assembly has a selector valve and housing with its allied functional parts; whereas, the control valve for Twins and Quads has a master selector valve to control all engines of the power unit simultaneously, and a separate shut-off valve for each engine.

Being familiar with the operation of the control valve for Twins and Quads, the operation of a like unit for the single engine is readily apparent. Therefore, the operation for the former only is discussed herein.

For the sake of simplicity, this discussion will be confined to what transpires inside of the control valve for application of the forward or the reverse drive clutches and when in neutral for one engine only, the events being the same on the other engines.

Forward Drive—Control Valve—Bearing in mind that tube "A" admits oil to operate the forward drive clutch, tube "C" admits oil to operate the reverse drive clutch, and tube "B" is always open for lubrication; then, with cut-off valve (162) in operating position (control lever (180) straight up) and selector valve (156) set for forward drive, as shown in Fig. 17, oil under pump pressure is admitted to the control valve at opening "E", then to a recess "F" in housing (155) registering with a recess "G" in the selector, thence inside the hollow selector. A cross bore in the selector valve (156) and one in the cut-off valve (162) registers with a passage in the housing to admit oil under pressure out through tube "A" and to the forward drive clutch.

When the selector valve is set for forward clutch operation, tube "B" is open to lubricate the gear box, and tube "C"—for reverse drive clutch—bleeds back through the cut-off valve, through a recess in the selector valve and openings in the valve housing, and then empties into the reverse gear.

Neutral—Control Valve—When the selector valve is set for neutral position, as shown in Fig. 18, tube "B" feeds oil under pressure to the reverse gear for

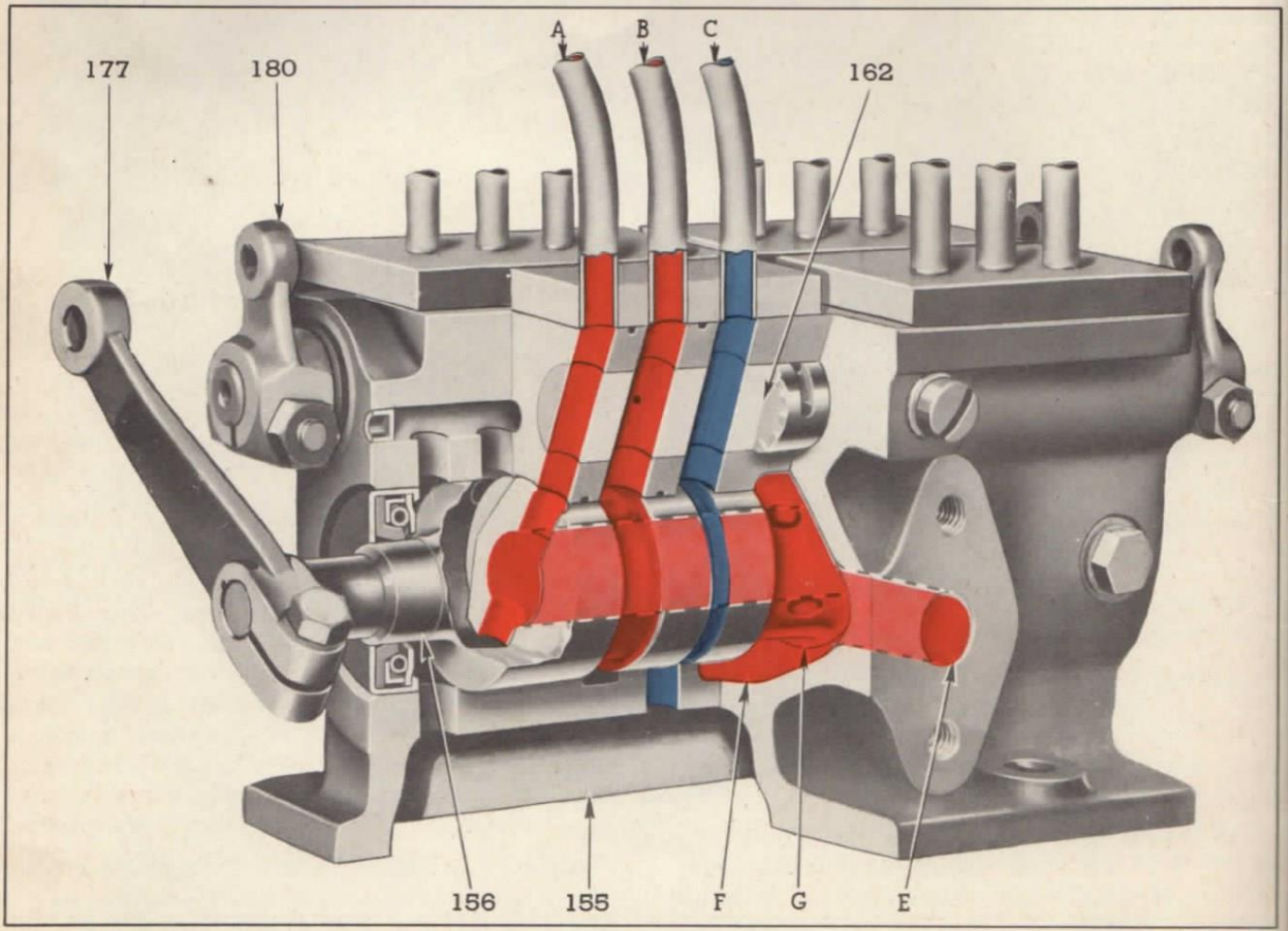

Fig. 17—Position of Selector and Shut-Off; Also Oil Flow Through Twin or Quad Control Valve for Forward Drive

155. Housing—Hydraulic Control Valve.
156. Selector—Control Valve.
162. Shut-Off—Control Valve.
177. Lever—Selector Control Valve.
180. Lever—Shut-Off.

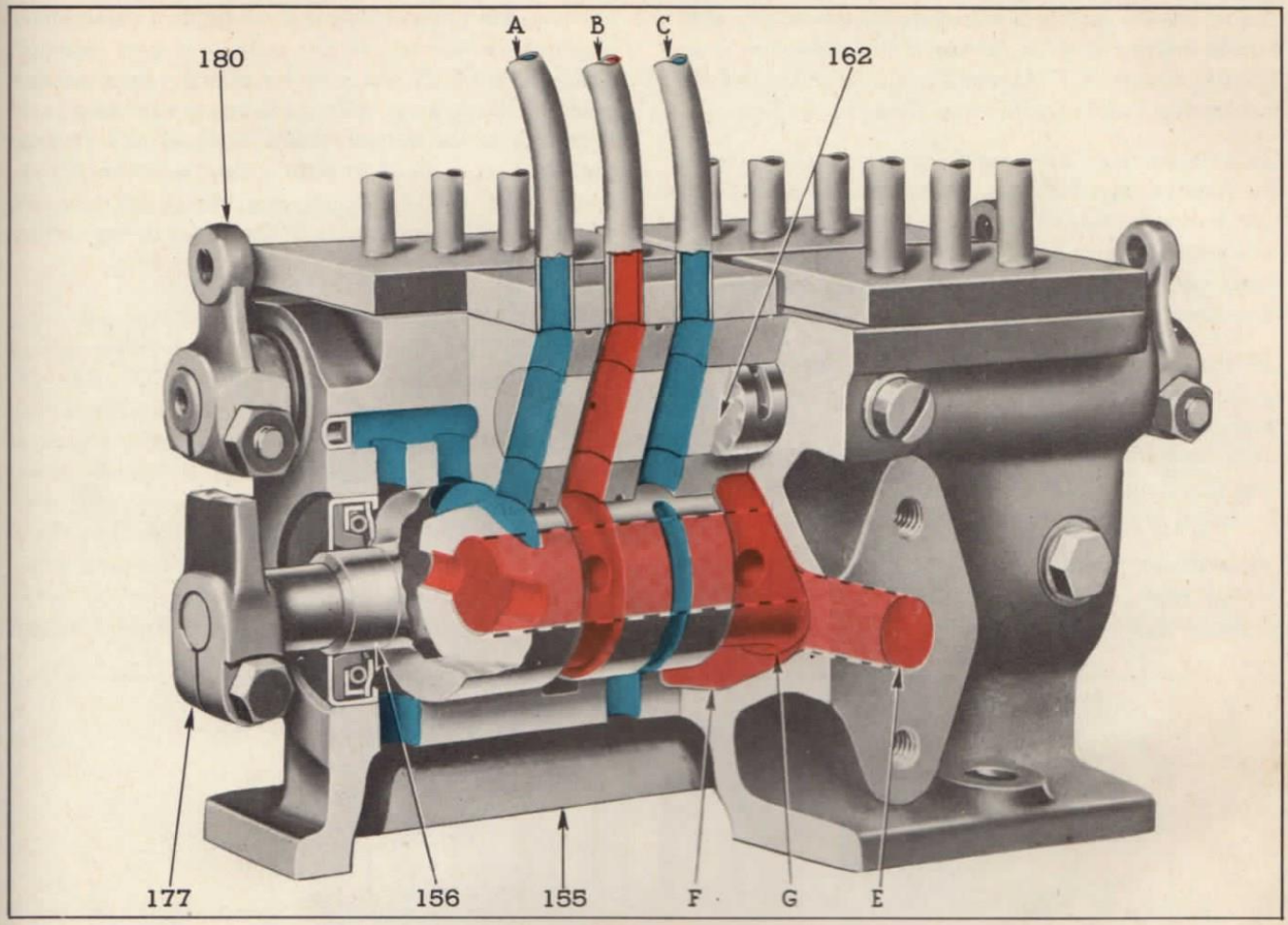

Fig. 18—Position of Selector and Shut-Off; Also Oil Flow Through Twin or Quad Control Valve in Neutral

155. Housing—Hydraulic Control Valve.
156. Selector—Control Valve.
162. Shut-Off—Control Valve (R.H.).
177. Lever—Selector Control Valve.
180. Lever—Shut-Off.

lubrication purposes and tubes "A" and "C" feed back into the reverse gear.

Reverse Drive—Control Valve—For reverse drive, oil is admitted to the selector valve in the same manner as for forward drive. Then, when the selector valve is moved to the reverse position, as shown in Fig. 19, oil under pump pressure flows through the selector valve and through passages in the housing and cut-off valve and out tube "C" to the reverse clutch.

When the valves are set for reverse position, tube "B" is still lubricating and tube "A", for the forward drive clutch, bleeds back through the cut-off valve, through a slot in the selector valve, through vertical and horizontal passages in the housing and then empties into the reverse gear.

Operation—Oil Supply from Sump Through Pump and Control Valve and Return to Sump

Fig. 20 represents the oil flow to the control valve and the scavenging of the reverse gear by the flywheel for the direct drive Hydraulic Reverse Gear.

When the **Direct Drive** Hydraulic unit is attached to the engine, oil for operating the reverse gear clutches is supplied from the engine oil pan. Oil is drawn by the pump (225) from inside a screen (22) through a pipe (221) leading into the engine cylinder block. A second pipe (222) connects the oil passage in the cylinder block and the oil pump intake. Still another pipe (223) connects the oil pump outlet with the control valve (227) mounted on the reverse gear housing (57). Bleed back from the control valve of those passages not carrying oil under pump pressure, returns to the sump at the bottom of the flywheel housing (1).

Oil that accumulates in the sump is picked up by the flywheel (2) and thrown out a scoop (152) mounted on the reverse gear housing over the flywheel. From the scoop the oil is forced through a pipe (224) and back into the engine oil pan.

The oil supply for the **Hydraulic Reverse** and **Reduction Gear** is at the bottom of the reduction gear housing. Pump (225) draws the oil from this supply to operate the hydraulic clutches. (See Fig. 21.)

Oil is drawn from the sump through pipe (226) inside the reverse gear housing, then through pipe (228) outside the housing to the pump intake. A pipe (223) connects the pump outlet with the control valve (227). Bleed back from the control valve spills into the reverse gear and returns to the sump.

On the Twin and Quad Hydraulic Reverse Gear applications, the hydraulic unit is sandwiched between the engine and a gear reduction unit which is bolted to the hydraulic reverse gear housing. Oil flow from the sump and back to sump for this hook-up is illustrated in Fig. 22.

Oil is drawn from the sump in the reduction gear through pipe (231) which connects to the intake of the oil pump (225). A second oil pipe (223) is connected between the pump outlet and the control valve (227) mounted on the top of the reduction gear housing (232). Surplus oil not used for clutch operation and pressure lubrication, spills back into the reverse gear. A trough at the bottom of the flywheel and reverse gear housings connects with a duct between the reverse gear and reduction gear housings through which the oil flows back into the sump in the reduction gear.

LUBRICATION—Lubrication of the Hydraulic Reverse and Reduction Gears is partly by pressure and partly by splash. The central oil passage "B", Figs. 13, 14, and 15 is open to oil pump pressure whenever the engine is running, and, when the reverse clutch is engaged, an oil hole in passage "C" sprays oil, under pressure, on the reverse planet. The reduction gear housing of the Hydraulic Reverse and Reduction Gear has an oil sump at the bottom of the housing fitted with an oil bayonet gauge to indicate the oil level. **The Oil Bayonet on These Units Must Always**

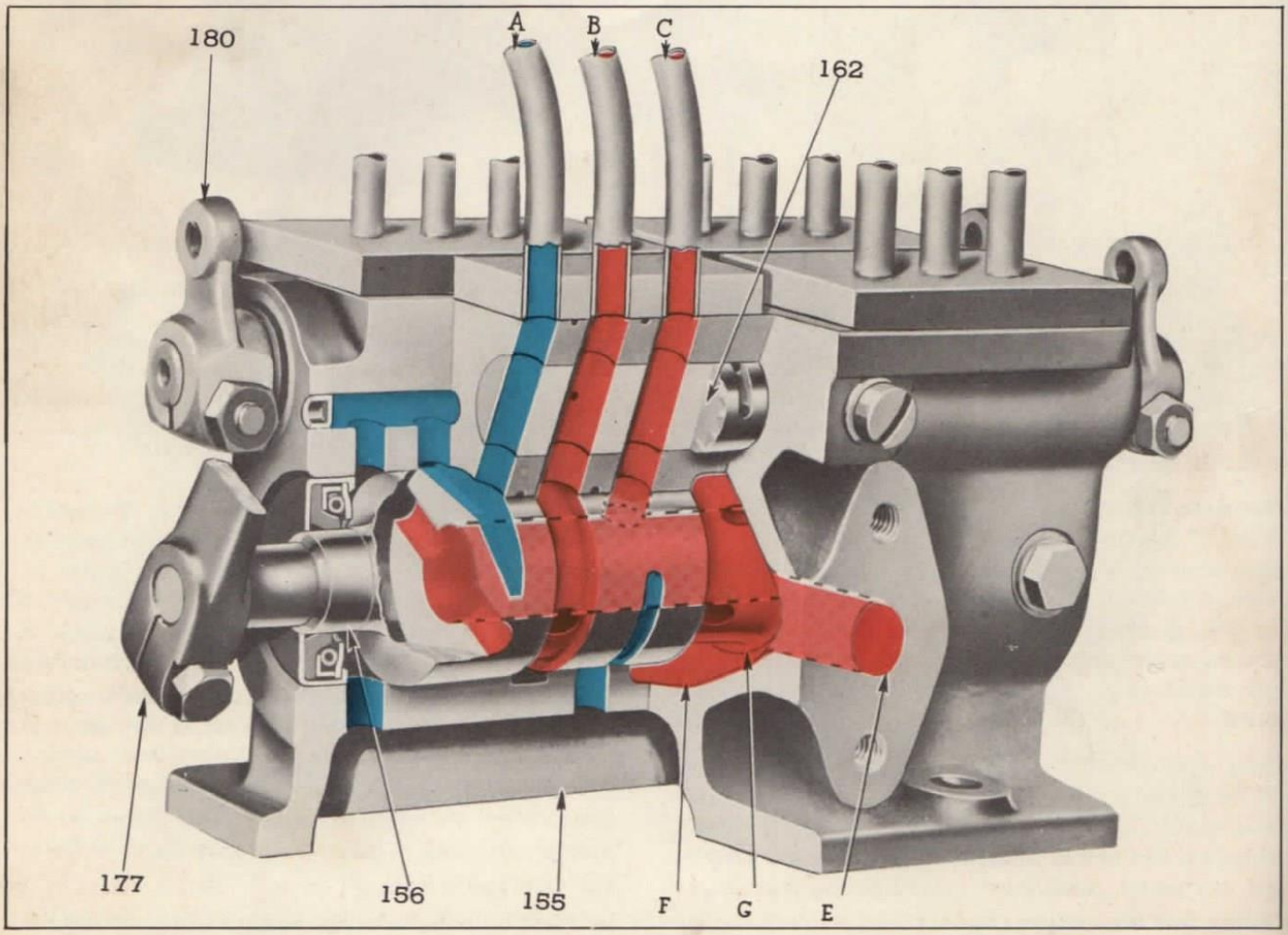

Fig. 19—Position of Selector and Shut-Off; Also Oil Flow Through Twin or Quad Control Valve for Reverse Drive

155. Housing—Hydraulic Control Valve.
156. Selector—Control Valve.
162. Shut-Off—Control Valve.
177. Lever—Selector Control Valve.
180. Lever—Shut-Off.

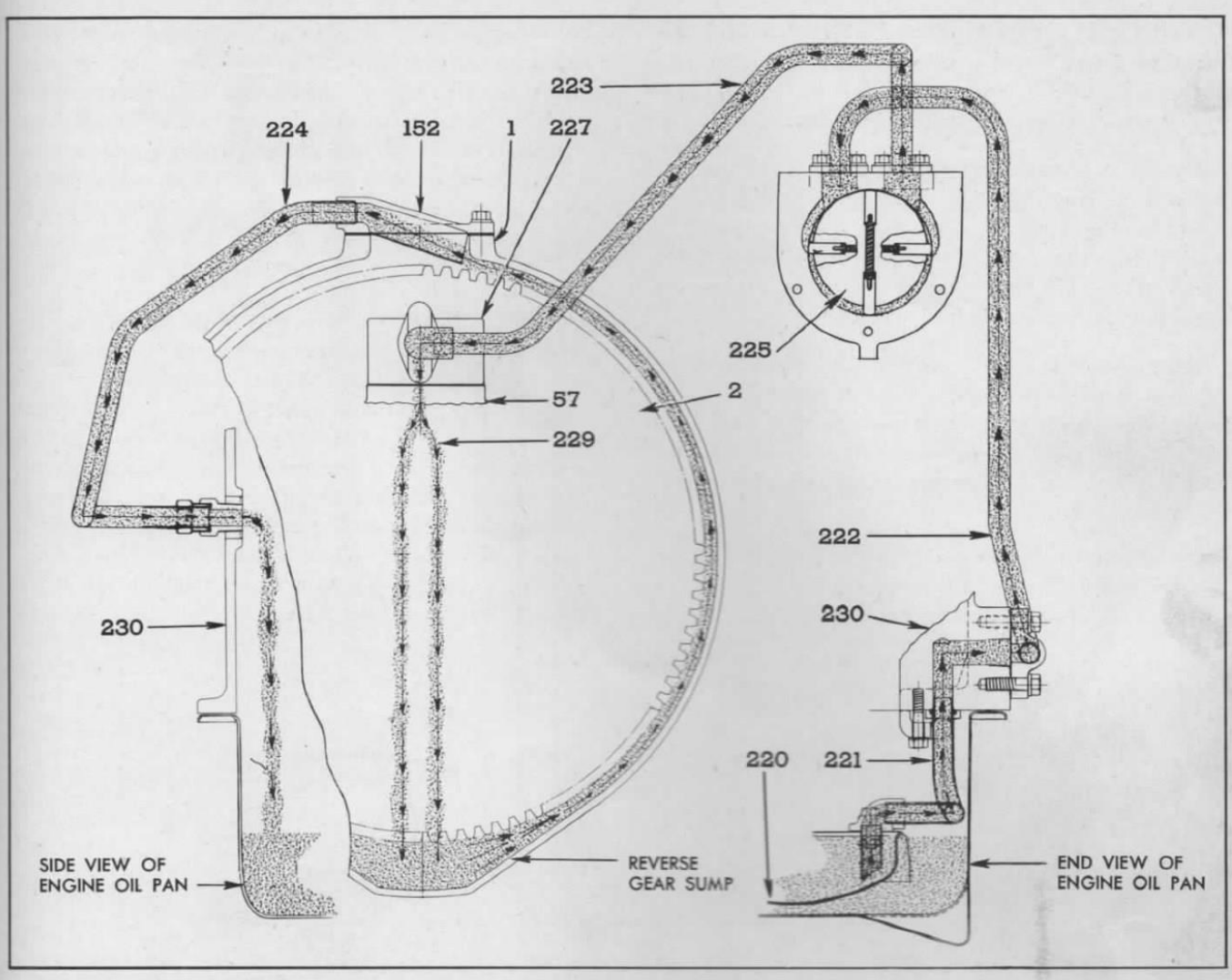

Fig. 20—Oil Flow Diagram from Engine Oil Pan Through Pump and Control Valve, Scavenge of Reverse Gear and Return to Engine Oil Pan for Single Engine With Direct Drive Hydraulic Reverse Gear

1. Flywheel Housing.
2. Flywheel.
57. Housing Assembly—Reverse and Reduction Gear.
152. Scoop—Scavenging.
220. Screen—Oil Pump.
221. Oil Pipe—Oil Pan to Cylinder Block.
222. Oil Pipe—Cylinder Block to Hydraulic Oil Pump Intake.
223. Oil Pipe—Hydraulic Oil Pump to Control Valve.
224. Oil Pipe—Return from Scavenging Scoop to Crankcase.
225. Oil Pump—Hydraulic.
227. Valve—Control.
229. Oil—Return from Control Valve to Reverse Gear.
230. Cylinder Block—Engine.

Be Located on the Side of the Gear Box Opposite to the Pump Suction Pipe.

On Twins and Quads the Reduction Gear—which is separate from but bolted to the Hydraulic Reverse Gear—is splash-lubricated with an oil sump at the bottom of the gear housing and an oil bayonet gauge to indicate the oil level. On these Twins and Quads, this one oil bayonet serves for the entire gear set, as oil from the reverse gear flows into the reduction gear housing.

Since the oil supply for the **Direct Drive Hydraulic Reverse Gear** is contained in the engine oil pan, the engine oil bayonet gauge will indicate the oil level. **Oil Level Should Be Maintained as Nearly as Possible to the "HIGH" Mark on the Bayonet Oil Gauge At All Times and Should Never Be Allowed to Drop Below the "LOW" Level.**

The Hydraulic Reverse and Reduction Gears, as well as the reduction gears on Twin and Quad units, are lubricated with the same oil as the Diesel engine at the prevailing outside temperatures (See "Lubricating Oil Specifications", on page 46).

Oil level should be checked at each change of shifts or daily as the case may be. On those units having the

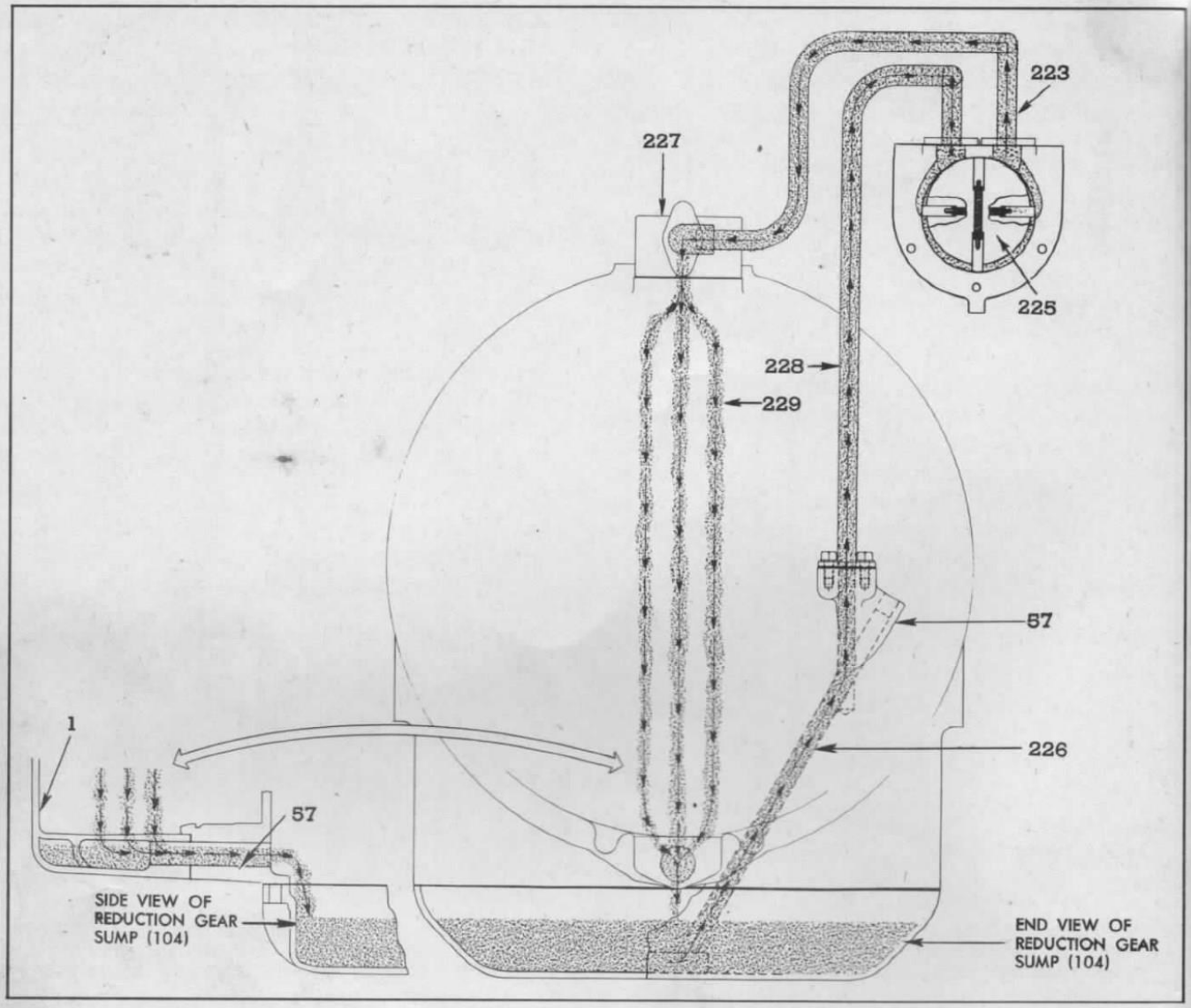

Fig. 21—Oil Flow Diagram from Sump in Reduction Gear Through Pump and Control Valve and Return to Sump in Reduction Gear for Single Engine with Hydraulic Reverse and Reduction Gear

1. Flywheel Housing.
57. Housing Assembly—Reverse and Reduction Gear.
223. Oil Pipe—Hydraulic Oil Pump to Control Valve.
225. Oil Pump—Hydraulic.
226. Oil Pipe—Reduction Gear Sump.
227. Valve—Control.
228. Oil Pipe—Reverse and Reduction Gear Housing to Oil Pump.
229. Oil—Return from Control Valve to Reverse Gear.

oil supply in the engine oil pan, **Stop the Engine When Checking Oil Level.** On units having the oil gauge stick in the gear box, de-clutch the engine or engines and stop the gears when checking the oil level.

Oil Removal—Engine—The frequency of oil change in the engine depends on the quality of the lubricant, the efficiency of filtration, and the severity of engine service.

In marine service, a change of oil each **200 hours** of operation is suggested when using recognized oils of the "Heavy-Duty" type.

Oil Renewal—Reverse and Reduction Gears when the oil supply is carried in the reduction gear housing—In these cases, a change of oil each **200 hours** is suggested to guard against accumulations of foreign matter which might choke oil passages and interfere with operation of the valves in the hydraulic system.

Every six months flush the gear case with light oil after draining to remove any accumulation of foreign matter.

Lubrication and care of the engine proper, other than the crankcase mentioned above, will follow the out-

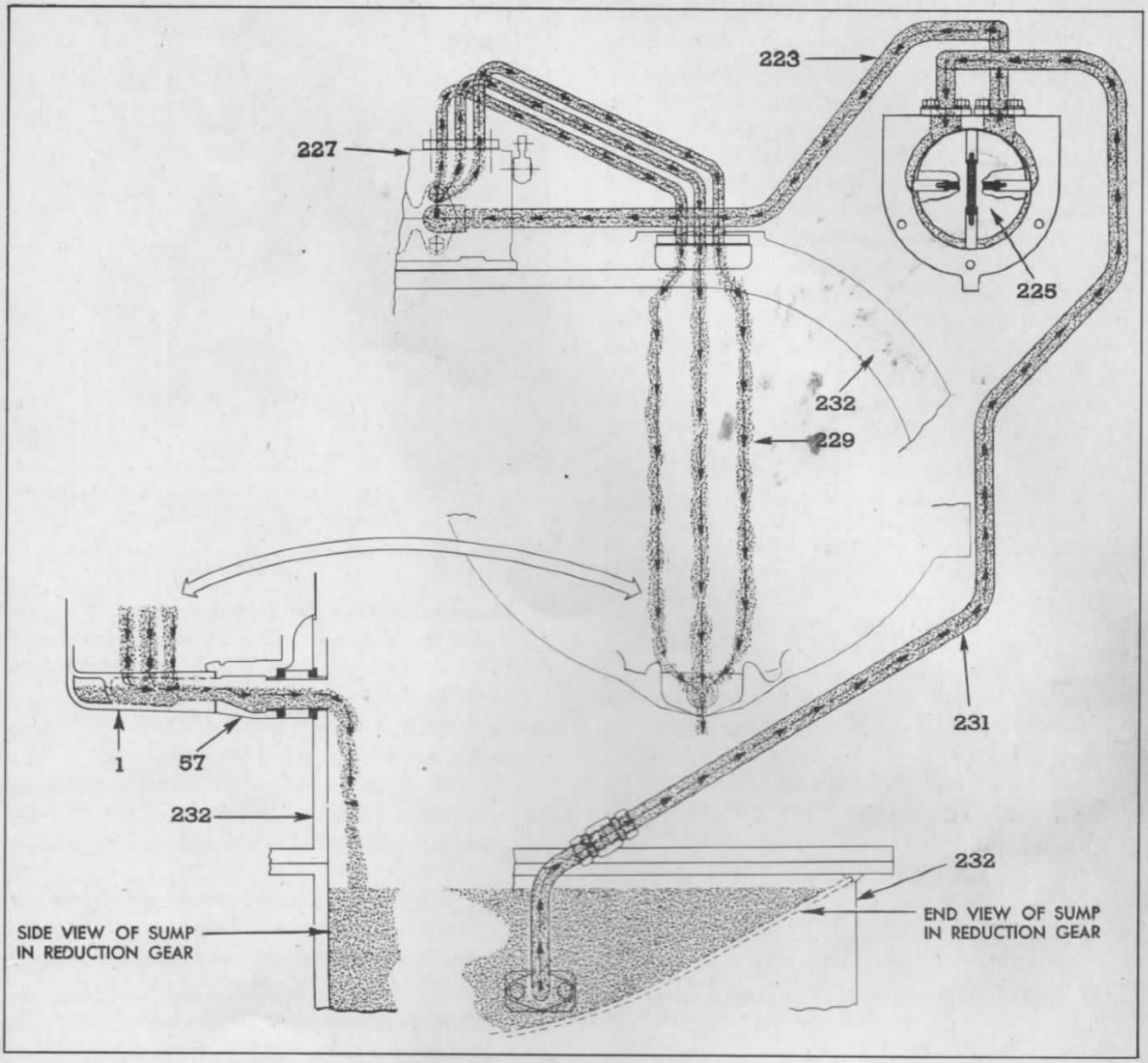

Fig. 22—Oil Flow Diagram from Sump in Reduction Gear Through Pump and Control Valve and Return to Reduction Gear

1. Flywheel Housing.
57. Housing Assembly—Reverse and Reduction Gear.
223. Oil Pipe—Hydraulic Oil Pump to Control Valve.
225. Oil Pump—Hydraulic.
227. Valve—Control.
229. Oil—Return from Control Valve to Reverse Gear.
231. Oil Pipe—Reduction Gear to Oil Pump.
232. Reduction Gear.

line in the "Lubrication Chart" of the Maintenance Manual for the 3, 4, and 6-71 engines.

SERVICE—Service operations outlined in this publication are those that fall within the scope of the Operator only. No attempt is made to deal with major repair operations. For major repairs, for the time being, see "Tentative Maintenance Instructions—Hydraulic Marine Reverse and Reduction Gears", Form DE-MHT. Complete maintenance procedure for the units shown herein will follow in the near future.

Service Items of Importance to the Operator Are:

1. **Check oil level daily.**
2. Keep the oil clean. Drain the engine crankcase and replenish with the specified lubricant as called for in "Lubrication" above. Recondition lubricating oil filters at each engine oil change. Where oil supply for the Hydraulic Reverse-Reduction Gear is contained in the reduction gear housing, remove

sediment from the sump after draining and before replenishing with oil.

3. A wise practice when changing the crankcase oil, particularly for the first few drainings on a new unit, is to remove the dump valve (23), Fig. 4, and wash the valve and the valve cover (24) in fuel oil, then replace. To remove the valve, see that engine throttle is in the STOP position, then: (a) remove the hand hole cover from the flywheel housing at the top of the flywheel. (b) Unscrew bolt (26) and remove cover (24) that conceals the valve. (c) Pick the valve from the flywheel and wash in fuel oil. Also, wash valve cover in fuel oil. (d) Examine valve bore in flywheel for scoring and foreign matter. Check valve in bore for free movement. (e) Replace valve and covers.

   NOTE: *Do not revolve the flywheel after the valve cover is removed or the valve spring (22) will be dislocated.*

4. Check oil pipe fittings and bolts occasionally to guard against oil leaks in the hydraulic system. Figs. 18, 19, and 20 show the arrangement of the suction lines to the hydraulic oil pump. All joints on the suction side of the pump must be kept tight to prevent air being drawn into the oil stream. Air in the line will interfere with dump valve and clutch operation.

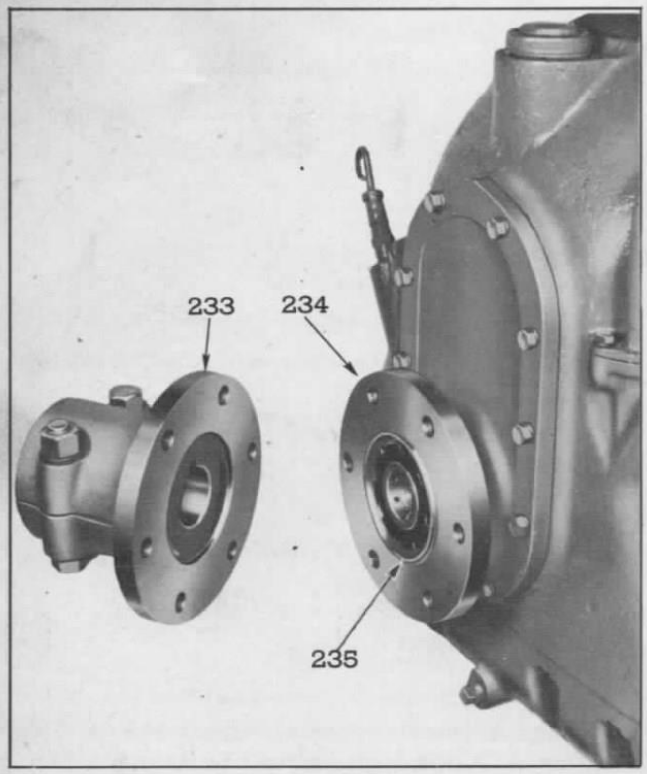

Fig. 23—Engine Shaft and Propeller Shaft Couplings

233. Propeller Shaft Half of Coupling.
234. Engine Half of Coupling.
235. Pilot.

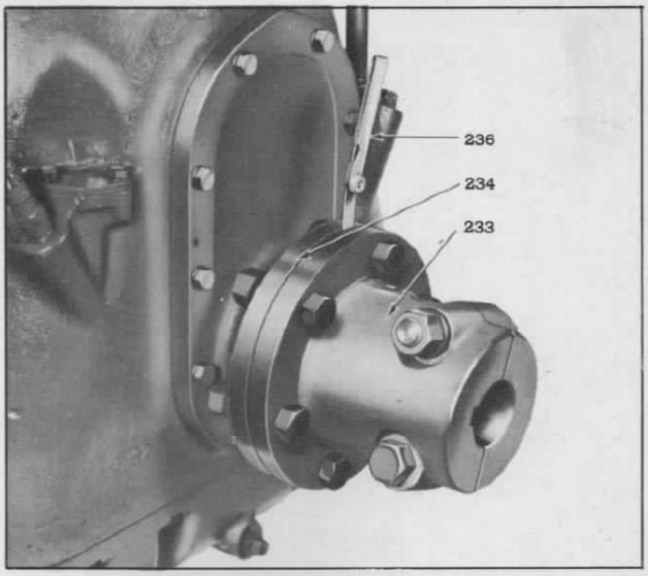

Fig. 24—Checking Engine to Propeller Shaft Coupling Alignment with Feeler Gauge

233. Propeller Shaft Half of Coupling.
234. Engine Half of Coupling.
236. Feeler Gauge.

5. ***Emergency Clutch Engagement***—If for any reason the clutches cannot be engaged hydraulically, the forward drive clutch may be engaged with six bolts (7), Fig. 6, as follows:
   (a) Remove a large pipe plug from the forward face of the flywheel housing (1).
   (b) With throttle set in STOP position, rotate the flywheel until one of the bolts (7), Fig. 6, aligns with the opening in the flywheel housing from which the plug was removed.
   (c) Remove bolt (7) being careful not to lose jam nut (8) when removing bolt.
   (d) Remove and save jam nut (8); then screw bolt back into flywheel ***finger-tight only.***
   (e) Remove the remaining five bolts (7) and jam nuts (8) in the same manner, then replace bolts finger-tight only.
   (f) Again starting on the first bolt, tighten all six bolts ***uniformly,*** thus locking clutch plate (12) between piston (9) and reaction plate (14). Replace pipe plug in flywheel housing.

   NOTE 1: *The six bolts (7) must be tightened uniformly to prevent bind between the close-fitting piston (9) and the bore in the flywheel.*

   NOTE 2: *On those units having reduction gears, whenever the forward clutch is engaged with the emergency bolts, at least one additional gallon of oil should be poured into the gear box to eliminate the possibility of overheating the gear box when the hydraulic oil pump is not running.*

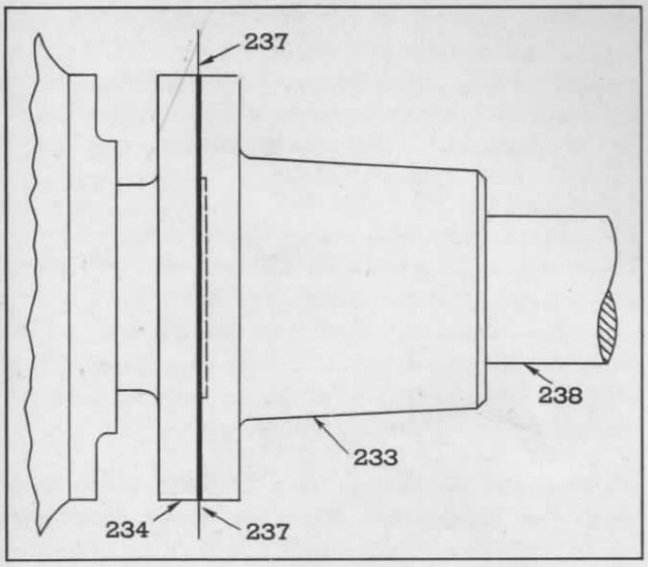

Fig. 25—Checking Engine to Propeller Shaft Alignment with Slips of Paper

233. Propeller Shaft Half of Coupling.
234. Engine Half of Coupling.
237. Slip of Paper.
238. Propeller Shaft.

INSTALLATION

Alignment between the engine and the propeller shaft is extremely important. Also, on twin engine installations, where the engine and reduction gear unit are mounted on a base with the reverse gear sandwiched between the two, the alignment between the engine flywheel housing and the reverse gear is very important.

Engine Alignment—The engine must be properly and exactly aligned with the propeller shaft. Misalignment between the engine and the propeller shaft is the source of difficulties which are often blamed on other causes. Misalignment will create excessive vibration, loss of power and speed, excessive bearing wear, rapid shaft wear, excessive wear and perhaps failure in the gear box, and reduce the life of the hull by loosening the hull fastenings. A bent propeller shaft will have exactly the same effect; it is therefore necessary to be very careful that the propeller shaft itself be perfectly straight.

Regardless of what material may be used to build the boat, the material will be flexible to some extent and the boat hull will change its shape to a greater extent than is usually realized after it is launched and operated in the water. Therefore, the engine alignment should be checked at frequent intervals and any misalignments corrected.

Propeller Coupling—The engine half of the propeller coupling is fitted with a male pilot (235), Fig. 23, which is carefully machined to be concentric with the bore. This pilot should slide easily into the counterbore in the propeller shaft half of the coupling when the engine is in proper alignment with the shaft. The engine must be so aligned that the two flanges meet exactly square and even. The after face of the engine coupling is machined accurately to be perpendicular to the plane of the engine shaft. This coupling can be distorted by a heavy blow and care should always be taken to prevent it being damaged. The engine should never be moved by using a crowbar or by prying against the engine coupling. If there is any question as to whether the after face of the engine coupling is true or not, this can be determined by using a dial gauge and rotating the coupling, or by using a feeler gauge and rotating the engine coupling against the propeller shaft coupling.

In case of misalignment, the engine should be moved on the bed and supported on the screwjacks or shims until the two halves of the coupling can be brought together without using force and so that the flanges meet evenly all around.

Never attempt a final alignment with the boat on land. The boat should be in the water and have had an opportunity to soak up somewhat so as to be as close as possible to its final water form. It is best to do the alignment with the fuel and water tank about half full

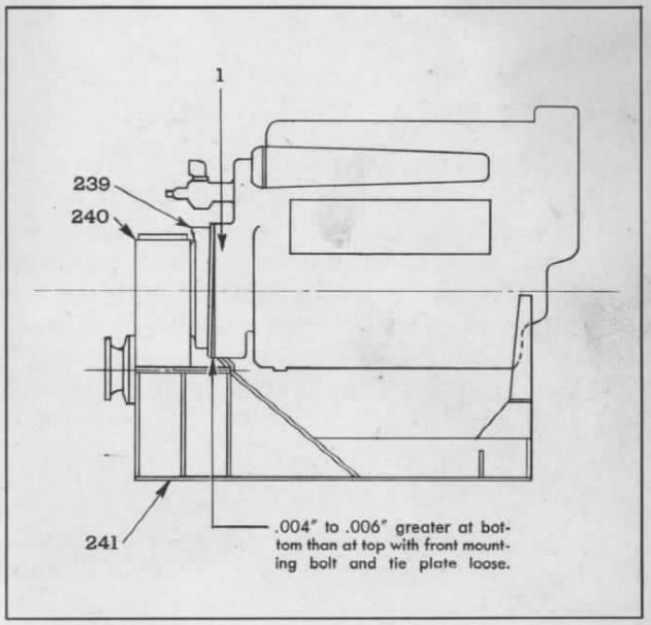

Fig. 26—Alignment Between Engine Flywheel and Hydraulic Reverse Gear Housings on Twin or Quad Engine Units

1. Flywheel Housing.
239. Reverse Gear Housing.
240. Reduction Gear.
241. Engine and Gear Box Base.

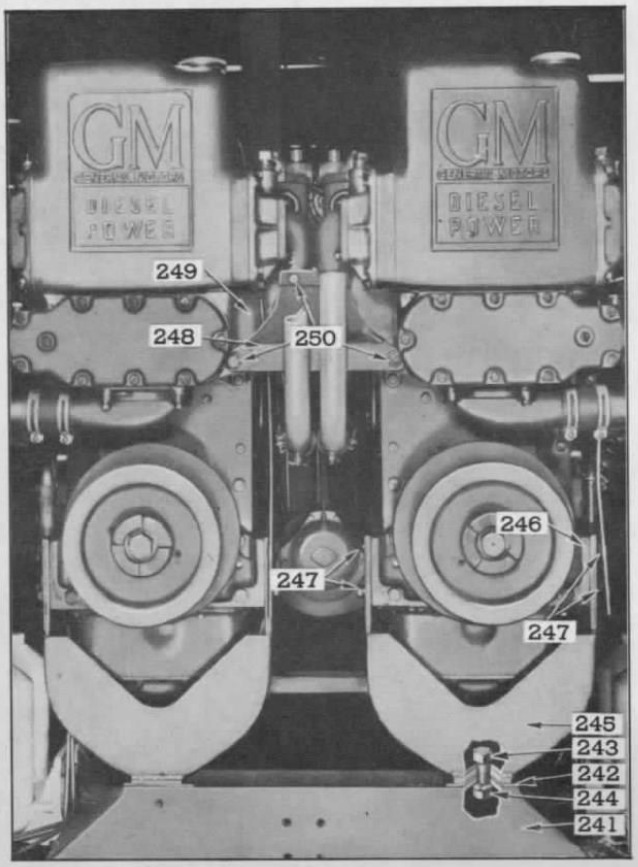

Fig. 27—Front Engine Mounting of Twin Marine Unit

241. Engine Base.
242. Shims.
243. Bolt.
244. Nut.
245. Bracket—Front Engine Mounting.
246. Crankshaft Front Cover.
247. Bolts.
248. Tie Plate.
249. Balance Weight Cover.
250. Bolts.

and all of the usual equipment on board. Take plenty of time in making this alignment and do not be satisfied with anything less than perfect results. The alignment is correct when the shaft can be slipped fore and aft with the pilot entering the propeller shaft half of the coupling very easily and when a feeler gauge indicates that the flanges come exactly together at all points. When using the feeler gauge, the spacing should be within .002" at all points around the circumference. (See Fig. 24.)

Another way to check the flange alignment is to use slips of paper between flanges as indicated in Fig. 25. Alignment is correct when the same pull is required to remove all pieces of paper when the coupling flanges are brought together.

In making the final check for alignment, the engine half of coupling should be held in one position and the alignment with the propeller coupling tested with the propeller coupling in each of four positions, rotated 90 degrees between each position. This last test will also check whether the propeller half of coupling is in exact alignment on its shaft. Then, keeping the propeller coupling in one position, the alignment should be checked rotating the engine half of coupling to four positions, each 90 degrees from the next one.

Sometimes the propeller half of coupling can be moved through quite a range up and down by hand. This is especially true when a flexible type of stuffing box is used at the inboard end or when there is considerable clearance between the stuffing box and the shaft. In such a case, the coupling end of the propeller shaft should be supported at approximately the middle position when making the alignment.

Alignment Between the Engine Flywheel and the Hydraulic Reverse Gear Housings on Twin or Quad units where the Hydraulic Reverse Gear is sandwiched between the engine and the reduction gear, should be as shown in Fig. 26. That is: The gap between the flywheel housing and the reverse gear should be from .004" to .006" greater at the bottom than at the top with the engine front mounting bolts and tie plate loose. Make this check as follows:

1. Refer to Fig. 27 and loosen the front mounting bolt (243) of the one engine being checked.
2. Loosen all four bolts (250) in tie plate (248).
3. Loosen all bolts between engine flywheel housing (1) and reverse gear housing (239), Fig. 26, until bolts are finger-tight only.
4. Install a .010" feeler between the flywheel housing and the reverse gear housing at opposite sides of housings and in a horizontal plane with the center line of the crankshaft. Tighten flywheel housing to reverse gear housing bolts just enough to hold shims in place.
5. Install sufficient shims between front mounting bracket (245) and engine base (241) so that space between the flywheel and reverse gear housings is .004" to .006" greater at the bottom than at the top, as shown in Fig. 26.
6. Remove shims from between flywheel and reverse gear housings and draw bolts tight.
7. Tighten front mounting bolt (243).
8. Repeat the above seven steps on the second engine.
9. Tighten tie plate bolts (250).

Raw Water Pipes must be properly installed and with no restrictions in the line. Use the full size pipe opening on the intake to the gear box. That is, do not use any reducers or other restrictions in the line.

ENGINE TUNE-UP PROCEDURE

From time to time the Operator will be called upon to make minor repairs and adjustments on the engine. Those operations that fall within the scope of the Operator and which are classified as "Tune-up Procedure" are:

I. Tracing a missing cylinder.

II. Remove an injector.

III. Install an injector.

IV. Check, and if necessary, adjust valve lash.

V. Time injectors.

VI. Set governor spring plunger gap.

VII. Position injector control racks.

VIII. Set governor no load top speed.

IX. Set governor idle speed screw.

X. Set governor buffer screw.

XI. Set governor speed control lever booster spring.

XII. Throttle adjustments for load equalization. (Twins and Quads.)

XIII. Adjust equalizer cross link.

I. TRACING A MISSING CYLINDER

(Cutting Out Injector)

One erratic or missing cylinder on a six-cylinder or twin engine unit is not easily detected when the engine is working at operating speeds. A periodic check of the injectors carried out as outlined below will show the presence and location of minor injector difficulties which may sometimes be "cleared" without removing the injector. A missing cylinder that is detected early and corrected may save costly repairs that can result from complications should the condition be allowed to continue.

To detect a missing or erratic cylinder:

1. Start engine and run until water and oil temperatures come up to the point reached during normal operation.
2. Stop engine and remove valve rocker cover. Unless exhaust valve lash is known to be correct, check the clearance on all valves and adjust to .012" (.011" "GO"—.013" "NO GO"). See page 21 for correct procedure.
3. Start engine and run at idle speed. If possible, have clutch engaged so engine will be under load.
4. Hold injector plunger of No. 1 cylinder down with a screwdriver as shown in Fig. 28, thus putting the injector out of operation. At the same time, note the tachometer for any difference in engine speed. If the cylinder is misfiring or the injector is not functioning properly, there will be no change in speed when the injector is put out of action. If the injector has been functioning properly, there will be a decrease in engine speed. Cutting out the cylinder in the manner described is similar to short-circuiting a spark plug on a gasoline engine.
5. If cylinder No. 1 proves to be firing properly, repeat the same procedure successively on all other cylinders until all have been tested.
6. If an injector is found to be firing poorly or not at all it may sometimes be "cleared" without removing by proceeding as follows:
   a. Keep engine running at idle speed (NO LOAD).
   b. Loosen both inner and outer adjusting screws (11 and 12, Fig. 33) on rack control lever of injector in question.

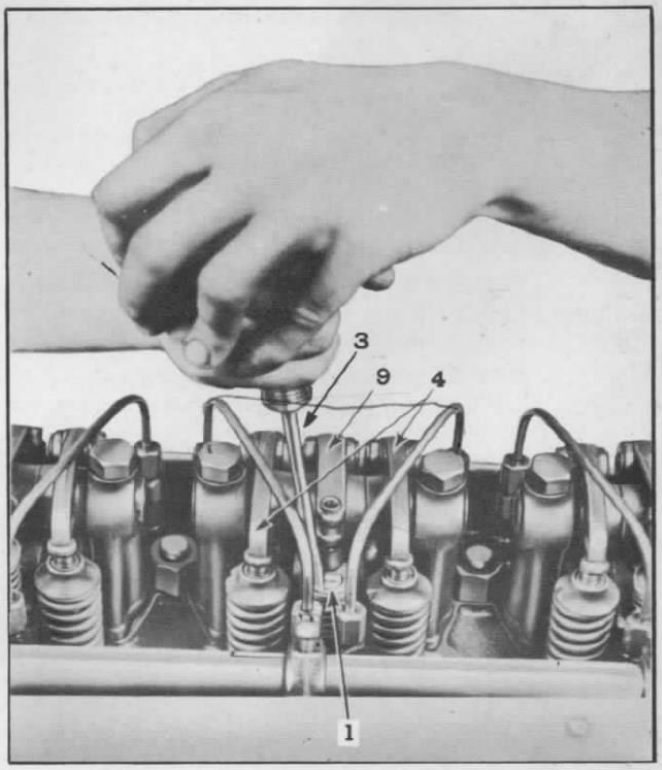

Fig. 28—Depressing Injector Follower with Screwdriver

1. Follower—Injector Plunger.
3. Screwdriver.
4. Arms—Valve Rocker.
9. Arm—Injector Rocker.

c. Hold injector rack way in (full fuel position) for an instant. If the injector "comes in", detonation will be heard, indicating a heavy fuel charge.

d. Stop engine and reposition control rack. (See page 37.)

7. If the injector cannot be "cleared" by the procedure outlined in item 6, it must then be removed and replaced with one known to be in good condition. Refer to the instructions below for removing and installing injectors.

II. REMOVE AN INJECTOR

When necessary, a fuel injector may be removed for inspection, repair, or replacement by following the procedure outlined below:

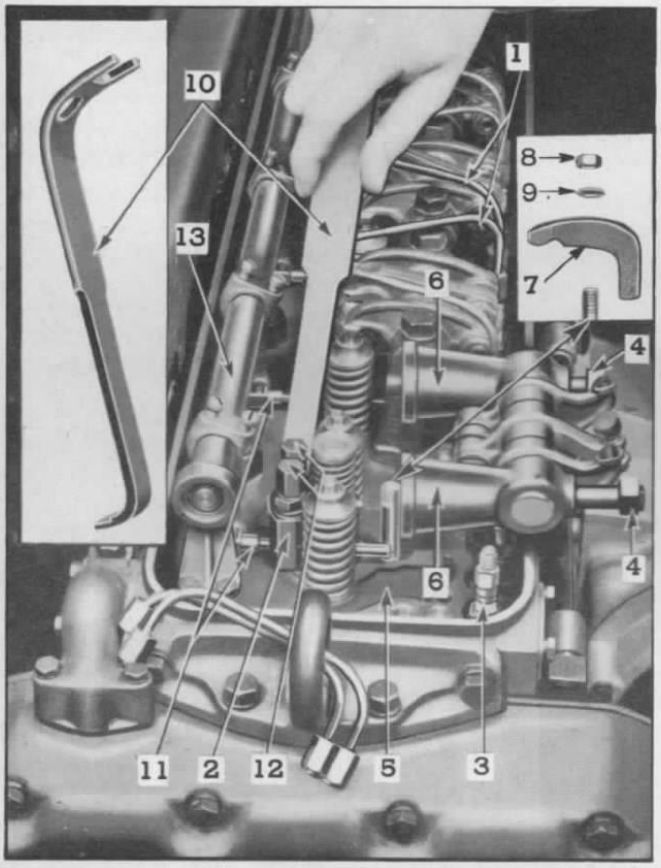

Fig. 29—Removing Injector from Cylinder Head with Tool J-1227-1

1. Fuel Lines.
2. Injector.
3. Fuel Connectors.
4. Bolts—Rocker Arm Shaft Bracket-to-Cylinder Head.
5. Cylinder Head.
6. Brackets—Rocker Arm Shaft.
7. Clamp—Injector Hold-down.
8. Nut—Injector Hold-down Stud.
9. Washer—Injector Hold-down Clamp.
10. Injector Removing Tool—J-1227-1.
11. Injector Control Rack.
12. Shipping Cap, No. 5226414.
13. Injector Control Tube.

1. Close fuel supply valve, if fuel level is above injectors.

2. Remove valve rocker cover.

3. Refer to Fig. 29 and remove fuel lines (1) from both the injector (2) and the fuel connectors (3).

NOTE: *Immediately after removal of the fuel lines from an injector, the two fuel feed fittings should be protected with the shipping cap, part number 5226414, to prevent dirt entering the injector.*

4. If necessary, crank the engine with the starter, or by hand, until the three rocker arm clevis pins—at outer end of rocker arms are in line.

NOTE: *When cranking the engine by hand (using a wrench on the retaining bolt at the front of the crankshaft), always turn it in a clockwise direction regardless of the engine's normal rotation. If the engine rotation is right-hand or counterclockwise (looking at water tank end), the firing order will be reversed when turning crankshaft clockwise.*

5. Loosen the two rocker arm bracket bolts (4) holding the brackets to the cylinder head (5) and swing the rocker arm assembly over away from valves and injector.

6. Remove injector hold-down stud nut (8), special washer (9) and injector clamp (7).

7. Using Tool J-1227-1, as illustrated in Fig. 29, pry injector from its seat.

8. Lift injector from seat; at the same time disengage the control rack linkage.

III. INSTALL AN INJECTOR

Supplied with an injector that has been tested and is known to be in first-class condition, refer to Fig. 29 and proceed to install it as outlined below.

1. Inspect the bore in the cylinder head into which injector is to be inserted. The inside of the copper tube should be clean; free from dirt, grit, oil or any particles which might keep the injector from sealing tight against the copper tube. The tube may be wiped clean with a cloth wrapped around a wood stick. Particular attention should be given to the beveled area just above the hole for the injector spray tip. At this point the seal is formed that keeps

compression pressure from escaping around the injector.

2. Set the injector into the tube with dowel of injector body entering into the small dowel hole in cylinder head and with the operating lug on the rack control lever engaging the coupling slot at the end of the injector rack.

3. Position injector clamp (7) over stud with forked end resting on injector body.

4. Set special washer (9) over stud with curved surface next to clamp and replace nut (8).

   CAUTION: 1. Be careful not to overstress clamp when tightening nut. If torque wrench is available, a 20 to 25 pound reading on the wrench is satisfactory; otherwise, use 40 pounds pull on a 6" wrench.

   CAUTION: 2. Injector rack must move freely after tightening nut.

5. Swing valve rocker assembly back into position and tighten bracket bolts (4).

6. Replace fuel lines (1).

7. Set operating lever on top of governor to the "STOP" position, thus throwing injector control tube and injector racks into the "NO FUEL" position. (Injector racks way out.) Adjust screws (11) and (12), Fig. 33, in rack control lever (8) of the injector, or injectors, just installed to bring the inner shoulder of the rack coupling (10) approximately $^{27}/_{32}$" distance from the injector body. This distance should be the same on all injectors, the one, or ones, just installed as well as the ones that have not been removed.

8. Valve lash on cylinders where the rocker mechanism was disturbed should be given a preliminary setting of .015" and then reset to .012" (.011" "GO"—.013" "NO GO") after engine has been started and reaches operating temperature. (See below.) Adjust the timing of the new injector, with correct timing gauge as outlined on page 21. If adjustment of valve clearance and injector timing was not carried out on all cylinders just before replacing the injector, proceed now to adjust valve lash and time injectors on the entire engine as outlined on pages 35 and 36.

9. Open fuel supply valve if it was closed. Do not replace valve rocker cover until after engine has been started and all fuel line connections have been checked for leaks.

10. Proceed to position injector control rack or racks as outlined on page 37.

IV. ADJUST VALVE LASH

(Clearance Between Valve Stem and Rocker)

Correct clearance between valve stem and valve operating rocker is especially important in a diesel engine because of the high compression pressure developed. Too little clearance will cause a loss of compression, a missing cylinder, and eventually, burned valves and valve seats. Too much clearance results in noisy operation of the engine, especially in the idling range.

The two valves over each cylinder of the Series 71 Diesel, open and close simultaneously to allow escape of exhaust gases. Consequently, all valves are adjusted to the same lash—.012" *with engine at operating temperature*. This clearance is correct when an .011" feeler will "GO" between valve stem and rocker and a .013" feeler will "NO GO" between valve stem and rocker.

When cylinder head has been removed, or valve rocker mechanism disturbed, lash valves to .015" with engines cold before starting by following the procedure outline in steps 2 and 3 below. After starting and warming up engines to operating temperatures, readjust valve clearance to .012" hot (.011" GO, .013" NO GO).

Adjustment of valve lash may be carried out as follows:

1. Shut down engine and leave throttle set in "STOP" position. Remove valve rocker cover.

2. Using a bar and socket on the front of the crankshaft or the starting motor, turn the engine until the *injector rocker arm* on the cylinder to be checked is fully depressing the injector plunger. Valves on this cylinder are now fully closed and in proper position for checking lash.

NOTE: *When cranking the engine by hand (using a wrench on the retaining bolt at the front of the crankshaft), always turn it in a clockwise direction regardless of the engine's normal rotation. If the engine rotation is left-hand or counterclockwise (looking at water tank end), the firing order will be reversed when turning crankshaft clockwise.*

3. Refer to Fig. 30 and loosen lock nut (3) just below the end clevises on each of the two valve push rods. Insert .011" feeler of gauge KMO-233-B (4) between end of valve stem and rocker and adjust clearance to a light contact with the feeler by turning push rod clockwise to increase clearance and counterclockwise to decrease clearance.

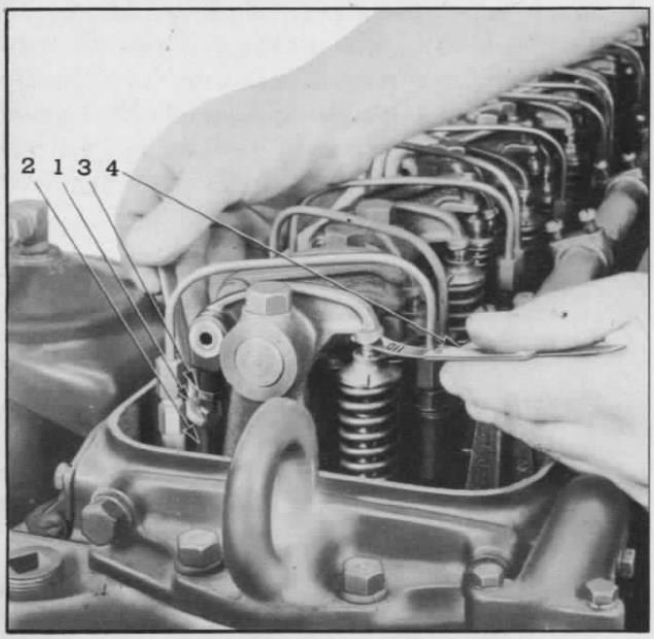

Fig. 30—Adjusting Valve Clearance

1. End Wrench—5/16".
2. Push Rod.
3. Push Rod Lock Nut.
4. Feeler Gauge.

Holding push rod from rotating, remove .011" feeler and try gap with .013" feeler. .013" feeler should be "NO GO". While still holding push rod, tighten lock nut and recheck lash with the two feelers to .011" "GO", .013" "NO GO".

4. Repeat steps 2 and 3 for the two valves on each cylinder. By taking cylinders in firing order, all can be checked while turning crankshaft only one revolution.

NOTE: *Whenever a push rod has been disconnected from the push rod clevis, the rod must be screwed back into the clevis until push rod end touches rocker arm before the valve lash is checked. If this is not done, the piston may hit the head of the valve when the engine is being turned, owing to the small clearance between the valves and piston head at the piston upper position.*

Before replacing the rocker cover, open the fuel supply valve, start the engine and inspect fuel line connections for leaks. Be sure fuel connections do not leak.

V. TIME FUEL INJECTORS

To insure fuel delivery to the cylinder at just the correct moment, the plunger follower of each injector must be adjusted to a definite position in relation to the injector body. If injectors are not properly "timed", engine operation will be "ragged" and power output will be reduced.

The injectors should be timed as follows:

1. Shut down engine and leave throttle control set in the "STOP" position.
2. Remove valve rocker cover.
3. Turn engine over with a bar and socket or with the starting motor until the exhaust valves of the cylinder to be timed are fully open. By taking the injectors in firing order, all may be timed by turning the crankshaft only *one* full revolution.

NOTE: *When cranking the engine by hand (using a wrench on the retaining bolt at the front of the crankshaft), always turn it in a clockwise direction regardless of the engine's normal rotation. If the engine rotation is left-hand or counterclockwise (looking at water tank end), the firing order will be reversed when turning crankshaft clockwise.*

4. Place the stem of the *correct* injector timing gauge (2), tool number J-1242 or J-1853, into the timing gauge hole bored in the top of the injector body.

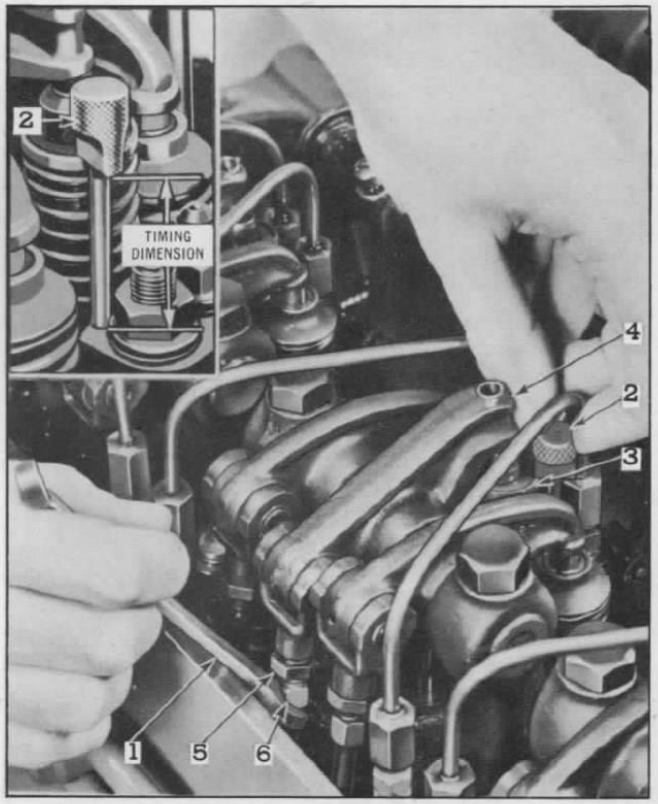

Fig. 31—Timing Fuel Injectors

1. Push Rod Adjusting Wrench.
2. Timing Gauge.
3. Injector Follower Guide.
4. Injector Rocker Arm.
5. Lock Nut—Push Rod.
6. Push Rod—Injector.

Injector Identification Tag	Gauge No.	Timing Dimension
Red 50 or Blue 60	J-1242	1.484″
Green 80	J-1853	1.460″

5. As illustrated in Fig. 31, adjust the position of the injector rocker arm (4) by means of the threaded adjustment on the upper end of the push rod (6) until the lowest surface of the timing gauge head (2), when rotated, will *just* pass over the top surface of the plunger follower guide (3). Tighten the lock nut on the push rod and recheck the setting. Timing gauge must be held perpendicular to top surface of the injector body.

VI. SET GOVERNOR SPRING PLUNGER GAP

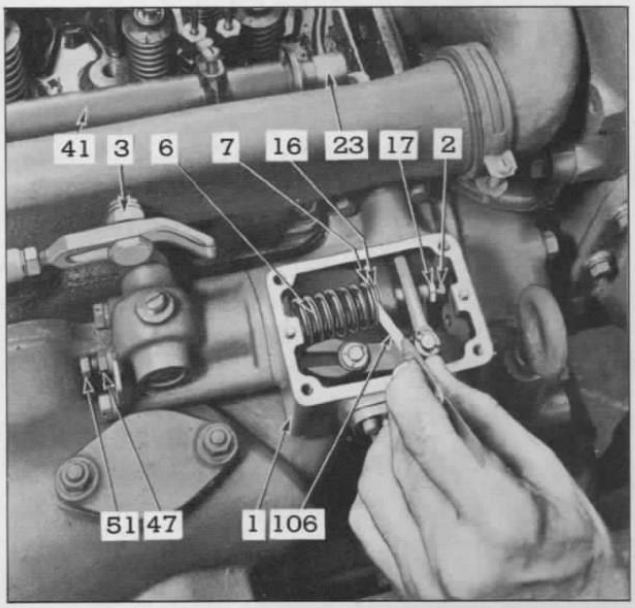

Fig. 32—Adjusting Spring Plunger Gap on Variable Speed Governor

1. Housing—Governor Control.
2. Screw—Gap Adjusting.
3. Lever—Speed Control.
6. Governor Spring.
7. Plunger—Governor Spring.
16. Guide—Governor Spring Plunger.
17. Lock Nut—Adjusting Screw.
23. Lever—Control Tube.
41. Tube—Injector Control.
47. Lock Nut—Idle Speed Screw.
51. Screw—Idle Speed Adjusting.
106. Feeler Gauge.

After checking valve lash and timing injectors, as outlined above, refer to Fig. 32 and adjust the governor spring plunger gap as follows:

1. With engine stopped, disconnect linkage to the governor shutdown lever (6), Fig. 33, and remove governor control housing cover assembly.
2. Secure the speed control lever (3) in the maximum speed position—all the way back.
3. With a feeler gauge, check clearance between shoulder of spring plunger (7) and plunger guide (16). This clearance should measure from .005″ to .007″.
4. If clearance is correct, install control housing cover. If adjustment of the gap is required, loosen gap adjusting screw lock nut (17) and turn gap adjusting screw (2) as required to establish clearance within the correct dimensions of .005″ to .007″. Tighten lock nut and recheck gap.
5. Replace control housing cover.
6. After adjusting the spring plunger gap, the injector racks must be positioned, as outlined below, to establish correct relationship between governor and injectors.

VII. POSITION INJECTOR CONTROL RACKS

After injectors have been installed in the engine, the control racks must be correctly positioned so that all cylinders carry an equal share of the load and so that the injector racks are in correct relationship with the governor. The amount of fuel injected into each cylinder is controlled by the position of the injector rack. The maximum amount of fuel is injected when the racks are all the way IN, and no fuel is injected when the racks are all the way OUT.

Two different conditions will arise when it will be necessary to position the injector control racks.

CONDITION I applies when one injector has been replaced and the engine was in good operating condition previous to such replacement. In this event, the valves should be lashed, injector timed, and the rack positioned on the cylinder involved to correspond with that of the other racks.

CONDITION II applies when more than one injector has been replaced; also, when cylinder head has been removed or the valve gear disturbed. For this condition, valves should be lashed, injectors timed, and racks positioned on all cylinders.

I. POSITION INJECTOR CONTROL RACK WHEN ONLY ONE INJECTOR HAS BEEN REPLACED.

If the remaining injectors or governor adjustments have not been disturbed, and the engine was in good working order otherwise, proceed as follows to position the injector rack:

1. Back off several turns (at least four) on both ad-

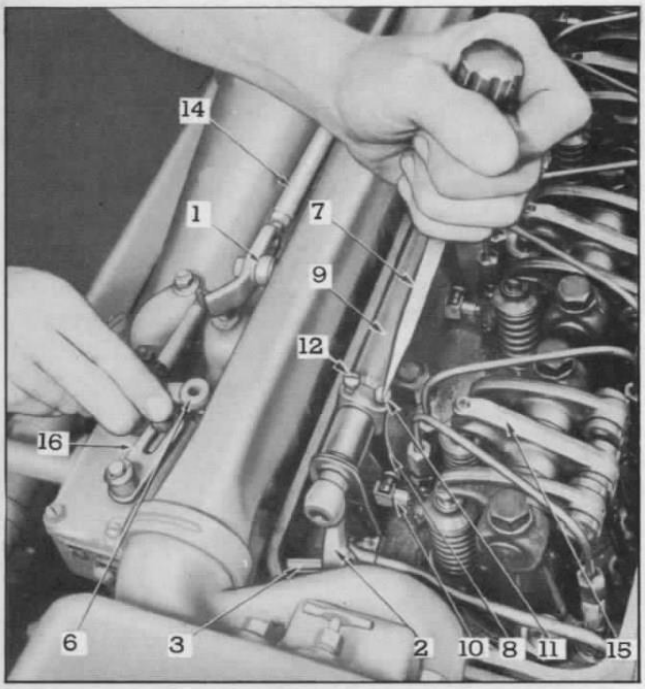

Fig. 33—Positioning Rack of No. 1 Injector on "Twin" Engine Equipped with Variable Speed Type Governor

1. Speed Control Lever.
2. Control Tube Lever.
3. Control Link.
6. Governor Control (Shutdown) Lever.
7. Screwdriver.
8. Rack Control Lever.
9. Control Tube.
10. Injector Rack.
11. Adjusting Screw—Inner.
12. Adjusting Screw—Outer.
14. Throttle Control Rod.
15. Injector Rocker Arm.
16. Slotted Cam.

justing screws (11) and (12) in rack control lever (8) at the injector being adjusted. (See Fig. 33.)

2. Secure the speed control lever (1) in the FULL OPEN position (all the way back), as shown in Fig. 33, and hold shutdown lever (6) in the RUN position at the end of the governor cam (16). Adjust rack control lever (8) to the FULL IN position, to correspond with that of the other injector racks, by slowly turning down inner adjusting screw (11) until injector rack can just be felt striking "bottom" and just before the racks of the other injectors start moving outward.

   Guard against moving the other injector racks OUT when positioning this one rack. Tighten outer adjusting screw (12) and then check as outlined in item 3 below.

3. While still holding the racks all the way IN, as outlined in item 2 above, check rack coupling (10) of injector in question for looseness, with the finger tips, or a similar method, and compare with the other injectors.

   Adjust rack coupling to the same degree of looseness as that felt at the other couplings by turning inner and outer screws (11) and (12) a very small amount.

II. POSITION INJECTOR CONTROL RACKS WHEN MORE THAN ONE INJECTOR HAS BEEN REPLACED IN THE ENGINE.

When more than one injector has been replaced in the engine, all injector racks must be correctly positioned so that each cylinder carries an equal share of the load and so that the injector racks are in correct relationship with the governor.

Since the governor spring mechanism is connected to the injector rack control tube through a link, *the governor spring plunger gap must be correctly set for the type of governor used to obtain full engine power.*

Position Injector Racks to Full Fuel Position (Engine not Running) As Follows:

1. After setting the governor spring plunger gap as outlined under "VI" above, refer to Fig. 33 and set the injector rack on No. 1 Cylinder by backing out governor buffer screw (4) until it projects about $\frac{5}{8}$" from the governor housing.

2. Back off several turns on both adjusting screws (11) and (12) of all rack control levers (8). Outer screw (12) on No. 1 lever should be backed off several additional turns. Be sure *all* levers are free to rotate on shaft.

3. Secure the speed control lever (1) in the FULL OPEN position (all the way back) as shown in Fig. 33. Place shutdown lever (6) in the OFF position.

4. Turn down inner adjusting screw (11) on No. 1 injector rack control lever (8) until screw "bottoms".

5. Move the governor shutdown lever (6) toward the RUN position at the end of the governor cam (16) as shown in Fig. 33. Do not force it past the point at which resistance to movement suddenly increases, but hold it at this point, pressing lightly toward the RUN position.

6. Back off the inner adjusting screw (11) on No. 1 injector rack control lever which will allow the shutdown lever (6) to move toward the RUN position. Continue backing out screw until the lever (6) just "bottoms" at the end of the governor cam.

7. Turn down *outer* adjusting screw (12) to lock rack control lever (8) in position. Tighten inner adjusting screw (11). This should accomplish the desired setting of No. 1 injector rack control lever (8).

8. Check the adjustment by holding the governor shutdown lever (6) in the RUN position (to aft end of slot in cam (16), as shown in Fig. 33), then note rotary movement of No. 1 injector rack to rack control lever (8).

a. If a light pressure of the finger tip shows the rack to be tight, and the governor shutdown lever (6) is free to travel to the extreme end of the slot in the governor cam (16) without encountering any step-up in resistance, *the rack control lever (8) has been properly adjusted.*

b. If a light pressure of the finger tip shows the injector rack to be tight and the governor shutdown lever (6) is not free to travel to the extreme end of the slot in cam (16), unless the step-up in resistance is overcome, the rack is too tight and the adjustment should be corrected by loosening the inner screw slightly and tightening the outer screw.

c. If a light pressure of the finger tip causes the rack coupling to rotate, the rack is too loose and the adjustment should be corrected by loosening the outer screw slightly and tightening the inner screw. *Once set, do not change the adjustment on No. 1 cylinder rack when adjusting the remaining injector racks.*

9. *Adjust Remaining Racks to FULL FUEL Position by:*

(a) Secure the governor shutdown lever (6) in the RUN position.

(b) Adjust No. 2 injector rack by turning down inner adjusting screw (11) while finger tip is touching No. 2 injector rack coupling. When coupling loses its rotary movement, tighten outer screw (12) and relock with inner screw (11).

(c) Compare No. 2 and No. 1 rack couplings with finger tip for tightness or looseness. If No. 1 rack feels loose, No. 2 rack is too tight. If No. 2 rack feels loose, it should be tightened. Always correct the condition by adjusting the No. 2 rack.

(d) When No. 2 rack coupling feels the same as No. 1, repeat procedure (b) and (c) on the remaining injector racks. That is, compare No. 3 rack with No. 1, etc.

(e) Reconnect linkage to the governor control lever (6).

NOTE: *If the Tune-up procedure is being carried out on a single engine unit, proceed to set the governor idle speed screw and the buffer screw as outlined in items IX and X below after positioning the injector control racks, thus completing the tune-up procedure. If the tune-up is being carried out on twin or quad units, proceed with items VIII, IX, X, XI, XII and XIII as outlined.*

VIII. SET GOVERNOR NO LOAD TOP SPEED (ENGINES RUNNING—EQUALIZER CROSS LINK DISCONNECTED)

Even though the no load top speeds of the governors on twin and quad Marine propulsion units are set before the units leave the factory, should a governor replacement be made, the no load top speed of the governors should be set after the governor replacement. To set the no load top speed:

1. Start and warm engines up to operating temperature.
2. With clutch disengaged place and hold the individual throttle lever (5) of the "B" engine in its full throttle position. (See Fig. 37.)
3. Check and record the tachometer engine speed, which should read approximately 1985 RPM.
4. If top speed is lower than 1975 RPM, remove the control lever housing (61) and add shims (55b) in the variable speed spring retainer cup (55a) behind the spring (55). (See Fig. 34.)

   If top speed is higher than 1995 RPM, remove shims from the spring retainer cup behind the spring.

   Shims are furnished in .010" and .080" thickness. Adding one .010" shim increases the engine speed from 10 to 15 RPM.

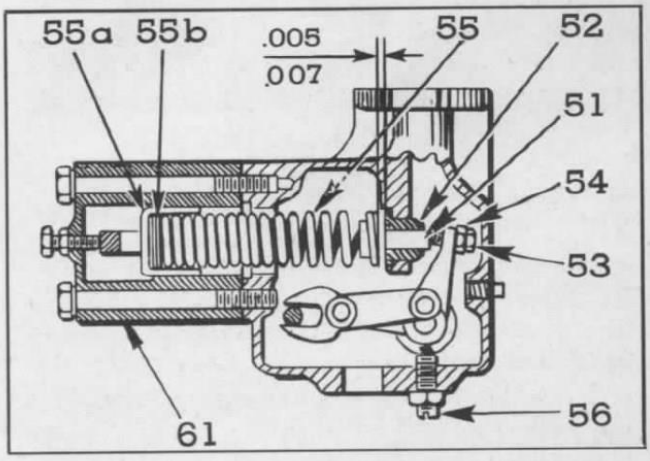

Fig. 34—Variable Speed Governor Spring and Housing Assembly

51. Spring Plunger.
52. Guide—Spring Plunger.
53. Adjusting Screw—Spring Plunger Gap.
54. Lock Nut—Spring Plunger Gap Adjusting Screw.
55. Spring—Governor.
55a. Retainer—Governor Spring.
55b. Shims—Governor Spring.
56. Screw—Buffer Spring.
61. Housing—Control Lever.

5. Check, and if necessary, correct the governor no load top speed on the "D" engine in the same manner; except, the no load top speed on the "D" engine should be approximately 2015 RPM, but must be between 2005 and 2025.

6. If quad unit is being checked, check, and if necessary, correct the speed on both of the "B" and the "D" engines.

IX. SET GOVERNOR IDLE SPEED SCREWS—TWINS AND QUADS (ENGINES RUNNING—EQUALIZER CROSS LINK DISCONNECTED). ALSO, SINGLE ENGINES

1. Back out buffer screw (49), Fig. 35 until it projects $\frac{5}{8}$" from side of governor housing.

2. With governor control shutdown lever (27) in RUN position and speed control lever (23) in approximately half-speed position—slightly forward of vertical—start and warm engines up to operating temperature.

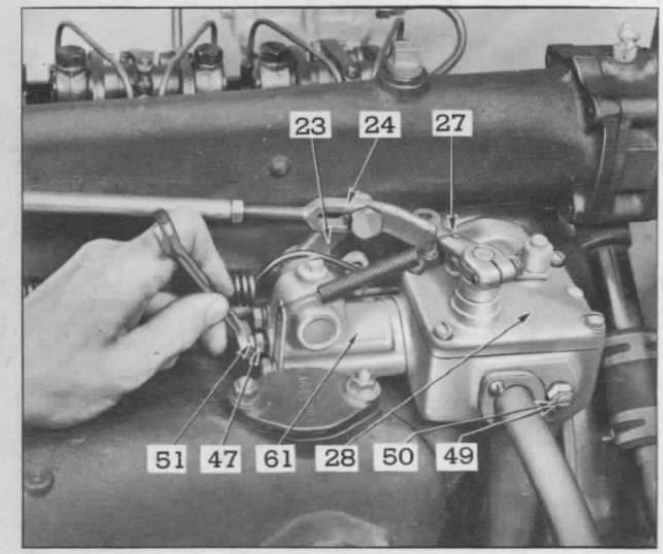

Fig. 35—Adjusting Governor Idling Screw

23. Lever—Speed Control.
24. Link—Throttle Control to Governor.
27. Lever—Governor Shutdown (Control).
28. Governor.
47. Lock Nut—Idle Screw.
49. Screw—Buffer.
50. Lock Nut—Buffer Screw.
51. Screw—Idle.
61. Housing—Variable Speed Spring.

3. Set the governor speed control lever (23) in the IDLE position—all the way forward—with the shutdown lever (27) still in the RUN position as shown in Fig. 35.

4. Loosen lock nut (47) on idle adjusting screw (51) and adjust engine idle speed on the "B" engines (Nos. 1 and 3 in Fig. 37) to 525 RPM and on the "D" engines (Nos. 2 and 4) to 575 RPM. Turn screw IN to increase and OUT to decrease engine speed.

NOTE: *On single engines loosen lock nut (47) on idle adjusting screw (51) and adjust engine idle speed to the required RPM.*

5. With throttle set in IDLE position, loosen clamp bolts in all governor shutdown levers (27) and position levers so there is from $\frac{1}{16}$" to $\frac{1}{8}$" between each lever and the forward end of the link (24). Tighten clamp bolts.

X. SET GOVERNOR BUFFER SCREW—TWINS AND QUADS (ENGINES RUNNING—EQUALIZER CROSS LINK DISCONNECTED). ALSO, SINGLE ENGINES

1. Refer to Fig. 36 and with buffer screw (49) backed out as directed for the idle speed adjustment above, turn screw in until the spring of the buffer screw contacts the governor differential lever and the idling speed is increased slightly (not to exceed 5 RPM), tighten buffer screw lock nut (50).

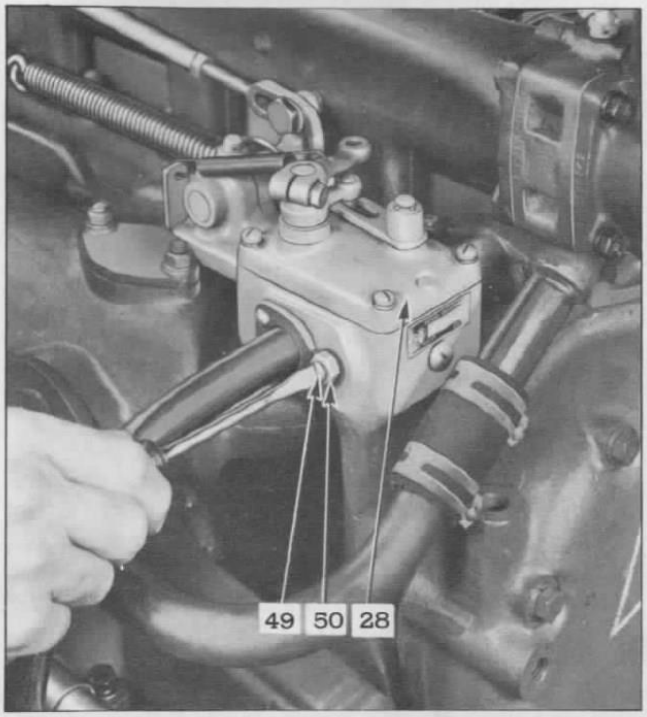

Fig. 36—Adjusting Governor Buffer Screw

28. Governor.
49. Screw—Governor Buffer.
50. Lock Nut—Buffer Screw.