position. Valve crossbar will assume angle illustrated, having moved in the plunger slot without moving plunger.

STEP **5.**
Manually raise opposite gear to up-locked position. Valve plunger will have moved in (test for seating of internal positioning ball), and crossbar positioned approximately 90 degrees to valve. Adjust length of striker pins if valve operation is not as outlined. Tighten striker pin locknut.



STEP **6.**
Place control handle and gears in down position. Reconnect cables and springs disconnected in Step 1. Adjust cables so that valve and crossbar will assume position described in Step 1.

## OPERATIONAL TESTS:

(A) With control handle and gear down, build up hydraulic pressure. While manually holding one gear down, move control handle to "UP." Opposite gear will retract but fairing doors should not close until held gear is released and in the up-locked position.

(B) With gear up, doors closed, and while manually holding one fairing door up, move control handle to "DOWN." Opposite gear will move down, but fairing door remains open until held door is released and gear reaches down position.

***Figure 137—Adjusting Main Gear Fairing Door Timing Valve Linkage***

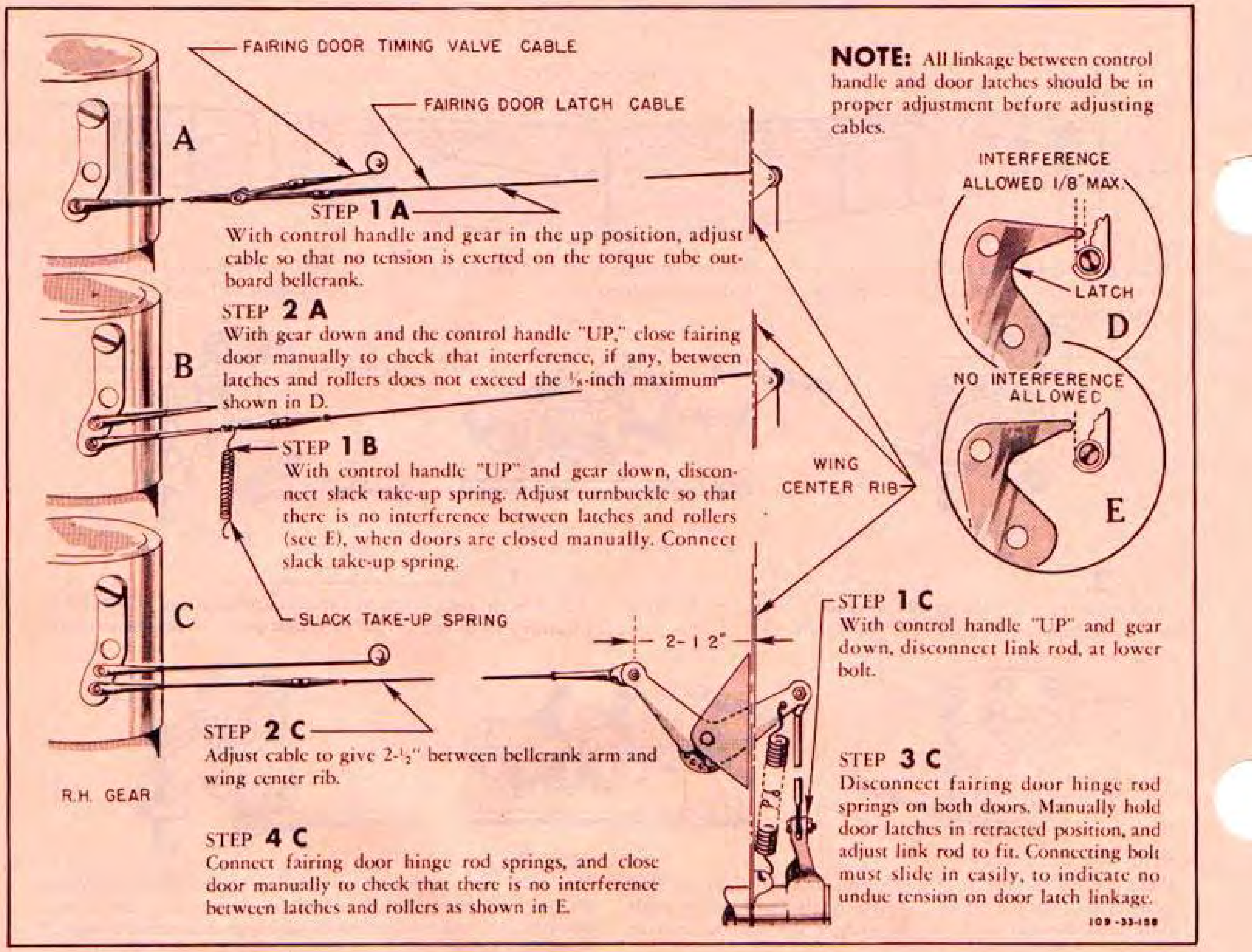



***Figure 138—Adjusting Main Gear Fairing Door Latch Cable—Three Types of Installation***

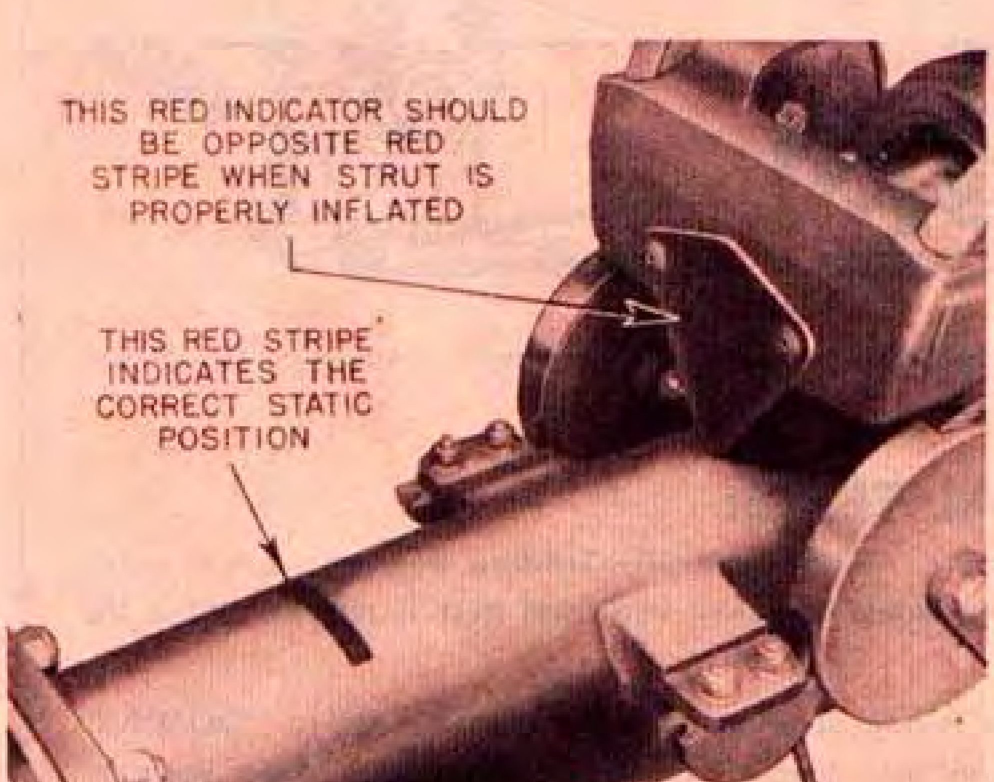



***Figure 139—Tail Gear Inflation Indicator***

engages the down-lock when the gear is extended. A declutching mechanism is installed on the post assembly at the top of the post assembly housing. *(See figure 140.)*

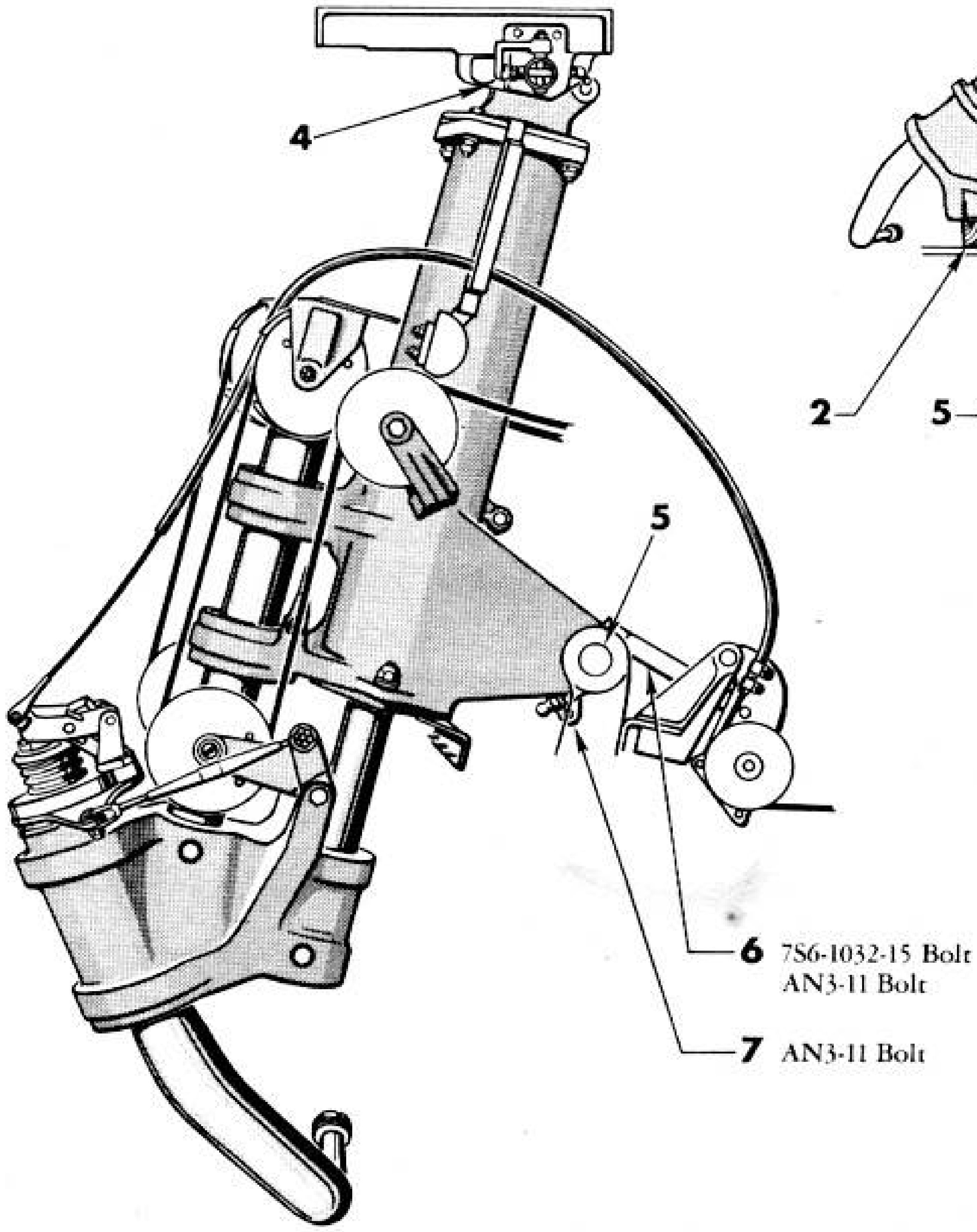
(2) SERVICING TAIL GEAR SHOCK STRUT.

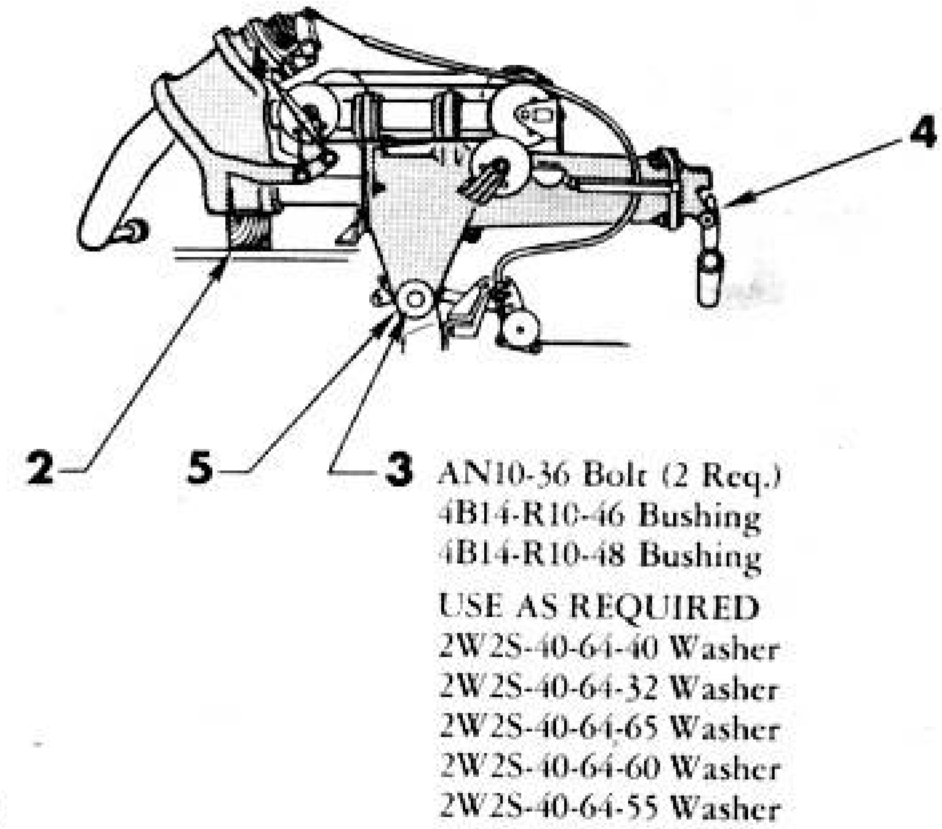
*(a)* SHOCK STRUT FLUID.—A mineral base fluid, Specification No. AN-VV-O-366, is used in the tail gear shock strut. The packing rings are designed for this type fluid only, and the use of any other type fluid might cause the shock strut to fail in service.

*(b)* FILLING TAIL GEAR SHOCK STRUT.—The tail gear shock struts are filled in the same manner as the main gear shock struts. *(See paragraph 4. f. (2) (b).)*

*(c)* INFLATING TAIL GEAR SHOCK STRUT. *(See figure 139.)*

*1.* Inflate the tail wheel strut until the red indicator at the top of the tail wheel torque tube is directly opposite the red line on the strut. This operation must be performed with the tail resting on the ground.




REMOVAL – Essentially the reverse of installation procedure. Weight of assembly approximately 50 pounds.

Save the washers used on each pivot pin for reinstallation. By replacing each in exact position, step 5 will be saved.

**1** Hoist or jack airplane tail to a convenient height (weight lift tube with 200 pounds). Remove fuselage access doors directly below horizontal stabilizers.

**2** Lift the assembly through the tail wheel opening, and place in gear up position. Place a temporary support over wheel opening to support assembly.

**3** Place bushings into the pivot bolt holes, and bolt to the support bracket.

**4** Remove support, release up-latch, and swing assembly 2 or 3 times from the up to the down position to test alignment with locks.

**5** If necessary to correct alignment, replace temporary support, remove pivot bolts, and substitute thicker washers on one side and thinner washers on other until alignment is made. .010 max. side play.

**6** Attach hydraulic strut actuating arm.

**7** Connect fairing door actuating link.

**8** Refer to applicable paragraphs for cable installations.

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***Figure 140—Installing Tail Gear Assembly***

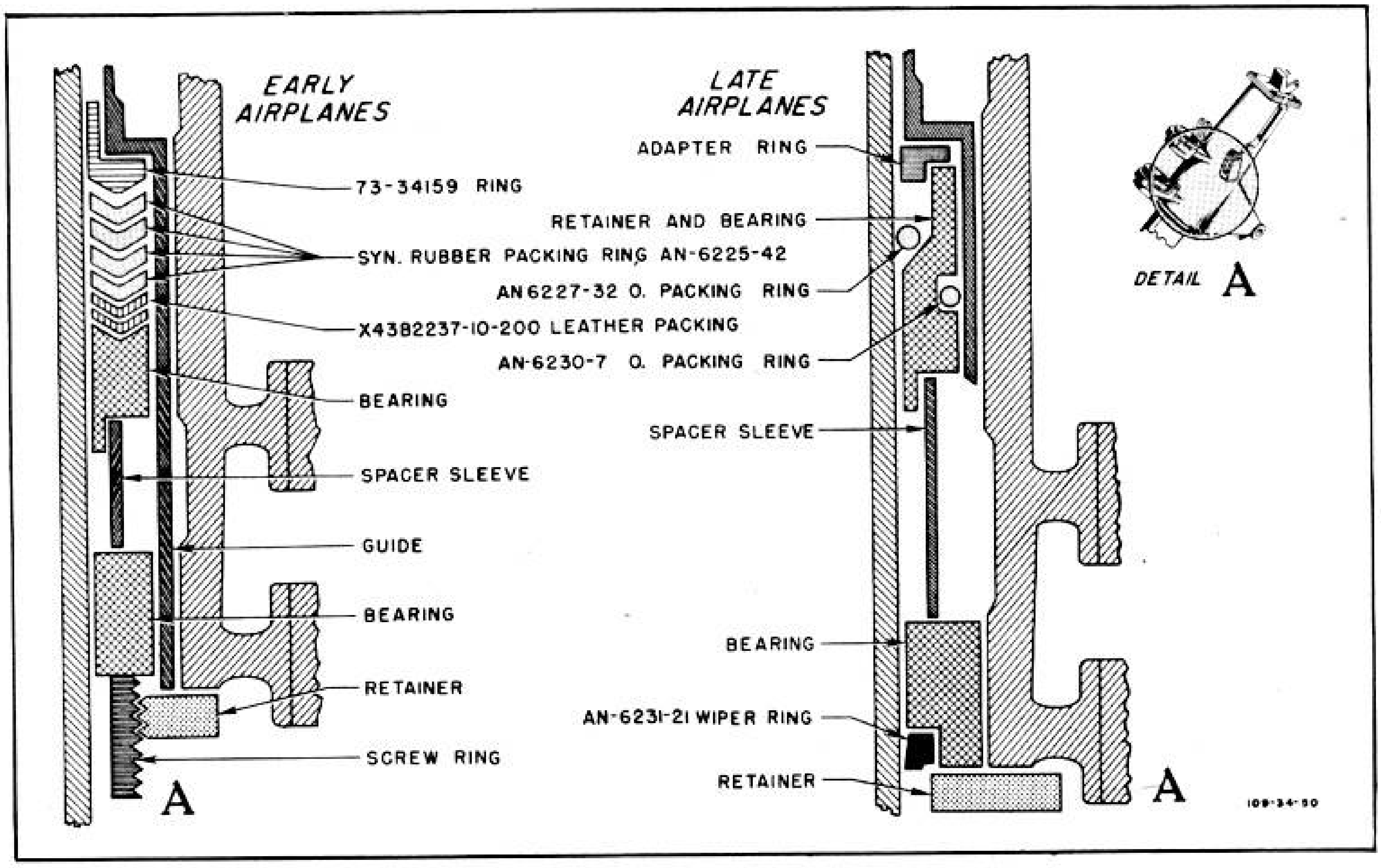



*Figure 141—Tail Gear Shock Strut Cylinder Packing*

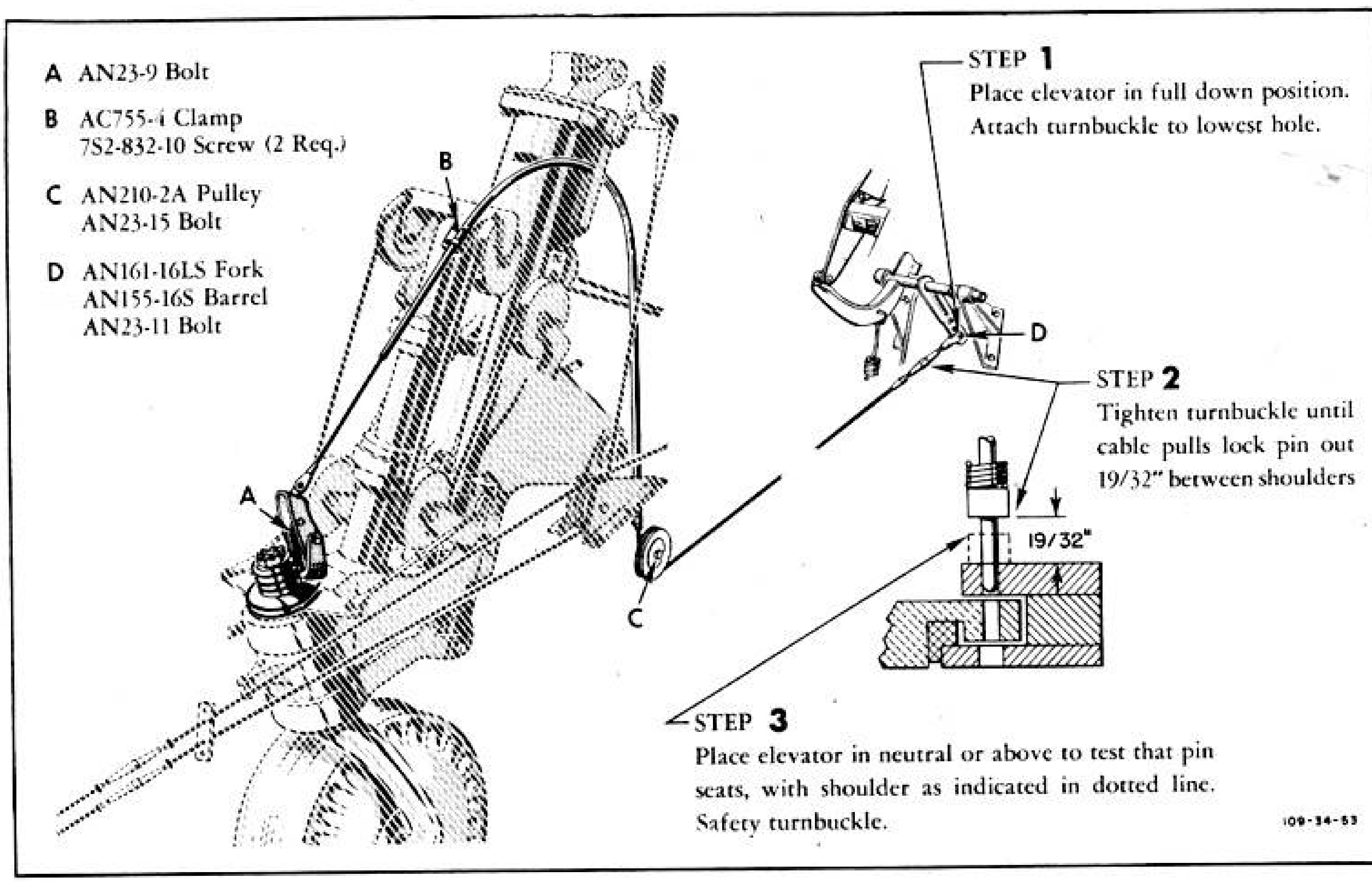



*Figure 142—Adjusting Tail Wheel Declutching Cable*

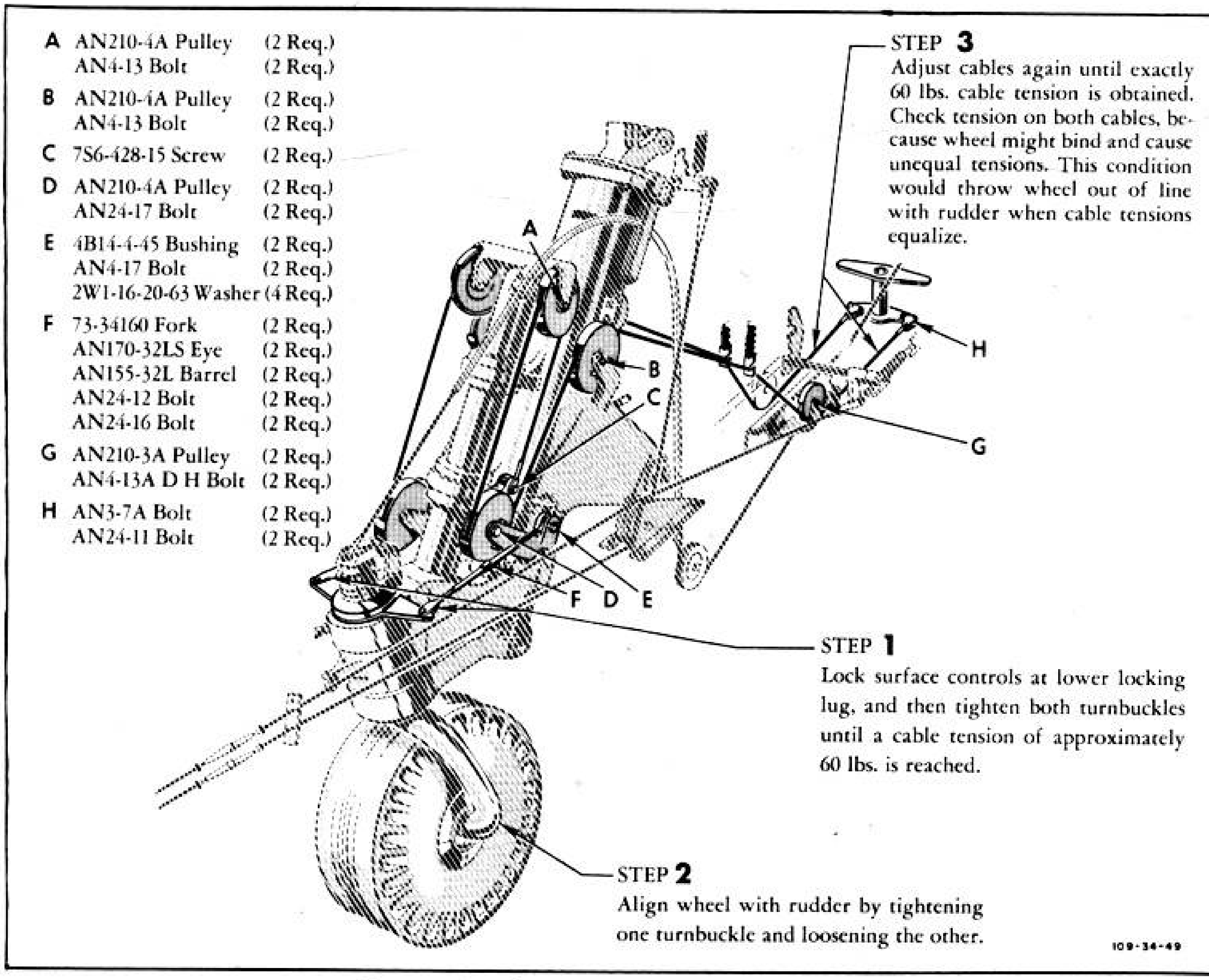



***Figure 143—Adjusting Tail Gear Steering Cables***

2. Replace the hex cap, which is a secondary seal, and tighten lightly with a wrench. Do not tighten cap excessively as the seat in the cap will be forced inward, thereby depressing the valve core stem.

3. Test valve core and seat around the filler plug by applying soapy water to these joints. Usually, leaks around other parts will be evidenced by seepage of fluid.

*(d)* CLEANING TAIL GEAR SHOCK STRUT.—Clean the shock strut piston and cylinder with kerosene or solvent, Specification No. P-S-661, and dry with a lint-free rag or compressed air. Wipe packing rings clean with a lint-free rag.

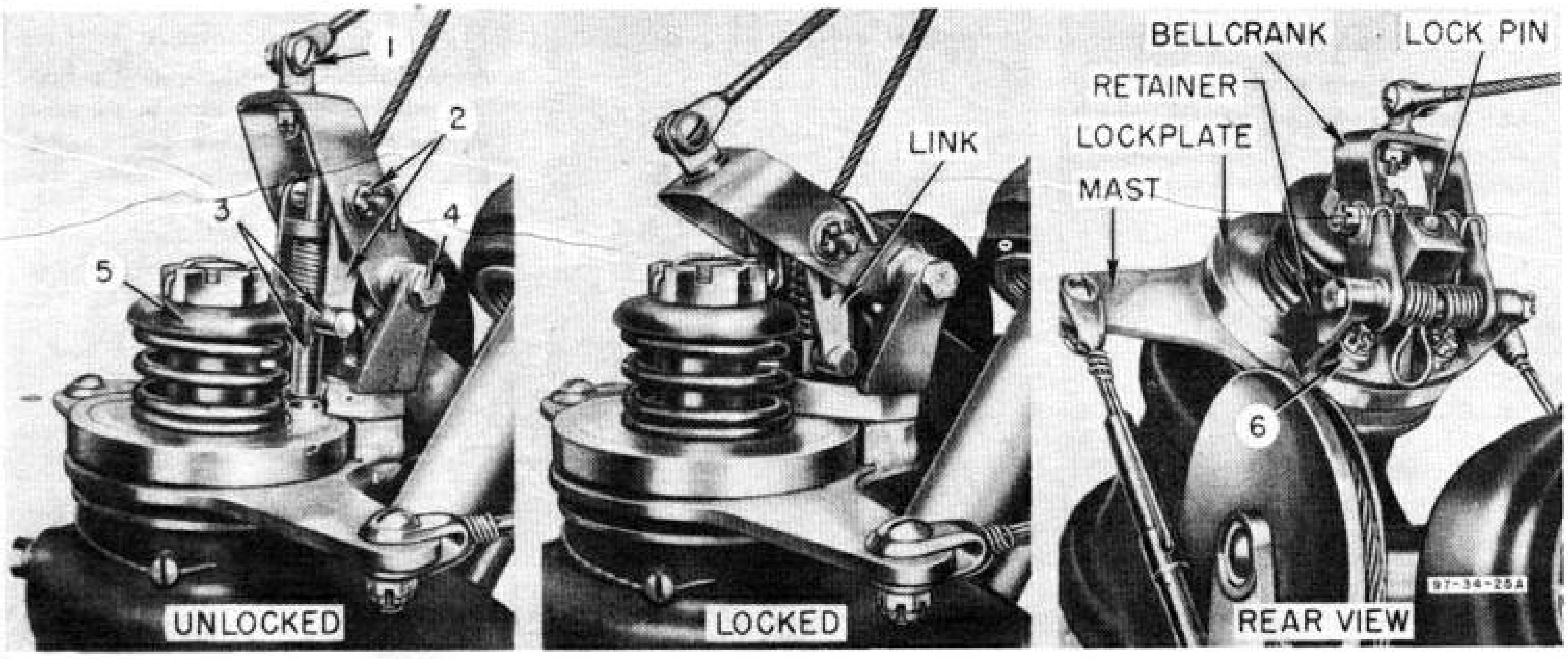
*(e)* TAIL GEAR SHOCK STRUT AIR VALVE.—The tail gear shock strut air valve is similar to the main gear shock strut air valves, and the same maintenance procedure applies.

*(f)* TAIL GEAR SHOCK STRUT PACKING.—For type of packing used, refer to figure 141.

(3) REMOVING AND INSTALLING TAIL GEAR ASSEMBLY. *(See figure 140.)*

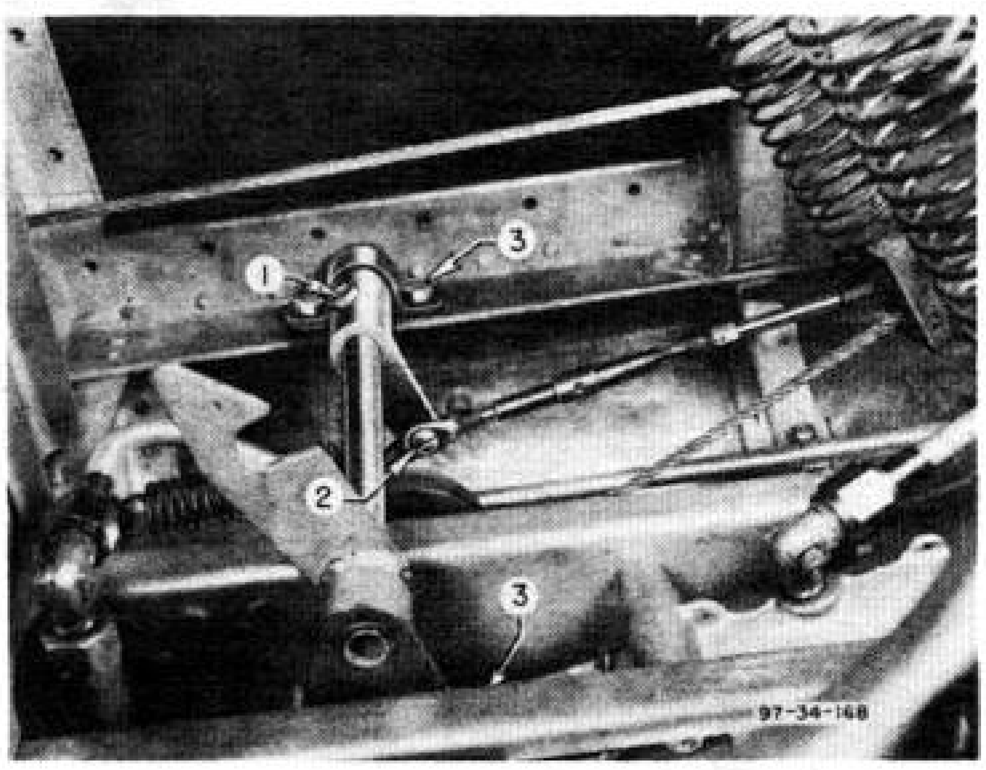
(4) TAIL GEAR STEERING MECHANISM.

*(a)* DESCRIPTION.—The tail gear is steered by means of two cables extending forward from the rudder bellcrank to the tail gear assembly. The steering mechanism on the tail gear assembly consists of a set of three pulleys and a bellcrank installed on each side of the shock strut. The bellcranks are pivoted on the post assembly housing. The lower pulley on each side of the shock strut is secured to an arm of the respective bellcrank and the steering arms are connected by a turnbuckle to the other arm of each bellcrank. *(See figure 143.)* When the rudder bellcrank is turned, by means of the rudder control pedals, the cables pull up the lower pulley on one side of the shock strut, and allow the lower pulley on the other side of the shock strut to move down. The movement of the lower pulleys is transmitted through the bellcranks and turnbuckles of the steering arms, which turn the wheel when the declutching mechanism is engaged. The pulley system is so designed that the cable tension is maintained when the shock strut piston is extended or compressed. The ratio of movement between the rudder and the tail wheel when the declutching mechanism




| PART NO. | NAME | NO. REQ. | PART NO. | NAME | NO. REQ. |
|---|---|---|---|---|---|
| 1. AN42-4 | Eyebolt | 1 | 3. AN393-49 | Pin | 1 |
| AN960-516L | Washer | 2 | 4. AN3-30 | Bolt | 1 |
| AN960-10 | Washer | 1 | 4B14-3-52 | Spacer | 1 |
| 4B14-3-6 | Spacer | 1 | 2W1-12-18-31 | Washer | 2 |
| 2. AN23-10 | Clevis Bolt | 2 | AN960-10 | Washer | 5 |
| AN960-516L | Washer | 2 | 5. 2W1AL-65-46-129 | Washer | 1 |
| 4B14R3-6 | Spacer | 2 | 35A231 | Washer | 1 |
| 2W1-12-18-31 | Washer | 2 | 6. AC386-2-9 | Taper Pin | 2 |
| AN960-10 | Washer | 2 | AN975-3 | Washer | 2 |

***Figure 144—Tail Wheel Declutching Mechanism***




| | | |
|---|---|---|
| 1. AN3-11A | Bolt | |
| 2. AN155-16S | Barrel | |
| AN160-16S | Fork | |
| AN23-9 | Bolt | |
| 3. AN3-4A | Bolt | 4 Req. |

***Figure 145—Tail Gear Up-latch***

is engaged is five to one; that is, a 30-degree turn of the rudder will result in a 6-degree turn of the tail wheel. Springs installed aft of the tail gear assembly pull the steering cables clear of the shock strut when the tail gear is retracted.

*(b)* REMOVING, INSTALLING, AND ADJUSTING TAIL GEAR STEERING CABLE. *(See figure 142.)*

(5 TAIL WHEEL DECLUTCHING MECHANISM.

*(a)* DESCRIPTION.—The tail wheel declutching mechanism on top of the tail wheel post assembly is operated by a roller on the elevator horn. When the elevator is down, the roller depresses a lever which pulls the declutching device actuating cable. *(See figure 144.)* When the elevator is in the neutral position or above, the roller is aft of the lever and the tail wheel is locked. A Shakespeare casing protects the declutching cable where it extends across the tail gear assembly. A pin, which is an integral part of the tail wheel post assembly, engages the tail wheel steering arms when the control handle is in the "LOCKED" position so that the tail wheel must move with the steering arms. The steering arm is released when the elevator is in the down

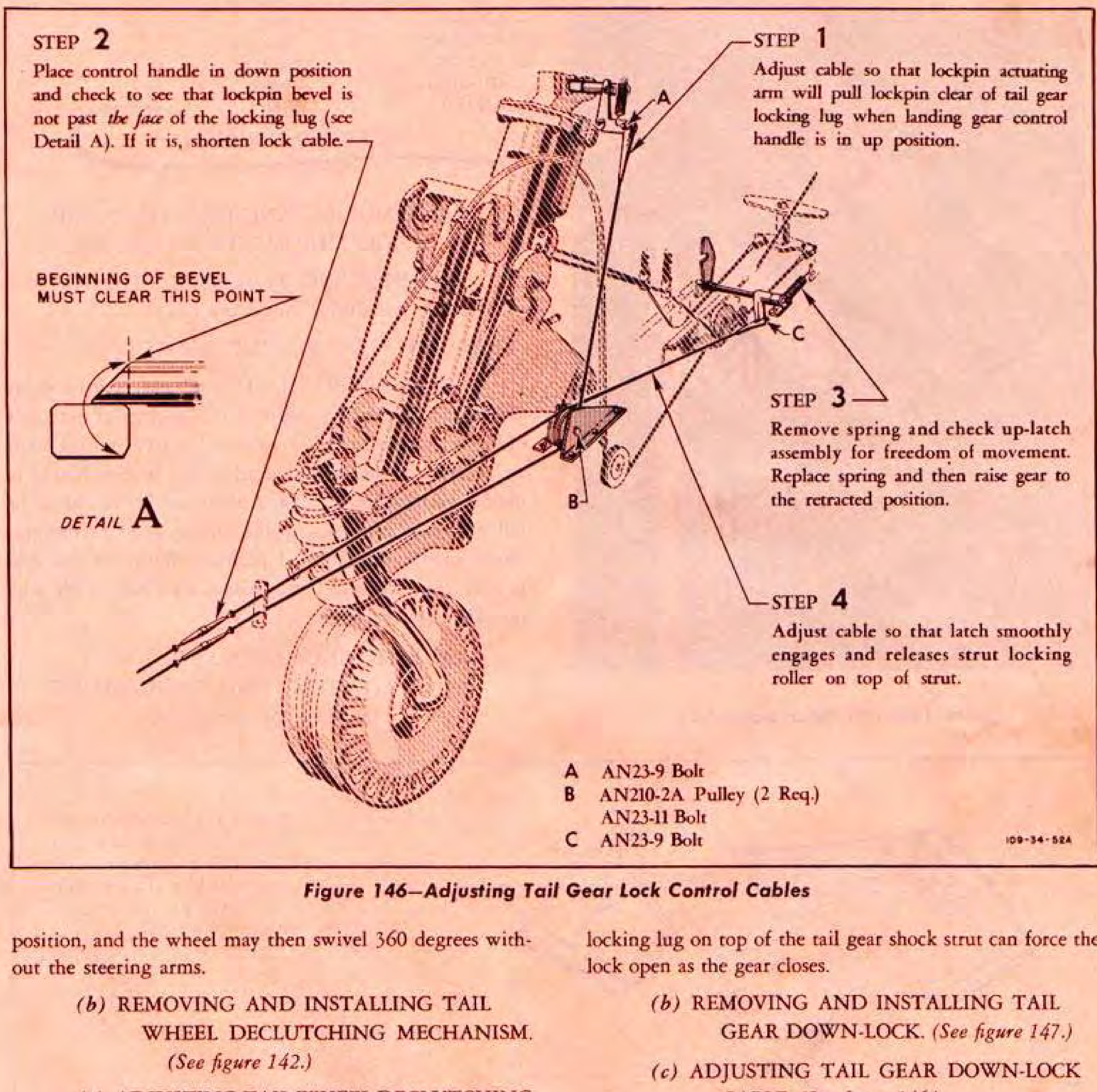



***Figure 146—Adjusting Tail Gear Lock Control Cables***

position, and the wheel may then swivel 360 degrees without the steering arms.

*(b)* REMOVING AND INSTALLING TAIL WHEEL DECLUTCHING MECHANISM. *(See figure 142.)*

*(c)* ADJUSTING TAIL WHEEL DECLUTCHING CABLE. *(See figure 142.)*

(6) TAIL GEAR DOWN-LOCK.

*(a)* DESCRIPTION.—A spring-loaded lockpin in the down-lock support casting, which is bolted to the upper structure of the fuselage just above the tail gear assembly, locks the tail gear in the down position. *(See figure 147.)* The lockpin is controlled by cables from the landing gear control handle in the cockpit. A bellcrank just outboard of the lockpin is connected to the lock control cable in such a manner that one arm of the bellcrank retracts the lockpin when the cable is pulled. The lockpin is beveled so that the locking lug on top of the tail gear shock strut can force the lock open as the gear closes.

*(b)* REMOVING AND INSTALLING TAIL GEAR DOWN-LOCK. *(See figure 147.)*

*(c)* ADJUSTING TAIL GEAR DOWN-LOCK CABLE. *(See figure 146.)*

(7) TAIL GEAR UP-LATCH.

*(a)* DESCRIPTION.—The tail gear up-latch is located aft of the tail gear assembly between the two lower longerons. *(See figure 145.)* The up-latch is controlled by a control cable from the landing gear control handle in the cockpit. When the control handle is in the down position, the cable holds the up-latch in the open position. The up-latch is spring-loaded so that it automatically snaps to the closed position when the landing gear control handle is placed in the up position. The up-latch engages the strut locking roller at the top of the tail gear assembly.

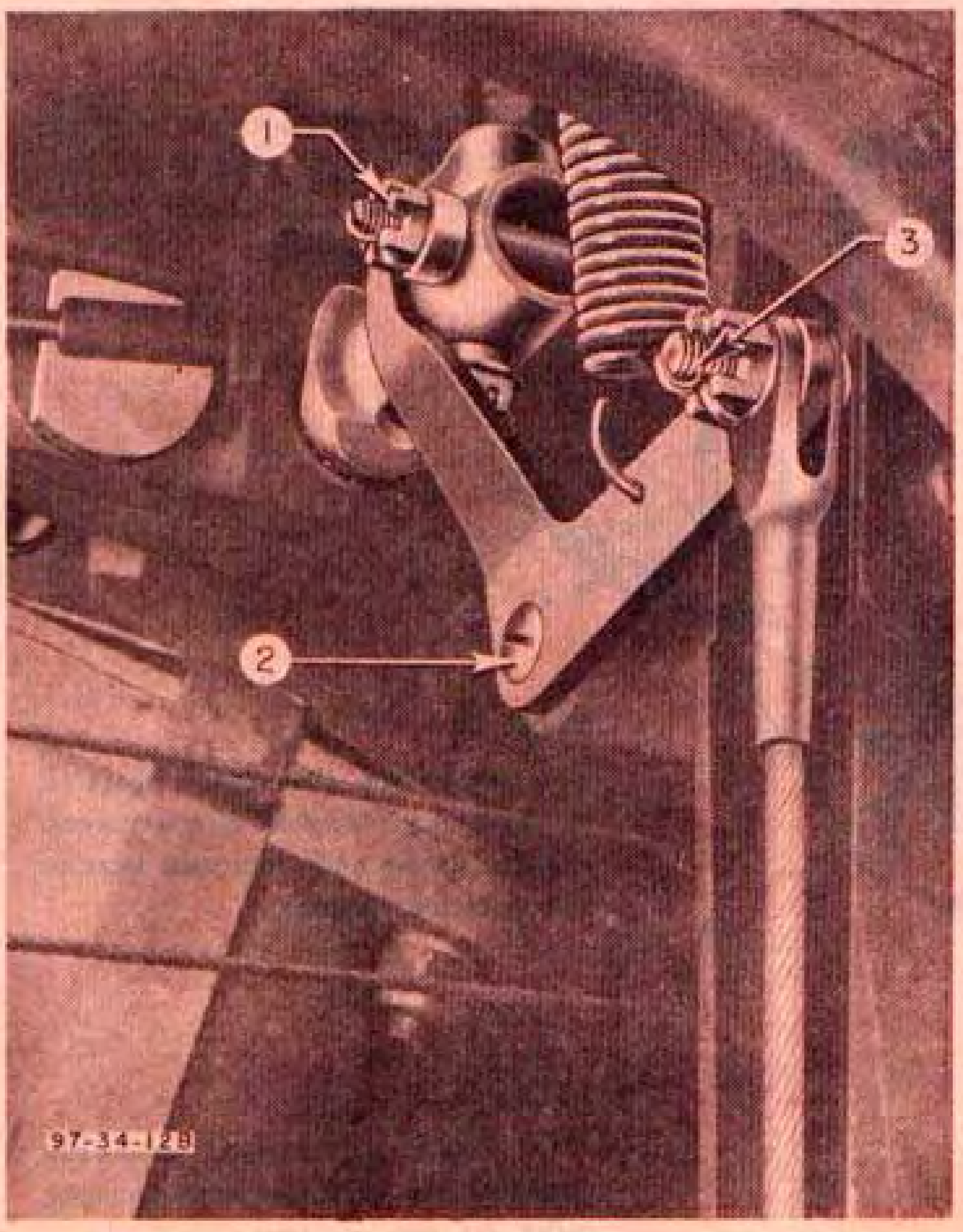



Figure 147—Tail Gear Down-lock

1. AN23-26 Bolt
   4B14R3-28 Spacer
2. AN23-27 Bolt
   4B14R3-41 Spacer
3. AN23-9 Bolt

KEY TO FIGURE 147

*(b)* REMOVING AND INSTALLING TAIL GEAR UP-LATCH. *(See figure 145.)*

*(c)* ADJUSTING TAIL GEAR UP-LATCH CABLES. *(See figure 146.)*

(8) TAIL GEAR FAIRING DOORS.

*(a)* DESCRIPTION.—The tail gear fairing doors are hinged to the lower skin of the fuselage at each side of the tail gear assembly. *(See figure 148.)* The fairing doors are actuated by turnbuckles attached to a bracket hinged to the tail gear support casting. A short link connected to the tail gear assembly pulls up the fairing doors as the gear moves toward the retracted position. When the tail gear is fully retracted, the fairing doors are closed flush with the skin of the fuselage.

*(b)* REMOVING, INSTALLING, AND ADJUSTING TAIL GEAR FAIRING DOORS. *(See figure 148.)*

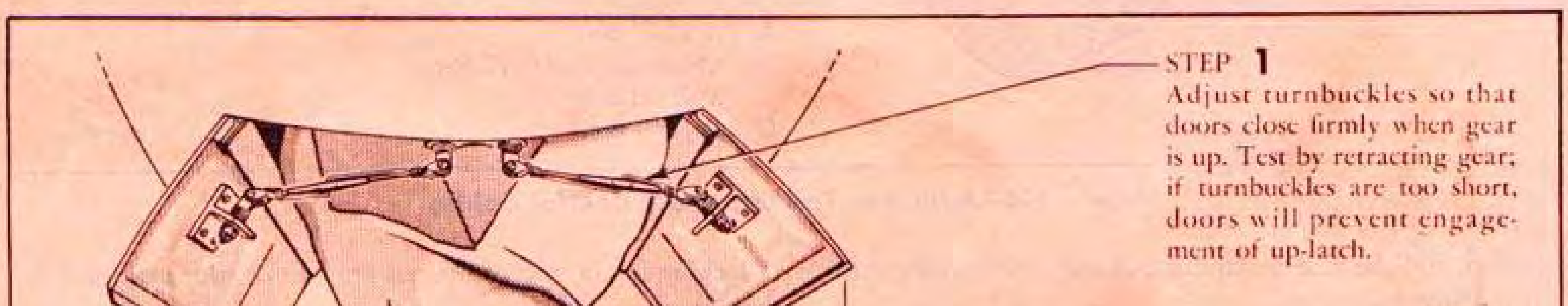



Figure 148—Adjusting Tail Gear Fairing Doors

**6. WHEELS AND BRAKES.**

*a.* BRAKE SYSTEM.

(1) GENERAL DESCRIPTION.—The hydraulic brake system consists of two master cylinders, one connected to each brake by means of hydraulic lines. *(See figure 149.)* The brake hydraulic system is entirely separate from the general hydraulic system, except that the same reservoir supplies hydraulic fluid to both systems. A standpipe arrangement within this reservoir assures a reserve of fluid for brake operation, even though the fluid for the general hydraulic system has been lost. The brakes are selectively controlled by toe pedals in the rudder control pedal assembly. These pedals are connected by mechanical linkage to the master brake cylinders. When a toe pedal is depressed, braking pressure is generated in the respective brake cylinder; and when the pedal is released, braking pressure is released. The brake system includes a parking brake operated by the control handle below center of instrument panel. The parking brake serves to lock fluid pressure in the lines between the master brake cylinder and the brakes for indefinite periods.

(2) BLEEDING THE BRAKE SYSTEM. *(See figure 150.)*

(3) FLUSHING THE BRAKE SYSTEM.—To remove dirt in the brake system, follow this procedure:

*(a)* Remove both brake master cylinders and the brake assemblies.

*(b)* Flush hydraulic fluid reservoir and brake lines with clean hydraulic fluid. Then discard fluid at once, or filter carefully with a micronic paper filter to remove foreign particles.

*(c)* Disassemble master cylinders, clean rubber seals in hydraulic fluid, and clean all metal parts.

*(d)* Clean the brake piston seals in hydraulic fluid, and clean the brake pistons and cylinders.

*(e)* Reassemble master cylinders and brakes, and install them as before.

*(f)* Fill hydraulic fluid reservoir with new clean fluid, and bleed the brakes.

(4) BRAKE SYSTEM TROUBLE SHOOTING.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Excessive forward travel of brake pedals.** | Normal wear of bronze discs. | Install new discs. |
| | Improper adjustment of disc clearance. | Readjust brakes. |
| | Leak in system. | Find and repair the leak. |
| | Air in system. | Correct fault; then bleed system. |
| | Brake pedal linkage set improperly. | Set rudder pedals to neutral; then adjust linkage so top of brake pedal is about ¾ inch forward of pedal hanger. |
| | Insufficient fluid in reservoir and brake standpipe. | Fill reservoir and bleed system. |
| | Vent in hydraulic system clogged. | Clear vent and see if it permits air passage. |
| | Improper bleeding—air left in system. | Wait until air accumulates in large bubbles; then bleed the brakes. |
| **Brakes dragging or locking.** | Improper adjustment of disc clearance. | Set disc clearance. |
| | Dirt in system. | Flush the system. |
| | Binding of brake piston or dust shield. | Remove parts and clean in hydraulic fluid. |
| | Use of improper brake fluid. | Replace seals; flush reservoir with mineral oil, Specification No. AN-VV-O-336. |
| | Weak or broken piston springs preventing or retarding piston return. | Replace the springs. |
| | Mechanical linkage frozen because of weak or broken brake pedal return spring. | Replace the spring. |
| | Damaged parking brake spring may prevent or retard release of pressure. | Replace the spring. |

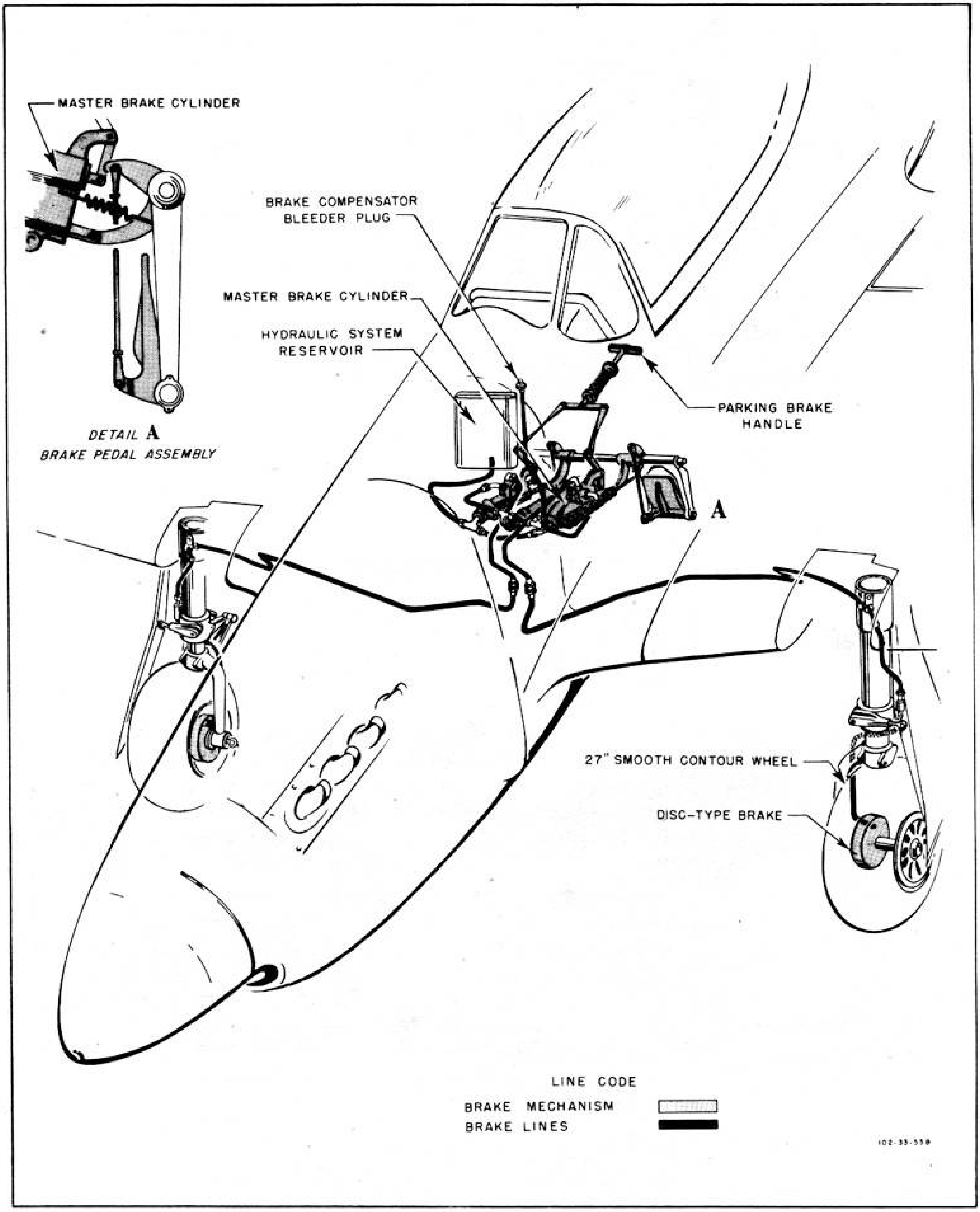
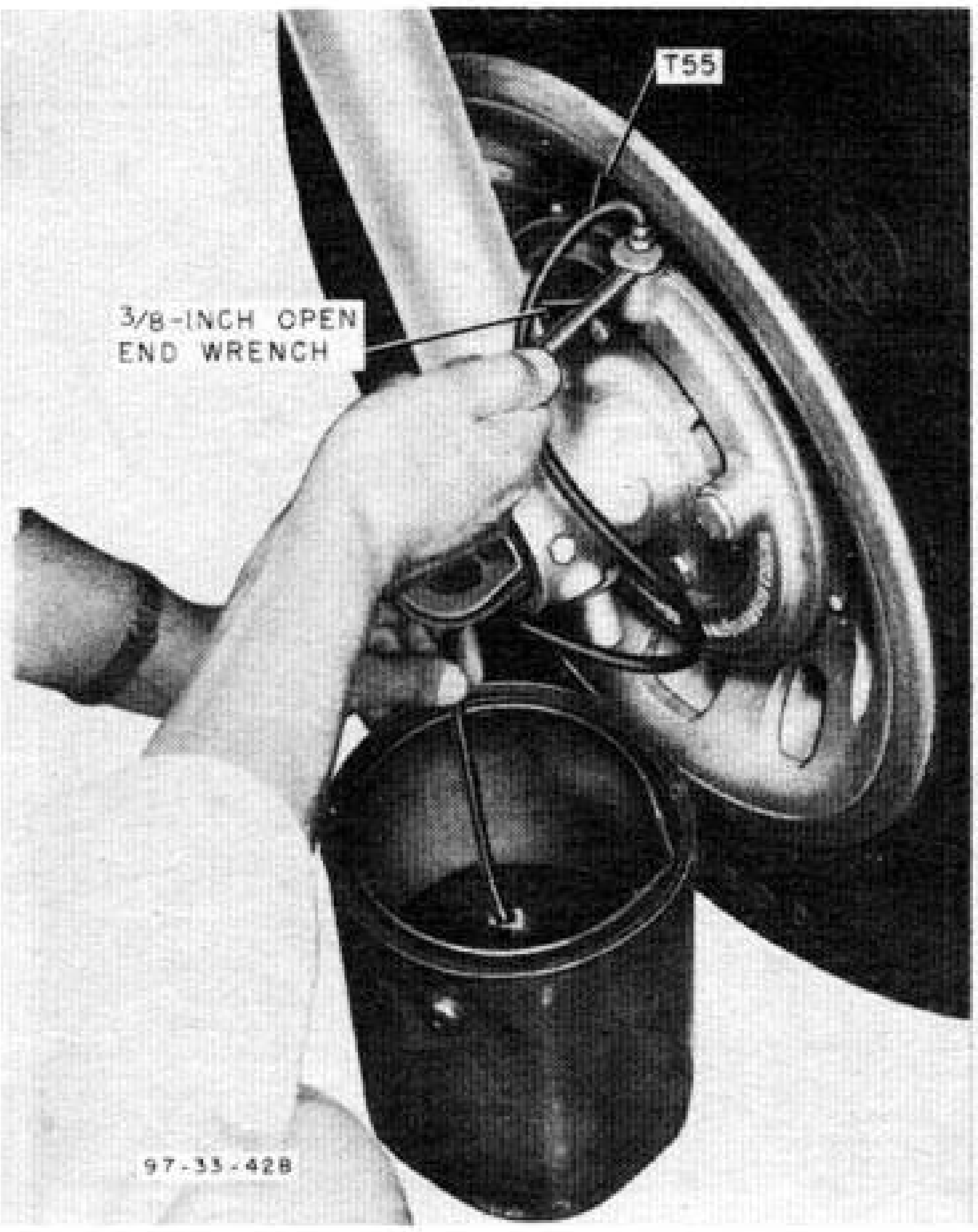



*Figure 149—Brake System*




Note:
Air in the brake system causes the pedals to have a springy, rubbery action, or a lack of resistance to foot pressure. The air must be eliminated by forcing fluid though the brake lines until there are no more air bubbles in the fluid.

STEP 1
See that hydraulic fluid reservoir is full.

STEP 2
Remove cap screw and washer from brake bleeder plug and insert bleeder hose.

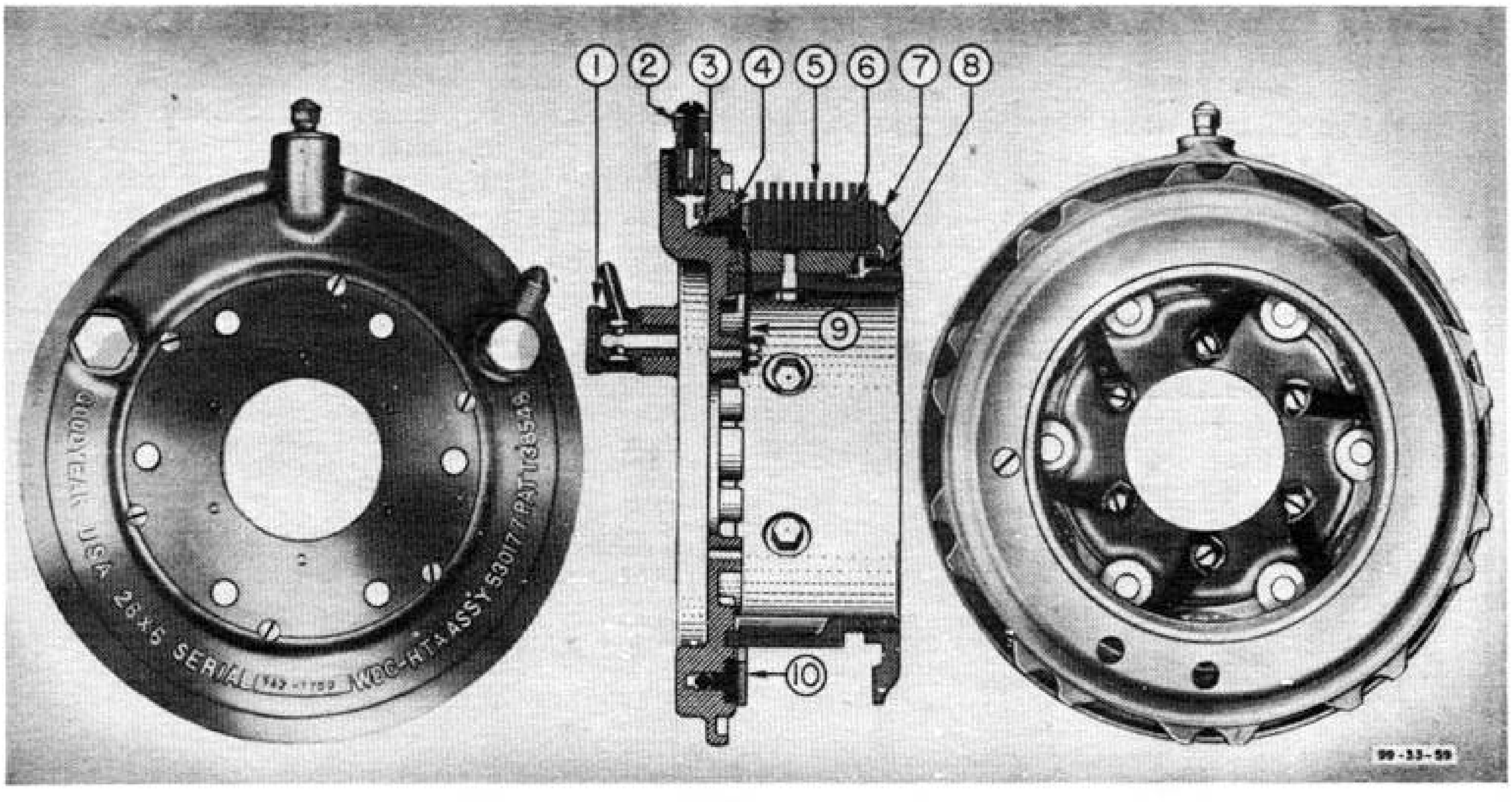
STEP 3
Place free end of bleeder hose in a clean receptacle containing a little hydraulic fluid, and then loosen the bleeder plug. This will allow fluid to flow by gravity and fill the brake system.

STEP 4
When fluid begins to flow out of the bleeder hose, hold free end of hose under the fluid level in the receptacle, push brake pedal forward, and then allow pedal to come back slowly. Repeat this operation until no more air bubbles come from bleeder hose.

STEP 5
Tighten bleeder plug, remove bleeder hose, and install bleeder plug cap screw and washer.

STEP 6
Follow same procedure at the opposite brake and at the parking brake compensator bleeder plug just aft of hydraulic system reservoir.

*Figure 150—Bleeding the Brakes*




1. 51897 (Bendix) Fitting
2. Bleeder Plug
3. Ring Piston Seal
4. Ring Piston
5. Rotating Discs
6. Stationary Discs
7. Brake Adjustment Nut
8. Brake Adjustment Nut Setscrew
9. Piston Return Springs
10. Asbestos Insulating Disc

*Figure 151—Main Gear Disc-type Brake*

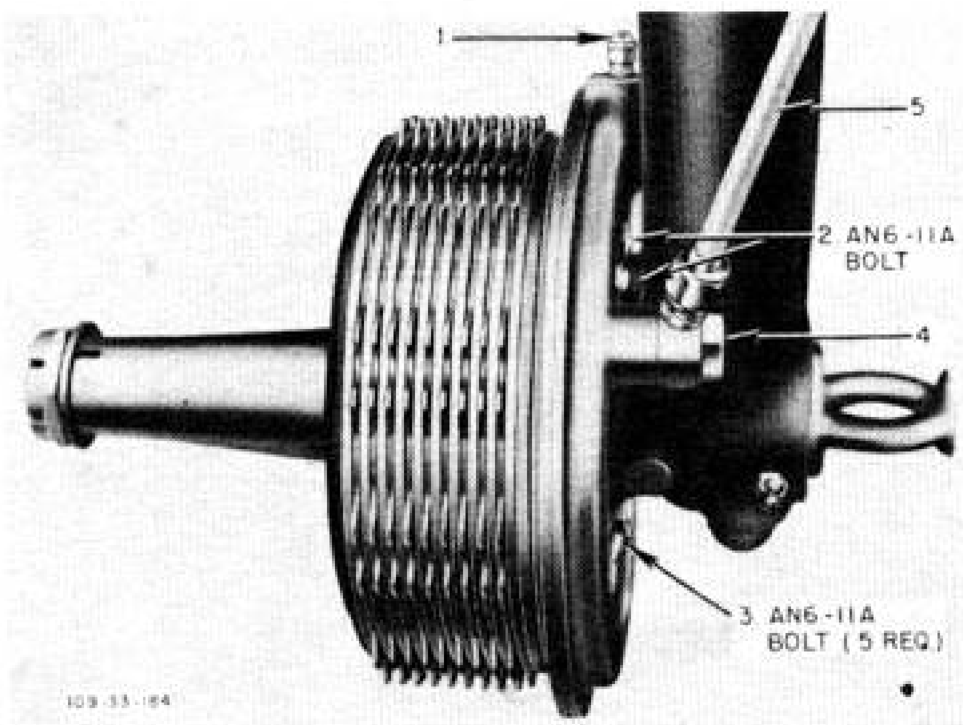



**Figure 152—Installing Main Wheel Brake**

(5) BRAKES.

*(a)* DESCRIPTION.—Goodyear hydraulic multiple-disc brakes *(figure 151)* are installed on each main landing gear axle. Bronze discs keyed to the wheel are alternated with steel discs keyed to the brake anchor bracket. The discs are held in position on the bracket by a steel anchor nut, which is adjustable to obtain proper clearance between the brake discs. A lockscrew holds the anchor nut in position. The brakes are interchangeable for right or left wheel axle.

*(b)* INSTALLING AND REMOVING BRAKES. *(See figure 152.)*

*(c)* ASSEMBLING AND DISASSEMBLING BRAKES. *(See figure 155.)*

*(d)* ADJUSTING BRAKES. *(See figure 154.)*

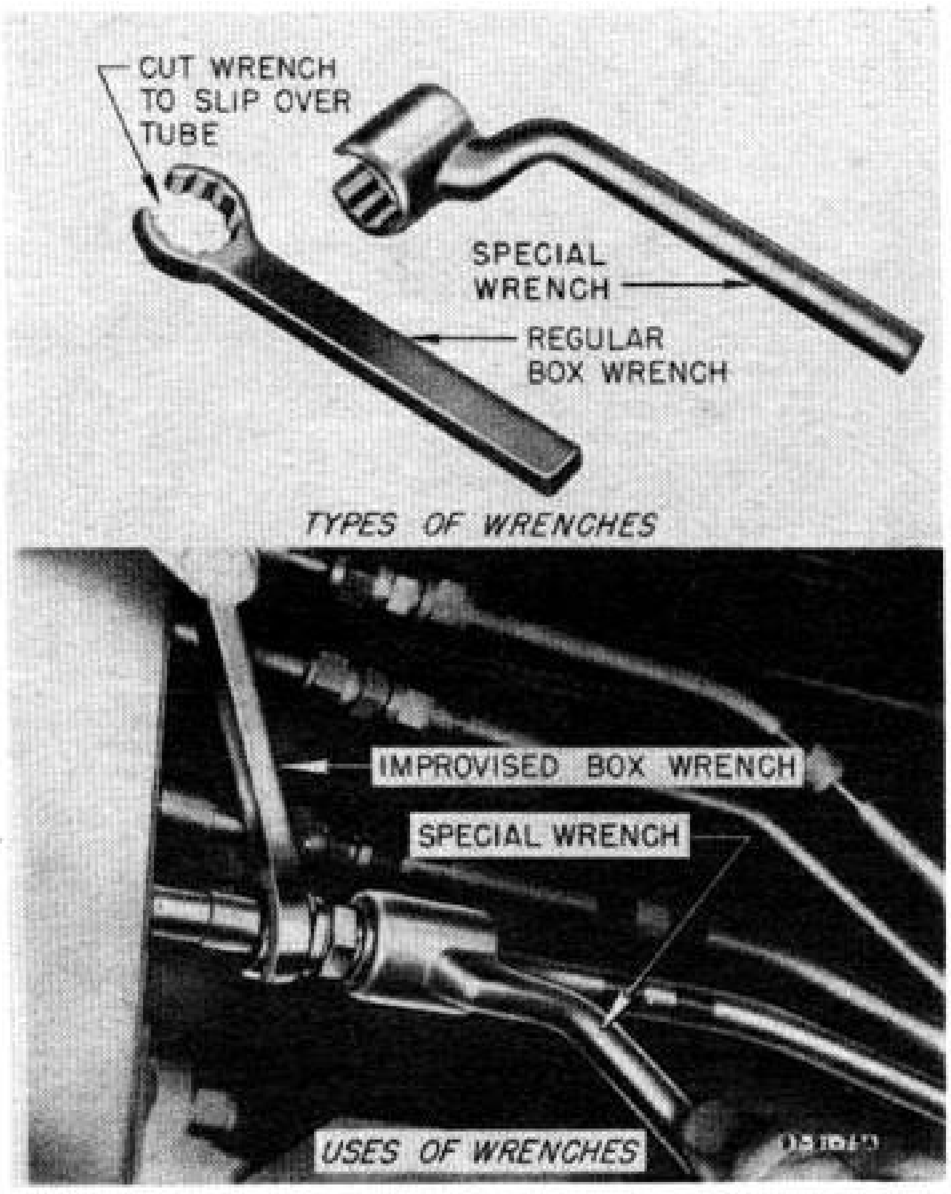
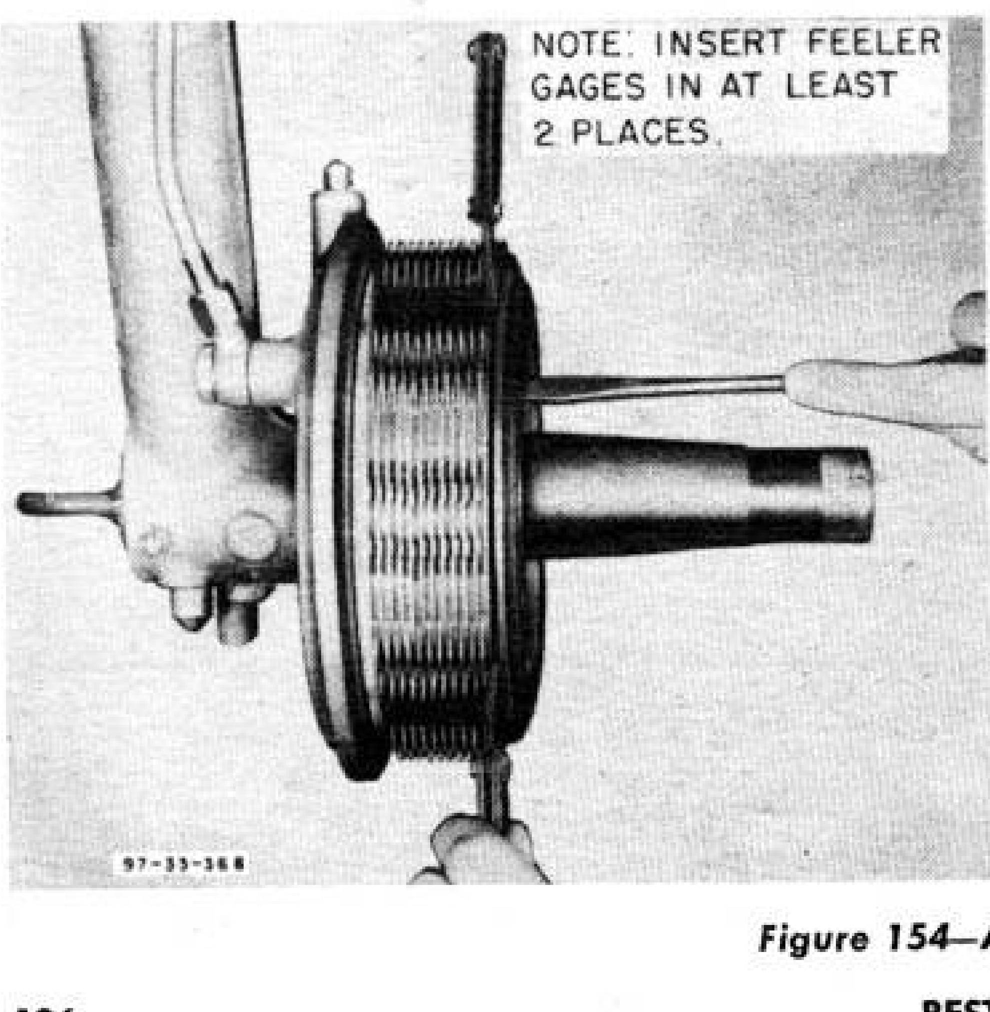



**Figure 153—Special Brake Line Wrenches**

(6) BRAKE MASTER CYLINDER.

*(a)* DESCRIPTION.—The brake master cylinders are installed forward of their respective actuating bell-cranks, which are in the rudder pedal assembly. The cross-sectional view of the brake cylinder *(figure 157)* shows the normal piston position with no pressure at brake pedal. With the piston in this position, the valve is held open




STEP **1**
Remove main landing gear wheel.

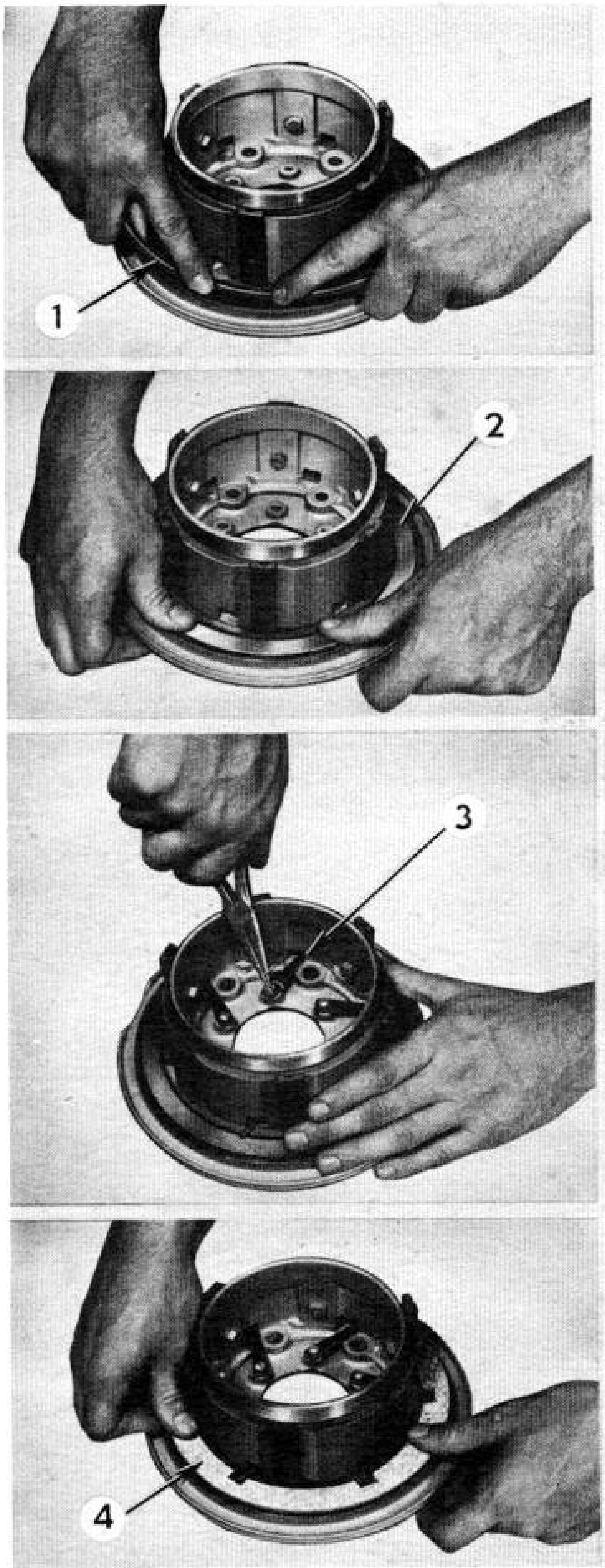
STEP **2**
Loosen adjustment screw until anchor-nut turns freely.

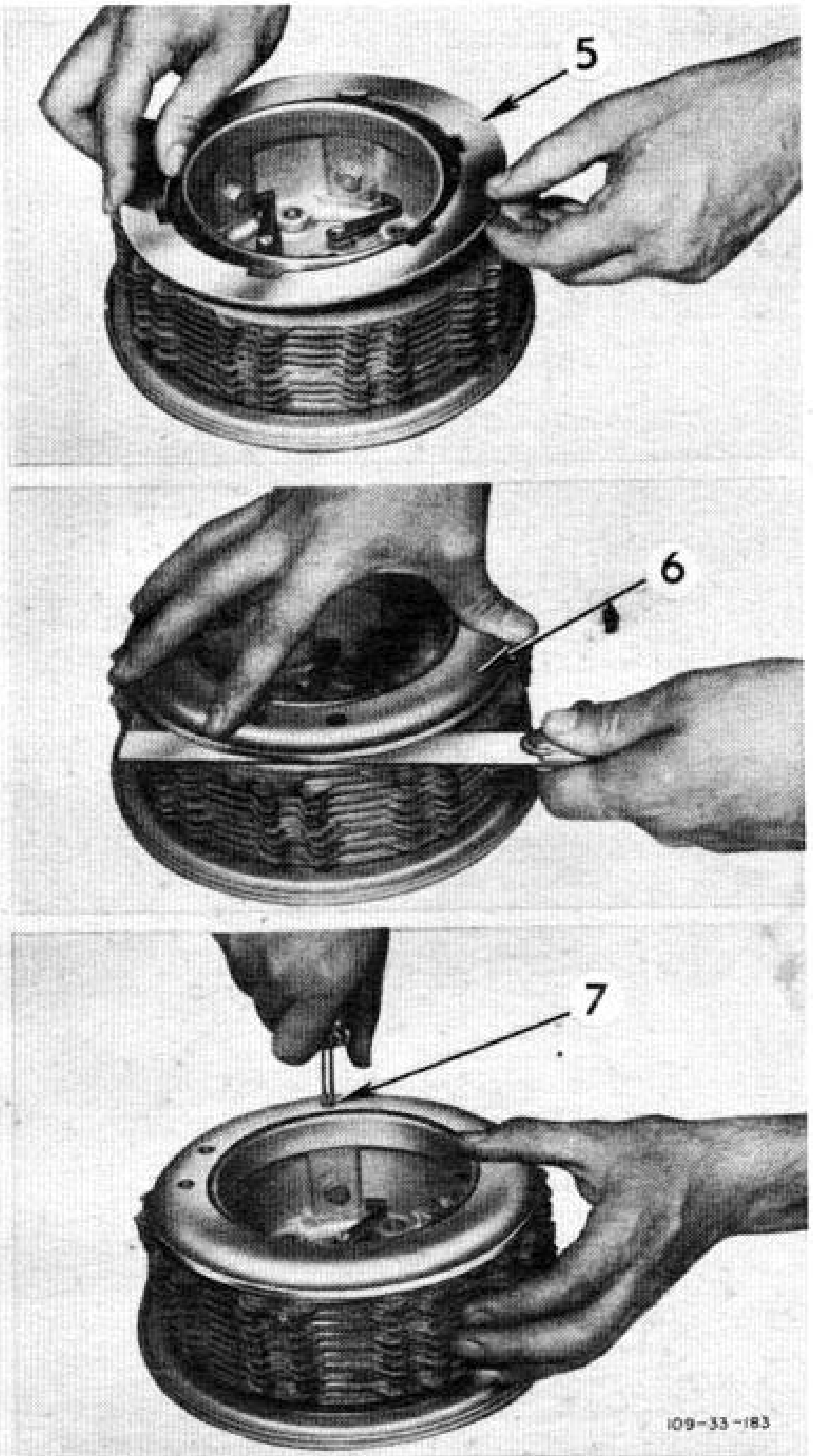
STEP **3**
Turn anchor nut clockwise until tight; then loosen to approximately .053 to .056-inch clearance.

STEP **4**
Turn anchor nut to next setscrew hole and tighten setscrew.

STEP **5**
Test anchor nut to see if it is tight. If nut turns more than 1/8-inch, the setscrew is not in a setscrew hole.

**Figure 154—Adjusting Brakes**




**1** Insert piston seal by working it carefully into piston.

**2** Insert piston.

**3** Install piston return springs.

**4** Place insulator disc on piston so cutouts fit around springs.

**5** Place a set of 9 bronze and 10 steel discs alternately on brake assembly. Make sure that a steel disc is installed next to the insulator disc and next to the disc retaining nut.

**6** Install and adjust disc retaining nut.

**7** Secure retaining nut with a setscrew and a shakeproof washer.

**Disassembly:** Essentially the reverse of assembly procedure.

*Figure 155—Assembling Disc Brake*

**1, 2** Install master cylinder.

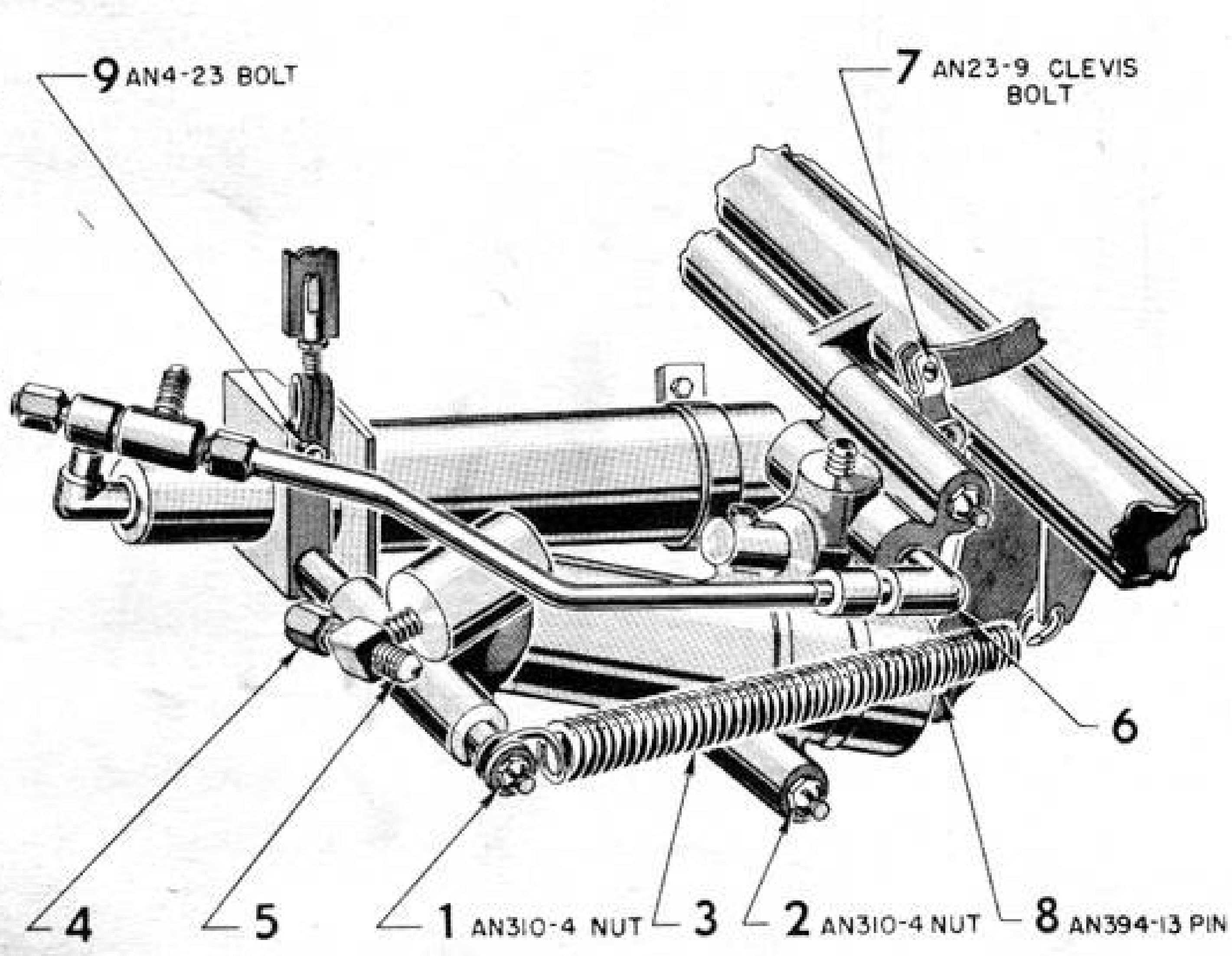
**3** Connect springs to each master cylinder.

**4, 5, 6** Connect hydraulic lines to cylinder.

**7** Connect parking brake linkage to each master cylinder.

**8** Connect brake pedal to each master cylinder.

**9** Connect rod to expansion cylinder.




**Removal:** Essentially the reverse of installation procedure.

*Figure 156—Installing Brake Master Cylinders*

**1** Insert stem assembly and install seal bearing.

**2** Install spring, washer, and ring.

**3** Install arm.

**4** Insert piston assembly and install seal bearing.

**Disassembly:** Essentially the reverse of the assembly procedure.

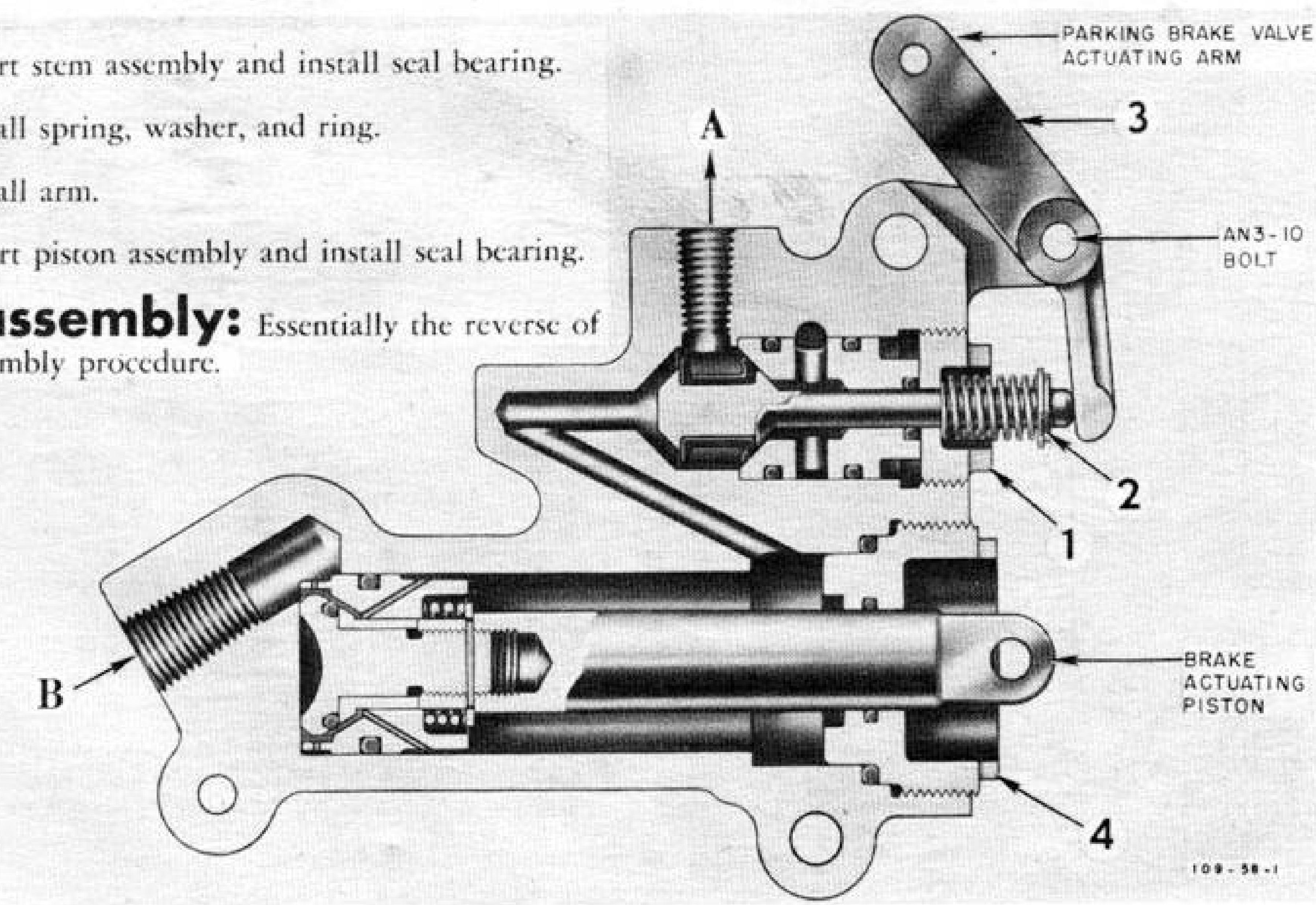



*Figure 157—Assembling Brake Master Cylinder*

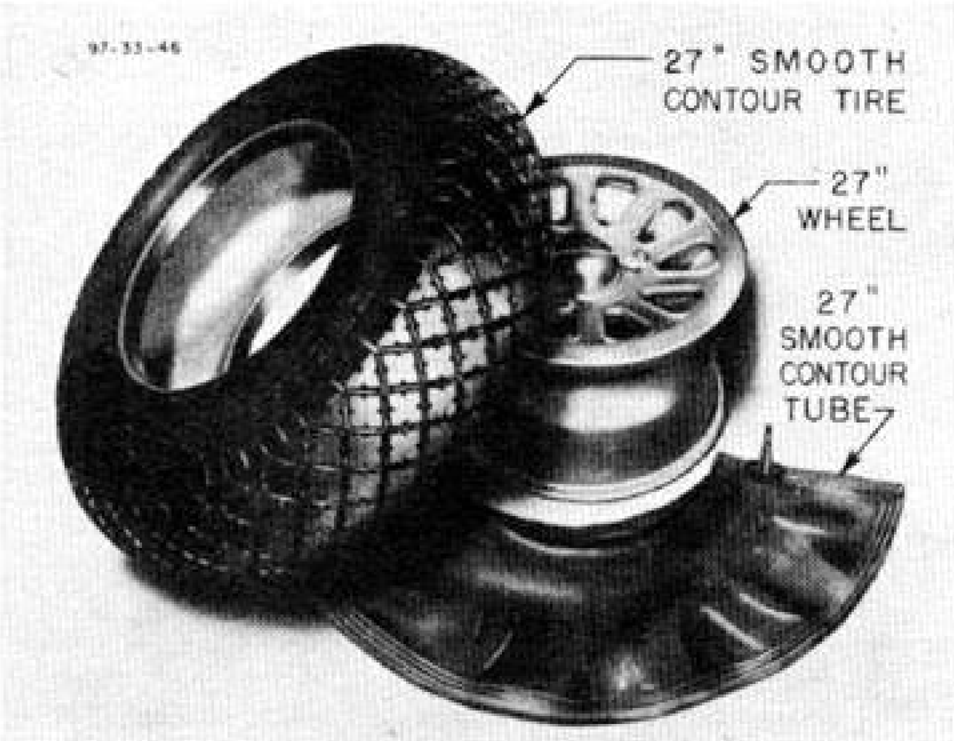


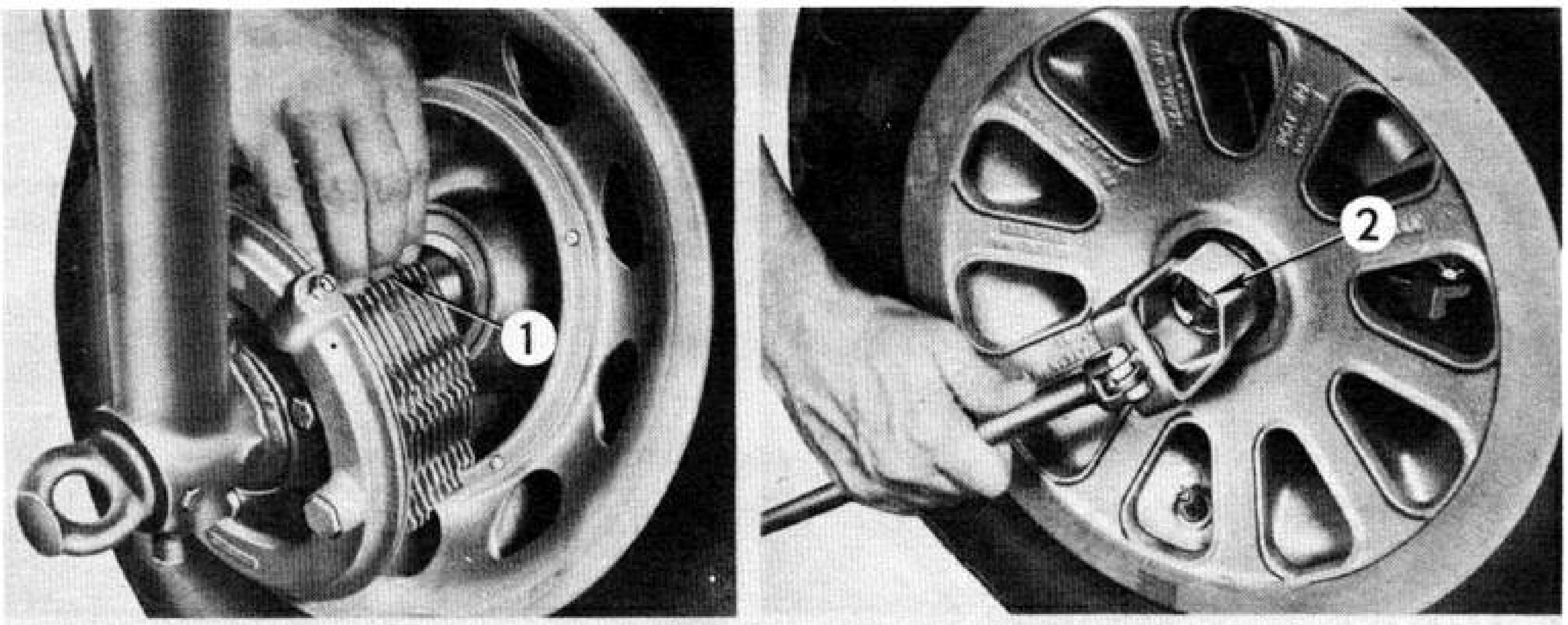

*Figure 158—Main Wheel, Tire, and Tube*

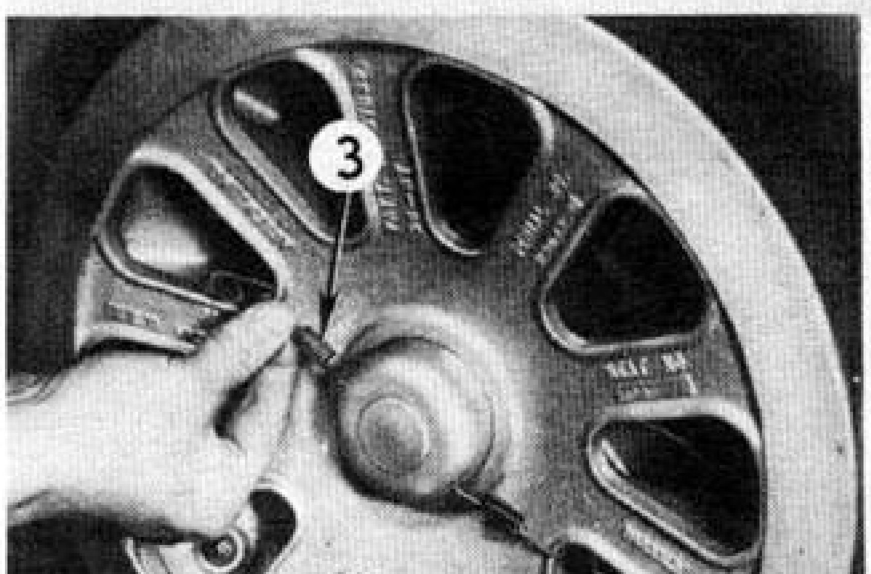
and fluid can flow freely to or from the brake. The fluid flows by gravity from the hydraulic system tank into the cylinder through port B, so that the master cylinder constantly maintains the correct volume of fluid under all conditions. When the piston rod is pulled back, the valve seats on piston, and the brake pressure is directly proportional to the force applied to the brake pedals. The brake pressure flows through the outlets in the piston wall around past the parking brake stem assembly and out port A to the brakes.

(*b*) INSTALLING AND REMOVING BRAKE MASTER CYLINDER. (*See figure 156.*)

(*c*) ASSEMBLING AND DISASSEMBLING BRAKE MASTER CYLINDER. (*See figure 157.*)

(*d*) PARKING BRAKE VALVE.—A parking brake valve is incorporated in each brake master cylinder. (*See figure 157.*) After braking pressure has been generated by the pedals, the parking brake is applied to lock pressure in the brake lines between the master brake cylinders and the brakes. The pressure in the brake lines holds the stem assembly seated until enough pressure is generated in brake cylinders to overcome pressure in the lines and




**1** Slide wheel part way on axle, line up the rotating brake discs with the steel tubes inside the wheel hub, and then push the wheel carefully over the discs.

**2** Insert outer bearing, install axle washer and nut, and secure wheel as follows:

a. Rotate wheel while tightening the adjusting nut. This will result in a definite drag or bind in the wheel bearing.
b. Back off nut until nut is free.
c. Again take up on nut until point is reached where there is a sudden, definite increase in drag of nut.
d. Continue to take up on nut until next cotter key hole is reached; then lock.

NOTE:
If next cotter key hole in axle is less than 1/8-inch away from cotter pin hole in nut when making this final take-up, the nut should be taken up to the second locking position.

**3** Install dust cap and retaining spring.

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*Figure 159—Installing Main Wheel*

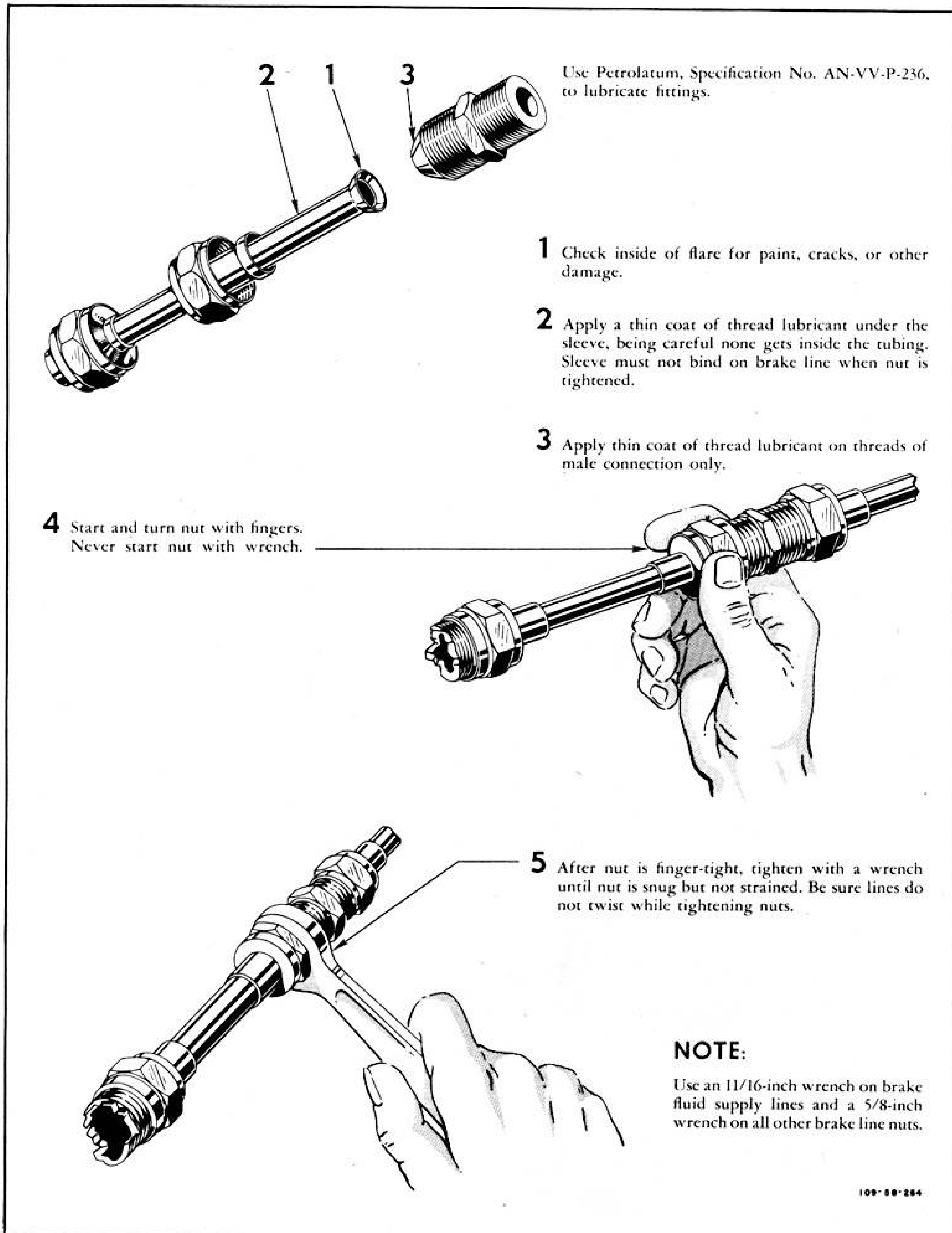



***Figure 160—Installing Brake Line Fittings***

unseat the stem assembly. The stem assembly is spring-loaded, so that it remains in open position during normal brake operation.

(7) BRAKE LINES.

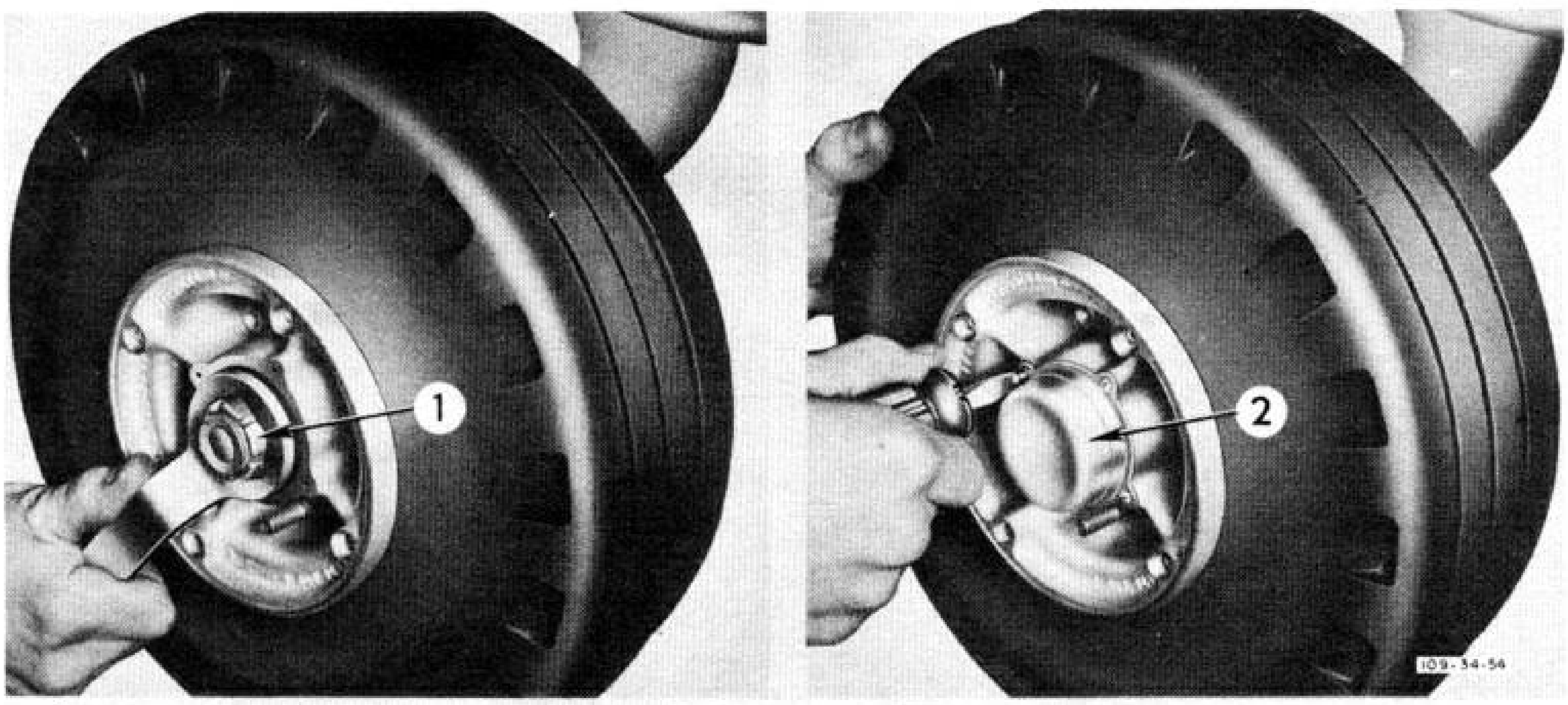
*(a)* DESCRIPTION.—Aluminum alloy tubing, 52SO, is used for all rigid lines throughout the brake system. All tubing, except the brake supply lines connecting the hydraulic reservoir to the brake master cylinder, has a $\frac{5}{16}$-inch outside diameter and a .042-inch wall thickness. The brake supply lines have a $\frac{3}{8}$-inch outside diameter with a .042-inch wall thickness. So the brake lines will not interfere with normal operation of the gear, a swivel joint is used to connect the lines from the top of the main gear shock struts to the wing nose section; and a flexible hose is used, between the shock strut cylinder and the strut fork lines to accommodate the movement of the shock strut piston.

*(b)* ASSEMBLING BRAKE LINES.—Before assembly, see that each brake line is clean, free from scratches and cuts, and that the flared ends are not damaged. The brake lines from each shock strut to the fuselage are secured with Adel 755-5-2-6 clips, AN530-8R8 screws, and 1348-M-1 speed nuts. The main landing gear shock strut brake lines can be installed as a separate assembly, before shock strut is installed in wing. Special wrenches facilitate the installation of the brake lines. *(See figure 153.)*

*(c)* INSTALLING BRAKE LINE FITTINGS. *(See figure 160.)*

*b.* MAIN WHEELS.

(1) DESCRIPTION.—Goodyear 27-inch, drop-center wheels *(figure 158)* are mounted on the main landing gear axles with Timken bearings. The inboard bearings are held in place by felt grease retainers and metal washers, secured by metal lockrings; the outboard bearings are held by wheel retaining nuts and washers on the axles. Steel tubes inside the wheels protrude into the brake drums just enough to engage the rotating brake discs when wheels are installed. Retaining discs, secured to the wheel hubs by screws, cover the inboard ends of the steel tubes. The wheel rims are integral parts of the wheel castings and cannot be removed to mount tires.




**1** See that wheel is clean and bearings are clean and greased. Check axle against corrosion, paint, and dirt and then slide wheel on axle. Install axle washer and nut and secure wheel as follows:

a. Rotate wheel while tightening the adjusting nut. This will result in a definite drag or bind in the wheel bearings.
b. Back off nut until nut is free.
c. Again take up on nut until point is reached where there is a sudden, definite increase in drag of nut.
d. Continue to take up on nut until next cotter key hole in axle is reached; then lock.

NOTE:
If next cotter key hole in axle is less than [illegible]-inch away from cotter pin hole in nut when making this final take-up, the nut should be taken up to the second locking position.

**2** Install dust cap.

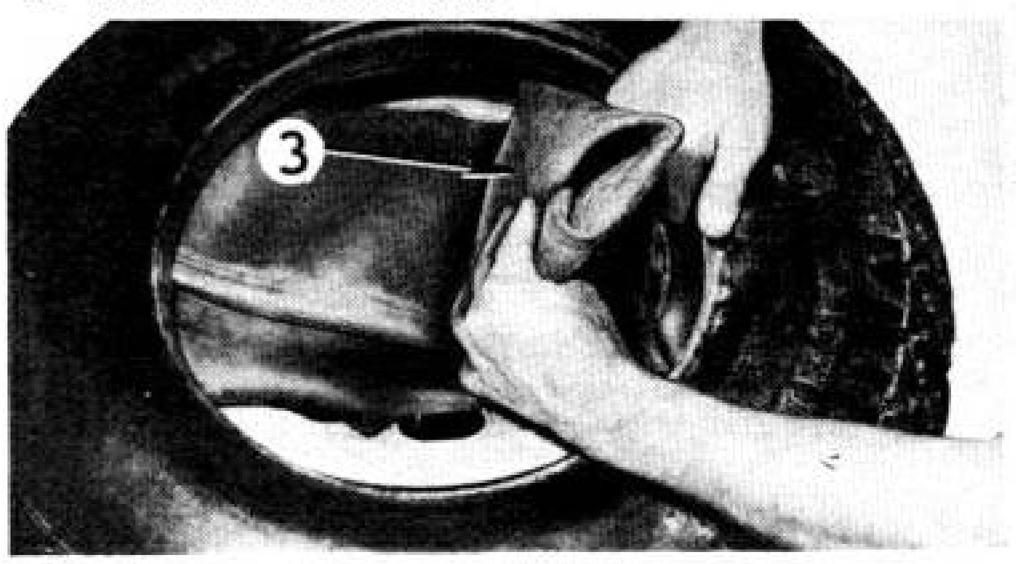
***Figure 161—Installing Tail Wheel***

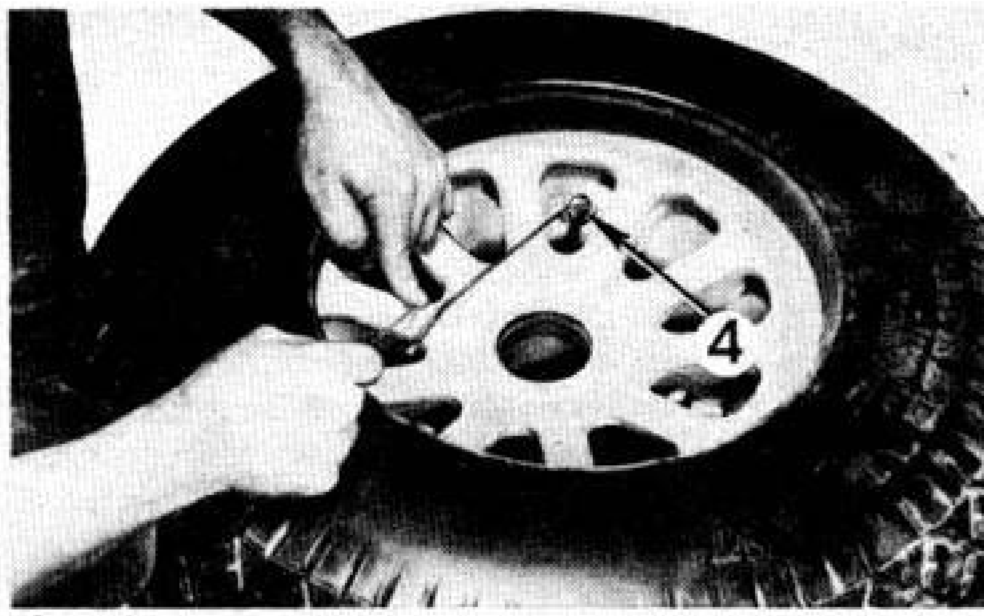

Note:
See that the wheel is clean and free from burrs. Check inside of casing for breaks and dirt.

**1** Place tire on wheel so lower bead is partially down on wheel rim. Hook clip on each side of wheel rim so tire cannot slip off; then force rest of bead on wheel rim with flat tire iron.

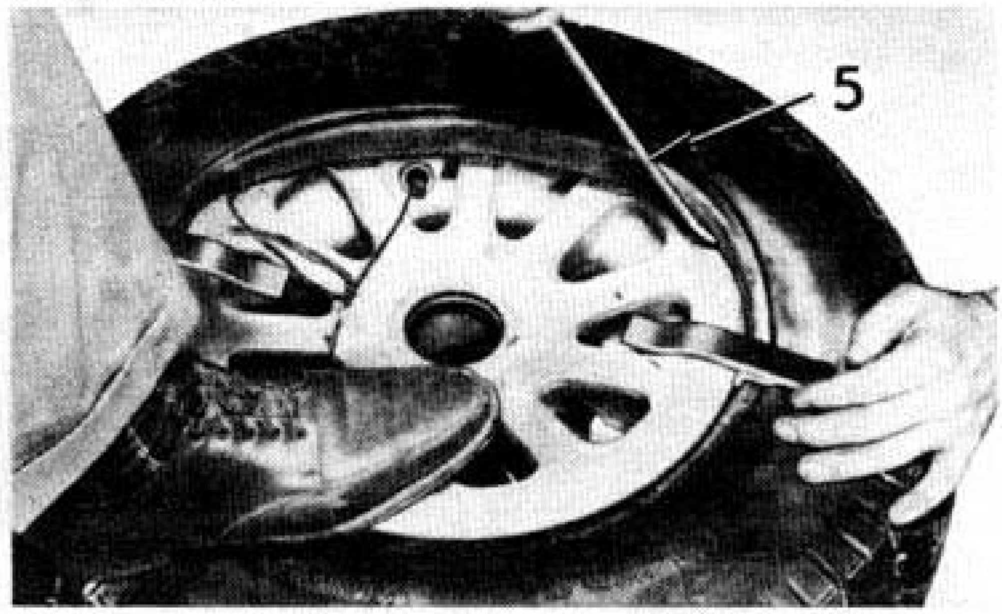

**2** Apply talc (Specification No. 1-33, Classification 29) to tube with a piece of cheesecloth.

**3** Insert tube into the tire.




**4** Push valve stem through hole in wheel rim. Then tie one end of a string to valve stem, and other end to wheel spoke, so valve stem will not slip back into tire. Line up heavy mark on tire with light mark on tube, if tube has been balanced.




**5** Force top bead of tire over wheel rim with a flat tire iron.

**6** When bead becomes hard to stretch, it may be pounded onto rim with a rubber mallet. Inflate tire to approximately 45 pounds pressure, deflate to allow valve stem to straighten, and then inflate tire again to 45 pounds pressure.

**Dismounting:** Essentially the reverse of the mounting procedure.

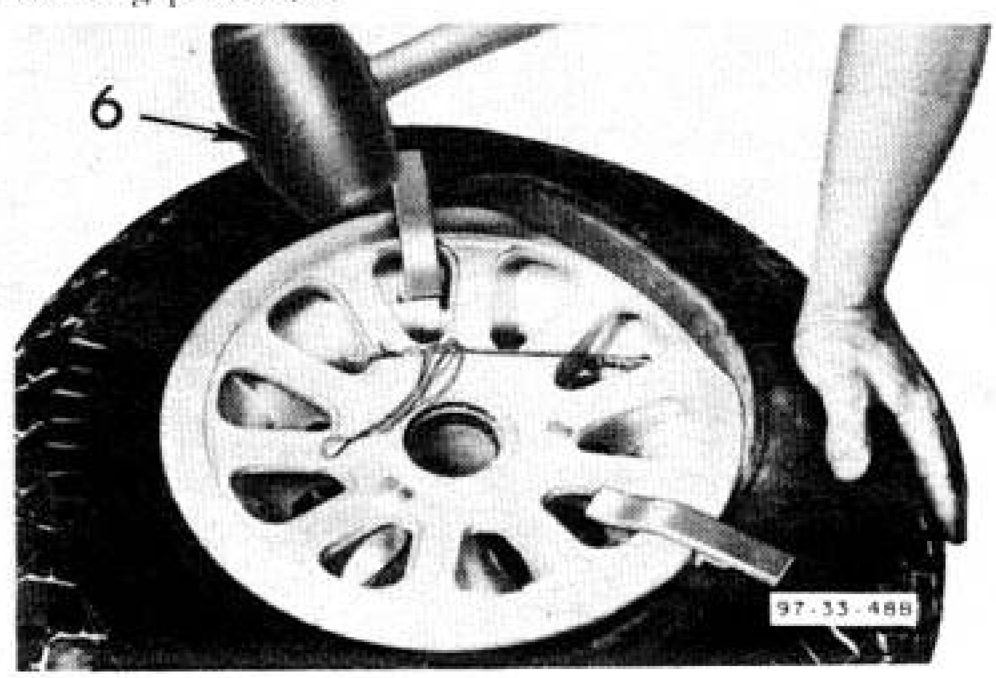


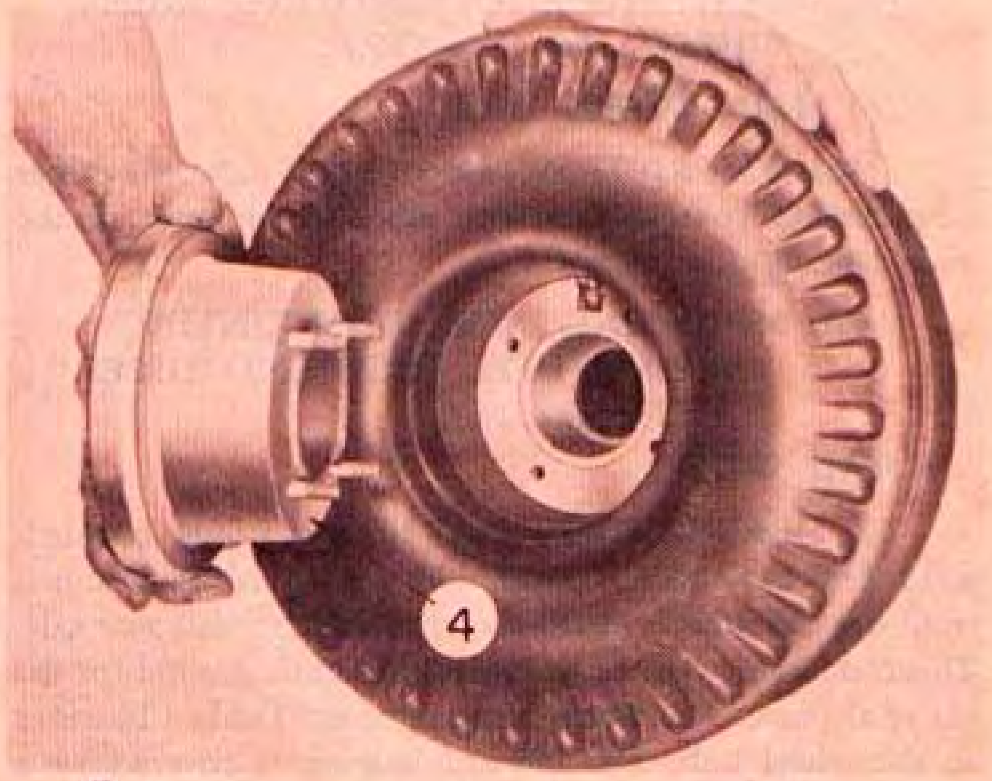

*Figure 162—Mounting Main Wheel Tire and Tube*


Note: See that the hub is clean and free from burrs. Check inside of casing for breaks and dirt.

**1.** Apply talc (Specification No. 4-33, Classification 29) to tube with a piece of cheesecloth, and insert tube in casing.


**2.** Inflate tube slightly to round it out.

**3.** Install inboard half of hub over valve stem.


**4.** Install outboard half of hub.


**5.** Install and tighten nuts on hub studs.

**6.** Inflate tire to approximately 70 pounds pressure; then deflate to allow valve stem to straighten. Inflate tire again to 70 pounds pressure.

**Dismounting:** Essentially the reverse of the mounting procedure.


*Figure 163—Mounting Tail Wheel Tire and Tube*

(2) INSTALLING AND REMOVING MAIN WHEELS. *(See figure 159.)*

(3) MAIN WHEEL TIRES.

*(a)* DESCRIPTION.—Goodyear 27-inch all-weather tread, smooth-contour tires with tubes are mounted on the main landing gear wheels.

*(b)* MOUNTING AND DISMOUNTING MAIN WHEEL TIRES AND TUBES. *(See figure 162.)*

*c.* TAIL WHEEL.

(1) DESCRIPTION.—A 12.50 x 4.5-inch channel-tread, detachable flange wheel, with a self-earthing channel-tread tire and tube, is installed on the auxiliary tail gear axle. This conducting type of tire forms the static ground for the entire airplane. The wheel is mounted on Timken bearings in the wheel hub. The inboard bearing is covered by a grease-retaining ring, and the outboard bearing is provided with a coverplate to keep out dirt.

(2) INSTALLING AND REMOVING TAIL WHEEL. *(See figure 161.)*

(3) MOUNTING AND DISMOUNTING TAIL WHEEL TIRE AND TUBE. *(See figure 163.)*

**7. ENGINE MOUNT AND COWLING.**

*a.* ENGINE COWLING.

(1) DESCRIPTION.

*(a)* REMOVABLE COWLING.—The engine section of the airplane is cowled by readily removable panels which are held to cowl formers by dzus fasteners. *(See figure 164.)* Small access panels and doors permit some servicing of the engine without removing the larger cowl panels. Access to the coolant header tank filler plug is gained by removing a small panel on the forward end of the left top cowl. Two hinged doors near the aft end of the left top cowl provide access to the aftercooling tank plug and to the oil tank filler neck. A ground-heating door and a door for draining the fuel strainer are provided in the bottom cowling. The front bottom cowl is equipped with two perforated panels which allow air into the induction system through filters as well as provide access to the carburetor air filters.

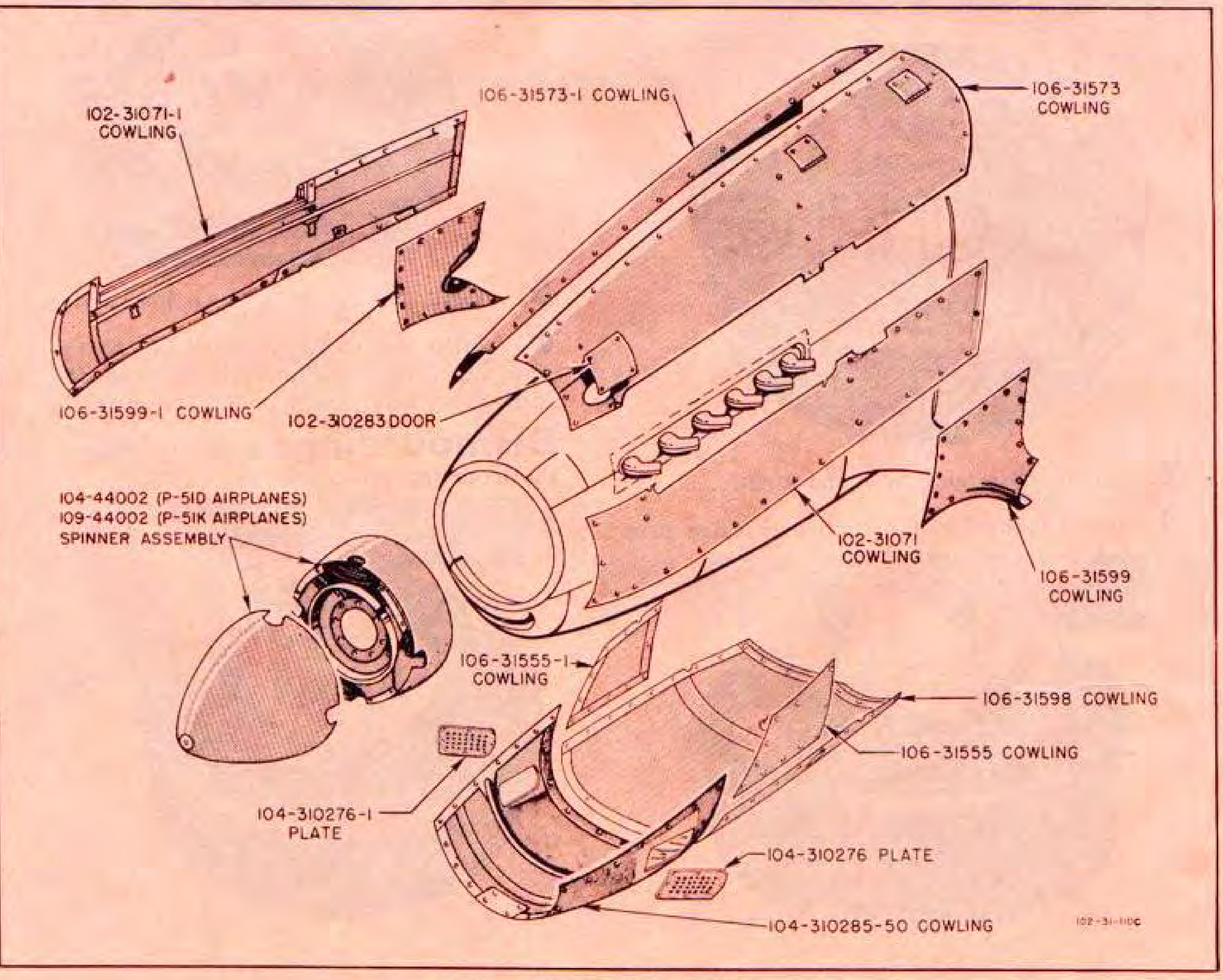



*Figure 164—Engine Cowling*

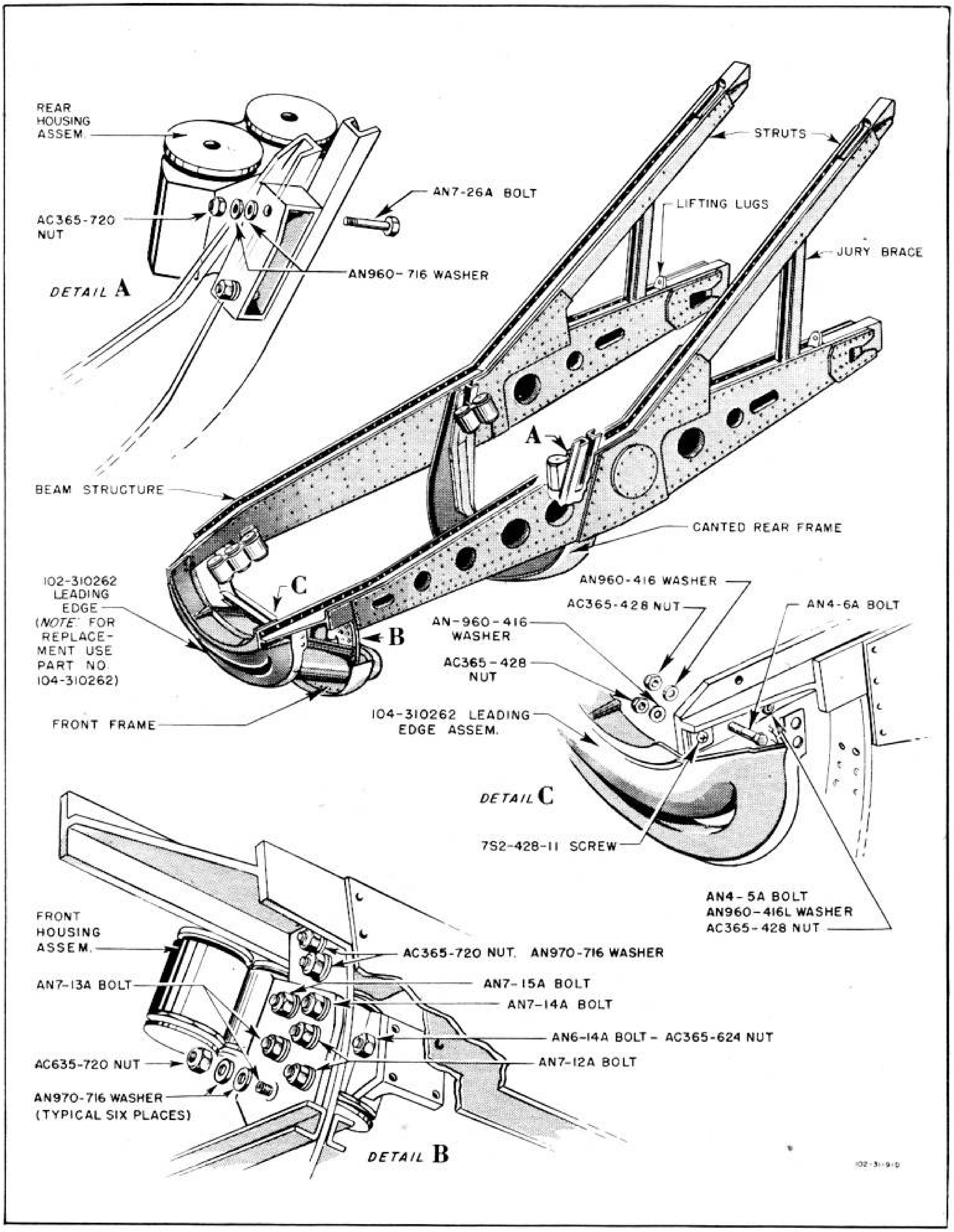



*Figure 165—Engine Mount Assembly*

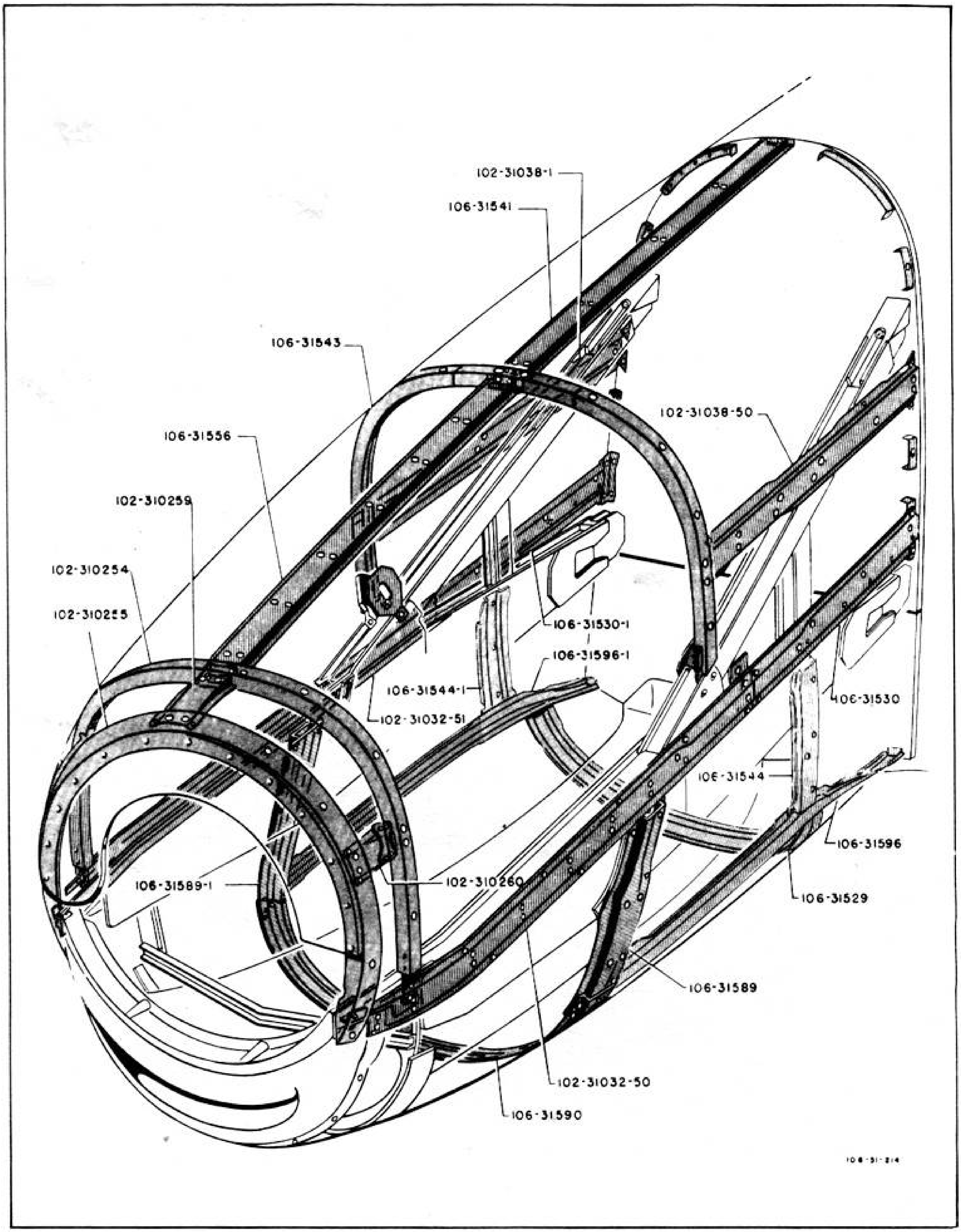



*Figure 166—Engine Cowling Supports*

All cowling panels are constructed of aluminum alloy, except the sections adjacent to the exhaust stacks; these are made of corrosion-resistant steel sheets.

*(b)* COWLING FORMERS.—The panels are fastened to aluminum alloy formers attached to the engine mount and firewall brackets. *(See figure 164.)* The coolant header tank armor plate is bolted to the upper forward former frame. The two lower cross formers are integral with the rear and elbow sections of the carburetor air duct. The entire former structure is bolted in place and may easily be removed.

*b.* ENGINE MOUNT.

(1) DESCRIPTION.—The engine mount consists of two Y-shaped, aluminum alloy box-beam structures and struts which are held together by two cross frames. The forward frame incorporates the leading edge and front duct section of the carburetor air scoop. The aft frame is canted and attaches to the beams. Four engine mount shock support housings containing Lord bushings are included in the engine mount assembly. Two housings are bolted to each cross frame as shown in figure 166. If the rubber bushings in the Lord mounts show signs of deterioration, they must be replaced. Evidence of excess oil or fuel on the rubber should warrant very close inspection of these bushings. The engine mount is bolted to the firewall at four places; the upper points of attachment are the forward extremities of the fuselage upper longerons, and the lower points are at fittings on the bottom of the fuselage frame structure. The engine is cradled between the mount beams and is attached to the four shock absorbing units by means of adapters. A lug located at the aft end of each beam is used for hoisting the engine and mount or the complete airplane.

## 8. ENGINE.

*a.* GENERAL DESCRIPTION OF ENGINE.—The P-51D Airplane is powered by a 12-cylinder, V-type Packard-built Rolls Royce V-1650-7 type engine equipped with an up-draft injection carburetor. The engine is liquid-cooled and incorporates an aftercooler in addition to the conventional cooling system. The fuel-air mixture is first cooled between the two supercharger stages by an intercooler incorporated within the intermediate volute housing. An aftercooler, located after the second stage supercharger and before the induction manifold, cools the mixture before it passes into the engine. The supercharger is of a centrifugal two-speed, two-stage, gear-driven type. A 24-volt solenoid, controlled by an aneroid switch, operates a balanced hydraulic valve to control the supercharger shift between low and high blower ratios. The lubrication system is of the force-feed, dry sump type having three pressure stages. The engine exhaust is discharged from each cylinder exhaust port through individual ejection-type, jet propulsion stacks. The stacks are covered by shrouds and dzus-fastened fairing plates through which the

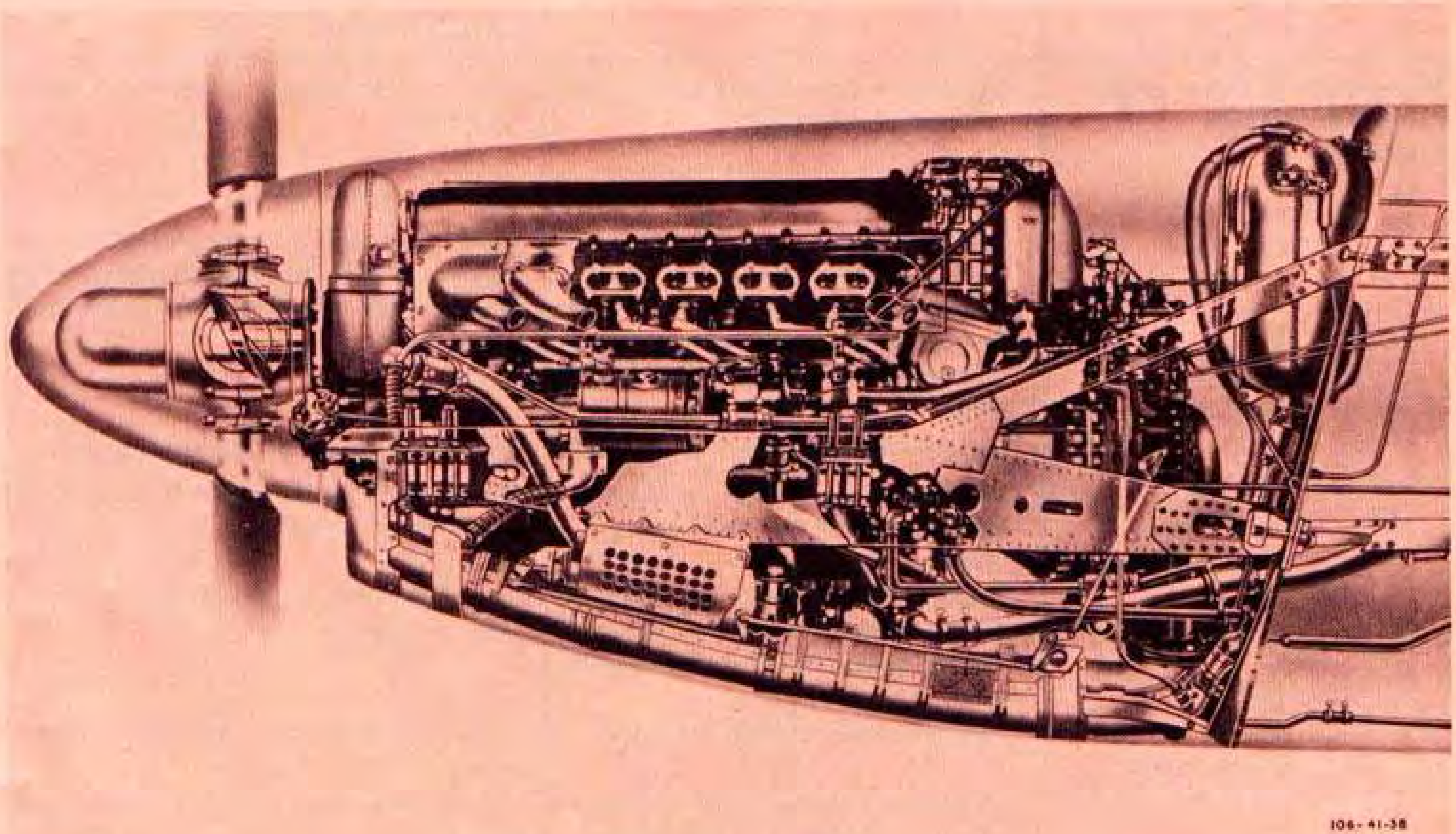



*Figure 167—Engine Installation Cutaway*

ends of the stacks protrude. The following table gives engine data and performance ratings.

| | |
|---|---|
| Bore | 5.4 in. |
| Stroke | 6.0 in. |
| Piston displacement | 1649 cu. in. |
| Compression ratio | 6.0:1 |
| Tappet clearances for running (exhaust) | 0.020 in. |
| Tappet clearances for running (intake) | 0.015 in. |
| Firing order | 1A, 6B, 4A, 3B, 2A, 5B 6A, 1B, 3A, 4B, 5A, 2B |

*b.* ENGINE TROUBLE SHOOTING.—Success in locating and correcting engine troubles depends upon logical reasoning and close observance of engine operation and instrument data. Obtaining engine operating temperatures and pressures from the pilot, crew chief, and airplane flight record forms will facilitate the location and correction of any minor troubles. For engine troubles caused by malfunctioning carburetor, see paragraph 12. *a.* (2).

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Engine fails to start or continue to run after starting.** | Improper starting procedure. | Start engine as instructed in AN 01-60JE-1. |
| | Defective primer pump causing under-priming. Lack of fuel at primer pump, or leaky primer pump lines and connections. Clogged lines, atomizers, or induction line filter. | Replace primer pump. Clean and tighten primer lines, atomizers, or induction line filter. |
| | Overpriming causing flooding of induction system. | Clear induction system of excessive fuel. |
| | Insufficient cranking speed due to faulty battery or starter motor. | Replace battery or starter motor. |
| | Lack of fuel. Insufficient fuel flow due to clogged lines and filters, choked tank vent lines, or loose and leaky fuel connections, fittings or piping. Fuel valves closed. | Refill fuel tanks. Open fuel valves. Clean lines, filters, and tank vents. Tighten fuel connections, fittings, or piping. |
| | Oil cold. | Drain and heat oil before starting or dilute before exceeding 1400 rpm. |
| **Engine fails to start; engine missing or running unevenly.** | Defective or fouled spark plugs. Incorrect type of spark plugs. | Clean or replace spark plugs. Install correct type plugs. |
| | Defective booster coil. | Adjust or replace unit. |
| | Defective ignition caused by loose primary terminals or connections at magnetos and switches, or by worn, burned, broken, or incorrectly connected secondary wiring at booster coil and spark plugs. | Tighten terminals or connections at magnetos and switches. Replace secondary wiring at booster coil and spark plugs. Connect wiring correctly. |
| | Defective breaker points or magneto. | Service breaker points. Replace magneto. |
| | Valves sticking, leaking or having improper clearances. Valve springs broken. | Clean valves. Adjust tappet clearances. Replace broken springs. |
| | Insufficient fuel pressure caused by incorrect setting of fuel valves, or defective fuel pump. Defective fuel pressure gage. | Open tank valve. Replace fuel pump and pressure gage. |
| | Fuel defective or of improper grade. | Drain fuel system and refill with correct grade. |
| | Air leaks in induction system. Worn inlet valve guides or broken valves and springs. | Tighten and replace loose nuts or blown gaskets. Replace worn inlet valve guides. Replace broken valves or springs. |
| | Incorrect timing. | Time valves and ignition. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Partial or complete loss of oil pressure.** | Insufficient oil. | Replenish supply. |
| | Excessive oil dilution caused by leaky oil dilution valve. | Replace valve. |
| | Bearing failure and excessive engine clearances. | Overhaul engine. |
| | Broken or leaky oil lines. | Repair or replace lines. |
| | Clogged oil filters. | Remove and clean. |
| | Dirt under relief valves. | Remove and clean. |
| | Faulty pressure gage. | Replace with new gage. |
| | Defective pressure pump. | Replace with new pump. |
| | Malfunctioning or maladjustment of oil pressure relief valves. | Readjust or replace oil pressure relief valves. |
| **Excessively high oil pressure (above 90 lbs./sq. in.).** | Faulty regulator unit caused by dirt under valve seat or broken spring. | Clean valve seat or replace spring. |
| | Improper adjustment of main pressure valve. | Readjust main pressure. |
| | Choked oil lines or passages on pressure side. | Clean. |
| | Defective oil pressure gage. Restricted or congealed gage line. | Replace gage. Clean line. |
| | Improper adjustment of scoop operating mechanism. | Adjust radiator scoop mechanism. |
| **Low oil temperature.** | Improper regulation of cooling equipment. | Regulate properly as per pilot's check-off chart. |
| **Oil inlet temperature excessively high (above 90°C (194°F) ).** | Insufficient oil in system. | Replenish oil supply. |
| | Oil of incorrect grade and/or insufficient viscosity. | Drain and refill system with correct oil. |
| | Engine speed too high, due to bearing failure evidenced by metallic particles in oil filter. | Overhaul engine. |
| | Oil-sludged radiator. | Remove radiator and clean. |
| **Engine overheating. (Noted by excessive oil or coolant temperatures.)** | Insufficient coolant. | Fill header tank to prescribed level. |
| | Air lock in cooling system. | Remove caps from radiator vent lines and allow air trapped in radiator to escape. Refill cooler systems and run engine for a few minutes. Stop engine and add coolant fluid necessary to bring level up to filler neck. If necessary, remove air release plug in coolant outlet manifold to clear remaining air in system. |
| | Leaks or restrictions in cooling system. | Tighten cooling system line connection. Drain system, locate and clean restrictions, reassemble connections, and refill systems with coolant fluid. |
| | Radiator clogged by corrosion deposits. | Clean radiator tubes or install new unit. |
| | Failure of coolant pump. | Replace pump. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| | Engine operation at incorrect rpm and manifold pressure, due to defective tachometer shaft or manifold pressure gage. | Replace tachometer system or manifold pressure gage. |
| | Defective ignition or spark plugs. | Replace or reset ignition and spark plugs. |
| | Induction system air leaks due to loose nuts or blown gaskets, worn inlet valve guides or broken springs. | Tighten or replace loose nuts or blown gaskets. Replace inlet valve guides and replace broken valve springs. |
| | Valves sticking, leaking, or having incorrect tappet clearances. | Readjust tappet clearances. |
| | Incorrect ignition and valve timing. | Reset and time engine valves and magnetos. |
| | Defective engine Lord mounts. | Replace mounts. |
| **Backfiring.** | Improper engine operation. | Start and operate engine according to AN 01-60JD-1. |
| | Engine operating at excessive rpm and manifold pressure, due to defective tachometer and manifold pressure gage. | Replace tachometer or manifold pressure gage. |
| | Engine overheated. | See "Engine overheating." |
| | Lack of fuel—insufficient flow. | Replenish fuel tank supply or replace fuel pump. |
| | Lean fuel mixtures. | Adjust for proper mixture. |
| | Induction system air leaks and restrictions. | Tighten loose nuts. Replace blown gaskets. Remove restrictions. |
| | Valves sticking, leaking, or having improper tappet clearances. | Reset tappet clearances. |
| | Loose ignition ground connections. | Tighten magneto ground wire connections securely. |
| | Incorrect ignition and valve timing. | Reset and time engine valves and magnetos. |
| | Defective ignition or spark plugs. | Replace ignition system and spark plugs. |
| **Engine smoking.** | Improper grade or defective fuel. | Drain fuel system and refill with correct grade fuel. |
| | Excessive rich fuel mixtures. | Readjust fuel mixture control. |
| | Valves sticking, leaking, or improperly adjusted. | Reset tappet clearances. |
| | Defective or weak ignition due to loose or incorrect connections, or worn, burned, or broken secondary wiring at magneto. | Make correct, tight connections. Replace worn, burned, or broken secondary wiring at magneto. |
| | Improper oil scavenging of engine and system due to faulty scavenge pumps or clogged filter screens. | Replace scavenge pumps. Clean filter screens. |
| | Incorrect ignition and valve timing. | Time engine valves and magneto. |
| | Defective engine cylinder rings. | Overhaul engine. |
| **Detonations.** | High fuel mixture temperatures due to low cooler fluid level, or corrosion deposits. | Replenish cooler fluid. Remove corrosion deposits. |

*c.* ADJUSTING ENGINE VALVE CLEARANCES.—The proper clearance is .015 inch for intake valves and .020 inch for exhaust valves. These clearances apply on a cold engine. To adjust valves, proceed as follows:

(1) Remove cylinder head cover and gasket.

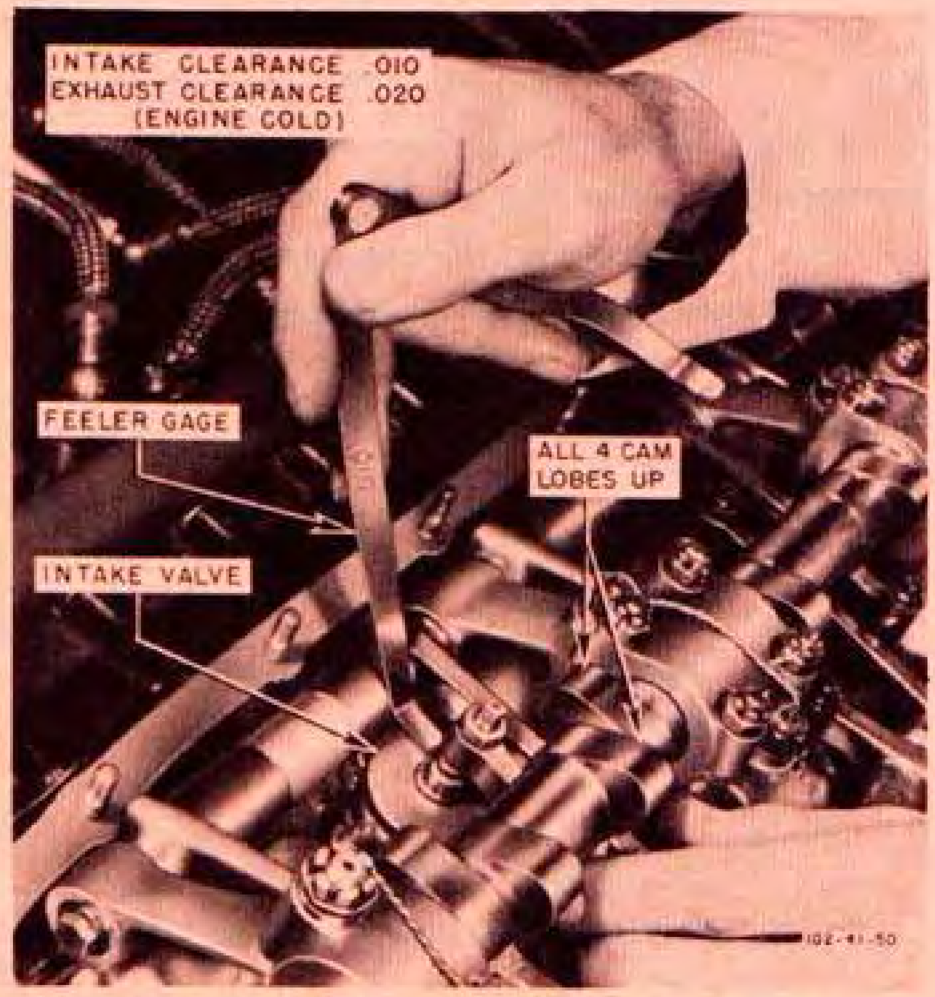



**Figure 168—Checking Valve Clearances**

(2) Check valve clearance while all four cam lobes for that cylinder are upward. *(See figure 168.)*

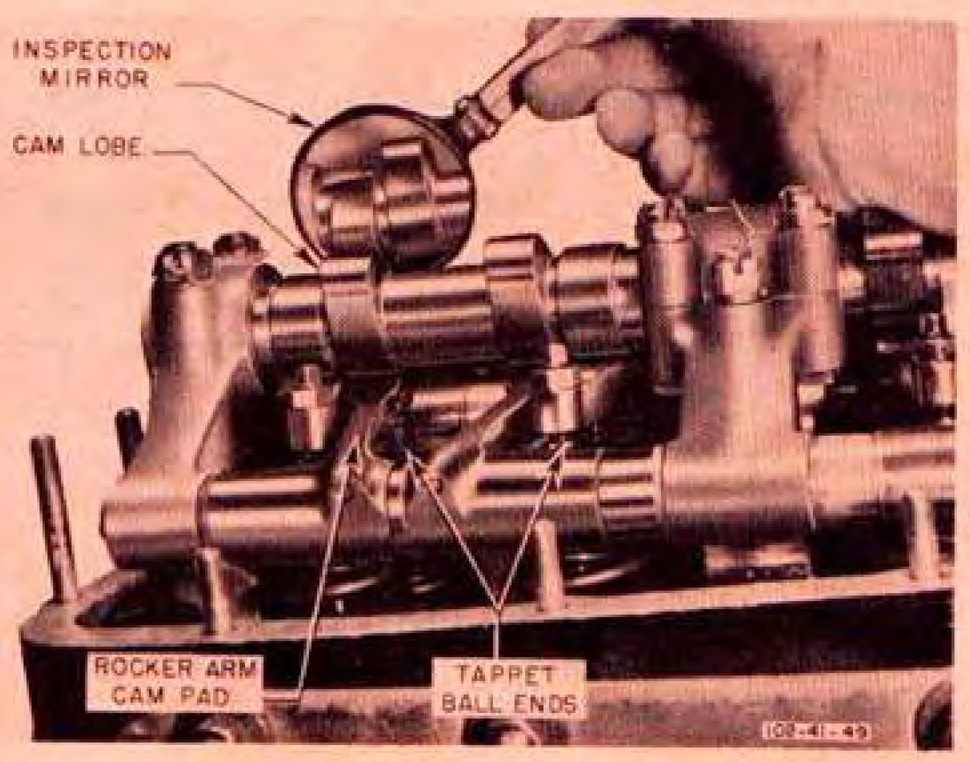



**Figure 169—Inspecting Valve Mechanism for Wear**

(3) If the clearance of any exhaust valve is more than .025 inch or .020 inch for intake valves, inspect ball end of tappet and face of related rocket arm cam pad for excessive wear. *(See figure 169.)* Replace tappet if pitted, rough, or worn. If chromium plating on rocker arm cam pad is flaked or worn through, install new rocker and inspect related cam on camshaft for "pick-up" metal, which should be removed with a fine stone.

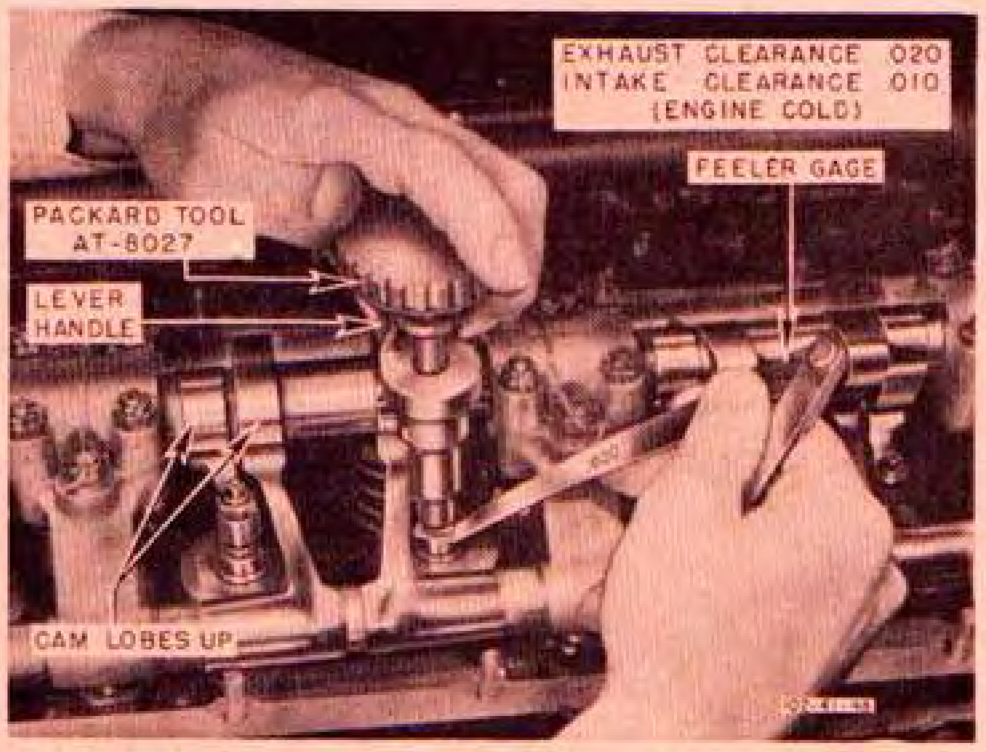



**Figure 170—Adjusting Valve Clearances**

(4) Adjust exhaust tappets to .020-inch clearance and intake tappets to .015-inch clearance with special tappet wrench, Packard tool AT-8027. After adjusting a tappet, tighten locknut securely with level handle of wrench. *(See figure 170.)*

**Note**

Make certain there is no oil film or foreign matter between end of valve stem and tappet. Be sure feeler gage is clean and has no burred edges.

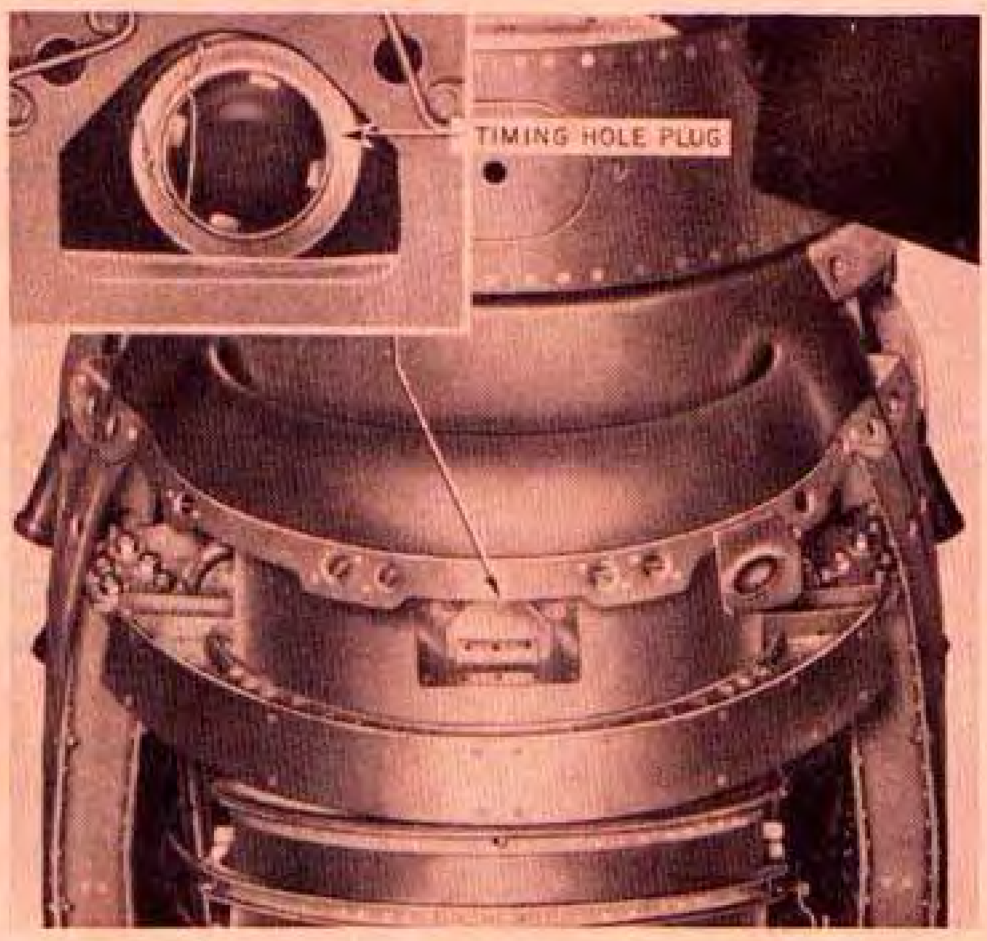



**Figure 171—Timing Inspection Port**

*d.* TIMING ENGINE.

(1) TIMING ENGINE VALVES.

*(a)* GENERAL.

*1.* Remove the two dzus-fastened timing inspection doors from the front section of the carburetor air scoop. *(See figure 171.)*

*2.* Remove the timing inspection hole plug from the lower crankcase, using socket AT-9209 and extension in the engine tool kit.

**Note**

If timing marks are not discernible, wipe oil from the crankcase coupling flange with a clean, lint-free rag.

*3.* Remove both cylinder valve covers.

**Note**

It is necessary to remove both cylinder valve covers in order to time one bank to the opposite bank, since timing is accomplished by observing the position of the valve cams.

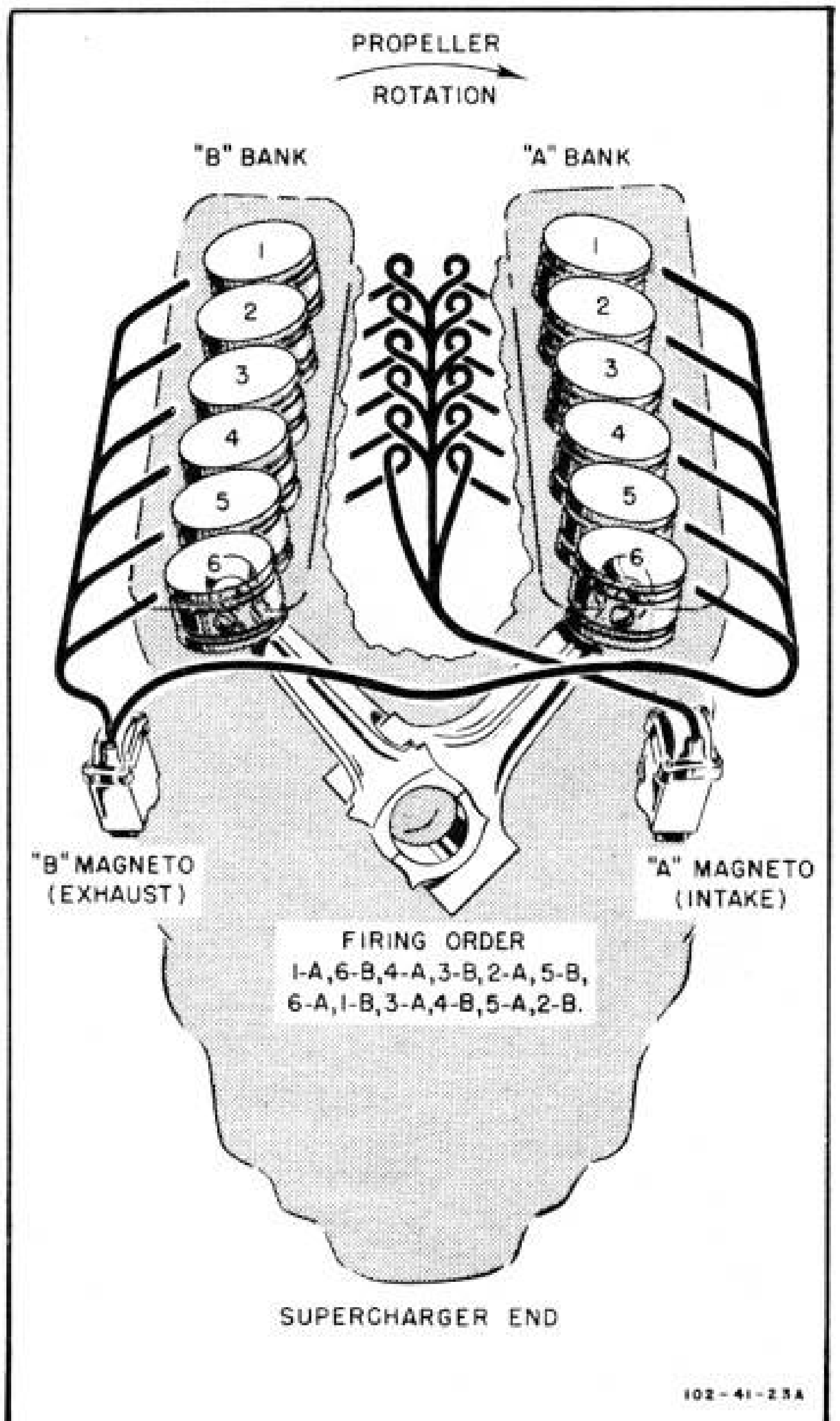



***Figure 172—Cylinder and Ignition Arrangement***

*(b)* TIMING "A" BANK (Oil Relief Valve Side). —For designation of cylinder banks and numbering of cylinders, see figure 172.

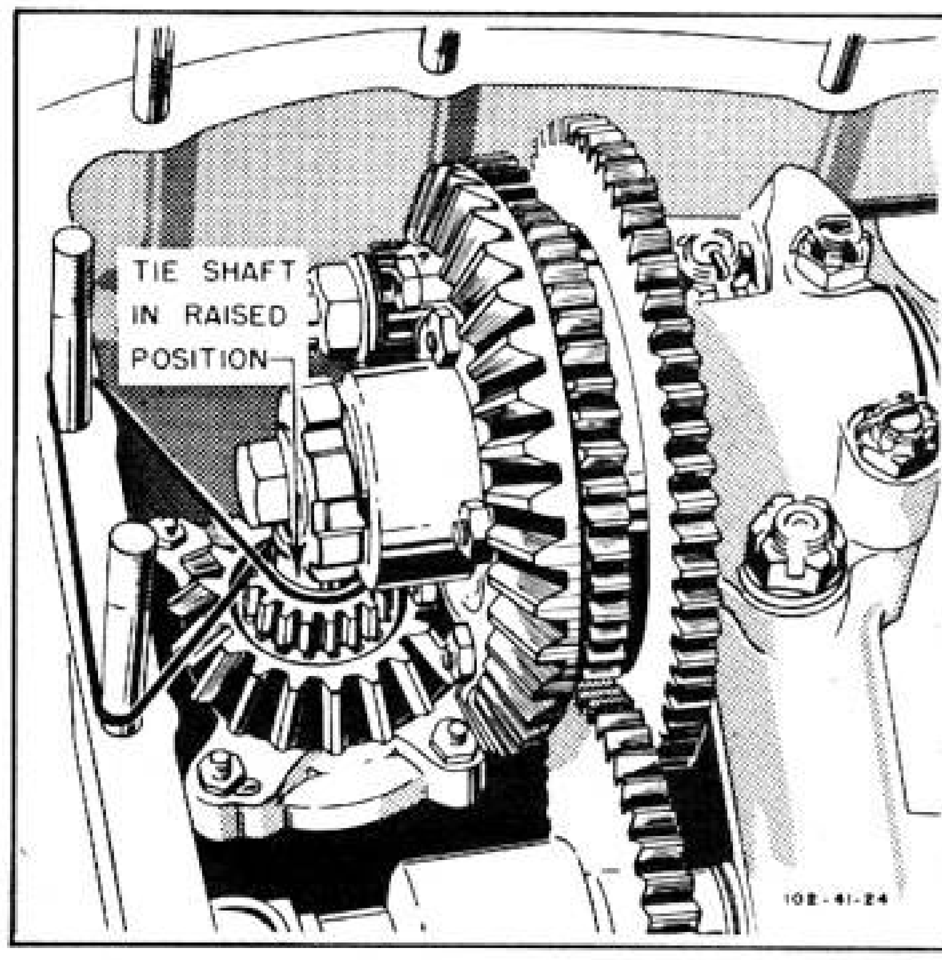



***Figure 173—Disengagement of Camshaft***

*1.* Remove circlip and selective spacer from upper end of camshaft drive gear pinion.

*2.* Lift inclined vernier camshaft drive shaft out of mesh with beveled pinion gear, and secure in raised position with a rubber band, safety wire, or a piece of cord as shown in figure 173 to permit the camshaft to be turned independently of the crankshaft.

**Note**

In order to lift drive shaft out of mesh with beveled pinion gear, it may be necessary to rock the crankshaft.

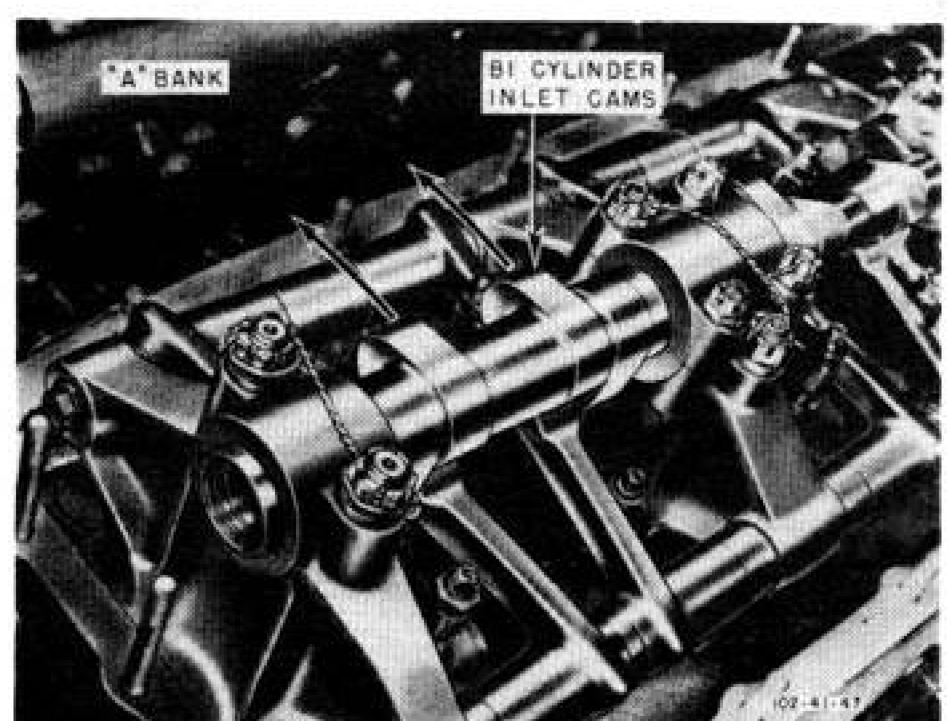



***Figure 174—B1 Cylinder Inlet Cams Set for A6 Cylinder Timing***

*3.* Set A6 piston on the proper stroke as follows:

a. Turn the engine so that the inlet cams for the B1 cylinder are horizontal and pointing toward the "A"

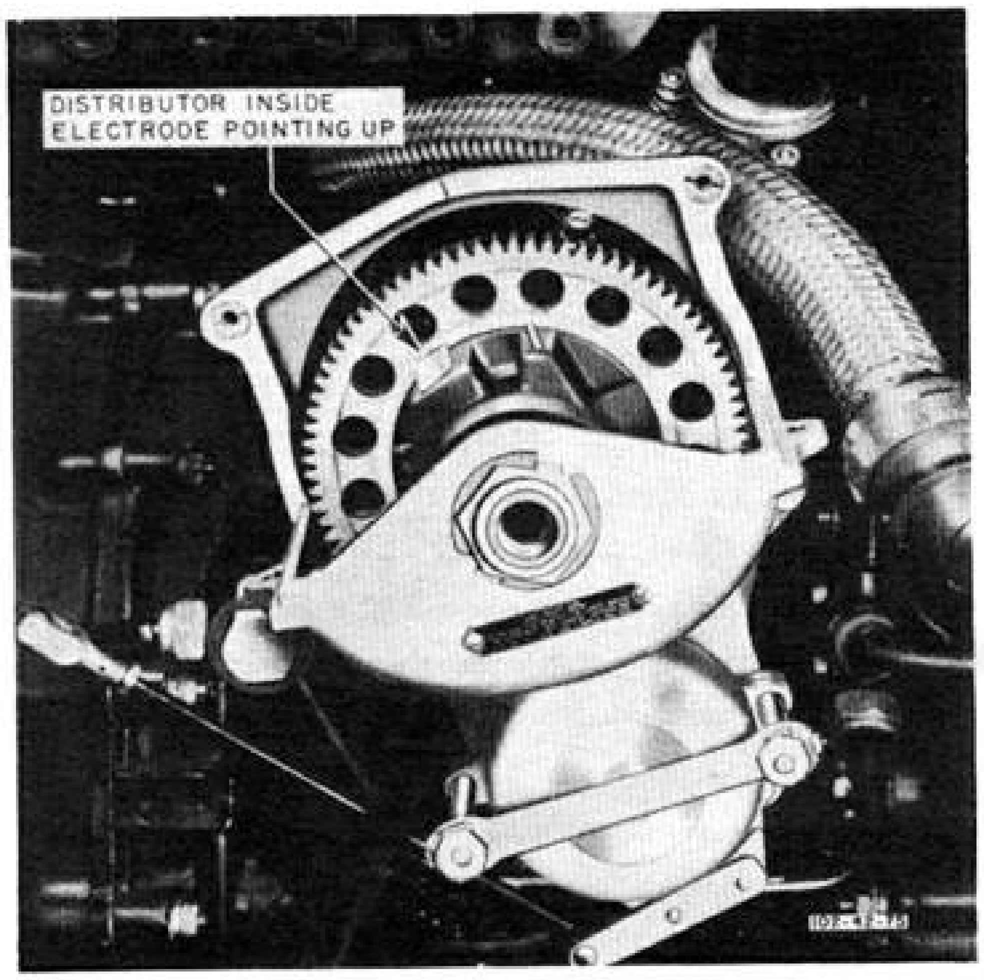



***Figure 175—Magneto Set for A6 Cylinder Timing***

bank as shown in figure 174, and that the distributor inside electrode, on either magneto, is pointing in the approximate upward position as shown in figure 175.

b. Continue turning engine in normal rotation until the "A6 IO" mark on the crankcase coupling flange is in register with marker. *(See figure 177.)* The "A" bank is now ready to be timed.

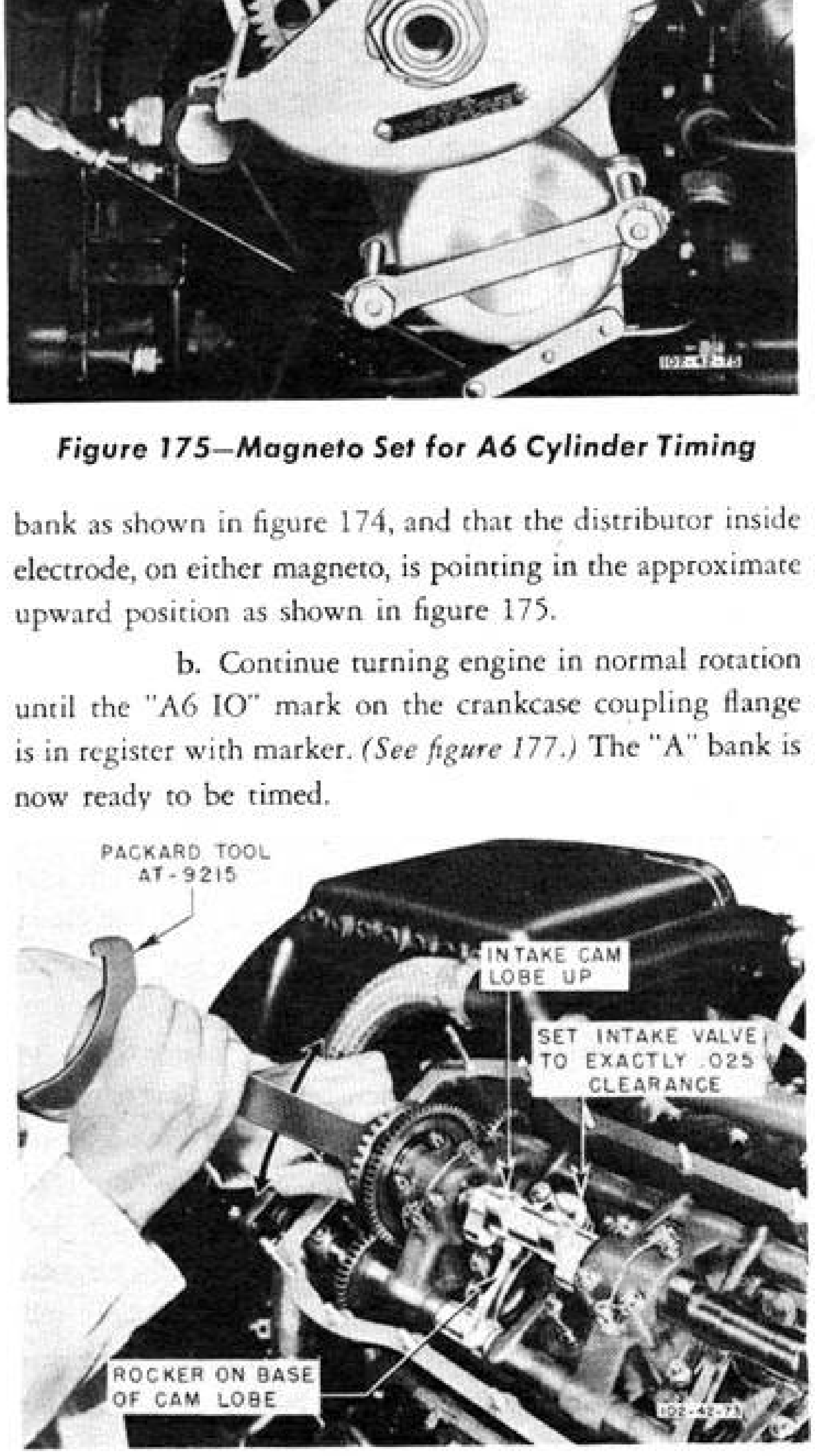



***Figure 176—Setting A6 Cylinder Intake Valve to .025 Clearance***

4. Turn "A" bank camshaft with tool AT-9215 and adjust one of the intake valves of A6 cylinder to exactly .025 inch as shown in figure 176. Be sure rocker is on the base of the cam with the intake cam lobe upward.

5. Insert a .005-inch feeler gage between the A6 cylinder intake valve and tappet; then, using tool AT-9512, turn camshaft clockwise (viewed from supercharger end) until feeler is just pinched, as shown in figure 178.

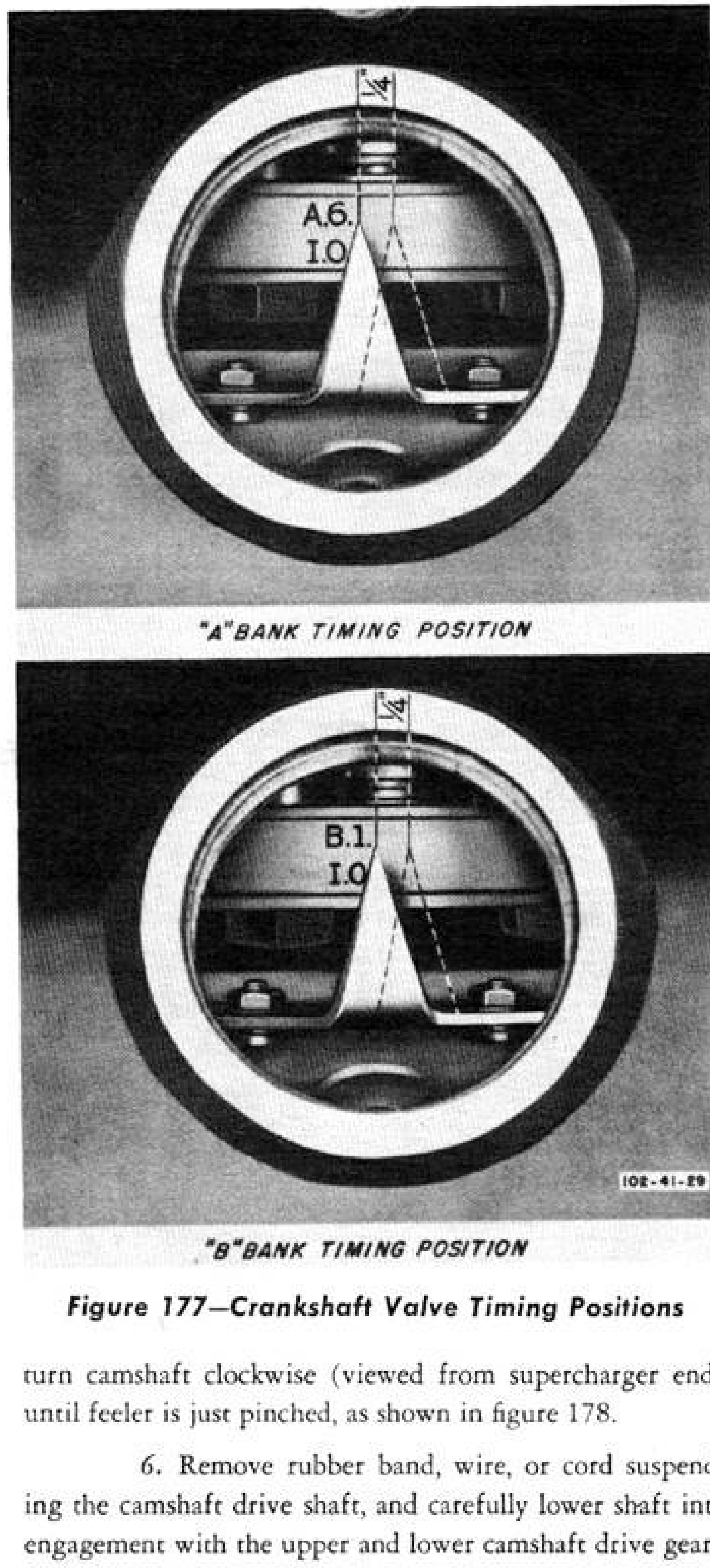



***Figure 177—Crankshaft Valve Timing Positions***

6. Remove rubber band, wire, or cord suspending the camshaft drive shaft, and carefully lower shaft into engagement with the upper and lower camshaft drive gears. *(See figure 179.)* As weight of shaft must determine the engagement, it may be necessary to try several different shaft positions.

7. With the .005-inch feeler gage in position between the A6 cylinder intake valve and tappet, check the timing for correctness as follows:

a. Turn the crankshaft backward by revolving the propeller at least ⅛ of a revolution in direction opposite to normal rotation; then, turn propeller slowly in normal direction. Stop turning propeller when feeler gage is just pinched between valve stem and tappet.

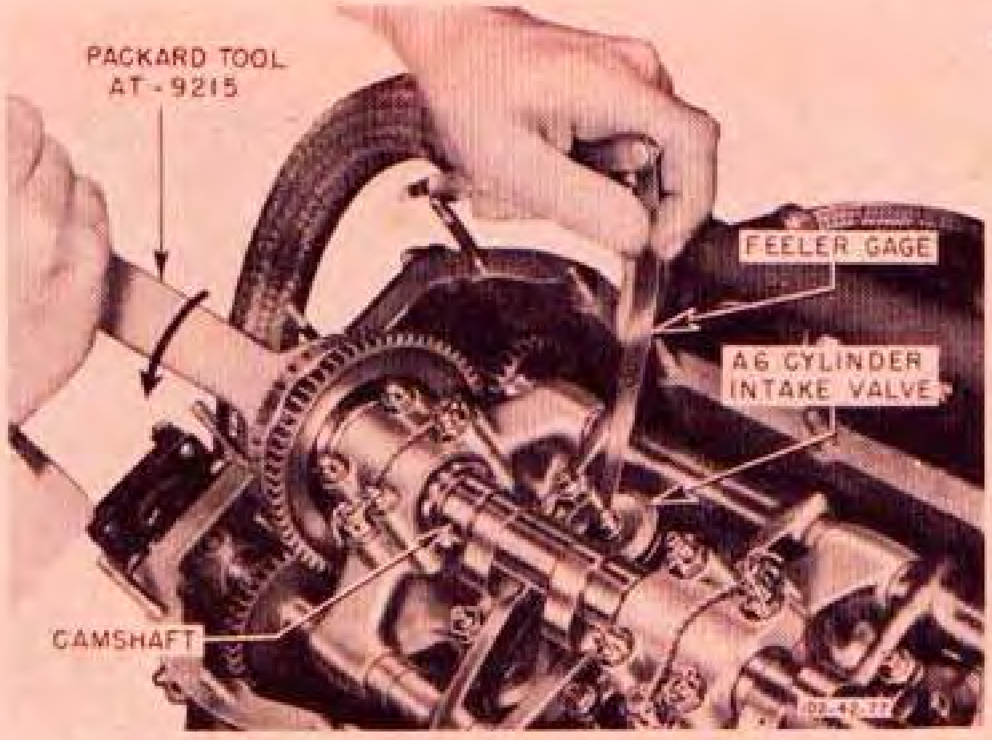



***Figure 178—Setting Camshaft for Engagement***

b. Check position of crankshaft by the timing marks. The pointer should register with the "A6 IO" mark or within ¼ inch past, as shown in figure 177. If the pointer does not register within this limit, repeat operations described in *(b)* *1.* through *7.*

**Note**

Make sure that A6 cylinder is in the proper stroke and the crankshaft is set at "A6 IO" mark before again attempting the valve timing procedure.

*8.* When correct valve timing has been obtained, reinstall drive shaft selective spacer and circlip.

*9.* Adjust all exhaust tappets to .020-inch clearance and intake tappets to .015-inch clearance.

*10.* When valve timing operations are completed, reinstall and lockwire timing plug and reinstall inspection doors in air scoop. Reinstall cylinder head covers, using new gaskets, and torque cover nuts to 65 inch-pounds.

*(c)* TIMING "B" BANK (Generator Side).—The "B" bank timing adjustment is accomplished in the same manner as outlined in paragraph *(b)*, except that the .025-inch valve adjustment is made on the B1 cylinder and the propeller is turned so that timing mark "B1 IO" registers with the pointer as shown in figure 177.

**Note**

Before timing the "B" bank, make sure the B1 cylinder is in the proper stroke as follows:

*1.* The proper stroke for the B1 cylinder is obtained by turning the engine so that the exhaust cams for the A6 cylinder are horizontal and pointing toward the "B" bank.

*2.* Continue turning engine in normal direction until the "B1 IO" mark on the crankcase coupling flange is in register with marker. The "B" bank is now ready to be timed.

(2) TIMING IGNITION.

*(a)* GENERAL.—The magnetos can be timed to any desired setting by means of the vernier coupling shaft and the free play of the crankcase mounting studs in the magneto mounting flange holes. The vernier coupling shaft has 12 internal splines at its outer end to engage with the magneto coupling, and 11 external splines at its inner end to engage with the magneto driving shaft. The difference in the number of splines at each end of the coupling shaft makes it possible to select an engagement that will give accurate timing. Ignition timing is synchronized, the intake and exhaust magnetos both being timed to fire 45 degrees before top dead center. A timing mark (A6 IMA) indicating this position (45 degrees b.t.d.c.) is stamped on the crankshaft coupling flange and may be seen by removing the lower crankcase inspection plug which is accessible through doors in the front air scoop section. The plug is removed by using socket AT-9209 in the engine tool kit. Recommended equipment for determining when the magneto breaker contacts are just opening is a buzzer or a dry cell-operated light bulb. A strip of feeler stock not more than .002 inch thick can be used where buzzer or light is not available.

*(b)* TIMING PROCEDURE.—Since both the intake and exhaust magnetos are timed to fire at 45 degrees before top dead center when fully advanced, the procedure to be followed when timing each magneto is virtually identical.

*1.* REMOVING MAGNETO FROM ENGINE. *(See figure 180.)*

a. Disconnect control linkage to magneto contact breaker assembly.

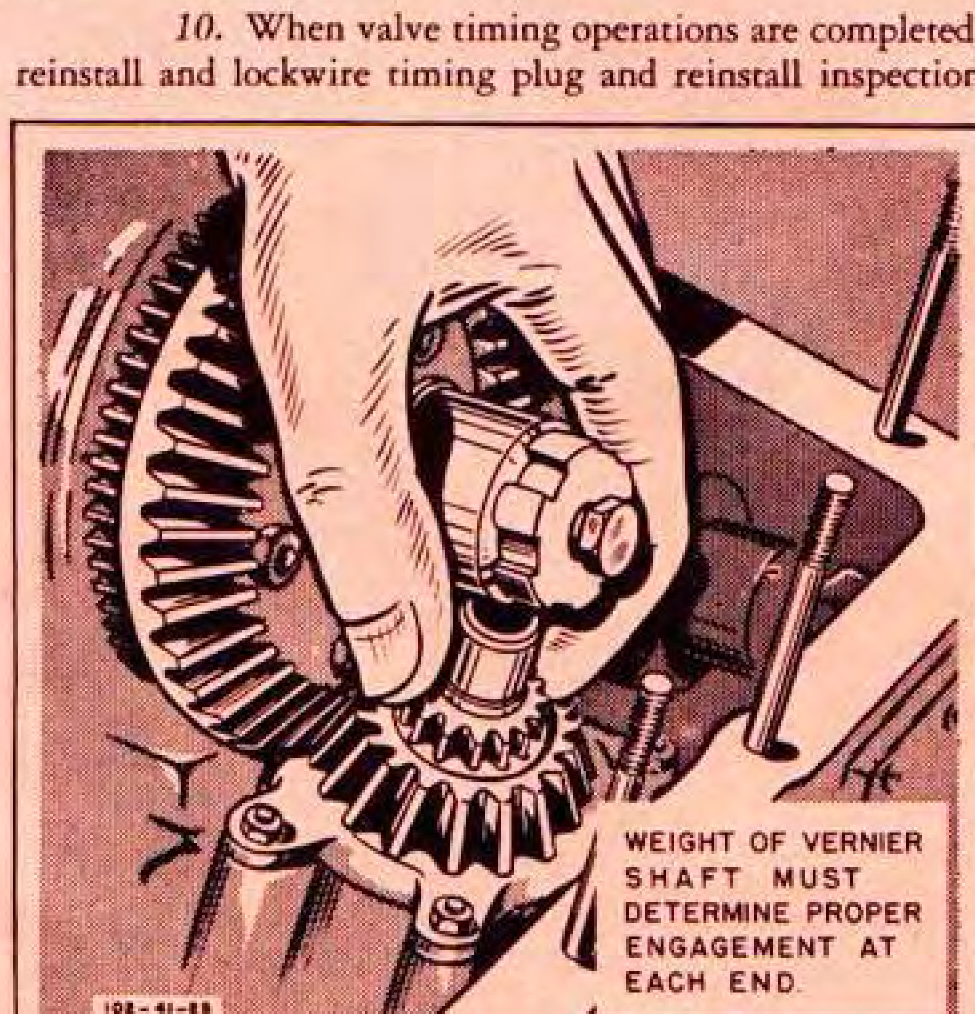



***Figure 179—Engaging Camshaft Drive Shaft***

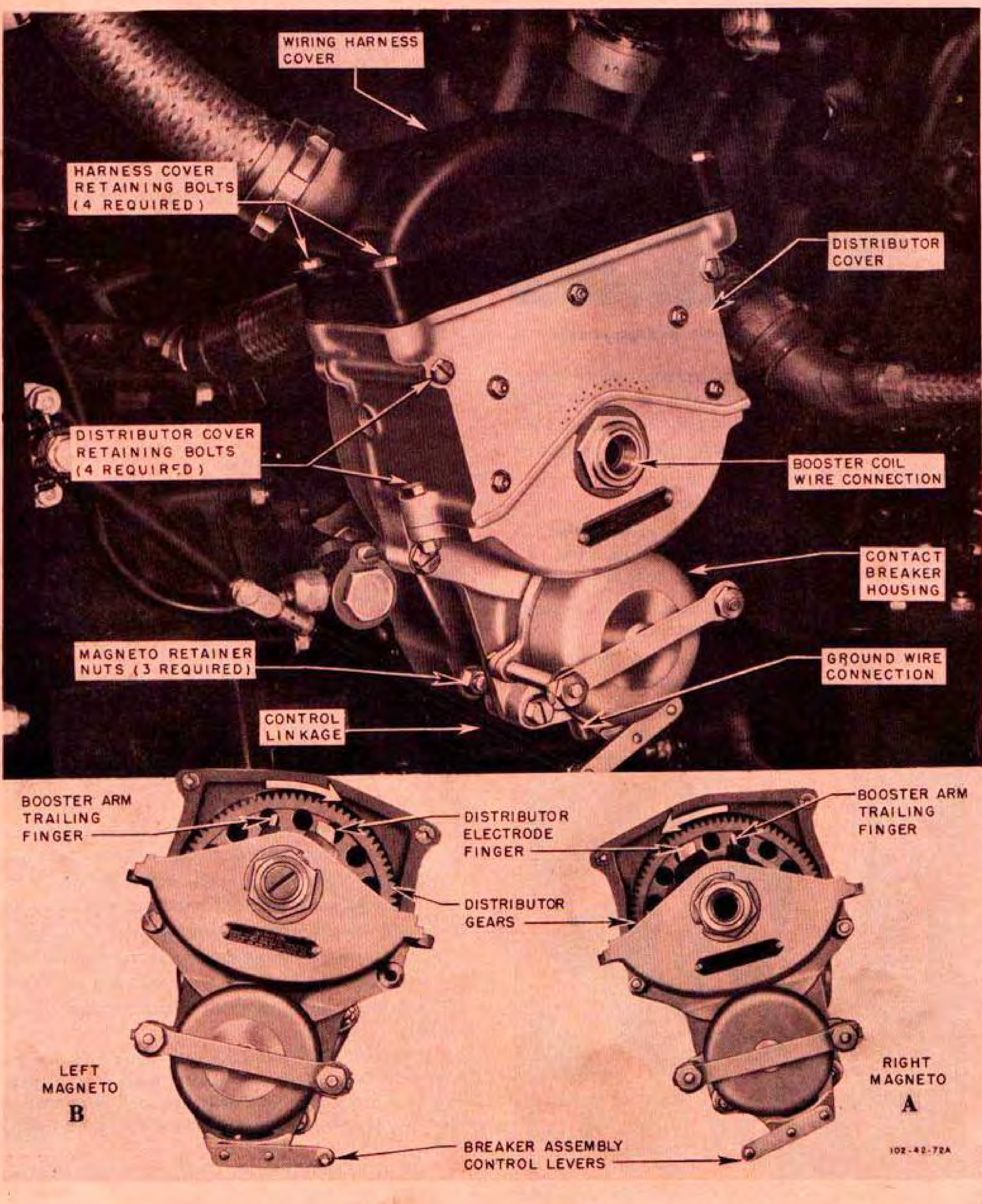



*Figure 180—C6 Magnetos*

**Note**

Do not loosen locknuts on linkage, as this will disturb the adjustment.

b. Disconnect magneto ground wire connection by loosening K nut and unscrewing adapter.

c. If the "A" side magneto is being removed, disconnect booster coil wire at connection on magneto.

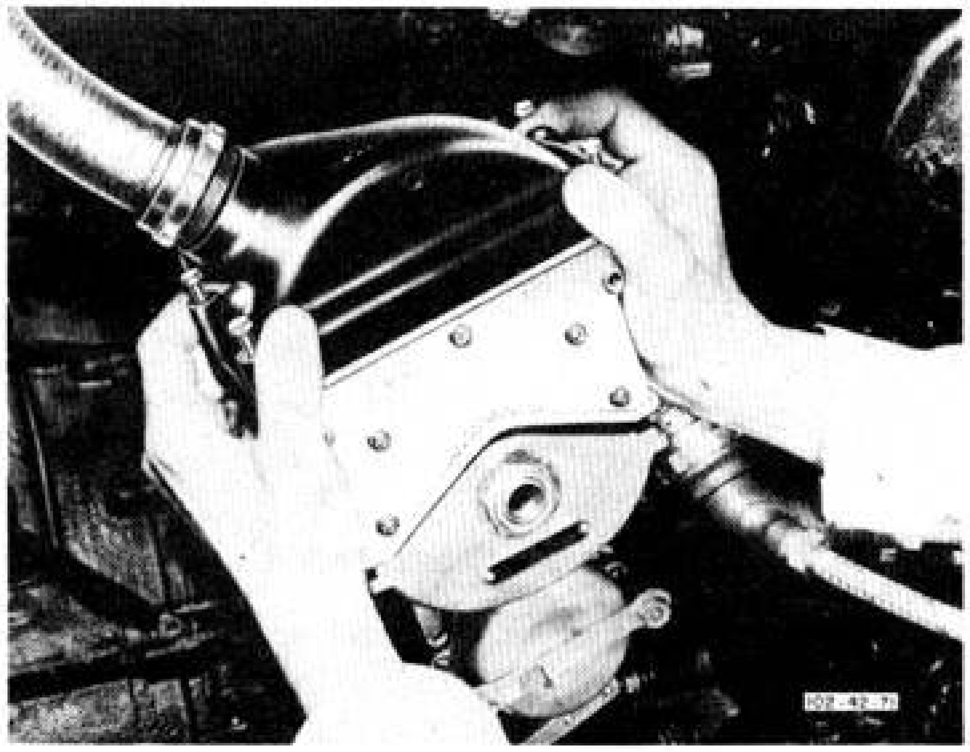



*Figure 181—Removing Harness and Distributor Covers*

d. Unscrew the four bolts holding the wiring harness connection cover to the magneto, the two bolts, and two bolts and nuts holding distributor cover; then remove as a unit as shown in figure 181. The harness and distributor covers may then be separated. *(See figure 182.)*


*Figure 182—Separating Harness and Distributor Covers*

**CAUTION**

When separating covers, be very careful to avoid breaking or cracking the insulators when withdrawing the cable leads.

e. Remove nuts from the three mounting studs and withdraw magneto. Place magneto on a clean, dry surface.

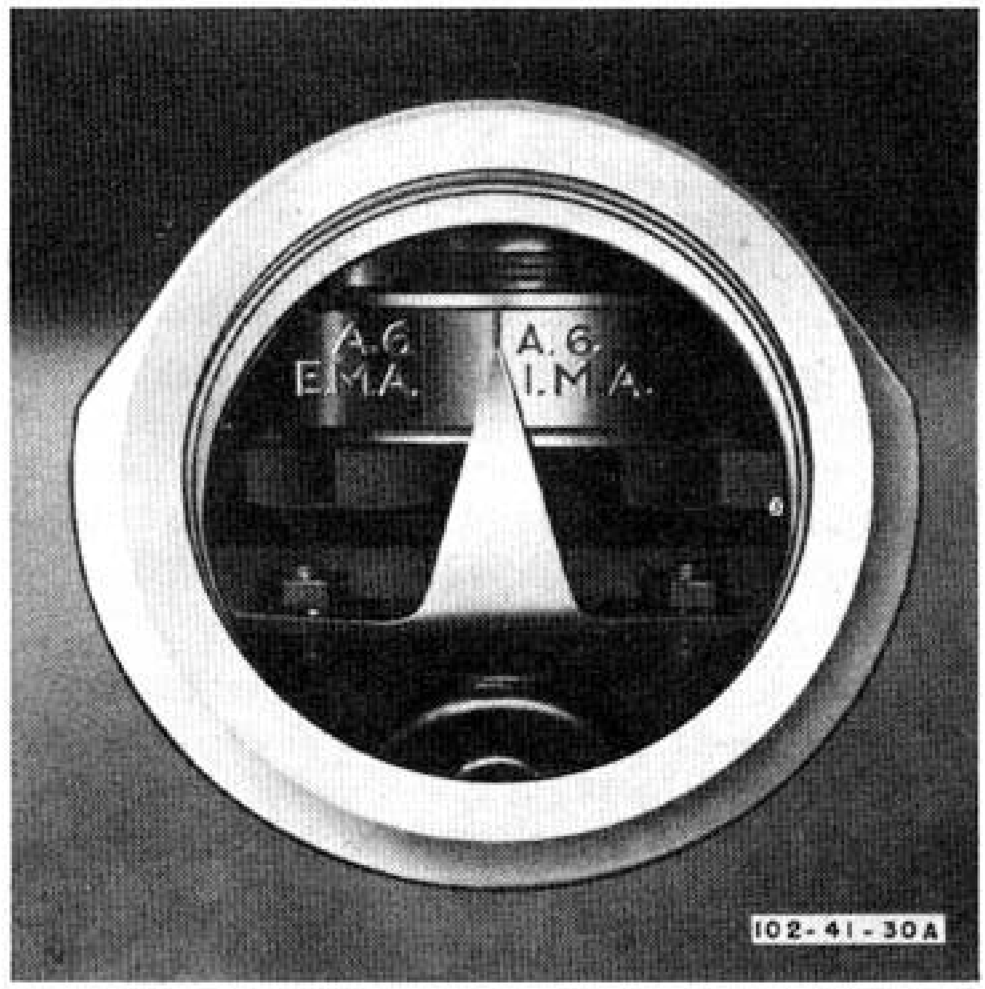



*Figure 183—Crankshaft Magneto Timing Position*

2. SETTING ENGINE FOR MAGNETO TIMING.—Turn crankshaft in normal direction of rotation until the A6 piston is coming up on the compression stroke. Stop turning when the mark "A6 IMA" on the crankshaft flange is in register with the pointer. *(See figure 183.)*

**Note**

As this engine is timed to fire at 45 degrees before top dead center, be careful not to use the mark "A6 EMA" on this installation, as this mark is used to time magnetos to fire at 50 degrees before top dead center. Make certain the correct mark "A6 IMA" (45 degrees before top dead center) lines up with the pointer.

3. TIMING MAGNETO.

**CAUTION**

To avoid demagnetizing the magneto when using a timing light or continuity buzzer, remove the contact breaker housing assembly and place a small piece of paper or thin cardboard between the low-tension contact brush and the contact in the magneto main housing. *(See figure 184.) Be certain to remove paper after timing operations are completed.*

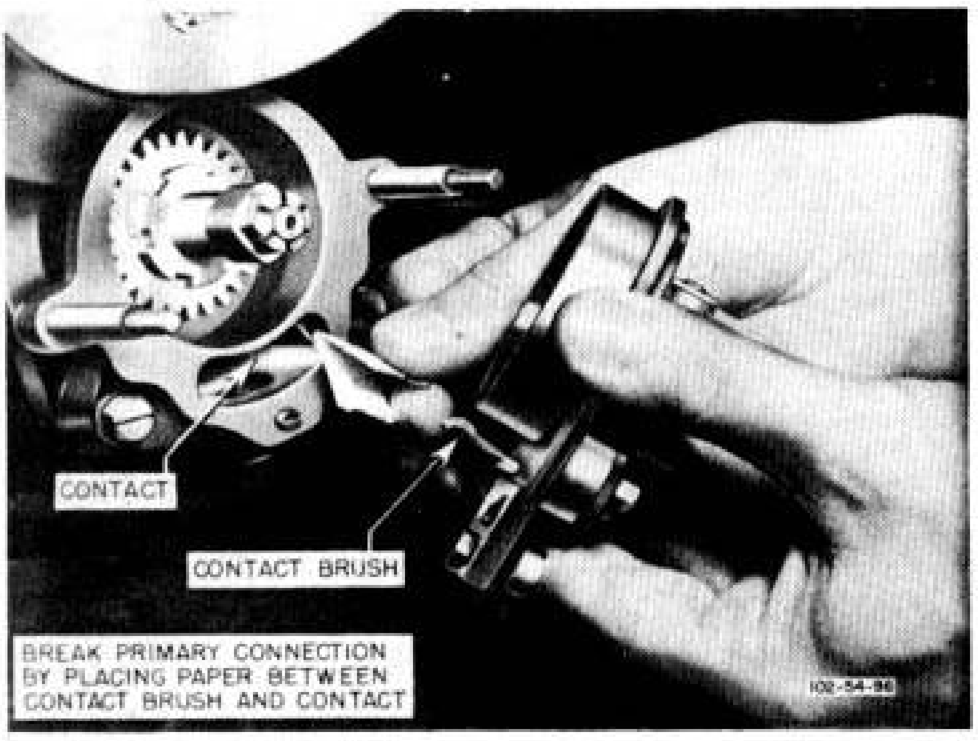



***Figure 184—Insulating Magneto Primary Connection***

a. Install a cutaway breaker cap as shown in figure 186. If this is not available, be sure to hold breaker base firmly in contact against end of magneto housing when setting the opening point of contacts as in paragraph c.

b. Move magneto contact breaker housing to the fully advanced position. To make sure it is so positioned, check that housing is in contact with stop on magneto.

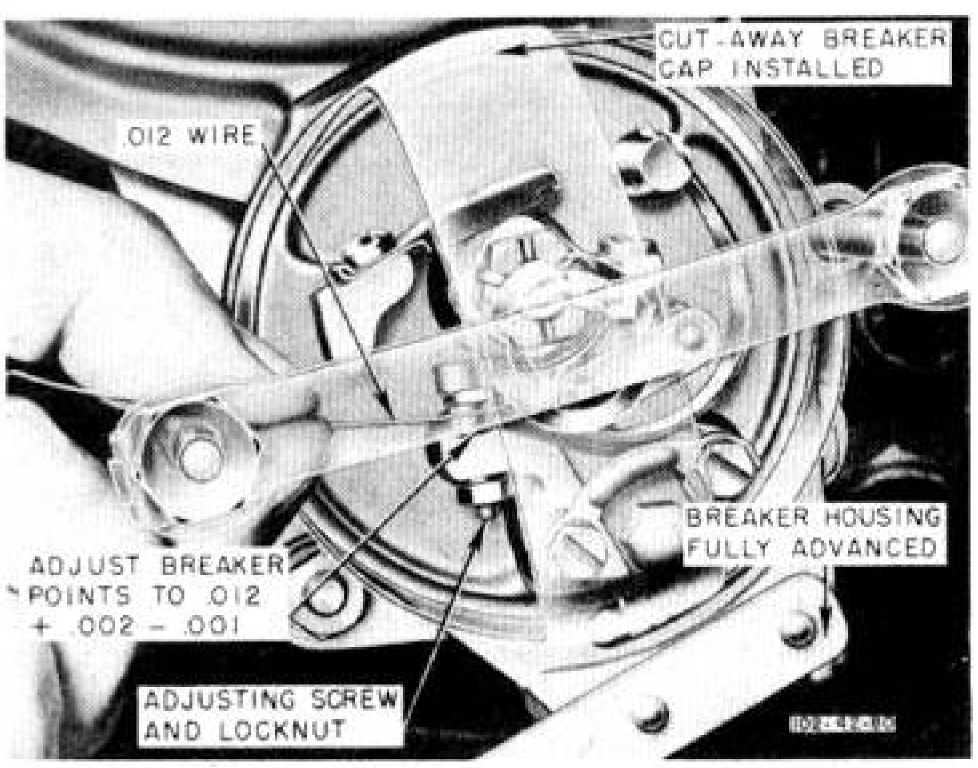



***Figure 185—Checking Magneto Contact Gap***

c. Check breaker contact gap. *(See figure 185.)* If gap is less than .011 inch or more than .014 inch, reset to .012 inch, using Packard wrench AT-8002 in engine tool kit to loosen or tighten locknut on adjustment screw.

d. Turn rotor until the large outboard distributor electrode is pointing up and in the approximate position to fire the A6 cylinder as shown in figure 186 (AI6 wire on "A" magneto wiring harness cover; AE6 wire on "B" magneto wiring harness cover).

e. Attach one wire on continuity light to magneto housing and hold other wire against contact point.

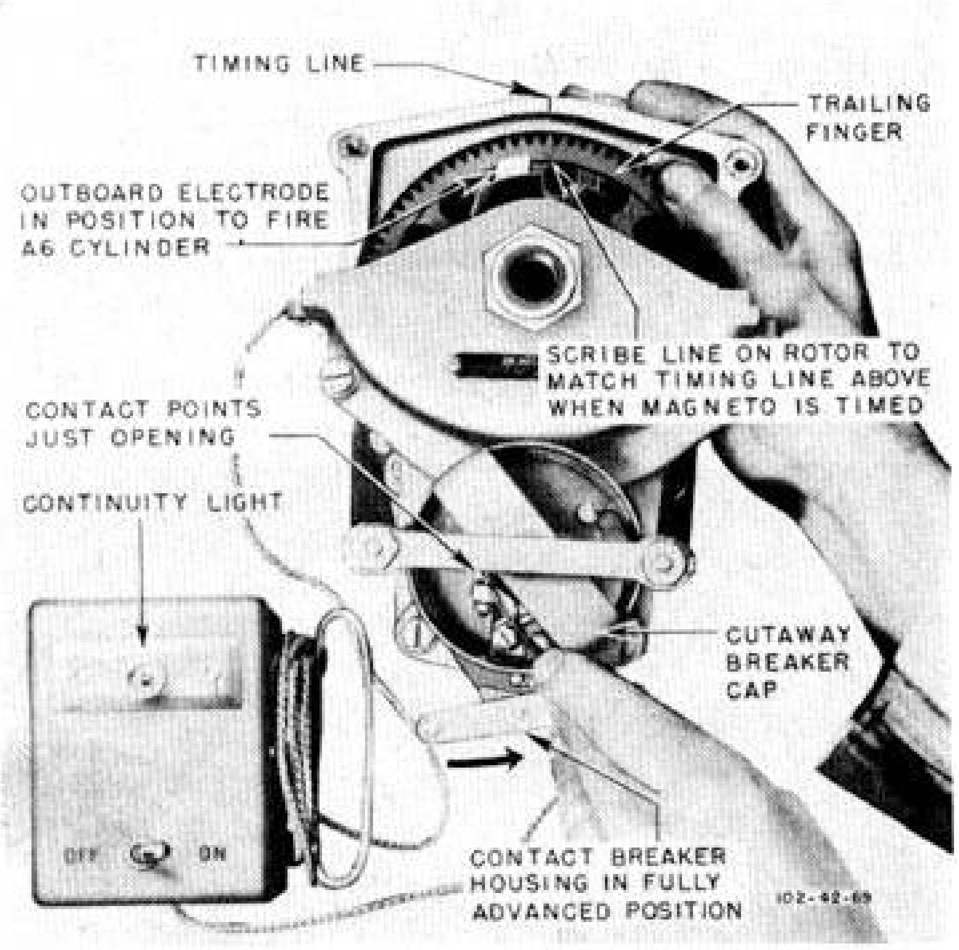



***Figure 186—Timing Magneto***

f. With contact breaker housing in the fully advanced position, turn rotor slowly in normal direction of rotation until continuity light goes out. *(See figure 180 for normal rotation of "A" and "B" magnetos.)* When the light goes out, the contact breaker points are just opening and the magneto is timed to fire the A6 cylinder.

g. Hold rotor in this position and scribe a line on the rotor to match with timing line directly above on the magneto housing. *(See figure 186.)* The magneto is now ready to be installed.

**Note**

If buzzer or timing light is not available, the magneto A6 cylinder firing point can be determined by inserting a piece of .002-inch feeler stock between the closed contacts. While exerting a slight pull on the feeler stock, turn rotor slowly in normal direction until feeler stock is just released.

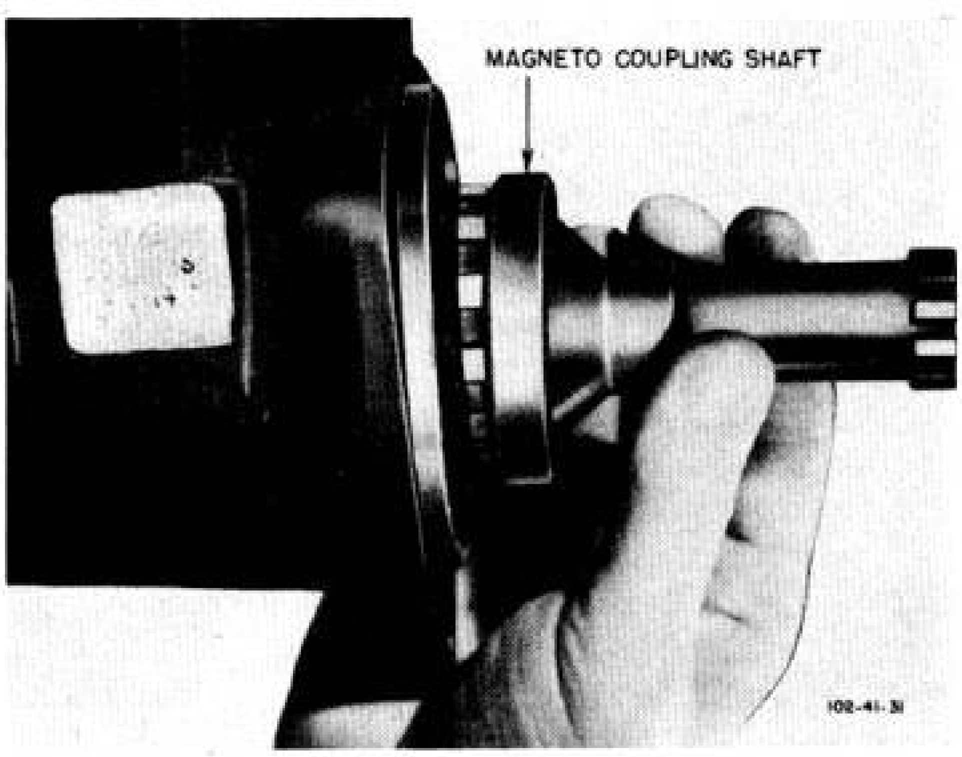



***Figure 187—Installing Coupling Shaft to Magneto***

4. TIMING AND INSTALLING MAGNETO TO ENGINE.

a. Attach vernier coupling shaft to magneto *(figure 187)* and check that breaker housing is in the fully advanced position.

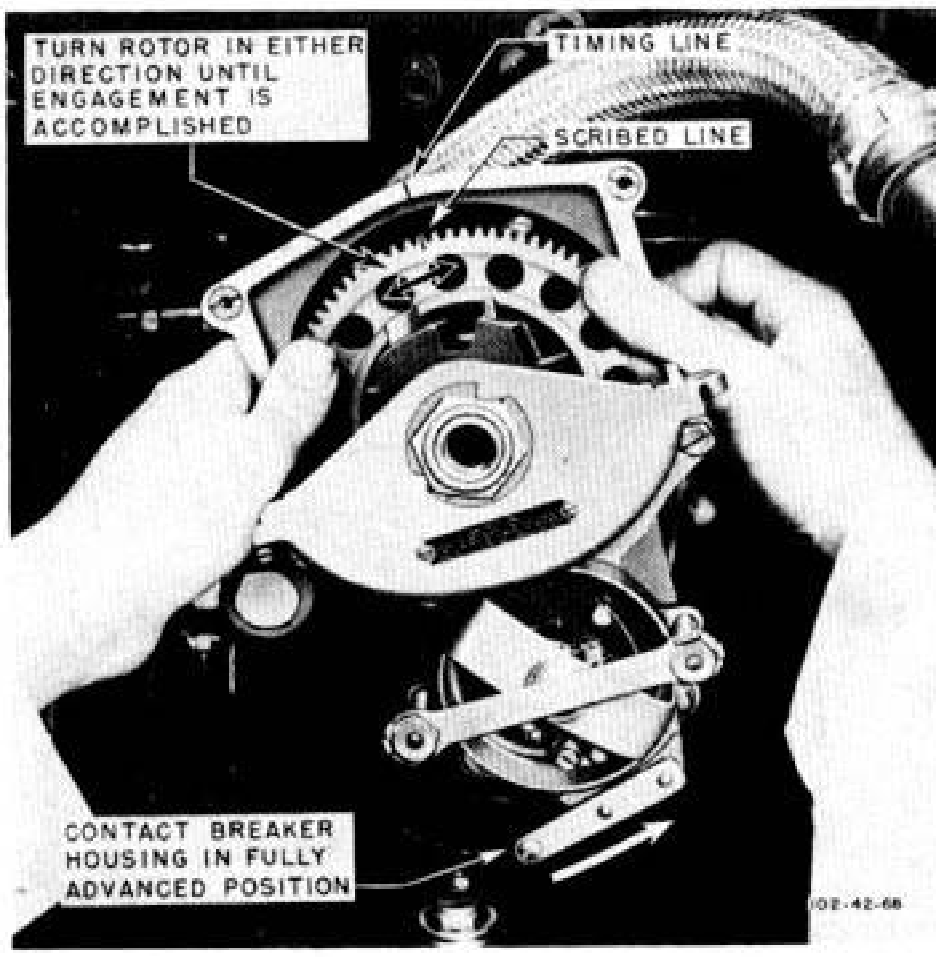



***Figure 188—Installing and Timing Magneto to Engine***

b. Grasp magneto, holding the scribed line on the rotor in line with the timing line on magneto housing as shown in figure 188, and slide magneto over mounting studs engaging vernier coupling shaft with the engine.

c. If coupling shaft will not engage to engine, turn rotor in either direction until engagement is obtained, as shown in figure 188. Note the number of rotor gear teeth between the scribed mark on rotor and the timing mark on magneto housing.

d. Carefully withdraw magneto and reset vernier coupling shaft as follows:

*(1)* If coupling remains in the engine, when the magneto is removed, turn coupling in the engine one spline in the same direction that the scribed line on the rotor varied from the timing line on the magneto housing when the engagement was made. *(See figure 189.)* (Approximately five splines on engine end of coupling constitute one tooth on rotor.)

*(2)* If coupling remains with the magneto, turn coupling on the magneto shaft one spline in the direction that scribed line varied from the timing line when the engagement was previously obtained. *(See figure 187.)* (Approximately four splines on magneto end of coupling constitute one tooth on rotor.)

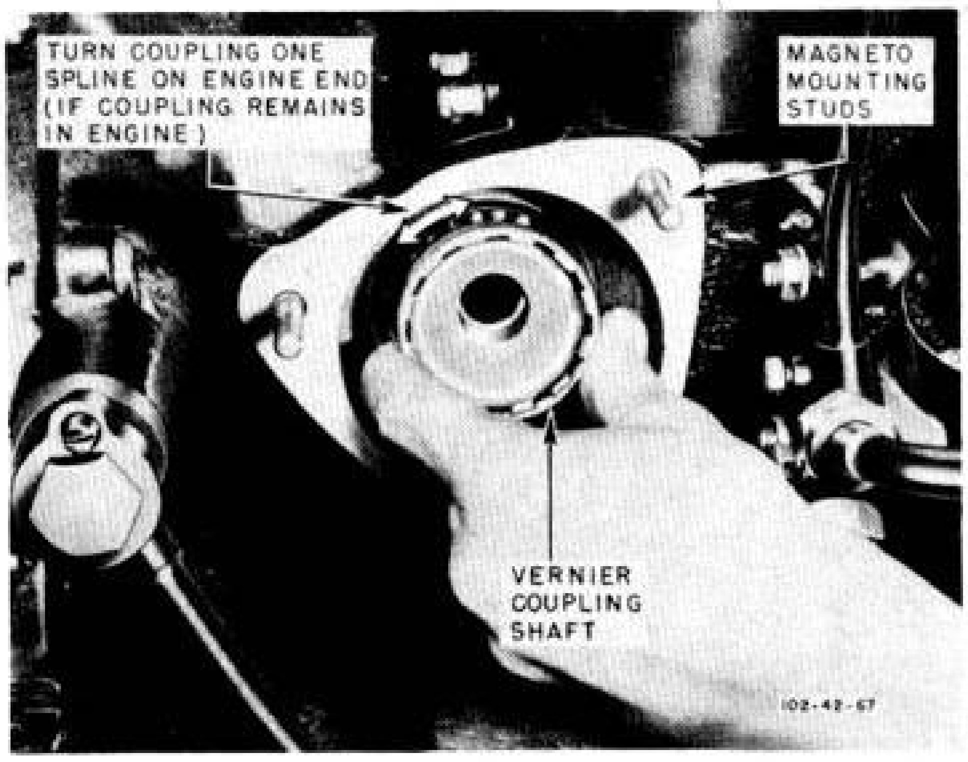



***Figure 189—Vernier Adjustment***

**Note**

It may be necessary to try several of the adjustment splines before proper magneto engagement can be obtained and before the scribed line on rotor and timing line on housing are in register.

e. When the proper engagement has been obtained, temporarily tighten the magneto mounting stud nuts; then check for exact ignition timing *(figure 190)* as follows:

*(1)* Attach one continuity light wire to magneto housing, and hold the other wire to the contact point in breaker housing.

*(2)* Turn crankshaft backward about ¼ revolution; then turn crankshaft slowly in direction of normal rotation until contacts are just opening as determined by dimming of timing light. The light should go on and off when rotor is rocked with thumb as shown in figure 190.

*(3)* If mark "A6 IMA" on crankcase timing flange *(figure 183)* is now in register with pointer or within 1/16 inch in either direction of being in register, the timing is correct. If pointer does not register within the tolerances, repeat the operation described in foregoing paragraphs 4. a. through e.

**CAUTION**

Before attempting to time magneto to engine, be sure to again turn crankshaft until A6 cylinder is on the compression stroke with "A6 IMA" mark on crankshaft flange in register with pointer.

f. When the proper timing has been made and checked, secure magneto *(figure 180)* as follows:

**CAUTION**

Be sure to remove paper from between low-tension contact brush and contact in the breaker housing.

*(1)* Tighten the three mounting stud nuts securely.

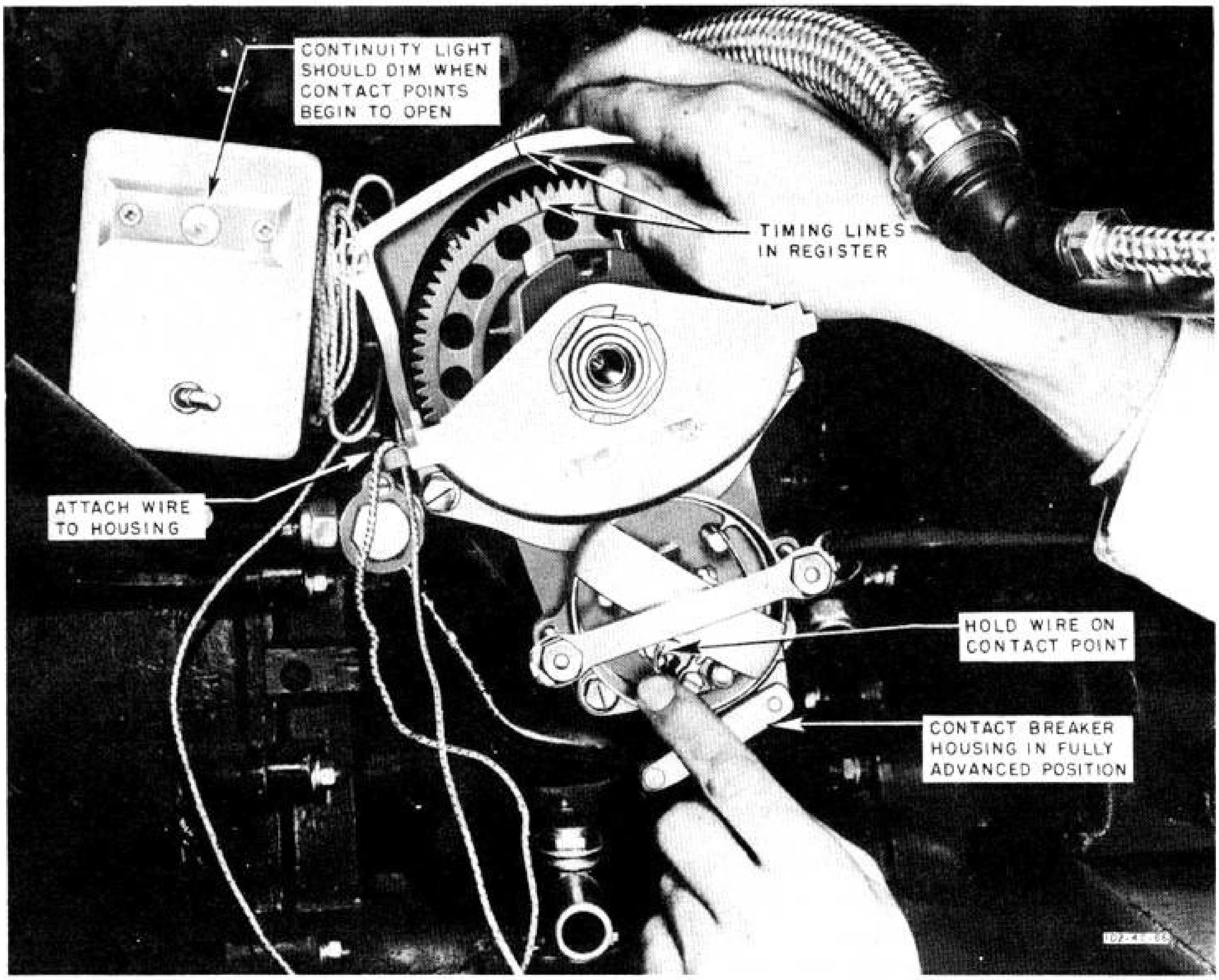



***Figure 190—Checking Magneto Timing***

*(2)* Assemble the harness and distributor covers; then assemble as a unit to the magneto.

*(3)* If "A" side magneto is being installed, connect booster coil conduit.

*(4)* Connect ground wire conduit to bottom of magneto.

*(5)* Connect control linkage to magneto contact breaker assembly.

*e.* REMOVING ENGINE.—Removal of the engine may be accomplished either by disconnecting the engine from the mount or by disconnecting the engine mount from the firewall and removing the entire power plant section as a unit.

(1) REMOVING ENGINE WITH MOUNT.

*(a)* Take off cowl panels, propeller, and spinner. Drain oil and cooling systems.

*(b)* Disconnect engine controls as follows:

*1.* Disconnect propeller control rod at jackshaft on engine mount left strut.

*2.* Disconnect cable from arm of automatic boost control if cable is installed.

*3.* Disconnect throttle and mixture control rods at connections forward of firewall.

*4.* Disconnect carburetor air control rod at jackshaft on engine mount left beam.

*(c)* Disconnect all necessary lines, cowl formers, and conduits from firewall connections or engine. *(See figure 200.)* All firewall disconnect points of lines, rods, and conduits are marked with orange.

*(d)* Attach hoisting sling (E751) to engine mount lugs and to propeller shaft. Take up enough slack on hoist to disconnect the four bolts which hold engine mount to firewall.

*(e)* Power plant unit may now be hoisted from the airplane and mounted on a fixed structure for disassembly.

(2) REMOVING ENGINE FROM MOUNT.
*(See figure 191.)*

*(a)* Take off all removable cowl panels. Remove all

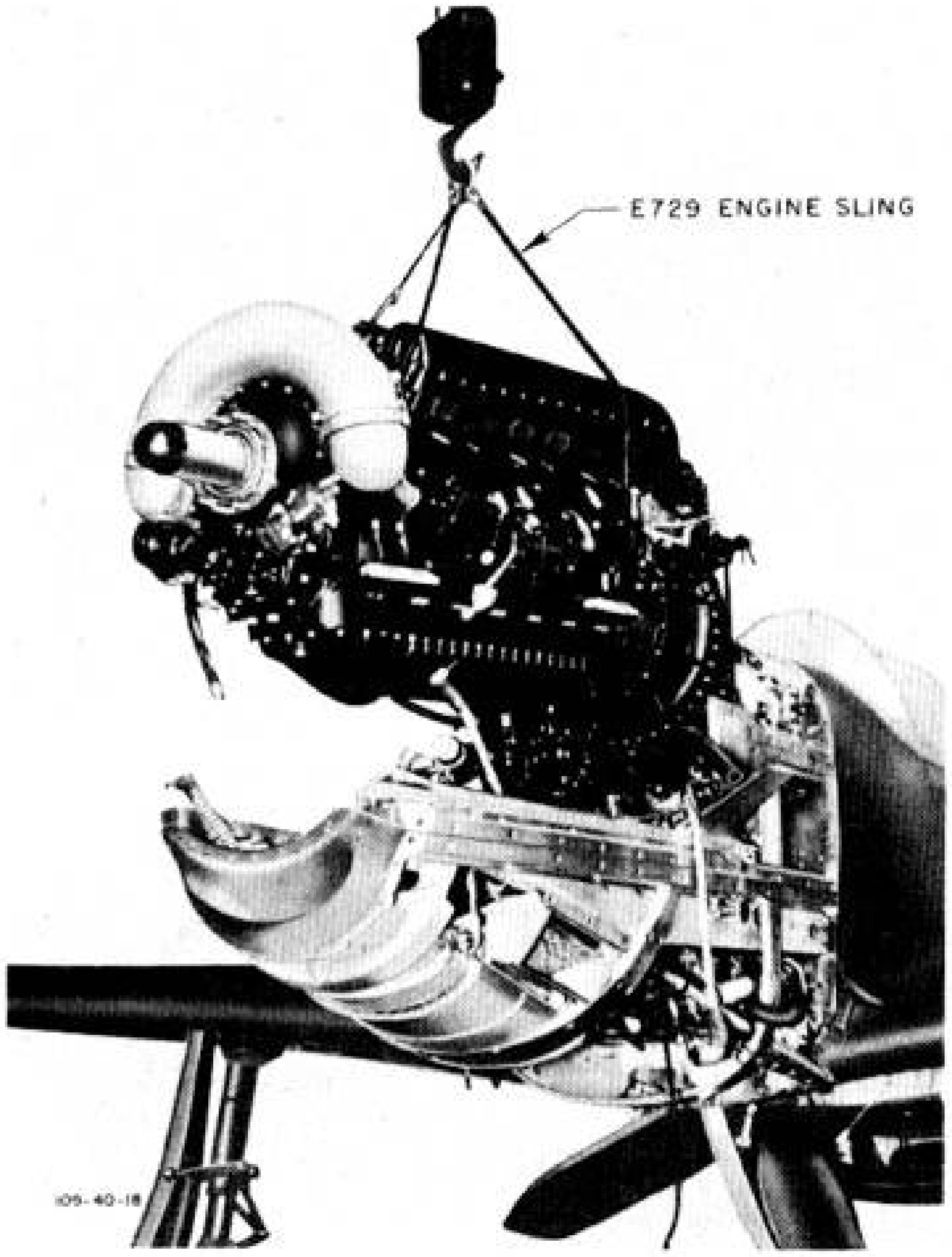



*Figure 191—Removing Engine From Mount*

upper cowl formers. It is not necessary to remove the side formers.

*(b)* Drain oil and cooling systems.

**Note**

It is not necessary to drain the fuel or hydraulic systems.

*(c)* Remove propeller and spinner.

*(d)* Disconnect engine controls as follows:

*1.* Disconnect control rod at propeller governor.

*2.* Disconnect cable from arm of automatic boost control if cable is installed.

*3.* Disconnect throttle and mixture control rods at connections forward of firewall.

*(e)* Remove carburetor air duct elbow and rear section. Cover carburetor intake.

*(f)* Disconnect all necessary lines and conduits from engine or firewall. Detach bonding.

*(g)* Remove exhaust stack fairings and the two rear exhaust stacks on each side, and the rear exhaust section shrouds to allow installation of engine sling. Cover the ports.

*(h)* Attach hoisting sling (E729) to the lifting eye on the crankcase half of the reduction gear casing and to the lifting lugs on the mounting feet on each side of the crankcase at supercharger end.

*(i)* Make a final thorough check to determine that all airplane-to-engine connections have been disconnected and that all openings have been closed.

*(j)* Remove the 10 Lord mount center bolts.

*(k)* Lift engine slowly and carefully. Prevent swaying to avoid damage to projecting parts. The engine weighs approximately 1690 pounds.

**CAUTION**

When removing the engine, watch that oil pressure pump inlet fitting is not damaged when passing the right rear Lord mount assembly. It is recommended that a rubber hose connection be installed over the fitting for protection against scratches and small dents.

*f.* INSTALLING ENGINE.—The power plant may be installed either by securing the engine, accessories, and engine mount as a complete unit to the firewall, or by attaching the mount to the firewall first and then installing the engine. In either case, the procedure for installing the engine to the mount is the same.

(1) PREPARING ENGINE FOR INSTALLATION.

**Note**

Prior to installing an accessory, turn its drive shaft manually to make certain of free movement. With each accessory, install a new, clean, dry gasket or one that is in good condition.

*(a)* PREPARING RIGHT SIDE OF ENGINE. *(See figure 192.)*

*1.* Install manifold pressure fitting first, then primer fitting to Y fitting located at the top of the engine just forward of the aftercooler tank.

*2.* Attach engine hoisting sling (E729) to the engine rear feet mounting lugs and to the lifting eye on the top of the reduction gear housing.

*3.* Install fittings to vacuum pump ports. Install pump to mounting pad and tighten nuts securely and uniformly. Attach flexible hoses to pump fittings.

*4.* Remove dehydrator plug from timing inspection hole. Allow any oil present to drain; then install regular plug and safety with wire.

*5.* Install oil pressure fitting to the oil pump housing so that the fitting points to the rear of the engine.

*6.* Remove and clean oil filter. Check for damaged plates. If serviceable, reinstall and safety bolts with wire, and nuts with palnuts.

*7.* Install fittings to hydraulic pump and install pump, tightening mounting nuts uniformly. Safety nuts with wire.

*8.* Drain shipping oil from engine by removing covers over inlet and outlet oil fittings.

*9.* Install rear breather port cover in place of Packard breather fitting, if engine is so equipped.

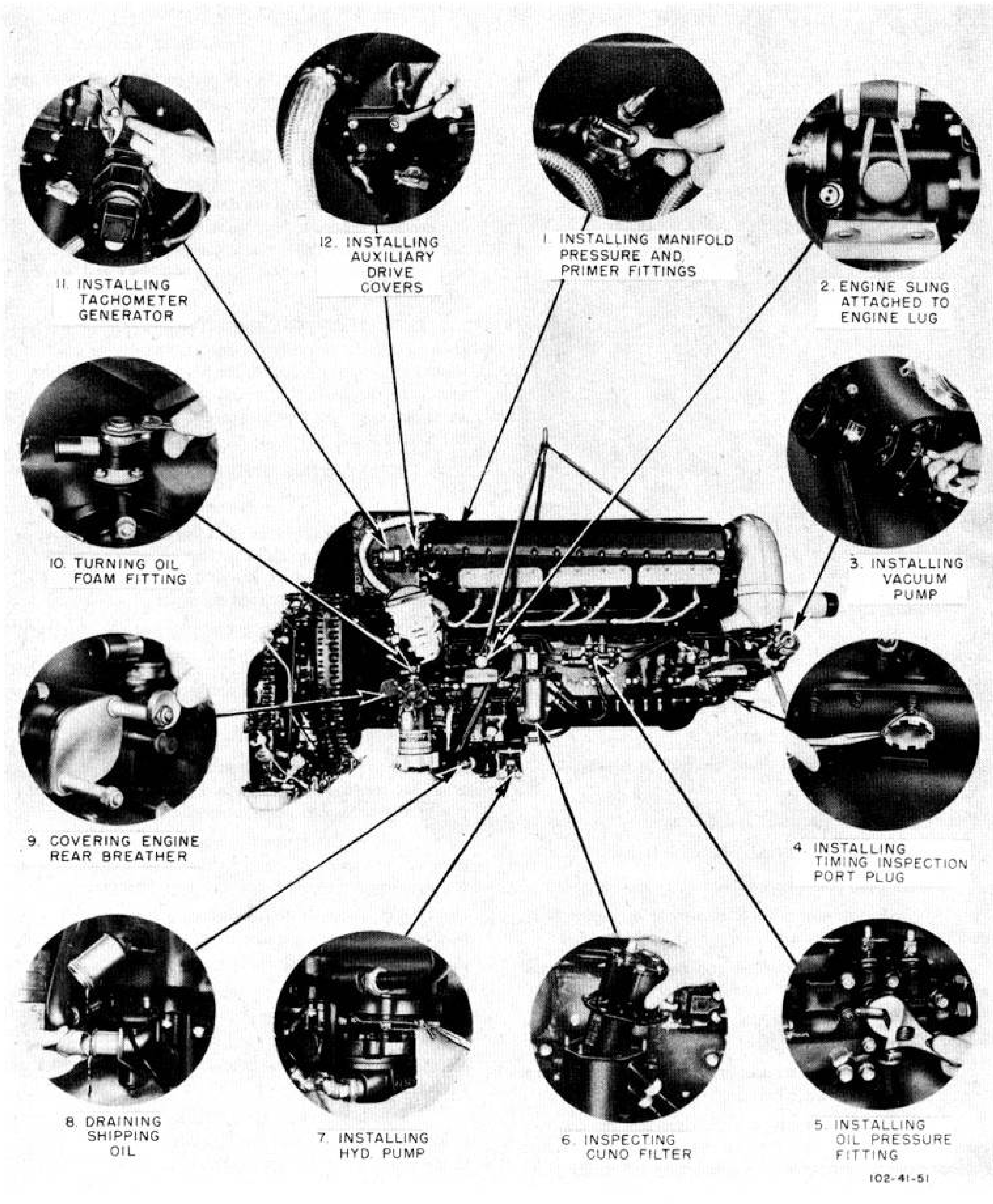



***Figure 192—Preparing Engine for Installation—Right Side***

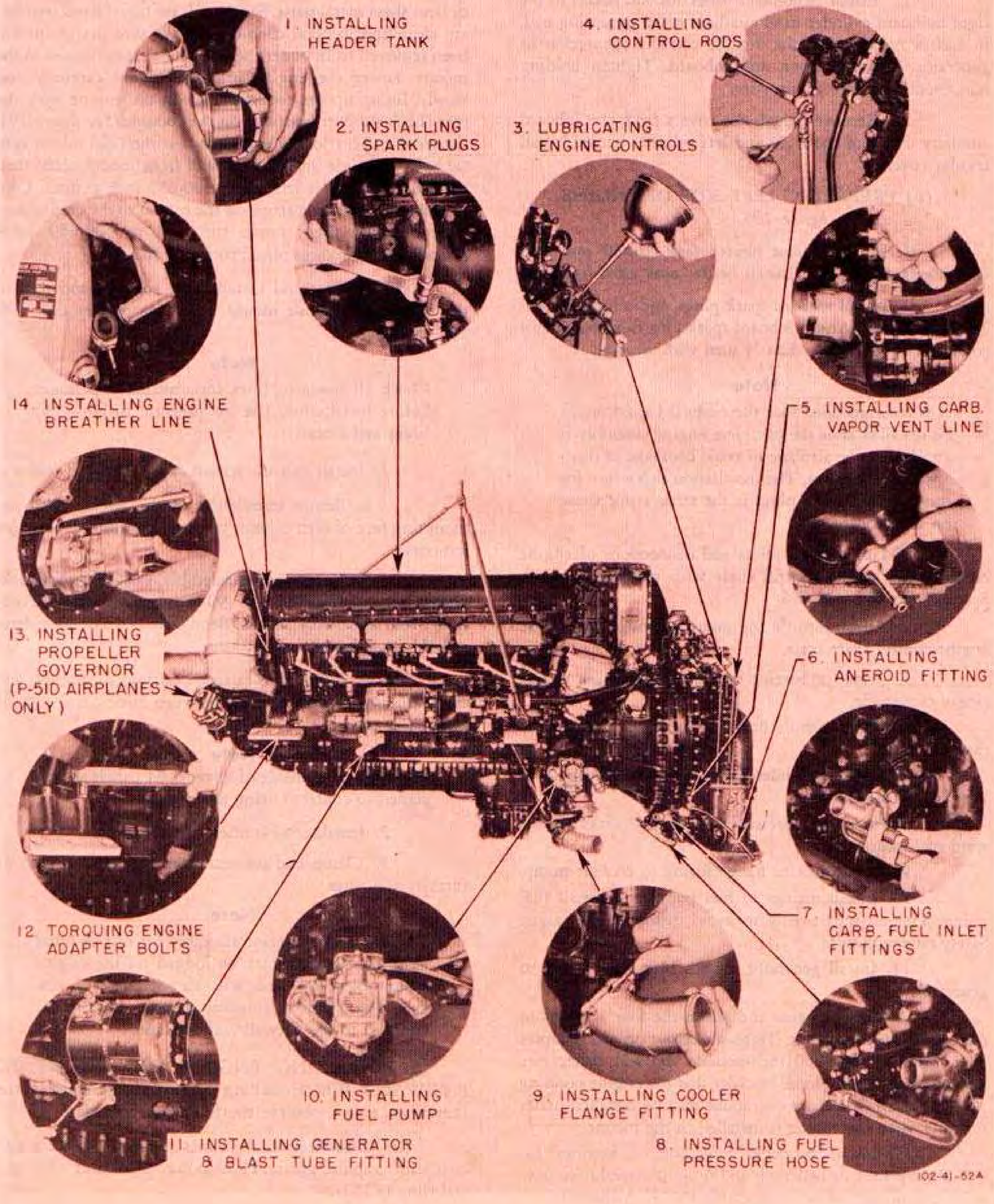



*Figure 193—Preparing Engine for Installation—Left Side*

*10.* Turn oil foam fitting toward the rear of engine.

*11.* Install tachometer generator and gasket to the right outboard cylinder head auxiliary drive mounting pad, in such a manner that the flexible conduit connection of generator is facing down and inboard. Tighten holding nuts evenly and safety with wire.

*12.* Remove dehydrator covers from the inboard auxiliary drives of the right and left cylinder banks. Install regular covers.

*(b)* PREPARING LEFT SIDE OF ENGINE. *(See figure 193.)*

*1.* Install coolant header tank. Install nuts and tank bonds. Safety nuts. Install header tank cross-feed line.

*2.* Install inboard spark plugs, and torque to 216-264 inch-pounds. Attach inboard spark plug flexible conduit connectors finger-tight, then ½ turn with wrench.

**Note**

It is recommended that the outboard spark plugs be installed after the complete engine assembly is attached to the airplane to avoid breakage or damage to spark plugs. The installation procedure for the outboard spark plugs is the same as for those on the inboard side.

*3.* Lubricate all joints and connections of engine controls and engine control shaft with machine gun oil, Specification No. AN-O-6.

*4.* Attach throttle and mixture control rods to the engine control shaft arms.

*5.* Install carburetor vent fitting and hose to left side of carburetor.

*6.* Install aneroid fitting to left side of carburetor throat.

*7.* Install fuel inlet fitting, elbow, and nipple to left side of carburetor.

*8.* Attach fuel pressure hose to fitting located forward of carburetor.

*9.* Install coolant flange fitting to coolant pump.

*10.* Install fittings to fuel pump and install fuel pump. Tighten nuts evenly to avoid distortion of gasket. Safety nuts with wire.

*11.* Install generator. Attach blast tube fitting to generator.

*12.* Hoist engine and attach the four adapters to the engine mounting feet. Tighten one nut on each adapter to a torque of 500-650 inch-pounds and add cotter pin, leaving the other nut loose in order that the engine bonding strips attached to the engine mount may be installed under the nuts when the engine is installed in the mount.

*13.* Install propeller governor on engines for P-51D Airplanes, or bellcrank and support assembly to governor mounting pad on engines for P-51K Airplanes.

*14.* Install breather hose and line to front crankcase breather fitting.

(2) INSTALLING ENGINE TO MOUNT.—Before installing engine to the mount, make a visual inspection of the mount, checking for loose rivets and nuts, and cracked or bent sheet metal parts. See that all units and lines attached are clean and in good condition. Make sure that paint has been removed from under the bonding strips attached to the mount. Lower the engine into the mount carefully and slowly, lining up the rear adapters on the engine with the rear shock support housings on the mount. *(See figure 194, details A and B.)* Jockey engine so that the Lord mount center bolts will slide into place. Install front mount bolts; then tighten all nuts to a tension of 500-650 inch-pounds. Connect the four bonding strips on the mount to the engine foot adapter bolts; then torque the nuts to 500-650 inch-pounds and add cotter pins. Proceed as follows:

*(a)* Connect and install lines, conduit, and rods to the engine and engine mount, following figures 195, 196, 197, and 198.

**Note**

Check all hoses or lines for obstructed passages before installation. Use air pressure to blow out hoses and lines.

*1.* Install exhaust system *(figure 199)* as follows:

a. Before installation of the stacks, clean the mounting face of each exhaust port and examine all studs for looseness.

b. Install shroud assembly, gaskets, stacks, lockplates, and nuts. Tighten nuts (90 inch-pounds torque) evenly to avoid distorting gaskets. Bend down tabs on lockplates to hold nuts securely in position.

c. Install dzus-fastened fairings to shrouds, and check for any possible rubbing between fairing and edge of cowl sheet cutouts.

**Note**

Flat springs on inside of lower cowl panels are designed to contact fairing as air seal.

*2.* Install cowl formers and rings.

*3.* Clamp and connect lines and conduit to cowl formers and rings.

**Note**

Visually inspect engine assembly for dirt or other loose articles that may be lodged on the engine mount. Blow unit clean with air pressure if obtainable. The engine and mount assembly can now be attached to the firewall and airplane.

(3) INSTALLING ENGINE AND MOUNT TO FIREWALL.—When installing the engine and mount to the firewall as a unit, observe the following procedure:

*(a)* Clean firewall attachment fittings and bolts, and coat with graphite grease. Hoist power plant unit with special sling (E752).

*(b)* Bolt engine mount to upper longeron and lower frame fittings as illustrated in figure 194, details C and D.

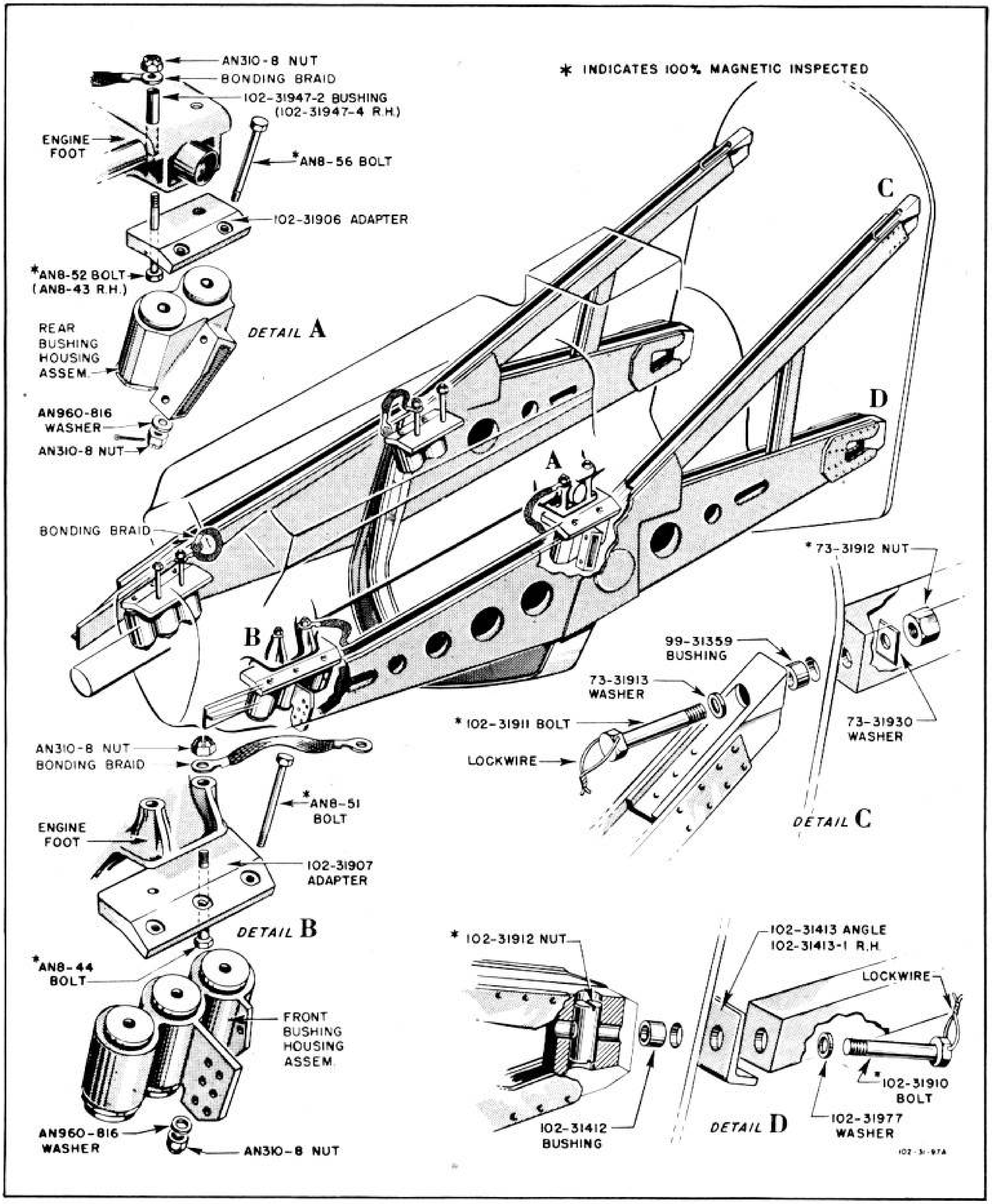



*Figure 194—Engine and Mount Installation*

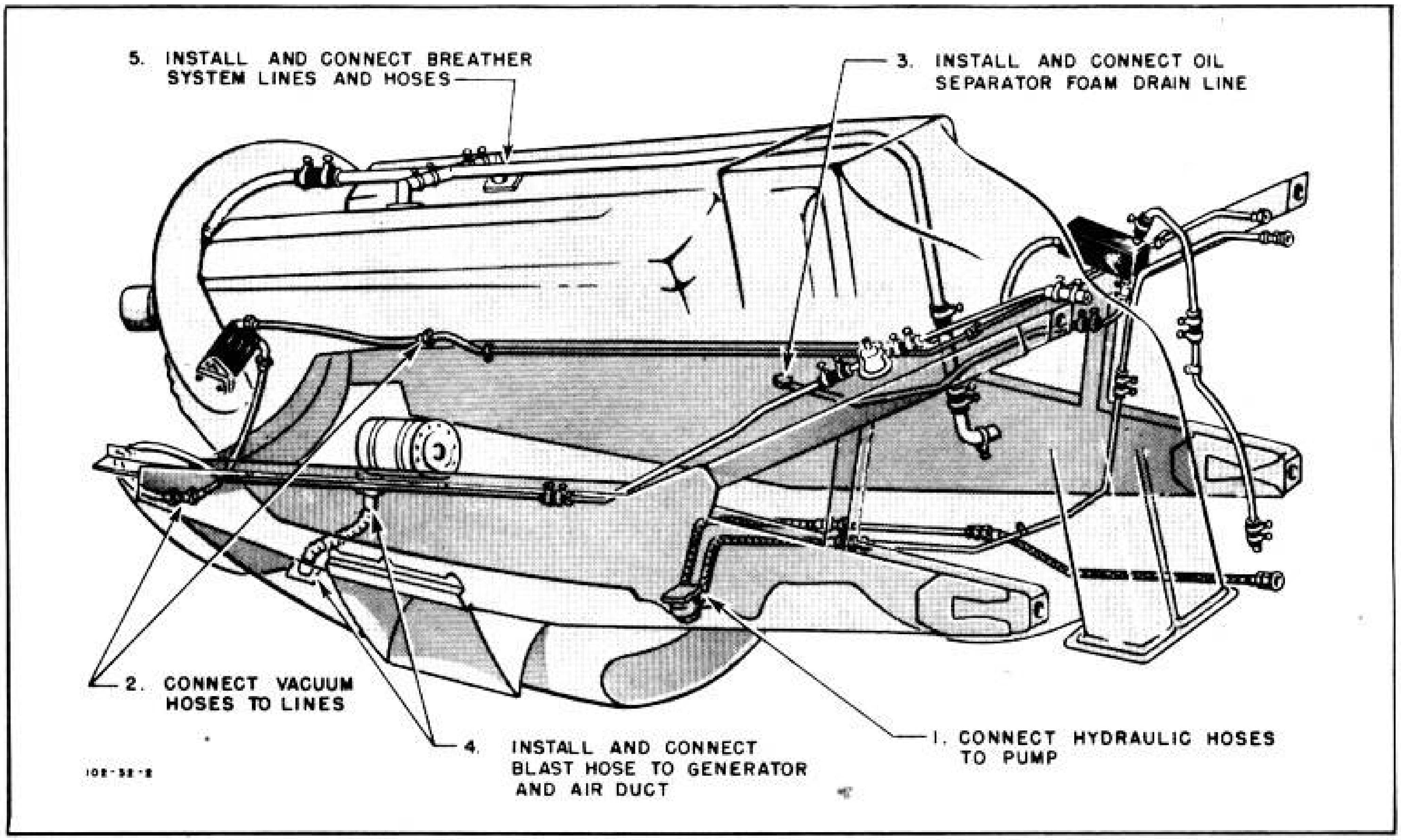



Figure 195—Power Plant Build-up I

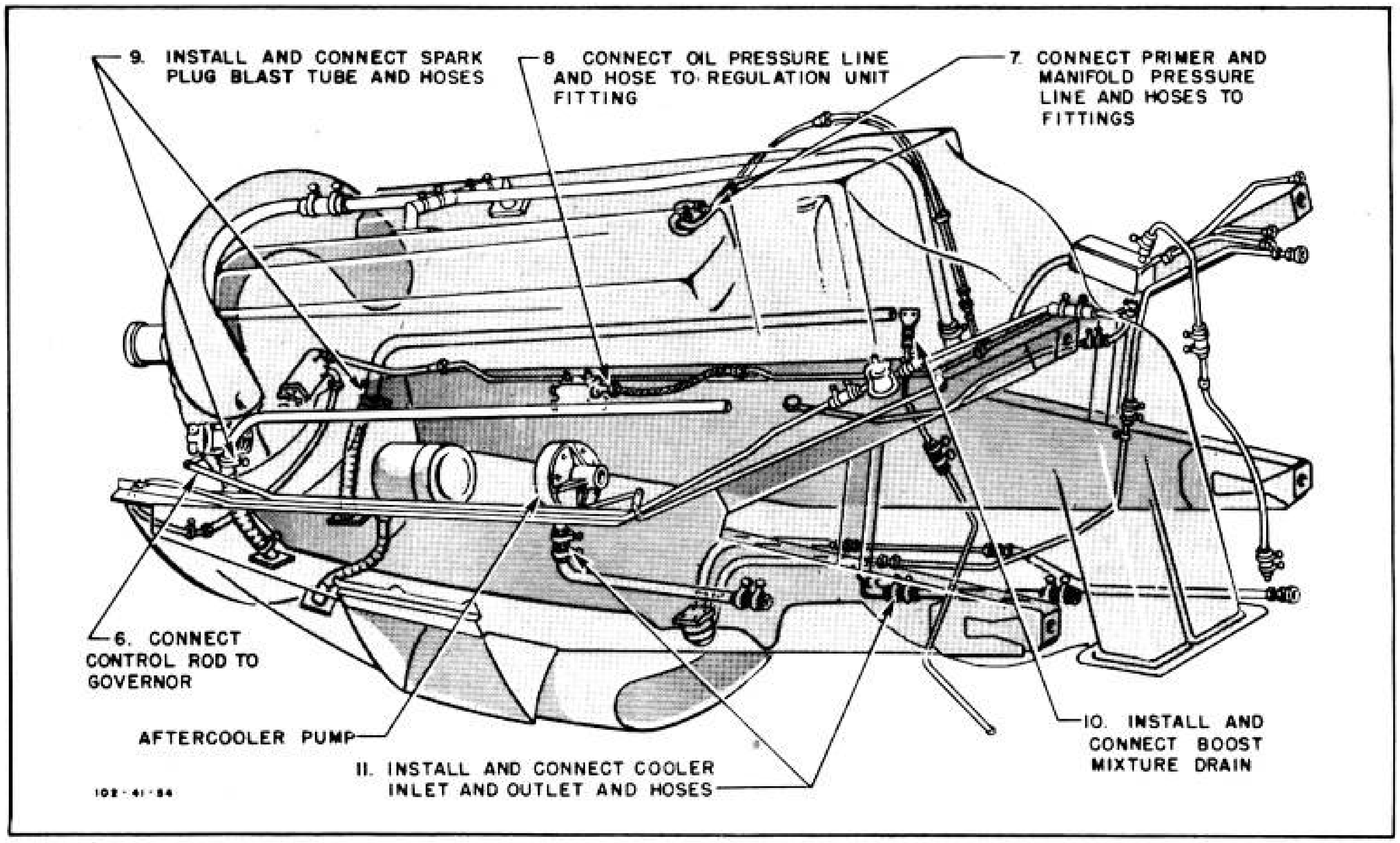



Figure 196—Power Plant Build-up II

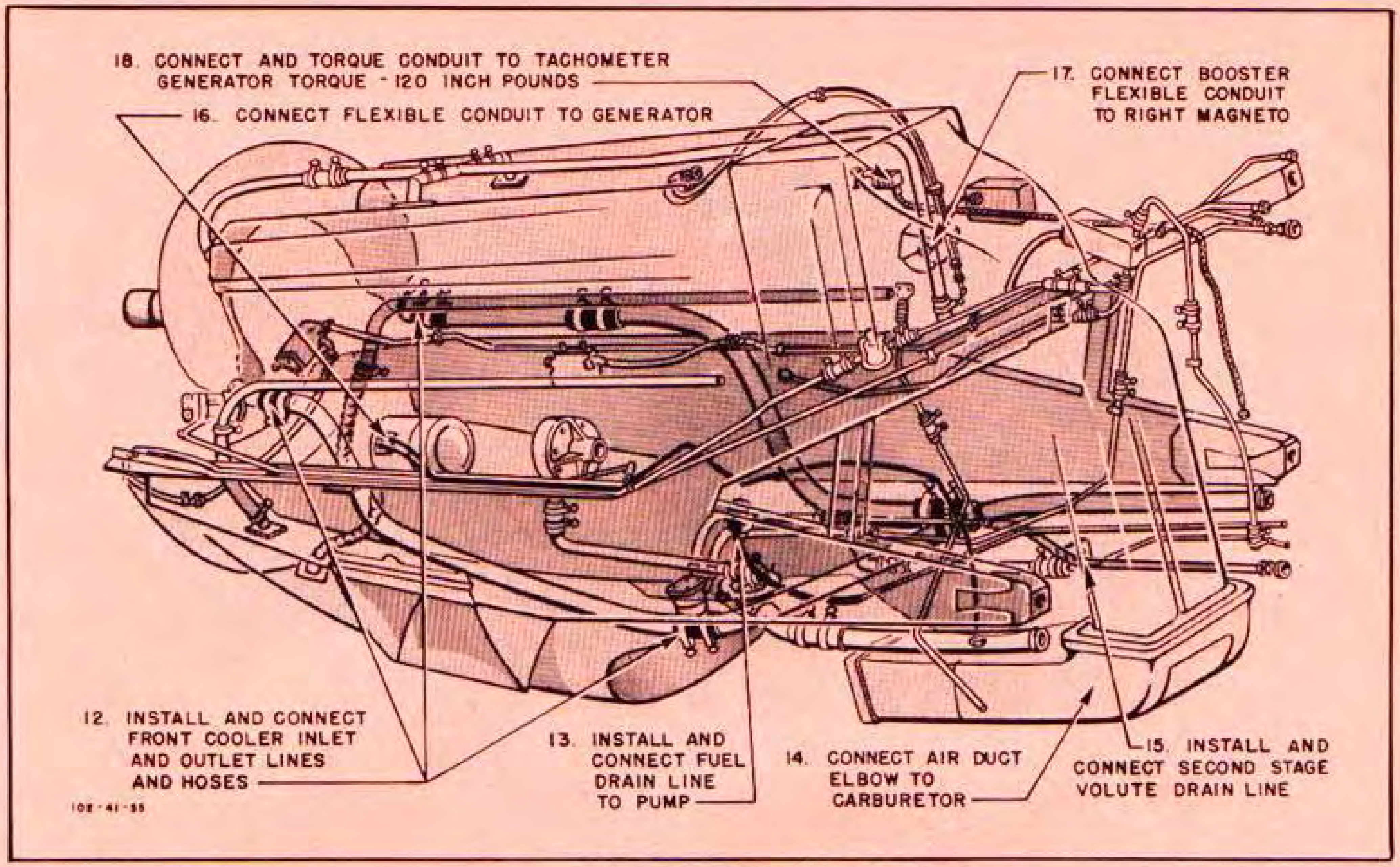



*Figure 197—Power Plant Build-up III*

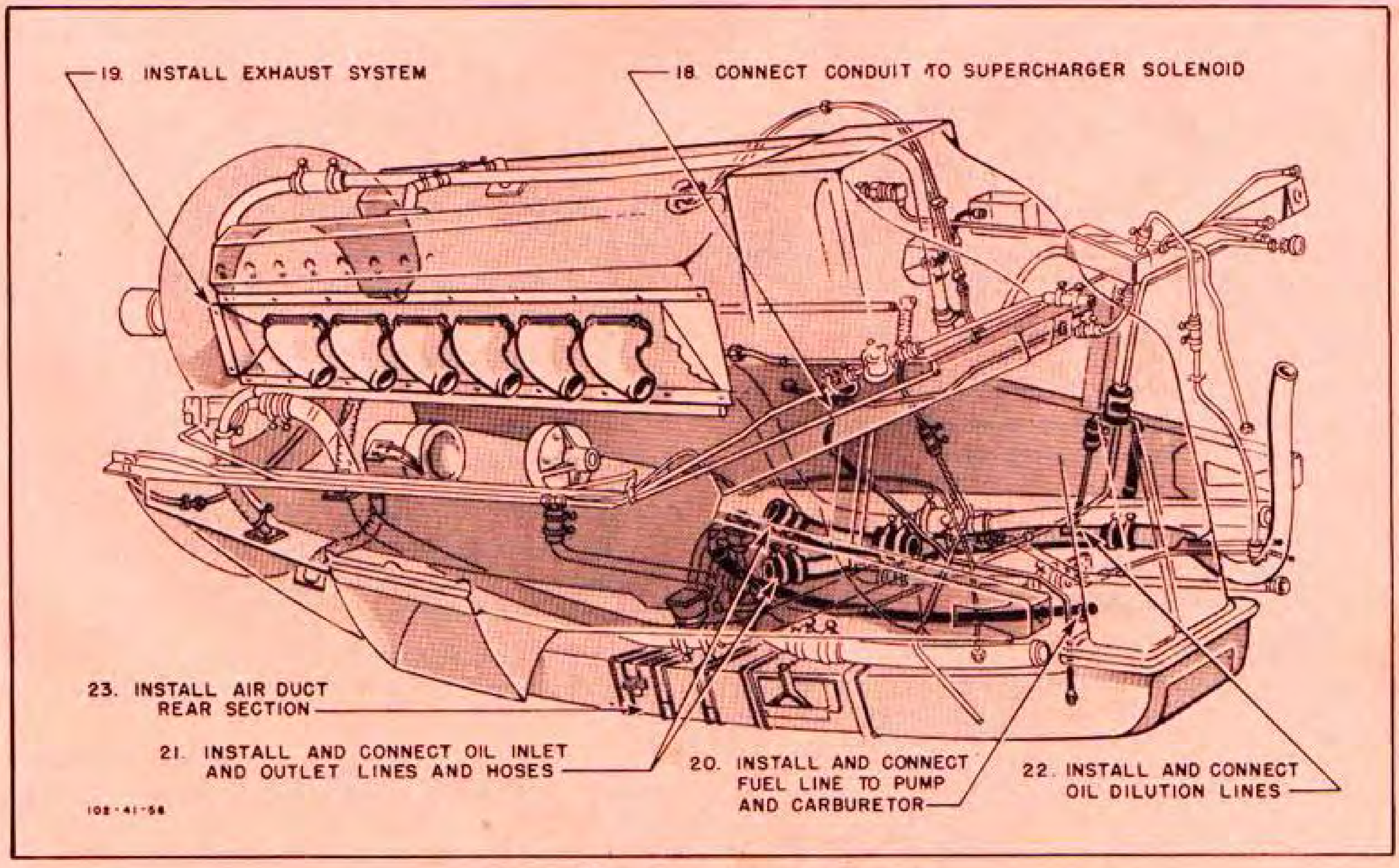



*Figure 198—Power Plant Build-up IV*

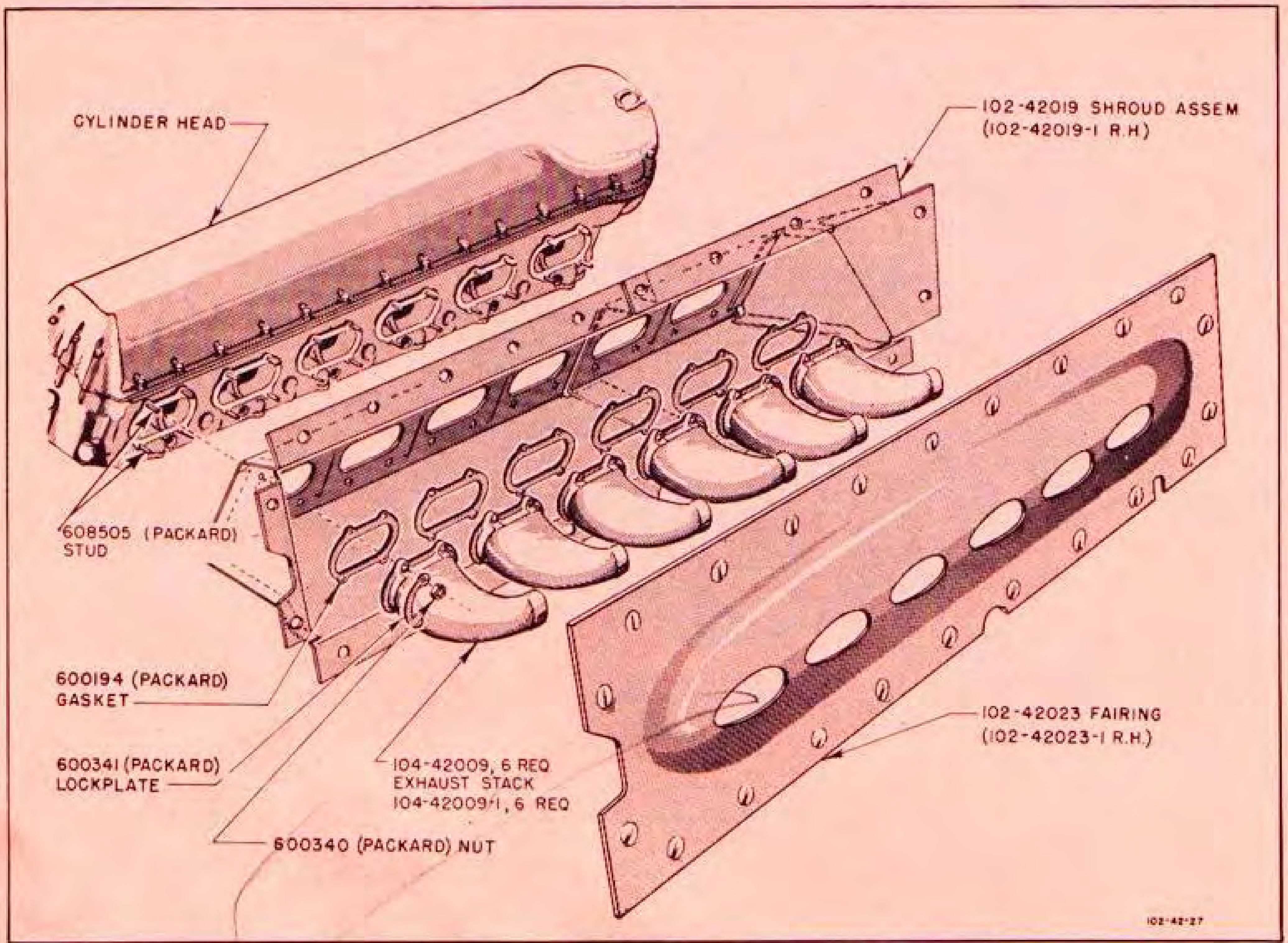



*Figure 199—Engine Exhaust System Installation*

1 Tighten top bolts to a tension of 2800 inch-pounds and lower bolts to 2400 inch-pounds.

(*c*) Connect the following units, lines, and piping (*figure 200*) to the firewall and engine assembly:

Fuel lines (indicated by red band)
Oil lines (yellow band)
Coolant lines (white—black—white bands)
Hydraulic lines (light-blue—yellow—light-blue bands)
Vacuum lines (white—light-green bands)

**Note**

All units of separation at firewall disconnect points are marked with a ¼-inch band of orange lacquer to facilitate reassembly.

(*d*) After the connections have been made, make a thorough inspection of the engine assembly, checking for following:

*1.* Proper clearances and alignment of all lines.

*2.* Proper safetying of all items required.

*3.* Properly tightened and spaced hose clamps.

*4.* Properly tightened clips and nuts.

(*e*) Clean assembly of dirt, tape, fallen safety wire, nuts, and bolts. Blow off assembly with air pressure, if obtainable.

(*f*) Install outboard spark plugs and connect flexible conduits.

(*g*) Install propeller and spinner. (*See paragraph 10. c.*)

(*h*) After all power plant units are installed, tested, and adjusted, install the cowl paneling.

*g.* TESTING NEW OR OVERHAULED ENGINE.

(1) The following procedure is recommended after installing a new engine or an engine received from repair depot after major overhaul.

(*a*) Fill main cooling system with a minimum of 15 US (12.5 Imperial) gallons and aftercooling system with a minimum of 4 US (3.3 Imperial) gallons.

(*b*) Place approximately 20 US (16.7 Imperial) gallons of fuel in left and right tanks and in the fuselage tank.

(*c*) Remove the sump plug and the two scavenge pump filter screens in the lower aft end of the crankcase and allow corrosion-preventive mixture to drain from engine. Replace filter screens and safety.

*(d)* Remove oil filter and wash in solvent. Do not rotate filter. Immerse in clean engine oil and reinstall in engine.

*(e)* Drain all weatherheads, and resafety.

*(f)* With boost pump in operation using external power (booster pump switch in "ON" position, fuel selector valve on "MAIN TANK L.H."), check oil dilution valve for proper flow. To make this check, disconnect dilution line where it connects to engine oil inlet line; then reconnect line. (This should be done in any event with mixture in "IDLE CUT OFF.")

*(g)* Check to determine if fuel regulator chamber on carburetor has been filled with fuel. If not, remove fuel regulator chamber pipe plugs and fill with fuel by means of fuel boost pump. Replace plugs and safety.

*(h)* PREOILING ENGINE.

*1.* Place one pint of oil (Specification No. AN-VV-O-446a, Grade 1120) in starter gear housing through breather connection on the wheel case located above the starting mechanism housing. Fill oil tank. Remove plug from oil drain fitting and drain approximately one gallon of oil. Reinstall plug. This oil may be re-used if properly strained.

*2.* Remove all exhaust spark plugs from engine.

*3.* Place fuel shut-off valve in "OFF" position, mixture control in "IDLE CUT OFF" position. Make sure ignition switch is "OFF."

*4.* Spray a quantity of oil into all cylinders.

*5.* Remove the ⅛-inch restricting pipe fitting for the oil pressure gage connection from the pressure relief valve on the right inside of the engine, and install a non-restricting union fitting.

*6.* Rotate crankshaft 2 or 3 times. Connect an oil pump to the union and force 3 gallons of hot oil (Specification No. AN-VV-O-446a, Grade 1120) at 50°C to 70°C (122°F to 154°F) at 80 pounds pressure into the engine while turning the propeller by hand or by means of the hand-turning gear.

*7.* Disconnect the preoiling pump and remove the union.

*8.* Turn engine over by hand until sufficient oil is expelled through the ⅛-inch pressure gage fitting to indicate that no air remains in the oil inlet line or pump.

*9.* Reinstall the ⅛-inch restricting pipe fitting and reservice oil tank to capacity.

*10.* Reinstall spark plugs. (Torque wrench check: 216-264 inch-pounds.)

*11.* Make normal engine start as soon as practicable after preoiling procedure.

*(i)* Check starter, booster coil, and primer operation.

*(j)* Check left and right fuel-boost pump for approximately 8-12 pounds per square inch with switch in "ON" position. (Mixture control must be in "IDLE CUT OFF" position.)

*(k)* With engine stopped and mixture control in "IDLE CUT OFF" position, disconnect dilution line from oil inlet line and check oil dilution system for leakage and proper flow as follows: Turn fuel selector valve to left main tank, turn boost control switch "ON," and check for leakage. Operate oil dilution switch, and observe if steady flow occurs from dilution line; then reconnect line.

*(l)* Start engine according to check list in cockpit. Run for 1½ minutes at 1300 rpm. Check oil pressure (50 pounds per square inch minimum). Stop engine according to pilot's check list in cockpit.

**Note**

At time of operation, run engine on left tank by using left-hand boost pump switch in "ON" position, having fuel selector valve in "MAIN TANK L.H." position. Repeat same procedure for right-hand tank. (Minimum operation on each tank, 30 seconds.)

*(m)* Refill oil tank, coolant system, and hydraulic system.

*(n)* Again start engine and run for 1½ minutes at 1300 rpm without cowl. Shut down and inspect for oil and coolant leaks.

*(o)* Run engine up to 1300 rpm until oil pressure remains steady; then gradually increase rpm until oil temperature shows a definite increase (15°C (59°F) minimum) and a desired operating oil pressure (70-80 pounds) can be maintained without fluctuation at 2300 rpm.

**CAUTION**

Do not use more than 40 in. Hg with tail unsecured.

*(p)* At 2300 rpm and propeller control in full "INCREASE RPM" position, check and adjust the following:

*1.* Fuel pressure 16-18 pounds per square inch with boost pump switch "OFF."

*2.* Oil pressure 70-80 pounds at 2300 rpm with oil as hot as possible (90°C (194°F) maximum, 70°-80°C (158°-176°F) is adequate).

*3.* Hydraulic pressure 1000 to 1100 pounds per square inch with pump unloaded.

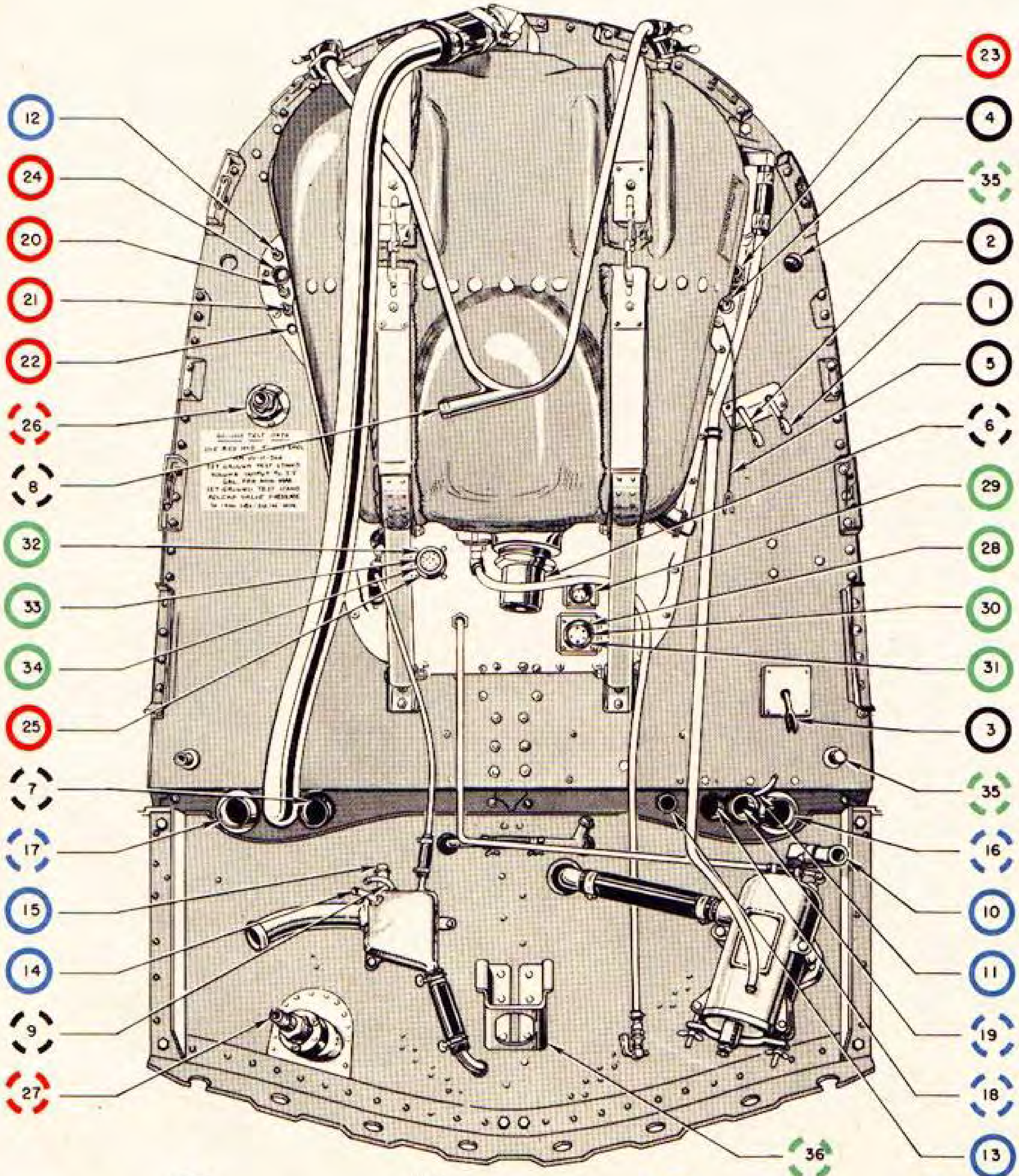
*4.* Hydraulic pump cut-in pressure 800 to 850 pounds per square inch.

*5.* Check magnetos (100 rpm maximum drop). Engines having 45°-45° ignition timing; left magneto 130 rpm maximum drop, right magneto 100 rpm maximum drop.

*6.* Coolant temperature 121°C (250°F) maximum.

*7.* Vacuum 3.75 to 4.25 in. Hg.

*8.* Check to see that ammeter indicates charging with landing light switch "ON" (100 amperes maximum).




*ENGINE CONTROLS*

1. THROTTLE CONTROL
2. MIXTURE CONTROL
3. CARB. AIR CONTROL
4. PROP. GOV. CONTROL
5. EMERGENCY BOOST CONTROL

*OIL SYSTEM*

6. OIL INLET LINE
7. OIL OUTLET LINE
8. OIL TANK FOAM LINE
9. OIL SEPARATOR OVERFLOW LINE

*FUEL SYSTEM*

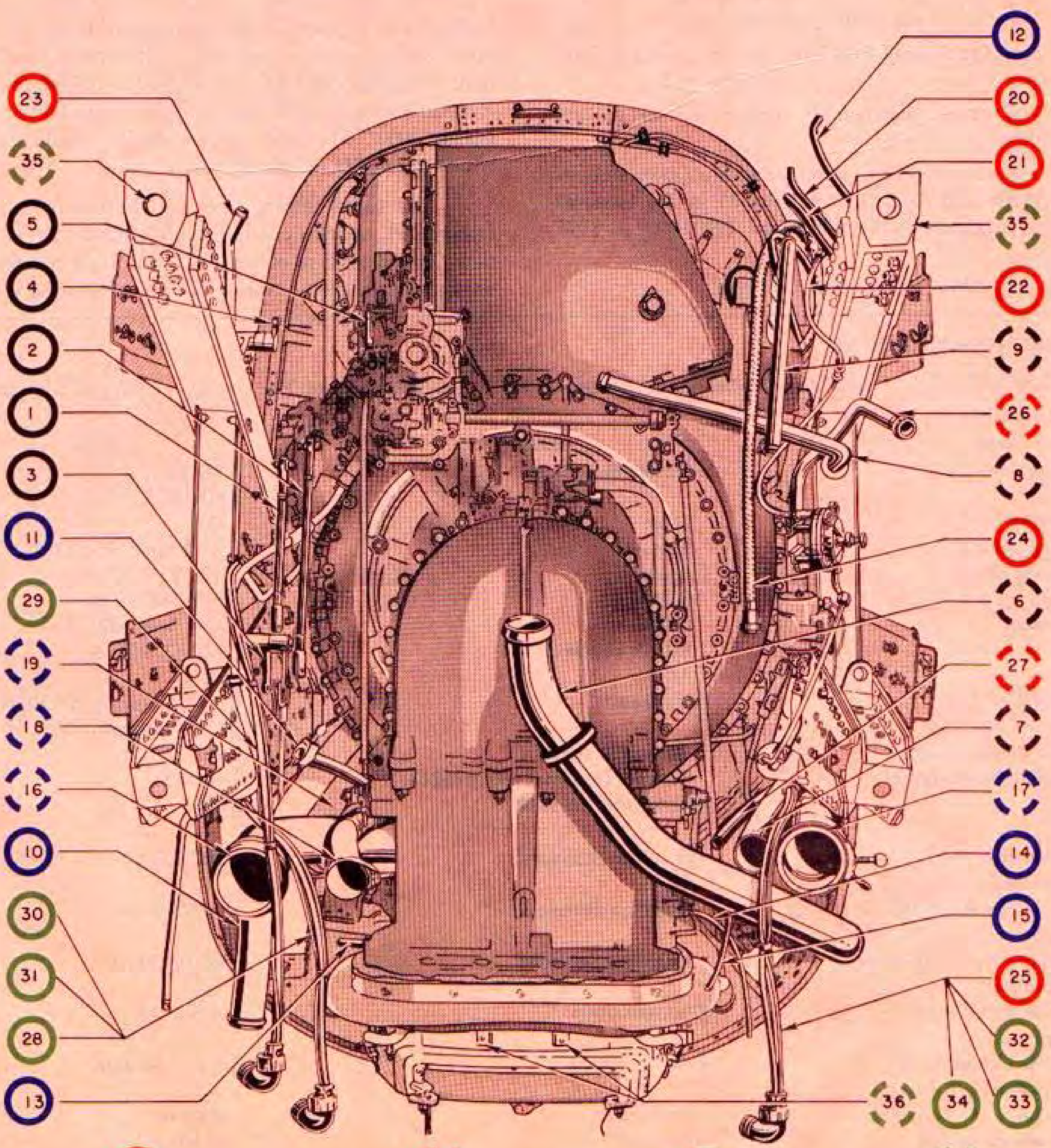
10. CARB. FEED LINE
11. CARB. VAPOR LINE
12. PRIMER LINE
13. ANEROID LINE
14. FUEL PUMP DRAIN LINE
15. SUPERCHARGER VOLUTE DRAIN LINE

*COOLANT SYSTEM*

16. MAIN COOLANT INTAKE LINE
17. MAIN COOLANT OUTLET LINE
18. AFTER COOLANT OUTLET LINE
19. AFTER COOLANT INTAKE LINE

108-41-37A

***Figure 200 (Sheet 1 of 2 Sheets)—Engine-to-Firewall Connections***




*INSTRUMENTS*

20. MANIFOLD PRESSURE
21. OIL PRESSURE
22. FUEL PRESSURE
23. VACUUM LINE
24. TACHOMETER CONDUIT
25. OIL TEMPERATURE

*HYDRAULIC SYSTEM*

26. HYD. PRESSURE LINE
27. HYD. SUCTION LINE

*ELECTRICAL SYSTEM*

28. GENERATOR WIRE
29. MAGNETO CONDUIT
30. STARTER WIRE
31. SUPERCHARGER SOLENOID CONDUIT
32. BOOSTER COIL CONDUIT
33. OIL DILUTION SOLENOID CONDUIT
34. CARBURETOR AIR TEMP.

*MISCELLANEOUS*

35. ENGINE MOUNT CONNECTION
36. CARB. AIR SCOOP BRACKET

10E-41-368

**Figure 200 (Sheet 2 of 2 Sheets)—Engine-to-Firewall Connections**

*9.* Move pitch control back to note 300 rpm drop (maximum); then move forward to full "INCREASE RPM."

*(q)* Check wing flap operation.

*(r)* Check wing flaps "UP," and set control in "UP" position.

*(s)* Check operation of coolant and oil radiator scoop flaps.

*(t)* Check propeller governor setting. Governor is set at 3000 rpm and should be correct to 61 in. Hg manifold pressure maximum (allowable limits 2950 rpm to 3025 rpm).

*(u)* Adjust idling (650-700) rpm.

*(v)* Adjust mixture for good acceleration.

*(w)* On airplanes equipped with Simmonds manifold pressure regulator, check operation of regulator as follows: Set propeller control in full "INCREASE RPM" position; set throttle control to obtain 2300 rpm. Reduce engine speed to 2000 rpm by moving propeller control toward "DECREASE RPM." Manifold pressure should remain constant within one in. Hg manifold pressure.

*(x)* Check supercharger high-blower operation as follows: Set propeller control in full "INCREASE RPM" position. Open throttle to obtain 2300 rpm. Hold supercharger switch in high blower. Note rpm drop (at least 50 rpm).

## 9. ENGINE ACCESSORIES.

*a.* ENGINE ACCESSORY UNITS.—See figure 201 for location of the various units. The engine is equipped with the following accessories:

| UNIT | MAKE | TYPE |
|---|---|---|
| Carburetor | Bendix-Stromberg | PD-18A1<br>PD-18C1 |
| Fuel pump | Pesco | G-9 |
| Vacuum pump | Pesco | B-12 Spec. 95-28391 |
| Hydraulic pump | Pesco | 1P-582F, FC, or L |
| Starter | Eclipse | F-89888 840 |
| Generator | Eclipse | O-4 Spec. 32415 |
| Spark plugs | KLG or Lodge (British) | RC5/3, RS5/5 |
| | AC | LE-44 |
| Magnetos | Northeast | ("B" Magneto) SF 12RA-P-4<br>("A" Magneto) SF 12LA-P-4 |
| Tachometer generator | General Electric | AN-5531-1 |
| Automatic boost control | Packard (optional with 615214) | 620500 |
| | Simmonds Modified | SA-5 |
| Propeller hub (P-51D Airplanes) | Hamilton Standard | 24D50-65 |
| Propeller blades (P-51D Airplanes) | Hamilton Standard | J-6523A-24 |
| Propeller governor (P-51D Airplanes) | Hamilton Standard | 4G10-G21D |
| Propeller hub (P-51K Airplanes) | Aeroproducts | A-542-A1 |
| Propeller blades (P-51K Airplanes) | Aeroproducts | A-20-156-24M |
| Oil pump | Packard | 607714 |
| Oil scavenge pumps | Packard | 615056 |
| Aftercooling pump | Packard | 617412 |
| Main coolant pump | Packard | 618610 |
| Supercharger solenoid | Delco | P-104 |
| Engine oil filter | Cuno | 11727 |

*b.* ENGINE ACCESSORY DRIVES.—See figure 202 for direction of rotation and ratio of the various drives.

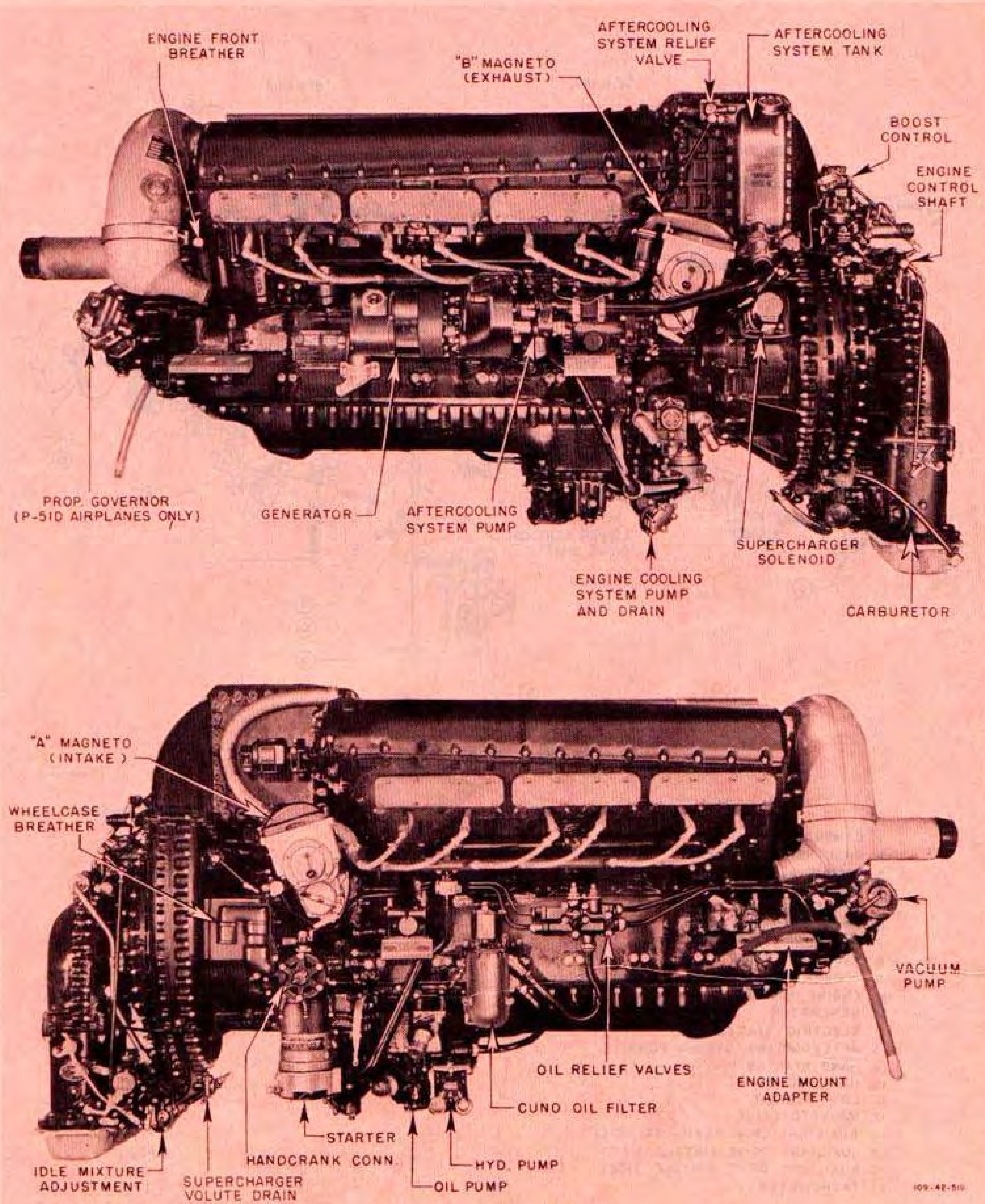
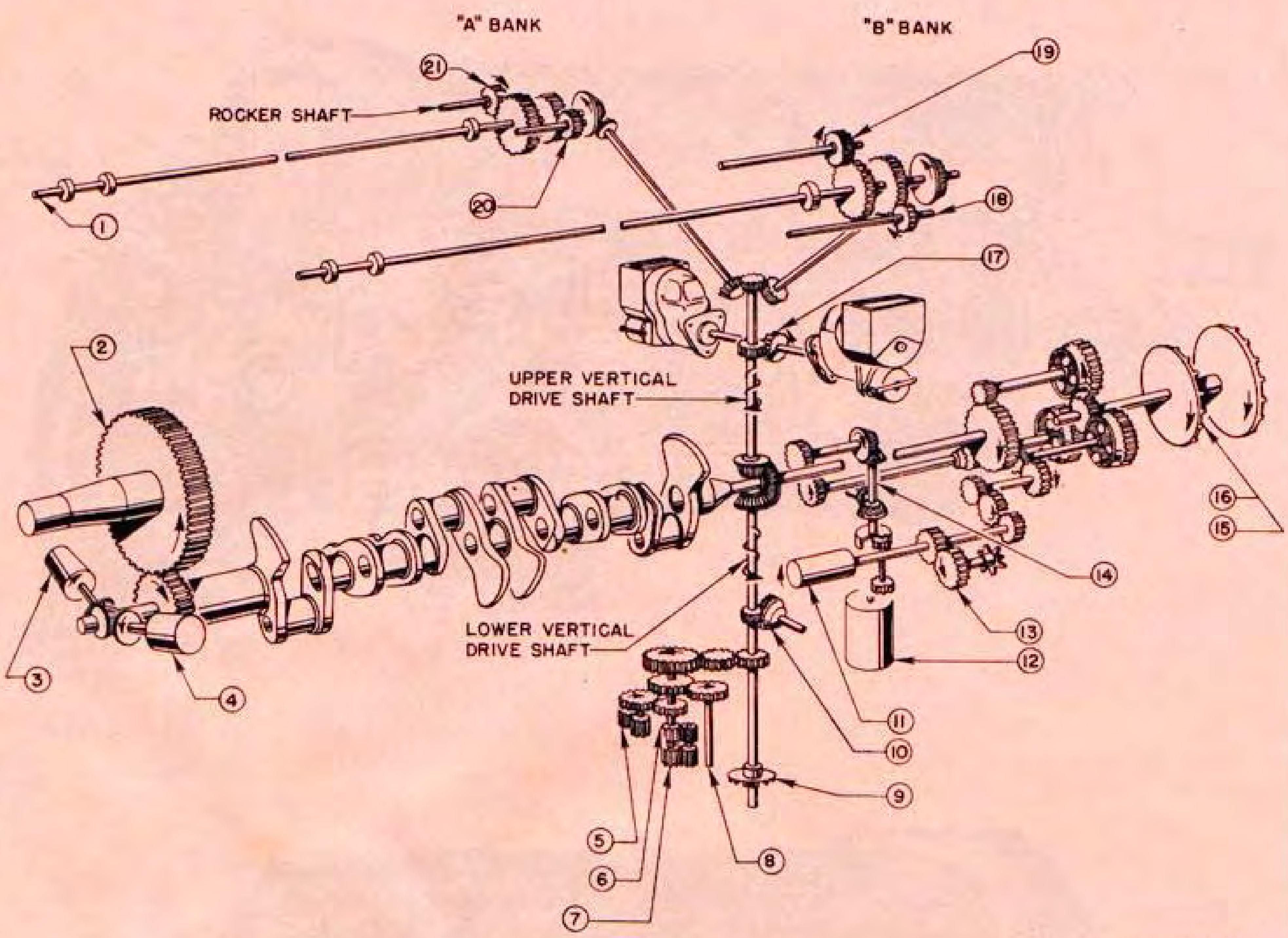



*Figure 201—Engine Accessories*




| | V-1650-7 ENGINE |
|---|---|
| 1. CAMSHAFT | 0.5:1 |
| 2. PROP. REDUCTION GEAR | 0.479:1 |
| 3. VACUUM PUMP | 0.828:1 |
| 4. PROP. GOVERNOR | 0.828:1 |
| 5. FRONT SCAVENGER PUMP | 0.814:1 |
| 6. REAR SCAVENGER PUMP | 0.814:1 |
| 7. PRESSURE (OIL) PUMP | 0.814:1 |
| 8. HYDRAULIC PUMP | 0.891:1 |
| 9. COOLANT PUMP | 1.5:1 |
| 10. ENGINE FUEL PUMP | 0.6:1 |
| 11. GENERATOR | 2.468:1 |
| 12. ELECTRIC STARTER | 104.252:1 |
| 13. AFTERCOOLING SYSTEM PUMP | 1.892:1 |
| 14. HAND STARTER | 18.92:1 |
| 15. HIGH BLOWER | 7.349:1 |
| 16. LOW BLOWER | 5.8:1 |
| 17. MAGNETO DRIVE | 1.5:1 |
| 18. AUXILIARY DRIVE (EXHAUST SIDE) | 0.777:1 |
| 19. AUXILIARY DRIVE (INTAKE SIDE) | 0.828:1 |
| 20. AUXILIARY DRIVE (INTAKE SIDE) | 1.0:1 |
| 21. TACHOMETER | 0.5:1 |

*Figure 202—Gear Ratios and Direction of Rotation*

## 10. PROPELLER.

A Hamilton Standard 4-blade propeller is installed on the P-51D Series Airplanes, and an Aeroproducts 4-blade propeller is installed on the P-51K Series Airplanes.

*a.* HAMILTON STANDARD PROPELLER.

(1) DESCRIPTION.—The Hamilton Standard Hydromatic propeller (24D50-65) has a diameter of 11 feet 2 inches. The paddle-type blades (Hamilton Standard, J-6523A-24), equipped with shank cuffs, are set at a 23-degree angle in low pitch, and a 65-degree angle in high pitch. No provision is made for feathering the propeller, as a shaft extension replaces the distributor valve used on full-feathering propeller models. The propeller is controlled by a governor which regulates the angle of the propeller blades to obtain and hold constant engine speed.

The blade angle variations required during constant-speed propeller operations are controlled by three forces: centrifugal twisting moment, which is utilized to move the blade angle toward low pitch; engine oil under pressure, to supplement the centrifugal twisting moment; and engine oil under boosted pressure from the governor which balances the centrifugal twisting moment and oil under pressure. *(See figure 203.)*

The streamlining spinner consists of two sections dynamically balanced; the aft section is secured to studs on the back side of the propeller hub, and is equipped with an air seal which is also fastened to the hub. *(See figure 205.)* The forward section of the spinner contains studs which hold it to the aft section. A dzus-fastened door in the rear spinner section affords access to the propeller governor and vacuum pump. A hole in the nose of the forward section, created in the process of fabrication, is closed with a butadiene plug (NA 73-44029).

(2) REMOVING HAMILTON STANDARD PROPELLER.—See figure 204 for identification of the various units referred to in the following instructions:

*(a)* Make sure that ignition switches are "OFF."

*(b)* Remove the right top cowl panel.

*(c)* Working through the aperture on the right side between the front cowl former frames and the engine, remove the eight nuts which hold the spinner front section to the spinner rear section. After a nut is removed, rotate the propeller to make the next nut accessible. Remove the butadiene plug at the front of the spinner; then pulling forward with fingers in the hole, rap spinner front section with palm of hand to free it from spinner rear section.

**Note**

If the spinner front section cannot be removed, it may be an indication of corrosion and seizure between the spinner centering ring bushing and the trunnion extending from the propeller dome. If this is the case, insert a tube 8 inches long, 13/16 inch in diameter, and 1/16 inch thick through the hole in the front of the spinner and fit it over the trunnion. Tap the tube lightly with a mallet to disengage the rust scale between the trunnion and bushing as shown in figure 234. Remove the spinner front section, and clean bushing and trunnion thoroughly; then apply a light coating of grease, Specification No. AN-G-3.

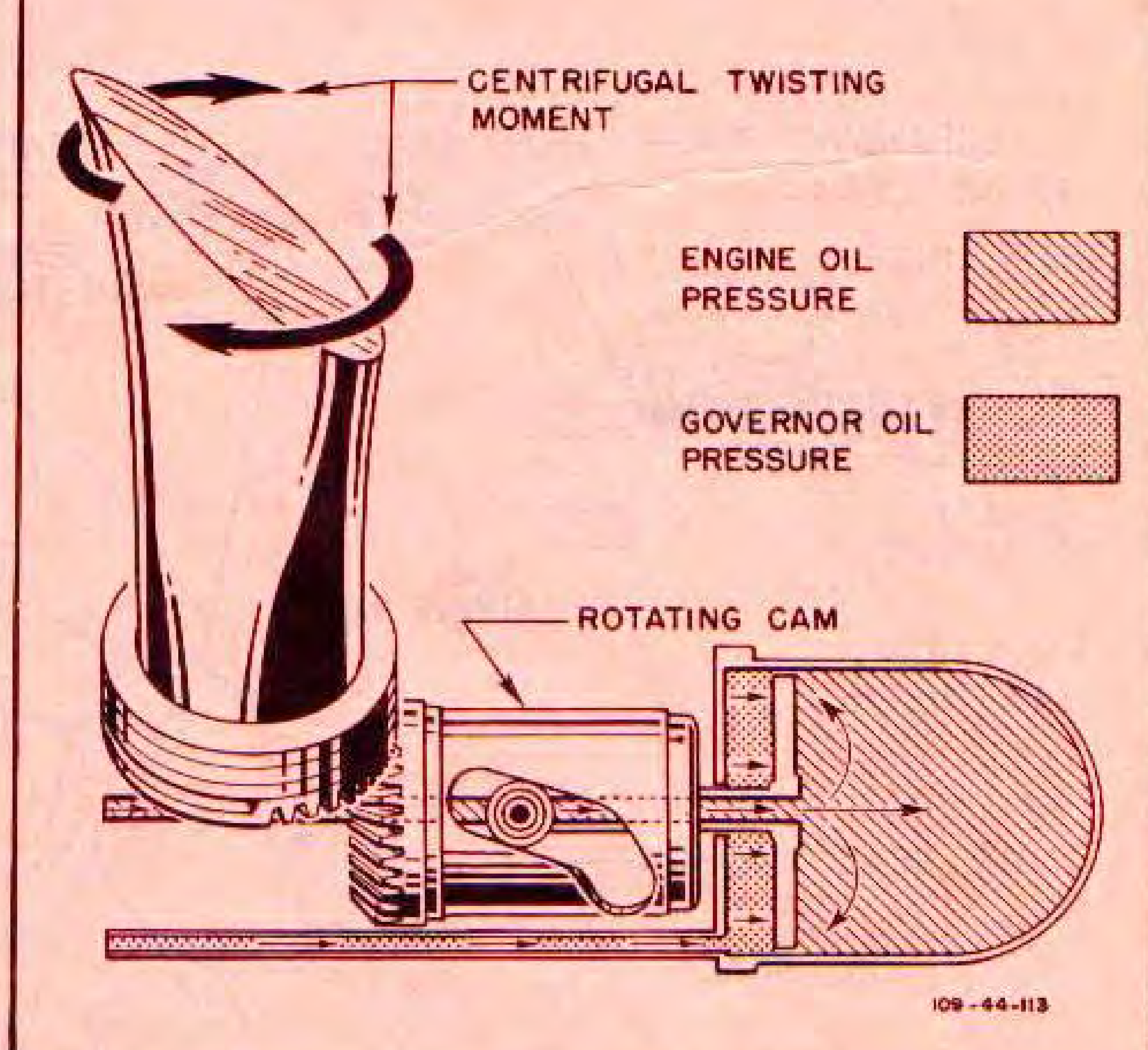



***Figure 203—Propeller Controlling Forces (Hamilton Standard)***

*(d)* Hold an oil receptacle under the dome and remove spinner trunnion.

*(e)* Turn the propeller blades to the 65-degree angle. The oil will spurt through the dome spinner trunnion hole during this operation.

*(f)* Thread lifting handle into dome.

*(g)* Unsafety and remove dome retaining nut lockscrew.

*(h)* Using a 3-foot bar in Hamilton Standard composite wrench, back off dome retaining nut, and carefully remove dome.

*(i)* Remove neoprene oil seal from base of dome.

*(j)* Remove and carefully preserve the brass preload shims.

*(k)* Remove the lockring from the propeller retaining nut. (This lockring locks both the retainer nut and the shaft extension to the propeller shaft.)

**CAUTION**

The lockring must be removed before unscrewing the shaft extension to prevent damage to lockring or shaft extension locking splines.

*(l)* Unscrew and remove shaft extension.

*(m)* Back off propeller retaining nut part way in order to break the seizure of the propeller to the cones.

**CAUTION**

Do not pry or hammer on the propeller to break it loose.

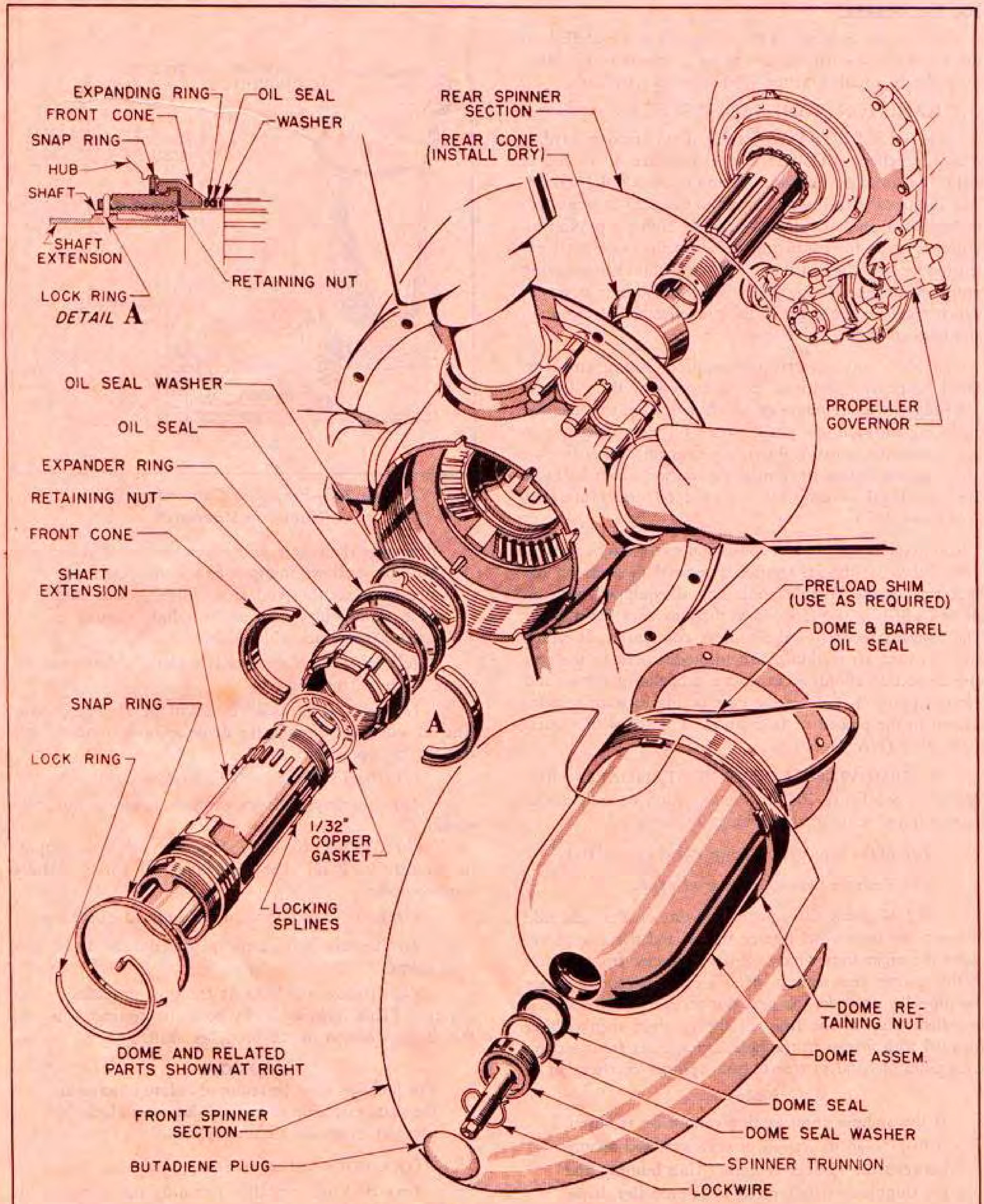



*Figure 204—Propeller Installation (Hamilton Standard)*

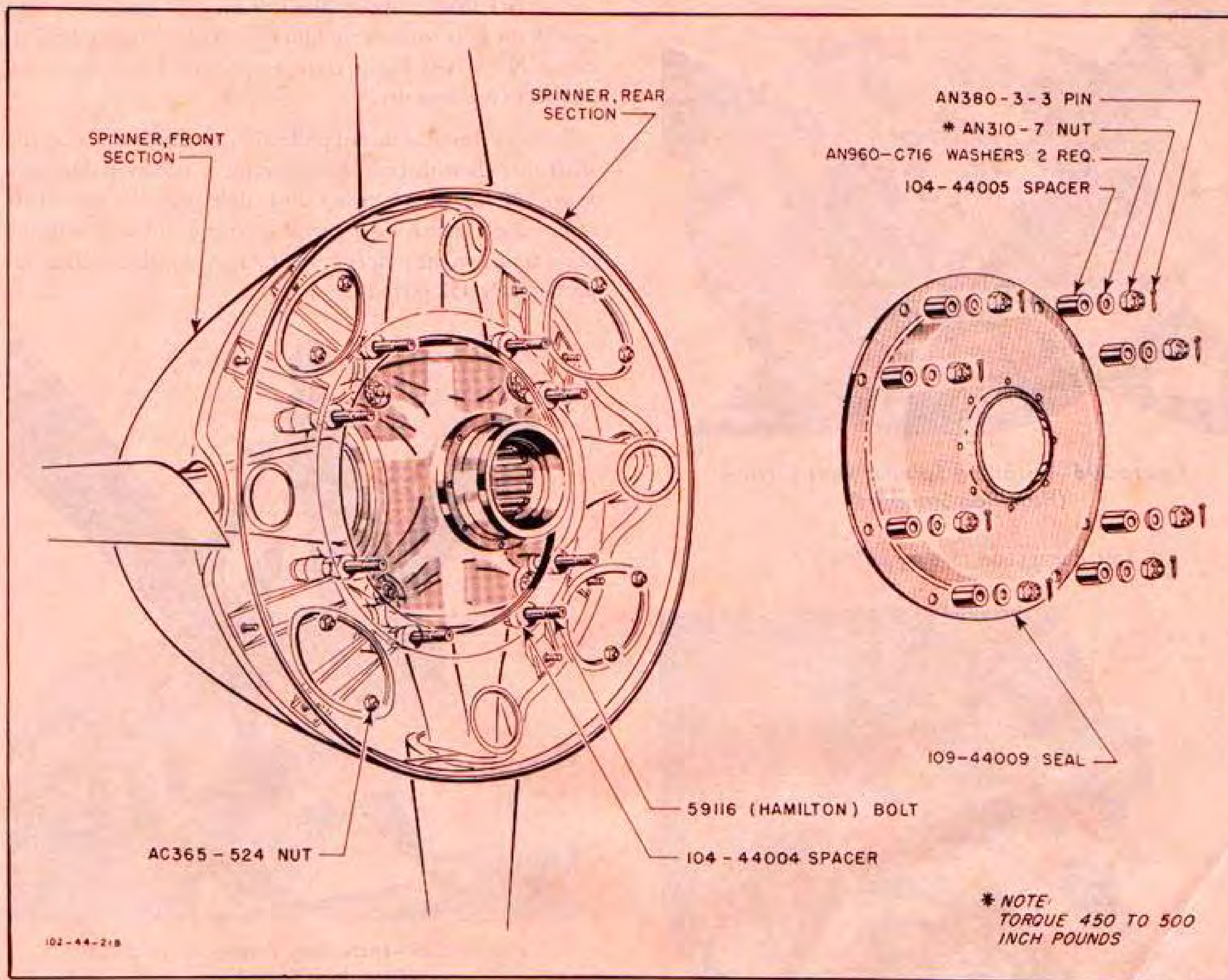



*Figure 205—Propeller Spinner Installation (Hamilton Standard)*

*(n)* Remove the snap ring. Pry up one end of snap ring and tie a piece of wire around it; then jerk ring straight out.

## WARNING

Hold hand over opening to catch the ring.

*(o)* Hold on to the split front cone carefully while turning off and removing the propeller retaining nut.

### CAUTION

If either half of cone is damaged, both halves must be replaced.

*(p)* Slide the propeller forward 2 or 3 inches and then push it aft. This will bring out the expander ring, oil seal, and the oil seal washer to where they can be easily removed.

*(q)* Install thread protector on shaft or tape the shaft threads if protector is not available and attach sling to propeller (the propeller weighs approximately 452 pounds).

*(r)* Slide propeller off shaft, being careful not to damage rear cone seat or shaft. Place propeller on a smooth clean surface.

*(s)* Remove rear spinner section and air seal. *(See figure 205.)*

*(t)* Remove rear cone from propeller shaft.

*(u)* Cover propeller shaft with an oil-soaked rag or suitable cover to protect threads and splines from dust or rust if replacement propeller is not to be installed immediately.

(3) INSTALLING HAMILTON STANDARD PROPELLER.

*(a)* Check thrust nut on the engine for tightness. Clean shaft threads and splines thoroughly, removing all nicks, burrs, and galls from shaft and face of thrust nut.

*(b)* Place propeller on a stand and install rear spinner section. Install and fasten air seal to spinner mounting studs. Safety nuts with lockwire as shown in figure 206.

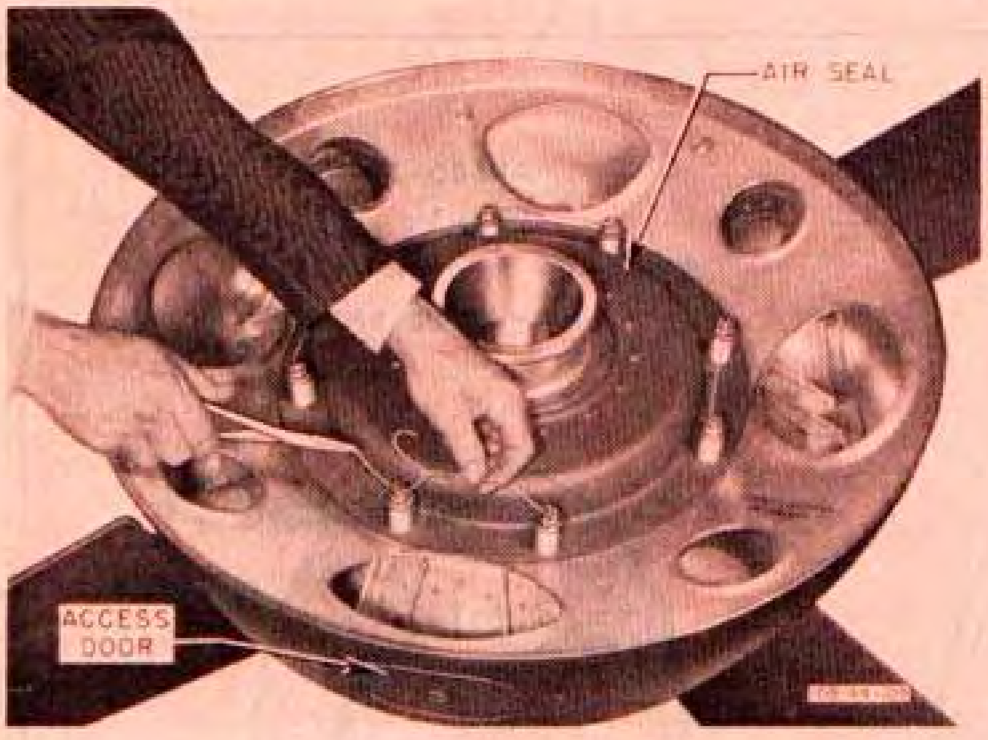



***Figure 206—Installing Spinner Rear Section (Hamilton Standard)***

*(c)* Install rear cone. *(See figure 207.)*

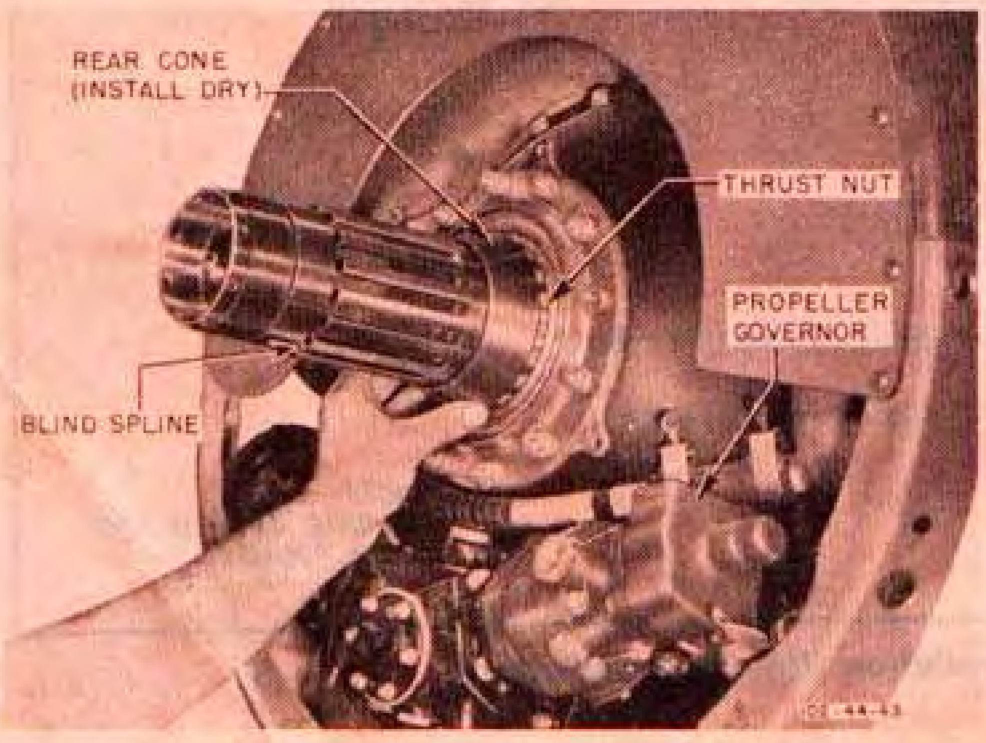



***Figure 207—Installing Rear Cone (Hamilton Standard)***

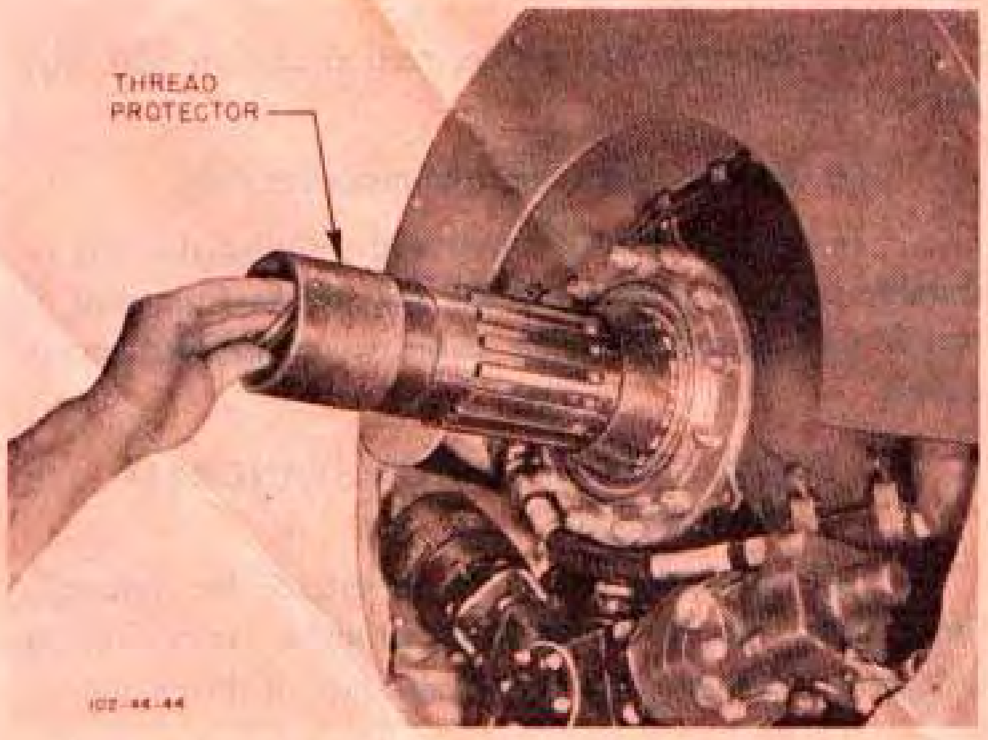



***Figure 208—Installing Thread Protector (Hamilton Standard)***

*(d)* Coat propeller shaft, front cone, and front cone seat in the hub with a thin film of thread lubricant, Specification No. AN-C-53, or clean engine oil. Leave rear cone and rear cone seat dry.

*(e)* Install a thread protector to the shaft or wrap the shaft threads with tape if a protector is not available. *(See figure 208.)* With a hoisting sling, slide propeller onto shaft *(figure 209)*, matching the wide groove in the hub with the blind spline on the propeller shaft. (The propeller weighs approximately 452 pounds.)

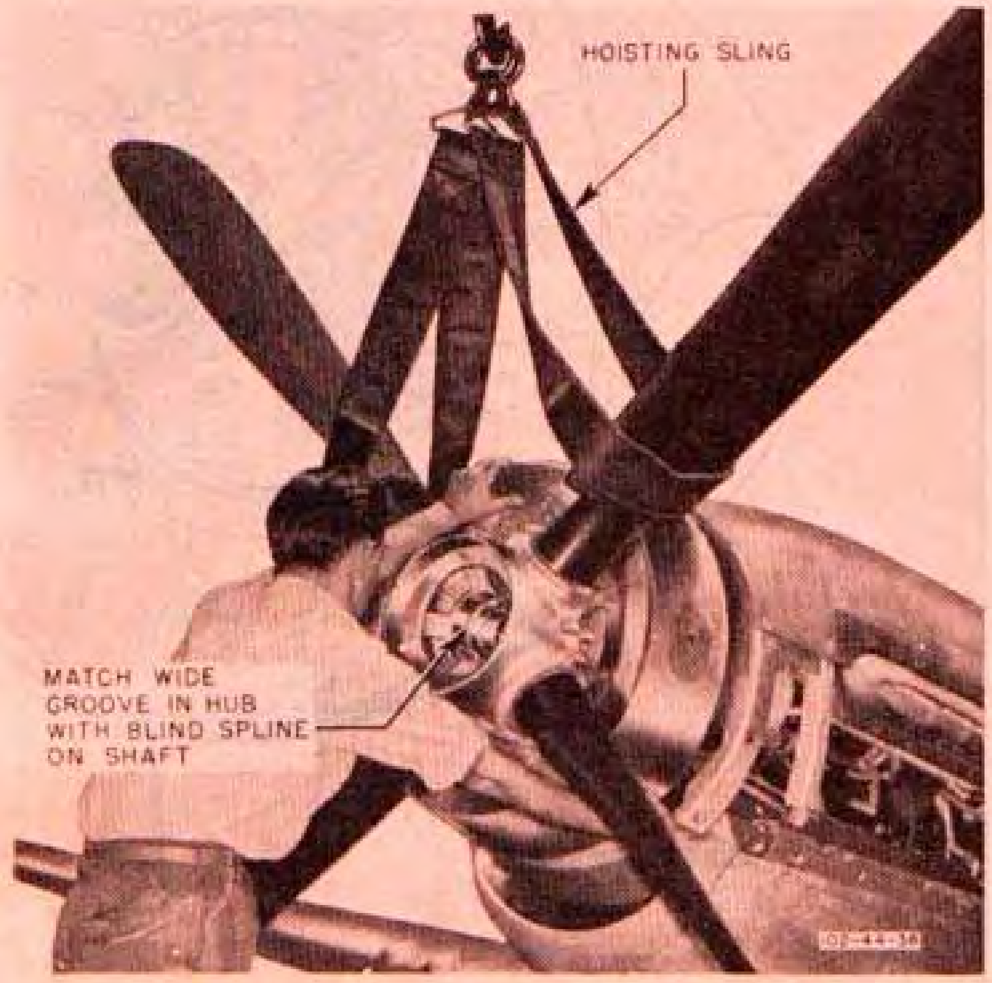



***Figure 209—Installing Propeller to Shaft (Hamilton Standard)***

*(f)* Remove the thread protector; then install the oil seal washer *(figure 210)*, the chevron oil seal *(figure 211)*, and the expander ring. *(See figure 212.)*

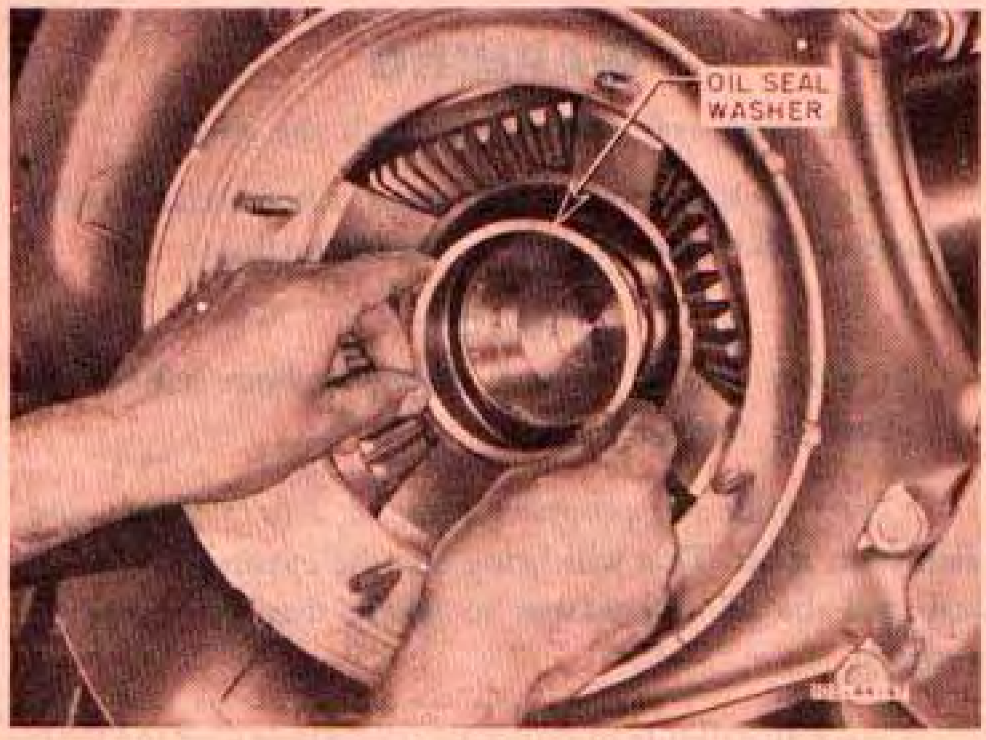



***Figure 210—Installing Oil Seal Washer (Hamilton Standard)***

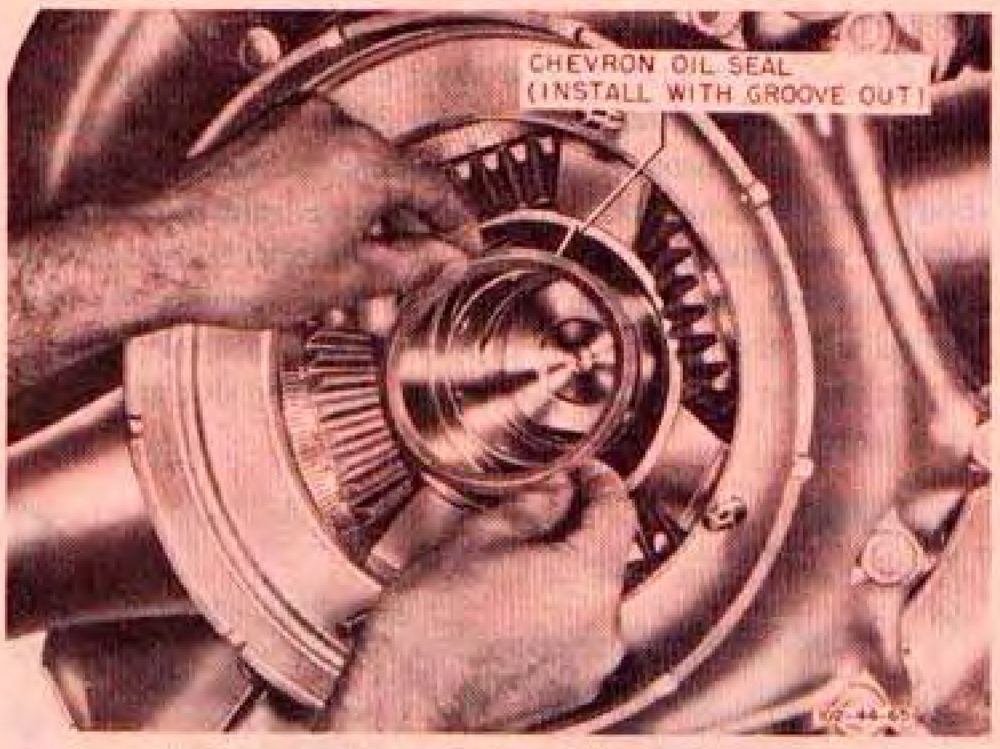



*Figure 211—Installing Oil Seal (Hamilton Standard)*

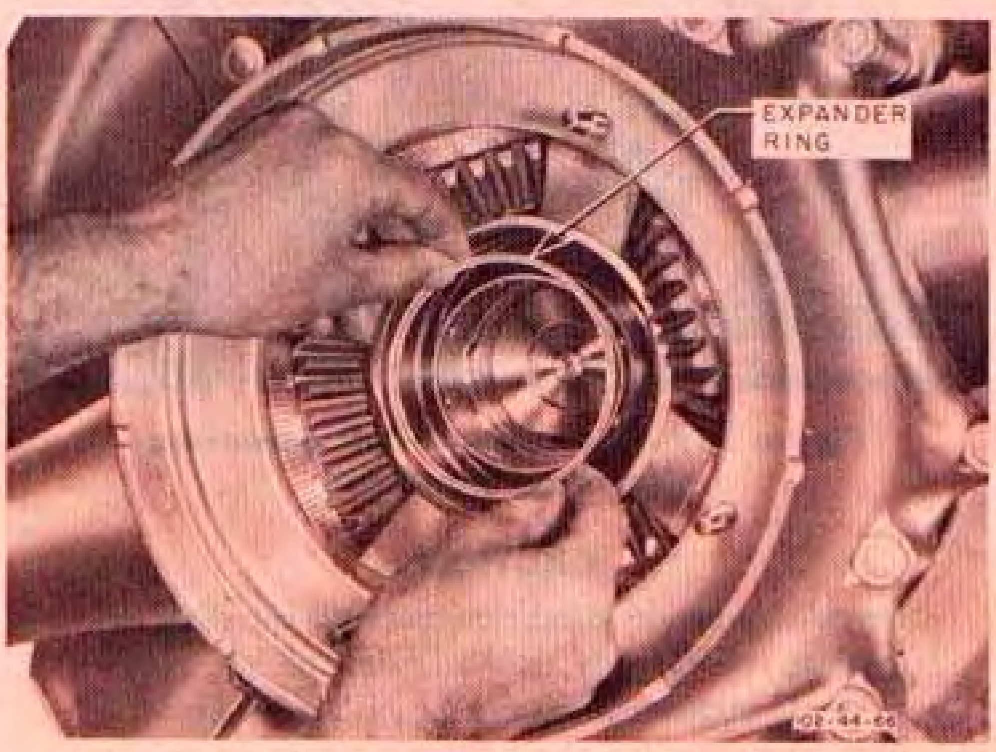



*Figure 212—Installing Expander Ring (Hamilton Standard)*

*(g)* Lubricate the retainer nut threads and attach the front split cone to the nut. Start the nut and cone onto the shaft by hand *(figure 213)* and screw up snug. Back off and

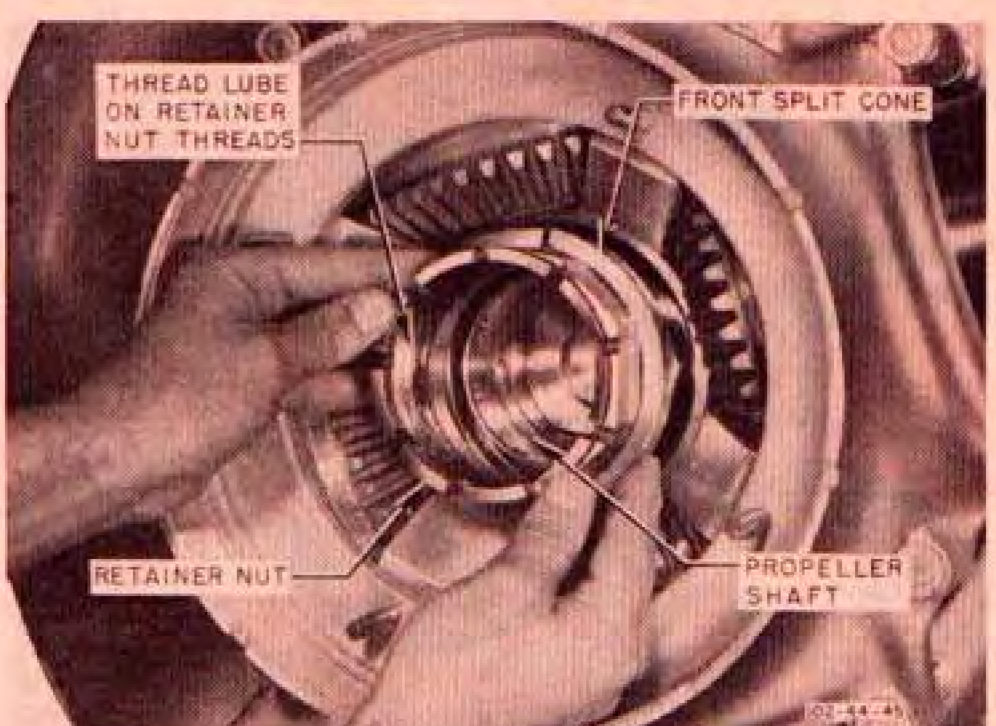



*Figure 213—Installing Front Cone and Retainer Nut (Hamilton Standard)*

remove the retainer nut. Examine the oil seal; if seal is in good condition, replace the nut.

*(h)* Tighten propeller retaining nut on the shaft. *(See figure 214.)* Apply and maintain a force of approximately 180 pounds at the end of a 3-foot bar, and strike the bar close to the wrench with a hammer weighing not more than 2½ pounds. Make sure one of the locking slots in the nut is in alignment with one of the holes in the end of the propeller shaft. If not, repeat tightening procedure until alignment is obtained; then install retainer nut snap ring. *(See figure 215.)*

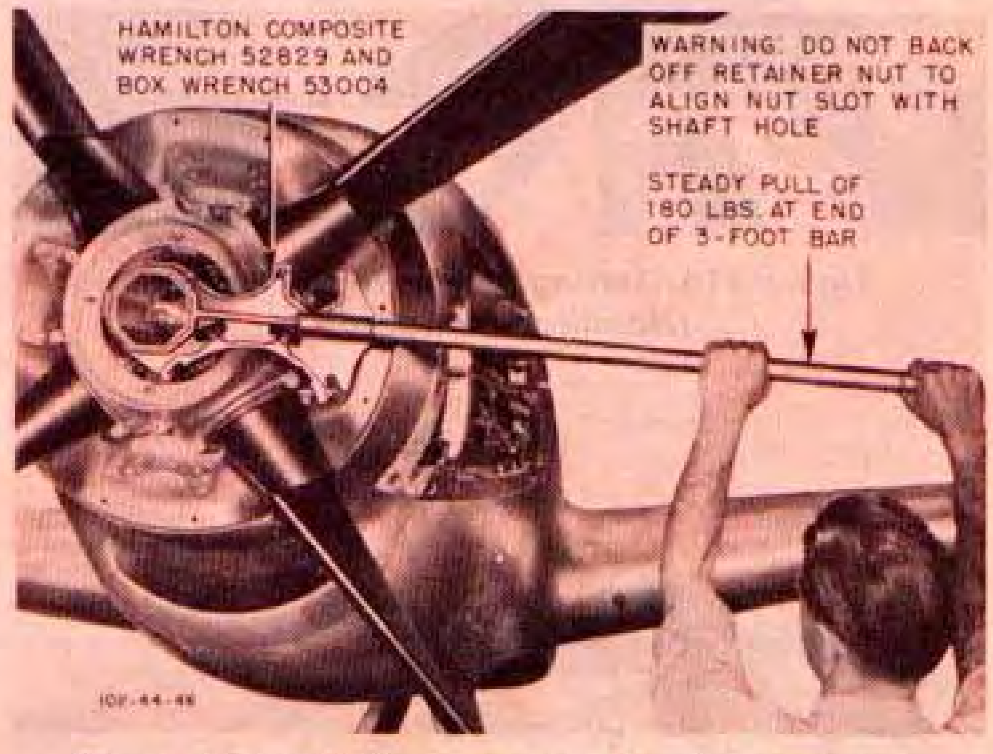



*Figure 214—Tightening Propeller Retainer Nut (Hamilton Standard)*


*Figure 215—Installing Retainer Nut Snap Ring (Hamilton Standard)*

*(i)* Turn each blade to the specified high pitch setting by lining up the 65-degree mark, stamped on each blade butt, with the respective index line on the inner surface of the dome-barrel shelf. *(See figure 216.)*

*(j)* Before installing the shaft extension, make sure that the hole in the oil transfer plate (on the base of the shaft extension), the hole in the 1/32-inch copper gasket (between the plate and the shaft extension housing), and the hole in the shaft extension housing are all in alignment. *(See figure 217.)*

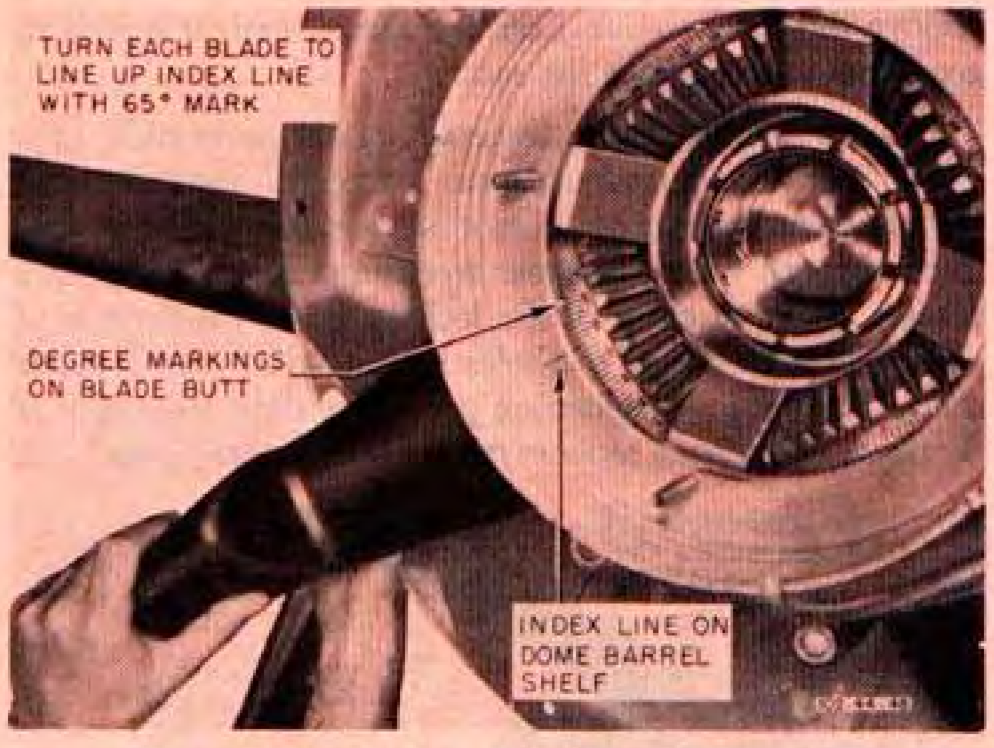



**Figure 216—Setting Blades to 65 Degrees (Hamilton Standard)**

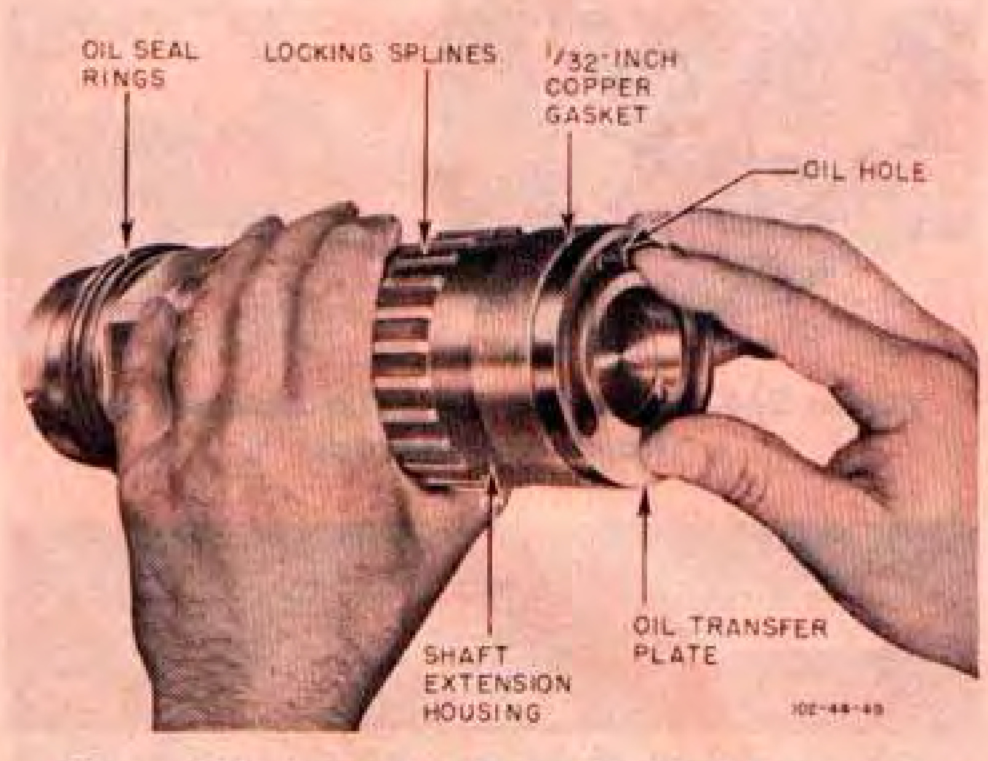



**Figure 217—Inspecting Propeller Shaft Extension (Hamilton Standard)**

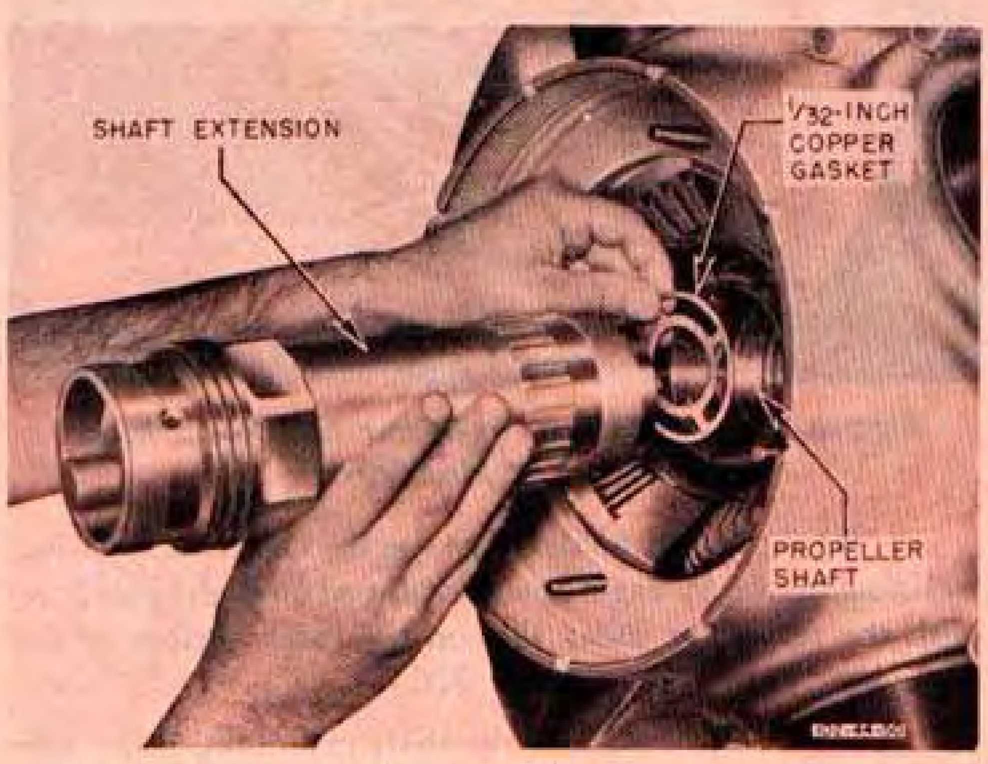



**Figure 218—Installing Shaft Extension and Gasket (Hamilton Standard)**

*(k)* Oil the threads of the shaft extension and install the 1/32-inch copper gasket and the shaft extension. *(See figure 218.)* The copper gasket rests against the adapter flange inside the propeller shaft. Screw shaft extension into the propeller shaft and tighten. *(See figure 219.)* Apply and maintain a force of approximately 100 pounds at the end of a bar about one foot long, and strike the bar one light blow with a hammer weighing not more than 2½ pounds. If the locking slots between the splines in the shaft extension are not aligned with the holes in the propeller shaft and the retainer nut, repeat the tightening procedure until the slot and holes are aligned.

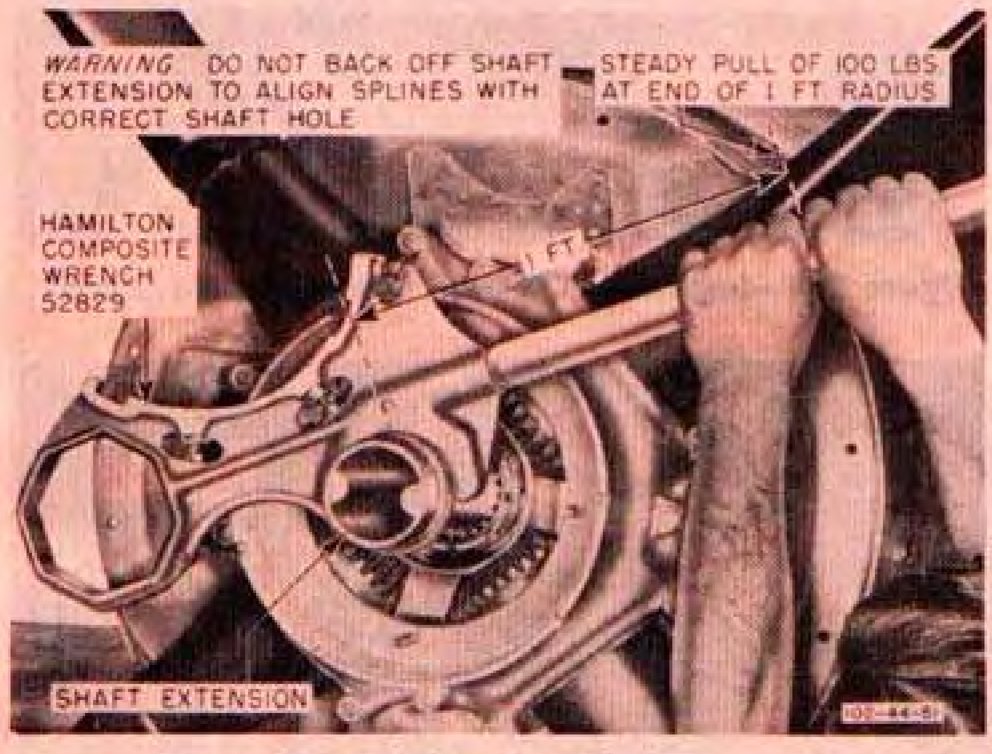



**Figure 219—Tightening Shaft Extension (Hamilton Standard)**

**CAUTION**

Do not, under any condition, back off the shaft extension, even slightly, to obtain slot and hole alignment. If alignment cannot be obtained, install a new gasket or lap the original gasket to reduce thickness.

*(l)* Install the lockring with the pin through the retaining nut slot, propeller shaft hole, and between the shaft extension locking splines. Snap the ring into position in retaining nut groove. *(See figure 220.)*

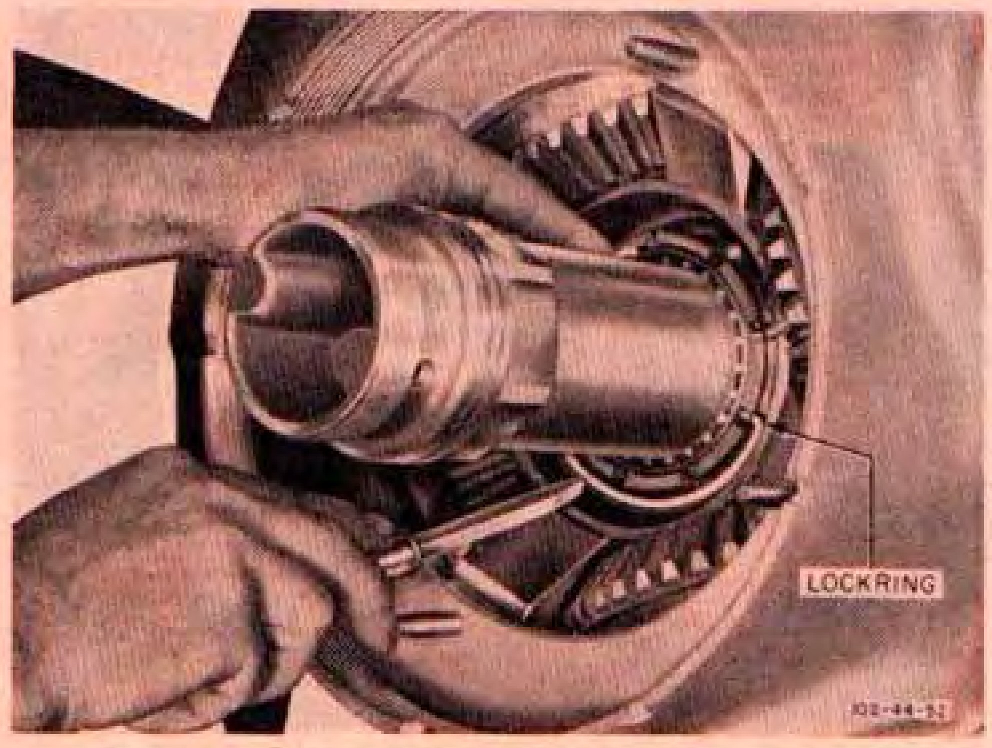



**Figure 220—Installing Retainer Nut and Shaft Extension Lockring (Hamilton Standard)**

*(m)* Before installing the dome assembly, make certain that the high and low limit adjustments are correct (high pitch, 65 degrees; low pitch, 23 degrees). If it is necessary to reset the stop rings to obtain these limits, proceed as follows:

*1.* Lift out the high and low-pitch stop rings by inserting Type 1024 screws or bolts into the tapped holes in the rings and lifting up. *(See figure 221.)*

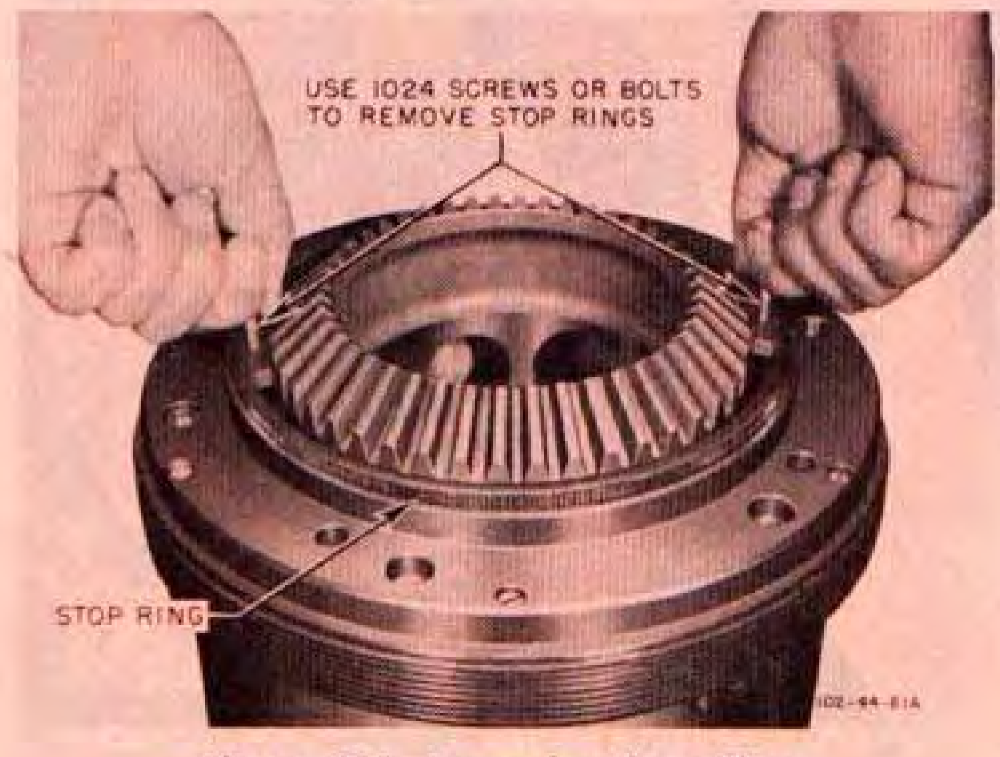



***Figure 221—Removing Stop Rings (Hamilton Standard)***

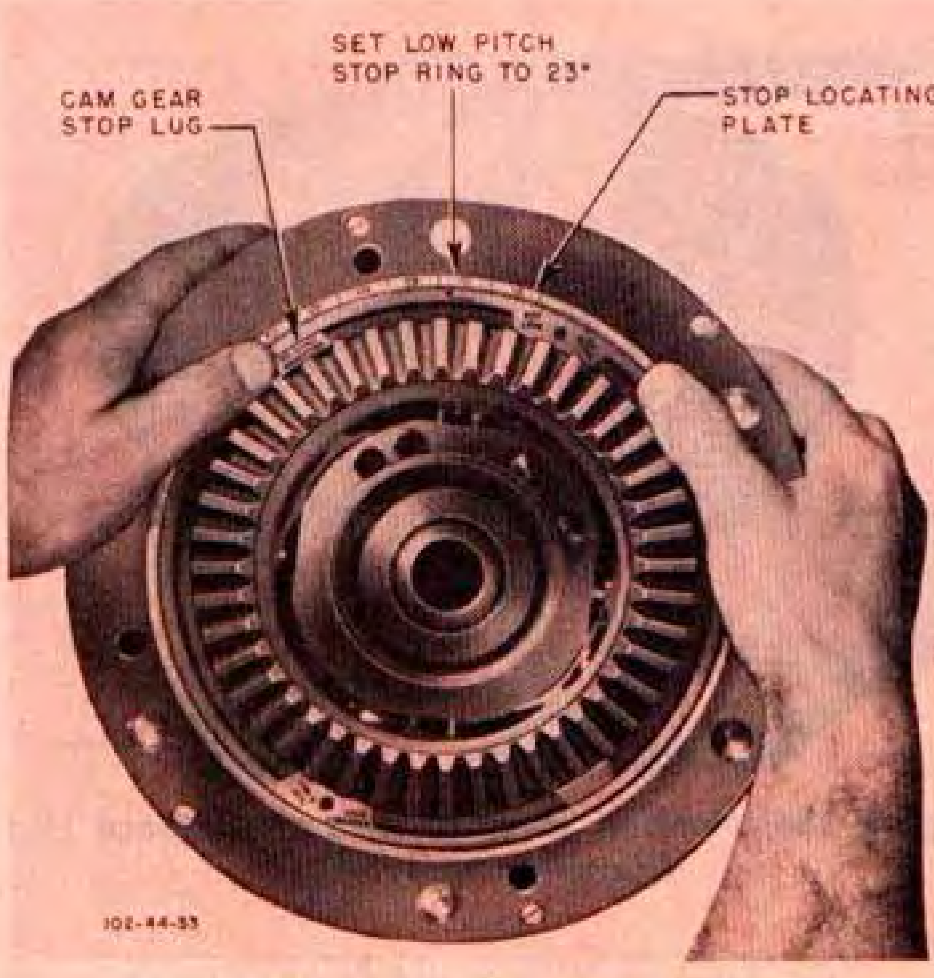



***Figure 222—Installing Low-pitch Stop Ring (Hamilton Standard)***

*2.* Reinstall low-angle stop ring (forward ring when dome is installed), inserting it so that the arrow on the ring coincides with the 23-degree mark on the stop locating plate. *(See figure 222.)* This is the low-angle stop ring and is marked "Set to Low Pitch" on one lug and "Assemble This Stop First" on the other lug. It may be necessary to rotate the cam gear slightly in a counterclockwise direction to permit insertion of the stop ring without interference with the stop lugs on the gear. The stop lug on the cam gear marked "Set Within Graduations" must be within the graduated arc of the stop locating plate after the stop rings have been installed.

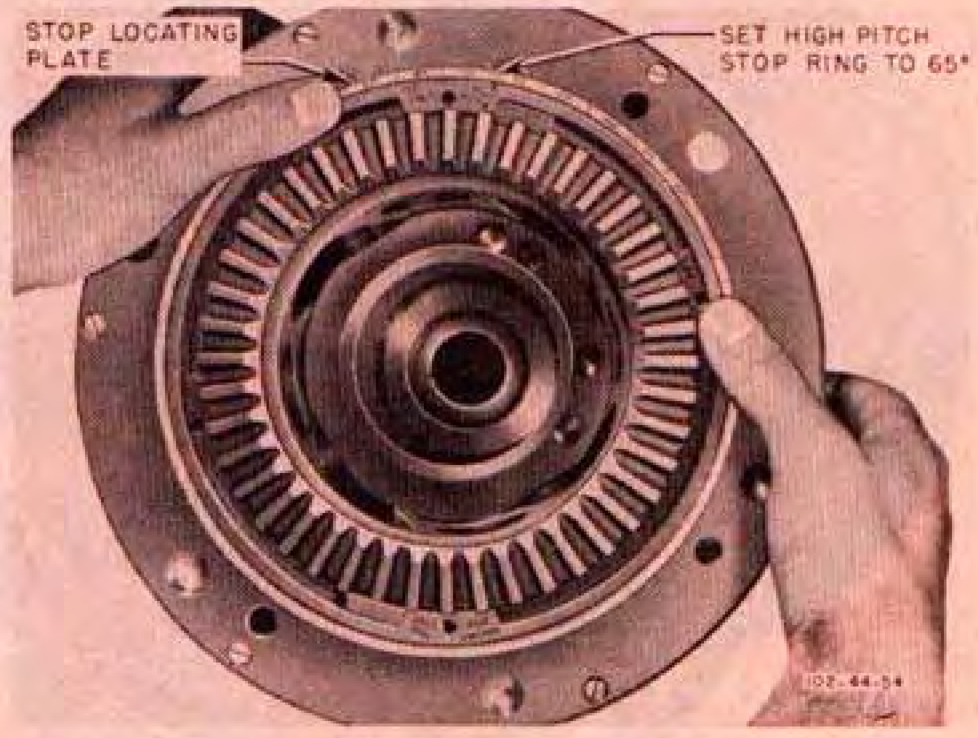



***Figure 223—Installing High-pitch Stop Ring (Hamilton Standard)***

*3.* Reinstall high-angle stop ring (aft ring when dome is installed) by inserting on top of low-angle stop ring so that the arrow on the ring coincides with the 65-degree mark on the stop locating plate. *(See figure 223.)* This is the high-angle stop ring and is marked "Set to High Pitch" on one lug and "Assemble This Stop Last" on the other lug.

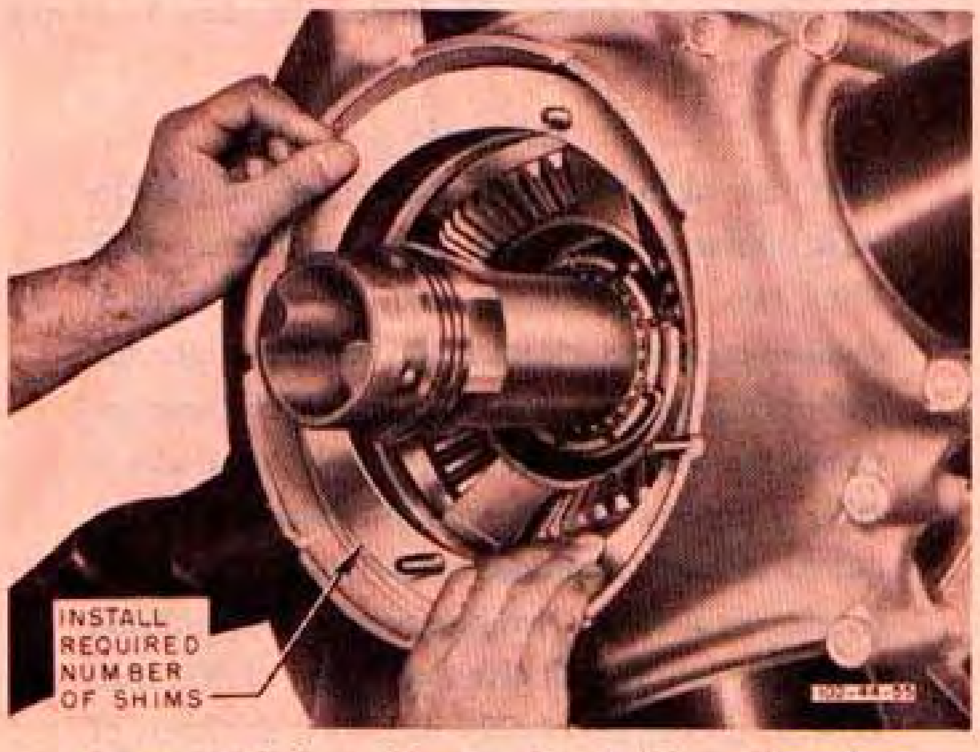



***Figure 224—Installing Preload Shims (Hamilton Standard)***

*(n)* Determine the gear preload, and install shims in the hub. *(See figure 224.)* To determine the number of preload shims required, proceed as follows:

*1.* Check the gear preload by inspecting the PD numbers on the stop locating plate at the base of the dome, and on the barrel dome shelf of the hub. *(See figure 225.)* The PD numbers indicate the dome and hub preload in thousandths of an inch.

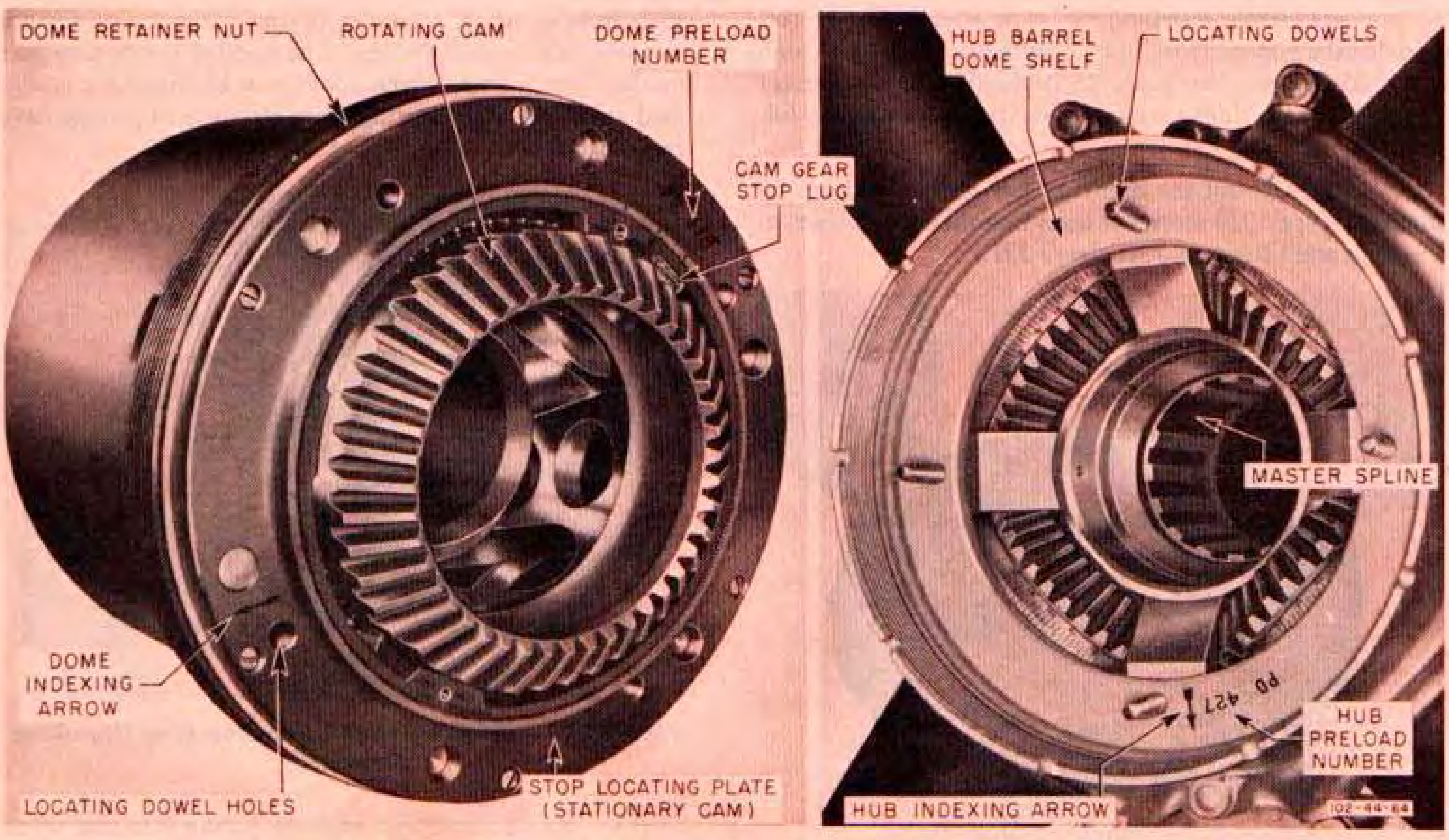



***Figure 225—Propeller Dome and Hub (Hamilton Standard)***

2. The difference between these two numbers indicates in thousandths of an inch the number of shims required; therefore, subtract the lowest number from the highest.

**Example**

Hub preload PD No. .427. Dome preload PD No. .418. Difference between two numbers is .009. Thus, two .005 shims are required. Add shims to obtain a maximum clearance of .002 inch tight and .003 inch loose. For example, if the difference between the PD numbers on the hub and dome is .011, two shims of .005-inch thickness will be required to give a clearance of .001 tight. If the difference between the two numbers is .009, addition of two .005 shims will give a clearance of .001 inch loose. A maximum of .025-inch total thickness of shims is permissible.

*(o)* By turning the rotating cam gear, move piston in dome into extreme forward position (cam gear stop lugs against the high-angle stop lugs).

**CAUTION**

When installing the dome assembly, it is *absolutely essential* that the cam gear in the dome be meshed with the blade gear segments in the proper angular relationship.

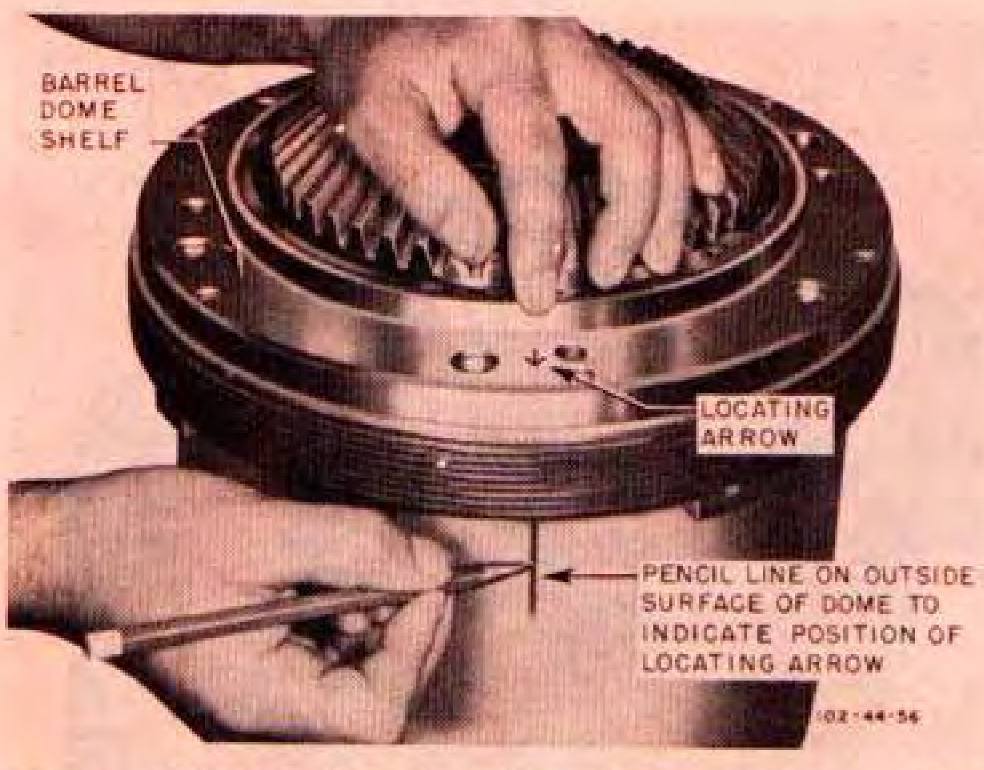



***Figure 226—Marking Locating Arrow Reference Line (Hamilton Standard)***

*(p)* When the arrow on the hub locating plate and the arrow on the barrel dome shelf are in register, the dome and the hub are in alignment and are properly engaged. As it is impossible to note the position of the two arrows when the dome is being installed, make a pencil mark on the outside surfaces of the hub and dome to indicate the position of the arrows. *(See figure 226.)*

*(q)* Remove dome spinner trunnion and install lifting handle into front of dome. Lubricate the dome retaining nut threads.

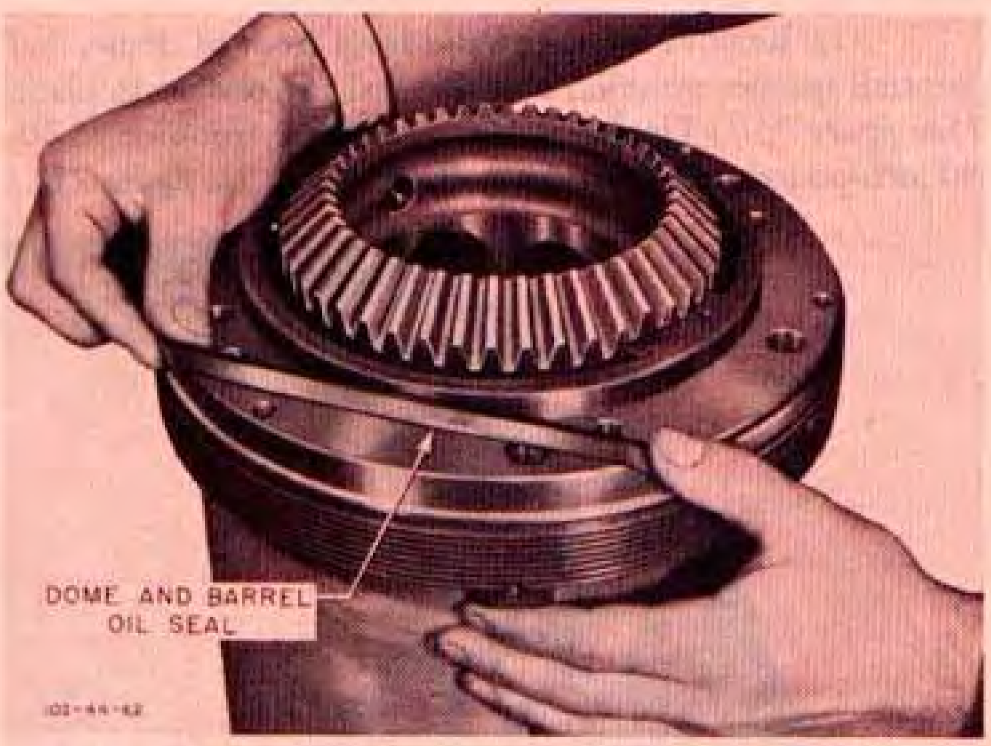



***Figure 227—Installing Dome Oil Seal (Hamilton Standard)***

**Note**

The propeller is furnished with two sizes of dome-barrel oil seals: 52478-F standard size and 52478-1-H oversize. Only one seal is required for propeller installation. *(See figure 227.)*

*(r)* In order to reduce the possibility of oil leakage past the dome seal on propeller assemblies having .010 to .020-inch preload, the following check installation of the dome must be made:

**Note**

Propeller assemblies which require .025-inch preload must be installed with the oversize seal, and will not require a check installation of the dome. Propeller assemblies which require *less* than three shims (.015 inch) will not require the check installation, and the standard seal will be installed.

*1.* Coat the skirt of the stationary cam and the dome seal seat on the front barrel with SAE No. 10 oil; then install the dome, *without dome-barrel oil seal,* over the end of the shaft extension, making sure the oil seal rings on the shaft extension are fitted into the sleeve inside piston. Turn dome in a counterclockwise direction until the dowels in the barrel dome shelf engage the proper holes in the stop locating plate *(figure 228)*, and the marks indicating the alignment arrows on the barrel dome shelf and stop locating plate are opposite each other. The cam gear and blade gears are now in proper alignment. Then, without turning it, slide the dome into the barrel until the dome retaining nut can be started.


***Figure 228—Installing Dome (Hamilton Standard)***

**CAUTION**

Do not turn the dome in a clockwise direction to align the dowels and holes, as such movement could move the stop lugs on the rotating cam away from the high-angle position and allow the gears to mesh incorrectly.

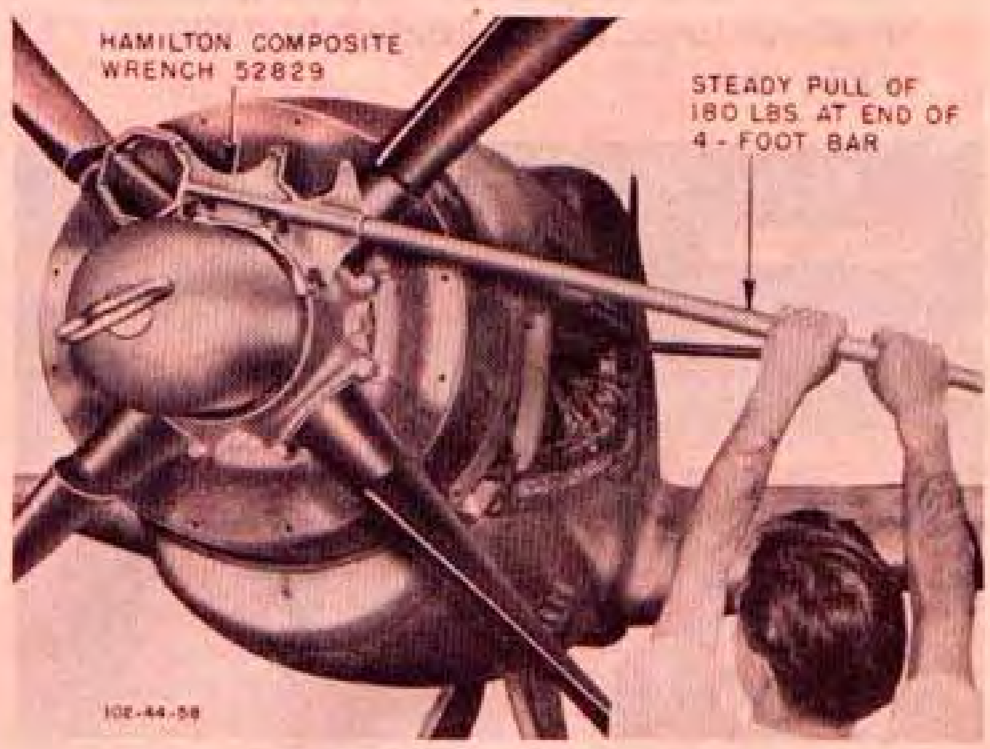



***Figure 229—Tightening Dome Retainer Nut (Hamilton Standard)***

*2.* Tighten the dome retaining nut with the Hamilton Standard composite wrench, and apply a force of approximately 180 pounds at the end of a 4-foot bar (720 foot-pounds). *(See figure 229.)*

*3.* Make sure the dome is completely seated on the barrel shelf; then make temporary matching marks on hub and dome retaining nut lug. (Use pencil or chalk, making sure no abrasive scratches the dome or barrel.) Do not confuse these marks with dome and hub aligning arrow marks previously made.

*4.* Remove the dome, noting the number of turns required to disengage the retaining nut from the hub.

*5.* Install the oversize dome-barrel oil seal (52478-1-H) properly with the tapered end facing away from the dome retaining nut. *(See figure 227.)* The oversize seal must be tried first, to obtain as tight a fit as possible.

*6.* Reinstall dome and turn the retaining nut the same number of turns as were required to remove it. Tighten the nut, applying a force of approximately 180 pounds at the end of the 4-foot bar to align the matching marks on the hub and retainer nut lug.

*7.* If the matching marks cannot be aligned when using the oversize seal, remove the dome, replace the oversize seal with the standard size seal (52478-F), and reinstall the dome.

**Note**

With the dome properly seated in the barrel, the front face of the dome retaining nut will be approximately flush with the front edge of the barrel. It is essential that the dome be firmly seated on the retaining shoulder in the barrel. Tightening of the dome retaining nut serves three purposes: It fastens the dome unit to the hub, applies preloading force to the gears, and compresses the dome and barrel seal. Therefore, relatively high wrench torque is required for proper tightening. Failure to tighten the dome unit securely will result in elongation or failure of the screws which fasten the dome cylinder and the stop locating plate to the stationary cam.

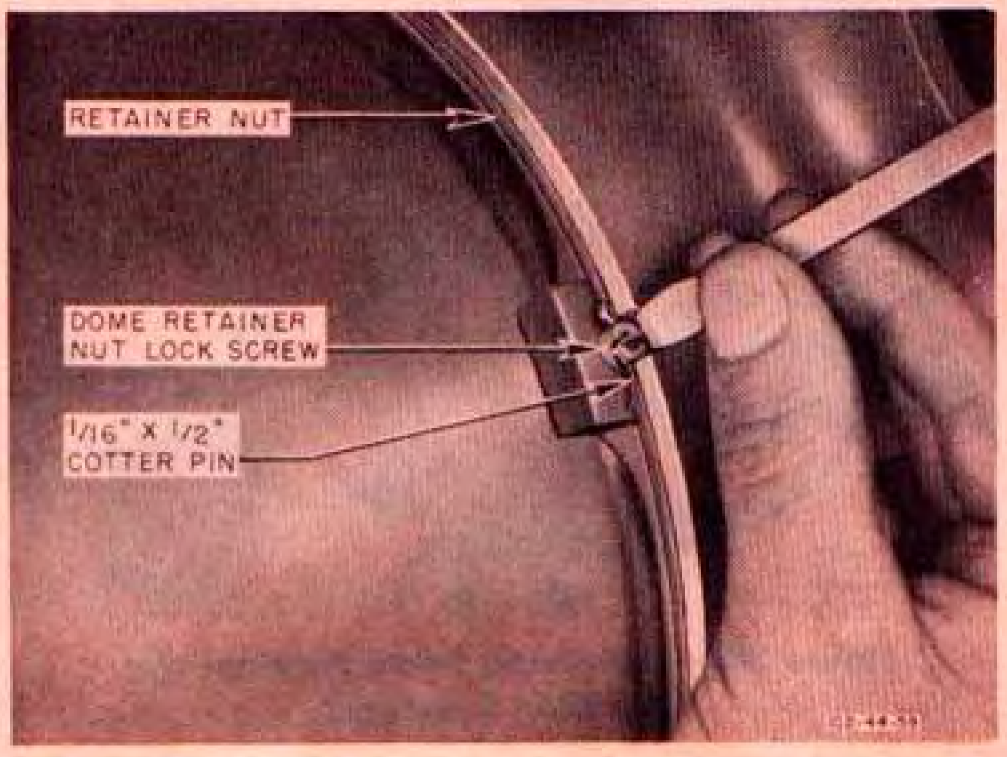



***Figure 230—Safetying Dome Retainer Nut Lockscrew (Hamilton Standard)***

*(s)* Install dome retaining nut lockscrew *(figure 230)* and safety with 1/16-inch x 1/2-inch steel cotter pin or safety wire.

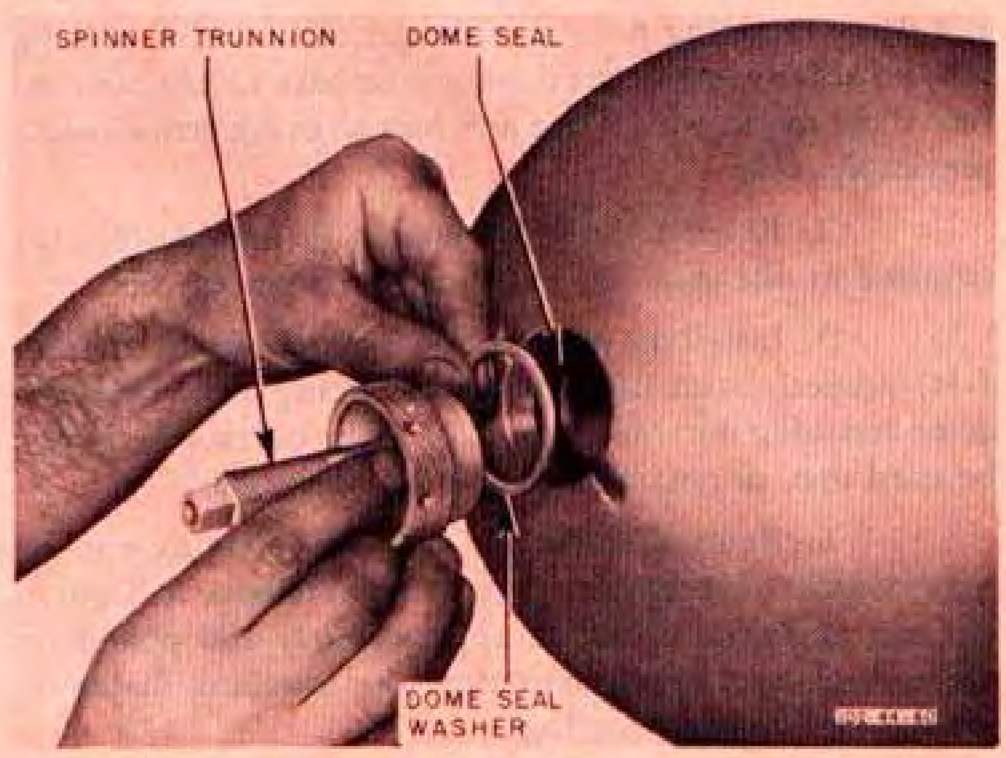



***Figure 231—Installing Spinner Trunnion (Hamilton Standard)***

*(t)* Remove lifting handle from front of dome, and reinstall spinner trunnion with the seal and washer in place. *(See figure 231.)* Tighten spinner mounting trunnion to 30-40 inch-pounds torque, and install lockwire. *(See figure 232.)*

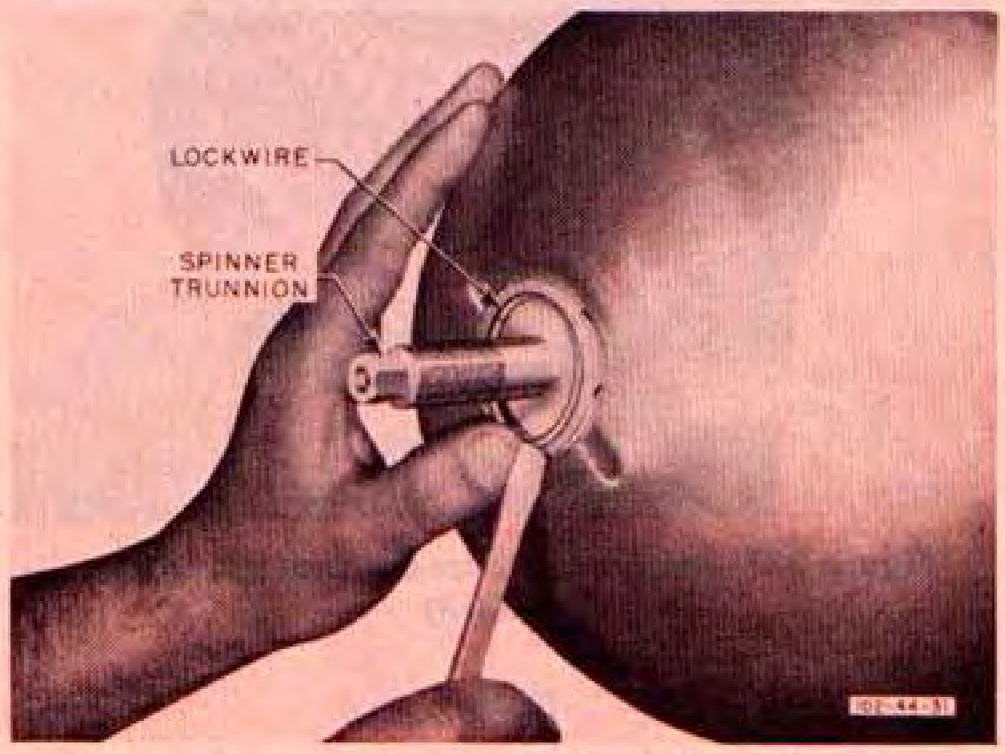



***Figure 232—Installing Spinner Trunnion Lockwire (Hamilton Standard)***

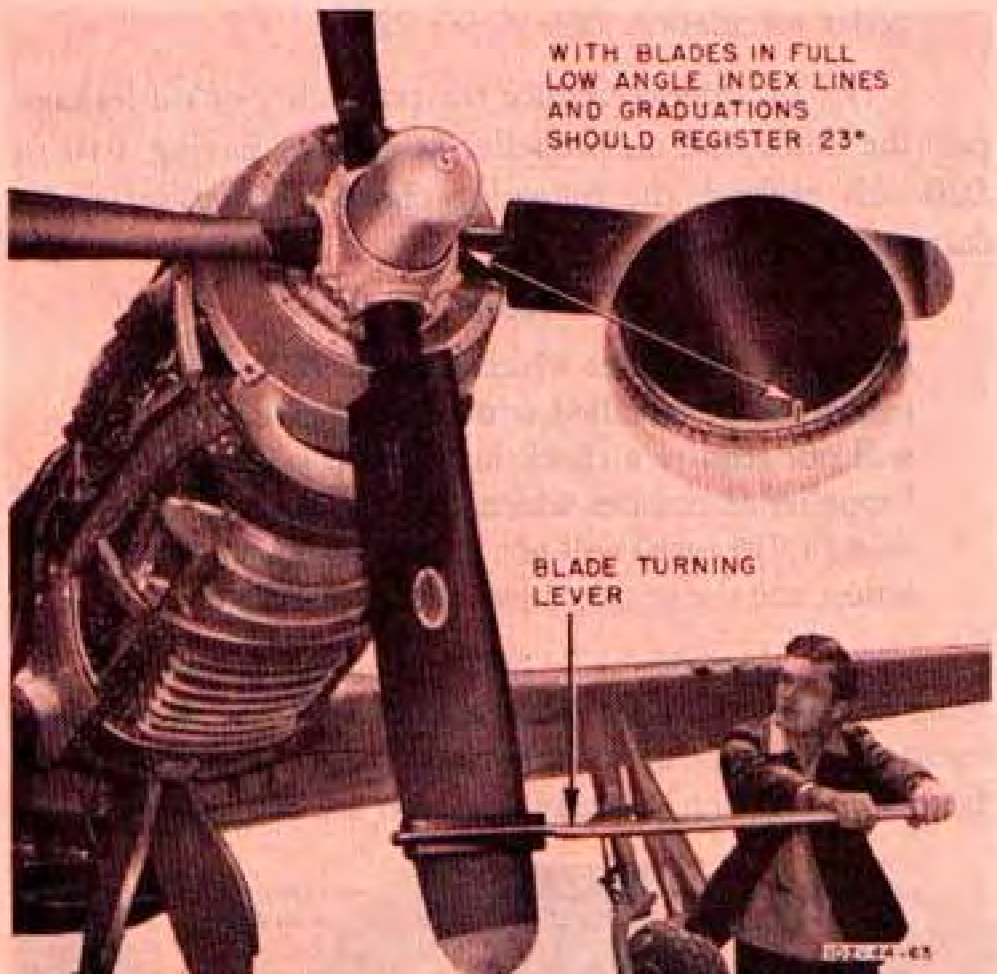



***Figure 233—Turning Blades to Low Pitch (Hamilton Standard)***

*(u)* Turn propeller blades into full low angle *(figure 233)* and check all four blade angles by the index lines on the blades and the graduations on the barrel, or with a protractor. These angles must be equal and must agree with the low-angle stop setting (23 degrees). This check indicates that the correct relationship between the blade gears and the cam gear has been obtained.

*(v)* Clean the spinner front section centering ring bushing and dome trunnion thoroughly; then apply a coat of grease, Specification No. AN-G-3 (low-temperature lubricant). *(See figure 234.)* This will prevent corrosion and seiz-

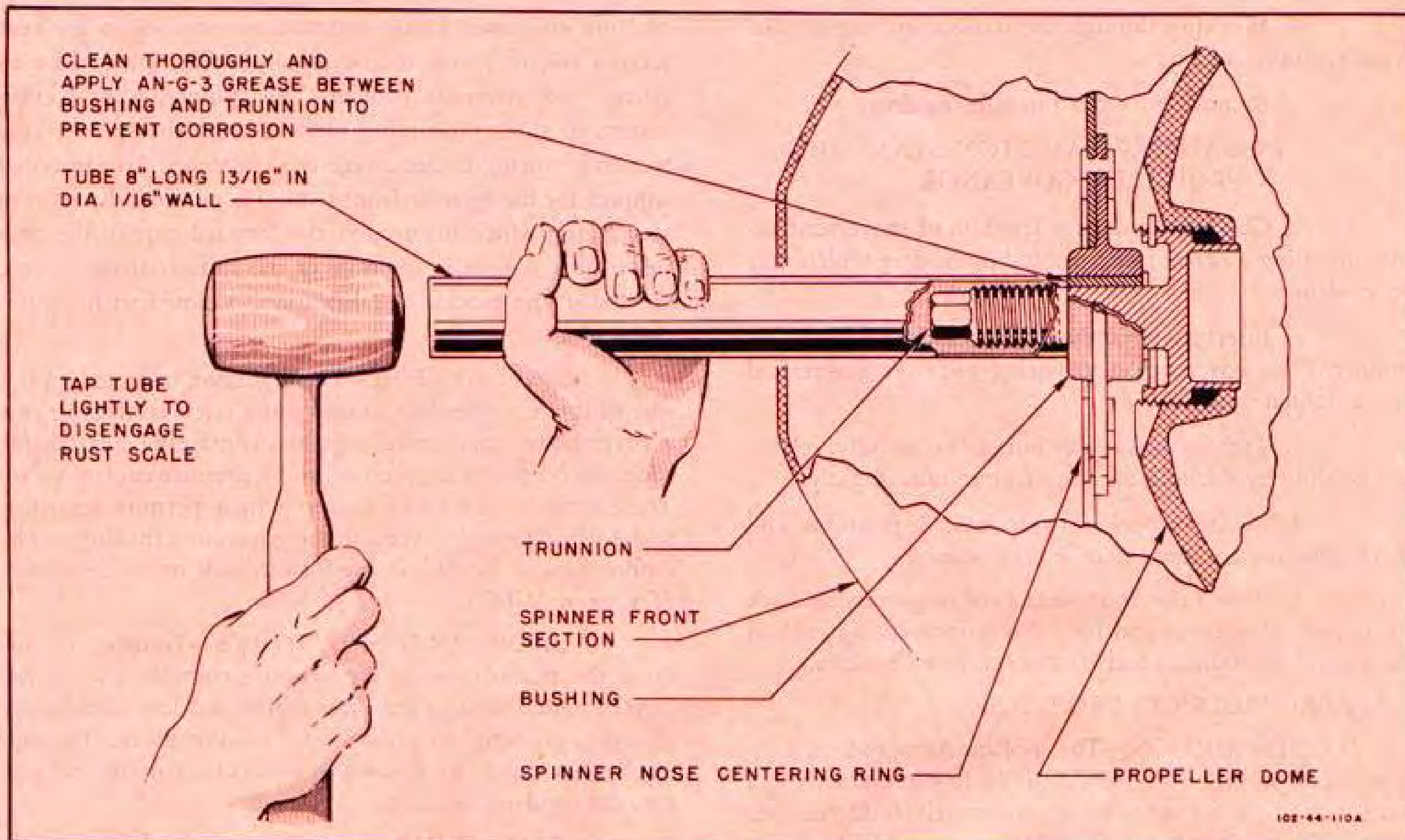



***Figure 234—Loosening Spinner From Trunnion (Hamilton Standard)***

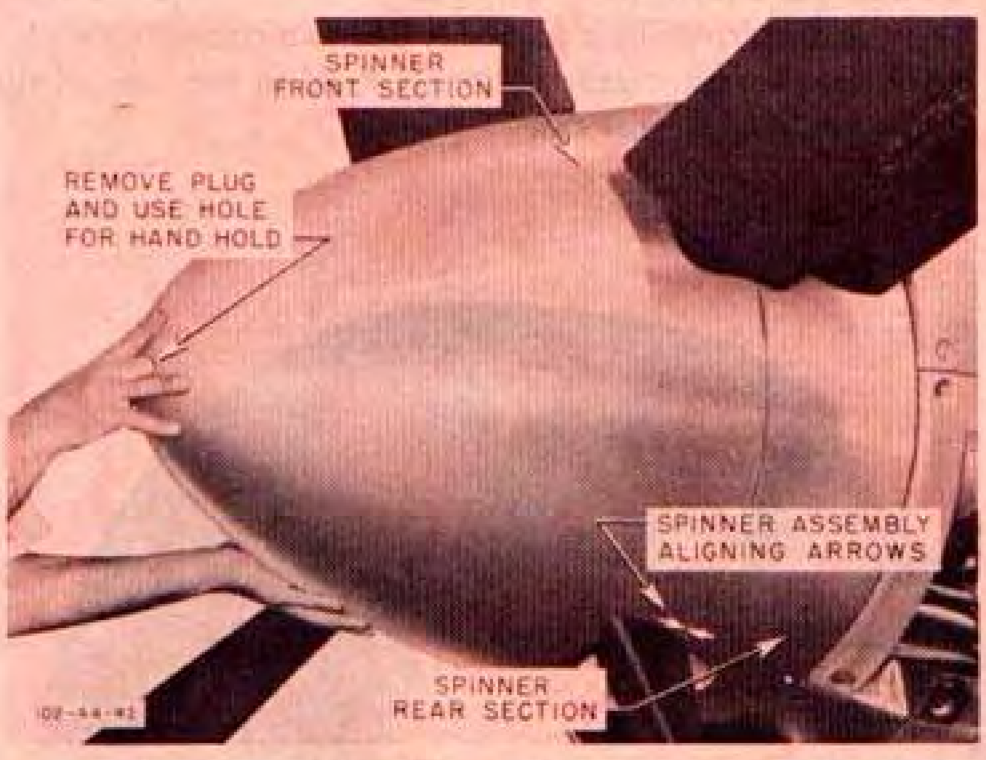



***Figure 235—Installing Spinner Front Section (Hamilton Standard)***

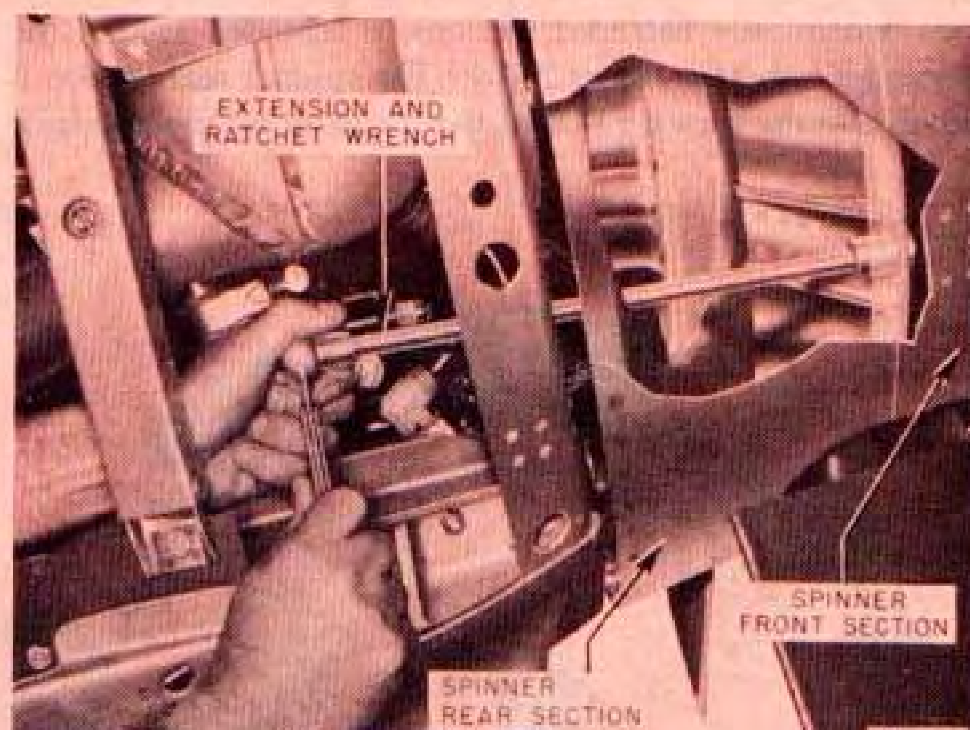



***Figure 236—Tightening Spinner Front Section Retainer Nut (Hamilton Standard)***

ure of the spinner, and facilitate removal of the spinner front section. Fit spinner front section to spinner rear section so that their respective studs and holes coincide, and the small arrows around the blade cutouts are matched. *(See figure 235.)* Tighten nuts by inserting wrench through aperture between right-hand cowling formers and engine; turn propeller after each nut is installed and tightened, and the next stud comes into view and is accessible. *(See figure 236.)*

(4) HAMILTON STANDARD PROPELLER GOVERNOR.

*(a)* DESCRIPTION.—A Type 4G10-G21D Hamilton Standard governor is mounted on a pad at the left-hand forward side of the engine.

*(b)* REMOVING HAMILTON STANDARD PROPELLER GOVERNOR.

*1.* Remove left top and side cowl panels, and disconnect control rod from the governor.

*2.* Remove the rear mounting stud nuts.

*3.* Remove the small access door from the propeller spinner; line up the aperture with the governor by turning propeller.

*4.* Working through the access door, remove the front mounting stud nuts.

*5.* Remove governor through the door.

*(c)* INSTALLING HAMILTON STANDARD PROPELLER GOVERNOR.

*1.* Check governor for freedom of movement before installing. Correct cause of binding or drag which may be evident.

*2.* Insert governor through access door in propeller spinner. Place governor on mounting pad over gasket, and finger-tighten nuts.

*3.* Tighten nuts evenly but not excessively; relieve any binding by slacking off one or more nuts slightly.

*4.* Rotate propeller to at least 3 positions and check governor for movement at each point.

*5.* Attach governor control rod to governor. Check for proper adjustment and for 3/16 to 1/4-inch spring-back at the control quadrant in full "INCREASE RPM" position.

*b.* AEROPRODUCTS PROPELLER.

(1) DESCRIPTION.—The 4-blade Aeroproducts constant-speed propeller (A-542-A1) is 11 feet in diameter and has a rate-of-pitch change of approximately 6 degrees per second. The blades (A-20-156-24M) are set at a 28.8-degree angle in low pitch and 58.8-degree angle in high pitch. *(See figure 236B.)* A streamlined fairing spinner, consisting of two dynamically balanced sections, is installed around the propeller hub. *(See figure 236A.)* The spinner rear section is secured to the forward side of the regulator by the regulator housing and cover bolts. A dzus-fastened door in the rear section affords access to the regulator filler plug, vacuum pump, and governor control. The spinner front section fastens to studs protruding forward from the spinner rear section by spring-loaded swage-type fasteners. An additional support for the spinner front section is provided by its centering ring which fits around the forward part of the propeller hub. A hole in the nose of the spinner front section, created in the process of fabrication, is closed with a butadiene plug.

*(a)* REGULATOR.—The regulator, mounted on the rear of the propeller hub, consists of a circular housing and a cover bolted and sealed together, containing oil transfer tubes, an oil pump, a governor, and a pressure control valve. The regulator cover has a plug which permits servicing with oil and provides access to the governor adjusting screw. A filter plug is located on the forward side of the regulator. *(See figure 236C.)*

*1.* OIL TRANSFER TUBES.—Transfer of oil from the pump through the pressure control valve to the governor, and then to the proper high and low blade angle changing ports for each hub socket, is accomplished through steel tubes which are formed in a circular pattern and cast into the regulator housing.

*2.* OIL PUMP.—The oil pump supplies the regulator system with a continuous working pressure up to 1200 pounds per square inch. The pump rotates with the regulator, and is driven by a planetary gear which meshes with a stationary regulator gear indirectly fixed to the nose of the engine reduction gear case.

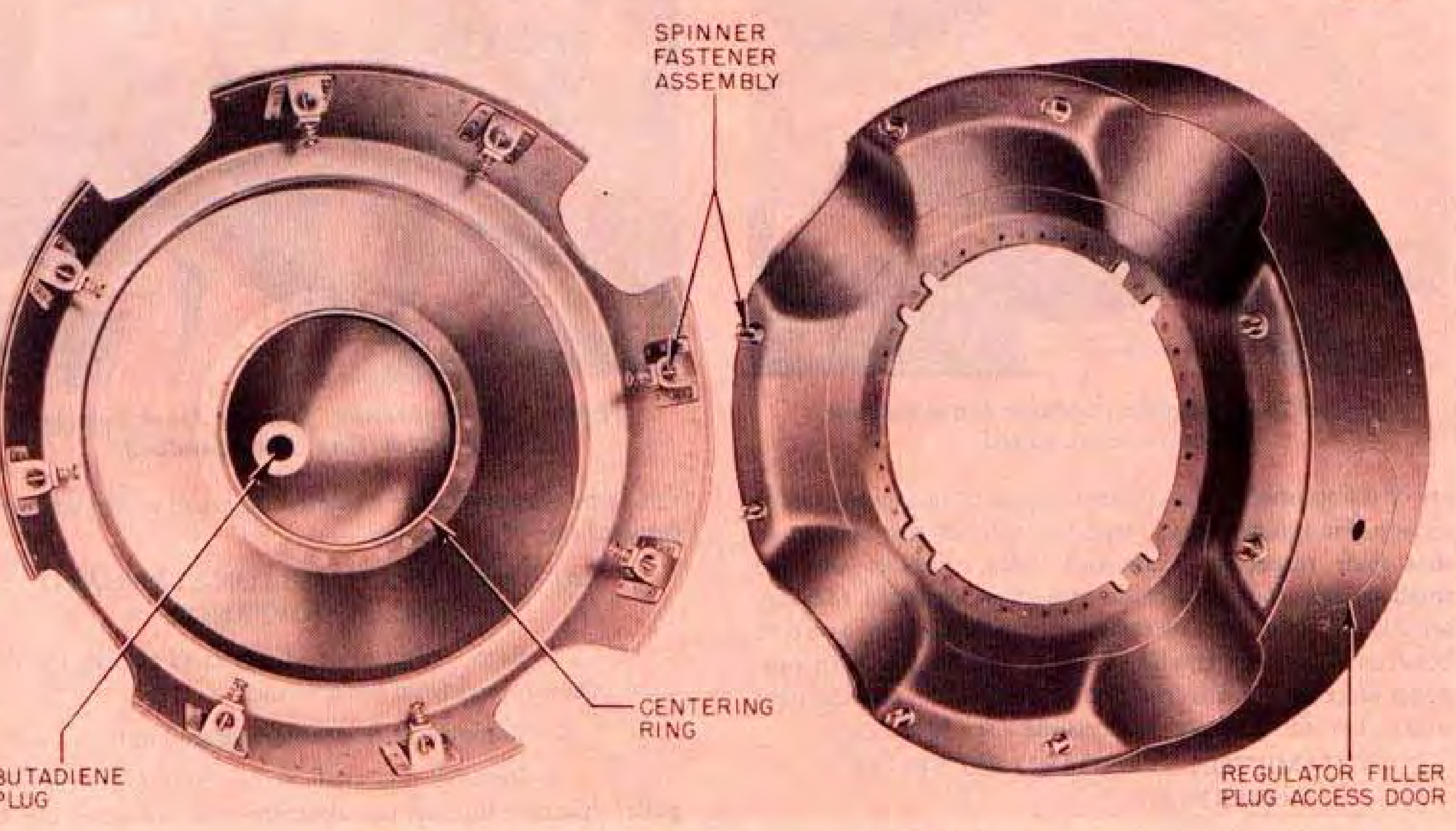



***Figure 236A—Aeroproducts Propeller Spinner Assembly***

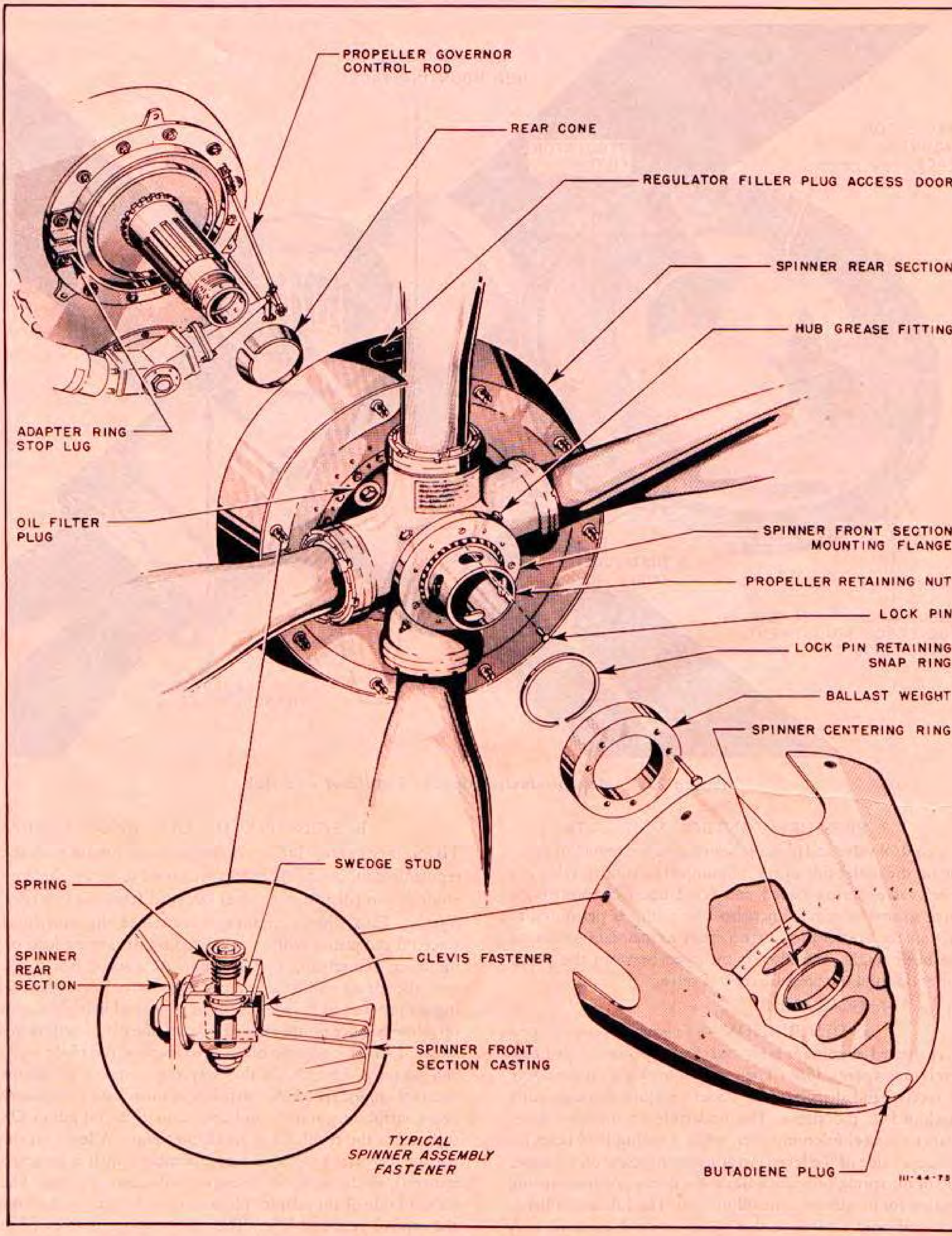



*Figure 236B—Propeller Installation (Aeroproducts)*


**Figure 236C—Aeroproducts Propeller Regulator and Hub**

3. PRESSURE CONTROL VALVE.—The pressure control valve and filter are fastened to the regulator housing on the outlet side of the oil pump. The control valve is a relief valve, spring-loaded and acted upon by centrifugal force so that as rpm is increased the pump is permitted to provide the greater pressure necessary to maintain or change the blade angle. The filter is mounted between the pump outlet line and the pressure control valve.

4. GOVERNOR.

a. DESCRIPTION.—The governor consists of a steel sleeved aluminum body and a steel piston hinged to a lever. *(See figure 236D.)* The piston moves within the sleeve to receive and distribute oil under pressure through ports machined in the sleeve. The underside of the steel lever bears on a steel fulcrum roller, while a spring load bears on the upper side of the lever. An adjustment screw on the outer end of the spring provides adjustment of the governor spring tension for maximum controlling rpm. The fulcrum roller is mounted onto a carriage that slides on steel guideways. A curved steel shoe which fits in the groove of the control ring extends from the underside of the carriage.

b. PRINCIPLE OF GOVERNOR OPERATION. *(See figure 236F.)*—As the governor rotates with the regulator unit, centrifugal force will tend to throw the governor piston (distributor valve) outward from the center of rotation. Thus, when a certain rpm is attained, the centrifugal force on the piston will be equalized by the spring load on the lever, neutralizing the governor. At a speed below this rpm, the spring will force the piston to move inward, allowing oil pressure to reduce the blade angle and bring the rpm up to the balance point; above this rpm, the piston will move outward, distributing the oil so as to increase the blade angle and decrease the rpm. In this way the governor maintains constant engine speed. A control mechanism and a stationary gear control the governor and operation of the oil pump. On the rear of the regulator is an adapter plate. A lever on the rear of the plate engages a stop assembly which is attached indirectly to the studs on the engine reduction gear case. The forward side of the adapter plate acts as a bearing surface for the control gear and lever. The adapter plate is screwed to the adapter ring and regulator gear to form a stationary assembly. The cockpit propeller control rod is attached to the control gear lever. When the control gear lever is moved, three interconnecting screws rotate and impart a fore-and-aft movement to the control ring in which the governor shoe rides.

*(b)* HUB ASSEMBLY.—The propeller hub contains the torque units in each hub socket and has oil transfer tubes for transferring oil under pressure to and from the regulator and the torque units. The hub contains four segment blade gears and one master gear. Each segment gear is doweled to a blade butt, and all four gears mesh with the master gear to coordinate the movement of all four blades. A spinner mounting flange on the front of the hub has a series of slots on its inner surface. These slots accommodate the lockpin and snap ring which lock the propeller retainer nut. The outer surface of the mounting flange supports the spinner front section at its centering ring. A circular ballast weight, attached to the front of the hub, compensates for the difference in weight between the Aeroproducts propeller and the Hamilton Standard propeller for which the airplane was designed.

*(c)* TORQUE UNITS.—The torque units consist of a steel fixed spline, a bronze piston, and a steel blade cylinder. The fixed spline is attached to the hub by a fixed hollow spline bolt that extends outward through the piston head, providing an oil passage to the outer side of the piston. An offset hole at the base of the fixed spline permits passage of oil to or from the inner side of the piston. The torque unit mechanism converts oil pressure into turning action. *(See figure 236F.)*

*(d)* BLADE ASSEMBLIES.—The blades are of hollow steel construction incorporating a longitudinal strengthening rib. The blade is composed of two members: the thrust member and the camber sheet which are brazed together. The internal surfaces of the blades are rustproofed and hermetically sealed. Each blade has a balancing cup within the shank having lead added to give uniform vertical and horizontal balance. *This lead should never be tampered with in service.* Balance washers may be mounted on a stud in the center of the blade balance cup, making possible a final balance of blades and hub in the field. *(See figure 236E.)* Each blade is retained in the hub socket by a blade retaining nut, a stack of ball bearings, and a blade nut. The blade nut holds the stack bearings onto the blade shank, while the blade retaining nut faces against the stack bearings, and screws into the hub socket, holding the entire blade assembly in place. Turning action on the blades is accomplished through four steel dowels that are pressed into the blade butt. These dowels mount in dowel holes in the torque unit in each blade hub socket. One dowel hole is offset so that the blade will fit in one way only.

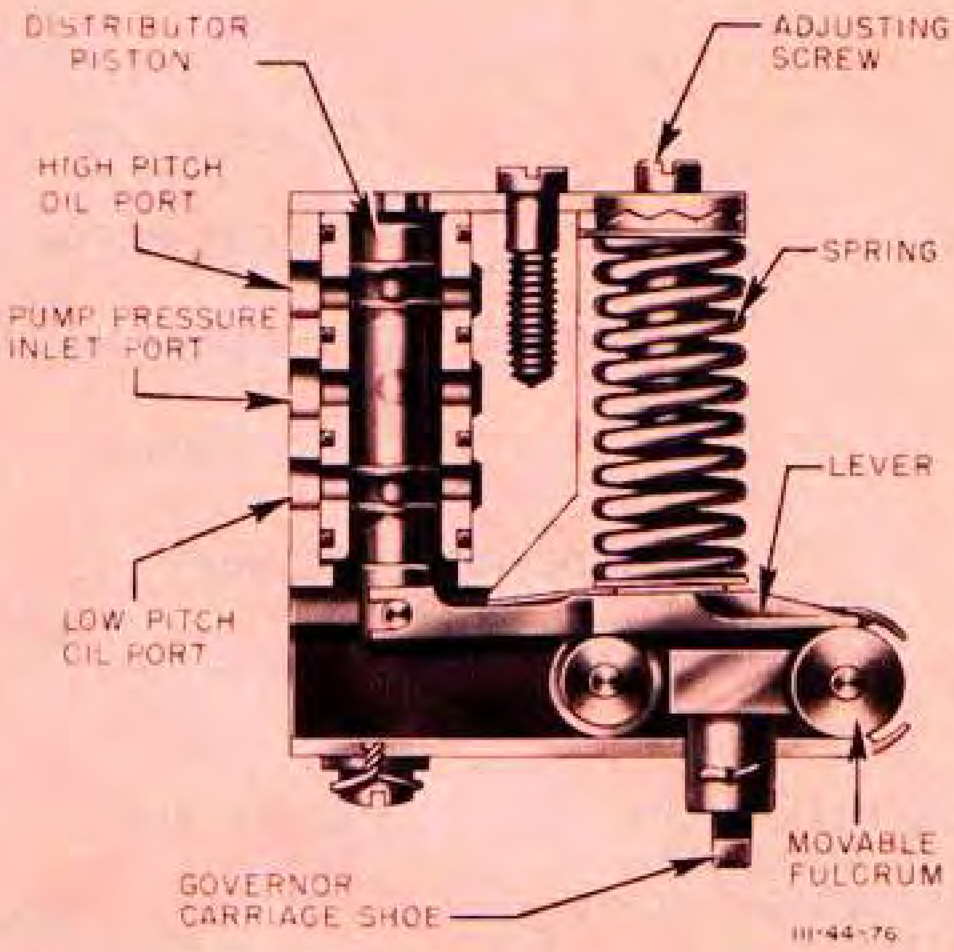



**Figure 236D—Aeroproducts Propeller Governor**


**Figure 236E—Aeroproducts Propeller Blade Details**

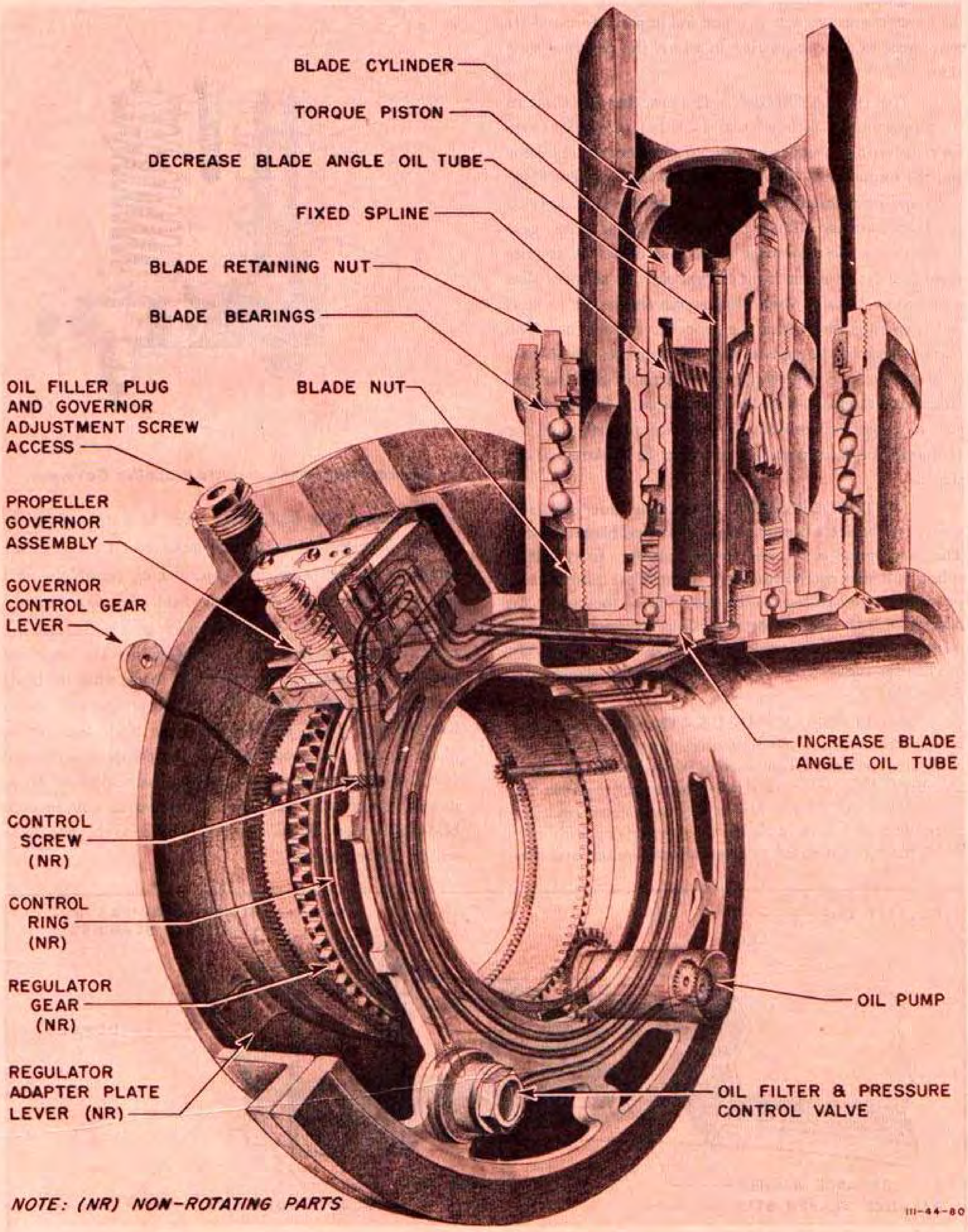



*Figure 236F—Operation of Aeroproducts Propeller*

(2) AEROPRODUCTS PROPELLER TROUBLE SHOOTING.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Incorrect maximum governing rpm.** | Regulator oil supply at improper level. | Establish proper level at half-full. |
| | Insufficient regulator control lever travel. | Disconnect control rod from regulator control lever and move the lever to "INCREASE RPM." Move cockpit control lever to "INCREASE RPM" position. The control rod should move approximately ⅛ inch beyond the regulator control lever to provide for proper linkage spring-back. |
| | Tachometer reading incorrect. | Repair or replace tachometer. |
| | Propeller governor improperly adjusted. | Adjust governor. |
| **Sluggish propeller response or hunting condition.** | Regulator oil supply at improper level. | Establish proper level. |
| | Clogged regulator oil filter cartridge. | Clean or replace the regulator filter cartridge. |
| | Clogged governor filter screen. | Replace the governor filter screen or disassemble and clean the regulator. |
| | Blown gaskets or seals; loose screws. | Replace oil pump if necessary. Replace oil pump seal, governor gasket, and pressure control valve gasket, if damaged. Tighten loose screws. |
| **Failure to change pitch.** | Regulator oil supply at improper level. | Establish proper level. |
| | Lack of oil pressure. | Clean or replace governor and control valve screens. Replace oil pump if drive shaft is sheared. |
| **Stiff cockpit controls.** | Control rods jammed or bound by foreign matter or heavy oil. | Clean control linkage, control bellcranks, and fairleads. |
| | Cocked control screw binding regulator control lever. | Remove rear adapter plate and control lever arm. Tighten the three control screws evenly, and reassemble. |
| **Oil in hub bore, or inside of propeller shaft.** | Leak at fixed spline gasket due to warped hub socket island boss. | Lap island with fine lapping compound and check with surface block, using Prussian blue. |
| | Propeller shaft oil passage plug leaking. | Tighten or replace plug. |
| **Oil on back side of spinner rear section.** | Loose regulator cover screws or damaged cover outer seal. | Tighten cover screws. Replace cover outer seal. |
| | Transfer seals leaking. | Replace transfer seals between hub and regulator. |
| **Oil on regulator cover, around adapter plate, in anti-icer slinger ring, or on back side of spinner rear section.** | Propeller shaft thrust bearing seal leaking. | Replace seal. |
| | Regulator oil level too high. | Drain out oil to half-full level. |
| | Regulator housing or cover seals damaged. | Replace regulator housing seal and cover seal. |
| | Adapter gasket damaged. | Replace gasket. |
| | Control screw packing or seal damaged. | Replace packing or seal. |
| | Loose regulator filler plug washer or filter seal. | Replace washers; tighten plug and filter. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Leakage when propeller is stationary, but not in flight.** | Regulator housing and cover seals not seating. Seals worn. | Replace seals. |
| **Rough operation, excessive vibration.** | Loose propeller shaft nut. | Tighten nut. |
| | Propeller unbalanced. | Balance propeller. |
| | Blades out of track. Improper blade angle setting. | Replace bent or damaged blades. Correct blade setting. |

(3) REMOVING AEROPRODUCTS PROPELLER.

*(a)* Loosen the swage-fastener nuts supporting the spinner front section to the rear section.

*(b)* Remove the spinner front section by rapping carefully on the reinforced part of the spinner with the palm of the hand only, to disengage it from the spinner rear section.

*(c)* Disconnect the propeller control rod from the regulator control lever located on the upper rear side of the regulator. This point may be reached through a dzus-fastened access door on the spinner rear section.

*(d)* Turn the propeller until the regulator oil filler plug points downward.

*(e)* Remove propeller retaining nut snap ring and lockring. (These rings prevent the retainer nut from turning.)

*(f)* Attach slings to the two upper propeller blades as close to the hub as is practicable. Put a light strain on the hoist to relieve the propeller weight from the shaft.

*(g)* Using the special retainer nut wrench, turn propeller retainer nut counterclockwise until it is clear of the shaft threads.

**Note**

The propeller front cone, retaining nut, and the snap ring which retains the nut in the hub are located inside the propeller hub, aft of the master gear; the hub is retained by a plate bolted to its face. This arrangement makes it unnecessary to remove the propeller retaining nut and related parts from the hub prior to removing the propeller from the shaft. As the retaining nut is backed off, it pulls the propeller with it until the nut reaches the end of threaded portion of the shaft.

*(h)* Using extreme care to prevent damaging the hub splines and shaft, slide the propeller forward until it is clear of the shaft; use the hoist as required to maintain clearance.

*(i)* Remove the rear cone from the propeller shaft, and cover shaft with oiled cloth to prevent dirt collecting.

*(j)* If the propeller assembly is to be disassembled after removal, remove the regulator filler plug, with a one-inch socket wrench, drain oil from regulator, and replace plug and washer.

*(k)* Supporting the free blades, carefully lower the propeller to a bench or other support with the regulator side up.

*(l)* Remove the spinner rear section. To do so, it is necessary first to remove the regulator unit from the hub, as explained in paragraph 10. *c.* (4) *(b)* *1.* through *5.*

*(m)* Remove the regulator cover bolts and nuts, and lift the spinner rear section from the regulator.

*(n)* Replace the cover bolts and nuts, adding washers with each bolt to compensate for the removal of the spinner rear section.

*(o)* Clean the spinner front and rear sections and inspect for cracks or damage. As the spinner assembly is dynamically balanced when manufactured, it is advisable to tie the spinner front and rear sections together for future use.

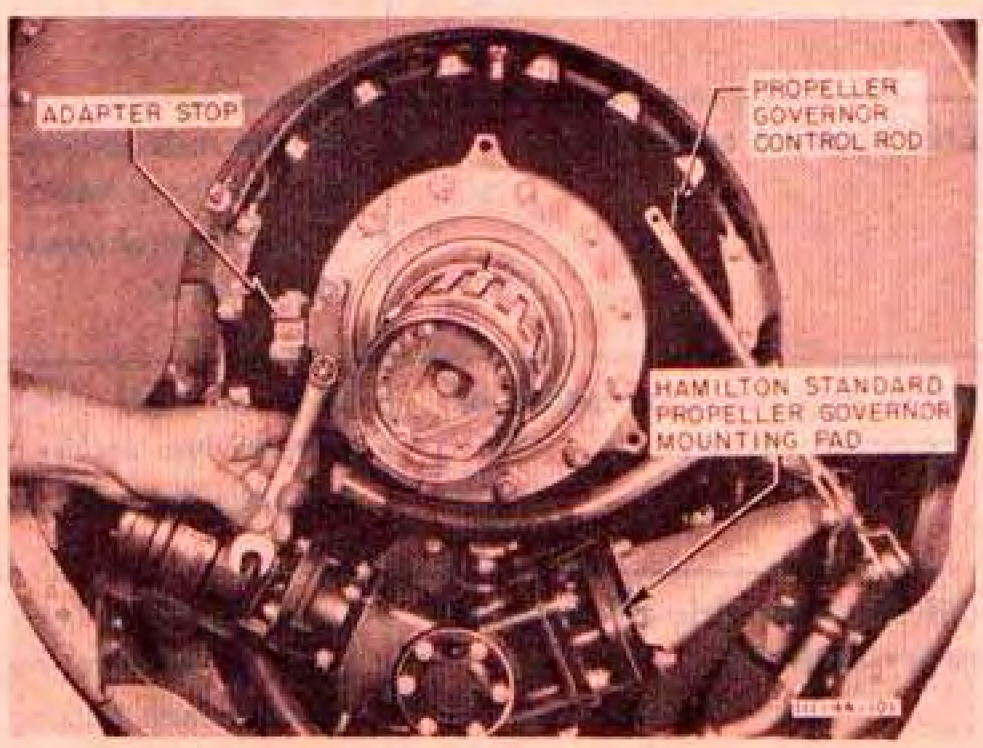



***Figure 236G—Installing Adapter Ring Stop***

(4) INSTALLING AEROPRODUCTS PROPELLER.

*(a)* Install and safety the adapter ring stop on the two studs of the engine-reduction-gear case thrust plate as shown in figure 236G.

*(b)* Remove the regulator from the propeller hub, and install the spinner rear section as follows:

*1.* Insert the special regulator nut wrench in the center of the regulator so as to engage the dovetail lobes of the wrench with the slots in the regulator nut. Then insert a 2-foot bar through the holes in the wrench.

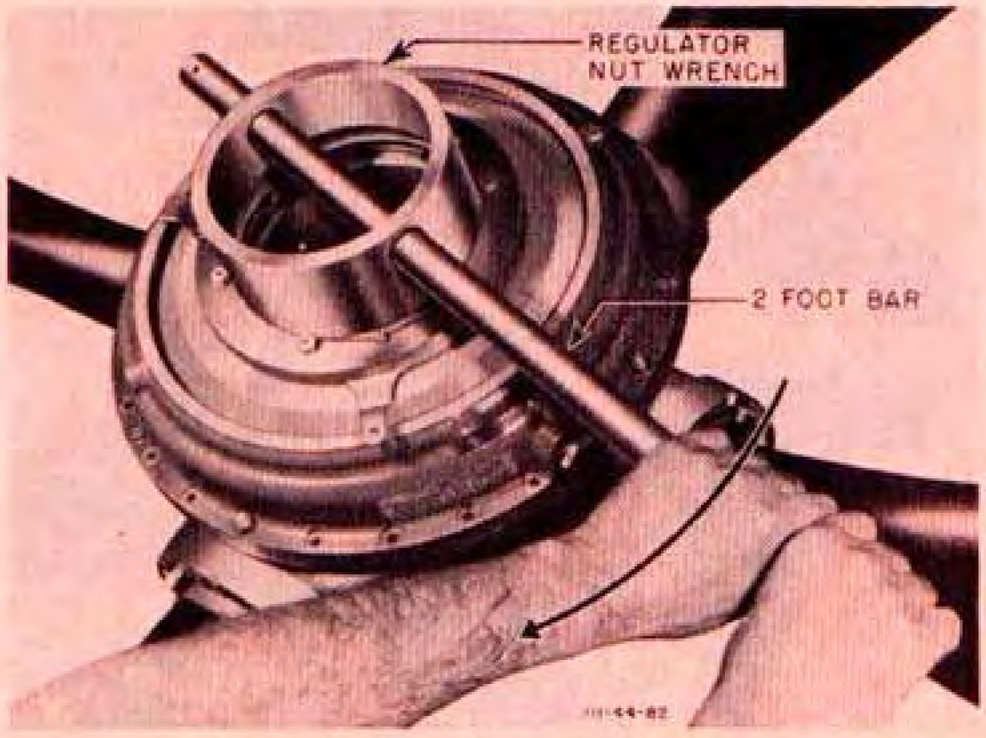



***Figure 236H—Loosening Regulator Retaining Nut (Aeroproducts)***

2. As the regulator nut has a left-hand thread, turn the wrench clockwise to loosen. *(See figure 236H.)* Lift out the regulator nut when free. *(See figure 236I.)*

**CAUTION**

Hold the wrench tightly in the nut to prevent burring the nut.

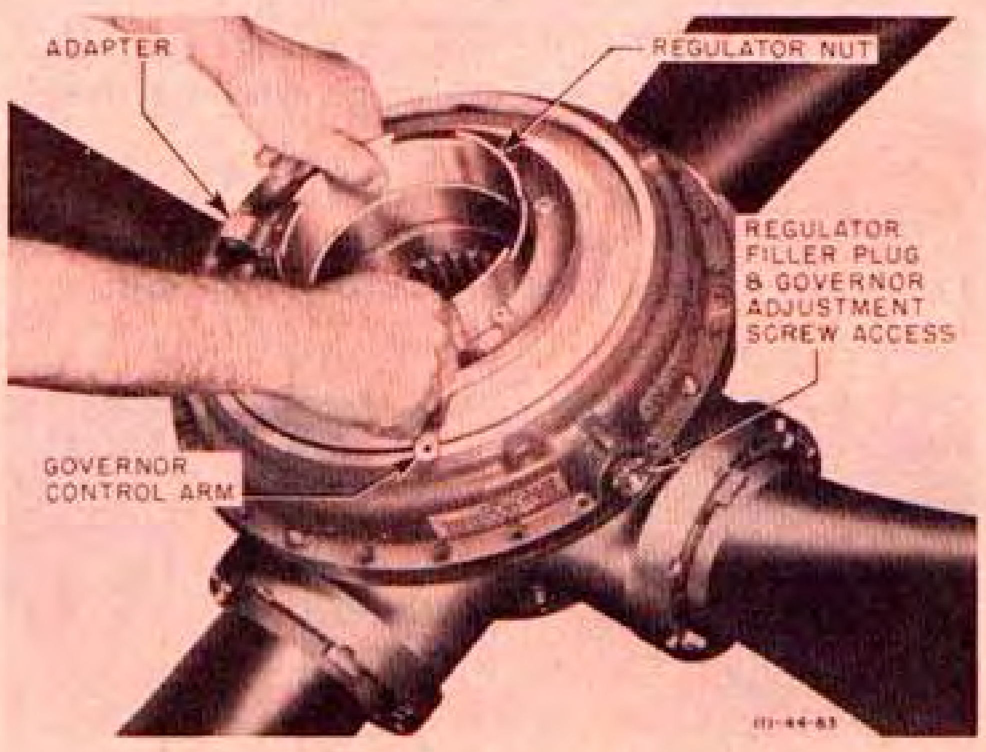



***Figure 236I—Removing Regulator Retaining Nut (Aeroproducts)***

3. Lift the regulator from the hub by hand. *(See figure 236J.)* The regulator is closely fitted to the hub and will bind if cocked or tilted. If binding occurs, tap back in place with a soft-faced mallet before lifting again. Do not pry the regulator from the hub.

4. Remove the oil transfer seals from the face of the hub.

5. Seal the regulator and hub oil transfer holes with masking tape to keep out dirt.


***Figure 236J—Removing Regulator From Hub (Aeroproducts)***

*(c)* Remove the regulator cover nuts and bolts, and install spinner rear section on the regulator, lining up the regulator filler plug and the dzus-fastened access door of the spinner rear section. Reinstall and tighten the regulator cover nuts and bolts, moving from one nut to another in a diametrically opposite position to draw the regulator cover down evenly. *(See figure 236K.)*

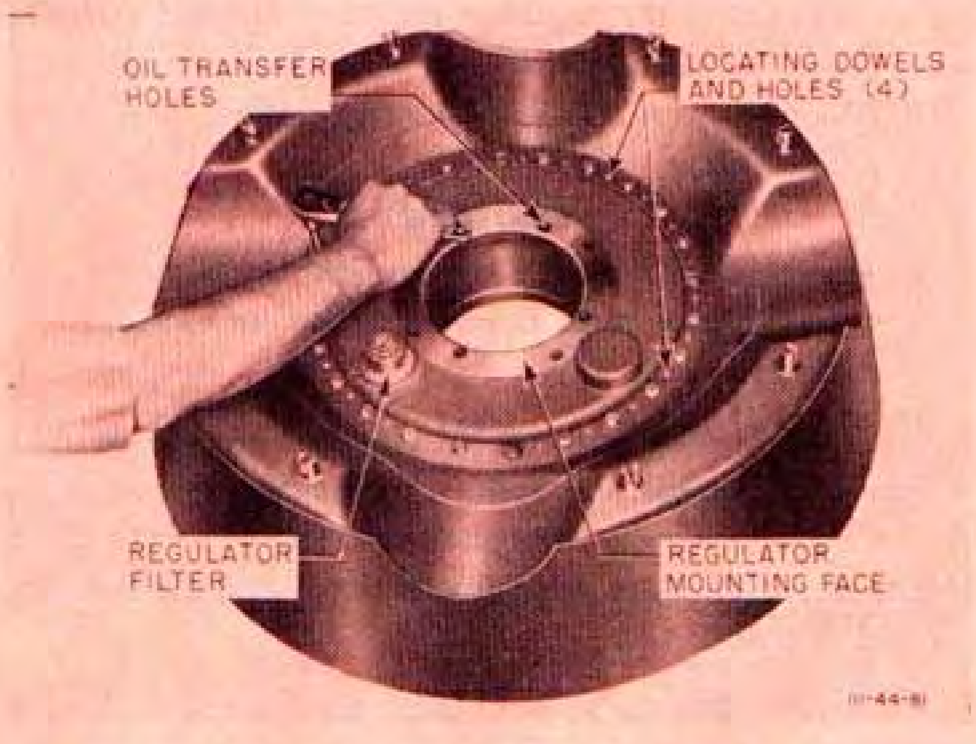



***Figure 236K—Installing Spinner Rear Section to Regulator (Aeroproducts)***

*(d)* Clean the regulator mounting face, nut threads, and regulator nut face with a lint-free cloth.

*(e)* Clean the regulator mounting face on the propeller hub.

*(f)* Apply a light coating of thin antiseize compound to the threads of the regulator nut.

*(g)* Insert the oil transfer seals into the countersunk ports of the hub.

*(h)* Using the hands only, start the regulator on the propeller hub, locating the proper dowels.

**Note**

The regulator bore is a close fit to the hub and care must be taken when assembling to prevent cocking and binding of the regulator.

*(i)* Tap the regulator into position with a soft-faced mallet.

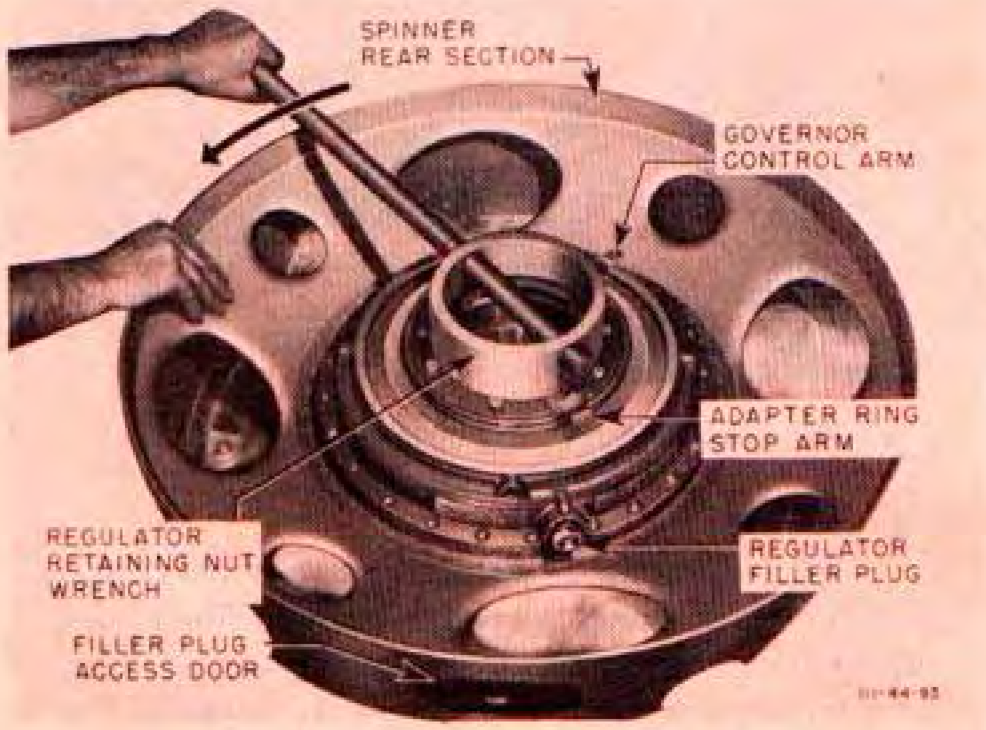



***Figure 236L—Tightening Regulator Retaining Nut (Aeroproducts)***

*(j)* Insert the regulator retaining nut and start the threads on by hand. Using special regulator nut wrench and 2-foot bar, turn the nut counterclockwise until tight. *(See figure 236L.)*

**CAUTION**

The regulator nut has a left-hand thread. Hold the wrench firmly in the dovetails of the nut to avoid damage.

*(k)* Check that thrust plate nuts on engine are tight. Clean shaft threads and splines thoroughly, removing all nicks, burrs, and galls from shaft and face of thrust plate. Make careful check to determine if threads on the shaft are burred or pulled.

*(l)* Rotate the shaft to bring the wide spline to the bottom.

*(m)* Install the rear cone clean and dry. Do not apply grease or oil. Install the felt insert in the rear cone split. *(See figure 236M.)*

*(n)* Apply a light coat of clean engine oil to the propeller shaft.

*(o)* Clean the propeller hub bore thoroughly. All grease or antirust compounds must be removed completely from the propeller and the bore wiped dry.

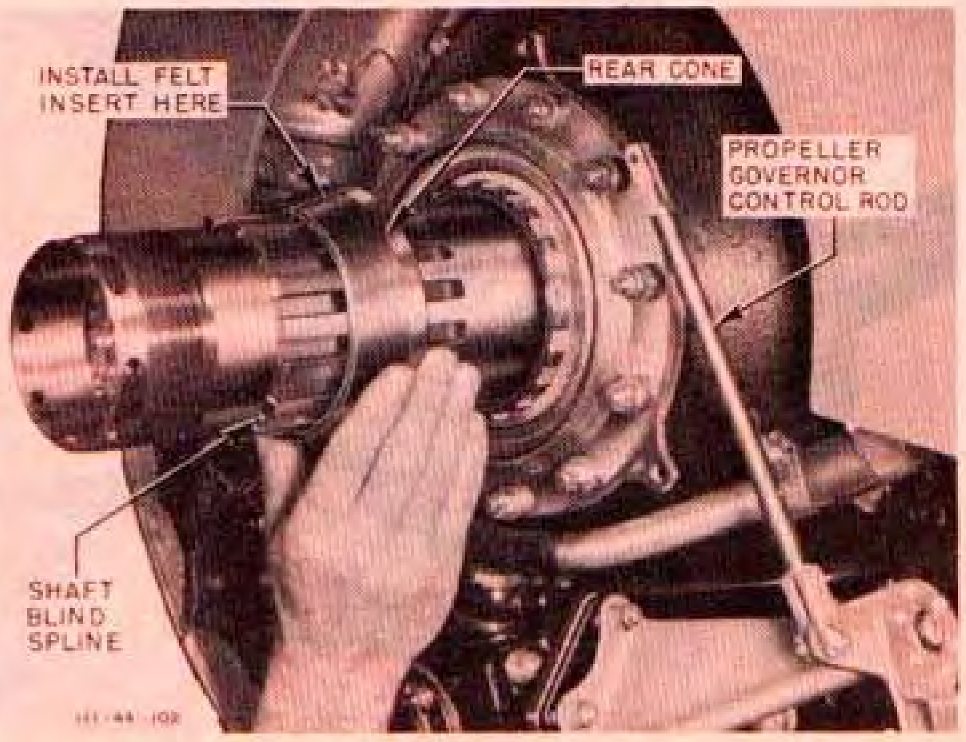



***Figure 236M—Installing Rear Cone (Aeroproducts)***

*(p)* Attach the slings to the two blades opposite the wide spline of the propeller hub. Keep the slings as close to the hub as is practicable.

**CAUTION**

See that there is clearance between the sling and the spinner rear section, thereby avoiding damage when the hoist is raised.

*(q)* Raise the propeller, manually supporting the free blades, and align the wide spline of the hub with the blind spline of the propeller shaft. Cautiously slide the propeller on the shaft until the propeller retainer nut engages the threads. Take care not to damage either the threads, splines, or cones.

*(r)* Thread the propeller retainer nut onto the shaft as far as possible by hand and until it has been determined that the retainer nut is threading correctly to the shaft.

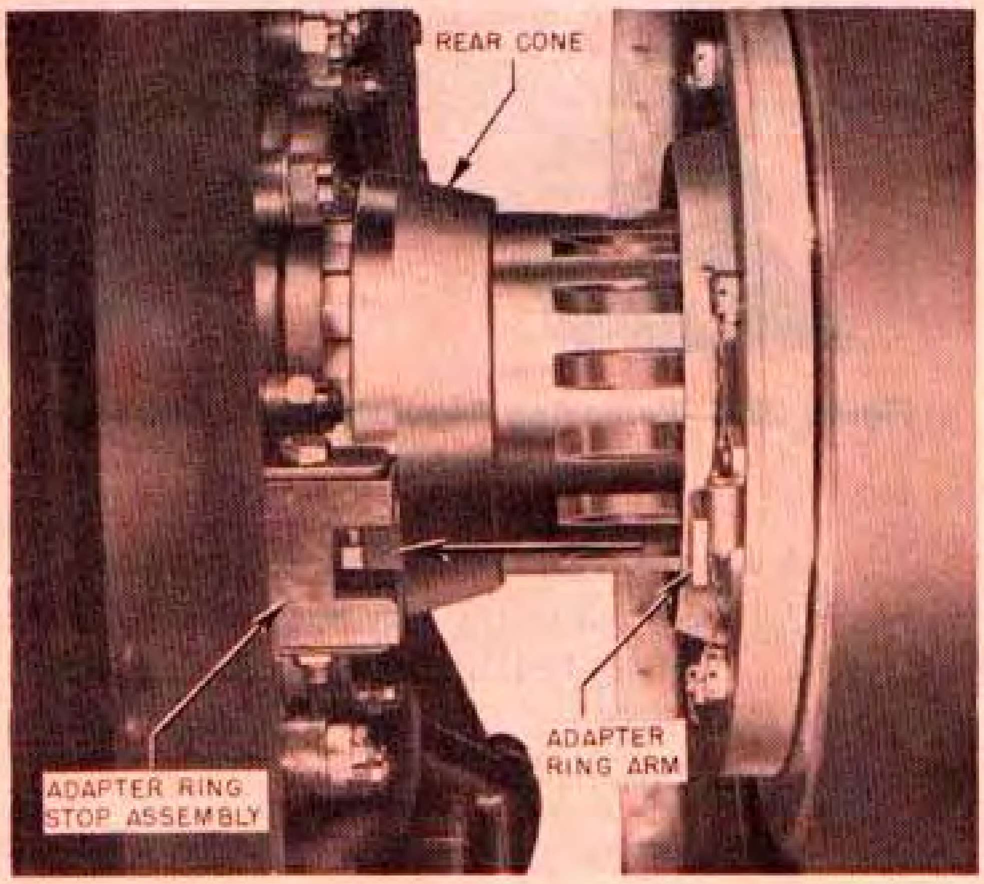



***Figure 236N—Aligning Adapter Ring With Stop (Aeroproducts)***

*(s)* Align the adapter plate lever with the stop slot on the thrust plate on the engine as shown in figure 236N.

*(t)* Using a four-foot bar, continue tightening the propeller shaft nut, making sure the adapter lever and stop line up until the propeller is solidly against the rear cone.

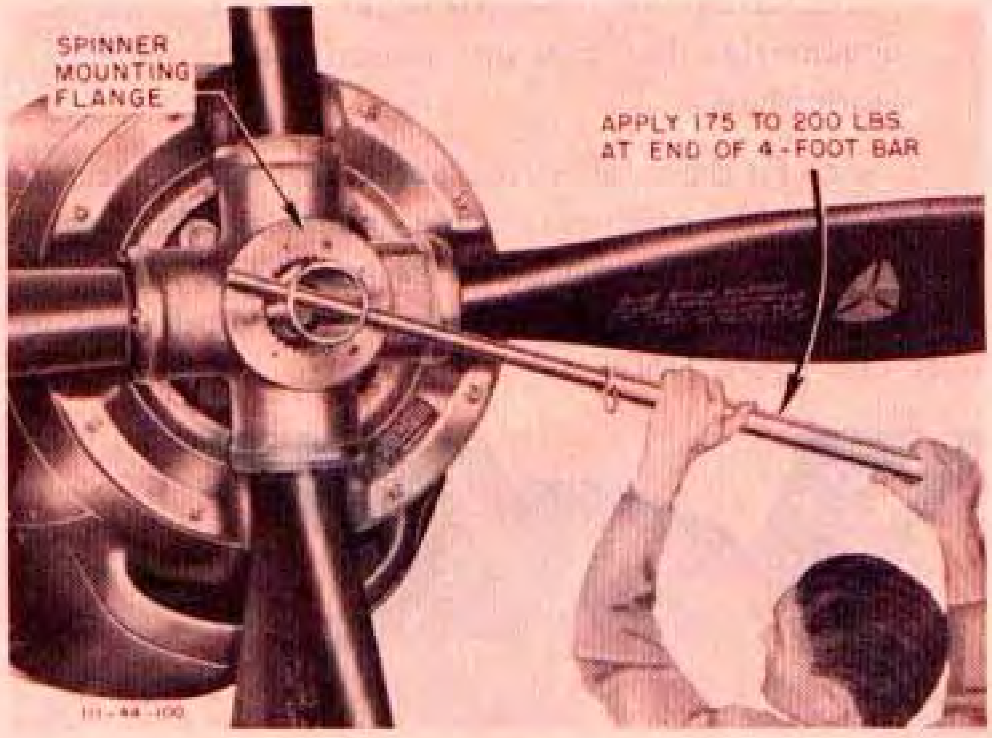



***Figure 236O—Tightening Propeller Retaining Nut (Aeroproducts)***

*(u)* Remove the hoist slings from the propeller; then while blocking one blade, tighten the propeller shaft nut, applying 175 to 200 pounds of weight at the end of the four-foot bar in the wrench as shown in figure 236O.

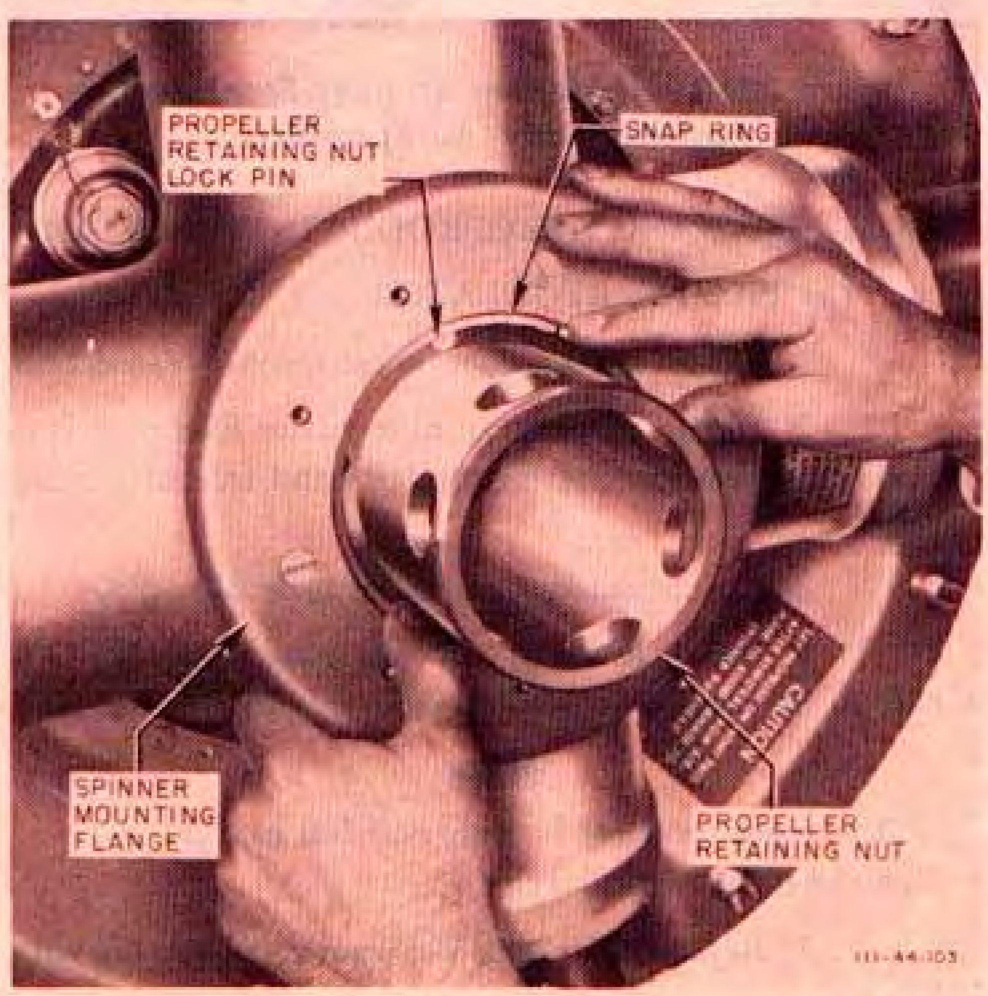



***Figure 236P—Installing Lockpin and Snap Ring (Aeroproducts)***

*(v)* Install the retainer nut lockpin in one of the aligned holes. Install snap ring over the lockpin *(figure 236P)*; then install the circular ballast weight to the hub with the six bolts. Safety the bolts with lockwire as shown in figure 236Q.

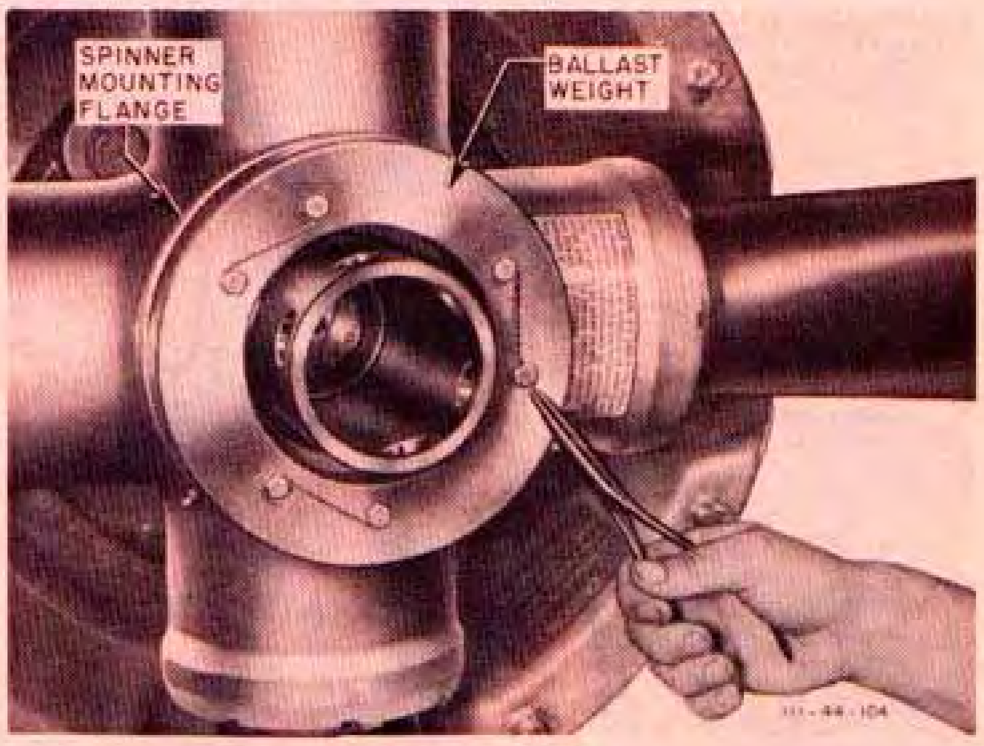



***Figure 236Q—Safetying Ballast Weight Retaining Bolts (Aeroproducts)***

*(w)* Connect control rod to regulator control arm *(figure 236R)* and operate control to determine that full travel is obtained.

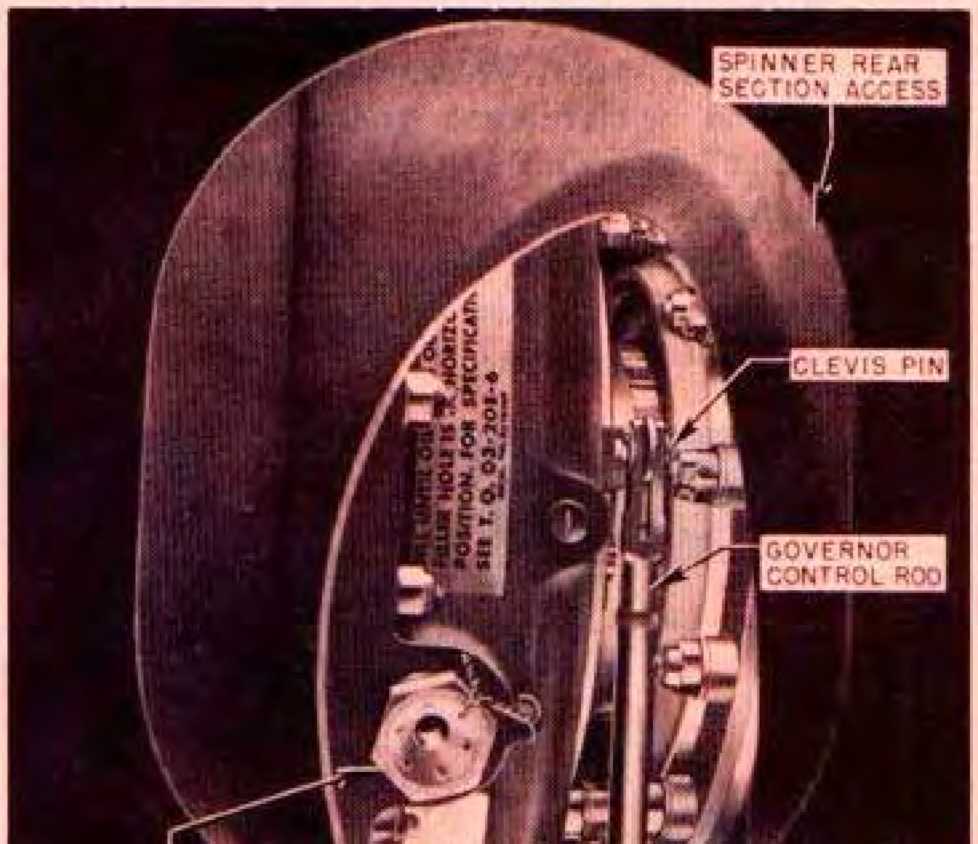



***Figure 236R—Control Rod Connected to Governor Control Arm (Aeroproducts)***

*(x)* Rotate the propeller until the regulator filler plug hole is in a horizontal position on the left-hand side of the airplane. Fill the regulator with clean AN-O-3, Grade L oil (Specification No. Y3587) until half-full. *(See figure 236S.)* Replace filler plug and washer. Safety with .032 wire.

*(y)* Lubricate the new or overhauled propeller hub as follows:

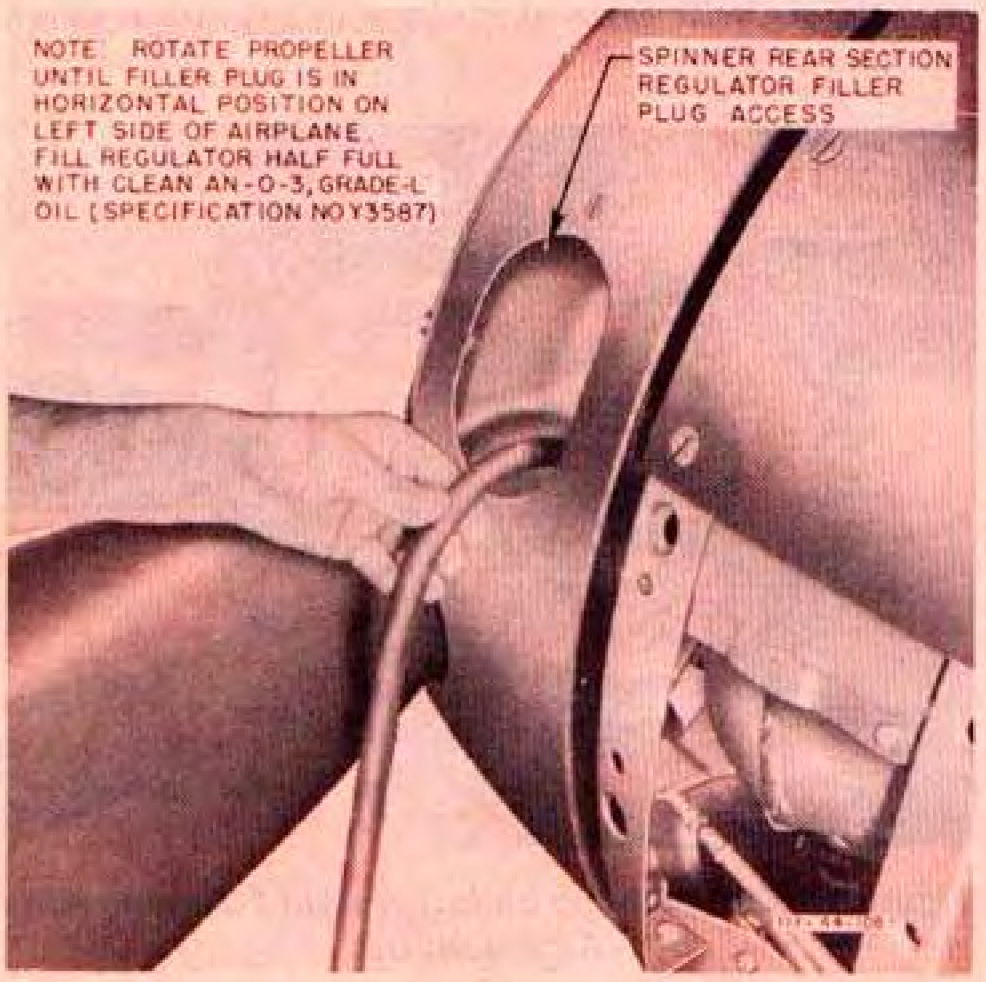



***Figure 236S—Filling Regulator (Aeroproducts)***

**Note**

Do not remove the lubricator relief valve fitting during this operation.

*1.* Insert special bleeder tool between the blade retainer nut and the blade shank, being careful not to damage the retaining nut seals. This is done to bleed the air in the hub while greasing.

*2.* Apply pressure with grease gun on hub fitting until grease appears at bleeder tool. Use grease (Specification No. AN-G-4, Grade AA).

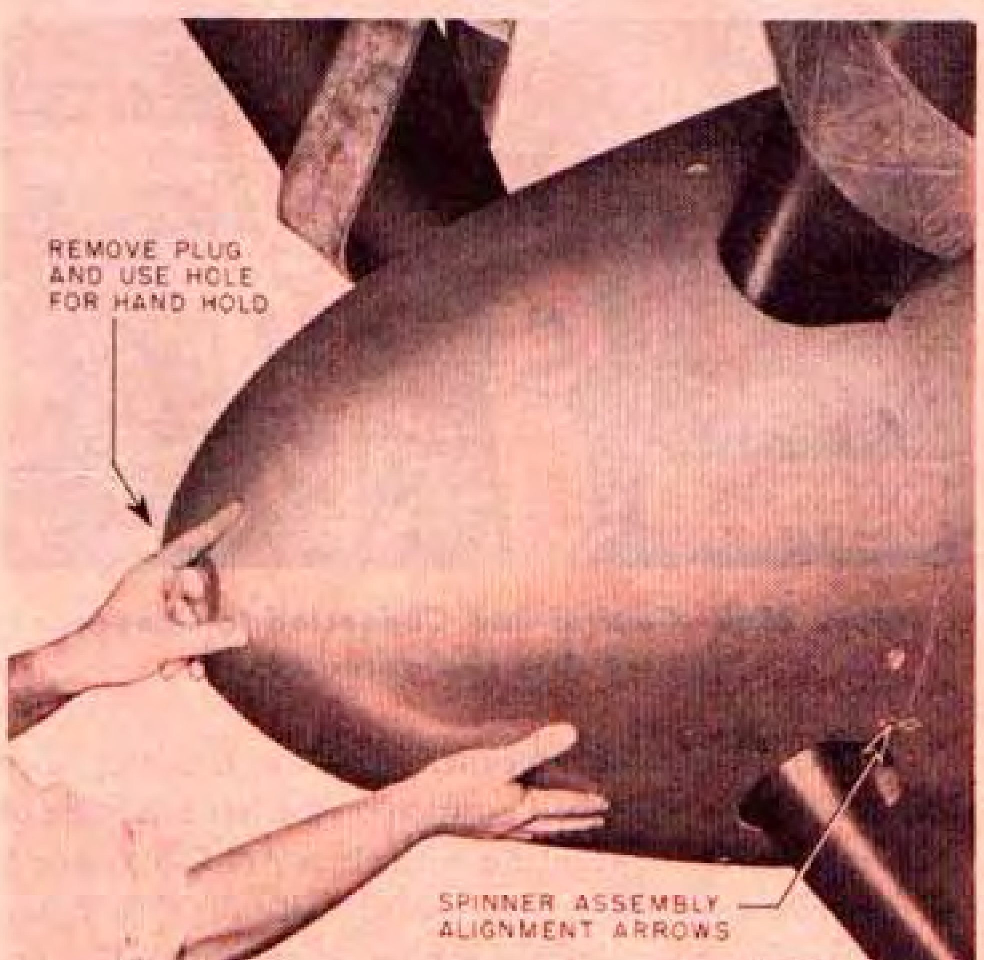



***Figure 236T—Installing Spinner Front Section (Aeroproducts)***

*3.* Repeat procedure at each fitting and hub socket.

**Note**

For regular refill lubrication the bleeder tool is not required; it is used only when lubricating a propeller for the first time. Air is bled from the hub by removing the grease fittings during subsequent lubrications.

*(z)* Fit the spinner front section to the rear section so that the studs and holes coincide, and the small arrows on the blade cutouts are matched. *(See figure 236T.)* Tap the spinner into place with hands only. Tighten all the locking nuts. *(See figure 236U.)*

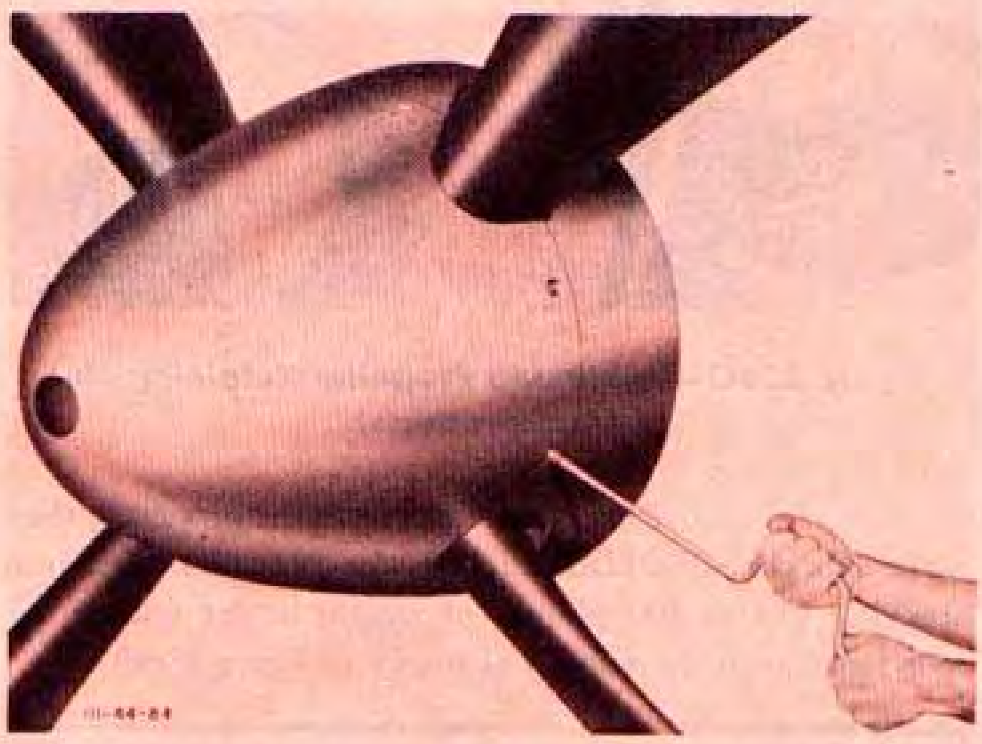


***Figure 236U—Tightening Spinner Front Section Fastener Nuts (Aeroproducts)***

(5) SERVICING AEROPRODUCTS PROPELLER.

*(a)* FILLING REGULATOR.

*1.* Remove access door on the spinner rear section.

*2.* Rotate propeller until regulator filler plug is in a horizontal position and on the left-hand side of the airplane.

*3.* Cut the safety wire and remove filler plug.

*4.* Pour clean oil (Specification No. AN-O-3, Grade L) into regulator until oil is level with the filler hole.

**Note**

The regulator must be only half-full of fluid and maintained at this level.

*5.* Replace filler plug and washer. Safety plug with .032 wire.

*6.* Replace the access door on spinner rear section.

*(b)* LUBRICATING HUB.

*1.* Remove spinner front section.

*2.* Remove the two upper grease fittings of the hub. Do not remove the lubricator relief fitting.

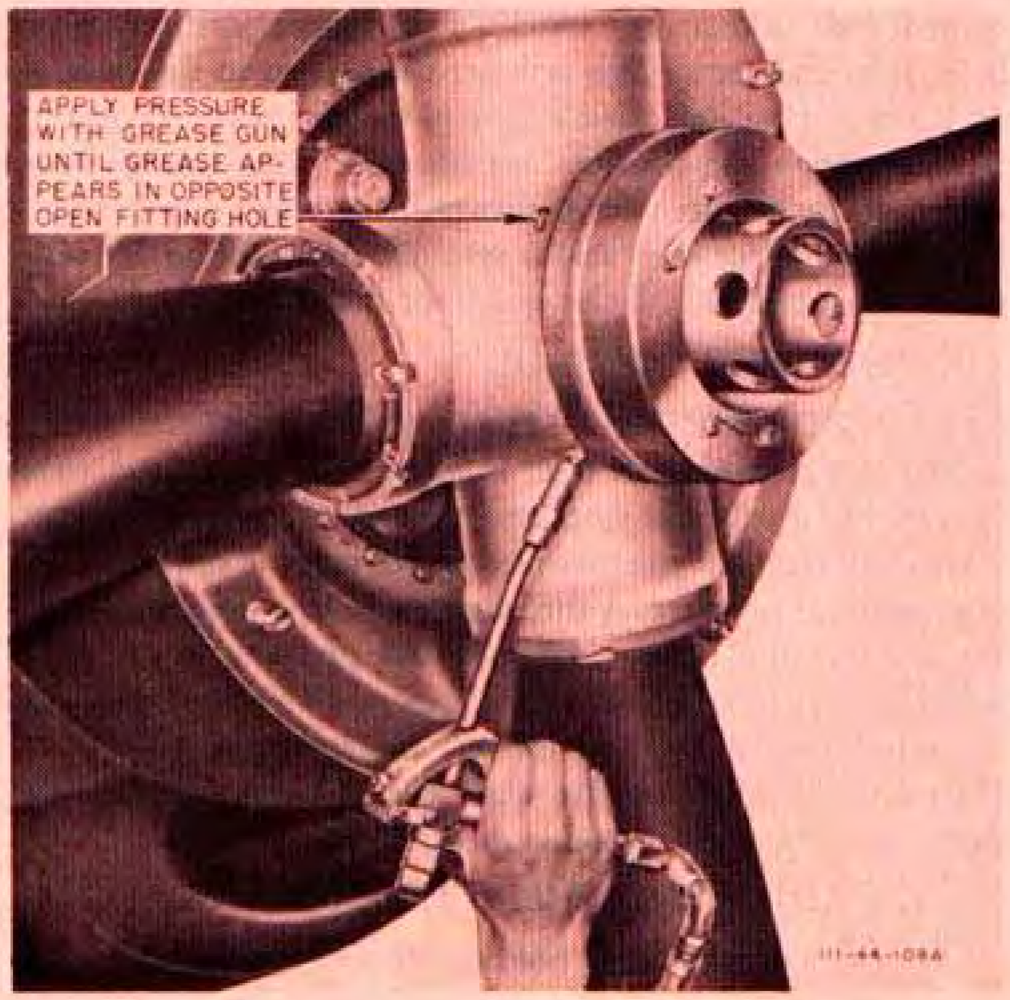



***Figure 236V—Greasing Propeller Hub (Aeroproducts)***

*3.* Using grease (Specification No. AN-G-4, Grade AA), place grease gun on one of the remaining grease fittings and apply pressure until grease appears at one of the open fitting holes. *(See figure 236V.)*

*4.* Reinstall the fitting in the holes where the grease appears.

*5.* Apply grease gun to that fitting until grease appears at the remaining fitting hole.

*6.* Reinstall remaining grease fitting.

*7.* Reinstall spinner front section.

(6) TESTING NEW OR OVERHAULED AEROPRODUCTS PROPELLER AFTER INSTALLATION.

*(a)* BLEEDING AEROPRODUCTS PROPELLER OIL SYSTEM.—Prior to ground run-up and flight test, it is necessary to purge air from the hydraulic system of the propeller as follows:

*1.* Move propeller control to full "INCREASE RPM" and start engine.

*2.* Advance throttle until an engine speed of approximately 2300 rpm is reached.

*3.* While adjusting the throttle to maintain a constant manifold pressure, pull the propeller control lever to full "DECREASE RPM."

*4.* Move the propeller control lever back to full "INCREASE RPM," maintaining manifold pressure.

*5.* Follow bleeding procedure through 3 cycles, and the propeller may then be considered as satisfactorily purged of air.

*6.* Stop engine and check regulator for proper oil level. Replenish supply if necessary.

**Note**

Prior to every flight, it is advisable to make the following functional check of the propeller. With the propeller control at full "INCREASE RPM," set throttle control to give 2300 rpm; then move the propeller control back to give a 300 rpm drop, and then forward to full "INCREASE RPM."

*(b)* CHECKING AEROPRODUCTS PROPELLER GOVERNOR ADJUSTMENT.—Before flight, test the governor to make sure it is properly adjusted for maximum rpm as follows:

*1.* Securely harness the airplane.

*2.* Move the propeller governor control lever to full "INCREASE RPM" and start the engine.

*3.* Open the throttle until 2800 rpm is indicated by the tachometer.

*4.* Closely observe the tachometer; then advance the throttle rapidly and note that the rpm increases slightly beyond 3000 rpm, and then settles back and remains at 3000

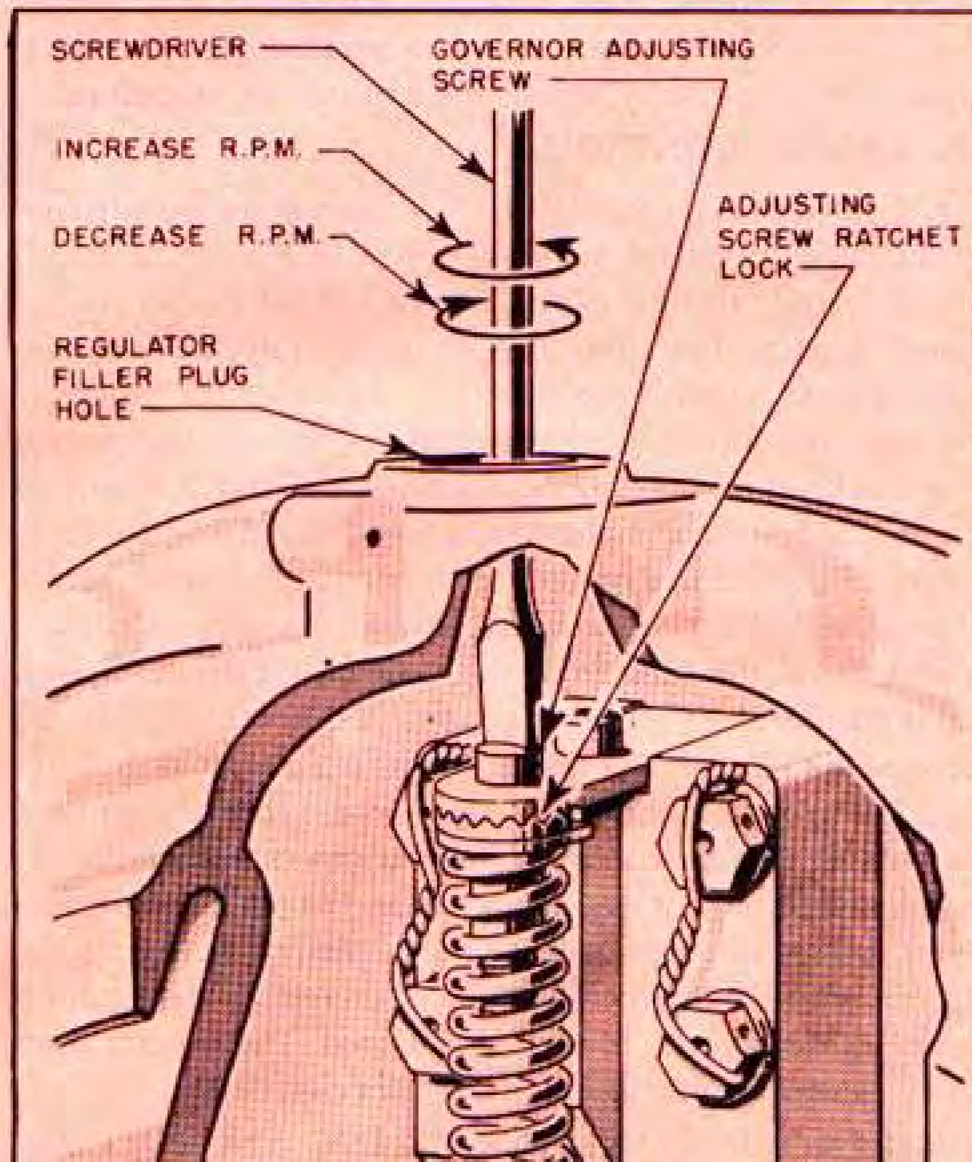



***Figure 236W—Adjusting Propeller Governor***

rpm. This indicates that the governor is properly adjusted. *Do not hold throttle fully open for longer than 5 or 6 seconds.* If the tachometer does not settle back and remain at 3000 rpm, the governor must be adjusted.

*(c)* ADJUSTING AEROPRODUCTS PROPELLER GOVERNOR.—The maximum rpm of the engine may be changed by an adjustment of the governor spring *(figure 236W)*, accessible through the filler plug access door on the spinner assembly and the filler plug hole in the regulator cover.

**Note**

Turn propeller by hand until the filler plug is well above the centerline of the regulator to prevent oil spilling out when the plug is removed.

*1.* Cut lockwire and remove the filler plug.

*2.* Turn the adjusting screw clockwise with a screwdriver to decrease the rpm, or counterclockwise to increase the rpm. One notch will give a change of approximately 15 to 20 engine rpm.

*3.* Replace filler plug, and safety.

*4.* Start engine and note maximum rpm. If further adjustment is necessary, repeat the adjustment procedure.

### 11. ENGINE CONTROLS.

*a.* GENERAL DESCRIPTION.—The engine is controlled by the cockpit control quadrant levers which are interconnected by rods, flexible cables, and bellcranks to their corresponding units. The control quadrant is equipped with two friction locks, one for the throttle and one for the propeller and mixture controls. On later airplanes, the throttle control lever has been changed to incorporate a twist-grip handle to operate the K-14 gun sight. *(See figure 238.)* A control shaft *(figure 237)*, mounted on the rear supercharger casing, serves as an intermediate connection between the cockpit control quadrant and the linkage to the magnetos, carburetor, and manifold pressure (boost) regulator. A differential unit, incorporated in the control shaft, permits the manifold pressure regulator to operate the carburetor throttles independently of the cockpit throttle control for variations corresponding to changes in altitude or engine speeds, and to obtain war emergency rating. Linkage on the control shaft connecting the throttle with the magnetos advances or retards the ignition timing as the throttle is opened or closed. The supercharger clutch control is automatic and operates electrically.

*b.* REMOVING AND INSTALLING ENGINE CONTROLS.—When removing the engine control rods and bellcranks, tag or mark each part to establish its location in the airplane. This will save considerable time when the control rods are reinstalled. To replace broken control quadrant discs or springs, refer to figure 238 for the correct order of assembly. The control quadrant may be removed or installed as a unit. When assembling control quadrant, coat the levers, discs, and spacers with a thin film of grease, Specification No. AN-G-3. When the quadrant is assembled and secured to the upper longeron, connect throttle, mixture, and propeller controls, making certain the controls have full travel and do not bind. Before making a final adjustment of the control system, check to determine that control quadrant, control arms, and bellcrank have full travel without binding. Rig control rods so that they assume a 90-degree position to the bellcranks and arms. This will set the system in the neutral or halfway position, which will give maximum travel obtainable when the controls are operated. The control rods may then be adjusted from this point to meet any particular adjustment for the various systems. After the adjustment is accomplished, install the quadrant name plate.

*c.* THROTTLE CONTROL.

(1) DESCRIPTION.—The throttle control lever is connected to a control shaft built integral with the engine. *(See figure 239.)* A throttle stop assembly on the upper longeron allows full travel of the throttle control lever to obtain 67 in. Hg manifold pressure. A throttle gate on the longeron stops the lever at the 61 in. Hg manifold pressure position. A safety wire is installed across the gate at this position and as the gate is passed to obtain the war emergency rating (67 in. Hg manifold pressure), the wire will be broken, indicating that 61 in. Hg manifold pressure has been exceeded.

(2) ADJUSTING THROTTLE CONTROL.

*(a)* Loosen screws holding throttle lever stop.

*(b)* Move throttle lever toward the full closed position, allow 1/16 to 1/4 inch between throttle lever and guide on longeron for spring-back, and then lock in this position.

*(c)* Set carburetor throttle arm against the closed position stop.

*(d)* Adjust the throttle control rod until it can be attached to the engine control shaft throttle arm without moving the arm or the throttle lever from its previous position.

*(e)* Loosen lock and operate throttle lever. Make any adjustment required to obtain a spring-back of 1/16 to 1/4 inch at fully closed position end of travel, by shortening or lengthening the throttle rod between the firewall and the engine control shaft. If still further adjustment is required, adjust the length of the rod between the throttle lever in the cockpit and the firewall.

*(f)* Operate the controls several times to make sure the rods do not bind at any point of their travel.

*(g)* Tighten all nuts and bolts on the rods, and safety with cotter pins where cotter pin holes are provided. Move throttle lever to full open position; then check that full throw has been obtained at carburetor.

*(h)* Start engine and advance throttle lever until 61 in. Hg manifold pressure at 3000 rpm is obtained.

**CAUTION**

Do not start engine until it is known that all other controls and carburetor settings are correctly set and adjusted.

*(i)* Set throttle assembly stop so that its shoulder is against the throttle lever; then tighten screws locking the stop to the longeron. Stop the engine.

*(j)* Loosen the screws holding the sliding upper plate of the stop. Deflect throttle lever inboard past the stop shoulder, and move lever into the U-shaped slot of the stop until full travel of the throttle lever is reached.

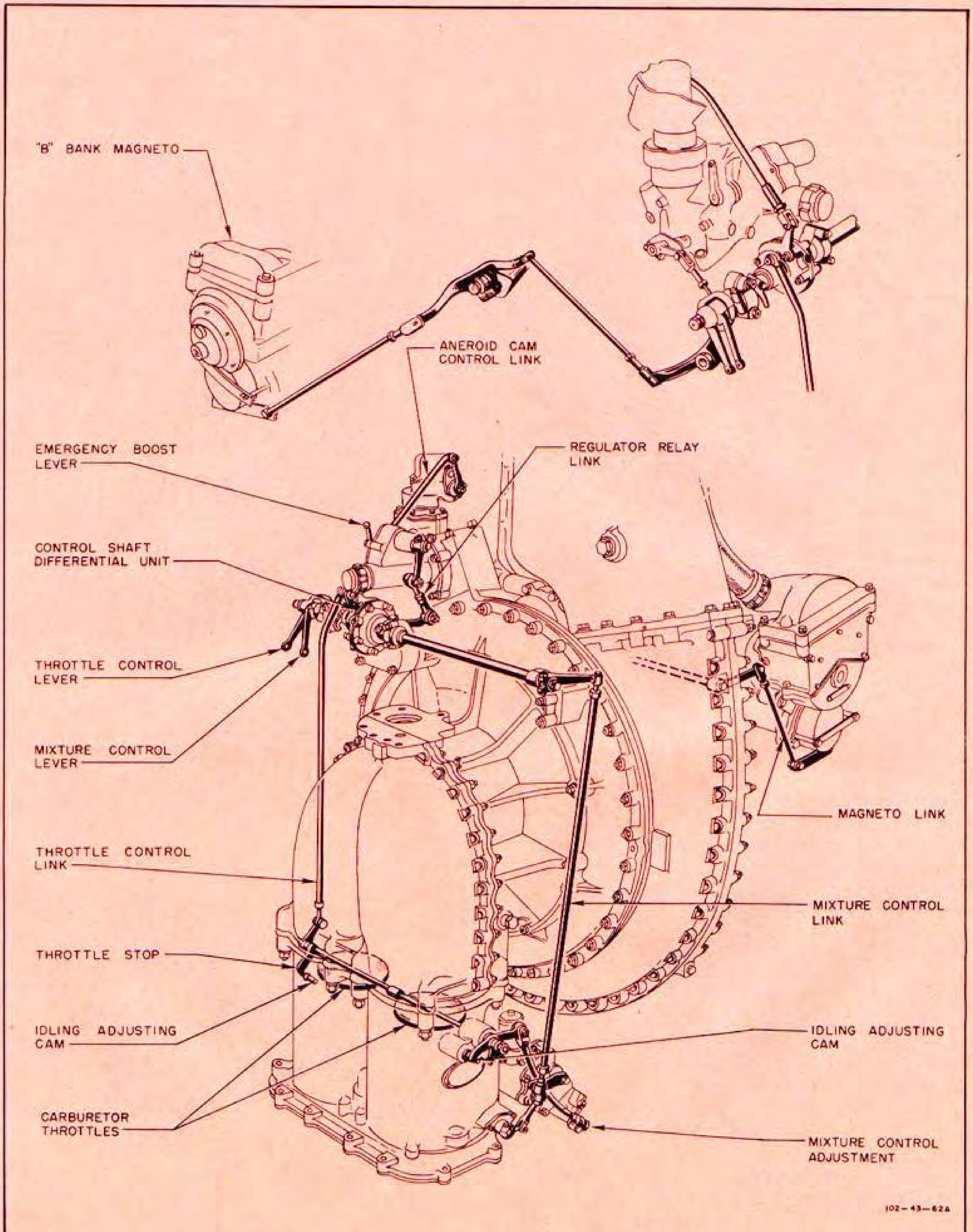
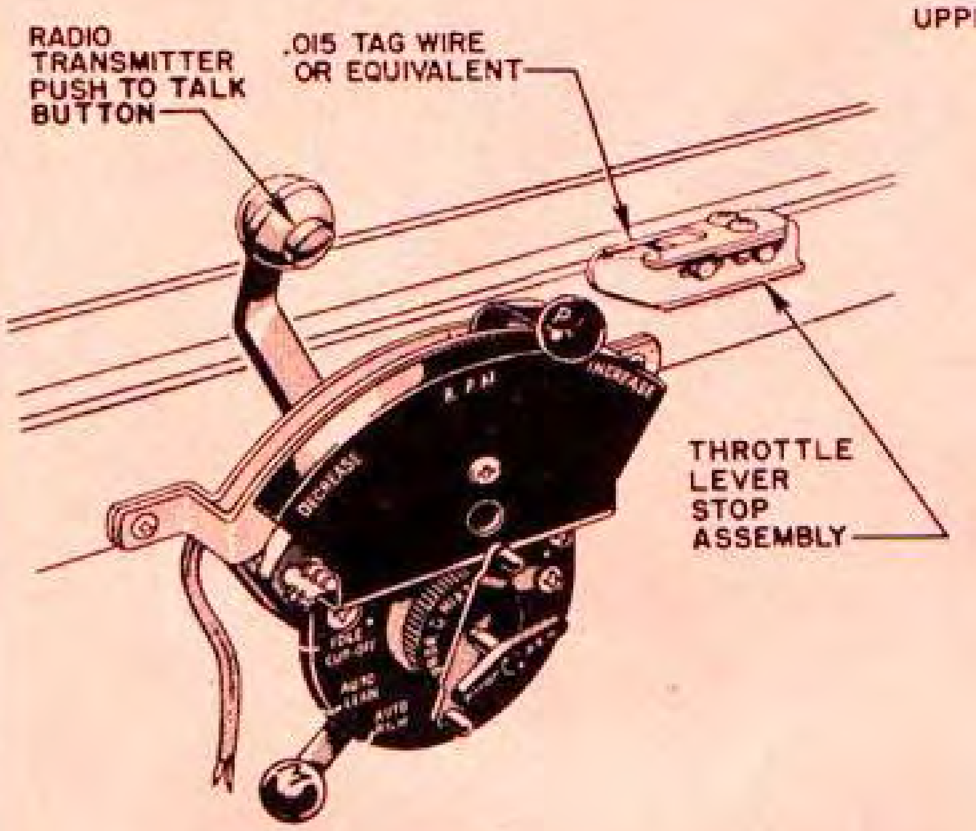
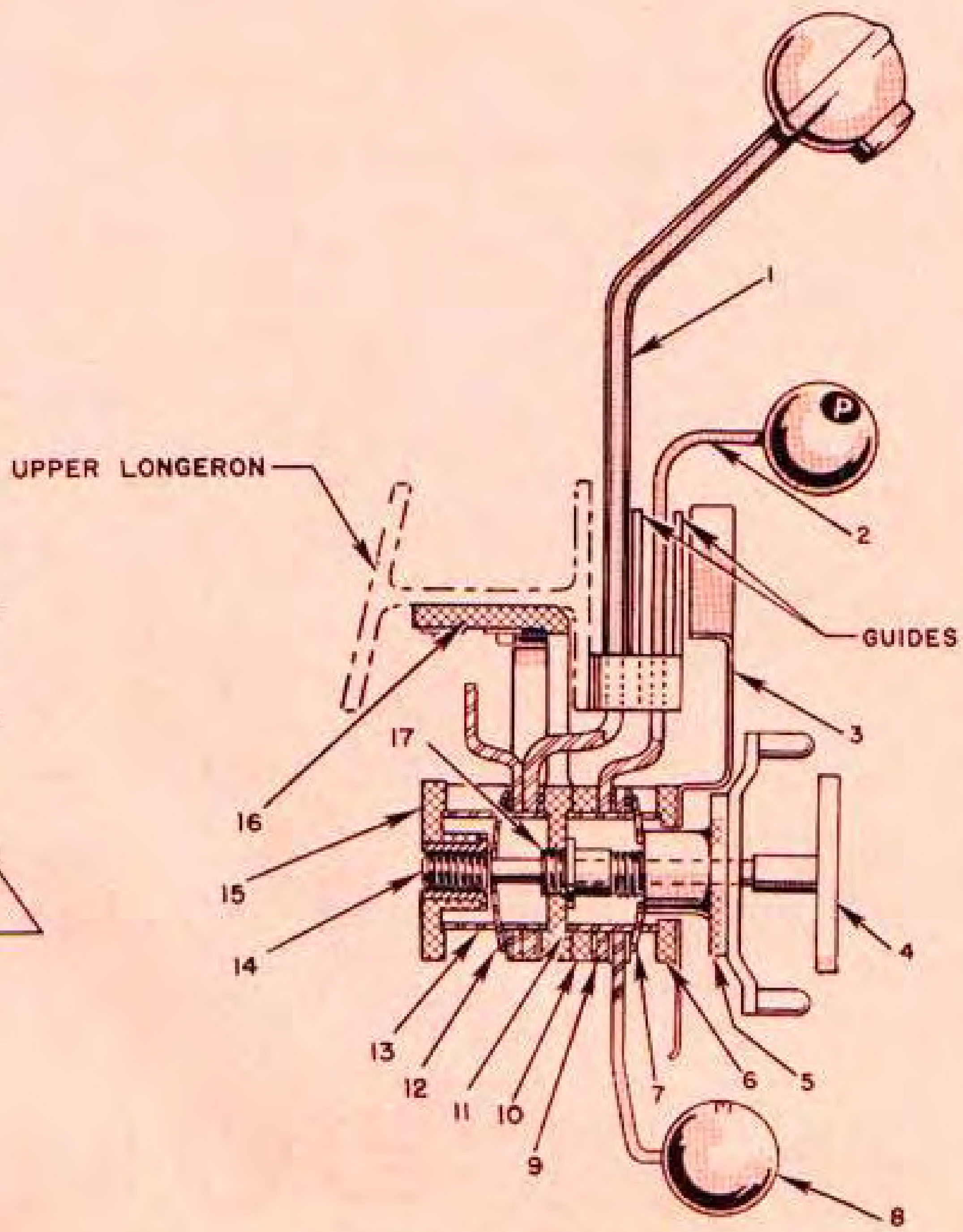



*Figure 237—Engine Control Shaft and Linkage*

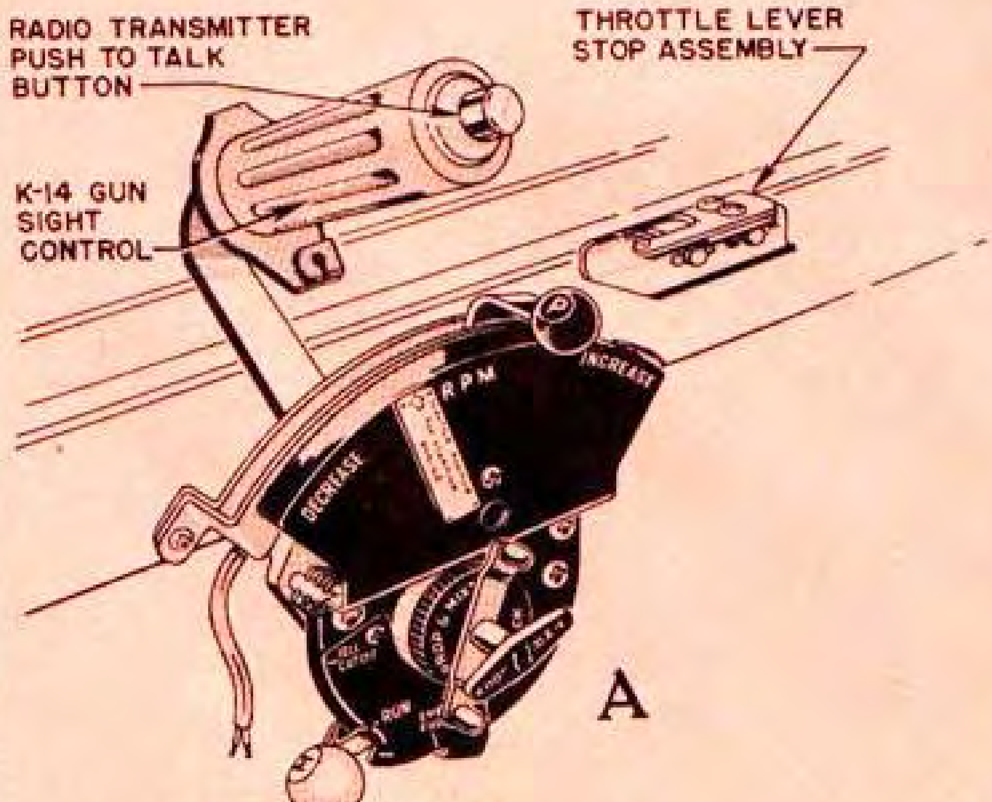
1. throttle lever
2. propeller governor lever
3. plate
4. throttle lock knob
5. propeller and mixture control lock knob
6. plate
7. spring
8. mixture control lever
9. plate (5 req.)
10. spacer
11. cylinder
12. spring
13. cylinder
14. shaft
15. plate
16. bracket
17. sleeve




*EARLY AIRPLANES*




*CROSS SECTIONAL VIEW OF TYPICAL QUADRANT*




*LATE AIRPLANES EQUIPPED WITH SINGLE-POSITION CARBURETOR*

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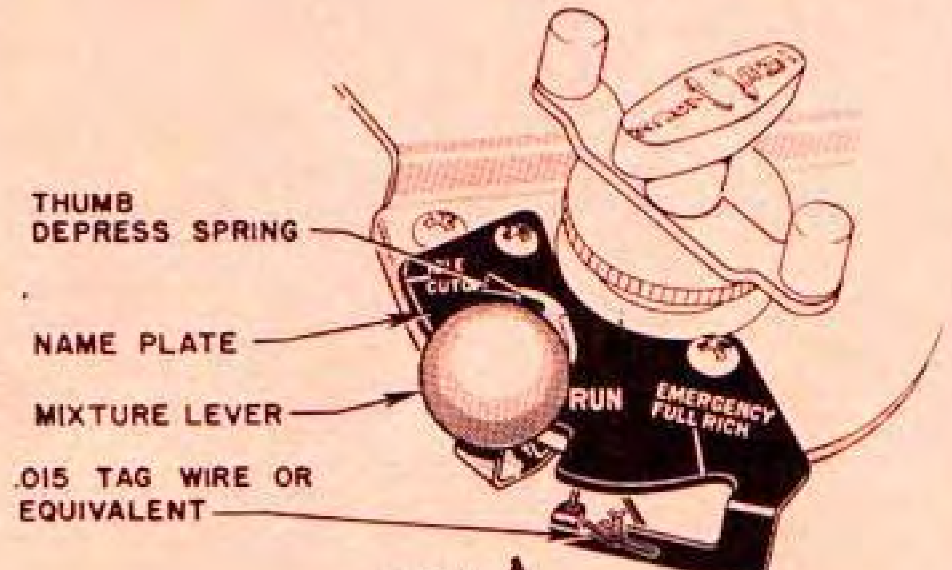



*MIXTURE CONTROL LEVER AND PLATE*

***Figure 238—Engine Control Quadrant***

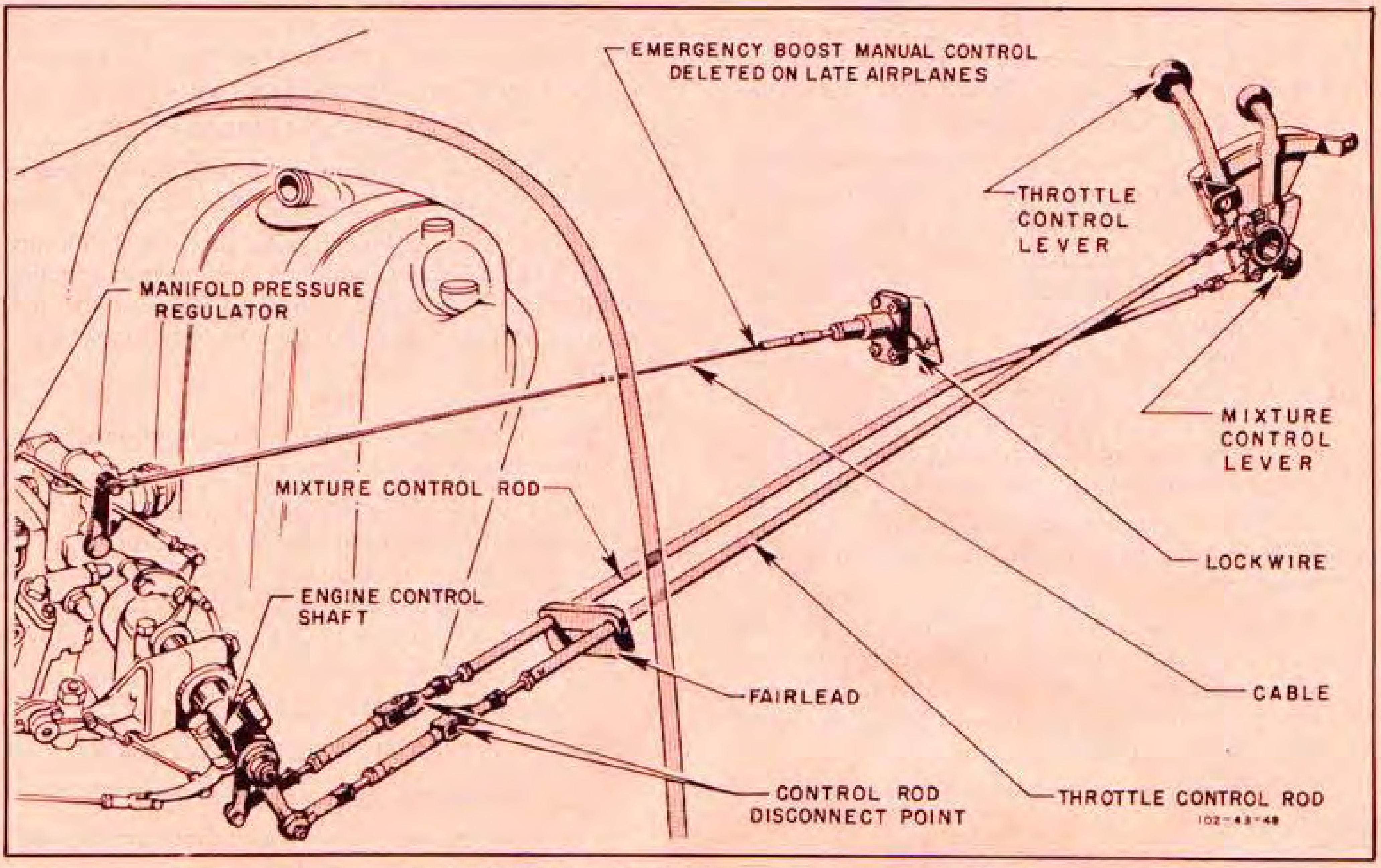



*Figure 239—Throttle, Mixture, and Boost Controls*

*(k)* Move the upper plate of the stop against the throttle lever; then tighten screws locking the plate to the main body of the stop.

*(l)* Move the throttle back, out of the stop slot. Install .015 tag wire (or equivalent) across the slot of the stop, using the holes at the entrance to the slot.

*d.* EMERGENCY BOOST CONTROL (For Early Airplanes So Equipped).

(1) DESCRIPTION.—A lockwired control handle on the left corner of the pilot's instrument panel is connected by a flexible cable to the emergency boost lever on the automatic manifold pressure regulator. *(See figure 239.)* This control is used to obtain war emergency rating from the engine. Ground crews should check this control following each flight to make certain that the lockwire on the handle remains unbroken. If the lockwire is broken, a special inspection of the engine should be made. *(See section X.)* On later airplanes, no separate emergency manual control is provided for the manifold pressure regulator, as the unit operates automatically when the throttle control is positioned for war emergency rating.

(2) ADJUSTING EMERGENCY BOOST CONTROL (For Early Airplanes So Equipped).

*(a)* Thread cable through firewall and fairleads, and attach to control handle on the instrument panel.

*(b)* Wind cable in or out of the control handle until the clevis end of the cable can just be connected to the control arm on the engine with the cable taut.

*(c)* Pull control handle up until its narrow flat side is against the instrument panel; then check the control arm on the engine to determine that the control is fully back against the internal stop or not over 3 degrees off the stop. Move handle to its normal position.

*(d)* After adjustment, check the cable end to make sure that not less than five threads are screwed into the control handle.

*(e)* Tighten locknut on cable, and safety clevis pin on boost control arm. Safety the control handle to the instrument panel with .015 tag wire (or equivalent).

*e.* MIXTURE CONTROL.

(1) DESCRIPTION.—The pilot's mixture control lever is also connected to a lever on the engine control shaft, which is in turn connected to the carburetor. *(See figures 237, 238, and 239.)* On early airplanes there are three mixture control positions: "AUTO RICH," "AUTO LEAN," and "IDLE CUT OFF." The "FULL RICH" position is blocked off by stops which prevent the control lever from going to its full forward position.

On later airplanes, which are equipped with the single-position carburetor, the mixture control has "IDLE CUT OFF," "RUN," and "EMERGENCY FULL RICH" positions. The lever is stopped in the "RUN" position by a stop incorporated on the control quadrant name plate. A lockwire across the stop slot prevents inadvertent movement of the lever into the "EMERGENCY FULL RICH" position. Under extreme emergency conditions, the pilot can move the lever into the "EMERGENCY RICH" position by depressing the thumb spring, moving the lever forward, and breaking the lockwire.

(2) ADJUSTING MIXTURE CONTROL.

*(a)* Move the mixture control lever until it strikes the stop in the "RUN" position ("AUTO RICH" position on early airplanes), and lock control with friction lock.

*(b)* Move control arm on the engine control shaft until it sets the mixture control on the carburetor in the "RUN" position ("AUTO RICH" position on early airplanes).

*(c)* Connect control rod, protruding through the firewall, to the rod extending from the engine control shaft. Tighten bolts, but do not safety.

*(d)* Unlock and move control lever to determine the travel and spring-back. Spring-back should be from 1/16 to 1/4 inch at the "IDLE CUT OFF" end of lever travel. This adjustment may be obtained by lengthening or shortening the rods between the firewall and the engine control shaft.

*(e)* Check to ensure that control lever moves the mixture control on the carburetor into the "EMERGENCY FULL RICH" position.

*(f)* When the correct adjustment has been obtained, tighten all nuts and bolts on the rods, and safety with cotter pins where cotter pin holes are provided. On control quadrants equipped with name plate, install .015 tag wire across stop slot at the "RUN" position.

*(g)* Operate the control several times to make sure there is no bind.

*f.* PROPELLER GOVERNOR CONTROL.
*(See figure 240.)*

(1) DESCRIPTION.—On P-51D Airplanes equipped with the Hamilton Standard propeller, the control lever is connected to the Hamilton Standard governor by a push-pull rod system extending along the left-hand beam of the engine mount.

On P-51K Airplanes equipped with Aeroproducts propeller, the governor is contained within the propeller and is controlled by a push-pull rod system which connects to the governor control arm on the rear of the propeller regulator. A bellcrank support assembly on the governor mounting pad supports the control system at the front of the engine.

(2) ADJUSTING PROPELLER GOVERNOR CONTROL (P-51D AIRPLANES).

*(a)* Move propeller governor control lever in cockpit to the full "DECREASE RPM" position, and lock.

*(b)* Move control on propeller governor until it hits the internal stop (decrease position); then move in opposite direction at least one degree. Adjust control rod so that rod end can be attached to governor control arm at this set position.

**Note**

This is done to obtain full travel of the governor without damaging the internal gears.

*(c)* Operate the cockpit control to make sure of full travel and spring-back. There should be a spring-back of 1/16 to 1/4 inch in the "INCREASE RPM" position; however, 1/2-inch maximum spring-back is allowable because of the variations in various governors. No spring-back is required in the "DECREASE RPM" position.

*(d)* Tighten and safety all bolts.

(3) ADJUSTING PROPELLER GOVERNOR CONTROL (P-51K AIRPLANES).

*(a)* Move propeller governor control lever in cockpit to full "DECREASE RPM", and lock.

*(b)* Move the governor control arm, on the rear of the propeller, to full "DECREASE RPM".

*(c)* Adjust the control rod so that the rod end can be attached to the governor control arm.

*(d)* Operate the control system to make sure that there is full travel in the "DECREASE RPM" position, and that there is spring-back in the full "INCREASE RPM" position. The "DECREASE RPM" position should have no spring-back.

*(e)* Tighten and safety all bolts as required.

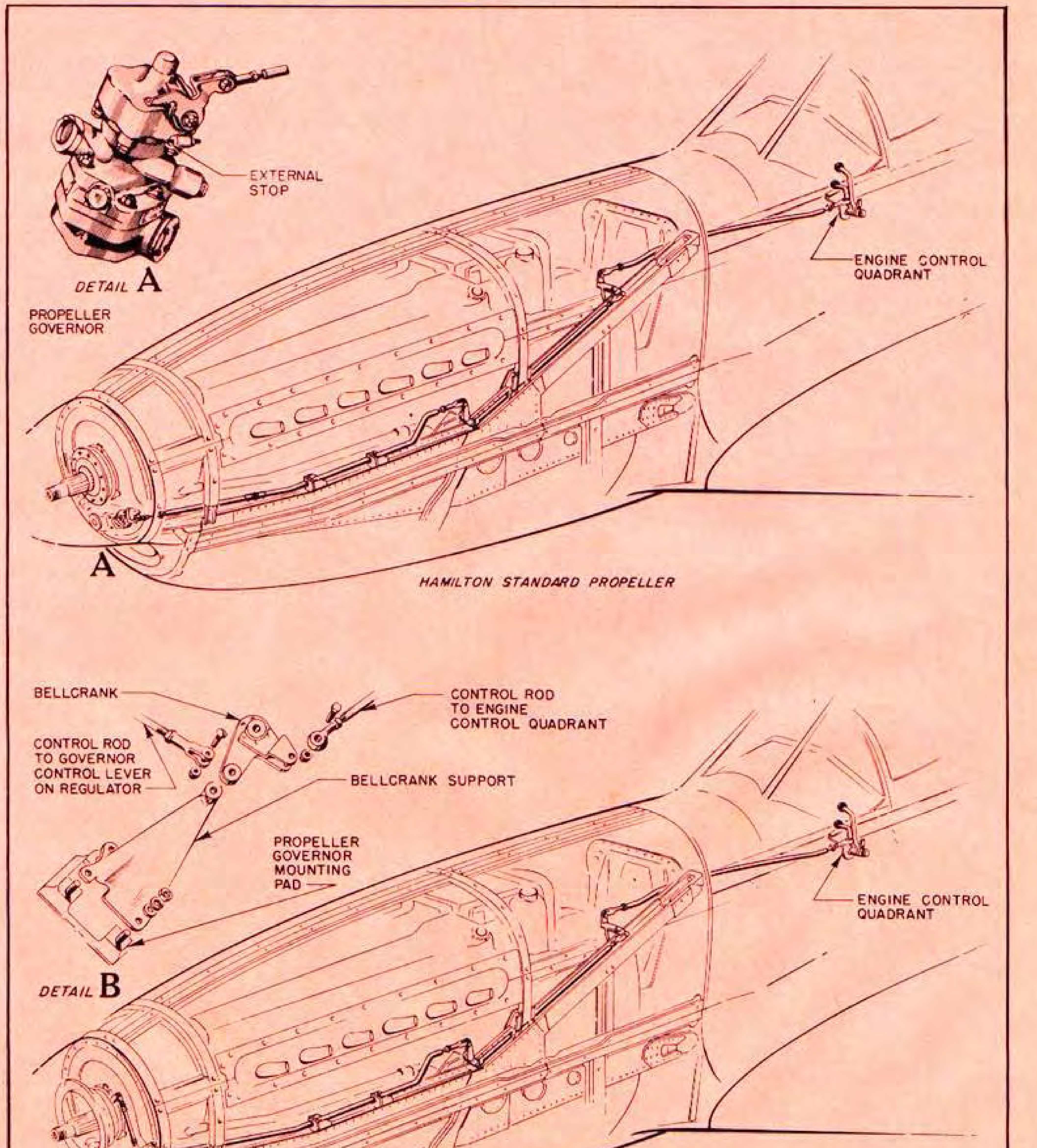



Figure 240—Propeller Governor Control System

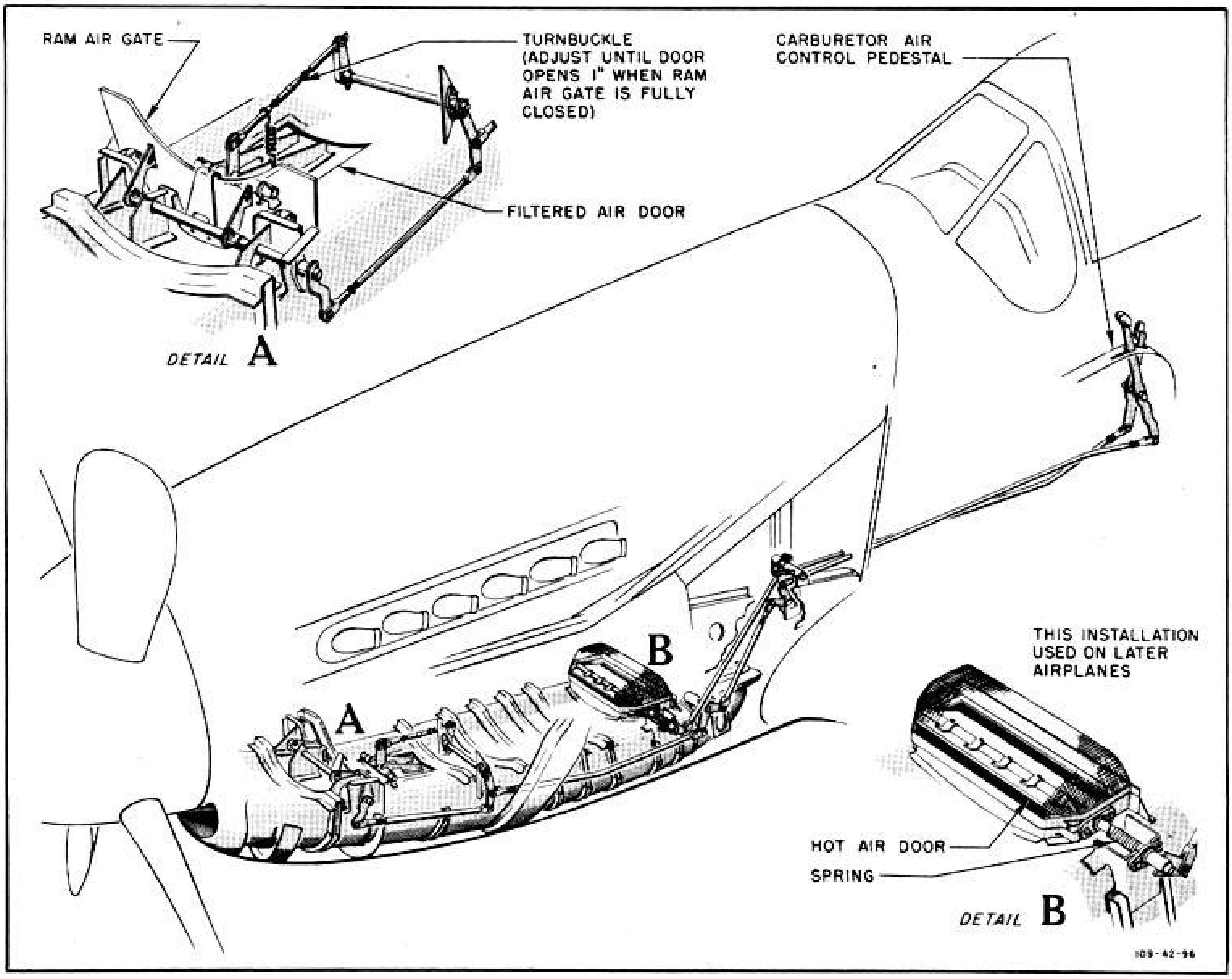



***Figure 241—Carburetor Air Control System***

*g.* CARBURETOR AIR CONTROLS.

(1) DESCRIPTION.—The carburetor air control is located on the control pedestal at the lower left side of the cockpit. *(See figure 241.)* Early airplanes have only a cold air control, with two positions: "RAM AIR" and "UNRAMMED FILTERED AIR." The control pedestal on later airplanes has an additional lever to open the hot air door in the carburetor air duct. This lever, when moved aft to the "HOT AIR" position, permits engine compartment air to enter the carburetor air duct, and when moved forward, permits the spring-loaded door to close.

(2) ADJUSTING CARBURETOR AIR CONTROLS.

*(a)* ADJUSTING COLD AIR CONTROL.

*1.* Move the ram air gate to the closed position.

*2.* Place control lever in cockpit in the "UNRAMMED FILTERED AIR" position. Connect rod to ram air gate, and adjust so that the ram air gate will be in the closed position.

*3.* With ram air gate closed, adjust filtered air door rod by its turnbuckle adjustment until this door is open to one inch maximum at its trailing edge. Tighten turnbuckle locknuts.

*4.* Move the cockpit control to the "RAM AIR" position. Check ram air gate to determine that it is fully open.

*5.* If necessary, adjust the control rods until the cockpit lever falls into the notches at each end of travel, with the doors opening and closing properly.

**Note**

Approximately ⅛-inch spring-back should be obtained in the "UNRAMMED FILTERED AIR" end before lever falls into notch.

*6.* Tighten all bolts and nuts, and safety. Operate controls several times to determine that rods clear in all positions and do not bind.

*(b)* ADJUSTING CARBURETOR HEAT CONTROL.

*1.* Move the control pedestal hot air lever to the closed position.

2. Check to make sure that the hot air door is fully closed and held in position by the spring.

3. Move the hot air door arm assembly down until the hot air door shaft pin is against the top shoulder of the arm assembly slot. In this position, the arm is ready to open the door.

4. Adjust the connecting rod and connect it to the hot air door arm assembly. Tighten all bolts and nuts, and safety as required.

5. Operate the control to determine that the hot air door will open fully and close completely by spring tension. Make sure control rods clear in all positions and do not bind.

**Note**

The hot air door should be able to open automatically when the control lever is in the closed ("NORMAL") position.

*b.* SUPERCHARGER CONTROL.

(1) DESCRIPTION.—The automatic aneroid switch which controls the supercharger shifting system is activated by carburetor entrance air pressure. A control switch on the pilot's switch panel is used to shift from high to low blower in case of aneroid switch failure. This switch has three positions: "AUTOMATIC," "LOW," and "HIGH." The "AUTOMATIC" position is normally used. The momentary "HIGH" switch position is used to operate high blower for ground check only. The aneroid switch is calibrated to change the supercharger from low to high blower when the air pressure, at carburetor entrance, is equivalent to 14,500 ($\pm$250) feet, depending on airspeed and airplane attitude. The change back to low blower is made at a carburetor entrance pressure equivalent to approximately 13,600 feet.

(2) ADJUSTING SUPERCHARGER CONTROL.—As this control is electrically operated, see paragraph 20 of this section for adjustment of aneroid switch and solenoid.

**12. FUEL AND AIR INDUCTION.**

*a.* CARBURETOR.

(1) DESCRIPTION.—The airplane is equipped with a Bendix-Stromberg PD-18A1 up-draft injection carburetor incorporating fuel head enrichment valves, automatic mixture control, and idle cut off. The carburetor is bolted to the bottom of the supercharger elbow. The adapter assembly, which contains the vapor portion of the constant pressure discharge nozzle and a double diaphragm type accelerating pump, is bolted on top the supercharger rear casing. Metered fuel from the fuel control unit on the carburetor throttle body is conducted to the discharge nozzle through an external line. To assist in idling, an internal passage bleeds air (at carburetor pressure) from one barrel of the throttle body to a point between the main venturi and the throttle valves to the atomizing air jets in the discharge nozzle.

To simplify pilot operation, the carburetor mixture control setting (on late airplanes) has been modified to give "IDLE CUT OFF," "RUN," and "EMERGENCY FULL RICH" positions. The "EMERGENCY FULL RICH" position is used only under extreme conditions. These modified carburetors, known as "single-position" type, are designated by a -8 or -9 after the part number on the carburetor specification plate. The -8 signifies that the particular carburetor was reworked in the field; the -9 indicates the carburetor was modified at the factory. The previous type carburetor, having four positions, "IDLE CUT OFF," "AUTO LEAN," "AUTO RICH," and "FULL RICH," is designated by a -7 after the part number on the carburetor specification plate.

(2) CARBURETOR TROUBLE SHOOTING.

**Note**

Do not change carburetor adjustments until it has been definitely established that unsatisfactory engine operation is the result of improper carburetor adjustment.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Engine will not start or continue to run after starting.** | Incorrect starting procedure. | Start engine as per instructions in AN 01-60JE-1. |
| | Insufficient fuel pressure, due to defective fuel pump, malfunctioning fuel pressure gage or clogged fuel strainer. | Replace fuel pressure gage or fuel pump. Clean fuel strainer. |
| | Idle adjustment too rich or too lean. | Readjust. |
| | Air in fuel section of the regulator unit. | Remove vent plug in top of fuel control unit. Pump fuel until it stands level with plug opening. Replace plug and safety. |
| | Discharge nozzle valve sticking open because of weak valve spring, dirt or other foreign matter between valve and valve seat, or worn or scored valve seat. | Replace valve spring. Clean between valve and valve seat. Replace valve assembly. |
| | Discharge nozzle not opening because of diaphragm failure. | Replace diaphragm. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Engine runs too rich or too lean at cruising power.** | Insufficient fuel pressure due to defective fuel pump, malfunctioning fuel pressure gage, or clogged fuel strainer. | Replace fuel pressure gage or fuel pressure pump. Clean fuel strainer. |
| | Enrichment valve leaking or stuck closed. | Wash unit in gasoline, and polish needle and needle guide in the bushing assembly. |
| **Engine runs too lean at take-off or rated power, but satisfactorily at cruising power.** | Enrichment valve binding or incorrectly set. | Correct setting on flow bench. |
| | Insufficient fuel pressure. | Replace fuel pressure gage or fuel pressure pump. Clean fuel strainer. |
| | Poppet valve having insufficient travel or sticking. | Reset setting. Overhaul if not seating properly. |
| **Engine runs too lean or too rich at altitude in automatic rich position, but satisfactorily at sea level.** | Vapor separator float needle stuck in closed position. | Remove strainer and clean float for free movement. |
| | Automatic mixture control unit incorrectly set or malfunctioning. | Replace unit. |
| | Manual mixture control valve set in wrong position. | Adjust control linkage. |
| | Emergency full rich valve plates leaking. | Lap plates with very fine compound. |
| **Engine does not accelerate properly but runs satisfactorily with slow throttle movements.** | Accelerating pump not functioning properly. | Remove and clean. |
| | Fuel inlet to accelerating pump clogged at intake restriction. | Remove pump cover diaphragm and clean. |
| | Pump discharge nozzle leaking. | Clean all parts with gasoline and dry with compressed air. Replace valve and diaphragm if worn. |
| | Fuel leak into air chamber in regulator unit. | Overhaul carburetor. |
| | Suction hole to air side of accelerating pump diaphragm closed. | Line up suction holes and clear. |
| **Engine does not shut off in idle cut off position.** | Leaking mixture control plates. | Clean and relap plates. |
| | Leaking fuel valve. | Clean valve. |
| **Engine does not idle properly.** | Discharge nozzle leaking or stuck open. | Remove and clean. |

(3) REMOVING CARBURETOR.

*(a)* To obtain access to the carburetor throttle body, remove the two lower rear cowl panels and the two side fairing panels which attach to the wing .

*(b)* Disconnect control linkage from jackshaft on air duct elbow.

*(c)* Remove rear section of duct.

*(d)* Disconnect air temperature bulb flex; then working through access door in duct elbow, disconnect air scoop flexible joint from carburetor. Remove four bolts holding the former to the engine mount to allow removal of air scoop elbow. Disconnect elbow bracket from firewall.

*(e)* When elbow is removed, disconnect all lines necessary to provide clearance for removal of carburetor throttle body.

*(f)* Disconnect line from fuel pump to carburetor.

*(g)* Disconnect fuel supply pipe on carburetor fuel control unit.

*(h)* Disconnect carburetor vapor vent line and fuel pressure gage line.

*(i)* Disconnect throttle and mixture control links from carburetor (do not change adjustment of control links).

*(j)* Unscrew the eight nuts which hold the throttle body to the carburetor elbow.

*(k)* Remove carburetor throttle body from elbow. Cover elbow and all open lines with tape or other material. Be careful not to damage any of the lines or protrusions near carburetor during removal.

(4) ADJUSTING CARBURETOR.—Special testing equipment, such as a flow bench, is required to calibrate the idle spring, the poppet valve, and the power enrichment valve.

**CAUTION**

These adjustments will *never* be attempted unless a flow bench is available.

(5) INSTALLING CARBURETOR.

*(a)* Clean and inspect mating faces of the throttle body and the carburetor elbow. Examine studs for condition and security.

*(b)* Place new gasket in position, mount carburetor on studs, and install washers and retaining nuts.

*(c)* Tighten the stud nuts evenly and in successive stages to 144 inch-pounds torque. Safety the stud nuts with cotter pins.

*(d)* Connect fuel feed line, fuel pressure line, and vapor vent line.

*(e)* Connect throttle and mixture control rods. Lubricate throttle shaft end bushings with machine gun oil, Specification No. AN-O-6.

*(f)* Install all lines which were detached to facilitate removal of carburetor.

*(g)* Install air scoop elbow and flexible joint to carburetor intake flange. Install air scoop duct sections and connect control linkage.

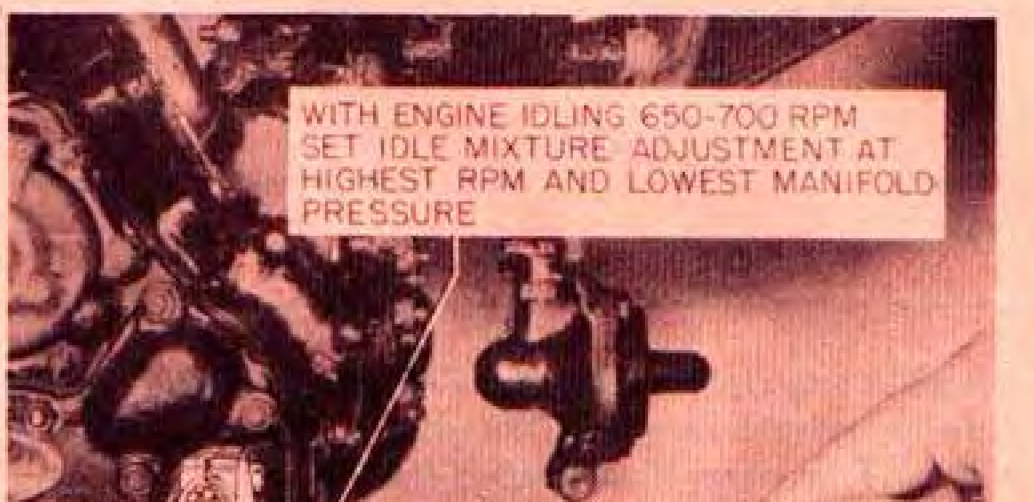



***Figure 242—Idle Mixture Adjustment***

*(h)* For initial use, fill the carburetor with fuel as follows:

**Note**

This applies to a carburetor that has been drained, one that has been replaced, or one that has been installed on a new engine which is being started for the first time.

*1.* Remove the plug from top of the fuel control unit so that air will not be trapped in the fuel passages and prevent the system from filling completely.

*2.* Move fuel selector valve to "MAIN TANK L.H." (On early airplanes, place valve in "MAIN FUEL TANKS" position.)

*3.* Set mixture control in "AUTO RICH" or "RUN."

*4.* Operate booster pump until fuel stands level with the unplugged opening in the fuel control unit.

*5.* Replace plug in top of fuel control unit, tighten securely, and safety.

**CAUTION**

A minimum 8-hour soaking period should follow initial filling of the carburetor to make sure that the diaphragms are thoroughly soaked and flexible. This is important, as the carburetor was originally calibrated with all its fuel diaphragms thoroughly soaked with gasoline.

(6) ADJUSTING CARBURETOR AFTER INSTALLATION.

*(a)* ADJUSTING IDLE MIXTURE CONTROL.

*1.* Adjustment of the idle mixture screw on the carburetor should never be made on either a cold or hot engine. If the engine has been run up and is quite hot, allow it to idle at approximately 1000 rpm for 5 minutes before setting the idle adjustment.

a. Set idle speed adjustment on left-hand side of carburetor to give an idling speed of 650-700 rpm with the throttle stop arm against the adjustment stop. Note manifold pressure.

b. Leaving the throttle set in this position, loosen idle mixture adjustment lockscrew and move idle mixture adjustment one notch toward the lean side (counterclockwise). Open and close throttle, and allow engine to run with this adjustment for at least 15 seconds, watching the tachometer and the manifold pressure gage. If the engine speed has increased, this will cause a corresponding decrease in manifold pressure and indicate that the mixture now being delivered is closer to proper strength.

c. Without moving the throttle, repeat this process on several different notches to find the one at which the engine speed is the highest and the manifold pressure is the lowest.

d. With the idle mixture adjustment set in the notch giving the best operation, reset idle speed adjustment to return idling rpm to 650-700. *(See figure 242.)*

e. Repeat procedures a. through d., to determine if the original mixture adjustment is still correct for the new throttle adjustment. In some cases it may be found necessary to repeat this process even a third time to ensure proper engine operation. The throttle must be opened and closed between each adjustment.

f. If engine operation is apparently the same in several notches, place the adjustment screw in the leanest of these notches.

**Note**

Under no circumstances should the idle mixture adjustment screw be leaned beyond the point of maximum speed. Such action will result in poor engine acceleration.

g. If there is insufficient travel of the idle mixture adjustment to obtain the correct idle mixture *(figure 243)*, disconnect idle link (1) from screw eye (8) by removing link bolt (6). Screw the screw eye (8) into threaded bushing (9) if leaner mixtures are required, or out of the bushing if richer mixtures are desired. One revolution of the screw eye is equivalent to approximately 13 notches of mixture adjustment indicator (12). Reconnect the idle link (1) with extreme care to be certain that the various parts are in their correct positions. The four plain washers (4) must be in the positions shown. Position the spring wave washer (2) so that it fits over the outside diameter of bushing (3) and is next to screw eye (8). Tighten the castle nut (5) enough to allow the yoke of idle link (1) and plain washers (4) to clamp bushing (3) tightly in place so it cannot move on bolt (6). If castle nut (5) is not sufficiently tight, the clearance between the inside diameter of bushing (3) and the outside diameter of bolt (6) will allow enough play in the linkage to cause inconsistent engine idling.

h. Tighten and lockwire the idle mixture adjustment lockscrew.

*b.* AIR INDUCTION SYSTEM.

(1) DESCRIPTION.

*(a)* GENERAL.—The carburetor air induction system consists of an air duct extending from a point aft and below the propeller spinner to the carburetor intake located in the rear of the engine compartment. *(See figure 244.)* The duct is constructed in four sections: the front scoop, which is an integral part of the engine mount, and the intermediate, rear, and elbow sections, which are clamped together and supported by cowl formers.

*1.* The front scoop section contains two small doors which must be removed for access to the engine timing inspection hole plug. Spark plug and generator blast tubes are connected to nipples protruding from the top of this duct section.

*2.* The duct intermediate section incorporates a movable ram air gate, two removable air filters, and a filtered air door.

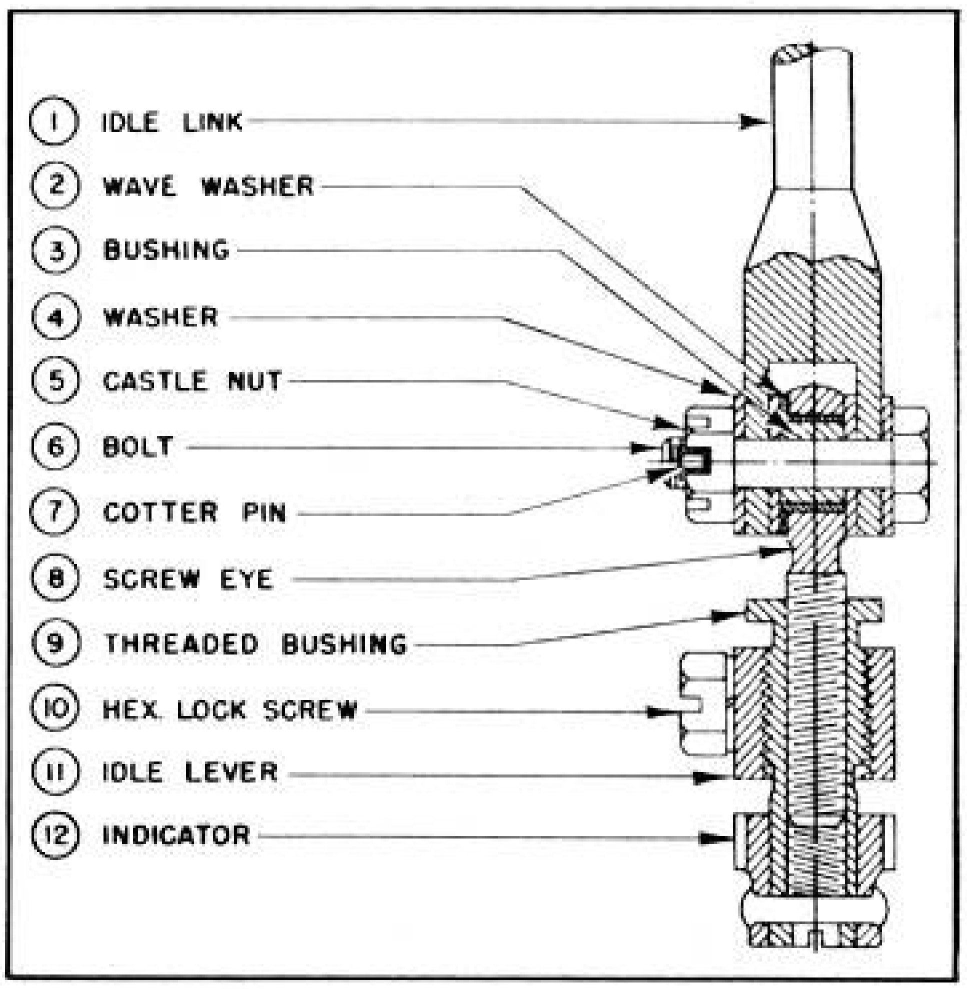



***Figure 243—Section Through Idle Adjustment Mechanism***

*3.* The duct rear section contains a hairpin-type icing screen in the low velocity section of the duct. On early airplanes, an emergency suck-open door is located on each side of the duct section and aft of the icing screen. A spring between the doors holds them closed. Late airplanes have one large manually controlled door on the top of the rear duct section instead of the two side doors. This door admits hot engine compartment air into the induction system and will also suck open automatically should the duct become obstructed at the icing screen.

*4.* The duct elbow section is attached to the carburetor by a flexible joint. Two drain lines, extending from the flexible joint to nipples of the elbow, prevent gasoline from collecting in the pockets of the joint while the airplane is on the ground. A removable door in the duct elbow affords access to the carburetor intake for installation or removal of the elbow. The duct elbow also incorporates a bracketed bellcrank for connecting the control rod from the air gates to the carburetor air control levers in the cockpit. See paragraph 11 of this section for adjustment of the carburetor air controls.

*(b)* AIR INDUCTION SYSTEM OPERATION.—The induction system on the early airplanes gave two kinds of carburetor air: ram air or unrammed filtered air as controlled by the single control lever in the cockpit. *(See figure 245.)* Late systems, controlled by two levers, give three kinds of carburetor air: cold ram air, unrammed filtered air, and warm air from the engine compartment. *(See figure 246.)* During normal operation, cold ram air enters the scoop and passes through the duct to the carburetor intake. In icing conditions, the pilot may close the cold ram air gate, and open the

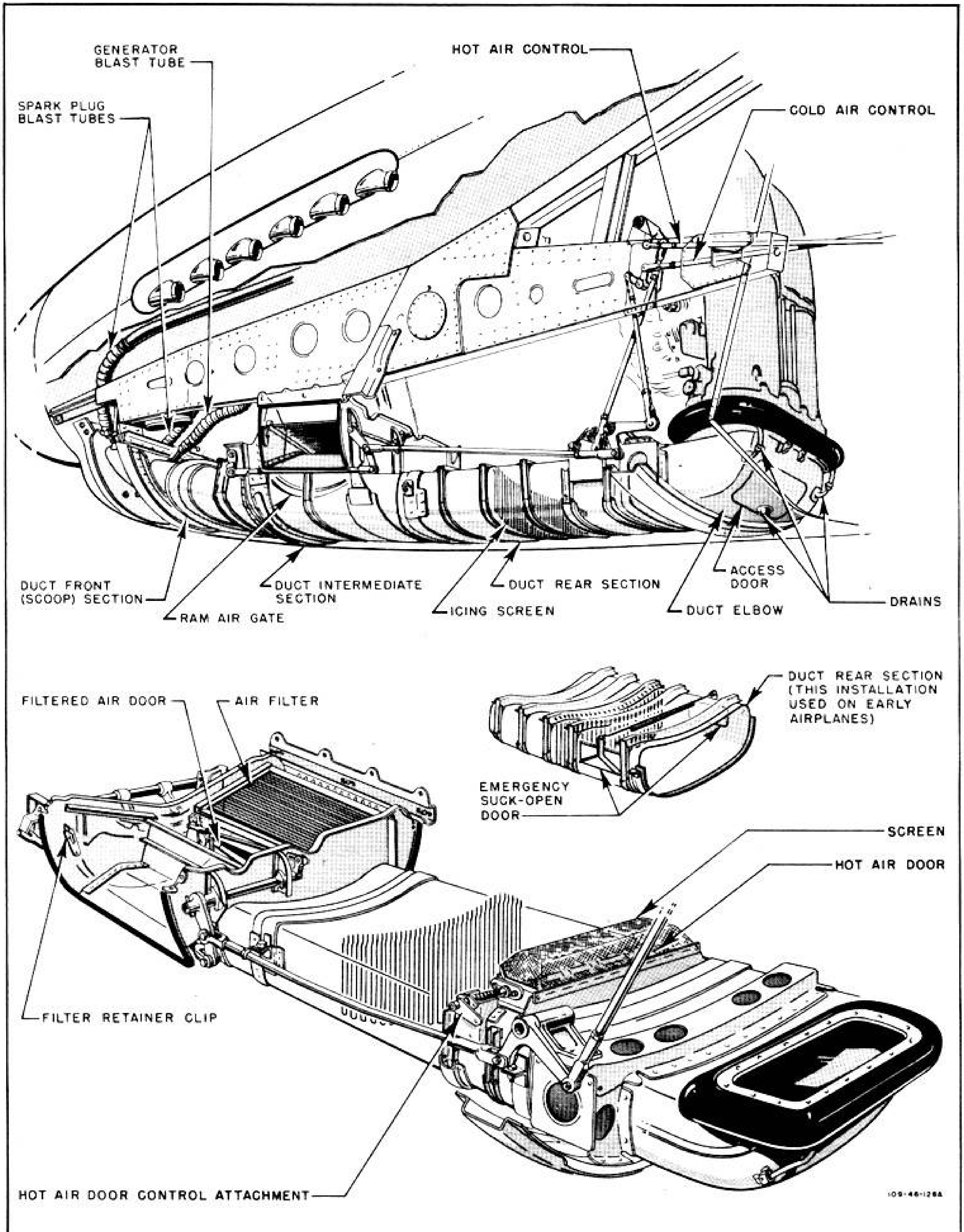



*Figure 244—Carburetor Air Induction System*

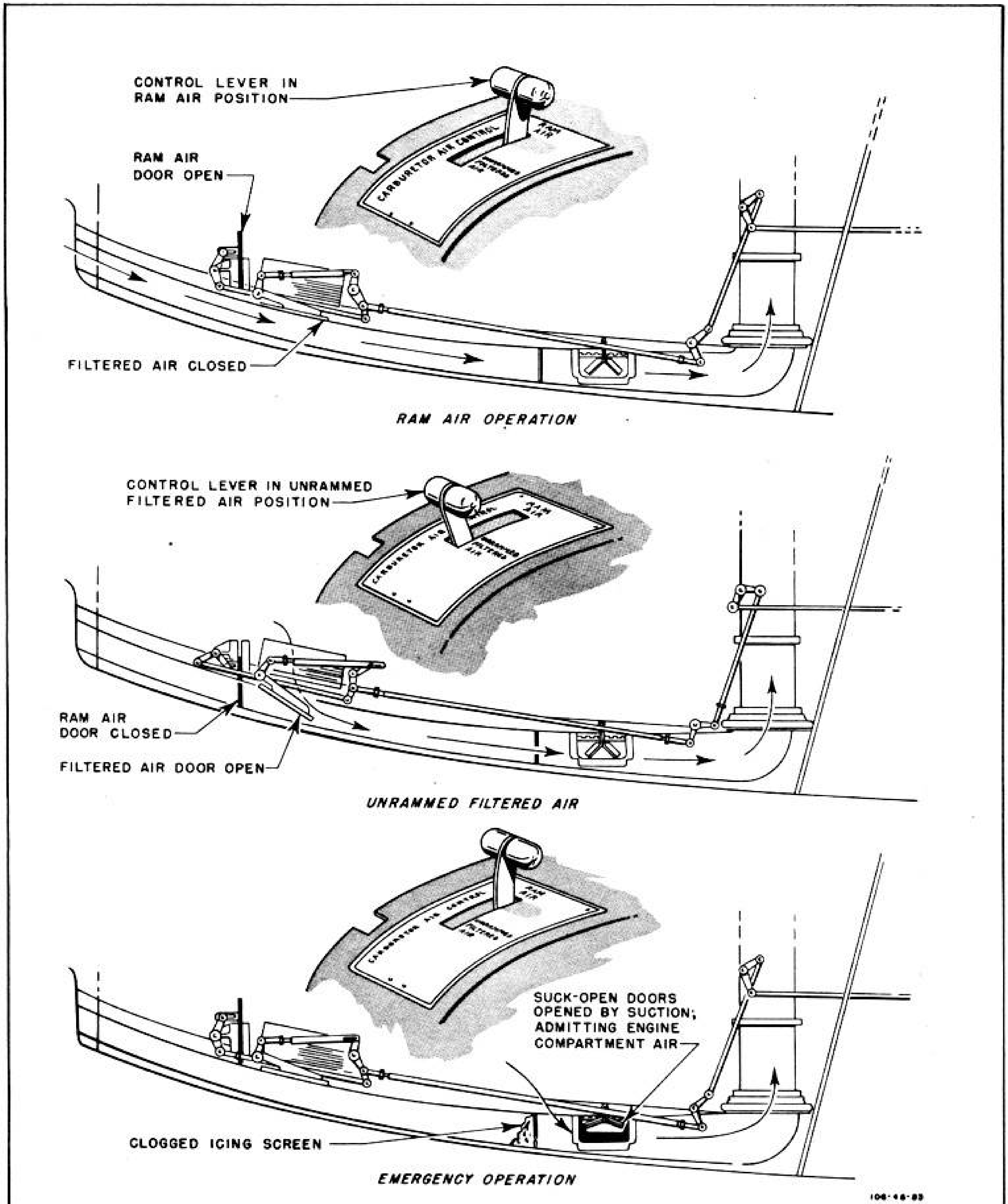



*Figure 245—Operation of Air Induction System—Early Airplanes*

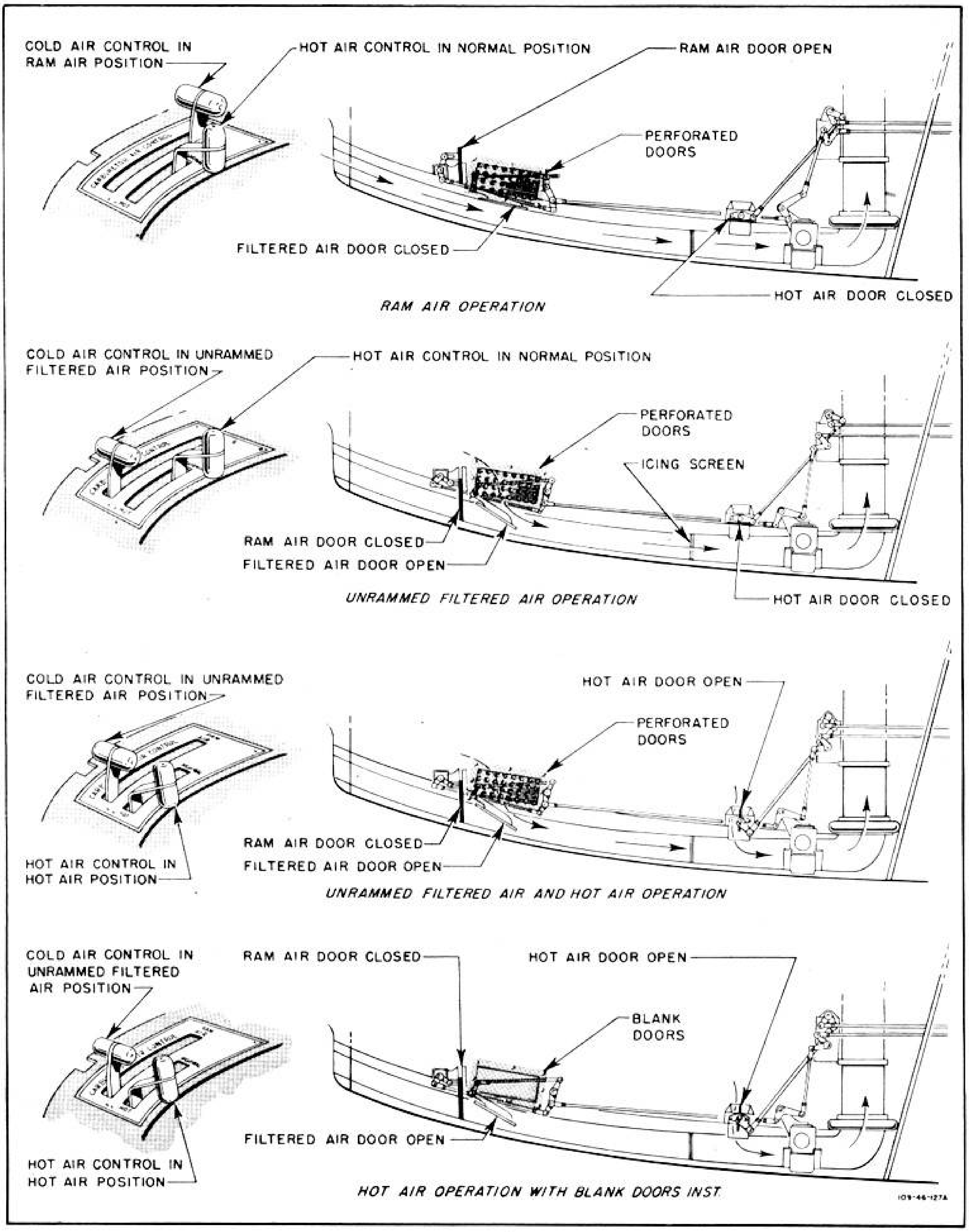



***Figure 246—Operation of Air Induction System—Late Airplanes***


*Figure 247—Removing Air Filters*

hinged warm air door which admits air from the engine compartment into the induction system. If the hairpin icing screen in the duct becomes obstructed by foreign matter during ram air or filtered air operation, the spring-loaded warm air door will open automatically, overriding the controls, as a result of the suction existing in the carburetor intake.

(2) REMOVING AND INSTALLING CARBURETOR AIR FILTERS.—Remove panels from each side of engine cowling, unfasten the thumbscrew-type dzus studs which secure the filter retainers, and remove the filters. *(See figure 247.)* Do not remove the retainers from the airplane. To install, place filters in their compartments and fasten the retainers securely. Replace access panel.

(3) CLEANING CARBURETOR AIR FILTERS.—Although the carburetor air filters must be inspected daily for evidence of dirt and insufficient lubrication, servicing of the filters may be required at more frequent intervals. If the filters have been exposed to heavy dust during an engine ground run, they should be cleaned immediately afterwards, if possible. Clean filters as follows:

***(a)*** Wash each filter in unleaded gasoline or other suitable cleaning fluid. While cleaning, the element must be rocked or the cleaning fluid agitated to ensure removal of dirt from the innermost part of the element.

***(b)*** Thoroughly dry the filter elements.

**Note**

It is essential that the element be thoroughly dry prior to immersion in oil; otherwise, the air filter will not be properly coated, resulting in impaired cleaning efficiency.

***(c)*** Immerse filter in a compound of one part corrosion-preventive compound, Specification No. AN-VV-O-576, and three parts of lubricating oil, Specification No. AN-VV-O-446a, Grade 1120, from 2 to 5 minutes.

***(d)*** Drain the elements from 2 to 4 hours to remove excess oil prior to reinstallation. If filters are too heavily oiled, clogging will result.

***(e)*** Reinstall filters in their compartments and fasten the retainers securely. Replace access panel.

## 13. IGNITION SYSTEM.

***a.*** GENERAL DESCRIPTION.—Ignition is supplied by two high-tension magnetos of the rotating magnet type, mounted one on each side of the wheel case, which are driven at 1½ times crankshaft speed by a serrated coupling shaft splined to the magneto drive. The right-hand or "A" bank magneto fires the intake spark plugs of both cylinder banks; the left-hand or "B" bank magneto fires the exhaust spark plugs of both banks. *(See figure 172 for magneto firing order.)*

The magneto breaker assemblies are centrally mounted, and the engine control mechanism moves the breaker base through 25 degrees of advance range. The contact breaker levers are connected to the throttle control through linkage and levers on the control shaft assembly in such a way that the ignition timing is advanced or retarded as the carburetor throttle is opened or closed. The arrangement of the magneto control levers gives a rapid ignition advance during the initial throttle opening, and fully advanced ignition is maintained over the cruising range for smooth running on lean mixtures and maximum fuel economy. A partial retard becomes effective at the higher speeds and manifold pressures to avoid detonation.

Each magneto has a radio shielded wiring harness complete with wires, 1000 to 1200-ohm resistors, connectors, and conduits. For starting, high-tension current may be conducted from an outside source to the spark plugs via the magneto boost connection at the top of the magneto and a separate finger on the magneto distributor rotor.

Both magnetos are equipped with boost connections and distributor booster fingers. The magneto on the "A" bank side is the only one connected to the booster coil.

*b.* IGNITION SYSTEM TROUBLE SHOOTING.

| TROUBLE | PROBABLE CAUSE | REMEDY |
| --- | --- | --- |
| **No spark at one or more cylinders.** | Faulty spark plugs. | Replace spark plugs. |
| | Faulty connection at spark plug end of cable. | Repair or replace. |
| | Faulty cable. | Repair or replace. |
| | Damaged cam follower, weak or broken contact breaker arm spring, worn or loose cam. | Replace part, or entire assembly. |
| | Distributor electrodes loose, pitted, burned, or dirty. | Clean electrodes. If necessary, replace block and cover assembly. |
| | Distributor block or finger cracked, or dielectric broken through to ground. | Replace block and cover assembly. |
| | Carbon brush worn or broken. | Replace the unit. |
| | Moisture inside the magneto. | Remove covers, including contact breaker assembly cover, and dry with a clean lint-free cloth. Blow dry. |
| **No output.** | Primary condenser burned out. | Replace. |
| | Loose or frayed primary wire at magneto ground terminal connection, causing accidental ground. | Replace faulty cable, terminal, or connection. |
| | Excessive clearance of low-tension contact brush with spigot. | Reset to .138 to .148 clearance from spigot. |
| | No rotation from stripped or broken gear. | Replace magneto. |
| **Engine missing or running unevenly.** | Dirty or inaccurately spaced contact breaker points. | Clean breaker points. Reset the gap between points. |
| | Sticking breaker arm. | Clean and lubricate. |
| | Breaker arm wobbles on pivot post. | Replace breaker arm and breaker arm spring. |
| **Engine missing or running unevenly at high altitudes.** | Too great an air gap between feeder block electrodes and collector. | Replace magneto. |
| | Too great an air gap between distributor rotor and distributor block electrodes. | Replace magneto. |
| | Dirty or inaccurately spaced contact breaker points. | Clean breaker points. Reset the gap between points. |
| **SPARK PLUGS** | | |
| **Weak or no spark.** | Terminal connection faulty or disconnected. | Connect or replace connection. |
| | Lost or faulty plug wire resistor. | Replace resistor, 1000 to 1200 ohms. |
| | Incorrect gap between electrodes. | Readjust gap. |
| | Electrodes fouled.<br>**Note**<br>This condition may be a sign of excessive oil consumption or of magneto, terminal or wire defects, causing the plug not to fire. | Clean electrodes. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| | Soot on nose of insulator. **Note** A thin layer of soot on nose of insulator, when plug otherwise looks quite free from deposit, may be sufficient to short plug, indicating that plugs are not operating at sufficiently high temperature. | Replace spark plugs with approved type. |
| **Roughness at high altitudes with smooth operation at lower altitudes.** | Wrong spark gap. | Readjust spark gap. |
| **No spark during start in cold weather.** | Ice forming on spark plug electrodes. | Remove ice, and dry plug thoroughly. |
| | Defective booster coil. | Replace. |

*c.* MAGNETOS.

(1) REMOVING MAGNETOS.
*(See paragraph* 8. ***d.*** (2) ***(b)*** *1.)*

(2) TESTING MAGNETO BREAKER SPRING TENSION.—Check load required to open the contact points, using spring scale. Load should be not less than 25 ounces and not more than 31 ounces, as the contact points first separate.

(3) TIMING MAGNETOS.
*(See paragraph* 8. ***d.*** (2) ***(b)*** *3 and 4.)*

(4) INSTALLING MAGNETOS.
*(See paragraph* 8. ***d.*** (2) ***(b)*** *4.)*

***d.*** IGNITION HARNESS SPARK PLUG CONNECTORS.

(1) DISASSEMBLING SPARK PLUG WIRING CONNECTORS. *(See figure 248.)*—As the insulator portion of the connector is molded into the outer body, it is necessary to remove the assembly in case of insulator failure. Disassemble connectors as follows:

***(a)*** Pull spring-loaded contact spring retainer assembly out of insulator with pliers and allow resistor to drop out of insulator.

***(b)*** Remove cable retainer from insulator with Packard tool AT-8903; the tool screws into the threaded hole in the retainer.

***(c)*** Unscrew flexible conduit connector nut and remove angle connector from the cable, being careful not to lose grommet.

***(d)*** To install a new sleeve, pull off ferrule with pliers, being careful not to lose small wedge, and remove sleeve.

(2) ASSEMBLING SPARK PLUG WIRING HARNESS CABLE CONNECTORS.

***(a)*** Install sleeve over cable; then install ferrule over wire strands.

***(b)*** Drive wedge into wire strands to anchor ferrule.

***(c)*** Insert grommet in nut, install cable in connector assembly, and screw down flexible conduit connector nut.

***(d)*** Using Packard tool, AT-8903, insert cable retainer into retainer assembly.

**CAUTION**

When inserting cable retainer, make sure yoke of retainer is properly fitted over ferrule in the insulator. If contact spring retainer does not enter insulator properly, cable retainer is not properly located and must be reassembled.

***(e)*** Check resistor for proper condition and to make sure that it is not burned out; then drop resistor into insulator.

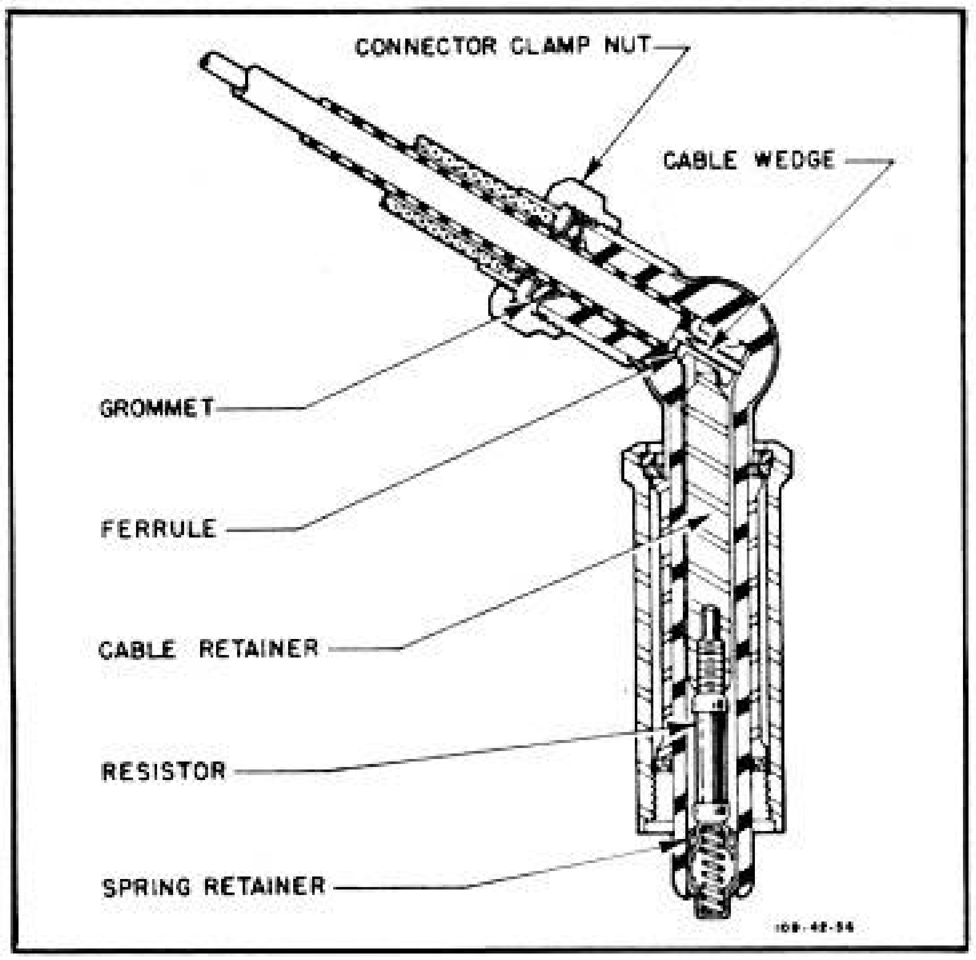



***Figure 248—Typical Spark Plug Cable Connector***

**Note**

A burned-out resistor will cause the engine to misfire, thus fouling the related spark plug. If trouble is traced to this vicinity, check resistor by giving ignition harness a continuity check with ohmmeter.

*(f)* Compress spring retainer assembly between fingers to test condition of spring. If spring is weak, replace assembly. Press spring retainer assembly into position in insulator. If it does not hold in place or if it is loose, expand it carefully with screwdriver, and reinstall retainer.

*e.* SPARK PLUGS.

(1) DESCRIPTION.—Each cylinder is fired by two radio-shielded 14 mm British KLG RC 5/3, Lodge RS 5/5, or AC-LE-44 spark plugs. The spark plug holes in the cylinder heads are fitted with threaded adapters into which the plugs are screwed, the adapters being locked in position by a retainer.

(2) MAINTAINING SPARK PLUGS.—Recommended gap for RC 5/3 and RS 5/5 spark plugs is .012 (+.002 −.001) inch. The proper gap for LE-44 spark plugs is .016 (+.002 −.001) inch. Gaps on plugs should be checked and reset every 25 hours.

**CAUTION**

Under no condition should the side electrode be reset when a thickness gage is between this part and the center electrode. Resetting in this manner will invariably damage the core insulation.

(3) INSTALLING SPARK PLUGS.

*(a)* Clean rust-preventive compound from each spark plug shell threads, electrode, or core insulator with clean rag or small soft brush.

**Note**

Carbon tetrachloride solvent may be used *only* on *shell threads* of spark plugs to remove rust-preventive compound.

*(b)* Dry spark plugs thoroughly with blast air.

*(c)* Check electrode gap with gap gage for proper setting.

*(d)* After cleaning and setting, place spark plugs in a tray to prevent damage before installation.

*(e)* Install solid copper gasket to each spark plug.

*(f)* Lubricate threads to plugs lightly with anti-seize compound, Specification No. AN-VV-C-566, thoroughly before applying to spark plugs.

**CAUTION**

Do not lubricate cylinder bushing threads, and avoid getting lubricant on electrodes. Any lubricant deposited on the firing end of the plug must be completely removed before installation of the plug.

*(g)* Install and draw down spark plugs firmly with a wrench having an 8-inch leverage. Tighten plugs to 216-264 inch-pounds.

**CAUTION**

Do not install any spark plug that has been dropped on floor or other hard surface. Do not install or tighten spark plugs when the engine is hot, as thread seizure with subsequent damage to the spark plug shell and cylinder bushing may result. If it is absolutely necessary to install plugs in a hot engine, install plugs finger-tight plus ½ turn.

## 14. STARTING SYSTEM.

*a.* GENERAL DESCRIPTION.—The starting system includes a direct-cranking starter, starter relay, a starter switch, and a booster coil. The starter is operated electrically through the starter relay, located in the generator control box, or on the right forward side of the firewall on later airplanes, when the starter switch on the front switch panel is closed. While the starter is cranking the engine, a booster coil aids the magnetos by intensifying the spark.

**Note**

Use an external source of power to start the engines whenever possible.

*b.* STARTER SYSTEM TROUBLE SHOOTING.

**Note**

In all cases of failure of the starting system, investigate and remedy the trouble before making any attempt to operate the system.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| | **STARTER** | |
| **Motor fails to operate, or low starter motor rpm and cranking speed.** | Low battery. | Replace battery. |
| | Defective or improper wiring, or loose connections. | Correct wiring, and clean and tighten all loose connections. |
| | Defective starter relay or control switch. | Replace faulty unit. |
| | Binding, worn, or improperly seated brushes, or brushes with excessive side play. | Replace brushes, or wipe binding brushes and brush boxes with undoped gasoline. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| | Dirty commutator. | Smooth and polish with No. 0000 sandpaper. If pitted, replace. |
| | Shorted, grounded, or open armature. | Replace armature. |
| | Grounded or open field circuit. | Replace. |
| **Motor operates at proper speed but fails to crank engine.** | Leakage of engine oil into clutch. | Replace clutch assembly. |
| | Worn baffle plate friction oil seal. | Replace oil seal. |
| | Worn or scored clutch discs. | Replace worn discs. |
| **Excessive arcing of motor brushes.** | Binding, worn, or improperly seated brushes or brushes with excessive side play. | Replace worn brushes, or clean binding brushes and brush boxes with undoped gasoline. |
| | Commutator dirty, rough, pitted, or scored. | Smooth and polish with No. 0000 sandpaper. If pitted, relace. |
| | Grounded or open field circuit. | Replace. |
| | Brush spring tension too high. | Replace brush springs. |
| **Motor operates at very high speed without cranking engine.** | Broken or damaged reduction gear. | Note whether handcranking mechanism shaft rotates when braking is applied with starter switch in the "ON" position. If handcranking mechanism can be restrained from turning without stopping the rotation of the starter motor, it indicates broken or damaged main reduction gearing. Replace starter main reduction gear unit. On early airplanes, the starter and reduction gear are all one unit. |
| | **BOOSTER COIL** | |
| **Coil inoperative.** | Condenser defective. | Replace booster coil. |
| | Winding burned out or open. | Replace booster coil. |
| | Points fused together. | Replace points, and adjust. |
| | High-tension lead grounded. | Isolate high-tension lead from ground. |
| | Defective wiring. | Repair wiring. |
| | Defective filter (later airplanes). | Replace filter. |
| **Contacts arcing.** | Out of adjustment. | Adjust. |
| | Contacts dirty. | Clean and adjust. |
| | Contacts oily. | Clean and adjust. |
| | Defective condenser. | Replace booster coil. |
| | **STARTER RELAY** | |
| **Does not operate.** | Open circuit to control switch. | Repair wiring. |
| | Dirty contacts on connector plug. | Clean contacts. |
| | Open-circuited solenoid coil. | Replace unit. |
| | Plunger binding. | Remove, and wash plunger with carbon tetrachloride.<br>**Note**<br>Change spring compression as a last resort, only. |
| **Intermittent operation.** | Short-circuited coil. | Replace coil. |
| | Loose electrical connection. | Clean and tighten electrical connections. |
| | Plunger binding. | Remove, and wash plunger and housing with carbon tetrachloride. |
| | Badly burned points. | Dress the points or replace. |

*c.* STARTER.

(1) DESCRIPTION.—An Eclipse, Type 840 direct-cranking electric starter is connected to a drive shaft on the right-hand side of the engine. The starter motor drive comprises a speed-reducing gear train incorporating a safety clutch, and a modified Bendix-type mechanism which engages with the supercharger clutch shaft.

(2) REMOVING STARTER.

*(a)* For access, remove the section of the carburetor air duct that is immediately below the starter.

*(b)* Remove the wire from the terminal strip on the starter.

*(c)* Remove the six nuts attaching the starter to the engine pad. Hold the starter while removing the nuts to relieve binding.

**CAUTION**

Care should be taken not to damage the oil line when removing the inboard nut next to the block.

(3) MEASURING STARTER BRUSH SPRING TENSION.

*(a)* Remove the window strap from the starter motor for access to the brushes and springs.

*(b)* Connect one end of a spring scale to the brush holder which normally rests on the top of the spring. Raise the spring brush holder ⅛ inch above the top of the brush box; the spring tension should measure between 24 and 28 ounces on the scale.

**Note**

Replace springs which do not have proper tension.

(4) REPLACING STARTER BRUSHES.—The maximum permissible wear of the brushes is 3/16 inch from a new serviceable length of ½ inch; however, replace brushes before their maximum wear limit is reached to ensure satisfactory operation of the starter. Replace the brushes as follows:

*(a)* Remove the brush leads, being careful not to tear or damage the sleeving on the brush leads.

*(b)* Raise the spring holder off the brush and remove the brush.

*(c)* Install a new brush. Make sure that brush lead sleeving is not burned or frayed, and properly covers the brush leads.

*(d)* In most cases, brushes will not seat properly when first installed. If facilities are not available for running in the brushes, insert a strip of No. 0000 sandpaper between the brush and commutator (sanded side facing the brush) and pull in the direction of rotation. Keep the sandpaper in the same contour as the commutator. Repeat the operation until the brush is fully seated.

**CAUTION**

Do not use coarse sandpaper or emery cloth.

*(e)* Thoroughly clean away all sand and metal particles.

*(f)* Install the window strap and reinstall the starter.

(5) INSTALLING STARTER.

*(a)* Position the starter on the mounting pad on the engine and install the six mounting nuts.

**CAUTION**

Be very careful not to damage the oil line when installing the inboard nut next to the block. Make sure the clip on the oil line is attached to this nut.

*(b)* Connect the electrical lead to the terminal strip.

*(c)* Install the section of the carburetor air duct that was removed.

*(d)* Make operational check.

*d.* BOOSTER COIL.

(1) DESCRIPTION.—A Type C-1 booster coil is located in the junction box near the top of the engine frame adjacent to the right-hand magneto. The low rpm of the engine

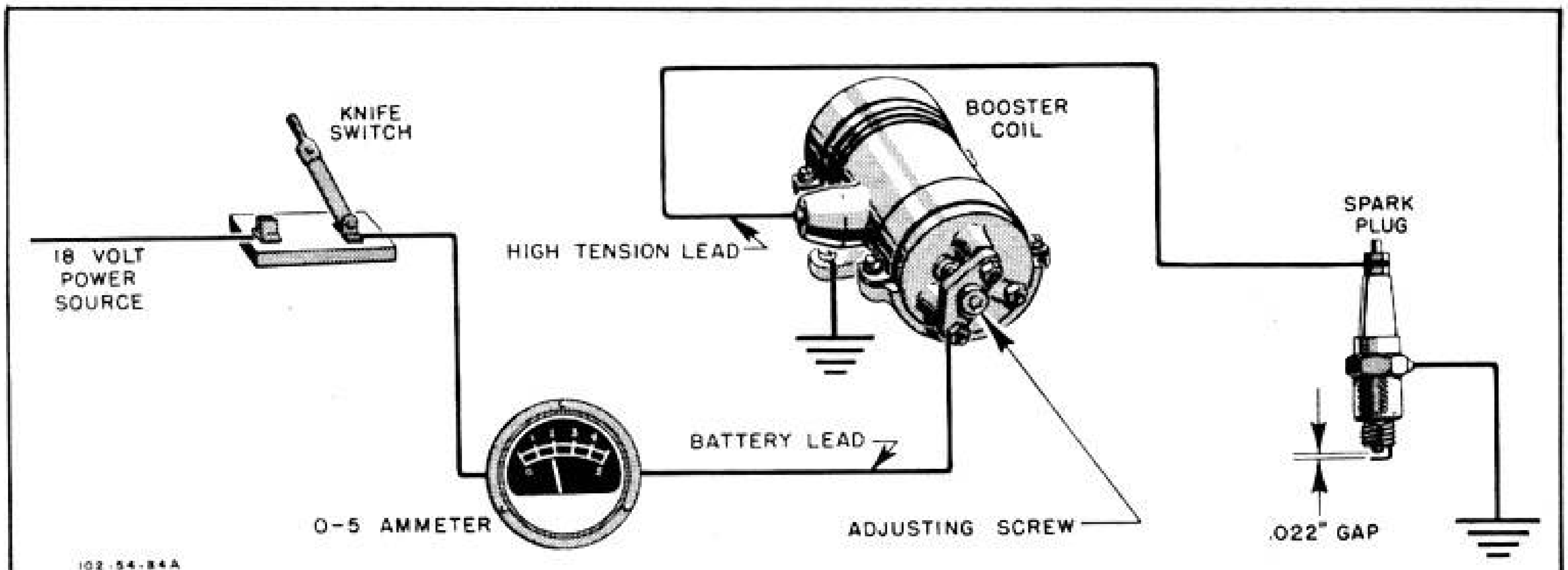



*Figure 249—Booster Coil Adjustment*

during initial starting fails to actuate the magneto with enough speed to generate the required high-tension current for engine ignition; consequently, the booster coil is actuated at the same time the starter switch is closed for cranking, and supplies the high voltage needed. On early airplanes, a filter is installed on the outside of the booster coil box. On later airplanes this filter is inside the box.

(2) REMOVING BOOSTER COIL.

*(a)* Remove the right engine access side panel for access to the booster coil junction box.

*(b)* Remove the cover on the box by unfastening the four dzus fasteners.

*(c)* Remove the high-tension, battery, and ground wires from the booster coil.

*(d)* Remove the coil.

(3) ADJUSTING BOOSTER COIL.—The correct gap setting can be obtained by adjusting screw contact on the booster coil and proceeding as follows:

*(a)* Connect primary terminals of the booster coil in series with an ammeter and control switch, and hook them to an 18-volt battery or generator supply. *(See figure 249.)*

*(b)* Connect high-tension terminal to a spark plug having a .022-inch gap.

*(c)* Install a return lead from spark plug housing to the booster coil housing or ground.

*(d)* Starting from extreme out position, close contact gap by turning the adjusting screw gradually in a clockwise direction until proper adjustment is obtained. With the booster coil firing the .022-inch gap, current drain should be 1.8 amperes.

(4) ALTERNATE METHOD OF ADJUSTING BOOSTER COIL.

*(a)* Disconnect wire from starter and insulate wire terminal.

*(b)* Pull out the high-tension wire from the high-tension socket of booster coil. Insert a high-tension wire in socket and locate the loose end of the wire ⅜ inch from ground (engine mount).

*(c)* Connect external power source of 18 volts. Close starter switch and back out the adjusting screw until there is no vibration of the coil points.

*(d)* Turn adjustment screw until there is a steady shower of sparks across the ⅜-inch gap to ground.

**CAUTION**

Take every precaution to prevent a fire hazard. If time permits, remove coil from the airplane and make the adjustment on the bench.

*(e)* Remove the test wire and insert the original wire. Connect starter wire.

(5) INSTALLING BOOSTER COIL.

*(a)* Position the booster coil in the box and install the two attaching screws.

*(b)* Connect the high-tension, battery, and ground wires to the coil.

*(c)* Install the booster coil junction box cover; then install the right engine access side panel.

### 15. FUEL SYSTEM.

*a.* GENERAL DESCRIPTION.—A self-sealing fuel tank is located in the inboard end of each wing panel, and a self-sealing fuselage auxiliary fuel tank is mounted on a shelf directly aft of the pilot's seat. To supplement these installations, when additional fuel is required, provisions are made for the installation of an auxiliary fuel tank on each wing bomb rack. Fuel lines are self-sealing, with the exception of the lines from the wing auxiliary tanks, and the line between the fuel selector and shut-off valves. These are of aluminum alloy. The two main fuel tanks and the fuselage auxiliary tank are equipped with a submerged centrifugal-type booster pump. Only one booster pump will be in operation at any one time, since the electrical circuit is connected by a switch to the fuel selector valve control handle, and the pumps are turned on or off by rotation of the selector valve to the tank desired. A fuel shut-off valve is located in the left wheel recess, and its control handle is mounted just to the left of the fuel selector valve control handle. Fuel is drawn from the wing auxiliary tanks by the engine-driven fuel pump. Normal fuel feed to the engine is maintained during steep climbs and dives through the incorporation of a sump chamber surrounding the booster pump in each main fuel tank. The sump chamber is formed by bulkheads fitted at the inboard end of each tank. Flapper valves in the bulkheads ensure one-way fuel flow through the sump chamber. The fuel injection-type carburetor is equipped with a vapor separation line ending at the vent fitting of the fuselage auxiliary fuel tank, and utilizes an idle cut off position for stopping the engine. All units of the fuel system are suitable for use with aromatic fuels.

*b.* MAIN FUEL TANKS.

(1) DESCRIPTION.—The main fuel tanks are of a self-sealing type incorporating an aromatic-resistant inner liner. The walls of the tank are constructed of layers of fabric and rubber cemented together. The self-sealing feature of the tank is made possible through a material, used in the wall construction, that expands rapidly upon contact with gasoline. Thus, in the event the tank is pierced, a rapid swelling takes place in the tank wall, effectively closing the puncture. This characteristic is essentially a means of providing an added measure of safety in combat, and does not preclude the necessity of fuel tank repair, inasmuch as the swelling in the area of the puncture may, in time, assume great enough proportions to materially reduce the fuel capacity of the tank. To hold the tank securely in place, and keep it from collapsing when empty, studs, screwed into fittings molded into the tank proper, are fastened to the wing upper and lower skins at the time of installing the tank in the wing. A magnetic, float-type fuel gage is mounted at the inboard end of each tank, and is visible on the floor of the cockpit. Each tank is fitted with a vent line terminating in the fuselage near the trailing edge of the wing, and a drain cock located on the underside of the tank at the aft inboard corner. Filler caps and inspection access doors are provided

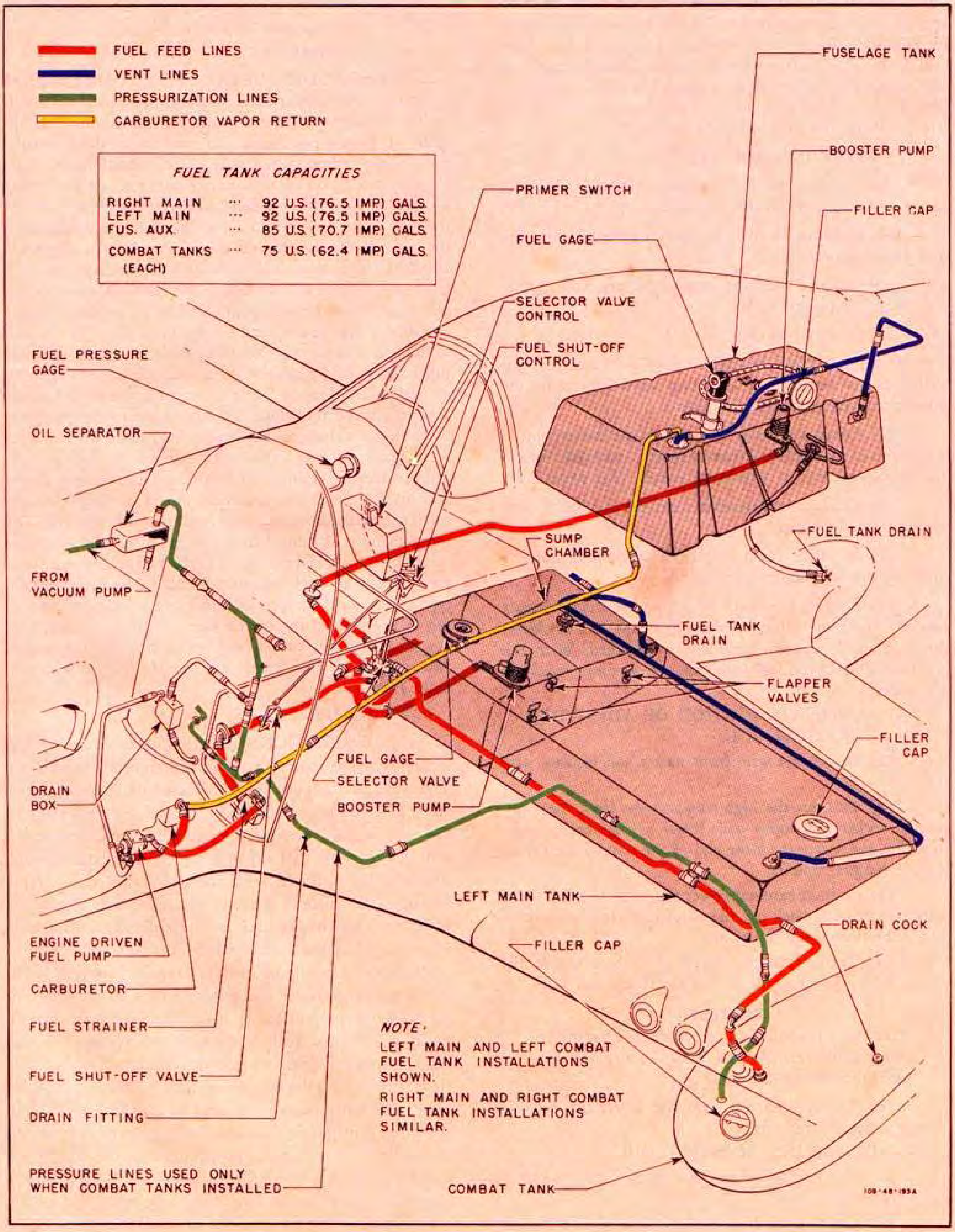



*Figure 250—Fuel System*

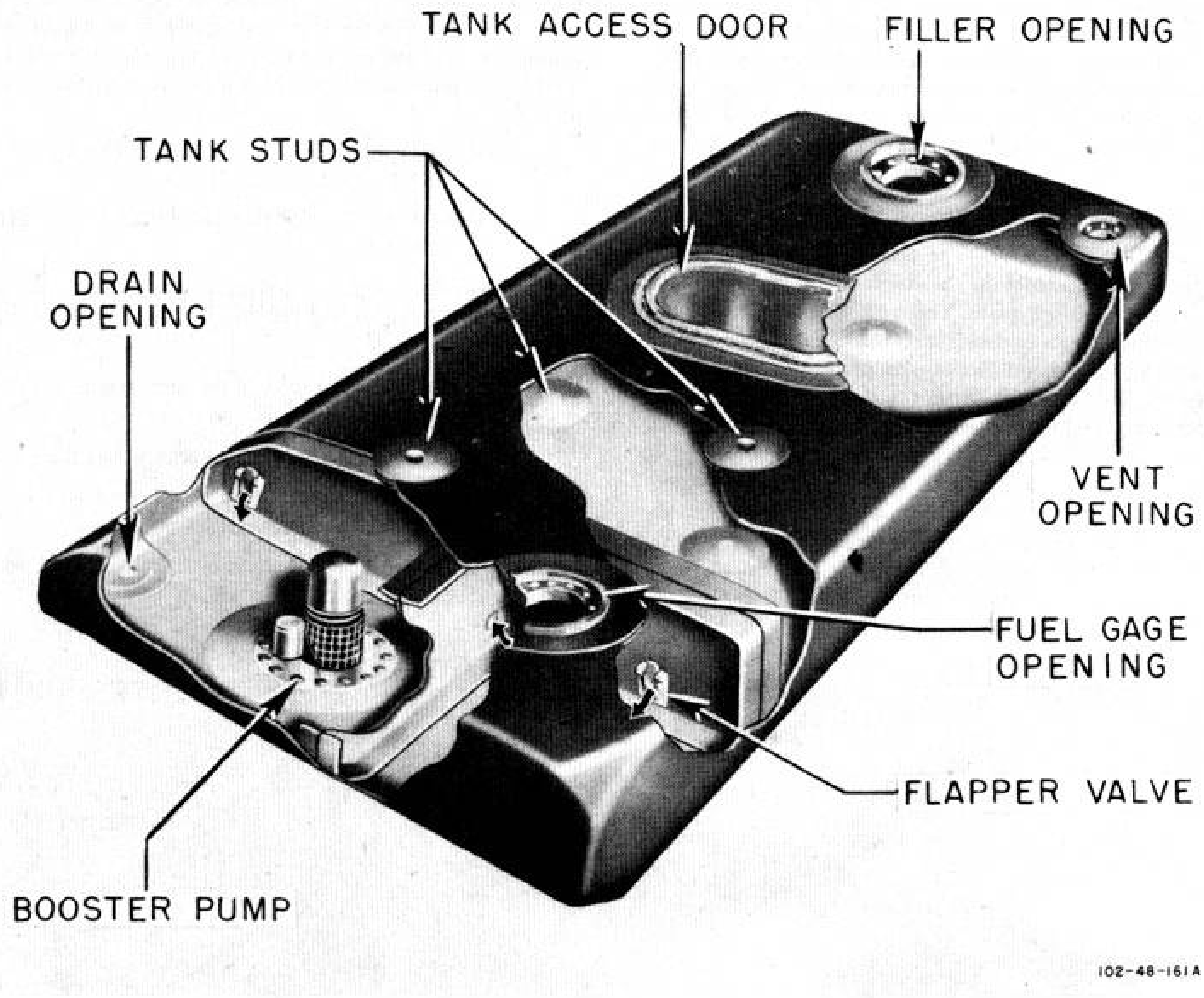



*Figure 251—Main Fuel Tank*

in the top of each tank. The filler cap is located at the extreme outboard end of the tank, and is designed in such a manner that it fits flush with the wing upper skin when the tank is installed.

(2) REMOVING MAIN FUEL TANKS.

*(a)* Drain the system and support the airplane on jacks, using the center jacking point to support the weight of the airplane, and the outer jacking points for balance only.

*(b)* Remove the forward scoop section, the wing attachment fairing, and the engine drain box overflow line. *(See paragraph 4. c. (4) (b) in this section.)*

*(c)* Remove booster pump access door, and disconnect bonding braid from tank door to booster pump.

*(d)* After removing three access plugs from fuel tank door, remove nuts and washers from tank studs.

*(e)* Remove screws and bolts holding tank door in place and remove tank door.

*(f)* Disconnect fuel hose and electrical plug at booster pump.

*(g)* Place a suitable support under the tank.

*(h)* Remove screws attaching filler neck adapter to wing skin.

*(i)* Remove cockpit floor to gain access to fuel gage adapter, and remove attaching screws from adapter.

*(j)* Remove center portion of wing-to-fuselage fairing on side having tank removed.

*(k)* Remove four plugs from top of wing, and four nuts and washers holding tank studs to wing.

*(l)* Lower aft end of tank enough to gain access to vent fitting at forward outboard end of tank, disconnect vent line, and lower tank to ground.

(3) INSTALLING MAIN FUEL TANKS.
*(See figures 253 and 254.)*

(4) TESTING MAIN FUEL TANKS.—After the main tanks are installed, a pressure test is made with a mercury

test stand at an air pressure of 2 pounds per square inch. Connect the stand to the main fuel tank vent line at the trailing edge of the wing. Fuel selector valve should be "OFF." Plug the filler neck on each tank, and run each test separately, using an air valve to regulate proper air pressure. Tank should hold specified air pressure for 15 minutes without pressure drop.

*c.* FUSELAGE AUXILIARY FUEL TANK.

(1) DESCRIPTION.—The self-sealing fuselage auxiliary fuel tank is fitted into the fuselage directly aft of the pilot's seat and armor plate. The tank is secured to a shelf by three studs on its undersurface, and is supported around the sides by balsa wood blocks, and cellulose sponge liners and fillers. The fuel tank fittings and accessories include a booster pump and drain fitted to the underside of the tank, a direct-reading fuel gage, goosenecked so that it is visible from the pilot's seat, a filler-neck opening, and a vent opening. A large access door in the top of the tank permits inspection of the interior surfaces. The filler-neck cap is on the left side of the fuselage just forward of the insignia, and the drain petcock is accessible through a dzus-fastened door located on the left side of the fuselage just forward of the radiator. The vent inlet is on the right side of the fuselage just below the insignia. A single baffle in the tank prevents undesirable rapid shifting of the fuel during changes in flight attitude.

(2) REMOVING FUSELAGE AUXILIARY FUEL TANK. *(See figures 255 and 256.)*

(3) INSTALLING FUSELAGE AUXILIARY FUEL TANK.

*(a)* Make sure that compartment is clean, and that the balsa wood blocks, and cellulose sponge liners and fillers are installed properly.

*(b)* Place the fuel tank in the compartment and see that it is correctly aligned.

*(c)* Secure the bottom of the tank to the shelf at the 3 places provided.

*(d)* Install booster pump as follows:

*1.* Install bridging plate over hole in shelf which is provided for the pump.

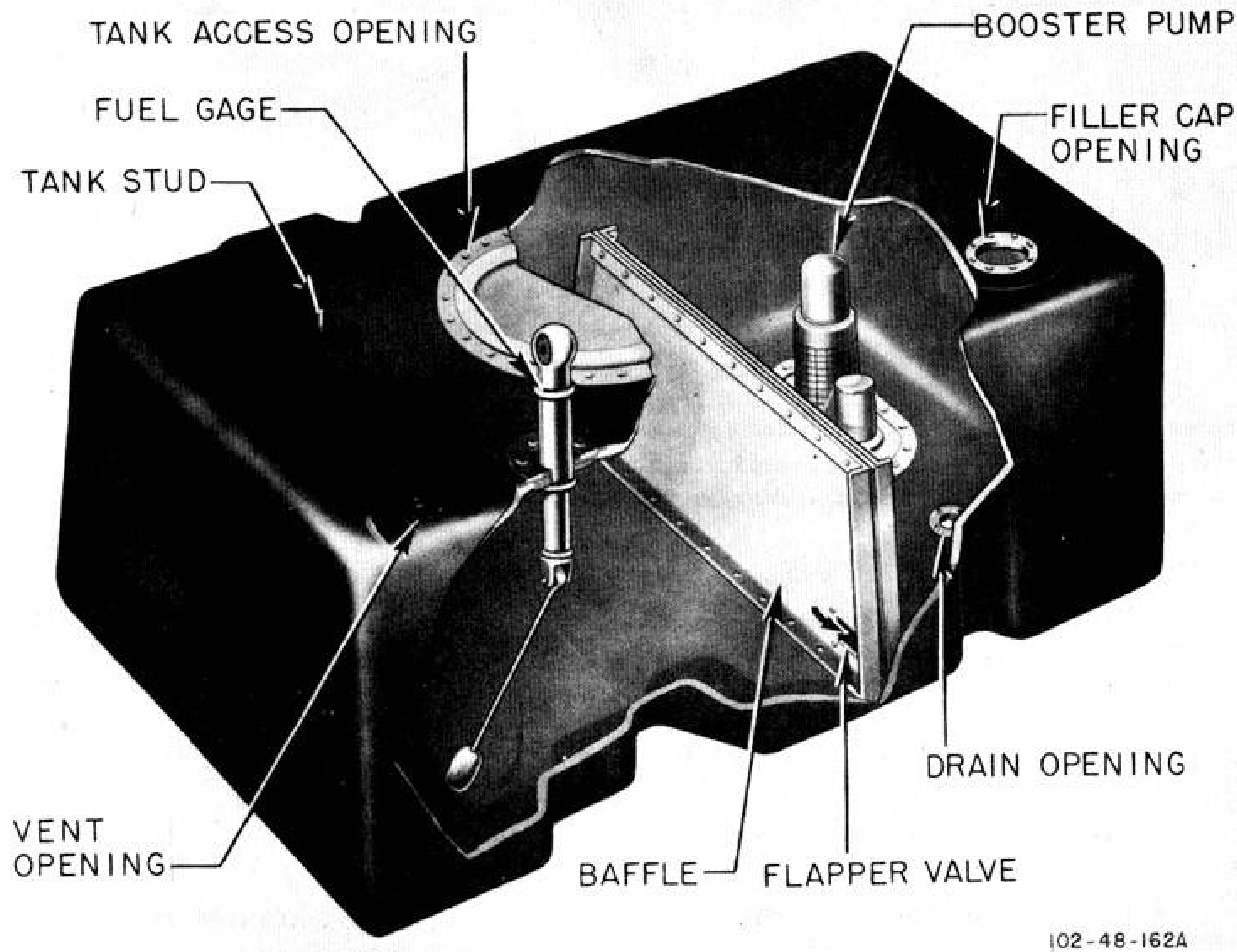



*Figure 252—Fuselage Auxiliary Fuel Tank*

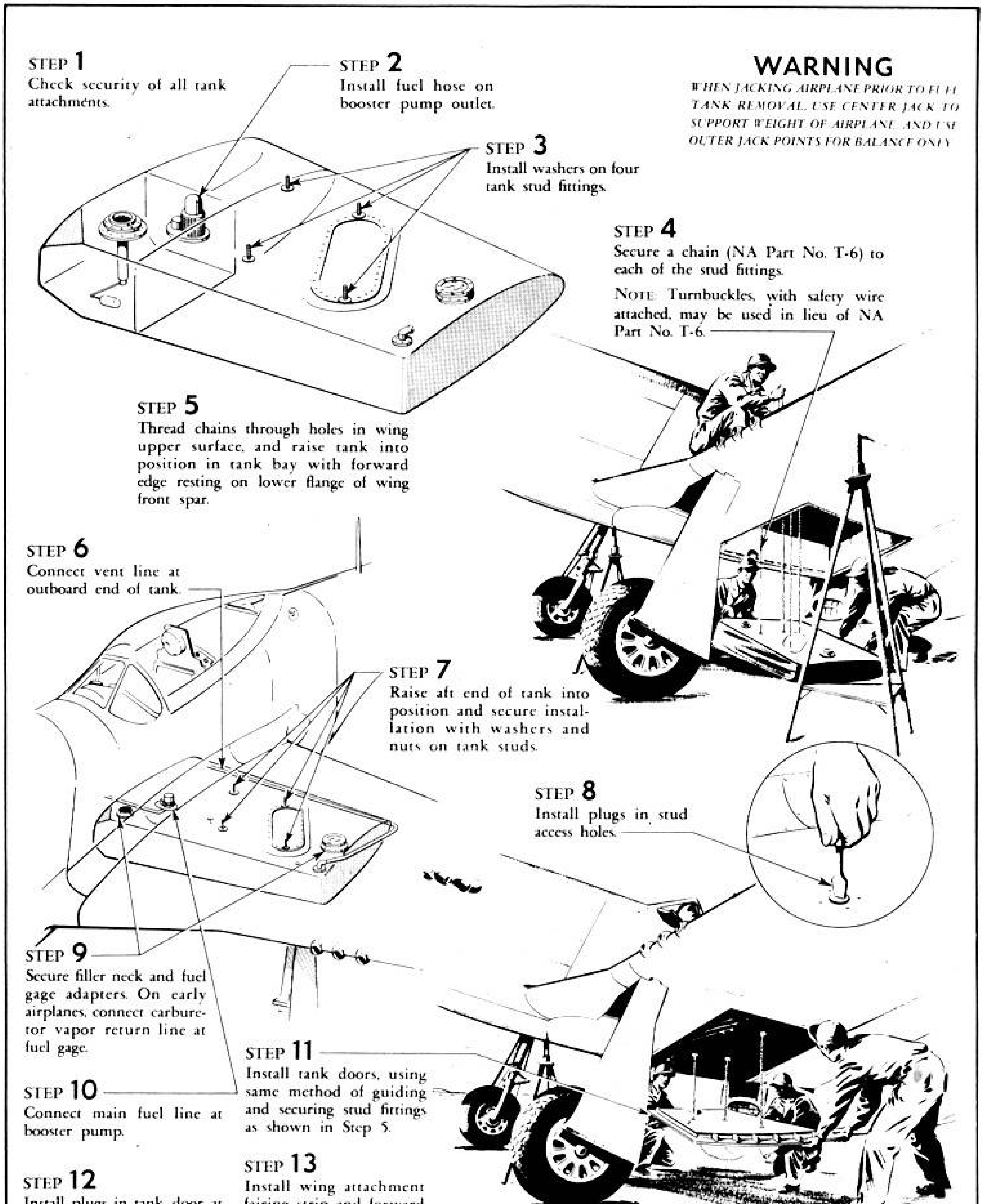



*Figure 253—Installing Main Fuel Tank*

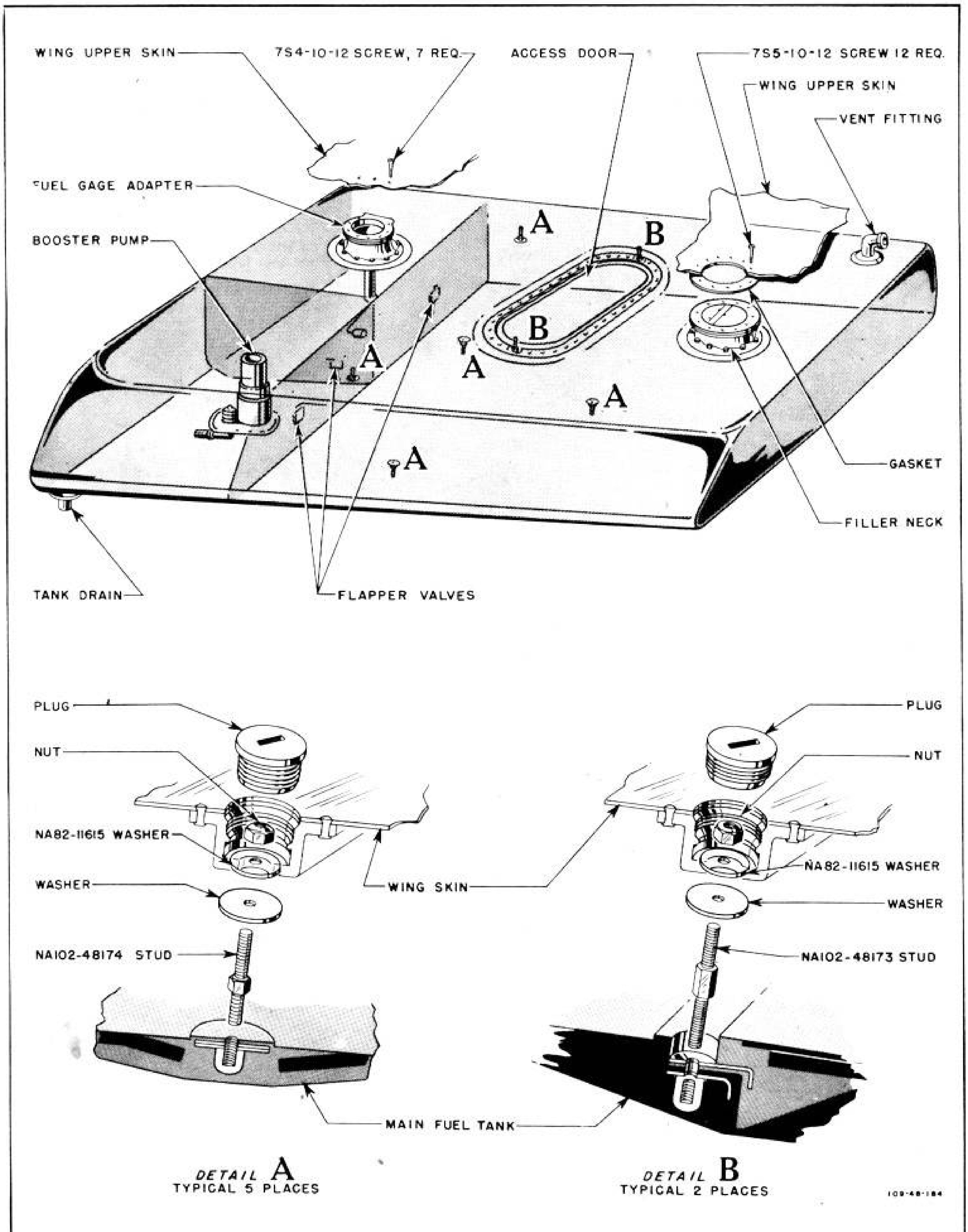



*Figure 254—Main Fuel Tank Installation Details*

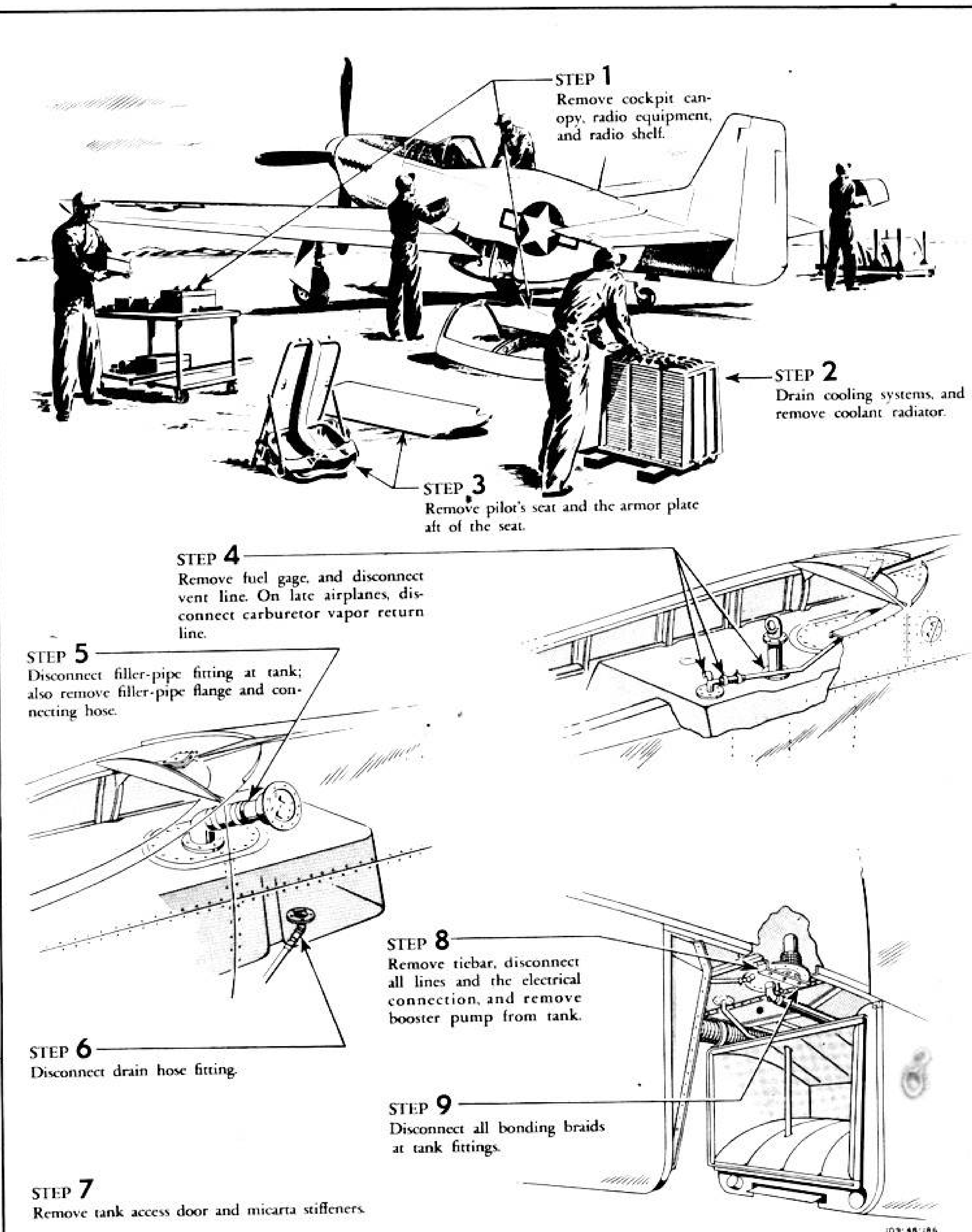



*Figure 255 (Sheet 1 of 2 Sheets)—Removing Fuselage Auxiliary Fuel Tank*

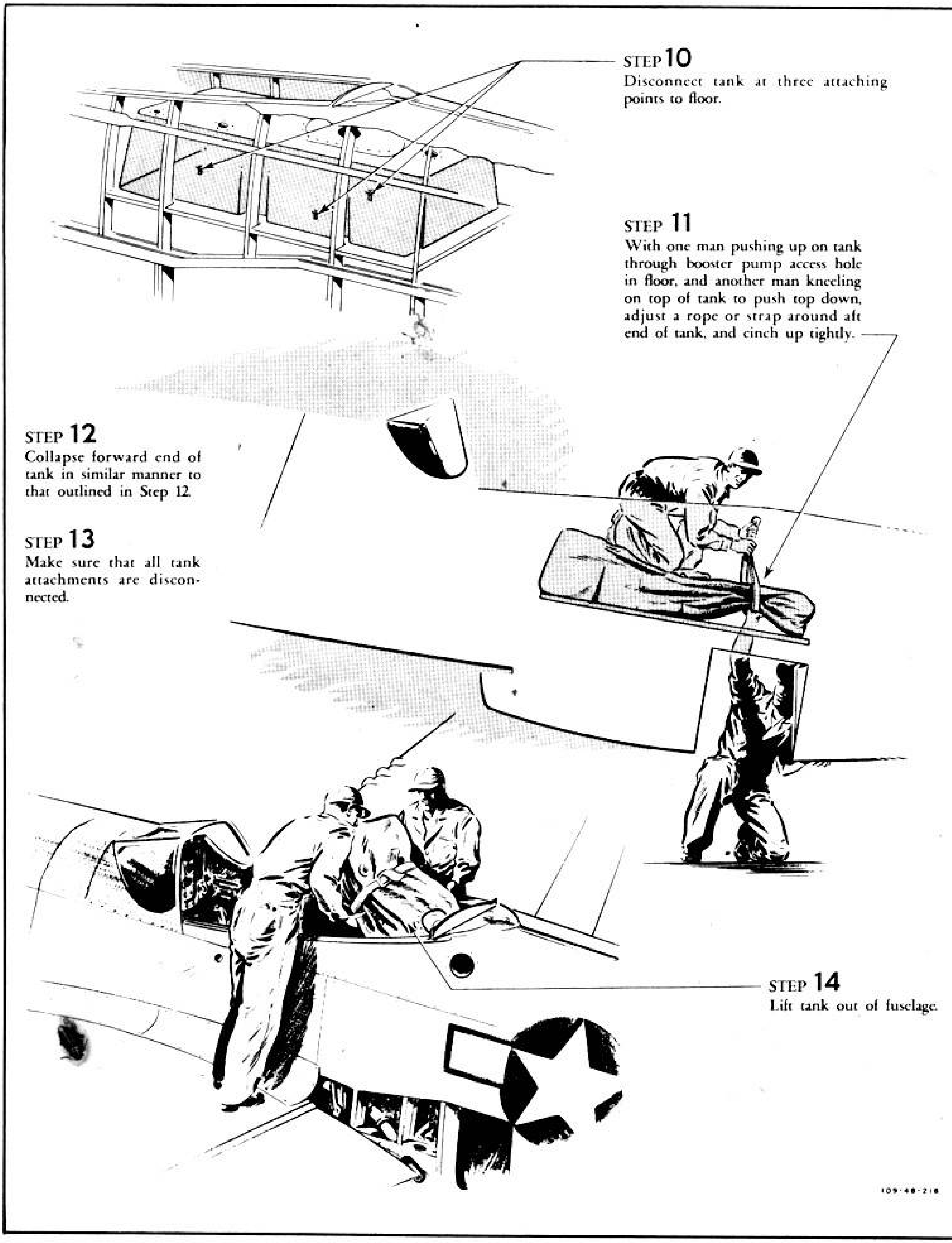



***Figure 255 (Sheet 2 of 2 Sheets)—Removing Fuselage Auxiliary Fuel Tank***

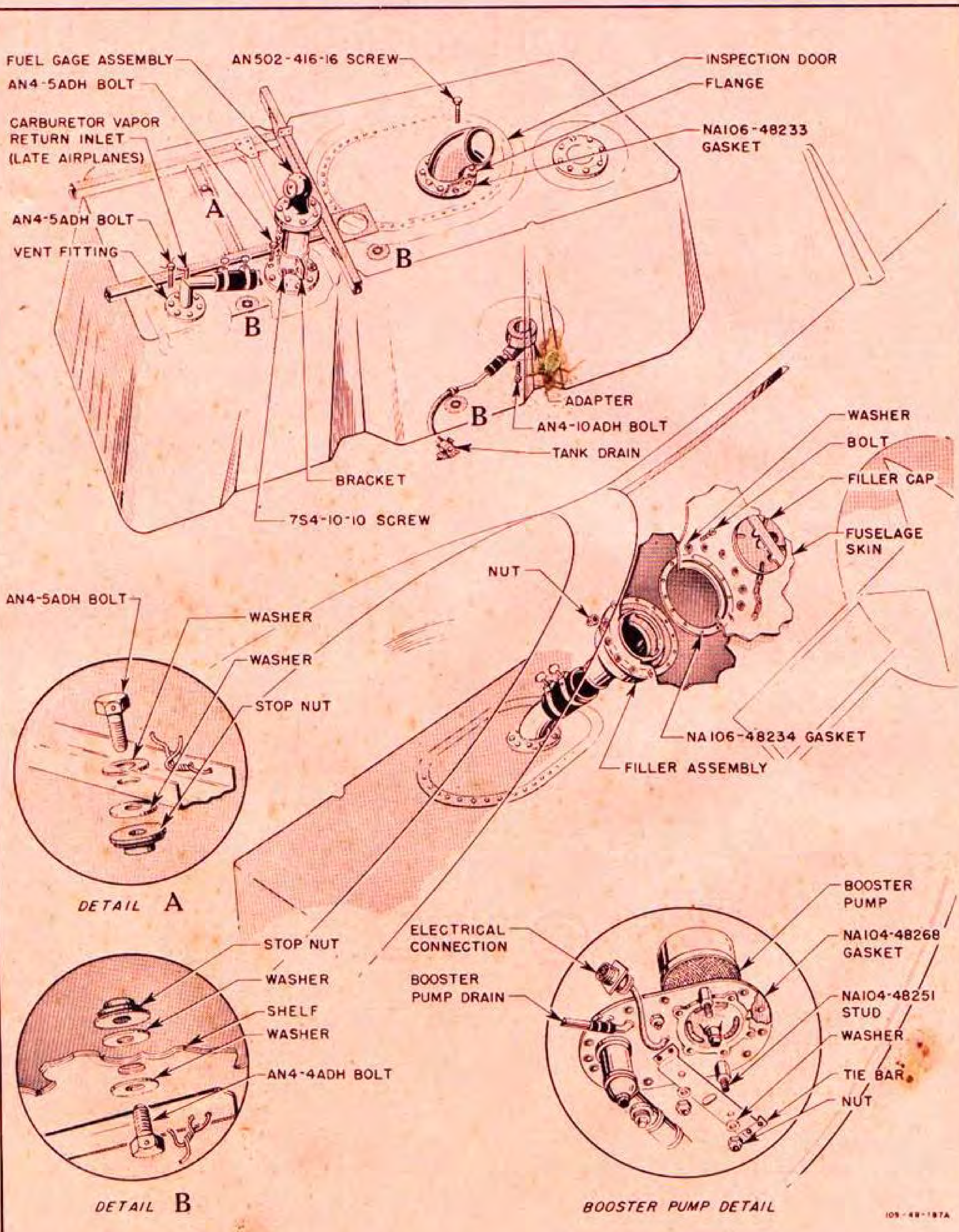



*Figure 256—Fuselage Auxiliary Fuel Tank Installation Details*

*2.* After placing gasket over plate, install pump with gasket between pump and plate. Secure pump with bolts, and safety the installation.

*3.* Install bar assembly and bonding braid with two nuts and spacers. *(See figure 256.)*

*4.* Safety the installation with lockwire.

*(e)* Install the drain fitting with six bolts, and safety the installation.

*(f)* Install filler-neck assembly. *(See figure 256.)*

*(g)* Connect fuel tank vent line.

*(h)* Install fuel gage with six bolts, and safety the installation with lockwire.

*(i)* Install micarta stiffeners at baffle, and install inspection door. Safety the door installation with lockwire.

*(j)* Install booster pump drain line and connect electrical plug.

*(k)* Connect fuel drain line.

*(l)* Connect main fuel line at booster pump.

*(m)* Install coolant radiator. *(See paragraph* 17. *c.* (5) *of this section.)*

*(n)* Install radio shelf and equipment.

*(o)* Run up engine and check cooling systems for leaks.

(4) TESTING FUSELAGE AUXILIARY FUEL TANK.—See paragraph 15. ***b.*** (4) of this section for applicable procedure.

*d.* COMBAT FUEL TANKS.

(1) DESCRIPTION. — The droppable, pressurized combat fuel tanks are designed to be carried on the wing bomb racks when additional range is desired. The discharge side of the engine-driven vacuum pump is utilized to maintain approximately 5 pounds per square inch pressure within the tanks, thus ensuring fuel feed at high altitude. A pre-adjusted pressure relief valve and two check valves are provided in the system. The relief valve maintains the desired pressure within the tanks, and the check valves are used to prevent back pressure from affecting vacuum instruments in the event of vacuum pump failure, and to preclude the possibility of damage to the tanks if the outside air pressure exceeds the pressure within the tanks, should the vacuum pump fail.

(2) REMOVING COMBAT FUEL TANKS.—Drain the tanks and place suitable racks under them. Five men are required for tank removal: one to jettison the tanks with the bomb control handle, and two to handle each tank when they are released simultaneously.

**Note**

After tank removal, the pressure lines should be left open to permit free discharge of vacuum pump pressure.

(3) INSTALLING COMBAT FUEL TANKS.

*(a)* PREINSTALLATION PROCEDURE.

*1.* Remove gland nut and plug from the forward fuel and pressure outlets in tank. Reinstall gland nuts.

*2.* Assemble fuel and pressure lines; leave clamps loose for adjustment purposes.

*3.* Install lines to tank, and position lines for ready connection to their respective seal rings. Do not tighten gland nuts at this time. *(See figures 257 and 258 for early airplanes, and figure 258A for late airplanes.)*

*4.* Remove plug from fuel line opening in wing.

*(b)* INSTALLATION.—For the 75-gallon tank installation, see figures 257 and 259. For 110-gallon tank installation, the 75-gallon tank installation is applicable. *(See figure 259.)* However, the 110-gallon tank will be installed only when the identical pad-type sway braces (NA 109-63101) are used.

**Note**

As neither the wing nor the bomb rack was designed for 110-gallon combat tanks, the use of these tanks is not recommended. However, if certain missions require their use, carry out the instructions given.

*e.* FUEL SELECTOR VALVE. *(See figure 260.)*

(1) DESCRIPTION.—The fuel selector valve, mounted in the left wheel recess, is manually operated by a control handle mounted below the front switch panel. A switch, incorporated in the control handle assembly, will start the booster pump in the tank selected provided the booster pump switch, located on the front switch panel, is in the "ON" position.

(2) REMOVING FUEL SELECTOR VALVE.—Disconnect all lines from valve and tape open ends. Disconnect control rod, remove attaching nuts and bolts, and remove valve from wheel recess.

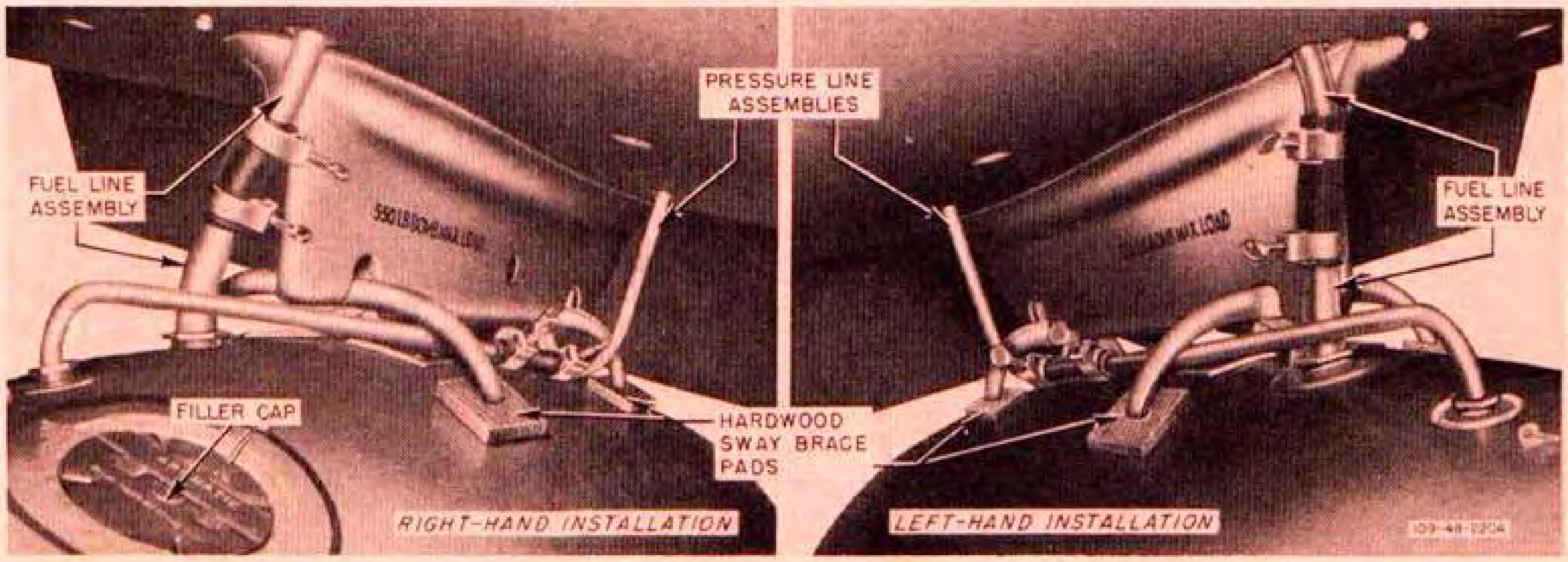



*Figure 257—75-gallon Tank Installation*

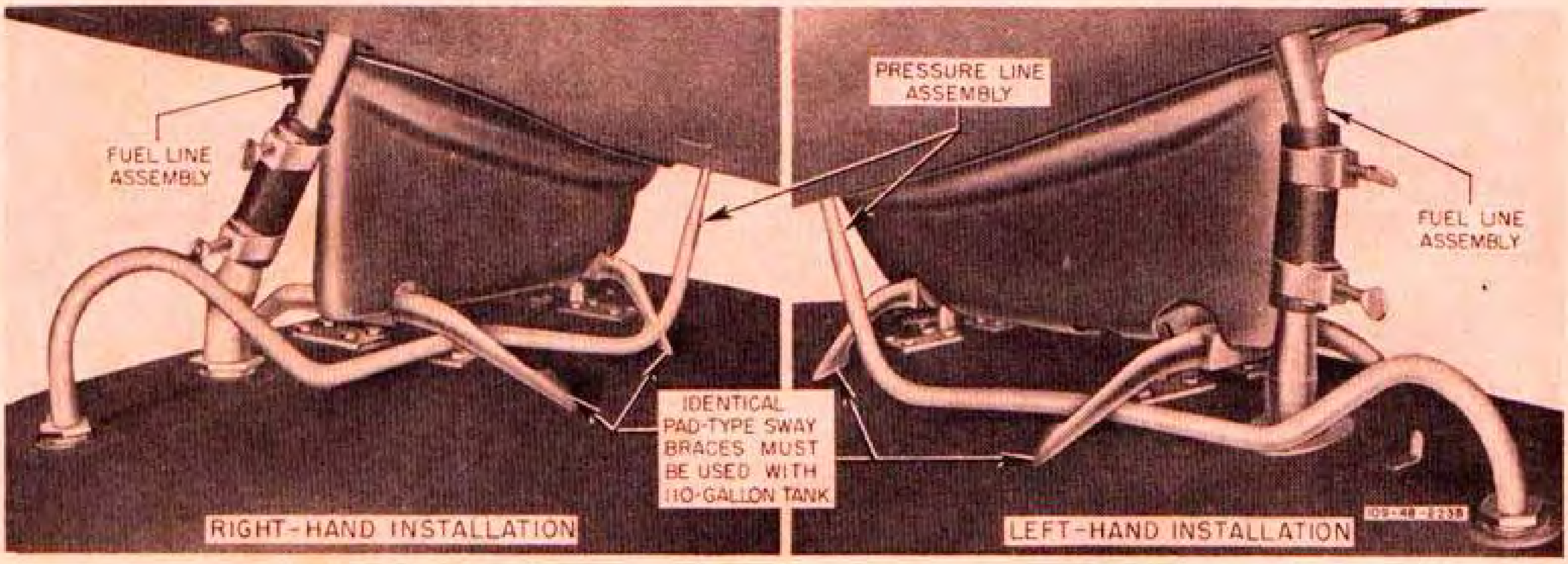



*Figure 258—110-gallon Tank Installation—Early Airplanes*

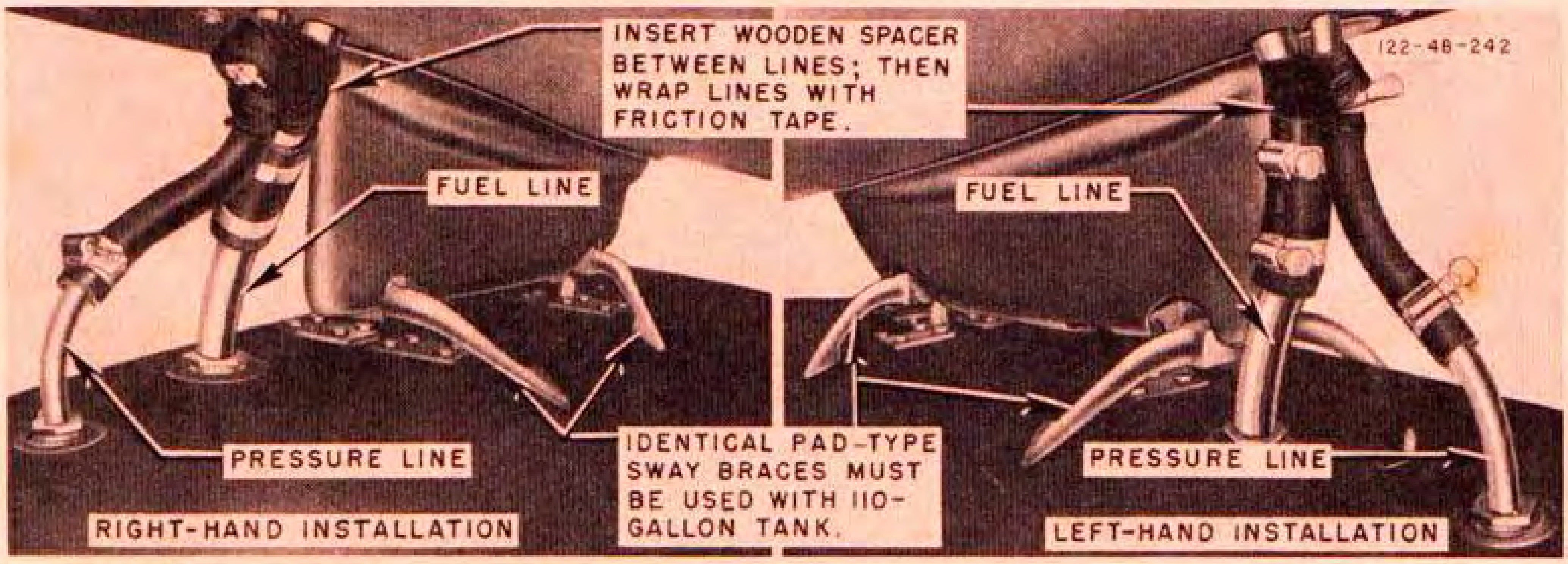



*Figure 258A—110-gallon Tank Installation—Late Airplanes*

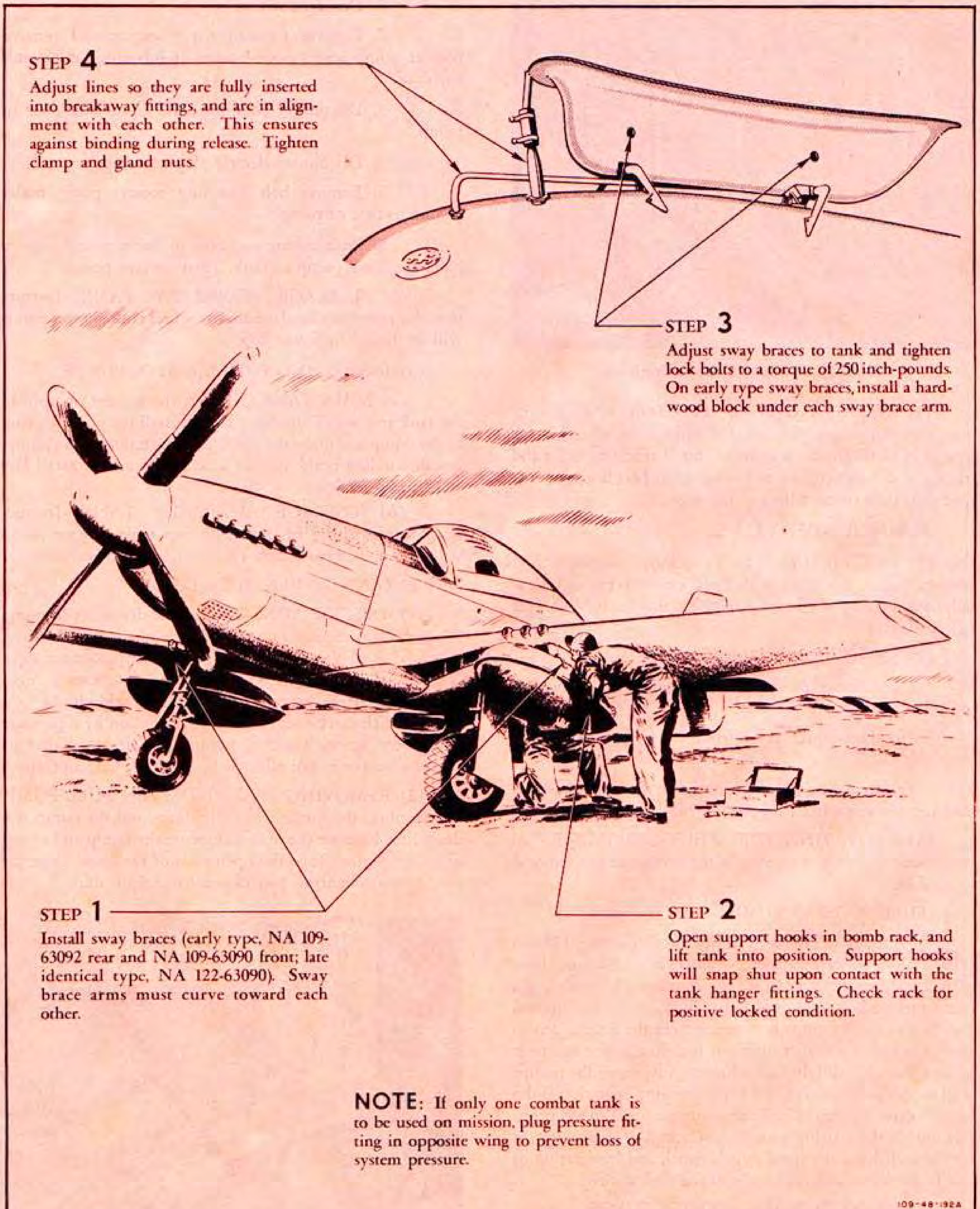



*Figure 259—Installing 75-gallon Combat Tank*

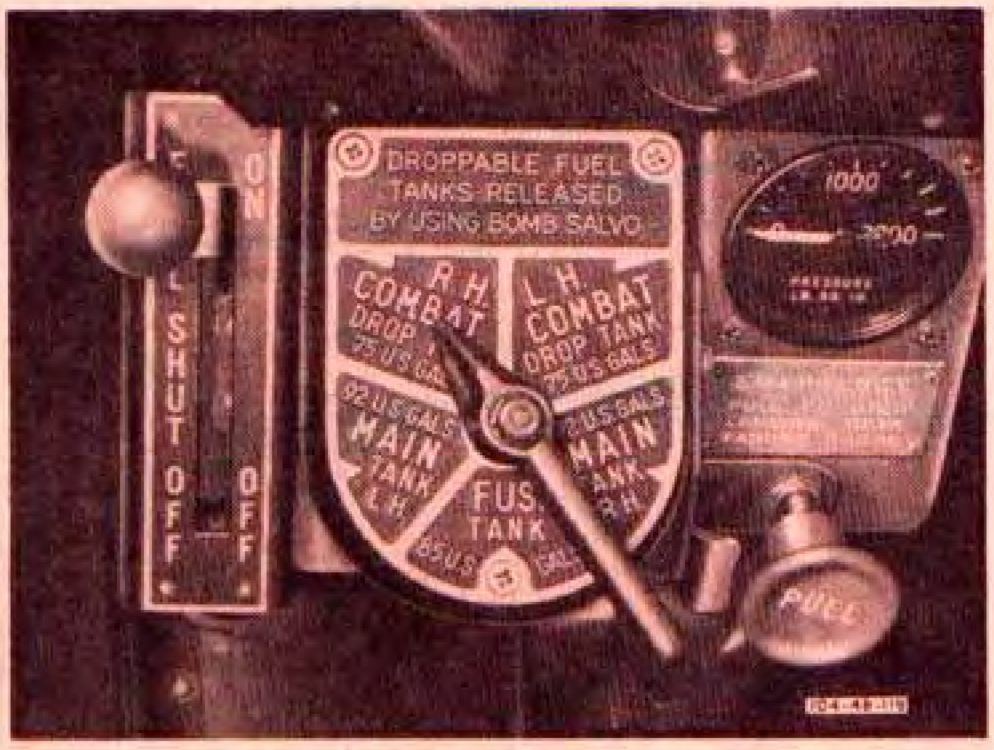



*Figure 260—Fuel System Controls*

(3) INSTALLING FUEL SELECTOR VALVE.—Locate valve in proper position and inspect the assembly for cracks in metal around bolt holes. Install attaching bolts and nuts, and connect control rod to valve. Inspect lines for cuts and dirt; then connect lines to the valve.

*f.* FUEL SHUT-OFF VALVE.

(1) DESCRIPTION.—The two-way, plug-type fuel shut-off valve, mounted in the left wheel recess, is manually operated by a control handle at the left of the fuel selector valve.

(2) REMOVING FUEL SHUT-OFF VALVE.

*(a)* Remove taper pin from operating arm on end of valve and remove the arm.

*(b)* Disconnect lines from valve, and tape open ends.

*(c)* Remove four attaching bolts, nuts, and washers, and remove valve from supporting brackets.

(3) INSTALLING FUEL SHUT-OFF VALVE.—Installation procedure is essentially the reverse of the removal procedure.

*g.* FUEL BOOSTER PUMPS.

(1) DESCRIPTION.—The booster pumps (Model TFD-13000 on early airplanes, and TFD-13900 on later airplanes) are the submerged type, mounted inside each main fuel tank and the fuselage auxiliary tank. The normal function of these pumps is to supplement the engine-driven pump in such a way that sufficient fuel flow to the engine is guaranteed under all flight conditions. Any one of the pumps will supply sufficient fuel for normal engine operation if the engine-driven pump fails. The booster pumps also aid priming during the starting procedure. Control of each pump is by the switch on the front switch panel, and by rotation of the fuel selector control handle to the tank desired.

(2) REMOVING FUEL BOOSTER PUMPS.

*(a)* MAIN TANKS.—The booster pumps may be removed from the tanks without removing the tanks or tank bay doors from the airplane.

*1.* Drain the system.

*2.* Remove forward scoop section and remove booster pump access door located at inboard end of tank bay door.

*3.* Disconnect bonding braid from tank door to pump.

*4.* Disconnect electric plug at pump.

*5.* Remove bolt attaching booster pump outlet casting to base of pump.

*6.* Push casting and hose to one side and remove bolts attaching pump to tank. Then remove pump.

*(b)* FUSELAGE AUXILIARY TANK.—Instructions for removing fuselage auxiliary fuel tank booster pump will be found in figure 255.

(3) INSTALLING FUEL BOOSTER PUMPS.

*(a)* MAIN TANKS.—Insert the booster pump into the tank and install attaching bolts. Install the outlet casting to the pump and make the electrical connection to the pump. Install bonding braid, replace access door, and reinstall forward scoop section.

*(b)* FUSELAGE AUXILIARY TANK.—Instructions for installing fuselage auxiliary tank booster pump will be found in paragraph 15. *c.* (3) *(d)* of this section.

*h.* ENGINE-DRIVEN FUEL PUMP.

(1) DESCRIPTION.—The engine-driven fuel pump (Type G-9) is mounted on the left side of the engine wheel case, and is of the rotary-vane, positive-displacement type. A relief valve, incorporated in the pump, functions to regulate the discharge pressure. The valve is held closed by a spring which can be set at the desired tension by a pressure adjustment screw. The fuel pump is so designed that its pressure output is not affected by booster pump operation.

(2) REMOVING ENGINE-DRIVEN FUEL PUMP.—Disconnect the intake and outlet lines, and the pump seal drain line. Remove the nuts that secure the pump and adapter to the engine. Tape the open ends of the lines. Tape the fuel pump mounting pad closed to exclude dust.


*Figure 261—Adjusting Fuel Pressure*

(3) CLEANING ENGINE-DRIVEN FUEL PUMP.

*(a)* The special vent plug in the valve housing cover should be cleaned at the 50-hour inspection period. Remove the plug, wash in gasoline, and blow out with an air hose.

*(b)* The most likely cause for difficulty with pressure regulation is dirt under the relief valve. Remove valve housing from pump body, take out relief valve, and clean valve and seat thoroughly. Also check the by-pass valve for obstruction.

(4) ADJUSTING ENGINE-DRIVEN FUEL PUMP.

*(a)* Remove necessary engine cowling and break safety on pressure adjustment screw locknut. Then loosen locknut.

*(b)* Two men are required to make the adjustment, one in the cockpit to run the engine up, and the other to make the adjustment. Run the engine up to 2000 rpm to check pressure.

*(c)* Turn the pressure relief valve adjusting screw clockwise to increase fuel pressure, and counterclockwise to decrease fuel pressure. Throttle engine while adjustment is being made; then run up to 2000 rpm again to check result.

*(d)* When the fuel pressure gage reads approximately 16 pounds per square inch, tighten the locknut. As tightening the locknut will often cause an additional rise in pressure, the engine should be run again at 2000 rpm to check the final result of the adjustment.

**WARNING**

Care should be exercised, during adjustment of fuel pressure, to keep clear of the propeller.

(5) INSTALLING ENGINE-DRIVEN FUEL PUMP. —Install the pump and adapter to the engine mounting pad. See that the pump is seated, and install the attaching nuts. Inspect lines for cleanliness, and install.

*i.* FUEL STRAINER.

(1) DESCRIPTION.—A Type C-5 fuel strainer, mounted on the left side of the firewall near the bottom, forms a trap for accumulated sediment and water. A petcock is provided at the bottom of the strainer to facilitate servicing the system. The strainer screen can be taken out for cleaning by removing the wing nuts on the bottom.

(2) REMOVING FUEL STRAINER.—Disconnect the inlet and outlet lines, and the line to the primer. Remove attaching bolts, remove strainer, and plug open ends of lines.

(3) INSTALLING FUEL STRAINER.—Position strainer on mounting bracket and install attaching bolts. Inspect lines for dirt, and connect lines to strainer.

*j.* ENGINE PRIMER SYSTEM.

(1) DESCRIPTION.—An electrically energized priming system is used. A primer, mounted at the bottom of the carburetor, directs fuel to the induction manifold at seven places. A solenoid valve, mounted on the carburetor, allows fuel to flow from the carburetor to the engine, at booster pump pressure. Actuation of the solenoid valve is by means of momentary switch located on the front switch panel just to the left of the starter switch. On early airplanes, a Type E-1, hand-operated engine priming pump is installed on the subpanel at the lower right side of the instrument panel. Fuel is drawn from the fuel strainer by the primer pump, and delivered to a combination filter and jet mounted on the supercharger induction elbow. A portion of the priming fuel is diverted to the induction elbow, and the remainder of the fuel is conducted via lines from the filter to the atomizer.

(2) REMOVING ENGINE PRIMER PUMP (Early Airplanes).—Disconnect the lines attached to the primer on the forward side of the instrument panel. Remove the three screws that hold the primer pump to the panel, and remove pump.

**CAUTION**

Do not grip plunger with vise or pliers.

(3) INSTALLING ENGINE PRIMER PUMP (Early Airplanes).—Insert the primer head into the instrument panel from the front side, and install the three attaching screws. Care should be exercised when tightening the screws, as excessive torque may strip them. Connect the two lines on the forward side of the instrument panel.

**16. OIL SYSTEM.**

*a.* GENERAL DESCRIPTION.

(1) UNITS.—The oil system consists essentially of the following units:

| UNIT | LOCATION |
|---|---|
| Oil tank | Forward side of firewall |
| Oil pump | Aft end of crankcase at bottom |
| Oil cooler | Center portion of scoop at bottom of fuselage |
| Oil filter | Right side of engine—center |
| Relief valves | Right side of engine—forward of oil filter |
| Scavenge pumps | Inside of crankcase at aft end of engine |
| Oil dilution solenoid | Inboard face of right engine mount beam at rear of engine |
| Temperature and pressure indicators | Lower right side of instrument panel |

(2) SYSTEM.—Oil from the tank is routed through lines directly to the pressure pump and oil filter, then to the relief valve unit where it is distributed to the engine at 3 different pressures. After lubricating the various engine parts, the oil drains into the sump, is picked up by the scavenge pumps, and is pumped aft to the pressure relief valve assembly mounted on the right side of the oil cooler. The pressure relief valve routes the oil either through the cooler or directly back to the tank, depending on the temperature of the oil and the pressure drop across the cooler core. The oil cooler is mounted in the lower portion of the cooling air duct on the bottom of the fuselage. A thermostatically controlled exit flap regulates the amount of air flowing through the cooler, thus regulating engine oil temperature. An oil dilution system, controlled by a solenoid valve, is provided to facilitate cold weather starting of the engine.

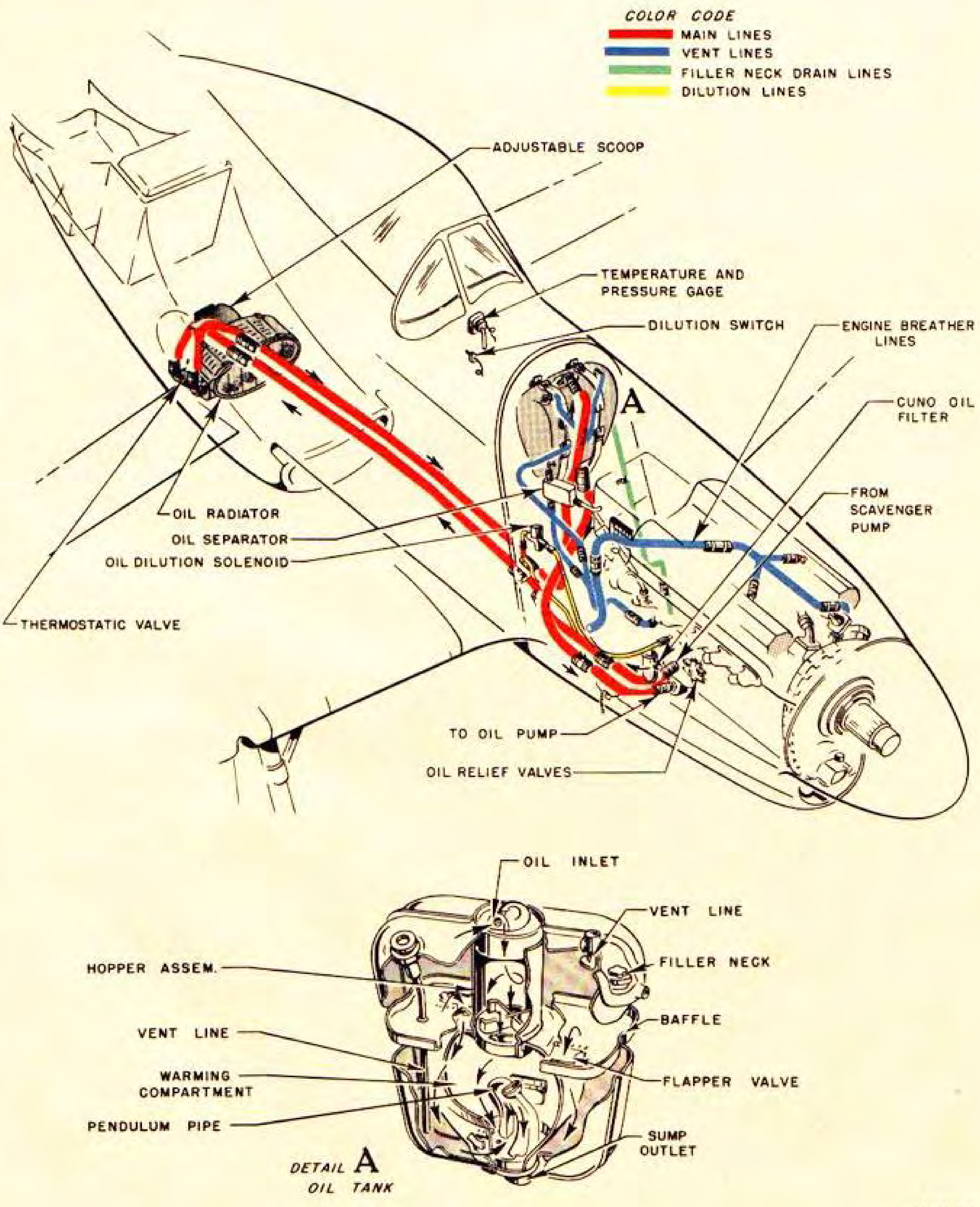



*Figure 262—Oil System*

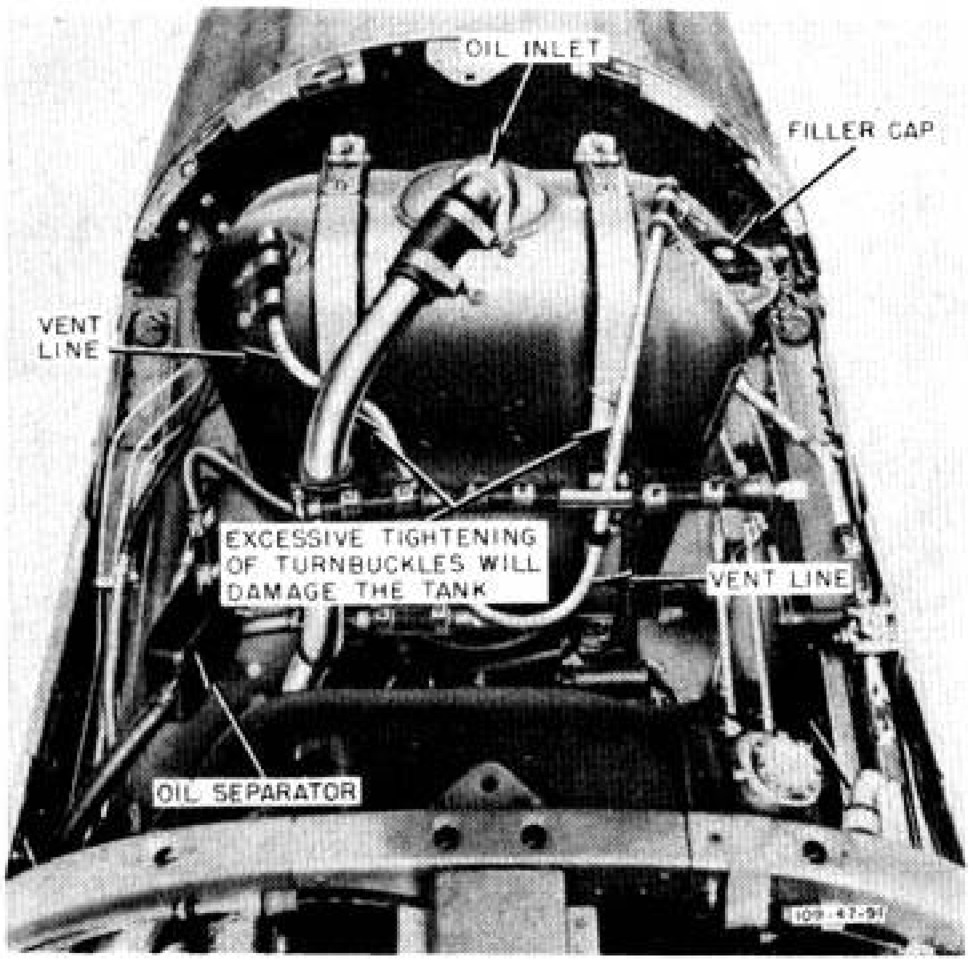



**Figure 263—Oil Tank Installed—Early Airplanes**

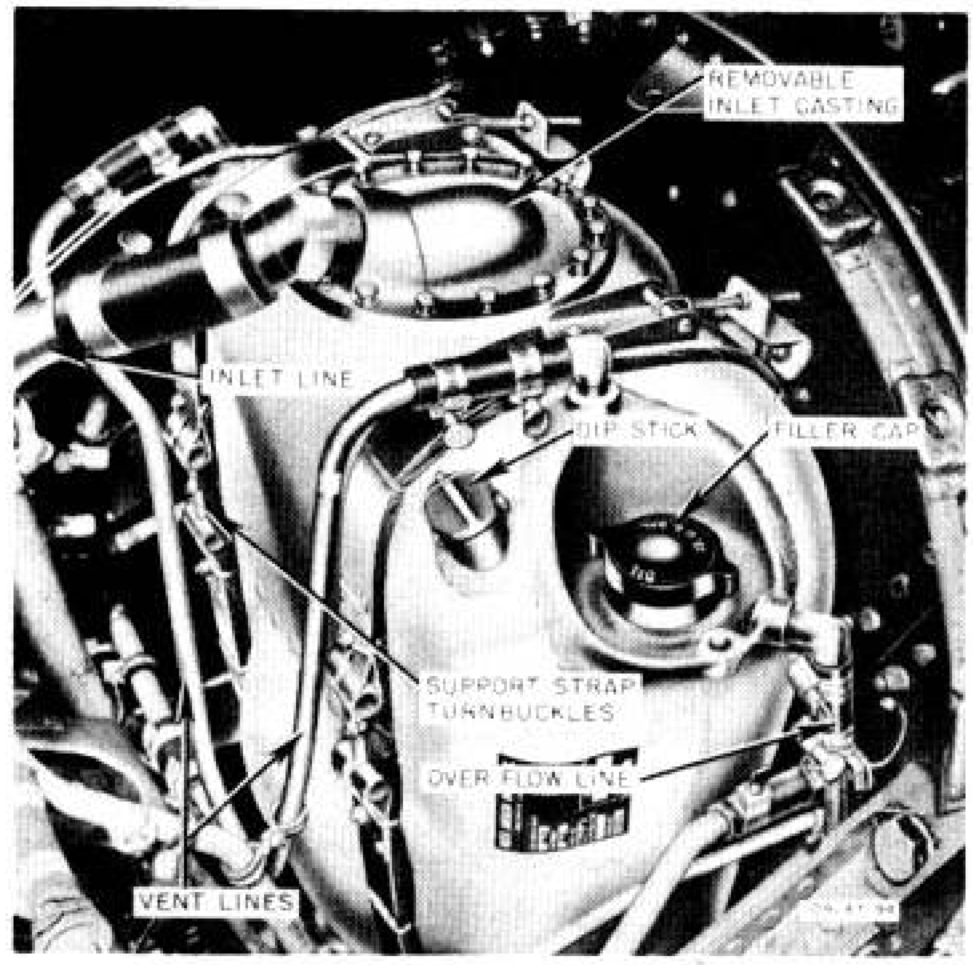



**Figure 264—Oil Tank Installed—Late Airplanes**

*b.* OIL TANK. *(See figures 263 and 264.)*

(1) DESCRIPTION.—The aluminum alloy oil tank is of the hopper type, making it unnecessary to drain engine lubricating oil except at engine change, unless a failure of an engine part necessitates an oil change before that time. Oil enters the top of the tank through a fitting arranged tangentially with a wall of the cylindrical hopper. The resultant centrifugal action effectively separates air from the oil as it flows through the hopper. Straightening vanes, in the bottom of the hopper, smooth out the oil flow as the oil enters the warming compartment in the bottom of the tank. Flapper valves are provided between the hopper and the warming compartment to prevent back flow of oil during inverted flight. A pendulum-type sump outlet, at the bottom of the tank in the warming compartment, provides positive oil supply to the pump during steep climbs and dives, even though the oil level in the tank has been appreciably depleted. The swivel joint of the sump is sealed from air by oil supplied from a small constantly filled cup at the top of the assembly. Fresh oil enters the warming compartment from the reserve chamber of the tank through two flapper valves in the walls of the compartment. The tank is provided with vents for all flight attitudes. The filler cap is located below the top of the tank to allow for expansion of oil and foaming. An overflow line is connected to a small well surrounding the filler cap and outlets overboard. A drain fitting on the bottom of the tank permits the removal of accumulated moisture and foreign matter. On later airplanes, a dip stick is provided at the top of the tank. Provision is also made on later airplanes for removal of the sump unit and the oil inlet fitting to facilitate cleaning.

(2) REMOVING OIL TANK. *(See figure 266.)*

(3) TESTING OIL TANK.—Prior to testing the oil tank, thoroughly clean and flush the inside. After plugging all other outlets, apply an air pressure of 5 pounds per square inch to the vent opening. The tank must withstand the specified pressure for one minute without distortion or drop in pressure.

(4) INSTALLING OIL TANK.

*(a)* Make sure the securing strap chafing pads are in good condition; if necessary, replace them.

*(b)* Position tank on firewall, being careful not to damage the tank by hitting it against surrounding objects.

*(c)* Connect securing straps, and check for proper alignment.

*(d)* Tighten, adjust, and safety the turnbuckles.

*(e)* Inspect all hoses for defective condition; replace if defective. Connect all lines, and properly adjust and tighten hose clamps.

*(f)* Connect bonding braid from firewall to tank.

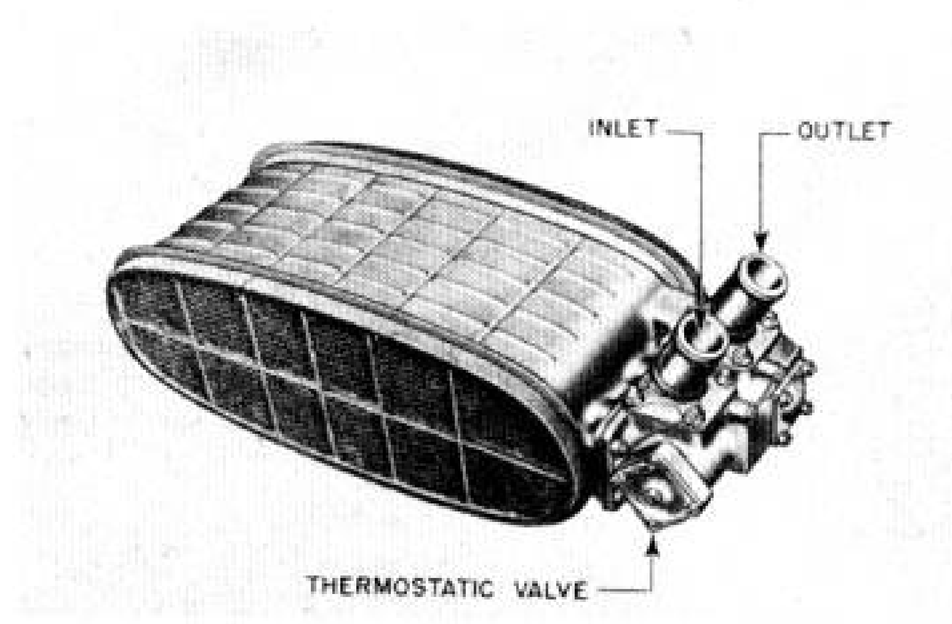



**Figure 265—Oil Cooler**

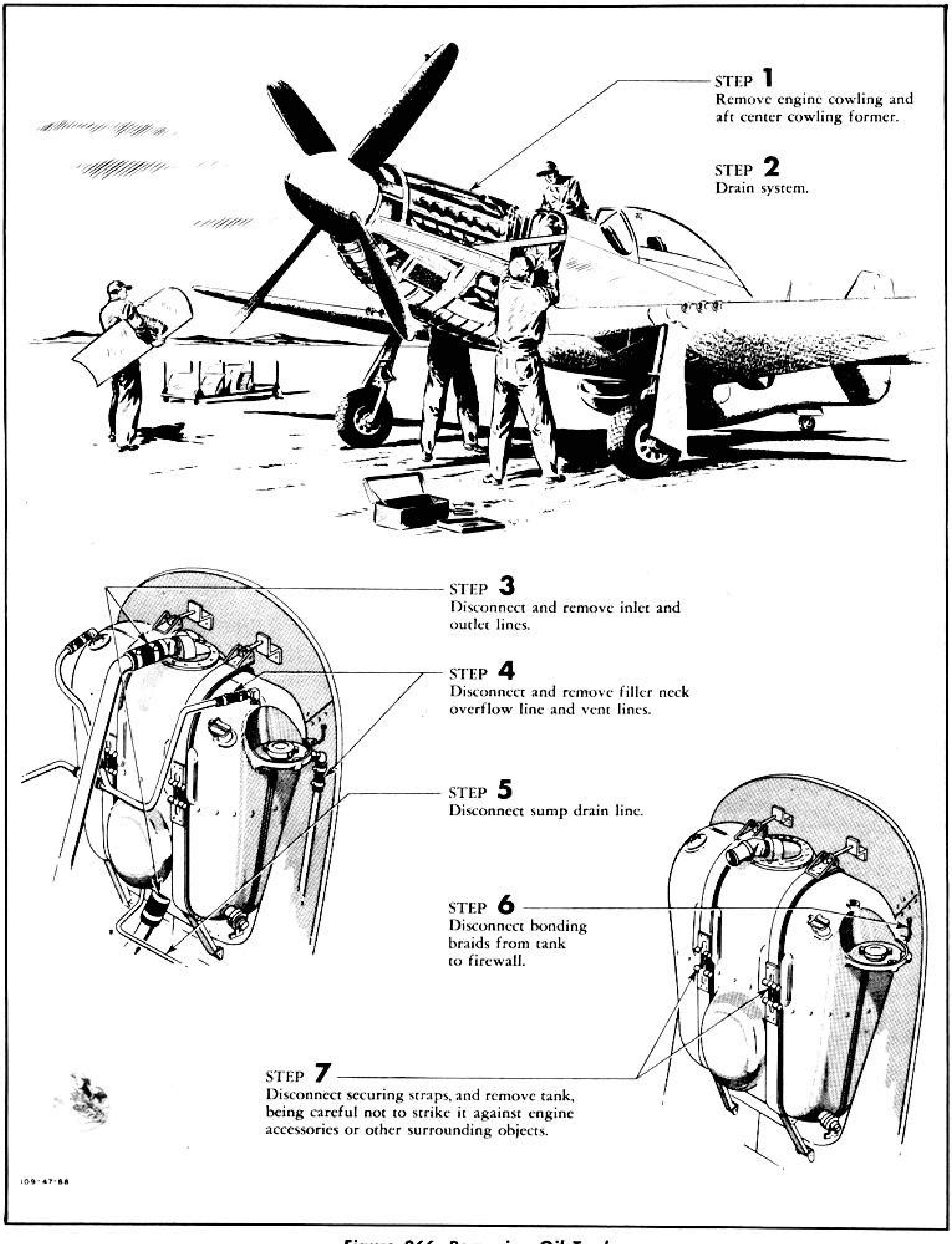



*Figure 266—Removing Oil Tank*

*c.* OIL COOLER. *(See figure 265.)*

(1) DESCRIPTION.—The oil cooler, Type U.A.P. 8000 Series, is a honeycomb type, and, when in operation, allows the oil to flow between the round portion of the copper cooling tubes. A combination by-pass and surge valve, mounted on one end of the cooler, by-passes oil directly to the cooler outlet if the temperature of the oil at the inlet is below 37.8°C (100°F). As the temperature of the oil at the inlet increases, the thermostatic surge element closes the by-pass and opens the core inlet. In this position, the by-pass valve acts as a 75-pound, spring-loaded relief valve which protects the oil cooler core from excessive pressures. After the oil leaves the valve and enters the top section of the cooler, it will by-pass the core tubes and relieve through a 40-pound, spring-loaded relief, in the valve body, if the resistance in the core section, due to cold oil, is in excess of 40 pounds. As this resistance decreases with a rise in the temperature of the oil, the oil passes through the core section to the outlet port of the valve. A check valve at the outlet port protects the core against high surge pressures encountered when the oil is by-passed during cold starting.

(2) REMOVING OIL COOLER. *(See figure 268.)*

(3) TESTING OIL COOLER.

*(a)* Remove the thermostatic control valve.

*(b)* Plug all outlets except one, and to this outlet apply an air pressure of 75 pounds per square inch.

*(c)* Submerge the cooler in warm water, mark the location of any leaks, and repair the cooler.

*(d)* Thoroughly flush the cooler with hot running water.

*(e)* Apply live steam to the cooler for 30 minutes.

*(f)* Thoroughly dry the cooler by heating it in an oven for approximately one hour at 121°C to 135°C (250°F to 275°F) until all moisture has evaporated.

**Note**

If an oven is not available or if the cooler is to be stored, immerse the cooler in a tank of clean, light, neutral lubricating oil at a temperature of approximately 121°C (250°F) and shake the cooler until all bubbling ceases. The moisture has then completely evaporated and the oil coating is complete.

(4) TESTING THERMOSTATIC BY-PASS AND SURGE VALVE.—The operation of this valve may be checked by pouring oil through the housing from the inlet side. The valve should start to close the by-pass when the temperature is 32° to 37.7°C (90° to 100°F) and be completely closed at 54.5°C (130°F). If no means are available for pouring oil through the housing, immerse the valve (assembled in the housing) in an oil or water bath, heat slowly, and observe the temperature at which the valve starts to move and is fully closed. Slight agitation in the bath is desirable to ensure the element being at the same temperature as the bath.

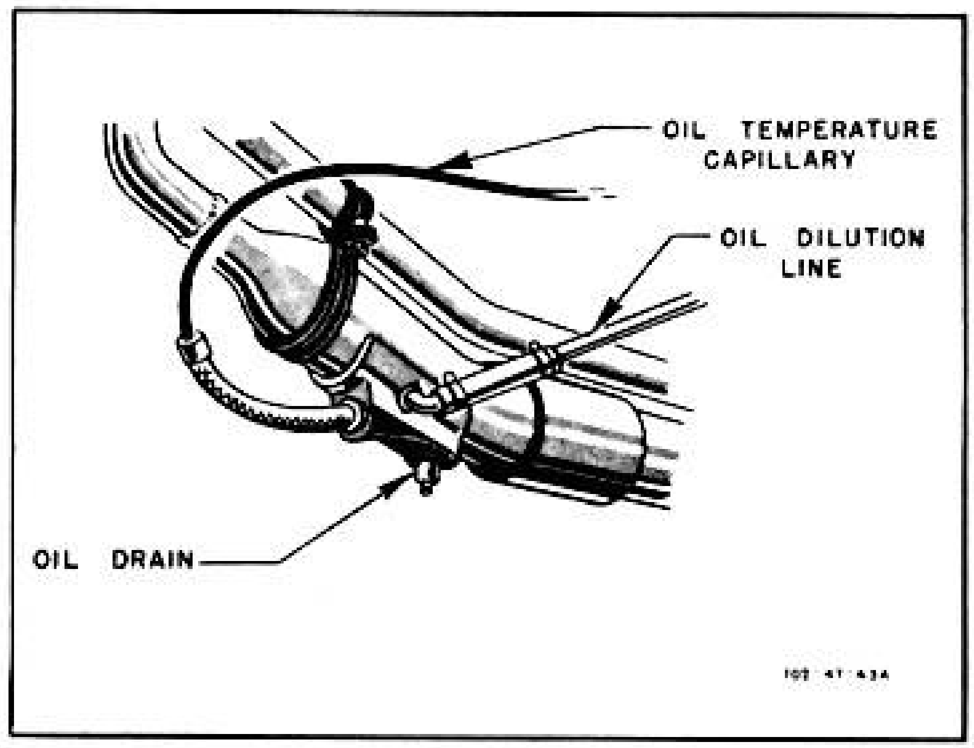



***Figure 267—Oil Drain Casting***

(5) INSTALLING OIL COOLER.

*(a)* Install the thermostatic control valve.

*(b)* Place the oil cooler in the support assembly and secure cooler by installing the two bolts in the straps.

*(c)* Connect inlet and outlet lines, properly adjust and tighten the hose clamps, and connect bonding braid.

*(d)* Install the access door on the lower right-hand side of the fuselage.

*(e)* Install door beneath cooler.

*(f)* Install forward scoop and trailing edge fillets. *(See paragraph 4. c. (4) (b) for installation of forward scoop assembly.)*

*d.* RADIATOR AIR INLET SCOOP.—The lower portion of the radiator air inlet scoop assembly houses the oil cooler. The forward end of the scoop is stationary and the aft end is movable. Movement of the aft portion of the radiator air inlet scoop is controlled by an automatic temperature-controlled electric actuator. A capillary bulb in the oil line from the cooler transmits the temperature to the actuator, which either extends or retracts according to the temperature of the oil. A control switch mounted on the left side of the cockpit serves as a manual override for the automatic positioning device.

*e.* OIL PRESSURE RELIEF VALVE UNIT.

(1) DESCRIPTION.—The oil pressure relief valve unit, on the right side of the engine, distributes oil to the engine in three different pressure stages: main pressure stage, medium pressure stage, and low pressure stage. Main pressure oil is conducted to the crankshaft and connecting rod bearings, and to the constant-speed governor and hollow propeller shaft. Oil at this pressure is regulated for an operating range of 60 to 90 pounds per square inch. Medium pressure oil provides lubrication for the supercharger impeller shaft, the clutch shaft bearings, and the planetary assembly. In addition to lubricating various bearing surfaces, this oil provides two points of cooling and lubrication for each planetary gear surface. The operating pressure range of this

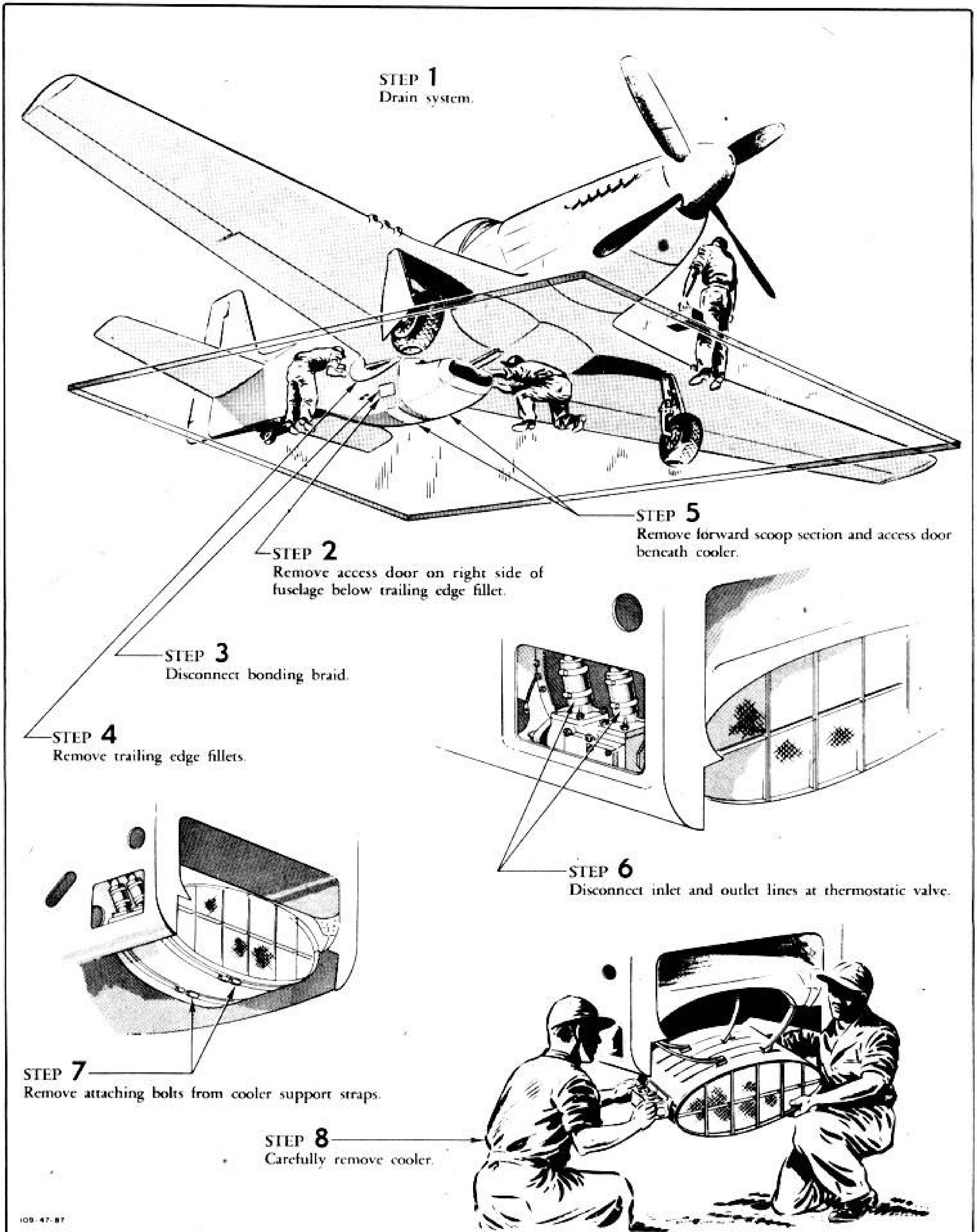



*Figure 268—Removing Oil Cooler*

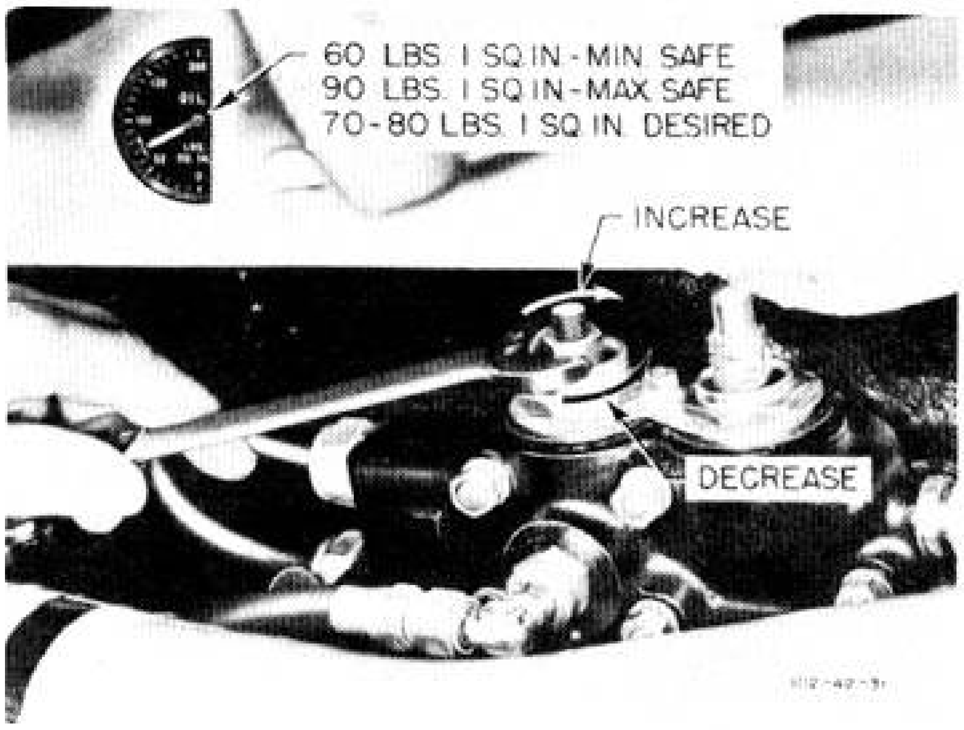



***Figure 269—Adjusting Oil Pressure***

stage is 28 to 32 pounds per square inch. Low pressure oil is directed to the camshaft rocker mechanism, tachometer generator drive, and forward to the reduction gear unit. This pressure stage is regulated for an operating range of 4 to 8 pounds per square inch.

(2) ADJUSTING OIL PRESSURE RELIEF VALVES. *(See figure 269.)*—Adjustment of the oil pressure in the engine main pressure and low pressure circuits is accomplished by varying the load on the relief valve spring provided for each circuit. The main pressure oil circuit, which is provided with a pressure gage on the instrument panel, should be set at approximately 75 pounds per square inch, at normal operating temperature. The low-pressure circuit, which is not provided with a gage, should be set at approximately 6 pounds per square inch at normal operating temperature. The low pressure should be checked and adjusted only when it is definitely known that the main pressure circuit is in proper adjustment. The procedure for adjusting the high or low pressure is as follows:

*(a)* Remove safety wiring from cap nut, locknut, and compartment cap.

*(b)* Remove cap nut, loosen locknut, and turn adjusting nut clockwise to increase oil pressure or counterclockwise to decrease oil pressure. When proper spring load (oil pressure adjustment) has been obtained, tighten locknut, install cap nut, and safety with wire through cap nut, adjusting nut, and compartment cap.

*(c)* To check and adjust the moderate pressure, remove banjo fitting bolt at supercharger end of moderate pressure line; drill a tap for a ⅛-inch pipe thread in the bolt head. Insert Weatherhead fitting and attach suitable testing gage. When pressure is in excess of 32 pounds per square inch, remove piston from valve housing. Clean piston, spring, and cylinder; then reinstall. If this procedure does not bring pressure within specified limits, remove one or more .025-inch shims from end of spring. If pressure is below limits, add one or more shims. Total amount of shims present must not exceed .075 inch. When replacement bolt is not available, insert ⅛-inch pipe plug in the hole that has been drilled and tapped for this operation.

## WARNING

Keep clear of the propeller when adjusting the oil pressure.

*f.* OIL FILTER. *(See figure 270.)*

(1) DESCRIPTION.—The engine is equipped with a full-flow, disc-type filter having self-cleaning discs which are automatically rotated by the built-in hydraulic turning motor. A built-in relief valve permits oil to by-pass when a predetermined pressure drop within the filter is exceeded.

(2) REMOVING OIL FILTER.—Remove the two elastic stop nuts next to the crankcase, the capscrew, and the three plain nuts which hold the hydraulic motor head and cartridge to the filter housing.

### CAUTION

Do not attempt to remove the filter by taking out the hex head capscrews in the head, as this will only separate the head from the cleaning element.

(3) CLEANING OIL FILTER.—The filter should be removed and cleaned every 25 hours of engine operation. Remove the filter, wash the cartridge with naphtha or unleaded gasoline, and flush with new engine oil. Check blades of cartridge to see that they are flat, free from burrs and nicks, and evenly spaced. If damaged, replace with a sound unit. Turn nut on protruding shaft to check cartridge for freedom of rotation. Drain filter casing by removing the plug at the bottom, and clean. Reassemble filter; then, with engine running, remove cap for turning shaft to make sure shaft is turning automatically. If not, install cap as a nut and turn shaft in normal direction of rotation. If this does not correct, remove cartridge and recheck for cleanliness.

(4) INSTALLING OIL FILTER.—Slip mounting flange of oil filter into place over stud bolts on housing.

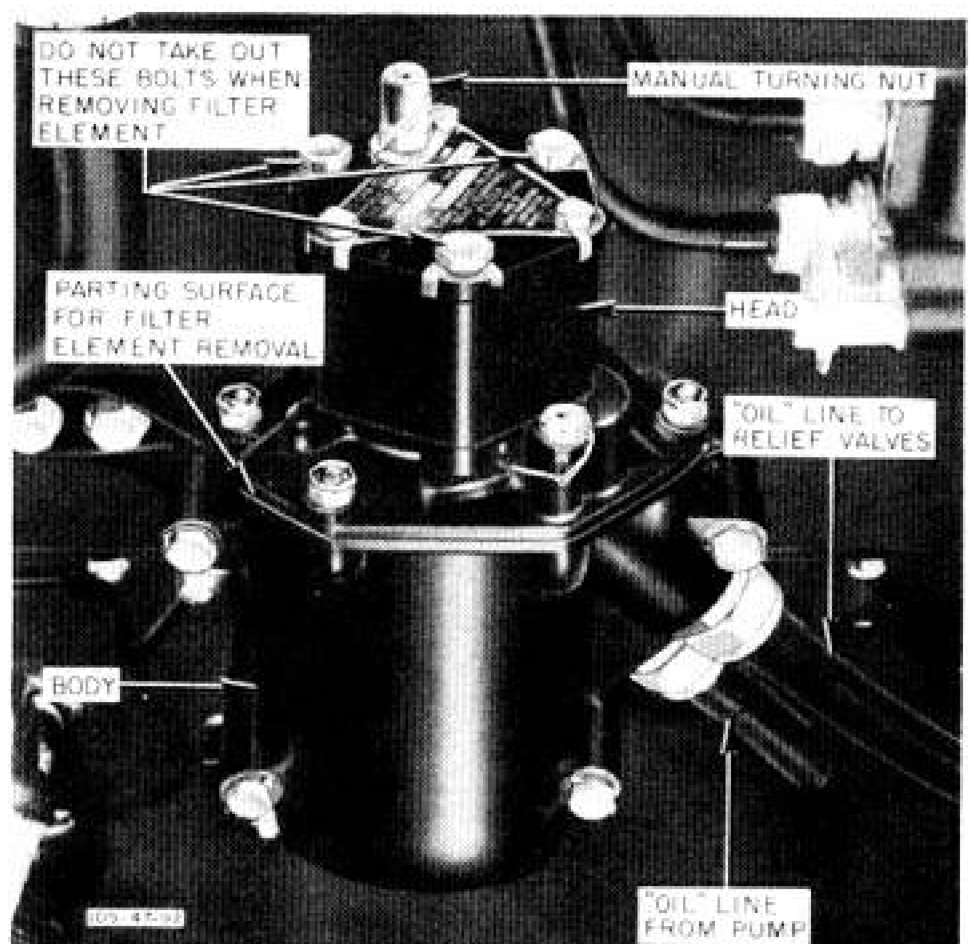



***Figure 270—Cuno Oil Filter***

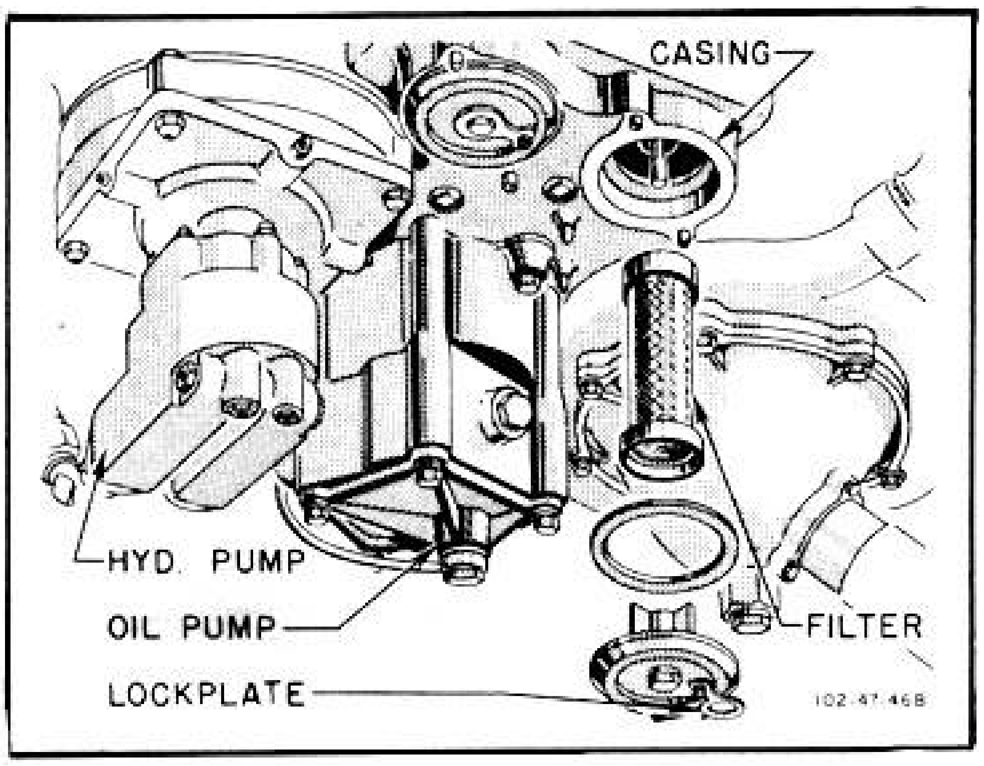



*Figure 271—Scavenge Oil Filter Screens*

Install the two elastic stop nuts next to the crankcase, one capscrew, and the three plain nuts which hold the hydraulic motor head and cartridge to the filter housing.

*g.* OIL SYSTEM PRESSURE PUMP.—The oil system pressure pump, furnished with the engine, is attached to the engine directly beneath the scavenge pumps. The pump is the conventional spur gear type. Constant pressure is maintained by the pump in combination with the pressure-sensitive relief valves.

*h.* SCAVENGE PUMPS.—The scavenge pumps are mounted inside of the crankcase directly over the pressure pump. One pump scavenges oil from the sump at the propeller end of the engine, and the other pump scavenges oil from the sump at the supercharger end of the engine.

*i.* SCAVENGE OIL FILTERS.

(1) DESCRIPTION.—Two filters on the inlet side of each scavenge pump clean the lubricating oil after it has passed through the engine; the scavenge pumps return the filtered oil through the cooler to the oil tank.

(2) CLEANING SCAVENGE OIL FILTERS. *(See figure 271.)*—The two scavenge filters, locate[illegible] the lower crankcase, will be removed and cleaned every [illegible] hours of engine operation. Unscrew the cap nuts to remove the screens, and clean the screens with naphtha or unleaded gasoline. While the screens are removed, clean their casings with lintless cloth. Then replace the filters.

**CAUTION**

Care should be exercised when installing the cap nuts. Overtightening will break the filter screen housing, with the result that the effectiveness of the scavenging system is materially reduced. A tightening torque of 8 to 10 foot-pounds is sufficient.

*j.* OIL SYSTEM INDICATORS.—The oil pressure, oil temperature, and fuel pressure indicators are incorporated into one instrument mounted in the lower right-hand corner of the instrument panel.

*k.* FINAL TEST OF OIL SYSTEM.

(1) Fill the oil tank to the desired level, and install and safety the filler cap.

(2) Run up the engine; if the oil pressure does not reach 50 pounds per square inch in 30 seconds, immediately stop the engine and investigate.

(3) After the engine run-up has proved satisfactory with a normal oil pressure (70 to 80 pounds per square inch) and temperature (approximately 75°C (167°F)), stop the engine and remove the engine and cooler access cowl.

(4) Check the oil tank for security and proper bonding.

(5) Check all oil line and vent connections.

(6) If repairs have been made to the tank, thoroughly check repaired section to see that there is no leakage.

(7) Check the cooler for security of mounting and evidence of leaks.

(8) Check all connections for security, and make sure that all of the lines have sufficient clearance to prevent damage or wear.

(9) If the inspection proves satisfactory, replace the access cowling.

## 17. COOLING SYSTEMS.

*a.* GENERAL DESCRIPTION.—Two complete and separate cooling systems are employed in this airplane: one, the engine cooling system to cool the engine proper, and the other, the aftercooling system to cool the supercharged fuel-air mixture. Inasmuch as the two systems are entirely separate from each other, the systems and their components will be treated individually throughout this section.

(1) ENGINE COOLING SYSTEM.—This system is unconventional in the respect that it operates at pressures up to 50 pounds per square inch. Otherwise, it is of the conventional type consisting of components normally found in a liquid cooling system. The normal cooling medium (30/70 ethylene glycol and water, inhibited with NaMBT) is circulated at relatively high velocity by an engine-driven centrifugal-type pump mounted on the bottom of the engine. The coolant flows from the pump to the exhaust lower side of each cylinder block, passes to the cylinder heads through brass, rubber-sealed transfer tubes, then out through manifolds attached to the intake side of each cylinder head. These manifolds discharge the coolant into the header tank mounted at the front of the engine. From the header tank, the coolant flows directly to the engine cooling system section of the radiator, then to the pump for another circuit of the system. A concentrated, high-velocity flow of air through the radiator dissipates heat from the coolant as it flows through the radiator tubes.

(2) AFTERCOOLING SYSTEM.—The aftercooling system lowers the temperature of the fuel-air mixture prior to its introduction into the combustion chambers of the engine, thereby minimizing the possibility of detonation at

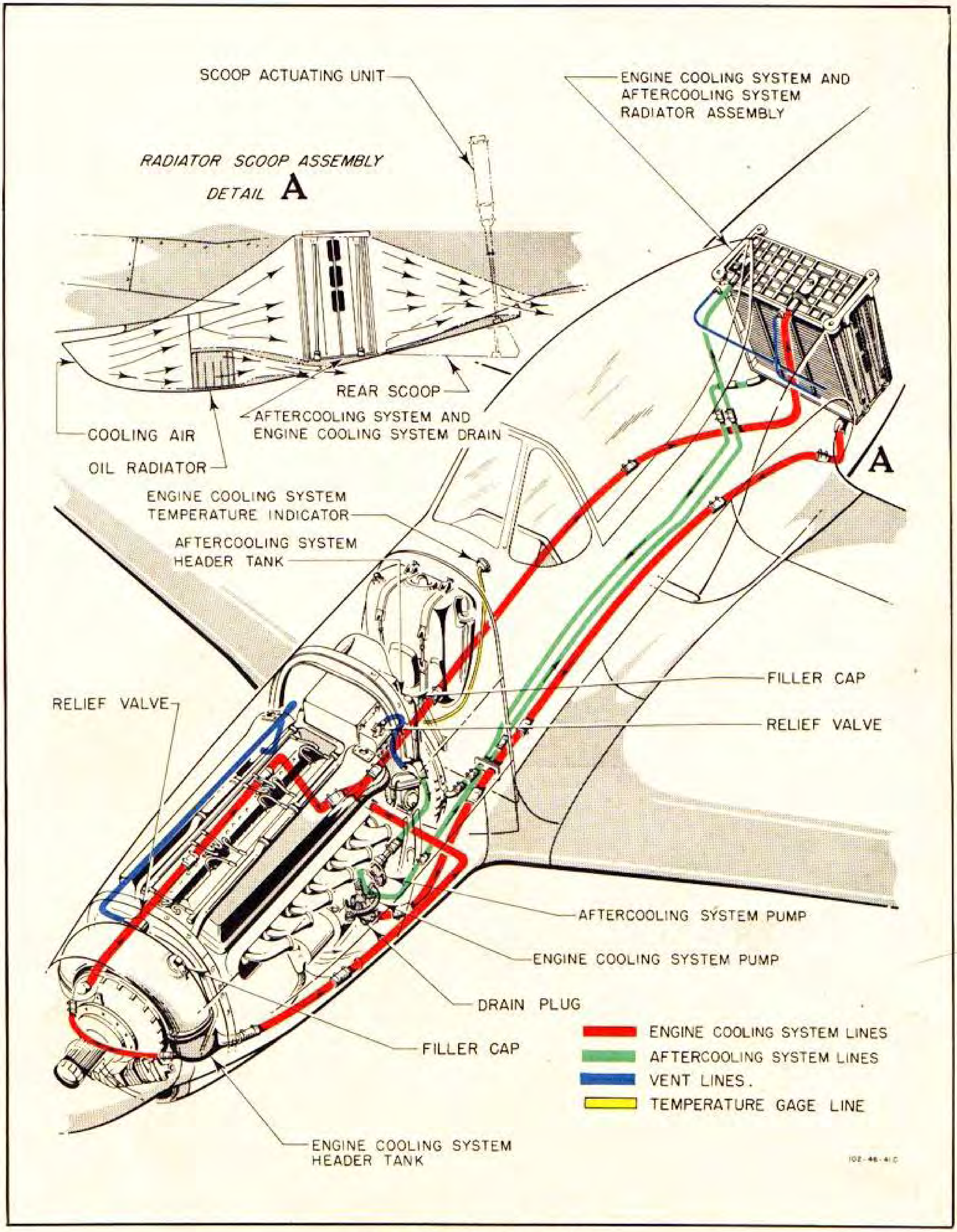



*Figure 272—Cooling System*

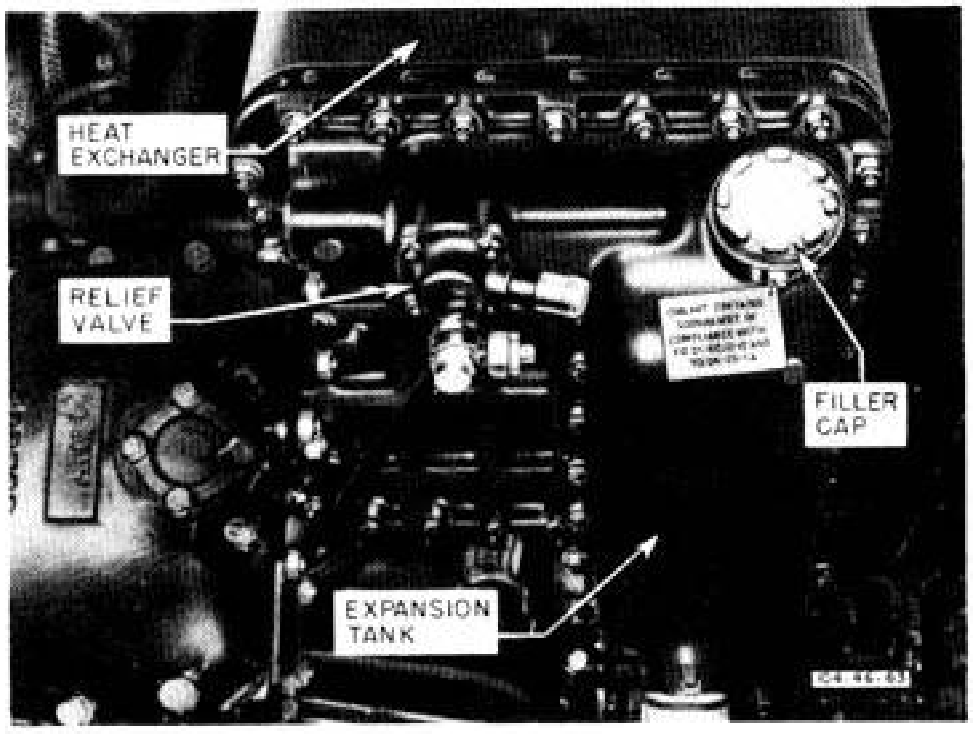



***Figure 273—Aftercooler Unit***

times when high performance is demanded of the engine. Coolant leaving the centrifugal-type pump, mounted on the left side of the engine, flows directly to the aftercooling system section of the coolant radiator, then forward to an inlet fitting on the engine wheelcase, where it flows through jackets that cool the fuel-air mixture between the first and second stages of supercharging. The fuel-air mixture is again cooled, after leaving the second stage of supercharging, by passing through an aftercooler unit mounted on the upper aft end of the engine. The aftercooler unit is comprised of a heat exchanger and a header tank. After leaving the wheelcase cooling jackets, the coolant passes through this aftercooler unit, and on to the pump, where it begins another cycle of circulation. The system is of the low-pressure type, incorporating a relief valve which relieves at approximately 18 to 20 pounds per square inch.

*b.* FLUSHING COOLING SYSTEMS.—Ethylene glycol, which is used in the coolant, tends to loosen rust, scale, etc.; therefore, at every 100-hour inspection period, the cooling system should be drained and flushed. The following instructions are for the prevention of corrosion in the cooling systems:

(1) Drain the cooling systems immediately after an engine run-up which has been conducted only long enough to raise the main coolant temperature of 80°C to 100°C (176°F to 212°F).

(2) Drain coolant into clean containers.

(3) Fill aftercooling system and main cooling system with clean water.

(4) Run the engine for a few minutes at such a speed that main coolant temperature does not exceed 100°C (212°F).

(5) Drain water.

(6) Filter original coolant through filtering material, such as very fine cheesecloth.

(7) After filtering, place the fluid in both cooling systems and replace any lost liquid with new coolant. Fill the systems completely and free air traps.

(8) Make an occasional check on the percentage of glycol in the coolant in order to keep the normal coolant as near a 30/70 ethylene glycol mixture (treated with NaMBT) as possible. The percentage of glycol may be determined by the use of a standard hydrometer or a glycol hydrometer, or by the boiling point method.

**Note**

For winter operation, a coolant solution consisting of 70/30 ethylene glycol (inhibited with NaMBT) is recommended.

**CAUTION**

While flushing, the coolant temperature should never exceed 120°C (248°F).

*c.* COOLANT RADIATOR.

(1) DESCRIPTION.—The fin-and-tube type coolant radiator is located in the radiator air scoop in the bottom of the fuselage. The assembly is divided into two sections, one section for the engine cooling system, and the other section for the aftercooling system. Coolant flow through the radiator is from top to bottom. Drain plugs for each system are provided at the bottom of the radiator.

(2) REMOVING THE COOLANT RADIATOR.

*(a)* Instructions for draining the cooling systems will be found in section III, paragraph 2. *b.* (3) *(d)* and *(e)*.

*(b)* Instructions for removing the coolant radiator will be found in figure 274.

(3) CLEANING COOLANT RADIATOR.—Steam cleaning is recommended, but if equipment is not available, thoroughly flush the radiator with hot water. After cleaning, blow compressed air through the radiator for approximately 15 minutes to dry it.

(4) TESTING COOLANT RADIATOR.—Test by applying an air pressure not to exceed 50 pounds per square inch, closing all openings, and immersing the radiator in warm water. If the leaks cannot be seen, remove the headers and apply air pressure to each tube individually. After all the leaks have been located, remove the radiator, release the air pressure and allow it to drain; then flush radiator with a quantity of coolant liquid.

**Note**

Radiator repair requires trained personnel, and permanent or major repairs should be made only at depots or subdepots.

(5) INSTALLING COOLANT RADIATOR.

*(a)* Make a careful check to be sure that there is no foreign matter clogging the radiator fins, and that the drain plugs are secure and properly safetied. Then proceed as follows:

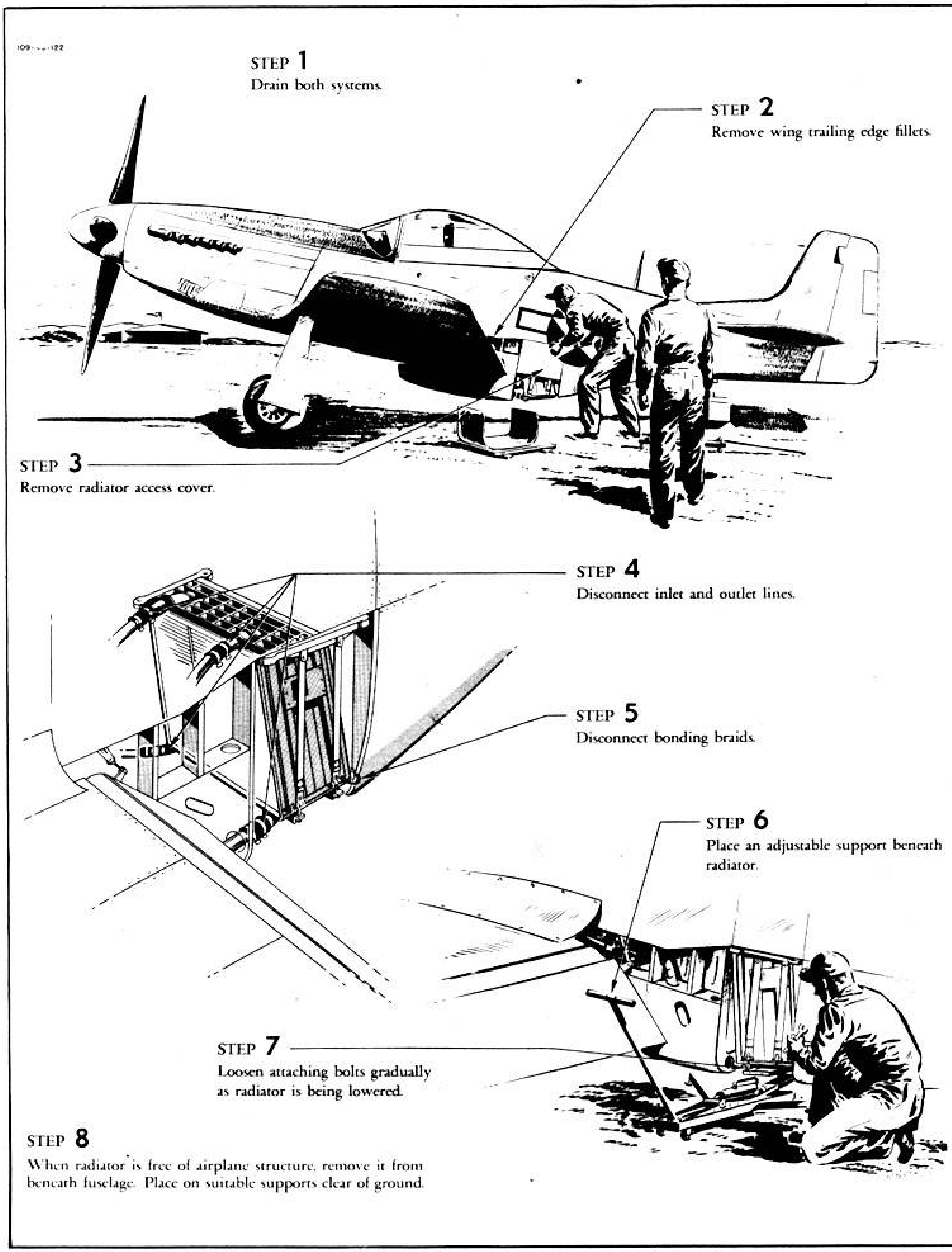



***Figure 274—Removing Coolant Radiator***

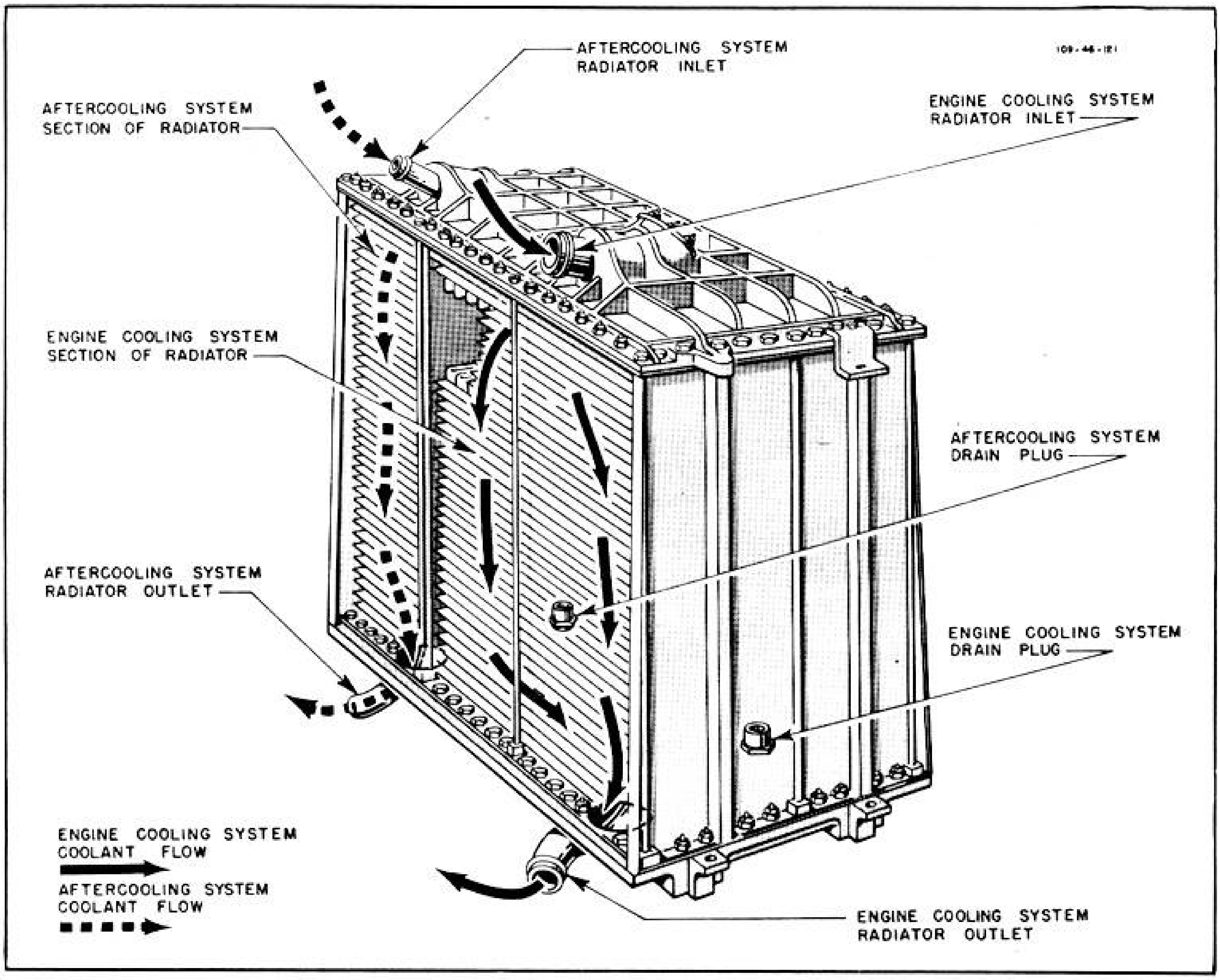



*Figure 275—Coolant Radiator*

*1.* Place the radiator on an adjustable stand or small jack, and slide it under the fuselage.

*2.* Raise radiator into place.

*3.* Insert bolts through brackets on bottom of radiator into straps which support radiator; tighten, and safety. Install bonding braids at aft lower left and right-hand sides of radiator.

*4.* Connect inlet and outlet lines for the aftercooling and engine cooling systems, and tighten hose clamps.

*5.* Replace radiator cover assembly, and the fuselage trailing edge fillets.

**Note**

If an adjustable stand or small jack is not available, place the radiator on a ladder or similar object, and men on either side of the fuselage can lift it into place.

*d.* RADIATOR AIR INLET SCOOP.

(1) DESCRIPTION.—The aft portion of the radiator air inlet scoop assembly houses the coolant radiator, which is located just behind the oil cooler. The forward end of the scoop is stationary, and the aft end is movable. Movement of the scoop is controlled by an automatic, temperature-controlled electric actuator. A capillary bulb in the radiator inlet line transmits the temperature to the actuator, which either extends or retracts, according to the temperature of the coolant. A control switch mounted on the left side of the cockpit has the following positions: "AUTOMATIC," "OFF," "CLOSE," and "OPEN." The "OPEN" and "CLOSE" positions are of the momentary-type switch, and serve as a manual override for the automatic positioning device.

(2) REMOVING RADIATOR AIR INLET SCOOP. —Remove the radiator inlet scoop as instructed in section IV, paragraph 4. *c.* (4) ***(b)***.

(3) INSTALLING RADIATOR AIR INLET SCOOP. —Install the radiator inlet scoop as instructed in section IV, paragraph 4. *c.* (4) ***(b)***.

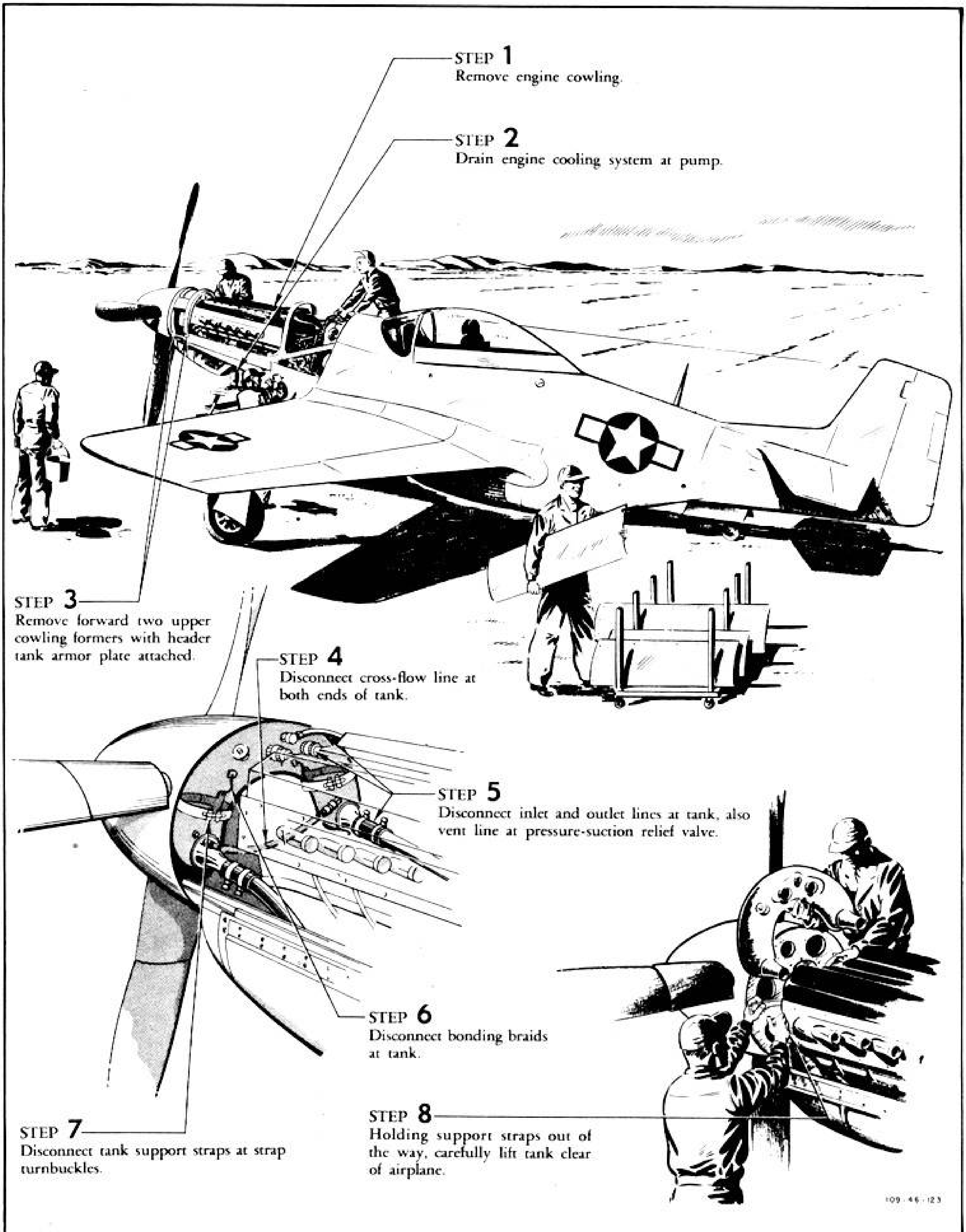



*Figure 276—Removing Engine Cooling System Header Tank*

*e.* ENGINE COOLING SYSTEM HEADER TANK.

(1) DESCRIPTION.—The engine cooling system header tank is fitted immediately behind the propeller spinner and is arranged around the reduction gear housing. The tank is designed for double outlets, one on each side of the gear housing; the lines from these outlets join in a "Y" just forward of the firewall and continue as a single line extending to the radiator. The filler neck on the tank is located to provide the required air space in the tank. The header tank serves as a coolant reservoir and expansion chamber, separates air and vapor from the coolant, reduces the suction head of the pump, and controls the pressure in the system. The separation of air and vapor is obtained by means of two cylinders through which the coolant liquid passes immediately after entering the tank. Centrifugal action forces the liquid to the outer portion of the cylinders, and the separated air is led off from the central portions through a tube. The cylinders which form the separators are, in effect, part of a closed circuit, so that the coolant liquid entering the tank passes around the separators, and then directly to the outlets without passing into the body of the tank, thus conserving the kinetic energy of the coolant liquid and reducing the pump suction. Reserve fluid in the header tank can enter this closed circuit at the header tank outlets. A cross-flow line equalizes the amount of coolant retained on each side of the tank. A combination pressure-suction relief valve at the top center of the tank limits the maximum possible pressure in the tank to 30 pounds per square inch. Vacuum relief is obtained when the pressure inside the header tank falls 1-1/2 pounds per square inch below atmospheric pressure. The cooling capacity of the radiator is sufficient to prevent the pressure in the header tank from rising above the set blowoff pressure to 30 pounds per square inch under normal conditions. If, for some reason, this figure is exceeded, the design of the tank is such that only steam will escape, leaving the liquid as reserve coolant. A vent line is connected to the valve, and exits on the right-hand side of the engine under the rear exhaust stack so that freezing cannot occur.

(2) REMOVING ENGINE COOLING SYSTEM HEADER TANK.

*(a)* Removal of propeller (though not necessary) will provide greater accessibility for header tank removal. Instructions for removing propeller will be found in section IV, paragraph 10. *b.*

*(b)* Instructions for removal of header tank will be found in figure 276.

(3) TESTING ENGINE COOLING SYSTEM HEADER TANK.

*(a)* Flush tank with hot water.

*(b)* Remove relief valve, and plug all openings except one.

*(c)* To this opening, apply a pressure of 50 pounds per square inch, and submerge tank in water.

*(d)* Mark location of any bubbles formed by leakage.

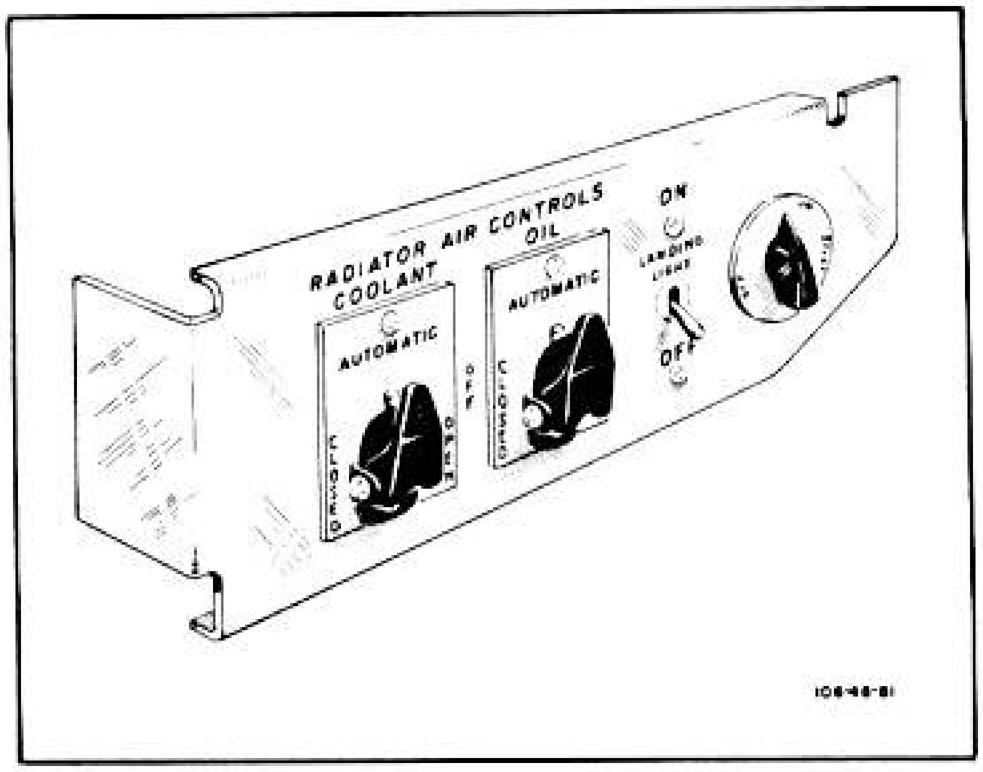



***Figure 277—Radiator Air Controls***

(4) INSTALLING ENGINE COOLING SYSTEM HEADER TANK.

*(a)* Reinstall pressure-suction relief valve.

*(b)* Carefully position tank in supporting straps.

*(c)* Connect and tighten supporting strap turnbuckle, and secure bonding braids.

*(d)* Connect all lines to tank, being especially sure to connect both ends of cross-flow line.

*(e)* Install engine cowling formers.

*(f)* Reinstall propeller if propeller has been removed. *(See section IV, paragraph 10. c.)*

*(g)* Reinstall engine cowling.

*f.* AFTERCOOLING SYSTEM HEADER TANK.—The aftercooling system header tank, commonly called the expansion tank, and the heat exchanger are located on the aft end of the engine above the supercharger case. The coolant passes through tubes in the heat exchanger, thus dissipating heat from the fuel-air mixture which is flowing past the tubes into the intake manifolds. The expansion tank is provided with a pressure-suction relief valve which relieves at a pressure of 18 to 20 pounds per square inch, and a suction of 1 pound per square inch.

*g.* ENGINE COOLING SYSTEM PUMP.—The centrifugal-type engine cooling system pump is attached to an adapter on the lower side of the wheel case. The spring-loaded packing does not require manual tightening.

*h.* AFTERCOOLING SYSTEM PUMP.—The centrifugal-type aftercooling system pump is located on the left side of the engine aft of the generator. The spring-loaded packing does not require manual tightening.

## 18. INSTRUMENTS.

*a.* GENERAL.—The instruments are classified into three groups: flight, engine, and miscellaneous. The flight instruments are classified further as to the system they operate in, i.e., vacuum, airspeed, or compass system. The instrument panel *(figure 280)*, used on later airplanes, employs all front mounted instruments; a yellow line on the panel separates the flight instruments from the other instruments. *(See figure 280.)* Suction for the directional gyro, gyro horizon, and bank-and-turn indicator is supplied by the engine-driven vacuum pump. Static pressure for the altimeter, airspeed indicator, and rate-of-climb indicator is taken through a static plate mounted on each side of the fuselage just forward of the empennage. Pitot pressure is supplied through the pitot head. A remote-indicating compass is installed. The engine instruments consist of a manifold pressure indicator, tachometer, engine gage, engine coolant gage, and carburetor air temperature indicator. On later airplanes, an AN pressure system is used to indicate fuel pressure. Miscellaneous instruments consist of hydraulic pressure gages, landing gear indicator (early airplanes), fuel gages, ammeter, and a clock. For identification of instrument lines, see color code chart in section VIII. Flexible hoses on later airplanes will have a band identifying their relation to the instrument. *(See figures 281 and 282 for a schematic diagram of the instrument system on early and late airplanes.)*

**CAUTION**

At all times, handle instruments with care, as rough treatment or jarring will damage them.

*b.* REMOVING THE INSTRUMENT PANEL.

(1) Remove the three dzus-fastened doors just forward of the windshield.

(2) Disconnect the rubber instrument hoses from the rigid lines. On early airplanes, using rear mounted instruments, the engine gage can be removed from the instrument panel and left in the airplane, making it unnecessary to disturb the capillary line.

(3) Disconnect the flexible and rigid lines at the vacuum and air filter manifold block.

(4) Disconnect the electrical connectors on the electrically operated instruments.

(5) Disconnect the two bonding braids where they attach to the instrument support panel.

(6) On early airplanes, remove the wiring from the landing gear signal light and light test switch.

(7) On early airplanes, remove the bolts from the four rubber shock mounts. On later airplanes, first remove the bolts that secure the Lord mounts to the instrument support panel; then remove the nut from each upper mounting bolt. A man in the cockpit must hold the instrument panel to prevent it from falling into the cockpit and damaging the instruments.

**Note**

As the mounting bolt has a ball-and-socket joint at one end, a portion of the bolt shank has been flattened to facilitate removal.

**CAUTION**

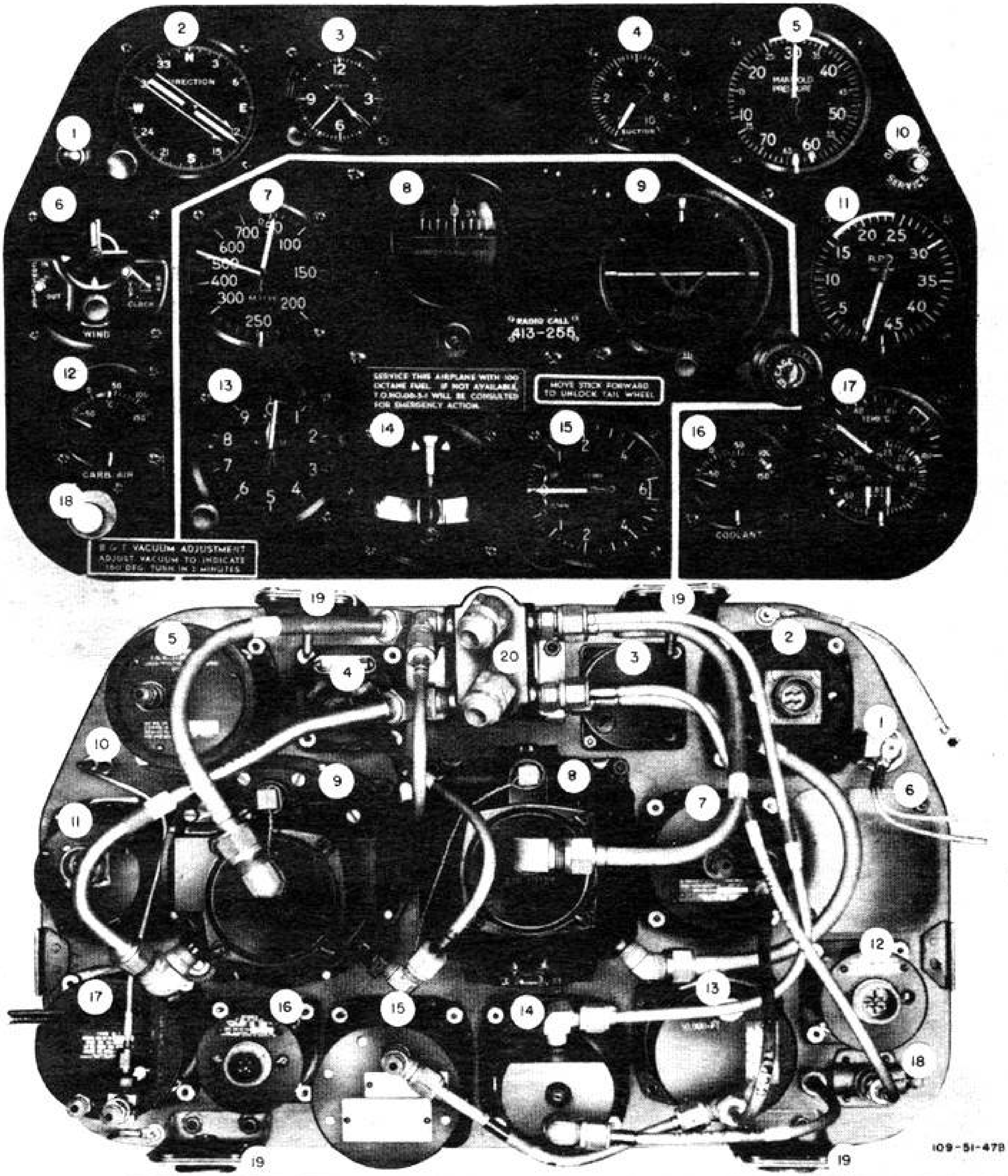
The instrument panel must be removed from the airplane carefully, as bumping the panel against the side of the cockpit is sufficient to damage the instruments.

*c.* REMOVING AND INSTALLING INSTRUMENTS. —When removing instruments that are not front mounted *(figure 279)*, access is made through the three access doors just forward of the windshield. In most cases an extra man will have to assist in removing the instrument from the panel after the connecting lines and screws have been removed. However, front mounted instruments can be removed by one man in the cockpit. This is done by removing the instrument attaching screws, and withdrawing the instrument sufficiently to disconnect the lines. *(See figure 278.)* Handle instruments with care. Cap all open lines to keep out dirt and debris. When installing an instrument, treat the threads on the fitting with thread lubricant, Specification No. AN-C-53. After installation is made, check the line connections for leaks.

**Note**

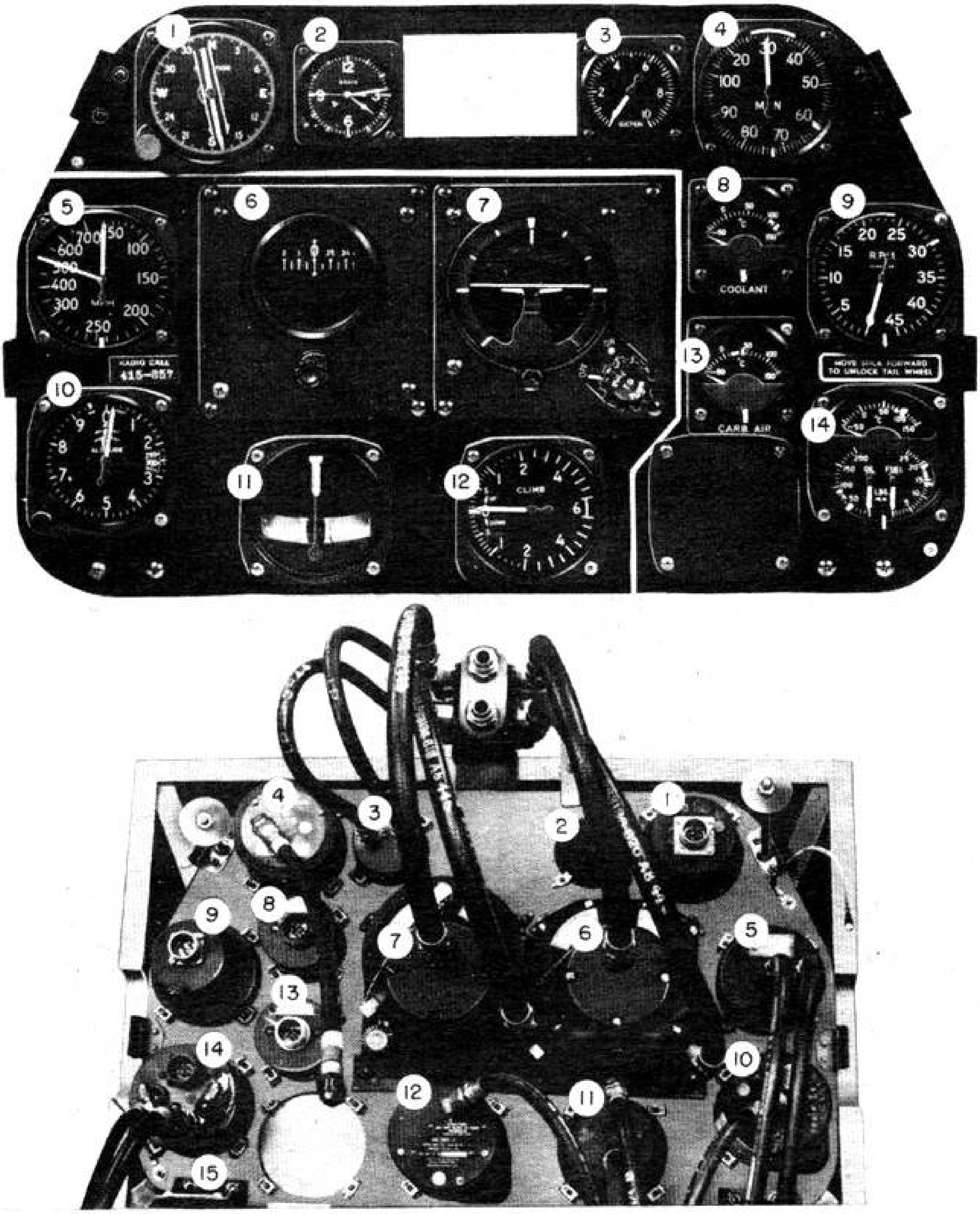
Defective instruments must be replaced. No attempt should be made in the field to repair instruments; send them to a repair depot.

*Figure 278—Removing Front Mounted Instrument*




1. Landing Gear Warning Light
2. AN5730-6 Remote-Reading Compass
3. Type A-11 Clock
4. AN5771-5 Suction Gage
5. Type D-10 Manifold Pressure Gage
6. Remote Contactor
7. Type F-2 Airspeed Indicator
8. AN5735 Directional Gyro
9. AN5736 Gyro Horizon
10. Oil Gage Service Port
11. AN5530-1 Tachometer
12. AN5790-6 Carburetor Air Temperature Gage
13. AN5160-2 Altimeter
14. AN5820 Bank-and-Turn Indicator
15. AN5825 Rate-Of-Climb Indicator
16. AN5790-6 Coolant Gage
17. Type B-7 Engine Gage
18. Bank-and-Turn Needle Valve Adjustment
19. Shock Mounts
20. Manifold Block

*Figure 279—Instrument Panel—Early Airplanes*




1. AN5730-6 Remote-Reading Compass
2. Type A-11 Clock
3. AN5771-5 Suction Gage
4. Manifold Pressure Gage
5. Type F-2 Airspeed Indicator
6. AN5735 Directional Gyro
7. AN5736 Gyro Horizon
8. AN5790-6 Coolant Gage
9. AN5530-1 Tachometer
10. AN5160-2 Altimeter
11. AN5820 Bank-and-Turn Indicator
12. AN5825 Rate-Of-Climb Indicator
13. AN5790-6 Carburetor Air Temperature Gage
14. Type B-7 Engine Gage
15. Shock Mounts
16. Manifold Block

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*Figure 280—Instrument Panel—Later Airplanes*

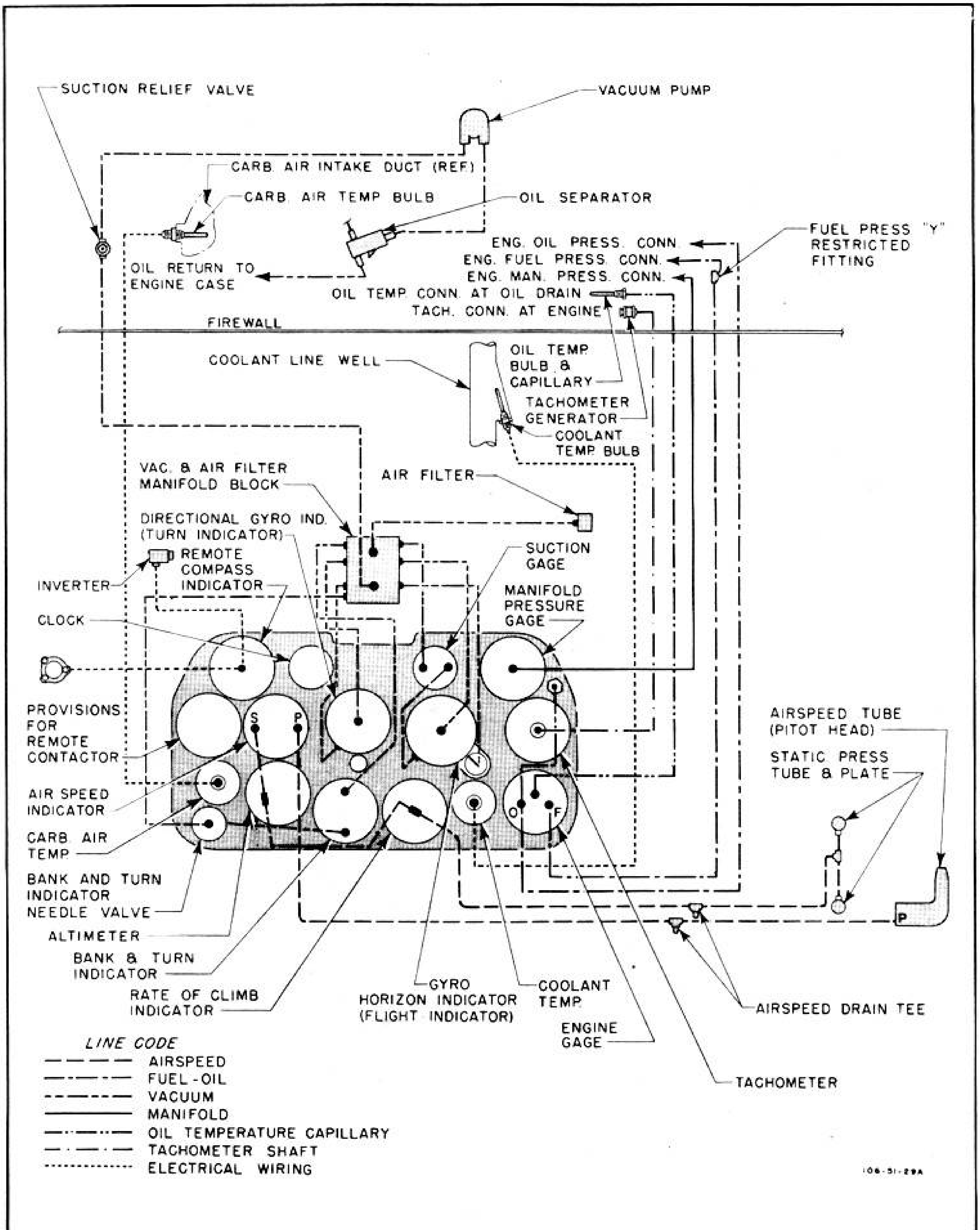



*Figure 281—Instrument System Diagram—Early Airplanes*

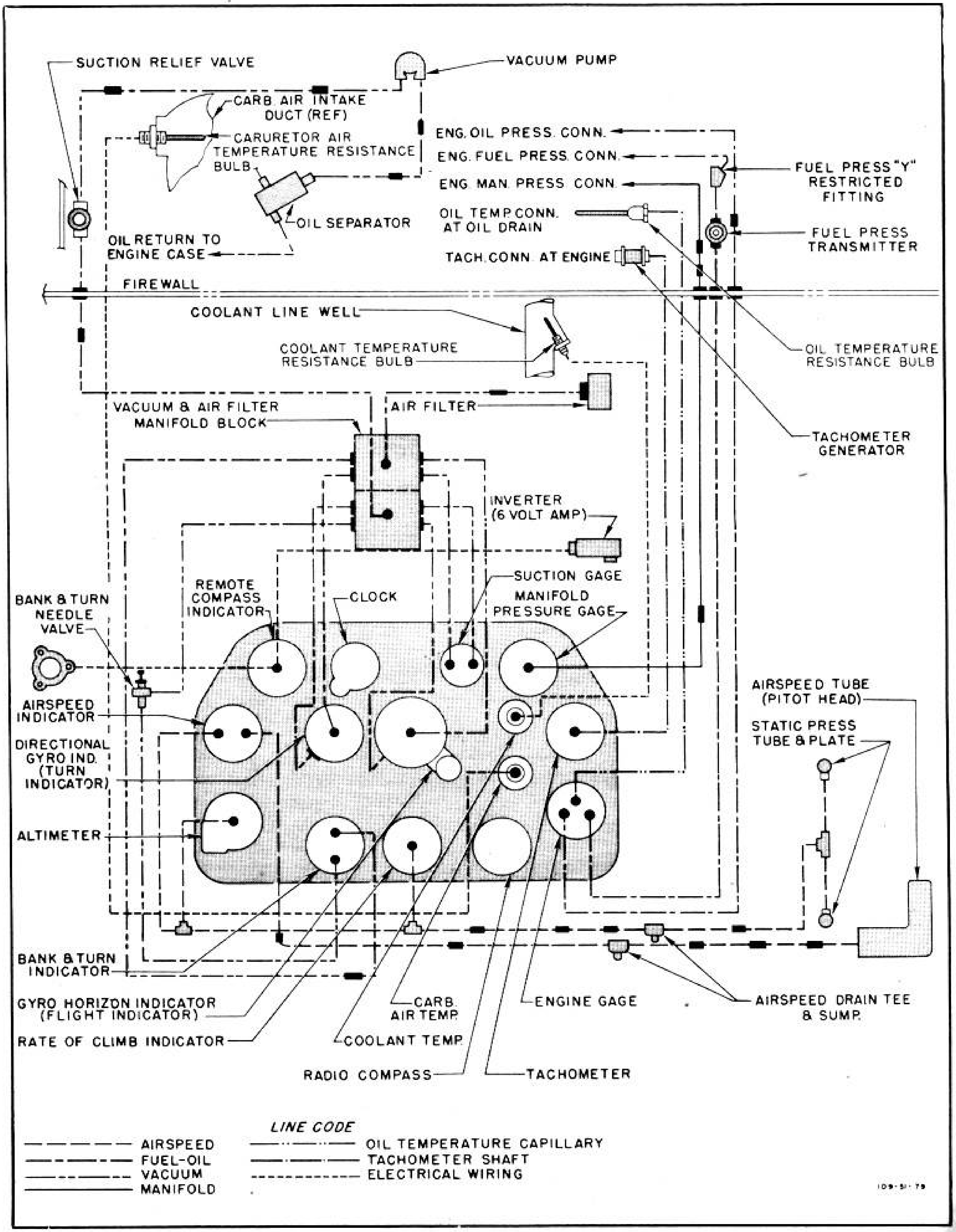



*Figure 282—Instrument System Diagram—Later Airplanes*

*d.* INSTRUMENT TROUBLE SHOOTING.—The following chart comprises a few of the more common troubles found in the instrument systems.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| | **PITOT STATIC TUBES** | |
| **Pitot head does not heat or clear itself of ice with "PITOT HEAT" switch turned on.** | Circuit breaker type switch defective. | Replace. |
| | Break in the wiring. | Repair. |
| | Heating element in the head burned out. | Check for 24 volts at the head. If there is voltage at this point, the element is probably burned out. Replace the entire head. |
| **Pointers indicate incorrectly or oscillate undesirably on altimeter, airspeed indicators, and rate-of-climb indicators.** | Leak in case of individual instrument. | Make a case leak test for this particular instrument. Replace. |
| | Leak in pitot or static line. | Make a static or pressure line test, whichever is the case. Replace. |
| | **AIRSPEED INDICATOR** | |
| **Pointer fails to respond.** | Pressure line not connected properly. | Make proper connections. |
| | Lines clogged. | Disconnect instrument. Open drains and blow the lines clear. |
| **Pointer indicates incorrectly.** | Leak in lines. | Check and correct. |
| | Leak in instrument. | Check and seal. If necessary, replace instrument. |
| | Defective indicator. | Replace instrument. |
| **Pointer does not set on zero unless airplane is in motion.** | Defective indicator. | Replace instrument. |
| **Pointer vibrates.** | Excessive vibration of instrument panel. | Check shock mounts. Replace shock mounts if worn. |
| | Connecting tubing vibrates. | Connect proper length of hose between line and instrument. |
| **Pointer oscillates.** | Leak in line. | Correct. |
| | Leak in case. | Seal or replace instrument. |
| | **RATE-OF-CLIMB INDICATOR** | |
| **Pointer not on zero.** | Aging diaphragm. | Return pointer to zero. Tap instrument lightly while making adjustment. |
| **Pointer fails to respond.** | Obstruction in static line. | Disconnect instrument. Open drain and blow lines clean. |
| | Defective instrument. | Replace instrument. |
| **Pointer indicates inaccurately.** | Leak in static line. | Check by static leak test. Correct leak or replace instrument. |
| | Defective instrument. | Replace. |
| | Leak in instrument case. | Test for case leak. Replace. |
| **Pointer oscillates.** | Leak in static line. | Use static leak test. Seal any leaks found. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **DIRECTIONAL GYRO INDICATOR** | | |
| **Excessive drift in either direction.** | Excessive vibration. | If amplitude is more than .004 inch, check shock mounts. If materially defective, replace the mount. |
| | Insufficient vacuum. If vacuum is below 3.5 in. Hg, check for the following: | |
| | Relief valve improperly adjusted. | Readjust relief valve. |
| | Incorrect gage reading. | Remove instrument and recalibrate in shop. |
| | Pump failure. | Repair or replace pump. |
| | Insufficient lubrication of pump. | Clear lubricating holes. |
| | Vacuum line kinked, leaking, or inner wall collapsed. | Repair or replace. |
| | Defective instrument. | Replace. |
| **Dial spins continuously.** | Defective mechanism. | Replace instrument. |
| **BANK-AND-TURN INDICATOR** | | |
| **Pointer fails to respond.** | No vacuum to instrument. | Check lines and pump. Check relief valve. |
| | Defective instrument. | Replace. |
| **Incorrect sensitivity.** | Vacuum too high or too low. | Check lines and pump. Check both valves for correct setting. |
| | Defective instrument. | Replace. |
| **Pointer does not set on zero.** | Defective instrument. | Replace. |
| **Pointer vibrates.** | Excessive vibration. | Check shock mounts. Replace if necessary. |
| **In low temperature, pointer fails or responds sluggishly.** | Oil becomes thick. | Replace instrument. |
| **VACUUM PUMP** | | |
| **Excessive oil in discharge.** | Excessive oil flow to pump. | Check engine drive seal for leaks. Replace seal if necessary. |
| **Low suction.** | Separator clogged. | Remove separator, drain plugs and clean. |
| **High suction.** | Suction relief valve screen clogged. | Clean. |
| | Suction relief valve leaks. | Replace. |
| | Pump fails. | Remove and replace. |
| **GYRO HORIZON INDICATOR** | | |
| **Horizon bar fails to respond.** | Instrument caged. | Uncage. |
| | Air filter dirty. High vacuum indication. | Clean or replace filter. |
| | Insufficient vacuum resulting from the following: | |
| | Suction regulator improperly adjusted. | Adjust suction regulator. |
| | Incorrect indicator reading. | Recalibrate. |
| | Pump failure. | Replace the pump. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Horizon bar does not settle.** | Insufficient vacuum. | Correct as outlined in preceding "probable cause." |
| | Defective mechanism. | Replace instrument. |
| | Excessive vibration. | Prevent flexible hoses from restricting normal movement of instrument panel; examine shock mountings and replace, if necessary. |
| **Horizon bar oscillates or vibrates excessively.** | Instrument caged. | Uncage the instrument. |
| | Excessive vacuum, resulting from the following: | |
| | Air filter dirty. | Clean or replace filter. |
| | Suction regulator improperly adjusted. | Adjust suction regulator. |
| | Incorrect instrument reading. | Recalibrate instrument. |
| | Defective mechanism. | Replace instrument. |
| | Excessive vibration. | Prevent flexible hoses from restricting normal movement of instrument panel; examine shock mountings and replace if necessary. |
| | **COOLANT TEMPERATURE INDICATOR** | |
| **No reading either permanent or intermittent.** | Break in bulb. | Replace the bulb. |
| | Broken electrical wires. | Replace. |
| | Defective indicator. | Replace instrument. |
| **Low reading either permanent or intermittent.** | Poor connections at indicator. | Clean and tighten. |
| | Poor lead connections. | Clean and tighten. |
| | Poor connections at bulb. | Clean and tighten. |
| | Short circuit in leads. | Repair. |
| | **TACHOMETER** | |
| **Excessive scale error.** | Weak magnets in the tachometer generator. | Replace tachometer generator. |
| **Pointer moves backward.** | Reversed polarity. | Change leads at terminals of tachometer generator. |
| **Indication only one-half actual speed.** | Leads connected to wrong terminal on indicator. | Refer to wiring diagram and connect wires correctly. |
| **No reading on indicator, either permanent or intermittent.** | Break or short circuit in leads. | Repair the break. |
| | Poor connection at indicator or generator terminals. | Clean and tighten terminals. |
| | Break inside indicator or generator circuit. | Replace the unit affected. |
| **Low reading on indicator, either permanent or intermittent.** | Poor connection at indicator or generator terminals. | Clean and tighten terminals. |
| **High reading on indicator, either permanent or intermittent.** | Indicator resistance off adjustment. | Replace the indicator. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **CARBURETOR AIR TEMPERATURE INDICATOR** | | |
| **No reading with battery disconnect switch "ON."** | Switch defective. | Replace switch. |
| | Poor connections at switch terminals. | Clean and tighten the connections. |
| | Break in the power lead. | Repair or replace lead. |
| | Break in the ground lead. | Repair or replace lead. |
| | Open or short circuit on indicator. | Replace indicator. |
| **Reading off scale at low temperature end.** | Short circuit in leads to resistance bulb. | Repair or replace lead. |
| | Ground in lead from resistance bulb to "R" terminal of indicator. | Make continuity check and repair or replace lead. |
| | Short circuit in resistance bulb. | Replace the bulb. |
| | Open or short circuit in the indicator. | Remove the indicator and repair or replace. |
| **Reading off scale at high temperature end.** | Breaks in leads to resistance bulb. | Replace or repair the leads. |
| | Open circuit in resistance bulb. | Replace the bulb. |
| | Open or short circuit in indicator. | Replace indicator or repair it. |
| **MANIFOLD PRESSURE INDICATOR** | | |
| **Excessive error at existing barometric pressure.** | Pointer shifted. | Reset pointer to "ZERO" position (existing manifold pressure). |
| **Excessive error when engine is running.** | Line leak. | Tighten line connections. |
| **Sluggish or jerky pointer movement.** | Improper damping adjustment. | Adjust damping screw. |
| **Broken or loose coverglass.** | Vibration. Excessive pressure. | Replace the glass, and reseal case. |
| **REMOTE-INDICATING COMPASS** | | |
| **Note:** The following data is applicable when the airplane is pointed on a north heading. Letters used refer to wires corresponding to plug terminal pin markings anywhere in the circuit. | | |
| **No torque.** | "A" shorted to "B." | Correct wiring. |
| | Inverter not operating. | Turn necessary switches on. Replace inverter, if necessary. |
| **Reverse rotation.** | "A" and "B" reversed with "C" and "D" reversed. | Correct wiring. |
| **Erratic operation in the 90-degree arc between 300 degrees and 30 degrees.** | Lead to "D" open. | Repair or replace lead. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Erratic operation in the 90-degree arc between 330 degrees and 60 degrees.** | Lead to "C" open. | Repair or replace lead. |
| **Pointer pulls in at both 30 degrees and 210 degrees. That is, at either of these headings the pointer is pulled away in one direction or the other.** | "A" wire open (power reaching one unit).<br>"D" shorted to "A" or "B."<br>"A"—"D" phase open in either transmitter or indicator coils.<br>"A" and "D" reversed. | Repair wiring.<br>Repair wiring.<br>Replace instrument.<br>Correct wiring. |
| **Pointer pulls in at both 330 degrees and 150 degrees.** | "B" wire open (power reaching one unit).<br>"C" shorted to "A" or "B."<br>"B" and "C" phase open in either transmitter or indicator coils.<br>"B" and "C" reversed. | Repair wiring.<br>Repair or replace wiring.<br>Repair the instrument.<br>Correct wiring. |
| **Erratic operation in the 120-degree arc between 300 degrees and 60 degrees.** | "C"—"D" open in either transmitter or indicator coils. | Repair or replace the instrument. |
| **Pointer pulls in both at 0 degrees and 180 degrees.** | "A" and "C" reversed with "B" and "D" reversed.<br>"A" and "D" reversed with "B" and "C" reversed. | Correct the wiring.<br>Correct the wiring. |
| **Pointer pulls in at both 60 degrees and 240 degrees.** | "A" and "C" reversed. | Correct wiring. |
| **Pointer pulls in at both 120 degrees and 300 degrees.** | "B" and "D" reversed. | Reverse the wiring. |
| **Pointer pulls in at both 90 degrees and 270 degrees.** | "C" shorted to "D."<br>"C" and "D" reversed.<br>"A" and "B" reversed. | Replace or repair the wiring.<br>Correct the wiring.<br>Correct the wiring. |
| **Swirl of liquid giving erratic indication.** | Not enough liquid in bowl. | Remove instrument and fill the bowl. |
| **Leakage of compass liquid.** | Leaky gaskets. | Remove instrument and replace gaskets. |
| **Compensator does not have sufficient effect.** | Weak compensation magnets. | Remove instrument and repair. |
| **Erratic indication on the indicator.** | Loose pointer. | Remove instrument and repair. |
| **Sluggish operation.** | Dirty jewels or dirty pivots. | Remove instrument and repair. |

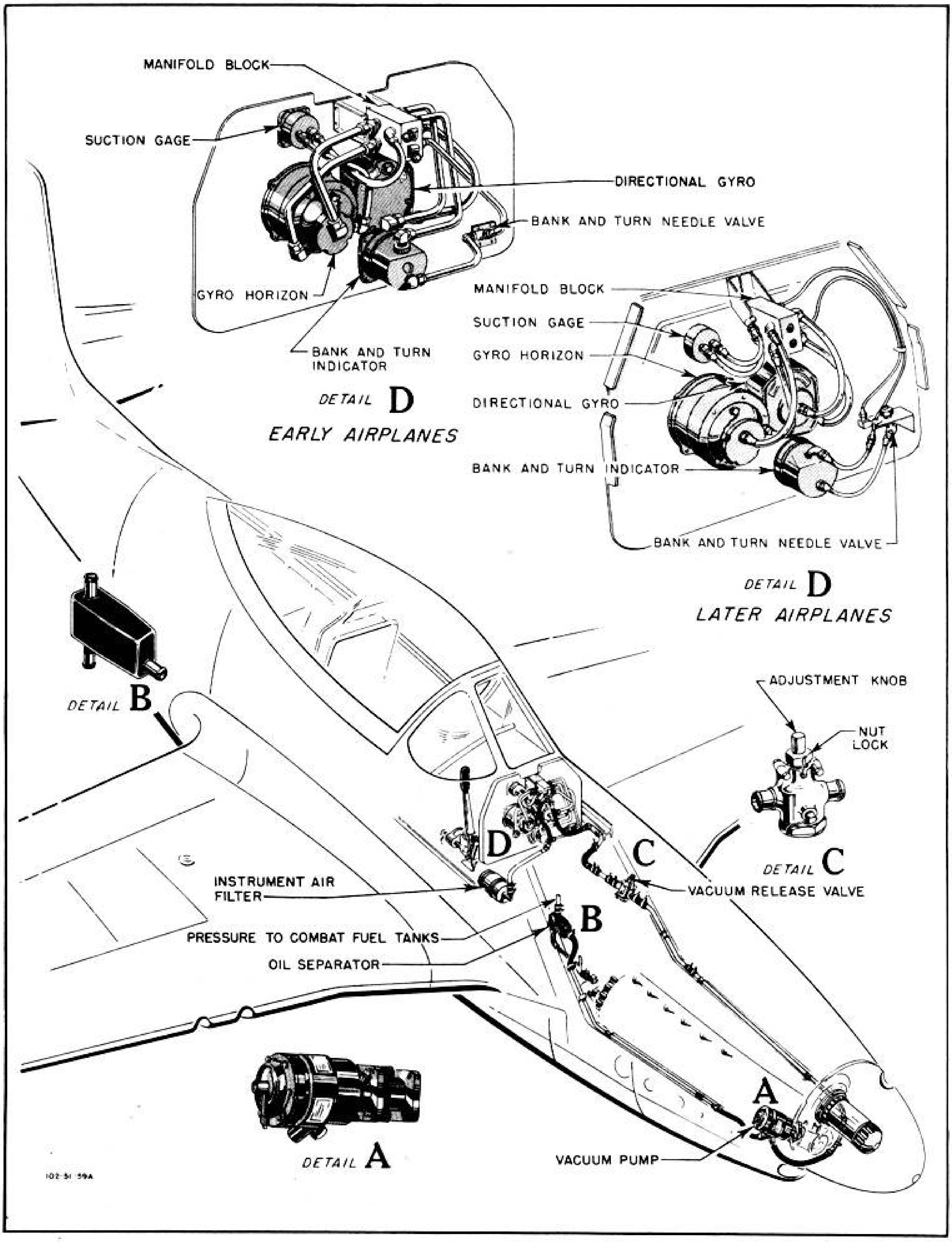



*Figure 283—Vacuum System*

*e.* FLIGHT INSTRUMENTS.

(1) VACUUM SYSTEM.

*(a)* GENERAL.—The vacuum system *(figure 283)* operates the gyroscopic instruments, i.e., the bank-and-turn indicator, directional gyro (turn indicator) and gyro horizon (flight indicator). Each of the two latter instruments is provided with a caging knob for locking the gyro. The suction gage measures the amount of suction for the flight indicator only. All vacuum lines are color coded white and green.

*(b)* VACUUM PUMP.

*1.* DESCRIPTION.—The Type B-12 vacuum pump *(figure 284)*, mounted on the right front end of the engine adjacent to the propeller governor, provides a suction flow of not less than 4.5 in. Hg when operating at 1500 rpm. Lubrication for this high-speed pump is provided by oil ducts in the engine pad, gasket, and pump mounting pad.

2. INSTALLING VACUUM PUMP.

a. Install a dry gasket over the mounting studs on pump, making certain that the oil holes in gasket line up with the oil holes on the engine pad and that the oil holes are clear of any gasket particles or foreign matter.

b. Position the pump on the mounting flange, being careful not to misalign the gasket, and tighten the mounting nuts carefully and evenly.

**CAUTION**

The oil holes *must* line up in order to ensure proper pump lubrication and to prevent seizure. These holes are the only source of pump lubrication.

c. Install suction and discharge lines to the proper pump ports. The inlet port for either direction of rotation is designated by arrows stamped on the exterior machined surface next to the cover.

*(c)* VACUUM RELIEF VALVE.

*1.* DESCRIPTION.—The Type B-12 relief valve *(figure 285)* on the upper left cowl former is a spring-loaded disc-type valve. The disc is held against a screened valve set by a spring. The tension of the spring can be adjusted by means of an adjustment nut on the outside of the housing. This valve serves to regulate the vacuum and relieves the pump, in case a vacuum line on the instrument side of the valve becomes closed.

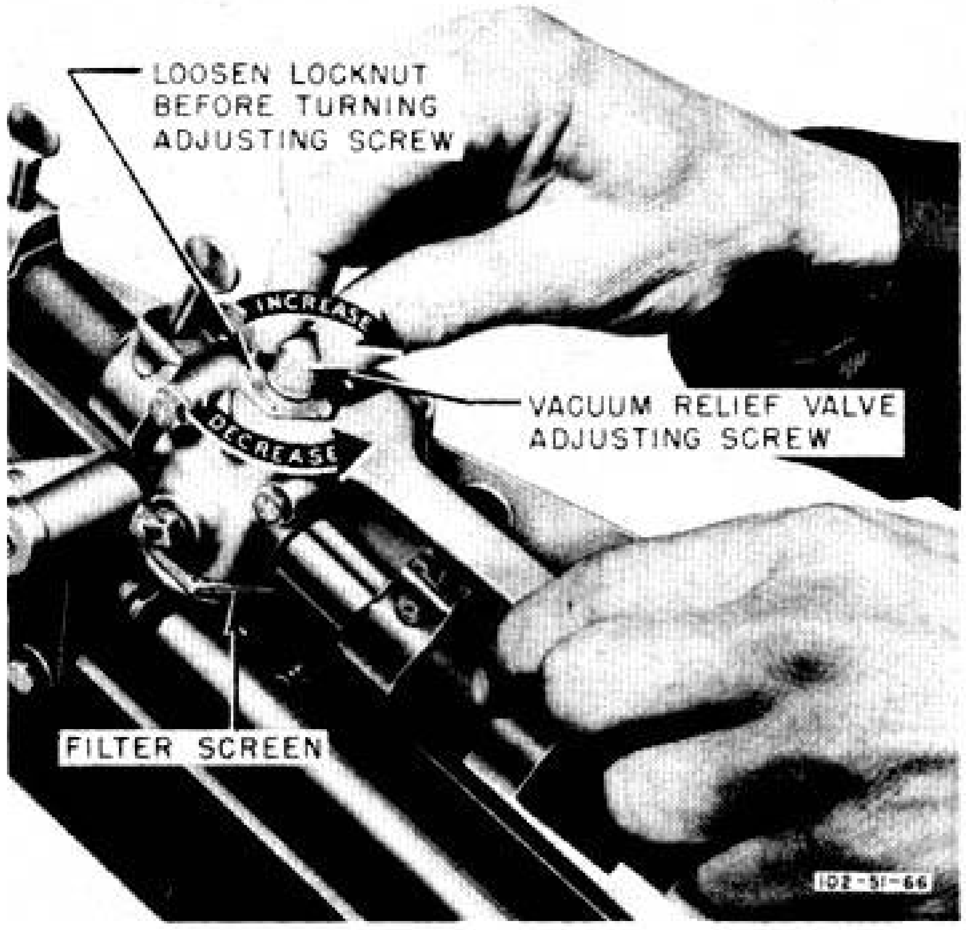



***Figure 285—Adjusting Vacuum Relief Valve***

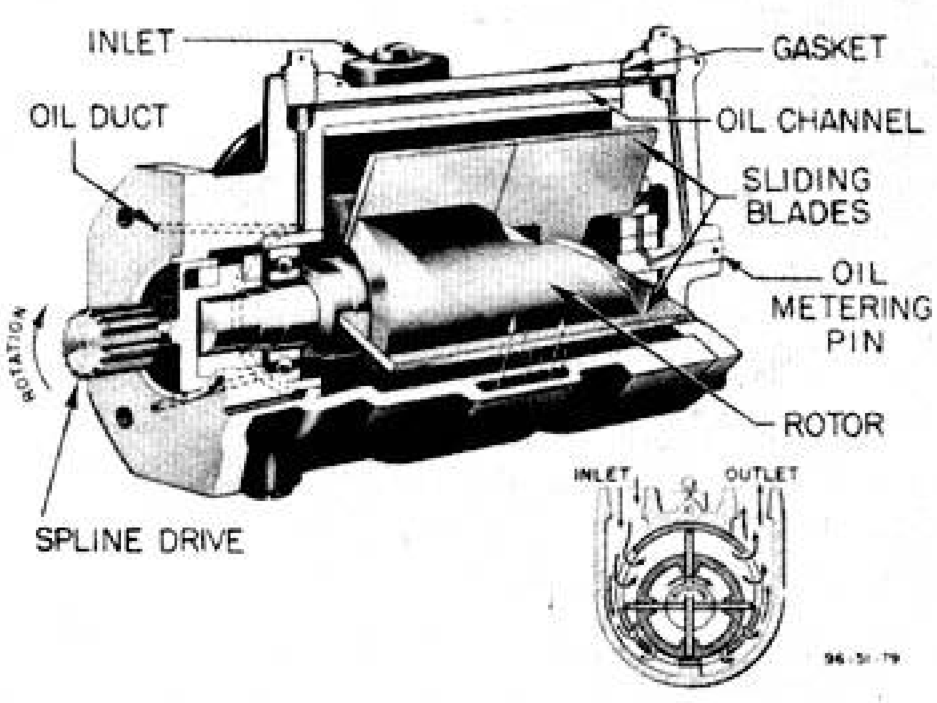



***Figure 284—Vacuum Pump***

2. ADJUSTING VACUUM RELIEF VALVE.

a. For access to the vacuum relief valve, remove the upper left engine cowling.

b. Run the engine at approximately 1000 rpm. The vacuum pressure will then be indicated at the suction gage on the instrument panel.

c. Remove lockwire, loosen locknut, and turn the valve adjusting nut *(figure 285)* to give a suction gage reading of 3.75 in. Hg.

d. Increase the engine speed to 3000 rpm and hold momentarily; the suction gage reading should not exceed 4.25 in. Hg. If this limit is exceeded, readjust the valve.

**Note**

If proper adjustment cannot be made by turning the adjustment nut, check the valve for cleanliness of screen, sticky valve, or loose adjustment.

e. After adjustment is made, tighten and safety the locknut and then replace the engine cowling.

*(d)* VACUUM SYSTEM OIL SEPARATOR.—The Type B-12 oil separator, located just forward of the firewall on the right-hand side, removes oil from the pump discharge air and returns it to the crankcase; the air is then utilized to pressurize the combat tanks when they are installed, or is exhausted to the outside air. The oil outlet has a removable fitting containing a perforated disc strainer which should be removed and cleaned in a suitable cleaning fluid every 100 hours. The unit contains no moving parts.

*(e)* VACUUM SYSTEM AIR FILTER.

*1.* DESCRIPTION.—An AN5822-1 air filter, attached to the cockpit floor (upper wing surface) directly below the instrument panel, is connected to the vacuum and air filter manifold block, and filters dust and other foreign matter out of the system. Two model air filters are used, the Skinner and Purolator.

*2.* CLEANING VACUUM SYSTEM AIR FILTER.

a. SKINNER MODEL. *(See figure 286.)*

**Note**

When compressed air is not available, clean the filter element with a stiff bristle brush and wipe with a clean cloth, or rinse the element in gasoline or flush with water under pressure; wipe the element with a clean cloth and allow it to dry thoroughly before installing.

b. PUROLATOR MODEL. *(See figure 287.)*

*(f)* BANK-AND-TURN INDICATOR.

*1.* DESCRIPTION.—The AN5820 bank-and-turn indicator is composed of a gyroscope-type turn indicator and a bank indicator. The bank indicator is a liquid-filled curved tube in which a free-rolling inclinometer ball changes position according to the direction of the force of gravity and centrifugal force. This instrument has no caging knob.

*2.* BANK-AND-TURN THROTTLING VALVE.

a. DESCRIPTION.—The bank-and-turn indicator is operated with less suction than the other gyroscopic instruments. Excessive suction applied to this indicator would cause the rotor to revolve at too high speed and increase the wear and also the sensitivity of the instrument to an undesirable extent. On early airplanes a throttling valve on back of the instrument panel is connected in the suction line to the indicator to regulate the suction to this particular instrument. The adjusting knob protrudes through the panel. *(See figure 288.)* On later airplanes the valve is mounted on the upper right longeron forward of the instrument panel.

b. ADJUSTING THE BANK-AND-TURN THROTTLING VALVE.

*(1)* Remove the left access door located just forward of the windshield.

*(2)* Connect a sensitive portable suction gage to the normally plugged opening on the back of the bank-and-turn indicator.

*(3)* With the engine running at approximately 1000 rpm, adjust the valve screw *(figure 288)* for a suction of 1.8 in. Hg.

*(4)* Run the engine up to 2600 rpm and take another reading of the portable suction gage; it must not exceed 2.05 in. Hg. Remove the portable suction gage and replace the plug in the back of the bank-and-turn indicator. It is desirable to have a deflection of one-pointer width (3/32 inch) on indicator for rate of turn of 180 degrees per minute at cruising speed. However, because of varying temperatures and individual instrument characteristics, a vacuum of 1.8 to 2.05 in. Hg will not always produce this desired

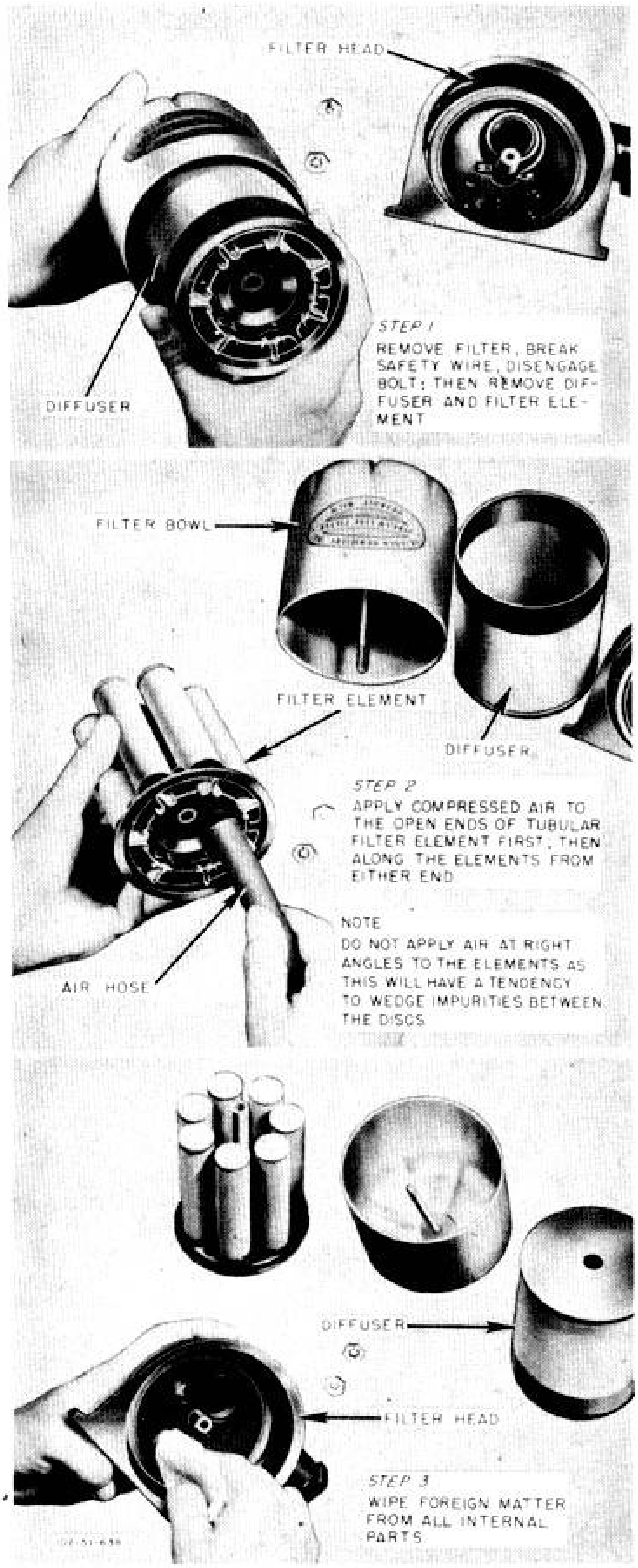



*Figure 286—Cleaning Air Filter Elements (Skinner)*

sensitivity. To secure the desired sensitivity of each individual instrument, the following procedure should be followed:

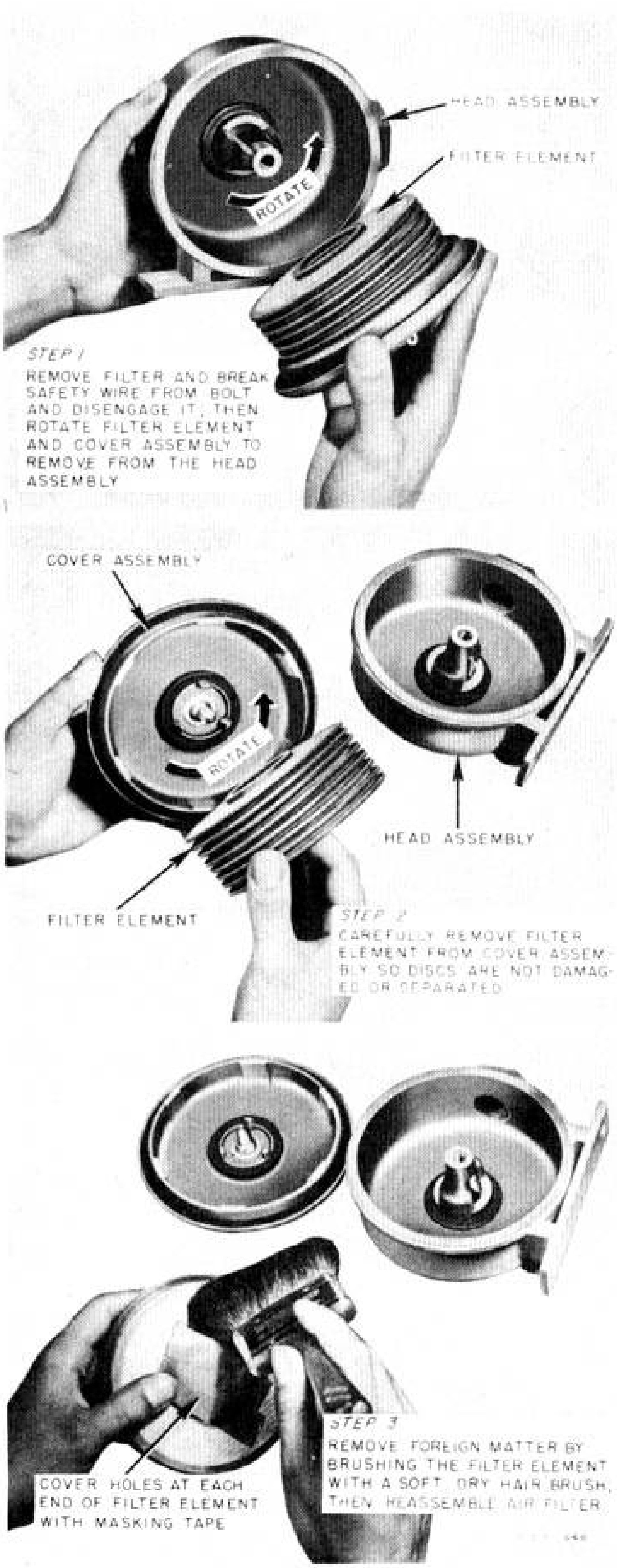



*Figure 287—Cleaning Air Filter Elements (Purolator)*

(a) During a flight test, make a one-pointer width turn at cruising speed and a 180-degree change in heading, as indicated by the directional gyro, timed with a stop watch.

(b) With the airplane on the ground and the engine running at cruising rpm (2400 rpm), measure the suction near the case of the bank-and-turn indicator with a test suction gage.

(c) From the chart (*figure 289*), obtain the suction value corresponding to the timed pointer width turn obtained in (a) preceding.

(d) Subtract this suction value from the standard value of 1.90 in. Hg. If the difference is plus, subtract it from the test suction gage reading; if minus, add it. Then adjust the valve to obtain the corrected test suction gage reading.

**Note**

On a flight check, a pointer-width turn at cruising speed will produce a 180-degree change in heading in 60 seconds.

(*g*) GYRO HORIZON INDICATOR (Flight Indicator).—The AN5736 gyro horizon indicator (flight indicator), employing a miniature plane and a gyro-actuated horizon bar, is used during instrument flights to indicate the relative longitudinal and lateral attitude of the airplane. The horizon bar will indicate a glide or climb of 60 degrees and a bank of 100 degrees, right or left. This instrument is provided with a caging knob.

(*h*) SUCTION GAGE.—An AN5771-5 vacuum system suction gage, mounted on the instrument panel, indicates the amount of pressure below atmospheric pressure to the gyro horizon indicator only. The dial of the suction gage is graduated in inches of mercury. Two in. Hg is approximately equivalent to one pound per square inch.

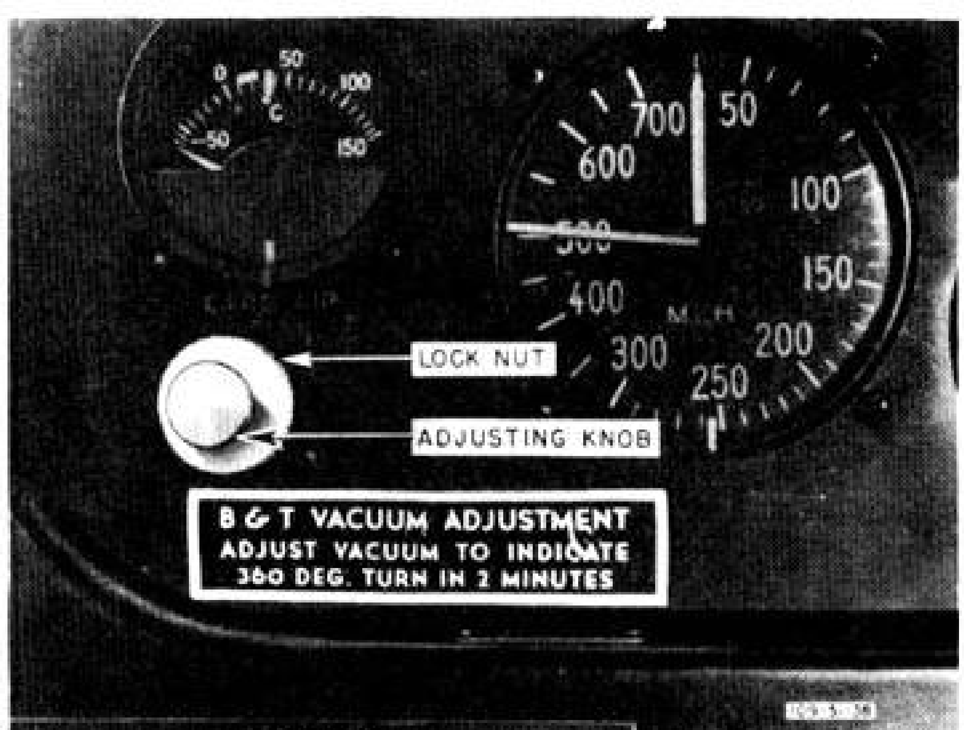



*Figure 288—Adjusting Bank-and-Turn Throttling Valve—Early Airplanes*

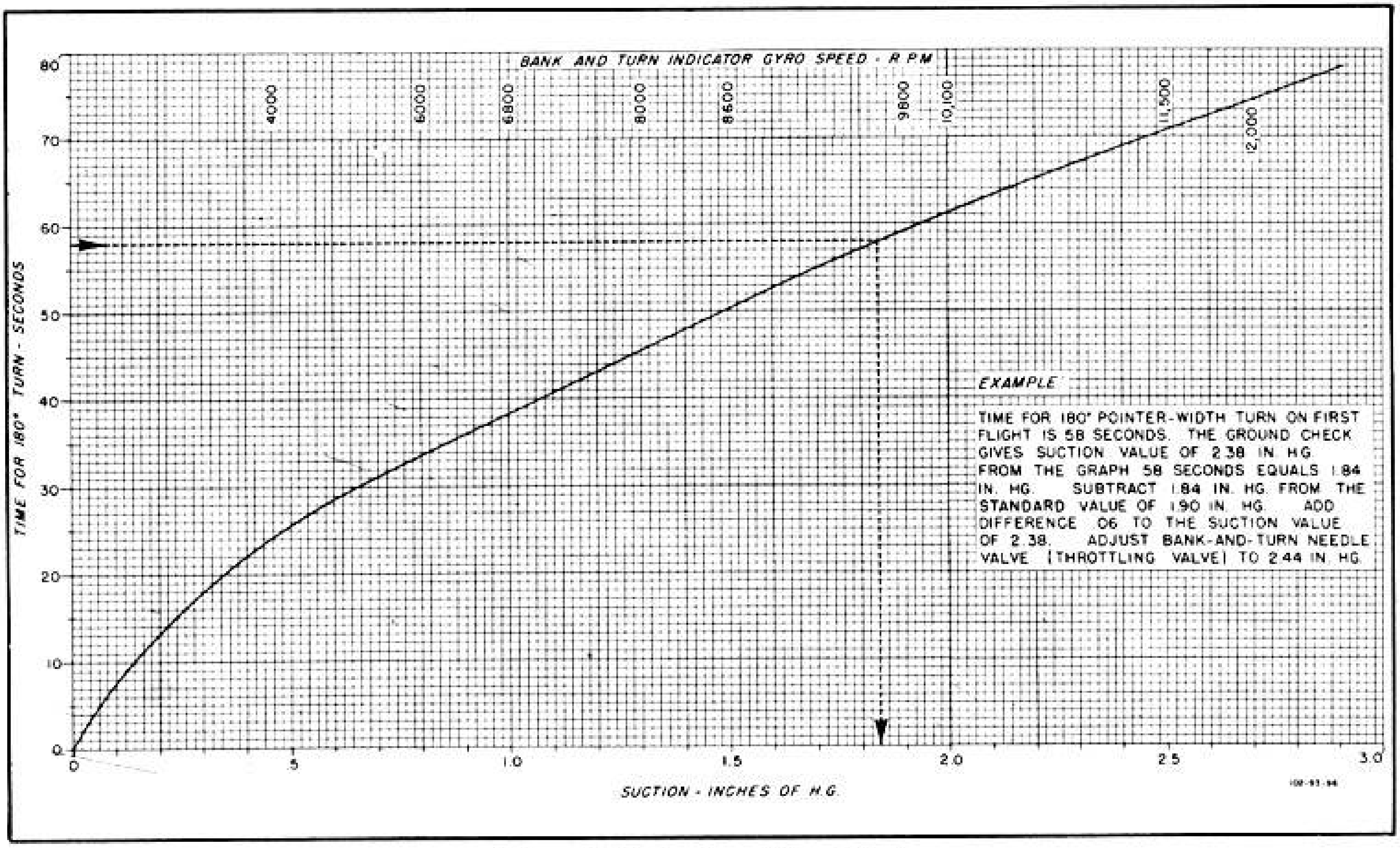



***Figure 289—Bank-and-Turn Chart***

*(i)* DIRECTIONAL GYRO (Turn Indicator).—The AN5735 directional gyro indicator is used to supplement the magnetic compass in maintaining the airplane on a straight course. The indicator is nonmagnetic. Relative movement of the airplane from right to left shows on the circular card which is graduated in degrees the same as a compass card. This instrument is provided with a caging knob.

(2) AIRSPEED SYSTEM.

*(a)* GENERAL.—The airspeed system *(figure 290)* consists of a Type G-2 pitot head, two static plates, an airspeed indicator, an altimeter, a rate-of-climb indicator and the connecting lines. The lines are identified by colored tape, the pressure line being coded black and the static lines green and black. To facilitate the proper connecting of the lines, the fittings on the lines and instrument cases are stamped with the letter "S" (static) and "P" (pressure).

**Note**

The static openings must be clear of dirt and debris at all times for proper functioning of the instruments affected.

*(b)* PITOT HEAD.

*1.* GENERAL. *(See figure 291.)*—The Type G-2 pitot head is a single unit installed on the underside of the right wing with its axis parallel to the longitudinal axis or thrust line of the airplane and furnishes an accurate value of impact (pitot) pressure, caused by the motion of the airplane through the surrounding air. The forward portion is open so that it may be subjected to the full force of the impact pressure. The head is equipped with two resistance-type heaters in the forward end which prevent the formation of ice and, consequently, the erroneous reading of the airspeed indicator.

**Note**

The pitot heat switch on right switch panel must be "OFF" when airplane is on the ground, or when heat is not required, to prevent discharging of the battery and to increase the life of the heating elements.

*2.* REMOVING THE PITOT HEAD.—The three procedure steps given in sequence in figure 291 illustrate the correct method of removing the pitot head from the airplane. The cautions given must be strictly adhered to or serious damage to the head will result and will cause the airspeed instruments to give incorrect readings.

*3.* INSTALLING THE PITOT HEAD.—In order to install the pitot head, the cautions and procedure steps 3, 2, and 1 in figure 291 must be followed in that sequence.

*(c)* TESTING AIRSPEED SYSTEM STATIC LINE. *(See figure 293.)*

*(d)* TESTING AIRSPEED PRESSURE LINE. *(See figure 292.)*

*(e)* TESTING AIRSPEED SYSTEM INSTRUMENT CASES. *(See figure 295.)*

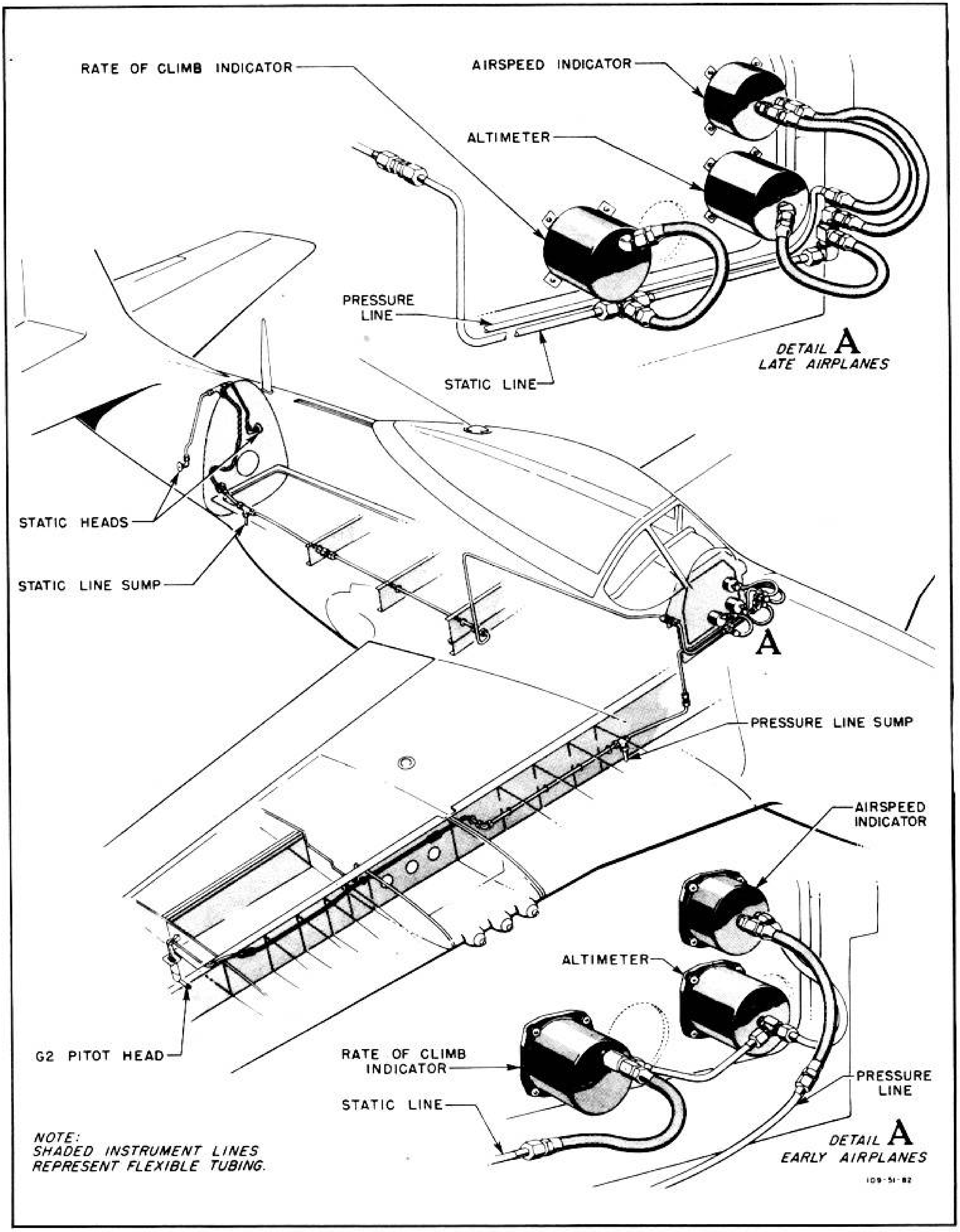



*Figure 290—Airspeed System*

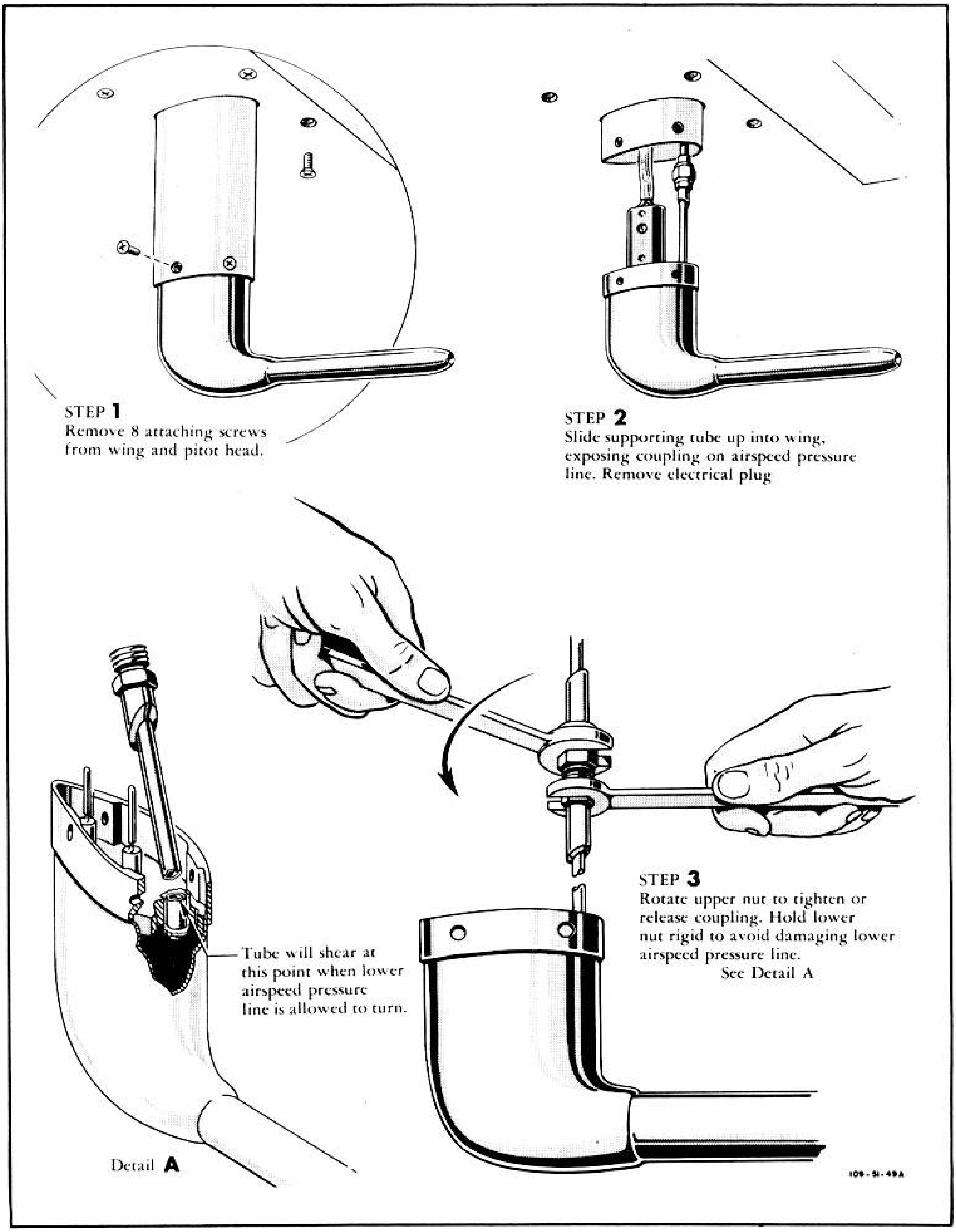



*Figure 291—Removing the G-2 Pitot Head*

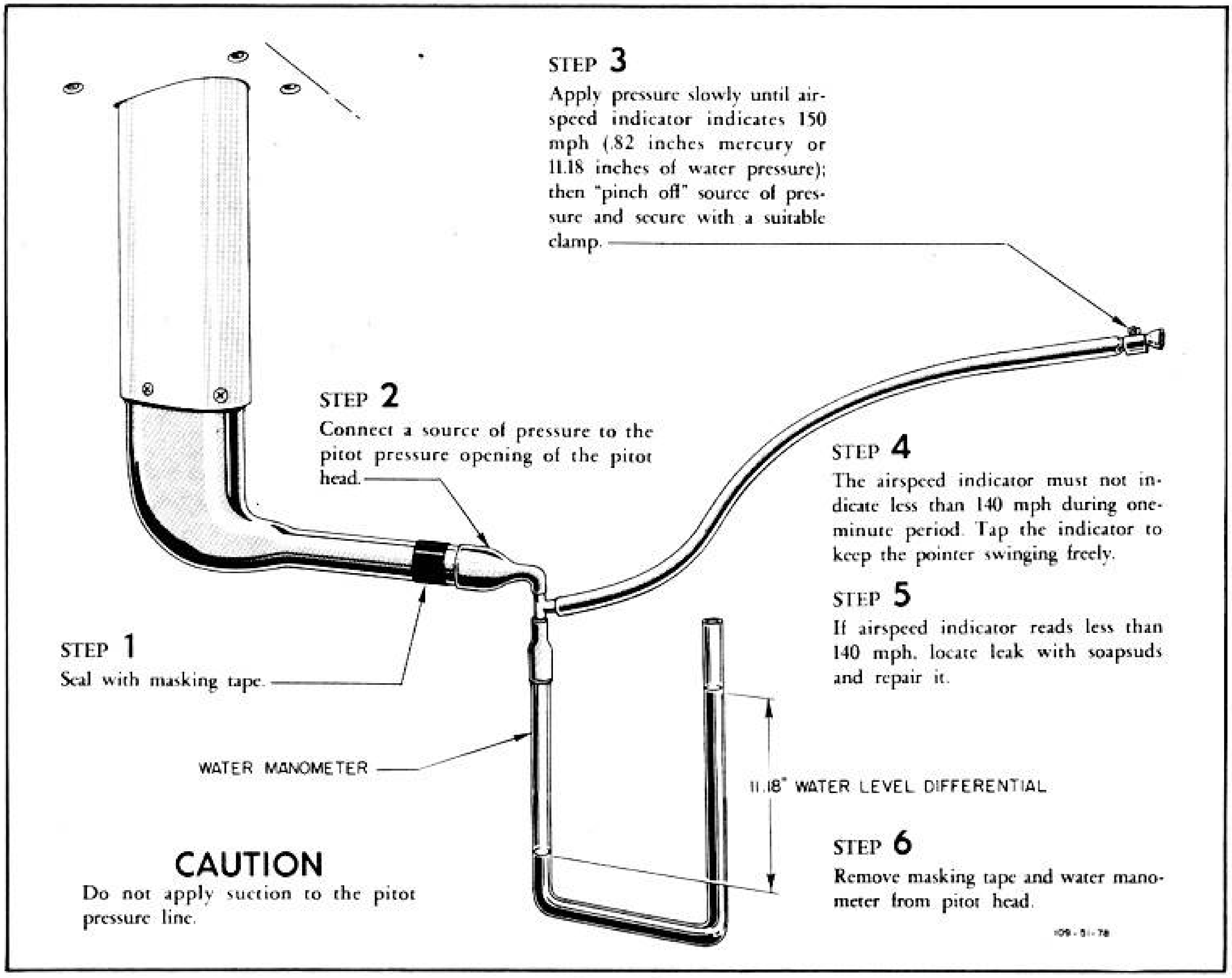



***Figure 292—Airspeed Pressure Test***

**Note**

Leaks in the cases of instruments operating under static pressure (altimeter, rate-of-climb indicator, and airspeed indicator) are the usual cause of undesirable pointer oscillation and errors in indication. If the case of an instrument leaks in excess of 0.80 of an inch of water under the test conditions, there is the possibility of the varying pressure of the cockpit leaking into the case and causing the pointers to oscillate.

*(f)* AIRSPEED INDICATOR.—The Type F-2 airspeed indicator is a sensitive differential pressure gage that measures the difference between pitot tube impact air pressure and static air pressure.

*(g)* ALTIMETER.—An AN5760-2 altimeter determines the altitude at which an airplane is flying by measuring atmospheric pressure.

*(h)* RATE-OF-CLIMB INDICATOR.—The AN5825 rate-of-climb indicator shows the rate of ascent or descent of the airplane; it is used in making banked turns without gain or loss of altitude, and in establishing a definite and constant rate of descent in making an instrument landing.

(3) REMOTE-INDICATING COMPASS.

*(a)* DESCRIPTION.—An AN5730-6 remote-indicating compass system is used because of the armor plate magnetic effect on the direct-reading magnetic compass. The system consists of a transmitter (compass) in the left wing near the tip and an indicator mounted on the instrument panel. *(See figure 294.)* The system is powered by 26 volts, 400-cycle alternating current supplied by the inverter. The transmission of the magnetic indications of the compass to the indicator is entirely electrical, the only rotating parts in the system being the compass float and the indicator rotors. The system uses a self-synchronous method of electrically transmitting induced voltages from the coil in the transmitter to the coil in the indicator. The coils are wired in parallel and energized by the alternating current. A permanent magnet mounted on a shaft is free to rotate in the center of the transmitter coil magnetic field. Rotation of the permanent magnet, by adjustment, will cause the indicator

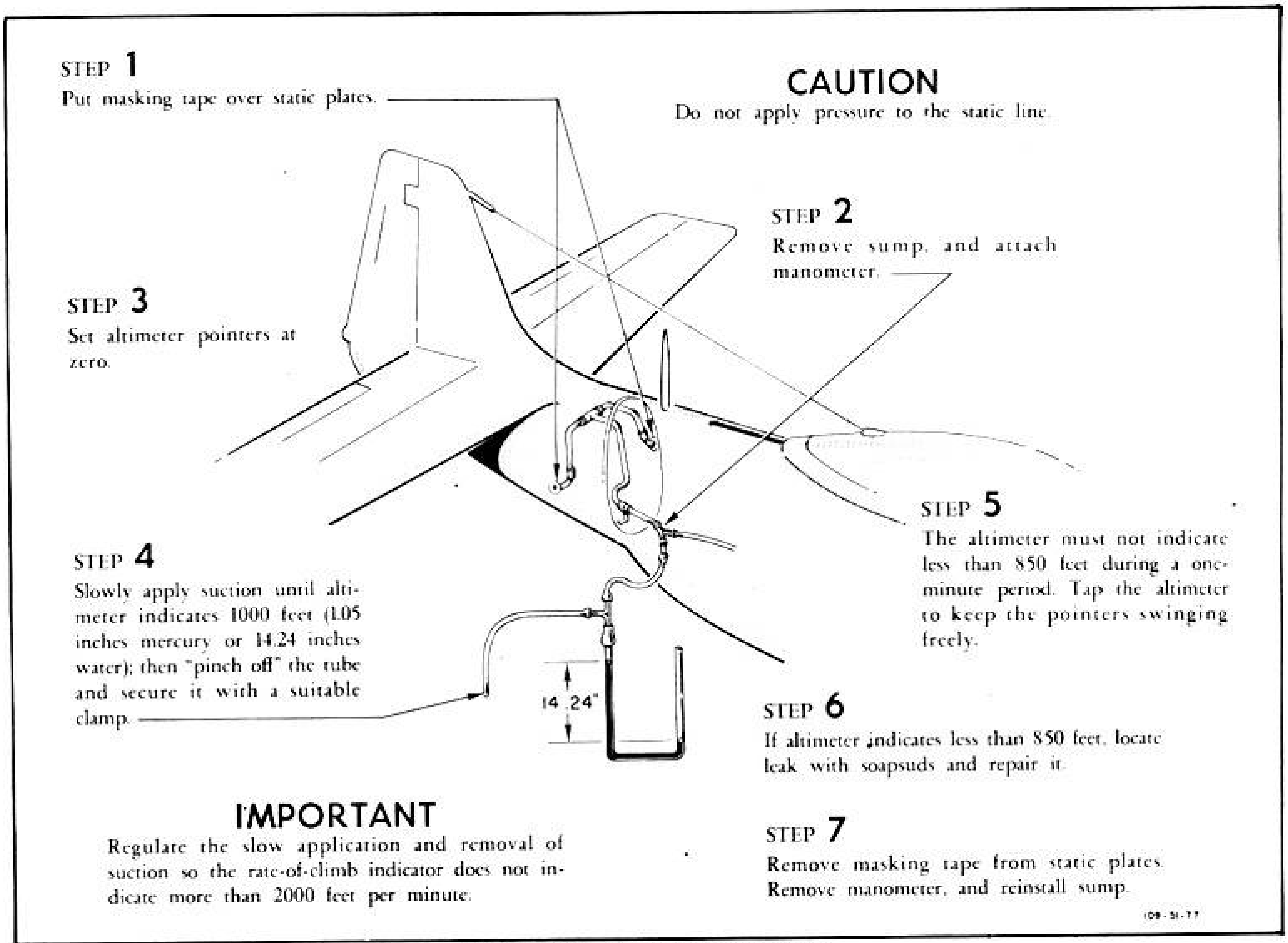



*Figure 293—Static Pressure Test*

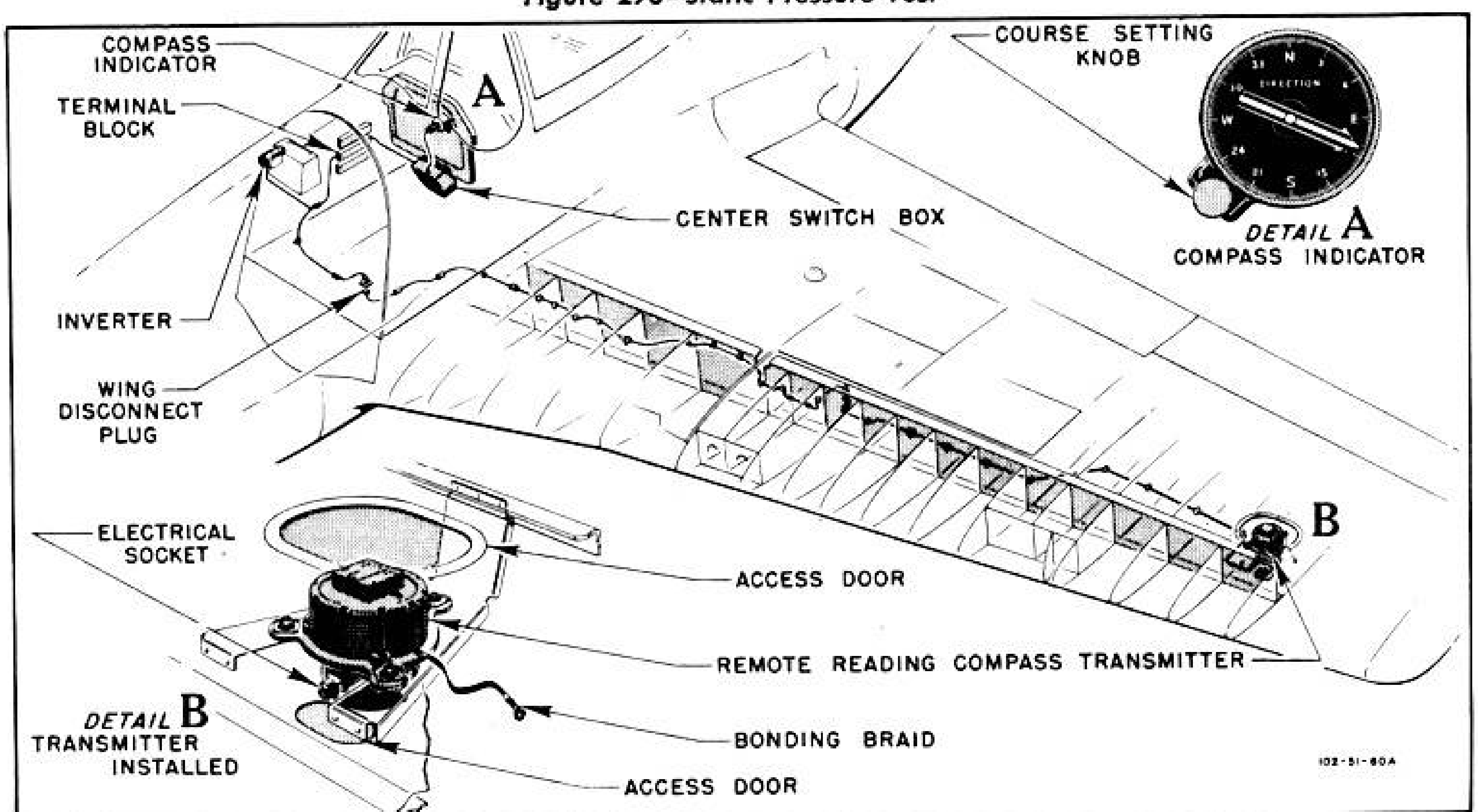



*Figure 294—Remote-indicating Compass Installation*

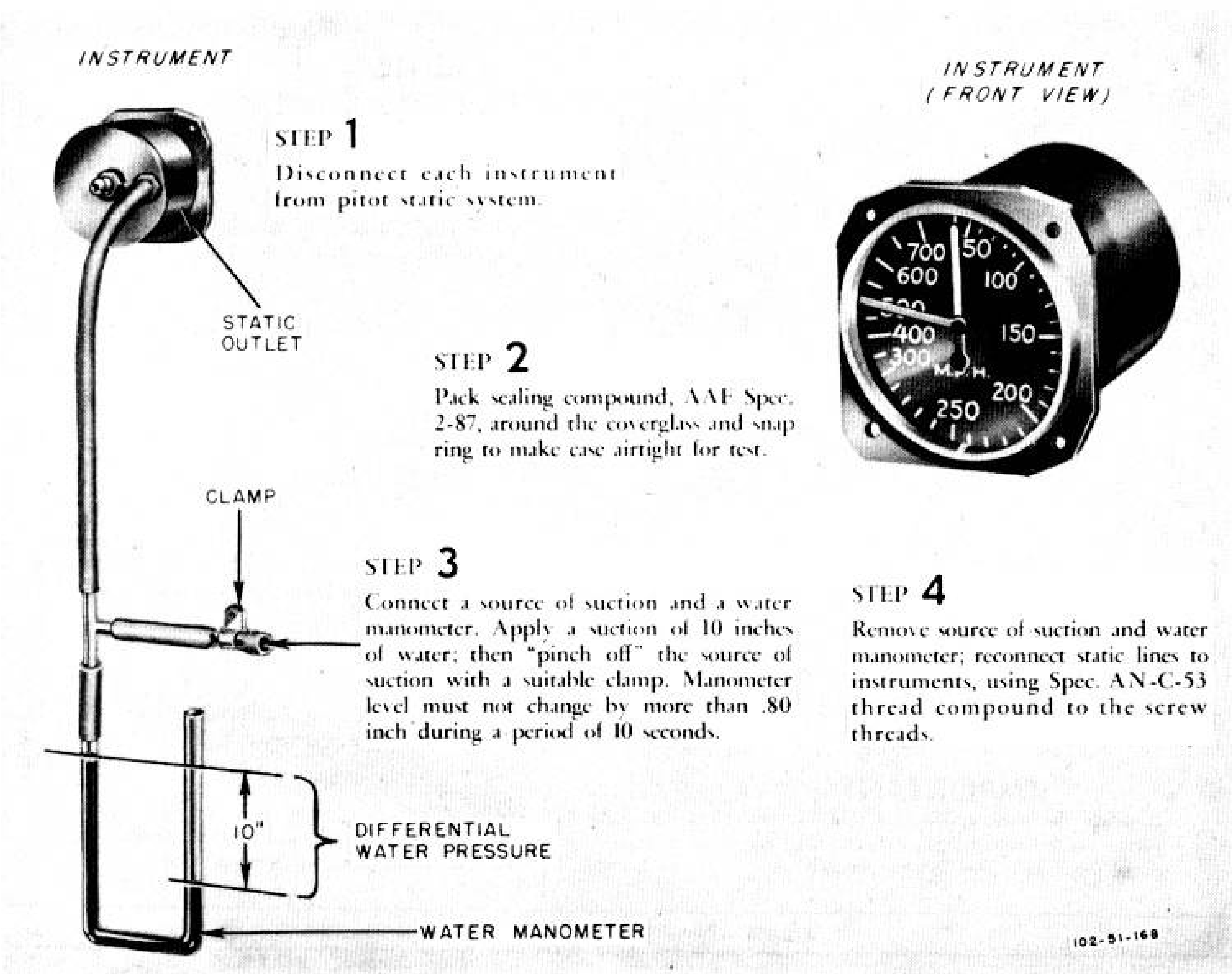



*Figure 295—Instrument Case Leak Test*

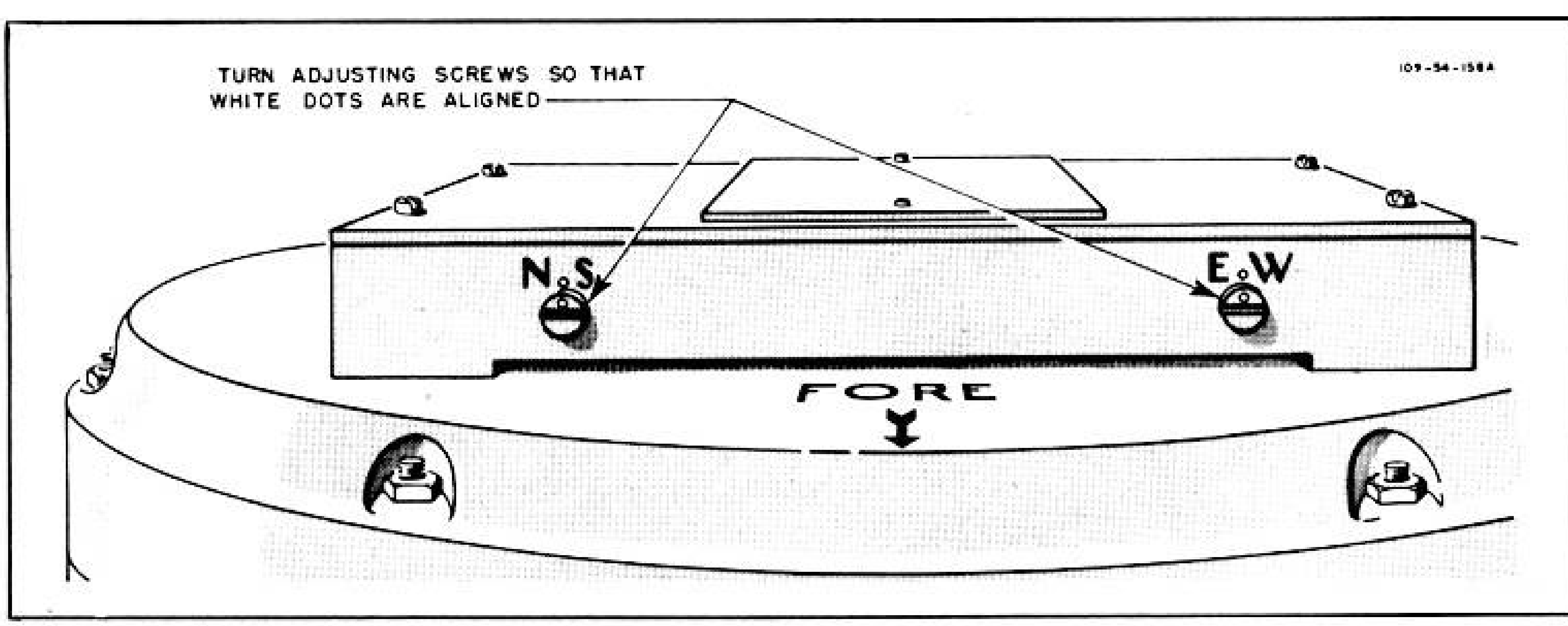



*Figure 296—Adjusting the Compensating Screws*

to follow in the same direction and with the same angular displacement. The indicator shaft carries the pointer which shows the airplane's magnetic heading.

**Note**

Compensation will be accomplished every 100 hours or at least once in each three-month period and at times when a change of equipment likely to affect the compass is made.

*(b)* GROUND SWINGING THE COMPASS USING A SWINGING COMPASS.—Ground swinging of the airplane can be accomplished by means of a compass base or a swinging compass. The swinging compass is a standard aircraft compass, Pioneer Type B-16, which has had its compensating assembly removed and a swinging compass sight, Stock No. 7800-725200, attached in its place. The magnetic heading of the airplane is determined with the swinging compass by standing at least 50 feet from the airplane. The observer aligns himself with the airplane's longitudinal axis by reference to a radio mast and fin, row of central fuselage rivets, or any suitable line or pair of objects on the airplane. With the swinging compass held in cupped hands, the observer looks both through and over the lens of the attached sight, through it at the hair line, and over it at the object sighted upon, and aligns the two by rotating the compass. The reading obtained is the magnetic heading of the airplane if the observer is behind the aircraft. If the observer is in front of the airplane, the magnetic heading is obtained by adding or subtracting 180 degrees from the reading obtained from the swinging compass.

**Note**

It is not necessary to run the engine, since its operation has no effect on the compass.

*1.* Having selected a suitable area for swinging, adjust the compensator on the airplane compass for zero effect. *(See figure 296.)*

*2.* Head the airplane East, within 5 degrees by its own compass. Allow the airplane compass sufficient time to settle; then read. Record reading in its proper space in the second column of card, AAF Form No. 57.

*3.* Determine the magnetic heading of the airplane with the swinging compass, and record in the proper space in the first column of the card.

*4.* Repeat preceding procedures *2.* and *3.*, first with the airplane headed on South, then West, and North. A card having the first two columns completed is shown in figure 297, step 1.

*5.* Calculate the deviation and its sign for each heading. The deviation and its sign are determined by subtracting the airplane compass reading from the actual heading; that is, the deviation and its sign indicate the quantity that must be added or subtracted to the airplane compass reading to make its value the same as the actual heading. If the quantity must be added, the sign is plus (+); if subtracted, it is minus (−). The deviations and their signs are entered in the column labeled "Dev'n." *(See figure 297, step 2.)*

*6.* Using the recorded deviations, calculate coefficients A, B, and C according to the formulae on the lower part of the form. *(See figure 297, step 3.)* All additions and subtractions are algebraic.

**Note**

Coefficient C is the deviation on North minus algebraically the deviation on South, divided by 2; that is, the sign of the deviation on South heading is made opposite to that recorded, and if the signs of both deviations are the same, the two quantities are added, the sum divided by two, and the result is given that same sign. If the signs of the two deviations are opposite, the smaller quantity is subtracted from the larger, the result divided by two and given the sign of the larger number. Coefficient B is the deviation on East minus algebraically the deviation on West, divided by 2; that is, the sign of the deviation on West is made opposite to that recorded. If the signs of both deviations are then the same, the two quantities are added, the sum divided by 2 and the result given the same sign. If the signs of the two deviations are opposite, the smaller quantity is subtracted from the larger, the result divided by 2 and given the sign of the larger number. Coefficient A is the sum of the deviations on North, East, South and West divided by 4; that is, all the plus (+) recorded deviations are added and all the minus (−) deviations are added, the smaller quantity subtracted from the larger, the result divided by 4 and given the sign of the larger number.

*7.* With the aircraft's heading on magnetic North within 5 degrees by its own compass, determine what the instrument should indicate when compensated, by adding coefficient C algebraically to the compass reading; that is, add or subtract coefficient C from the compass reading on that heading as indicated by the sign of the coefficient.

*8.* Adjust the North-South compensating screw (using nonmagnetic screwdriver) to make the compass indicate the compensated value. For example, the aircraft compass reads one degree and coefficient C is +4 degrees. To correct for coefficient C, the compass should be made to read one degree plus 4 degrees or 5 degrees.

*9.* With the aircraft heading on magnetic East within 5 degrees by its own compass, add coefficient B algebraically to the compass reading, determine what the instrument should indicate when compensated by adding coefficient B algebraically to the compass reading; that is, add or subtract coefficient B as indicated by its sign to the compass reading on the East heading. Make the compass indicate the compensated value by adjusting the East-West compensating screw (use nonmagnetic screwdriver). For example, the aircraft compass reads 90 degrees and coefficient B is +2½ degrees. To correct for coefficient B, the compass should be made to read 90 degrees plus 2½ degrees or 92½ degrees by rotating the East-West compensating screw.

| | Compensating Swing: Actual Head (M) | Compensating Swing: Aircraft Comp. | Dev'n | Residual Swing: Actual Head (M) | Residual Swing: Aircraft Comp. | Aircraft Comp. C to M | Date | M to C |
|---|---|---|---|---|---|---|---|---|
| N 000 | 005 | 001 | | | | | 000 | |
| NE 045 | | | | | | | 045 | |
| E 090 | 087 | 090 | | | | | 090 | |
| SE 135 | | | | | | | 135 | |
| S 180 | 176 | 180½ | | | | | 180 | |
| SW 225 | | | | | | | 225 | |
| W 270 | 265 | 273 | | | | | 270 | |
| NW315 | | | | | | | 315 | |
| | (1) | (2) | (1)-(2) | (3) | (4) | (3)-(4) | | (4)-(3) |

If swinging compass used ahead of aircraft add or subtract 180 degrees.

$$\text{COEFF. C} = \frac{N-S}{2} = \frac{(\quad)-(\quad)}{2} =$$

$$\text{COEFF. B} = \frac{E-W}{2} = \frac{(\quad)-(\quad)}{2} =$$

$$\text{COEFF. A} = \frac{N+E+S+W}{4} = \frac{(\quad)+(\quad)+(\quad)+(\quad)}{4} =$$

16-29598-1

STEP 1

| | Compensating Swing: Actual Head (M) | Compensating Swing: Aircraft Comp. | Dev'n | Residual Swing: Actual Head (M) | Residual Swing: Aircraft Comp. | Aircraft Comp. C to M | Date | M to C |
|---|---|---|---|---|---|---|---|---|
| N 000 | 005 | 001 | +4 | | | | 000 | |
| NE 045 | | | | | | | 045 | |
| E 090 | 087 | 090 | -3 | | | | 090 | |
| SE 135 | | | | | | | 135 | |
| S 180 | 176 | 180½ | -4½ | | | | 180 | |
| SW 225 | | | | | | | 225 | |
| W 270 | 265 | 273 | -8 | | | | 270 | |
| NW315 | | | | | | | 315 | |
| | (1) | (2) | (1)-(2) | (3) | (4) | (3)-(4) | | (4)-(3) |

If swinging compass used ahead of aircraft add or subtract 180 degrees.

$$\text{COEFF. C} = \frac{N-S}{2} = \frac{(\quad)-(\quad)}{2} =$$

$$\text{COEFF. B} = \frac{E-W}{2} = \frac{(\quad)-(\quad)}{2} =$$

$$\text{COEFF. A} = \frac{N+E+S+W}{4} = \frac{(\quad)+(\quad)+(\quad)+(\quad)}{4} =$$

16-29598-1

STEP 2

| | Compensating Swing: Actual Head (M) | Compensating Swing: Aircraft Comp. | Dev'n | Residual Swing: Actual Head (M) | Residual Swing: Aircraft Comp. | Aircraft Comp. C to M | Date | M to C |
|---|---|---|---|---|---|---|---|---|
| N 000 | 005 | 001 | +4 | | | | 000 | |
| NE 045 | | | | | | | 045 | |
| E 090 | 087 | 090 | -3 | | | | 090 | |
| SE 135 | | | | | | | 135 | |
| S 180 | 176 | 180½ | -4½ | | | | 180 | |
| SW 225 | | | | | | | 225 | |
| W 270 | 265 | 273 | -8 | | | | 270 | |
| NW315 | | | | | | | 315 | |
| | (1) | (2) | (1)-(2) | (3) | (4) | (3)-(4) | | (4)-(3) |

If swinging compass used ahead of aircraft add or subtract 180 degrees.

$$\text{COEFF. C} = \frac{N-S}{2} = \frac{(+4)-(-4\frac{1}{2})}{2} = +\frac{8\frac{1}{2}}{2} = +4\frac{1}{4} \text{ OR } +4$$

$$\text{COEFF. B} = \frac{E-W}{2} = \frac{(-3)-(-8)}{2} = +\frac{5}{2} = +2\frac{1}{2}$$

$$\text{COEFF. A} = \frac{N+E+S+W}{4} = \frac{(+4)+(-3)+(-4\frac{1}{2})+(-8)}{4} = -\frac{11\frac{1}{2}}{4} = -3$$

16-29598-1

STEP 3

| | Compensating Swing: Actual Head (M) | Compensating Swing: Aircraft Comp. | Dev'n | Residual Swing: Actual Head (M) | Residual Swing: Aircraft Comp. | Aircraft Comp. C to M | Date | M to C |
|---|---|---|---|---|---|---|---|---|
| N 000 | 005 | 001 | +4 | 002½ | 001 | | 000 | |
| NE 045 | | | | 040 | 043 | | 045 | |
| E 090 | 087 | 090 | -3 | 095 | 094 | | 090 | |
| SE 135 | | | | 136 | 134 | | 135 | |
| S 180 | 176 | 180½ | -4½ | 185 | 184 | | 180 | |
| SW 225 | | | | 222 | 225 | | 225 | |
| W 270 | 265 | 273 | -8 | 275 | 276 | | 270 | |
| NW315 | | | | 317 | 316 | | 315 | |
| | (1) | (2) | (1)-(2) | (3) | (4) | (3)-(4) | | (4)-(3) |

If swinging compass used ahead of aircraft add or subtract 180 degrees.

$$\text{COEFF. C} = \frac{N-S}{2} = \frac{(+4)-(-4\frac{1}{2})}{2} = +\frac{8\frac{1}{2}}{2} = +4\frac{1}{4} \text{ OR } +4$$

$$\text{COEFF. B} = \frac{E-W}{2} = \frac{(-3)-(-8)}{2} = +\frac{5}{2} = +2\frac{1}{2}$$

$$\text{COEFF. A} = \frac{N+E+S+W}{4} = \frac{(+4)+(-3)+(-4\frac{1}{2})+(-8)}{4} = -\frac{11\frac{1}{2}}{4} = -3$$

16-29598-1

STEP 4

| | Compensating Swing: Actual Head (M) | Compensating Swing: Aircraft Comp. | Dev'n | Residual Swing: Actual Head (M) | Residual Swing: Aircraft Comp. | Aircraft Comp. C to M | Date | M to C |
|---|---|---|---|---|---|---|---|---|
| N 000 | 005 | 001 | +4 | 002½ | 001 | +1½ | 000 | -1½ |
| NE 045 | | | | 040 | 043 | -3 | 045 | +3 |
| E 090 | 087 | 090 | -3 | 095 | 094 | +1 | 090 | -1 |
| SE 135 | | | | 136 | 134 | +2 | 135 | -2 |
| S 180 | 176 | 180½ | -4½ | 185 | 184 | +1 | 180 | -1 |
| SW 225 | | | | 222 | 225 | -3 | 225 | +3 |
| W 270 | 265 | 273 | -8 | 275 | 276 | -1 | 270 | +1 |
| NW315 | | | | 317 | 316 | +1 | 315 | -1 |
| | (1) | (2) | (1)-(2) | (3) | (4) | (3)-(4) | | (4)-(3) |

If swinging compass used ahead of aircraft add or subtract 180 degrees.

$$\text{COEFF. C} = \frac{N-S}{2} = \frac{(+4)-(-4\frac{1}{2})}{2} = +\frac{8\frac{1}{2}}{2} = +4\frac{1}{4} \text{ OR } +4$$

$$\text{COEFF. B} = \frac{E-W}{2} = \frac{(-3)-(-8)}{2} = +\frac{5}{2} = +2\frac{1}{2}$$

$$\text{COEFF. A} = \frac{N+E+S+W}{4} = \frac{(+4)+(-3)+(-4\frac{1}{2})+(-8)}{4} = -\frac{11\frac{1}{2}}{4} = -3$$

16-29598-1

STEP 5

109-51-80

*Figure 297—Filling Out Form AAF57 (AN5803)*

*10.* With the aircraft on any heading, determine what the instrument should read when corrected for coefficient A by adding coefficient A algebraically to the reading of the compass on that heading; that is, add or subtract the value of coefficient A as indicated by its sign to the compass reading. Make the compass indicate the corrected value by rotating the compass bowl bodily. For example, the compass reads 92½ degrees (after the correction for coefficient B), and coefficient A is −3 degrees. To correct for coefficient A, make the compass read 92½ degrees −3 degrees or 89½ degrees by rotating the compass bowl counterclockwise 3 degrees. The correction of the three coefficients A, B, and C completes the compensation of the compass.

*11.* Securely fasten the compass and swing for residual errors. The residual errors result from causes other than those which give rise to coefficients A, B, and C, and no provision is made to compensate for these errors. The residual swing is accomplished in the same manner as the swing before compensation was performed except that eight headings are used instead of four. The airplane is placed on the cardinal and quadrantal magnetic headings (East, Southeast, South, Southwest, West, Northwest, North, Northeast) and the magnetic headings and the corresponding compass readings are entered in their proper spaces on the card. The card will appear as shown in figure 297, step 4, after the data from the residual swing are entered.

*12.* Complete AAF Form No. 57 by filling in the remaining two columns from data obtained in the residual swing. The entries for the left-hand column (C to M) are obtained by subtracting Column 4 from Column 3 for each heading. The C to M Column indicates that the tabulated corrections are to be added or subtracted to the compass reading to obtain the magnetic heading. The entries for the right-hand column (M to C) are obtained by subtracting Column 3 from Column 4 for each heading. The completed Column labeled M to C indicates that the corrections are added or subtracted to the magnetic heading to obtain the compass reading. For example, using the card shown in figure 297, step 5, if the compass heading is 225 degrees, subtract 3 degrees (C to M Column) to determine the corresponding magnetic heading, 222 degrees M. If the magnetic heading is 45 degrees, add 3 degrees (M to C Column) to determine the corresponding compass reading, 48 degrees C. Complete the correction card, adding the information required in the blanks on the rear of the card. Detach the compass card and insert it in the compass card holder in the airplane. Place the remainder of the form in a permanent file.

*(c)* GROUND SWINGING THE COMPASS USING COMPASS "ROSE."

*1.* To swing the airplane on a prepared base or compass "rose," the airplane is turned to the desired heading as determined by the base. These magnetic headings are entered in the Column, Actual Head (M). In every respect, the compensation and swinging are the same as when using the swinging compass method.

*f.* ENGINE INSTRUMENTS.

(1) GENERAL.—The engine instruments consist of the following: manifold pressure indicator, tachometer, carburetor air temperature indicator, engine gage, and coolant temperature gage. *(See figure 298.)* The engine gage consists of three gages in one case for indicating oil temperature, oil pressure, and fuel pressure. The operational limits of engine instruments are indicated by fluorescent decalcomania markers. *(See figure 299.)*

(2) MANIFOLD PRESSURE INDICATOR.

*(a)* DESCRIPTION.—The Type D-10 manifold pressure indicator is of the vaporproof, absolute-pressure type. The indicator consists of a two-celled, evacuated diaphragm and a linkage system which transmits movements of the diaphragm to the indicating pointer. The gage has a range from 10 to 75 in. Hg. On later airplanes, an indicator covering from 15 to 100 in. Hg is used.

*(b)* ADJUSTING THE DAMPING SCREW.—The damping screw is located in the socket outlet. To dampen, remove the line from the indicator and proceed as follows:

*1.* Tighten the damping screw until it seats and then back it off slightly.

*2.* Apply a pressure to the instrument sufficient to bring pointer reading to 50 in. Hg.

*3.* Pinch off the pressure and note the time, which will be between 1.5 to 2.5 seconds, for the pointer to indicate a reading of 32 in. Hg. Several damping screw adjustments will probably be required before the correct calibration is obtained.

*(c)* TESTING MANIFOLD PRESSURE INDICATOR FOR LEAK.—Apply a suction equivalent to 10 in. Hg absolute pressure to the pressure connection of indicator. Pinch off the source of suction. The pointer must not change its position for a period of one minute.

(3) TACHOMETER.—The tachometer is used for remote indication of engine speed. An engine-driven three-phase alternating current tachometer generator (AN5531-1) having a 4-pole permanent magnet rotor is connected electrically to a synchronous motor in the indicator (AN5530-1). The frequency of the three-phase power is proportional to the engine speed.

(4) TYPE B-7 ENGINE GAGE (Early Airplanes).

*(a)* DESCRIPTION.—The Type B-7 engine gage has a thermometer to indicate the oil temperature (range 0-100°C), and two gages to indicate oil pressure (0-200 pounds per square inch) and fuel pressure (0-25 pounds per square inch). *(See figure 279.)* The thermometer, of the *vapor pressure* type, comprises a bulb, capillary, and bourdon spring system partially filled with a volatile liquid so that the junction of the liquid and vapor phases always remains in the bulb. The vapor pressure corresponding to the bulb temperature is transmitted to the bourdon spring in the instrument and then to the pointer. The oil and fuel pressure gage units are arranged in the lower half of the case and are

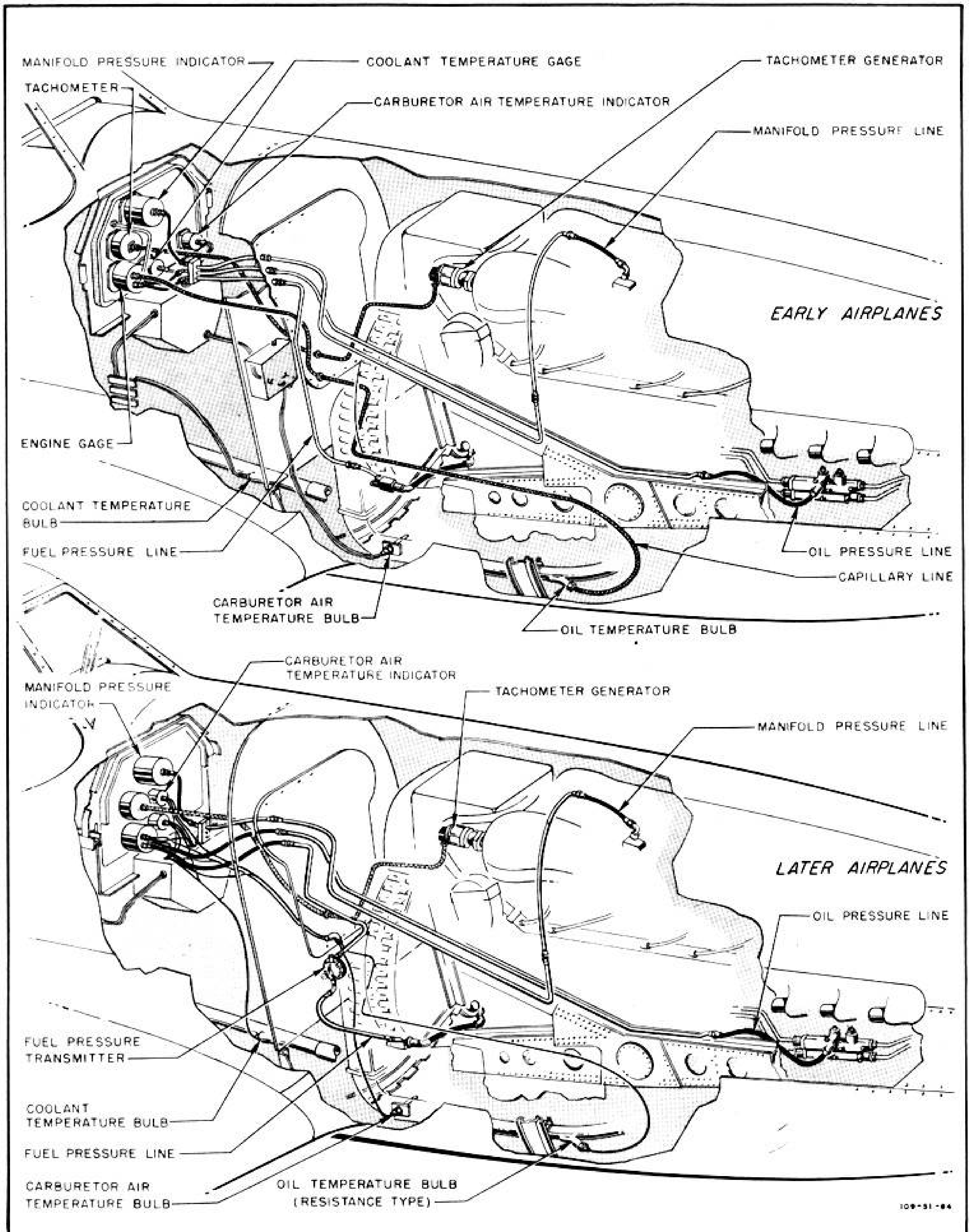



*Figure 298—Engine Instrument System*

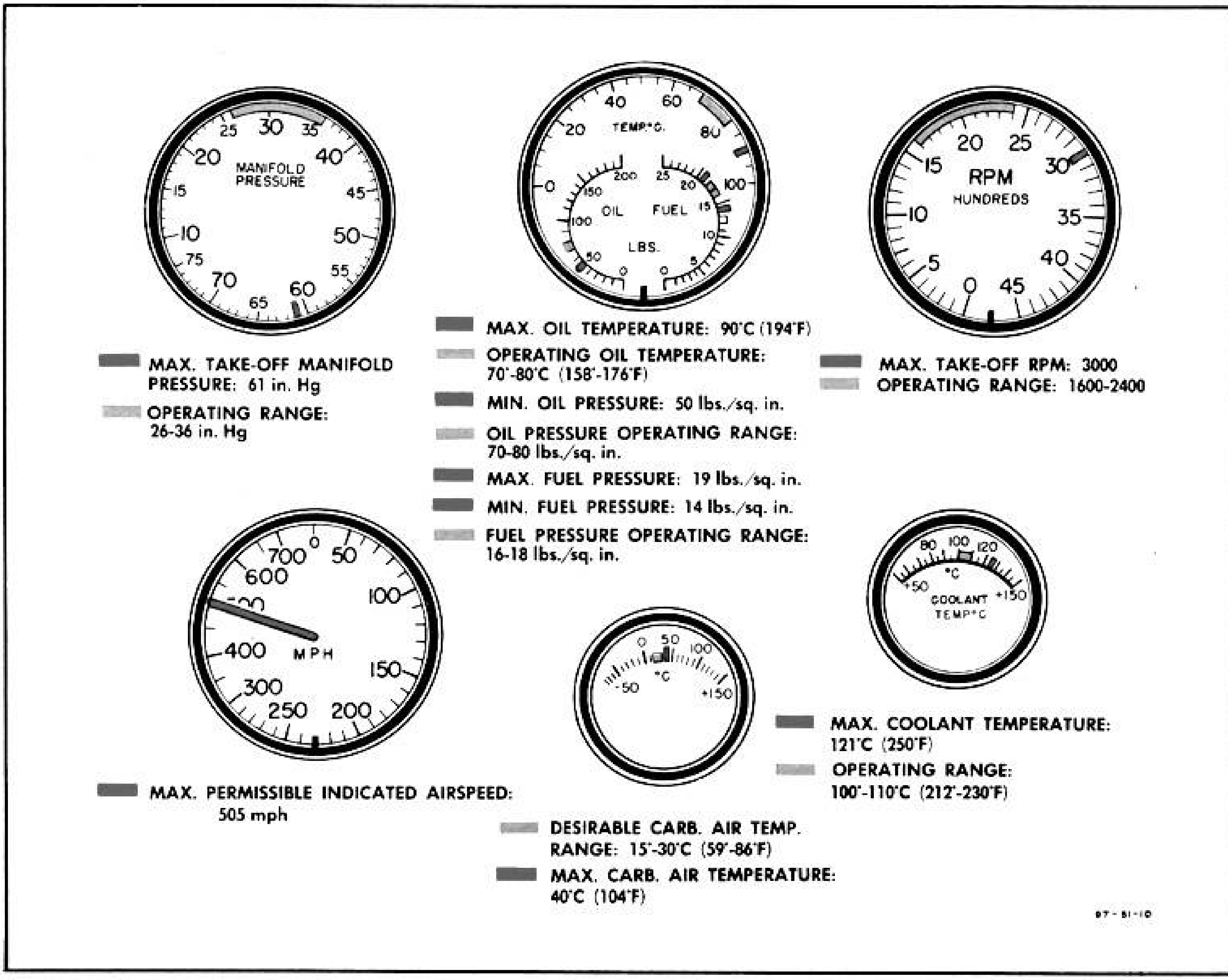



*Figure 299—Instrument Limitations*

of the conventional design bourdon springs with sector and pinion movements to transmit spring deflection to the pointer. On some airplanes, a filler port mounted on the upper right corner of the instrument panel enables the engine oil normally contained in the oil gage line to be replaced with a light oil for cold weather operation. The installation consists of a ⅛-inch aluminum line leading from the filler port connecting with a check valve (AC43A-14985) mounted in a brass fitting (AC43A-14984) which is attached to the bottom of the gage. Flexible hose is used for the connection to the oil pressure port on the engine and the oil pressure gage on the instrument panel. The oil line is color coded yellow; the fuel line is red.

(*b*) FILLING THE OIL PRESSURE GAGE LINE.

*1.* Disconnect the pressure gage line at the engine and remove cap from the filler port on the right side of the pilot's instrument panel.

*2.* Fill oil pressure gun with instrument oil, Specification No. AN-VV-C-366. On early airplanes, connect gun to filler cap on the instrument panel (*figure 300*) and on later

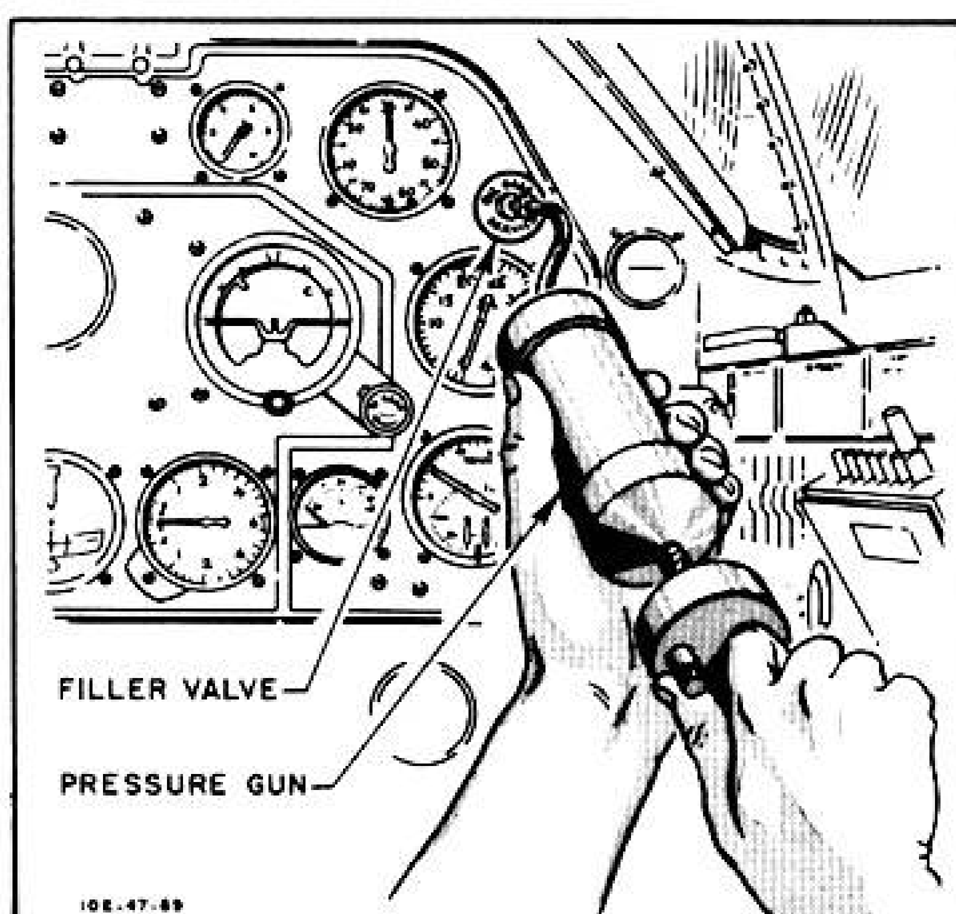



*Figure 300—Filling the Oil Pressure Gage Line*

airplanes, remove instrument from panel and connect gun to filler cap on fitting on back of instrument; slowly inject oil into the pressure line until a small amount drips from the engine end.

*3.* Connect line to engine before removing the oil pressure gun from the filler port.

(5) AN5773-1 ENGINE GAGE (Later Airplanes).

*(a)* DESCRIPTION.—This instrument differs from the Type B-7 engine gage in that the oil temperature indicator is an electrical instrument connected to a resistance bulb in the oil line on the right side of the engine. The fuel pressure indicator is connected to an AN5765-2 pressure transmitter on the lower right side of the firewall. The transmitter consists of a chamber divided by a synthetic rubber diaphragm. One side of the chamber is connected to the fuel pressure connection; the opposite side is connected to the indicator by a small line filled with compass fluid. The fluid transmits to the indicator the fuel pressure imposed on the engine side of the diaphragm. A line attached to the oil pressure port on the engine is routed directly to the firewall fitting. A flexible hose is connected from this fitting to the instrument.

*(b)* TESTING FUEL PRESSURE LINE FOR OBSTRUCTIONS.

*1.* Disconnect the fuel line at the instrument and at the transmitter.

*2.* Apply air pressure at the instrument end of the line and check the other end for free flow of air.

*3.* Connect the flexible line to the instrument fitting but do not connect the rigid line to the transmitter.

*4.* Test line fitting for leakage. *(See (c) following.)*

*(c)* TESTING FOR LEAKS IN FUEL PRESSURE LINE FITTINGS.

*1.* Install a suitable valve (a Schrader valve assembly, AN812-1, in accordance with figure 285, Specification No. 27497-A, is recommended) on the transmitter end of the fuel instrument line.

*2.* Fill system through this valve from an AN air bottle fitted with a pressure regulator, and test at 20 pounds per square inch maximum pressure as indicated on the instrument.

**CAUTION**

Do not exceed 20 pounds per square inch maximum pressure.

*3.* Test will be successful if no pressure drop is indicated on the instrument gage after the pressure has been maintained for at least one hour.

*4.* If instrument gage shows a pressure drop, check the valve and all joints in the system for leaks, using a brush and soapsuds.

*5.* If there is no leakage, remove the valve and connect the fuel pressure to the transmitter.

**CAUTION**

The threads of each fitting used in the installation must be carefully coated with sealing compound conforming with AAF Specification No. 3603 (Gasoila Varnish) before filling the system. The compound must be of proper working consistency prior to application. Excess amounts must not be applied.

*(d)* FILLING "AN" PRESSURE SYSTEM. *(See figure 301.)*

*1.* Remove the cap from the bleeder check valve fitting.

*2.* Connect a bleed tube from the bleeder check valve to a collector tank.

*3.* Loosen locknut on transmitter knob until it is off the threaded portion of the stem. Push the knob inward and turn clockwise about one-quarter turn until the stem locks in place.

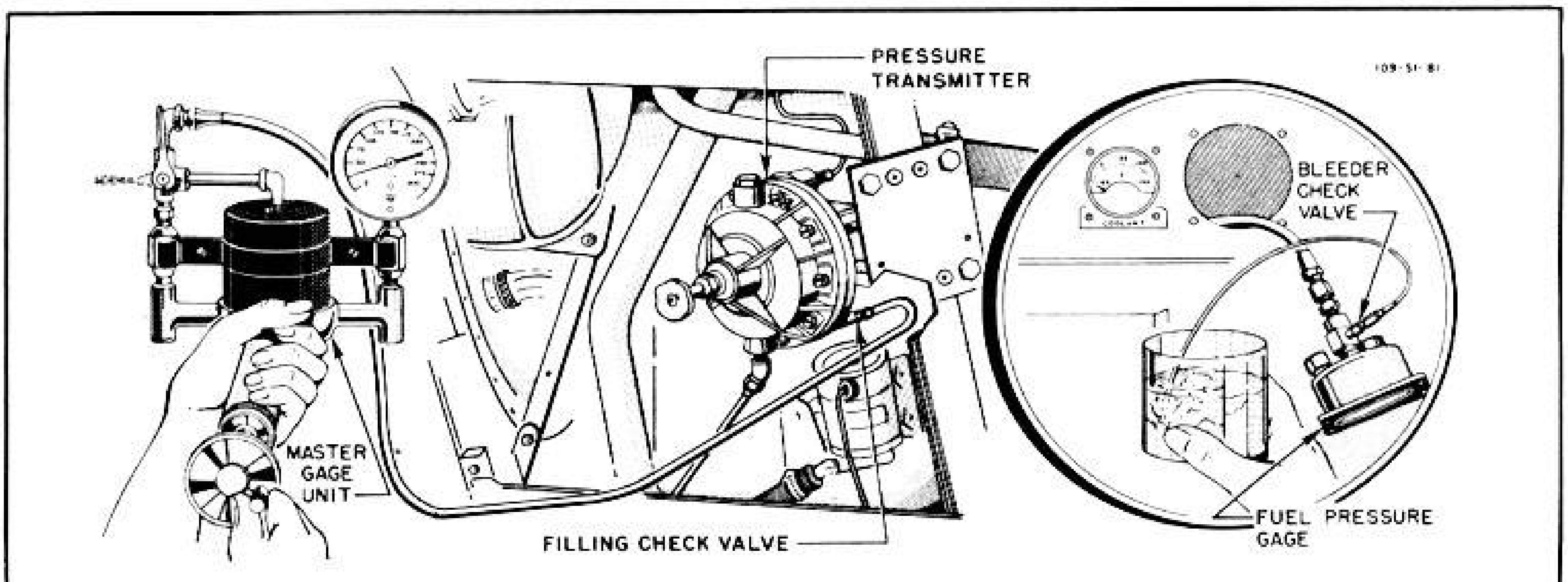



***Figure 301—Filling AN Fuel Pressure System***

*4.* Remove the cap from the filler check valve fitting on the transmitter and connect a filling tube from this fitting to an outside source of hydraulic pressure, such as the master gage pressure unit from a C-1 instrument field test set.

**Note**

Successful operation of the system is dependent upon a complete air-free filling of the transmitter and the line to the gage. The filling and bleed lines must be made of flexible, transparent material, such as Surco, in order that air bubbles may be seen.

*5.* Fill the master gage pressure unit with compass fluid, Specification No. AN-VV-C-551. Flush the unit out completely. Engine oil or similar liquids must not be introduced into the pressure transmitter system as these heavier fluids will result in faulty operation during low temperatures.

*6.* With the piston of the master gage pressure unit turned all the way in, fill the reservoir of the unit with compass fluid. Set the control valve to "RES." and screw the piston all the way out in order to fill the cylinder with fluid. Then set the control valve to "LINE" and slowly turn the pressure screw, forcing the liquid into the pressure transmitter system.

**Note**

When filling the transmitter system from the master gage pressure unit, be sure that the unit is held nearly level so that air will not be drawn into the cylinder and then forced into the pressure transmitter or connecting lines. It is very important to keep sufficient liquid in the reservoir of the master gage unit at all times to prevent air from entering the transmitter system.

*7.* Force the fluid through the pressure line removing all the air from the transmitter and the connecting lines. Continue the filling operation until the air bubbles stop coming through the bleed line.

**Note**

"Pinching off" the bleed line several times during the filling operation helps draw bubbles out of the fittings and the gage, and results in a more complete filling.

*8.* Remove the bleed line from the gage fittings and replace cap.

*9.* Remove the filling line at the fuel pressure transmitter, and replace cap. Be sure that the caps are tight and do not leak.

*10.* Turn transmitter knob counterclockwise and pull it out as far as possible. Tighten the locknut. This seals the pressure plate stem at the point where it passes through the casting.

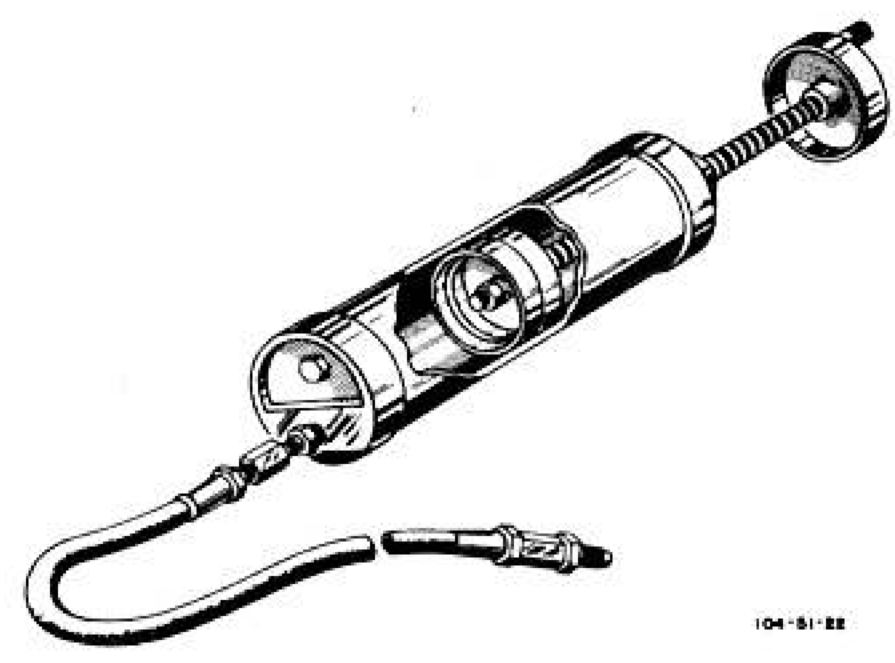


***Figure 302—Pressure Gun***

**Note**

If a master gage pressure unit is not available, a pressure gun of the type shown in figure 302 can be used. Fill the gun with compass fluid, connect gun to check valve fitting on the transmitter, and then inject the contents of the gun.

*(e)* PRESSURE TEST FOR LEAKS IN SYSTEM.

*1.* After filling operations are completed *(paragraph (d) preceding)*, apply air pressure through a pressure regulator to the engine side of the transmitter, using the special air valve. A pressure of 20 pounds per square inch must be maintained on the fuel pressure gage for a period of 30 minutes with no visible drop in fuel pressure gage.

*2.* If there is no leakage, connect the engine line to the transmitter.

*3.* If leakage is indicated by a drop in the pressure, check the pressure connection with soapsuds before checking the lines and fittings in the system. Repair leak and repeat the test.

(6) ENGINE COOLANT GAGE.—The AN5790-6 engine coolant temperature gage, mounted on the instrument panel, is of the ratiometer type connected electrically to a Type AN5525-2 resistance bulb in the coolant line just aft of the firewall on the right side of the airplane. This instrument operates off the airplane's 24-volt D.C. system.

*(a)* REMOVING THE ENGINE COOLANT RESISTANCE BULB.—Access to the resistance bulb is made through the right wheel well. Remove the bulb in the following manner:

*1.* Unscrew the connector plug from the bulb and remove the socket from the pins in the fitting.

*2.* Remove the safety wire.

*3.* Unscrew the bulb from the fitting in the well.

(7) CARBURETOR AIR TEMPERATURE INDICATOR.

*(a)* DESCRIPTION.—The AN5790-6 carburetor air temperature indicator is of the ratiometer type and is

electrically connected to a Type AN5525-2 resistance bulb in the carburetor air scoop elbow on the right side of the airplane forward of the firewall.

*(b)* REMOVING THE CARBURETOR AIR TEMPERATURE BULB.

*1.* For access to the bulb, remove the lower engine cowl just forward of the firewall.

*2.* Unscrew the electrical connector from the bulb and remove the socket from the pins in the fitting.

*3.* Remove the safety wire.

*4.* Unscrew the bulb from the fitting in the well.

*g.* MISCELLANEOUS INSTRUMENTS.

(1) GENERAL.—Miscellaneous instruments include the hydraulic pressure gages, remote contactor, fuel gages, ammeter and clock. Provisions are made on the instrument panel for the remote contactor.

(2) HYDRAULIC PRESSURE GAGES.—A hydraulic pressure gage is located immediately below the pilot's switch panel. The accumulator pressure gage is on the center beam of the wing and accessible from the right wheel well.

(3) REMOTE CONTACTOR (Early Airplanes Only). —The remote contactor is concerned only with the radio equipment. *(See paragraph* 21. ***e.*** (10).*)*

(4) FUEL GAGES.—The two wing tank fuel gages are of the direct-reading magnetic type and are recessed on each side of the cockpit floor just forward of the seat. The fuselage tank gage is located in a gooseneck behind the pilot's seat. In each gage, a magnet is connected to the float arm inside the tank and the indicator needle is pivoted directly above the magnet. When the float rises or falls, the magnet is rotated accordingly, causing the needle to align itself with the magnet indicating the fuel level in the tank.

(5) AMMETER.—The ammeter, mounted on the right switch panel, indicates the current output of the generator, but does not indicate the current flowing when the batteries are carrying the electrical load.

(6) CLOCK.—A Type A-11 clock is installed on the left in the upper row of instruments. The winding knob is on the front of the clock case and the adjustment needle is accessible by removing a plug at the back of the case.

**19. HYDRAULIC SYSTEM.**

*a.* GENERAL DESCRIPTION OF HYDRAULIC SYSTEM. *(See figure 303.)*—The hydraulic system operates the landing gear, fairing doors, and wing flaps. The system operating pressure is 1050 ± 50 pounds per square inch. A separate brake system is supplied with fluid from the hydraulic system reservoir. A hand-pump, provided as loose equipment, makes it possible to operate the hydraulic system when the airplane is on the ground with the engine inoperative.

*b.* GENERAL INSTRUCTIONS FOR HANDLING HYDRAULIC EQUIPMENT.

*(See figures 304 through 308.)*

(1) REMOVING AND DISASSEMBLING HYDRAULIC SYSTEM UNITS.

***(a)*** Exhaust the pressure from the system as instructed in section III, paragraph 2. ***b.*** (4) ***(d).***

***(b)*** When disconnecting hydraulic lines, plug the ends to prevent loss of fluid and to keep out foreign matter.

***(c)*** Disassemble any unit of the hydraulic system in as clean a place as possible, and with the proper tools.

(2) REPLACING HYDRAULIC SYSTEM UNITS.

***(a)*** Thoroughly clean component parts immediately after disassembly. Use naphtha diluent or kerosene on metal parts only and wipe the parts thoroughly dry with a clean, lint-free cloth.

**Note**

Do not clean packing with naphtha or kerosene—use only a clean, dry, lint-free cloth and hydraulic fluid.

***(b)*** Cover all parts with fluid conforming to Specification No. AN-VV-O-366 before reassembling.

***(c)*** When repairing or replacing a part, disturb as little of the unit as possible. Before disassembling any part of the unit, study all diagrams and drawings available to become thoroughly familiar with the unit's construction.

(3) ASSEMBLING AND INSTALLING HYDRAULIC UNITS.

***(a)*** Make sure washers, retainers, and packing are the correct size, are facing the correct surface, and are in the proper order.

***(b)*** Do not apply too much pressure to retainers and heads which are seated on gaskets and washers. A firm, not tight, seating is sufficient. Nuts should be only tight enough to prevent leakage.

***(c)*** Remove all plugs and clean lines thoroughly. Be sure sleeves are not cracked. Check the inside of the flare for bends, cracks, or other imperfections.

***(d)*** When installing the lines, only the line fitting should be moved. Line fittings must fit perfectly, or there will be leakage at the connection. If necessary, apply a thin coating of thread lubricant conforming to Specification No. AN-P-51. Make sure excessive lubricant does not get inside of the line as it will plug line or valves, resulting in damage.

(4) TESTING HYDRAULIC SYSTEM.

***(a)*** TEST STAND.—Any standard test stand may be used to operate the hydraulic system; however, to simulate actual operation, a stand capable of producing a fluid flow of 4 gpm at 1300 pounds per square inch is recommended.

***(b)*** CONNECTING TEST STAND.—Attach the test stand at disconnect fittings forward of firewall on the right-hand side of airplane (½-inch line to pressure, ⅝-inch line to suction). When operating a single unit or separate system, connect the test stand pressure and return lines to either the operating unit or corresponding ports of the selector valve for that particular system. Plug any lines left open.

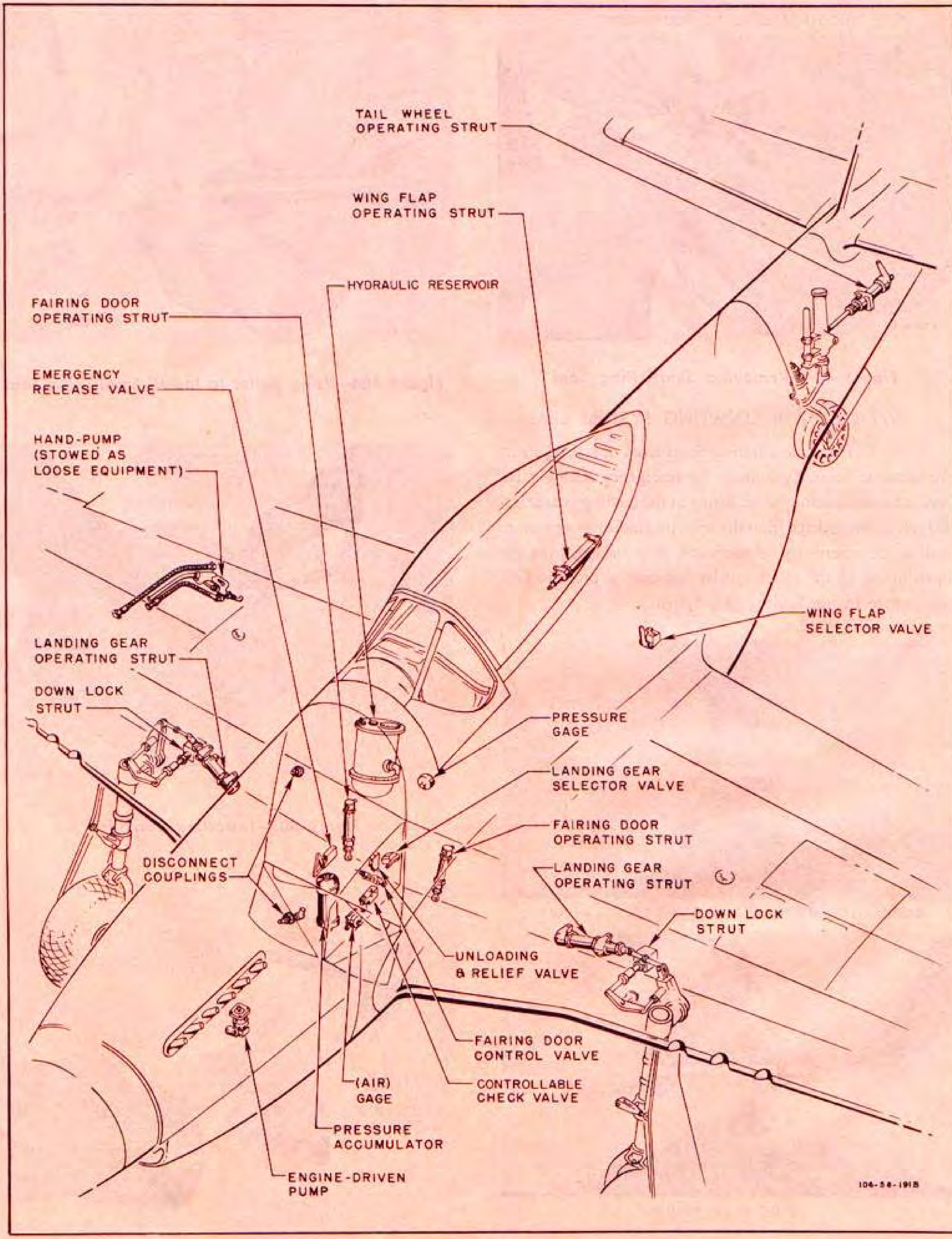



*Figure 303—Hydraulic System Unit Location*

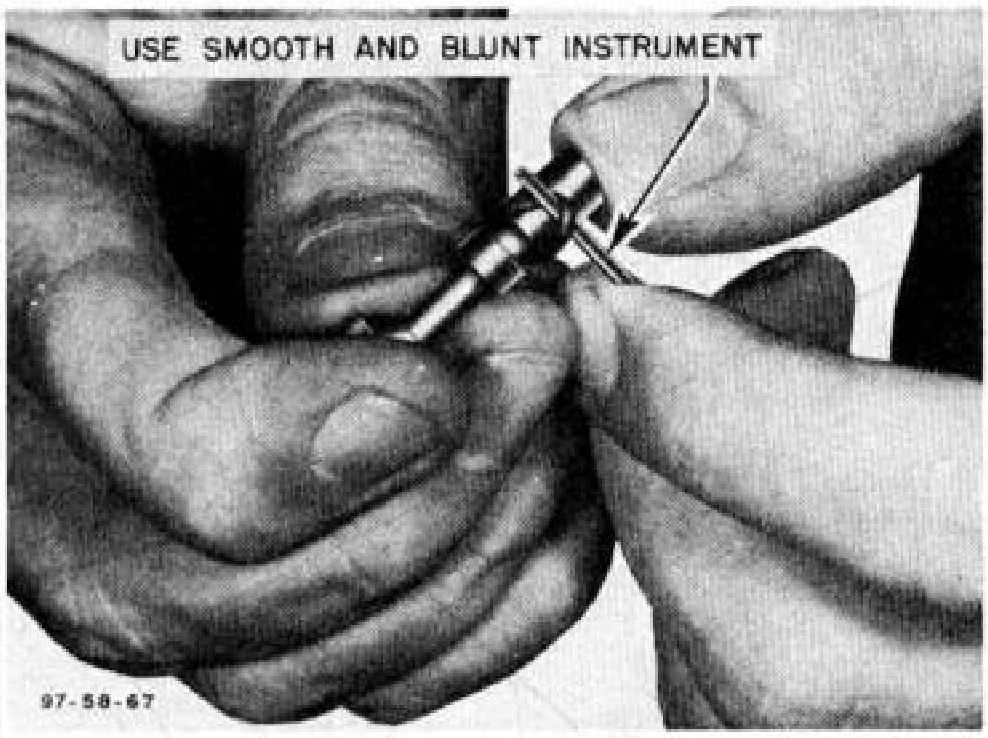



*Figure 304—Removing Small Ring Seal*

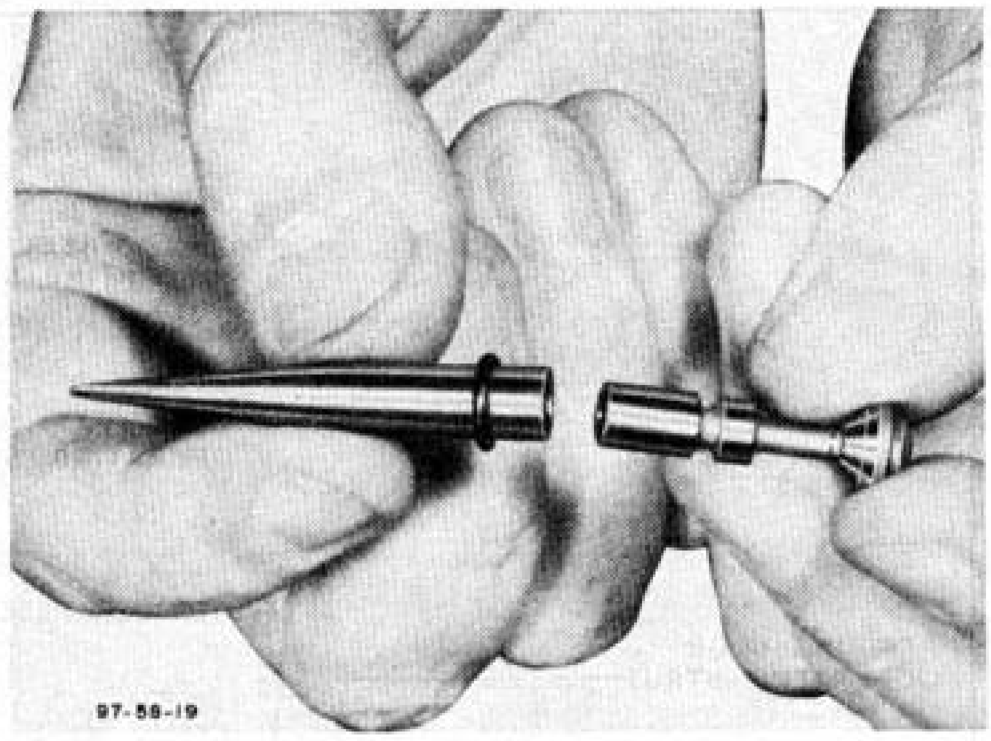



*Figure 306—Using Bullet to Install Small Ring Seal*

(*c*) TEST FOR LOCATING SYSTEM LEAKS.

*1.* Disconnect fairing doors from operating struts for access to units. Disconnect the emergency release valve return line connecting to the fitting at the landing gear selector valve. Any leakage from the open line indicates a pressure leak in the emergency release valve. Any leakage from the open fitting in the selector valve indicates a pressure leak somewhere in the landing gear system.

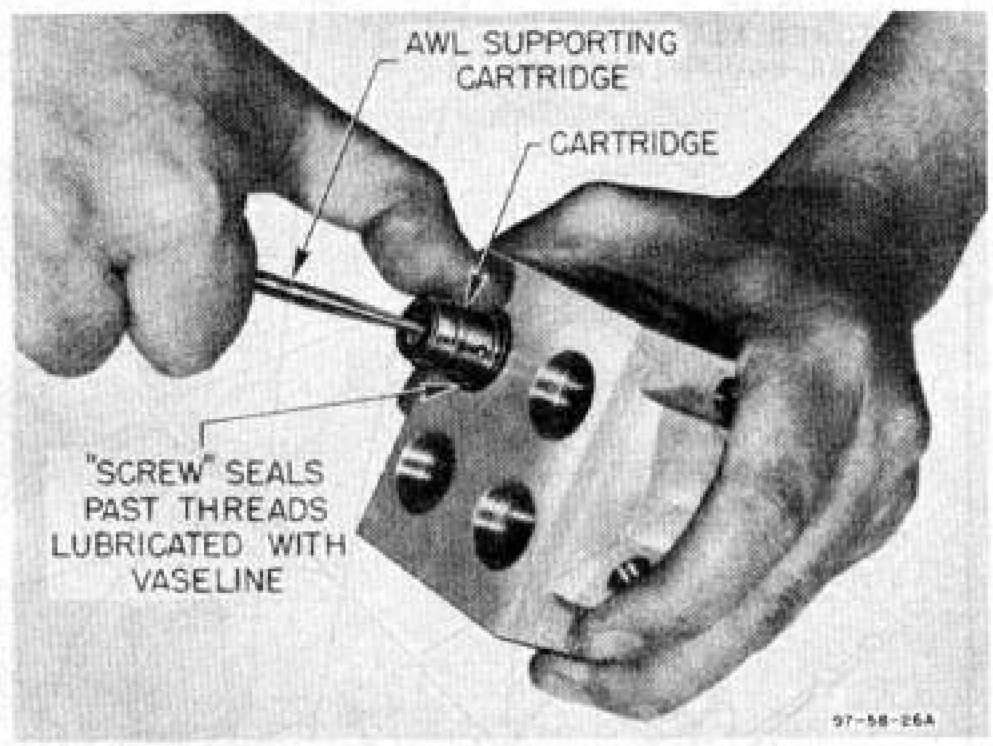



*Figure 307—Installing Cartridge*

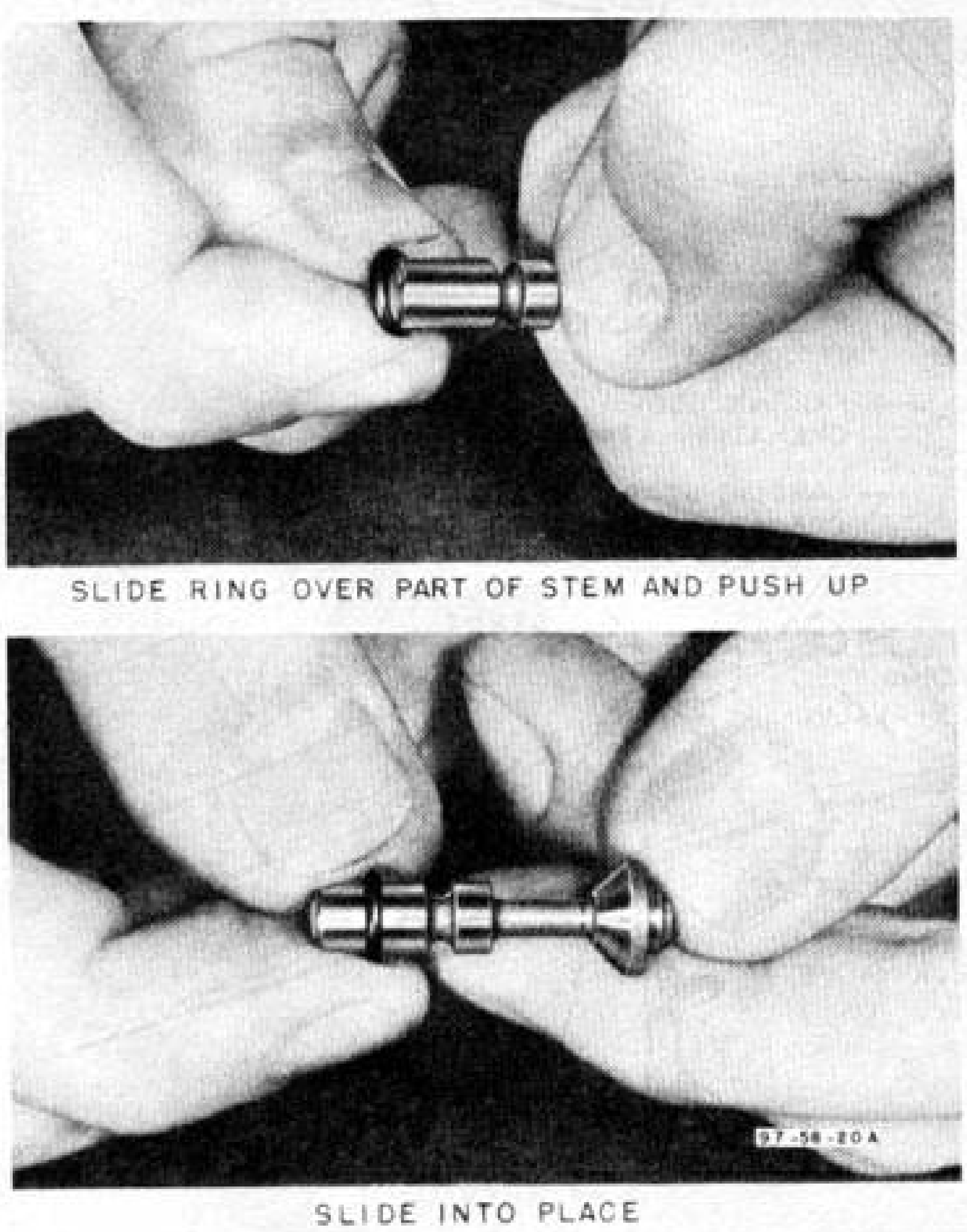



*Figure 305—Replacing Small Ring Seal*

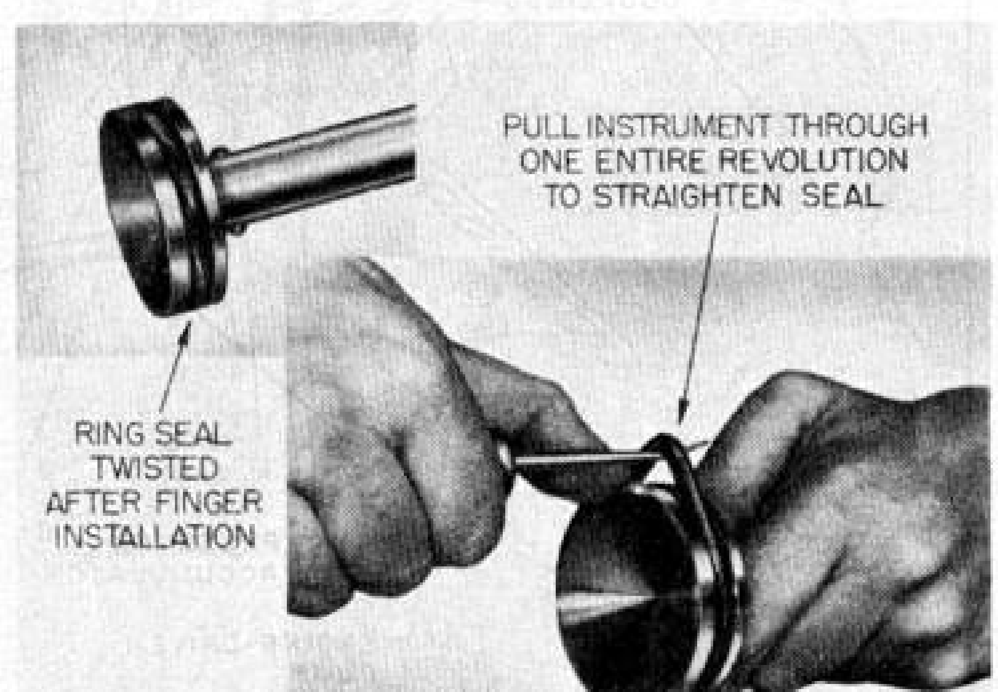



*Figure 308—Installing Ring Seal*

**Note**

The fairing door timing valve has an allowable leakage of approximately 25 drops per minute.

a. LOCATING LANDING GEAR SYSTEM LEAKS.—Disconnect the clevis attached to the landing gear selector valve lever, and allowing the valve to move to neutral, a leak indicates a faulty selector valve. If the system pressure remains constant with the valve in neutral, it indicates a pressure leak in the fairing door control valve or one of the operating struts. Disconnect the return line of each unit and check for leak.

*2.* If the landing gear system and the emergency release valve do not show leakage, disconnect the return line from the wing flap control valve. A leak from the control valve return port indicates a faulty valve.

*3.* If the wing flap system does not show leakage, block off the unloader valve at the system pressure port fitting and time out the system. If the unloader does not show leakage, the trouble will be found in the pressure check valve connecting the system pressure line to the reservoir.

*(d)* TESTING HYDRAULIC OPERATING STRUTS.—The following procedure should be used for testing all hydraulic operating struts.

*1.* LOW PRESSURE TEST BY HAND.

a. Secure operating strut in holding device and open the ports.

b. Retract the piston and close the extending pressure port.

c. Pull the piston into the extended position and release. Atmospheric pressure, caused by vacuum, should return the piston in the retracted direction; if not, the seal ring on the piston is by-passing.

*2.* HIGH PRESSURE TEST WITH HYDRAULIC EQUIPMENT.

a. Apply 2000 pounds per square inch pressure at the extending pressure port for 5 minutes with the retracting pressure port open; there should be no internal or external leaks.

b. Apply 2000 pounds per square inch pressure at the retracting pressure port for 5 minutes with the extending pressure port open; there should be no internal or external leaks.

*3.* All tests should be made in temperatures between 21° to 38°C (70° to 100°F) and the fluid used should conform to Specification No. AN-VV-O-366.

*c.* HYDRAULIC SYSTEM TROUBLE SHOOTING.

**Note**

This chart is not intended to cover all the troubles that could occur, but rather to enumerate a few to suggest how the trouble shooter should reason when confronted with a problem.

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| | **POWER SYSTEM** | |
| **System will not build up pressure (as evidenced by pilot's and accumulator gages).** | Insufficient fluid in reservoir.<br>Insufficient air in accumulator.<br><br>External leak in system with loss of fluid. | Refill reservoir.<br>Exhaust system and check accumulator air gage for correct pressure (375-425 pounds per square inch).<br>Trace leak and repair. |
| **Rapid or erratic unloading of the system.** | Insufficient accumulator air pressure. | Exhaust system and check accumulator air pressure. |
| **System will not retain pressure.** | Slow internal or external leak. | Trace leak and repair unit or line. |
| **Pilot's gage does not register correct pressure. (Check accumulator gage for correct reading.)** | Defective gage or gage pressure snubber. | Readjust. |

**Note**

Airplane must be properly jacked before landing gear is operated.

| | | |
|---|---|---|
| **Fairing doors are not in synchronization with gear.** | Strut to fairing door control valve linkage is out of adjustment. | Readjust. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Gear will not go to down-locked position.** | Internal leakage. Probably defective ring seal in operating strut, down-lock actuating strut or fairing door control valve. | Trace leakage and replace seal. |

**WING FLAP SYSTEM**

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Erratic flap movement.** | Defective operating strut piston ring seal. | Replace seal. |
| | Preselective follow-up linkage out of adjustment. | Readjust. |
| **Too rapid or too slow flap movement.** | Defective restrictor. | Replace. Make sure restrictor hex head is facing aft. |
| | External leakage. | Inspect lines and units for excessive leakage. |
| **Flaps "creep."** | Maladjustment of selector valve lever setscrews. | Reset. |

**DOWN-LOCK ACTUATING STRUT**

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Strut will not pull or lock lockpin.** | Piston head binding. | Replace ring seal and inspect cylinder barrel for scratches. |
| **Flow at port D on landing gear down cycle.** | Valve is not seating properly. | Replace or regrind valve and lap-fit to seat. |
| | Plunger binding. | Inspect ring seal and replace if necessary. Inspect plunger guide hole for scratches and burnish if necessary. |
| **External leakage.** | Defective ring seal. | Replace seal at point where leakage occurs. |

**WING FLAP SYSTEM CONTROL VALVE**

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Valve leaks internally as evidenced by system operating strut "creeping."** | Corresponding pressure poppet not seating properly. | Replace cartridge. |
| | Poppet stem ring seal is defective and is sticking. | Replace cartridge. |
| | Valve lever setscrews are out of adjustment. | Readjust setscrews to .002-inch clearance in neutral position. Use test stand if possible. |
| **Leaks develop around plugs.** | Excessive torque tending to destroy sealing qualities of rubber ring seals. | Replace ring seals. DO NOT TIGHTEN EXCESSIVELY. Safety all plugs. |

**ENGINE PUMP UNLOADING VALVE**

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Valve will not load pump, or loads for only short periods.** | Defective check valve. (Accumulator gage will register slow pressure drops.) | Replace. (Fiber parts cannot be relapped to seat.) |
| | Unloader valve binding in unloading position. | Inspect unloader valve guide seal at relief valve end for binding. Check plug for excessive torque. |
| | Relief valve stuck in unloading position. | Correct improper functioning; check spring or guide and barrel surfaces for scratches. |
| | Spring guide sticking. | Inspect for surface scratches causing binding and burnish if necessary. Replace guide. |

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Rapid loading and unloading of valve.** | Insufficient air pressure in accumulator. | Exhaust system (pull landing gear emergency knob) and build accumulator air pressure to 375-425 pounds per square inch. |
| **Valve will not unload pump.** | Leak in system beyond unloading valve or in accumulator. | Trace leakage and correct. |
| | Relief valve stuck in the loading position. | Inspect for cause at relief valve guide, or spring.<br>Trace leak in system and correct. Test entire hydraulic system thoroughly for damaged lines or units. |
| **Unloading range off.** | Maladjustment of setscrew. | Reset at test bench. Screw in to raise range and out to lower range. |
| **Erratic loading and unloading readings.** | Relief valve or unloading valve binding or sticking slightly. | Inspect for cause of restricted operation of either valve. |
| | **ACCUMULATOR** | |
| **Accumulator will not retain air charge.** | Loose connections at air fitting. | Inspect and replace defective part. Use soap solution to detect air leaks. |
| | Valve core damaged. | Test and replace if necessary. |
| | Bleeder plug loose. | Tighten. |
| | Defective piston seal ring. | Replace rings. |
| | Defective air chamber ring seal. | Replace. |
| **Oil appearing at air bleeder fitting. (Air must be exhausted.)** | Defective ring seals. | Replace. (Hydraulic system must be bled before flight.) |
| **Accumulator causes rapid unloading of pump.** | Low pressure in accumulator. | Pull emergency fairing door open knob before reading accumulator air pressure gage. Recharge to 375-425 pounds per square inch. Make sure to push emergency knob in AFTER air pressure has been corrected. |

*d.* HYDRAULIC MAIN POWER SYSTEM. *(See figure 309.)*

(1) DESCRIPTION.

*(a)* UNITS.—Included in the main power system are the pressure supply pump, pressure unloading valve, pressure relief valve, pressure accumulator and all piping, with necessary check valves and restrictors, to carry the pressure to the different system selector valves.

*(b)* PRINCIPLE OF OPERATION.—The hydraulic pump draws the fluid from the reservoir and forces it under pressure to the unloading valve, which regulates the pressure of the system. From the unloading valve, fluid is routed to the accumulator and to the system selector valves. When the predetermined pressure is built up in the system, the unloading valve will open, creating an idling circuit back to the reservoir to relieve the pump of continuously pumping pressure. The idling circuit will prevail until system pressure drops low enough for the unloading valve to close. A one-way check valve built into the unloading valve holds the pressure in the system when pump pressure drops. Return fluid from operating systems is routed back to the reservoir.

(2) TESTING POWER SYSTEM.—Be sure the landing gear control handle is in the "DOWN" position. Set the ground test stand for 2.5 to 3.5 gpm output. While system is loading pressure should be 1100-1250 maximum, indicated by the gage on the instrument panel. Check air pressure reading at the accumulator gage (1000-1100 pounds per square inch). Unloading valve should unload when accumulator attains this pressure. If pump does not unload, check output pressure of test stand pump (1300 pounds per square inch minimum). When pump unloads, test stand pressure should drop to 50 pounds per square inch maximum, which is back pressure due to system and hose connecting to test stand. Hydraulic pressure gage should read 1000-1100 pounds per square inch when the test stand pressure drops (system unloads).

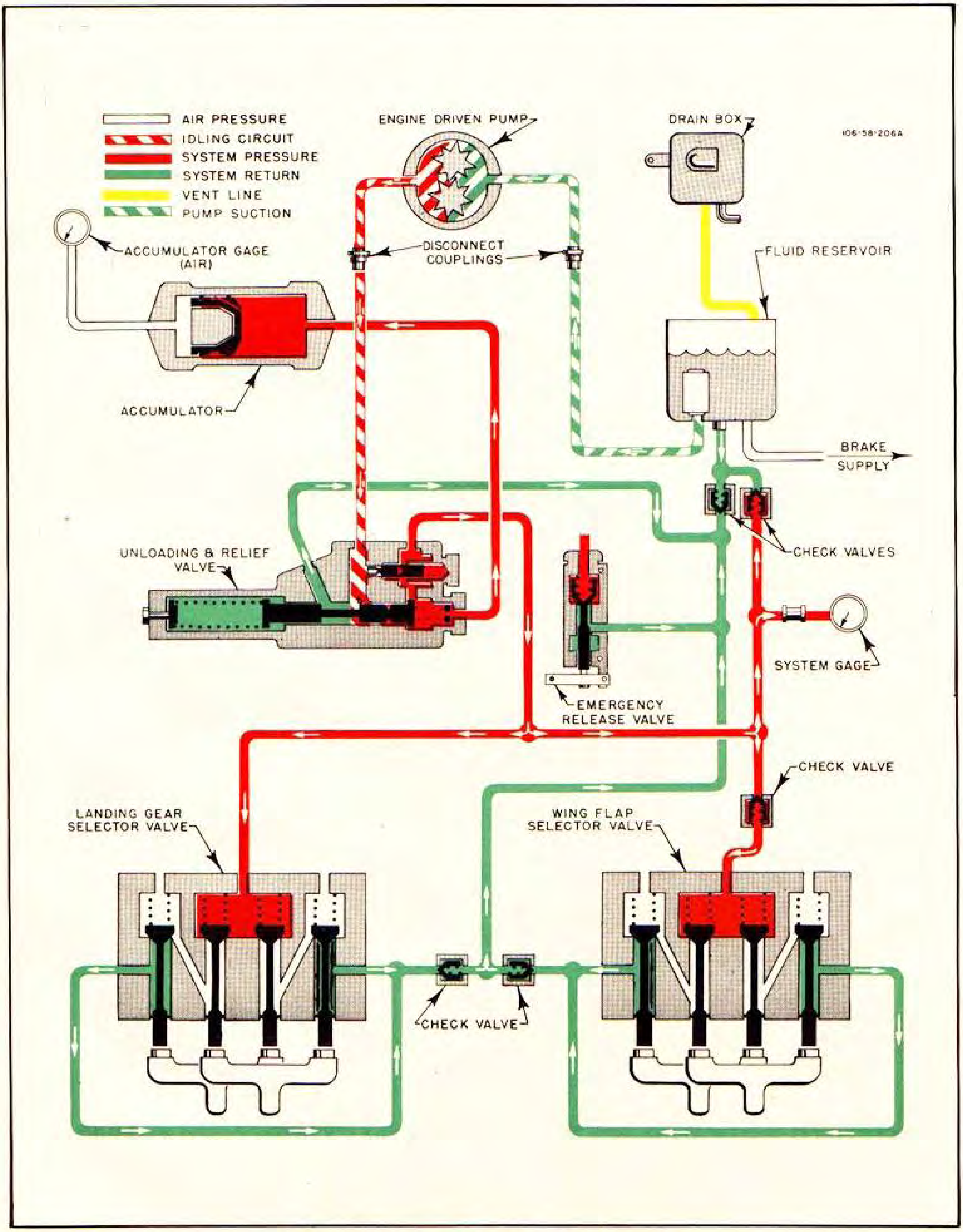



*Figure 309—Hydraulic Power System Flow Chart*

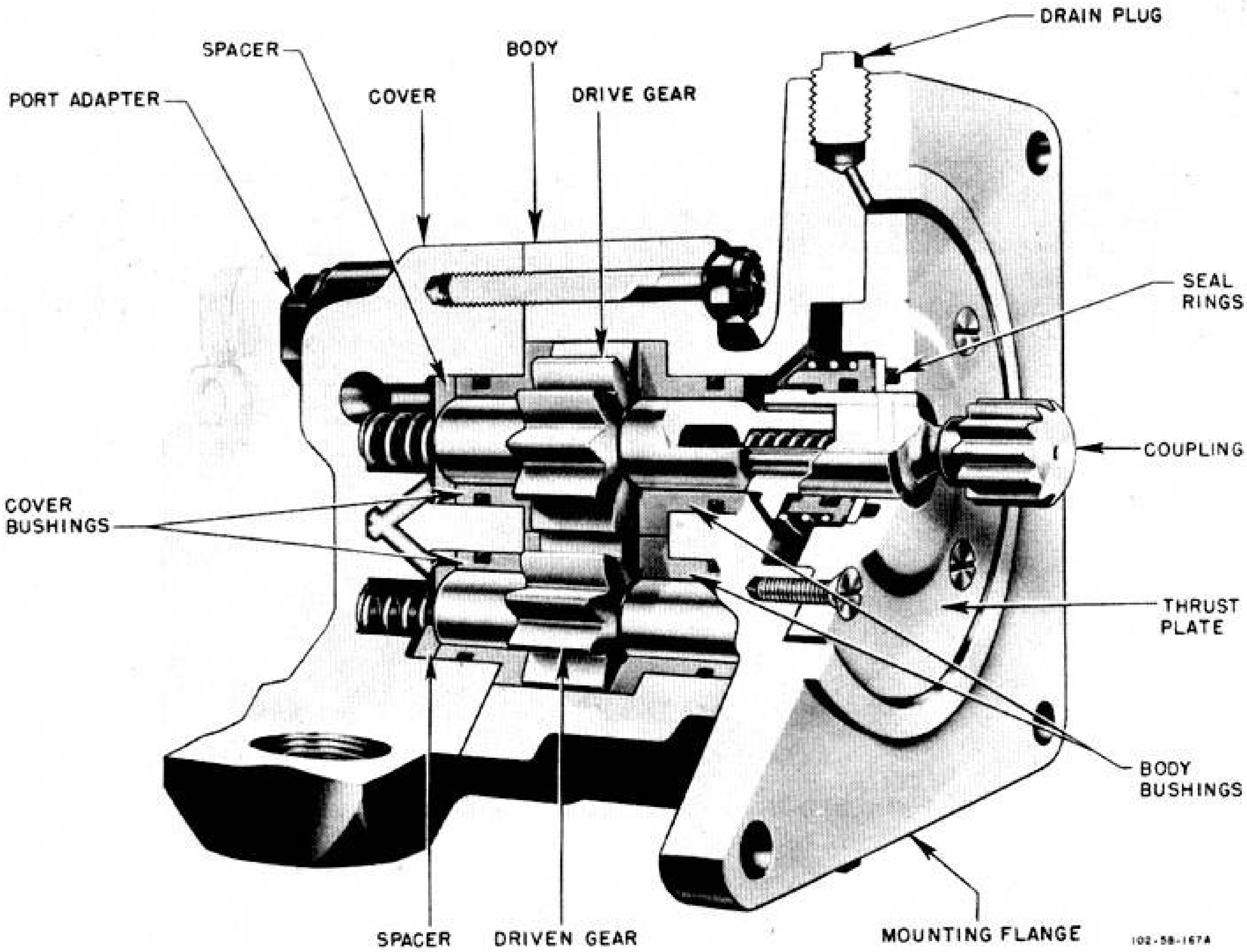



***Figure 310—Hydraulic Engine-driven Pump***

**Note**

Test stand output lower than 2.5 gpm may cause a lower reading on pressure gage.

Pressure just after unloading valve unloads may be only 900 pounds per square inch minimum due to lower test stand output. Two thousand rpm of airplane engine should give full pressure reading. If pump loads at lower pressure than 800 pounds per square inch, raise the unloading point to 1100 pounds per square inch maximum by adjusting unloader. Operate the wing flap control handle carefully to relieve pressure in the accumulator slowly, noting pressure at which unloader cuts in and starts building system pressure again (800-850 pounds per square inch). This pressure may also drop if pump output in gpm is not sufficient. After system has been completely timed and adjusted, with no unit of the system operating and the gear down, the unloading valve should stay unloaded for a minimum of 5 minutes before the system loads again. The same condition should exist for gear up. If pressure should fall too rapidly, causing the pump to load in less than minimum time, check for leakage in the system. Final check should be made at engine run-up, repeating operation which caused trouble during test stand check (except landing gear operation). If the unloader valve tends to stick at test during engine run-up, replace valve. Hydraulic pressure gage should be checked for proper action. The gage should not lag the actual pressure by more than 2 seconds. An excessive fluttering of the gage hand is caused by insufficient snubbing and lag is caused by too much snubbing. Temperature changes may cause a variation as high as 100 pounds per square inch of air in accumulator.

(3) HYDRAULIC ENGINE-DRIVEN PUMP.
*(See figure 310.)*

*(a)* DESCRIPTION.—Three types of Pesco pumps are used on the P-51D Airplanes: 1P-582F, 1P-582FC, and 1P-582L. These pumps are interchangeable. The 1P-582F rotates in either direction while the 1P-582FC and 1P-582L rotate in only one direction, depending on installation of heavy springs or port plugs on one side. A tag attached to the pump should give direction of rotation. ***Be sure all pumps are for clockwise rotation.*** The pump is mounted on the bottom center of the engine accessory section, and is a two-gear, positive-displacement type with a pressure limit of 1500 pounds per square inch for continuous operation or a

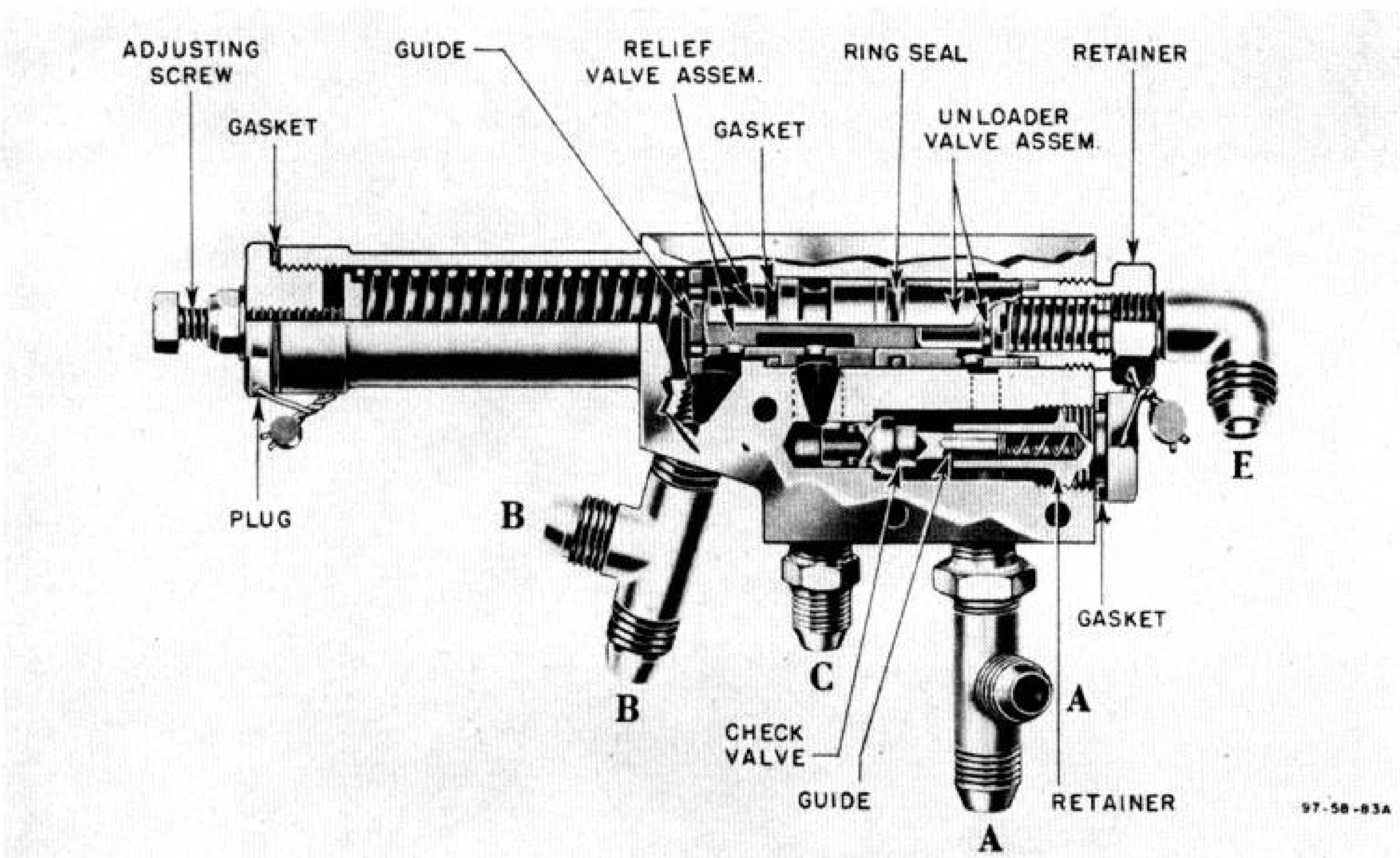



*Figure 311—Hydraulic Unloading and Relief Valve*

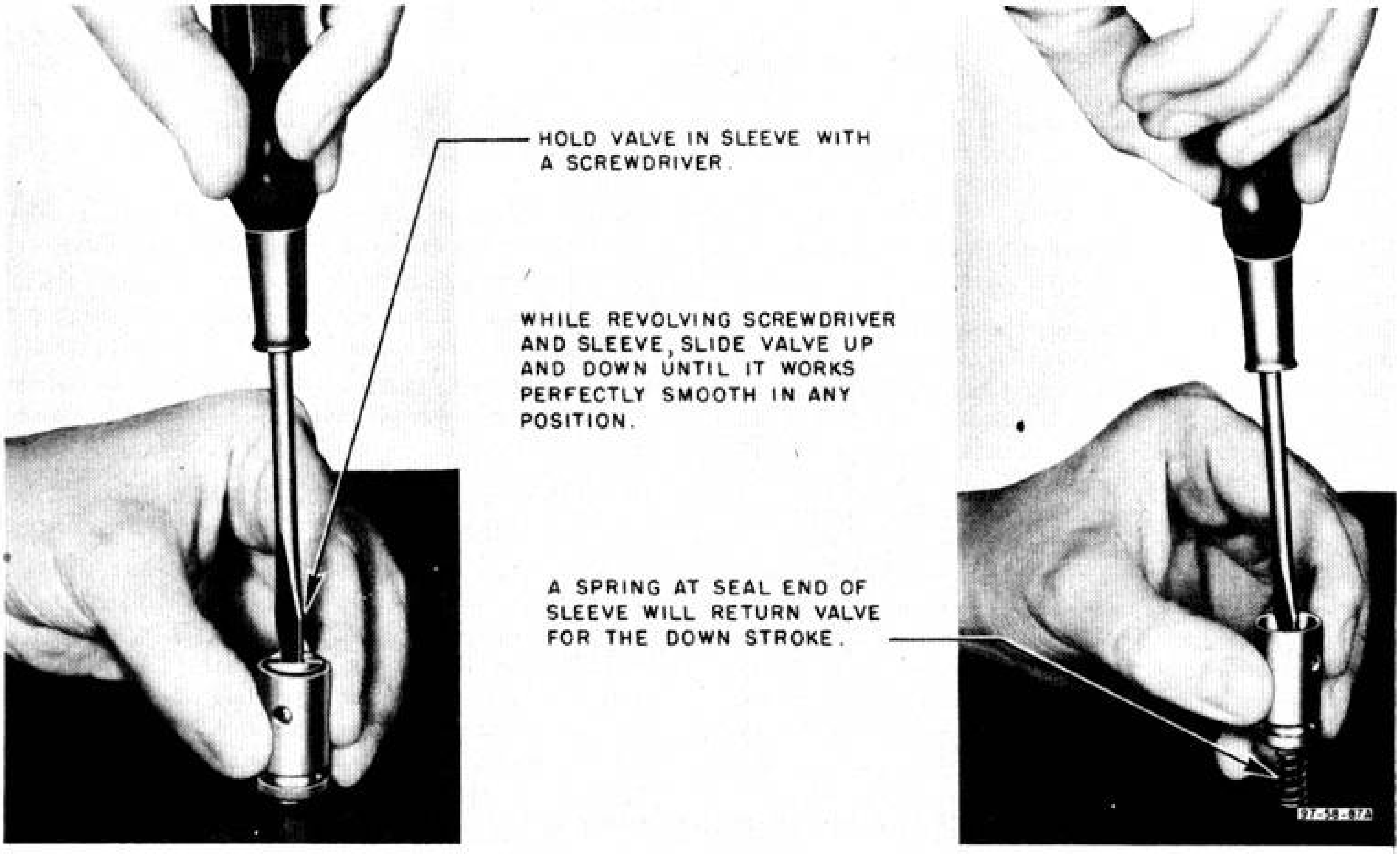



*Figure 312—Lap-fitting Unloader Valve*

maximum of 1750 pounds per square inch for 15 seconds. The maximum operating speed is 4300 rpm. The bushings are pressure loaded to minimize gear clearance at all times. The pump is completely lubricated by the fluid passing through and is satisfactory for cold weather operation.

*(b)* REMOVING HYDRAULIC PUMP.—Access to the pump is obtained by removing the engine section rear underside cowl panel and second section of carburetor air scoop. Disconnect two lines and plug them. Remove the four attaching bolts.

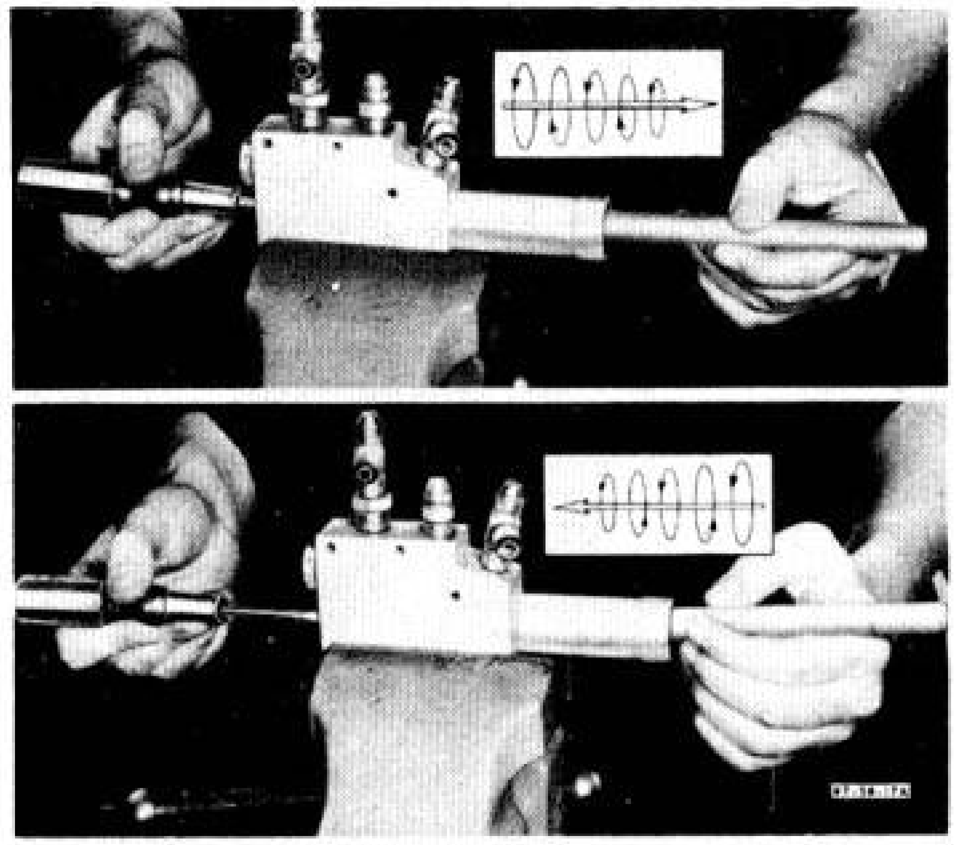
*(c)* REPLACING HYDRAULIC PUMP COUPLING.—When replacing a sheared or worn coupling, remove thrust plate and pull out coupling. Note position of spring retainer and seal rings. The pump should be removed occasionally to inspect the coupling for excessive wear due to misalignment.

*(d)* INSTALLING HYDRAULIC PUMP.—Check pump for free movement before installation. Attach the pump by four bolts, making sure bolts are tight. These bolts should be checked frequently for tightness. Attach pressure and suction lines, and install the section of carburetor air scoop and the lower engine cowl plate.

*(e)* TESTING HYDRAULIC PUMP.—After overhaul or repair, thoroughly test each pump before restoring to service.

(4) HYDRAULIC UNLOADING AND RELIEF VALVE. *(See figure 311.)*

*(a)* DESCRIPTION.—The engine pump unloading valve is mounted on the right side of the wing center rib, and is accessible from the right landing gear bay. The valve automatically by-passes the pressure flow from the engine pumps back to the reservoir when the predetermined system pressure has been built up in the system accumulator. The unloading valve operates in this way: Fluid from the engine-driven pump enters the valve at port C, unseats the one-way check valve, and flows unrestricted out port D to the selector valves. A restricted flow out port E charges the hydraulic system accumulator. This restriction prevents depriving pressure flow from the main system if a unit is being operated. However, if no unit of the system is being operated, as soon as the pressure in the accumulator reaches 1000 to 1100 pounds per square inch, an idling circuit is established from port C to port B, allowing unrestricted flow back to the reservoir. The one-way check valve will seat when the pressure drops in the engine pump pressure line, and pressure stored in the accumulator and lines between the unloader valve and system selector valves is prevented from escaping back to the reservoir. The idling circuit is therefore maintained until system pressure drops to 800 to 850 pounds per square inch, at which time the head of the unloader valve is displaced to the opposite side of the laterally drilled passage, permitting unrestricted flow from the accumulator in the direction of port E to port D. As soon as pressure in accumulator has been reduced to 800 to 850 pounds per square inch, spring pressure will force the unloading valve back to the system charging positions.



TO MAKE SURE VALVES ARE NOT BINDING, TURN SCREWDRIVER THROUGH ENTIRE REVOLUTION WHILE SLIDING VALVES BACK & FORTH

***Figure 313—Assembling Unloader and Relief Valve***

*(b)* REMOVING UNLOADING AND RELIEF VALVE.—The unloading valve is easily accessible in the right landing gear bay, and can be removed by disconnecting the lines and removing the two attaching bolts.

*(c)* DISASSEMBLING UNLOADING AND RELIEF VALVE.—To disassemble the unloading valve, remove adjusting screw, take out plug in end, and remove retainer, spring and guide. Then remove retainer in opposite end so that relief valve and unloading valve assemblies may be removed. A piece of round wood or fiber stick may be used to push chambers out of body. To remove the check valve, take out plug on end of body.

*(d)* REPLACEMENTS IN UNLOADING AND RELIEF VALVE.—The unloader and relief valve must be replaced along with the accompanying sleeve as the valves are lap-fitted in the sleeves and cannot be separated. The parts should be stocked together as one assembly.

*(e)* ASSEMBLING UNLOADING AND RELIEF VALVE. *(See figures 312 and 313.)*—Make sure the unloader and relief valves are lap-fitted before installing. With fitting removed, install and tighten retainer snug against sleeve. After retainer is tight, check for smooth and unrestricted movement of valves through entire range. This may be done with two screwdrivers. Be careful not to scar sleeves. Install spring washers and fitting in retainer. When installing unloader spring, be sure to install spring guide ahead of spring.

**CAUTION**

Excessive tightening of chamber retainer nut, at the accumulator port, may cause binding of the unloading and relief pins.

*(f)* INSTALLING UNLOADING AND RELIEF VALVE.—Attach with two bolts and connect lines.

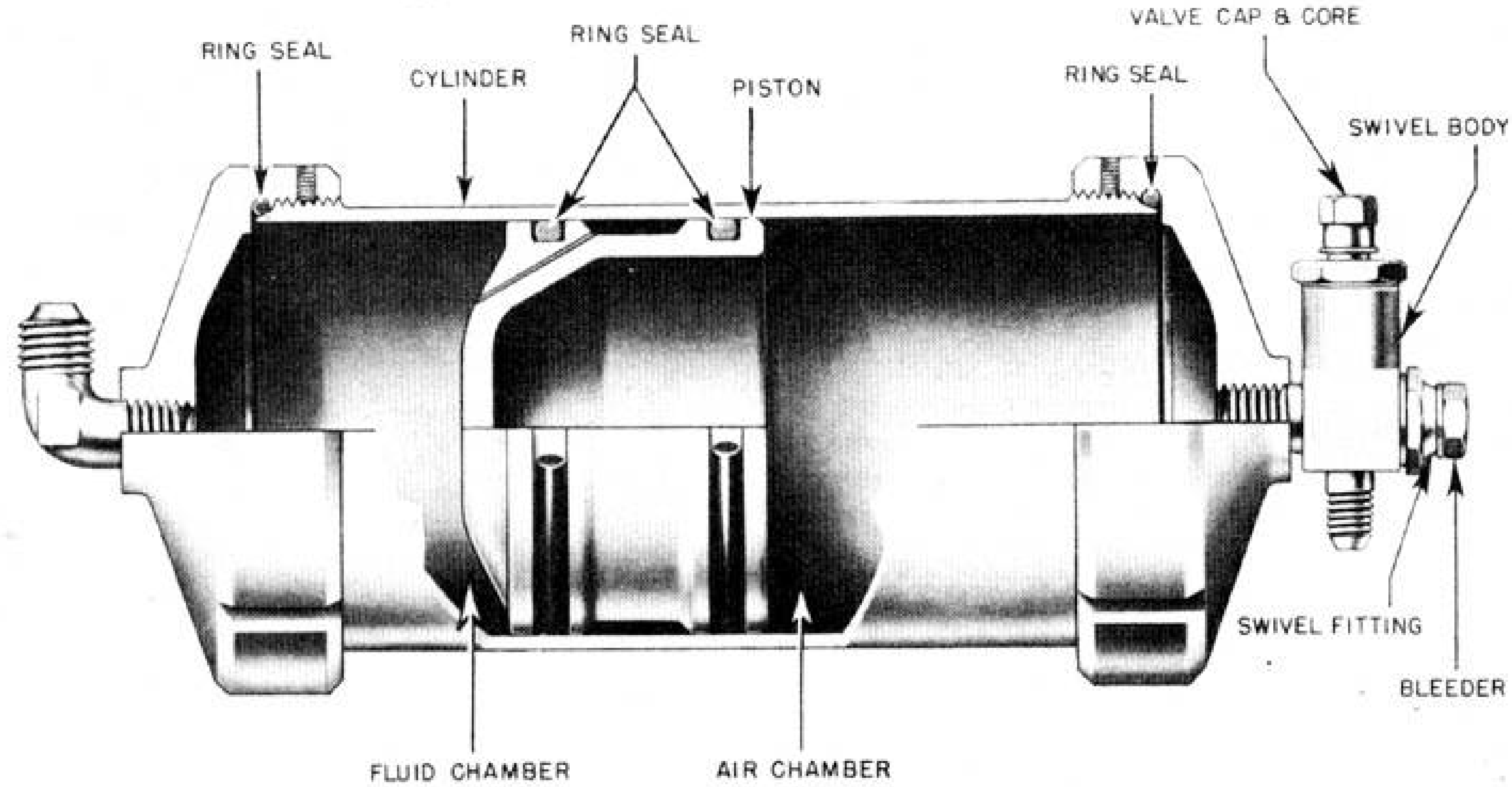



***Figure 314—Hydraulic Pressure Accumulator***

*(g)* TESTING AND ADJUSTING UNLOADING AND RELIEF VALVE.

*1.* Flow through the valve to be 3.5 gpm at 1000 pounds per square inch.

*2.* Plug ports E and A, and screw out adjusting screw to relieve all spring compression. Apply pressure at port C and screw in adjusting screw to set relief valve pressure at 1100 to 1250 pounds per square inch.

*3.* Connect accumulator to port E; valve should unload when accumulator pressure reaches 1000 to 1100 pounds per square inch. Valve should load again when accumulator pressure drops to 800 to 850 pounds per square inch. Adjust the unloading range by turning setscrew in to raise and out to lower.

*4.* With accumulator pressure at 1000 pounds per square inch, shut off pump with port A plugged; leakage at port B must not exceed 40 drops per minute.

*5.* Plug return, accumulator, and system ports (A, B, and E). Apply 2000 pounds per square inch pressure at port C and inspect for external leaks.

(5) HYDRAULIC PRESSURE ACCUMULATOR. *(See figure 314.)*

*(a)* DESCRIPTION.—The hydraulic system accumulator is bolted to the right side of the wing center rib, and the accumulator air pressure gage is mounted just below and aft of the accumulator, facing the right side of the wing center rib. The accumulator functions in this way: The lower chamber is inflated with air through a high-pressure valve located at the bottom. When hydraulic fluid or sufficient pressure is pumped into the opposite or upper chamber, the piston is forced down, compressing the air correspondingly and maintaining equilibrium between the two chambers. Apart from providing adequate thermal expansion for air and fluid, the accumulator acts as a buffer for shocks within the system. The air chamber of the accumulator can be inflated on the ground only. A pressure gage is adjacent to the accumulator. With the engine pump inoperative and the system pressure exhausted, this gage should register from 375 to 425 pounds per square inch. A bleeder valve is incorporated next to the air valve to bleed fluid or water from the air chamber.

*(b)* REMOVING HYDRAULIC ACCUMULATOR.—Be sure all hydraulic pressure and air pressure is exhausted from accumulator. Then disconnect all lines and remove the bolts holding the supports.

**Note**

System pressure must be exhausted before air pressure is released from the accumulator.

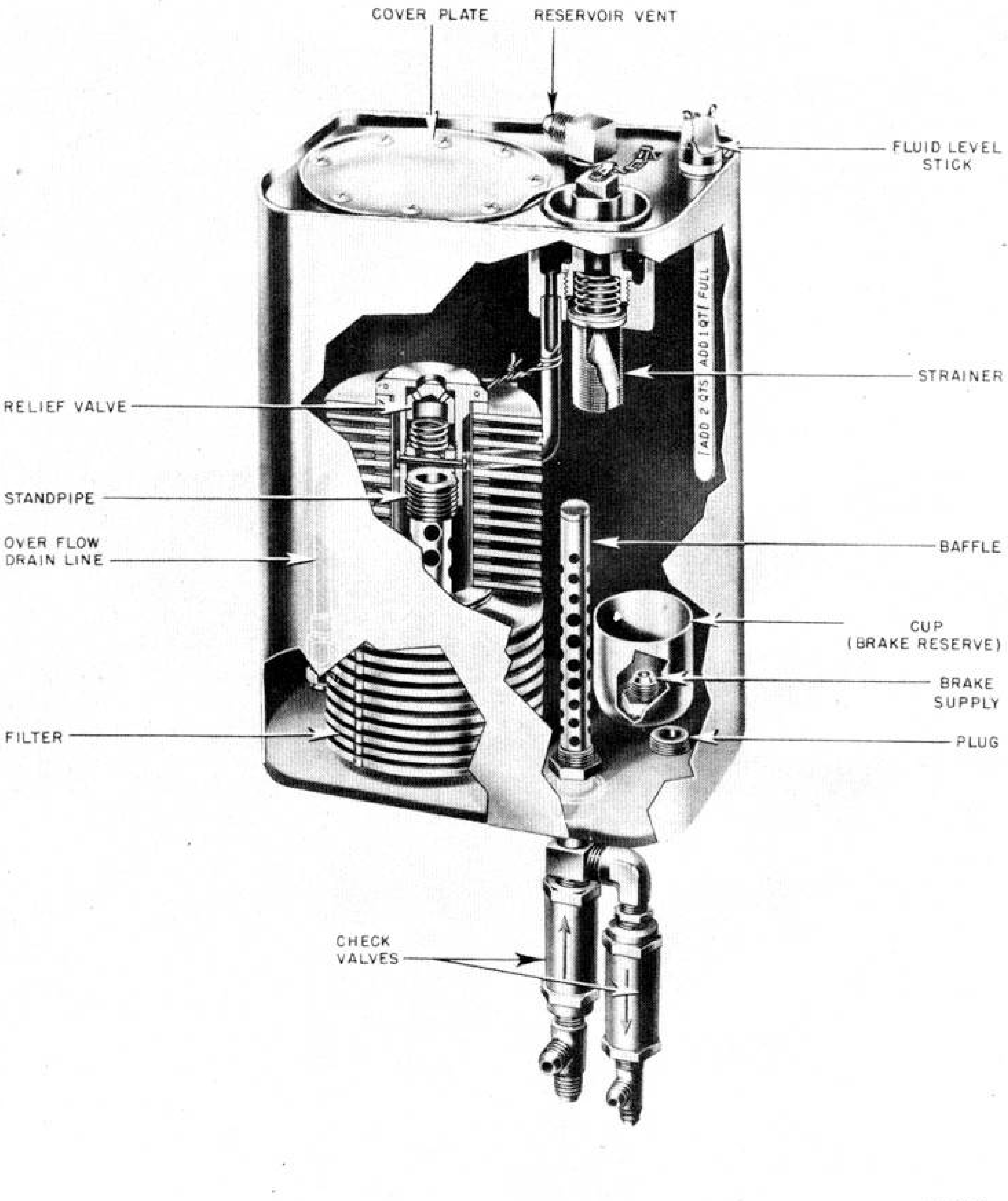



*Figure 315—Hydraulic Fluid Reservoir—Early Airplanes*

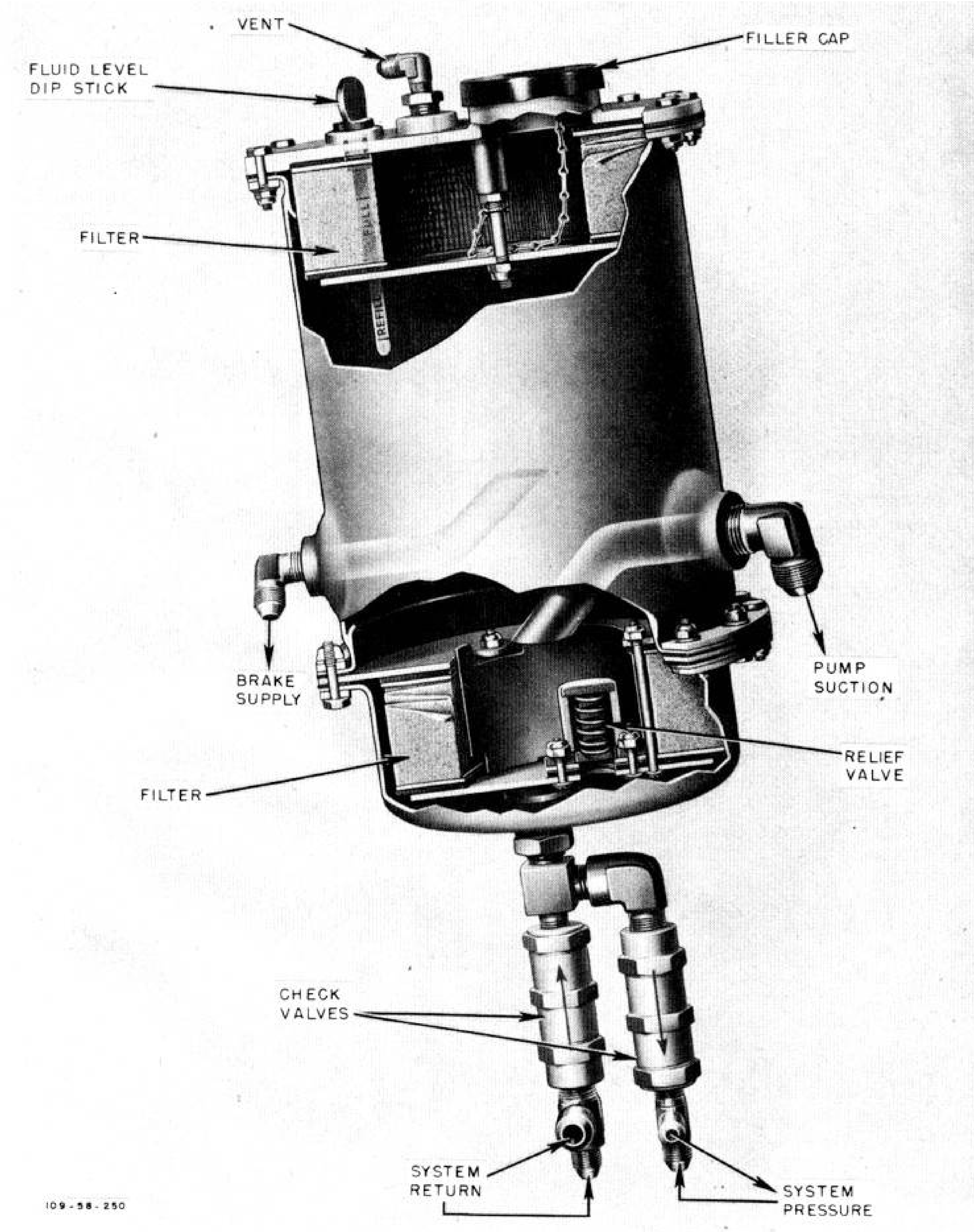



*Figure 316—Hydraulic Fluid Reservoir—Later Airplanes*

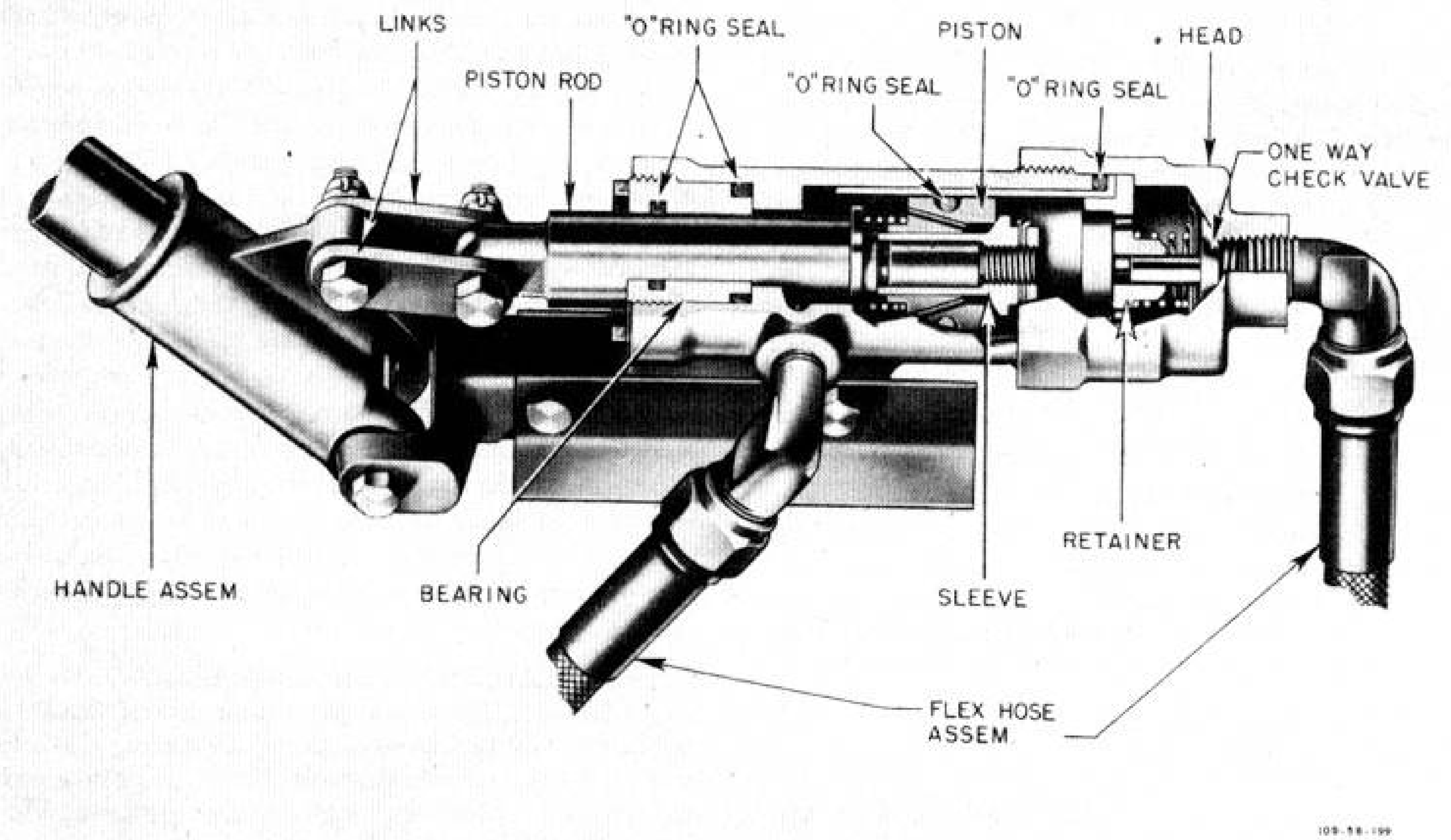



*Figure 317—Hydraulic Hand-pump*

*(c)* REPLACEMENTS—HYDRAULIC ACCUMULATOR.—When replacing piston seal rings, unscrew end of cylinders; be sure setscrew is loose. Remove piston and faulty rings. When installing new rings, be sure they are not twisted.

*(d)* INSTALLING HYDRAULIC ACCUMULATOR.—The accumulator is held by two clamps. Tighten clamps and connect the lines.

**CAUTION**

Overtightening of clamps will cause piston to bind in cylinder.

*(e)* TESTING HYDRAULIC ACCUMULATOR.—Fill the air chamber with 425 pounds per square inch of air pressure, fill oil chamber to approximately 1500 pounds per square inch of fluid pressure, and check for external leaks. Soapy water can be used for finding air leaks.

(6) HYDRAULIC FLUID RESERVOIR (Early Airplanes). *(See figure 315.)*

*(a)* DESCRIPTION.—The hydraulic fluid reservoir is mounted to the upper rear left side of the firewall. The main system return line port is provided with a baffle pipe to direct the flow upward as it enters the reservoir, thus purging it of air in the foaming space at the top of the reservoir. The bottom plate has outlets for the engine pump suction line and the brake system supply line. A special standpipe arrangement in the reservoir assures sufficient fluid capacity for normal operation of the brakes even though the supply of oil for the operation of the general hydraulic system has been lost. The Purolator filter element in the reservoir connects to the engine suction line, and the fluid is drawn through by the engine pumps. The particulars of the reservoir are as follows:

| | |
|---|---|
| Total capacity | 2.16 US (1.80 Imperial) gallons |
| Fluid capacity | 1.86 US (1.55 Imperial) gallons |
| Hand-pump reserve | .62 US (.52 Imperial) gallons |
| Brake reserve | 3.2 cubic inches |

*(b)* REMOVING HYDRAULIC RESERVOIR.—Remove cowl plate at top and just forward of windshield. Remove plate on left side and just forward of windshield for access to reservoir. Disconnect lines from bottom and top of reservoir, and plug the lines. Remove attaching bolts and lift out reservoir.

*(c)* REPLACEMENTS—HYDRAULIC RESERVOIR.—When replacing filter, remove coverplate from top of reservoir and remove safety wire attached to relief valve body. Remove nut from standpipe fitting on the bottom of the reservoir, and lift out filter.

**Note**

Before installing filter, make sure relief valve is not stuck.

*(d)* INSTALLING HYDRAULIC RESERVOIR.—Reservoir will drop into place easily. Attach with two bolts and connect lines.

*(e)* TESTING HYDRAULIC RESERVOIR.—Apply 5 to 7 pounds per square inch air pressure and check for leaks. Soapy water may be used.

(7) HYDRAULIC FLUID RESERVOIR (Late Airplanes). *(See figure 316.)*

*(a)* DESCRIPTION.—The reservoir, which is mounted on the upper rear left side of the firewall, has a fluid capacity of 1.209 gallons. A small tube, inside of the reservoir and connecting to the brake supply port, retains .5 cubic inch reserve, should the reservoir fluid be lost. The reservoir has a filler neck and dip-stick gage. A screen in the top of the reservoir filters the fluid when filling the reservoir. The reservoir also has a filter assembly in the bottom for filtering system return fluid. If the lower filter becomes clogged, a relief valve (which opens at 9 to 11 pounds per square inch pressure) allows the return fluid to by-pass the filter.

(8) HYDRAULIC HAND-PUMP. *(See figure 317.)*

*(a)* DESCRIPTION.—The hand-pump, furnished as loose equipment, is stowed in the right wing gun bay. The hand-pump is attached to the airplane by means of a mounting bracket on the right-hand engine mount jury brace just forward of the firewall. Two flexible hoses furnished with the pump assembly attach to the firewall disconnect couplings. The pump is a double-acting differential type with a one-way check valve at the inlet end; oil is forced into the system with both strokes.

*(b)* INSTALLING HAND-PUMP.—Remove the two right-hand engine cowl panels. The pump mounts on the bracket attached to the jury brace just forward of firewall. Be sure to insert the two pins in the bracket after pump is mounted. Disconnect the airplane lines at firewall disconnect couplings and connect the hand-pump hoses.

*(c)* DISASSEMBLING HAND-PUMP. — Disconnect linkage from handle to piston rod; disconnect flex hoses. Remove the head from the body; check valve will slip out of head. Slide piston and sleeve out together.

**Note**

The retainer in opposite end does not have to be removed unless the seal ring is to be replaced.

*(d)* ASSEMBLING HAND-PUMP.—When assembling hand-pump, be careful not to damage the seal ring when sliding piston rod through the retainer.

*(e)* TESTING HAND-PUMP.—Apply 2000 pounds per square inch pressure and check for external leaks.

*e.* LANDING GEAR HYDRAULIC SYSTEM.

(1) DESCRIPTION.—The main landing gear and tail wheel are operated by the landing gear selector valve.

*(a)* LANDING GEAR EXTENSION. *(See figures 318 and 319.)*—When the landing gear control handle in the cockpit is moved to the gear down position, the fairing door up-locks are mechanically disengaged and hydraulic pressure is admitted to the system. Fluid flows simultaneously to the landing gear fairing door control valve, where it is directed to the extension side of the fairing door operating struts, the landing gear operating struts and the down-lock actuating struts. As the pressure supply of the engine-driven pump is inadequate to supply fluid fast enough, the landing gear operating struts, requiring the largest fluid displacement, will not be moved hydraulically during the initial part of their travel, but will be pulled by the falling gear. A line interconnecting the reservoir with the system pressure line permits the system to draw additional fluid when there is a fluid deficiency. A one-way check valve prevents fluid from being pumped back into the reservoir during normal operating conditions. Return flow from the operating struts and fairing door struts offers sufficient back pressure to prevent the gear from falling too fast. When the fairing doors are opened and the gear approaches the extended position, the engine pump output will complete the stroke. When the gear is approximately 5 degrees from the down-locked position, it mechanically actuates the fairing door control valve actuating linkage; this in turn shifts the fairing door timing valve plunger, and pressure flow is directed to the retracting side of the fairing door operating struts. The fairing doors are held closed by hydraulic pressure when the gear is extended.

*(b)* LANDING GEAR RETRACTION. *(See figures 320 and 321.)*—When the cockpit control handle is moved to "GEAR UP," pressure flow at the landing gear control valve is directed simultaneously to the fairing door control valve and the down-lock actuating strut. However, as the pressure required to unlock the down-lock is greater than that required to actuate the fairing door operating struts, the retraction operation will start by the opening of the fairing doors. As soon as the door struts are fully extended, system pressure will increase and unlock the landing gear down-locks. As the down-locks retract, pressure is released to the retracting side of the landing gear operating struts. When the gear leaves the down position, the tension of the fairing door control valve linkage cable is relieved. As the gear approaches the up position, its action upon the control valve actuating linkage is reversed, mechanically resetting the fairing door timing valve to close the fairing doors. Because of pressure drop in the landing gear system as the fairing doors start to close, it is necessary to have a controllable check valve in the landing gear up pressure line to prevent the landing gears dropping down before the doors close. Return flow from the fairing door operating struts is thereby returned back to the reservoir, as pressure retracts the fairing door struts. As the doors reach the closed position, they are mechanically locked to complete the cycle of landing gear operations. A fairing door emergency release valve installed in the door up pressure line and connected to system return line relieves up pressure on doors when emergency knob is pulled. Mechanical linkage also releases door locks, allowing doors to fall open.

(2) ADJUSTING LANDING GEAR AND FAIRING DOORS.

*(a)* ADJUSTING LANDING GEAR CONTROL LINKAGE.

*1.* Pull the fairing door emergency release knob and place the cockpit control handle 13/16 inch from "UP" position.