

Turn the magneto drive shaft in normal rotation, as indicated by the arrow on the cam, until No. 1 cam lobe is about to open the contact points. (No. 1 cam lobe is marked by a red dot on the face of the cam. When facing the magneto drive shaft end, this position can also be observed by the white mark on the distributor gear, on the side nearest the coil, and the white mark on the red pad on the inner face of the gear housing. When these two points are in line, No. 1 lobe of the cam is about to open the contacts for firing No. 1 cylinder).

Note

In case the paint mark on the distributor gear is obliterated, the correct point on the gear can be identified by the drill hole spot which normally contains the paint.

4. Determine the exact breaker point opening by inserting a .001-inch feeler gage between the points, or by connecting a timing light across the points. Correct instant of opening is determined when a slight pull releases the gage or the timing light indicates opening. Hold the cam in this position by either pressing the fingers against the distributor gear or holding the drive coupling so that the inductor rotor shaft cannot turn.

5. Apply a heavy grade of petrolatum to the drive spline on the magneto drive shaft and mount the magneto on the engine by means of the mounting studs. It is important that these studs be approximately in the center of the magneto mounting flange slots. If the teeth of the magneto drive spline will not mesh with the gear teeth of the engine drive in the position first tried, then remove the magneto and remove the cotter pin, castle nut, lock washer, and recessed plain washer, and withdraw the drive spline from the magneto drive shaft. Temporarily remount the drive spline in a different position on the magneto drive shaft and install washer and nut.

6. After the drive spline has been mounted in a new position, repeat the procedure of mounting magneto on engine. One of the six positions of the magneto drive spline will allow it to readily mesh with the internal spline on the engine drive, with the mounting studs in the middle of the magneto mounting flange slots.

7. After determining this position, remove the magneto from the engine and secure the drive spline with the recessed plain washer, lock washer, castle nut, and cotter pin. Reinstall magneto in correct predetermined position.

8. When both magnetos have been mounted, tighten the holding nuts firmly against the mounting brackets, but loose enough so that they can be moved in their flange slots for the final accurate timing adjustment (synchronizing).

9. When making the final timing adjustments of the magnetos, all adjustments must be made through the drive gear assemblies by moving the complete mag-

netos in their mounting flange slots. For synchronizing the timing of the two magnetos, both sets of points on No. 1 cam lobes must open simultaneously. Although final timing of both magnetos can be carried on at the same time, it is recommended that one magneto only be timed perfectly with the engine, and that the second magneto be synchronized with the first one. With the piston of No. 1 cylinder in the advance firing position required on compression stroke, as described above, and both magnetos mounted, proceed as follows:

a. Assuming that the left magneto is the one chosen for timing with the engine, loosen the nuts on the retaining studs of the mounting flange sufficiently to permit rotating the engine magneto slightly until its cam follower is in the cam well preceding No. 1 cam lobe, with the breaker points closed. Insert a .001-inch feeler gage between the points, or connect timing light across the points. Now rotate the magneto frame carefully until the feeler gage is released by a gentle pull, or the timing light indicates point opening. To insure absolute accuracy, the contact opening position should be rechecked before tightening the fastening nuts sufficiently to prevent any movement of the magneto.

b. The magneto timing should now be checked with the engine-timing marks by movement of the propeller. Rotate the propeller clockwise (facing front of engine) approximately one-quarter turn, then reverse the rotation sufficiently to bring the cam follower into the cam well preceding the No. 1 cam lobe. At this position, reinsert the .001-inch feeler gage between the points, or reconnect the timing light across the points. Continue to move the propeller in a counterclockwise direction, by a very slight jarring movement, until the engine crank angle, as seen through the timing inspection hole, is 20 degrees before top center. A slight pull should release the feeler gage, or the timing light should indicate point opening at this position.

c. The correct setting having been obtained, secure the left magneto by means of the holding nuts. **DO NOT DISTURB THIS SETTING.**

d. With the engine and the left magneto in the above position, adjust the right magneto in its mounting slots until the breaker points just open, by either using the feeler gage or timing light method. This is the synchronizing operation and should be carefully carried out. The right magneto should now be tightened, but only enough to permit further adjustment if necessary.

e. Check the synchronization of both magnetos with the engine by turning the propeller clockwise approximately one-quarter turn, and then turning counterclockwise until cam followers are in cam wells preceding No. 1 cam lobes. Insert feeler gages between both sets of points, or connect two timing lights across them.

f. Continue counterclockwise movement of the propeller by a slight jarring action on the propeller.

Both feeler gages must release at the same time, with equal pulling effort, or both timing lights must indicate point opening at the same time. If this instantaneous action is not obtained, any equalizing adjustments must be made on the magneto being synchronized—in this case the right magneto. All adjustments must be made at the magneto drive end. Under no circumstances is the breaker point adjustment to be changed. Retighten the fastening nuts of both magnetos, and secure with safety wire.

10. Install the plug in the timing inspection hole, in the crankcase front section, with the copper-asbestos gasket under its head. Tighten and safety wire.

11. Reinstall the breaker housing cover and tighten the two cap screws. Check the cap screws for a lock washer under the head of each.

12. Reinstall the ground terminal, distributor block, dust cover, and radio shielding as described in paragraph (10).

CAUTION

When connecting ground lead, be sure that ignition switch is "OFF" and that ignition ground plugs are "IN" at the fire wall, to assure control.

(c) MINOR REPAIR.

1. When inspecting the contact points for any reason, do not raise the breaker main spring beyond a point giving 1/16-inch clearance between the contact points. Any further tension on the main spring caused by raising it beyond this point will weaken the spring, thereby causing unsatisfactory magneto performance.

2. During normal operation of the magneto a small amount of pitting and burning of the contact points may occur. This is permissible unless visual inspection indicates that points are burned so badly that they may shortly interfere with proper operation of the magneto. In this case the entire breaker assembly must be removed from the magneto, and the points either replaced or dressed, using the American Bosch dressing tool TSE 5229.

CAUTION

Never use a file, sandpaper, or emery cloth for dressing breaker points, as they will leave minute particles imbedded in the contact area, and cause excessive arcing and pitting.

(12) FUEL PUMP DRIVE SHAFT AND OIL SEAL REPLACEMENT.

(a) DISASSEMBLY.

1. With the fuel pump removed from its mounting pad (Section IV, paragraph 6. b.) insert the two puller screws, and remove the fuel pump drive shaft and support assembly as one unit.

2. Insert a small diameter fiber drift pin in the outer end of the support, and drive the fuel pump drive shaft from its supporting bushings.

(b) OIL SEAL REPLACEMENT.

1. The fuel pump drive shaft oil seal assembly consists of a steel cup in which is assembled a leather seal reinforced by a coiled-type spring. This assembly is replaced as one unit and cannot be disassembled.

2. Remove the oil seal by inserting a drift in the inner end of the support and drive out the oil seal.

3. Replacement of the oil seal is accomplished by pressing the new seal into its recess in the drive shaft support until the spring side of the seal bottoms in the recess.

(c) ASSEMBLY.

1. Insert the drive shaft into the support, with the gear end of the shaft towards the inner end of the support. Tap the gear into place until the shoulder at the inner end seats against the flange of the rear supporting bushing.

2. Insert the support and drive shaft assembly into the supercharger rear housing, rocking it slightly to insure proper meshing of the gears. A new gasket should be installed under the flange of the support.

3. Install the fuel pump as directed in paragraph 14 of this section.

(13) DUAL ACCESSORY DRIVE ASSEMBLY.

(a) DISASSEMBLY AND REMOVAL.

1. Make sure the dual accessory drive housing is accessible by removing all lines from the accessories driven by that unit. Remove the palnuts, nuts, and washers from the attaching studs on each of the two mounting pads, and withdraw the accessories or cover plates with their gaskets. Remove the loose fitting tongue-drive adapters where utilized in the splined drive shafts. Break the safety wire, and remove the special cap nuts and washers from the two studs extending from the supercharger section rear housing cover, through the upper left side of the dual accessory drive housing. Remove the palnut, nut, and washer from the one remaining attaching stud on the right side of the cover adjacent to the lower drive mounting pad.

2. Remove the dual accessory drive cover and gasket, by tapping on its sides with a rawhide mallet, being careful not to allow the spur gears to drop out of their bushings in the housing. Withdraw the upper and lower gears, after which the two intermediate gears may be removed, exposing the nuts holding the dual accessory drive housing to the supercharger rear housing cover.

3. Remove the castellated nuts and washers from the two studs extending from the supercharger rear housing cover, through the central portion of the accessory drive housing wall section. Break the safety wire, and remove the shouldered nuts and washers, located at the corners of the housing, using an off-set box socket wrench and handle. Remove the acorn nuts and copper washers from the studs which extend from the

bottom of the accessory drive housing, through the rear housing and cover parting flanges. Remove the dual accessory drive housing and gasket from the rear housing cover, by tapping with a rawhide mallet.

(b) DUAL ACCESSORY DRIVE SPEED RATION CHANGE.

1. To change the speed ratio of the accessory drives to the crankshaft, it is necessary to replace the two gears in primary gear train (identified by their large teeth) with two gears of the desired ratio. The primary gear train consists of the drive gear machined integral with a splined shaft, and the intermediate gear which is bolted to the driving gear of the secondary train (identified by their small teeth).

2. Six cap screws are employed to retain the intermediate gears together. The drilled heads are safety wired together and do not require washers.

(c) INSTALLATION.—Prepare the supercharger rear housing cover to receive the dual accessory unit as follows:

1. Remove the two pipe plugs from the lower left-hand corner of the dual accessory mounting pad on the supercharger rear housing cover, thus uncovering holes through which the dual accessory drive gear lubrication oil drains into the supercharger rear housing. Remove the two flathead bolts extending through the supercharger rear housing and cover parting flanges, at the lower right corner of the dual accessory drive mounting pad. Remove the palnuts and nuts from two supercharger rear housing cover attaching studs, immediately above the countersunk flathead bolt holes, and from the adjacent attaching stud at the left of the countersunk holes. Remove the palnuts and nuts from the four studs holding the cover plate over the spare accessory drive shaft, and withdraw the cover plate and gasket. Place a dual accessory drive mounting pad gasket over the studs now exposed.

2. Make sure the pipe plug has been removed from the tapped drain hole in the lower corner of the dual accessory driving housing. Place the housing in position on its attaching studs, but do not push it all the way onto its mounting pad until the nuts are started on the studs under the overhanging parting flange. The three supercharger section rear housing cover attaching studs at the outer corners of the accessory drive housing utilize plain washers and special shouldered nuts, which require the use of an off-set box-socket wrench and handle. The two studs extending from the supercharger rear housing cover through the central part of the accessory drive housing employ plain washers and castellated nuts. The castellated nut, in the center of the housing, is cotter pinned and the other four nuts are safety wired. Install cupped washers and acorn nuts on the two studs, which extend from the bottom of the accessory drive housing through the countersunk holes in the supercharger rear housing cover, and safety wire the drilled tips of the acorn nuts together.

3. Oil the four bushings in the accessory drive housing with engine oil. Place the primary drive gear (large teeth) in mesh with the intermediate gear, and insert the two gears together into their supporting bushings in the accessory drive housing. The upper and lower accessory drive gears may then be placed in the housing, taking care to have the gear with involute splines and short front journal in the upper blind bushing, and the gear with spare splines and long front journal in the lower open bushing. Timing marks are not necessary on any of the spur gears making up the dual accessory drive.

4. Install a gasket on the dual accessory drive housing parting surface, and smear the gears with engine oil. Place the cover on its attaching studs, and slide it forward over the rear journals of the gears. Place a plain washer and special cap nut on each of the two studs extending from the supercharger rear housing cover through the upper left side of the accessory drive housing. Similarly install a plain washer and plain nut on the cover attaching stud, located between the upper and lower drives. Tighten these nuts evenly, safety wiring the two special nuts together and installing a palnut over the plain nut. Tighten the palnut finger tight and then turn 1/6 turn with wrench.

5. Install gaskets and accessories (or cover plates) on the two mounting pads following the instructions in applicable paragraphs, this Handbook. Secure the accessories or cover plates with plain washers, nuts and palnuts.

(14) TACHOMETER AND OIL PUMP.

(a) GENERAL.—The oil pump and tachometer assembly is located on the supercharger rear housing cover at the lower left side. A mounting pad for an electric-type tachometer, and a screw-type connection for a mechanical-type tachometer are provided at the rear of the pump, to the right of the oil pressure relief valve.

(b) OIL PRESSURE RELIEF VALVE REPLACEMENT.

1. Break the safety wire and remove the cad-

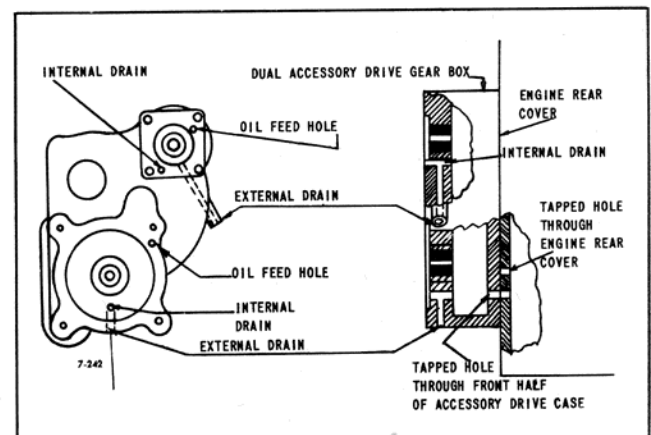


Figure 123—Accessory Drive Drain Holes

mium plated steel cap and gasket from the oil pressure relief valve assembly, located on the rear of the oil pump, adjacent to the end plate. Remove the large lock nut and its shouldered copper gasket. Unscrew the slotted adjusting screw all the way off the bronze relief valve body, being careful not to lose the coiled spring which is immediately behind the adjusting screw. Remove this coiled spring and withdraw the piston or ball from the bore of the bronze relief valve body.

2. The relief valve body may be unscrewed from the aluminum alloy oil pump body by using a 7/8-inch hex box wrench (Wright No. 83472). Insert the lugs of the wrench into the slots on the rear end of the relief valve body. Installation of a replacement bronze body is accomplished with the same tool.

3. To assemble the unit, insert the hollow piston or ball-type valve into the bronze relief valve body, and replace the coiled spring. Screw the adjusting screw in approximately one-third of its length on the outside diameter of the bronze body over the extended end of the coiled spring. Install the lock nut and its shouldered copper gasket loosely on the adjusting screw. Set the adjusting screw to give the desired engine oil pressure; tighten the lock nut, and install the steel cap and its gasket.

(c) OIL INLET CHECK VALVE
REPLACEMENT.

1. Break the safety wire and remove the cadmium plated retainer from the left-hand side of the oil pump. Remove the copper-asbestos gasket, spring, and hollow piston from the bore of the bronze valve body.

2. The bronze valve body is pressed into the oil pump body and cannot be removed in the field. The piston employs one piston ring and may be replaced without the use of special tools. Expand the ring slightly and slide it over the chamfered end of the piston dome and into the piston ring groove. Ring clearance—.002L minimum, .006L maximum. Spring tension at two inches height—3.5 to 4.0 pounds.

3. Assembly is accomplished by inserting the piston and ring into the bronze check valve body, compressing the ring to permit entrance. Insert the spring into the hollow piston and screw on the retainer having a new gasket under the flange. Tighten and safety wire the retainer to prevent its loosening.

(d) OIL PUMP REMOVAL.

1. Unscrew the temperature bulbs from the inlet and outlet chambers of the oil pump. Remove the oil inlet and outlet lines and remove the tachometer connections.

2. Break the safety wire and remove the special shouldered cap screw from the attaching leg at the right of the oil pump. Break the safety wire and remove the nuts and washers from the eight long attaching studs, and remove the pump. Support the pump to prevent separation of the covers and housings. Temporarily

retain the housings and covers by installing two long bolts of the same diameter as the mount studs.

(e) OIL PUMP INSTALLATION.

1. Place a new gasket over the long oil pump attaching studs; make sure the oil holes line up correctly. Coat the oil pump drive shaft coupling with petrolatum, Specification No. AN-VV-P-236, and install the pump over the attaching studs, meshing the coupling with the splined end of the drive shaft in the supercharger rear housing cover. Install the plain washers and castellated nuts on the attaching studs. Tighten and safety wire the nuts together. Place a plain washer under the head of the special shouldered cap screw which secures the attaching leg of the oil pump to the supercharger rear housing cover. Safety wire the cap screw.

2. Reinstall the tachometer cables, oil lines, and temperature bulbs (thermocouple) on the pump.

3. If it is found necessary to readjust the oil pressure relief valve to obtain the desired pressure, remove the steel cap from the valve body, loosen the lock nut, and turn the adjusting screw clockwise to increase the pressure. The pressure regulation should be accomplished with the oil inlet temperature at 70°C (158°F). Tighten the lock nut and reinstall the steel cap. Insure that the shouldered washer is installed under the cap.

(15) CUNO AUTOMATIC OIL FILTER
REPLACEMENT.

(a) The Cuno automatic oil filter is attached to the left side of the supercharger rear housing, slightly below its midsection.

(b) Removal of the filter is accomplished by breaking the lock wire and removing the three shouldered attaching cap screws. It may be necessary to tap the filter lightly with a rawhide mallet to effect removal if the filter is stuck.

(c) Removing the extended cap nut on the outer face of the filter head exposes a pinion shaft, which is provided to turn the filter manually for test or inspection purposes. Reverse the cap nut and screw it on the end of the pinion shaft thus providing a means of turning the filter.

(d) Reinstall the cap nut in its original position on the pinion shaft bushing and lock wire. Insert the filter in its recess in the supercharger rear housing, with its inner end fitting snugly in the supporting boss at the center of the supercharger rear housing cover. Make sure a new gasket is installed under the head of the filter. Insert the three retaining cap screws, tighten, and lock wire together.

(16) SUPERCHARGER DRAIN VALVE.

(a) REMOVAL.—Disconnect the drain line from the outlet connection in the drain valve housing. Break the lock wire securing the valve housing to the supercharger section rear housing, and unscrew the valve housing from the valve body. Take care not to drop the

piston and disc unit which may remain either with the valve body or in the valve housing. Remove the piston and disc unit. Using the special wrench, unscrew the valve body from the supercharger rear housing, and withdraw the body and tube assembly as a unit.

(b) INSTALLATION.

1. Install two new rubber packing rings in the groove at the small end of the valve body, and one below the flange at the large end of the valve body. If the drain valve is not assembled, place the piston and disc unit on the valve body. Assemble the housing to the valve body.

2. Insert the complete assembly in the supercharger rear housing, using a washer between the flange on the valve body and the supercharger rear housing. Lock wire the drain valve housing to the supercharger rear housing, and install the drain line in the valve housing outlet.

(17) SUPERCHARGER OIL SEAL VENT.

(a) At the forward end of the supercharger section rear housing, adjacent to the carburetor adapter, is located the supercharger oil seal atmosphere vent fitting. This fitting consists of a hollow hex head steel plug, having breather holes drilled under the head, and a fine mesh brass screen over the bottom of the pipe threaded shank. Outwardly the oil seal vent resembles a large cap bolt screwed part of its length into the supercharger rear housing.

(b) This vent fitting may be removed from the supercharger rear housing for cleaning or replacement. Use thread lubricant, Specification AN-C-53, on the threads when reinstalling, being careful not to clog the fine brass screen on the inner end.

(18) GROUND RUN-IN OF ENGINES.—When piston and ring assemblies or cylinder assemblies are replaced in service, the following run-in of the engine will be accomplished:

(a) LUBRICATION.—Prior to starting the run-in the oil tank will be filled to the proper level. Break the oil inlet connection at the oil pump and drain sufficient oil to insure that there is no air lock between the oil pump and the tank. Reinstall oil inlet line to pump. Remove all front or outside spark plugs from the engine. Remove oil pressure relief valve. Make sure that the fuel valve and ignition switch are in the "OFF" position. Turn engine over by hand until sufficient oil is expelled through the relief valve opening. Reinstall the oil pressure relief valve. Make a "dummy" start of the engine to obtain an indication of pressure on the oil gage. (Use a portable energizer or external battery source if available.) Reinstall spark plugs and make a normal engine start.

(b) WITH PRERUN REPLACEMENT PARTS.—If the replacement piston and rings or cylinders are removed from another engine that has already been in

service or run in, or if prerun piston rings and mating cylinders are obtained from stock and installed, the engine will be run-in for a period of 30 minutes. During this time the operation of the engine, engine instruments, and related accessories will be thoroughly checked for proper functioning. Warming up speeds of 800 to 1000 RPM are recommended. Care must be taken not to exceed maximum cylinder and oil temperatures during this period. Continued operation at either low idling speeds or at manifold pressures approaching rated power must be limited to short bursts of only sufficient duration to obtain instrument readings, and to make certain that the acceleration of the engine is satisfactory.

(c) WITH REPLACEMENT PARTS NOT PRERUN.—If piston and rings or cylinders other than those mentioned in paragraph (b) above, are used for replacements, the engine will be run-in as follows in order to properly seat the rings: (Propeller in low pitch "HIGH RPM" position.)

1000 RPM for 15 minutes
1200 RPM for 20 minutes
1400 RPM for 30 minutes
1600 RPM for 30 minutes
1800 RPM for 15 minutes
2000 RPM for 10 minutes

CAUTION

If at any time the cylinder head temperature exceeds 195°C (380°F) or the oil temperature exceeds 85°C (185°F), the engine will be shut down and cooled off, after which the test will be continued. The ignition system will not be checked by operating on one magneto above cruising manifold pressure, as serious detonation may result.

(d) FUEL.—Fuel pressure will be maintained at approximately 14 pounds per square inch. The mixture control should be set in the "AUTO RICH" position for the full duration of the test.

(19) FLIGHT TESTS.—Upon completion of the ground test specified above, the airplane will be flight tested as follows:

(a) A flight of one hour's duration, the first 50 minutes of which at reduced power, and the last ten minutes at normal rated power, followed by an inspection for evidence of visible defects, malfunctioning parts, etc.

(b) If no malfunctioning or defects are noted, an additional one hour's flying at cruising power when two or more engines have been repaired or replaced, or an additional 1/2 hour's flying at cruising power if only one engine has been repaired or replaced.

(c) All removable oil screens will be cleaned at the completion of both the ground and flight tests.

d. ADJUSTMENTS.

(1) VALVE CLEARANCES.—Set the valve tappet clearance in accordance with the following instructions:

(a) Install a top center indicator in the front spark plug bushing of the cylinder in which the valve tappet clearance is being adjusted.

(b) Turn the crankshaft until the piston in this cylinder is at the top dead center position *on the firing stroke* (both valves closed) as shown on the indicator.

(c) Loosen the adjusting screw lock screw. Screw in the adjusting screw until the rocker arm roller bears against the valve stem, and the tappet spring is fully compressed. Tap the adjusting screw end of the rocker arm to insure that the spring is fully compressed.

(d) Turn the adjusting screw in a counterclockwise direction until .010 inch is obtained if it is anticipated that the atmospheric temperature will not reach 0°F. In climates where 0°F and below temperature is prevalent, the valve clearances should be set at .018-.020 inch.

Note

Valve adjusting screws used on these engines have three oil pressure holes incorporated. The screw is marked on the top surface with three 1/16-inch diameter circles in line with the three drilled oil passages. If one of these holes is aligned with the clamp joint of the rocker arm, oil will escape into the rocker box without properly lubricating the rocker arm bearing. Care will be exercised when adjusting the valve clearance in order to insure that none of the drilled holes in the adjusting screw line up with the clamp joint in the rocker arm within 3/32 inch. If, after adjusting the valves to the desired value, the oil pressure holes are found to be closer than 3/32 inch to the nearest edge of the clamp joint, turn the adjusting screw in the shortest direction that will bring the mark within the required limits and tighten the locking screw. However, if the oil pressure hole is in line with the clamp joint, the valve clearance will be increased rather than decreased. The maximum error in the desired clearance caused by the above procedure is approximately .002 inch, which will in no way affect engine operation.

(e) Adjust all remaining valve tappet clearances in firing sequence: 1-3-5-7-9-2-4-6-8.

(2) OIL PRESSURE.—Break the safety wire and remove the cadmium plated steel cap and gasket from the oil pressure relief valve assembly, located on the rear of the oil pump, adjacent to the end plate. Loosen the large lock nut on the slotted adjusting screw. Turn the adjusting screw in the clockwise direction to increase the engine oil pressure. Turn the screw counterclockwise to decrease oil pressure. When the desired oil pressure has been obtained, tighten the lock nut against its shouldered copper gasket. Reinstall the steel cap and its shouldered copper gasket.

(3) MAGNETOS.

(a) Check timing and synchronization of magnetos. The instant at which contact points start to open on No. 1 cam lobe (indicated by red dot) should be checked. At this instant, a straight edge placed across step of timing collar should coincide with registering marks on rim of gear housing. Permissible limits are 1/32 inch on either side of registering marks. If this checks, no adjustments need be made. However, should the straight edge fail to come within these limits at the instant the contact points on No. 1 cam lobe are about to open, then correct in following manner:

(b) Facing the front of the engine, turn the propeller counterclockwise (thereby causing magneto distributor gear shaft to turn in normal direction, as indicated by arrow on cam) until the cam follower is in the cam dwell preceding No. 1 cam lobe. Place a straight edge across the step of the timing collar. Jar the propeller in a counterclockwise direction until the straight edge just lines up with the center of the timing marks on the rim of the gear housing. Loosen the adjustable contact bracket locking screw and shift the contact bracket, by means of the eccentric screw, until the contact points exert a slight pressure on a .001-inch feeler gage. Secure the adjustable contact bracket and recheck with the feeler gage to make certain that the securing operation did not change contact position.

(c) When the setting is correct, the feeler gage will become free just as the straight edge coincides with the timing marks when the propeller is turned counterclockwise, indicating that the contact points on No. 1 cam lobe are just beginning to open. Now make certain that the locking screw is securely tightened. Recheck this adjustment by moving propeller as outlined. After final adjustment, recheck the synchronization of both magnetos to engine timing marks as instructed in paragraph 8. c. (11) above.

e. REMOVAL, DISASSEMBLY, ASSEMBLY, AND INSTALLATION OF THE COMPLETE ENGINE SECTION.

(1) GENERAL.—The engine section forward of the firewall, including the engine, engine mount, accessories, tubing, wiring, and control cables can be removed and installed as a unit. Detailed removal and installation procedures for those components of the engine and nacelle which must be dismantled during an engine section removal are outlined under their respective headings in this section.

(2) PRIOR TO REMOVAL OF THE ENGINE SECTION.

(a) Assemble the necessary equipment such as stands, hoists, slings, rags, wire, tools, etc.

(b) Check that the magneto switches are secured in the "OFF" position.

(c) Check that the cowl flap control valve is in the "LOCKED" position.

(d) Check that the fuel shut-off valve is in the "CLOSED" position.

(e) Drain the oil from the "Y" drain cock at the bottom of the oil tank inside the nacelle. Inspect the magnetic sump plug for black sludge and metallic particles.

(f) Drain the glycol. Flush or clean the system, if necessary, as instructed under "HEATING SYSTEM"; if flushing is not necessary, disconnect the glycol "IN" line hose on the inboard side of the nacelle. *Do not* attempt to pry off the hose as the softer tubing may be crushed. Cut the hose carefully.

Note

The check valve on the pressure side of the hydraulic pump eliminates the necessity of draining the hydraulic fluid.

(3) REMOVAL OF THE ENGINE SECTION.

(a) With the magneto switches secured in the "OFF" position and the magneto plug at the firewall connected, remove the propeller—using the propeller tool kit—as follows:

1. Turn the propeller blades to the fully feathered position.
2. Remove the dome plug lockwire and the dome plug.
3. Screw the dome handle into the dome.
4. Remove the dome retaining nut lock screw from the lug. This screw will be found in any of the

lugs but the holes are so arranged that no two will engage at the same time.

5. Remove the dome, unscrewing with the multiple wrench.

6. Remove the propeller retaining nut lockwire.

7. With the hub wrench and using the multiple wrench for a handle, back off the propeller nut until approximately 1/2 inch of the threads show.

8. Remove the distributor valve with the multiple wrench.

9. Loosen the propeller retaining nut with the hub wrench, bringing the front cone to bear on the snap ring which pulls the propeller away from the rear cone. Tighten the propeller retaining nut two turns and remove the snap ring. Remove the propeller retaining nut.

CAUTION

The front cone is in two pieces. Do not let them fall as the propeller retaining nut is removed.

10. Remove the front cone.

11. Remove the spider shaft oil seal expander ring, spider shaft oil seal, and the spider shaft oil seal washer.

12. Attach the propeller sling to the propeller.

13. Install a thread protector on the propeller shaft.

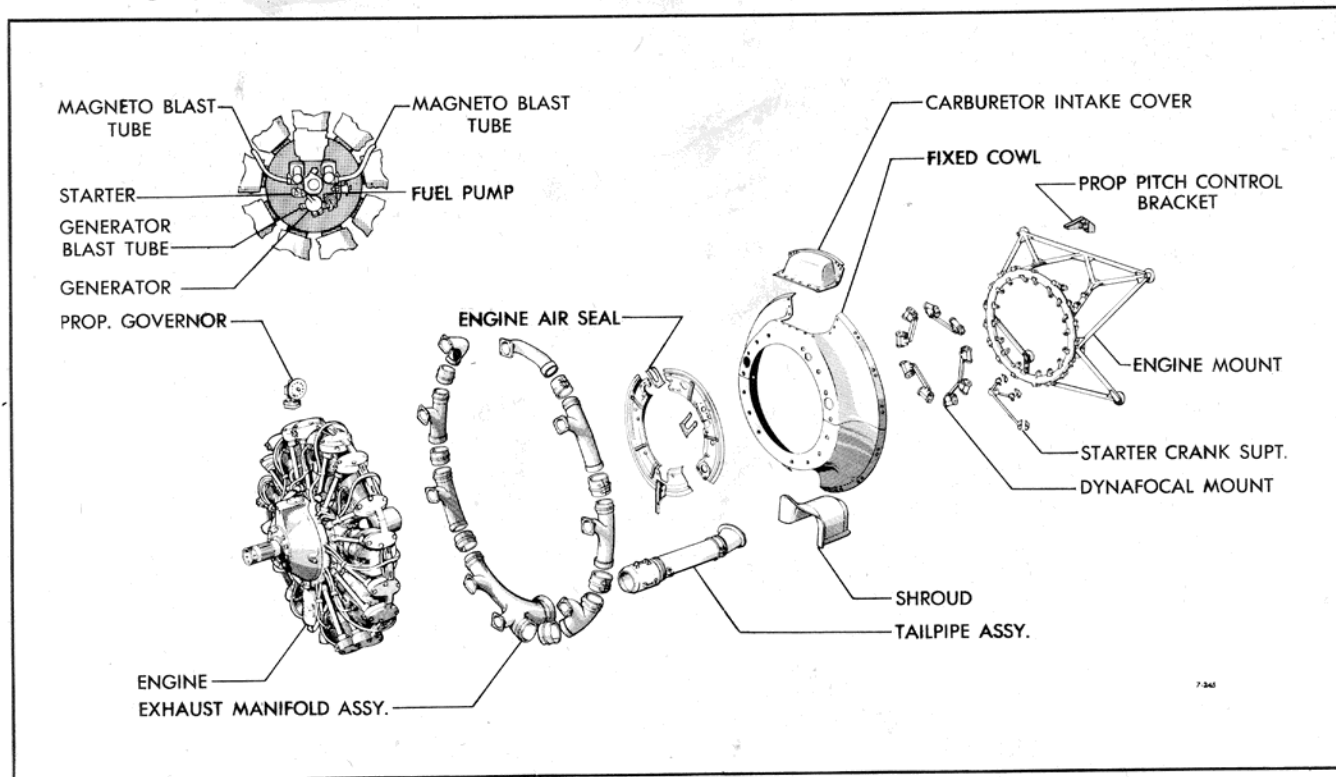
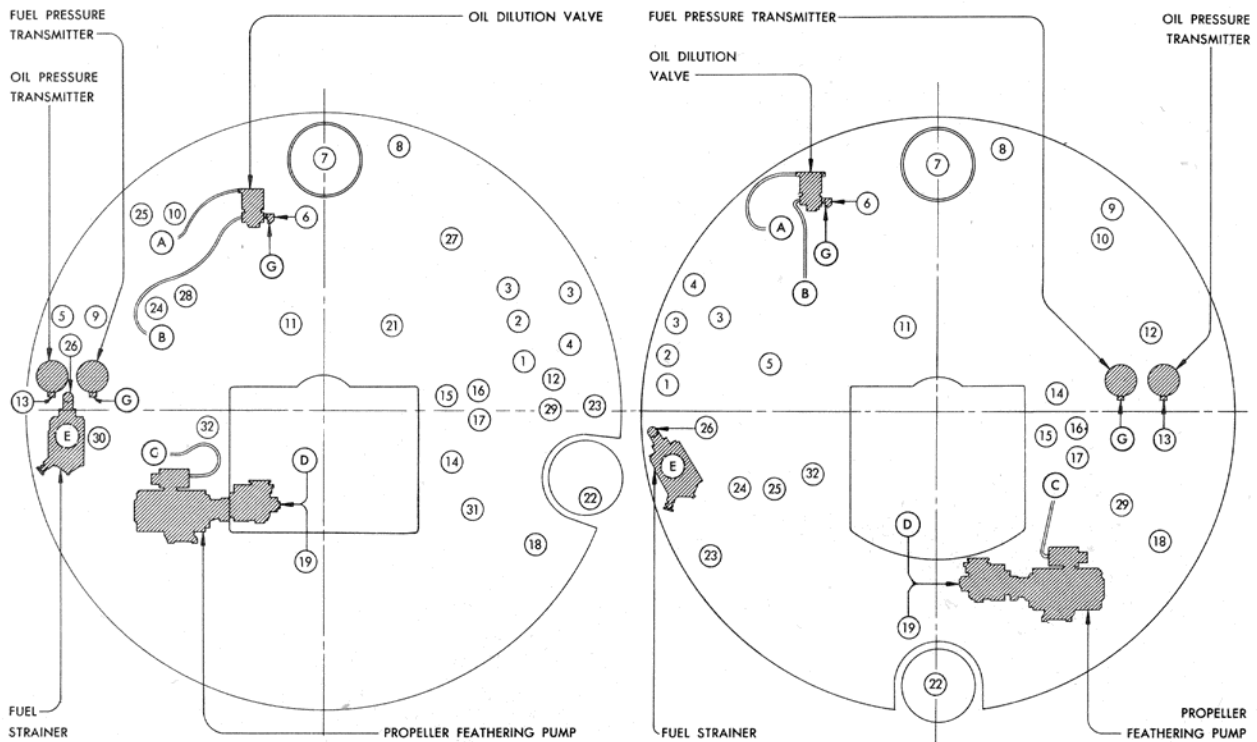


Figure 124—Engine Installation Breakdown



FRONT VIEW NO.2 FIREWALL

FRONT VIEW NO.1 FIREWALL

| A* | B* | SYSTEM | IDENTIFICATION | SIZE | MATERIAL | FIREWALL | | | POWER PLANT | | | INSTALLED ON | |
|--------------------------|-----|--------------------------|----------------------------------|-------------------|---------------------------------|--|---|----------|---|--|----------|------------------------|--|
| | | | | | | CONNECTION | | COUPLING | CONNECTION | | COUPLING | | |
| | | | | | | FITTING | TYPE | | FITTING | TYPE | | | |
| 1 | 1 | MIXTURE CONTROL | BAC 1861-23-75 | 3/8 x .035 x 7.5 | STL ROD ASSY. | 3-8202-100 | CRANK ASSY. | ----- | ----- | ----- | ----- | CARBURETOR | |
| 2 & 3 | | | BAC 1861-23-78 | 3/8 x .035 x 7.8 | | | | | | | | | |
| 4 | | | BAC 1861-23-73 | 3/8 x .035 x 7.3 | | | | | | | | | |
| 1 & 4 | | | BAC 1861-24-130 | 1/2 x .035 x 13.0 | | 3-13530 | CRANK ASSY. | ----- | ----- | ----- | ----- | CARBURETOR | |
| 2 | 2 | THROTTLE CONTROL | BAC 1861-24-136 | 1/2 x .035 x 13.6 | STL ROD ASSY. | 3-13504-13 | CRANK ASSY. | ----- | ----- | ----- | ----- | | |
| 3 | | | BAC 1861-24-136 | 1/2 x .035 x 13.6 | | 3-12090-14 | CRANK ASSY. | | | | | | |
| 3 | ALL | PROP. PITCH CONTROL | 15-7040 (REF.) | 3/32 | CARBON STEEL CABLES | ----- | ----- | ----- | ----- | ----- | ----- | **GOVERNOR PULLEY | |
| 4 | 1 | OIL (RETURN) | 15-9470-26 | 1-1/4 x .049 | 5250 TUBING | AN844-21 | ELBOW | HOSE | AN 842-21 | ELBOW | HOSE | ENGINE | |
| | 2 | | 15-9470-17 | | | AN844-21 | ELBOW | HOSE | AN 844-21 | ELBOW | HOSE | | |
| | 3 | | 15-9470-34 | | | AN844-21 | ELBOW | HOSE | AN 842-21 | ELBOW | HOSE | | |
| | 4 | | 65-6242-659 | | | AN840-21 | NIPPLE | HOSE | 895-6 AN 842-21 | STREET ELBOW ELBOW | HOSE | | |
| 5 | ALL | HYD. COWL FLAPS | 43D 2475-6-330 | 5/16 I.D. | WIRE BRAIDED HOSE | 39 B-1024-6 AN960-916 | NUT WASHER | ----- | 811-CT-6 | ELBOW | ----- | HYDRAULIC CYLINDER | |
| 6 | 1 | OIL DILUTION | 65-6242-646 | 1/4 x .032 | COPPER TUBING | 37-A-3528 AN842-4 | TWIN RESTR. ELBOW | HOSE | 850-4 995-C40 | ELBOW LOCKWIRE | HOSE | CARBURETOR | |
| | 2 | | 65-6242-649 | | | 895-50 | COUPLING | | 850-4 995-C40 | ELBOW LOCKWIRE | HOSE | | |
| | 3 | | 65-6242-647 | | | 37-A-3528 AN840-4 | TWIN RESTR. ELBOW | HOSE | | | | | |
| | 4 | | 65-6242-648 | | | | | | | | | | |
| 7 | ALL | CARBURETOR PRESSURE DUCT | ----- | ----- | ----- | 41-8374 | RING ASSY. | ----- | 9-3080-22 6-8072-2 | ELBOW CORRUG. AIR HOSE | ----- | CARBURETOR | |
| 8 | ALL | ELECTRICAL | FLEX. COND. ASSY. 55-7332-447 | 1 1/4 I.D. x 9.40 | FLEXIBLE CONDUIT 55-7332-455 | AN3064-4 AN3066-4 AN3050-4 AN3054-4 | CONNECTOR NUT FERRULE COUPLING NUT | ----- | AN5525-2 AN3108-125-35 AN3050-4 AN3054-4 | BULB THERM. TYPE PB PLUG FERRULE COUPLING NUT | ----- | CARBURETOR AIR DUCT | |
| 9 | 1 | OIL (TANK VENT LINE) | 55-6242-42 | 1/2 x .035 | 5250 TUBING | 811CT8 811BTD 811T8CS | ELBOW NUT SLEEVE | ----- | AN840-8 | NIPPLE | HOSE | ENGINE | |
| | 2 | | 55-6242-41 | | | AN 840-8 | NIPPLE | HOSE | AN844-8 | ELBOW | HOSE | | |
| | 3 | | 55-6242-537 | | | 811CT8 811BTD 811T8CS | ELBOW NUT SLEEVE | ----- | 895-32 AN844-8 895-92 | PLAIN TYPE TEE ELBOW NIPPLE | HOSE | | |
| | 4 | | 15-9470-8 | | | AN 840-8 | NIPPLE | HOSE | AN840-8 | NIPPLE | HOSE | | |
| | 1 | | 15-9470-5 | | | 811CT8 811BTD 811T8CS | ELBOW NUT SLEEVE | ----- | 895-32 AN842-8 895-92 | PLAIN TYPE TEE ELBOW NIPPLE | HOSE | | |
| 10 | 2 | | 55-6242-515 | | | AN840-8 | NIPPLE | HOSE | AN844-8 | ELBOW | HOSE | | |
| | 3 | | 15-9470-11 | | | 811CT8 811BTD 811T8CS | ELBOW NUT SLEEVE | ----- | 895-32 AN842-8 895-92 | PLAIN TYPE TEE ELBOW NIPPLE | HOSE | | |
| | 4 | | 15-9470-1 | | | AN840-8 | NIPPLE | HOSE | AN 844-8 | ELBOW | HOSE | | |
| | 1 | | 55-6242-512 | | | 811CT8 811BTD 811T8CS | ELBOW NUT SLEEVE | ----- | AN 844-8 | ELBOW | HOSE | | |
| | 2 | | 15-9470-14 | | | | | | | | | | |
| A* IDENTIFICATION NUMBER | | | B* INSTALLED ON NACELLE | | | 7-346 | | | ** CONNECTS TO PROPELLER GOVERNOR PULLEY | | | | |

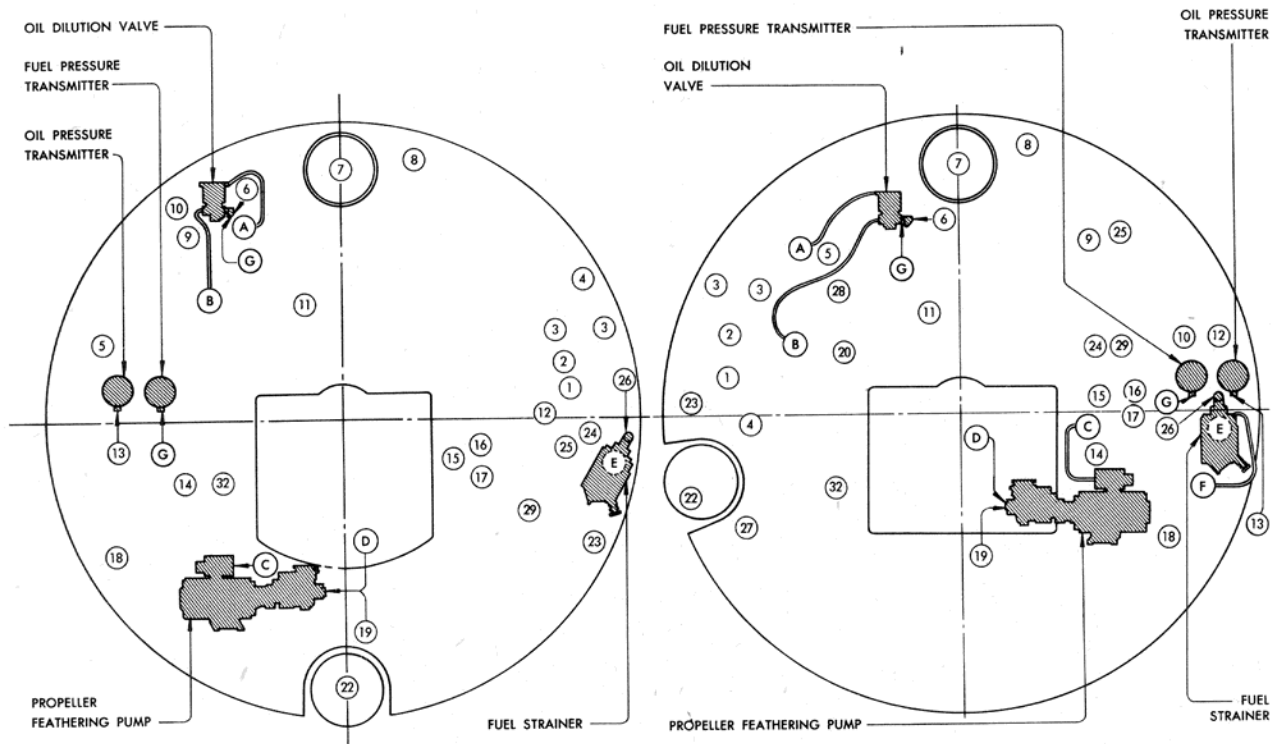
A* IDENTIFICATION NUMBER

B* INSTALLED ON NACELLE

7-546

** CONNECTS TO PROPELLOR GOVERNOR PULLEY

Figure 125—Engine to Firewall Connections (Sheet 1 of 4)

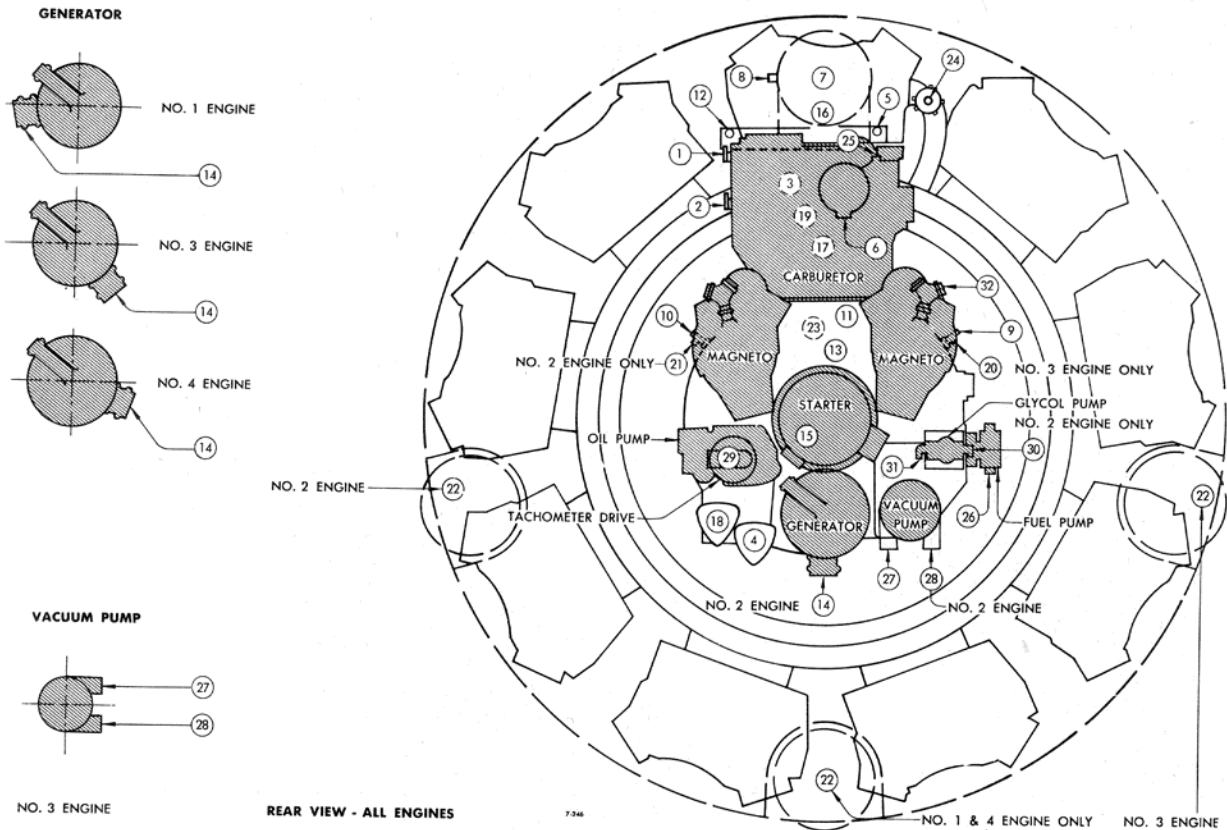


FRONT VIEW NO.4 FIREWALL

FRONT VIEW NO.3 FIREWALL

| A* | B* | SYSTEM | IDENTIFICATION | SIZE | MATERIAL | FIREWALL | | | POWER PLANT | | | |
|--------------------------|------------|-------------------------------------|-------------------------|------------------------|---------------------------------|---------------------------------------|--|----------|---------------------------------------|---|----------|--|
| | | | | | | CONNECTION | | COUPLING | CONNECTION | | COUPLING | INSTALLED ON |
| | | | | | | FITTING | TYPE | | FITTING | TYPE | | |
| 11 | ALL | SUPERCHARGER (MANIFOLD PRESSURE) | BAC 884-4-60 | 1/4 I.D. x 15 | HOSE (SYNTHETIC) | AN844-4 | ELBOW | ----- | AN840-4 | NIPPLE | ----- | ENGINE |
| 12 | ALL | HYD. COWL FLAPS | 43D-2475-6-330 | 5/16 I.D. | WIRE BRAIDED HOSE | 398-1024-6 AN960-916 | NUT WASHER | ----- | 811-CT45-6 | ELBOW | ----- | HYDRAULIC CYLINDER |
| 13 | 1 | OIL (PRESSURE TRANSMITTER) | BAC 884-4-146 | 1/4 I.D. x 38 | HOSE (SYNTHETIC) | AN842-4 | ELBOW | ----- | AN840-4 | NIPPLE | ----- | ENGINE |
| | 2 | | BAC 884-4-135 | 1/4 I.D. x 33 3/4 | | | | | | | | |
| | 3 | | BAC 884-4-152 | 1/4 I.D. x 38 | | | | | | | | |
| | 4 | | BAC 884-4-122 | 1/4 I.D. x 38 | | | | | | | | |
| 14 | 1 2,394 | ELECTRICAL | 15-11371 (REF.) | ----- | ----- | ----- | ----- | ----- | AN3106-32-15 AN3108-32-15 | TYPE PA PLUG TYPE PB PLUG | ----- | GENERATOR |
| 15 | 1 | ELECTRICAL | WIRE NO. 536 | SIZE 14, LENGTH 21.3 | ----- | AN3108-24-1P | TYPE PB PLUG | ----- | 10-32 1/4 DIA. | TERMINAL | ----- | STARTER |
| | 2 | | WIRE NO. 543 | SIZE 2, LENGTH 21.3 | | | | | | | | |
| | 3 | | WIRE NO. 539 | SIZE 14, LENGTH 25.3 | | | | | | | | |
| | 4 | | WIRE NO. 540 | SIZE 2, LENGTH 24.8 | | | | | | | | |
| 16 | 1 | ELECTRICAL | WIRE NO. 528 | SIZE 14, LENGTH 21.8 | IRON CONSTANTAN | AN3106-16-135 | TYPE PA PLUG | ----- | WRIGHT DWG. NO. 68326 | THERMOCOUPLE | ----- | NO. 1 CYLINDER REAR SPARK PLUG |
| | 2 | | WIRE NO. 529 | SIZE 2, LENGTH 18.5 | | | | | | | | |
| | 3 | | WIRE NO. 534 | SIZE 14, LENGTH 18 | | | | | | | | |
| | 4 | | WIRE NO. 535 | SIZE 14, LENGTH 18 | | | | | | | | |
| 17 | 1 | ELECTRICAL | WIRE NO. M-1, WH. | 2 NO. 20, LGTH. 53-6-0 | FLEXIBLE CONDUIT 15-7332-151 | AN3106-165-4P AN3052-4 AN3054-8 | TYPE PA PLUG TWO STEP FERRULE COUPLING NUT | ----- | AN3108-125-45 AN3050-4 AN3054-4 | TYPE PB PLUG FERRULE COUPLING NUT | ----- | PROP. FEATHERING SWITCH (PROP. GOVERNOR) |
| | 2 | | WIRE NO. M-2, RED | 1 NO. 19, LGTH. 53-6-0 | | | | | | | | |
| | 3 | | WIRE NO. 3, WHITE | 1 NO. 16, LGTH. 53-6-0 | | | | | | | | |
| | 4 | | WIRE NO. 4, RED | 1 NO. 16, LGTH. 53-6-0 | | | | | | | | |
| 18 | 1 | OIL (IN) | WIRE NO. 5, WHITE | 1 NO. 16, LGTH. 53-6-0 | 52SO TUBING | AN840-21 | NIPPLE | HOSE | 895-6 AN842-21 3-16922 | ELBOW STREET ELBOW "Y" TYPE | HOSE | ENGINE |
| | 2 | | WIRE NO. 6, RED | 1 NO. 16, LGTH. 53-6-0 | | | | | | | | |
| | 3 | | WIRE NO. 7, WHITE | 2 NO. 20, LGTH. 53-6-0 | | | | | | | | |
| | 4 | | WIRE NO. 8, RED | 1 NO. 19, LGTH. 53-6-0 | | | | | | | | |
| 7-246 | | | | | | | | | | | | |
| A* IDENTIFICATION NUMBER | | | B* INSTALLED ON NACELLE | | | | | | | | | |

Figure 125—Engine to Firewall Connections (Sheet 2 of 4)



| A* | B* | SYSTEM | IDENTIFICATION | SIZE | MATERIAL | FIREWALL | | | POWER PLANT | | | INSTALLED ON |
|--------------------------|-------------|------------------------|--------------------------------|--------------------------------|-----------------|-------------------------|-------------------|----------|--------------|---------|----------|--|
| | | | | | | CONNECTION | | COUPLING | CONNECTION | | COUPLING | |
| | | | | | | FITTING | TYPE | | FITTING | TYPE | | |
| 18 | 2 | OIL (IN) | 65-6242-654 | 1 1/4 x .049 | 52 SO TUBING | AN844-21 3-16923 | ELBOW "Y" TUBE | HOSE | AN 842 21 | ELBOW | HOSE | ENGINE |
| | 4 | | 15-9470-41 | | | AN844-21 3-19973 | ELBOW "Y" TUBE | HOSE | AN844-21 | ELBOW | HOSE | |
| 19 | 1 | OIL (PROP. FEATHERING) | 39G-1030-12W-30 | 1/4 x 30 | FLEXIBLE HOSE | 1/4 CD-5 | ELBOW STREET | ----- | ----- | ----- | ----- | PROP. GOVERNOR |
| | 2 | | 65-6242-636 | 1/4 x .049 | BRONZE TUBE | 12FTS | NIPPLE-TRIPLE | ----- | ----- | ----- | ----- | |
| | | | 65-6242-696** | 1/4 x .049 | BRONZE TUBE | ----- | ----- | ----- | 12-8-CT455 | ELBOW" | | |
| | 3 | | 65-6242-655 | 1/4 x .049 | BRONZE TUBE | 12CT-455 | ELBOW-TRIPLE | ----- | ----- | ----- | ----- | |
| | | | 39G-1030-12W-27 | 1/4 x 27 | FLEXIBLE HOSE | 12 B7S | NUT | ----- | ----- | ----- | ----- | |
| | 4 | | 65-6242-634 | 1/4 x .049 | BRONZE TUBE | 811T12CS | SLEEVE | ----- | ----- | ----- | ----- | |
| | | | 65-6242-696** | 1/4 x .049 | BRONZE TUBE | ----- | ----- | ----- | 12-8-CT455 | ELBOW | | |
| | 20 | | 3 | VACUUM (OIL SEPARATOR VENT) | 39G-1030-12W-30 | 1/4 x 30 | FLEXIBLE HOSE | 1/4 CD-5 | ELBOW STREET | ----- | ----- | |
| 2 | | 65-6242-634 | 1/4 x .049 | | BRONZE TUBE | 12FTS | NIPPLE-TRIPLE | ----- | ----- | ----- | | |
| | | 65-6242-696** | 1/4 x .049 | | BRONZE TUBE | ----- | ----- | ----- | 12-8-CT455 | ELBOW | | |
| 21 | | 2 | VACUUM (OIL SEPARATOR VENT) | | 65-5594-573 | 1/2 x .035 | 52 SO TUBING | 1-21074 | COUPLING | HOSE | 895-92 | NIPPLE |
| | 3 | 895-32 | | TEE | ----- | | | ----- | ----- | | | |
| | | AN844-8 | | ELBOW | ----- | | | ----- | ----- | | | |
| | 22 | 2 | | EXHAUST | 65-5594-568 | | | | | 1-21074 | COUPLING | HOSE |
| 3 | | 895-32 | TEE | | ----- | ----- | ----- | | | | | |
| | | AN844-8 | ELBOW | | ----- | ----- | ----- | | | | | |
| 23 | | 1 | PROP. ANTI-ICER | | 65-5660-532 | 1/4 x .035 | 52 SO TUBING | | | 811TF6 | NIPPLE | ----- |
| | 65-5660-525 | 6001-DD-1/4D | | NIPPLE | ----- | | | ----- | ----- | | | |
| | 65-5660-540 | 895-91 | | NUT | ----- | | | ----- | ----- | | | |
| | 811BT60 | NUT SLEEVE | | ----- | ----- | | | ----- | | | | |
| A* IDENTIFICATION NUMBER | | | | | | B* INSTALLED ON NACELLE | | | | | | 7346 |
| | | | | | | | | | | | | ** INSULATE WITH UNARCO INSUTUBE NO. 650 |

Figure 125—Engine to Firewall Connections (Sheet 3 of 4)

| A* | B* | SYSTEM | IDENTIFICATION | SIZE | MATERIAL | FIREWALL | | | POWER PLANT | | | INSTALLED ON |
|-----------------------|----------------|------------------------|---|-----------------------------------|--|---|---------------------------------|----------------|-------------------------------|------------------------|----------|-----------------------|
| | | | | | | CONNECTION | | COUPLING | CONNECTION | | COUPLING | |
| | | | | | | FITTING | TYPE | | FITTING | TYPE | | |
| 23 | 2 | PROP. ANTI-ICER | 65-5660-526 | 1/4 x .035 | 5250 TUBING | 811CT-45-6 6001-DD-1-D 895-91 811BT4D 811T6CS | ELBOW VALVE NUT SLEEVE | | | | | FRONT OF ENGINE |
| | 3 | | 65-5660-523 65-5660-540 65-5660-534 65-5660-539 65-5660-540 | | | SEE NAC. NO. 2 | | SEE NAC. NO. 1 | | | | |
| | 4 | | 65-5660-535 65-5660-528 65-5660-540 | | | SEE NAC. NO. 1 | | SEE NAC. NO. 1 | | | | |
| | 4 | | | | | | SEE NAC. NO. 1 | | | | | |
| 24 | 1 | FUEL— ENGINE PRIMER | 15-7348-27 15-7348-28 15-7348-39 | 1/4 x .035 | 5250 TUBING | 811CT-4 811BT4D 811T6CS | ELBOW NUT SLEEVE | | 811CT-4 811BT4D 811T6CS | ELBOW NUT SLEEVE | | PRIMER DISTRIBUTOR |
| | 2 | | 15-7348-38 15-7348-39 | | | AN844-4 | ELBOW | HOSE | SEE NAC. NO. 1 | | | |
| | 3 | | 15-7348-47 55-7348-407 | | | AN840-4 | NIPPLE | HOSE | SEE NAC. NO. 1 | | | |
| | 4 | | 15-7348-50 55-7348-407 | | | AN840-4 | NIPPLE | HOSE | SEE NAC. NO. 1 | | | |
| 25 | 1 | FUEL— VAPOR VENT | 15-7348-66 15-7348-67 | 1/4 x .035 | 5250 TUBING | 811CT-4 811BT4D 811T6CS | ELBOW NUT SLEEVE | | 850-4 | ELBOW | HOSE | CARBURETOR |
| | 2 | | 15-7348-72 | | | AN840-4 | NIPPLE | HOSE | 850-4 | ELBOW | HOSE | |
| | 3 | | 15-7348-118 15-7348-77 | | | AN844-4 | ELBOW | HOSE | 850-4 | ELBOW | HOSE | |
| | 4 | | 15-7348-82 15-7348-83 | | | 811CT-4 811BT4D 811T6CS | ELBOW NUT SLEEVE | | 850-4 | ELBOW | HOSE | |
| 26 | 1 | FUEL | 15-7348-10 15-7348-13 | 1 I.D. | RUBBER HOSE | AN842-16 | ELBOW | | AN842-16 | ELBOW | | FUEL PUMP |
| | 2 | | 15-7348-11 | | | AN842-16 | ELBOW | | 895-5 AN844-16 | ELBOW ELBOW | | |
| | 3 | | 15-7348-12 | | | AN844-16 | ELBOW | | 895-5 AN844-16 | ELBOW ELBOW | | |
| | 3 | | | | | AN840-16 | NIPPLE | HOSE | AN842-16 | ELBOW | HOSE | |
| 27 | 2 | VACUUM | 65-5594-561 65-5594-563 65-5594-569 65-5594-564 | 1 x .049 | 25 1/4" TUBING | AN840-16 | NIPPLE | HOSE | AN842-16 | ELBOW | HOSE | VACUUM PUMP |
| 3 | 65-5594-567 | | AN840-16 | | | NIPPLE | HOSE | AN840-16 | NIPPLE | HOSE | | |
| 2 | | | AN840-16 | | | NIPPLE | HOSE | AN842-16 | ELBOW | HOSE | | |
| 3 | | | AN840-16 | | | NIPPLE | HOSE | AN840-16 | NIPPLE | HOSE | | |
| 29 | 1 & 4 2 & 3 | ELECTRICAL | FLEX. COND. ASSY. 55-7332-467 FLEX. COND. ASSY. 55-7332-469 | 1/4 I.D. x 14.25 1/4 I.D. x 18 | FLEX. COND. 55-7332-468 FLEX. COND. 55-7332-470 | | | | AN3106-145-15 | TYPE PA PLUG | | TACHOMETER |
| 30 | 2 | | 85-6691-710 | 1/4 x .042 | 5250 TUBE | 895-4 AN840-10 | ELBOW NIPPLE | HOSE | AN 842-10 | ELBOW | HOSE | |
| 31 | 2 | GLYCOL HEATING | 85-6691-708 | 1/4 x .042 | 5250 TUBE | 811CT-8 811BT8D 811T8CS | ELBOW NUT SLEEVE | | 895-84 811CT-8 | REDUCER ELBOW | | GLYCOL PUMP |
| | | | 39G-1030-8-16 | 1/2 x 16 | HOSE | | | | | | | |
| A* | | B* | | C* | | D* | | E* | | F* | | |
| IDENTIFICATION NUMBER | | INSTALLED ON NACELLE | | | | 7-346 | | | | | | |

A* IDENTIFICATION NUMBER B* INSTALLED ON NACELLE

| A* | B* | SYSTEM | IDENTIFICATION | SIZE | MATERIAL | FIREWALL | | | POWER PLANT | | | |
|----|-----|------------|---------------------------------|--------------|---------------------------------|--|---|----------|-------------|---------|----------|--------------|
| | | | | | | CONNECTION | | COUPLING | CONNECTION | | COUPLING | INSTALLED ON |
| | | | | | | FITTING | TYPE | | FITTING | TYPE | | |
| 32 | ALL | ELECTRICAL | FLEX. COND. ASSY 55-7332-472 | 1/4 ID. x 20 | FLEXIBLE CONDUIT 55-7332-477 | AN 3106-20-65 AN 3054-12 AN 3050-6 | TYPE PA PLUG COUPLING NUT FERRULE | | BAC 764-3B | FERRULE | | MAGNETO |

CONNECTIONS FROM FIREWALL TO UNITS ON ITS FWD. SIDE

| A* | B* | SYSTEM | IDENTIFICATION | SIZE | MATERIAL | FIREWALL | | | UNITS ON FWD. SIDE OF FIREWALL | | | |
|---|----------------|---|---|------------------|---------------------------------|-------------------------------------|--------------------------------------|------------------------|------------------------------------|-------------------------------|------------------------|------------------------------|
| | | | | | | CONNECTION | | COUPLING | CONNECTION | | COUPLING | INSTALLED ON |
| | | | | | | FITTING | TYPE | | FITTING | TYPE | | |
| A | ALL | ELECTRICAL | FLEX. COND. ASSY. 55-7332-409 | 1/4 I.D. x 10 | FLEXIBLE CONDUIT 55-7332-410 | AN 3050-4 AN 3054-4 AN 3064-4 | FERRULE COUPLING NUT CONNECTOR | ----- | AN 3050-4 AN 3054-4 | FERRULE COUPLING NUT | ----- | OIL DILUTION VALVE |
| B | 1 & 4 | OIL (DILUTION) | 15-9470-10 | 1/4 x .032 | COPPER TUBING | AN 842-4 | ELBOW | HOSE | AN 842-4 | ELBOW | HOSE | OIL DILUTION VALVE |
| | 2 | | 55-6242-544 | | | AN 840-4 | NIPPLE | HOSE | AN 842-4 | ELBOW | HOSE | |
| | 3 | | 15-9470-4 | | | AN 842-4 | ELBOW | HOSE | AN 840-4 | NIPPLE | HOSE | |
| C | 1 | ELECTRICAL | FLEX. COND. ASSY. 15-7332-33 | 1/4 I.D. x 13.25 | FLEXIBLE CONDUIT 15-7332-91 | 36A2214-5 | FERRULE CLAMP NUT | ----- | 36A2214-5 | FERRULE CLAMP NUT | ----- | PROPELLOR FEATHERING PUMP |
| | 2 | | FLEX. COND. ASSY. 15-7332-45 | 1/4 I.D. x 46.50 | FLEXIBLE CONDUIT 15-7332-103 | 31-1176-3 | | 31-1176-3 | | | | |
| | 3 | | FLEX. COND. ASSY. 15-7332-46 | 1/4 I.D. x 13.50 | FLEXIBLE CONDUIT 15-7332-104 | 3-1177-3 | | 31-1177-3 | | | | |
| | 4 | | FLEX. COND. ASSY. 15-7332-34 | 1/4 I.D. x 37.50 | FLEXIBLE CONDUIT 15-7332-92 | | | | | | | |
| D | 1 | OIL PROP. FEATH. PUMP | 55-6242-499 3-16922 "Y" TUBE 15-9470-27 | 1 1/4 x .049 | 5250 TUBE | AN 840-21 | NIPPLE | HOSE | ----- | ----- | ----- | PROPELLOR FEATHERING PUMP |
| | 2 | | 65-6242-653 | 1/4 x .049 | 5250 TUBE | AN 840-21 3-16923 | ELBOW "Y" TUBE | HOSE | AN 842-12 | ELBOW | HOSE | |
| | 3 | | 55-6242-499 3-16922 "Y" TUBE 15-9470-60 | 1 1/4 x .049 | 5250 TUBE | AN 840-21 | NIPPLE | HOSE | ----- | ----- | ----- | |
| | 4 | | 15-9470-61 | 1/4 x .049 | 5250 TUBE | ----- | ----- | ----- | 811CT45-12 811BT12D 811T12CS | ELBOW NUT SLEEVE | ----- | |
| | 5 | | 65-6242-701 | 1/4 x .049 | 5250 TUBE | AN 844-21 3-19973 | ELBOW "Y" TUBE | HOSE | AN 842-12 | ELBOW | HOSE | |
| E | 1 & 4 2 & 3 | FUEL (FITTING FROM FIREWALL TO FUEL STRAINER) | ----- | ----- | ----- | AN 840-16 AN 844-16 | NIPPLE ELBOW | HOSE HOSE | ----- | ----- | ----- | ----- |
| | F | 3 | FUEL (PRIMER) | 55-7348-405 | 1/4 x .035 | 5250 TUBE | 811CT-4 811BT4D 811T4CS | ELBOW NUT SLEEVE | --- | 811CT-4 811BT4D 811T4CS | ELBOW NUT SLEEVE | ----- |
| G | ALL | FUEL (FROM RESTRICTION FITTING TO PRESSURE TRANSMITTER) | 15-11693-3 | 1/4 x .032 | COPPER | 811T4CS | SLEEVE | --- | 811BT4 | NUT | --- | FUEL PRESSURE TRANSMITTER |
| A* IDENTIFICATION NUMBER B* INSTALLED ON NACELLE X-36 | | | | | | | | | | | | |

A* IDENTIFICATION NUMBER B* INSTALLED ON NACELLE

Figure 125—Engine to Firewall Connections (Sheet 4 of 4)

Check the anti-icer feeder tube assembly to assure that it will clear the slinger ring when the propeller is removed.

14. Remove the propeller.

(b) Remove the accessory cowl.

(c) Remove the ring (nose) cowl as follows:

1. Disconnect the electrical bonding at the center of each cowl section.

2. Remove the lower stationary cowl flap.

3. Unscrew the nuts on the three cowl bolts, at the lower connection, until the bolts can be removed. A strap or rope tightened around the ring cowl makes it easier to remove these bolts. If no strap or rope is available, loosen and disengage the forward and rear bolts first, without removing the cotter pins. Take out the cotter pin from the center bolt and unscrew the nut until the bolt can be disengaged.

4. Loosen the Dzus fasteners on the sides of the ring cowl. Lift and pull the two side pieces forward to remove them. The top section can then be removed.

(d) Disconnect the flap control rods at the engine. Remove the vertical control rods up to the bell cranks to allow the top back cross bar of the engine mount to go forward. Replace the bolts in the part of the control rods connected to the firewall.

(e) Remove the manual meshing cable at the starter.

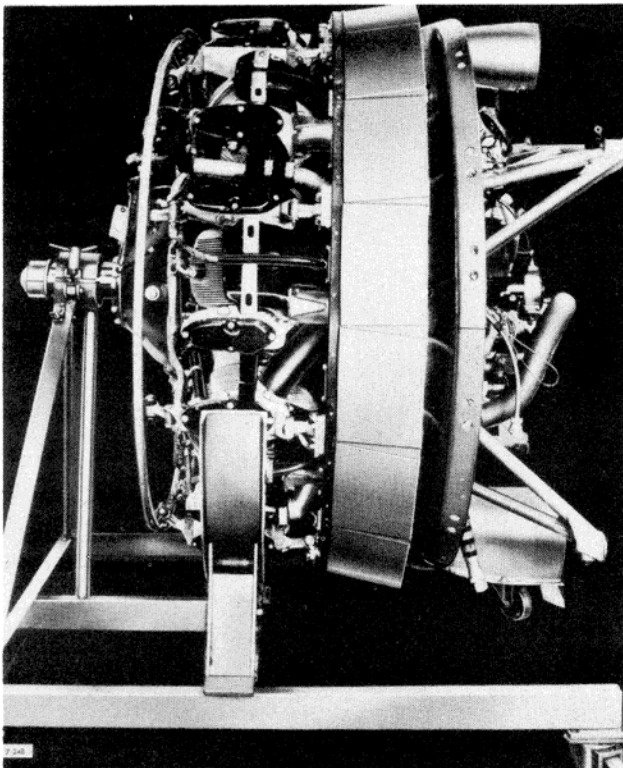


Figure 126—Engine on Handling Dolly

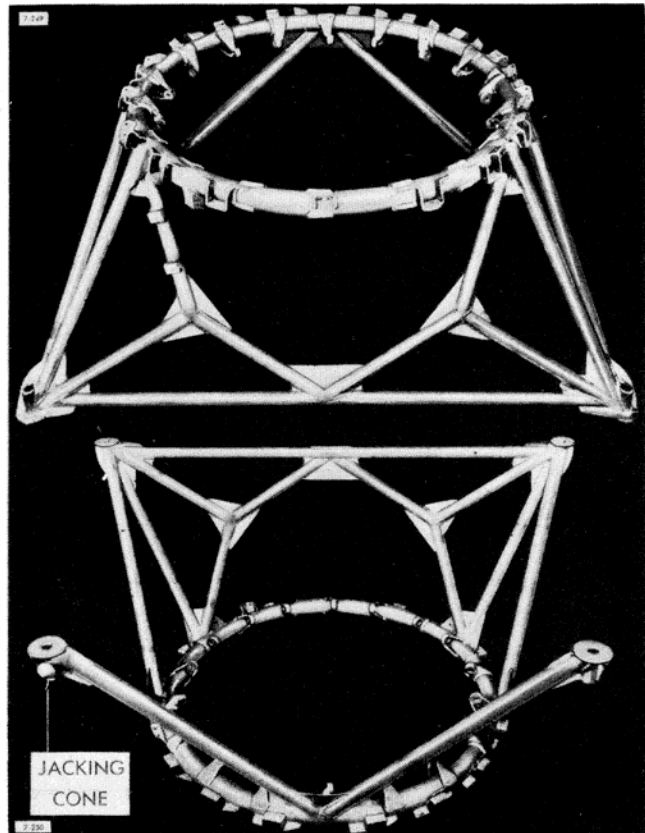


Figure 127—No. 1 Engine Mount Details

(f) Make all disconnections necessary at the firewall at the points indicated by a coating of yellow paint, observing the following precautions:

1. Tubes which are anchored to either the firewall or the engine mount may be separated along the line at the hose connection.

2. Leave the hose connection on the lines which are connected to the mount or to the engine. They will be of help when new connections are installed, as required at engine change.

3. Make all electrical disconnections at the double knurling.

WARNING

Remove the "Y" leads at the top of the magneto before removing the magneto plug at the firewall. Unless this is done, the engine will be capable of full operation when the magneto plug is removed, regardless of the position of the ignition switches.

4. Lash the propeller governor control cables to the firewall without releasing all of its tension.

5. Disconnect the carburetor linkage at the carburetor side of the bell crank.

6. Wire both halves of the exhaust flexible coupling together and wire to the shroud to prevent damage to it when the engine is removed.

7. Check to see that all disconnections have been made.

(g) Remove the ring cowl support brackets and the cowl flap support brackets from number 1 and number 9 cylinders.

(h) Install the engine sling to number 1 and number 9 cylinders adjusting the metal straps so that the longer strap is on number 9 cylinder allowing the engine to be lifted vertically. Attach the sling, using the special nuts provided on the strap. Screw the pin flush but not tight. Check the strap; it should rest on the shoulder of the nut and not on the stud.

(i) Place the hoist directly in front of the propeller shaft and adjust the hook and the wire line clamp. (On engines number 1 and 2, the adjustment of the wire line clamp can be found almost in the middle of the wire line. On engines number 3 and 4, it is approximately straight up from the strap fastened to number 1 cylinder.)

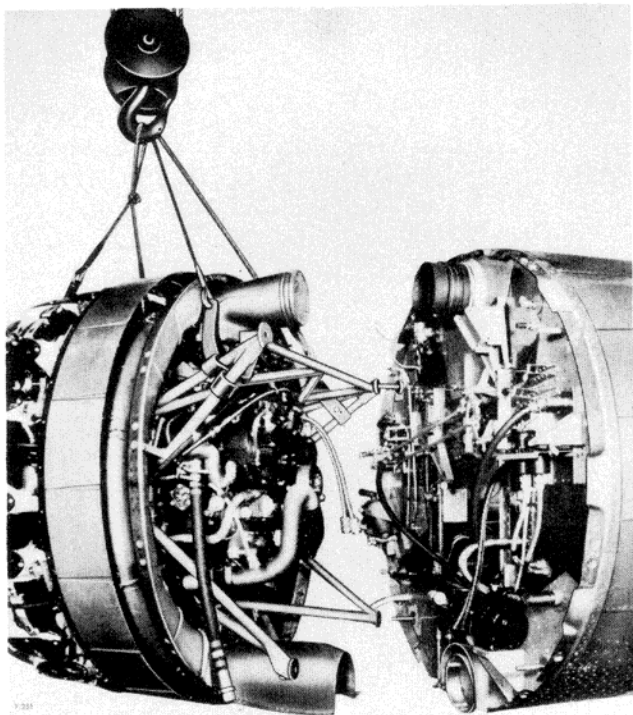


Figure 128—Typical Engine Removal

(j) Tighten the hoist and loosen all four engine mount nuts. Loosen the lower nuts about 1/4 inch and continue to tighten the hoist until the bottom of the mount begins to travel away from the mounting pads. Remove the nuts, lower ones first, and swing the engine free of the firewall—taking care that the mount comes off all four bolts evenly.

(k) As soon as the mount is free, check all lines, tubes, and controls to see that they are disconnected.

(l) Carefully lower the engine onto the over-haul or assembly stand.

WARNING

Stay clear of the engine while it is on the hoist.

(m) Cover all open ports and tube openings with cover plates, cardboard, or tape. *Do not plug the ports or openings.*

WARNING

Removal of the plug at the fire wall breaks the magneto ground connection, permitting full operation of the engine regardless of the position of the ignition switches in the cockpit. In order to avoid injuries to personnel, provisions must be made to ground the magneto immediately after disconnecting the magneto plug. For this purpose a dummy receptacle in which all three prongs are wired together (thus grounding the magneto) will be substitute for the receptacle at the fire wall.

(n) Disconnect the turbo supercharger pressure duct elbow at the flexible joint at the fire wall.

(o) Attach hoist sling securely to engine and engine mount.

(p) Loosen the four bolts attaching the engine mount to the fire wall, but do not remove completely.

(q) Remove lower bolts and make a final check to be sure that everything is clear and the hoist is tight.

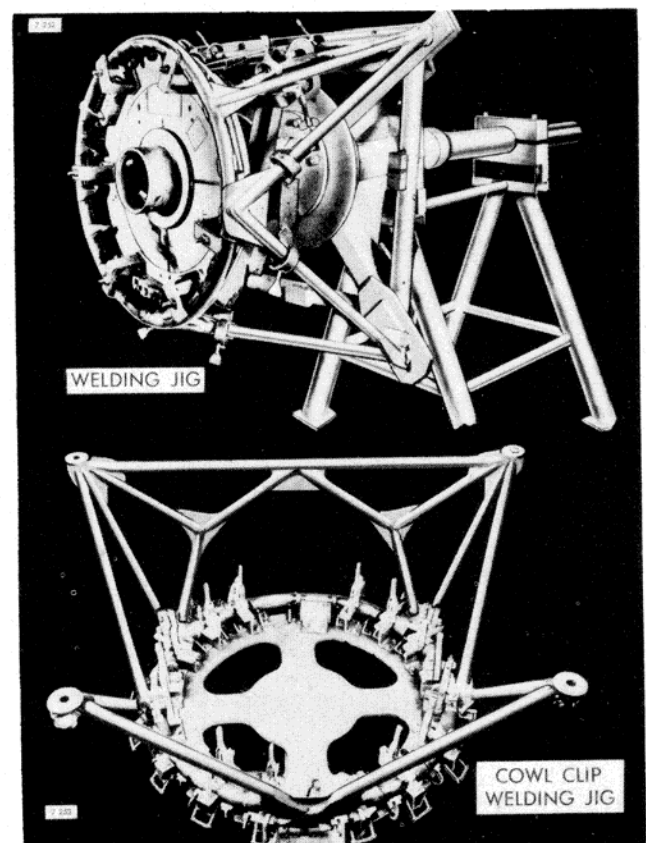


Figure 129—No. 1 Engine Mount Assembly

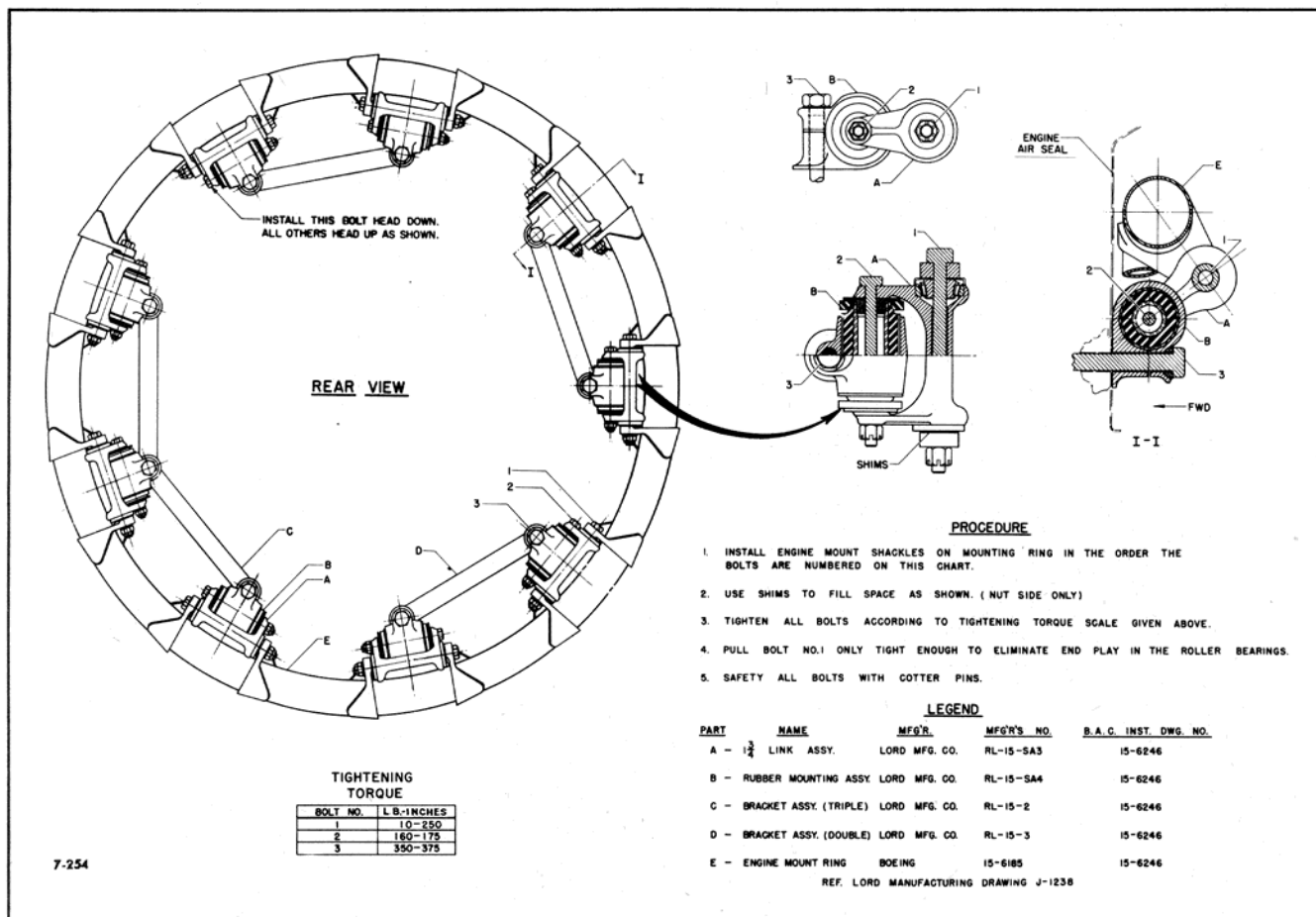


Figure 130—Engine Dynafocal Suspension Details

(3) INSTALLATION OF ENGINE SECTION.

(a) The procedure to be followed in replacement of the engine section is in general the reverse of that specified for removal.

(b) The Lord dynafocal engine suspensions should require very little attention, if any; but at major engine overhauls they should be disassembled, magna flux tested, and inspected for flex cracks in the rubber parts and for flat spots or brinelling in the tapered roller bearings. The bearings should be thoroughly washed out at this time and repacked with fresh grease when re-installed. At the second major engine overhaul or approximately 800 hours of operation, the mountings should be removed, and it is probable that a number of the units will be sufficiently flex cracked that the rubber elements will have to be replaced.

(c) In attaching the engine mounts to the nacelles, the four 5/8-inch steel nuts should be tightened to a torque of 900 to 1,200 pound-inches. The usual procedure is to tighten the nuts to a 600 to 800 pound-inch torque, then tighten the nuts to the next castellation and cotter securely.

(d) Install the flexible ball and socket joint in the exhaust stack with the smaller diameter tube forward. This precaution minimizes the amount of exhaust gases escaping from the joint.

WARNING

Do not start engine without installing the nacelle cowling as the engine fire extinguishers require a closed accessory compartment for satisfactory operation.

(e) Whenever a new or overhauled engine is installed, the installation will be ground tested and flight tested as directed in paragraphs c., (18) and (19).

b. EXHAUST, AIR INDUCTION AND TURBO SYSTEMS.

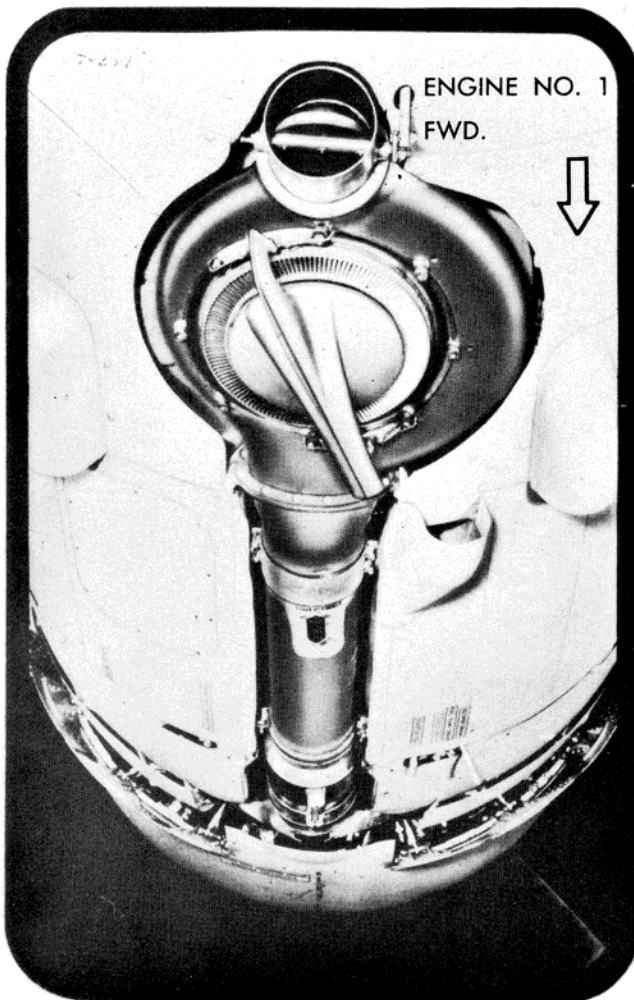
(1) GENERAL.

(a) Each engine is individually equipped with either the type B-2 or the type B-22 General Electric exhaust-driven turbosupercharger. The type B-2 and the type B-22 turbosuperchargers are interchangeable and differ only in their structural characteristics and the type of lubricating oil lines which they use. Unless otherwise noted, the material given in this section is applicable to both types of turbosuperchargers. Duct inlets for carburetor air and intercooler air are paired near the nacelles in the leading edge of the wing. The turbo is installed in the engine exhaust system at the bottom of the nacelle. On the outboard nacelles the location is forward of the front spar, but on the inboard nacelles



Figure 132—Exhaust Manifold and Tail Pipe Details, Engine No. 2



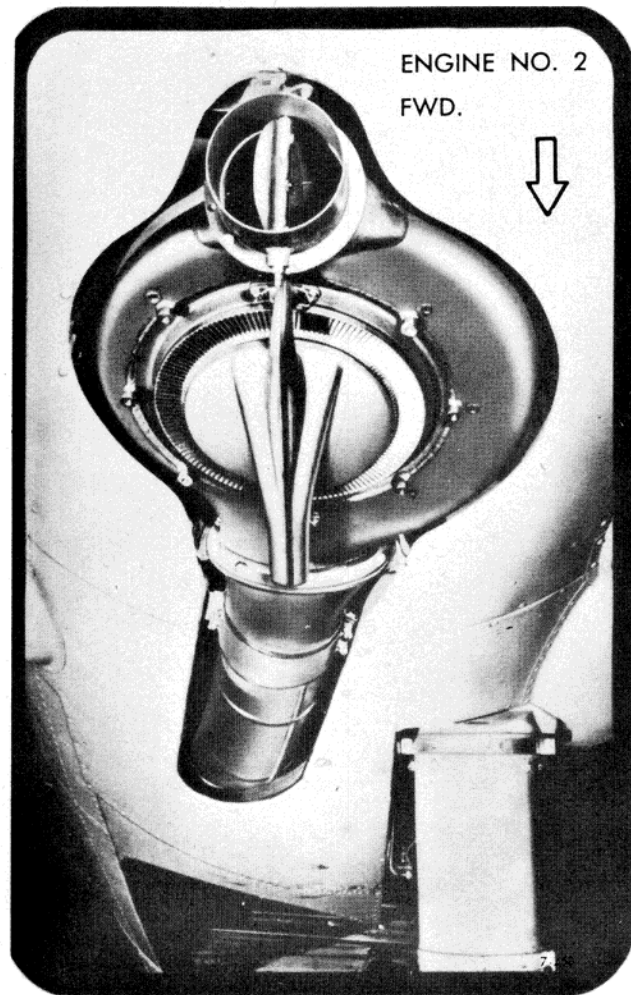


**Figure 133—Turbosupercharger Installation,
Engine No. 1**

the wheel well forces installation of the turbo (and intercooler) aft of the front spar.

(b) The induction system is designed so that carburetor air must pass through the turbosupercharger impeller and intercooler at all times. Exhaust gas pressure drives the turbosupercharger impeller by being forced to flow through a nozzle box where the gases are directed against a turbine wheel mounted on the lower end of the impeller shaft. The flow of exhaust gas through the turbine wheel is controlled by the waste gate in the nozzle box; thus all or a part of the exhaust gas may be utilized to obtain the desired manifold pressure. The exhaust tail pipe terminates at the turbo.

(c) Carburetor air flows into the duct system at the wing leading edge and passes to the turbosupercharger impeller, by which it is compressed and forced through the intercooler into the carburetor. A relief valve is provided in the turbosupercharger intake duct to permit the entrance of air to the turbosupercharger in case the flow through the inlet is accidentally restricted.



**Figure 134—Turbosupercharger Installation,
Engine No. 2**

(d) Selection of either filtered or unfiltered air for the carburetor is possible through a tee joint and valve assembly installed in the intake duct to the turbosupercharger. Filtered air is obtained by adjusting the control valves so that air from inside the wing (or nacelle) passes through cleaning elements before being introduced into the turbosupercharger. Unfiltered air is supplied to the turbosupercharger by moving the valves to the alternate position which allows air to flow from the wing leading edge directly to the turbosupercharger. The electric motor for operating the valves is mounted on the valve duct assembly and is controlled by a switch in the cockpit.

(e) The inboard intercooler is located in the wing, directly aft of the nacelle, while the outboard intercooler is situated vertically in the nacelle, immediately behind the fire wall. The purpose of the intercooler is to reduce the carburetor air heat resulting from compression by the turbosupercharger. This reduction in temperature is accomplished by the passage of cold air around the intercooler from a second intake duct. The cooling air is then spilled overboard through

slots in the wing surface. Thus the intercooler is similar to a Prestone radiator or oil cooler. On some airplanes there is a system to determine the carburetor air temperature just before it enters the carburetor. This consists of an AN 5525-2 bulb thermometer located in the air duct elbow on the carburetor, and an F-10 or an AN 5795-6 indicator located on the lower right hand side of the co-pilot's instrument panel.

(f) A turbosupercharger lubricating oil tank of 1.5 U. S. gallons (1.2 Imperial gallons) capacity is located on the upper inboard side of each outboard nacelle and aft of each inboard nacelle at the wing rear spar.

(2) EXHAUST SYSTEM.

(a) REMOVAL.

1. The outboard exhaust tail pipe may be removed by disconnecting two ring clamps, one immediately forward of the supercharger and the other near the spring-loaded flexible coupling at the rear of the engine. An access door is provided on the lower outboard side of the nacelle to facilitate this operation.

2. In removing the inboard stacks it will be necessary to remove the access panels on the bottom of

the nacelle fairing aft of the wheel well. Better access to the clamp may be obtained by removing portions of the exhaust shroud in the rear of the wheel well.

(b) MINOR REPAIRS AND REPLACEMENTS.

1. EXHAUST COLLECTOR RING SEGMENTS—The following outline gives briefly the steps and materials needed to repair exhaust segments in the field. An attempt has been made to simplify the requirements as much as possible in order to suit service conditions.

Exhaust collector rings can be repaired by welding. The extent of welding required to effect a repair is of no consequence providing the quality of the weld is satisfactory. The welding procedure will depend on the material of the exhaust collector. 18 and 8 stainless steel is the material used on most B-17G airplanes; however, on earlier airplanes of this model, inconel was used. Before the repair can be attempted, the type of material must be determined by preparing a solution of 10 grams of cupric chloride with 100 c.c. of concentrated hydrochloric acid. Place a few drops of this solution on a cleaned flat spot on the surface of the exhaust collector and let it stand from two to four min-

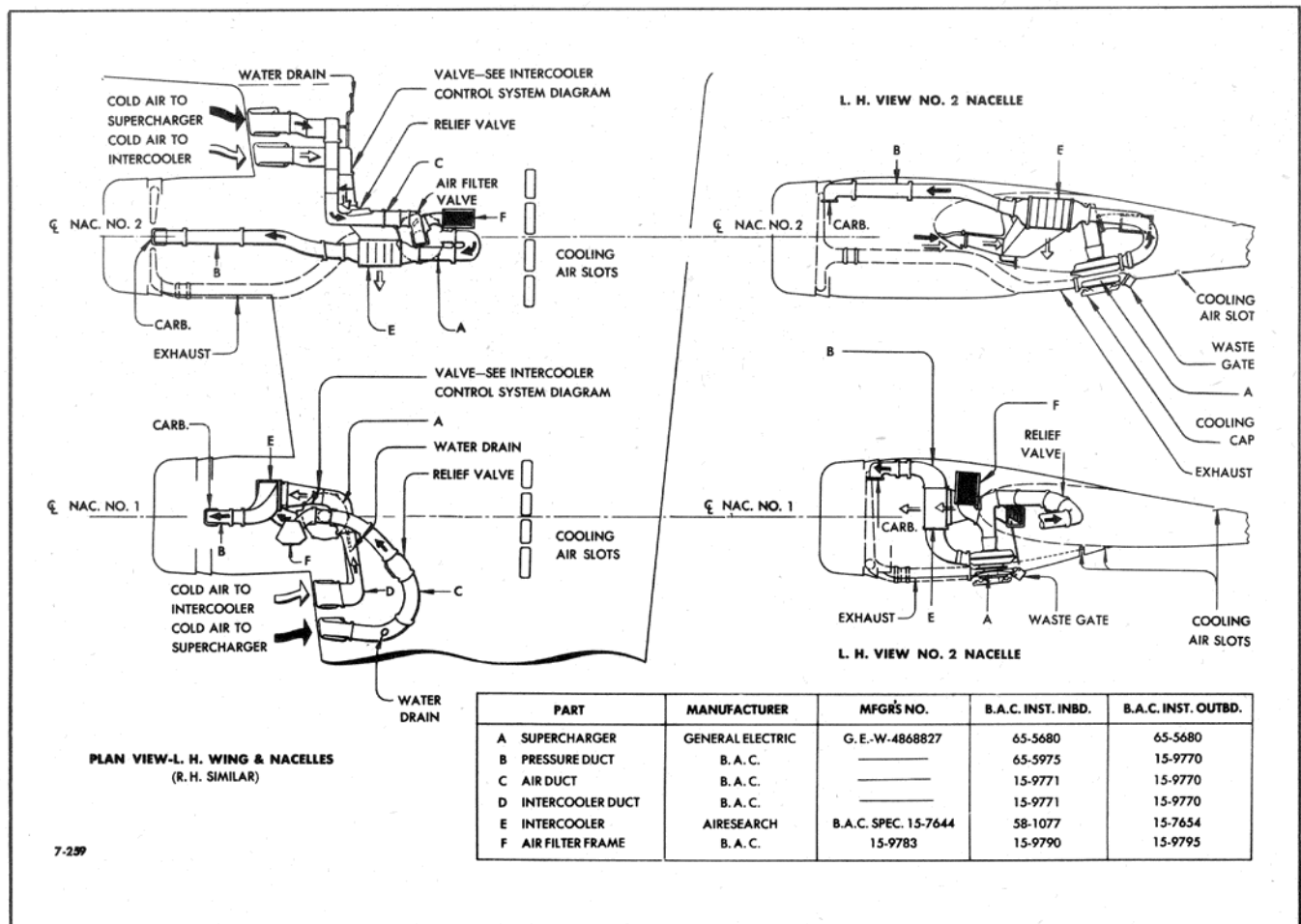
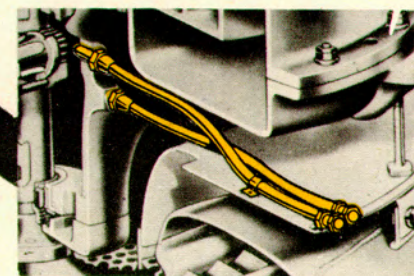
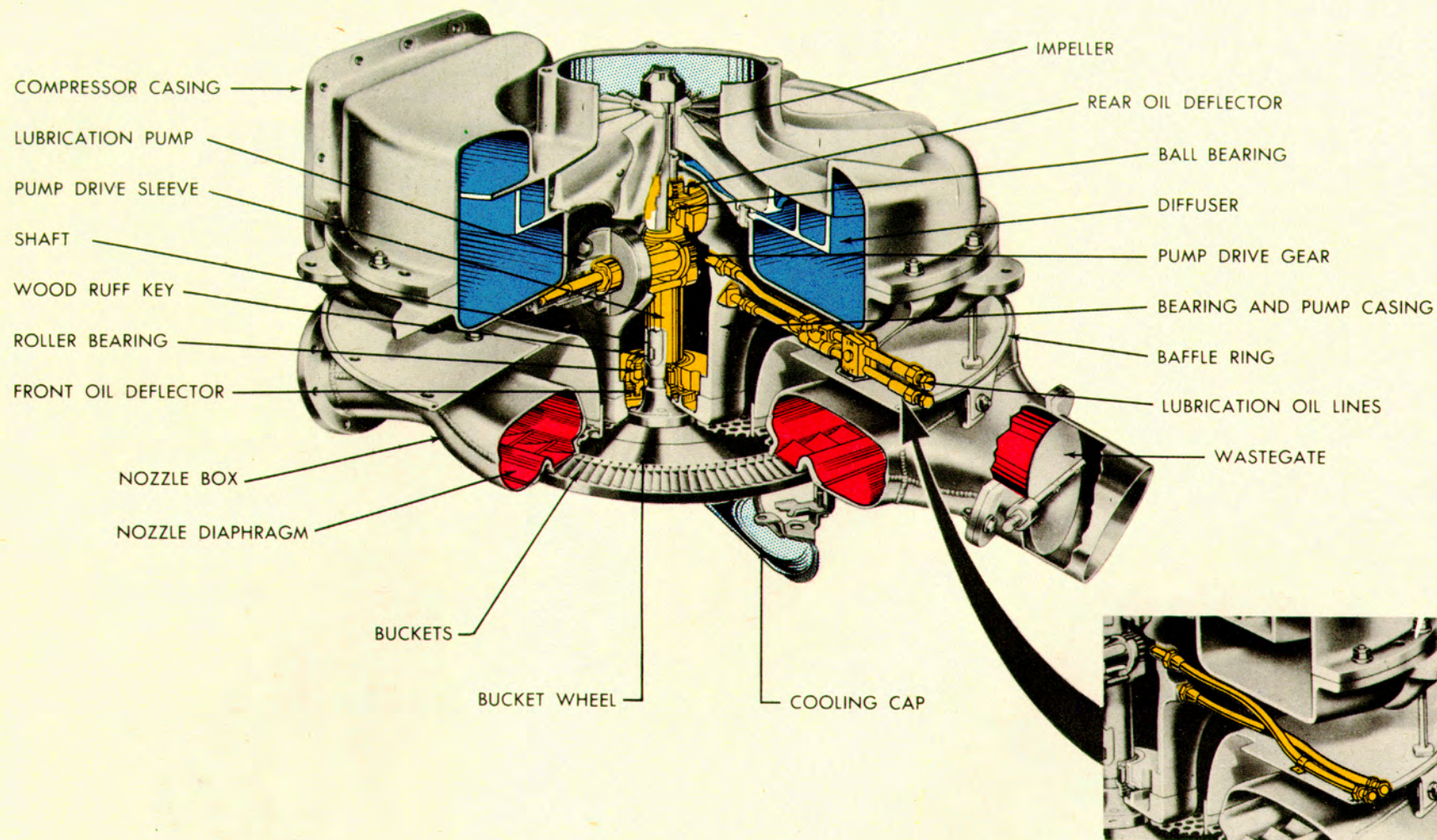


Figure 135—Supercharger Installation Diagram



LUBRICATION OIL LINES
TYPE B-22 TURBOSUPERCHARGER

■ EXHAUST GASES
 ■ OIL
 ■ COMPRESSED AIR
 ■ ATMOSPHERIC AIR

Figure 136—Cutaway View—Type B-2 and Type B-22 Turbosuperchargers

utes. Then slowly add three or four drops of water before washing the spot completely. If the material is 18 and 8 stainless steel, the spot will be copper colored; if it is inconel, the spot will be white. After the type of material used in the collector has been determined, the collector may be repaired by welding as follows.

a. WELDING PROCEDURE—18 AND 8 STAINLESS STEEL

(1) Gas weld using Page Allegheny or any A.C. specification rod, (flux on rod). In the event that these are not obtainable, an Oxyweld No. 28 rod with Chromalox flux is permissible.

(2) Pickle after welding in a solution containing by volume: 10 percent sulphuric acid, 10 percent common salt-NaCl, 80 percent water. (The temperature of the solution should be between 67° and 77° C. (150°-170° F.).

(3) Rinse in hot water.

(4) Neutralize in a solution of 20 percent to 30 percent nitric acid and water at room temperature.

b. WELDING PROCEDURE—INCONEL.

(1) Weld using a No. 132 inconel arc welding rod (flux on rod) or a No. 42 inconel gas welding wire with an inconel gas welding flux.

(2) Pickle after welding in a solution consisting of one gallon of nitric acid (38 percent Beame), 1¼ pints of hydrofluoric acid (40 percent), and one gallon of water.

(3) Rinse in hot water.

(4) Neutralize in a 50 percent ammonia bath.

(c) ADJUSTMENTS.—Adjust the clearance between the exhaust collector segments and the exhaust collector ring clamps so that the clamp can barely be rotated with both hands. This adjustment is to be made with the segment and the clamp concentric by either removing material from the lug faces or by shimming

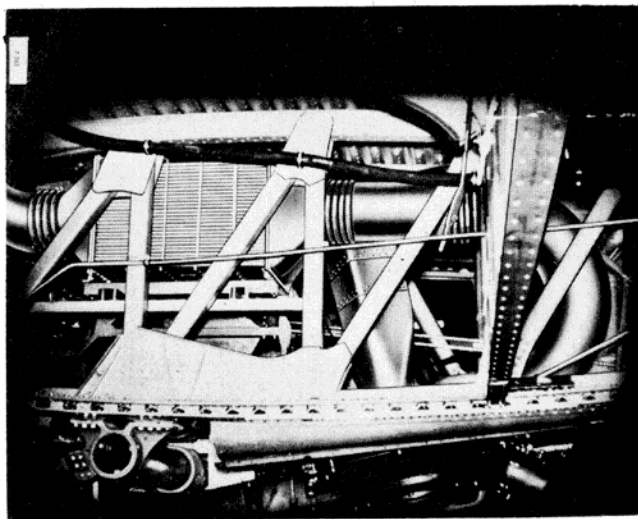


Figure 137—Intercooler Installation, Engine No. 2

between the lugs. The clearance must not exceed .040 inches.

(d) ASSEMBLY AND INSTALLATION.—REVERSE THE REMOVAL PROCEDURE.

(3) AIR INDUCTION SYSTEM.

(a) REMOVAL.

1. INTERCOOLER.—The outboard intercoolers are located on the inboard side of the nacelle and removal must be accomplished through the access door in the upper portion of the nacelle. Remove the mounting bolts in the lower portion of the intercooler; disconnect the duct from the intercooler inlet at the flexible coupling and the duct to the carburetor at the top of the intercooler. Take special care to avoid damage to the intercooler from surrounding structure when removing from the nacelle. The inboard intercoolers must be

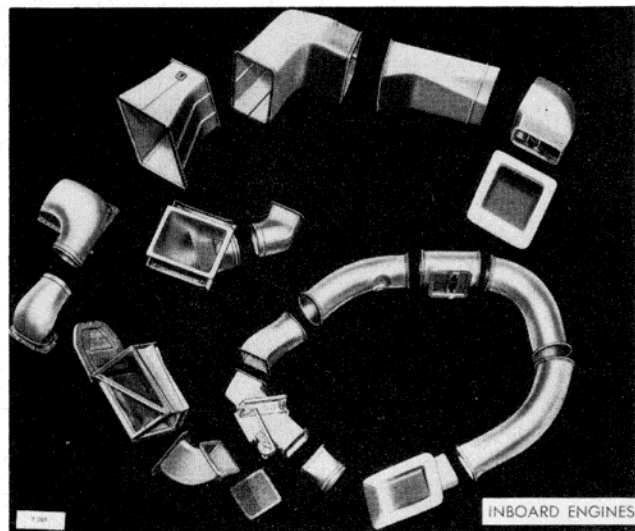


Figure 138—Turbosupercharger Ducts, Engine No. 1

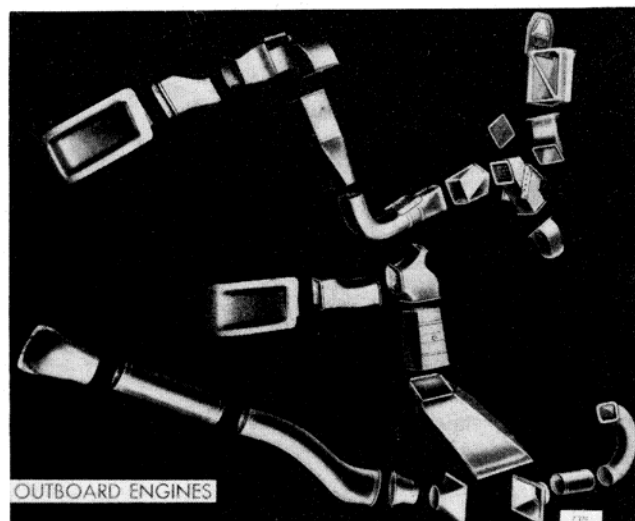


Figure 139—Turbosupercharger Ducts, Engine No. 2

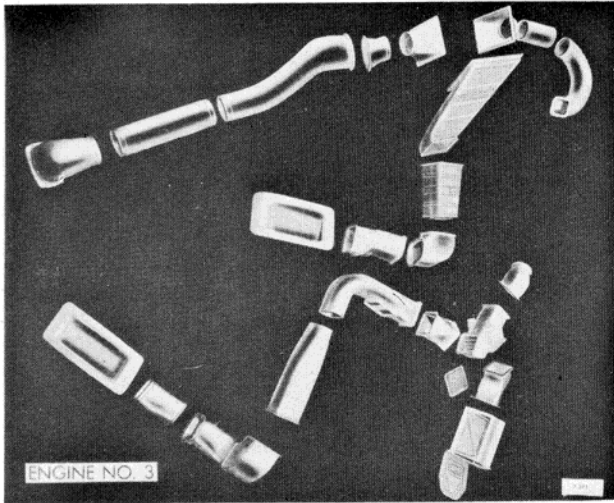


Figure 140—Turbosupercharger Ducts, Engine No. 3

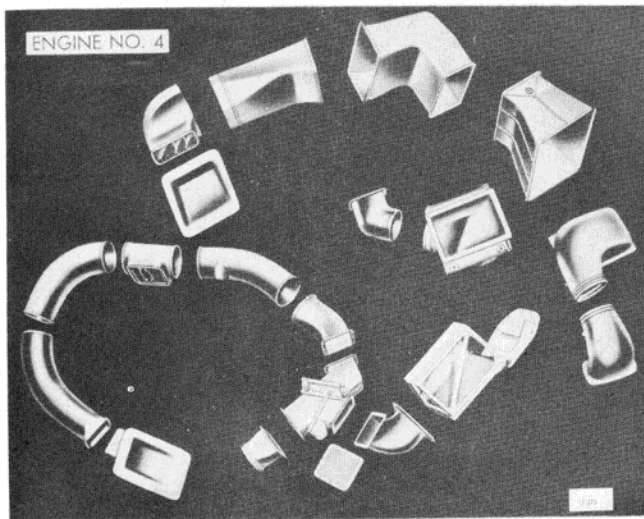


Figure 141—Turbosupercharger Ducts, Engine No. 4

removed through the supercharger emplacement and the same precautions must be applied as those observed in removing the outboard intercoolers.

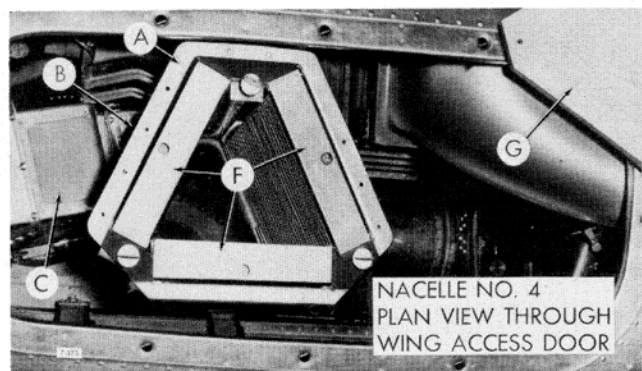
2. DUCTS.—In removing any duct, special care must be taken to protect all flexible couplings from undue damage. Vibrational failure or buckling of the duct may occur in dented or bruised areas after installation.

3. CARBURETOR AIR FILTERS.—The outboard filter frames and valve assemblies are removed through the access door in the top of the nacelle. The filter elements only may be removed for cleaning by loosening one Dzus fastener in the retaining door and withdrawing the three elements from the frames. Removal of the filter elements permits access to the mounting bolts for both the filter frames and the control valve ducts. Disconnect the electrical wiring to the valve motor before attempting to remove either an inboard or outboard valve duct assembly. The filter elements on

the inboard assembly are reached through the inboard access door in the lower surface of the wing and are removed rearward from the frames by loosening one Dzus fastener. The inboard filter frames and control valve ducts can be removed only after removal of the inboard fuel tank and the turbosupercharger.

(b) MINOR REPAIRS AND REPLACEMENTS.

1. Leaks of any description in either the engine exhaust system or the carburetor air induction system will result in reduced performance. Leaks in the exhaust system will reduce the ability of the supercharger to maintain sea level pressure up to the rated altitude of the supercharger. Aside from this there will be no other apparent effect on engine operation from this cause. Leaks in the induction system will be directly reflected in engine operation and, in many cases, engine malfunctioning from this cause may be erroneously attributed to icing or to improper operation of some other engine accessories or to the engine itself. The joints in the air induction system should be made airtight by means of shellac or gasket paste. Carburetor shaft pack-



A. Air Filter Frame
B. Carburetor Air Filter
C. Air Filter Valve
D. Valve Control Motor
E. Supercharger Duct
F. Filter
G. Filter Cover

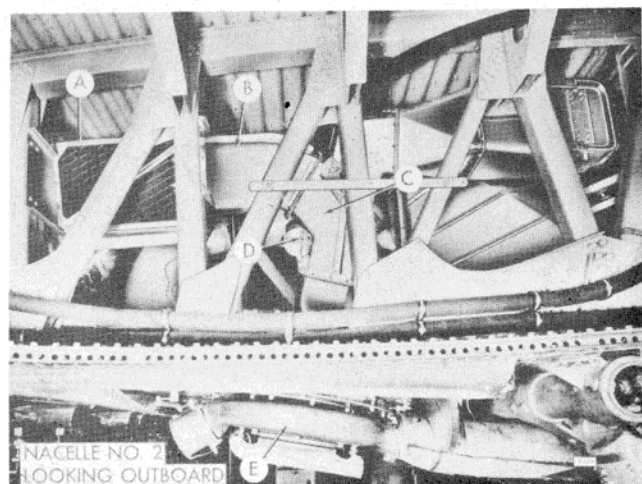


Figure 142—Carburetor Air Filter Installation

ings should be properly adjusted so as neither to leak nor bind the shaft.

2. Repairs for minor injuries in ducts may be made by welding or riveting. In case of damage the equipment should be surveyed to determine the advisability of attempting a repair or of replacing with a new part. A welded repair may be accomplished by trimming a patch of soft aluminum sheet, one gage heavier than the part being repaired, and sufficiently large to extend approximately one inch beyond the edges of the injury. Form the patch to suit the contour of the duct and weld the edges securely. A permanent repair may also be made by riveting, provided a suitable gasket is placed under the patch to prevent leakage. In many cases standard riveting will be found impracticable as both sides of the repair may not be accessible, in which event blind rivets may be used satisfactorily.

3. Should welding or riveting equipment not be available, temporary repairs may be made as follows: Smooth off the edges of the damaged area and wrap the

duct with a layer of doped tape, covering the hole and extending approximately three inches on either side. Next shape a piece of soft sheet aluminum to fit the contour of the damaged duct and sufficiently large to extend about one inch beyond the edges of the hole. Place this piece of material over the injury and hold in place with several layers of spirally wrapped pinked tape impregnated with dope. If desired, the metal patch may be held in place with sheet metal screws followed by wrapping with doped tape. This procedure is to be used only in an emergency and must be replaced with a suitably welded or riveted repair, or a new part, at the first opportunity.

4. INTERCOOLER AND DUCTS.—Repair of the intercooler should not be attempted and any damaged units must be replaced by a new part. The ducts and intercooler may be pressurized for test by disconnecting and sealing at the supercharger and at the carburetor. Apply 10 pounds per square inch air pressure to a fitting at the seal on the carburetor end.

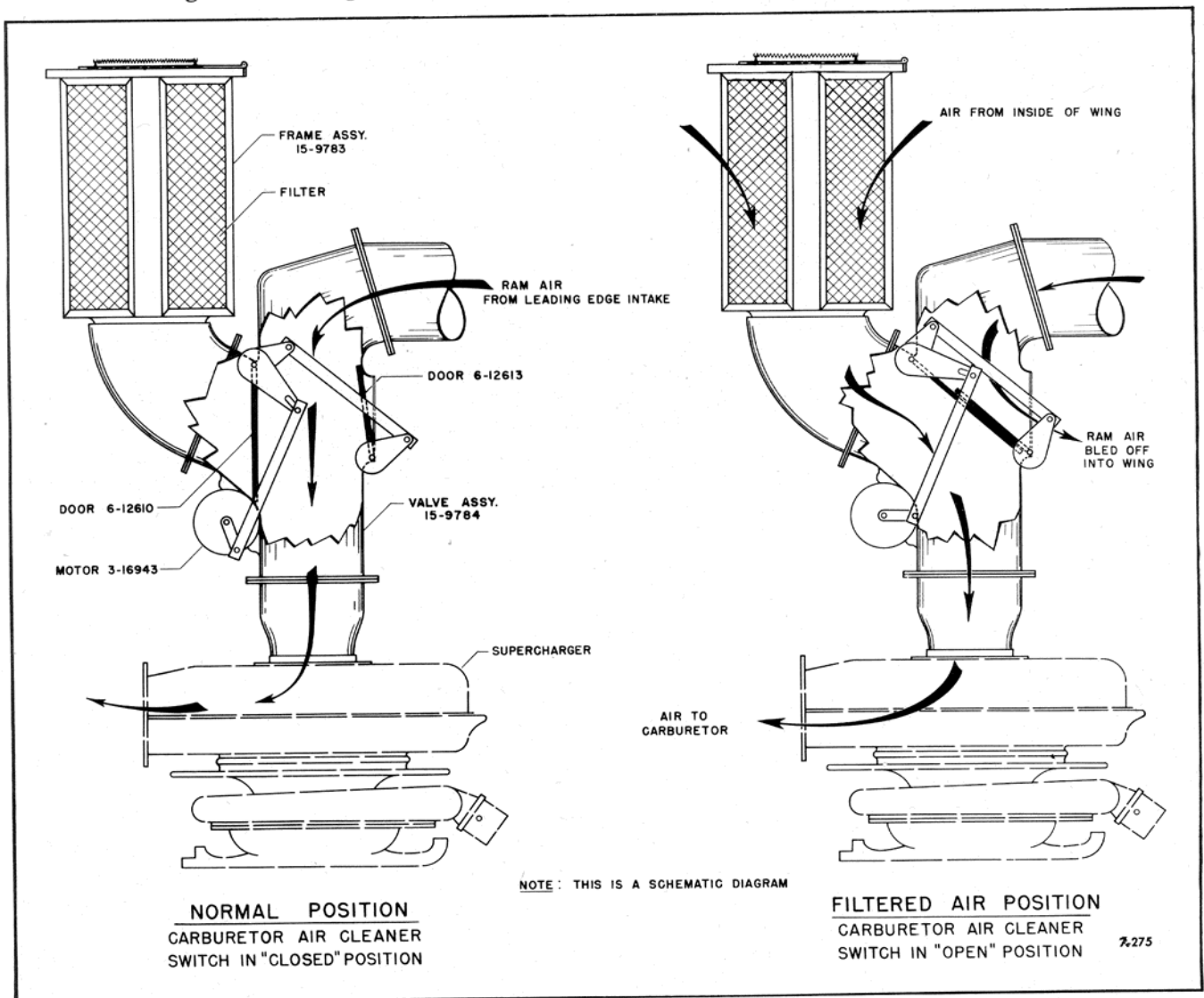


Figure 143—Carburetor Air Filter Valve Control

5. CARBURETOR AIR FILTERS.—Minor repairs for the filter and valve assembly should be confined to operations as described for intake ducts. In case of damage to the valve assembly, it will in all probability require a new part since injury to the vanes would render them inoperative and irreparable. Clean filter elements as described in section X, Daily Inspection.

(c) ADJUSTMENTS.

1. CARBURETOR AIR FILTER LINKAGE AND MOTOR LIMIT SWITCHES.

a. Adjust the controlling linkage to permit complete opening and closing of the vanes before installing the motor on the valve assembly. This is accomplished by properly locating the bolt in the serrated slot at the upper end of the link connecting the vane bell cranks.

b. Remove the motor actuating arm from the splined shaft.

c. Mount the motor loosely in the supporting bracket with the electric receptacle at an angle of 60 degrees to 90 degrees from the horizontal, which will provide proper clearance for electrical wiring.

d. To locate the fixed limit stop of the motor, attach the power plug to the receptacle.

CAUTION

Since all air filter motors are controlled by one switch in the cockpit, it is imperative that the power plugs be inserted in left installations only or right installations only, during their respective linkage adjustments.

e. Turn the motor to the *fixed* limit stop by opening the switch in the cockpit. For right installations turn the switch to "ON" and for left installations turn the switch to "OFF."

f. Turn the *adjustable* limit screw and lock nut, located on the end of the motor housing, COUNTER-CLOCKWISE until the screw engages its stop.

g. Assemble the linkage from the vane bell crank to the motor as follows:

(1) Locate the bolt in the extreme end of the vane bell crank slot.

(2) Place the motor arm in the splined shaft so that the vanes are in the open (unfiltered air) position for right installations and in the closed (filtered air) position for left installations. The linkage should be sufficiently free to eliminate excessive friction and to permit limited motor coast without distorting the vanes.

h. Clamp the motor in its support; then secure the motor against rotation by tightening serrated lock.

i. Turn filter control switch to "ON" to close vanes on left-hand installations or to "OFF" to open vanes on right-hand installations. The limit switch will stop the motor before the vanes complete their travel to the positions given.

j. Make repeated trials, closing the limit stop adjusting screw only 1/16 turn, CLOCKWISE, per trial, until the motor stops the vanes in the desired position.

CAUTION

Should the limit switch adjusting screw be rotated more than 1/16 turn per trial, the vanes may be seriously damaged by the motor failing to stop when the vanes reach the full closed or full open position.

k. Operate the filter valves several times to check proper final position and acceptable motor coast. Vanes should come to rest in either the full open or full closed position with sufficient pressure to assure an effective air seal without exerting undue tension or strain on the vanes. Lock nut the limit switch adjusting screw when the desired vane position has been obtained.

l. If the limit switch adjusting screw reaches the end of its travel before the vanes are in the desired position, proceed as follows:

(1) Move the link bolt 1/8 inch up the serrated slot in the vane bell crank.

(2) Remove the actuating arm from the splined shaft on the motor.

(3) Loosen the motor clamp and serrated lock, allowing rotation of the motor if necessary.

(4) COMPLETELY REPEAT ALL THE ADJUSTING PROCEDURE OUTLINED ABOVE, BEGINNING WITH ITEM (c).

(d) TESTS.—In most cases of air leaks, the manifold pressure gage will either show a falling off of pressure or give an erratic reading which will usually be accompanied by malfunctioning of the engine, as evidenced by detonation, preignition, or loading. In attempting to supercharge with a leaky induction system, a progressively higher exhaust back pressure is built up, which is required to drive the supercharger at higher speeds to supply the excessive quantities of air required. This condition finally will reach the point where the exhaust back pressure will become so high that normal engine operation can no longer be maintained. Whenever evidence of this condition appears, the induction system must be thoroughly checked for leaks and if necessary, pressure tested. Induction system pressure tests are performed as follows:

1. Remove the supercharger from the airplane, providing a support for the air cooler if required.

2. Bolt a plate, which is fitted with a 3/8-inch pipe fitting to the air cooler inlet, sealing with a suitable gasket.

3. Close throttle and apply about 10 pounds air pressure to the pipe fitting on the plate, using soap suds on all joints to discover leaks. This pressure must not fall below five pounds per square inch in less than three minutes. If the above pressure cannot be main-

tained, leaks may be detected by bathing the induction system with soapy water. Maintain free action of the relief valve in the inlet duct at all times. Under certain conditions it may be advisable to smoke test the induction system for leaks as outlined under "INSTALLATION" of the turbosupercharger.

(e) ASSEMBLY AND INSTALLATION.

1. CARBURETOR AIR FILTERS.

a. The actuating motor is mounted on the valve body before the assembly is installed in the airplane. The valve linkage and the motor limit switches are adjusted to permit proper seating of the vanes in either the open or closed position.

b. In some filter equipment the valves are not edged with sealing felt, thus requiring a close fit between the valves and valve body. In extreme cases these valves may bind when the assembly is installed in the airplane. When this condition arises it is recommended that the motor arm bolt be removed, so that the linkage may be operated manually, and a check made for interference. Undue binding which may develop can be remedied by inserting a shim, on one side only, under the flange immediately above the supercharger body. Proper location of the shim must be determined by inserting the shim, tightening the mounting bolts, and checking for valve clearance. If binding still exists, relocate the shim and recheck. This procedure is entirely unnecessary when installing valve assemblies equipped with the felt sealing strip.

c. The inboard valve assemblies must be installed before the inboard fuel tanks or the supercharger are in place. After the valve assemblies are installed, mount the filter frames and insert the filter elements. Make certain that the filter elements have been cleaned before installation in accordance with instructions given in section X of this Handbook.

2. DUCTS.—Special care must be exercised to prevent damage to the ducts and flexible couplings when reinstalling them. Dented or bruised areas in the ducts may cause buckling or vibrational failure during the operation of the airplane.

3. INTERCOOLER.—The outboard intercoolers are in the inboard side of the nacelle, and are installed through the access door on top of the nacelle. The inboard intercoolers are forward and above the supercharger installation and are installed through the supercharger well. Before the inboard intercooler can be installed, the supercharger and the inboard fuel tank must be removed. Special care must be exercised to prevent the structure from damaging the intercoolers when they are moved into position. When they are in position attach the fuel transmitter balance line and the duct connection. Replace the intercooler mounting bolts and attach the flexible duct connections. Then connect the intercooler cable controls.

(4) TURBOSUPERCHARGERS.

(a) REMOVAL.—Remove the panels from the

nacelle on each side of the turbosupercharger. Drain the turbosupercharger lubrication tank and disconnect the oil lines from the turbosupercharger, installing protective covers at the connections leading into the turbosupercharger. Remove the cooling cap from its support brackets and install the bucket wheel guard. (Do not remove the support brackets from the mounting lugs, but adapt the wheel guard to fit inside the brackets. Removal of the support brackets should not be attempted in the field as it might result in the bolts breaking off in the mounting lugs.) Disconnect the clamp on the exhaust stack immediately forward of the turbosupercharger, leaving the transition coupling attached to the nozzle box. Detach the intake and the pressure duct from the turbosupercharger; the inboard ducts are reached through the access door in the lower surface of the wing, aft of the turbosupercharger. The access opening in the spar is limited, thus requiring a mechanic of slight stature. On the outboard nacelles the duct connections are accessible through the door in the top of the nacelle. Remove the carburetor air filter (this step is required only in the removal of the turbosupercharger from either *outboard* nacelle). Disconnect the flexible shaft of the turbo governor at the turbosupercharger tachometer connection on the end of the pump shaft. Disconnect the wastegate control linkage from the wastegate lever (bellcrank). Remove the nuts and washers from the mounting bolts supporting the turbosupercharger and carefully remove the turbosupercharger from the airplane.

Note

To remove the outboard turbosupercharger, tip the outboard side downward first. To remove the inboard turbosupercharger, tip the aft side downward first. In order to remove the inboard turbosupercharger, the inboard fuel tank must be removed.

(b) MINOR REPAIRS AND REPLACEMENTS.

1. All repairs involving disassembly of the turbosupercharger proper will be made only by air depots. The turbosupercharger must be kept clean at all times so that failures can be detected by visual inspection.

2. The turbine element of the supercharger, when operating at maximum output, is highly stressed and operates at high temperatures. Therefore, utmost care should be observed to reduce to a minimum the occurrence of the following causes of stretched or broken buckets:

a. Supercharging in excess of the recommended manifold pressure.

b. Excessively rich or excessively lean mixtures.

c. The electrodes on the spark plugs or thermocouples used to measure exhaust gas temperature may break and be blown into the turbine wheel. This

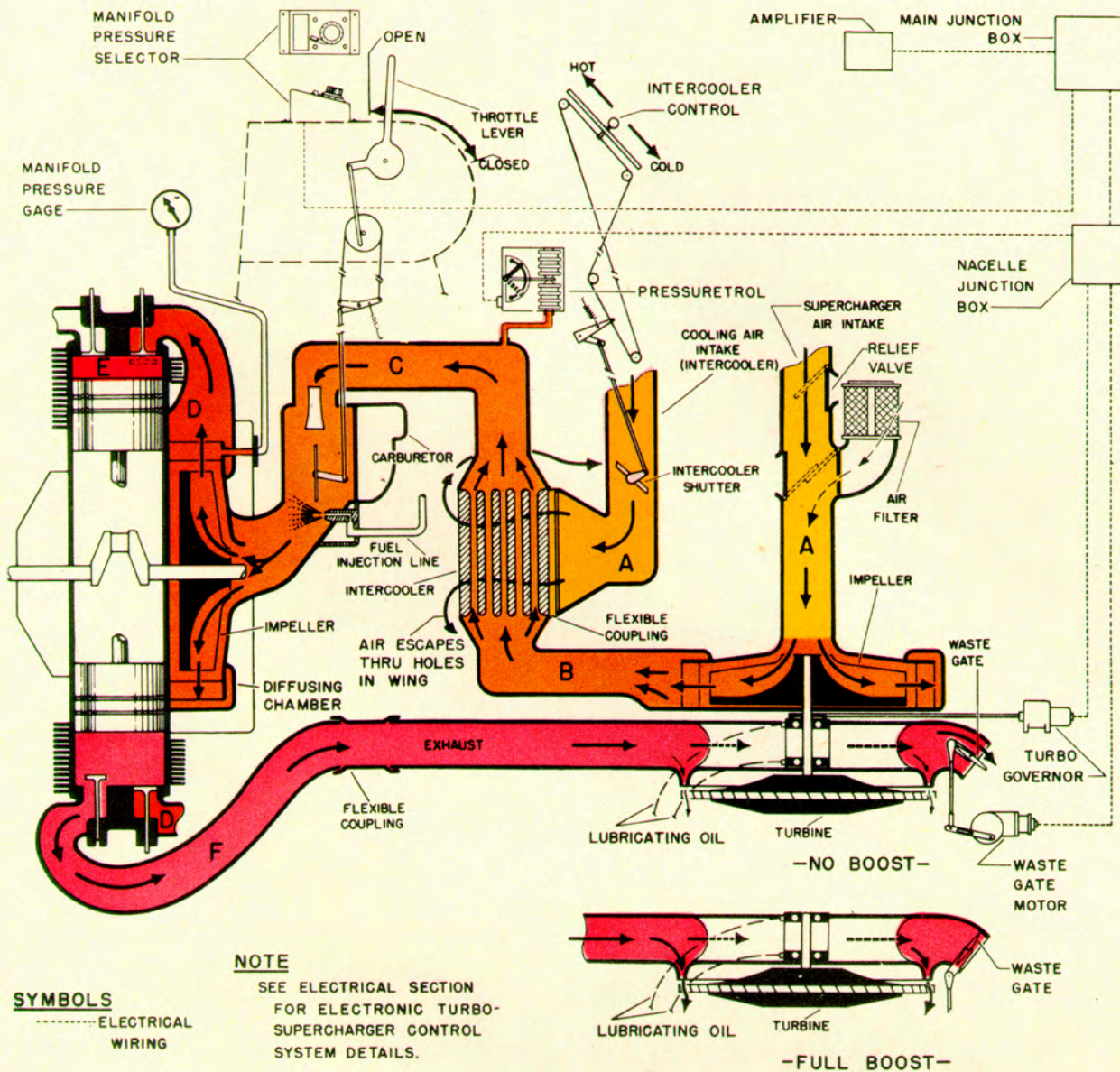


Figure 144—Supercharger Flow Diagram

also applies to any other foreign parts which may pass through the nozzles, such as nuts, cotter pins, etc.

d. Proper clearance must be maintained between the nozzle box and turbine wheel. (Refer to section X—"Service Inspection.")

3. In some turbine wheels there is a tendency for the buckets to tip slightly or open up at the periphery when first operated at high speed and high temperature. When this occurs the rim of the wheel becomes slightly irregular. This condition is normal and may be disregarded unless the distortion is excessive.

(c) ADJUSTMENTS.—Shim the nozzle box mounting bolts to obtain from .070 inch to .160 inch clearance between the nozzles and the turbine wheel buckets. A constant clearance between these limits *must be* maintained to provide satisfactory operation. After replacing the transition clamp in the exhaust stack immediately forward of the supercharger, *recheck* the clearance between the nozzle box and the turbine buckets. In extreme cases an accumulation of shop tolerances may alter the clearance given above. This condition is corrected by reshimming the clamp or reworking the clamp supporting angles.

(d) INSTALLATION.

1. Prior to the installation of the turbosupercharger, measure and record the clearance between the nozzle box and the bucket wheel at four equi-distant points.

2. Inspect all the ducting of the airplane that is to be connected to the turbosupercharger, being sure that no tools, cotter pins, or other loose objects are inside.

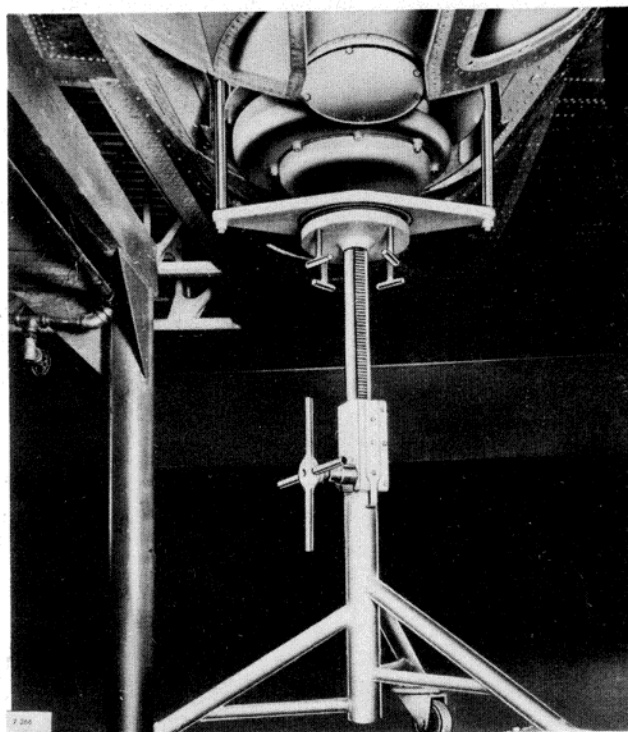


Figure 145—Typical Turbosupercharger Installation Jack

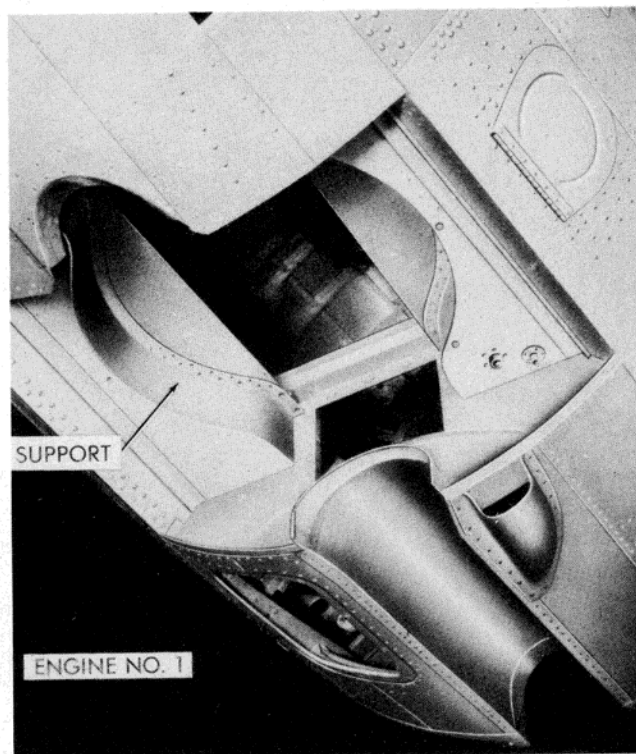


Figure 146—Turbosupercharger Support Installation, Engine No. 1

3. Remove the covers over the nozzle box inlet and the compressor casing inlet and discharge openings. Install the transition pipe of the exhaust stack to the nozzle inlet. Care must be taken to tighten the flange nuts only until the gasket bears firmly against the flanges, as any additional tightening of these nuts will result in failure of the flange bolts when the exhaust system becomes heated during operation.

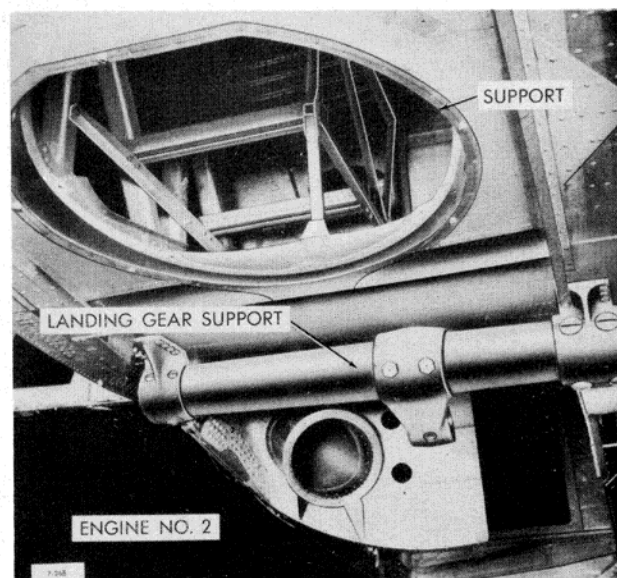


Figure 147—Turbosupercharger Support Installation, Engine No. 2

4. Place the turbosupercharger in the airplane, and install the mounting bolts. Tighten the nuts to such a degree that they will afford support for the turbosupercharger.

Note

When the turbosupercharger is installed in the airplane, its entire weight is carried by the mounting pads on the compressor casing flange. This flange is designed to support the turbosupercharger so that it can withstand the stress produced by every possible maneuver of the airplane. The flanges of the nozzle box and compressor casing openings are not designed to carry any of the weight. This fact must always be borne in mind when installing the turbosupercharger. Neglect of this precaution can result in serious damage to these parts.

5. Line up the connections to the exhaust stack and air intake and air discharge ducting so that there is no pressure required for the connection and so that the mating faces of the flanges are parallel. This usually can be accomplished by shimming the turbosupercharger mounting pads and adjusting the angles by reworking the ducting support brackets. Any misalignment of the connections will result in serious distortion of the nozzle box when the turbosupercharger is operating.

6. Connect the transition pipe attached to the nozzle box inlet to the exhaust stack. Allowance must be made for the expansion of the connection during operation and it is therefore important that a clearance of .020 to .040 inches be provided between the transition section and its supporting clamp. It may be necessary to elongate the bolt holes in the angles attaching the clamp to the shroud to obtain this clearance if it cannot be accomplished by slightly reforming the angles with a mallet.

7. Assemble the ducting of the induction system to the corresponding compressor casing openings, taking care to obtain an air tight connection. Shellac or

gasket paste should be applied to both flanges and to the gasket of each connection to assure an air tight joint.

Note

After the supercharger lubrication lines have been connected and their supply tank has been refilled as outlined in the following paragraph, the induction system ducting may be tested for leaks by disconnecting the elbow duct at the flexible coupling forward of the firewall and placing a cover with a small hole in the opening. If a smoke source is then placed opposite the leading edge duct and the turbo turned over rapidly, the smoke will be pumped through the system and out the hole in the cover. After the ducts are filled with smoke as evidenced by a good smoke flow through the hole, the hole may be plugged and the pressure allowed to rise. Leaks will be easily located by watching for wisps of smoke along the ducts. For a smoke source, it is suggested that titanium tetrachloride be used. This, when wet with water, creates a dense white vapor. To drive the turbo an air jet from a portable air pressure source may be directed at the turbo wheel. After the leaks have been found, remove the smoke source and the duct cover. The turbo should then be run about three minutes to clear the duct system of fumes.

8. Check the stamped markings on the gear housing to assure that the supercharger lubricating oil "IN" and "OUT" lines are correctly identified at the supply and return line connections. Remove the protective cap from the turbosupercharger oil "IN" line and attach it to the feed line from the oil supply tank. Fill the supply tank with lubricating engine oil, Specification AN-VV-O-446, grade 1065. For ground temperatures below -9.4°C or 15°F use hydraulic fluid Specification AN-VV-O-366. Then prime the pump to remove air locks by spinning the turbine wheel with compressed air until oil flows through the return ("OUT") line or until air bubbles appear on the surface of the oil in the turbo lubricant tank, indicating that the oil flow is established. Remove the protective cap from the oil "OUT" line and attach it to the return line leading to the supply tank and refill the oil supply tank to the bottom of the filler neck.

9. Remove the wheel guard protecting the bucket wheel and bolt the cooling cap to the support brackets, shimming the bolts so that a clearance of between .095 and .160 inches exists between the bucket wheel and the cooling cap. Safety-wire the connections with .0625 (1/16) inch nicrome or galvanized wire.

10. If protective material is installed between the baffle ring and the turbosupercharger nozzle box and compressor casing, it must be removed.

11. Install the supercharger cooling air duct to the baffle ring so that 60 percent of air will flow into the compressor side.

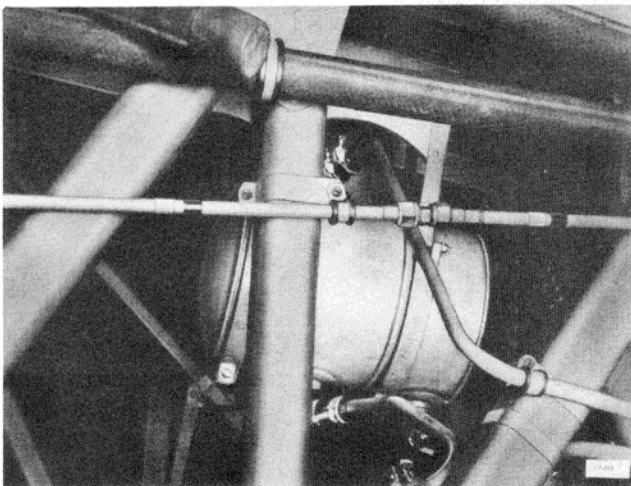
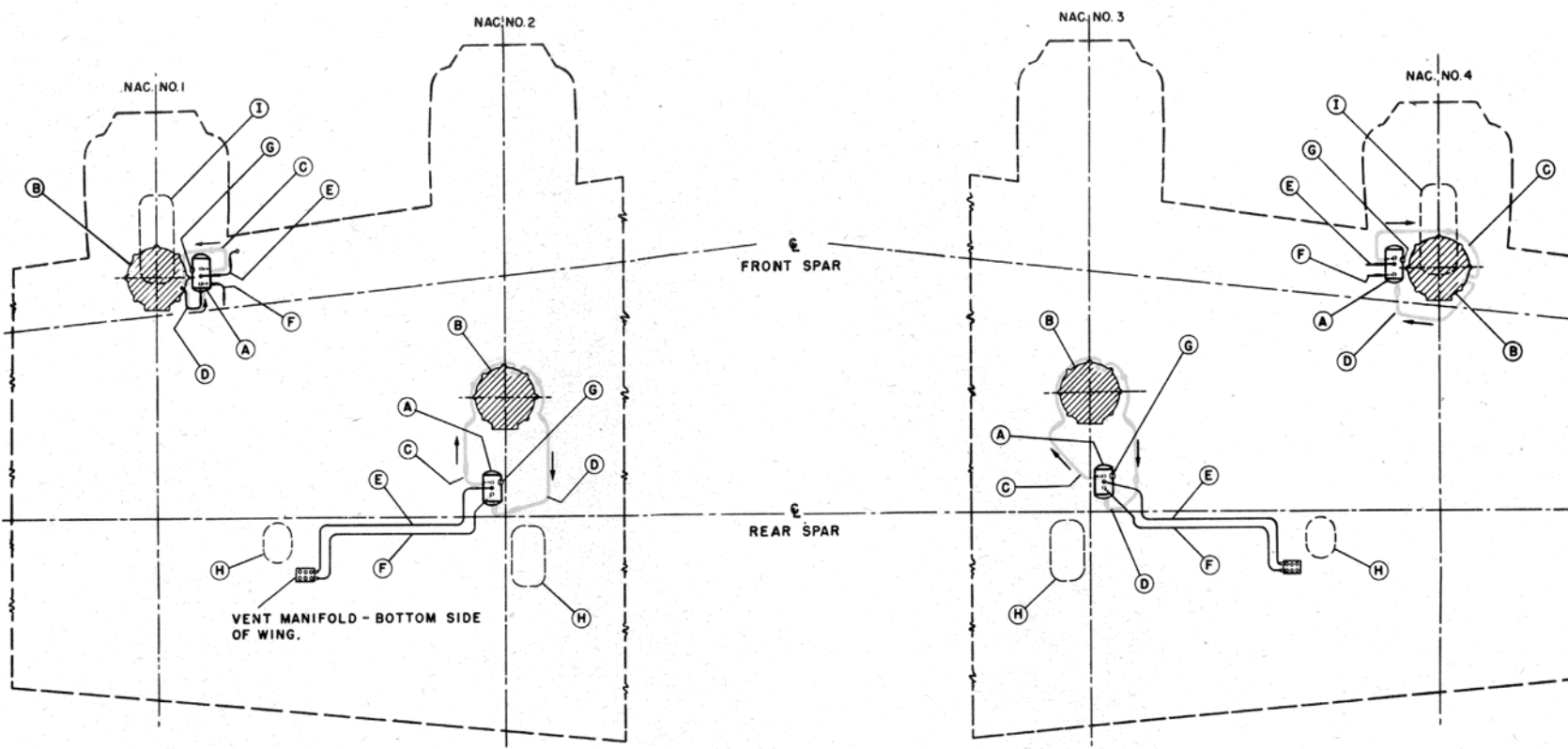


Figure 148—Supercharger Oil Tank, Engine No. 2



LEGEND

- (A) OIL SUPPLY TANK (BAC. 49-3047, CAPACITY 1.5 U.S. GAL.)
- (B) ENGINE SUPERCHARGER (GEN. ELEC. TYPE B-2 OR TYPE B-22.)
- ★ (C) SUPPLY LINE. (ALLUM. ALLOY 3/8" TUBING)
- ★ (D) RETURN LINE. (ALLUM. ALLOY 3/8" TUBING)
- (E) VENT.
- (F) DRAIN.
- (G) FILLER CAP.
- (H) ACCESS DOOR, BOTTOM SIDE OF WING.
- (I) ACCESS DOOR, TOP OF NACELLE.

★ 1/2" FLEXIBLE HOSE FOR
B-22 TURBO SUPERCHARGERS

NOTES

1. KEEP OIL SUPPLY TANK FILLED WITH OIL, SPEC. 3580 A.
2. ALL TUBING 52 SO ALUM. ALLOY. SPEC. 57-187-3. MIN. 6 BEND RADIUS NOT LESS THAN 3 X PIPE DIA. TUBE IDENTIFICATION, HALF INCH YELLOW BAND.
3. NO TRAPS TO EXIST IN ANY LINE WHEN PLANE IS AT REST.
4. MOUNT TANKS WITH OUTLET AND INLET IN VERTICAL POSITION.
5. SEE DRAWING NO. 55-6088 FURTHER DETAIL.
6. SYMBOLS, — = UNION, — = HOSE CONNECTION.

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Figure 149—Supercharger Lubrication Diagram

12. Connect the wastegate control linkage to the wastegate lever. With the wastegate motor run to the closed position, the linkage should be adjusted so that the wastegate is held approximately $3/32$ inches away from the stop in its closed position. Refer to section IV, paragraph 6. c. (1) for additional information.

13. Rotate the exhaust collector ring clamps by hand to see that they are not bound. If the manifold segment and the clamp are concentric and the manifold segments line up, a slight clearance (not to exceed .040 inches) between the clamp and the segment will allow the clamp to be barely rotated when both hands are used.

14. Remeasure the clearance between the nozzle box and the bucket wheel at four equi-distant points. If the clearance is not within .005 inches of the clearance measured before installation (paragraph 6. b. (4) (c) 1 preceding), disconnect the exhaust stack coupling at the stub on the supercharger. The loosening of the exhaust stack coupling should relieve the stresses on the

nozzle box and permit it to assume its normal relation to the bucket wheel. Then reconnect the exhaust stack coupling to the stub on the supercharger, attempting to line up the connection so that stresses are not imposed on the nozzle box. If a clearance within .005 inches cannot be obtained, the supercharger should be removed and replaced. Turn the expansion springs of the flexible joint of the exhaust stack by hand to see that they are free and that they are adjusted evenly. Improper adjustment of these connections will result in warpage of the nozzle box during operation.

15. Install the skin panels to the nacelle on each side of the turbosupercharger.

c. POWER PLANT CONTROLS.

(1) TURBOSUPERCHARGER ELECTRONIC CONTROL SYSTEM.

(a) GENERAL.—The turbosupercharger electronic control system maintains any selected manifold pressure in all four engines simultaneously by individu-

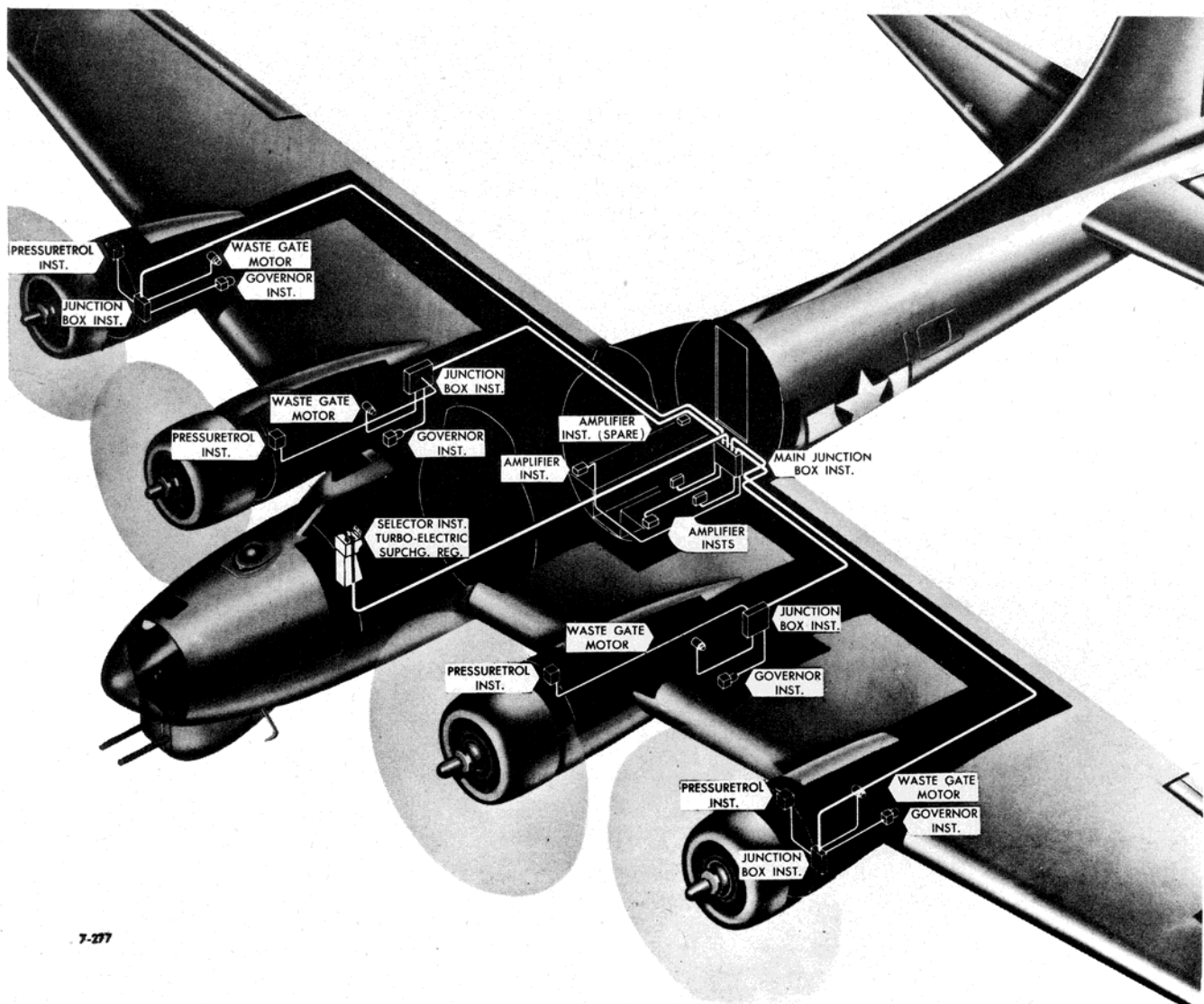


Figure 150—Supercharger Regulator System

ally controlling the RPM of their turbosuperchargers. The manifold pressure for any engine, however, may be separately controlled with its throttle or propeller controls. The components of the system are the turbo boost selector, induction system pressure controls, turbosupercharger governors, turbo waste gate motors, turbo control amplifiers, and main and nacelle junction boxes. The required power of 67 volt-amperes (.8 power factor) is supplied from the airplane inverter (115 volt, 400 cycle alternating current) through a 20 ampere fuse in the AC fuse shield beneath the pilot's seat.

1. OPERATIONAL ADJUSTMENT AND CHECK.

a. ENGINE RUN-UP ADJUSTMENT.

(1) Start engines and go through usual low power preflight engine checking procedure with turbo boost selector dial at "0".

CAUTION

Never operate engines without the turbosupercharger control system in operation. *Do not* turn the inverter off while engines are running. With the turbosupercharger control system off, no control of the waste gate is possible and it will remain in the position it was in when the control system was turned off. With the governor not functioning, no over-speed control is possible.

(2) Check inverter output voltage. Voltage should be 115 volts at input terminal in main "J" box. Permissible tolerances are 100 volts minimum and 125 volts maximum.

(3) Check DC voltage. Voltage must be between 26 and 28.5 volts.

(4) With turbo boost selector set at "0" and propeller governors set at minimum pitch (maximum engine RPM advance throttles and observe manifold pressures. Manifold pressures should increase uniformly on all four engines. A difference in pressure of more than one inch indicates a malfunction of the engine, which should be corrected before calibration is attempted.

b. GROUND CALIBRATION.—If the engine run-up check shows all four engines to be operating normally, the control system may be calibrated. Calibration should be made with 100 octane gasoline if possible. It is not necessary to change calibration settings when changing grades of gasoline. The system should be re-calibrated when any of the units have been replaced, but it should not be necessary to change the settings during regular engine run-up procedure or preflight checks if the initial calibration has been made carefully. Variations in manifold pressure will then indicate engine trouble or malfunction of the turbo control system.

IMPORTANT

Do not use the calibration adjustment to compensate for engine malfunction.

Use the following procedure for ground calibration.

(1) Start engines and go through usual low power engine run-up check. Check to see that inverters and filters are on.

(2) Set propeller governors for maximum RPM.

(3) Set turbo boost selector at "8" (with 100 octane fuel).

(4) Advance throttle to full open position.

(5) With throttles full open and take-off RPM calibrate each engine individually by turning the calibration screw clockwise, increasing manifold pressure to within one inch of take-off manifold pressure (45 inches of mercury). In actual take-off, ram air will provide the additional one inch increase to bring manifold pressure to the required value of 46 inches. In the event that an engine does not come up to maximum RPM, proper allowance should be made in calibrating; approximately 1 1/2 inches less manifold pressure for each 100 RPM below take-off RPM.

Note

It is not recommended that calibration settings be changed in flight unless absolutely necessary. Compensate for minor differences in manifold pressure in flight by adjusting the throttles.

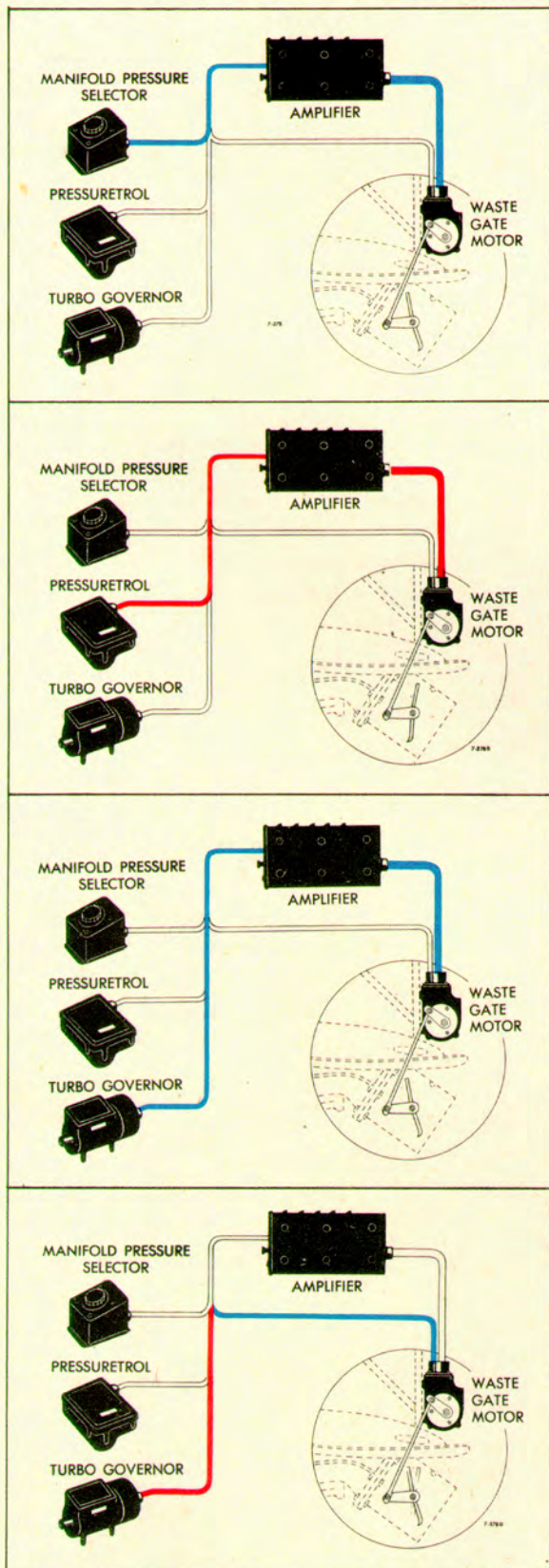
(b) TURBO BOOST SELECTOR.

1. GENERAL.—The turbo boost selector is located on the pilots' aisle stand. A dial knob with vernier scale markings, rotates the dial shaft and wiper of the turbo boost selector potentiometer. The divisions on the dial are numbered from "0" to "10"; a dial setting reference arrow is marked on the case directly above the dial. Clockwise rotation of the dial causes the waste gate to move automatically toward the closed position with resultant manifold pressure increase. The dial range from "0" to "8" is used to select the desired manifold pressure for all normal conditions. When properly calibrated a dial setting of "8" should provide maximum take-off power (1200 HP at 46 inches of mercury) at ground level. The dial range from "8" to "10" is red lined and should be used only for emergency military power. A dial stop prevents dial rotation beyond "8" unless the dial stop release is pressed.

Note

Dial settings and manifold pressures referred to are for 100 octane gasoline. Proper allowances must be made when using fuel with a lower octane rating. For example: A dial setting of "7" should be used for take-off power with 91 octane fuel.

SIGNALS WHICH TEND TO CLOSE THE WASTE GATE ARE REPRESENTED BY RED LINES AND SIGNALS WHICH TEND TO OPEN THE WASTE GATE ARE REPRESENTED BY BLUE LINES



a. **TURBO BOOST SELECTOR.**—In this illustration assume that the turbo boost selector has just been adjusted from "8" for take-off, to "5" for cruising. The change in position of the wiper on the potentiometer in the turbo boost selector has created an electrical unbalance in the bridge circuit, causing a voltage signal to be sent to the amplifier, and on to the waste gate motor. The resulting rotation of the waste gate motor has re-positioned the waste gate to satisfy the demands of the new setting on the turbo boost selector.

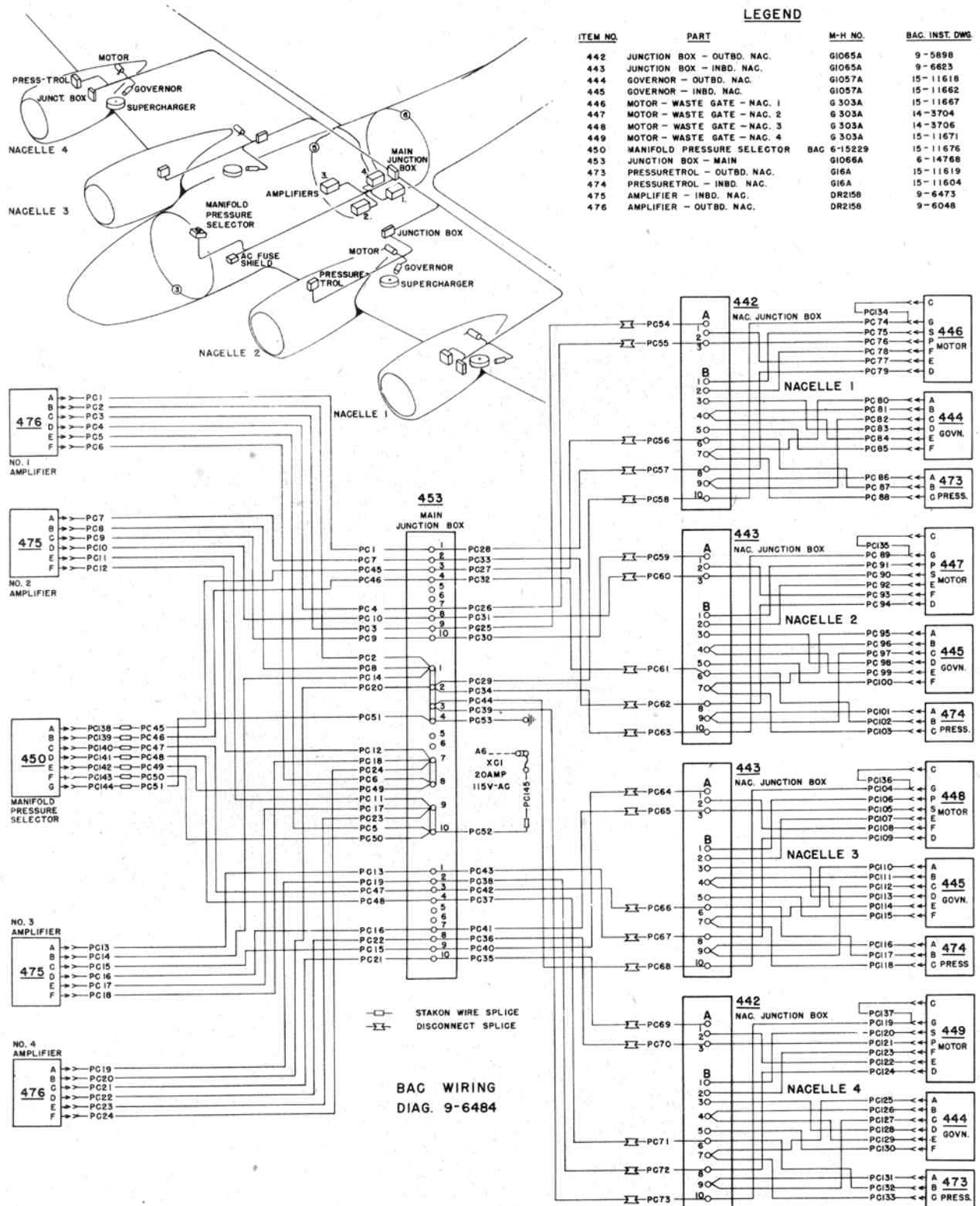
b. **PRESSURETROL.**—Assume that in cruising, the airplane has gained altitude slightly. The sensitive bellows in the pressuretrol here has registered the slight drop in induction system pressure and moved its potentiometer wiper, unbalancing the bridge circuit. The resulting voltage signal has caused the waste gate motor to rotate, closing the waste gate slightly and thus bringing the induction system pressure up to its original value.

(For purposes of illustration, the amount of waste gate movement has been greatly exaggerated.)

c. **TURBO GOVERNOR.**—In this example suppose that the closing of the waste gate in the previous illustration has either caused the turbo to accelerate too rapidly or to reach its maximum safe RPM. Either of these conditions produce the same result—shifting of wiper position on one of the two potentiometer windings in the turbo governor. The voltage signal thus created results in rotation of the waste gate motor, opening the waste gate slightly to reduce the speed of the turbo.

d. **WASTE GATE MOTOR.**—Here is illustrated the "follow-up" signal from the waste gate motor which causes it to stop when the demands of the unit which initiated the action have been satisfied. Movement of the waste gate motor arm moves the potentiometer wiper in the motor until it reaches the position where electrical balance in the bridge circuit has been restored. At this point the voltage signals cease and the motor rotation stops.

Figure 151—Typical Operation of the Electronic Turbosupercharger Control System



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Figure 152—Power Plant Control Circuit—Turbosupercharger



CAUTION

Never use red lined emergency power settings with a fuel of less than 100 octane. The high manifold pressures resulting from dial settings in this range will cause detonation and preignition with low grade fuel, causing severe stress on the engines.

e. A calibration potentiometer for each of the four engines is also provided in the manifold selector case. With a given dial setting, the calibrating potentiometers can be adjusted to regulate the manifold pressure to the desired value for this setting. In this way, the manifold pressure of all four engines can be synchronized. Calibration adjustments are made with a screwdriver at four screws under caps on the face of the selector box.

2. REMOVAL AND DISASSEMBLY.

a. Disconnect the electrical receptacle from the selector box.

b. Remove four screws fastening the control box assembly to the control stand.

3. ASSEMBLY AND INSTALLATION.

a. Install the unit on the control stand with the four mounting screws.

b. Connect the electrical receptacle.

(c) INDUCTION SYSTEM PRESSURE-TROLS.

1. GENERAL.—Four pressuretrols, one in each nacelle, are the primary automatic controls. The pressuretrol measures the carburetor air inlet pressure, which is a determining factor of engine manifold pressure. The pressuretrol, as can be seen in figure 154, consists of an evacuated bellows vented by a 1/4-inch hose to the air duct at the carburetor air inlet and connected through a sector lever and pinion to a wiper contact on the voltage divider potentiometer. The operating or pressure bellows and the evacuated bellows are rigidly fastened together by the cross-member "A". The lower end of the pressure bellows is fastened to the bottom of the case, and the interior is vented to the induction system through a pipe connection on the bottom of the case. The upper end of the evacuated bellows is anchored by adjustment screw "C". The internal spring "B" prevents atmospheric pressure from collapsing the bellows. The evacuated bellows has exactly the same cross-sectional area as the operating bellows, so atmospheric pressure changes will affect both equally, and since they are arranged to oppose each other, the atmospheric change is cancelled out or neutralized. The upper bellows is evacuated so that temperature changes will not produce pressure changes in the interior. The weight attached to arm "D" serves to dampen out any minor pressure surges which may occur in the induction system, and to balance the bellows assembly against accelerating forces and vibration. A vent "L" is provided to permit atmospheric pressure

to surround both bellows and to drain any condensate that may accumulate.

As the pressure in the operating bellows is increased, cross-member "A" will move upward and cause lever "D" to pivot about point "E," driving pinion "F" in a clockwise direction. Wiper arm "G," rigidly fastened to pinion "F," moves downward across the potentiometer "H," introducing a voltage signal to the electrical bridge to energize the waste gate motor and open the waste gate, thereby reducing the pressure back to the original value. The calibration screws "C" and "J" are used to adjust the pressure range through which the pressuretrol operates. This adjustment should not be attempted in the field. New units are factory calibrated and no adjustment is necessary at installation.

2. REMOVAL AND DISASSEMBLY.—The pressuretrol is located in each nacelle aft of the firewall, just outboard of the carburetor air duct.

a. Disconnect the electrical receptacle and the pressure tube.

b. Remove the three screws fastening the pressuretrol to the shock mount.

c. To remove the shock mount, disassemble the four rubber mounts.

3. ASSEMBLY AND INSTALLATION.

a. Attach mounting plates to pressuretrol.

b. Bolt pressuretrol and mounting plates to shock mounts on the mounting bracket installed in each nacelle.

c. Connect the electrical receptacle, being careful to see that the guide key is properly aligned.

d. Connect the pressure tube from the carburetor inlet duct making certain that connection is tight. Use pipe joint compound (gasket paste, Specification AN-G-14) on the threaded hose connection.

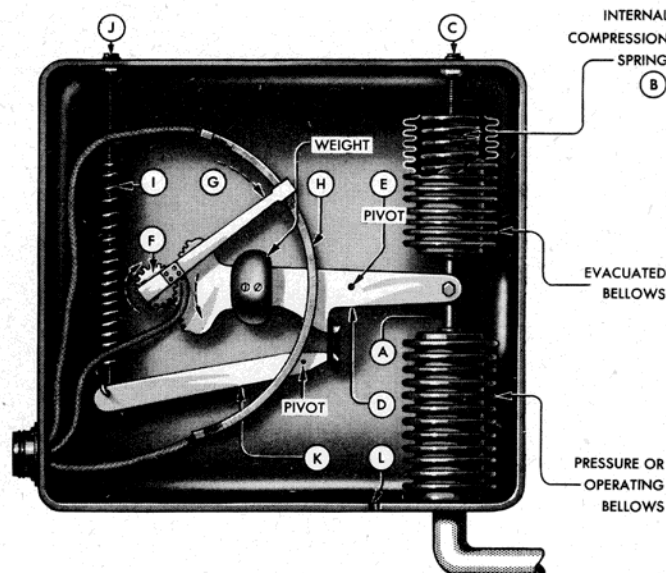


Figure 154—Pressuretrol

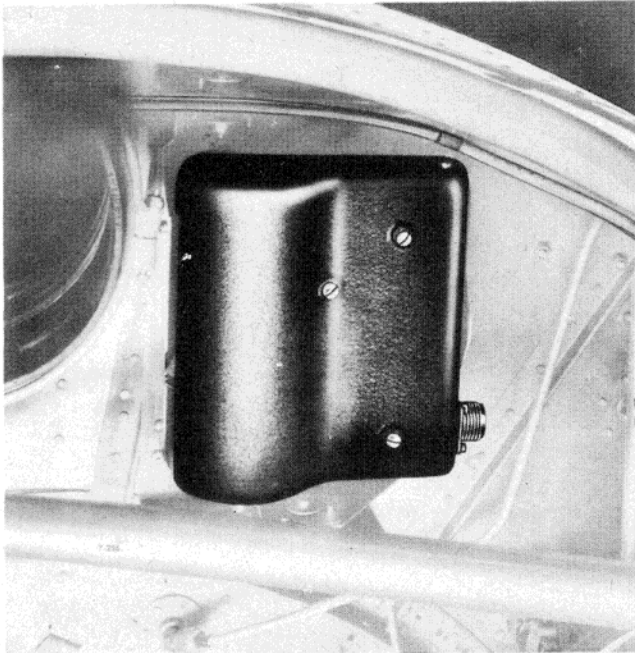


Figure 155—Pressuretrol Installed in Outboard Nacelle

CAUTION

When screwing the mounting screws in the pressuretrol, avoid using a wrong thread or damaged screw which might result in aluminum chips entering the unit. Do not tamper with the two red-lacquered adjusting screws on the top of the pressuretrol.

(d) TURBOSUPERCHARGER GOVERNOR.

1. GENERAL.—The turbosupercharger governor is driven by a short flexible shaft from the turbosupercharger tachometer connection on the end of the pump shaft. Both accelerometer and overspeed portions of the governor are installed on a common shaft. The accelerometer inertia wheel rotates with the main shaft, since the torque spring transmits energy to it from the torque spring collar which is rigidly fastened to the shaft. During rapid acceleration of the turbine and the governor shaft, the inertia wheel lags behind the shaft, producing a rotational displacement between the inertia wheel and the shaft which forces the cam roller assembly to climb the inclined cam attached to the wheel. The cam roller assembly is raised, the push pin moves the pivoted accelerometer wiper upward over the accelerometer pot (potentiometer), introducing a voltage signal to the system to energize the waste gate motor and open the waste gate to decrease the speed of the turbine.

a. The function of the overspeed portion of the turbosupercharger governor is to prevent the turbine from operating at excessive speeds which might cause structural failure of the turbine wheel. As the turbine reaches its maximum safe operational speed of 23,400 RPM for the type G1057A3CA1 governor used with the B-2 turbosupercharger, or 26,400 RPM for the

type G1057A4CA1 governor used with the B-22 turbosupercharger, the overspeed weights, swung outward by centrifugal action, move the governor spring assembly downward against the clutch arm. The clutch arm is pivoted at the adjustment screw end and bears against the upper end of the clutch disc shaft, which is splined to gear No. 2 and to the clutch disc which is faced on both sides. The lower end of the shaft is continually pressed upward by the compression swing. As the clutch disc shaft is forced downward, the clutch disc contacts gear No. 4 which is driven from a gear cut in the main shaft. This causes the clutch disc and gear No. 2 to rotate and drive gear No. 1 which turns the potentiometer wiper screw so that the threaded overspeed wiper moves toward the upper end of the potentiometer. This action introduces a voltage signal in the system to move the waste gate toward the open position and reduce the speed of the turbine. As soon as a safe operating speed is again reached, the governor weights move closer to the shaft under action of the governor spring, allowing the clutch arm to move upward. When the clutch disc moves upward, it will contact gear No. 3 as illustrated. Gear No. 3 is driven in a direction opposite that of gear No. 4 by three gears not shown in the section view. The clutch disc and gear No. 2 therefore rotate in the opposite direction, turning gear No. 1 and the potentiometer wiper screw to move the wiper downward, removing the voltage signal calling for an open waste gate. When the overspeed wiper reaches the lower end of the poten-

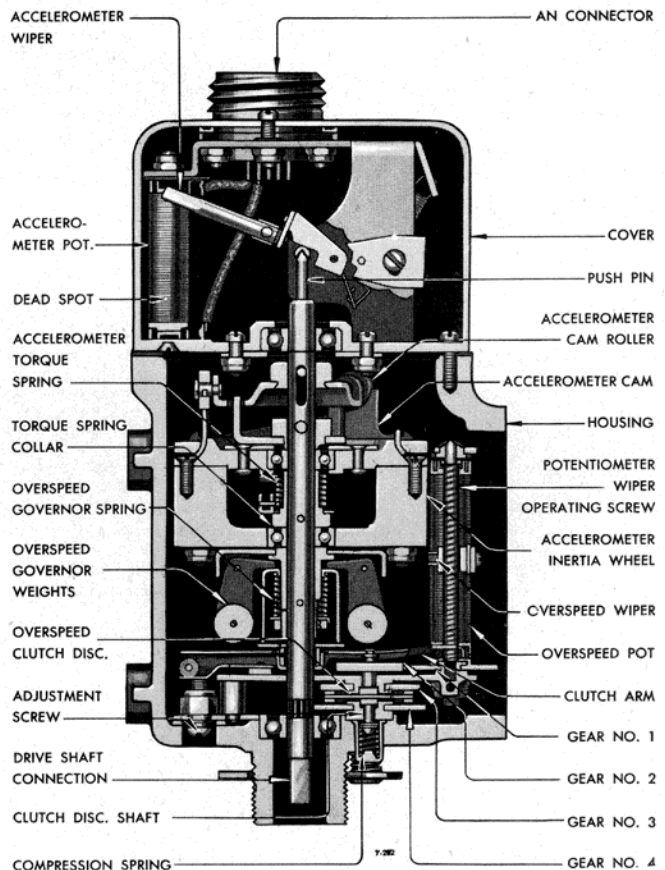


Figure 156—Turbosupercharger Governor

tiometer, it presses against the clutch arm to disengage the clutch disc from gear No. 3, limiting its travel and allowing the turbo to operate in the safe speed range. The gear train is arranged to introduce the overspeed signal quickly to prevent damage to the turbine and to remove the signal slowly to prevent overshooting. The adjusting screw on the clutch arm is set at the factory, and must not be altered.

2. REMOVAL AND DISASSEMBLY.—The governor in each nacelle is located immediately aft of the turbosuperchargers. The governors in the outboard nacelles are reached through the access doors provided in the upper portion of the enclosures, and a door in the lower portion of the wing, aft of the supercharger, provides access to the governors in the inboard nacelles.

- a. Outboard nacelles only: Remove the lower access panel.
- b. Inboard nacelles only: Remove the access door aft of the nacelle, between wing stations 4 and 5.
- c. Disconnect the electrical receptacle.
- d. Disconnect the flexible drive shaft at the governor connection.
- e. Outboard nacelles only: Remove four bolts fastening mounting bracket.
- f. Inboard nacelles only: Remove two bolts and two flat head screws fastening mounting bracket.
- g. The governor is attached to the mounting bracket by four fillister head screws.

3. ASSEMBLY AND INSTALLATION.

- a. Attach governor to mounting bracket with four fillister head screws.
- b. Install bracket and governor. The inboard nacelle installation uses two bolts and two flat head screws; outboard installation uses four bolts. The governors are located directly behind the waste gate. On the inboard installation, the governors are mounted inside the wing about 15 inches to the right of the waste gate motor.
- c. Connect the electrical receptacle.
- d. Connect the flexible drive. If the flexible drive has not been disconnected from the turbo tachometer connection, and the governor has been properly re-installed in the same exact location, the flexible drive should operate satisfactorily. If it does not, or if the drive has been re-installed on the supercharger, refer to the following paragraph on flexible drive.

CAUTION

Before installing a new flexible drive, remove the split brass washer from the end which connects to the turbosupercharger. This washer is put on merely to keep the shaft from slipping out of its housing while in shipment.

WARNING

The B-2 and the B-22 turbosuperchargers require different types of governors. A type G1057A3CA1 governor is used with the B-2 turbo, while the B-22 turbo requires a type G1057A4CA1 governor. *A B-22 turbo should never be installed in an airplane with a G1057-A4CA1 governor.* The maximum RPM setting of the governor used with the B-22 turbo installations is 4000 RPM higher than the maximum safe RPM of the B-2 turbosupercharger.

- e. Pull the shaft from its housing and lubricate with grease, Specification AN-G-3.
- f. Replace the shaft in its housing; then fasten the flexible drive to the tachometer connection on the turbosupercharger. The flexible shaft can be pulled from the housing very easily. When replacing the flexible shaft in a housing which is attached to the turbosupercharger, merely press inward on the shaft and turn the shaft slowly until it engages with the drive on the turbo tachometer.
- g. Connect the other end of the flexible drive to the governor. The squared end of the shaft fits on the governor and both ends of the housing are secured to their respective units by means of coupling nuts.

IMPORTANT

It is important that the flexible drive have a slight bend to prevent the shaft from whipping in the housing. There should not, however, be a compound bend in the drive. If necessary, use washers under some corners of the governor mountings to prevent a compound bend in the flexible drive.

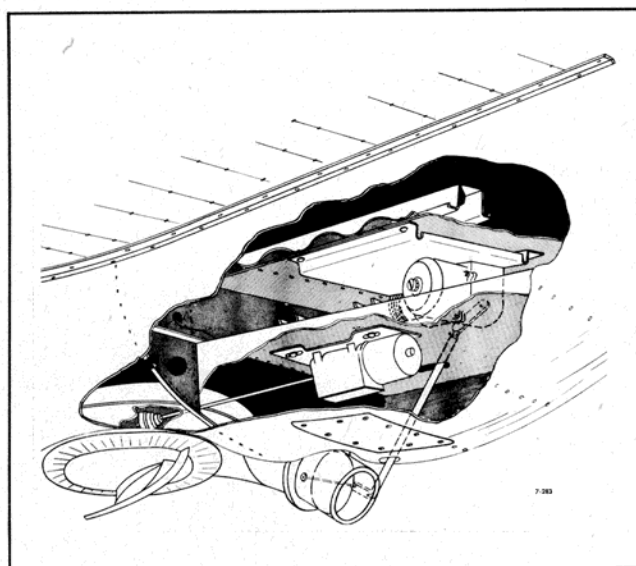


Figure 157—Waste Gate Motor and Turbo Governor—Typical Installation

(e) TURBO WASTE GATE MOTOR.

1. GENERAL.—The turbo waste gate motor varies the position of the waste gate in each nacelle through a gear train, crank arm, and rod linkage, and introduces the follow-up signal to the control system when the gate reaches the position called for. Mechanical stops in the motor limit the rotation of the crank arm to 90 degrees, and a clutch absorbs the rotor inertia when a stop is reached, and prevents damage to the motor if either waste gate jams. The rotor shaft in the motor has approximately 1/32-inch end play, and a spring acting on the end of the shaft shifts the rotor lengthwise with respect to the field windings when it is not rotating. This movement engages two breaking surfaces, one on the rotor and one on the housing. This maintains the setting of the waste gate when the motor is de-energized or the power fails due to damage to the system. When the amplifier field winding of the motor is energized, magnetic action on the rotor moves the shaft lengthwise and disengages the braking surfaces to allow the motor to rotate. A potentiometer wiper is attached to the motor drive shaft and moves across the potentiometer fixed to the motor housing to balance out the original signal.

a. One motor field winding is directly and continuously excited from the inverter line through a condenser in the nacelle junction box. The other field is excited by current from the control system amplifier. The direction of motor rotation is dependent upon whether the amplifier current phase leads or lags the condenser phase. As the motor rotates due to an unbalanced condition of the control system, the wiper moves across the potentiometer in a direction which tends to balance the system. When the wiper has moved far enough to attain this balance, the actuating signal is cancelled and the motor rotation is automatically stopped. The motor and gear housing is sealed and partially filled with oil, so that no other lubrication is necessary.

2. REMOVAL AND DISASSEMBLY.—The outboard nacelle waste gate motors are located on the lower wing surface, inside of the nacelle fairing. The inboard units are located on the inside of the lower wing surface, approximately 18 inches forward of the rear spar.

a. Outboard nacelles:

- (1) Remove waste gate inspection panels.
- (2) Remove access door in wing as outlined above under removal of the governor.
- (3) Disconnect the linkage from the waste gate motor arm, leaving the crank arm on the motor.
- (4) Disconnect the electrical receptacle.

CAUTION

Never disconnect the electrical connection to the waste gate motor with the AC power turned on. The excessively high voltages applied to the vacuum tubes as a result of this action will cause tube failure.

b. Inboard nacelles:

(1) Remove flap control inspection door in lower wing surface. The waste gate motor may be reached from inside the wing after disconnecting the flap control rod.

(2) Disconnect the linkage from the waste gate motor arm, leaving the crank arm on the motor.

(3) Disconnect the electrical receptacle.

(4) Remove motor and mounting bracket by removing the four mounting screws.

IMPORTANT

Before removing the waste gate motor, note the exact position of the motor crank arm relative to the waste gate arm as a reference for checking the motor arm position when reconnecting the linkage. Do *not* remove the motor crank arm while the motor is still mounted in the airplane. Also carefully reference mark the exact position of the mounting bracket so it can be remounted in the same position. Any change of bracket position will require readjustment of the linkage.

3. ASSEMBLY AND INSTALLATION.

a. Mount the waste gate motor to its mounting bracket with the four fillister head screws. Be sure the short screw is used in the shallow hole. If the motor is attached to a bracket already in the airplane, make sure that the bracket has not moved and that the motor shaft is parallel with the shaft of the waste gate so there will be no binding at the linkage bearings when the motor rotates. *Before connecting the linkage, run the motor against its stop in the fully closed position.* To do this, use a separate calibrator potentiometer (from a turbo boost selector) wired to an AN connector used on the pressuretrol. (See figure 160.) Disconnect the pressuretrol and attach this special test potentiometer in its place. The waste gate motor can be run in either direction by turning the wiper shaft of the test potentiometer. If a spare potentiometer is not available, solder a small battery clip to each end of a piece of insulating wire about six inches long. Attach one clip to terminal A3 and the other clip to terminal A1 in the main "J" (junction) box. The waste gate for engine No. 1 can then be opened and closed as desired by turning the dial of the manifold pressure selector. Short across the terminals as listed below to operate the waste gate on the other engines.

| Engine No. | Terminals in Main "J" Box | |
|------------|------------------------------|----|
| 1 | A3 | A1 |
| 2 | A4 | A2 |
| 3 | C3 | C1 |
| 4 | C4 | C2 |

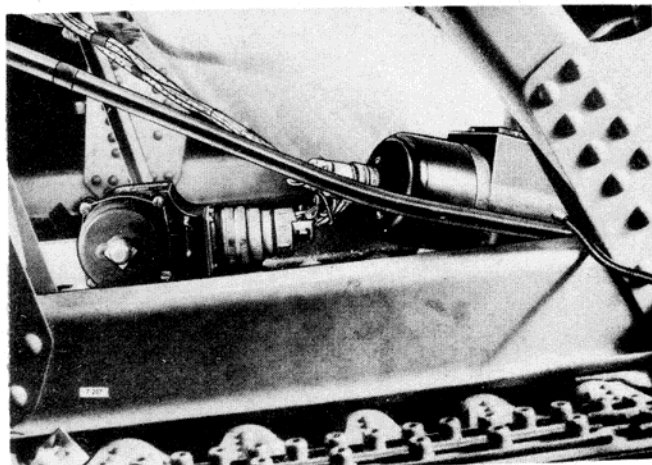


Figure 158—Governor and Waste Gate Motor—
Inboard Nacelle

CAUTION

Do not short any other terminals in the main or nacelle "J" boxes or damage to the turbo control system may result.

b. After running the motor to the closed position, connect the linkage to the motor crank arm. Check the waste gate to see that it is approximately $3/32$ inches away from the stop in its closed position.

Note

The shaft on the waste gate motor is splined so that the motor crank arm may be adjusted in steps of $22\frac{1}{2}$ degrees; however, the arm is factory set in a definite position relative to the mechanical stops inside the motor and in most cases the arm will not require changing. If for any reason the direction of rotation of any of the waste gate motors must be changed, this

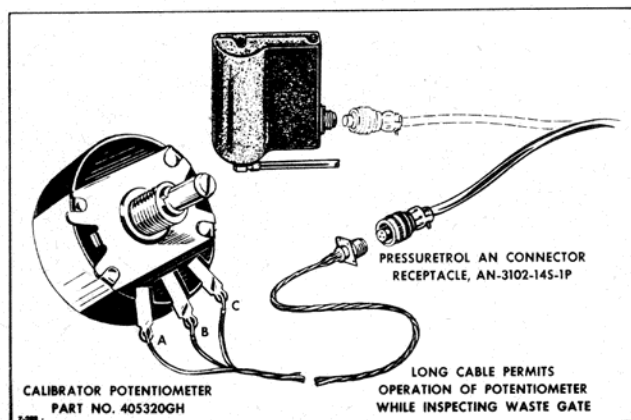


Figure 160—Service Test
Potentiometer

can be accomplished by reversing four wires in the nacelle "J" box. The proper wires to reverse are listed below:

At Nacelle "J" Box Terminals:

A3 and B1 and at A2 and B2

| | Reverse | Reverse |
|--------------|-------------|-------------|
| Engine No. 1 | PC75-PC76 | PC77-PC78 |
| Engine No. 2 | PC90-PC91 | PC92-PC93 |
| Engine No. 3 | PC105-PC106 | PC107-PC108 |
| Engine No. 4 | PC120-PC121 | PC122-PC123 |

The position of the waste gate motor arm in relation to the waste gate arm is very important because of the flow characteristics of the waste gate. After linkage has been connected and the $3/32$ inch clearance between waste gate and stop has been established, check for proper travel of the waste gate. To do this, place the waste gate protractor behind the waste gate arm

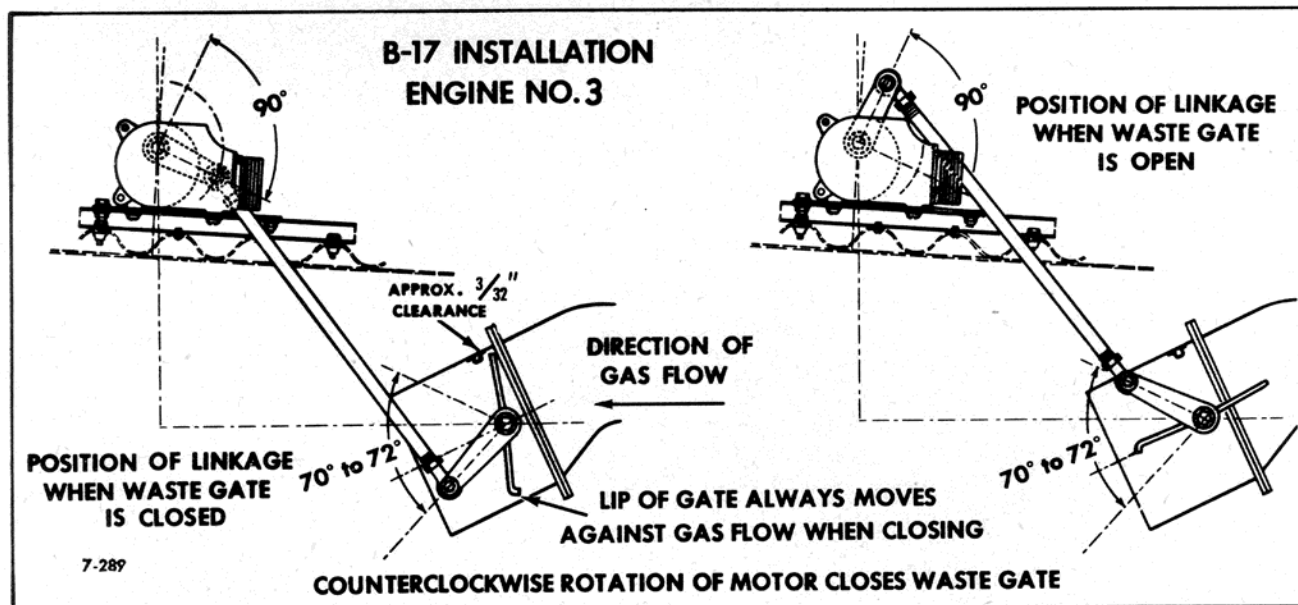


Figure 159—Waste Gate Motor Linkage

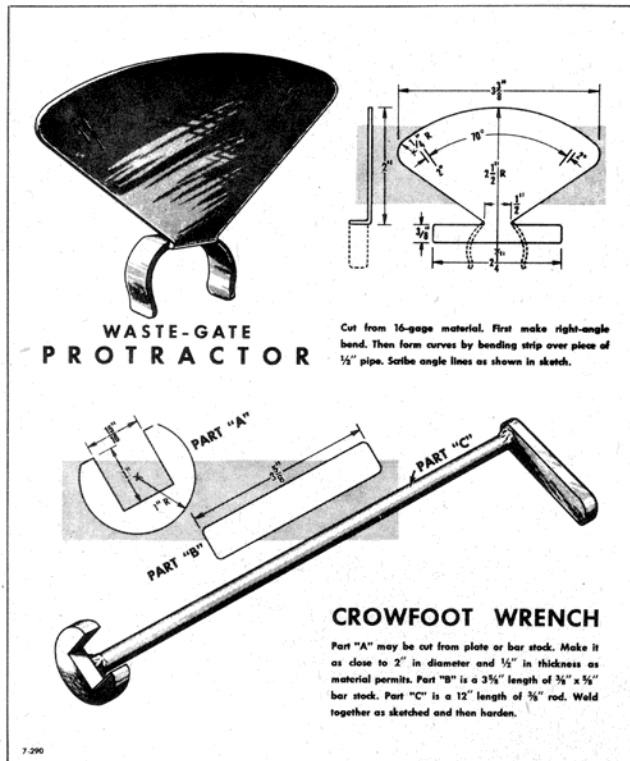


Figure 161—Field Maintenance Tools for Turbo Control System

and open and close the waste gate (see preceding paragraph). The waste gate arm should travel not less than 70 degrees and not more than 72 degrees. Waste gate arm motor mounting bracket or linkage may have to be adjusted slightly to give the proper combination for correct waste gate travel.

Note

If a turbosupercharger is to be replaced, check waste gate operation after the turbo has been run in, as the turbosupercharger may shift its position slightly when it "sets" after its first high temperature run-in.

(f) TURBO CONTROL AMPLIFIER.

1. GENERAL.

Four amplifiers, one for each nacelle unit, are installed on shock mounted racks in the radio compartment. One amplifier is installed under the radio operator's table, one under the command radio, two under the floor at the rear of the camera well, and a spare on the floor at the right rear of the compartment. The amplifier is a three-stage unit, consisting of two voltage amplifier stages and one discriminator stage. The tubes used are one 7Y4 as a rectifier, one 7F7 duotriode as a voltage amplifier, and two 7C5 tubes. Incoming voltage signal is amplified in the two stages of the 7F7 tube and is then applied to the grids of the two 7C5 tubes. The grids of these tubes are connected together and will therefore go positive at the same instant. The

plates are energized from the ends of a secondary winding of the power transformer with a center tap to the motor amplifier field. When the plate of the upper 7C5 tube goes positive, the plate of the lower tube goes negative, and vice versa. Thus, if the plate of the upper tube goes positive at the same instant that the grids go positive, the tube will pass current. At this same instant, however, the plate of the lower tube is negative and will therefore not pass current. At the next instant (half a cycle later) when the plate of the lower tube is positive, both grids are negative, and the current will not flow in either tube. As long as this phase relationship exists between incoming signal voltage and plate voltage, the upper tube will pass current and the lower will not. If, however, the phase relationship is shifted 180 degrees by the incoming signal voltage such that when the grids go positive, the plate of the lower tube goes positive, the reverse condition exists, and the lower tube passes current while the upper one does not. Either resultant signal (180 degrees apart in phase, and variable in strength) is applied to the amplifier field circuit of the turbo waste gate motor. The line excited field current in the motor is changed 90 degrees in phase by the line condenser so that it either leads or lags the current in the amplifier field winding by approximately 90 electrical degrees, causing motor rotation in one direction or the other. A one-ampere fuse in the amplifier protects the power transformers and motor line field windings.

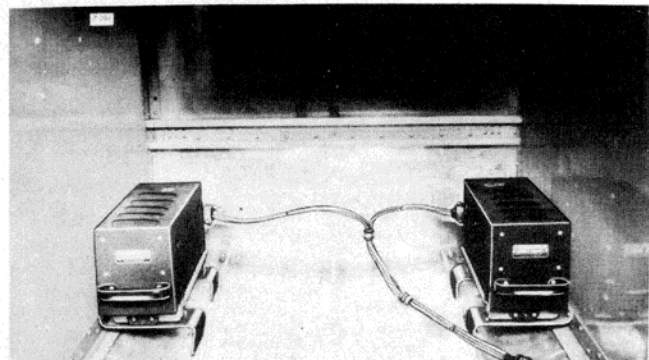


Figure 162—Amplifiers No. 1 and 4 Installed in Camera Well

2. REMOVAL AND DISASSEMBLY.—

Amplifiers for the inboard nacelle systems are shock mounted on the radio compartment floor, between stations 5a and 5b. Amplifiers for the outboard units are shock mounted to the fuselage structure under the floor, at station 5h.

a. To remove the amplifier case from the tray, disconnect the AN receptacle at the rear of the case, unlock the Dzus fastener below the front of the case, and pull out from the mating pins and holes at the rear.

b. To remove the amplifier from the case, unlock the Dzus fastener at the rear of the case and slide the chassis out on the two horizontal guide rails.

c. To remove the mounting tray, remove the amplifier cases and disassemble the rubber shock mounts.

(g) JUNCTION BOXES.

1. NACELLE JUNCTION BOXES.

a. GENERAL.—One junction box in each nacelle contains the bridge transformer for the presuretrol, turbo governor, and waste gate motor bridge circuits for that nacelle, as well as the condenser and protective resistors of the waste gate motor circuits. The terminal board provides ready servicing and test connections for the circuit.

b. REMOVAL AND DISASSEMBLY.

- (1) Remove the cover of the box.
- (2) Disconnect the external wiring.
- (3) Remove the three mounting bolts.

2. MAIN JUNCTION BOX.

a. GENERAL.—The main junction box is located on the forward side of station 6, under the radio compartment floor. The box contains a terminal panel for interconnection of the circuit wiring.

b. REMOVAL AND DISASSEMBLY.

- (1) Remove the cover of the box.

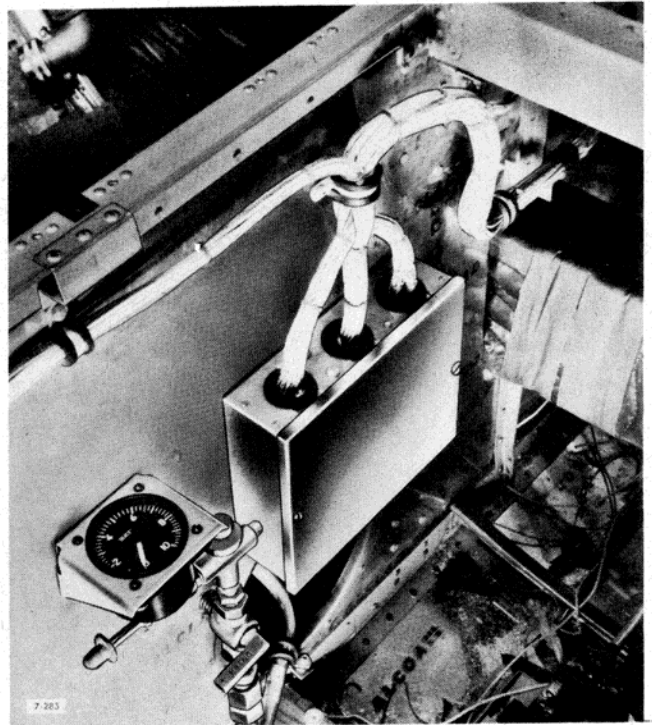


Figure 164—Main Junction Box Installation in the Forward End of Camera Well

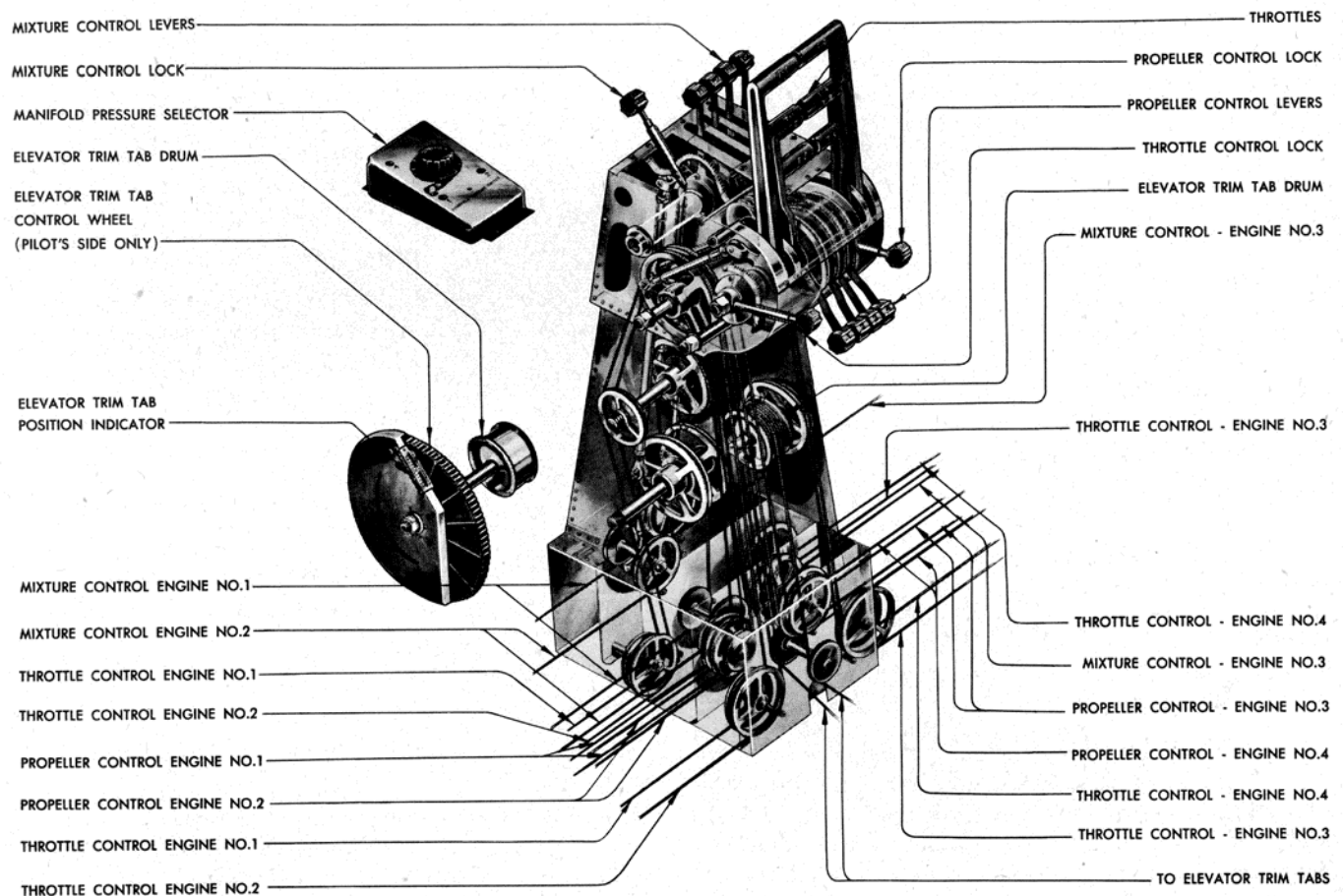


Figure 163—Engine Control Stand—Cutaway View

- (2) Disconnect the electrical wiring.
- (3) Remove the four mounting bolts.

(2) THROTTLE, MIXTURE, PROPELLER
PITCH, AND INTERCOOLER
CONTROL SYSTEM.

(a) GENERAL.

1. The throttle, mixture and propeller pitch controls are on the engine control stand. The control cables run aft on both sides of the pilots' compartment to bulkhead 4 and outward to the nacelles along the forward side of the front spar. The intercooler controls are to the right of the copilot and the cables follow a similar path.

2. The propeller pitch cables run through the firewall to the governor. All others stop aft of the firewall and are connected to the equipment with rod and bellcrank linkages.

3. All of the engine controls (except the mixture controls) have spring devices which move them to the positions indicated on the diagrams if the cables are cut.

(b) REMOVAL AND DISASSEMBLY.

1. REMOVAL.—To remove the cables loosen the turnbuckles to release cable tension then disconnect or remove pulleys and fairleads so that the swaged cable terminals may be drawn free. For access to the main pulley bracket at bulkhead 4, remove the oxygen cylinders obstructing this bracket. The carburetor air duct must be removed to gain access to the engine control cable pulleys on the inboard side of the outboard nacelles.

CAUTION

Attach a feeder line before removing the cables in order to facilitate reassembly.

2. DISASSEMBLY.

a. Turnbuckles and adjusting links as shown on the diagrams make it possible to disconnect the cables for disassembly and to adjust them to the correct tension.

b. All cables have been dipped in hot 71°C (160°F) heavy rust-preventive compound (AN-C-52) and the pulley bearings have been pre-packed with lubricant. Therefore, these parts should not be washed in gasoline or other cleaning solvents unless a re-application of the treatment to the cables or installation of new pulleys is anticipated.

(c) MINOR REPAIR AND REPLACEMENTS.

1. All engine control cables are 3/32 inch 7 x 7 extra flexible pre-formed steel, Specification AN-RR-C-43. Replacements are to be made according to specified sizes and detail drawings as indicated on the diagrams.

2. In case of an emergency cable repair, the

True Lock portable swager (American Chain and Cable Company, Inc., No. 28-HS) or equivalent may be used. Avoid the use of too many splices made in this manner, because the increased weight of terminals and turnbuckles will tend to cause excessive vibration in long, unsupported cable spans. When the repaired cable may be required to stay in service for a considerable length of time, make the splice near a pulley or fair-lead but take care to leave ample clearance for full cable travel.

3. Cables that are found to be frayed will be considered serviceable unless there are more than three broken wires per inch of 7 x 7 cable and six broken wires per inch of 7 x 19 cable.

d. INSTALLATION AND ADJUSTMENT.

(1) CABLES.—Refer to the applicable diagrams and rig all systems with controls in the mid-travel position. Make approximate adjustments with the cable links and take up the final adjustments with the turnbuckles until the proper tension is applied. The cable travels and tensions shown on the diagrams are necessarily approximate and will not govern in all cases. Cable tensions indicated are based on a balanced temperature condition of 21°C (70°F) and applied tensions in general must be greater when rigging at higher temperatures, and less when rigging at lower temperature. It has not been possible to develop a satisfactory temperature correction chart, and corrections will have to be based on experience with the equipment involved. It will be well to note that corrections will vary with different cable runs depending on cable size, length, direction of travel, and location in the airplane. Therefore, do not acquire the habit of making temperature corrections with any blanketing or arbitrary ratio.

WARNING

All cable turnbuckles and control rod linkage must be properly safetied after adjustment.

(a) THROTTLE CONTROL SYSTEM
RIGGING PROCEDURE.

1. Set the throttles in the mid-travel position.
2. Set the bell crank in the particular nacelle at the neutral position.
3. Take up the slack at the wing gaps.
4. Take up the tension in the accessory compartment.
5. Check the neutral position on the indicator in the cockpit and at the carburetor. If they do not agree, set the indicator at the neutral position and adjust the rods at the carburetor to the neutral position.
6. Check the 1/8-inch (minimum) cushion at each end of the throttle movement. If less than 1/8-inch replace or build up with serrated washers.
7. Install the spring between the throttle arm and the clip angle as shown on figure 165.

| TERMINAL I-FWD. OR INBOARD END OF CABLE | | TERMINAL II FOR TURNBUCKLES WITH R.H. THREADS UP, TO THE REAR OR TO THE RIGHT EXCEPT AS NOTED | |
|---|-------------------------|---|------------|
| TERMINAL I | CABLE LGT* DIA. TYPE | TERMINAL II | TURNBUCKLE |
| A | 96.0 | | |
| B | 117.8 | | |
| C | 106.1 | | |
| D | 127.4 | | |
| E | 32.2 | | |
| F | 44.9 | | |
| G | 48.0 | | |
| H | 62.4 | | |
| J | 133.4 | | |
| K | 136.2 | | |
| L | 230.4 | | |
| M | 228.5 | | |
| N | 128.4 | | |
| O | 106.3 | | |
| P | 97.1 | | |
| Q | 117.4 | | |
| R | 62.4 | | |
| S | 32.2 | | |
| T | 48.0 | | |
| U | 44.9 | | |
| V | 136.2 | | |
| W | 230.4 | | |
| X | 132.6 | | |
| Y | 228.5 | | |

*FOR TERMINAL AN 668, THE CABLE ASSEMBLY LENGTH IS MEASURED TO CENTER OF BOLT HOLE, FOR TERMINALS AN 669, THE ASSEMBLY LENGTH INCLUDES FULL LENGTH OF TERMINALS. FOR BAC 1828, THE ASSEMBLY LENGTH DOES NOT INCLUDE THE TERMINALS.

***ADJUSTING LINK**

POULSON & NARDON BALL & STRAP & AMERICAN CHAIN & CABLE BALL & STRAP TERMINALS MAY BE USED IN PLACE OF STANDARD AN667 & AN668 SWAGED TERMINALS

IDENTIFICATION COLORS:
THROTTLE OPEN—BLACK—BLACK
THROTTLE CLOSED—BLACK—RED—BLACK

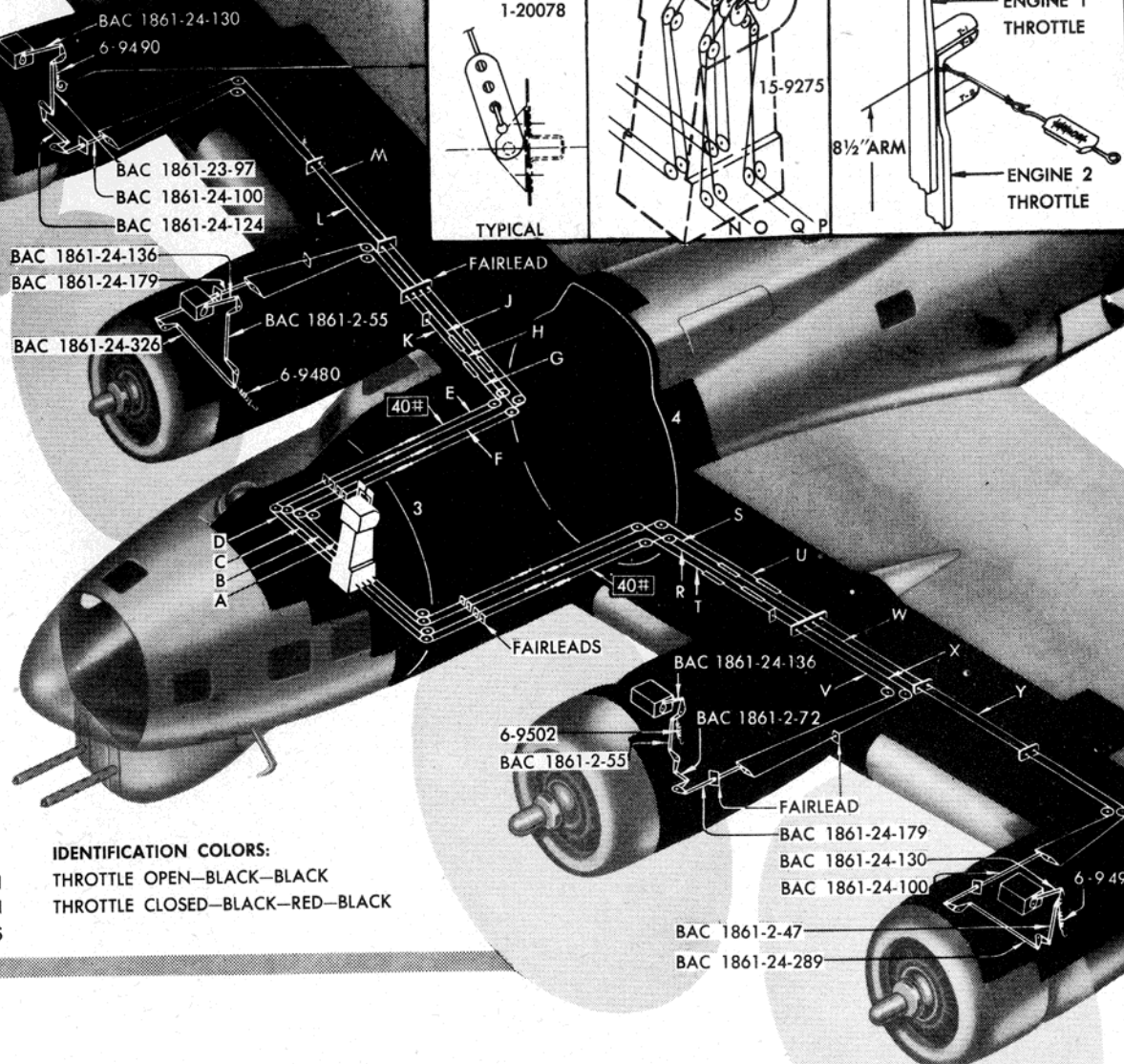
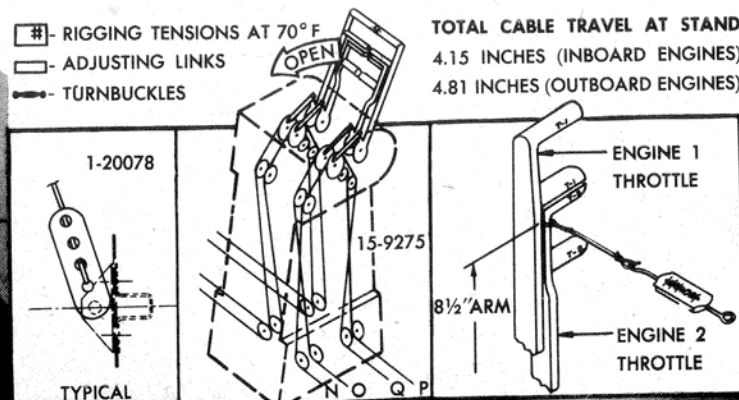
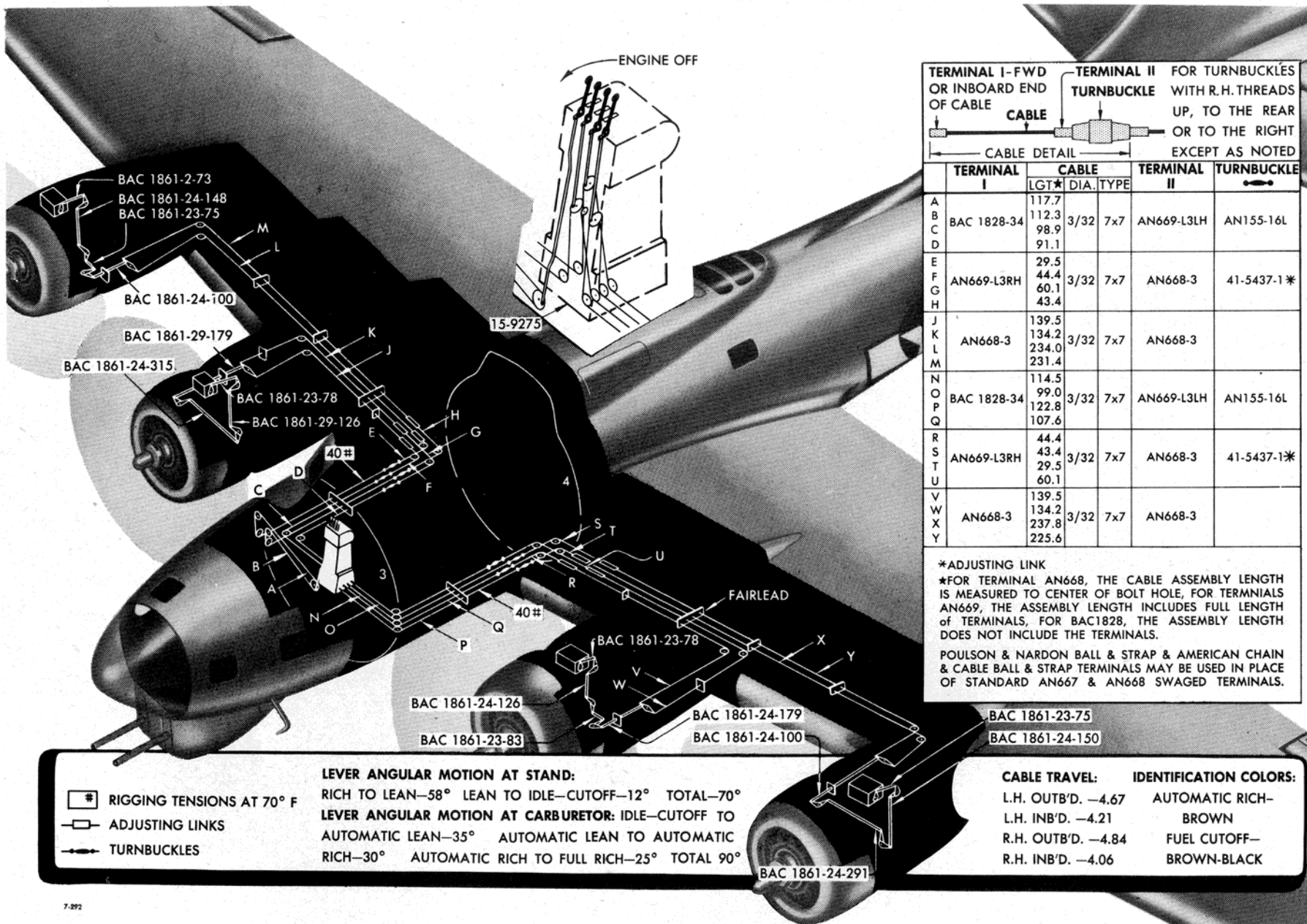


Figure 165—Throttle Control System



7-292

Figure 166—Mixture Control System

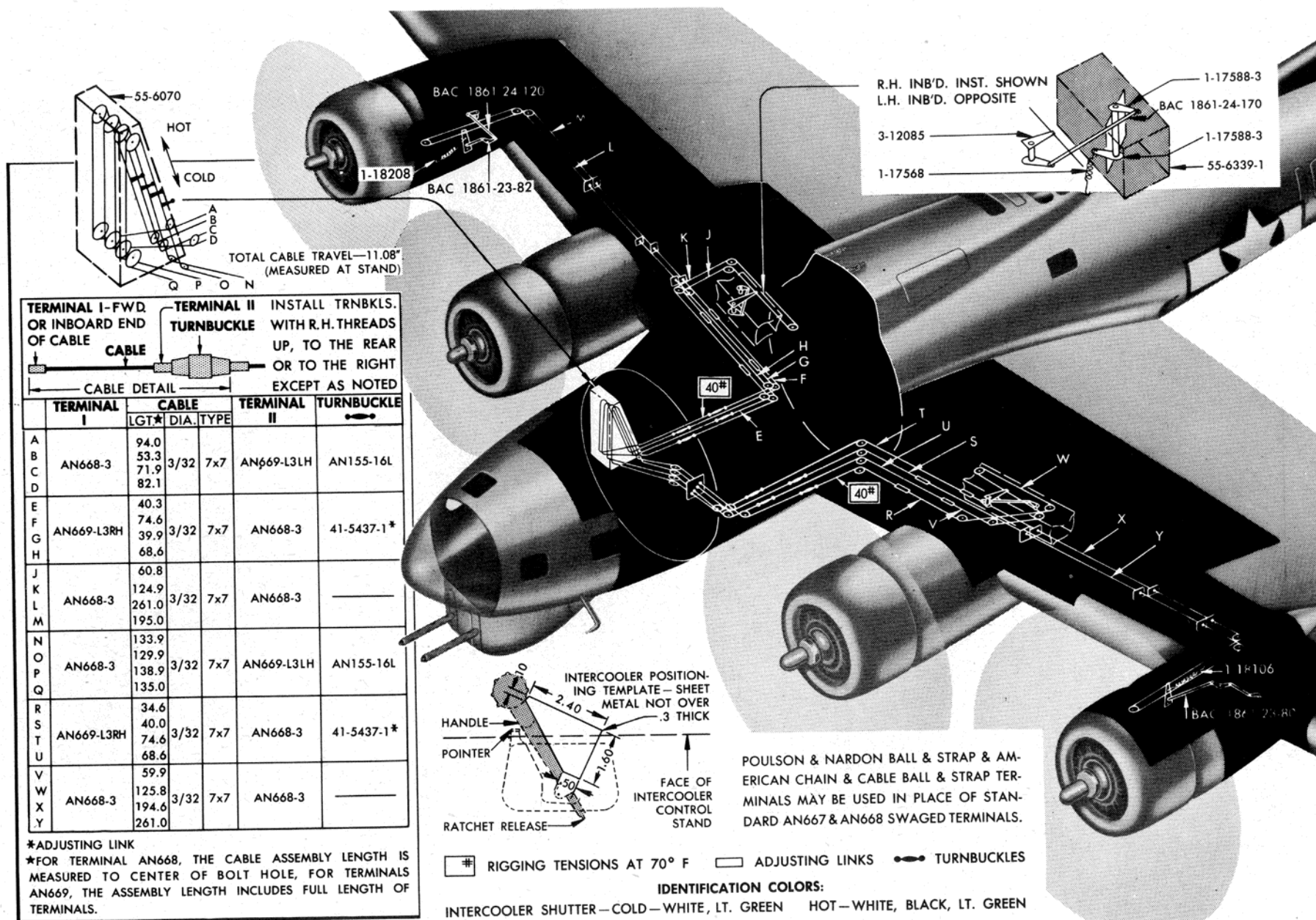


Figure 167—Intercooler Control System

Note

The spring is designed to put the throttle in the full open position if the cables are severed.

8. Check the action of the throttle lever in the cockpit. It should not require more than three pounds to open or seven pounds to close the throttle from the unlocked mid-travel position. Measure the opening and closing forces with a spring scale attached to the throttle as shown in use on figure 165.

9. If the throttle lever forces are too high or if the throttles tend to creep, install link 1-20078 as shown on figure 165. Use progressively less tension, if necessary, until the last hole in the link is reached.

10. If the throttles still tend to creep do NOT reduce tension further and do not increase friction in the throttle control system. Any further adjustment will result in unsatisfactory operation of the system.

11. Check to find out if the system is working right.

**(b) MIXTURE CONTROL RIGGING
PROCEDURE.**

1. Set the mixture controls in the mid-travel position.

2. Set the bell crank in the particular nacelle in the neutral position.

3. Take up the slack at the wing gaps.

4. Take up the tension in the accessory compartment.

5. Check the neutral position on the indicator in the cockpit and at the carburetor. If they do not agree, set the indicator at the neutral position and adjust the rods at the carburetor to the neutral position.

6. Check the 1/8-inch cushion at each end of the mixture control movement. The cushion can be built up with serrated washers.

7. Check to find out if the system is working right.

**(c) PROPELLER PITCH CONTROL
RIGGING PROCEDURE.**

1. Disconnect the cables from the pulleys and set the levers in the cockpit to the high rpm position and lock.

2. Locate the pin on the pulley and screw the top on the governor so that 2500 RPM or more can be obtained by moving the pulley.

a. The slot in the propeller governor shaft should coincide with No. 3 on pulley wheel.

b. High RPM stop pin should be set at second hole past No. 6 and can be moved to either side if necessary.

3. Place the pulley against the stop in the high RPM position and connect the cables.

4. Start the engine and adjust the control lever in the cockpit until you get 2500 RPM. Mark the position on the stand.

5. Stop the engine with the controls still locked in this position and adjust the pin and the screw stop so that they engage.

6. Repeat 2, 3, 4 and 5 for the other engines.

7. With the pulleys on the governors secured against the stops, adjust the turnbuckles under the cockpit floor until the control levers are all even and about 1/8 inch from the steps at high RPM position.

8. Check and readjust the system if necessary.

**(d) INTERCOOLER CONTROL RIGGING
PROCEDURE.**

1. Install the spring between the valve arm and the structure as shown on figure 167.

ENGINE CONTROL BUSHINGS

| Bushings Part No. | Location of Bushing | Reaming Dimensions (Dia.) | | | |
|-------------------|--|---------------------------|------------------|-------------|------------------|
| | | Before Inst. | | After Inst. | |
| 1-18984 | Rod Assy. on Turbo Electric Motor Turbo Motor (15-11671) | .408 | + .000 - .002 | .191 | + .001 - .000 |
| 6-7595-3 | Throttle Control Engine Control Stand Throttle (75-5690) | 1.345 | + .002 - .000 | 1.240 | + .001 - .000 |
| BAC 343-4-220 | Arm Assy. Aft Sta. 2—Nacelle Throttle (55-6191) | .3125 | + .000 - .002 | .125 | + .001 - .000 |
| BAC 283-10ST | Arm Assy. Aft Sta. 2—Nacelle Throttle (55-6191) | .281 | + .001 - .000 | .191 | + .001 - .000 |
| 1-16752-34 | Rod Assy. Above Supercharger Throttle (55-7037) | .248 | + .000 - .002 | .191 | + .001 - .000 |

Note

The spring is designed to place the cooling air valve in the full open position if the control cables are severed.

2. Prop the ratchet release on the handle in the cockpit in the release position.

3. Move the control handle to the full "HOT" position and release. Spring action should return the handle to the full "COLD" position.

4. Repeat the check for the $3/4$, $1/2$, and $1/4$ position from the "COLD" or "ZERO" position. If the return from the $1/4$ open position is about position No. 2 as marked on the stand, the adjustment is satisfactory.

5. If the spring action is checked in flight, the controls will probably return to about position No. 7 because of the added air loads on the valve. This should be considered satisfactory because this corresponds to about 75 percent of the valve opening, and in case of actual cable failure, restriction of travel by the control system would be reduced.

6. Check the adjustment and repeat if necessary.

d. PROPELLER SYSTEM.

(1) GENERAL.—The propellers used on this airplane are Hamilton Standard hydromatic, full feathering type, and are controlled by governors which maintain constant propeller speed as selected from the cockpit. Four handles on the engine control stand provide individual control for each governor which, in turn, controls the propeller.

(a) The propeller feathering system is an auxiliary hydraulic system for full feathering and unfeathering, using engine oil. Each system is operated by an electric motor-driven hydraulic pump, mounted on a bracket on the lower front side of the fire wall.

1. CONTROL.—The pump motor is connected to the battery power by a type D-1 solenoid switch in the nacelle junction shield on the front wing spar in each nacelle. The solenoid is operated by a push button switch with a holding coil, mounted on the instrument board. The holding coil is in series with a pressure cutout switch on the propeller governor.

2. OPERATION.—To feather a propeller the push button switch is pushed in. It is held in by its own holding coil. When feathering is completed, the pressure builds up to 400 pounds per square inch at which point the pressure cut-out switch opens the circuit to the holding coil. The switch opens, allowing the solenoid switch to open and stop the pump. If it is desired to stop the feathering operation before it is completed, the push button may be pulled out. Unfeathering requires pressure above 600 pounds per square inch and the push button must be manually held in because the pressure cut-out switch holds the solenoid circuit open. Hold the control switch closed until the desired amount of unfeathering is accomplished.

CAUTION

Do not attempt to feather or unfeather more than one propeller at a time except in emergency. The feathering motor circuit is not fused. If no feathering action occurs within 90 seconds, pull out the push button switch.

a. Practice feathering and unfeathering will be performed between 5,000 and 10,000 feet above the surface over which the flight is being made.

b. Emergency feathering will be performed at any altitude including take-off and flight condition.

c. Emergency unfeathering will be performed only when the use of the stopped engine is needed for landing or continued flight. In case the propeller was feathered because of a damaged engine, the use of this engine may result in further damage. Every precaution must be taken in warming up the cold engine.

d. A slow increase in RPM is indicative of insufficient oil supply. When this condition is noted, the manifold pressure and speed of the airplane will be reduced to prevent further increase in rpm and overspeeding of the propeller. If reducing the manifold pressure does not prevent an increase in rpm, the propeller will be feathered and the altitude of the airplane will be decreased to the level where proper propeller governor functioning last occurred.

e. Discharge, usually at altitude, of a large quantity of oil through the engine breather indicates the formation of a vacuum in the engine oil pump. If this occurs, an attempt will immediately be made to feather the propeller and the altitude of the airplane will be decreased to the level where proper functioning of the propeller last occurred. The loss of a small quantity of oil through the engine breather sometimes occurs under normal operation, and is not necessarily an indication of a vacuum in the scavenge pump. If the discharge of engine oil does assume appreciable quantities, or if a small quantity discharges for a long period of time, the altitude of the airplane will be decreased to the level where proper functioning of the equipment last occurred.

f. If all oil is lost or the propeller will not feather, an attempt will be made to windmill the propeller at lowest possible speed (high pitch). Place the propeller control in "LOW RPM," the mixture control in "ENGINE OFF." Shut off the ignition, and place the throttle in wide open position to reduce air pumping losses. Shut off gasoline supply. In case icing conditions are encountered, the throttle will be placed in the full closed position.

3. See figure 178 for wiring diagram.

(2) PROPELLERS.

(a) REMOVAL.—A suitable sling and hoist will be used to support the propeller during removal.

| TERMINAL I-FWD OR INBOARD END OF CABLE | | TERMINAL II INSTALL TRNBKLS. TURNBUCKLE WITH R.H. THREADS UP, TO THE REAR OR TO THE RIGHT EXCEPT AS NOTED | |
|--|--|---|------------|
| TERMINAL | CABLE | TERMINAL | TURNBUCKLE |
| | LGT* DIA. TYPE | II | |
| A B C D | BAC1828-34 120.8 110.0 132.1 119.6 | AN669-L3LH | AN155-16L |
| E F G H | AN669-L3RH 44.2 44.6 26.5 55.8 | AN668-3 | 41-5437-1* |
| J K L M | AN668-3 201.2 199.2 257.0 253.0 | AN668-3 | |
| N O | AN667-3 73.0 73.0 | AN667-3 | |
| P Q R S | BAC1828-34 118.6 131.5 109.0 120.2 | AN669-L3LH | AN155-16L |
| T U V W | AN669-L3RH 43.7 45.2 55.8 26.5 | AN668-3 | 41-5437-1* |
| X Y Z | AN668-3 167.5 167.5 294.8 285.2 | AN668-3 | |
| AA BB CC | AN667-3 74.0 74.0 | AN667-3 | |

* ADJUSTING LINK.

★ FOR TERMINAL AN668, & AN667 THE CABLE ASSEMBLY LENGTH IS MEASURED TO CENTER OF BOLT HOLE, FOR TERMINALS AN669, THE ASSEMBLY LENGTH INCLUDES FULL LENGTH OF TERMINALS, FOR BAC1828, ASSEMBLY LENGTH DOES NOT INCLUDE THE TERMINALS.

IDENTIFICATION
COLORS:
PROP. PITCH
WHITE — YELLOW

POULSON & NARDON BALL & STRAP & AMERICAN CHAIN & CABLE BALL & STRAP TERMINALS MAY BE USED IN PLACE OF STANDARD AN667 & AN668 SWAGED TERMINALS.

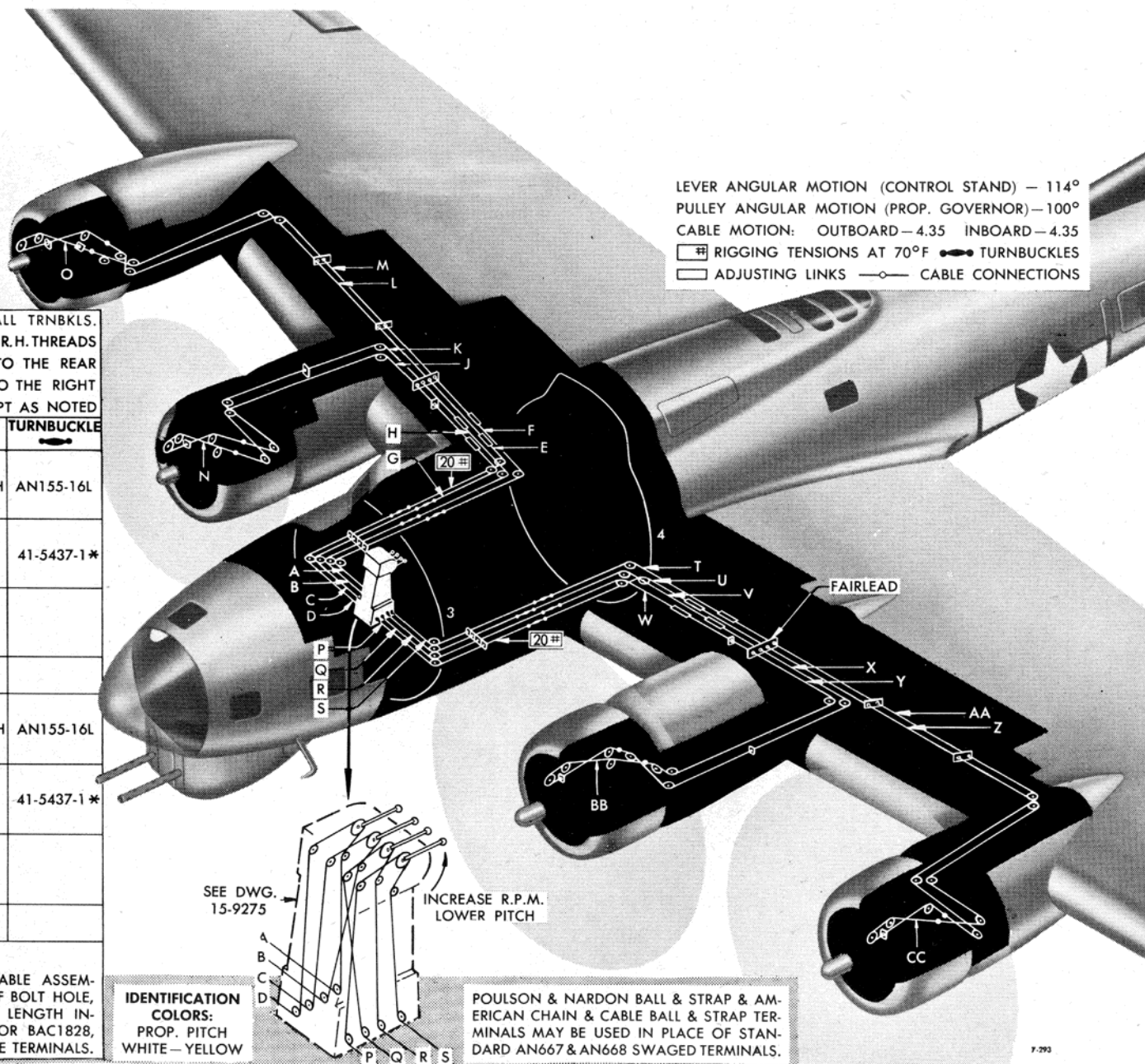


Figure 168—Propeller Pitch Control System

1. Remove the lock screw from the dome retaining nut and unscrew the nut. The nut is attached to the dome and acts as a puller when the nut is unscrewed.

2. Remove the dome assembly.

3. Remove the lock ring from the propeller retaining nut.

CAUTION

It is imperative that this ring be removed before unscrewing the distributor valve, in order to prevent shearing of the valve housing locking splines.

4. Loosen the retaining nut.

5. Unscrew and remove the valve assembly.

6. Unscrew and remove the propeller retaining nut.

(g) Remove the propeller from the shaft.

Note

The hub snap ring and related parts inside the spider are so arranged that, as the retaining nut is backed off, it pulls the propeller with it, until the nut reaches the end of the propeller shaft thread.

(b) MINOR REPAIRS AND REPLACEMENTS.

1. GENERAL.—The operating time between propeller overhauls will not exceed 1400 hours. At each engine change within this period, and if the 1400-hour limit will not be exceeded before the next engine change, propellers may be reinstalled without overhaul. At each engine change, or at any other time when the dome assembly is removed from the propeller, and visual inspection indicates deposits of sludge or carbon, the propeller dome assembly will be disassembled and cleaned as follows.

a. Remove the positive high and low pitch stops, the pitch stop plate screws and plate.

b. Remove the piston and cam assembly from the dome shell. Do not disassemble the cam and piston.

c. Wash the cam, the piston, and the inside of the dome shell in gasoline to remove carbon and sludge deposits.

d. Reassemble the dome assembly and install it on the propeller.

2. COATING WITH OIL.—On completion of each day's flying, clean all external surfaces of each propeller and coat with clean engine oil.

3. LOCAL ETCHING.—To determine whether visible lines on the propeller blade surface are actually cracks instead of scratches and to determine, with minimum removal of metal, when shallow cracks and doubled-back edges of metal have been fully removed:

a. Prepare etching solution by adding to the required amount of water as much commercial caustic soda as the water will dissolve.

b. Clean and smooth the area containing the apparent defect with No. 00 sandpaper or fine steel wool.

c. Apply a small quantity of caustic solution to the suspected area. After the area is well darkened, wipe it thoroughly with a cloth dampened with clean water.

d. If a crack or other defect extending into the metal exists it will appear as a dark line or other mark in which small bubbles may be seen forming with the use of a magnifying glass.

e. Several applications may be necessary to determine when all shallow cracks and doubled-back edges have been removed.

f. Immediately after completing the final inspection, all traces of the caustic soda will be removed with nitric acid solution, which in turn will be thoroughly rinsed off with clean water. The blade will then be dried and coated with clean engine oil.

Note

General etching will be accomplished only at repair depots.

4. CONDEMNATION.—Defects that are definitely identified as slag inclusions will not be considered cause for condemning a blade, unless such defects are excessively numerous. A propeller blade having any of the following defects will be condemned:

a. A longitudinal crack, cut, scratch, scar, etc., that cannot be dressed off or rounded out without materially weakening or unbalancing the blade, or materially impairing its performance.

b. Unserviceability due to removal of too much stock by etching, dressing off defects, etc.

c. An excessive number of slag inclusions.

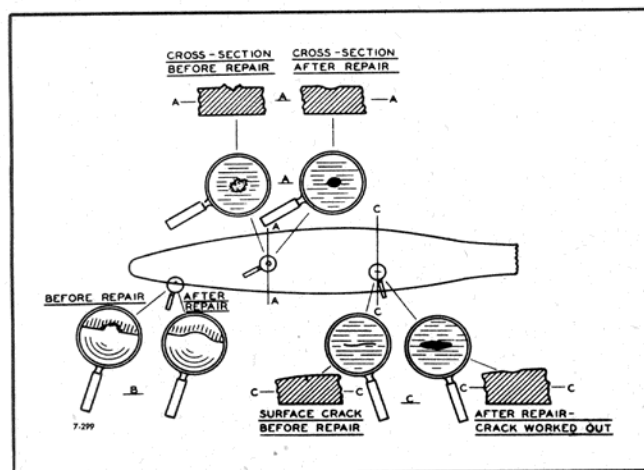


Figure 169—Repairing Propeller Blade Surface Cracks

5. MARKING PROPELLER BLADES.—

Between the 18- and 24-inch stations on the camber side, each blade will bear the following markings:

Army Air Forces Serial Number.

Part or drawing number.

Blade angle settings on all blades installed in hub whether in stock or on aircraft.

The foregoing data will be painted or stenciled with enamel, or stamped with a rubber stamp and printer's ink using numbers and letters 1/2 inch high. In no instance will such markings be indented or cut into the metal. The markings will be protected by a coat of spar varnish or clear lacquer.

(c) INSTALLATION.

1. Coat engine shaft and front cones with engine oil, making certain that the rear cone and cone seat are free from oil and dirt. Using a suitable hoist and sling, install the propeller hub and blade assembly on the propeller shaft, sliding it back only far enough to engage the threads of the propeller retaining nut by hand.

2. Check to be sure that the 1/32-inch copper gasket is in place against the adapter flange inside the propeller shaft and that the valve housing oil transfer plate on the base of the distributor valve assembly is in place, with the 1/32-inch copper gasket between it and the valve housing.

3. Oil the threads of the valve assembly, screw it into the shaft and tighten it with the composite wrench, using adapter, tool No. 41B1862. Apply a force of approximately 100 pounds at the end of the bar and while this force is being maintained, strike the bar one light blow with a hammer weighing not more than 2 1/2 pounds. If the locking slots in the valve housing are not aligned with the holes in the propeller shaft, repeat this tightening operation until the slots and holes are in alignment.

CAUTION

Under no conditions will the valve housing be backed off even slightly in order to obtain slot and hole alignment. If alignment cannot be obtained, a new gasket will be used or the original gasket will be lapped to reduce thickness.

4. Tighten the propeller retaining nut on the shaft using the tubular wrench together with composite wrench and a bar about three feet long.

a. Apply a force of approximately 180 pounds at the end of the bar and while this force is being maintained, strike the bar close to the wrench with a hammer weighing about 2 1/2 pounds. Do not tighten the nut excessively by the use of the extension on the wrench handle or by hammering on the handle.

b. Determine if one of the locking slots in the nut is in alignment with one of the holes in the

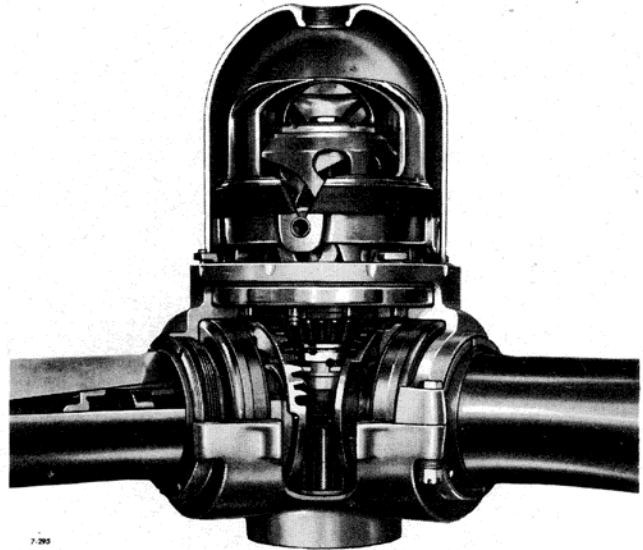


Figure 170—Hydromatic Propeller

propeller shaft. If not, repeat the tightening procedure until alignment is obtained.

5. Install the locking ring with the pin through the retaining nut slot, the propeller shaft hole and into the valve housing slot. Snap the wire into position in the retaining nut.

6. Before installing the dome assembly, check to be sure that the low and high angle limit adjustments are correct. Adjust as follows if required:

a. Lift out the uppermost stop ring. 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.

b. Lift out the lower stop ring. 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. The stop rings may be removed by inserting No. 10-24 screws in the tapped holes in the rings.

c. Reinstall the low angle stop ring to the desired low angle limit by inserting it so that the arrow on the stop ring coincides with the desired degree mark (indicating the degrees of blade angle at the 42-inch station) stamped on the stop-locating plate. It may be necessary to rotate the cam gear a small amount in a counterclockwise direction to permit inserting the stop ring without interfering 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.

d. Reinstall the high angle stop ring to the desired high angle limit by inserting it, on top of the low angle stop ring, so that the arrow on the high angle stop ring coincides with the desired degree mark on the stop-locating plate.



Figure 171—Changing Propeller Blade Angle

7. Make certain that the dome and barrel oil seal is properly installed around the stationary cam base against the dome.

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 and the following steps should be carried out to insure correct meshing.

8. By turning the rotating cam gear, move the piston in the dome assembly into the extreme forward position. This position will be reached when the cam gear stop lugs are against the high angle stop lugs.

9. Turn each blade to the high angle position against the stop pins.

10. Slide the dome assembly over the end of the valve assembly, making sure that the oil seal rings on the valve assembly enter properly into the sleeve inside the piston. Turn the dome in a counterclockwise direction until the dowels in the barrel dome shelf engage the aligning holes in the stop location plate. (The dome unit may be installed in any of three possible positions, one of which is suitable marked.) The cam

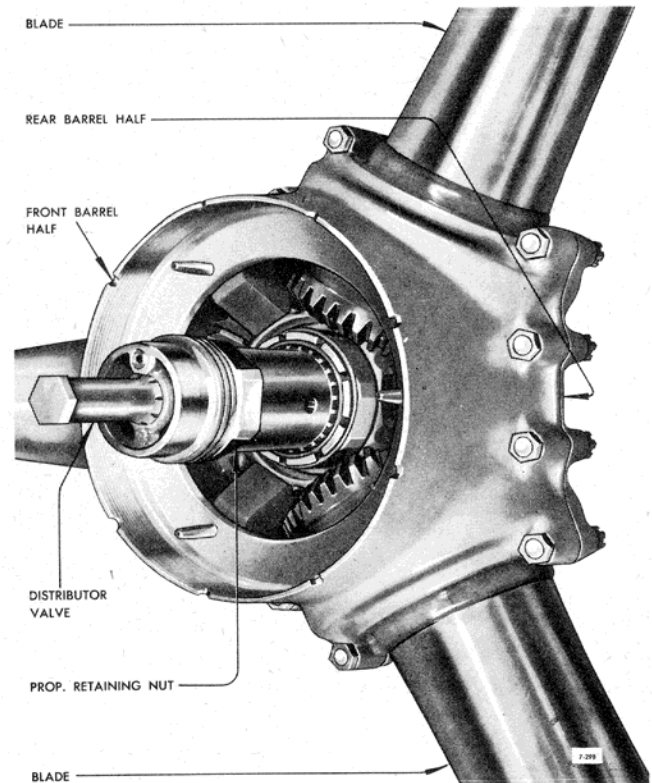


Figure 172—Hydromatic Propeller Hub and Distributor Valve

gear and blade gears are now in proper alignment; slide the dome assembly, without turning it, into the barrel until the dome retaining nut can be started.

11. Do not turn the dome assembly in a clockwise direction in order to align the dowels and holes, as this will tend to move the stop lugs on the rotating cam away from the high angle position, thus allowing the gears to mesh incorrectly.

12. Tighten the dome retaining nut, using

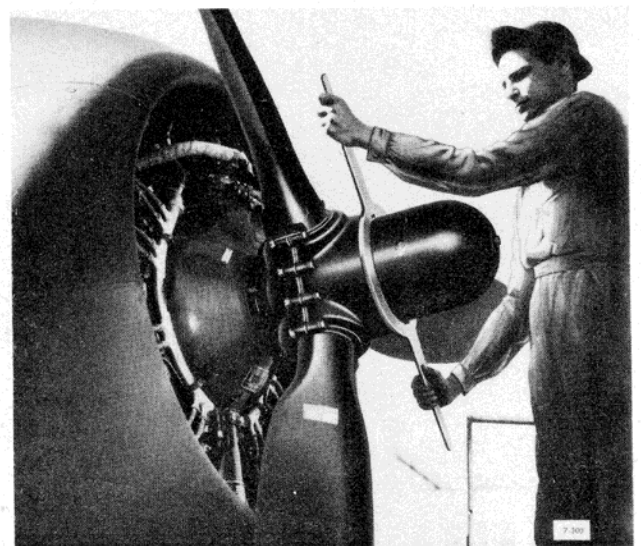


Figure 173—Tightening Propeller Dome

composite wrench, or a special propeller dome wrench as shown in figure 173, applying a force of approximately 180 pounds at approximately 4-foot radius. With the dome assembly properly seated in the barrel, the front face of the dome retaining nut will be approximately flush with the front edge of the barrel.

13. It is essential that the dome unit be firmly seated on the retaining shoulder in the barrel. Tightening of the dome retaining nut, in addition to fastening the dome unit to the hub, serves to apply the preloading force to the gears and to compress the dome and barrel seal. Its tightening, therefore, requires a relatively high wrench torque as indicated above. Failure to tighten the dome unit securely in the hub will result in elongation or failure of the assembly screws which fasten the dome cylinder and the stop locating plate to the stationary cam.

14. Install the dome retaining nut lockscrew and safety the screw with a 7/16 x 1/2-inch steel cotter pin.

15. Make sure that the dome breather hole nut in the front of the dome is tight and the lock wire is in place.

CAUTION

Using suitable levers to turn the blades, shift the propeller into full low angle and check all three blade angles by the index lines on the blades and the graduations on the barrel or with a protractor. These angles should be equal and should agree with the low angle stop setting. This check indicates that the correct relationship between the blade gears and the cam gear has been obtained. (See figure 171.)

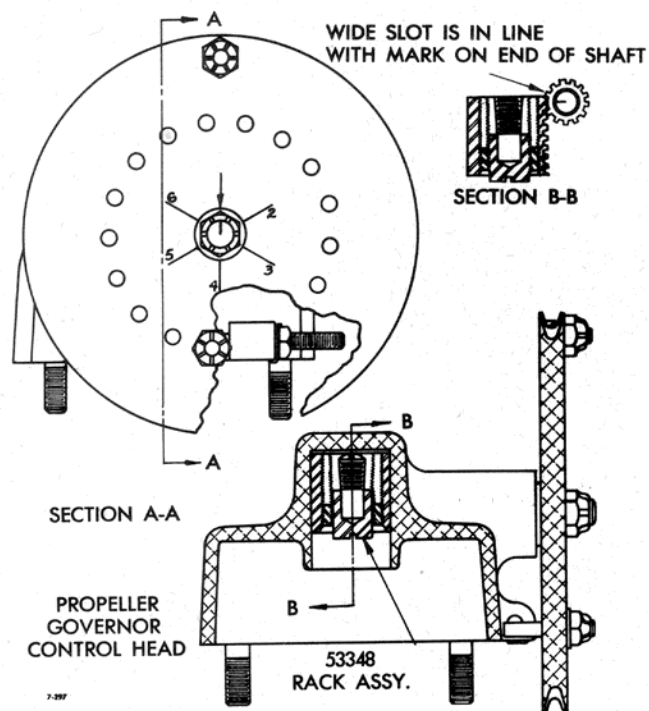


Figure 174—Propeller Governor Control Head

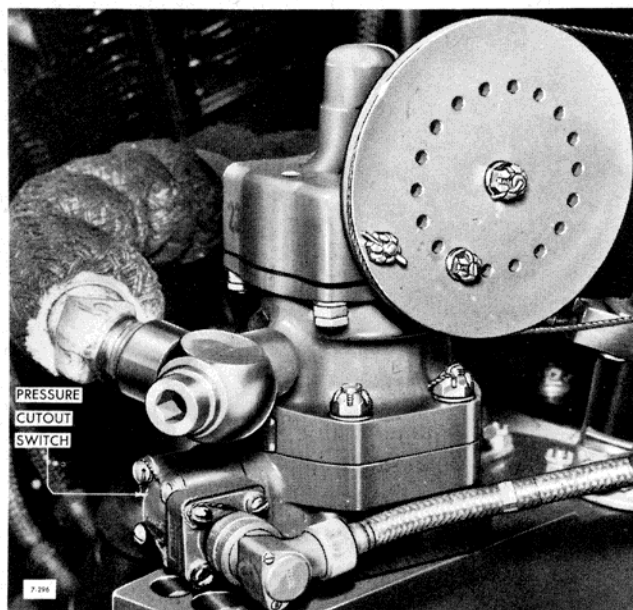


Figure 175—Propeller Governor

16. Check all external screws, nuts, etc., for proper safetying.

(3) PROPELLER GOVERNOR.

(a) REMOVAL.

1. Unless it is specifically necessary, do not remove the control cables from the governor pulley.
2. Remove the pulley from the governor shaft, carefully noting the relation between the reference mark on the shaft and those at the hexagonal hole in the pulley, in order to facilitate reassembly.
3. Remove the four mounting stud nuts.
4. Remove the governor unit from the engine.

(b) INSTALLATION.

1. Check governor for freedom of movement before installing. Any binding or drag should be investigated.
2. Place the governor on the mounting pad over the proper type of gasket.
3. Screw the securing nuts on the mounting studs and run down finger tight.
4. Remove the governor head, and check for backlash and freedom of movement while tightening down the mounting nuts. These nuts must be tightened down evenly, but not excessively tight. If binding is noted after the nuts are tightened the condition can usually be relieved by slacking off slightly one or more nuts.
5. The propeller shaft should be rotated to at least three positions while tightening the securing nuts, and the governor checked for backlash and freedom of movement at each point.
6. Rig control cables as directed on figure 168.
7. With control cables disconnected at the pulley, lock the control handle in the cockpit in the "HIGH RPM" position.

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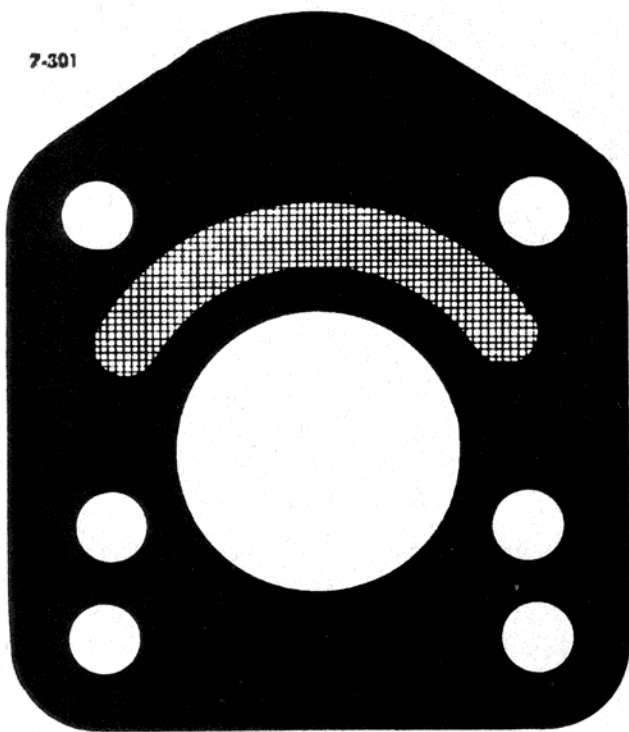


Figure 176—Propeller Governor Gasket

8. Adjust the stop screw on the governor housing and shift the stop pin (if necessary) so that the governor pulley may be rotated to the full high position.

9. Right the pulley cables in the full high position.

10. Start the engine and adjust the propeller pitch control lever until engine speed is exactly 2500 RPM and lock the control handle in this position.

11. Stop the engine and, with the control handle still locked, adjust the stop screw on the governor to contact the pin on the pulley.

12. Unlock the control handle and adjust the turnbuckles on the cables to hold the pin on the pulley against the stop on the governor with the control handle 1/8 inch away from the extreme high position on the control stand. Apply full rigging tension.

13. After adjusting all propeller controls, start all engines and readjust, if necessary, to synchronize propellers with control handles aligned.

(4) PROPELLER FEATHERING PUMP.

(a) REMOVAL.—When removing the feathering pump disconnect and cap the oil supply line, and either pull the control circuit fuses or wrap the connector plug with a rag or tape to prevent damage from accidental operation of the control switch.

(b) MINOR REPAIR AND REPLACEMENTS.—If it is necessary to replace a broken line between the feathering pump and the propeller governor, use corrosion resistant tubing capable of withstanding 700 pounds per square inch pressure. If unable to replace with suitable material, remove the damaged line, insert

plugs at the governor and at the pump, remove the control circuit fuse, and operate temporarily without the feathering feature.

(c) INSTALLATION.—Reinstall the feathering pump, connect the oil supply line and replace the circuit fuses.

e. STARTING SYSTEM.

(1) GENERAL.—Each engine is equipped with either a type G-6 or a type JH-3R combination inertia and direct-cranking starter which is installed on the center mounting pad of the engine accessory drive cover. The starters receive power directly from the batteries through the battery solenoid switches and a starter solenoid switch in each nacelle junction shield. The starter solenoids are controlled by two double-pole, double-throw switches on the copilot's auxiliary panel. Each switch controls two solenoids. Two similar switches operate the meshing solenoid in the starters and at the same time supply power to the induction vibrators and magnetos for the starting ignition spark. During an electrical start, the flywheel will accelerate to its normal running speed of 16,000 RPM in 10 to 12 seconds. By holding the "START" switch on after depressing the "MESH" switch, the motor will directly crank the engine after the breakaway torque of the flywheel is expended. A slip clutch of alternate steel and copper plates protects the starter during excessive loading or in case of backfire. The starter jaw disengages automatically when the engine starts. A hand crank and extension are carried in the radio compartment and, for the manual starting, are inserted in the receptacle located in the lower right side of the nacelle just behind the cowl flaps. (Airplanes equipped with JH-3R starters carry a gear box stowed in the radio compartment which is to be used with the hand crank—no extension is required.) A manual meshing handle adjacent to the crank receptacle is connected by cable to the starter meshing lever.

(a) STARTING PROCEDURE—ELECTRICAL.

1. Pull the propellers through with the ignition switches "OFF."

2. Turn on the master ignition switch and all three battery switches.

3. Depress the proper "MESH" switch momentarily, thus assuring that the starter motor brushes are on the commutator. (Type JH-3R starters only.)

Note

In order to lower the motor brushes for the type G-6 starter, it is necessary to remove the firewall door and move the brush lifting lug on the rear face of the starter to "ON."

4. Depress the proper "START" switch.

5. After 15 to 20 seconds of starter acceleration (maximum RPM of the starter is indicated when its "whine" stabilizes at a constant high pitch) and with

Section IV
Paragraph 6

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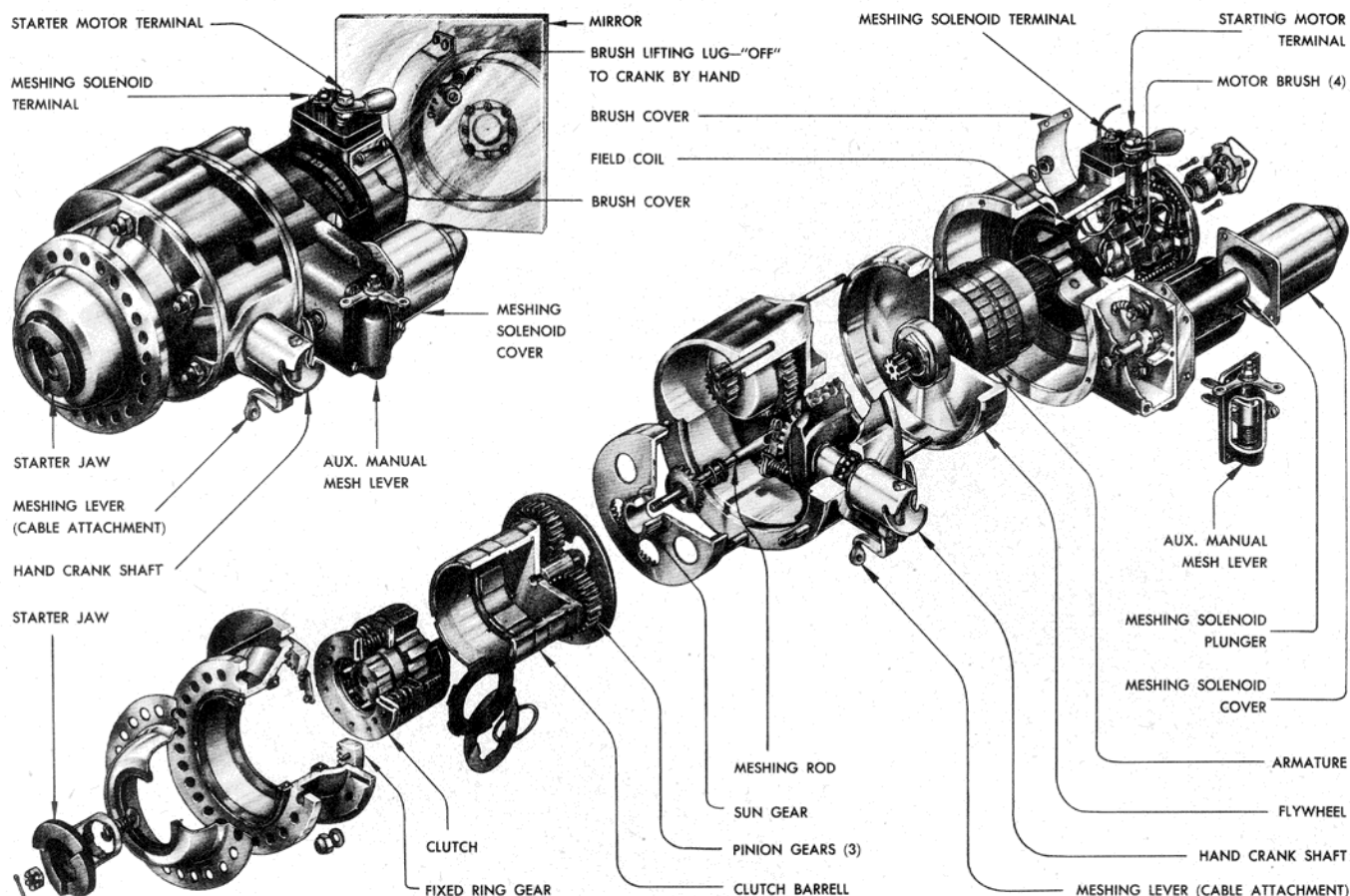


Figure 177—Engine Starter Type G-6

the "START" switch still depressed, engage the starter and engine jaws by depressing the "MESH" switch.

6. When the propeller has completed approximately one revolution, turn the ignition switch for the engine being started to "BOTH." (This is a precautionary measure to prevent the engine from firing "backwards." There is no retarded spark feature with ignition systems which employ the Induction Vibrator.)

CAUTION

Do not attempt to accelerate the starter either electrically or manually when the starter and engine jaws are engaged. If propeller kicks forward when the "START" switch is depressed, release the switch instantly and turn the propeller backwards by hand (ignition "OFF") at least one turn to disengage the jaws.

7. Release the "START" and the "MESH" switches when the engine fires.

Note

In order to prevent damage to the starting system, release the "START" and the "MESH" switches and re-energize the starter (after a cooling period of 30 seconds) if the engine fails to start after 15 seconds of direct-cranking ("START" and "MESH" switches engaged).

(b) STARTING PROCEDURE—MANUAL.

Note

It is recommended that a crew of at least four men be used to hand start the engines. These include operators in the pilot's and the co-pilot's seats, a signalman, and an energizer (two men may be used for this purpose if a two-handed starter crank is available) who also acts as a fireman.

1. Pull the propellers through with the ignition switches "OFF."

2. Turn on the master igniton switch and all three battery switches.

3. Lift the starter motor brushes from the commutator, thus eliminating motor drag. For the type G-6 starter, remove the nacelle firewall door and move the brush lifting lug on the rear face of the starter to "OFF". The brushes of the type JH-3R starter are lifted by pulling the manual meshing handle.

4. Install the handcrank extension (used with the G-6 starters) or the handcrank gearbox (used with the type JH-3R starters) in the handcrank receptacle and insert the handcrank.

5. Turn the handcrank until the starter inertia wheel reaches its maximum possible RPM which is at-

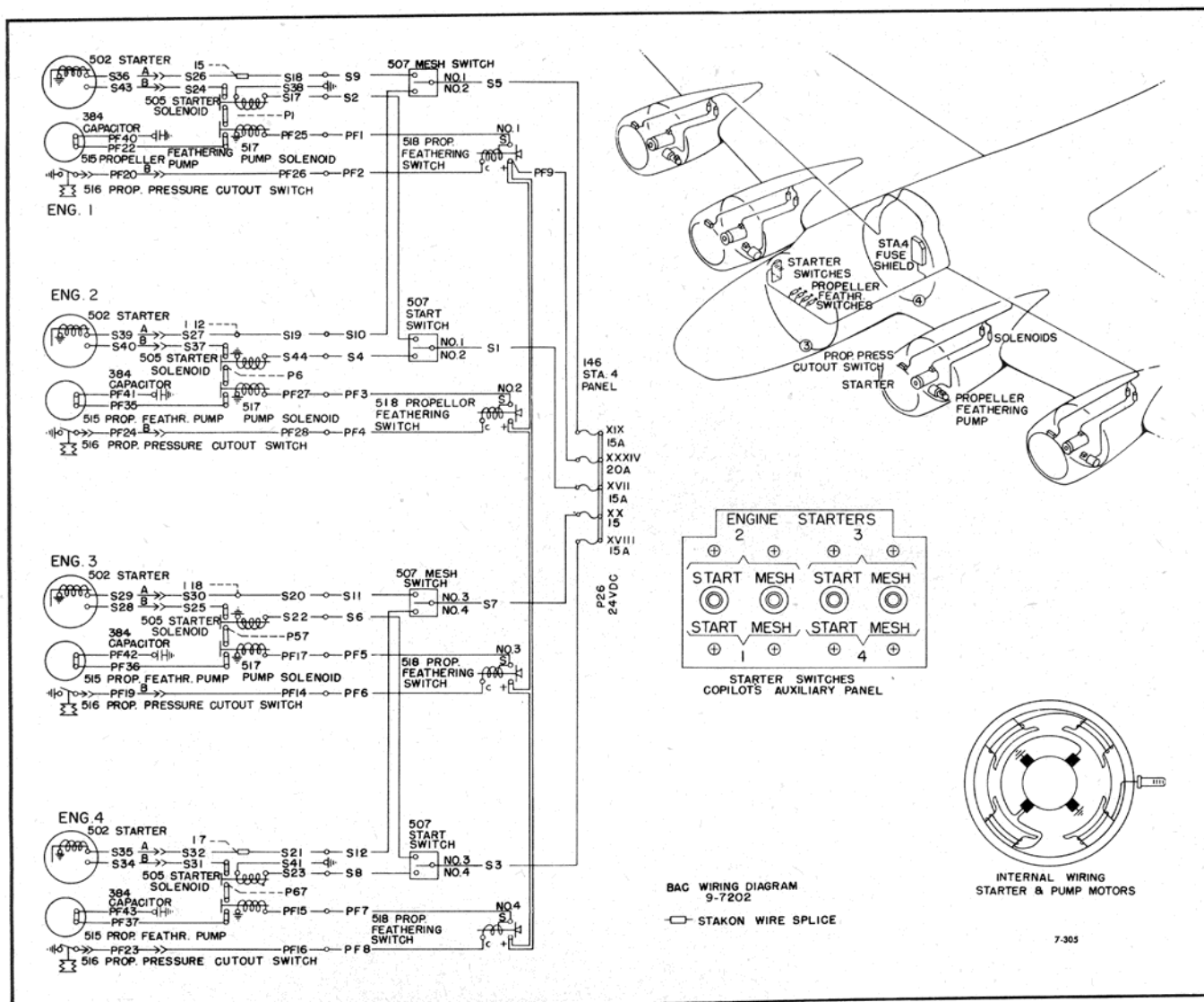


Figure 178—Starter and Propeller Feathering Circuit

tained when the handcrank RPM is approximately 80 for type G-6 starters or approximately 95 for type JH-3R starters.

6. Remove the handcrank from its receptacle and indicate to the signalman to have the operator in the copilot's seat mesh the starter and engine jaws by depressing the proper "MESH" switch. Usually it is not necessary to engage the starter and engine jaws with the manual meshing handle. However, under certain circumstances such as circuit failures, limited number of the starting crew, or exceptionally weak batteries, it may be advisable or necessary to manually mesh. *In this case, it is necessary to depress the proper "MESH" switch simultaneously with the pulling of the manual meshing handle in order to obtain ignition boost.*

Note

When engaging the starter manually, give the handle a firm, hard pull to insure adequate meshing of the starter and engine jaws to avoid chipping these parts.

7. When the propeller has completed approximately one revolution, turn the ignition switch for the engine being started to "BOTH."

8. Release the manual meshing handle and the "MESH" switch when the engine fires.

9. If the engines are equipped with the type JH-3R starters, lower the starter motor brushes to the commutator by returning the brush lifting lug on the rear face of the starter to "ON"—after the completion of a successful hand start. (The motor brushes on the type JH-3R starters are automatically lowered to the commutator when the "MESH" switch is depressed.)

CAUTION

Do not attempt to accelerate the starter either manually or electrically when the starter and engine jaws are engaged. If excessive handcranking forces or propeller movement are present during handcranking, indicating jaw engagement, turn the propeller backwards by

hand (ignition "OFF") at least one turn to disengage the jaws.

(2) STARTER.

(a) REMOVAL.—Starter equipment at the engines and nacelles is easily removed after dismantling the nacelle cowl and access doors. *Be sure that the battery power is "OFF" or remove the control circuit fuses before disconnecting any equipment.*

Note

The starter and starting system accessories should be replaced and forwarded to the depot for overhaul at each engine change.

1. Remove the electrical connections to the starter and clutch solenoids. Disconnect the manual meshing cable at the clutch lever connection and remove the six nuts from the studs in the mounting flange. (If a type JH-3R starter is being removed, the handcranking flexible drive must also be disconnected from the starter.) Remove the starter and install a protective cover plate on both the mounting pad and the starter jaw.

Note

Do not set the starter on its jaw unless the jaw is protected by a cover plate. Any scratches or burring of the jaw teeth would impair the disengagement of the engine and the starter, resulting in serious damage to one or both.

2. The meshing solenoid may be removed from the starter by removing the two bolts in the bracket and disconnecting the clutch lever. The solenoid assembly should require no attention between major overhaul periods.

(b) MINOR REPAIR AND REPLACEMENTS.

Note

No activity, other than the engineering departments of air depots, will perform any repairs on electrical starting equipment other than exterior cleaning, replacement of brushes, complete starter motors, field post nuts and washers, and the replacement of solenoid starter switches, induction vibrators and cables.

(c) INSTALLATION.

1. Before mounting the starter on the engine, remove the protective cover over the starter jaw. Examine the end of the engine crankshaft and ascertain if the engine jaw and starter jaw are of the same type and are of the correct rotation for proper engagement. With the engine gasket removed the distance from the mounting flange to the outermost part of the engine jaw must be $1\frac{11}{16}$ inch plus or minus the $\frac{1}{32}$ inch. The clearance between the engine jaw and starter jaw must be $\frac{1}{16}$ inch minimum when the latter is fully retracted. Wipe the mounting flange clean, replace gasket and mount the starter securely with washers, nuts, and palnuts.

2. Check carefully for correct electrical connections. The starter control and meshing circuits are fused, but the starter motor circuit is not fused. Adjust the solenoid cable for full travel to permit complete retraction of the starter jaw, but allow only negligible excess slack between the solenoid and the meshing mechanism. This protects the cable terminals from shock loads when the solenoid is energized. If excessive friction is present in the engaging linkage, an external spring should be added to assist in returning the starter jaw. Electrical cable lengths in the main starter circuit should be kept as short as possible to minimize voltage drop, as well as to decrease the weight of the cable. All cable ends should be securely soldered to terminals and completely covered with rubber nipples or tape to prevent accidental short circuit.

(d) TROUBLE SHOOTING.

1. If the starter motor operates but does not engage flywheel:

- a. The motor jaw may be binding on the armature shaft.
- b. Motor rotation may be incorrect. Replace motor.

2. Engine oil leakage into starter may be due to:

- a. Worn oil seal leather in baffle plate.
- b. Insufficient slack in engaging linkage, preventing complete retraction of starter jaw against oil seal. Provide sufficient slack to permit seating of the jaw.

c. Excessive friction in engaging linkage. Incorporate an auxiliary spring in engaging linkage to assist in retracting jaw.

3. Free running time of starter too low. Look for:

- a. Engine oil leakage into starter.
- b. Improper lubrication.
- c. Barrel adjusting nut too tight. Should be tightened until snug, then backed off one full hole. Clearance between nut and the ball rack should be at least .003 inch.

d. Ball bearings worn or rough turning.

4. Difficult hand cranking may be due to:

- a. Misalignment of cranking extension.
- b. Crank extension bearings not lubricated. Lubricate with engine oil, grade 1100. (If the engines are equipped with the type JH-3R starters, the handcrank gear box or the handcrank flexible shaft may be in need of servicing. Disassemble and thoroughly clean; if exposed to low temperatures, apply a light coat of grease, Specification AN-G-3.)

- c. Improper starter lubrication.
- d. Engine oil leakage into starter.

- e. Barrel adjusting nut too tight. See above.
- f. Ball bearings rough and worn.
- 5. Fluctuation in clutch setting, with gradually increasing value, may be due to:
 - a. Worn or scored discs.
 - b. Clutch adjusting nut not locked in place.
 - c. Clutch not properly set. Should be set at 650 ± 20 -foot pounds.
- 6. Motor fails to operate. Look for:
 - a. Wiring not properly connected. See figure 178.
 - b. Loose or high-resistance connections. Clean and tighten.
 - c. Loose or corroded battery terminals. Clean and tighten.
 - d. Low voltage input. Check and recharge battery.
 - e. Brushes binding. Remove and wipe clean with gasoline-moistened cloth.
 - f. Worn brushes. The brushes should be replaced before their maximum wear limit is reached to insure proper operation between inspection periods. The maximum permissible wear of brushes is $3/16$ inch from a new length of $1/2$ inch. When replacing a worn brush, the new brush should be properly seated by inserting a strip of No. 000 sandpaper between the brush and the commutator with sanded side next to the brush and pulling in the direction of rotation. Repeat until brush is fully seated.

CAUTION

DO NOT USE COARSE SANDPAPER OR EMERY CLOTH. REMOVE SAND OR METAL PARTICLES WITH COMPRESSED AIR.

- g. Brushes not properly seated. See above.
- h. Excessive brush side-play. Replace brushes.
- i. Rough or dirty commutator. Smooth with No. 000 sandpaper. Badly scored commutator should be resurfaced (depot operation).
- k. Shorted, grounded, or open armature.
- l. Grounded or open field coil.
- m. Solenoid starting switch coil grounded or open. Connect a heavy jumper cable across the two contact studs to determine whether the switch is at fault. Replace faulty switch.
- n. Toggle switch inoperative.
- 7. Excessive arcing of motor brushes. See above steps e. to i.
- 8. Solenoid meshing device fails to operate. Look for:

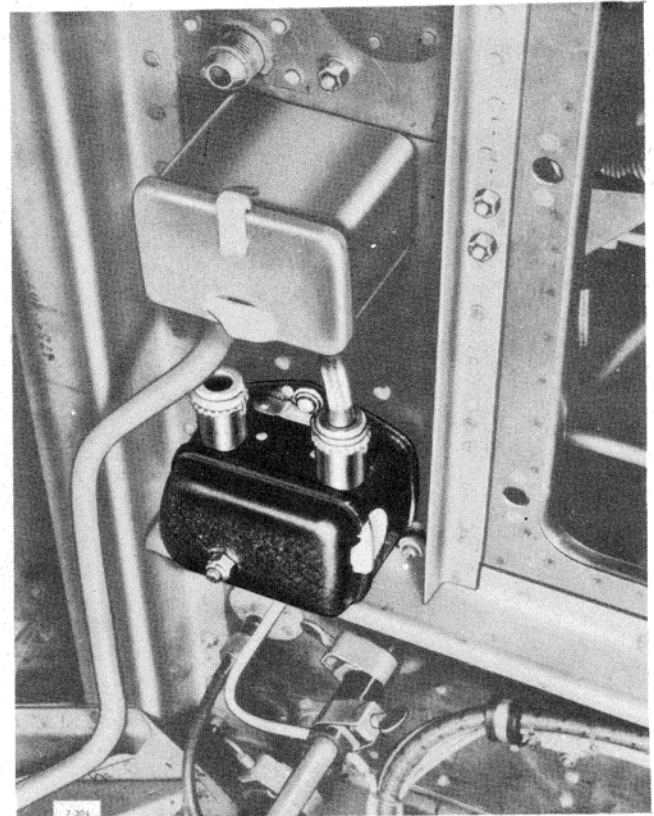


Figure 179—Induction Vibrator Installation—Inboard Nacelle

- a. Improper electrical connection. See wiring diagrams.
- b. Coil burned out. Replace coil.

(3) INDUCTION VIBRATOR.

(a) **GENERAL.**—A type VJR-24B5 induction vibrator is mounted on the rear side of the firewall in each nacelle. The vibrator includes a relay which connects the vibrator coil to the right hand magneto primary when the starter "MESH" switch is depressed, and disconnects it when the switch is released to prevent grounding the magneto primary, rendering the magneto inoperative. The vibrator coil, operating much like a common buzzer, changes 24 volt DC from the starter meshing circuit to low voltage pulsating DC which is transformed in the primary and secondary of the magneto to high voltage current. This current is distributed through the magneto rotor and fixed contacts to the spark plugs. The induction vibrator is not energized when the manual meshing handle is pulled.

(b) **REMOVAL.**—To remove the induction vibrator, remove the cover and disconnect the short length of shielded conduit at the bottom of the vibrator. Remove the three bolts in the mounting flange.

(c) **INSTALLATION.**—Replace three bolts in mounting flange, connect conduit, replace cover.

(d) **TROUBLE SHOOTING.**—If the induction

vibrator fails to operate, it may be due to any of the following causes:

1. Grounding plate at the lower mounting bolt is not grounded.
2. Open circuits in the relay or vibrator coils.
3. Relay point opening is not between .015 and .020 inches.
4. Relay armature plate does not move freely.
5. Knurled adjusting nut on the relay is improperly adjusted. (Send the relay to an overhaul depot for adjustment.)

Note

The gap between the rivet on the bottom of the vibrator armature plate and the core of vibrator coil should be between .055 and .075 inches for the type VJR24B5 induction vibrator.

(4) PRIMER.

(a) REMOVAL.—The mounting bolts for the primer are reached through the access bolts at the right side of the cockpit enclosure.

(b) TROUBLE SHOOTING.—If leakage occurs through the primer connections of the cylinders with the primer locked in the "OFF" position, replace the primer.

f. COWLING.

(1) GENERAL.—The engine cowling consists of four main parts: The antidrag ring (nose cowl), the cowl flaps, the fixed cowl, and the nacelle cowl.

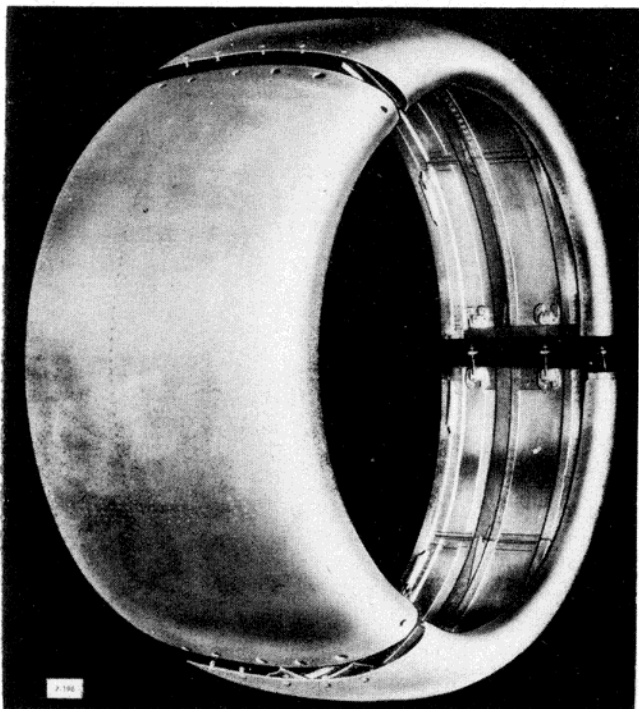


Figure 180—Engine Ring Cowl Details

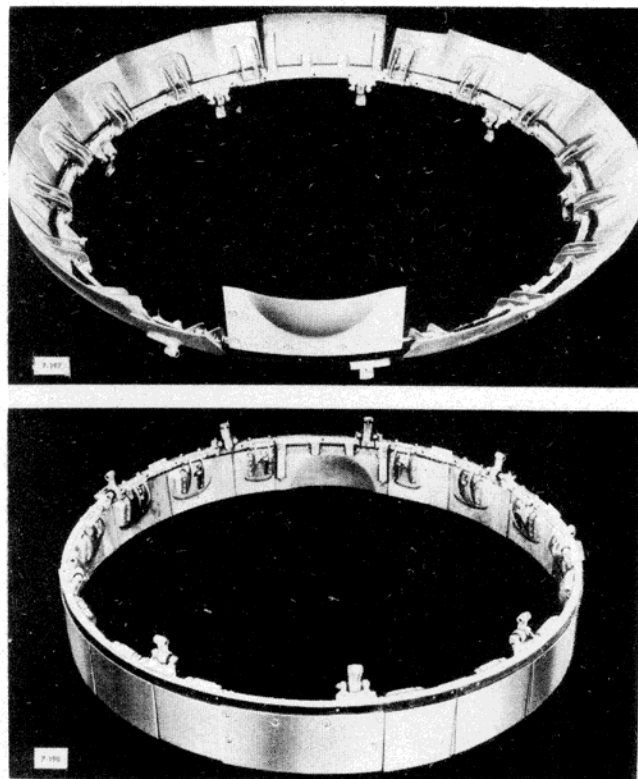


Figure 181—Engine Cowl Flap Details

(2) ANTIDRAG RING.

(a) GENERAL.—The antidrag ring consists of three sections which fasten together to form the fairing around the cylinders. Two lower sections attach to the upper section by means of Dzus fasteners.

(b) REMOVAL AND DISASSEMBLY.

1. The antidrag ring may be removed with the propellers in place. Loosen the clamping bolts at the bottom connection and swing them free. Then release the Dzus fasteners and lift off the sections. The sections are interchangeable, except for adjustments necessary to maintain the maximum clearance at the rear supports, as shown in figure 184.

(c) MINOR REPAIR AND REPLACEMENTS.

—Minor repairs should consist primarily of maintaining smooth, even contours and dressing down deep scratches or gouges. The antidrag ring, especially, should have the gouges dressed down carefully and the Alclad coating should be worked over the exposed alloy sheet.

(d) ASSEMBLY AND INSTALLATION.—Refer to figure 201 and install the parts in the following order:

1. Install the nose cowl as indicated in figure 184. Put the top section in place and check for proper contact of stops. Connect the bottom sections to the top section and draw them together enough to latch the clamping bolts. Check for proper contact of the stops and for mating of the tongues in the notches at the flap support ring fittings on the rocker boxes. Draw the clamping bolts tight and set the lock nuts.

(3) COWL FLAPS.

(a) GENERAL.—The cowl flaps assembly consists essentially of a shock-mounted support ring and eight movable flaps on each side of the nacelle, with one stationary flap at the top and one at the bottom. The support ring is composed of five sections which are joined by means of bolted splice plates. The flap hinges bolt to the support ring and the two stationary flaps are attached to the ring by means of Dzus fasteners. The flap-operating mechanism (push-pull rods and bell cranks) is actuated hydraulically by means of a cylinder suspended in the upper part of the linkage on the aft side of the fixed cowl. Refer to figure 183 for arrangement of the mechanism, and to Section IV, paragraph 7. c. for information on the cowl flap hydraulic system.

(b) REMOVAL AND DISASSEMBLY.

1. COWL FLAPS.

a. Before starting to remove the cowl flaps, operate all flaps to the "OPEN" position, leave the valve turned to "OPEN," and open the accumulator bleed valve to release all hydraulic pressure.

b. The antidrag ring must be removed before attempting to dismount the cowl flap ring. During removal it will be advisable to disconnect the ring at the two positions that are nearest the bottom and top stationary flaps because of greater accessibility at these two points. Release the Dzus fasteners and remove the top and bottom stationary flaps. Disconnect the eight flap actuating struts at the flaps, and remove the splice plates at the top and at the bottom of the support ring. Be careful to retain the washers and the loose

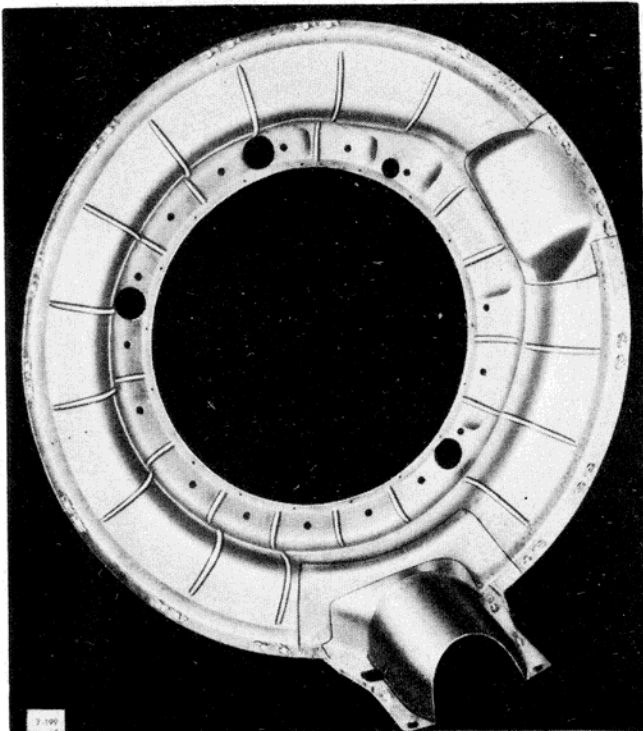


Figure 182—Typical Fixed Cowl

spacer at the top left strut. Disconnect the support ring mounts from the rocker boxes and remove each half of the ring with the flaps attached.

2. COWL FLAP MECHANISM.

a. Before disconnecting the hydraulic tubing at the cylinder, check to see that the valve is in the "OPEN" position, that the accumulator bleed valve is open, and that the hydraulic pressure is zero. The flap actuating cylinder may then be removed by disconnecting the rod-end bearings at the mechanism.

b. Disconnect the push rods from the cowl flaps at the self-aligning bearings, break the cowl flaps into two pieces at the splices in the cowl flap ring. Remove the flaps from the cylinder head brackets (do not disconnect at the rubber shocks). For further disassembly remove the engine mount from the engine. The push rods and levers should be disconnected as a unit from the engine mount bearing. Next remove the fixed cowl from the engine mount ring. The link rods may now be disassembled and the hydraulic cylinder removed. The aft levers can now be removed from the engine mount ring bearing. For replacement, the bearings assembled on the right side of the ring should have odd part numbers, those on the left side, even numbers. The two top bearings are not interchangeable, either with each other or the other bearings. For further details see figure 185. Where complete disassembly is not necessary, tag the parts so as to take advantage of previous adjustments.

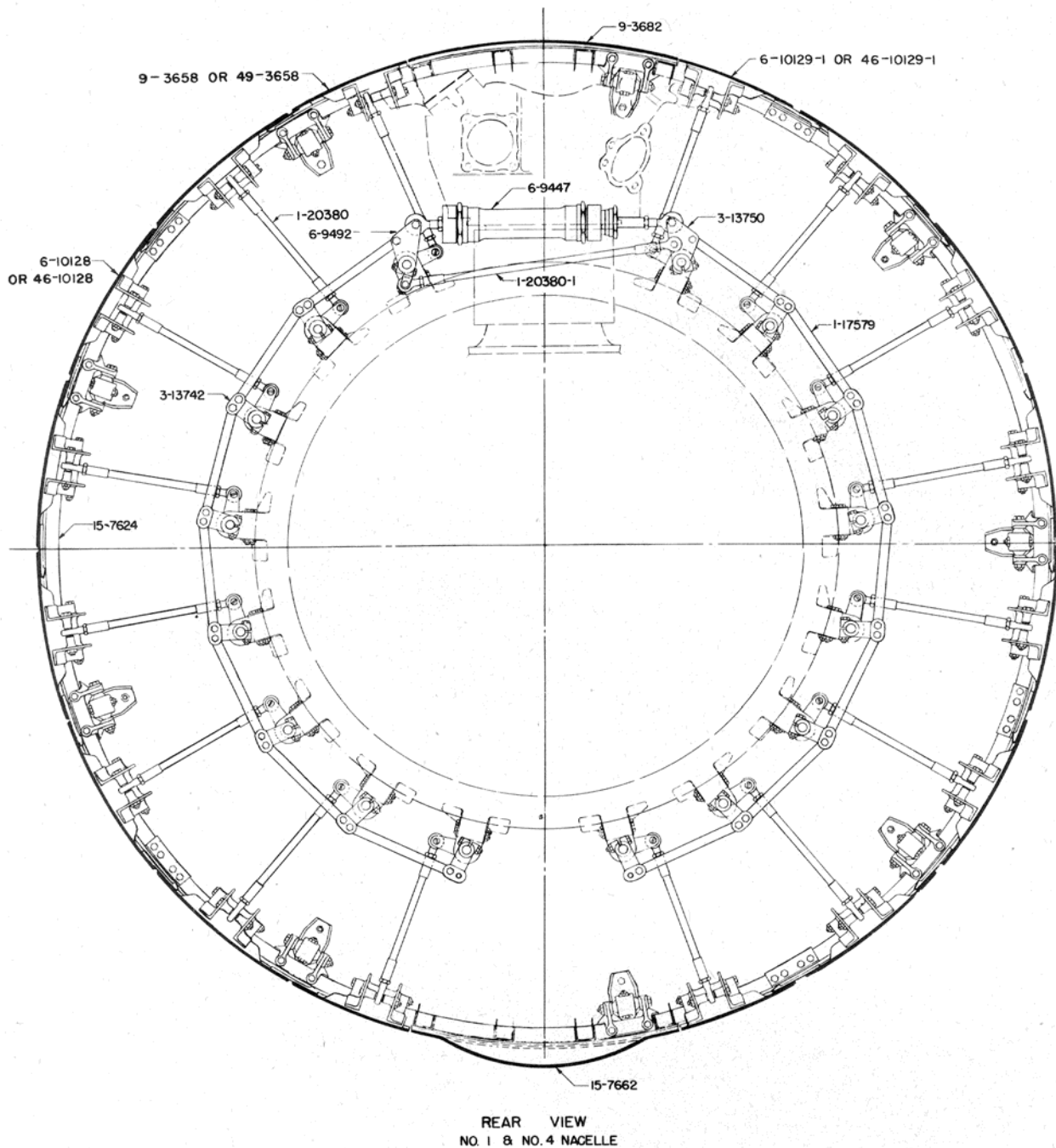
(c) MINOR REPAIR AND REPLACEMENTS.

—Minor repairs should consist primarily of maintaining smooth, even contours and dressing down deep scratches or gouges. The antidrag ring, especially, should have the gouges dressed down carefully and the Alclad coating should be worked over the exposed alloy sheet with a burnishing tool. Since the flaps are assembled with a double sheet construction, repair will be more difficult and, when badly deformed or torn, they should be replaced with new flaps. See Section IV, paragraph 7. c., for repair of the cowl flap operating mechanism.

(d) ASSEMBLY AND INSTALLATION.—Install the cowl flaps as directed in figure 185. Make final adjustment with the nacelle cowl installed to permit check of the closed position. If it is inconvenient to install the nacelle cowl at this time, defer the final adjustment and install the removable panel in the fixed cowl, making sure that the Dzus fasteners in the stationary panels are securely locked.

(4) FIXED COWL.

(a) GENERAL.—The fixed cowl is installed on the engine mount and forms the front portion of the engine accessory compartment enclosure. This cowl butts against the engine housing, thereby providing both an air seal for the accessory compartment and a shroud for the exhaust collector ring. The rear edge of the fixed cowl provides the front support ring for the nacelle cowl.



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Figure 183—Cowl Flap Assembly Diagram

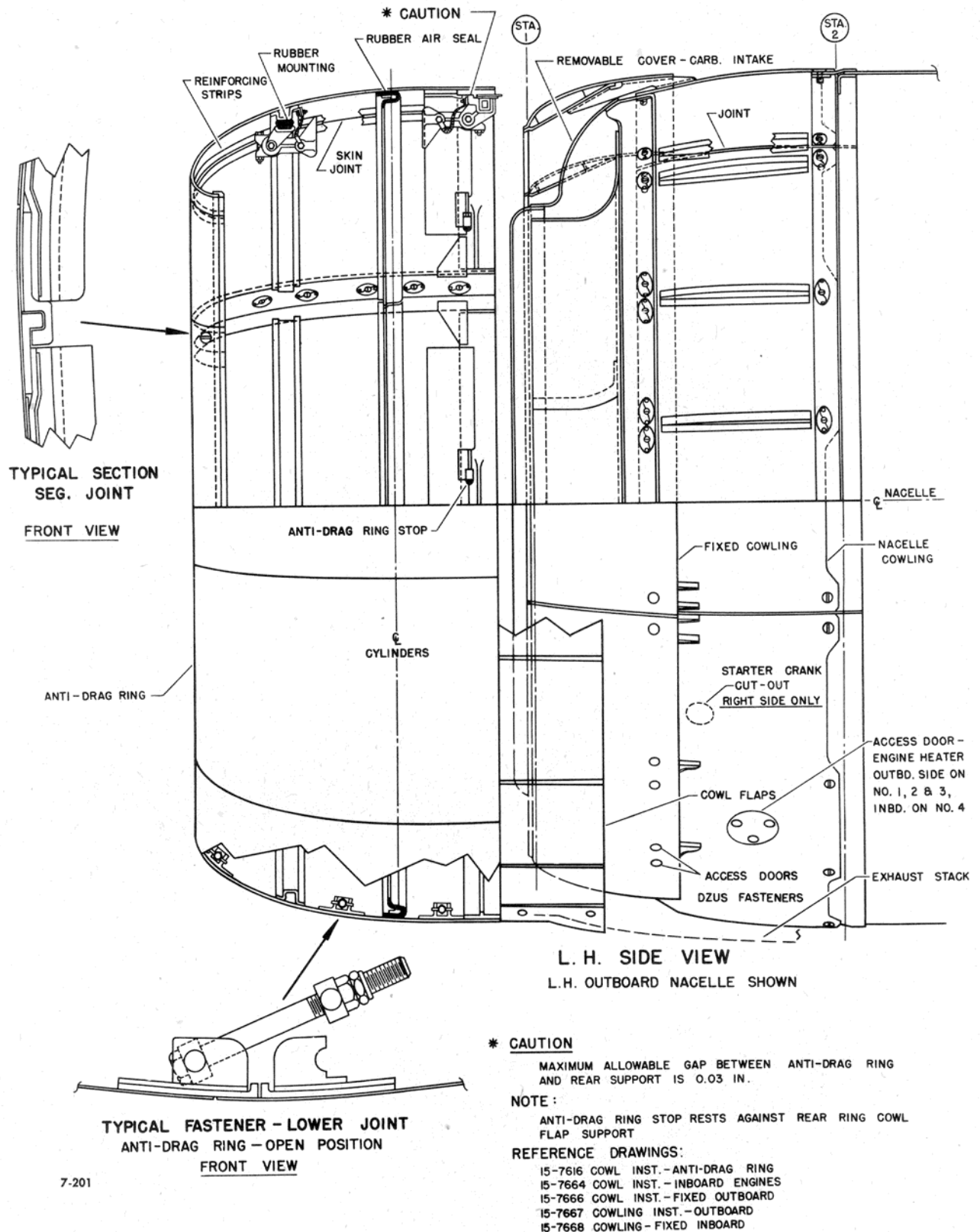


Figure 184—Engine and Nacelle Cowling Diagram

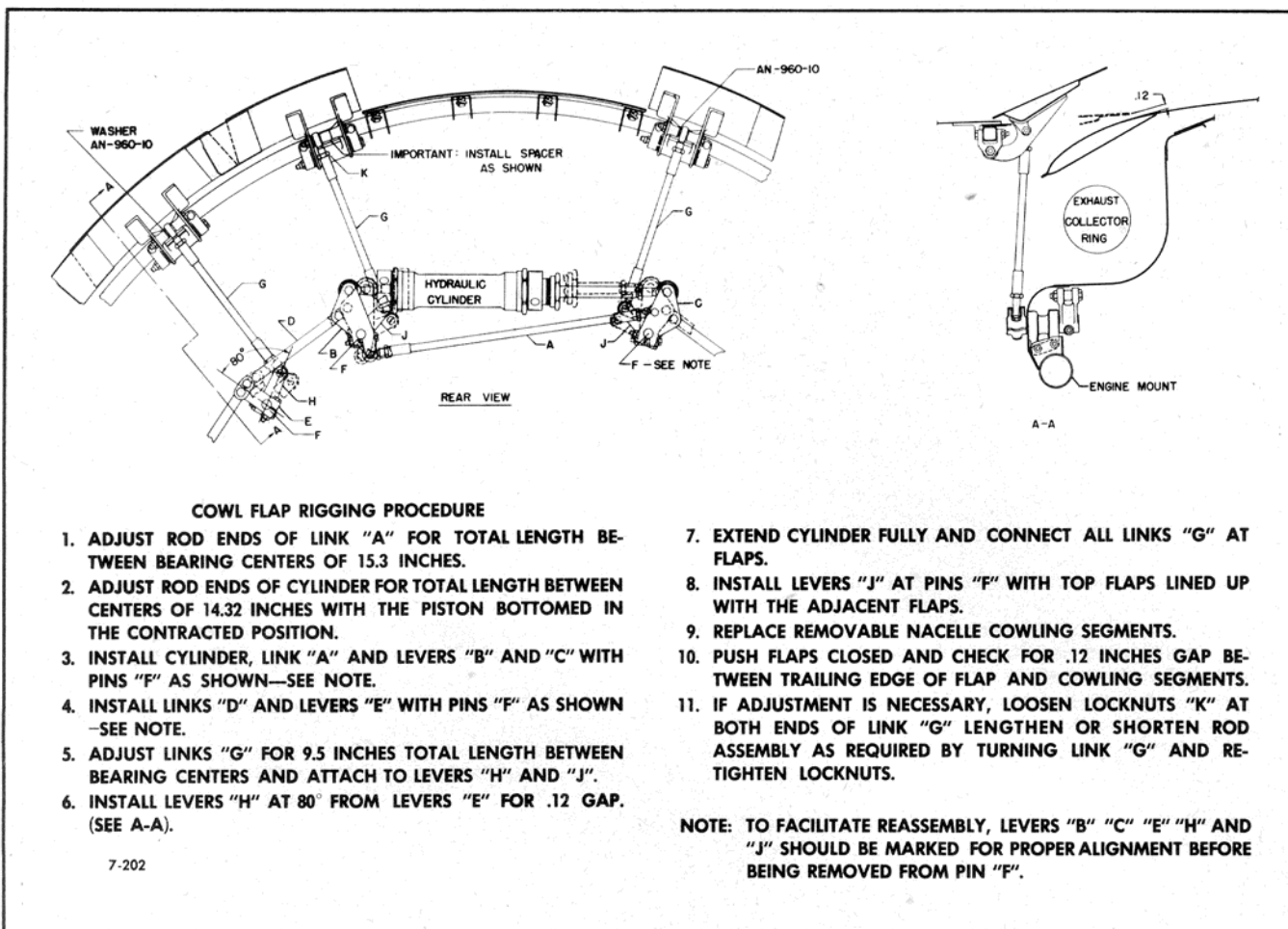


Figure 185—Cowl Flap Rigging Diagram

(b) REMOVAL AND DISASSEMBLY.—The fixed cowl is not removable from the mount with the engine installed. However, a removable panel is provided at the top and is attached by means of screws and nut plates. Removal of this panel provides access to the cowl flap actuating cylinder and to the carburetor.

(c) ASSEMBLY AND INSTALLATION.—If the fixed cowl has been removed, it must be replaced before the engine is installed. Leave off the removable panel at the top until the carburetor duct elbow and the cowl flap cylinder have been installed.

(5) NACELLE COWLING.

(a) GENERAL.—The nacelle cowling consists of five removable panels which complete the enclosure of the engine accessory compartment, between the engine and the nacelle fire wall. The panels butt against each other and lap the front support ring on the fixed cowl and the rear support at the nacelle. Each nacelle cowling panel has an additional section of cowling attached to it which extends over the forward edge of the panel, into the gap between the fixed cowl and the cowl flaps. These additional sections form a continuous ring to meet the aft edges of the closed flaps and also form a

portion of the exhaust collector ring shroud. A gap between the nacelle cowling panel and the additional section permits the continuous cooling of the exhaust collector ring regardless of flap position. A small access door is provided on the lower portion of the nacelle cowling to allow insertion of the heater stack for pre-warming of engine accessories in cold weather. The doors are held in place by three dot fasteners. A half turn of each fastener will allow removal of the door. The door also permits access to the propane starting injection line.

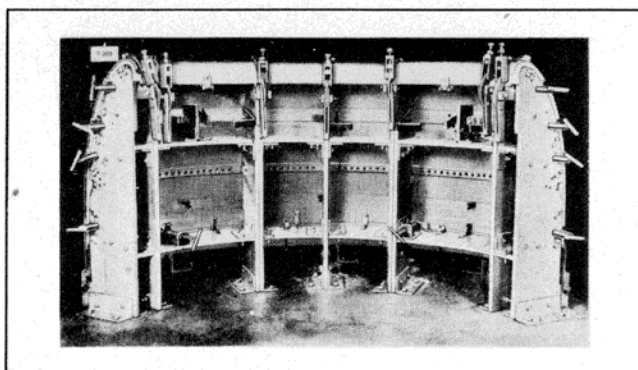


Figure 186—Engine Cowl Ring Construction

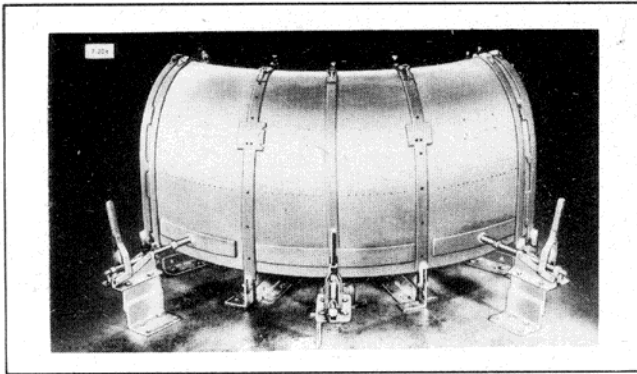


Figure 187—Engine Cowl Ring Construction

(b) **REMOVAL AND DISASSEMBLY.**—Release the Dzus fasteners and lift off each panel of the nacelle cowl ring separately. Spring-loaded, hinged covers, attached to the overlapping thickness, swing inward to provide access to the fasteners at the forward edges of the panels. The panels are interchangeable, except for those adjacent to the exhaust shroud on each nacelle.

(c) **MINOR REPAIR AND REPLACEMENTS.**
—Minor repairs should consist primarily of maintaining smooth, even contours and dressing down deep scratches or gouges. The antidrag ring, especially, should have the gouges dressed down carefully and the Alclad coating should be worked over the exposed alloy sheet with a burnishing tool. Since the flaps are assembled with a double sheet construction, repair will be more difficult and, when badly deformed or torn, they should be replaced with new flaps. See Section IV, paragraph 7. c., for repair of the cowl flap operating mechanism.

(d) **ASSEMBLY AND INSTALLATION.**—Install the nacelle cowl ring panels and make sure all Dzus fasteners are securely locked.

g. OIL SYSTEM.

(1) **GENERAL.**—Lubricating oil is supplied to each engine individually from a self-sealing tank installed in the nacelle between the fire wall and the front spar. Each of the four tanks has a capacity of 36.9 U. S. (30.7 Imperial) gallons (maximum quantity required with full fuel load, including bomb bay tanks) with an additional expansion space of approximately 10 percent. A self-turning Cuno filter is integral with the engine and an oil temperature regulator with a type D-8 thermostatic relief valve is installed directly behind an air inlet in the leading edge of the wing, adjacent to each nacelle. The cooling core shutters are operated thermostatically and therefore there are no oil cooler controls in the cockpit. Automatic action results normally in a continuous oscillation of the shutters, since the engine scavenger pump does not provide a constant flow of oil, and therefore the oil temperature must fluctuate. A surge valve is installed in the oil line between the engine and the inlet side of the oil cooler with a line running from the relief port to a tee in the line between the oil cooler outlet and the oil tank. A check valve is provided at the latter point between the oil cool-

er and outlet tee. The function of the surge valve is as follows: Should oil pressures in excess of 75 pounds build up due to restricted flow through the oil cooler, the piston of the surge valve shifts to open the relief port which permits direct flow past the oil cooler to the tank. The check valve is provided between the oil cooler outlet and the tee where the by-pass line connects into the tank line to prevent pressures in excess of 75 pounds being imposed upon the oil cooler in the event of congealed oil in the line to the tank. Dilution of oil is accomplished with fuel under pressure from the carburetor valve on the forward side of the fire wall in each nacelle.

(a) Each oil tank consists of an aluminum-alloy shell enclosing a self-sealing cell. The ends of the shell are attached with bolts to permit installation of the leakproof cell. The cell is attached to the metal casing by securing all tank outlets to the shell with fittings bolted in place. An oil temperature accelerating well, or "hopper", is provided in each tank. This is an aluminum cylinder which leads from the oil inlet to the oil outlet. Warm oil enters the hopper and flows immediately to the tank sump and back to the engine. Oil consumed by the engine is replaced by cold oil which enters the hopper through openings in the upper and lower ends of the cylinder. The entire tank must be removed from the nacelle to repair a damaged hopper.

(b) Draining provisions for the oil system consist of a self-locking "Y" type draincock located below the oil tank in the out line.

(2) OIL TANKS.

(a) **REMOVAL AND DISASSEMBLY.**—To remove the asbestos lagging from the oil lines without damaging it, the tubes must be disconnected and the asbestos sock pulled off. This allows the insulation sleeves to remain intact and serviceable.

1. **OUTBOARD NACELLE TANKS.**—Remove the access doors at top and bottom of the nacelle and drain the tank. Remove the turbosupercharger elbow duct on the intake side of the blower. Disconnect all tubing from the tank and remove the tubing clamped at the top of the nacelle above the oil tank to gain clearance. Disconnect the bonding wires at the fore and aft ends of the tank and remove the oil line elbow

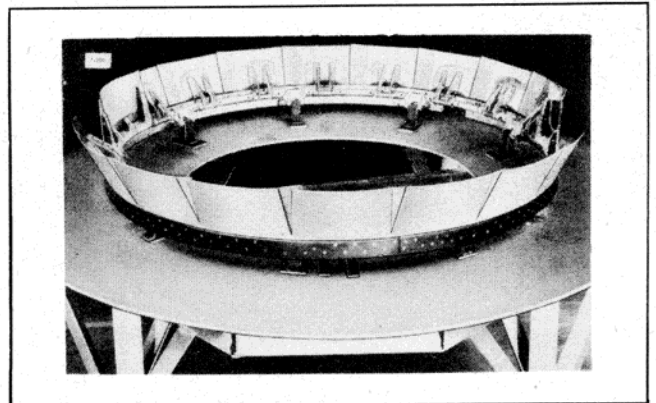


Figure 188—Engine Cowl Ring Flap Construction

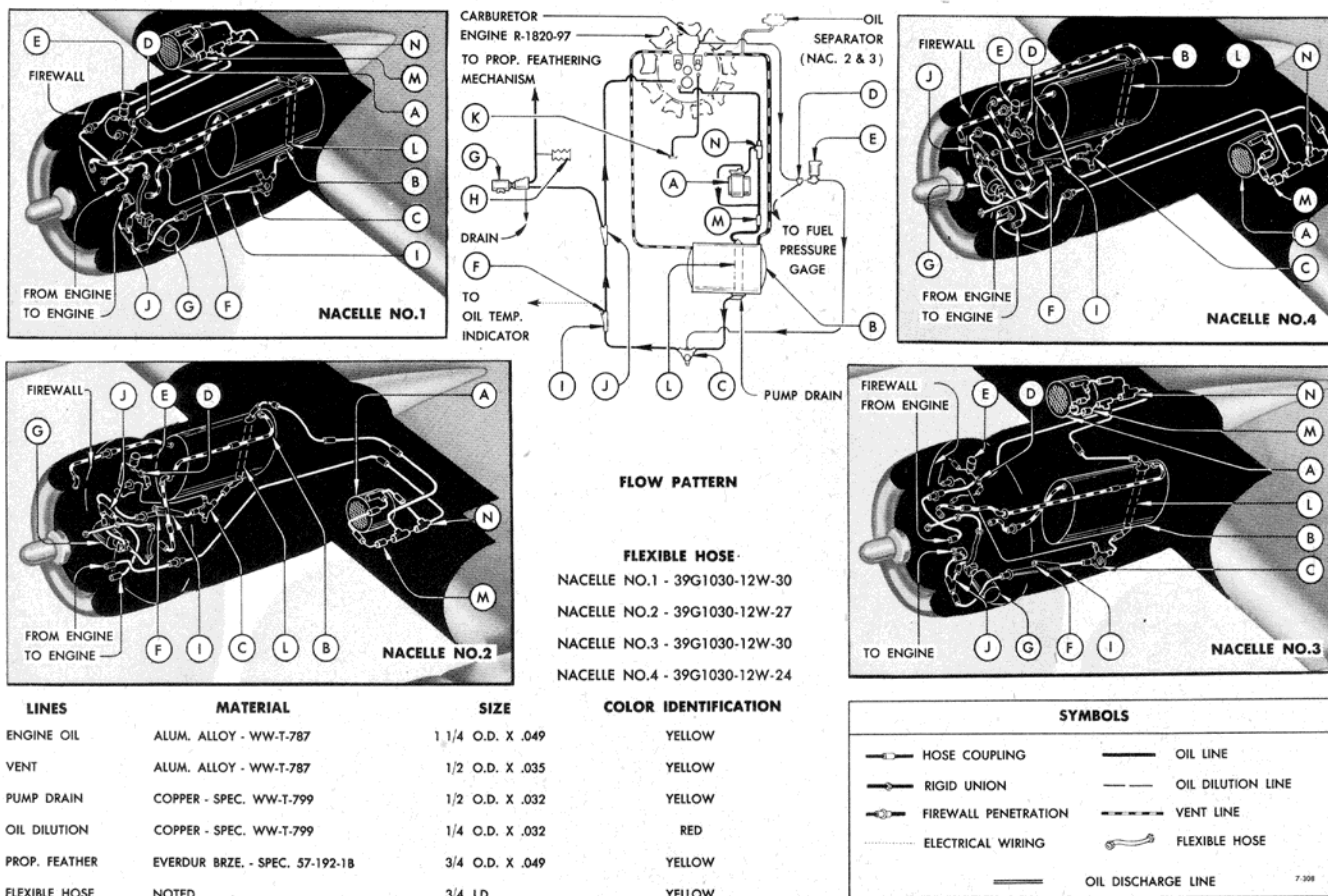


Figure 189—Oil System Diagram

from the bottom of the tank at the aft end through the access door in the lower side of the nacelle. Remove the oil tank straps and the front end of the forward cradle. Tip the tank so that the front end moves down and toward the center of the nacelle while the back end is raised to clear the intercooler duct. Then juggle the tank into a vertical position and remove it through the access door in the top of the nacelle, taking care to avoid contact between the tank and any part of the airplane.

WARNING

Cover the intercooler and ducts with cardboard to prevent scratching or denting the tank. Handle the tank carefully, as any damage may result in tank failure.

2. **INBOARD NACELLE TANKS.**—Disconnect all lines from the tank and remove the bonding at the aft end. Remove the filler neck and supporting straps, raise the aft end while tilting toward the center of the nacelle, and remove the tank through the wheel well, taking care to avoid contact between the tank and any part of the airplane.

(b) MINOR REPAIR AND REPLACEMENTS.

1. In case the tank has been damaged, remove the leakproof liner by dismantling the metallic shell. Special care must be taken in removing the liner that

further damage is not incurred by contact with sharp protrusions on the damaged casings. Whether the damaged shell should be repaired or replaced with a new part will be determined by each individual circumstance. If the hole in the shell is small, and the number of cracks originating at the hole is less than five, it may be advisable as a temporary measure to carefully smooth off all rough edges and drill a small hole (approximately 1/16 inch in diameter) at the termination of each

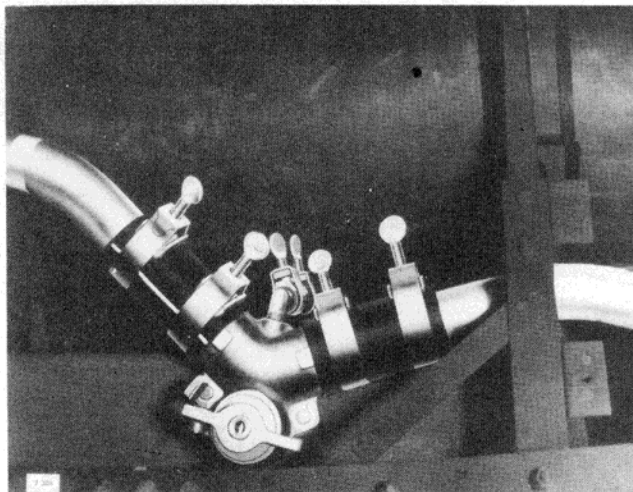


Figure 190—"Y" Cock Installation

| LEGEND FOR OIL SYSTEM FLOW DIAGRAM | | | | |
|---|----------------------------------|-----------------------------|--|--|
| PART | LOCATION | MFR. | MFR'S. NO. | B.A.C. INST. NO. |
| A OIL TEMPERATURE REGULATOR | WING LEADING EDGE | AIRESEARCH CO. | 2E-30781 | 15-7772 OUTBD. 15-7773 INBD. |
| B OIL TANK | NACELLE | GOODYEAR | NAC 1, 2F1-1-3074 NAC 4, 2F1-1-3074-1 NAC 2, 2F1-1-3073 NAC 3, 2F1-1-3073-1 | 15-8541 OUTBD. 15-8522 INBD. |
| C "Y" DRAIN VALVE | NACELLE | | 37D6114-5 | 15-9470 |
| D RESTRICTION FITTING | FIREWALL - FWD. SIDE | | 37A3528 | 53-11715 OUTBD. 43-11714 INBD. |
| E OIL DILUTION VALVE | FIREWALL - FWD. SIDE | AIR ASSOCIATES, INC. | 37D6210 | 53-11715 OUTBD. 43-11714 INBD. |
| F OIL TEMPERATURE BULB (ELEC. RESISTANCE) | NACELLE | | *AN5525-2 | 15-9470 |
| G PROP. FEATHERING PUMP | FIREWALL - FWD. SIDE | HAMILTON STANDARD PROP. CO. | *54772-2 | 15-9470 |
| H PRES. CUTOUT SWITCH | ON PROPELLER GOVERNOR (AG8-G15D) | HAMILTON STANDARD PROP. CO. | *55526 | 65-7359 |
| I TUBE ASSEMBLY (WELDED) | NACELLE | B. A. C. | 65-6242 | 15-9470 |
| J TUBE ASSEMBLY (WELDED) | FWD. OF FIREWALL | B. A. C. | 3-16922, 3-16923 | 15-9470 |
| K OIL PRESSURE TRANS. (TYPE A-1*; SPEC. 27383-A) | FIREWALL - FWD. SIDE | | AN5765-1 | NAC.1, 15-11692 NAC.2, 15-11693 NAC.3, 15-11694 NAC.4, 15-11695 |
| L OIL TEMPERATURE ACCELERATING WELL | OIL TANK | GOODYEAR | INTEGRAL PART OF OIL TANK (B) | 15-8541 OUTBD. 15-8522 INBD. |
| M CHECK VALVE | WING | PARKER | 6-1443-2 | NAC.1, 15-12943 NAC.2, 15-12944 |
| N SURGE VALVE | WING | AIRESEARCH CO. | 2D-6928-4 | NAC.3, 15-12945 NAC.4, 15-12946 |
| *GOVERNMENT FURNISHED | | | | |

Figure 191—Oil System Diagram Legend

crack. This method prevents the crack from traveling to other portions of the tank shell. At the earliest opportunity the tank shell should be repaired as described in the following paragraph.

2. Restore the damaged portions to as near the original position as practicable, and remove all sharp edges. In extreme cases it may be necessary to entirely remove deformed portions of the shell, thus presenting a smooth area to be patched. Trim a patch from sheet metal, of the same gage as the tank shell, and sufficiently large to extend 2 inches beyond the edges of the injury. Feather the edges adjacent to the liner to allow a smooth contact surface. Shape the patch to conform to the *inside* contour of the tank shell. Rivet the patch in place with rivets of 5/32 inch diameter minimum. The spacing between rivets should be about six times the diameter of the rivets used. After the patch is firmly in place smooth off all corners and edges from the inside. This procedure is absolutely necessary as protection against vibrational chafing of the leakproof liner.

(c) ASSEMBLY AND INSTALLATION.—At installation of the oil system units, take care to handle the oil tanks with extreme caution to avoid damaging the tank shells. Vibration during flight may easily cause failure in a tank that seems only slightly damaged. Set the tanks in the cradles to obtain full surface contact with the pads on the cradles and straps and tighten

sufficiently to prevent vibration, but do not crush the tank. Connect all lines tightly and lock wire the clamps.

Note

Bleed the engine inlet line if necessary before starting the engine so that the oil supply will not be delayed.

(3) OIL TEMPERATURE REGULATOR.

(a) REMOVAL AND DISASSEMBLY.—Remove the access door above the oil cooler and the air opening fairing in the leading edge of the wing. Disconnect the hoses, bonding, and straps holding the oil cooler in place. The oil temperature regulator may then be removed through the front opening in the wing. Disassembly of the regulator assembly may be accomplished by removing the valve mounting bolts.

(b) MINOR REPAIR AND REPLACEMENT.

1. CLEANING.—Oil temperature regulators will be cleaned at each normal engine change or prior to making any solder repairs. In the event of an engine change resulting from an internal engine failure that releases metal particles into the oil system, the oil temperature regulator is dangerous to future engine operation and will be removed, marked "Removed due to engine failure," and forwarded to control depot for storage pending repair investigation.

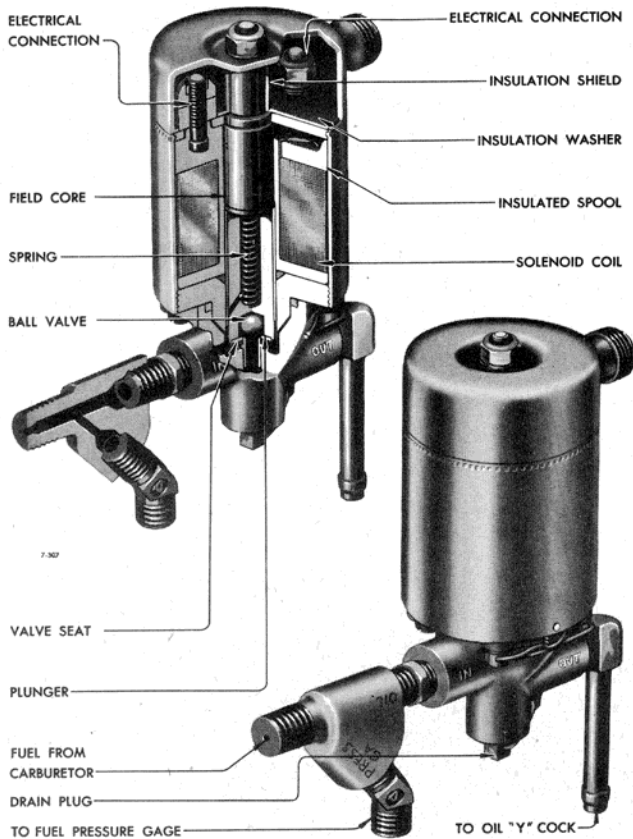


Figure 192—Oil Dilution Valve

a. A cleaning solution prepared from the following constituents will be good for 40 to 60 oil temperature regulator cleanings:

| | |
|--|--------------------|
| Oleic Acid | 7 parts by volume |
| Triethanolamine | 3 parts by volume |
| Aromatic Naphtha, stock No. 8500-617700 (Specification No. AN-VV-N-96) | |
| Type III | 90 parts by volume |

CAUTION

This fluid is highly inflammable.

b. Remove the thermostatic or viscosity control valve from the oil temperature regulator.

c. Clean the outside of the oil temperature regulator and the outside and inside of the valve by immersion and rotation in separate tanks containing the above cleaning solution.

d. Install the oil temperature regulator in the cleaning machine and pump cleaning solution at 60-70°C (140-158°F) through the regulator at flow rate of from 15 to 20 gallons per minute. The regulator shall be rapidly rocked and turned during this operation in order to facilitate removal of foreign material. A fine screen located in the return from the oil temperature regulator to the pump prevents any particles from being pumped back into the oil temperature regulator.

e. Circulate the cleaning solution through the regulator for 30 minutes and then drain the regulator completely.

f. Rinse the cleaned oil temperature regulator immediately after cleaning by pressure forcing aromatic naphtha, Specification No. AN-VV-N-96, type III at room temperature through it for two 8-minute periods. Rinsing should be done with two portions of the solution, using the minimum amount which will fill the regulator and provide smooth circulation through the system. The rinsing circulation system will consist of an auxiliary pump, the oil temperature regulator and necessary connecting hose, and will be made locally from available equipment. The last 8-minute rinse should be made with fresh naphtha which may be re-used in the first rinsing of the oil temperature regulator following.

Note

If naphtha is not available, kerosene, Federal Specification No. VV-K-211, may be substituted.

g. If the regulator will not fit into the cleaning machine or if a cleaning machine is not available, clean the regulator, using the following instructions:

(1) Fill the regulator three-quarters full of cleaning solution described in (a) 2. a. and close all openings.

(2) Shake and rotate the oil cooler violently for four minutes and then drain the cooler.

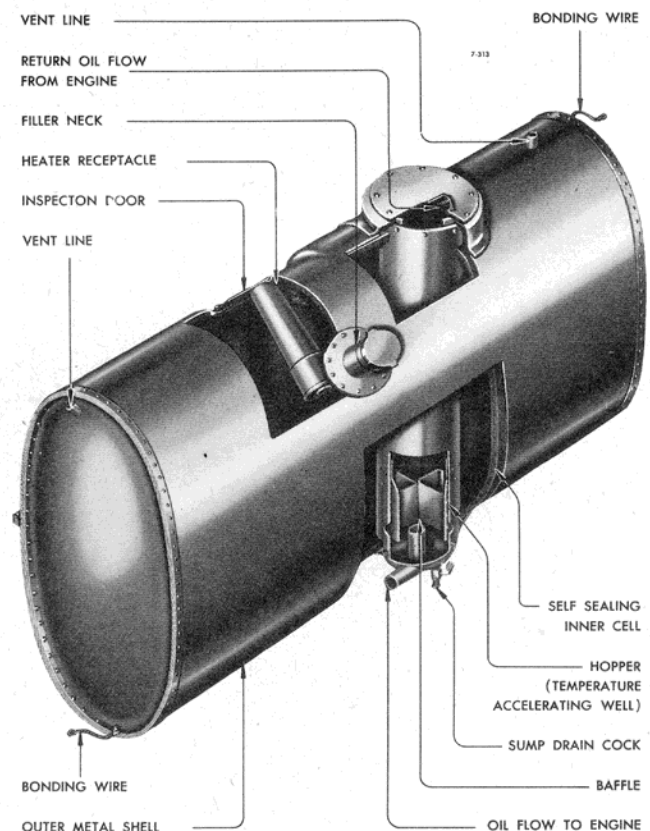


Figure 193—Oil Tank

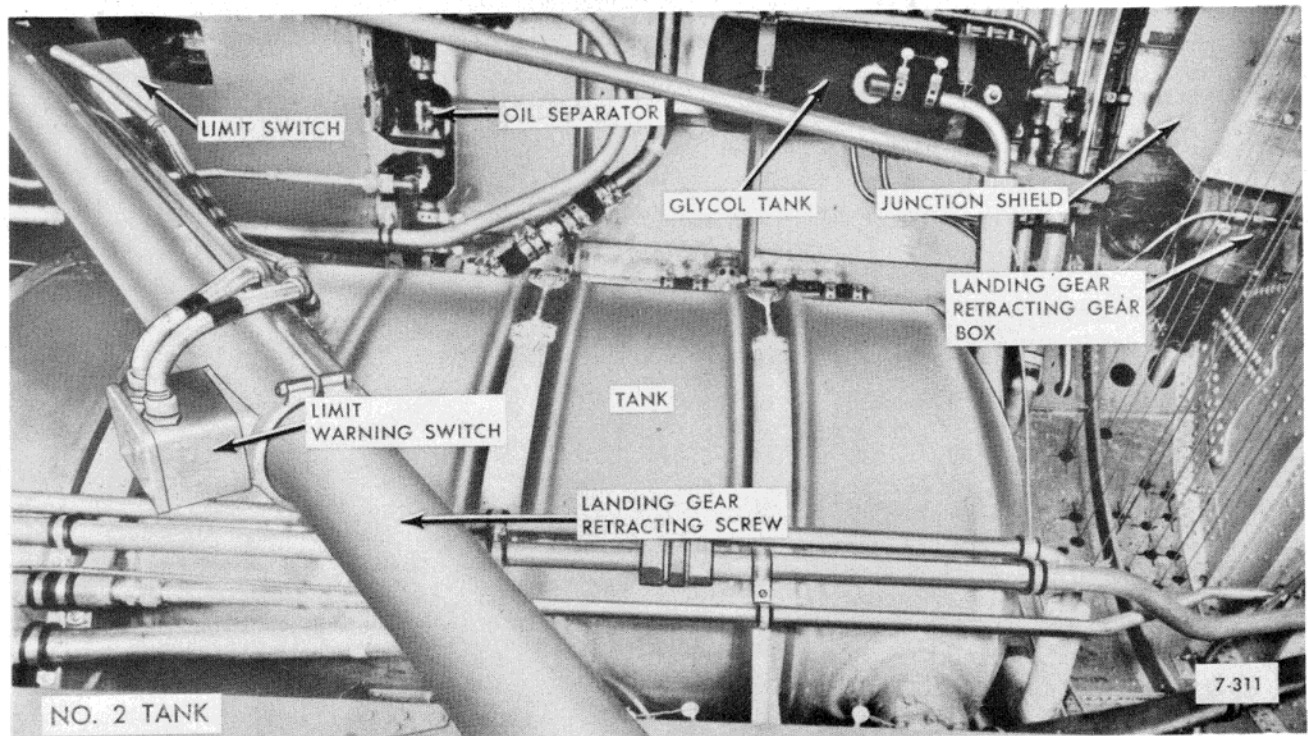
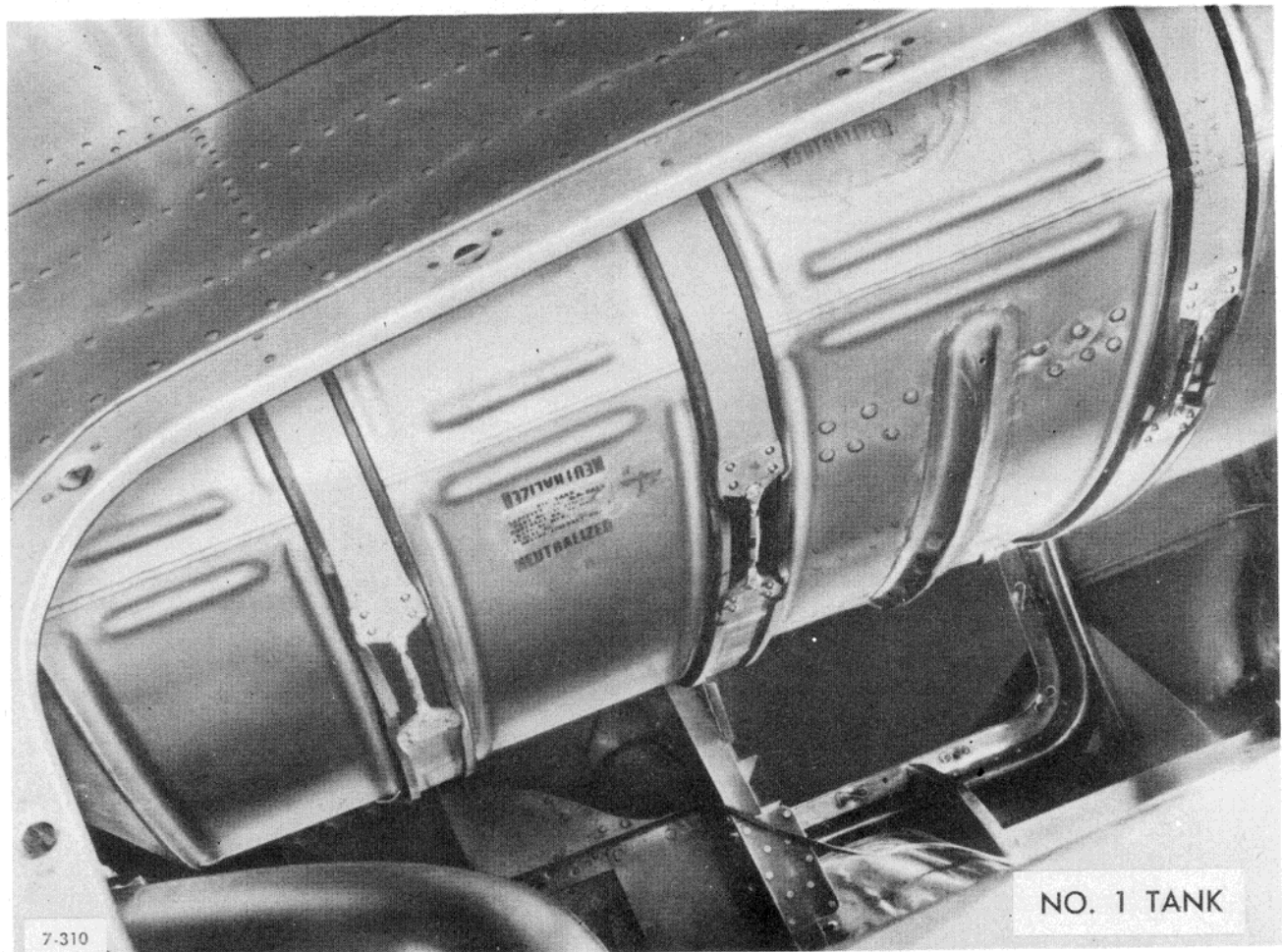


Figure 194—Oil Tank Installation

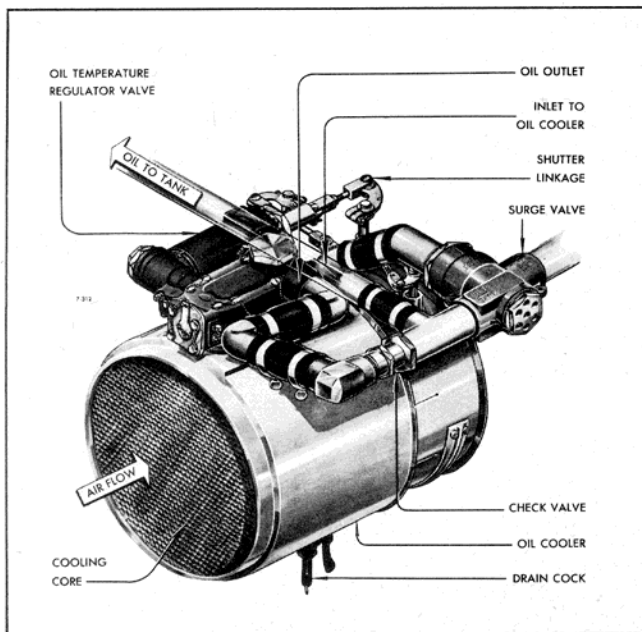


Figure 195—Oil Cooler

(3) Perform the preceding operation two additional times using a fresh cleaning solution each time.

h. The regulator shall be drained and then compressed air shall be blown through it for not less than 15 minutes to dry it out for testing.

2. TESTING PROCEDURE.—Test the oil temperature regulator for leaks at 100 pounds per square inch air pressure by submerging the regulator in warm water. Necessary fittings will be manufactured locally.

3. REPAIR PROCEDURE.

a. Repair of oil temperature regulators is an operation requiring trained personnel, and permanent or major repairs will be completed only by depots, sub-depots, or depot groups.

b. Care will be exercised to prevent mechanical damage to any equipment.

c. The cores of the oil radiators are composed of round tubes having hexagonal ends. Individual leaky tubes, up to three percent of the total number of tubes, will be repaired by plugging their ends with loose-packed copper wire, Specification No. 57-222-1, and soft solder, Specification No. QQ-S-571. Make sure soldering is thorough.

d. If over three percent of the tubes are defective, the oil temperature regulator core will be replaced and salvaged, unless a replacement core is not available. In this case the defective tubes will be replaced with tubes that have been carefully inspected, cleaned, and thoroughly tinned on the hexagonal ends before insertion.

e. Special soldering iron, part No. 076707, which can be obtained by local manufacture, will enable removal of tubes from these soft solder assembly oil coolers. Best results in removal of tubes will be at-

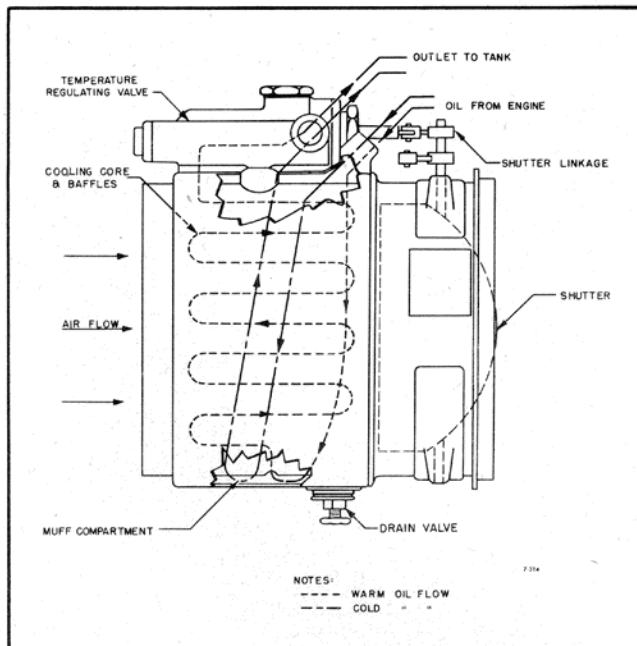


Figure 196—Oil Cooler Flow Diagram

tained by first cleaning the soldered ends of the tube with concentrated hydrochloric acid (muriatic acid) and then swabbing with zinc chloride flux. Use two heated tinned irons, one in each end of the tube to be removed and remove the tube, being careful not to deform the hexagonal ends of the adjacent tubes. Install the new replacement tubes with a minimum amount of soft solder, Specification No. QQ-S-571, class A, and a standard commercial soldering iron (some skilled operators prefer radiator torches). Concentrated hydrochloric acid improves tinning and solder flow, and pulverized sal ammoniac in the zinc chloride flux improves the

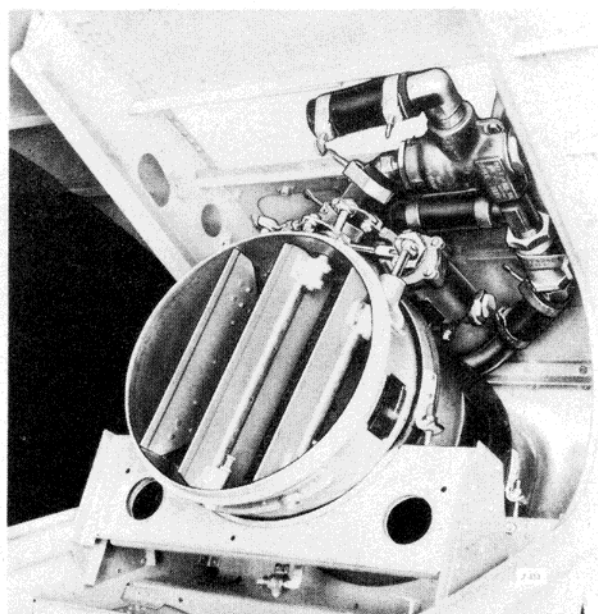


Figure 197—Oil Cooler Installation

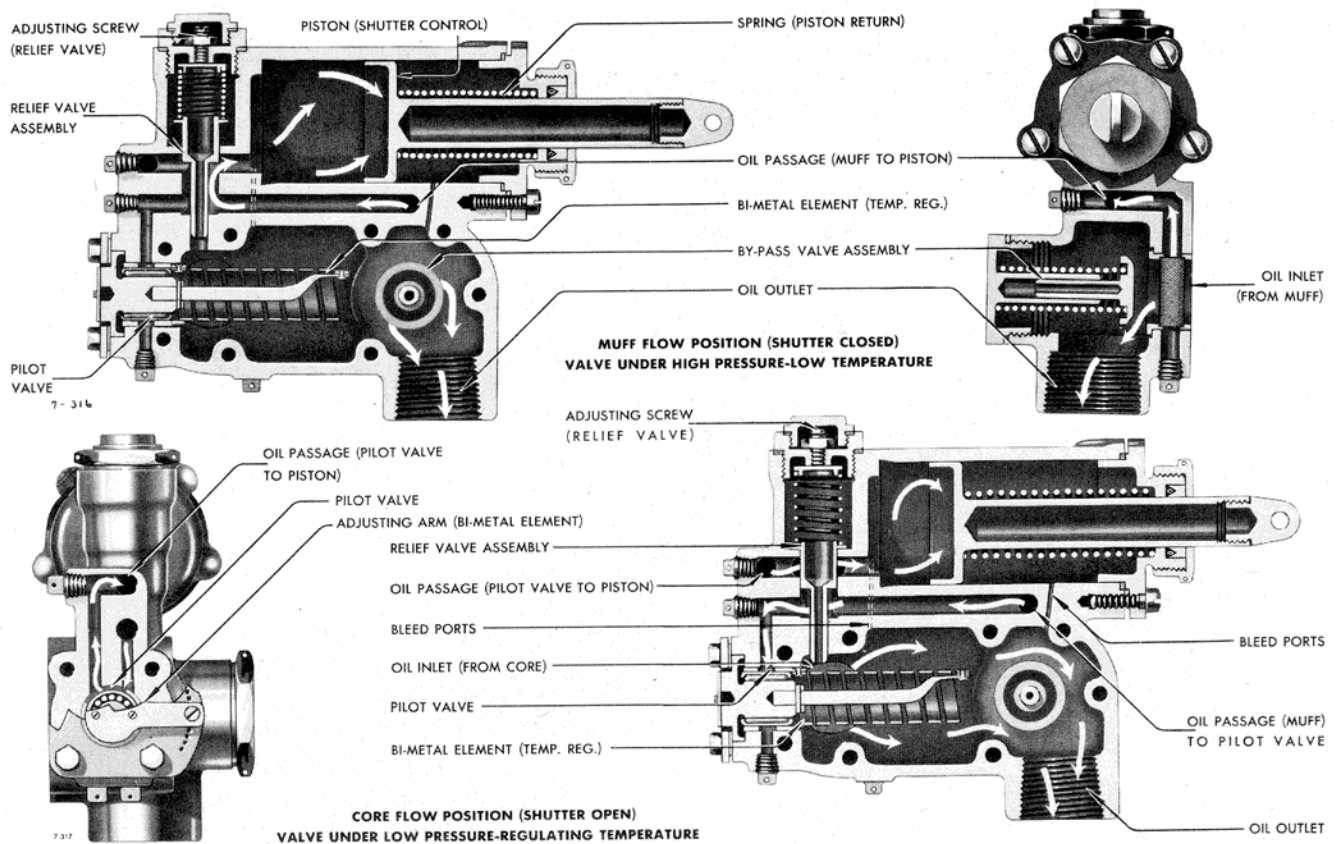


Figure 198—Oil Temperature Regulator Valve

solder flow. If concentrated hydrochloric acid is used, flush it off as soon as practical. Test the oil temperature regulator again as in paragraph 2.

4. FINAL TREATMENT.—After final testing, flush all the oil coolers inside and out with hot running water and then steam for 1/2 hour, allowing the condensate to leave from the bottom of the regulator. Thoroughly dry the oil cooler by heating it in an oven for approximately one hour at 121-135°C (250-275°F) until all moisture has evaporated and then reinstall oil temperature regulator. If an oven is not available or if storage of the oil cooler is desired, perform a hot oil treatment to remove moisture and give corrosion protective oil coating in accordance with following instructions:

a. Immerse the oil cooler in a tank of clean, light, neutral lubricating oil (SAE 20), Federal Specification No. VV-O-496, at approximately 121°C (250°F) and shake the oil cooler until all bubbling ceases, indicating that the water has completely evaporated and the oil coating is complete.

b. Drain the oil cooler and then either reinstall it on the airplane or place in stock.

(c) ADJUSTMENTS.—See figure 198.

(d) ASSEMBLY AND INSTALLATION.—Reverse the removal procedure.

b. FUEL SYSTEM.

(1) GENERAL.—The fuel system is composed of four independent fuel supplies, each feeding one engine. Each outboard engine is fed from a 425 U. S. (354 Imperial) gallon tank and each inboard engine is fed from a 213 U. S. (177.4 Imperial) gallon tank having in addition a feeder tank of 212 U. S. (176.6 Imperial) gallons, making 425 gallons for each engine. B-17G airplanes have a supplemental fuel supply carried in collapsible self-sealing fuel cells installed in the wing between the ribs outboard of the existing main tanks. The installation includes nine cells with permanent aromatic resistant liners in each wing, providing additional capacity of approximately 1,080 gallons or an increase of 270 gallons per engine. The cells in each wing are divided into two groups, each of which acts as a feeder tank for one of the main tanks. The four inboard cells tie into the feeder tanks through a 1-1/4-inch inside diameter self-sealing hose and an E-5 or D-5 valve. This valve is controlled from the rear bulkhead of the bomb bay compartment or the forward bulkhead of the radio compartment by a self-contained hydraulic system. When the valve is OFF, accidental loss of hydraulic fluid or pressure will cause the valve to open, permitting delivery of fuel from the outer wing tanks. The five outboard cells are provided with a similar connection to the engine No. 1 and No. 4 tanks. Venting is accomplished by interconnecting the out-

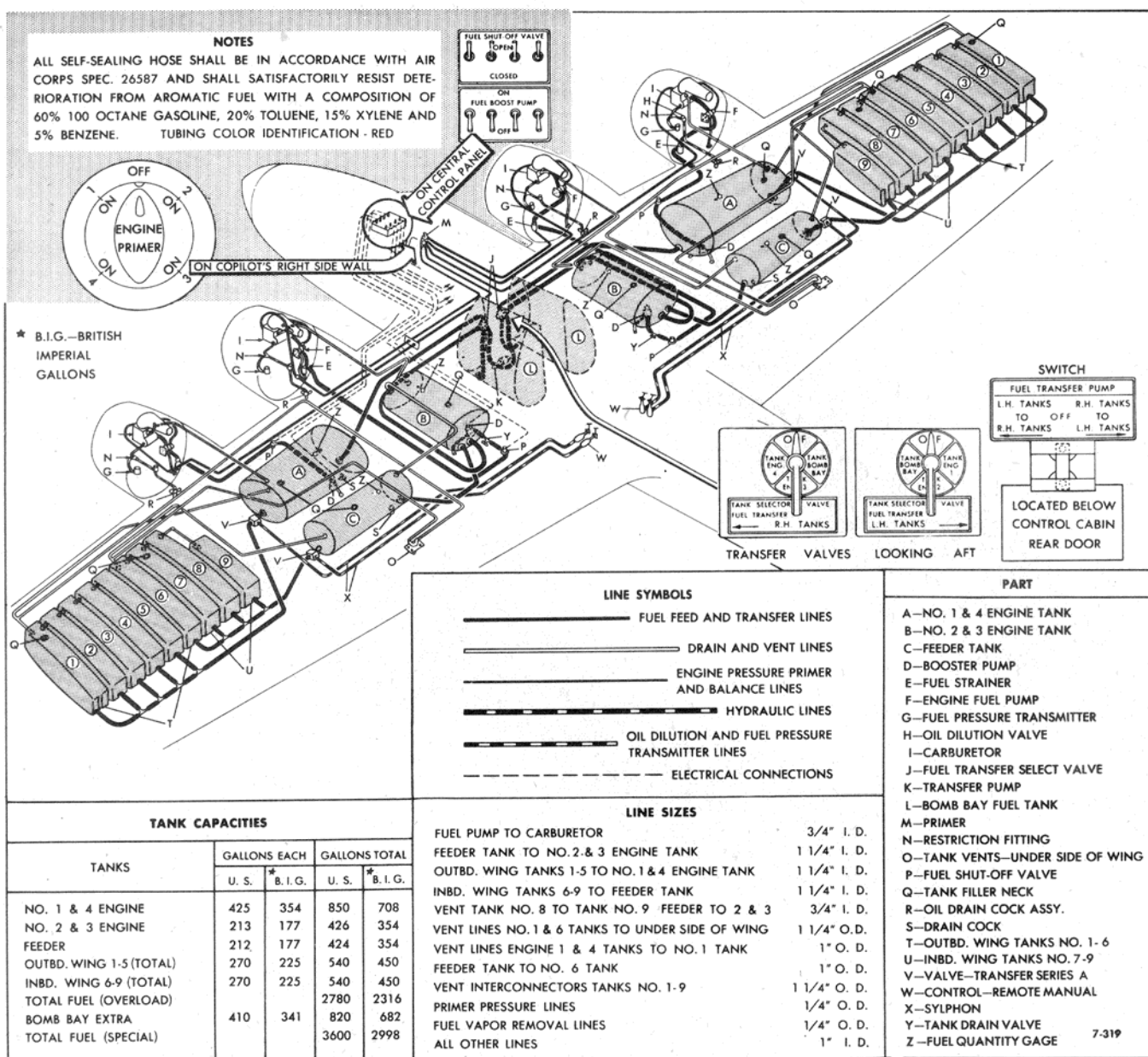


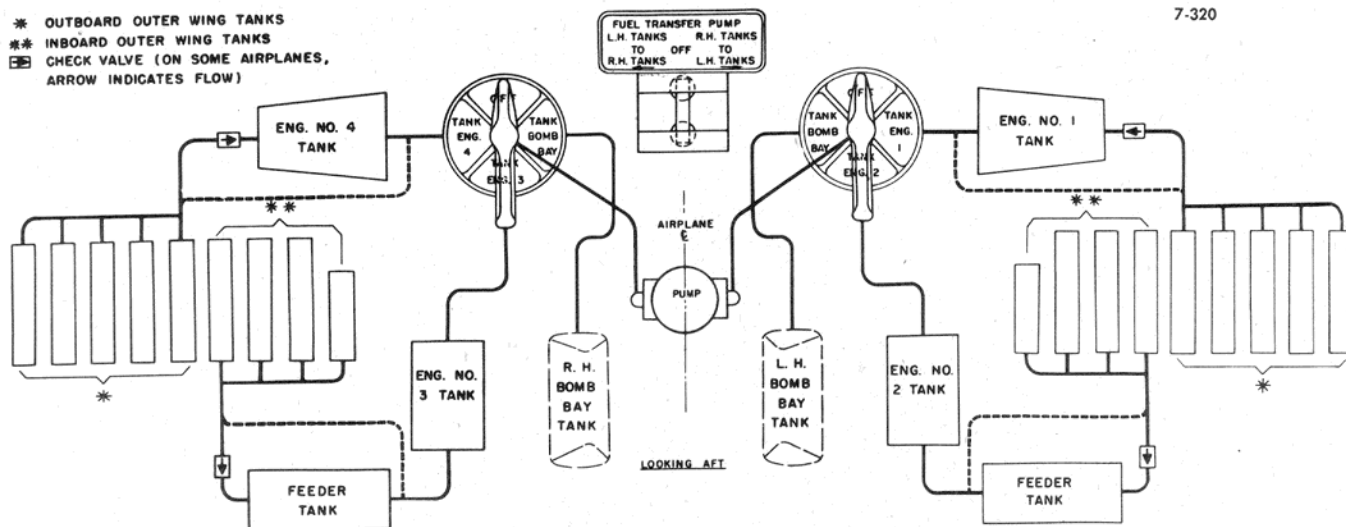
Figure 199—Fuel System Diagram

board cells in each group at their forward ends by internal hoses and connecting these outboard cell group vents to the line from the corresponding inboard tank. Venting is accomplished by interconnecting the outboard cells in each group at their forward ends by internal hoses and connecting these outboard cell group vents to the line from the corresponding inboard tank. The vent lines then pass from the most outboard cell of each group to the vent manifold. Two additional filler necks are provided, one at the most outboard tank for filling the outboard cell group, and one at the first cell inboard of the station 19 cell. The filler caps for the outboard cells are sealed with copper asbestos gaskets against the upper wing surface, while the filler pans are so vented through the bottom of the wing as to provide a ram during flight. These vents also act as filler pan

drains during replenishing operations. This vent-drain arrangement eliminates the possibility of fuel loss during flight maneuvers. A wing nut, bolt, gasket, and spring, which, when tightened, will cause a positive pressure seal between the neoprene gasket in the cap and the filler neck flange, are installed at the main tank filler caps to prevent fuel loss due to the static pressure head created by fuel in the outboard cells. To further increase the fuel supply, two tanks of 410 gallons each are suspended in the bomb bay. These tanks are releasable in the same manner as bombs, when the switches in the bomb bay are on. All fuel feed lines, transfer lines, and vent lines are of self-sealing or leak-proof construction, and are designed to accommodate aromatic fuels. The primer, vapor removal and balance lines are aluminum tubing, while the oil dilution line

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- * OUTBOARD OUTER WING TANKS
- ** INBOARD OUTER WING TANKS
- ☐ CHECK VALVE (ON SOME AIRPLANES,
ARROW INDICATES FLOW)



NOTES: DIRECT TRANSFER CAN ONLY BE MADE ACROSS CENTERLINE OF AIRPLANE. DOTTED LINES INDICATE FUEL FLOW IN INSTALLATIONS WITHOUT CHECK VALVES, PERMITTING FUEL TRANSFER TO OUTER WING TANKS.

| DESIRED TRANSFER | OPERATION OF CONTROLS | | | FLOW PATTERN |
|--|-----------------------|--------|-------------|--------------|
| | R. H. VALVE | SWITCH | L. H. VALVE | |
| LEFT HAND TO RIGHT HAND TANK <u>EXAMPLE:</u> FROM LEFT HAND BOMB BAY TO ENGINE NO. 4 TANK | | | | |
| LEFT HAND TO LEFT HAND TANK (TWO TRANSFERS REQUIRED) <u>EXAMPLE:</u> FROM LEFT HAND BOMB BAY TO ENGINE NO. 1 TANK BY WAY OF RIGHT HAND BOMB BAY TANK | STEP 1 | | | |
| | STEP 2 | | | |
| RIGHT HAND TO LEFT HAND TANK <u>EXAMPLE:</u> FROM RIGHT HAND BOMB BAY TO ENGINE NO. 2 TANK | | | | |
| RIGHT HAND TO RIGHT HAND TANK (TWO TRANSFERS REQUIRED) <u>EXAMPLE:</u> FROM ENGINE NO. 3 TO ENGINE NO. 4 TANK BY WAY OF ENGINE NO. 1 TANK | STEP 1 | | | |
| | STEP 2 | | | |

Figure 200—Fuel Transfer Operation Diagram

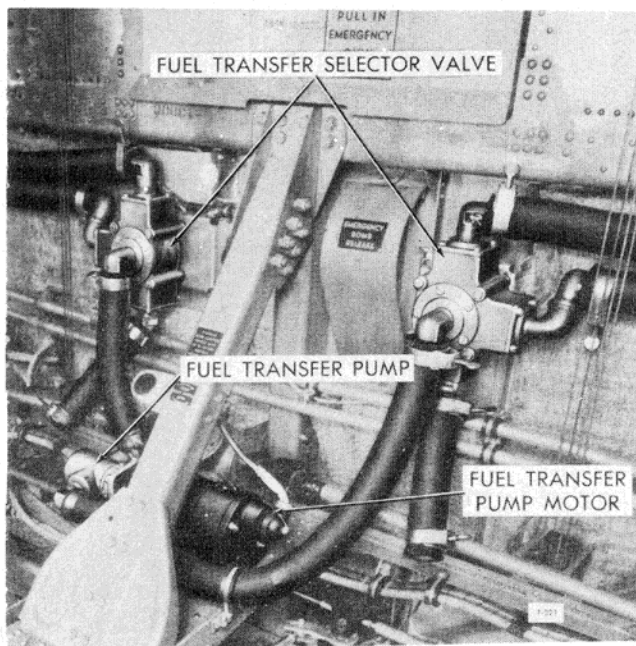


Figure 201—Fuel Transfer Units Installed

is copper. In disconnecting any fuel line it is recommended that the open ends be securely plugged to eliminate the entrance of foreign matter. In removing the leakproof hoses from metallic connectors it is mandatory that the hoses be protected from damage due to rough handling. Disassembly of any of the units comprising the fuel system will not be attempted without the approval of the resident engineering officer, or without access to pertinent Technical Orders. In the absence of either of the above sources of information, the unit should be removed from the airplane and referred to the proper repair depot. Electric driven fuel booster pumps are installed at the outlets of the main tanks to eliminate vapor lock between the tanks and the engine fuel pumps. An electrically controlled fuel shut-off valve is installed in the line after the fuel booster pump to prevent fuel loss through a severed gasoline line. From the shut-off valve the fuel passes through a strainer located on the forward side of the fire wall and enters the engine-driven fuel pump. Fuel may be transferred from one main tank to another by the fuel transfer system which consists of two selector valves and an electrical transfer pump. For further information see figure 200.

(2) TANKS.

(a) GENERAL.—The main fuel tanks and the feeder tanks are retained by heavy metal straps riveted to the spars and the upper wing surface. These tank supporting straps are formed aluminum-alloy channel sections with neoprene pads and are held in place by bolts at either end. No. 1 and No. 4 main tanks are located between rib stations 6 and 12, directly behind the front spar in the left- and right-hand wings. No. 2 and No. 3 main tanks are located between rib stations 1 and 4, between the spars in the right and left wings. The

feeder tanks for the No. 2 and No. 3 main tanks are located between rib stations 6 and 12 directly in front of the rear spar. The outer wing tanks are comprised of self-sealing cells placed between wing ribs outboard of main tanks. These cells are interconnected to act as four units. The outboard group of outer wing tanks is comprised of the five outermost cells located between rib stations 20 and 25. The inboard is comprised of the four inboard cells located between rib stations 16 and 20. Two auxiliary tanks may be hung in the bomb bay by slings which are attached with type B-7 bomb shackles. These tanks are releaseable in the same manner as bombs. Westinghouse metallic leakproof bomb bay tanks may be used interchangeably with Goodyear and U. S. Rubber non-metallic leakproof tanks. All tanks are self-sealing and carefully bonded to the structure. The outer wing tanks rest on micarta abrasion strips on the lower wing surface, and being collapsible, have their upper portions tied secure to the adjacent wing ribs with stout cotton cord.

1. A small drain valve is provided on the bottom of the feeder tanks and each outboard engine tank. This valve is attached to the leakproof liner, and consequently must be operated with extreme care.

2. The bomb bay tanks are of non-metallic leakproof construction. Two types may be installed interchangeably; the Goodyear Rubber Co. type, constructed of a non-metallic shell with an integral rubber

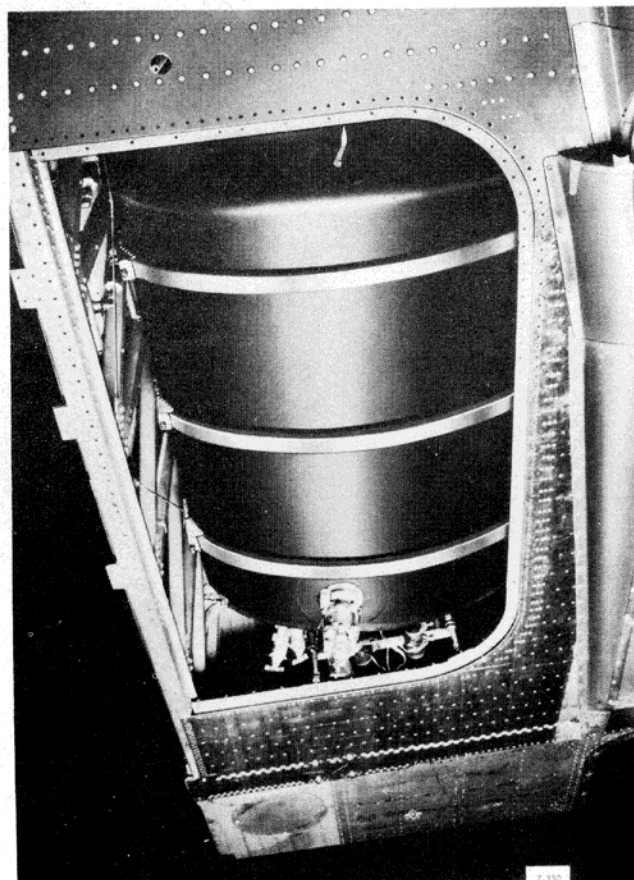


Figure 202—Fuel Tank Installation—Inboard

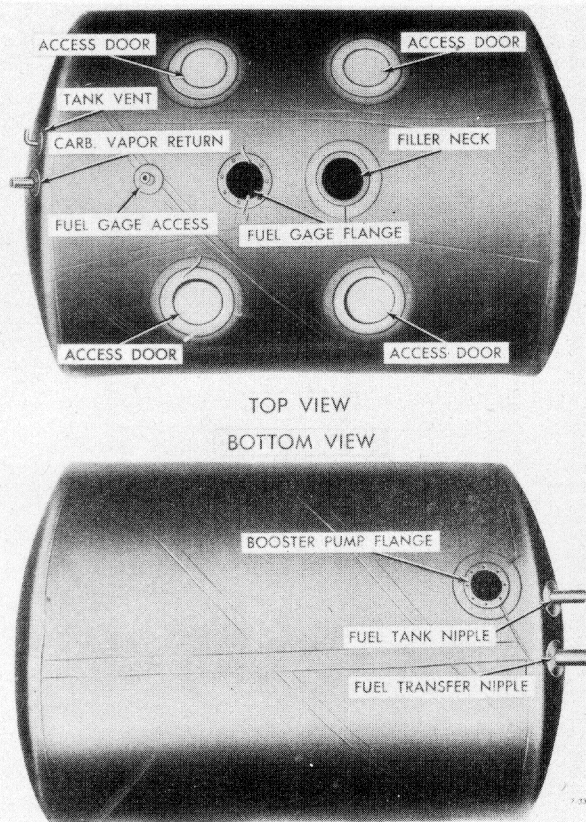


Figure 203—Fuel Tank—Inboard

lining, and the U. S. Rubber Co. type, constructed of a non-metallic shell with a replaceable leakproof bag.

(b) REMOVAL AND DISASSEMBLY.

1. MAIN TANKS.

a. There are three removable panels in the bottom of each wing for access to the fuel tanks. These panels are held in place by washer head screws and gang nuts riveted inside the door frames. Since the skin is subjected to structural loads, it is necessary to place jacks at the outboard nacelles to relieve torsional stresses before removing the tank doors. Before attempting to remove a fuel tank, booster pump, or any other electrical mechanism associated with the fuel system, make sure that the airplane master switch, battery switches, and external power are "OFF," and that the airplane is completely grounded.

WARNING

The mechanic must repeatedly make contact with the airplane structure AWAY from possible gasoline or fumes to be certain that his electrical potential remains the same as that of the airplane. It is possible that static charges will exist in the airplane or in his body which may ignite the gasoline fumes. This is very important when outside temperatures are around -6.7°C (20°F) or below, as the fuel is very explosive in these temperature ranges.

b. Drain fuel tanks and place jacks under

the outboard nacelle jack pads. Remove the tank access doors, fuel lines, and electrical connections to booster pumps. Remove the booster pumps, all electrical bonding, and the remaining fuel lines. Remove the liquidometer fuel transmitter gage before attempting to remove tanks from wing.

c. In removing engine No. 1 and engine No. 4 tanks and engine No. 2 and engine No. 3 feeder tanks, remove the tank straps and support the outboard end of the tank on the wing structure. Lower the inboard end far enough to permit disconnecting all vent and vapor removal lines at the top outboard end of the tank; then lower the tank. Follow the same procedure for removal of engine No. 2 and engine No. 3 tanks except the forward end of the tank should be supported on the wing structure and the aft end lowered far enough to disconnect the vent and vapor removal lines. Connections are made between the outer wing tanks and the main and feeder tanks through an access door located aft of the rear spar just outboard of the outboard nacelle.

2. OUTBOARD WING TANKS (TOKYO TANKS).—To remove the outer wing tank cells, first remove the outer wing panel (refer to section IV, paragraph 2. b.) and detach the leading edge. Disconnect all fuel lines and bonding on both fore-and-aft ends of cells to be removed. (Cells must be withdrawn successively.) Remove the round access doors in the forward ends of the cells and remove the cell interconnectors. Untie the cords which secure the cells to the upper part of the wing ribs. Collapse the cells in paper bag fashion and tie securely. A pair of one-inch web straps about five or six feet long will prove very useful for this operation. Do not attempt to collapse the cells while they are cold and stiff. Remove the cells through the ribs, being very careful not to damage the cells on sharp edges that may exist within the wing. It is not recommended that cells be removed through a tank bay, but this method can be resorted to in an emergency where no cradles for the outer wings are available.

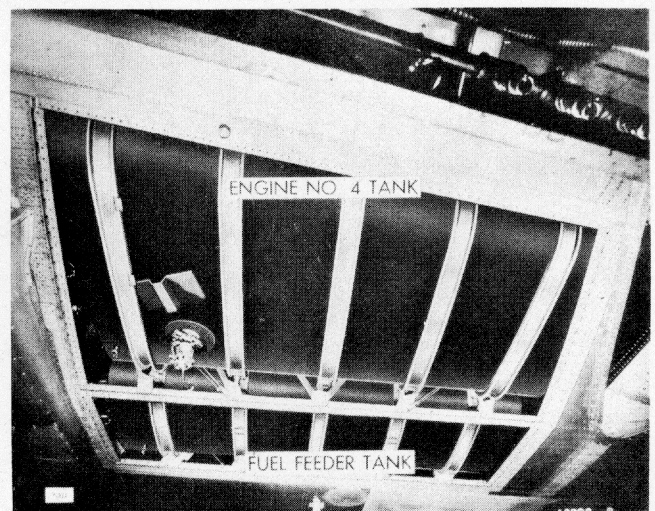


Figure 204—Fuel Tank Installation—Outboard

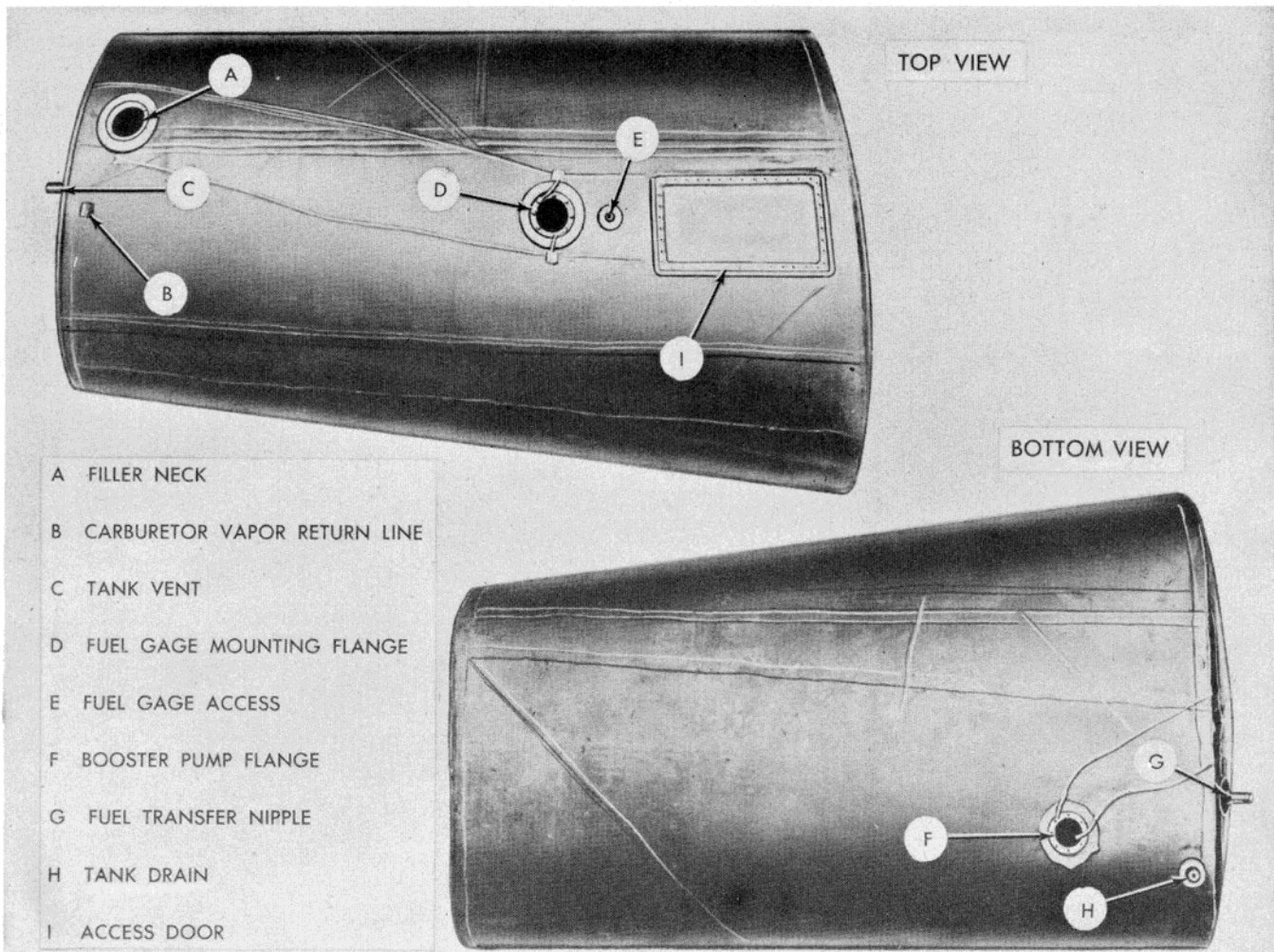


Figure 205—Fuel Tank—Outboard (Forward)

CAUTION

Support the tanks rigidly at all times to avoid damage from falling or contact with airplane structure.

3. BOMB BAY TANKS.—For removal of the bomb bay tanks, follow the same precautionary measures as given for removal of wing fuel tanks. Open the bomb bay doors and drain the tanks. Disconnect the fuel lines and support the tanks on a temporary platform or hoist, then release them by operating the emergency release mechanism. Lower the tanks to the ground carefully to avoid damage from contact with the surrounding structure.

(c) ASSEMBLY AND INSTALLATION.

1. MAIN FUEL TANKS.

a. Replace all bonding carefully to avoid the possibility of electrical charges remaining on the cell or on the leakproof hoses. It is particularly important that all the metal tank fittings be provided individually with a good electrical ground.

b. When replacing the wing tank doors, do not use the dowel pins to force the doors in place. The

doors will fit satisfactorily if the nacelle jacks are adjusted properly to relieve the torsion loads in the wing surfaces.

c. The self-locking gang nuts used to attach

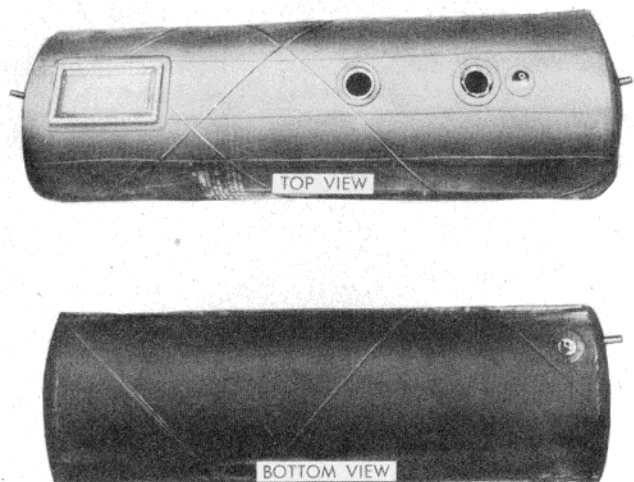


Figure 206—Fuel Tank—Outboard (Aft)

the fuel tank doors in the wing may not lock securely after several cycles of removal and replacement of the screws. If necessary, give them a light tap with a wooden mallet to compress the fiber inserts and force the screw to cut a new thread.

2. OUTBOARD WING TANKS. (TOKYO TANKS)

a. To install the outer wing cells, all access doors on the top of the tanks must be securely lock

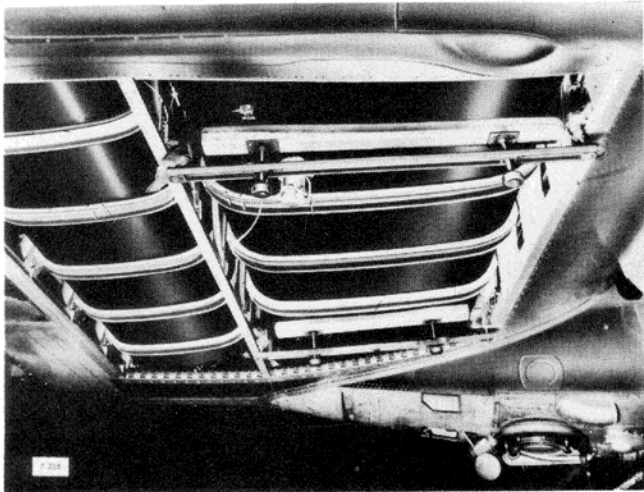


Figure 207—Typical Fuel Tank Installation Supports

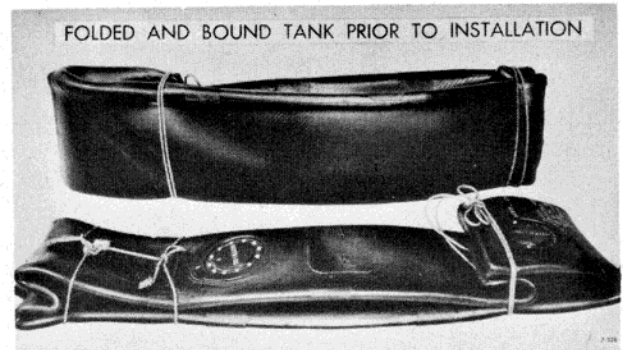


Figure 209—Outer Wing Tank Installation (Step 2)

wired and pressure sealed. The forward doors need be held in place only by two or three nuts during this procedure. Collapse the cells by kneeling on them and strapping flat. A vacuum not to exceed three pounds per square inch as supplied by a vacuum cleaner facilitates this process if the openings are covered during the deflation. Push the cells, one at a time, out into the wing, through the rib structure adjacent to the front spar. The aft end of the cell must lead, for it will be twisted and turned into place in the bay in which it is located. Leave the cell in the collapsed condition in the wing, while the tie-up cords are made fast to the upper rib chord, adjacent to the outboard side of the cell, and threaded

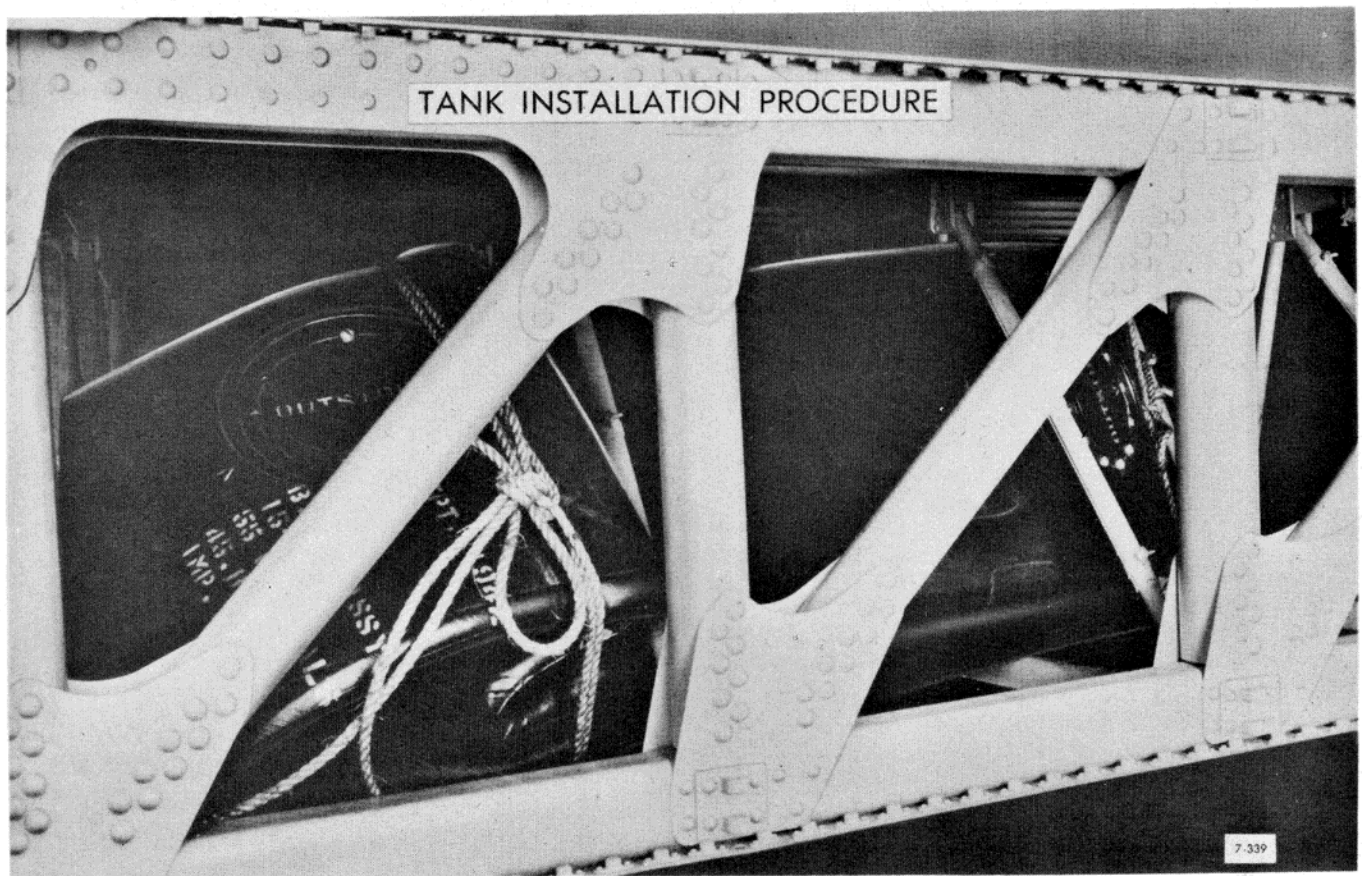


Figure 208—Outer Wing Tank Installation (Step 1)

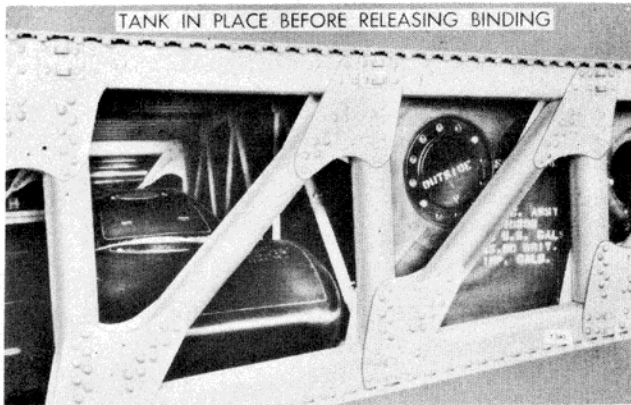


Figure 210—Outer Wing Tank Installation (Step 3)

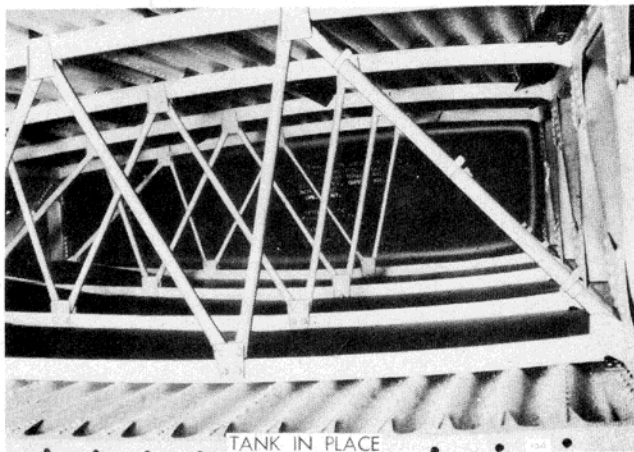


Figure 211—Outer Wing Tank Installation (Step 4)

through the tie-up loops on the cell itself. After this, the straps can be released and the cell will expand to its normal shape. The tie-up cords should then be stretched tight and made fast to the upper rib chord adjacent to the inboard side of the cell. Extreme care must be taken to see that any protruding molded rubber nipples are not pulled or severely twisted. Nor should cells ever be allowed to stand or rest on any protruding molded fittings. Do not keep cells in a collapsed condition for more than 15 to 20 minutes at a time because they have a tendency to take a permanent set. Cells should be collapsed at room temperature or above; under no circumstances should cells be collapsed at freezing temperature.

b. At the No. 1 cell, which is farthest outboard, the filler overflow drain tube should be installed after the tank is lashed in place and before installing the other cells. It is necessary to install the farthest outboard first and then install each succeeding cell progressing inboard. This may be done by removing the outboard wing panel and working through the wing opening, or by removing the engine No. 1 or No. 4 tank or the feeder tank. In any case it is necessary to remove the leading edge of the outboard wing to connect the vents. Cells cannot be installed through the front spar. After the cells are installed and lashed, the

forward access doors may be removed and the vent lines connected. Connect the fuel lines, and install the filler necks and the forward vent access doors to complete the installation.

c. Installation or servicing of the vent lines requires removal of the outboard wing leading edge. Servicing the fuel lines from each cell group is accomplished by opening the access doors which are located on the undersurface of the wing between stations 20 and 24 aft of the rear spar.

d. The system does permit bypassing a damaged cell. To do so, remove the lower surface access door and replace the tee in the fuel hose at the damaged cell with a piece of dural tubing or plug the tank end of the tee. Except in emergency, a vent must be provided running all the way through the damaged cell making a continuous link between the adjacent undamaged cells. The two cells with filler necks cannot be bypassed if damaged. They must be removed and repaired or replaced. Do not delay in making repairs to cells any more than with the main fuel tanks. Residual gasoline will continue its action although the cell has been drained.

3. BOMB BAY TANKS.—When installing the bomb bay fuel tanks, check to insure clearance with the landing gear hand retracting crank.

CAUTION

Do not operate the fuel transfer pump with any selector valve ports plugged without

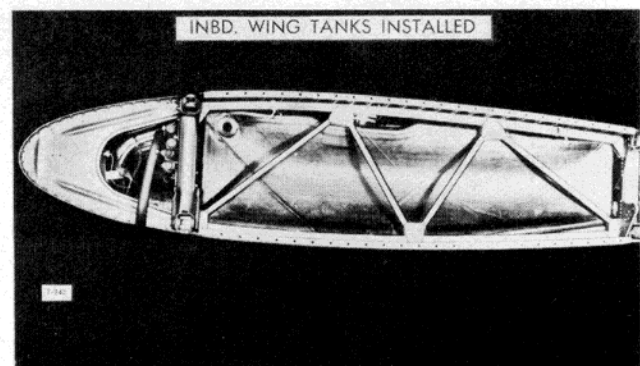
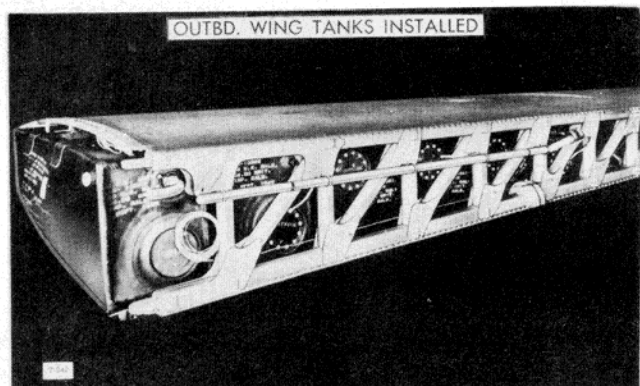


Figure 212—Left Hand Outer Wing Tanks

removing the poppet from the plugged port. This condition arises when the bomb bay tanks are not installed. It is recommended that a six-inch length of hose, plugged at the outer end, be attached rather than removing the poppet valve and plugging the port.

(3) FUEL BOOSTER PUMP (Thompson TFD 12,000.

(a) GENERAL.—A fuel booster pump assembly, consisting of an electric motor and an impeller type pump, draws fluid from the bottom of the tank through a screened outlet. This pump is designed to produce a discharge pressure against a closed port of eight pounds per square inch, and with the engine pump operating, should develop a pressure of approximately six pounds per square inch. The clearance between the impeller blades and the housing is sufficient to permit fuel flow to the engine when the booster pump is inoperative.

(b) REMOVAL.

WARNING

Before attempting to remove a fuel booster pump, make certain the master battery switches in the cockpit are "OFF" or remove the booster pump fuses in the station 4 fuse panel. The pump assemblies are very well bal-

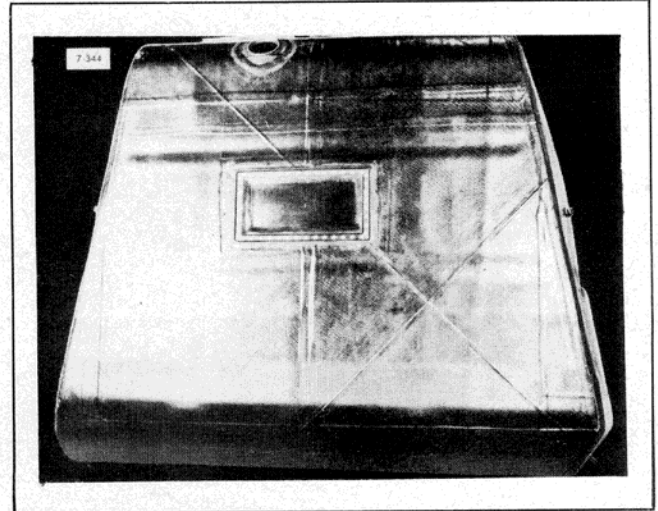


Figure 214—Left Bomb Bay Fuel Tank

anced and operate so quietly that it is possible to remove them without observing that they are operating. With power on, removal of the assemblies from the airplane would result in breaking the electrical circuit at the *most likely location for explosion or ignition of gasoline.*

The fuel booster pump and screen may be removed as a unit through the opening in the fuel tank door on the lower surface of the wing. The pump assembly and opening are normally covered by a streamlined fairing hinged at the forward end and held in place by three Dzus fasteners. Drain the fuel tank and disconnect the hoses and electrical leads. In removing the bolts in the mounting flange take every precaution

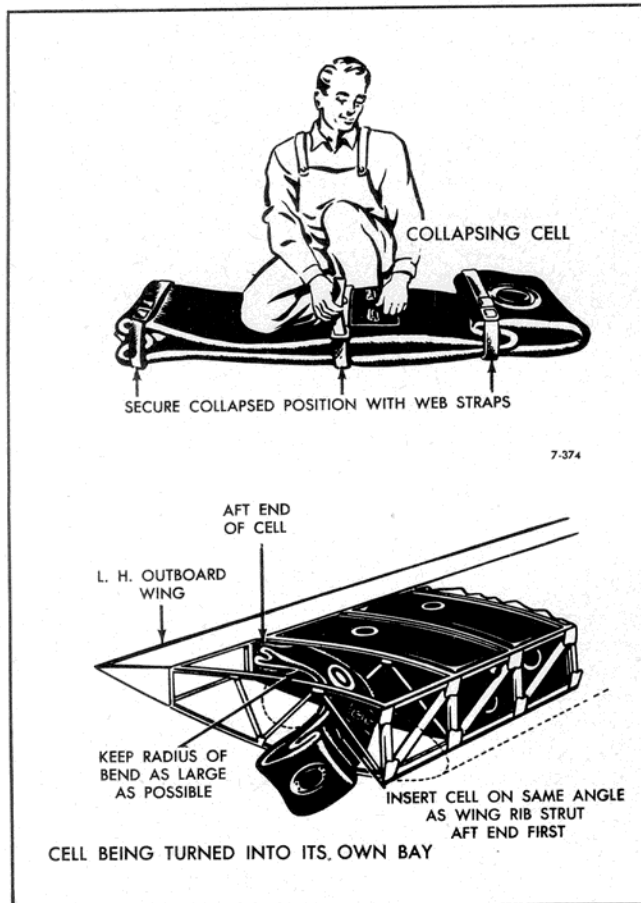


Figure 213—Outer Wing Tank Installation Procedure

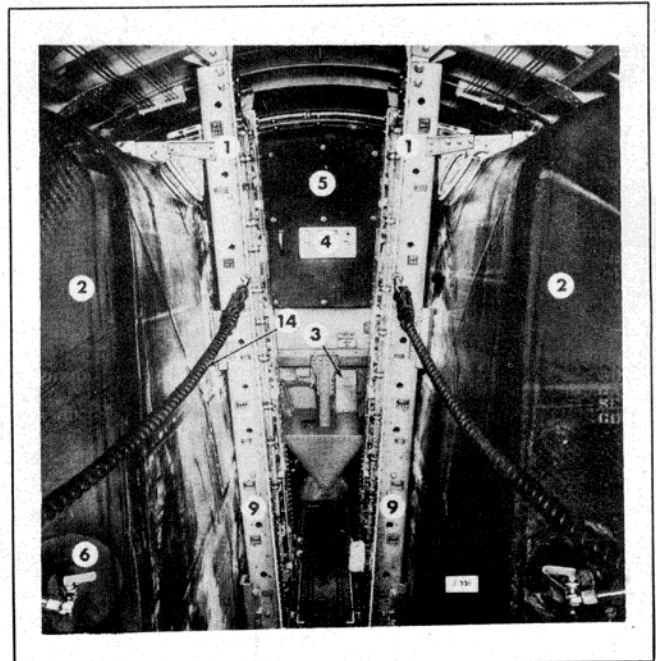


Figure 215—Bomb Bay Fuel Tank Installation (Interior View)

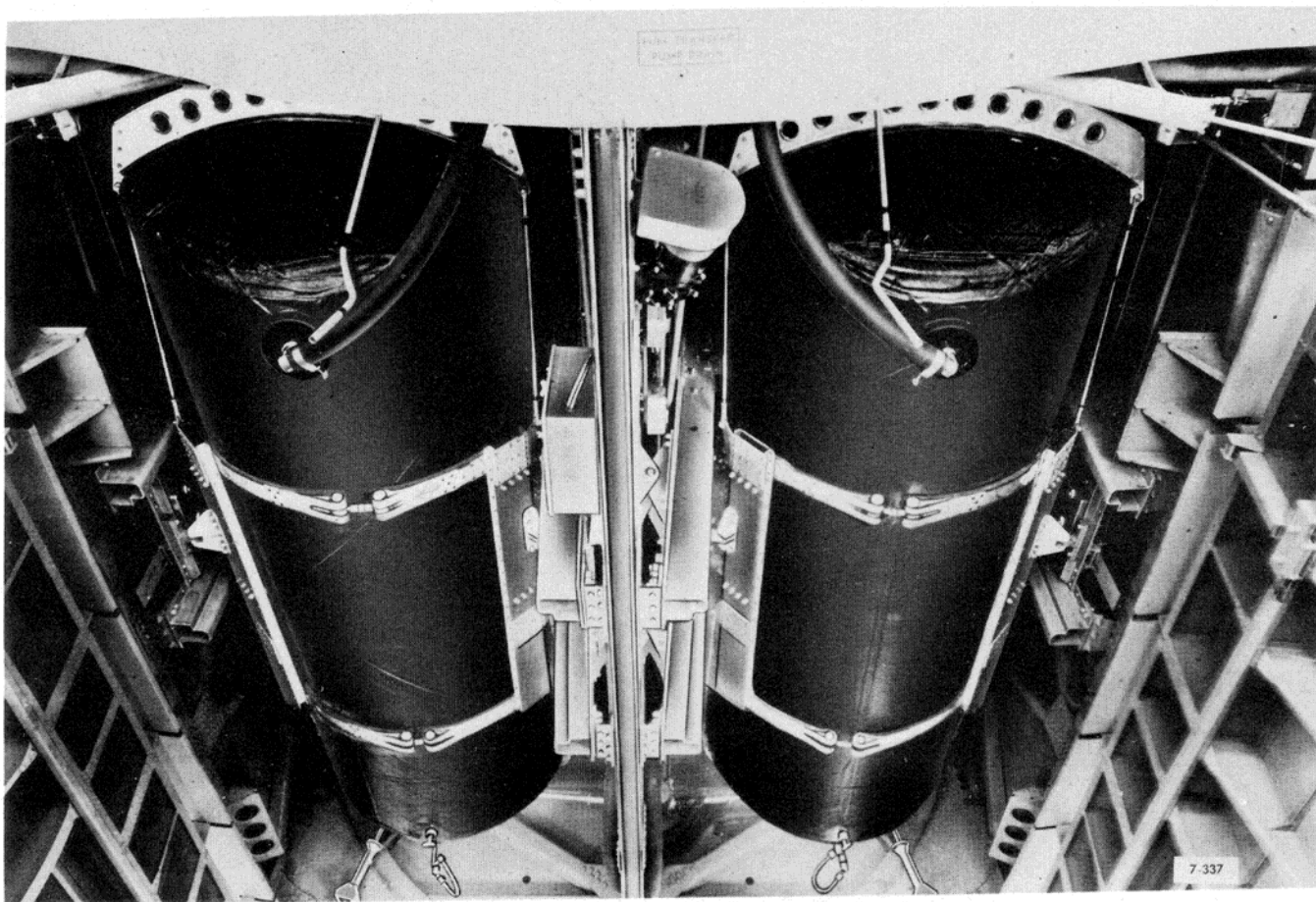


Figure 216—Bomb Bay Fuel Tank Installation (Bottom View)

to protect the leakproof bag. After removal of the pump assembly close the opening with a suitable stopper or cover plate for protection against entrance of foreign matter.

(c) **MINOR REPAIRS AND REPLACEMENTS.**—One set of spare brushes for each fuel booster pump is supplied with the airplane. Replace the booster pump brushes when the brush tension has been reduced to two-thirds of the original tension. Brush replacement must be determined in conjunction with other necessary maintenance operations.

(d) **ADJUSTMENTS.**—If the booster pump does not deliver sufficient pressure, check the voltage and inspect the motor brushes for full contact on the commutator. If this does not correct the pressure, remove the pump and inspect the inlet screen for foreign particles and see that the impeller turns freely.

(e) **INSTALLATION.**—Install new gasket and replace the four mounting bolts. Connect the hose and electrical lead.

(4) **FUEL SHUT-OFF VALVE** (Electromatic No. 2660).

(a) **GENERAL.**—A solenoid operated fuel shut-off valve is installed in the line between the booster pump and the fuel strainer. The valve controlling the

flow from the inboard tank is mounted directly aft of the tank, whereas the valves in the main tank line (engines 1 and 4) are located in the wing leading edge near the inboard oil cooler.

Note

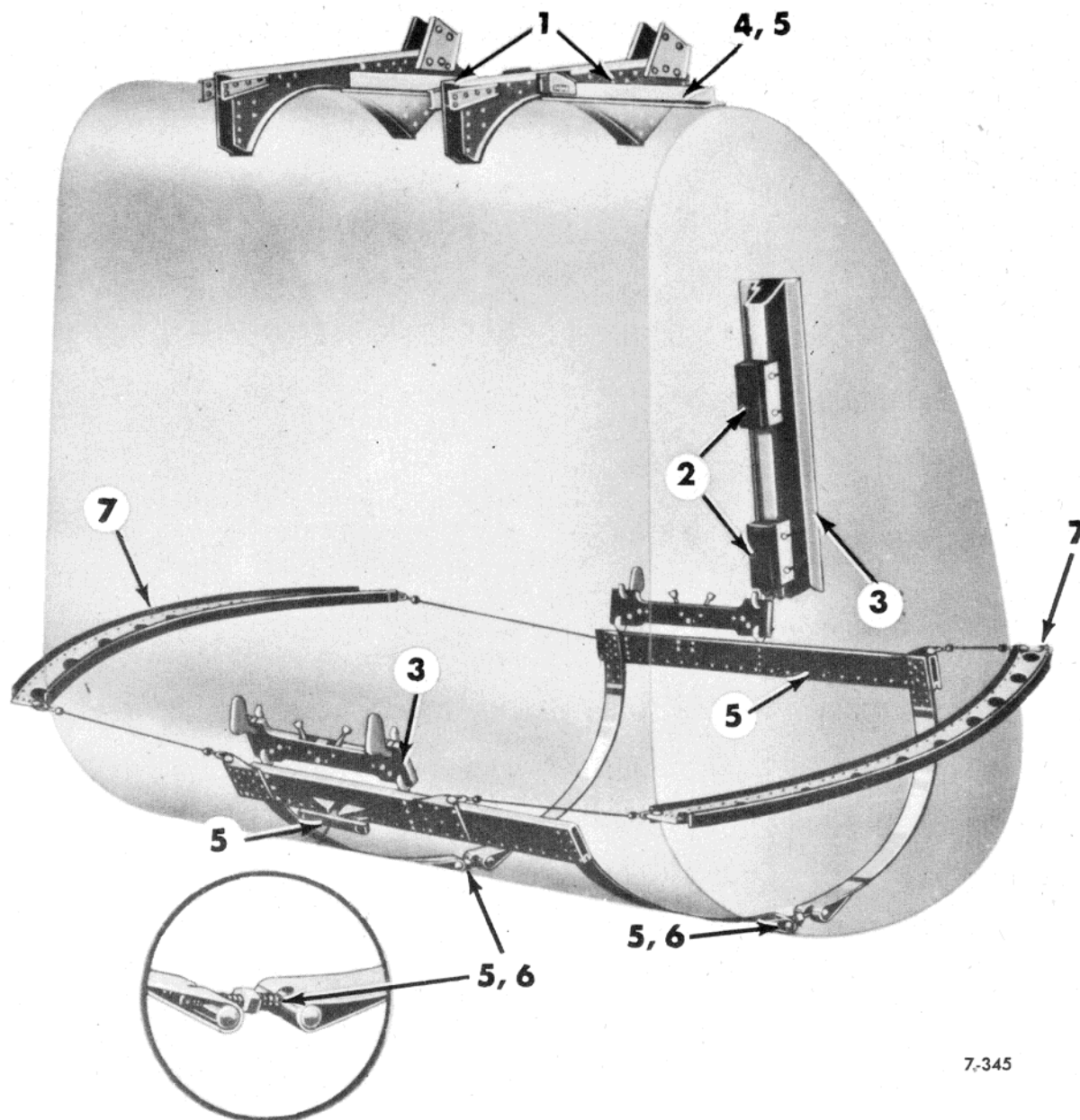
Fuel shut-off valves are to be used in emergencies, such as a severed fuel line or fire. The valves are spring loaded and are normally open. They are closed by an electric solenoid, and remain closed only as long as the current is on.

(b) **REMOVAL.**—With the inboard wing tank installed, the fuel shut-off valve is reached through the access door in the lower portion of the wing. Disconnect the electrical leads and the fuel lines and remove the mounting bolts at the base. Stop all fuel lines with a suitable plug, and tape the ends of the electrical connections.

(c) **INSTALLATION.**—Replace mounting bolts; connect fuel lines and electrical leads. Seal fuel lines as per Specification AN-G-14.

(5) **FUEL STRAINER.**

(a) **GENERAL.**—A fuel strainer is mounted on the forward inboard side of each fire wall. The primer



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INSTALLATION PROCEDURE

1. Install tank cradles. Cradles should be interchangeable, but after airplane has been in service may not always be interchangeable.
2. Install two pads on each bomb rail. Adjust pads parallel with rail and with 1/8" clearance between rail and back of pad, except for bottom pad on each outboard rail. Adjust this pad with 1/8" clearance at top and no clearance at bottom. Apply vaseline to surface of pads.
3. Attach beam assemblies to type B-7 bomb shackles and install at bottom stations on racks. Keep bomb release handle in "locked" position.
4. Remove aft sway block at top of bomb bay fuel tank and lift tank into place, taking care to avoid contact between the tank and sharp corners at the bottom of the bomb rails. Adjust tank position so that the forward sway block rests against the side of the aft cradle and so that the tank seats against all four pads on the cradles.
5. Engage turnbuckles to connect the straps between the beams and before tightening fully, replace the aft sway block at the top of the tank, and install sway blocks at beams.
6. Tighten and lockwire turnbuckles.
7. Install fore and aft beam assemblies and tighten to a snug fit. Be sure that rod end extends past inspection hole in each clevis. These beams must be installed with the rivet manufactured heads up.
8. The two upper pads on the inboard rails may be adjusted if necessary for full contact with the tank.
CAUTION: Too much contact pressure between the rail pads and the tank will tend to make the tank hang up instead of dropping out when the emergency release is operated.
9. Install sight gage, vent line and fuel transfer line. The hose connection at the selector valve must be finger tight only, as the hose goes with the tank when released.

Figure 217—Bomb Bay Fuel Tank Installation Procedure

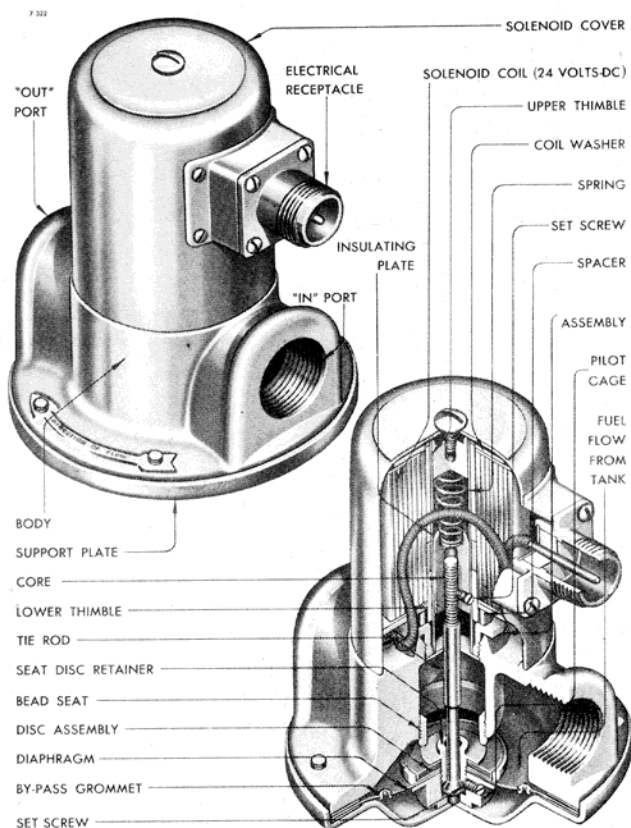


Figure 218—Fuel Shut-Off Valve

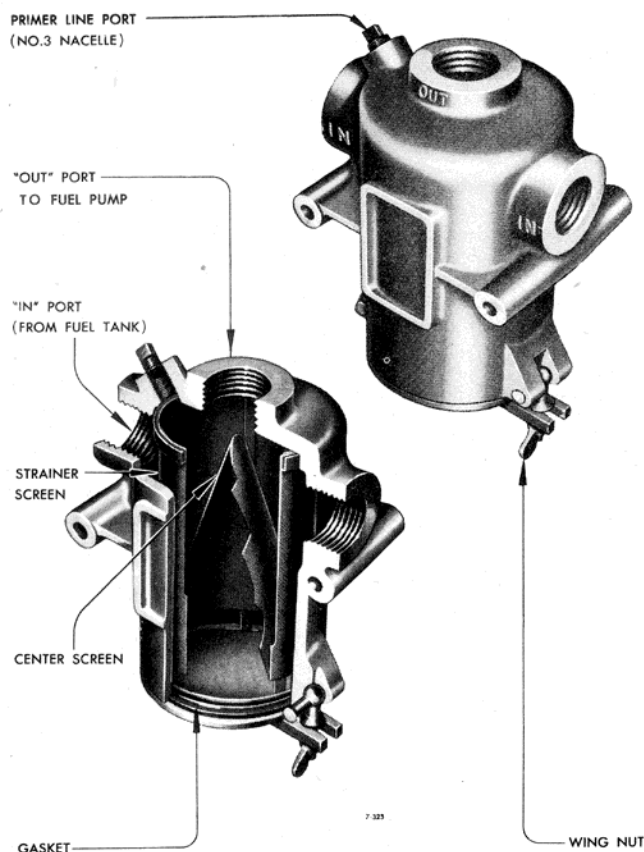


Figure 219—Fuel Strainer

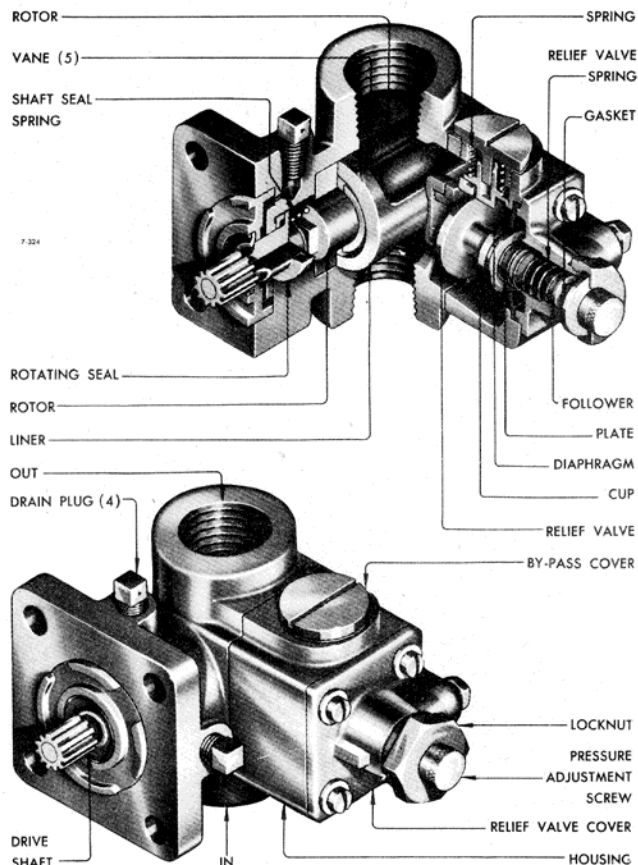


Figure 220—Engine Fuel Pump

system is fed from the fuel strainer on the inboard side of No. 3 engine.

(b) REMOVAL.—The screens may be removed for cleaning without disconnecting the fuel tubing. Removal of the entire unit is accomplished by disconnecting the fuel lines at the strainer and loosening the mounting bolts. On the No. 3 engine fuel strainer the primer line must also be disconnected.

(c) INSTALLATION.—Replace the mounting bolts and connect the tubing. Seal fuel lines as per Specification AN-G-14.

(6) ENGINE-DRIVEN FUEL PUMP.

(a) GENERAL.—The fuel from the fuel strainer is directed to a type G-9 sliding vane fuel pump located on the right side of each engine accessory housing. An adjustable relief valve is incorporated in the unit to maintain a constant differential between the fuel pressure and the pressure in the carburetor intake duct.

(b) REMOVAL.—The fuel pump is mounted on the right accessory pad of each engine. Its removal requires disconnecting the fuel lines and the balance line to the intake duct. The unit is removed after taking out the cap screws in the accessory pad.

(c) ADJUSTMENTS.—The fuel pressure regulating valve should be adjusted to maintain 12 to 16 pounds per square inch, as indicated by the fuel pres-

sure gage. Adjustment is accomplished by removing the hex head cap on the upper portion of the fuel pump and rotating the adjusting screw clockwise to increase the fuel pressure or counterclockwise to decrease the pressure. The pressure variation is approximately two turns per pound. After the adjustment is made, securely lock the adjusting screw and replace, and lockwire the cap screw.

(d) **INSTALLATION.**—Replace the cap screws in the accessory pad and connect the fuel lines and the balance lines to the intake duct. Seal fuel lines as per Specification AN-G-14.

(7) **HAND PRIMER.**

(a) **GENERAL.**—A hand priming pump is mounted on the floor near the right sidewall beside the copilot. A selector valve is incorporated in the unit which directs priming fuel (drawn from engine No. 3 fuel strainer) to any desired engine.

(b) **REMOVAL.**—The fuel lines to the primer unit are disconnected through the access panel on the right side of the fuselage. The mounting screws are removed within the cockpit. Refer to section IV, paragraphs 6. a. and 6. e. for further information on the priming system.

(c) **INSTALLATION.**—Replace the mounting screws and connect fuel lines. Seal fuel lines as per Specification AN-G-14.

(8) **FUEL TRANSFER PUMP (Romec RG 4420).**

(a) **GENERAL.**—An electrically driven vane type fuel transfer pump is mounted in the bomb bay beneath the forward end of the catwalk truss. The pump has a capacity of approximately 900 gallons per hour, discharging against a pressure of five pounds per square inch. The motor is reversible, explosion-proof, and designed to operate satisfactorily at altitudes up to 35,000 feet.

CAUTION

The transferred fuel lubricates the pump; therefore, the pump should not be left running after the tank upon which it has been drawing is emptied. Do not reverse the pump motor before it has come to rest.

(b) **REMOVAL.**

WARNING

Remove the motor fuse first.

Turn the fuel transfer valve controls on the rear bulkhead of the pilots' compartment to "OFF." In order to remove both the pumps and the motor, disconnect and plug the lines to the pump and disconnect the pump drain tube. If it is not necessary to remove the pump, leave the fuel lines connected and disconnect the pump from the motor housing. Then disconnect all

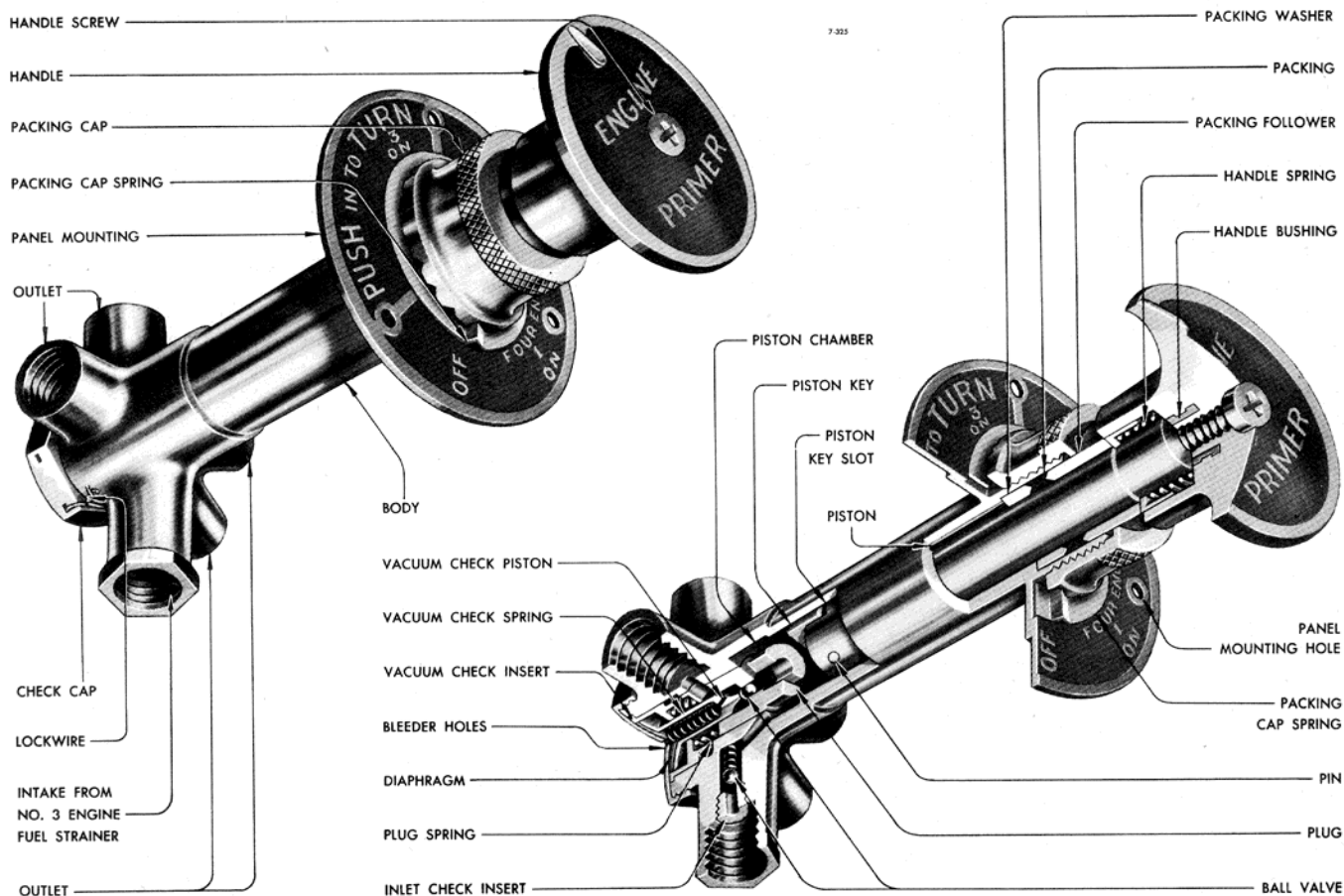


Figure 221—Engine Primer

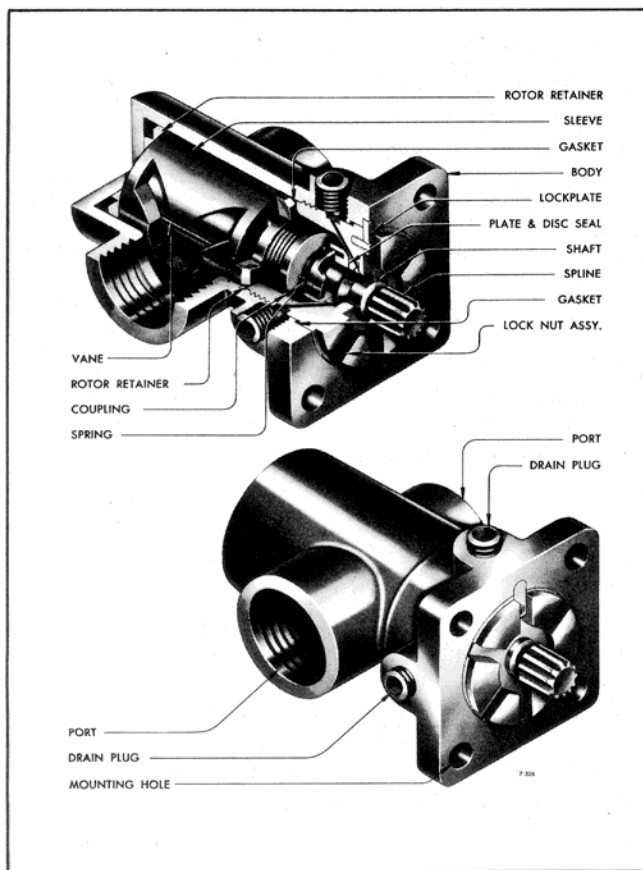


Figure 222—Fuel Transfer Pump

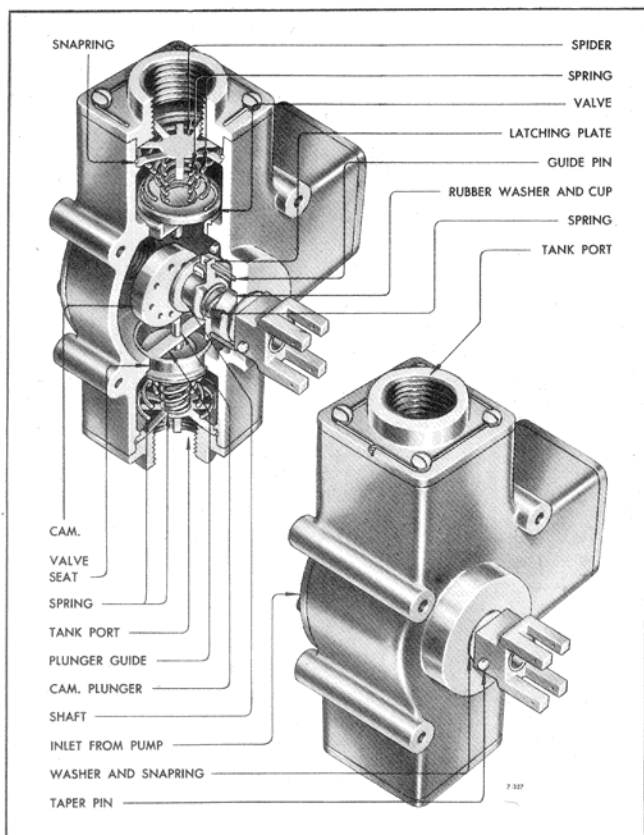


Figure 223—Fuel Transfer Selector Valve

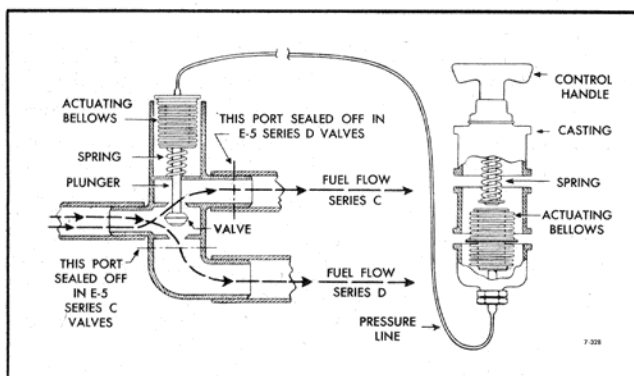


Figure 224—E-5 Fuel Shut-Off Valve

electric wires. The motor leads must be disconnected at the control switch because no junction is provided. Remove the four motor mounting bolts from the support and take the motor out toward the left side of the airplane.

(c) ADJUSTMENTS.—One set of spare brushes for the fuel transfer pump is supplied with the airplane. Replace the booster pump brushes when the brush tension has been reduced to two-thirds of the original tension. The fuel transfer pump is a shunt wound motor, which naturally has poor starting characteristics under load, and brush replacement must be determined in conjunction with other necessary maintenance operations.

(d) INSTALLATION.—Install the motor and connect the fuel lines, pump drain line and electric leads. Seal the fuel lines as per Specification AN-G-14. Connect the electric leads at the control switch. Replace the motor fuse.

(9) TRANSFER SELECTOR VALVE.

(a) GENERAL.—Two transfer selector valves are mounted on the rear side of bulkhead 4, one on either side of the door, and the control handles are mounted on the forward wall. These valves are designed to direct fuel from any tank on one side of the airplane center line to any tank on the opposite side. A transfer between two tanks on the *same* side of the airplane center line

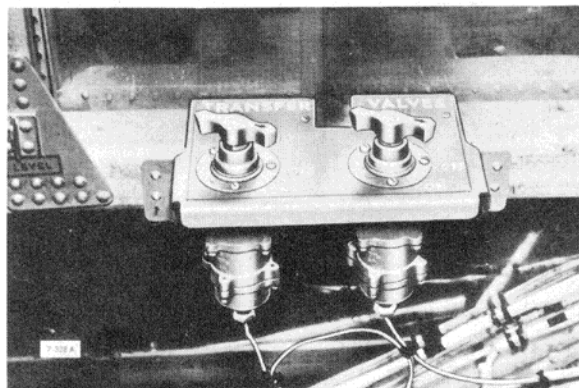


Figure 225—Fuel Shut-Off Valve Control Unit Installation

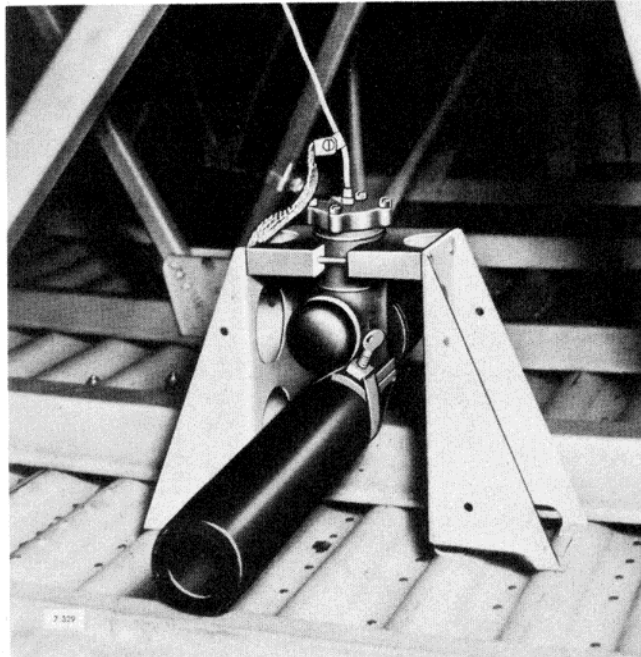


Figure 226—E-5 Fuel Shut-Off Valve (Installed)

must first be routed to a tank on the opposite side and then returned to the desired tank. As a safety feature, a switch is installed on each valve handle which closes the circuit to the pump motor at the time any valve port is opened. This eliminates possible damage to the valve from pump pressure against a closed port.

(b) REMOVAL.—Removal of the transfer valve body requires disconnection of the control handle, the electrical leads to the unit, and the fuel lines. The assembly may then be removed from the airplane by disassembling the mounting bracket on the rear side of bulkhead 5.

(10) SHUT-OFF VALVES.—This D-5 or E-5 series "D" valve is controlled from the rear bulkhead of the bomb bay compartment or from the forward bulkhead of the radio compartment by a self-contained hydraulic system. When the valve is OFF, accidental loss of hydraulic fluid or pressure will cause the valve to open, permitting delivery of fuel from the outer wing tanks.

7. FIXED EQUIPMENT GROUP.

a. INSTRUMENTS AND INSTRUMENT PANELS.

(1) GENERAL.—The flight and engine instru-

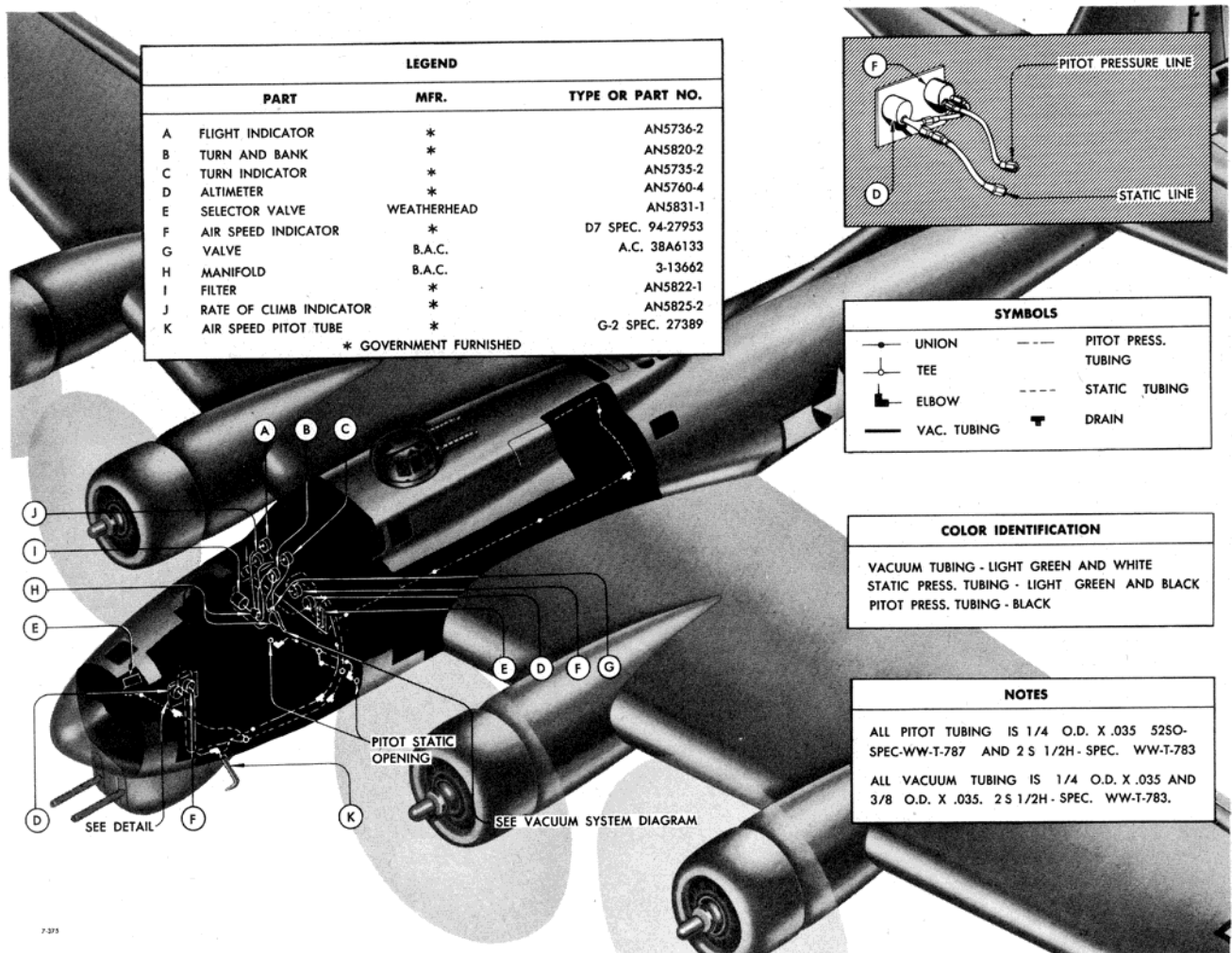


Figure 227—Flight Instruments Diagram



Figure 228—Instruments Circuit (A & M)

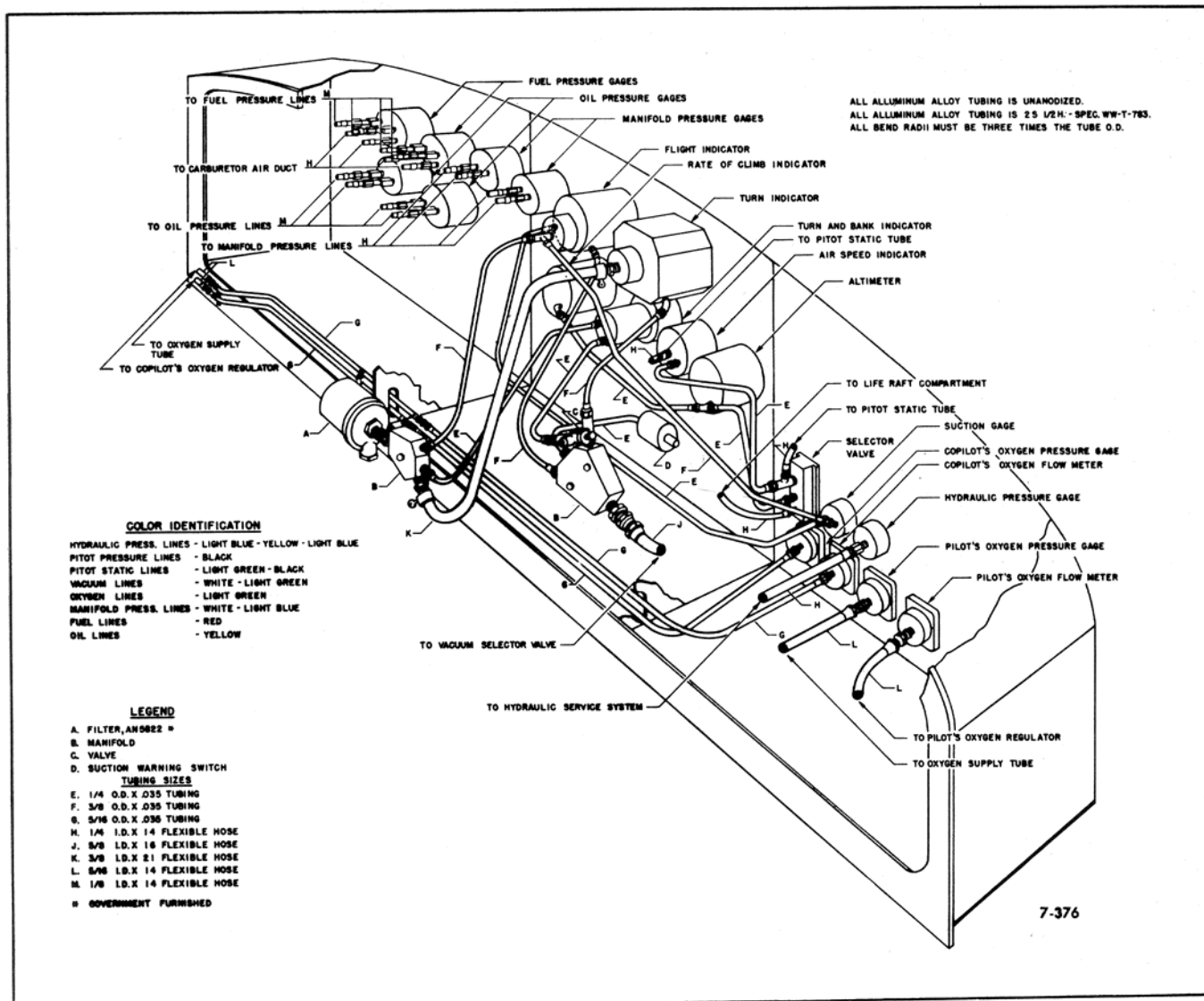


Figure 229—Pilots' Instrument Tubing Diagram

ments, on panels in the pilots' and bombardier-navigator's compartments, are of four main types: electrical, pitot and static pressure, gyroscopic and magnetic. Do not attempt to repair the instruments themselves unless you are a specialist. Internal and external circuits of all electrical instruments are shown on figure 387. The circuits should always be checked thoroughly before replacing an instrument.

(2) AIRSPEED INDICATOR.

(a) GENERAL.—The air speed indicator operates by measuring the difference in pressure between ram air (air pressure built up by the airplane's speed) and static pressure (atmospheric pressure). The pitot static system supplies these pressures. The ram air is directed to one side of a diaphragm and the static air pressure to the other. The diaphragm is connected to the pointer by a linkage and gear system and movement of the diaphragm is thus translated into pointer movement. The gage is calibrated in MPH.

(b) TROUBLE SHOOTING.

| Trouble | Probable Cause | Remedy |
|---------------------------|---|---|
| Pointer fails to respond. | Pitot pressure line improperly connected or clogged. | Check tubing connection and leaks. Blow out to remove foreign matter from lines. |
| Pointer vibrates. | Excessive vibration of instrument board. Excessive vibration of tubing. | Replace worn mounting units holding instrument board. Connect about 10 inches of non-magnetic flexible tubing between the indicator and each solid airspeed line. |
| Other troubles. | Any. | Replace instrument. |

(3) TURN AND BANK INDICATOR.

(a) GENERAL.—The turn and bank indicator is really two separate instruments in the same case. The "turn" indicator contains an air driven turbine which acts as a gyro. The air stream which drives the turbines is pulled into the instrument from the outside air through a filter and screen by an engine driven suction

pump. Suction is maintained at two inches Hg. below atmospheric pressure. The gyro, connected to the pointer by a simple linkage, remains in position while the airplane turns around it and this relative change is translated, through the linkage, into pointer movement. The "bank" indicator shows the movement of the airplane about an axis parallel with the line of flight. It consists of a ball in a curved tube containing liquid. The liquid smoothes out the movement of the ball. When the airplane banks during a turn centrifugal force tends to drive the ball in the opposite direction from the turn. When the correct angle of bank is used, the forces equalize and the ball remains in the center of the tube. (If the ball is driven outward, the bank is too shallow; if pulled down, the bank is too steep.)

(b) TROUBLE SHOOTING.

| Trouble | Probable Cause | Remedy |
|---------------------------|----------------|--|
| Pointer fails to respond. | No vacuum. | Check vacuum lines and instrument filters. |
| Other trouble. | Any. | Replace instrument. |

(4) RATE OF CLIMB INDICATOR.

(a) GENERAL.—The rate of climb indicator operates by quickly and accurately measuring the difference in atmospheric pressure as altitude changes, and by recording this pressure change. This is done by measuring the pressure drop between the outside (atmospheric) air pressure and the air pressure in a sealed chamber (instrument case). A "calibrated and compensated diffuser" (leak) permits outside pressure changes to enter the sealed chamber. The pressure change in the sealed chamber lags behind the outside change and the differential pressure causes movement in the pressure diaphragm which is magnified and translated mechanically to a pointer which indicates the pressure differential in terms of feet per minute.

(5) TURN INDICATOR.

(a) GENERAL.—See turn and bank indicator (uses revolving dial instead of pointer).

(b) TROUBLE SHOOTING.

| Trouble | Probable Cause | Remedy |
|--------------------------------------|---|---|
| Excessive drift on either direction. | Excessive vibration. | Test with vibrometer. Examine shock mountings and note whether connections are pulling on instrument. |
| | Insufficient vacuum; if below $3\frac{3}{4}$ inches Hg. check as follows: | |
| | Suction regulator improperly adjusted. | Adjust regulator. |
| | Incorrect gage reading. | Check calibration of gage. |
| | Pump failure. | Repair or replace pump. |
| | Improper functioning of vacuum line. | Check for kinks, leaks or collapsed inner wall. |
| Any other. | Any. | Replace instrument. |

(6) ALTIMETER.

(a) GENERAL.—The altimeter, like an aneroid

barometer measures the outside (atmospheric) air pressure. It is vented to the atmosphere through the static system. This pressure moves a diaphragm which is connected to the pointer by a balanced linkage. The dial is calibrated in terms of feet.

(b) TROUBLE SHOOTING.—If the instrument is not working properly, check the lines for leaks and obstructions and see that the case is securely mounted on the panel. If the instrument still doesn't work, replace it. Do not attempt to adjust its mechanism.

(7) GYRO HORIZON.

(a) GENERAL.—This is a gyro instrument. The gyro is vacuum driven ($4 \pm .25$ inches Hg.) and is so mounted as to retain its upright position regardless of the airplane's movement. The white horizontal line on the dial face is held in position by the gyro while the airplane and calibrated portions of the instrument are fastened to the panel and moved in relation to the line as the airplane changes its horizontal axis. The instrument should be caged if acrobatics or violent maneuvers are anticipated.

(b) TROUBLE SHOOTING.

| Trouble | Probable Cause | Remedy |
|-------------------------------------|--|--|
| Bar fails to respond. | Instrument caged. | Uncage. |
| Bar fails to respond (high vacuum). | Air filter dirty. | Clean filter. |
| Bar fails to respond (low vacuum). | Suction regulator improperly adjusted. | Adjust suction regulator. |
| | Incorrect gage reading. | Check calibration of gage. |
| | Pump failure. | Repair or replace pump. |
| | | Check lubrication. |
| | | Check for collapsed inner wall of flexible hose. |
| Instrument trouble. | Any. | Replace instrument. |

(8) RADIO COMPASS INDICATOR.

See "Communication Equipment," paragraph 7. e. (1) (c).

(9) PILOT DIRECTOR INDICATOR.

See "Autopilot," paragraph 7. b. (10) (a).

(10) OIL TEMPERATURE INDICATOR.

(a) GENERAL.—Current flows through a wire in *universe* proportion to the temperature. The hotter the wire, the less the current flow. Direct current flow from the airplane electrical system flows through a special resistance wire in the temperature bulb and actuates an ammeter calibrated in degrees Centigrade on the instrument panel to indicate the temperature of the medium surrounding the bulb.

(b) TESTS.—To check a temperature instrument circuit:

1. Disconnect the power by pulling the fuse or removing the indicator receptacle.

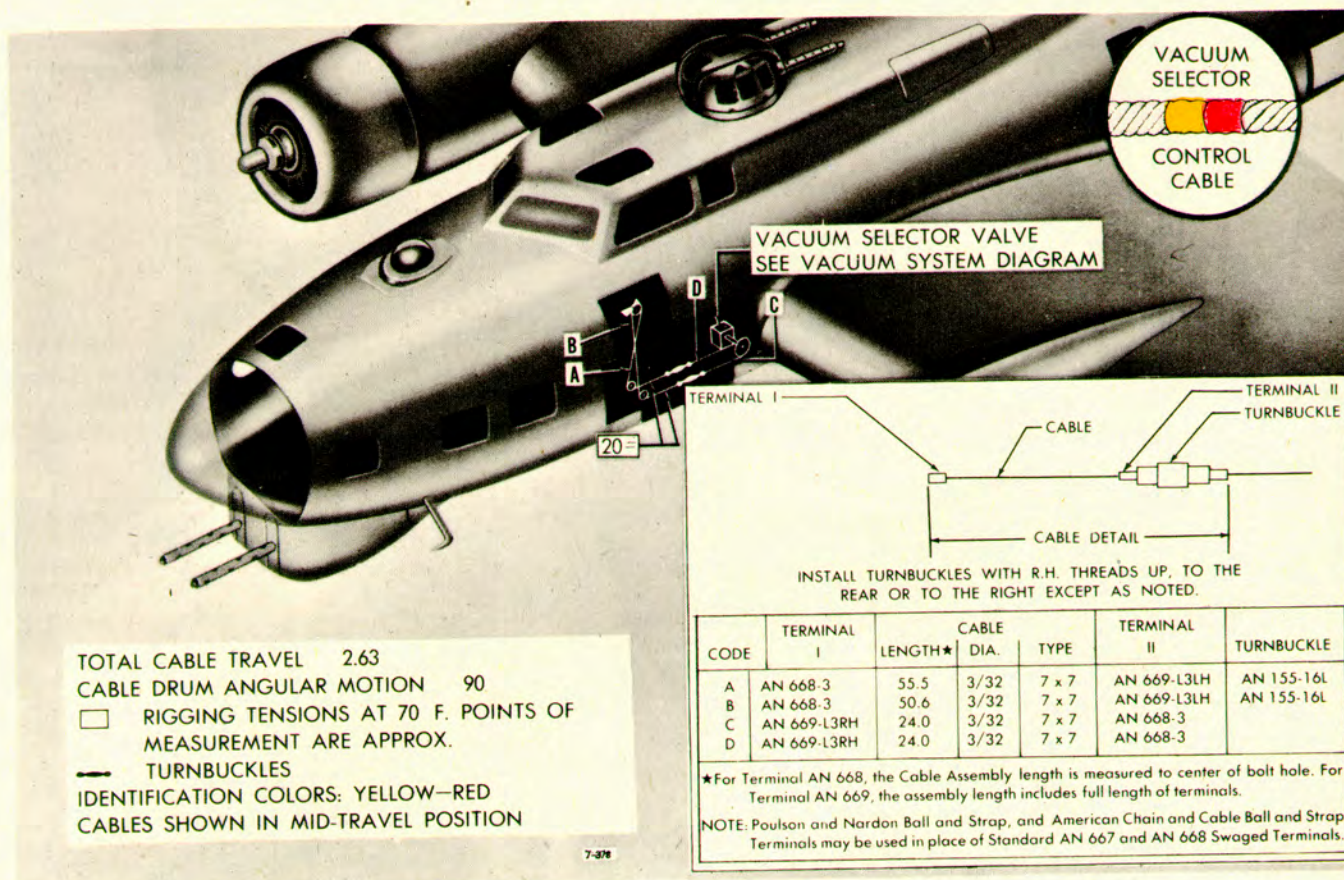


Figure 230—Instrument Vacuum Control System

WARNING

Always remove the 15-ampere thermometer fuse in the station 4 fuse shield or disconnect the indicator receptacle before disconnecting a temperature bulb. An open bulb circuit with power on will burn out the indicator.

2. Disconnect the bulb and allow it to cool to room temperature.

3. Test the bulb with an ohmmeter. The resistances for good bulbs are approximately as follows:

| Air Temperature | Bulb Resistance |
|-----------------|-----------------|
| -50°C (-58°F) | 74 ohms |
| -20°C (-4°F) | 84 ohms |
| 0°C (32°F) | 90 ohms |
| 20°C (68°F) | 97 ohms |
| 40°C (104°F) | 105 ohms |

4. Check the wiring (indicator receptacle disconnected) with an ohmmeter or a "cold" wire test light (see "Electrical Trouble Shooting").

5. If the circuit is faulty and both bulb and wiring check all right, replace the indicator. Do not attempt to repair the indicator or the bulb.

6. Connect the bulb before connecting the indicator, and turn on the power last.

(11) FREE AIR TEMPERATURE INDICATOR.

(a) GENERAL.—The indicator on the copilot's instrument panel is controlled by an electric resistance bulb in the right wing gap. The bombardier has a self-contained type C-13A bi-metallic thermometer in the Plexiglas nose.

(b) TESTS.—See paragraph (10) (b) preceding.

(12) CARBURETOR AIR TEMPERATURE INDICATOR.

(a) GENERAL.—Two dual indicators are mounted on the copilot's instrument panel, and an electric resistance bulb is installed in each carburetor air duct forward of the fire wall.

(b) TESTS.—See paragraph (10) (b) preceding.

(13) CYLINDER HEAD TEMPERATURE INDICATOR.

(a) GENERAL.—The thermocouples are self-generating electrical instruments and do not receive power from the airplane electrical system. When any two dissimilar metals are joined, a difference in electrical potential (voltage) is set up across the bond. When two such bonds at two different temperatures are connected with ammeter in the line, an electrical current

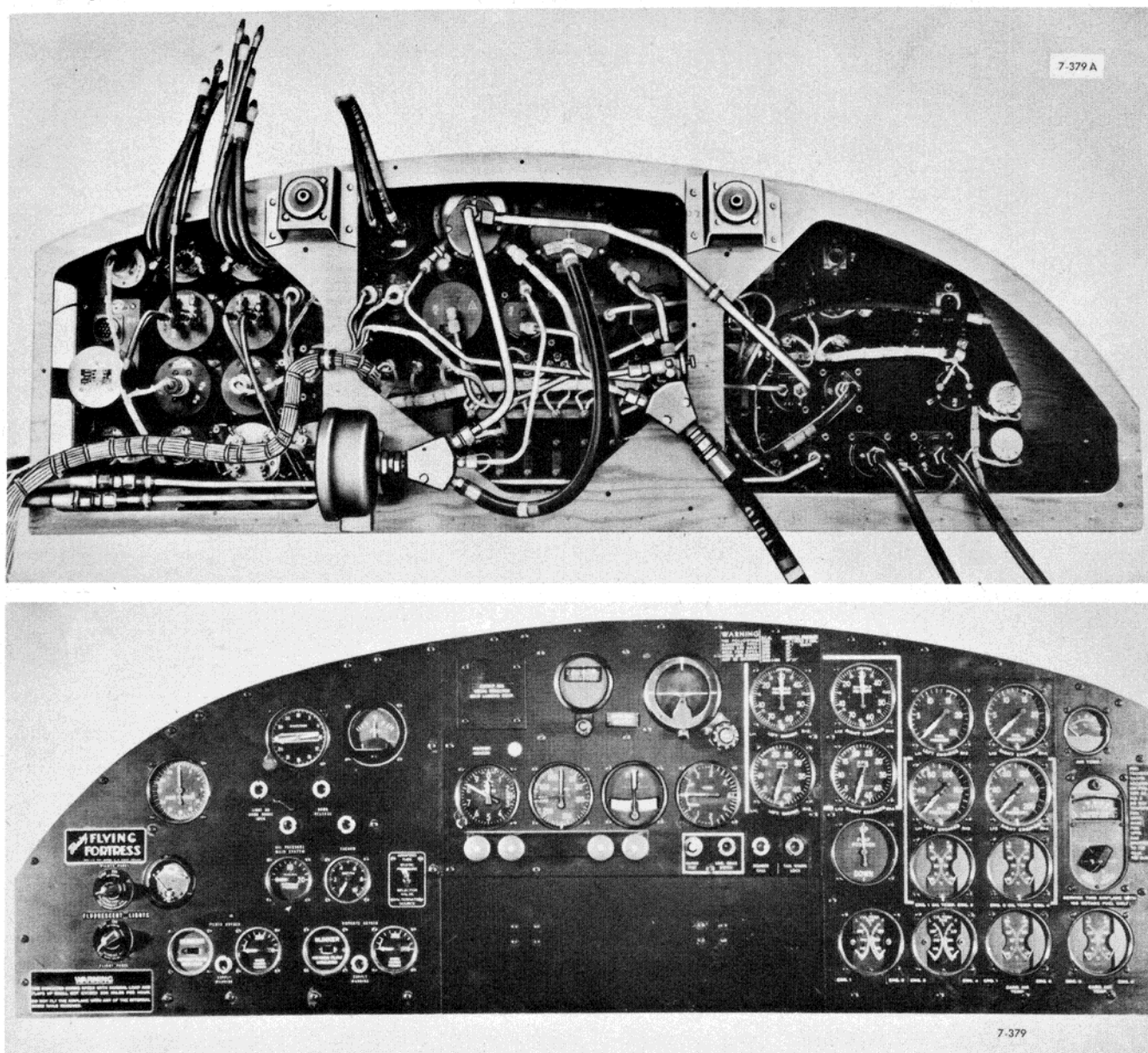


Figure 231—Pilots' Instrument Panel (Front View)

will flow which will be measured by the ammeter and can be calibrated in degrees Centigrade. The thermocouple consists of an iron and constantan bond connected through accurately calibrated wires to the indicator on the instrument panel. The thermocouple on the engine is the "hot junction," and the "cold junction" is in the indicator.

(b) MINOR REPAIRS AND REPLACEMENTS.

1. Do not repair any thermocouple wires if replacements are available, since the indicator will then read incorrectly. Replace the wires in accordance with the M1 through M24 wires in the wire table.

2. If replacements are not available, the wires can be repaired by stripping the insulation from the

broken ends of the wire, looping the protruding portion, laying the two ends together, and clamping them tightly between two washers with a No. 6 bolt and a fiber locknut. Tape and shellac the joint to prevent a short circuit. This type of splice has a minimum effect on the instrument reading.

3. Engine vibration and air blast occasionally cause chafing through the thermocouple lead insulation where the leads enter the engine conduit. The insulation wear can be prevented by sliding the conduit away from the spark plug connection and wrapping the leads with tape so that when the conduit is replaced, approximately one-half inch of taped lead is packed firmly inside it.

(14) FUEL QUANTITY GAGE.

(a) GENERAL.—The transmitter in each of the

six main tanks consists of a simple float-actuated rheostat with adjustable end taps to set the full and empty limits. The indicator includes an ammeter and a six-position switch which connects the ammeter to the desired transmitter and at the same time rotates the corresponding dial mask into view behind the pointer. Twenty-four volt direct current flowing through the transmitter rheostat causes the ammeter to indicate the remaining gallons of gasoline in the tank on the calibrated dial mask.

(b) TROUBLE SHOOTING.

1. No reading at any of the six positions of the selector switch may indicate a blown fuse, a poor connection at the indicator, a break in wire M33, or a defective indicator.

2. No reading on one setting indicates a faulty connection at the respective transmitter.

3. A center reading at one setting indicates the wire to the "C" terminal of the transmitter is broken.

4. A high or low reading at one, at several, or at all settings, may indicate, respectively, that the wire to the "B" terminal of the transmitter, the branching wire to several transmitter "B" terminals, or wire M35 is broken.

5. Service is limited to repair of broken wires, adjustment of the full and empty limits, tightening connections and replacing the units.

(15) FUEL AND OIL PRESSURE GAGES.

(a) GENERAL.—These instruments consist of transmitting and indicating units. Fuel or oil pressure acting on a diaphragm transit pressure through a liquid (AN-VV-C-551) on the other side of the diaphragm to a Bourdon tube in the indicator. As varying pressures induce movement in the Bourdon tube they are transmitted to the indicator pointer through linkages.

(b) MINOR REPAIR.—Add AN-VV-C-551 (compass fluid) to the system through the port in the lower side of the transmitter. Fluid must be under 25 PSI. Don't let filling pressure exceed the maximum gage reading.

1. Be sure the system is completely filled or the reading will be low.

2. During replenishing, loosen the locknut and tighten the diaphragm locking screw to avoid damage to the diaphragm.

3. Due to the weight of the fluid the dial will read less than "0" when the engine is not running. Correct this by removing the instrument from the case and setting the pointer up 1.2 pounds with the adjusting screw.

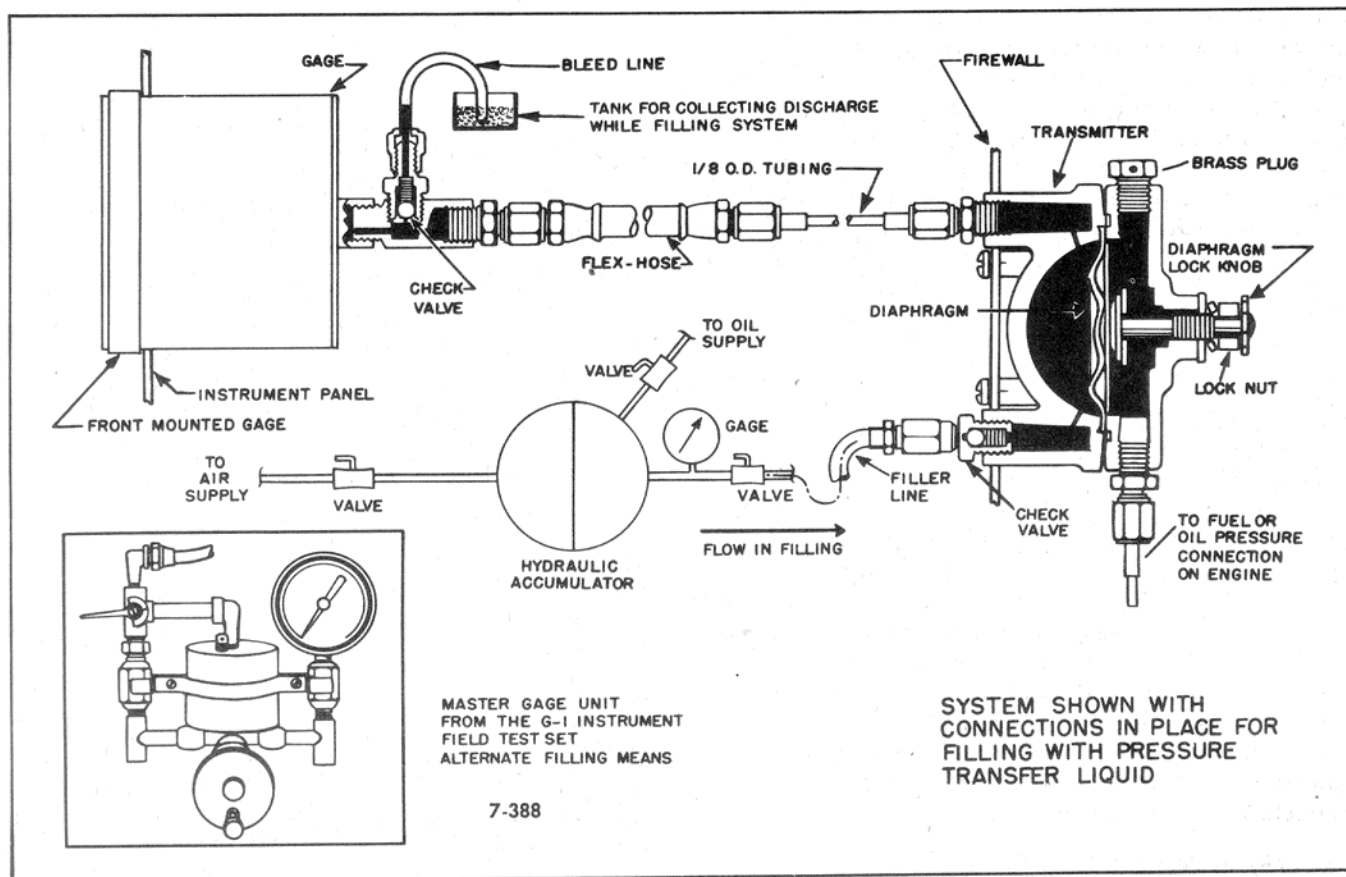


Figure 232—Fuel and Oil Pressure Gage System

(c) TROUBLE SHOOTING.

| <i>Trouble</i> | <i>Probable Cause</i> | <i>Remedy</i> |
|---------------------------------|---|---|
| Does not register. | Pressure line plugged. | Remove dirt from line and tighten connections and fittings. |
| Pointer fails to return to "0." | Foreign matter in line on engine side of transmitter. | Clean line. |

(16) MANIFOLD PRESSURE GAGE.

(a) GENERAL.—The instrument contains two flexible metallic bellows equal in cross section area. These two bellows are connected by a spacer. One of the bellows is evacuated and the other is connected by a tube to the source of manifold pressure. The ends of the bellows unit are fastened to the base and thus any increase or decrease in manifold pressure acting on the bellows moves the spacer connecting the two bellows. This spacer movement is registered on a dial calibrated in terms of inches Hg.

(b) TESTS.—Check against altimeter for correct setting.

(17) TACHOMETERS.—The tachometers are self-generating electrical instruments and are not connected to the airplane electrical system. A permanent magnet driven from a geared shaft on the engine sets up electrical currents proportional to the speed of rotation in three field windings. The field windings are connected to similar windings in a synchronous motor in the indicator, where the currents set up a rotating magnetic field. A four-pole magnet and a lag disk are carried around by the rotating magnetic field and in turn drive a split magnet assembly. A drag disk, which is connected to the pointer and restrained by coil springs, is located between the halves of the split magnet assembly and is pulled around against the springs by the magnetic field. Two such synchronous motors are combined in one indicator and are geared to the two concentric pointer shafts.

(18) WING FLAP POSITION INDICATOR.

(a) GENERAL.—The Autosyn transmitter consists of a simple armature rotor and a three-phase field winding. The rotor is connected by levers to the wing flap. Alternating current, 26 volts, 400 cycle, from the airplane's inverter, is passed through the windings of the two pole rotor. A current is induced in each of the three field windings in proportion to the position of the rotor. The three unequal currents are carried to three respective field windings in the indicator where their magnetic fields act on the indicator rotor and cause it to assume the same position as the transmitter rotor. The indicator rotor could be a permanent magnet, but is an electromagnet for simplified production. A pointer is attached to the indicator rotor.

(b) MINOR REPAIRS.—A broken or shorted wire in the field circuits will cause the pointer to move

part of a turn when the flap is operated and suddenly snap to a new position where it will probably oscillate.

Note

Only authorized instrument shops may repair autosyn instruments.

(19) AC VOLTMETER.—The voltmeter consists of a cylindrical, hollow coil in which are a fixed, triangular soft iron magnet and a pivoted, triangular soft iron magnet to which the pointer is attached. Alternating current flowing through the coil sets up north and south magnetic poles which also appear on the soft iron magnets. Since one end of both magnets is north and the other south at the same time, the magnets repel each other in a rotary direction due to the triangular shape, causing the pointer to indicate the strength of the alternating current. Alternating polarity in the field alternates the north and south poles in both magnets at the same time so the direction of current flow makes no difference.

(20) DC VOLTMETER.—A five-position (OFF-1-2-3-4) selector switch below the voltmeter connects the voltmeter to the positive "B" terminal of each of the four generators. Current through a pivoted coil rotating in a permanent magnet field against coil springs causes a pointer to indicate the strength of the current which is a measure of the voltage.

(21) INVERTERS.

(a) GENERAL.

1. Either inverter is turned on by a bar toggle switch on the pilot's control panel. In the "NORMAL" position, the switch turns on the inverter under the pilot's seat. In case of failure of the normal inverter, the switch should be turned to "ALTERNATE" to employ the inverter under the copilot's seat.

2. The inverter consists of a governor-controlled DC motor, two AC field windings, and a radio

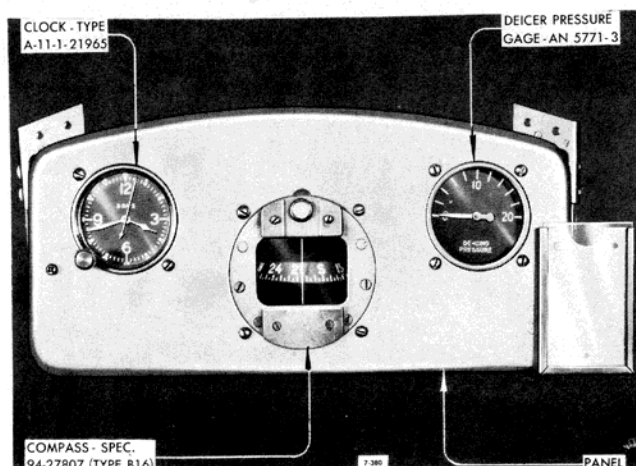


Figure 233—Pilot's Compass Panel

interference filter pack. The governor cuts a resistance in and out of the DC field to maintain the AC frequency at 400 cycles per second. One AC winding ("B" terminal) provides 26-volt, single-phase, 250-volt-ampere, 40 percent power factor alternating current. The other AC winding ("A" terminal) supplies 115-volt, single-phase, 500-volt-ampere alternating current. A "HI-LO" switch on the inverter in the "LO" position cuts off part of the 115-volt winding if the load is less than 75 percent of the 500-volt-ampere rating. The switch is safety wired in the "LO" position in this airplane.

(b) MINOR REPAIRS AND REPLACEMENTS.—If the inverter fails to operate or output is low (AC voltmeter on pilot's panel should show 26 volts) look for:

1. BINDING BRUSHES.—Wipe brushes with a cloth moistened with unleaded gasoline.

2. WORN BRUSHES.—Replace when the brush holder spring is $\frac{1}{8}$ inch from the bottom of the slot in the brush holder. Seat new brush in the contour of the commutator with a strip of No. 000 sandpaper $\frac{7}{8}$ inch wide.

WARNING

Do not attempt to adjust the governor controls. This is a major depot adjustment.

(22) HYDRAULIC OIL PRESSURE GAGE.

(a) GENERAL.—See FUEL AND OIL PRESSURE GAGES for principle of operation—a. (15).

(23) SUCTION GAGE.

(a) GENERAL.—Suction gage measures the amount of suction in the flight indicator only.

(24) INSTRUMENT PANELS.

(a) PILOTS' INSTRUMENT PANEL.

1. GENERAL.—The pilots' instrument panel is supported on a beam across the front of the cockpit. The panel frame is supported on four double shock mounts and steadied on its vertical axis by two shock mounts. The copilot's auxiliary panel is installed at the right end of the main instrument panel, but is rigidly mounted. Three panels containing instruments and controls are rigidly mounted on the main panel frame. The manifold pressure gage connects directly to the source of pressure by means of tubing. The fuel and oil pressure indicators are connected by tubing to type A-1 pressure transmitters on the forward side of each firewall. The electric tachometers operate from individual dual generators at each engine.

| <i>Instrument</i> | <i>Type</i> | <i>Spec. or Mfr.</i> |
|----------------------------|-------------|----------------------|
| Turn and Bank Indicator | AN5820-2 | * |
| Flight Indicator | AN5763-2 | * |
| Radio Compass Indicator | D-81-A | *H41D7019 |
| Altimeter | AN5760-4 | * |
| Air Speed Indicator | D-7 | *94-27953 |
| Rate of Climb Indicator | AN5825-2 | * |
| Manifold Pressure Gage (2) | AN5770-2 | * |
| Tachometer (2) | AN5530-2 | * |

| <i>Instrument</i> | <i>Type</i> | <i>Spec. or Mfr.</i> |
|---------------------------------|-------------|----------------------|
| Flap Position Indicator | 5911-12B | Pioneer Instrs. |
| Fuel Pressure Gage (2) | AN5772-1 | * |
| Oil Pressure Gage (2) | AN5772-2 | * |
| Oil Temperature Gage (2) | AN5795-6 | * |
| Thermocouple Indicator (2) | B-11 | *94-27971-A |
| Fuel Quantity Indicator | EA-47-2C | Liquidometer |
| Suction Gage | AN5771-5 | * |
| Hydraulic Oil Pressure Gage | AN5771-4 | * |
| Voltmeter | S-15172 | Weston |
| | Mod. 517 | Electric |
| Pilot Director Indicator | D-12 | *C-24580-D |
| Turn Indicator | AN5735-2 | * |
| Air Temperature Indicator | AN5790-6 | * |
| Oxygen Pressure Gage (2) | K-1 | *27368 |
| Static Pressure, Selector Valve | AN5831-1 | * |
| Remote Compass Indicator | 10061-1E | * |
| Oxygen Flow Indicator (2) | A-3 | *4-427 |
| Carburetor Air Temperature (2) | AN5795-6 | * |

*Government furnished equipment.

2. REMOVAL.—For removal of any part of the pilots' instrument panel, it will first be necessary to remove the interior lining panel at the rear of the bombardier-navigator compartment. This panel is attached by means of snap fasteners and provides access to the back of the entire instrument panel. There are no soldered connections and removal of individual instruments or any of the complete panels is easily accomplished. If desired, the entire panel assembly may be removed by disconnecting the four shock mounts at the bottom and the two vertical mounts near the top.

3. MINOR REPAIR AND REPLACEMENTS.

a. Repairs to aircraft instruments will ordinarily be made at depots by properly authorized personnel. Refer to section X, paragraph 1., for servicing of the electrical equipment. Any repairs to the shock-mounted panels that change their balance must be compensated for by adjustments at the shock mounts. If instruments or control equipment become damaged or in-

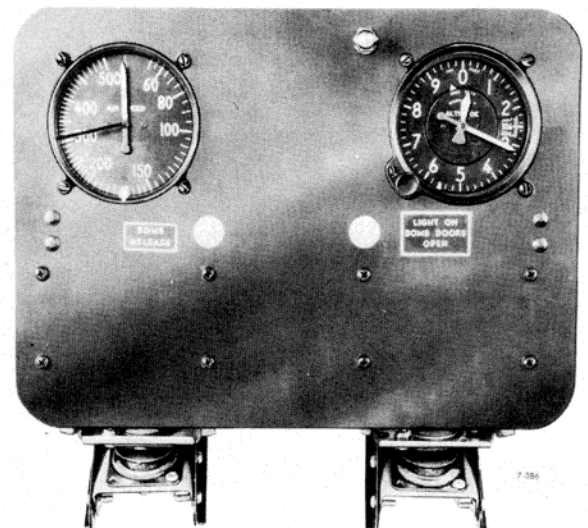


Figure 234—Bombardier-Navigator Instrument Panel

operative, replacements should be made with parts identical to the original installation.

b. The manifold, oil, and fuel pressure gages and the tachometer indicator are all front mounted on the instrument panel, so that the gages may be pulled forward and serviced or disconnected in front of the panel.

4. ASSEMBLY AND INSTALLATION.—At installation of the shock-mounted panels, take care to adjust the supporting mounts so that panels, complete with instruments, controls, tubing, and wires, balance with the face of the panel vertical when the airplane is in the level flight position. Then adjust the steady mount connecting rods so that there is no load in the rods.

(b) PILOTS' COMPASS PANEL.

1. GENERAL.—The pilots' compass panel is supported in the "V" of the windshield next to the ceiling and is attached to the support through shock mounts.

| Instrument | Type | Specification |
|----------------------|------|---------------|
| Compass | B-16 | 94-27807 |
| Clock | A-11 | 94-27970 |
| Deicer pressure gage | G-2 | 94-27924 |

2. REMOVAL.—Remove the panel by removing the screws at the lower shock mounts and at the bottom and upper front corners of the pan; also remove the ground strap on the left side of the pan adjacent to the clock. Disconnect the plug at the temperature indicator, and remove the mounts. If desired, alignment of the panel bracket and upper shock mounts may be retained and the disengagement accomplished by removal of the center bolts in the shock mounts.

3. MINOR REPAIR AND REPLACEMENT.

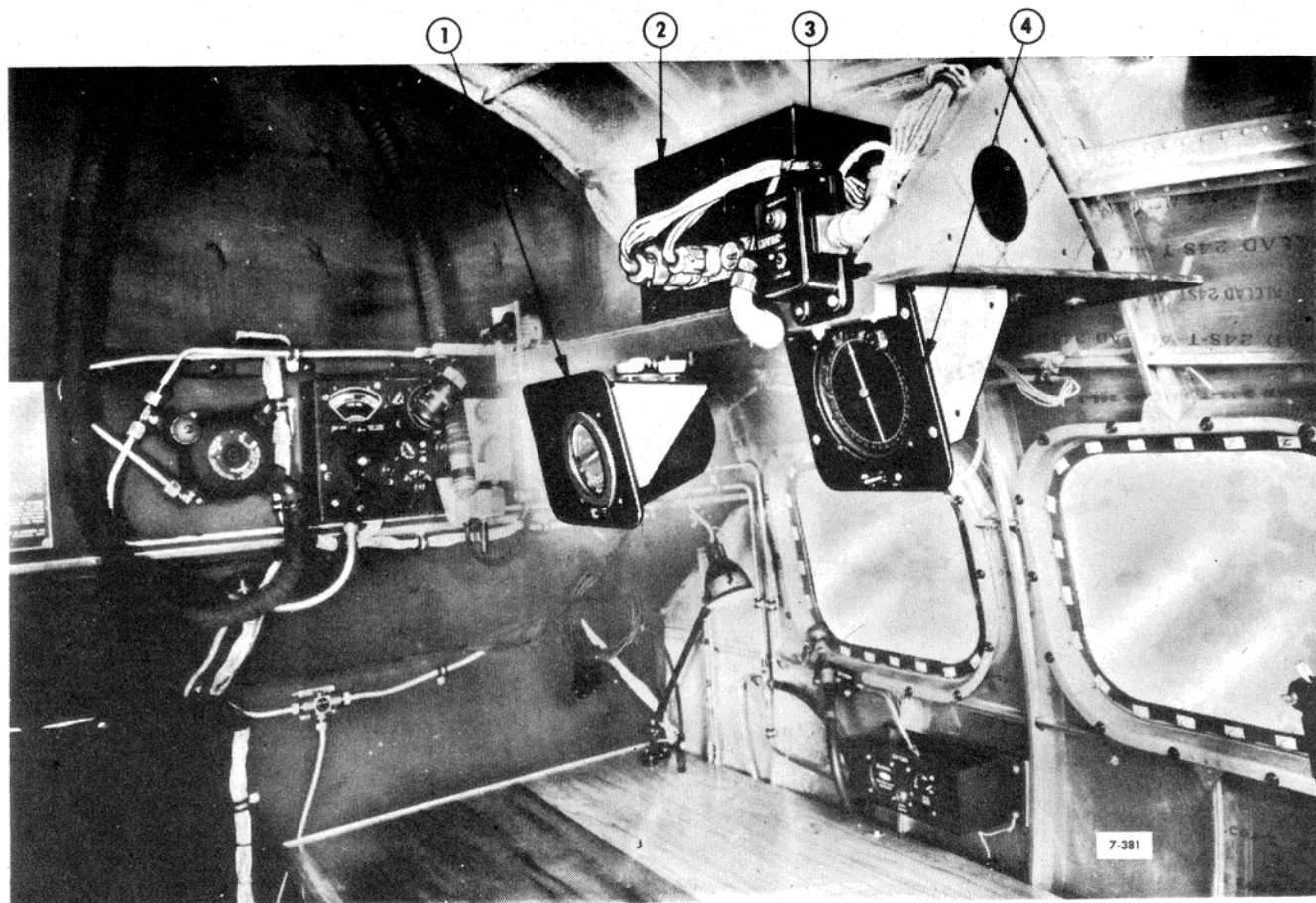
—See paragraph (24) (a) 3.

4. ASSEMBLY AND INSTALLATION.—See

paragraph (24) (a) 4.

(d) BOMBARDIER-NAVIGATOR
INSTRUMENT PANEL.

1. GENERAL.—The instrument panel for the bombardier and navigator is located on the sidewall at the left of the bombardier's station. A support installed on the airplane structure forms three shields for the instrument, control, and bomb indicator panels, and in addition provides a bracket for an oxygen regulator and the bomb interval release unit. The instrument panel is shock mounted, and contains the following instruments:



1. GYRO COMPASS MASTER INDICATOR

2. GYRO COMPASS AMPLIFIER

3. GYRO COMPASS CAGING SWITCH

4. RADIO COMPASS INDICATOR

Figure 235—Navigator's Station

| Instrument | Type | Specification |
|-----------------------------------|-------|---------------|
| Air-speed indicator | C-14 | 94-27952-A |
| Altimeter | C-12 | 94-27957 |
| Clock | A-11 | 94-27949-A |
| Air temperature indicator | C-11 | 94-27970 |
| Air thermometer in Plexiglas nose | C-13A | 94-27328 |

2. REMOVAL.—For removal of the instrument panel remove the cap screw at the top of the panel. This will release the connecting rod from the vertical shock mount and permit the hinged panel to swing outward. After disconnecting the equipment on the panel, the center bolt in each of the two supporting shock mounts may be removed for complete disengagement of the panel.

3. MINOR REPAIR AND REPLACEMENT.—See paragraph (24) (a) 3.

4. ASSEMBLY AND INSTALLATION.—See paragraph (24) (a) 4.

(e) CENTRAL CONTROL BOARD.

1. REMOVAL.—Remove the screws holding the panel to the shield and lay the panel back against the engine control stand. There are no soldered connections at this panel.

2. MINOR REPAIR AND REPLACEMENT.—See paragraph (24) (a) 3.

3. ASSEMBLY AND INSTALLATION.—See paragraph (24) (a) 4.

(f) PILOT'S CONTROL PANEL.

1. The pilot's control panel is rigidly attached

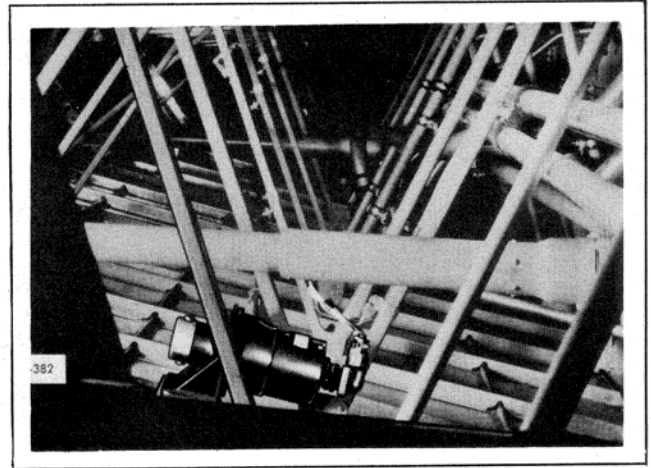


Figure 237—Caging Motor Installed

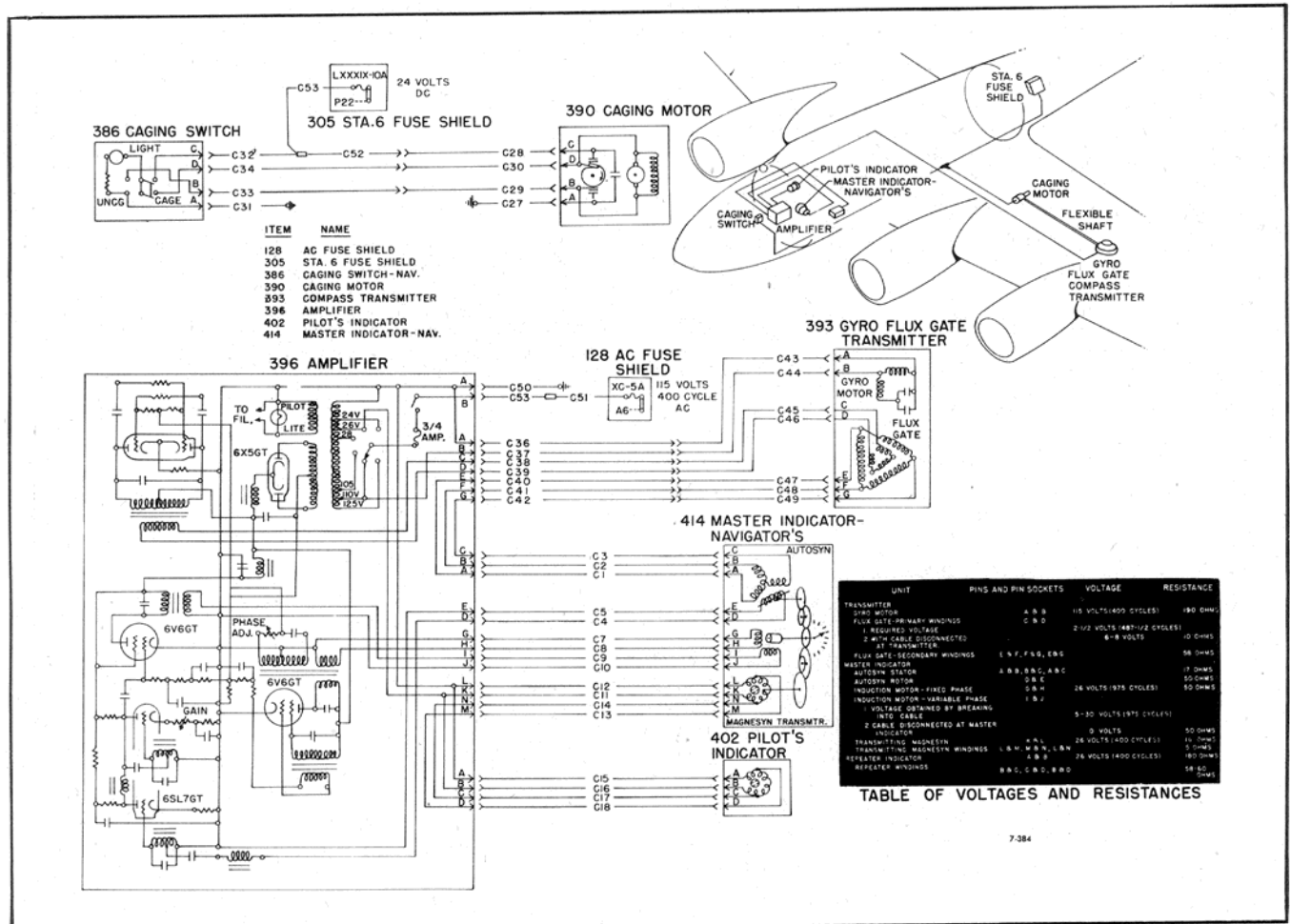


Figure 236—Gyro Flux Gate Compass Circuit (C)

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to a shield mounted on the sidewall at left of the pilot. Instruments and controls on this panel are all electrical.

| <i>Instrument</i> | <i>Type</i> | <i>Specification</i> |
|-------------------|-------------|----------------------|
| Volmeter | B-1 | 94-32172 |
| Ammeter (4) | D-2 | 94-32191 |

2. REMOVAL.—In removing this panel, take out the screws holding the panel to the shield and lay the panel flat on the floor. In order to remove the entire panel it will be necessary to disconnect the wires at the equipment. Connections at the formation lamp rheostat must be unsoldered.

3. MINOR REPAIR AND REPLACEMENT.

—See paragraph (24) (a) 3.

4. ASSEMBLY AND INSTALLATION.—See

paragraph (24) (a) 4.

(25) ASTRO COMPASS.

(a) GENERAL.—The astro-compass MK 11, is designed to provide the navigator with the true heading of the aircraft and the true bearing of a distant object, both quickly and accurately. The compass is carried in a transit case which is stowed in a shock proof box, mounted on the aft end of the navigator's table. The astro-compass standard (base) is permanently secured to the airplane on the support bracket located beneath the navigator's astrodome. This standard must be aligned correctly fore and aft in the airplane.

(b) REMOVAL AND DISASSEMBLY.—The astro-compass is a precision instrument and disassembly should be avoided. In case of damage it is desirable to replace an entire assembly instead of attempting to repair a minor part.

(26) GYRO FLUX GATE COMPASS.

(a) GENERAL.

1. The gyro flux gate compass indicates the heading of the airplane with respect to the horizontal component of the earth's magnetic field. The flux gate compass replaces the magnetic compass because it is more sensitive and gives a direct dial reading compensated for the magnetic field of the airplane itself and corrected for the variation of true North from magnetic North. (A magnetic compass is in the panel over the pilot's windshield in case of failure of the gyro flux gate compass).

2. The compass system operates electrically, and consists of the gyro-stabilized flux gate transmitter and a gyro caging motor in the left wing, an amplifier, the master indicator, the caging switch on the shelf above the navigator's table and a secondary indicator on the pilot's instrument panel. Compensation for magnetic variation and deviation are mechanically introduced in the navigator's indicator, and the corrected bearing appears on the navigator's and the pilot's indicator so that no compass correction cards are necessary.

(b) OPERATION.

1. The compass is turned on and off by a switch on the amplifier. The switch should be left on at

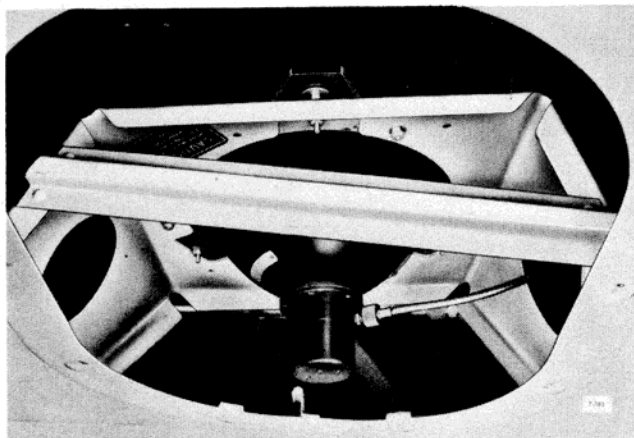


Figure 238—Compass Transmitter Installed

all times so that the compass will be on whenever either inverter is running. An amber light on the amplifier indicates that the compass is on.

2. A gain control knob on the amplifier controls the sensitivity of the unit, depending on the latitude or the distance of the airplane from the magnetic pole. Changes to the gain control need be made only after a substantial change in latitude.

3. Magnetic variation for the latitude and longitude is introduced by offsetting the outer dial against a scale on the inner dial by rotating the knob at the bottom of the navigator's master indicator.

4. The stabilizing gyroscope in the compass transmitter is caged and uncaged by operating a toggle switch on the switch box at the navigator's station. A warning light above the switch is on when the gyro is caged. The caging mechanism employs the gyroscopic principal of precession so that the gyro must be running at full speed to be caged. The gyro should be left uncaged at all times except when maneuvers exceeding 65 degree angles are anticipated or when you wish to erect the gyro quickly without waiting for the erecting mechanism, which might take as long as 20 minutes.

5. The pilot's indicator has a course setting pointer which is rotated by a knob on the face of the indicator to aid in maintaining the desired heading.

6. The compass is compensated for the magnetic field of the airplane by swinging the airplane in the flight position with wheels retracted by any of the standard compass swinging procedures. See section X. At 24 equally spaced directions (every 15 degrees starting from North) the compass is compensated by removing the knob-screw-driver at the top of the master indicator, which allows the bezel ring to be removed, and setting the dial pointer to that heading with the set screw at the top of the pointer. The compensation is aided by the fact that the uncorrected reading appears in the dial cutout while the main pointer and dial show the compensated reading. In cases where large corrections have to be introduced, the adjustment should be distributed on adjacent screws to avoid straining the compensating cam.

(c) REMOVAL AND INSTALLATION.—The removal and installation of the gyro flux gate units are elementary operations if the following precautions are observed:

1. REMOVAL.—Before removing the transmitter, cage the gyro if possible. The gyro should be caged before it is shipped.

2. INSTALLATION.

CAUTION

Place rubber lines parallel to the longitudinal axis of the ship.

a. The transmitter disconnect plug must point forward and the caging head must be down.

b. Turn the caging head until the flexible shaft can be connected.

(1) Loosen screws on the flange of the head one turn only. Do not remove the screws.

(2) Turn the head as many degrees as necessary.

(3) Tighten the screws after the caging head is in the correct position.

(4) Do not, at any time, bring a strong magnet near transmitter.

3. TO INSTALL A FLEXIBLE DRIVE SHAFT IN THE TRANSMITTER CAGING HEAD.

a. Turn amplifier switch to "ON." Allow the gyro to run 10 minutes.

b. Uncage the gyro by turning the manual caging knob 30 turns clockwise.

c. Remove manual caging knob by unscrewing the knurled knob on the top part of the caging head.

d. Set caging switch to "UNCAGE" position.

e. After flexible shaft stops turning, connect the shaft to the caging head of the transmitter.

4. TO INSTALL THE AMPLIFIER.

a. Secure Lord shock mounts to the shelf.

b. Check to see that link switch is set at 115-volt tap.

c. Install a 1-ampere fuse in amplifier chassis receptacle.

d. Connect the wiring to the control panel. Only smooth bends are allowed in the cables.

(d) TESTS.

1. FUNCTIONAL TEST.

- a. Throw inverter switch to "NORMAL."
- b. Put amplifier switch to "ON."

(1) See that the warning light on the amplifier is lighted.

(2) Check to see that the gyro in the transmitter is warming up.

c. Check the caging pin, which should protrude 3/16 inch.

d. Allow the gyro to run 10 minutes.

e. Uncage the gyro.

(1) Check to see that the warning light of the caging switch goes off when the gyro is uncaged.

(2) Check the caging pin which should be flush with the case of the transmitter when the gyro is uncaged.

(3) Check the speed of the erection disk, which should be between 35 and 42 RPM.

f. Allow the gyro to run an additional 20 minutes after uncaging.

g. Head the ship North and then swing it around and stop at 15 degree intervals. Both indicators should be within two degrees of each heading.

2. TEST AFTER INSTALLATION.

a. Recheck wires for proper shielding and good electrical connections.

b. Recheck Lord shock mounting on all units.

c. Perform functional test of the system as outlined under paragraph (d) 1. preceding.

d. Recheck any repaired units or newly installed unit.

(e) TROUBLE SHOOTING.

1. If the light on the amplifier is not on when the inverter is running, check the switch on the amplifier, the fuse in the amplifier, the fuse in the AC fuse shield under the pilot's seat, the wiring, and the plug and receptacle connections.

2. Failure of any unit or of the wiring or connections will be indicated by the pointers remaining stationary, no matter to what heading the aircraft is turned. The only exceptions which would produce a characteristic indication are as follows:

a. Pointers swinging erratically through wide angles as the airplane is turned indicate failure of the gyro motor or the erection system.

b. Pointers indicating first one, then the other of two headings as the airplane turns through 360 degrees indicates an open circuit in the coupling autosyn in the master indicator or an open circuit in one of the wires between the flux gate transmitter and the amplifier.

c. Failure of the pilot's indicator to follow the navigator's indicator are at once traceable to trouble in the pilot's indicator, loose receptacles or broken wires between pilot's and navigator's indicators, or trouble in the magnesyne transmitter in the navigator's indicator.

d. Magnetization of sub-assemblies in the transmitter would be noticeable in the form of undue

deviation, an oscillation of the indicators through 3 or 4 degrees, or a loss of sensitivity.

e. The only possibility of erroneous readings, other than those indicated, would be the effect of a damaged flux gate element. This would be suggested by erratic readings of the system as a whole.

b. SURFACE CONTROL SYSTEM.

(1) **GENERAL.**—The control surfaces are operated directly by means of cable systems from dual controls in the cockpit. Aerodynamic counter-balance combines lightness of controls for all normal use with effective feed-back for indication of variations in control surface loads. Conventional dual wheel, column and stirrup controls are provided at the pilots' stations. Cables provide single control from the ties beneath the cockpit and radio compartment floors except for the elevator system, which is dual throughout. Refer to the cable system diagrams for complete information on all surface controls. Trim tabs are cable operated through screw type actuating struts at the tabs. The control wheel for the elevator trim tabs is on the left side of the engine control stand. The rudder trim tab control wheel is installed laterally in the cockpit floor directly behind the engine control stand, and the aileron trim tab control is mounted on the floor panel to the left of the pilot. It is imperative that the trim tabs on the elevators and rudder do not have a free motion of over 3/16 (.187) of an inch at the trailing edge due to "play" in the control system. Likewise, the aileron trim tabs should not have over 5/32 (.156) of an inch "play." "Play" in excess of these dimensions may result in structural failure. A control handle recessed in the cockpit floor, between the pilot and the copilot, operates spring-loaded pins for locking the rudder and elevator quadrants. A double cable connects the cockpit control handle with an arm assembly attached to the forward side of bulkhead 9, which operates both locks. The aileron is locked by a pin which is inserted in a hole in the pilot's control column and engages the center spoke of the wheel. Clips for stowage of the aileron lockpin, when not in use, are provided on the pilot's column.

WARNING

NEVER LASH SURFACE CONTROLS INSTEAD OF USING THE LOCKING SYSTEMS PROVIDED. THE LOCKING SYSTEMS ARE DESIGNED TO FAIL BEFORE FAILURE OF THE CONTROLS AND THUS PROVIDE PROTECTION AGAINST UNOBSERVED FAILURES.

(a) REMOVAL.

1. FLIGHT CONTROL CABLES.

a. In order to remove the flight control cables, first release all cable tension by loosening the turnbuckles. Then remove the pulleys and fair-leads.

b. To remove the cables around the aileron control quadrant, remove the spacer bolt which acts as a

stop for the aileron movement. The quadrant may then be moved either way to facilitate cable disassembly.

c. For access to the aileron pulley bracket in the wing gap at station 1, remove the heating duct section.

d. When cable drum and actuating strut operation is used, it is necessary to lock the cable around the drums with a clamp in order to prevent unwinding of the cable from the drum after disconnection. The cables on the elevator trim tab drums, due to single cable operation for separate drums, should be tapered to prevent unwinding. Tape may be used in any case where clamps are inconvenient or impossible to use.

Note

A feeder line should be attached, when removing cables, to facilitate reassembly.

(b) MINOR REPAIR AND REPLACEMENTS.

1. CABLES.

a. All cables have been dipped in hot, 71°C. (160°F), heavy rust preventive compound, AN-C-52, and pulleys are equipped with prelubricated sealed bearings. These parts therefore should not be washed in gasoline or other cleaning solvents unless a re-application of the cable treatment or replacement of the pulleys is anticipated.

b. Surface control cables are 3/16-inch 7 x 19 extra flexible preformed steel, with the exception of the servo unit cables, which are 1/8-inch 7 x 19 extra flexible. The trim tab cables are 3/32-inch 7 x 7 extra flexible preformed steel.

c. Cables that are found to be frayed will be considered serviceable unless there are more than six broken wires per inch of 7 x 19 cable and three broken wires per inch of 7 x 7 cable.

(c) ADJUSTMENTS.

For adjustment of surface controls refer to the control diagrams

(d) ASSEMBLY AND INSTALLATION:

1. All systems must be rigged with controls in mid-travel position except the elevators, which are rigged with the control column 10½ degrees forward of mid-travel with the elevators in neutral position. Turnbuckles and adjusting links as shown on the diagrams permit full adjustment for position and tension. Cable travels and tensions given on the diagrams are necessarily approximate.

2. Cable tensions indicated are based on a balanced temperature condition of 21° C. (70°F.) and applied tension in general must be greater when rigging at higher temperatures and less when rigging at lower temperatures. Correction for temperature will vary with cable size, length, direction of travel, and location in the airplane.

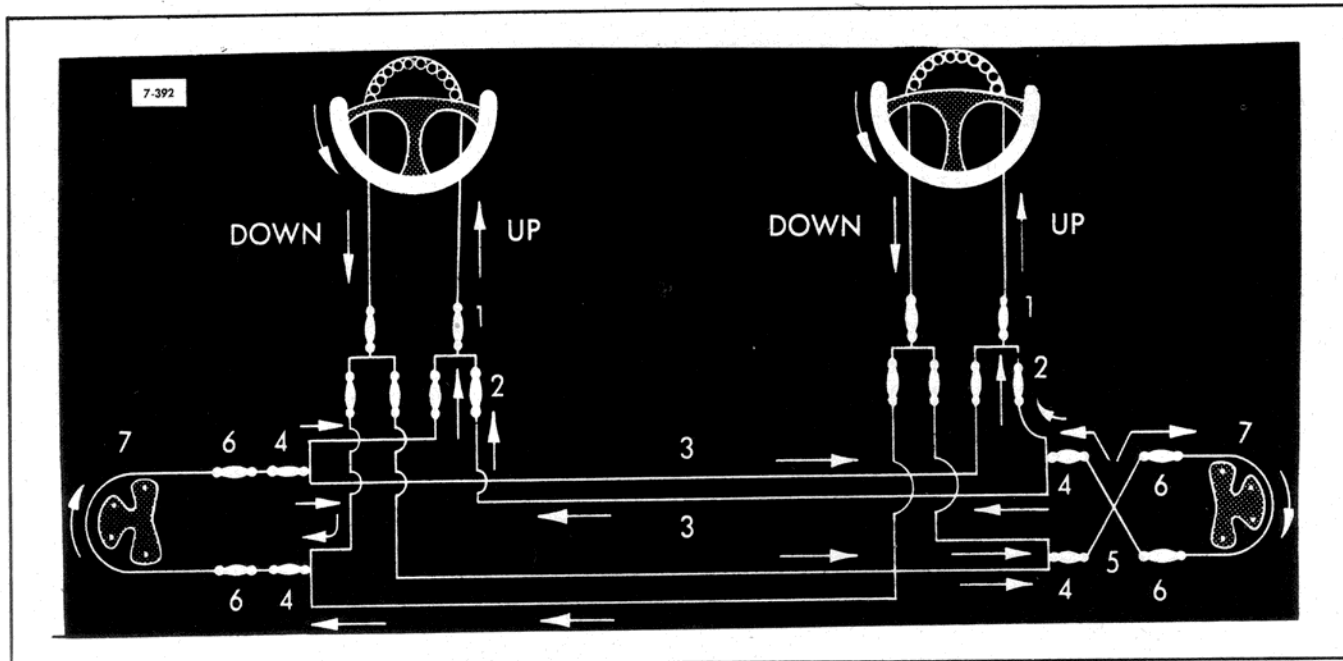


Figure 239—Aileron Control Diagram (Schematic)

WARNING

ALL CABLE TURNBUCKLES AND CONTROL ROD LINKAGE MUST BE PROPERLY SAFETIED AFTER ADJUSTMENT.

(2) AILERON CONTROL.

(a) DESCRIPTION.—The wheel on each control column is connected to a sprocket and chain. When the controls are in the neutral position the master link in the chain is at the top of the sprocket. This makes it easy to connect or disconnect the chain. The ends of the chain are connected to the 3/16-inch 7 x 19 cables by pin-eye terminals. The cables travel down the tubular section of the columns and outward to the space between the cockpit wall and skin. *Be sure that the cables are not crossed.*

To service this part of the system, open the control access doors in the body forward and above the nose section of the wing. From there cables travel aft and the dual system of cables is interconnected along the aft side of the rear spar. Then single control extends through each wing to the aileron quadrant. An adjustable connecting rod transmits control from the quadrant to the aileron.

1. Figure 239 supplements the aileron control system diagram and clarifies the rigging procedure references. The schematic diagram (figure 239) is described as follows:

- The first set of single turnbuckles (1) is in the space between the cockpit wall and the skin.
- The first set of bus line turnbuckles connections (2) is in the bomb bay next to the compression rib truss.
- Aft of bulkhead 5 the cables (3) travel through the fuselage into the wings.
- Pin-eye link terminals connect the bus

lines and the second set of single terminals (4) at station 5 of the wing. (Directly aft of nacelles 2 and 3.)

e. The up and down cables (5) cross in the right wing between nacelles 3 and 4.

f. The third set of single turnbuckles (6) is at station 19 of the wing where the outboard and inboard panels meet.

g. The quadrants (7) are at station 24 of the wings.

2. Two 1/8-inch 7 x 19 cables, attached to the copilot's aileron cables under the control cabin floor, are connected to the aileron servo unit of the auto pilot.

(b) AILERON CONTROL RIGGING TOOL.—For best results in rigging the aileron control system, use the tool illustrated in figure 240. This tool permits rigging the aileron cables from the control wheels to the cable junction at the connection between the inner and outer wings, before installation of the outer wing. At installation of the outer wing, aileron adjustments may be made and full rigging load applied without disturbing the rigging from this point to the control wheels. Take care to make a fine adjustment of tension so that no further adjustment will be necessary after removal of the tool.

(c) AILERON RIGGING PROCEDURE.

1. Lock control wheel and quadrants in the neutral position.

2. Take up the single turnbuckles on the left side of the body until the "up" cable has three threads showing and bring the "down" cable flush, no threads showing. ("Down" cable is slightly longer.)

3. Take up the single turnbuckles on the right side of the body until they are flush.

4. Take up the single turnbuckles at stations 5 and 19 until they are flush. If the cables are a little

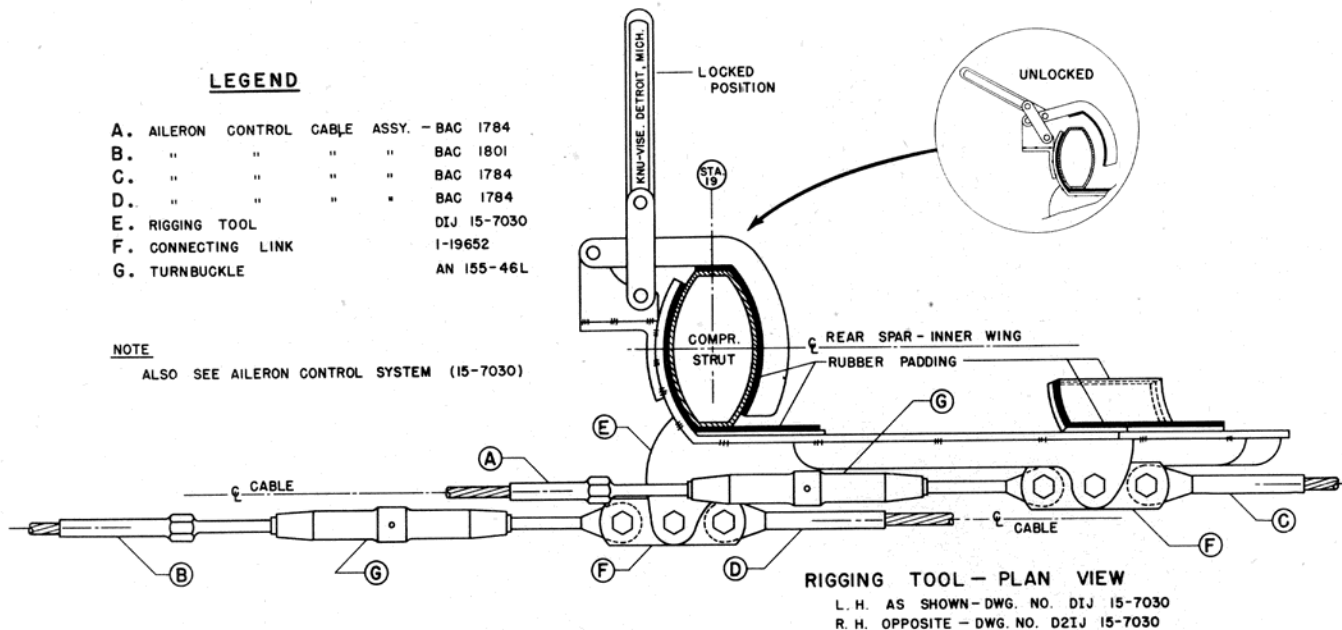
RESTRICTED
AN 01-20EG-2

LEGEND

| | | |
|----|-----------------------------|-------------|
| A. | AILERON CONTROL CABLE ASSY. | BAC 1784 |
| B. | " | " BAC 1801 |
| C. | " | " BAC 1784 |
| D. | " | " BAC 1784 |
| E. | RIGGING TOOL | DIJ 15-7030 |
| F. | CONNECTING LINK | I-19652 |
| G. | TURNBUCKLE | AN 155-46L |

NOTE

ALSO SEE AILERON CONTROL SYSTEM (15-7030)



RIGGING PROCEDURE

STEP NO. 1

BEFORE INST. OF OUTBOARD WING, BOLT INBOARD CABLES AND LINKS (I-19652) TO RIGGING TOOL (DIJ 15-7030) AT STA. 19 OF WING. RIG CABLES WITH CONTROL WHEEL IN NEUTRAL POSITION.

STEP NO. 2

ON INST. OF OUTBOARD WING, ADJUST LENGTH OF CONTROL ROD BETWEEN AILERON AND CABLE QUADRANT TO GIVE 12° UP AILERON WITH QUADRANT AGAINST ITS STOP. EACH AILERON SHALL HAVE THIS ADJUSTMENT MADE BEFORE OUTBOARD CABLES ARE FASTENED TO THE SYSTEM.

STEP NO. 3

OUTBOARD CABLES SHALL BE BOLTED INTO LINK I-19652 AND RIGGED WITH AILERONS IN NEUTRAL POSITION. WHEN INBOARD AND OUTBOARD RIGGING LOADS ARE EQUAL, REMOVE RIGGING TOOL FROM AIRPLANE.

STEP NO. 4

A CHECK OF THE SYSTEM SHALL SHOW 12° ± 1/4° UP AILERON AND 12° ± 1° DOWN AILERON.

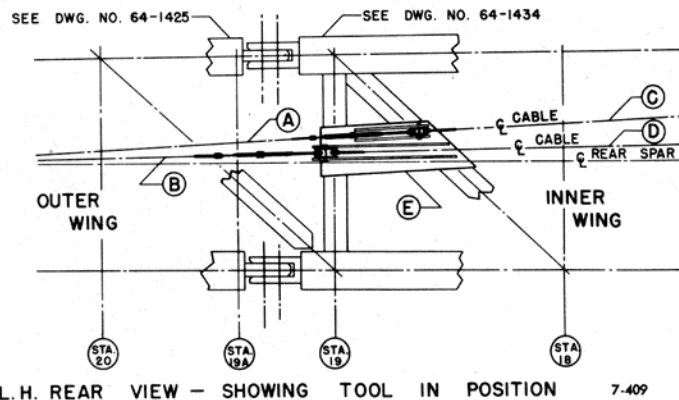


Figure 240—Aileron Rigging Tool Procedure

short, leave threads showing at station 5 and bring 19 up flush.

5. Adjust the bus line turnbuckles in the bomb bay until a tension of 85 pounds is obtained on each of the dual lines. This will produce a 170-pound tension on the single line coming from the cockpit. Tension for the system is 160 ± 10 pounds.

6. Tighten the aileron servo unit turnbuckle until the tension measures 105 pounds. Tension for this unit should be 90 ± 10 pounds. (After the cables have been worked a few times the tension should be well within the limits.)

7. Work the controls a few times until the cable tension drops a few pounds.

8. Check visually the operation of the controls. Turn the control wheel to the left; the left aileron should come up and the right down. Check, turning the wheel to the right. (The action must reverse.)

(3) AILERON TRIM TAB CONTROL.

(a) DESCRIPTION.

1. Aileron trimming is accomplished by a tab in the left aileron only. The tab is controlled by a wheel mounted on the floor panel at the left of the pilot. A 3/32-inch 7 x 7 cable is routed over the control drum toward the left side of the ship, aft to bulkhead 5, and out the left wing to the trim tab drum which operates the actuating strut at the tab.

(b) AILERON TRIM TAB RIGGING PROCEDURE.

1. Place the trim tab in the neutral position.
2. Block the drums at the wing gap, and tape the cables on the drums so they won't unravel.

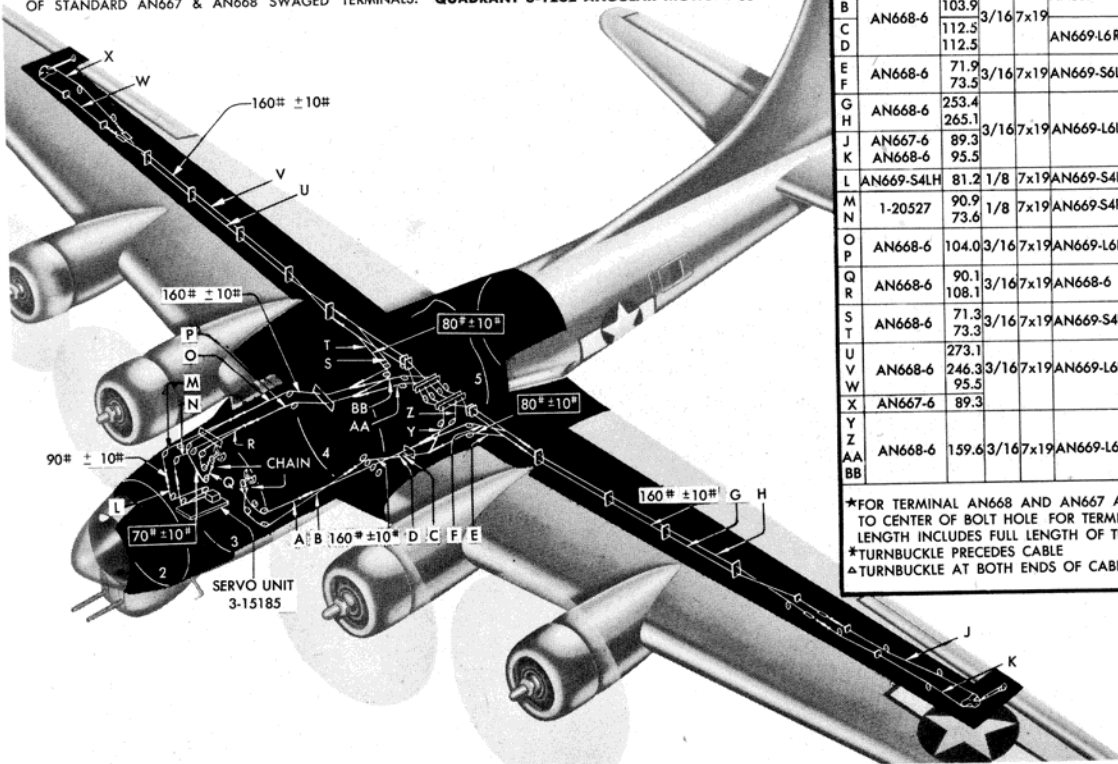
3. Connect the cables to the outer holes in the adjusting links at station 18. Take up the slack and take the tape off the drums.

4. Adjust the turnbuckles at the wing gaps to 40 ± 10 pounds tension.

5. Set the stops by wiring and soldering (new cables) them so that the trim tab travels 15 ± 2 degrees up and 15 ± 2 degrees down.

RIGGING TENSION IN LBS. LINK TURNBUCKLE
IDENTIFICATION COLORS:
 AILERON LEFT UP AND RIGHT DOWN—WHITE
 AILERON LEFT DOWN AND RIGHT UP—WHITE-BLACK
 POULSON & NARDON BALL & STRAP & AMERICAN CHAIN
 & CABLE BALL & STRAP TERMINALS MAY BE USED IN PLACE
 OF STANDARD AN667 & AN668 SWAGED TERMINALS.

CABLES SHOWN IN MID-TRAVEL POSITION
CABLE TRAVEL: TO STOPS AT CONTROL WHEEL-4.66°
 AT QUADRANT IN WING-2.5°
AILERON ANGULAR MOTION: $12^\circ \pm 1/2^\circ$ UP AILERON
 $12^\circ \pm 1^\circ$ DOWN AILERON
CONTROL WHEEL ANGULAR MOTION: 126° APPROX.
 289° TO STOPS
QUADRANT 8-1262 ANGULAR MOTION: 36°



| TERMINAL I—FWD OR INBOARD END OF CABLE | | TERMINAL II | | TURNBUCKLE | | INSTALL TRNBKLS WITH R.H. THREADS UP TO THE REAR OR TO THE RIGHT EXCEPT AS NOTED | |
|--|----------------|-------------|-----------|------------|----------------|--|--|
| TERMINAL | CABLE | TERMINAL | LINK | TURNBUCKLE | TURNBUCKLE | | |
| | LGT* DIA. TYPE | | | | TURNBUCKLE EYE | | |
| A | AN668-6 | 83.7 | 3/16 7x19 | AN669-L6LH | AN155-46L | | |
| B | | 103.9 | | | | | |
| C | | 112.5 | | AN669-L6RH | | | |
| D | | 112.5 | | | | | |
| E | AN668-6 | 71.9 | 3/16 7x19 | AN669-S6LH | AN155-46L* | AN165-46S* | |
| F | | 73.5 | | | | | |
| G | AN668-6 | 253.4 | 3/16 7x19 | AN669-L6LH | AN155-46L* | AN165-46L* | |
| H | | 265.1 | | | | | |
| J | AN667-6 | 89.3 | 3/16 7x19 | AN669-L6LH | | | |
| K | AN668-6 | 95.5 | | | | | |
| L | AN669-S4LH | 81.2 | 1/8 7x19 | AN669-S4LH | AN155-21S* | | |
| M | | | | | | | |
| N | 1-20527 | 90.9 | 1/8 7x19 | AN669-S4RH | | | |
| O | | 73.6 | | | | | |
| P | AN668-6 | 104.0 | 3/16 7x19 | AN669-L6LH | AN155-46L* | 161-46RL* | |
| Q | | | | | | | |
| R | AN668-6 | 90.1 | 3/16 7x19 | AN668-6 | | | |
| S | | 108.1 | | | | | |
| T | AN668-6 | 71.3 | 3/16 7x19 | AN669-S4LH | AN155-46L* | AN165-46S* | |
| U | | 73.3 | | | | | |
| V | AN668-6 | 273.1 | 3/16 7x19 | AN669-L6LH | AN155-46L* | AN165-46L* | |
| W | | 246.3 | | | | | |
| X | AN667-6 | 95.5 | | | | | |
| Y | | 89.3 | | | | | |
| Z | | | | | | | |
| AA | AN668-6 | 159.6 | 3/16 7x19 | AN669-L6LH | AN155-46S* | AN165-46L* | |
| BB | | | | | | | |

*FOR TERMINAL AN668 AND AN667 ASSEMBLY LENGTH IS MEASURED TO CENTER OF BOLT HOLE FOR TERMINALS AN669, THE ASSEMBLY LENGTH INCLUDES FULL LENGTH OF TERMINALS.
 *TURNBUCKLE PRECEDES CABLE
 *TURNBUCKLE AT BOTH ENDS OF CABLE

Figure 241—Aileron Control System

6. Check the neutral position of the tab and the indicator. If the indicator does not agree with the tab, take off the top and adjust it at the worm gear.
7. Check the operation of the system visually.

CAUTION

THE PLAY IN THE TRIM TAB MUST NOT EXCEED 5/32 (.156) OF AN INCH.

(4) RUDDER CONTROL.

(a) DESCRIPTION.

1. Dual cable control for the rudder is carried from the pedals aft as far as bulkhead 4 by 3/16-inch 7 x 19 cables. A single 3/16-inch 7 x 19 cable continues on the left side to the top of the body at bulkhead 4, and aft to the control masts on the rudder torque tube; another cable extends forward along the top of the body on the right to complete the circuit. Aft of bulkhead 6 the rudder cables are guided by fair-leads only.

2. The rudder servo unit of the auto pilot is connected to the rudder control cables aft of station 8 with two 1/8-inch 7 x 9 cables.

(b) RUDDER RIGGING PROCEDURE.

1. Lock the foot pedals and the rudder in the neutral position.

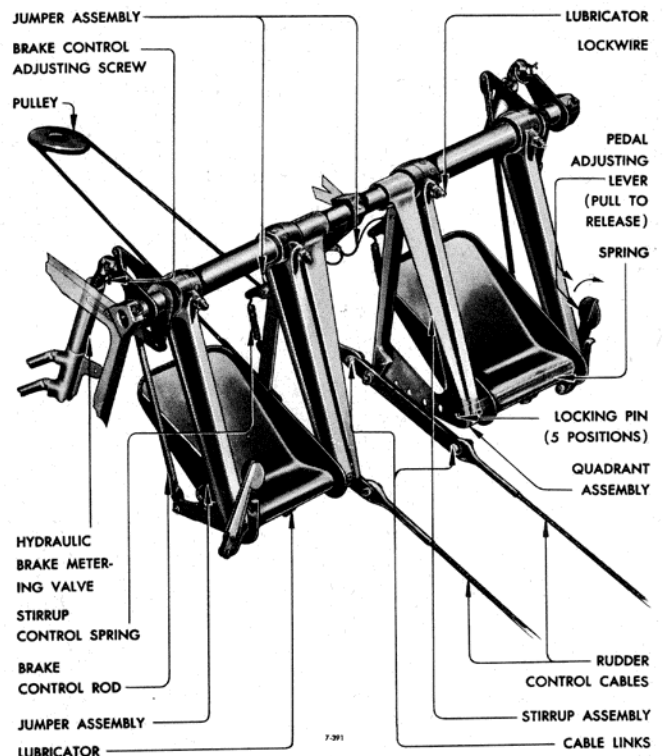


Figure 242—Rudder Pedals (Pilot's)

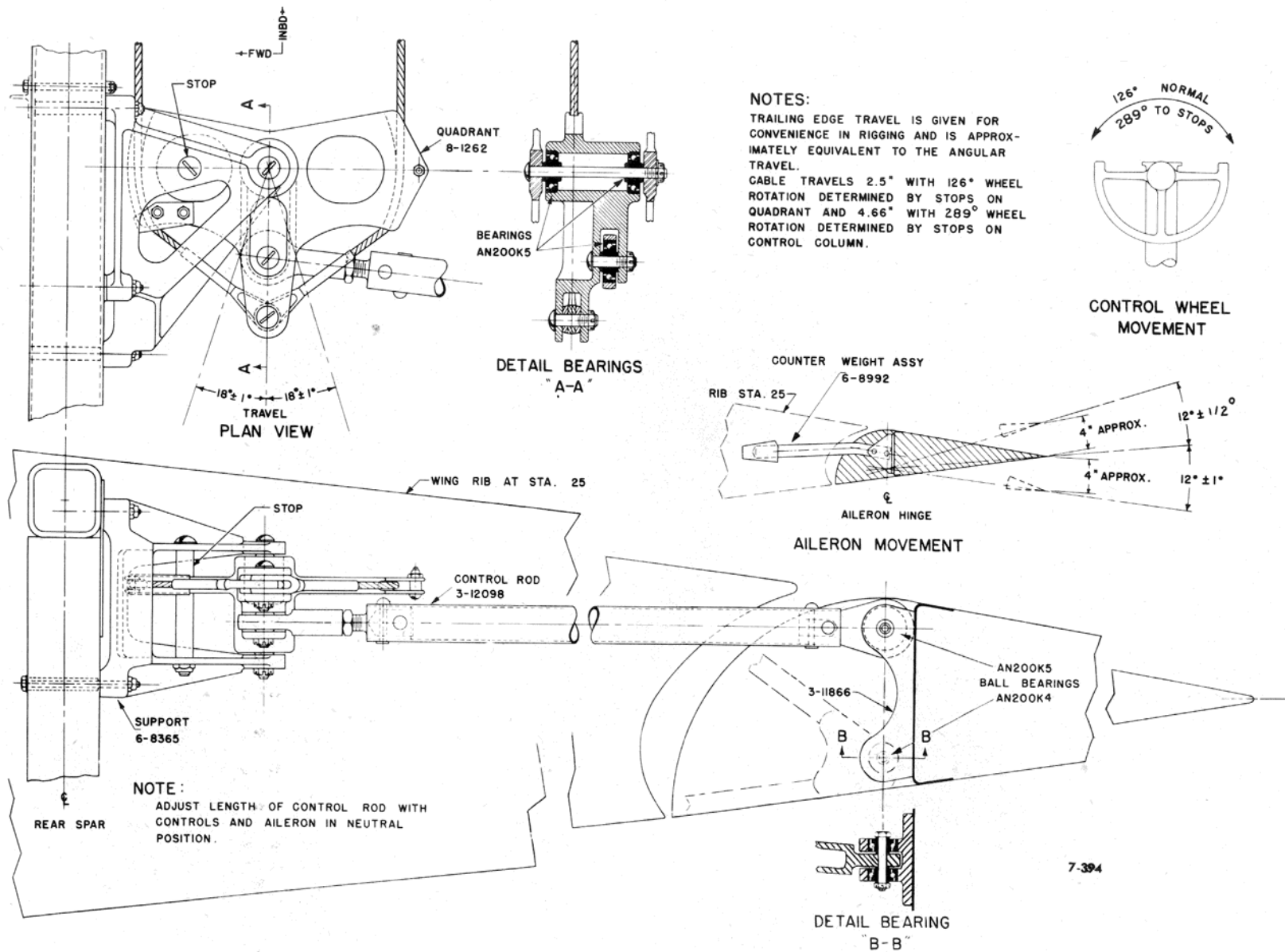
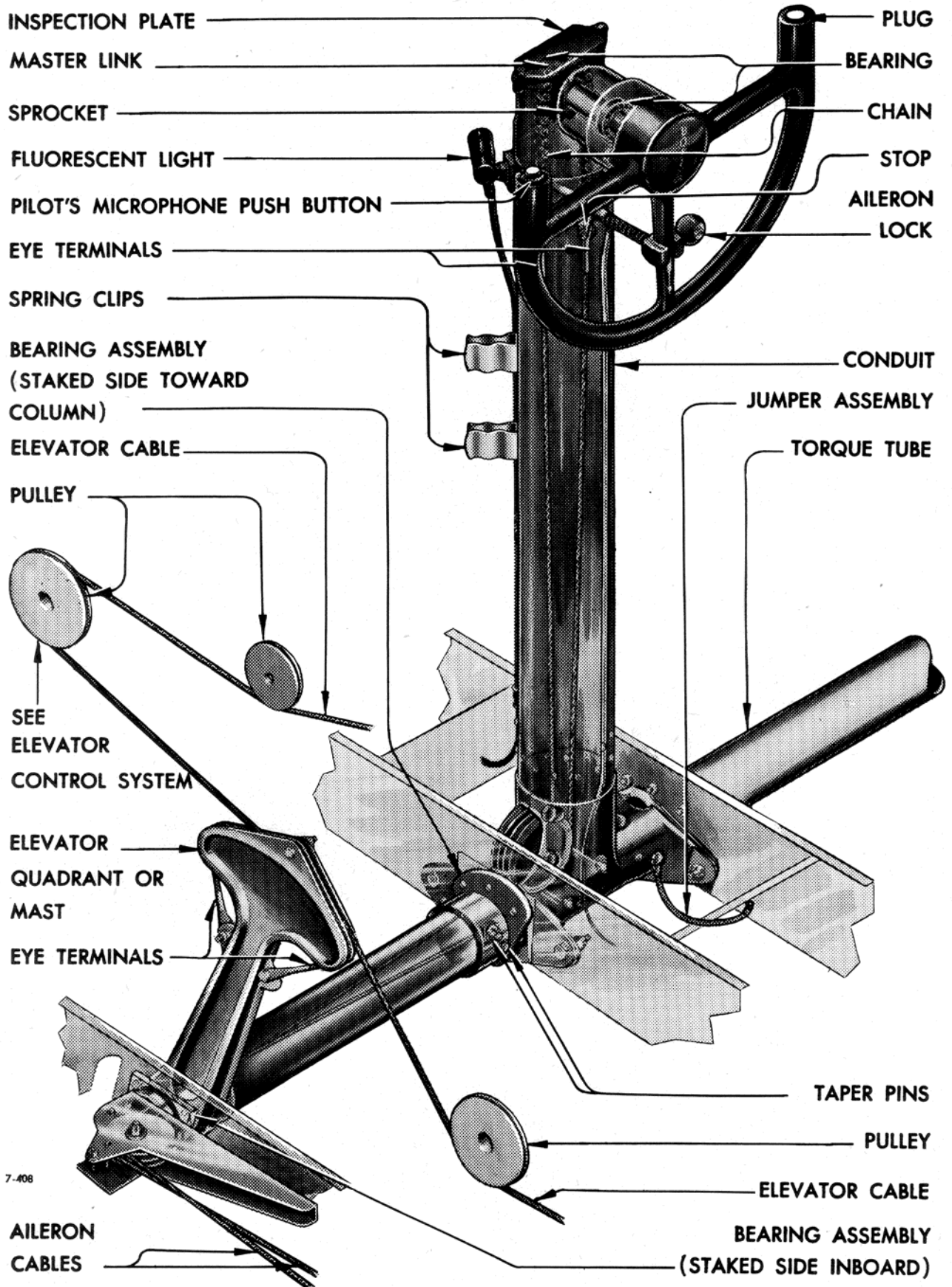


Figure 243—Aileron Mechanism Diagram



7-408

Figure 244—Control Column (Pilot's)

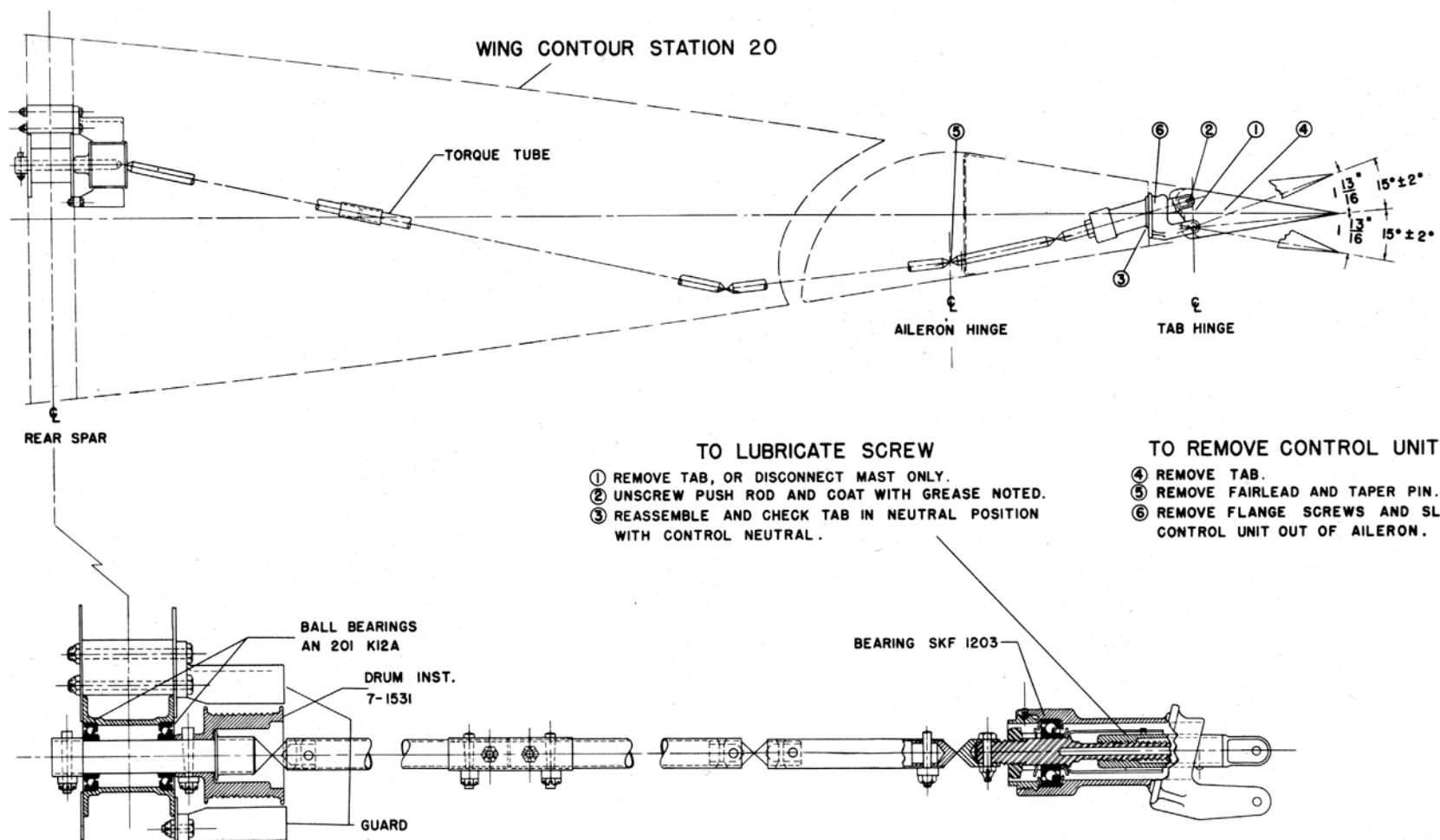


Figure 245—Aileron Trim Tab Control and Movements

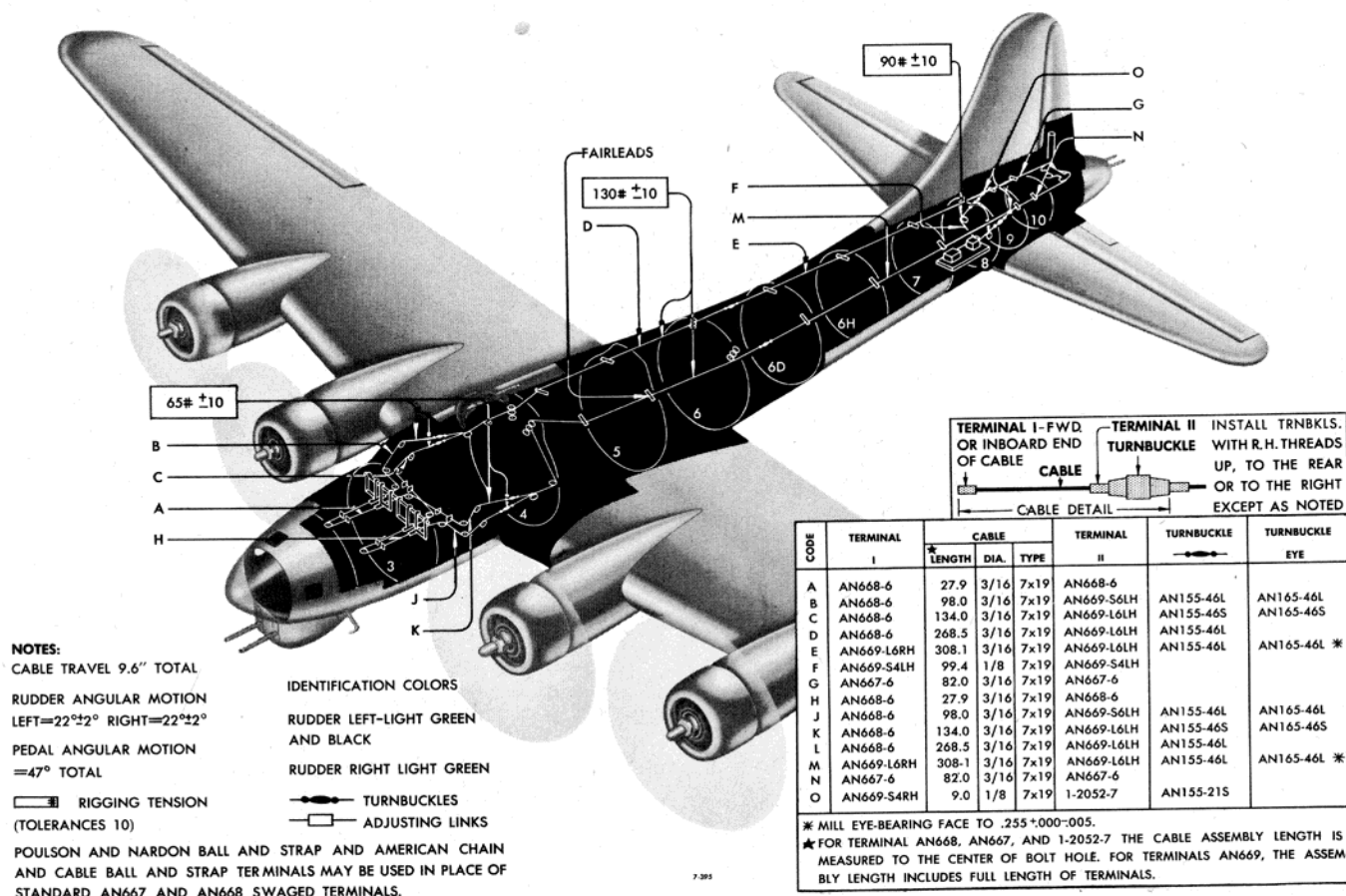


Figure 246—Rudder Control System

2. Attach the cable forward of the foot pedal assembly to the forward links on the assembly.

3. Attach the cables to the aft links on the pedal assembly and lead them back to the bus line turnbuckles forward of bulkhead 4 (under the pilots' compartment). Take up the turnbuckles until they are flush.

4. Lead the single lines back aft of bulkhead 6.

5. Attach the cables to the rudder quadrant aft of bulkhead 10 and lead them forward to the bus line turnbuckles forward of bulkhead 9. Take up the turnbuckles until they are flush.

6. Lead the cables forward to bulkhead 6 and adjust the turnbuckles to 140 pounds tension. (System tension should be 130 ± 10 pounds.)

7. Take up the rudder servo turnbuckles until you get 100 pounds tension. (Servo unit tension should be 90 ± 10 pounds.)

8. Work the system several times and check its operation visually.

(5) RUDDER TRIM TAB CONTROL.

(a) DESCRIPTION.

1. The rudder trim tab control cables follow substantially the same course as the rudder control cables. From the drum in the trim tab control 3/32-inch 7 x 7 cables continue to the top of the body at bulkhead 4, and rearward past bulkhead 10 to pulleys which direct

the cables upward at the rudder hinge line. The cables terminate at the trim tab drum which operates the actuating strut at the tab.

(b) RUDDER TRIM TAB RIGGING PROCEDURE.

1. Place the trim tab in the neutral position.

2. Tape the cable on the drums to prevent unraveling.

3. Lead the left cable aft to the turnbuckles aft of bulkhead 7.

4. Lead the right cable aft to the turnbuckle forward end aft of bulkhead 6H.

5. Lead the cables forward from the rear drum to the turnbuckles forward of bulkhead 7.

6. Take up these turnbuckles to 40 ± 10 pounds tension.

7. Check the operation of the system visually. Readjust the stops if they are not against the fairleads. Check the angular movement of the tab; if it is not correct, disconnect the activating rod at the tab hinge and adjust from the neutral position.

(6) ELEVATOR CONTROL.

(a) DESCRIPTION.

1. Dual control of the elevators is extended to double masts on the elevator torque tube. Movement is

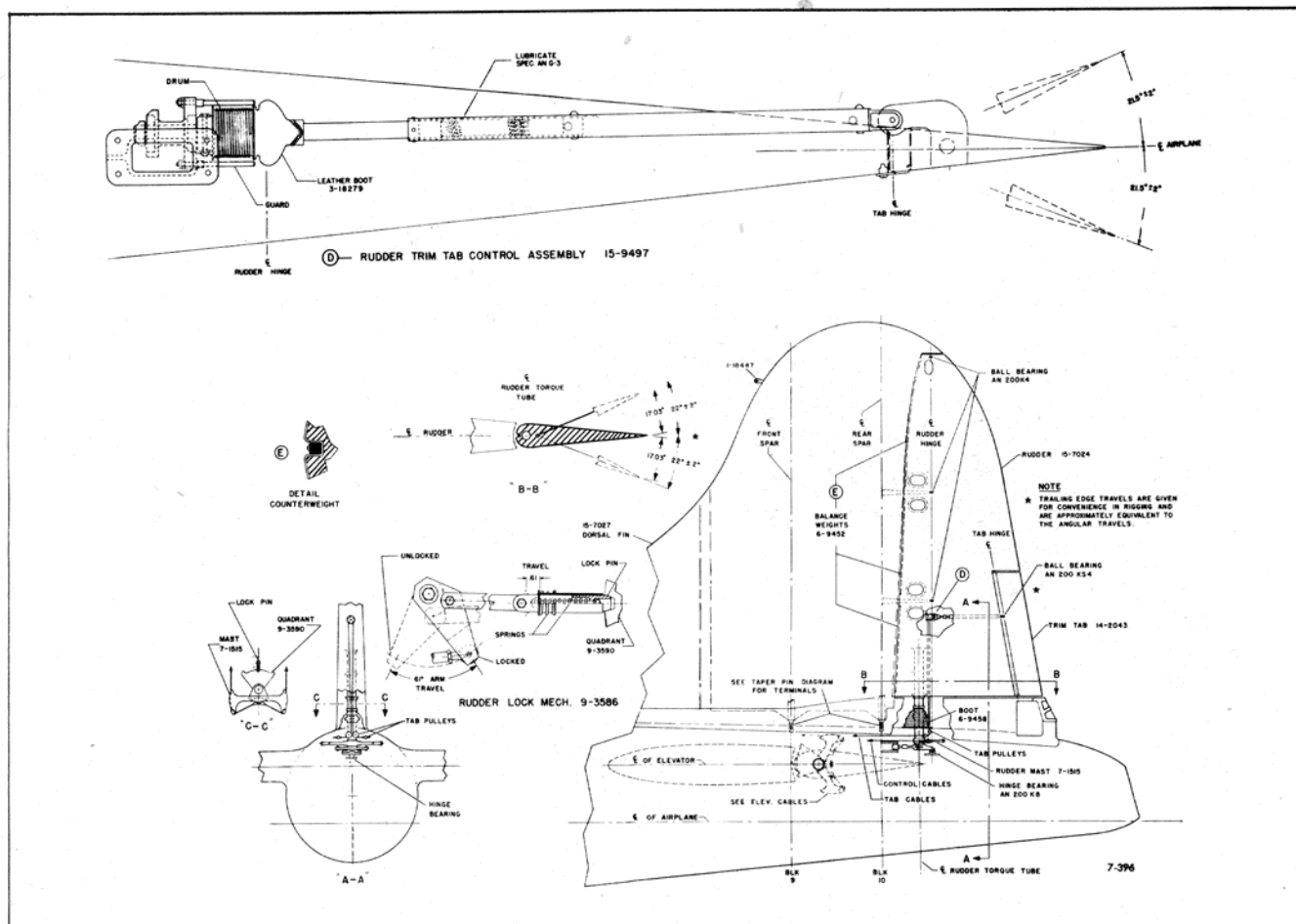


Figure 247—Rudder Control Mechanism Details

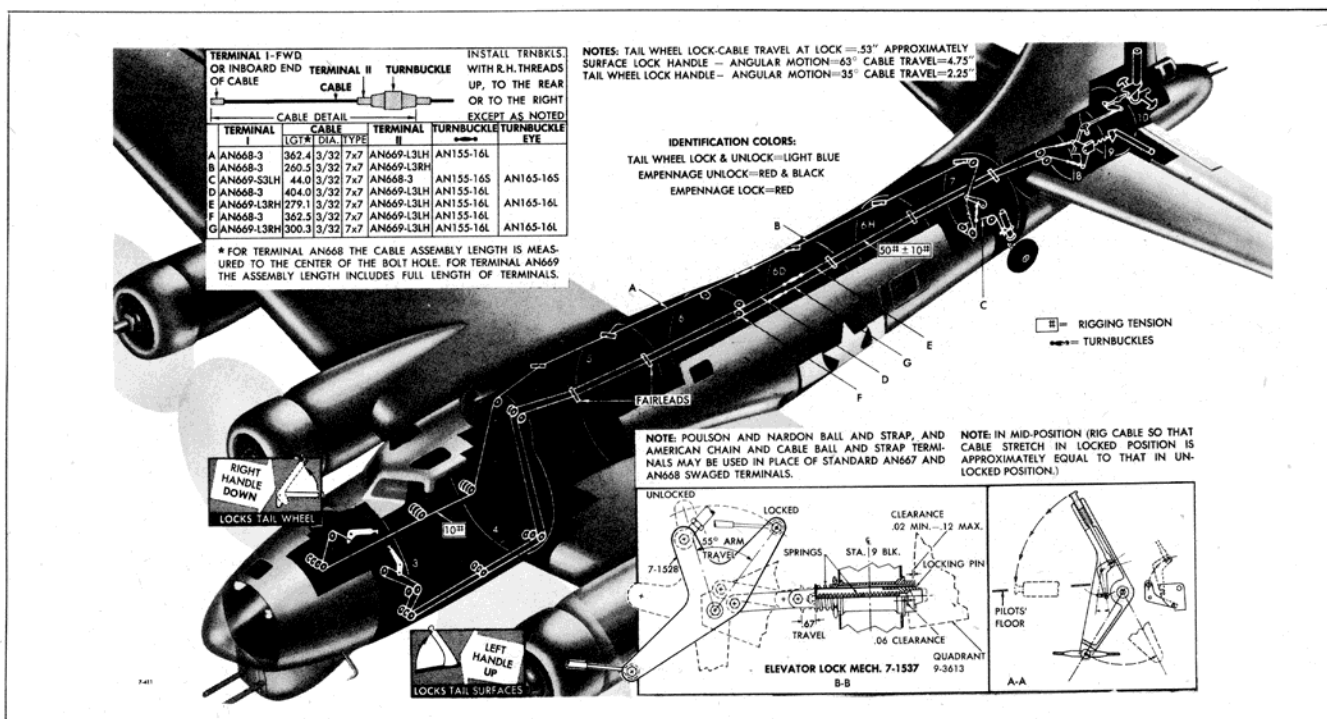


Figure 248—Tail Wheel and Surface Lock Control System

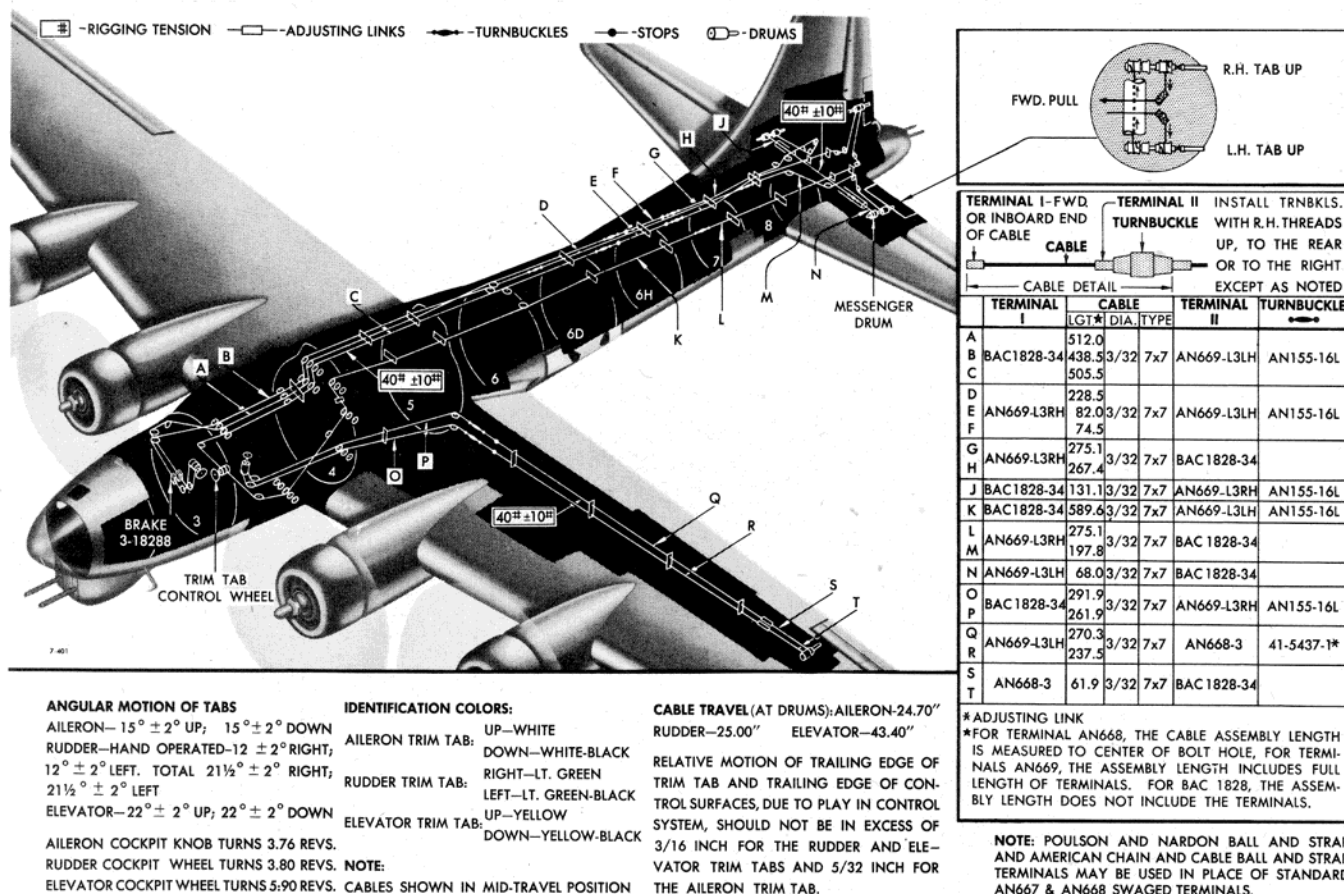


Figure 249—Aileron, Rudder and Elevator Trim Tab Control System

controlled by the use of a mast on each end of the control column torque tube, under the cockpit floor, to which the cables are attached. From each control mast, a 3/16-inch 7 x 19 cable is carried forward over an idler pulley at bulkhead 3, and aft to bulkhead 4. Here the cables are directed to the top of the body, then aft to the upper end of the masts on the elevator torque tube. Return lines are carried from the bottom of the masts on the elevator torque tube, back over the same route to the control column masts.

2. The elevator servo unit of the auto pilot is connected to the elevator dual control cable system aft of bulkhead 8. One cable attaches to the pilot's control, on the upper quadrant of the elevator torque tube, and the other is secured to the copilot's control on the lower quadrant.

3. The elevator downspring (on early B-17G airplanes) exerts a constant downward force on the elevators. This aids the stability of the airplane by moving the elevators in the proper direction when the airplane is disturbed from its trimmed speed. It also permits the C.G. position to be extended rearward from 32 percent to 35 percent of the mean aerodynamic chord.

(b) ELEVATOR RIGGING PROCEDURE.

1. Attach the cable to the control column masts and lead them back to aft of bulkhead 6.

2. Attach the cables to the elevator torque tube masts and lead them forward to bulkhead 6.

3. Clamp both elevators in the neutral or streamline position.

4. Set the control column 10-1/2 degrees forward of a 90-degree angle.

5. Take up the slack on the turnbuckles just forward of bulkhead 9 until the terminals are flush with the barrel.

6. Take up the turnbuckles aft of bulkhead 6 to tension. (If new cables, take up to maximum 150 pounds.)

7. Take up the elevator servo unit turnbuckles forward of bulkhead 8 to 100 pounds. (Correct tension 90 ± 10 pounds.)

8. Check the operation of the controls visually. If the stops are not hitting the elevator quadrant, adjust the cables to give the elevators their full throw.

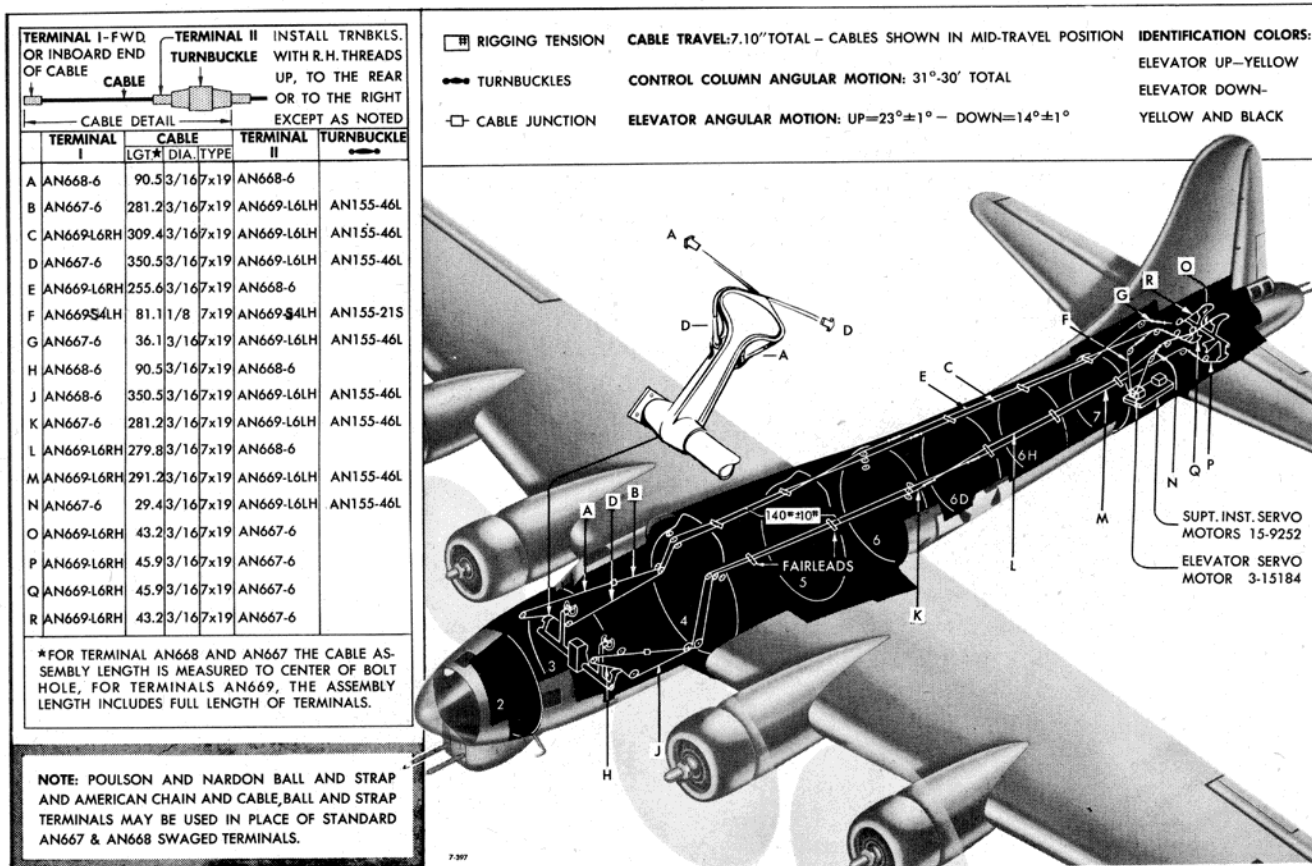


Figure 250—Elevator Control System

(7) ELEVATOR TRIM TAB CONTROL.

(a) DESCRIPTION.

1. Elevator trimming is accomplished by means of a tab in each elevator. Each tab is operated by a rod at the cable drum assembly mounted in the elevator. A constant pressure friction brake is located inside the control stand to prevent creeping of the tab controls. The 3/32-inch 7 x 7 cables, looped around the drum in the engine control stand, follow substantially the same course as the copilot's elevator cables. The cables extend along the aft side of the elevator torque tube to the drums, which operate the actuating struts, at the tabs. The circuit is completed by means of a "messenger" cable, which is routed through the center of the torque tube to a second drum at each actuating strut.

2. On later B-17G airplanes the elevator downspring is replaced by the bulbous elevator trim tab. The under surface of the trim tab has a 3/4-inch camber which causes changes in air loads to move the elevators in the proper direction to stabilize the airplane at the speed for which it was trimmed. This convex shape on the underside of the tab causes it to exert a greater trimming force than the other tab. Thus the elevator trim tab screw is changed from a double to a single thread. This change reduces the tab travel from 22 to 11 degrees on the side of the neutral position.

(b) ELEVATOR TRIM TAB RIGGING PROCEDURE.

1. Place the tabs in the neutral position.
2. Wrap the cable around the right and left messenger drums. Connect the turnbuckle on the left hand side.

Note

When wrapping the drums, disconnect the rods from the trim tabs and move the drums. Place masking tape around the cables at the drums after wrapping them.

3. Wrap the cables around the right and left main drums.
4. Wrap the cable around the main control stand drum. (Tap the drum axle out until the key holding the drum can be removed; then the two cables can be wrapped in opposite directions.) If the indicator is not correct, remove the control wheel at the pilot's side and adjust it by screwing it down in place.
5. Connect the cables at bulkhead 6.
6. Connect the cables forward and aft of bulkhead 7.
7. Take up the tension to 50 pounds. If the cables do not come together take off half a turn from the main cables.

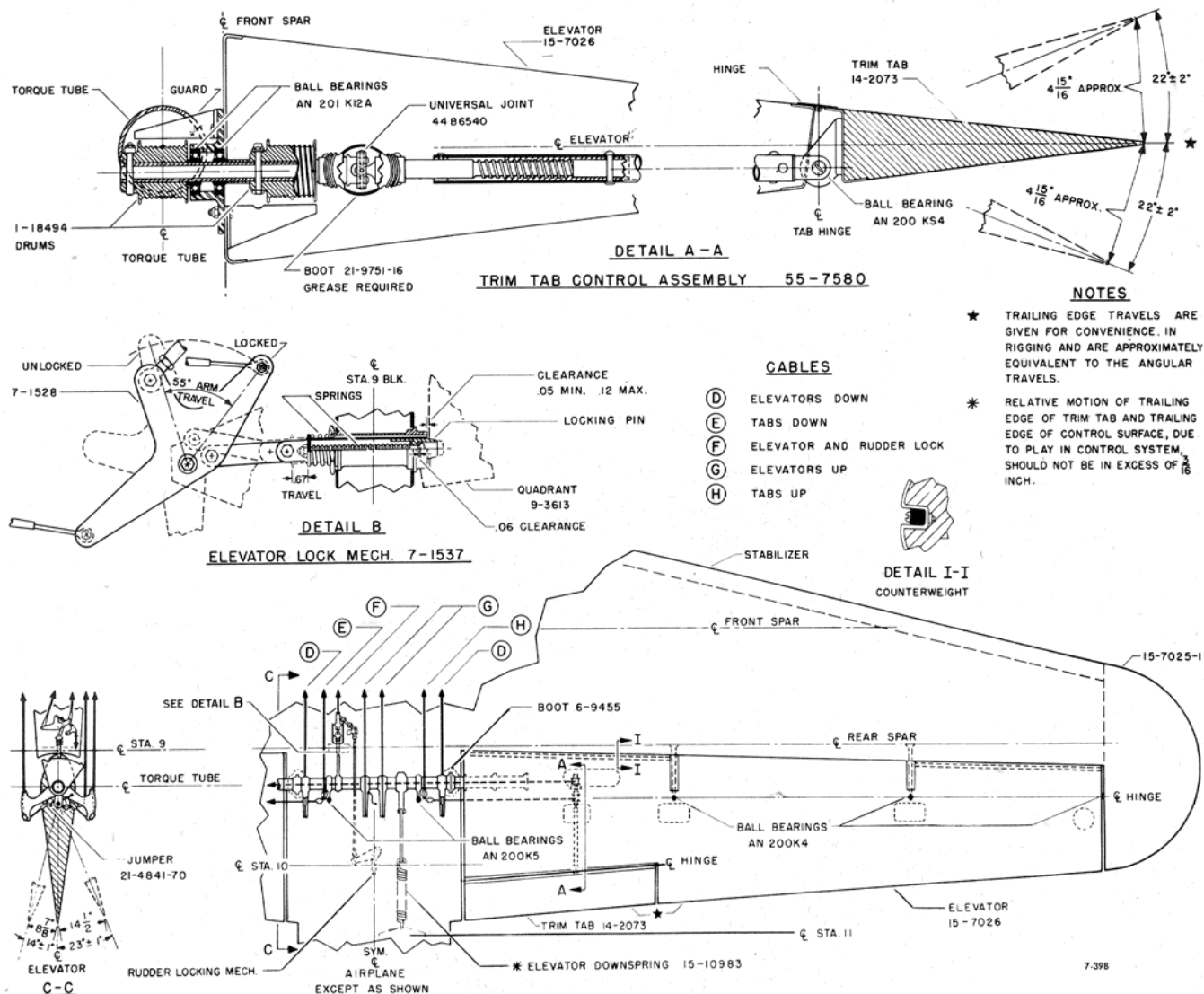


Figure 251—Elevator Control Mechanism Details

8. Check the operation of the system visually.
9. Check the movement of the tabs with a protractor (should be 22 ± 2 degrees up and 22 ± 2 degrees down). If incorrect, disconnect the actuating rod at the tab hinge edge and adjust it. If the stops are not against the fairleads, readjust the stops.

(8) SURFACE CONTROL LOCK.

(a) DESCRIPTION.

1. Both of the empennage surface control locks are operated simultaneously by one cable control system and a connecting rod between the horns on the elevator and rudder locking cranks. See figure 248.

(b) ADJUSTMENT.—Adjustment of the locking mechanism is not difficult if performed in the proper sequence and with proper regard to the functions of the various parts. Adjust the cable system and elevator lock first. The rudder lock should then be connected and set in its approximate position, thus permitting its adjustment without changing the cable rigging and elevator lock adjustment.

1. ELEVATOR LOCK ADJUSTMENT.

a. The clearance between the stop bushing, which is installed in the bulkhead spar, and the elevator lock quadrant will vary on different installations due to unavoidable differences in the accumulation of tolerances. For satisfactory operation, this clearance must not be less than .02 inch or more than .120 inch. Shim at the shoulder, or dress down at the aft end of the bushing, to attain a clearance within this tolerance. Measure the exact clearance obtained, and adjust the plunger in the lock housing so that the plunger extends beyond the end of the housing a distance equal to the measured clearance plus .40 inch. This adjustment may be made by adding washers under the head of the plunger retaining bolt. This will leave a .060-inch clearance under the bolt head when the plunger is firmly seated in the quadrant.

b. With the control handle in the locked "UP" position, rig the cables so that the proper rig-

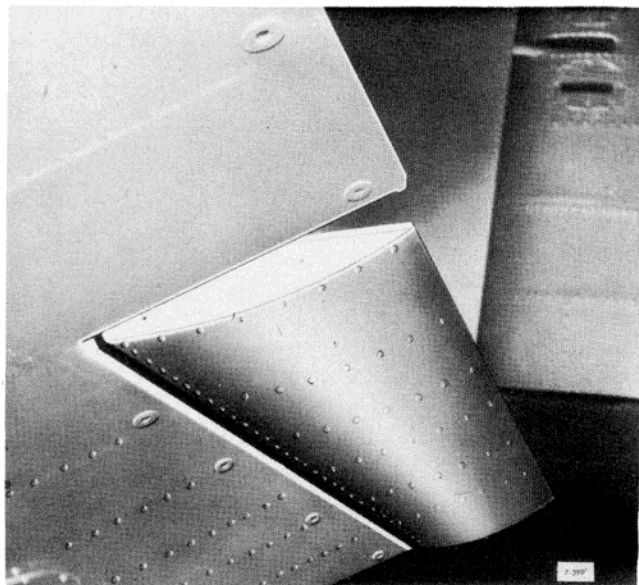


Figure 252—Bulbous Elevator Trim Tab

ging tension is obtained with the end of the lock housing flush with the aft end of the stop housing.

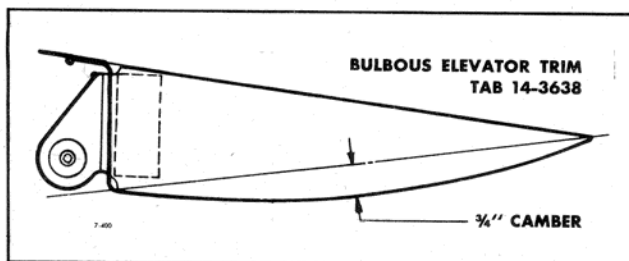


Figure 254—Bulbous Elevator Trim Tab (Side View)

2. RUDDER LOCK ADJUSTMENTS.

a. The stop bushing for the rudder lock is a block bolted to the structure. The clearance between the stop block and the rudder lock quadrant must be not less than .02 inch nor more than .120 inch. Measure the actual clearance obtained and adjust the plunger in the lock housing so that the plunger extends beyond the end of the housing a distance equal to the measured clearance plus .39 inch, in the same manner prescribed for the elevator lock plunger.

b. With the control handle in the locked "UP" position, adjust the two connecting rods so that the end of the lock housing is flush with the aft end of the stop block.

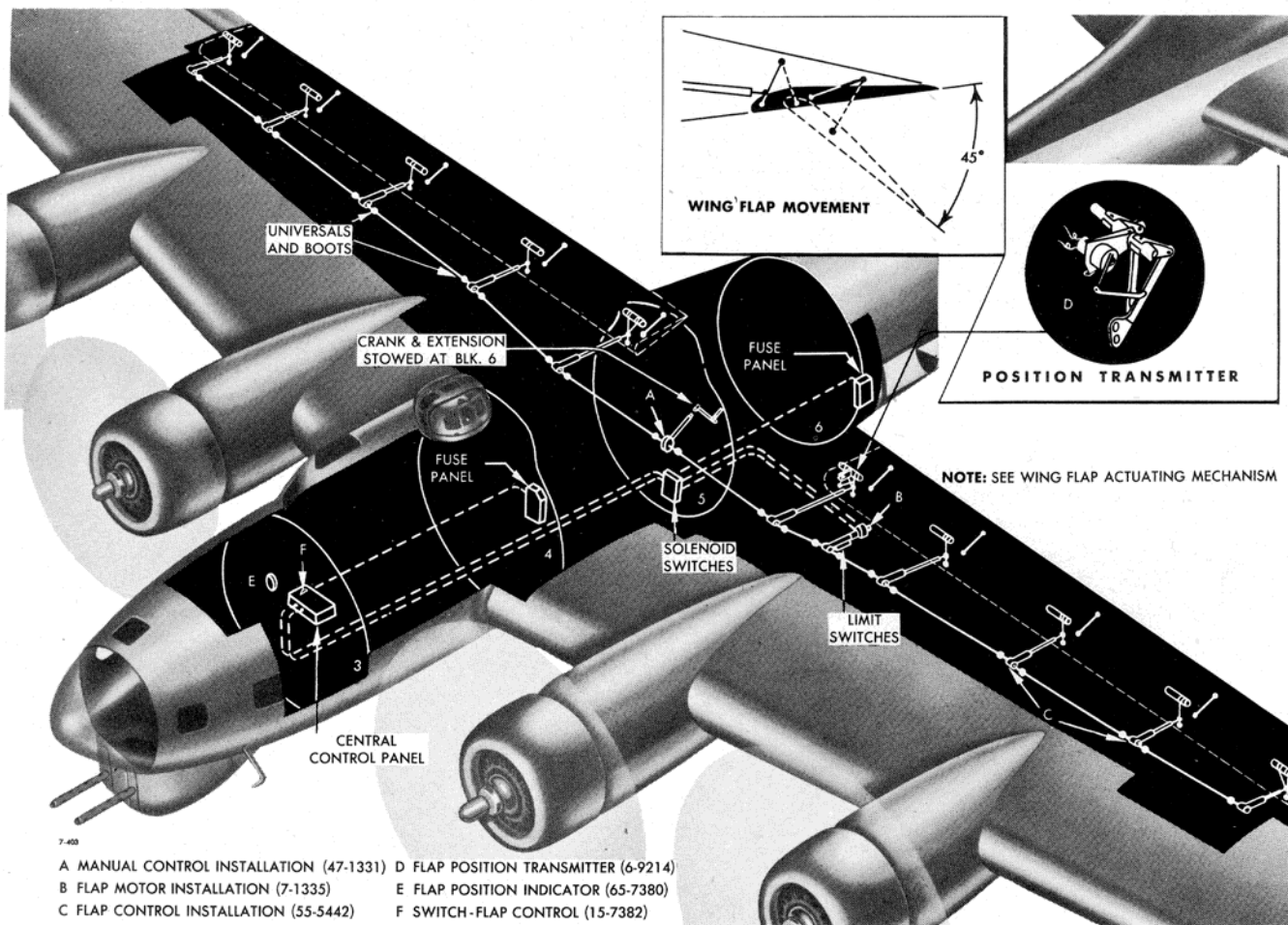


Figure 253—Wing Flap Actuating System

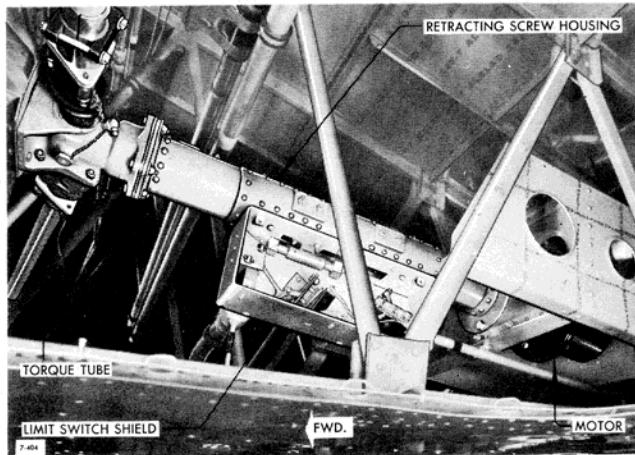


Figure 255—Wing Flap Drive Mechanism

(9) WING FLAP CONTROL SYSTEM.

(a) GENERAL.—

1. The wing flaps are controlled by a toggle switch on the central control panel. This switch closes the circuit to either the up or down solenoid switch. The solenoid switches are mounted in the left rear corner of the bomb bay, and admit power from a fuse in the station 6 fuse shield to the proper field winding of the motor. A limit switch in the control circuit of each solenoid turns off the solenoid to break the motor circuit at

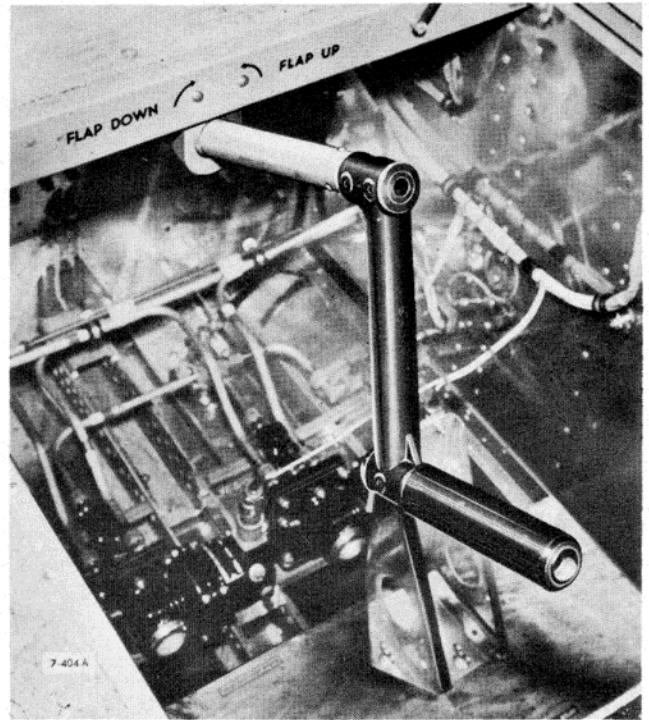


Figure 257—Wing Flap Hand Crank Installation

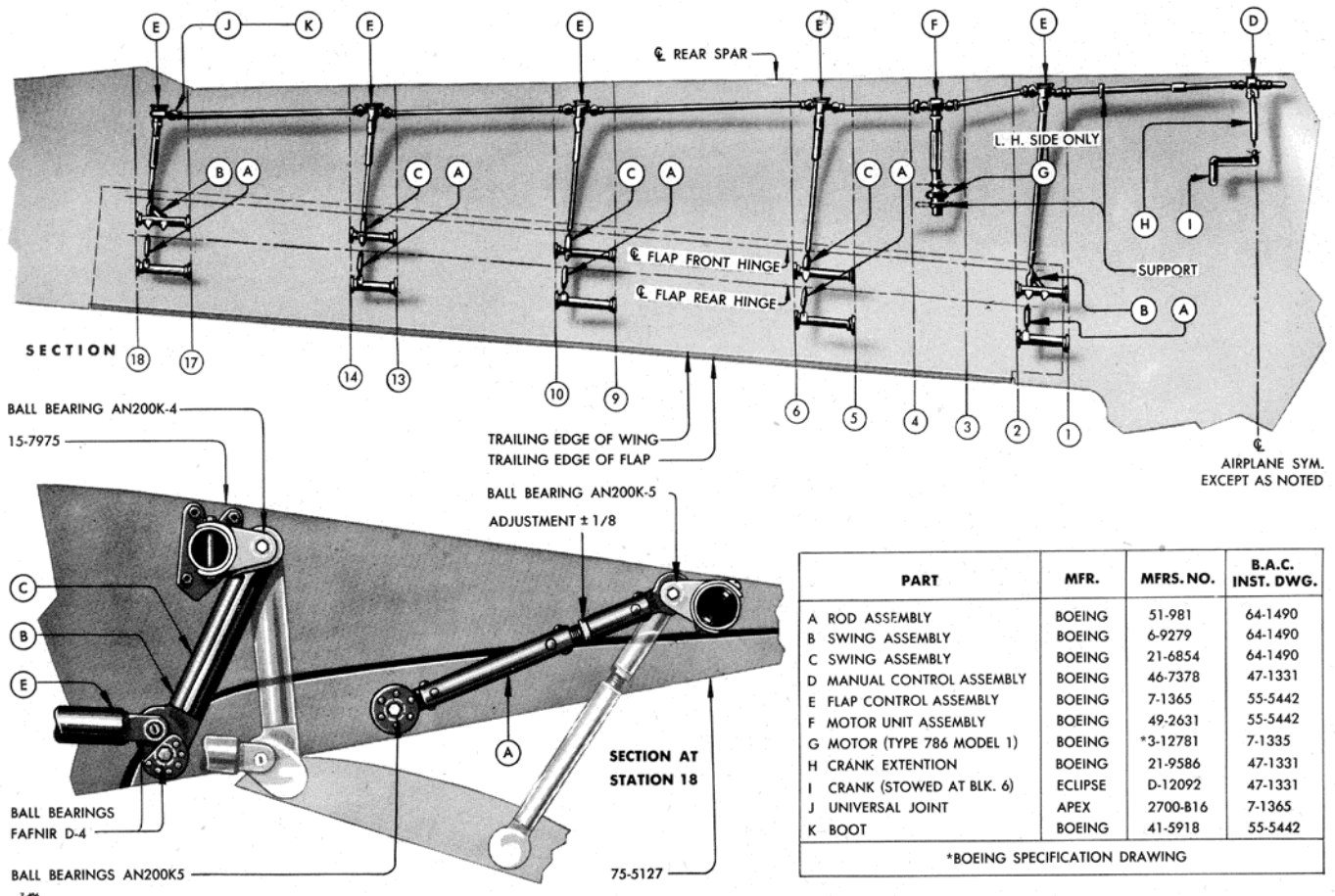


Figure 256—Wing Flap Actuating Mechanism

the extreme positions of flap travel. The actuating motor is in the rear inboard end of the left wing. The motor assembly has a reversible electric 24 volt DC motor, a 40-to-1 planetary reduction gear, an adjustable slip clutch assembly, a solenoid meshing jaw (engaged only when motor is on to make handcranking easier), and a driveshaft. This motor on the end of the drive and limit switch screw housing, turns the torque tube, gear, and retracting screw mechanism which extends through both wings. The motor drive screw carries a traveling nut which not only actuates the limit switches, but also engages the rubber bumpers and metal stops which hold the wing flap in its retracted or extended position. The retracting screw mechanism drives a series of five actuating struts spaced along the length of each flap at the hinges. For emergency manual operation use the hand crank torque connection in the forward end of the camera pit. See figure 256 for further information.

2. The limit switches (Cutler Hammer 8909-K-520) are on the rectangular shield below the motor drive screw in the left wing. It is an instantaneous opening switch which provides satisfactory operation with either the Eclipse or General Electric motor. Two limit switches stop the wing flaps at the extreme position of travel by opening the control circuits of the retracting motor solenoid switches. The limit switches are operated by a traveling stop nut and adjustable strikers on the motor drive screw. One switch is actuated directly by the striker and the other by a cam which is depressed by the striker.

(b) REMOVAL AND DISASSEMBLY.—The wing flap operating motor is accessible through a door

in the bottom surface of the left wing. To remove the motor, disconnect the ventilating tubing and the wires and remove the shield. Remove the bolts in the mounting flange and slip the unit back toward the trailing edge to free it from the supporting structure.

(c) MINOR REPAIRS AND REPLACEMENTS.—One set of spare brushes is supplied for the wing flap operating motor. Replace the brushes when they have worn 3/16 inch from a new length of 9/32 inch, or when the brush spring tension has been reduced.

(d) ADJUSTMENTS.

1. WING FLAP LIMIT SWITCH SETTING.

a. Adjustment for an Eclipse or General Electric motor is accomplished in the following manner: Turn the wing flap switch on the central control stand "off." Remove the cover on the switch shield forward of the retracting unit in the left wing. Connect a test light with an external power source between the terminals of the switch to be adjusted. Turn the retracting screw against the stop with the hand crank. Back the hand crank off one-quarter turn of the motor drive screw. Remove the cotter pin from the striker and screw the striker out until the test light just goes off. Screw the striker, not more than a quarter turn either way, until the cotter pin can be reinserted and then bent open. Check by backing the hand crank off and then up again several times to see that the test light goes off one-quarter turn of the drive screw before engagement of the stops.

FLIGHT CONTROL BUSHINGS

| Bushing Part No. | Location of Bushing | Reaming Dimensions (Dia.) | | | |
|----------------------|---|---------------------------|----------------|-------------|----------------|
| | | Before Inst. | | After Inst. | |
| 41-1457-35 | Cable Inst. Top of Bomb Bay Aileron (15-11162) | .311 | +.000 -.001 | .250 | +.001 -.000 |
| BAC 326-17S | Pulley Bracket Fwd. of Rudder Pedals Rudder (55-7031) | .374 | +.000 -.001 | .250 | +.001 -.000 |
| 41-1457-35 | Cable Inst. Adjacent to Rudder Pedal Rudder (55-7031) | .311 | +.000 -.001 | .250 | +.001 -.000 |
| 21-2136 21-2136-2 | Stirrup Assy. On Rudder Pedals Rudder (75-3508) | 1.001 | +.002 -.000 | .877 | +.001 -.000 |
| 51-424 | Rod Assy. On Rudder Pedals Rudder (75-3508) | .804 | +.000 -.002 | .434 | +.001 -.000 |
| BAC 326-34S | Cable Inst.—Link Adjacent to Rudder Pedals Rudder (75-3508) | .374 | +.000 -.001 | .250 | +.001 -.000 |
| BAC 326-15S | Link—Brake Stop On Rudder Pedals Rudder (75-3508) | .374 | +.000 -.001 | .250 | +.001 -.000 |

FLIGHT CONTROL BUSHINGS (Cont'd)

| Bushing Part No. | Location of Bushing | Reaming Dimensions (Dia.) | | | |
|-----------------------------|---|---------------------------|------------------|-------------|------------------|
| | | Before Inst. | | After Inst. | |
| BAC 330-104S | Rudder Lock—Crank Assy. Below Rudders Leading Edge Rudder (9-3586) | .624 | +.000 -.001 | .500 | +.001 -.000 |
| BAC 344-4-205 1/4 staked | Rudder Lock—Crank Assy. Below Rudders Leading Edge Rudder (9-3586) | .375 | +.000 -.002 | .218 | +.001 -.000 |
| BAC 350-8-267 5/8 staked | Rudder Lock—Crank Assy. Below Rudders Leading Edge Rudder (9-3586) | .750 | +.000 -.002 | .593 | +.001 -.000 |
| BAC 328-108B | Rudder Lock—Crank Assy. Below Rudders Leading Edge Rudder (9-3586) | .499 | +.000 -.001 | .375 | +.001 -.000 |
| 1-18546-2-34 | Supt. Assy. Lock Plunger Below Leading Edge of Rudder Rudder (15-7536) | 1.064 | +.002 -.000 | .920 | +.005 -.005 |
| 41-1457-35 | Cable Inst. Above Servo Unit—Tail Sec. Elevator (55-7032) | .311 | +.000 -.001 | .250 | +.001 -.000 |
| BAC 326-141ST | Arm Assy. Elevator Lock Attached to Blk. 9 Elevator (7-1537) | .374 | +.000 -.001 | .250 | +.001 -.000 |
| BAC 286-138S | Army Assy.—Elevator Lock Attached to Blk. 9 Elevator (7-1537) | .5015 | +.0020 -.0000 | .367 | +.002 -.000 |
| 1-18545 | Control Surface Lock Attached to Blk. 9 Elevator (3-13618) | 1.25 | +.01 -.01 | 1.062 | +.001 -.000 |
| 1-24204 1-24204-2 | Elevator Stop Assy. Attached to Blk. 9 Elevator (3-13618) | 1.063 | +.001 -.000 | .9375 | +.0020 -.0000 |
| BAC 344-5-253 1/4 staked | Bracket Assy. Between Wing Sta. (1-2) (5-6) (9-10) (13-14) (17-18) Wing Flat (64-1490) | .375 | +.000 -.002 | .250 | +.001 -.000 |
| 41-4222-253-3 | Bracket Assy. Between Wing Sta. (1-2) (5-6) (9-10) (13-14) (17-18) Wing Flap (64-1490) | .4375 | +.000 -.002 | .250 | +.001 -.000 |
| Oilite No. A-1323 | Flap Control Under radio compt. floor Wing Flap (3-11852) | 1.378 | +.001 -.000 | 1.14 | +.01 -.01 |
| 21-6264-9 | Flap Hinge Wing Sta. 5 Flap Leading Edge Wing Flap (75-5127) | | | .250 | +.001 -.000 |
| 21-5947 | Flap Hinge Wing Sta. 1 Flap Leading Edge Wing Flap (75-5127) | | | .3125 | +.001 -.000 |
| 1-16964 | Lever Assy. on Bulkhead 7 Tail Wheel Lock (7-1507) | .2827 | +.0005 -.0000 | .190 | +.001 -.0000 |
| BAC 285-32S | Lever Assy. on Bulkhead 7 Tail Wheel Lock (7-1507) | .4390 | +.002 -.000 | .304 | +.002 -.000 |

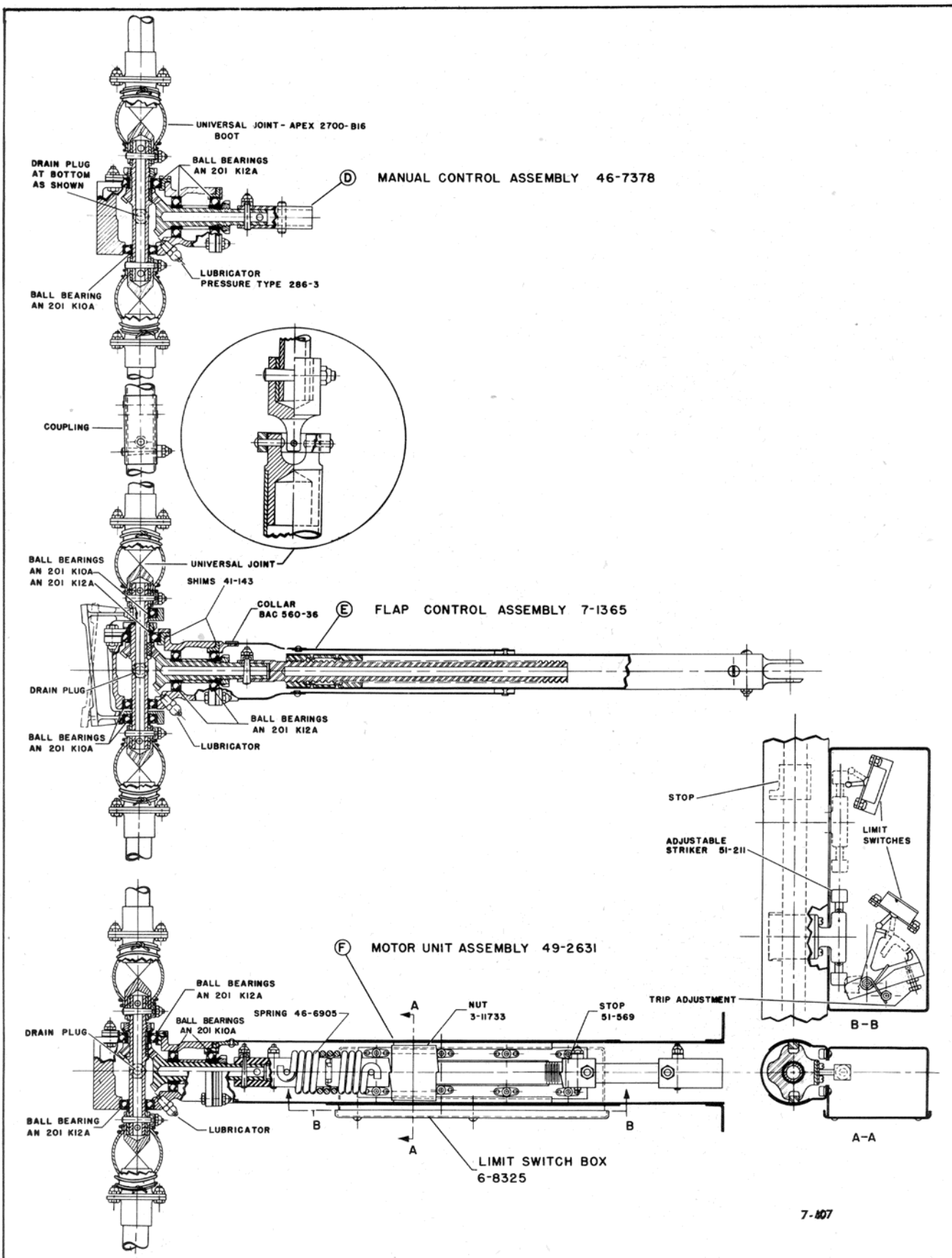


Figure 258—Wing Flap Control System Diagram

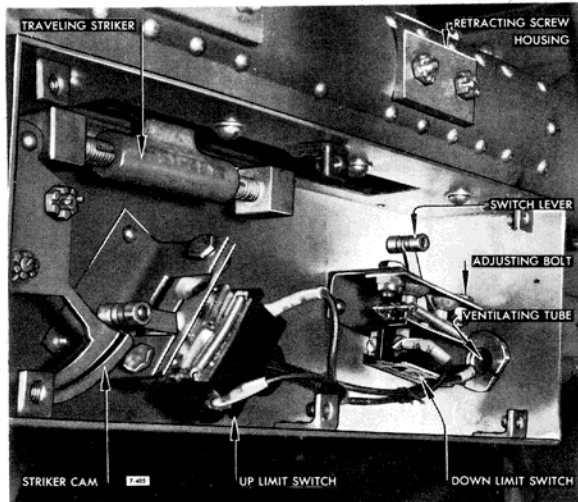


Figure 259—Wing Flap Limit Switches

Note

(The one-quarter turn can be seen on the torque tube running longitudinally along the wing from one side of the airplane to the other. The hand crank can also be turned one-quarter turn, but allowance must be made for backlash and spring.)

b. Make a service check by running the flaps up and down with the motor. On the down limit the stops should engage fairly solidly. On the up limit, the traveling nut should coast up to the stops before engagement.

2. WING FLAP OPERATING MOTOR CLUTCH.

a. The time required for lowering flaps should be approximately 14 seconds, operating on 28 volts. A longer operation period indicates clutch slip-page. The proper clutch setting requires a torque of 600 pound-inches. The setting must be approached

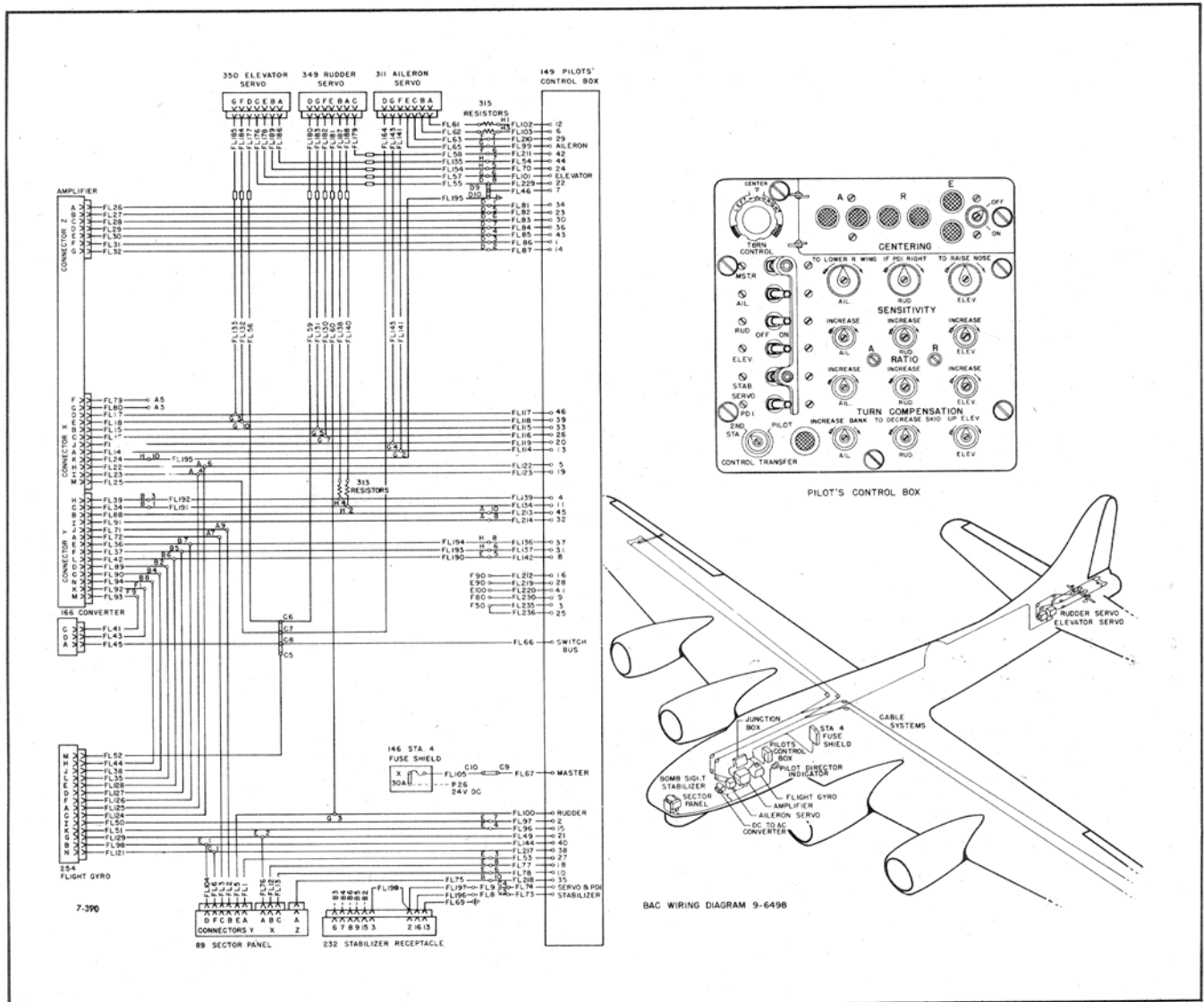


Figure 260—C-1 Autopilot Circuit (F L)

gradually, starting with approximately one-half maximum setting. Operate the motor for periods of 10 seconds duration at one-minute intervals, until clutch maintains a constant torque value. Then gradually increase the clutch value, operating the motor between each increase, until the required setting is obtained. When the final setting is reached, allow the unit to cool to room temperature and give five consecutive engagements of 10 seconds duration at one-minute intervals. If the setting remains constant the clutch has been properly adjusted.

(10) C-1 AUTOPILOT.

(a) GENERAL.

1. The C-1 autopilot is an electromechanical robot which automatically flies the airplane in straight-and-level flight or maneuvers it in response to fingertip controls operated by the human pilot or bombardier. The equipment consists of various separate units electrically interconnected to operate as a system.

2. While reading the following explanation, assume that the autopilot is in operation and that the airplane in figure 260, is flying straight and level. Assume that a cross-wind suddenly turns the airplane away from its established heading (direction). The gyro-operated directional stabilizer (1) in the bombardier's compartment will detect or sense this deviation and move the directional panel to one side or the other, depending upon the direction of the deviation.

3. Banking pot and rudder pickup pot are electrical devices in the directional panel which send signals to the aileron and rudder section of the amplifier (3) whenever the directional panel is operated. The amplifier amplifies the signals and converts them by means of magnetic switches (relays), into electrical impulses, which are applied to the aileron and rudder servo units, causing them to operate the ailerons and rudder of the airplane in the proper direction and amount to turn the airplane back to its original heading.

4. In a similar manner, if the nose of the airplane should drop, the vertical flight gyro detects the vertical deviation and operates the elevator pickup pot, which sends an electrical signal to the elevator section of the amplifier. Here the signal is amplified and relayed in the form of electrical impulses to the elevator servo unit which in turn raises the elevators of the airplane the proper amount to bring the airplane back to level flight.

5. If one wing should drop appreciably, the vertical flight gyro operates the aileron pickup pot, the skid pot, and the up-elevator pot. The electrical signals, caused by the operation of these units, are transmitted to their respective (aileron, rudder, and elevator) sections of the amplifier. The resulting impulses to the aileron, rudder, and elevator servo units cause each of these units to operate its respective control sur-

face just enough to bank and turn the airplane back to an "even keel" or level flight position.

6. When the human pilot wishes to make a turn, he merely sets the turn control knob at the degree of bank and in the direction of turn desired. This control then sends signals, through the aileron and rudder sections of the amplifier, to the aileron and rudder servo units which operate ailerons and rudder in proper amount to execute a perfectly coordinated (non-slipping, non-skidding) turn. As the airplane banks, the vertical flight gyro operates the aileron, skid, and up-elevator pots. The resulting signals from the aileron and skid pots cancel the signals to the aileron and rudder servo units to streamline these controls during the turn.

7. The signal from the up-elevator pot causes the elevators to rise just enough to maintain altitude. When the desired turn is completed, the pilot turns the turn control back to "zero," applying a reverse signal, and the plane levels off on its new course. A switch in the turn control energizes the directional arm lock on the stabilizer, which prevents the stabilizer from interfering with the turn by performing its normal "direction-correcting" function.

8. The autopilot control panel provides the pilot with fingertip controls by which he can conveniently engage or disengage the system, adjust the alert-

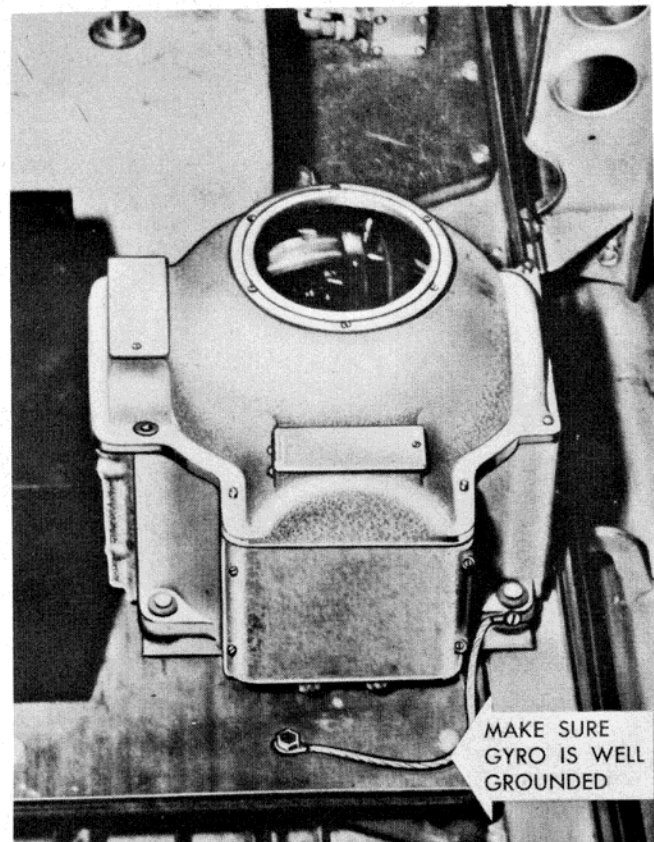


Figure 261—Vertical Flight Gyro Must Be Securely Grounded

ness and speed of its response to flight deviations, or "trim" the system for varying load and flight conditions.

9. The pilot director indicator or "PDI", located on the pilot's instrument panel, is a remote indicating device operated by the PDI pot. Normally it indicates to the pilot any course correction desired by the bombardier during the bombing run. When the autopilot is used, the PDI indicates to the pilot when the system and airplane are properly trimmed. Once the autopilot is engaged with PDI centered, the autopilot makes the corrections automatically.



Figure 262—Slot on Plug Must Mate with Key on Receptacle Sleeve

10. The rotary inverter is a motor-generator unit which converts direct current from the airplane's battery into 105-cycle alternating current for the operation of the autopilot.

(b) VERTICAL FLIGHT GYRO.

1. DESCRIPTION.—The vertical flight gyro, located in the lower accessory compartment, contains a rapidly spinning gyroscope and an erecting mechanism which keeps the spindle of the gyroscope vertical with respect to the earth at all times. It serves as a reference point by which the autopilot operates to keep the airplane flying level with respect to the earth. Potentiometers in the vertical flight gyro detect any tipping of the gyro housing caused by deviations of the airplane in its roll and pitch axes. Electrical signals produced by the movement of these pots cause the autopilot to operate the controls of the airplane to correct the deviations.

2. REMOVAL.—To remove the vertical flight gyro, disconnect the flexible grounding cable and the AN connector. Remove the four 1 1/2-inch size 10-32

cadmium-plated aircraft hex-head steel bolts and lift out the unit.

3. INSTALLATION.—Mount the unit with the four rubber shock-absorbing grommets in place, install the four hex-head bolts and the lock washers, and secure the self-locking stopnuts. Connect the flexible grounding cable and fasten securely.

Note

It is extremely important that the grounding cable be securely fastened each time the gyro is installed.

Insert the AN connector plug in the receptacle. The slot in the plug sleeve must be lined up with the projection on the receptacle. Lock the plug in place with the knurled locking ring on the plug.

(c) DIRECTIONAL STABILIZER, DIRECTIONAL PANEL, AND DIRECTIONAL ARM LOCK.

1. DESCRIPTION.—The directional stabilizer, located in the bombardier's compartment of the airplane, utilizes a gyroscope mounted with its spin axis horizontal in order to provide a directional reference for the airplane. The directional stabilizer detects and measures directional deviations of the airplane, and moves the slide of the attached directional panel in the proper direction proportional to the deviation. The pots within the directional panel transform this motion into electrical signals which control the operation of the C-1 autopilot system to hold the airplane on an established heading. The directional arm lock is a magnetic locking device mounted on the rear side of the directional stabilizer. It functions to hold the autopilot clutch and directional panel drive arm in fixed position relative to the stabilizer case and the directional panel during turns made from the turn control.

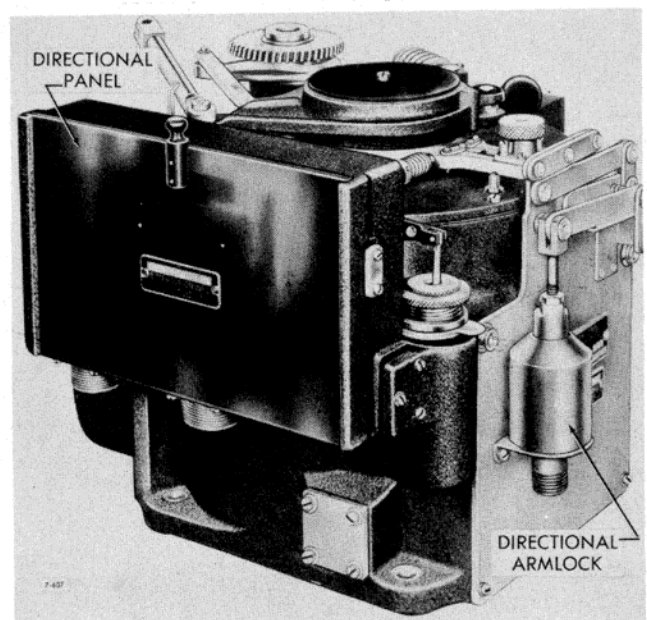


Figure 263—Directional Panel Mounted on the Directional Stabilizer

2. **REMOVAL.**—Disconnect electric cable connector plugs from receptacles and remove the directional stabilizer, the directional panel, and the directional arm lock as a complete unit by removing the four 10-24 bolts and lifting unit from mount.

3. **INSTALLATION.**—Place the directional stabilizer unit on the mount and bolt it firmly in position with four 10-24 mounting bolts. Mate the electric cable connectors with their proper receptacles and tighten.

(d) **SERVO UNITS.**

1. **DESCRIPTION.**—Three identical servo units supply the mechanical force required to operate the control surfaces of the airplane. Each unit incorporates a cable drum driven by an electric motor through a gear reduction and reversible differential assembly. The aileron servo unit is located in the lower accessories compartment and the rudder and elevator servo units are located in the rear fuselage compartment between bulkheads 7 and 8. The aileron servo unit operates the ailerons to correct deviations in the roll axis; the rudder servo unit operates the rudder to correct deviations in the turn axis; another operates the elevators to correct pitch axis deviations. Each unit is connected to its respective control surfaces by 1/8-inch flexible steel servo cables which attach to the airplane's control surfaces in either direction. The design and construction of the servo unit enable it to respond instantly with full rated power to drive the airplane's control surfaces in either direction.

CAUTION

If the servo unit will be out of the airplane for only a few hours, it is necessary to hang a red tag on the control column and properly mark "Form 1", advising that the airplane is not in flying condition. The tag will of course be removed as soon as the servo unit is reinstalled and its operation tested. If the servo unit is to

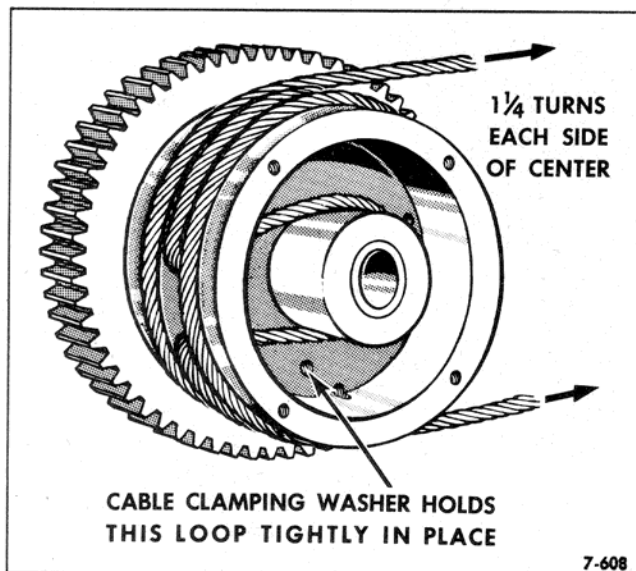


Figure 264—Cable Looped Around the Cable Drum Hub

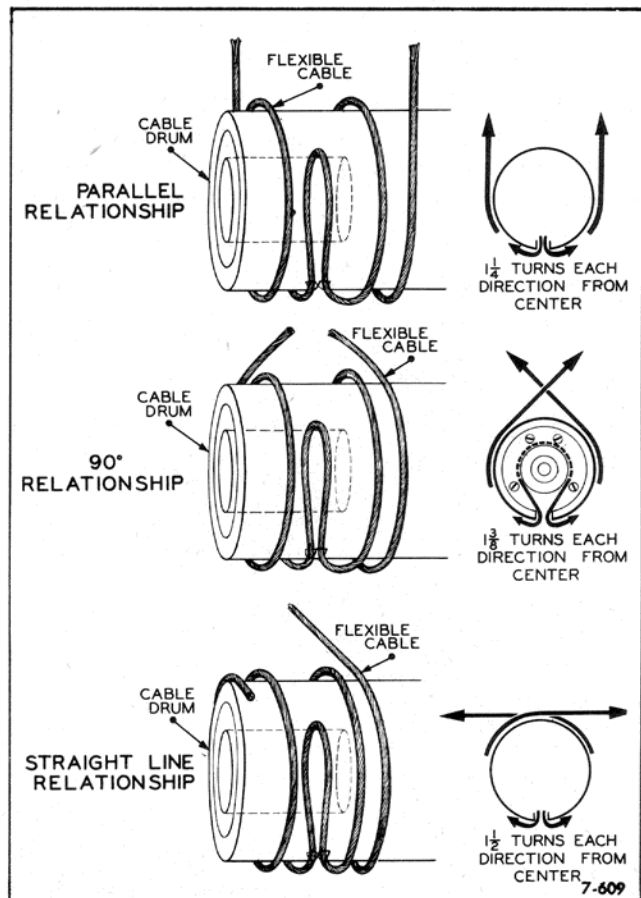


Figure 265—Arrangement of Cable on the Cable Drum

be removed from the airplane for a period of time when the plane must be kept in service, the servo cables must be disconnected from the main control cables.

2. **REMOVAL.**

- a. Remove balance pot assembly.
- b. Remove servo cable drum.

c. Remove the four mounting bolts and lift unit from its mounting platform or bracket.

3. **INSTALLATION.**

Note

It is preferable that the unit be mounted so its base is level during flight, but if necessary it may be tilted slightly to one side or the other, provided the cable drum axis is kept horizontal. The unit must never be mounted with the cable drum axis inclined, because neither the motor shaft nor differential shaft is fitted with thrust bearings.

a. Place unit on mounting platform or bracket and bolt in place with size 10-32, 1 1/8-inch long (AN 3-11) mounting bolts. Lockwashers (AN935-10) must be used to securely fasten unit to its mounting platform. Stopnuts should be used wherever possible.

b. Reinstall servo cable drum.

c. Reinstall balance pot assembly.

d. Center limit cam and balance pot according to instructions in paragraph (j). 9. h.

CAUTION

Make a final inspection to be sure that turnbuckles are safety wired and that clamps are secure on main control cables.

4. CONNECTING SERVO CABLES.

a. Lock the airplane controls in their neutral or level-flight position.

b. Remove the balance pot and its supporting brackets from the servo unit.

c. Remove the cable drum end-plate and remove the cable clamping washer from inside the drum.

d. Attach the ends of the servo cable temporarily to the main control cables by means of clamps fastened to the control cables. If guide pulleys are required to insure that the servo cable is parallel to the main cable at the point of connection, make sure the cable passes over the pulleys. Then make a loop at the proper point for insertion through the slot in the cable drum.

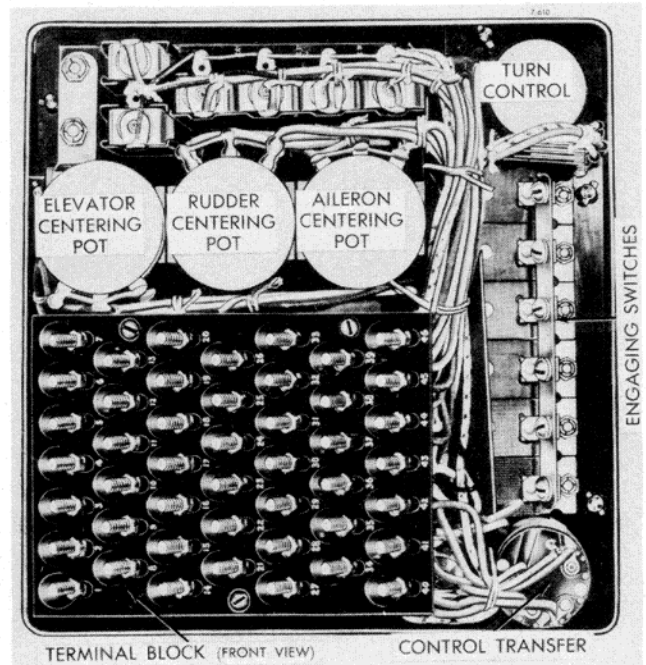
e. Turn the drum so its slot faces away from the main cable. Insert the loop through the cable drum slot and lay it around the hub of the cable drum as shown in figure 264. Then remove the ends of the cable from the clamps and tighten wind each end of the cable at least $1\frac{1}{4}$ turns around the drum, making a total of $2\frac{1}{2}$ turns of cable on the drum. This will make the cable ends parallel with each other, as shown at the top of figure 265. If a 90 degree or straight-line cable relationship is required, cross the cable ends as shown in the center or bottom illustration of figure 265. Make sure the slot through which the cable loop passes into the drum is opposite the direction of cable lead-off.

f. Take special care that there will not be any end pull on the cable drum or any tendency for the cable windings to cross.

g. The servo cable ends should then be passed over the guide pulleys and connected to the main control cables. A turnbuckle must be provided in each leg of the servo cable to permit proper adjustment of the cable tension.

h. The servo cables are always adjusted to a value 5 or 10 pounds below the tension of the main control cables to which they are attached, but never to exceed 100 pounds. It is important that control cable tensions be maintained at the amount indicated in figures 241, 246, and 250.

i. A cable tensiometer, or tension-indicating meter, should be used to measure the exact cable tensions. It must be remembered that cable tensions are adjusted for a given temperature condition (70°F). The cable tension will slacken off appreciably with a drop in temperature. On the other hand, if the cables are adjusted for normal tensions when the adjusting temperature is low, the cables will tighten considerably when the airplane moves into a higher temperature zone.



**Figure 266—Rear View of Autopilot Control Panel
Removed from Its Case**

j. After the servo cable tension has been adjusted, manually move the control surfaces through their entire range of travel in order to be sure the cable does not bind at any point or that the clamps and turnbuckles do not interfere with any portion of the airplane's structure. The controls should be moved through the entire range manually at least 20 times, so that the servo cable will be flexed and formed to the contour of the servo drum and to the guide pulleys. This process will of course decrease the tension of the servo cables, so it will again be necessary to tighten them by means of the turnbuckles and to check their tension again. If everything has checked satisfactorily, replace the cable clamping washer in the cable drum and tighten its four screws firmly in place. Replace balance pot assembly, brackets, and cover. Safety wire turnbuckles and make a final inspection to be sure that clamps are secure on main control cables.

(e) AUTOPILOT CONTROL PANEL.

1. DESCRIPTION.—The autopilot control panel (ACP), located on the pilot's control pedestal, is an assembly of the switches and controls that are required for the operation and adjustment of the C-1 autopilot. Although it provides a convenient means for making a large number of separate adjustments, most of these adjustments are made only at the time of installation and need not be changed except for extreme changes in operating conditions of the airplane.

2. REMOVAL.—Loosen the seven bayonet-type fasteners on the face of the autopilot control panel. Remove panel from case and disconnect the cable wires from their terminals on the terminal block. Remove the mounting bolts securing the case to the control pedestal.

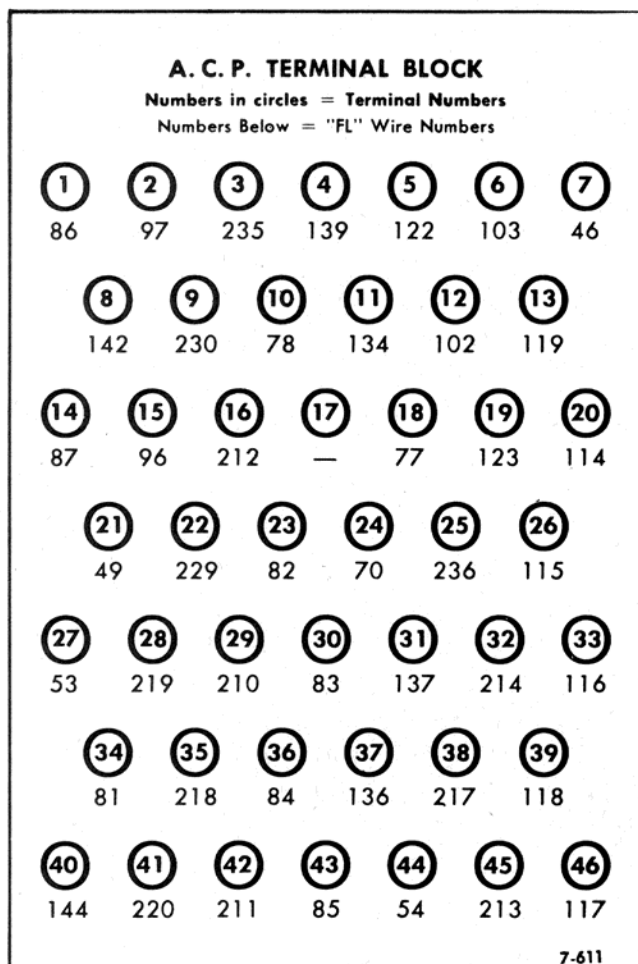


Figure 267—Diagram of Wire Connections at ACP Terminal Block

Place the autopilot control panel in the case and fasten in place with the bayonet fasteners.

3. **INSTALLATION.**—Place the rubber grommet in the large hole in the back of the case. Thread the cable through the hole and fasten the case in place. Connect the cable of the ACP, using figure 267 as a guide. Bend the cable upward at the point where it comes through the back of the case so it will form a smooth loop at the back of the case when the autopilot control panel is installed. Place the autopilot control panel in the case and fasten it in place with the bayonet fasteners.

(f) **AMPLIFIER.**

1. **DESCRIPTION.**—The purpose of the amplifier, located in the lower accessory compartment, is to control the operation of the servo units, causing them to move the control surfaces of the airplane in one direction or the other in response to signals received from the control bridge circuits of the autopilot. The amplifier may be divided into five sections, all of which are mounted on a single chassis. The five sections include:

a. The AC power supply, consisting of three transformers which supply AC voltages to the amplifier

itself and to the various control pots in the bridge circuits.

b. The DC power supply, or rectifier and filter circuit, which supplies the DC voltages used by the amplifier.

c. The aileron amplifier channel, consisting of a complete two-tube amplifier channel, conspense to signals from the aileron bridge circuit, which operates the aileron servo unit.

d. The rudder amplifier channel.

e. The elevator amplifier channel.

2. **REMOVAL.**—Remove the cable plugs from the receptacles at the back of the amplifier. Remove the four mounting bolts securing the amplifier and lift from the mounting.

3. **INSTALLATION.**—Place the amplifier in position on the four built-in rubber shock mounts and fasten, using aircraft hexhead cadmium-plated size 10-32, 1 3/8-inch long mounting bolts. Use lockwashers, AN935-10, and stopnuts. Mate the cable plugs to the proper receptacles and tighten the coupling sleeves. Facing the plug end of the amplifier, the 16 wire connector (y) is left connector, 7 wire connector (z) is middle connector, 14 wire connector (x) is right connector. The (y) connector is, or should be, painted yellow, and the (x) connector is, or should be, painted green.

(g) **ROTARY INVERTER.**

1. **DESCRIPTION.**—A rotary inverter unit, located in the lower accessory compartment, is used to generate the 19-volt, 105-cycle alternating current required for the operation of the autopilot system. It operates on the 26-volt direct current supplied by the airplane's batteries.

2. **REMOVAL.**—Disconnect the grounding cable at point of attachment to frame of airplane. Remove the mounting bolts securing the base to the airplane structure and lift out the inverter.

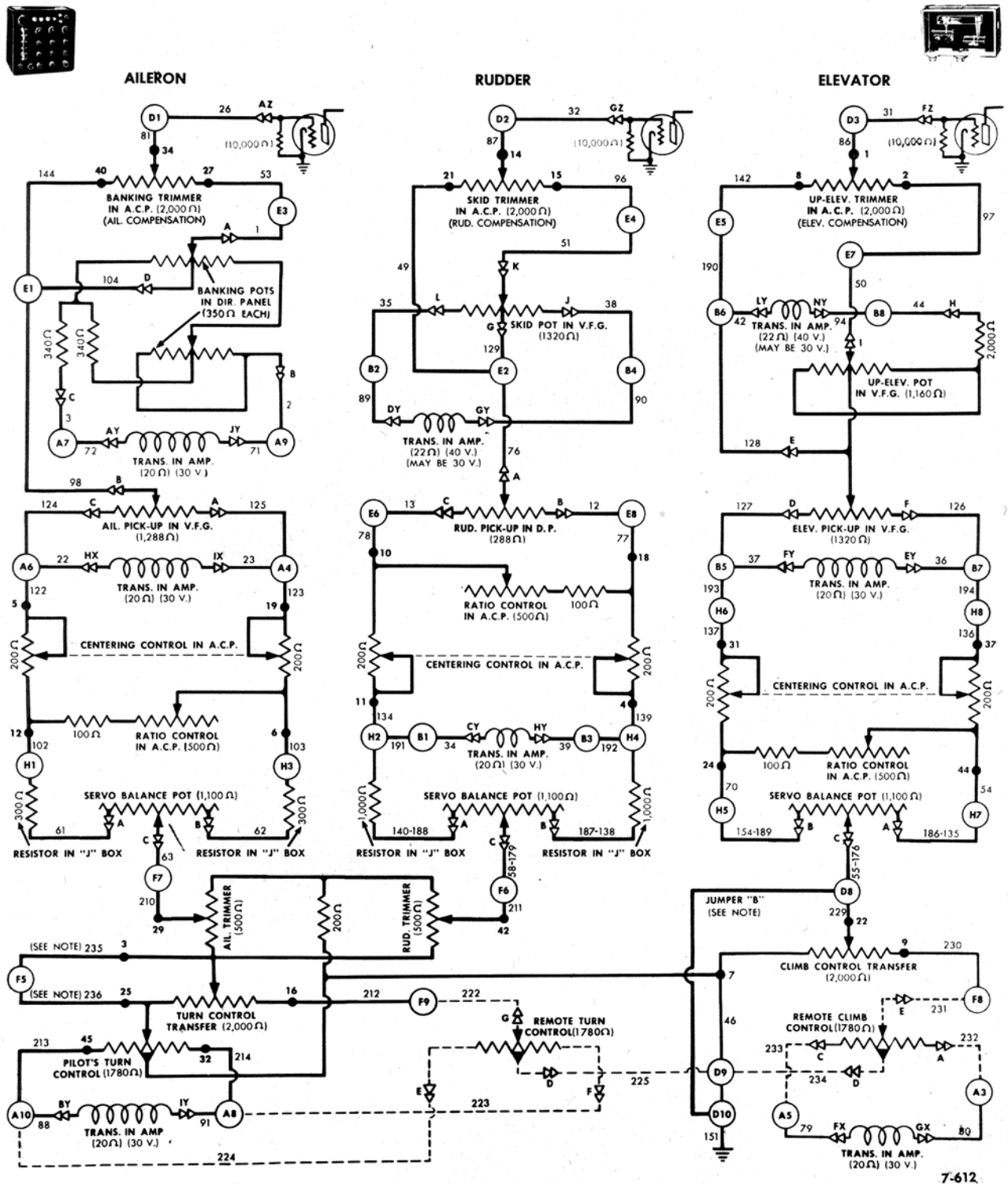
3. **INSTALLATION.**—Place the inverter in position and securely bolt the base to the airplane structure with mounting bolts. Insert the proper AN connector in the receptacle on the base of the inverter and tighten the coupling. Connect the grounding cable and fasten securely.

Note

The rotary inverter is adequately shock-mounted to its base, and, therefore, its base may be rigidly bolted to the airplane structure without further consideration of vibration damping. Since the inverter is not provided with thrust bearings, it must always be mounted in such a position that its armature shaft will be horizontal in normal flight.

(b) **JUNCTION BOX.**

1. **DESCRIPTION.**—A junction box is incorporated in the C-1 autopilot system to provide a convenient central location for making the many intercon-



FOR B-17 INSTALLATIONS WITH THE TYPE G1047 AUTOPILOT CONTROL PANEL AND THE TYPE G1005B DIRECTIONAL PANEL.
WIRES 235 AND 236 ARE REMOVED IF REMOTE TURN CONTROL IS USED. JUMPER "B" IS REMOVED IF REMOTE CLIMB CONTROL IS USED.
DOTTED LINES INDICATE CONNECTIONS USED IF INSTALLATION INCLUDES REMOTE TURN CONTROL OR REMOTE CLIMB CONTROL.

Figure 268—A.C. Bridge Circuit Diagram—C-1 Autopilot

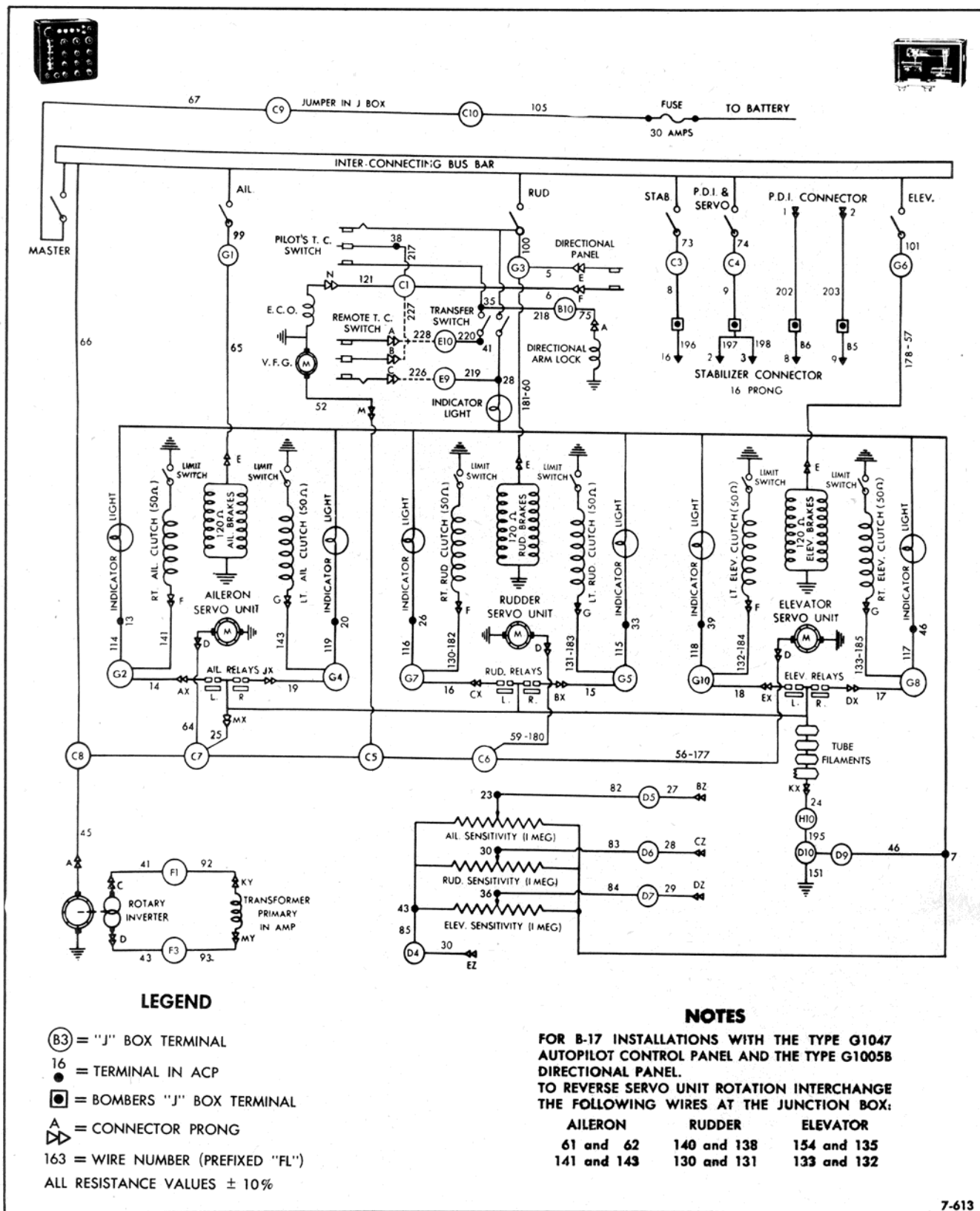
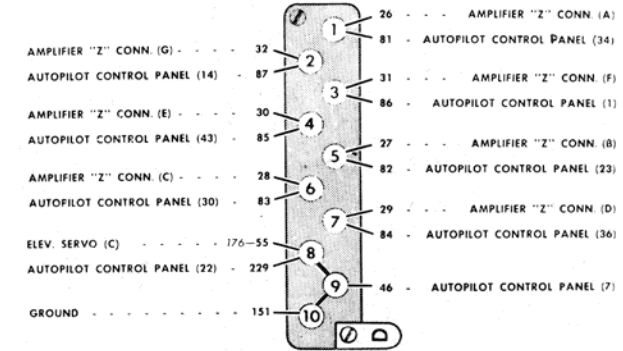
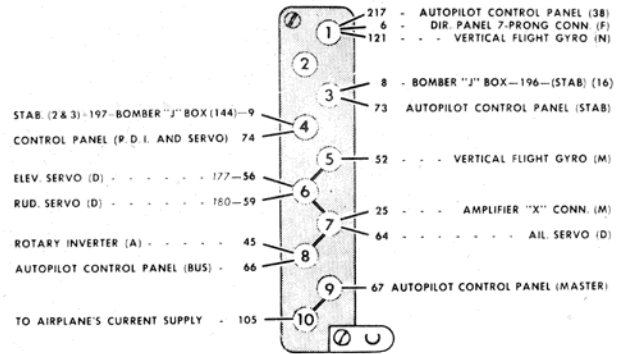
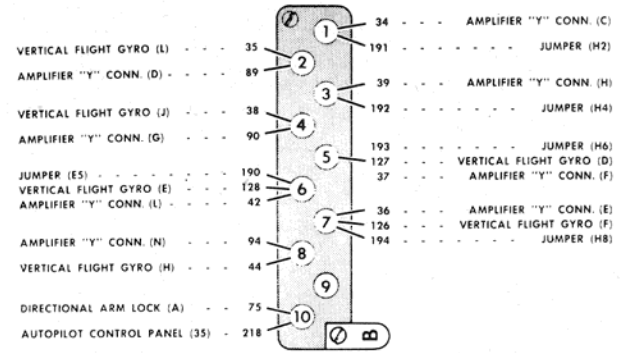
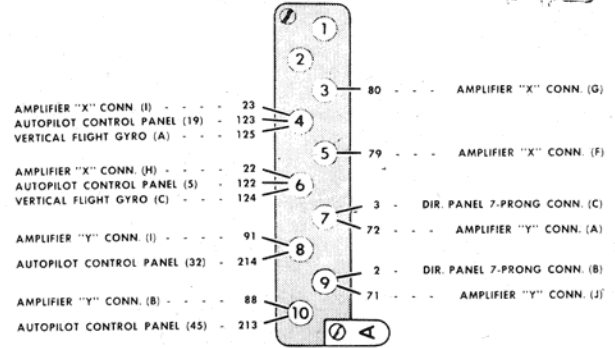
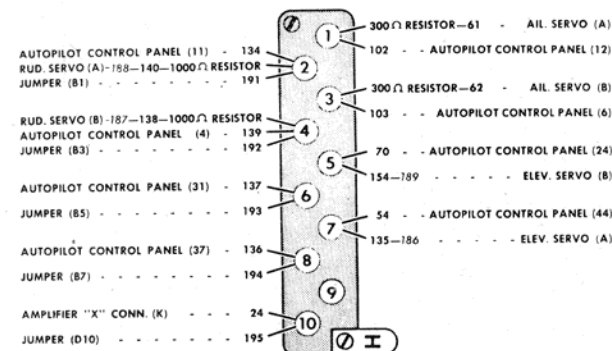
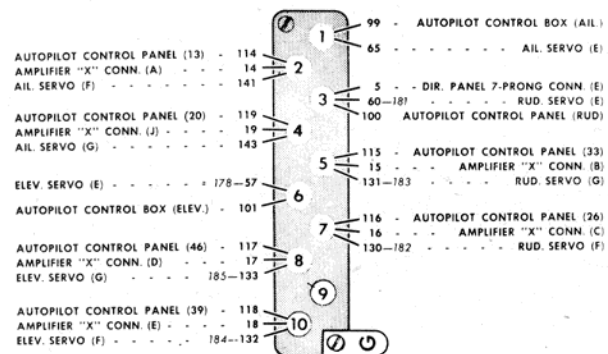
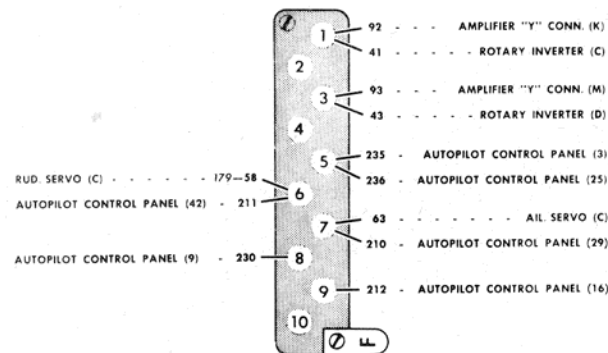
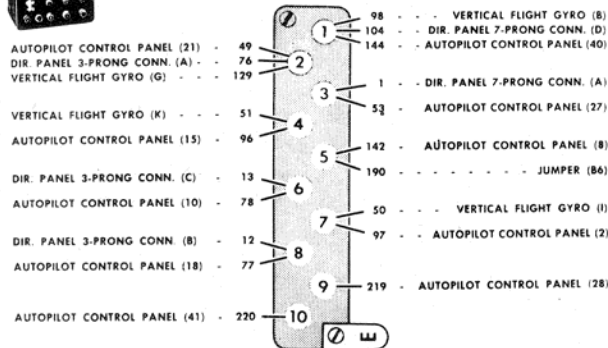


Figure 269—D.C. Power Circuit—C-1 Autopilot



FOR B-17 INSTALLATIONS WITH THE TYPE G1047 AUTOPILOT CONTROL PANEL AND THE TYPE G1005B DIRECTIONAL PANEL. 7-614

Figure 270—Junction Box Connection Diagram—C-1 Autopilot



AUTOPILOT CONTROL PANEL

| | | | | | |
|----|-------|----|----------------|-------|-----|
| 1 | Ⓢ 86 | D3 | 28 | Ⓢ 219 | E9 |
| 2 | Ⓢ 97 | E7 | 29 | Ⓢ 210 | F7 |
| 3 | Ⓢ 235 | F5 | 30 | Ⓢ 83 | D6 |
| 4 | Ⓢ 139 | H4 | 31 | Ⓢ 137 | H6 |
| 5 | Ⓢ 122 | A6 | 32 | Ⓢ 214 | A8 |
| 6 | Ⓢ 103 | H3 | 33 | Ⓢ 115 | G5 |
| 7 | Ⓢ 46 | D9 | 34 | Ⓢ 81 | D1 |
| 8 | Ⓢ 142 | E5 | 35 | Ⓢ 218 | B10 |
| 9 | Ⓢ 230 | F8 | 36 | Ⓢ 84 | D7 |
| 10 | Ⓢ 78 | E6 | 37 | Ⓢ 136 | H8 |
| 11 | Ⓢ 134 | H2 | 38 | Ⓢ 217 | C1 |
| 12 | Ⓢ 102 | H1 | 39 | Ⓢ 118 | G10 |
| 13 | Ⓢ 114 | G2 | 40 | Ⓢ 144 | E1 |
| 14 | Ⓢ 87 | D2 | 41 | Ⓢ 220 | E10 |
| 15 | Ⓢ 96 | E4 | 42 | Ⓢ 211 | F6 |
| 16 | Ⓢ 212 | F9 | 43 | Ⓢ 85 | D4 |
| 17 | | | 44 | Ⓢ 54 | H7 |
| 18 | Ⓢ 77 | E8 | 45 | Ⓢ 213 | A10 |
| 19 | Ⓢ 123 | A4 | 46 | Ⓢ 117 | G8 |
| 20 | Ⓢ 119 | G4 | | | |
| 21 | Ⓢ 49 | E2 | MASTER | Ⓢ 67 | C9 |
| 22 | Ⓢ 229 | D8 | AIL. | Ⓢ 99 | G1 |
| 23 | Ⓢ 82 | D5 | RUD. | Ⓢ 100 | G3 |
| 24 | Ⓢ 70 | H5 | ELEV. | Ⓢ 101 | G6 |
| 25 | Ⓢ 236 | F5 | STAB. | Ⓢ 73 | C3 |
| 26 | Ⓢ 116 | G7 | P.D.I. & SERVO | Ⓢ 74 | C4 |
| 27 | Ⓢ 53 | E3 | BUS | Ⓢ 66 | C8 |

*REMOTE
TURN CONTROL

| | | |
|---|-------|-----|
| A | Ⓢ 228 | E10 |
| B | Ⓢ 227 | C1 |
| C | Ⓢ 226 | E9 |
| D | Ⓢ 225 | D9 |
| E | Ⓢ 224 | A10 |
| F | Ⓢ 223 | A8 |
| G | Ⓢ 222 | F9 |

LEGEND

ALL CONNECTIONS ARE LISTED BY UNITS
FIRST BOLD-FACE COLUMN = CONNECTOR PRONGS
SECOND " " = "FL" WIRE NO.
THIRD " " = "J" BOX TERMINAL
ITALIC NUMBERS (175) = SPLICED WIRE NOS.
Ⓢ = WIRE SIZE

*Remote Turn Control may not be included in some installations.

STABILIZER

| | | |
|----|------|----------------|
| 1 | | |
| 2 | 197 | |
| 3 | 198 | Ⓢ 9 C4 |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | Ⓢ B6 | 202 P.D.I. (1) |
| 9 | Ⓢ B5 | 203 P.D.I. (2) |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | Ⓢ 69 | GROUND |
| 14 | | |
| 15 | | |
| 16 | 196 | Ⓢ 8 C3 |

DIRECTIONAL PANEL

7-PRONG CONNECTOR

| | | |
|---|-------|----|
| A | Ⓢ 1 | E3 |
| B | Ⓢ 2 | A9 |
| C | Ⓢ 3 | A7 |
| D | Ⓢ 104 | E1 |
| E | Ⓢ 5 | G3 |
| F | Ⓢ 6 | C1 |
| G | | |

3-PRONG CONNECTOR

| | | |
|---|------|----|
| A | Ⓢ 76 | E2 |
| B | Ⓢ 12 | E8 |
| C | Ⓢ 13 | E6 |

"X" CONNECTOR

| | | |
|---|------|-----|
| A | Ⓢ 14 | G2 |
| B | Ⓢ 15 | G5 |
| C | Ⓢ 16 | G7 |
| D | Ⓢ 17 | G8 |
| E | Ⓢ 18 | G10 |
| F | Ⓢ 79 | A5 |
| G | Ⓢ 80 | A3 |
| H | Ⓢ 22 | A6 |
| I | Ⓢ 23 | A4 |
| J | Ⓢ 19 | G4 |
| K | Ⓢ 24 | H10 |
| L | | |
| M | Ⓢ 25 | C7 |
| N | | |

VERTICAL
FLIGHT GYRO

| | | |
|---|-------|----|
| A | Ⓢ 125 | A4 |
| B | Ⓢ 98 | E1 |
| C | Ⓢ 124 | A6 |
| D | Ⓢ 127 | B5 |
| E | Ⓢ 128 | B6 |
| F | Ⓢ 126 | B7 |
| G | Ⓢ 129 | E2 |
| H | Ⓢ 44 | B8 |
| I | Ⓢ 50 | E7 |
| J | Ⓢ 38 | B4 |
| K | Ⓢ 51 | E4 |
| L | Ⓢ 35 | B2 |
| M | Ⓢ 52 | C5 |
| N | Ⓢ 121 | C1 |

ROTARY
INVERTER

| | | |
|---|------|----|
| A | Ⓢ 45 | C8 |
| C | Ⓢ 41 | F1 |
| D | Ⓢ 43 | F3 |

DIRECTIONAL
ARM LOCK

| | | |
|---|------|-----|
| A | Ⓢ 75 | B10 |
|---|------|-----|

AMPLIFIER

"Z" CONNECTOR

| | | |
|---|------|----|
| A | Ⓢ 26 | D1 |
| B | Ⓢ 27 | D5 |
| C | Ⓢ 28 | D6 |
| D | Ⓢ 29 | D7 |
| E | Ⓢ 30 | D4 |
| F | Ⓢ 31 | D3 |
| G | Ⓢ 32 | D2 |

AILERON SERVO

| | | |
|---|-------|----|
| A | Ⓢ 61 | H1 |
| B | Ⓢ 62 | H3 |
| C | Ⓢ 63 | F7 |
| D | Ⓢ 64 | C7 |
| E | Ⓢ 65 | G1 |
| F | Ⓢ 141 | G2 |
| G | Ⓢ 143 | G4 |

RUDDER SERVO

| | | |
|---|-------|--------|
| A | Ⓢ 188 | 140 H2 |
| B | Ⓢ 187 | 138 H4 |
| C | Ⓢ 179 | 58 F6 |
| D | Ⓢ 180 | 59 C6 |
| E | Ⓢ 181 | 60 G3 |
| F | Ⓢ 182 | 130 G7 |
| G | Ⓢ 183 | 131 G5 |

ELEVATOR SERVO

| | | |
|---|-------|---------|
| A | Ⓢ 186 | 135 H7 |
| B | Ⓢ 189 | 154 H5 |
| C | Ⓢ 176 | 55 D8 |
| D | Ⓢ 177 | 56 C6 |
| E | Ⓢ 178 | 57 G6 |
| F | Ⓢ 184 | 132 G10 |
| G | Ⓢ 185 | 133 G8 |

"Y" CONNECTOR

| | | |
|---|------|-----|
| A | Ⓢ 72 | A7 |
| B | Ⓢ 88 | A10 |
| C | Ⓢ 34 | B1 |
| D | Ⓢ 89 | B2 |
| E | Ⓢ 36 | B7 |
| F | Ⓢ 37 | B5 |
| G | Ⓢ 90 | B4 |
| H | Ⓢ 39 | B3 |
| I | Ⓢ 91 | A8 |
| J | Ⓢ 71 | A9 |
| K | Ⓢ 92 | F1 |
| L | Ⓢ 42 | B6 |
| M | Ⓢ 93 | F3 |
| N | Ⓢ 94 | B8 |

FOR B-17 INSTALLATIONS WITH THE TYPE G1047 AUTOPILOT CONTROL PANEL AND THE TYPE G1005B DIRECTIONAL PANEL. 7-615

Figure 271—Unit to "J" Box Connections—C-1 Autopilot

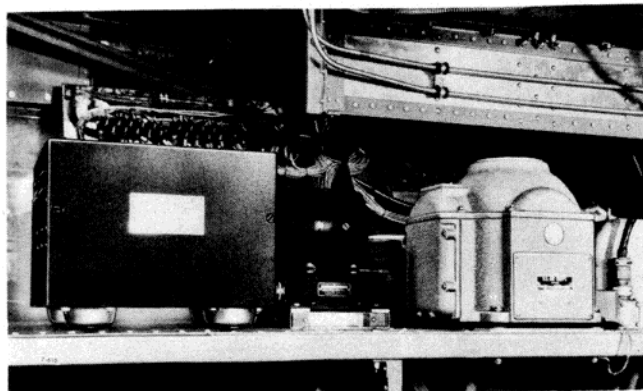


Figure 272—Amplifier Installation

nections required among the various control units of the system. The junction box, or "J" box, as it is usually called, is located in the lower accessory compartment. It makes easier the search for causes of trouble and the isolation of malfunctions, as it facilitates checking the various units separately.

2. **REMOVAL.**—Remove mounting screws which pass through holes in bottom of junction box and lift out unit.

3. **INSTALLATION.**—Fasten the unit in place by means of mounting screws which pass through holes in the bottom of the box.

CAUTION

After mounting the box, be sure to remove any metal shavings, bolts, or nuts which may have dropped inside.

(i) PILOT DIRECTOR INDICATOR.

1. **DESCRIPTION.**—The pilot director indicator, located on the pilot's instrument panel, is a remote indicating device which provides visual indication of aircraft deviation from the course chosen by the bombardier upon approaching an objective. When the autopilot is used, the "PDI" indicates to the pilot when the system and airplane are properly trimmed. When the autopilot is engaged with "PDI" centered, the autopilot makes the corrections automatically.

2. **REMOVAL.**—Using a screwdriver, take out the four mounting screws and remove the instrument from the panel. Loosen the cable coupling and disconnect the cable plug from the receptacle on the back of the instrument.

3. **INSTALLATION.**—Install the instrument on the panel and fasten with the four mounting screws. Adjust the instrument pointer to zero with a screwdriver. Mate the cable connection plug to the receptacle and secure by tightening the coupling.

(j) GROUND CHECK (FUNCTION TEST).

1. GENERAL.

a. A complete ground check on the functioning of the C-1 autopilot must be conducted immediately after the equipment is installed, after each major overhaul or exchange of any of the autopilot units,

and after each 100 hours that the airplane has been in service. In combat operations, it is strongly recommended that the lead ship in each bombing formation be thoroughly "ground-checked" before take-off on each mission.

b. The "ground check" consists essentially of a number of visual inspections and test procedures which can be completed in an hour's time, once the maintenance crew has gained experience in its performance.

c. The procedure is outlined in such a manner that most of the mechanical checks will be completed before the equipment is energized, so that the inspection work may be carried on more easily. The electrical checks which follow serve as a double check on the mechanical functioning, as well as a final check on the performance of the whole C-1 autopilot system.

d. Ground check work on the C-1 autopilot can be more easily carried on by two men working as a team. One of the two will be in charge and will supervise the entire ground check from the cockpit of the airplane. It is suggested that the two men use the airplane's intercommunication system to facilitate this work. Extra long leads may be required on one headphone set in order to reach to the servo units in the tail of the airplane. The assistant will first enter the nose of the plane and make the following mechanical inspections:

2. DIRECTIONAL ARM LOCK.

a. Push the plunger in and out of the solenoid several times to be sure it is free to move up under the action of the return spring. Rust, dirt, or other foreign matter must not impede travel of the plunger.

b. Check the AN connector plug to see that it is properly connected in the receptacle.

c. Make sure the directional arm lock does not bind on the autopilot clutch arm in any way.

d. Make sure mounting screws are tight. Then manually press the plunger into the solenoid until the clamping jaws just begin to grab. Mark a pencil line on the plunger at the top of the solenoid. Force

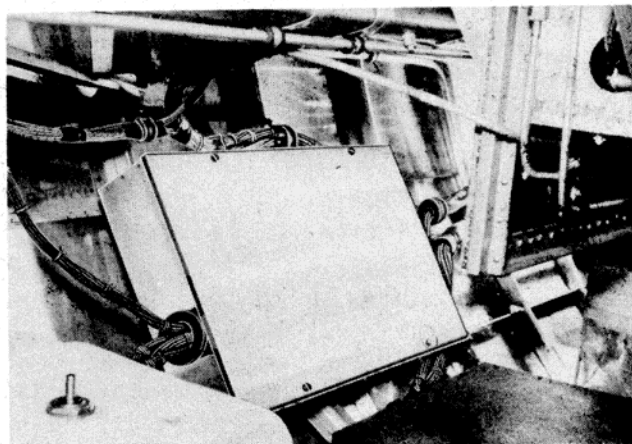


Figure 273—Junction Box Installation

plunger to bottom of solenoid and mark another pencil line on the plunger. The distance between the two lines should be $\frac{3}{32}$ inch to $\frac{1}{8}$ inch apart. Readjust plunger if necessary. Then make sure plunger lock nut is tight.

3. DIRECTIONAL PANEL.

a. Disconnect the dashpot plunger from its crank arm and pull the plunger from the cylinder. Make sure the oil level is within one inch of the top. If necessary, add hydraulic fluid, Spec. AN-VV-O-366.

b. Inspect the inside of the panel and remove any dirt which may have accumulated.

c. Be sure that AN plugs are properly mated to receptacles.

d. Disengage autopilot clutch and move it abruptly from side to side while watching swivel action of rudder pickup pot wiper in the directional panel. Wiper should recenter smoothly and uniformly from both sides.

4. DIRECTIONAL STABILIZER.

a. Check autopilot clutch (secondary) to be sure it moves freely when disengaged but holds firmly to the clutch drum when engaged.

b. Check bombsight clutch (primary) to make certain that it does not bind when unclutched.

5. C-1 AUTOPILOT JUNCTION BOX.

a. Remove any foreign matter, especially metal shavings, loose nuts, or pieces of wire which might short or ground terminals.

b. Make sure all the terminal nuts are tight.

c. Inspect junction box cables to make sure there are no wires with the insulation stripped off or wires which have been pulled from their eyelets. Inspect grommets and cables passing through grommets. Do not bend cables or pull on the wires during this inspection. Avoid excessive handling of wires.

6. ROTARY INVERTER.

a. Inspect both sets of brushes for undue wear or uneven seating.

b. See that the commutator is clean and free from pits and roughness.

c. Check AN connector for proper mating. Check ground strap for good grounding contact.

7. AMPLIFIER.

a. Remove cover and press each tube individually with the fingers and try to move it about to make sure it is firmly seated in the socket.

b. Inspect all relay contacts for dirt or pitting.

c. Make sure throttle adjustments are properly set. Turn all three adjustments to extreme counter-clockwise position; then turn elevator throttling clockwise $\frac{1}{2}$ turn.

d. Make sure connector plugs are tight.

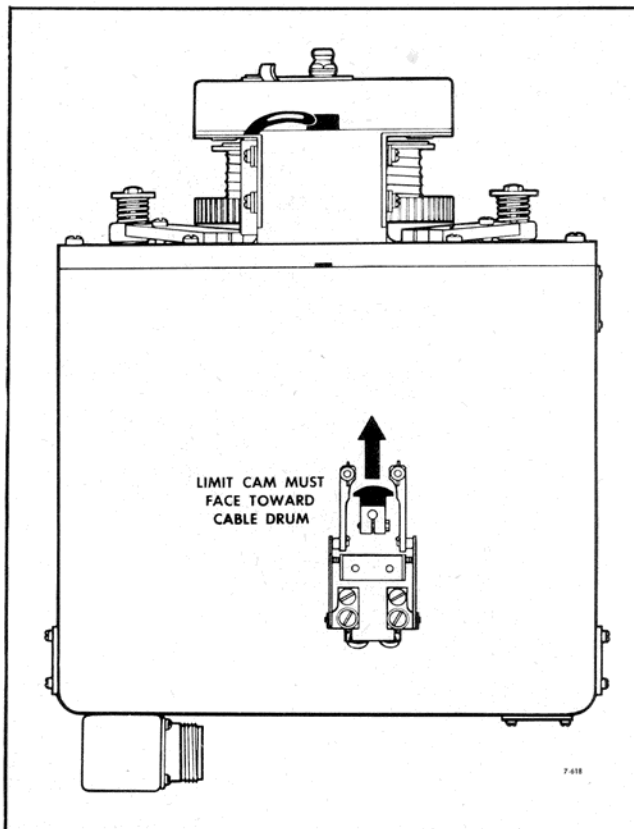


Figure 274—Limit Cam Must Face Toward Cable Drum

8. VERTICAL FLIGHT GYRO.

a. See that the glass cover is not cracked or broken. (If broken, remove gyro for repair or replacement.) If gyro has a plastic cover, make sure the plastic has not warped or sagged so its center interferes with the top of the gyro spindle.

b. See that the ground strap is making good contact at both ends.

c. Check AN connector to be sure that the plug is properly mated to the receptacle.

9. SERVO MOTORS.

a. Push in on brake tension springs to make sure brake solenoids and pull-rods operate freely and brake arms snap back when pressure is released.

b. Clean all dust and dirt away from around the servo and remove cover.

c. Make sure limit cam faces toward the drum end of the servo unit, as in figure 274, when the controls are centered for normal flight.

d. Make sure that cable is wound on drum so it will permit full cable travel in either direction. Check this by having the control surface move throughout its entire range in both directions.

e. Observe that the drum rotates freely in both directions.

f. Check all cable tensions and inspect safety wires on turn buckles and cable fittings. (See figures 241, 246, and 249.)

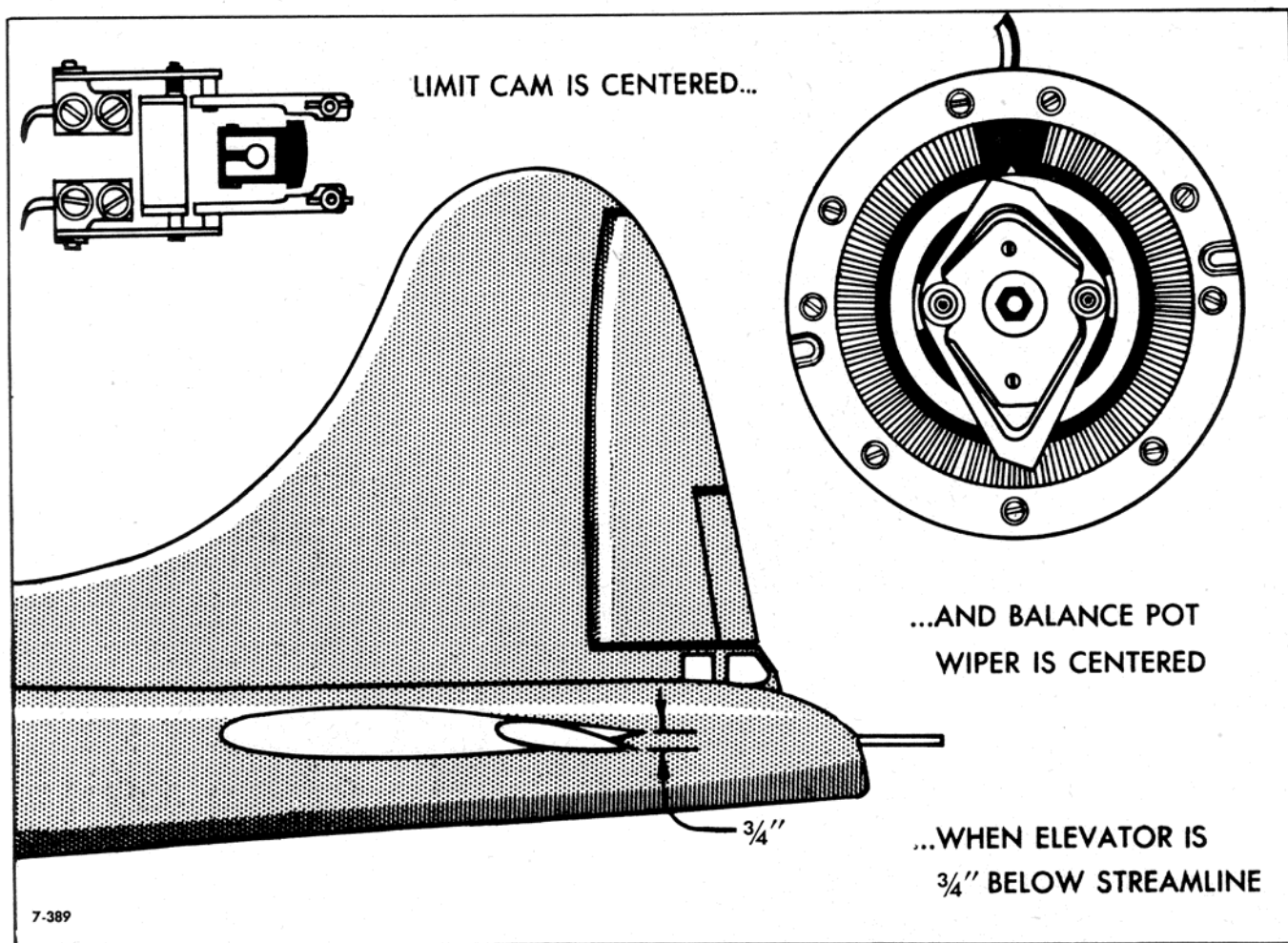


Figure 275—Level Flight Position for Elevator

g. Inspect balance pot and wiper to make sure wiper makes good contact with the pot and the pot is clean.

h. Move ailerons and rudder surfaces to streamline position and place elevator in level flight position. Servo unit pot wipers should be in center position and limit cams should be at the midpoint of their operating range. Figure 275 illustrates level-flight elevator position for the B-17F airplanes.

i. Center the balance pot wiper if necessary, proceeding as follows:

(1) The balance pot is mounted at the front of the servo unit with the ends of the pot winding "up" and the center of the winding directly "down."

(2) The balance pot wiper is mounted on a friction collar which is held in place on the cable drum by a clutch friction disc. This assembly makes it possible to turn the wiper assembly by hand while the drum remains in a fixed position. Thus, no matter in what position the cable drum happens to be, the wiper assembly can be manually turned to contact the center of the pot winding.

(3) Before centering the pot wiper, make

sure all control surfaces are at their level flight positions, as explained in preceding paragraph h.

(4) To center pot wiper, grasp the two protruding lugs and rotate wiper assembly until the wiper blades which contact the pot are straight down or as close to the center of the winding as can be determined visually.

j. Center the limit cam if necessary, proceeding as follows:

(1) Remove servo unit cover and manually set the airplane's control surfaces at their TRIM positions for normal load and cruising speed.

(2) With control surfaces in this position, place the limit cam on its shaft so the cam surface faces toward the cable drum and is centered between the cam switch levers.

(3) Lock the limit cam in place by tightening its small lock screw. Be careful not to turn this small screw more than 3/16 turn after the cam has tightened on its shaft, or the screw head will shear off.

10. TURN CONTROL.

a. See that operating knob is firmly fastened to shaft.

b. Pointer should be in exact center when cam is at detent position.

c. Check to see that the force required to turn the knob from center position in either direction is not excessive and that the operation is smooth over the entire range of the turn control.

d. Check AN connector for proper mating and tightness.

11. AUTOPILOT CONTROL PANEL.

a. See that all knobs are tight on their shafts.

b. Be sure that all knob pointers are fastened firmly. If any have come loose, realign before fastening, proceeding as follows:

(1) Turn all knobs to their extreme counter-clockwise positions; then set the pointers so they all point at "7 o'clock."

(2) Rotate the centering knobs clockwise, watching the action of the pointers to make sure they move more slowly than the knob, indicating that the verniers are working properly. If the pointers do not operate properly, loosen the knob and slide it further on the shaft; then tighten it in place and reset the pointer.

(3) Turn all knobs to their extreme clockwise position and see that all pointers now point to "5 o'clock".

(4) Return all knobs to "12 o'clock" or "pointers up" position.

c. Operate knobs to determine whether action is smooth throughout entire range.

d. See that switch bar is firmly fastened to toggle switches.

e. Make sure all toggle switches operate with proper "snap" action.

f. Be sure the cover is held firmly in place by Dzus fasteners.

12. HARNESS.

a. Inspect cable for any evidences of wear or damage. Be sure that cable is not permitted to move against other parts of the airplane.

b. Make sure that grommets are used wherever necessary.

Note

After the completion of the visual check on mechanical details, make certain that the airplane's batteries are well charged and that the controls are unlocked before starting the electrical functioning check. If possible, use a portable external energizer during the check to conserve the airplane's batteries.

13. PREPARATION FOR ELECTRICAL CHECKS.

a. Place all control surfaces in normal, level-flight position.

b. With all knobs on autopilot control panel in "pointers up" position, center turn control.

c. Turn on master, stabilizer, and tell-tale light switches, and check to determine that amplifier, vertical flight gyro, stabilizer, all three servos, and rotary inverter are operating. Allow this much of the system to operate for at least ten minutes before proceeding with the next step.

d. Turn on stabilizer servo (torque motor) switch on the autopilot control panel.

e. Turn on PDI switch.

f. Disengage autopilot clutch and center PDI.

14. CHECK OPERATION OF SERVO UNITS AND CENTERING.

a. Check cleanliness of the aileron servo balance pot by slowly operating the aileron control wheel from one extreme to the other. One aileron tell-tale light or the other should glow steadily except when the balance pot crosses its electrical center or balance position; at this point the one light will go out and the other will come on. If the light goes out at any other position, it indicates a dirty spot on the pot. To check the center portion on the pot, turn the aileron centering knob to one side and repeat the test. This time the point at which one light will go out and the other come on will be moved to a different position.

b. Repeat for rudder and elevator.

c. Return all controls to level flight position.

d. Put out aileron tell-tale lights with aileron centering knob. Then turn on aileron engaging switch.

e. Slowly turn aileron centering knob clockwise. Aileron control should "peck" into position for

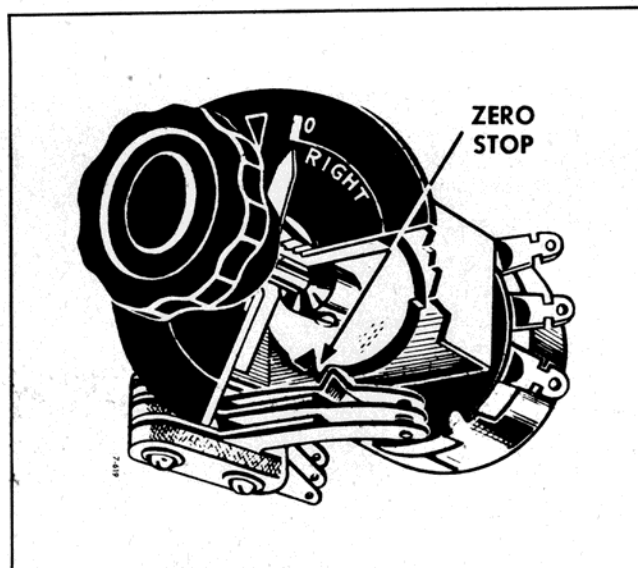


Figure 276—Position of Turn Control Cam Switch at Zero Position of the Dial

a right turn. Then turn aileron centering knob counterclockwise. Aileron control should "peck" into position for a left turn. Note amount of control movement for each peck. This movement should be equal in both directions. If it is not, either the equalizer or brake tension springs on the servo unit need adjustment, and the unit will be removed for bench work. Check limit switch operation by turning centering knob far enough in each direction to cause limit switch to open. Light will stay on, but control will not move after limit switch opens.

f. Repeat steps d. and e. for rudder and elevator.

Note

A cross-wind will produce unequal rudder movement even if equalizer springs are properly adjusted. Therefore, be sure airplane is heading into the wind when checking rudder movement. When checking elevator movements, allowances must be made for the unbalancing effect of the elevators' weight.

g. Return all centering knobs to "pointers up" position.

15. CHECK TURN CONTROL OPERATION.

a. Rotate turn control clockwise to maximum and note that ailerons and rudder move to the proper position for a right turn.

b. Repeat with counterclockwise rotation for a left turn.

c. Return turn control to zero mark. DO NOT RECENTER.

d. Make sure top erecting roller on vertical flight gyro is not rotating.

e. Make sure autopilot clutch on the stabilizer is locked firmly in place by the directional arm lock.

f. Center turn control. There should be no movement of either aileron or rudder.

g. Turn the pointer to the zero mark on the other side of detent. Be careful not to go beyond the zero mark. Then recenter the pointer. There should be no movement of the ailerons or rudder with either motion. If control movement occurs in steps f. and g. the deadspots in the turn control pots are not properly centered. To adjust proceed as follows:

(1) Rotate the turn control counterclockwise past the zero mark.

(2) Loosen the two set-screws which hold the cam to the turn control shaft, and rotate the cam back toward the detent to the point where the zero stop just touches the hump on the erecting cutout switch.

(3) Connect a low-reading ohmmeter between terminals 7 and 25 on the autopilot control panel terminal board and then rotate the turn control knob toward the center position while holding the cam with

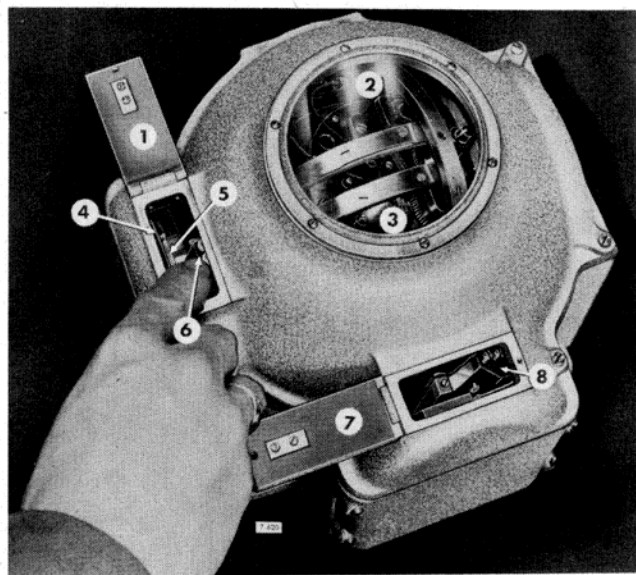


Figure 277—Hinged Covers Provide Access to Gyro Pot Without Removing Housing Cover

the thumb. As soon as the ohmmeter reads zero, tighten the cam set-screws.

(4) Rotate the turn control knob and cam to the opposite side of the turn control; then rotate it back until the cam just hits the zero stop on the opposite side of the center position.

(5) If the ohmmeter reads zero, the cam is properly adjusted and needs no further attention.

(6) If the ohmmeter indicates a resistance, divide this value in half, loosen the set-screws on the cam, and, while holding the cam on the zero stop, turn the turn control knob until the ohmmeter reads half of the value, as indicated previously.

(7) Tighten the two set-screws holding the cam to the shaft. The unit is then in proper adjustment.

16. CHECK AUTOPILOT FOR CORRECT OPERATION IN "ROLL AXIS"—This check includes aileron pickup, aileron ratio, rudder compensation, and elevator compensation.

a. With aileron, rudder, and elevator servo units engaged, and with turn control centered, set aileron ratio, rudder compensation (skid trimmer), and elevator compensation (up-elevator trimmer) at maximum.

b. Clean off the top of the vertical flight gyro and open the access door above the elevator pot. Taking care not to drop any dust or dirt into the unit, place the index finger on the bakelite block which supports the pot wiper. (Be careful not to bend the pot wiper blade.) Apply pressure toward the nose of the airplane to precess the top of the gyro slowly to the right. (See figure 277.) As gyro tilts, one tell-tale light in each axis should flash on and off repeatedly, and aileron and rudder controls will move into posi-

tion for a right turn. Control column should move backward.

c. If, during this test, the opposite light in any axis flashes, or if any control reverses its movement, the corresponding pot is dirty and should be cleaned immediately, according to the following instructions (see figure 277):

(1) Slightly dampen a clean white lint-free cloth (or aircraft linen) with a small amount of WHITE gasoline (or alcohol) and then wrap cloth around index finger. (Gasoline must be used very sparingly.) DO NOT USE ANY COLORED GASOLINE. Carefully clean the portion of the pot (4) not covered by the wiper (5). Rub pot crosswise or in a direction parallel to the wire windings. Be sure not to disturb or bend the wiper while cleaning the pot. Immediately remove the gasoline and residue by rubbing the pot with a clean, dry, lint-free cloth.

(2) Move wiper blade supporting block to other end of the pot. Clean the balance of the pot with the gasoline-dampened cloth and then wipe with dry cloth. Close inspection door and tighten screw holding it in place. Be careful that the cover gasket lies flat and seals properly.

(3) Open inspection door (7), move bakelite wiper supporting block (8) to end of the three pots, and repeat operations (1) and (2) on the three pots. Close cover and fasten.

(4) Observe condition of cover glass (2). If it is cracked or broken, remove the Gyro from the airplane and clean thoroughly. If there is reason to believe that dust or dirt may have got into the bearings or otherwise impaired the operation of the gyro, send it to a fourth echelon repair station for overhaul.

d. As the limit switch of each servo unit opens (indicated by the tell-tale light shining steadily while the control stops moving), turn the corresponding centering knob counterclockwise to bring the control back to center. Then continue precessing the gyro and watching the action of tell-tale lights and controls until gyro spindle approaches the stop ring in the gyro cover. Do not let the spindle strike the stop.

e. Return centering knobs to "pointers up" position. Controls will again move to their limits.

f. Allow gyro to erect until the limit switches close (indicated by flickering of the light and movement of the controls).

g. Then turn aileron ratio, rudder compensation, and elevator compensation to minimum. The corresponding controls should move quickly toward their center position.

h. Turning the same knobs back to maximum should cause the corresponding controls to move out again.

i. Repeat steps a. through h., precessing the gyro to the left. Aileron and rudder controls

should move into position for a left turn, and control column should again move backward. Turning aileron ratio, rudder compensation, and elevator compensation from maximum to minimum should again cause the controls to move toward center.

j. Precess gyro to center and close pot cover.

17. CHECK AUTOPILOT FOR CORRECT OPERATION IN "PITCH AXIS"—This check includes elevator pickup and elevator ratio.

a. With elevator servo unit engaged, set elevator ratio to maximum.

b. Open access door above triple pot and press pot wiper block to the left to slowly precess the top of the gyro forward. One tell-tale will flicker as control column moves forward. If opposite light flashes, the elevator pickup pot is dirty and should be cleaned immediately.

c. When elevator servo limit switch opens (indicated by a steady light and cessation of control movement), turn elevator centering knob clockwise to return control column to center, and continue precessing gyro until it approaches its stop.

d. Return elevator centering knob to "pointers up." Control column will move forward until limit switch opens.

e. Allow gyro to erect until the light flickers and control starts moving back, then turn elevator ratio to minimum. Control column should move quickly back toward center. Turning elevator ratio back to maximum should cause control column to move forward again.

f. Repeat steps a. through e., precessing the gyro backward. The control column should move backward while gyro is being precessed, then forward toward center when elevator ratio is reduced.

g. Return all knobs to "pointers up" position.

18. CHECK AUTOPILOT FOR CORRECT OPERATION IN "TURN AXIS"—This check includes rudder pickup, rudder ratio, aileron compensation, and PDI.

a. With turn control centered and aileron and rudder servos engaged, set rudder ratio and aileron compensation (banking pot) to maximum.

b. Making sure autopilot clutch on the stabilizer is engaged, slowly move the autopilot clutch engaging knob toward the right. Aileron and rudder controls should move into position for a left turn while one tell-tale light in each of these two axes flickers. If the opposite light in either axis flashes or if the control movement reverses, the corresponding pot in the directional panel is dirty and should be cleaned immediately.

c. As the servo limit switches open, turn the corresponding centering knobs clockwise to return the control surfaces to center; then continue moving the autopilot clutch to its extreme position.

d. Make sure PDI pot wiper on the stabilizer is at the extreme right and PDI needle on pilots' instrument panel is at extreme left.

e. Return aileron and rudder centering to "pointers up". Controls should move to limit.

f. Move autopilot clutch back toward center just far enough to cause movement of both aileron and rudder controls.

g. Turn rudder ratio and aileron compensation to minimum. Rudder and ailerons should move toward center.

h. Repeat steps a. through g., moving autopilot clutch to the left. Rudder and ailerons should move into position for a right turn. Reducing aileron compensation and rudder ratio should again return controls toward center.

19. CHECK ALIGNMENT OF PDI AND DIRECTIONAL PANEL POT WIPERS.

a. With aileron compensation at minimum and aileron sensitivity at maximum, throw aileron engaging switch OFF, and put out aileron tell-tale lights with the centering knob.

b. Center PDI pot wiper on the stabilizer by moving the autopilot clutch.

c. Increase aileron compensation to maximum. If either aileron tell-tale light comes on, move autopilot clutch to put out the light. If PDI needle still appears to be centered, the alignment is satisfactory; but if PDI has been moved off center, readjust the directional panel drive arm.

20. CHECK SENSITIVITY CONTROLS.

a. Throw off aileron engaging switch. Reduce aileron sensitivity to minimum. Rotate aileron centering knob from a position where one tell-tale light is barely on to a position where the other tell-tale light just comes on. Make a mental note of the amount of knob movement required. Rotate aileron sensitivity knob clockwise to maximum. Repeat the action of rotating the aileron centering knob from the point where one tell-tale light just comes on to the point where the other light just comes on. If the sensitivity control is correct, the amount that the centering knob must be turned from one light to another will be much less.

b. Repeat the above procedure for the rudder axis.

c. Repeat the above procedure for the elevator axis.

21. CHECK STABILIZER OPERATION.

a. Engage autopilot clutch with PDI centered.

b. Make sure turn control is centered.

c. Turn off all switches on the stabilizer and make sure stabilizer gyro and torque motor continue

to operate on energy supplied through the autopilot control panel.

d. Allow unit to run for one hour; then note position of PDI.

e. If PDI has moved more than one degree in one hour, stabilizer gyro may be statically unbalanced, in which case the unit must be replaced.

IMPORTANT

Before leaving the airplane:

Throw off all autopilot switches.

Throw off the ship's master switches.

Lock the control surfaces.

c. HYDRAULIC SYSTEM.

(1) COMPLETE SYSTEM.

(a) GENERAL.—In this airplane the brakes, cowl flaps and the chin turret gun charger are operated by the hydraulic system. In figure 278 it will be noted that pressure is supplied by an electric motor-driven pump regulated by a pressure cut-out switch. This switch automatically maintains the pressure in the accumulator between 600 and 800 pounds per square inch by closing the power circuit to the electric pump at the lower pressure and breaking the circuit at the higher pressure. If the pressure drops below 200 ± 25 pounds per square inch the circuit is automatically opened. In this event it will be necessary to over-ride the pressure switch momentarily by holding the hydraulic pump switch on the pilot's control panel in "MANUAL" position until the gage registers hydraulic pressure. Low temperature hydraulic hose with detachable fittings is provided on the landing gear and brake installation. The hose is in accordance with specification AN-H-6a, which calls for the following fittings: AN 796—Nipple—Hose to fitting (bulkhead), AN 797—Socket—Hose retaining, AN 798—Nipple—Hose to swivel fitting, AN 799—Nipple—Hose to fitting (gasket seal). The pump, filter, pressure switch, pressure relief valve, accumulator service valve, a check valve, and self-sealing couplings are mounted on a removable panel installed in the right rear portion of the control cabin. A hand pump is provided on the right sidewall at the copilot's station, and is used only for building up pressure during ground service operation. The brakes and cowl flaps utilize the same tubes for pressure and return flow. Air is bled from the cowl flap lines during the functional test operation. Bleeding of the brake lines is accomplished by several complete applications and releases, permitting the displaced air to rise into the supply tank, which is vented to the atmosphere.

(b) REMOVAL AND DISASSEMBLY.—The removal and disassembly of the units in the hydraulic system require no special tools or operations except as indicated below. In general, the following precautions should be observed: Relieve the system pressure by opening the accumulator service valve on the removable panel. Cap all lines to the unit undergoing removal to prevent loss of fluid and arrange the component

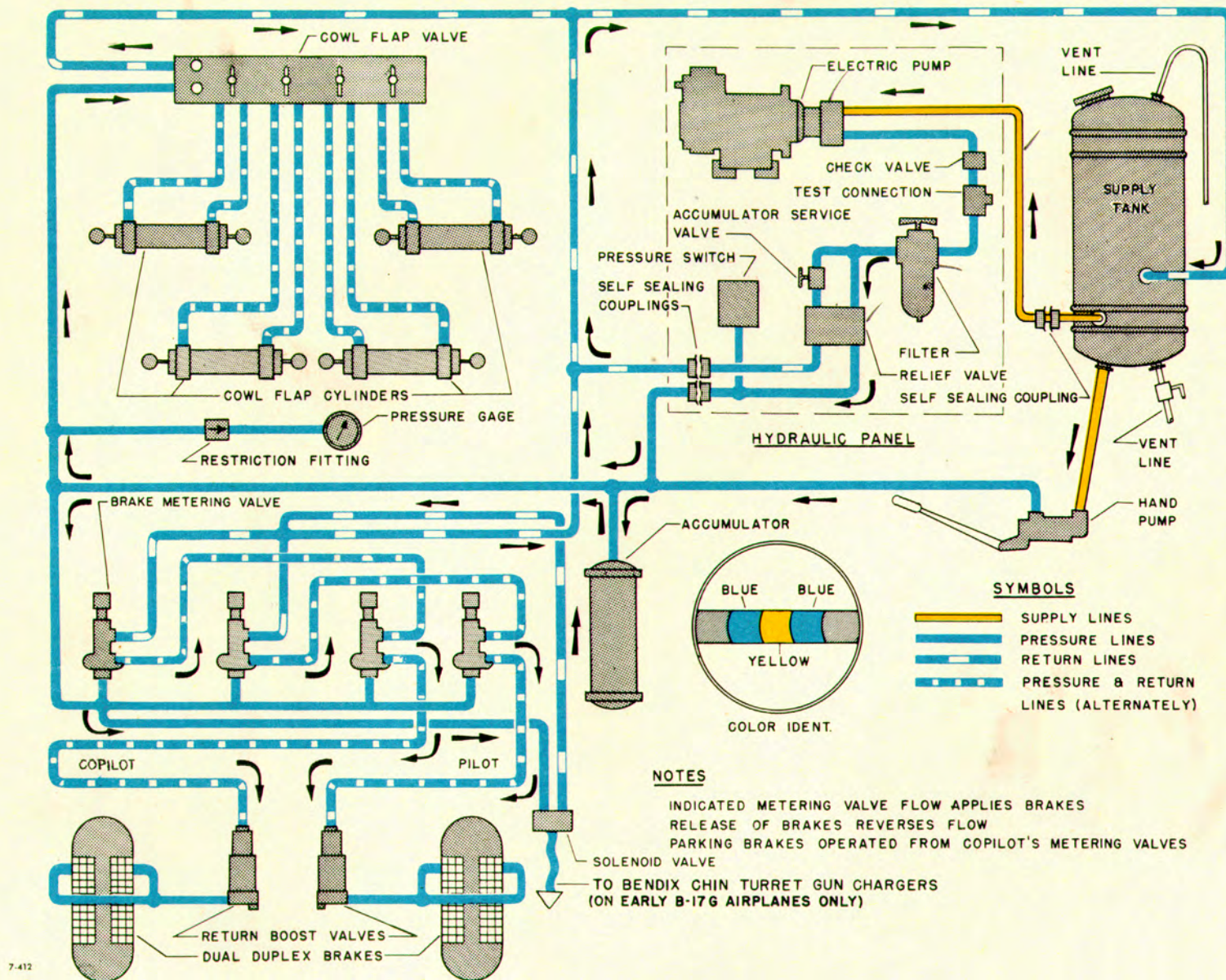


Figure 278—Hydraulic System Flow Diagram

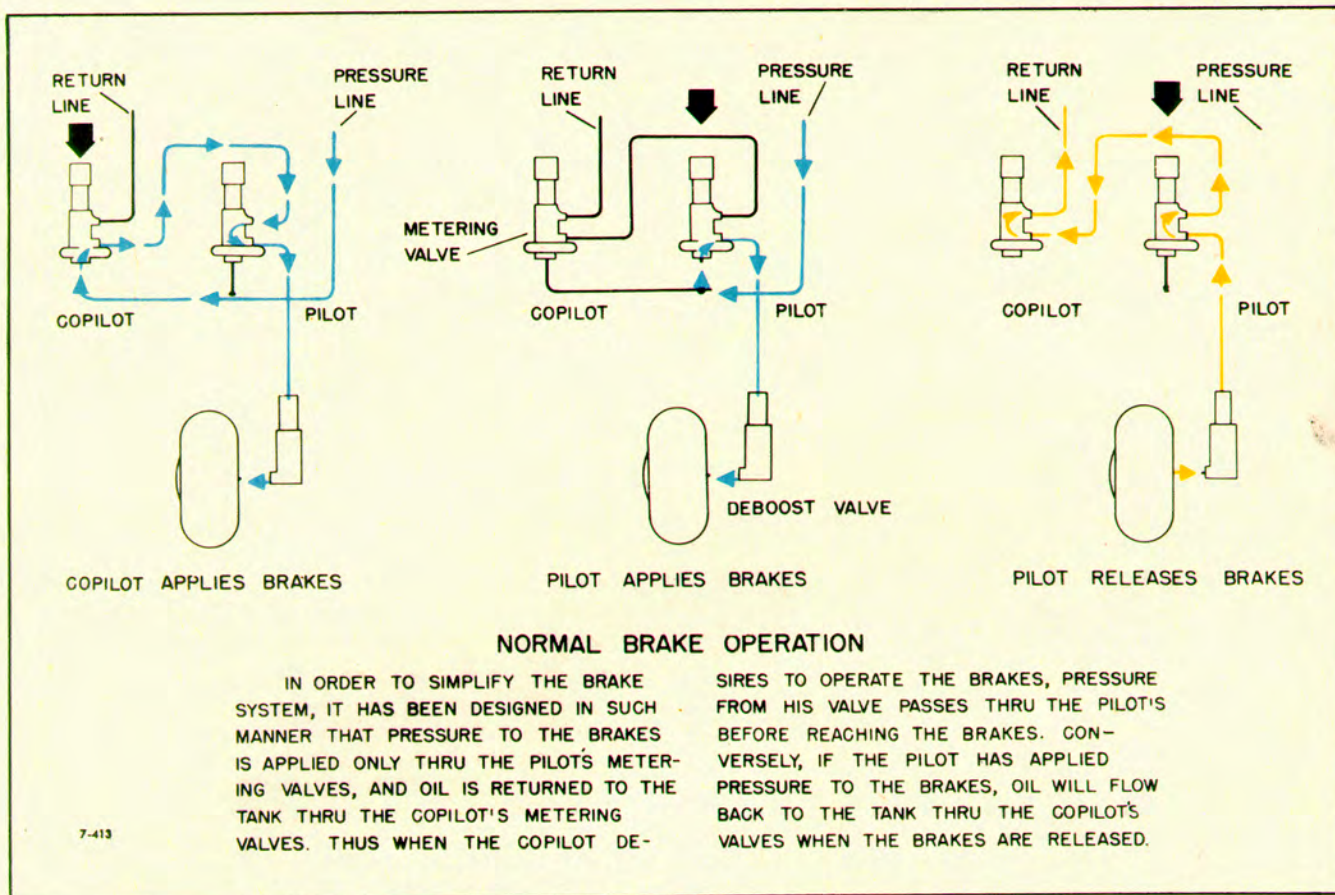


Figure 279—Brake Operation Diagram

parts of the unit definitely in the sequence in which they were removed from the assembly.

(c) MINOR REPAIR AND REPLACEMENT.

1. Throughout the hydraulic system the only common malfunctioning is due to chipped, deteriorated, or worn packing, foreign matter collecting on valves, and checks or possible improper seating of ball check valves. In rare cases springs may lose tension, but this is unlikely. Repair instructions are given only for units for which service operations were found desirable by past experience, or units for which special tools or special precautions are necessary. All parts should be thoroughly cleaned before replacement. At disassembly of any unit, all packing should be replaced as a precautionary measure, since the actual replacement time is small compared with the time required to bleed the system and correct any malfunctioning caused by faulty packing. New packing should be wrapped in heavy, moisture-proof paper and stored in a cool, dry location.

2. Improper ball seatings may be detected by removing oil and foreign matter from the seat and turning a bright light on the opening. Proper seating will be observed by a continuously bright ring around the periphery of the seat. Hairline cracks or roughness may be removed and proper seating accomplished by lightly tapping the ball against the seat. Do not tap

the ball with any hard material, or abrasion or scoring will render it useless.

(d) INSTALLATION.—Install the complete system as shown in figure 280, and the mechanism operating units as shown in the applicable system diagrams.

1. The following precautions are to be taken in operating, testing, flushing, and adjusting individual units of the hydraulic system:

- Use only clean hydraulic fluid, Specification AN-VV-O-336, (red color).
- All units and tubing must be kept free of dust, dirt, or foreign matter.
- Carefully protect tube fittings and dural threads from excessive tightening.
- A good grade of thread lubricant should be used sparingly for making connections to the units.
- After testing any unit it should be drained, leaving just sufficient fluid to prevent corrosion.
- Plug all ports immediately after test to prevent the entrance of foreign matter.
- If any unit of the hydraulic system remains in storage for a period exceeding 20 days after a functional test, it must receive a repetition of the prescribed test before installation.

2. Before circulating the fluid through the complete hydraulic system, perform the following:

a. Connect the auxiliary apparatus as shown in figure 282.

b. Open the accumulator service valve.

c. Inflate accumulator to 350 pounds per square inch air pressure only after following the instructions in 2. above.

d. Use hydraulic fluid, Specification No. AN-VV-O-366.

e. Set parking brake handle in "OFF" position.

f. Place all control levers on cowl flap control valve in the "LOCKED" position.

(e) ADJUSTMENTS.—All adjustments normally required may be made after installation of the system. However, some units are adjusted during manufacture and should not require attention until a major overhaul is necessary.

(f) FLUSHING THE HYDRAULIC SYSTEM.

1. SUPPLY TANK AND RELIEF VALVE.

a. With the auxiliary apparatus connected as shown in figure 282, and with the valve on the suction line closed and the valve to the fluid pressure reservoir open, attach a flexible hose to the system supply tank drain, lead hose into fluid reservoir and open drain cock.

b. Open accumulator service valve.

c. Circulate fluid with the auxiliary pump, using the auxiliary fluid supply until clear fluid flows freely from the tank drain flexible hose.

d. Close the accumulator service valve and build up system pressure to 900 pounds per square inch or until the relief valve relieves and fluid flows freely from the supply tank drain. Permit flow for 15 seconds.

e. Stop the auxiliary pump, open accumulator service valve, close supply tank drain cock after all the fluid has been drained from the tank, and disconnect the flexible hose.

2. HAND PUMP, BRAKE PEDAL, AND BRAKE LINES.

a. Disconnect the flexible hoses leading from the deboost valves to the wheels at the wheel connection, and lead into the fluid reservoir of the auxiliary apparatus. If desired, these hoses may be led into clean containers and the fluid returned to the supply tank after flushing the brake lines.

b. Set the parking brake handle in the "ON" position.

c. Fill the system supply tank with clean hydraulic fluid, Specification No. AN-VV-O-366.

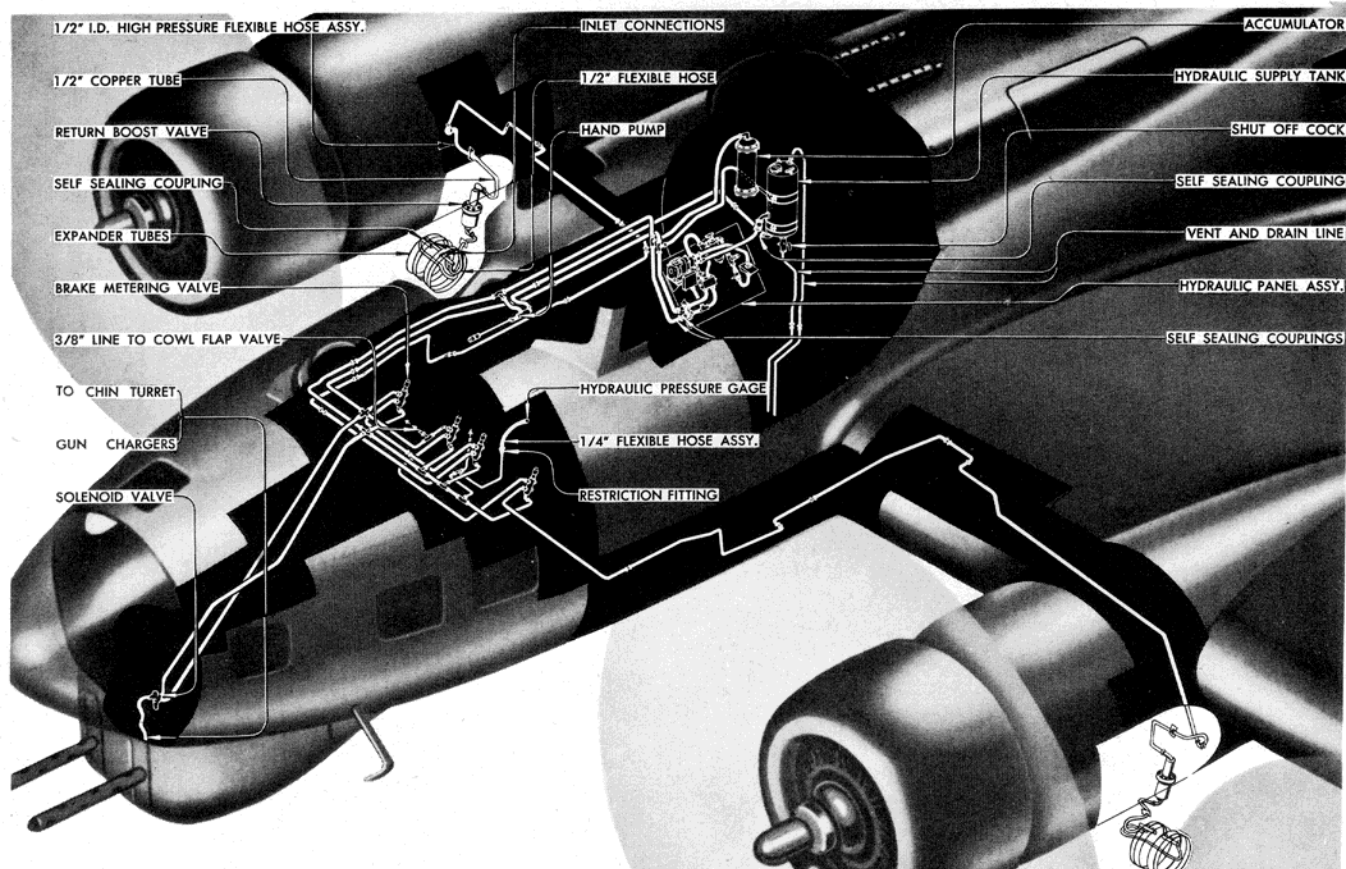


Figure 280—Hydraulic System Diagram