OPERATOR'S INSTRUCTIONS

FOR

HYDRAULIC MARINE REVERSE

AND

REDUCTION PROPULSION UNITS

USED WITH

THREE, FOUR AND SIX-CYLINDER,

SERIES 71, TWO-CYCLE,

SINGLE, TWIN AND QUAD ENGINE UNITS

GM
GENERAL MOTORS
DIESEL
POWER

DETROIT DIESEL ENGINE DIVISION
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LITHO IN U.S.A.—SEPT. 1946

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FOREWORD

Instructions contained herein are compiled for the benefit of Operators as a guide in the proper maintenance of the General Motors Hydraulic Marine Reverse and Reduction Gears as applied to the Series 71, three, four and six-cylinder, Single, Twin and Quad engine units.

No attempt has been made herein to deal with major repair operations. This booklet contains only the information most required by the Operator, such as: Description of the units, how the various parts function, lubrication of the moving parts and the proper maintenance together with adjustments for wear.

The Operator will do well to acquaint himself with this text, thereby being more able to maintain the units properly.

SUBJECT INDEX

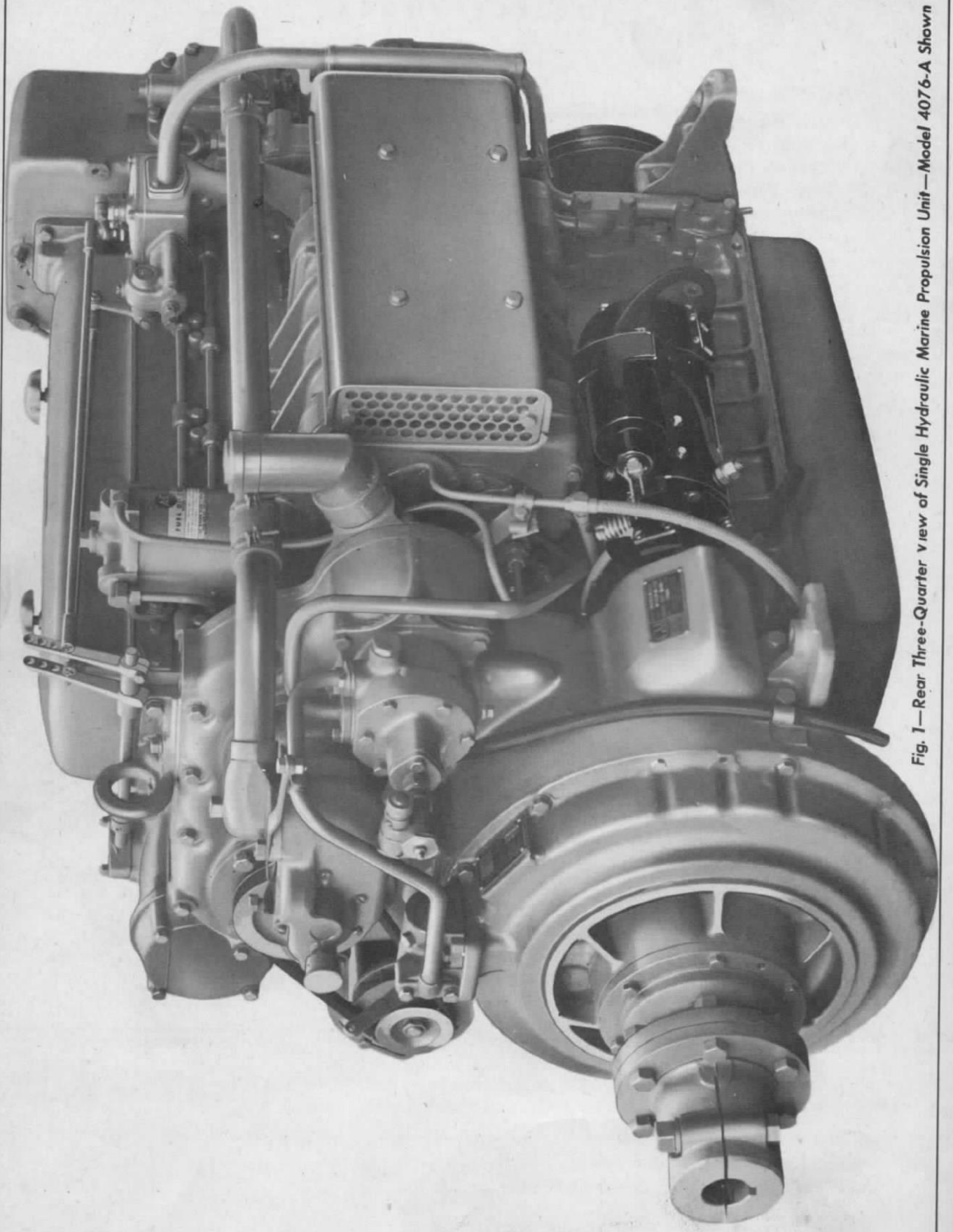

Fig. 1—Rear Three-Quarter View of Single Hydraulic Marine Propulsion Unit—Model 4076-A Shown

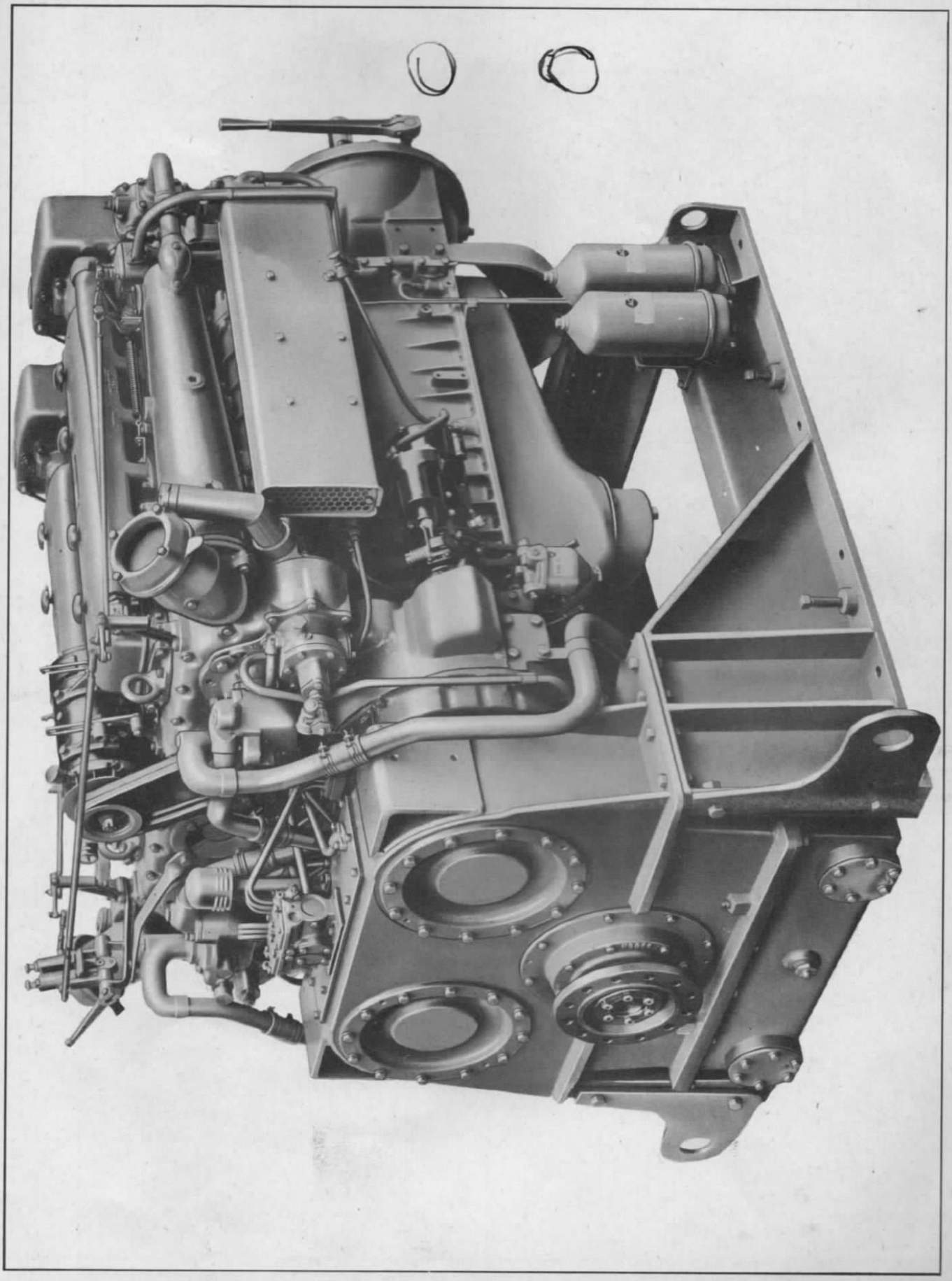

Fig. 2—Rear Three-Quarter View of Twin Hydraulic Marine Propulsion Unit—Model 12001-B Shown

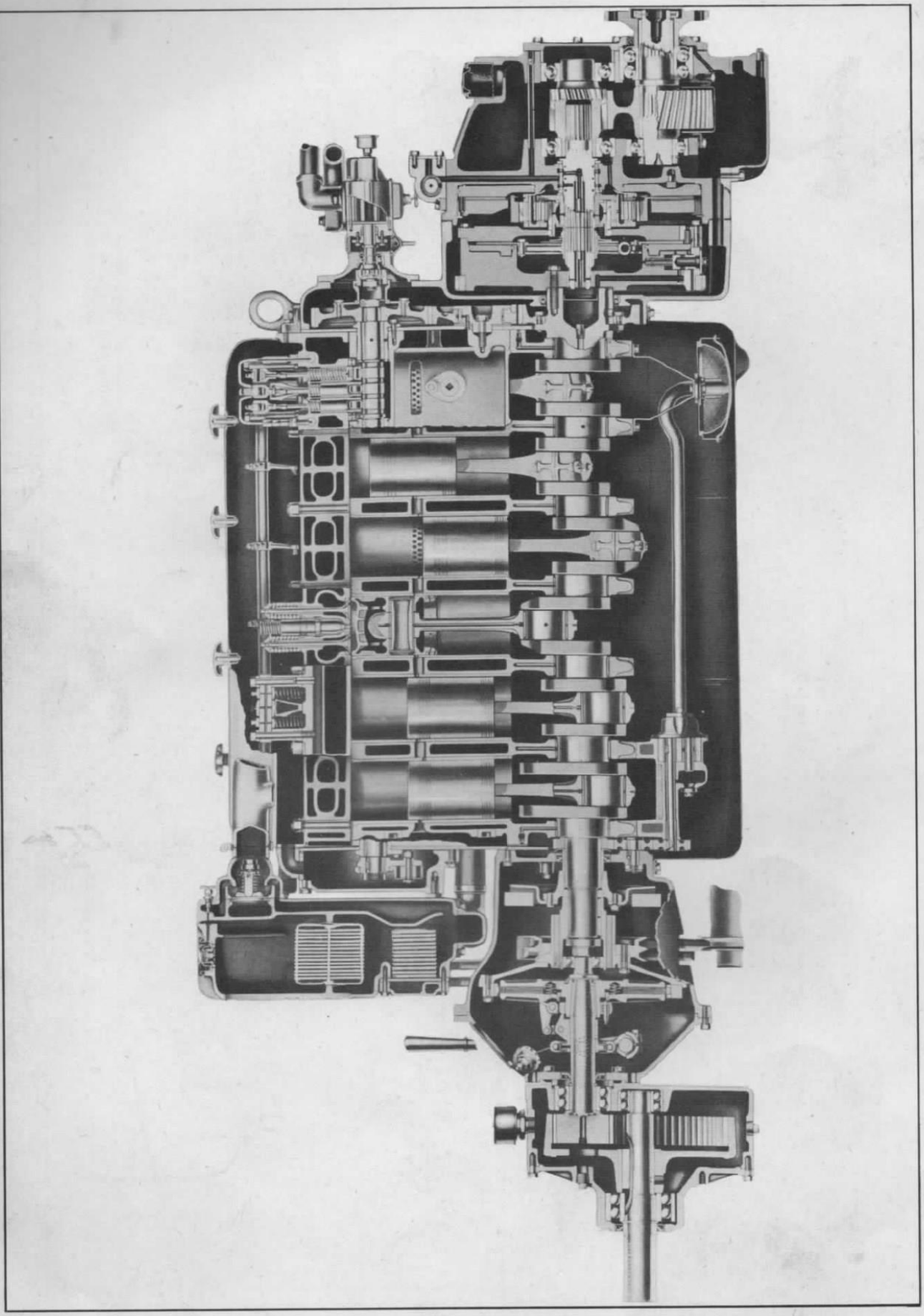

Fig. 3—Side Cross Section of Hydraulic Marine Reverse-Reduction Gear Applied to Six-Cylinder, Series 71 Engine

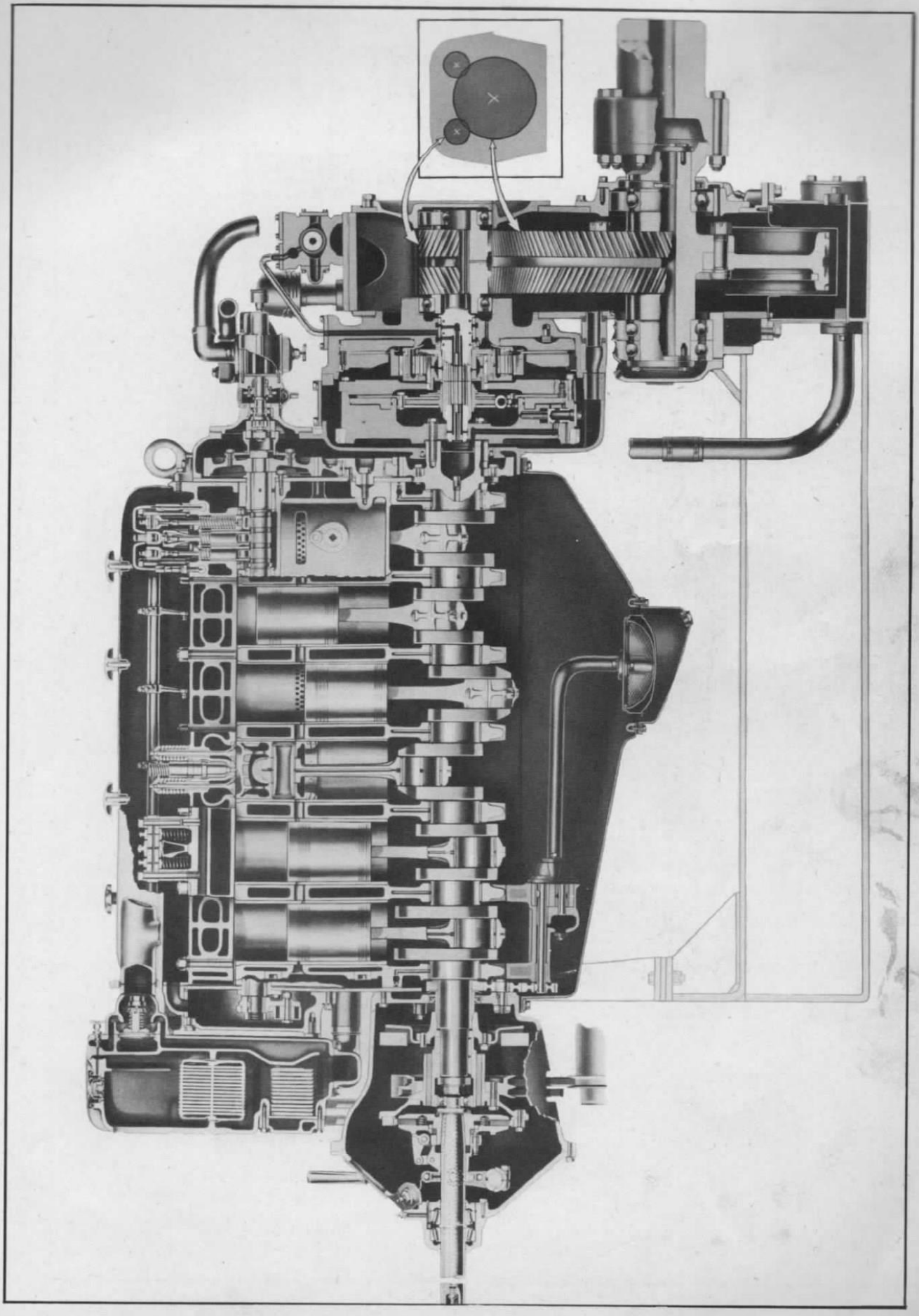

Fig. 4—Side Cross Section of Hydraulic Marine Reverse Gear and a Reduction Gear Applied to a Twin Six-Cylinder Unit

Fig. 5—Side Cross Section of Hydraulic Marine Reverse Gear

1. Flywheel Housing.
1a. Crankshaft.
2. Flywheel.
3. Plug—Oil Passage.
4. Ring Gear—Flywheel.
5. Bushing—Flywheel.
9. Piston—Forward Clutch.
10. Seal Ring—Forward Clutch (Outer).
11. Seal Ring—Forward Clutch (Inner).
12. Plate—Forward Clutch.
13. Spring—Clutch Release.
14. Plate—Forward Clutch Reaction.
15. Bolt—Reaction Plate to Flywheel.
16. Lock Washer.
22. Spring—Forward Clutch Dump Valve.
23. Valve—Forward Clutch Dump.
24. Cover—Forward Clutch Dump Valve.
25. Lock Washer.
26. Bolt—Forward Clutch Dump Valve Cover.
29. Piston—Reverse Clutch.
30. Seal Ring—Reverse Clutch (Outer)
31. Seal Ring—Reverse Clutch (Inner).
32. Gear—Reverse Ring.
33. Plate—Reverse Clutch.
34. Snap Ring.
35. Spring—Clutch Release.
37. Plate—Reverse Clutch Reaction.
38. Snap Ring—Reverse Clutch Reaction Plate.
39. Washer—Planetary Gear Thrust.
40. Washer—Reverse Sun Gear Thrust.
41. Sun Gear—Reverse.
42. Planetary Assembly—Reverse.
49. Planet Gear.
49a. Planet Gear.
55. Washer—Reverse Planetary Retaining.
56. Snap Ring—Reverse Planetary Retaining Washer.
59. Sleeve—Oil Transfer.
61. Pin—Clutch Drive.
65. Shaft—Reverse Gear Drive.
68. Bearing—Reverse Gear Drive Shaft Thrust.
69. Slinger—Thrust Bearing Oil.
73. Ring—Reverse Gear Drive Shaft Oil Seal.
74. Housing—Thrust Bearing.
78. Gasket—Thrust Bearing Housing.
82. Bolt—Thrust Bearing Housing.
84. Lock Washer.
86. Seal—Thrust Bearing Housing Oil.
98. Flange—Drive.
99. Nut—Drive Flange.
100. Cotter Pin—Drive Flange Nut.
118. Bolt—Oil Line Flange.
119. Lock Washer.
121. Cover—Oil Line Flange.
126. Gasket—Selector Valve Housing.
127. Lock Washer.
128. Housing—Selector Valve.
131. Seal—Selector Valve Oil.
132. Valve—Selector.
140. Bolt—Selector Valve Housing.
146. Carrier—Reverse Planet.
147. Shaft—Reverse Planet Gear.
151. Inlet From Oil Pump.
152. Scoop.

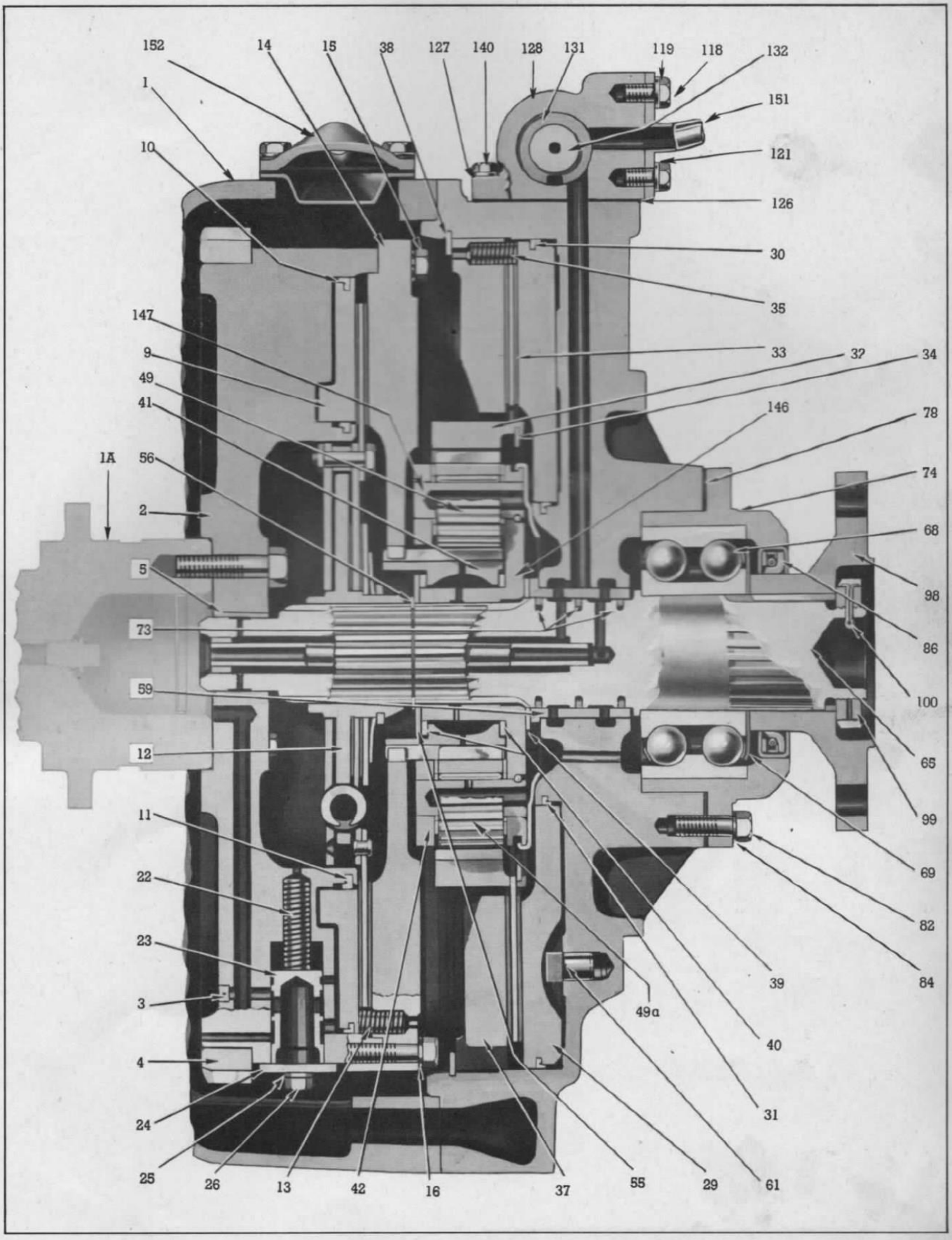

Fig. 5—Side Cross Section of Hydraulic Marine Reverse Gear

Fig. 6—Side Cross Section of Hydraulic Marine Reverse and Reduction Gear

1. Flywheel Housing.
1a. Crankshaft.
2. Flywheel.
3. Plug—Oil Passage.
4. Ring Gear—Flywheel.
5. Bushing—Flywheel.
6. Pin—Clutch Drive.
7. Bolt—Emergency Engagement.
8. Nut—Emergency Engagement Jam.
9. Piston—Forward Clutch.
10. Seal Ring—Forward Clutch (Outer).
11. Seal Ring—Forward Clutch (Inner).
12. Plate—Forward Clutch Driven.
13. Spring—Clutch Release.
14. Plate—Forward Clutch Reaction.
15. Bolt—Reaction Plate to Flywheel.
16. Lock Washer.
22. Spring—Forward Clutch Dump Valve.
23. Valve—Forward Clutch Dump.
24. Cover—Forward Clutch Dump Valve.
25. Lock Washer.
26. Bolt—Forward Clutch Dump Valve Cover.
29. Piston—Reverse Clutch.
30. Seal Ring—Reverse Clutch (Outer).
31. Seal Ring—Reverse Clutch (Inner).
32. Ring Gear.
33. Plate—Reverse Clutch Driven.
35. Spring—Clutch Release.
36. Pin—Reaction Plate Dowel.
37. Plate—Reverse Clutch Reaction.
38. Snap Ring—Reverse Clutch Reaction Plate.
39. Washer—Planetary Gear Thrust.
40. Washer—Reverse Sun Gear Thrust.
41. Sun Gear—Reverse.
49. Planet Gear.
49a. Planet Gear.
55. Washer—Reverse Planetary Retaining.
56. Snap Ring—Reverse Planetary Retaining Washer.
57. Housing Assembly—Reverse and Reduction Gear.
59. Sleeve—Oil Transfer.
61. Pin—Clutch Drive.
64. Washer—Pinion Drive Shaft Thrust.
65. Shaft—Reverse Gear Pinion Drive.
70. Bearing—Reduction Gear Pinion (Front).
71. Bearing—Reduction Gear Pinion (Rear).
72. Pinion—Reduction Gear.
73. Ring—Reverse Gear Pinion Drive Shaft Oil Seal.
75. Cover—Reduction Gear Bearing.
79. Gasket—Reduction Gear Bearing Cover.
82. Bolt—Reduction Gear Bearing Cover.
84. Lock Washer.
86. Seal—Reduction Gear Bearing Cover Oil.
87. Nozzle—Reduction Gear Oil.
88. Spacer—Reduction Gear Pinion Bearing.
91. Bearing—Reduction Gear Drive Shaft Pilot.
92. Bearing—Reduction Gear Drive Shaft Thrust.
93. Reduction Gear.
94. Shaft—Reduction Gear Drive.
95. Slinger—Thrust Bearing Oil.
96. Special Lock Washer.
97. Nut—Bearing Retaining.
98. Flange—Drive.
99. Nut—Drive Flange.
100. Cotter Pin.
101. Baffle—Reduction Gear Oil.
102. Bolt—Reduction Gear Oil Baffle Attaching.
103. Lock Washer.
104. Sump—Reduction Gear Oil.
105. Gasket—Reduction Gear Oil Sump.
106. Bolt—Reduction Gear Oil Sump Attaching.
111. Pipe Plug—⅜" Square Head.
113. Cap Assembly—Oil Filler.
118. Bolt—Oil Line Flange.
119. Lock Washer.
121. Cover—Oil Line Flange.
126. Gasket—Selector Valve Housing.
128. Housing—Selector Valve.
129. Spring—Selector Valve Poppet.
130. Poppet—Selector Valve.
131. Seal—Selector Valve Oil.
132. Valve—Selector.
133. Washer—Selector Valve Locating Screw.
134. Screw—Selector Valve Locating.
135. Lever—Selector Valve.
140. Bolt—Selector Valve Housing.
142. Bolt—Flywheel to Crankshaft.
146. Carrier—Reverse Planet.
147. Shaft—Reverse Planet Gear.
151. Inlet from Oil Pump.

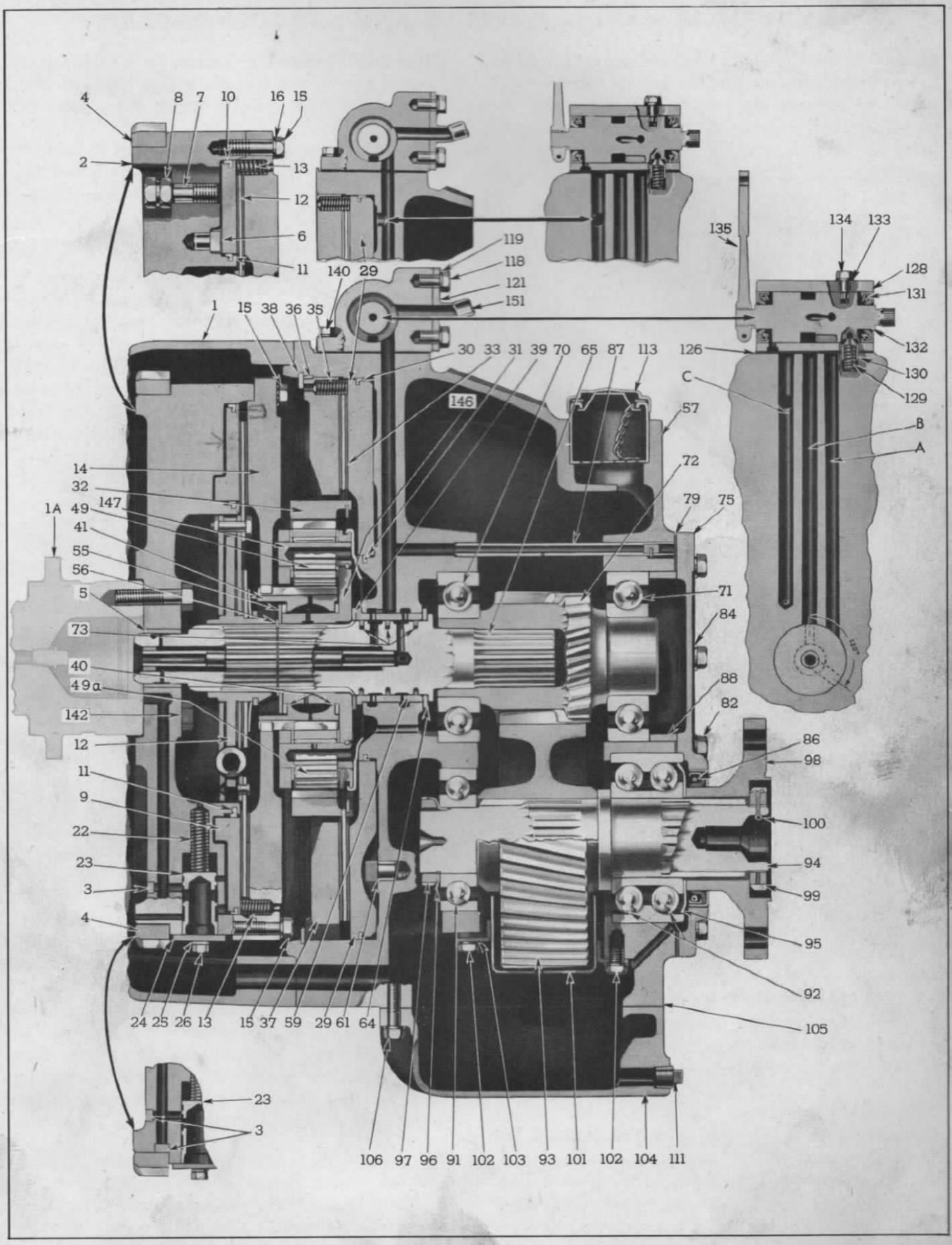

Fig. 6—Side Cross Section of Hydraulic Marine Reverse and Reduction Gear

HYDRAULIC MARINE REVERSE AND REDUCTION GEAR

General Motors Hydraulic Marine Gears are furnished in a series of ratios ranging from direct drive to 4.5:1 reduction between the engine crankshaft and the propeller shaft, as shown in the model-ratio chart below.

MODEL	RATIO	REMARKS
M10A	Direct Drive	Engine crankshaft and propeller shaft same speed both forward and reverse.
M15A	1.52:1	Reduction ratio between engine crankshaft and propeller shaft.
M20A	2.06:1	Reduction ratio between engine crankshaft and propeller shaft.
M30A	3.0:1	Reduction ratio between engine crankshaft and propeller shaft.
M45A	4.5:1	Reduction ratio between engine crankshaft and propeller shaft.
M10B	Direct Drive	Similar to M10A but with pinion on drive shaft for multiple engine reduction gear boxes and provision on housing for mounting on reduction gear box housing.

Hydraulic Marine Gear Model and Ratio Chart

A flywheel assembly, containing the shifting mechanism for forward gear, a planetary reverse gear set, and a control valve assembly constitute the direct drive Hydraulic Reverse Gear; while a suitable reduction gear set is included in the reverse gear housing for the reduction units. The flywheel and reverse gear mechanism is the same, for all models.

Among the outstanding features of the Hydraulic Marine Gears are: hydraulic application of both forward and reverse clutches; compact design with the combined flywheel and forward shifting mechanism occupying approximately the same space as the conventional flywheel; identical ratios in forward and reverse; an emergency forward clutch lock; and positive clutch engagement by simply moving the hydraulic control valve lever to the desired position for either forward or reverse. Clutch release is equally as positive on the disengaged clutch when the control valve is moved from forward to reverse or vice-versa.

DESCRIPTION—Direct Drive Hydraulic Marine Gears are made up of three units: The flywheel, the reverse gear and the control valve, as shown in Fig. 5. Reduction gear sets have the same flywheel and reverse gear and simply incorporate the necessary drive pinion and mating gear of the proper ratio, with their mountings, in the reverse gear housing as illustrated in Fig. 6.

Flywheel Assembly is made up of a flywheel (2), forward clutch reaction plate (14), forward clutch piston (9), and the forward clutch dump valve (23).

A flywheel (2), at the outer diameter of which is contained a forward clutch dump valve (23) and dump valve spring (22), is bolted directly to the crankshaft flange (1a).

A heavy forward clutch reaction plate (14) is bolted to the aft face of the flywheel which also serves as a drive for the reverse planetary gear set by virtue of gear teeth at the inner diameter meshing with teeth on the sun gear (41). Three large drive pins (6) anchored in the flywheel, drive a forward clutch piston (9) which is moved aft by oil pressure to engage the clutch plate (12) against the reaction plate (14) or forward to free the clutch plate when the oil pressure is released. A series of clutch reaction springs (13) move the forward piston away from the clutch plate quickly and free the clutch plate as soon as the oil pressure is released. Seals (10) and (11) at the outer and inner diameter, respectively, of piston (9) prevent oil leaks when the piston is moved to the engaged position by oil pressure.

Facings at the outside diameter of the forward clutch plate (12) are sandwiched between the reaction plate (14) and the forward piston (9) while splines at the hub of the clutch plate engage mating splines on the drive shaft. When the forward clutch is engaged, therefore, and the engine is running, the forward clutch plate drives the shaft in a forward direction. Likewise, when the clutch is released, the clutch plate and shaft are stationary. To minimize torsional vibration, a system of coil springs is introduced between the clutch hub and the outer plate to which the friction mats are secured.

Dump Valve—Oil pressure behind the forward clutch piston is controlled by a pressure-sensitive centrifugally-balanced dump valve (23) moving in a cavity at the outer diameter of the flywheel. This valve is of such weight and area that its mass exactly balances the oil pressure due to centrifugal forces. (This principle is explained more fully under "Operation" in the following pages.) A spring (22) behind the valve provides a constant force for returning the valve to the dump position when the oil pressure is reduced.

Oil is supplied to the dump valve from a positive pressure pump, driven off the blower shaft, (see Fig. 10), through the control valve (132), an oil passage in the reverse gear housing (57), through a duct at the center of the drive shaft (65) and through a passage in the flywheel. When the pump pressure is

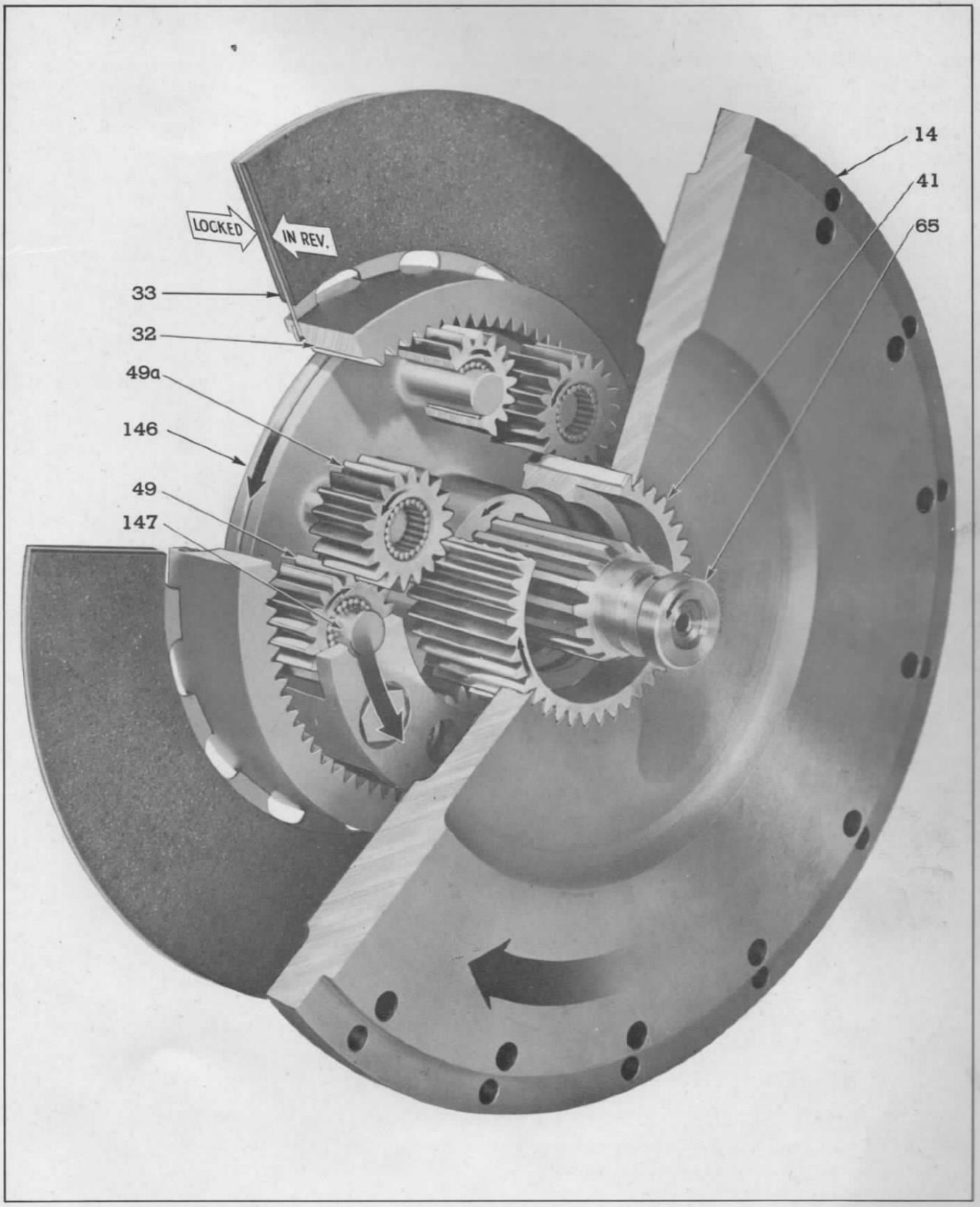

Fig. 7—Gear Train Diagram of Planet and Reverse Drive

14. Plate—Forward Clutch Reaction.
32. Ring Gear.
33. Plate—Reverse Clutch.
41. Sun Gear—Reverse.
49. Planet Gear.
49a. Planet Gear.
65. Shaft—Reverse Gear Pinion Drive.
146. Carrier—Reverse Planet.
147. Shaft—Reverse Planet Gear.

applied by moving the selector of the control valve to the forward position, the dump valve moves toward the center of the flywheel, compressing spring (22). Conversely, when the pump pressure is cut off, the valve moves out toward the outer diameter of the flywheel.

Emergency Clutch Engagement—If for any reason the clutches cannot be engaged hydraulically, the forward clutch may be engaged by six bolts (7) in the front face of the flywheel. For this emergency clutch engagement, see item 5 under "Service", page 30.

Reverse Gear—Reverse rotation of the reverse gear drive shaft (65) is accomplished through a planetary gear set contained in a housing (57) just aft of and bolted to the flywheel housing (1). Gear teeth at the inner diameter of the forward clutch reaction plate (14) mesh with teeth on the sun gear (41) which drives the planetary gear set. A ring gear (32) surrounding the planet pinions (49) and (49a), is splined to a reverse clutch plate (33) which is held stationary in reverse between the reverse reaction plate (37) and piston (29).

Reverse clutch reaction plate (37) is restrained axially by a snap ring (38) imbedded in the reverse gear housing and from rotating by three dowel pins (36) coincident with the reaction plate and its housing. A hydraulically-operated reverse clutch piston (29) —sealed against oil leaks by synthetic rings (30) and (31) at the outer and inner diameters, respectively—rides inside the main housing aft of the reverse reaction plate and the reverse clutch plate (33). Like the forward drive piston (9), this reverse clutch piston moves forward, when oil pump pressure is applied back of the piston, and locks the clutch plate stationary between the piston and the reaction plate. Reverse clutch plate (33) is splined to the ring gear (42) of the planetary assembly. Consequently, when clutch plate (33) is locked between the piston and the reaction plate, ring gear (42) is held stationary. Conversely, when the reverse clutch is released and the engine is running, the planet assembly, together with the reverse clutch plate, revolves in a forward direction at engine speed, driven by the forward reaction plate (14), the gear teeth of which mesh with the sun gear (41).

Planet Assembly—Fig. 7 illustrates the working principle of the planet assembly which imparts a reverse motion to the drive shaft when the engine is running.

Four pairs of needle bearing-mounted planet pinions (49) and (49a) meshing together are carried on spindles (147) fixed in carrier (146). The mounting spindles for four of the pinions (49a) are closer to the center of the carrier than the other four spindles for pinions (49) so that pinions (49a) mesh with the sun gear (41) at the center of the carrier and pinions (49) mesh with the ring gear (32) surrounding the planet carrier. Planet carrier is splined to and rotates with the drive shaft (65). Sun gear (41) is free to rotate on the hub of carrier (146) while ring gear (32) may be locked from rotating by the reverse clutch plate (33). Since the sun gear (41) meshes with and is driven by the forward clutch reaction plate (14), which is a part of the flywheel; when the engine is running, motion is imparted to the sun gear in a forward direction and if the ring gear (32) is held stationary, the planet assembly will revolve in a reverse direction to the engine flywheel carrying the drive shaft along with it. This reversal of motion is more fully explained under "Operation" on later pages.

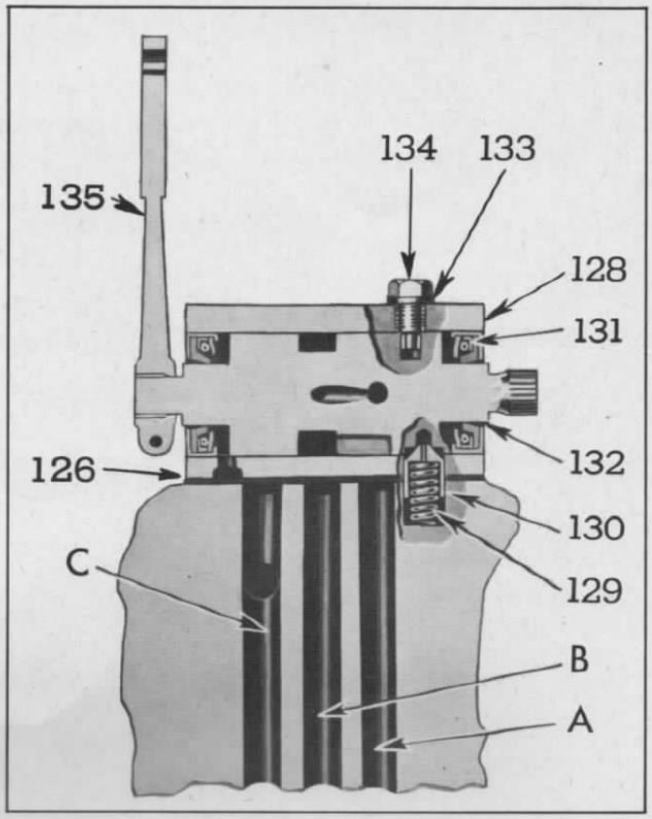

Fig. 8—Control Valve Assembly—Single Engine

126. Gasket—Selector Valve Housing.
128. Housing—Selector Valve.
129. Spring—Selector Valve Poppet.
130. Poppet—Selector Valve.
131. Seal—Selector Valve Oil.
132. Valve—Selector.
133. Washer—Selector Valve Locating Screw.
134. Screw—Selector Valve Locating.
135. Lever—Selector Valve.

Control Valve—Single Engine—Oil for operating the forward and reverse clutch pistons as well as for lubrication of certain parts not subject to splash lubrication, is admitted to the gear box through a control valve (132), illustrated in Figs. 6 and 8.

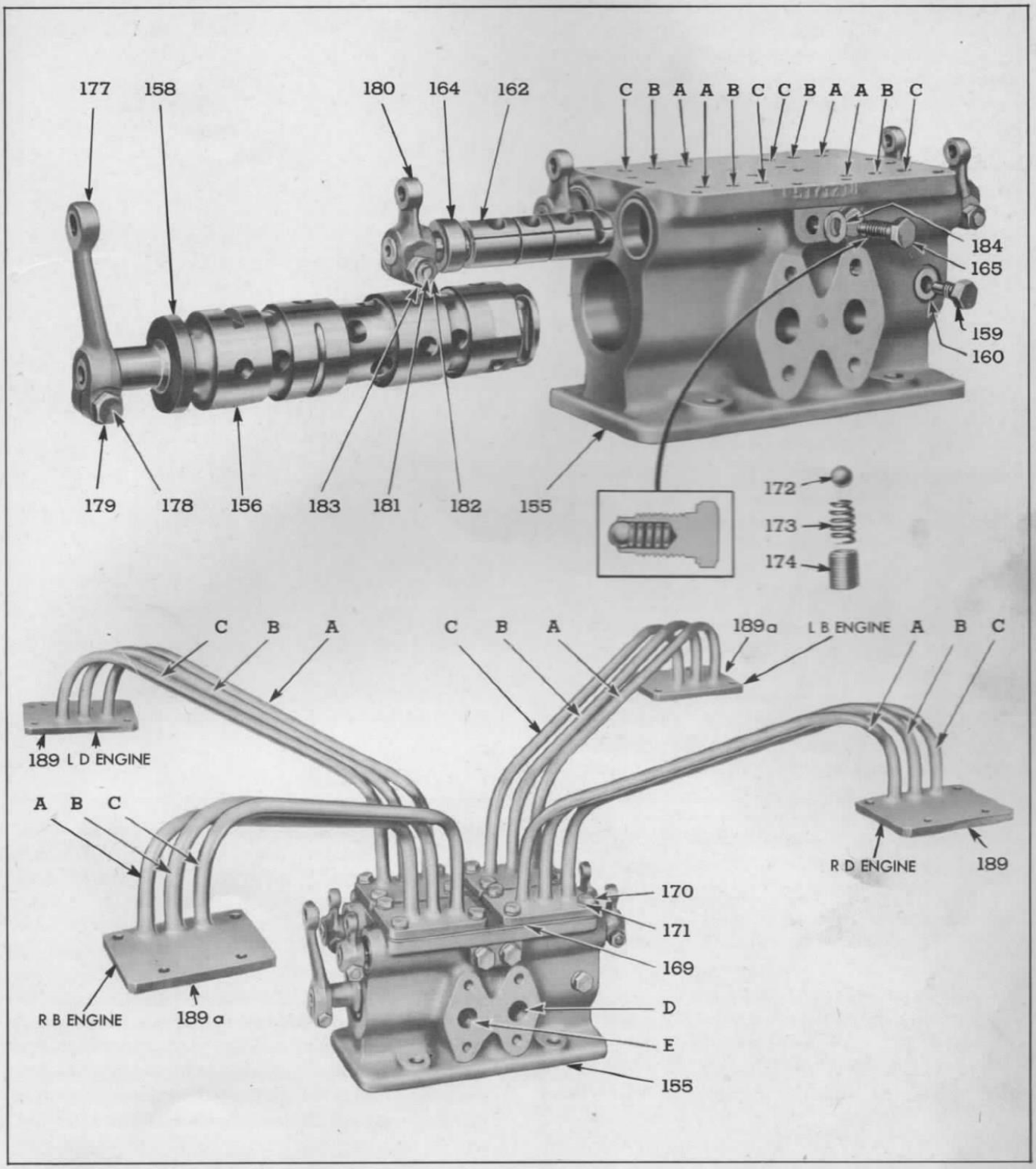

Fig. 9—Control Valve Assembly—Twins and Quads

155. Housing—Hydraulic Control Valve.
156. Selector—Control Valve.
158. Oil Seal Selector.
159. Lock Screw—Control Valve Selector.
160. Lock Washer—Control Valve Selector Screw.
162. Shut-Off—Control Valve (R.H.).
164. Oil Seal—Shut-Off.
165. Lock Screw—Shut-Off.
169. Gasket—Tube Flange.
170. Bolt—Tube Flange.
171. Lock Washer—Tube Flange Bolt.
172. Poppet Valve—Selector.
173. Spring—Selector Poppet Valve.
174. Plug—Selector Poppet Valve.
177. Lever—Master Control.
178. Bolt—Master Control Lever Clamp.
179. Lock Washer—Master Control Lever Clamp Bolt.
180. Lever—Shut-Off.
181. Bolt—Shut-Off Lever.
182. Nut—Shut-Off Lever Bolt.
183. Lock Washer—Shut-Off Lever Bolt.
184. Lock Washer—Cut-Off Lock Screw.
189. Tube and Flange Assembly—Control Valve to Gear Box—"D" Engines.
189a. Tube and Flange Assembly—Control Valve to Gear Box—"B" Engines.

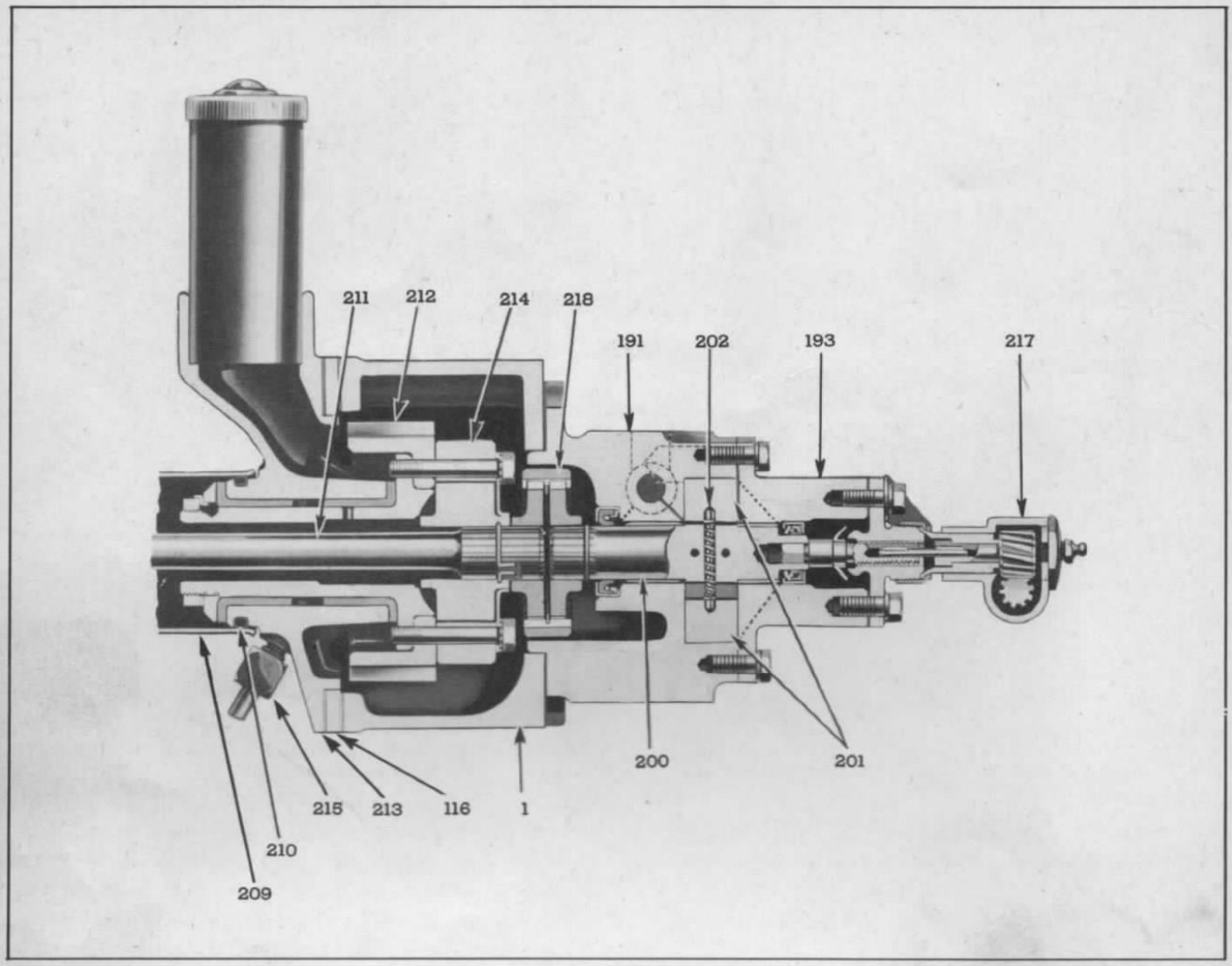

Fig. 10—Hydraulic Marine Reverse Gear Oil Pump Mounting and Drive

1. Flywheel Housing.
116. End Plate—Cylinder Block Rear.
191. Body—Hydraulic Oil Pump.
193. Cover—Hydraulic Oil Pump.
200. Rotor—Hydraulic Oil Pump.
201. Vane—Hydraulic Oil Pump.
202. Spring—Hydraulic Oil Pump Vane.
209. Cover—Blower Drive Shaft.
210. Packing—Blower Drive Shaft Cover.
211. Shaft—Blower Drive.
212. Gear—Blower Drive.
213. Support—Blower Drive Gear Hub.
214. Coupling Assembly—Blower Drive.
215. Oil Pipe—Blower Drive Bearing.
217. Tachometer Drive Assembly.
218. Coupling Assembly—Hydraulic Oil Pump Drive.

Three oil passages—one for forward speed "A", one for reverse speed "C", and one for lubrication "B"—are provided in the reverse gear housing, as shown in Fig. 6. Oil grooves and passages are machined in the valve so that when it is rotated to the forward position by the lever (135), oil is admitted to the forward passage in the reverse gear housing and when the valve is rotated to the reverse position, oil is admitted to the reverse passage. Lubricating passage "B" is never cut off regardless of valve position. A control valve poppet (130) backed up by spring (129) holds the valve in the selected position after the shift has been made; while screw (134) locates the valve endwise in its cage. An oil seal (131) at each end of the valve is to prevent outside leakage of any oil that might seep past the valve and housing.

Control Valves for Twins and Quads are different than for single engines in that a master selector controls the flow of oil from the pump to either the two twin engines or the four engines, as the case may be, simultaneously, and individual shut-off valves are provided for each engine, as illustrated in Fig. 9.

The master control valve selector (156) is carried in housing (155) along with the four individual shut-off valves (162)—one for each engine—a lever (177) on the selector and individual levers (180) on the shut-off valves provide a means of moving the valves to the desired positions.

Passages in the housing (155) lead into the bores for the selector (156) and the shut-offs (162), while cross passages and grooves in the hollow selector and cross

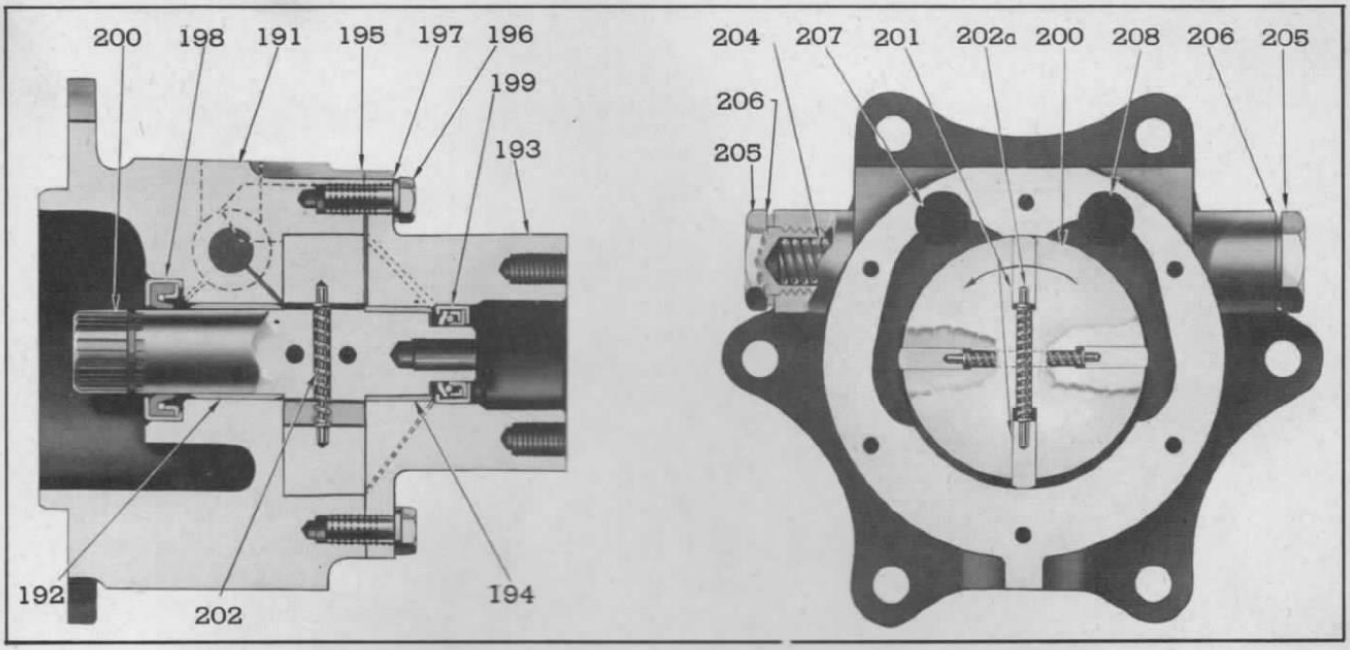

Fig. 11—Oil Pump Assembly—Hydraulic Marine Reverse Gear

191. Body—Pump.
192. Bushing—Pump Body.
193. Cover—Pump.
194. Bushing—Pump Cover.
195. Gasket—Cover.
196. Bolt—Cover to Body.
197. Lock Washer—Cover Bolt.
198. Oil Seal—Engine End of Rotor.
199. Oil Seal—Tachometer Drive End of Rotor.
200. Rotor—Pump.
201. Vane—Pump.
202. Spring—Pump Vane.
202a. Guide—Vane Spring.
204. Spring—Pump Valve.
205. Screw—Pump Valve.
206. Gasket—Pump Valve Screw.
207. Inlet—Port.
208. Outlet—Port.

passages in the shut-offs register with the passages in the housing to either admit oil to the gear box or cut off the supply, as the case may be.

A group of three tubes (189), marked "A", "B", and "C", for each engine, are bolted to the top of the control valve housing at one end and the Hydraulic Reverse Gear housing at the other end. Tube "A" admits oil to the forward drive clutch, tube "C" admits oil to the reverse drive clutch, and tube "B" is for lubrication of certain parts in the gear set. The individual tubes register with the passages in the control valve housing (155) leading to the cross passages in the shut-off (162) and then to the selector (156). When, therefore, cut-off (162) is in the open position—lever (180) straight up—and selector (156) is set for forward drive, oil from the pump flows through the selector (156), the housing (155), the cut-off (162) and tube "A" to apply the forward clutch and through tube "B" to lubricate the gear set. When the selector is positioned to admit oil to the forward clutch, oil is cut off to the reverse clutch and the pressure in tube "C" (reverse clutch) is relieved by a direct opening into the gear box via grooves in the selector and passages in the selector housing. The same thing is true when selector is moved to reverse position; then tube "A" by-passes the oil into the gear box and the reverse clutch is applied. Remember, passages from lubricating tube "B" are always open so gear set is lubricated at all times. Also, an oil bleed hole through the cut-off at oil passage "B" permits oil to feed through the tube when the cut-off is in the OFF position for that particular engine. Thus, the reverse gear parts, which are in motion due to the motion of the reverse gear shaft being driven by the bull gear in the reduction gear box, are lubricated even though the engine is temporarily not running.

Oil Pump—Each engine equipped with an hydraulic marine reverse gear is provided with a positive displacement, vane-type oil pump mounted to the flywheel housing and driven from the blower drive shaft by a flexible coupling, as shown in Fig. 10.

As illustrated in Fig. 11, an integral rotor and shaft (200), mounted on a bronze bearing (192) in the pump body (191) forward and a bronze bearing (194) in the pump cover (193) aft of the rotor, revolves in the pump body, the bore of which is eccentric to the rotor. Practical bearing alignment for the rotor shaft and true travel of the rotor in the housing is provided by dowels in the cover to the pump body. Bolts and lock washers fix the cover rigidly to the pump body. An oil seal (198) in the pump body and another (199) in the pump cover at opposite ends of the rotor shaft, ride on the shaft to guard against oil leaks along the shaft.

Four spring-loaded vanes (201), with vane guides

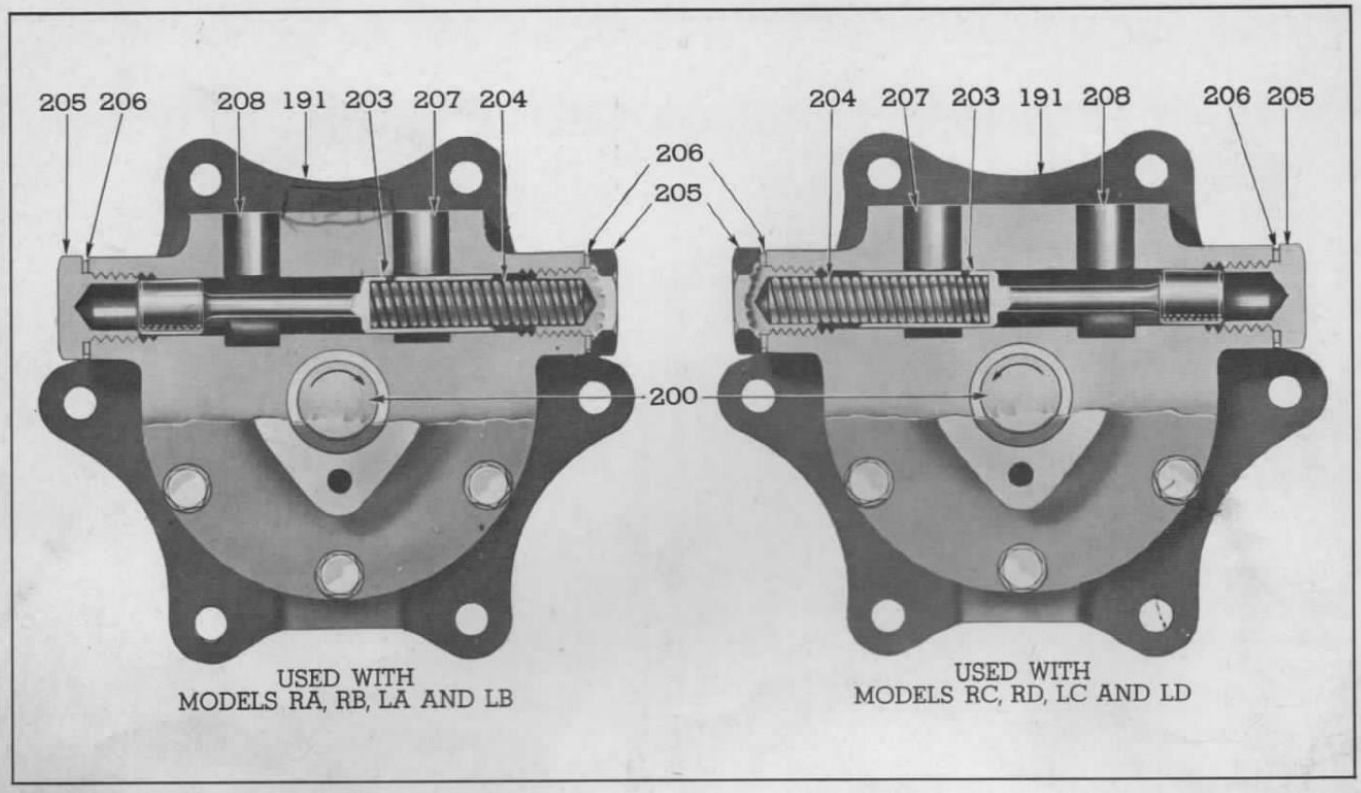

Fig. 12—Position of Relief Valve in Hydraulic Oil Pump Body for Engine Models as Indicated

191. Body—Pump.
200. Rotor—Pump.
203. Valve—Pump.
204. Spring—Pump Valve.
205. Screw—Pump Valve.
206. Gasket—Pump Valve Screw.
207. Inlet—Port.
208. Outlet—Port.

(202a), carried in the rotor (200), revolve inside the eccentric body, thus creating a partial vacuum and displacing the liquid from the inlet to the outlet port.

A spring-loaded horizontal relief valve (203) is provided in the pump body connecting the inlet and outlet ports (207) and (208), as shown in Fig. 12. This valve provides a by-pass from the outlet to the inlet side of the pump when excessive pressure is built up inside the pump. Pumps are built for right-hand and for left-hand rotation, depending on the engine model on which the pump is used. Viewing the pump from the aft end (end opposite to pad for mounting to the flywheel housing), pumps with R. H. rotation (clockwise) are used on RA, RB, LA and LB engines and pumps with L. H. rotation (counterclockwise) are used on RC, RD, LC and LD engines, as shown in Fig. 12. The direction of rotation is shown by an arrow on the pump cover. Note that valve spring (204) and the hollow end of the relief valve (203), which receives the spring, is located on the inlet side of the pump.

NOTE: *Because of certain design features, the pump cannot be converted from right to left-hand or vice-versa, by changing the relief valve and spring from one side of the pump to the other.*

OPERATION—Hydraulic Reverse Gear—As the name implies, motion from the prime mover is imparted to the hydraulic reverse gear drive shaft by locking either the forward or reverse clutch plate between a hydraulically-operated piston and a backing plate.

Construction of the reverse gear, which must be understood before the operation becomes clear, is discussed under "Description" above. This chapter explains how the mechanism operates. (See Fig. 6 and the following illustrations.)

Forward Drive Operation—When the engine is running, forward drive to the shaft (65) is accomplished by moving the selector valve handle (135), Fig. 6, to the forward position which admits oil under pressure from the pump to the oil passage (A) in the reverse gear housing (57), through the quill in the reverse shaft; thence to the oil passage in the flywheel; through the dump valve (23) and to the cavity forward of piston (9). When oil pressure is applied to this piston, it moves aft to lock clutch plate (12) between the piston and the reaction plate (14), and, since the clutch plate is splined to the drive shaft, the shaft is driven in a forward direction at engine speed. (See Figs. 5 and 13.)

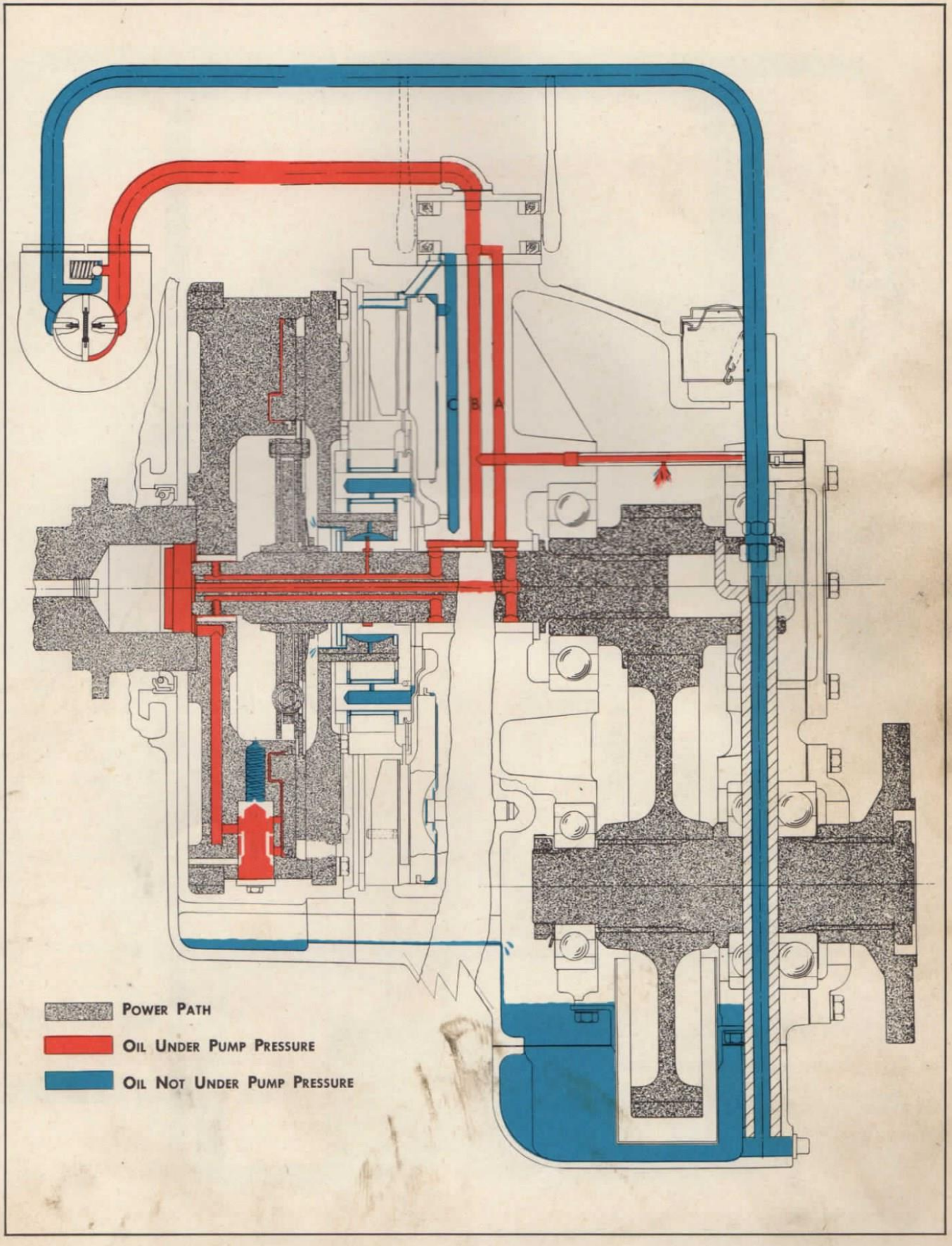

Fig. 13—Oil Flow Diagram for Application of Forward Drive Clutch Including Power Flow

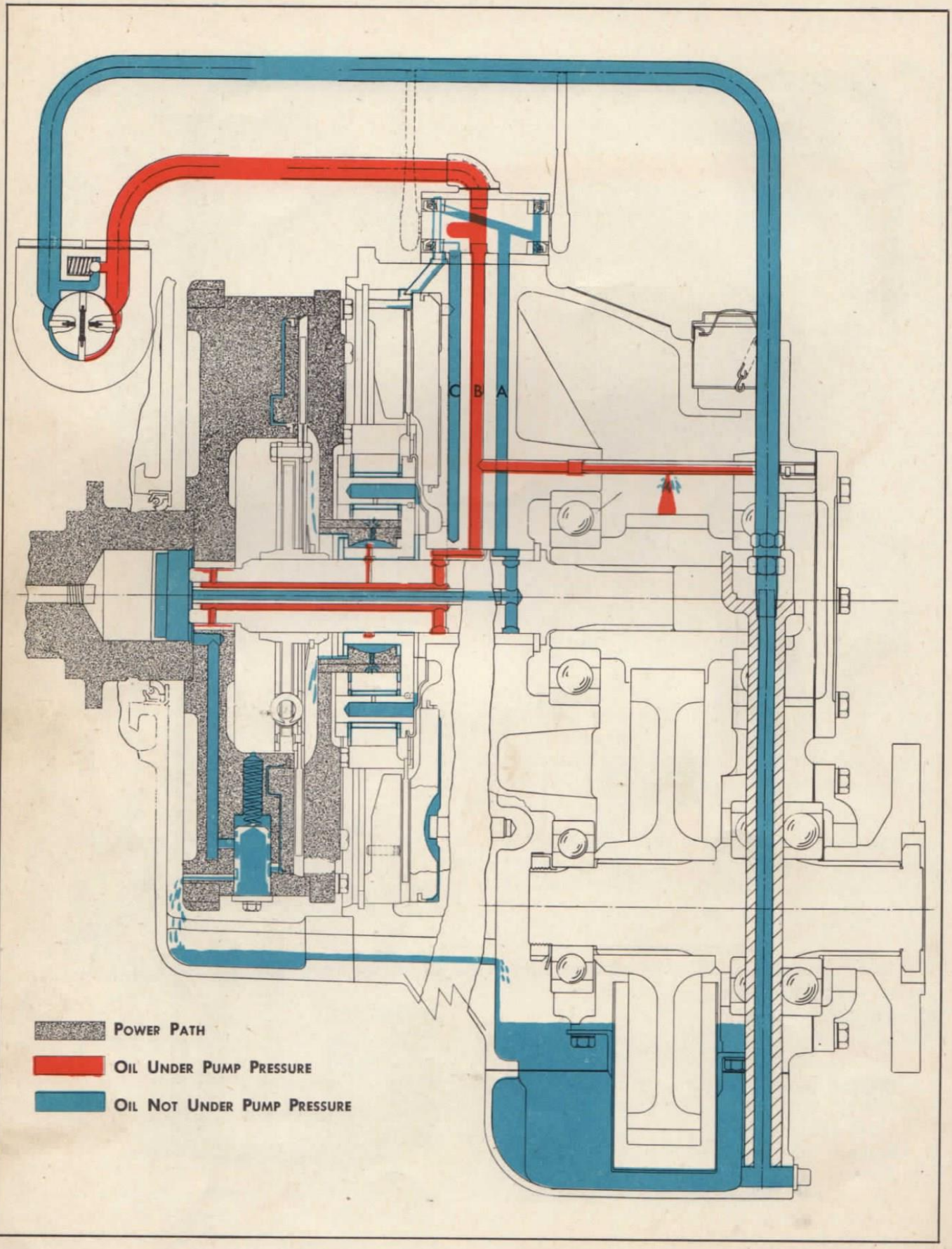

Fig. 14—Oil Flow Diagram for Lubrication of Reverse Gear in Neutral

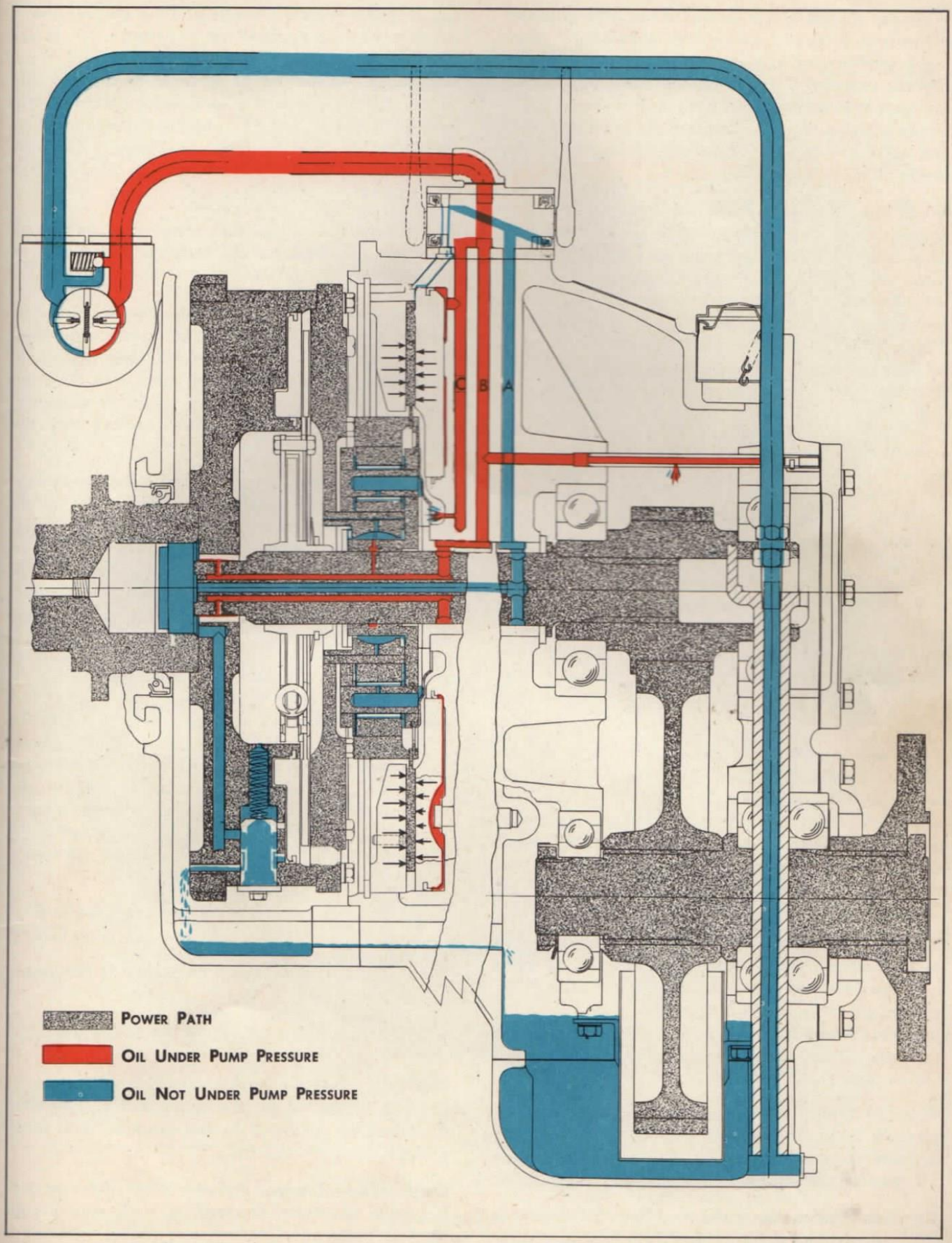

Fig. 15—Oil Flow Diagram for Application of Reverse Clutch Including Power Flow

A Dump Valve (23) is located at the outer diameter of the flywheel and backed up with a spring (22) tending to push the valve outward. When the flywheel is rotated, centrifugal action on the valve and spring creates a force **outward.** A body of oil is always maintained in the quill at the center of the drive shaft (65) and a column of oil in the flywheel leading to the inside of the dump valve.

When the flywheel is rotated, centrifugal action creates an oil pressure which acts on the valve as a force **inward.** These two forces are controlled by the same law; that is: centrifugal actions vary with the square of the speed. The valve and spring combined are of such weight and the valve of such area that their masses exactly balance that portion of oil pressure due to centrifugal force. Thus, these two forces irrespective of speed, are exactly balanced.

While the two forces due to speed are exactly balanced, the pressure due to the spring (22) back of the valve, tends to push the valve out toward the periphery of the flywheel. When the control valve is opened to admit oil to operate the forward piston (9), the pump pressure on the oil over-rides the tension of the valve spring (22) and pushes the valve in toward the center of the flywheel. When the valve is pushed in, the port in the valve aligns with the port in the flywheel leading to the piston (9), and admits oil under pressure in the cavity forward of the piston to move the piston aft and lock the clutch plate (12) between piston and reaction plate (14). Thus, drive is accomplished to the shaft in a forward direction.

Since reaction plate (14), which is a part of the flywheel, is locked to the sun gear (41) and the planet carrier (146) is splined to the drive shaft, there is no relative motion between the sun gear and the planet gears (49a) when in forward drive, with the result that the planet assembly, including ring gear (32) and reverse clutch plate (33), revolves in a forward direction with the flywheel.

In a similar manner, when the control valve is moved to the neutral position, oil pump pressure is relieved from the dump valve and the pressure of spring (22) pushes the valve out, cutting off the oil supply to the valve and bleeding the oil from the cavity forward of the piston. Thus, the piston moves forward releasing clutch plate (12).

With the control valve set in neutral position, pump pressure is cut off from both the forward and reverse clutches (pipes "A" and "C"); but, not from pipe "B" as shown in Fig. 14.

Reverse Drive Operation—When the engine is running, reverse drive to the shaft (65) is accomplished by moving the selector valve handle (135), Fig. 6, to the reverse position which admits oil under pressure from the pump to the oil passage "C" in the reverse gear housing (57) and to the cavity aft of the piston (29). When oil pressure is applied to this piston, it moves forward to lock clutch plate (33) between the piston and the stationary reaction plate (37); and, since the clutch plate is splined to ring gear (42), the ring gear is held stationary. (See Figs. 3 and 13.)

Fig. 16 illustrates the direction of motion of the various gears and allied parts of the planet to impart reverse motion to the drive shaft.

The sun gear (41) is free to rotate around the hub of the planet carrier (146) which is, in turn, splined to the drive shaft (65). Gear teeth at the inner diameter of the flywheel reaction plate (14) mesh with the teeth on the sun gear. Consequently, when the engine is running, the sun gear is carried around with the flywheel.

Four pairs of planet gears (49) and (49a) are needle-bearing mounted on shafts (147) fixed in the carrier (146). Four of the planet gears (49a) mesh with the sun gear; the other four planet gears (49) mesh with gears (49a) and with a ring gear (32) surrounding the planet gears but separate from the planet carrier (146). The reverse clutch plate (33) is splined to the ring gear (32).

When the reverse clutch is applied, the ring gear is held stationary. Then, with the sun gear traveling in a clockwise direction at engine speed, planet gear (49a) revolves counterclockwise, planet gear (49) revolves clockwise walking around inside of the stationary ring gear (32) and turning the planet carrier and drive shaft in a counterclockwise direction and at engine speed, as shown in Fig. 14. The speed of the carrier for this particular design of planet gear set is computed from the formula:

$$\text{Carrier Speed} = \left(1 - \frac{\text{No. teeth in ring gear}}{\text{No. teeth in sun gear}}\right) \text{Speed of Sun Gear}$$

Then by substitution, assuming engine is running at 1000 r.p.m.:

$$\text{Carrier Speed} = \left(1 - \frac{80}{40}\right) 1000 = (1-2)\ 1000 = -1000 \text{ r.p.m.}$$

This shows that the carrier, which is splined to the shaft, is turning at engine speed and in a reverse direction, as the result in the example is a minus quantity.

Operation—Control Valve—While different control valve assemblies are used on single engine units than on Twins and Quads, the operating principle is similar for both. For single engines, the control valve

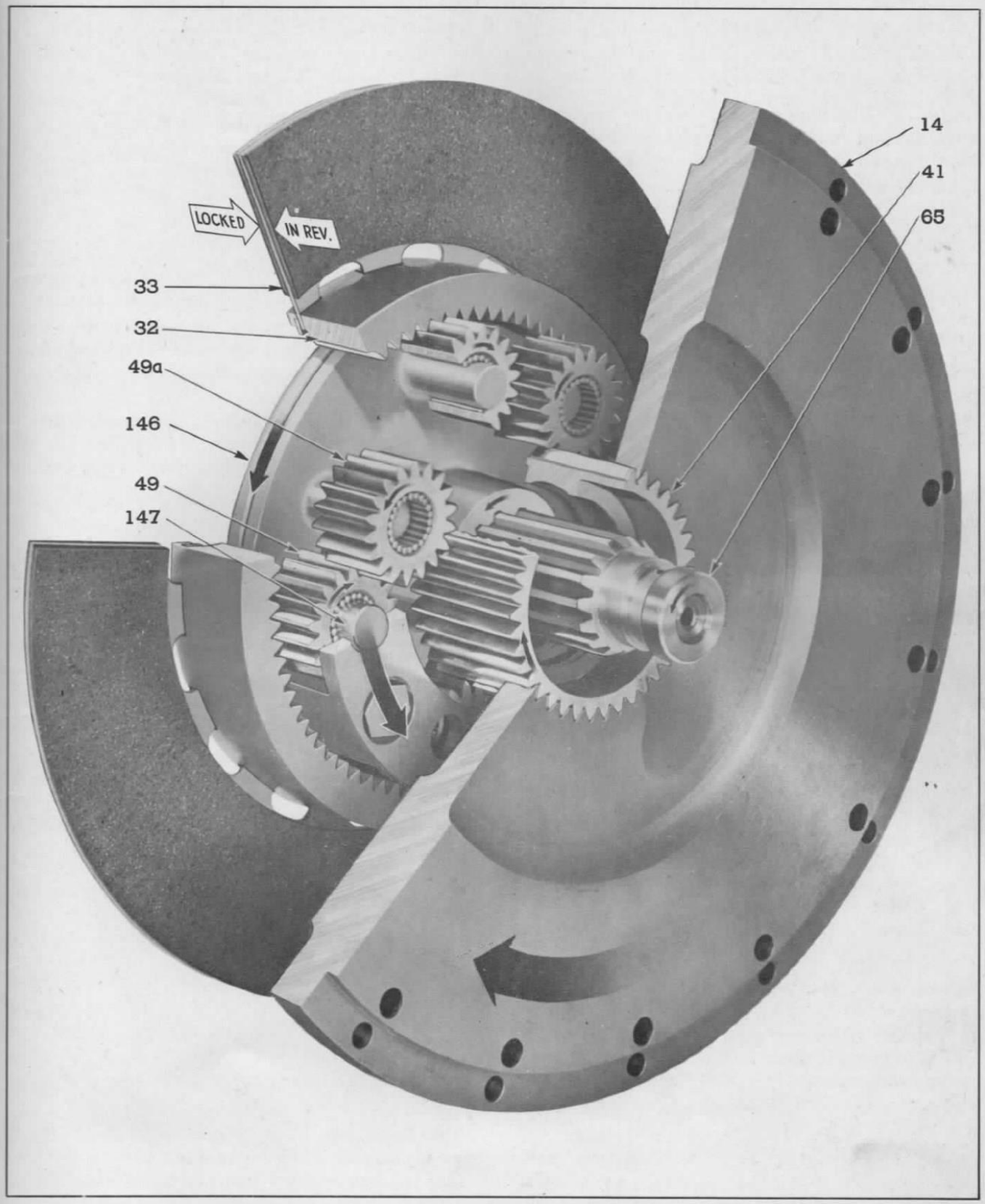

Fig. 16—Power Flow of Reverse Planet Gearing

14. Plate—Forward Clutch Reaction.
32. Ring Gear.
33. Plate—Reverse Clutch.
41. Sun Gear—Reverse.
49. Planet Gear.
49a. Planet Gear.
65. Shaft—Reverse Gear Pinion Drive.
146. Carrier—Reverse Planet.
147. Shaft—Reverse Planet Gear.