LUBRICANTS FOR "CAPITOL" MARINE GEAR UNITS

We recommend the use of high quality foam-resistant motor oils as follows:

A. All Normal Operating Conditions
Use S.A.E. 30 oil.

B. Cold Operation
Under conditions such as cold sea water cooling, etc., which will cause the gear unit to run below our recommended full load temperatures of 160° F. minimum and 195° F. maximum, use S.A.E. 20 oil.

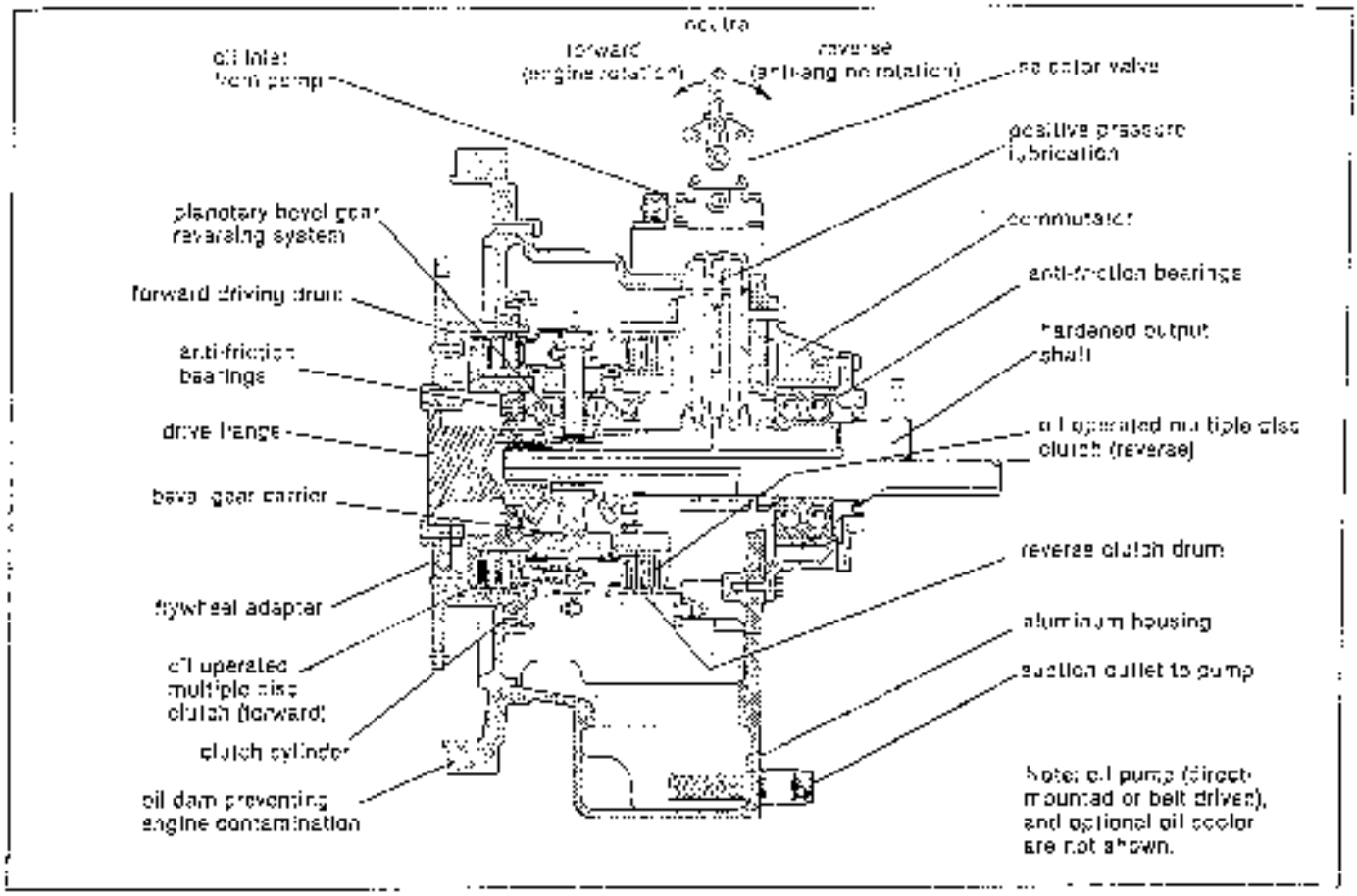


Figure 3. Cross-Section Showing Internal Components (HY 400 shown).

SECTION 1. INTRODUCTION

The function of this manual is to provide information for the installation, operation, maintenance and repair of the "CAPITOL" direct drive reverse gear. This manual should be made readily available to all those responsible for the operation or servicing of the reverse gear.

This service manual contains a troubleshooting guide which will aid in assessing difficulties promptly. A series of exploded views are provided in the parts information section.

1.1 DESCRIPTION

The transmission is operated hydraulically. The clutch is activated by high presure oil and the gears, bearings, and clutch discs are lubricated and cooled by low pressure oil.

The direct drive transmission consists of four major subassemblies; clutch pack, oil pump, selector valve and shaft. The clutch pack consists of reciprocating cylinders, clutch discs and a planetary bevel gear reversing system. The oil pump supplies oil pressure for clutch engagement and lubrication for bearings, gears and clutch. The selector valve is used to obtain forward, neutral or reverse. The output shaft may be keyed or flanged depending upon application. The reverse gear is direct mounted to the engine flywheel by means of a flywheel adapter and an oil dam keeps the transmission sump free from engine contamination.

1.2 OUTPUT ROTATION

The Capitol reverse gear in forward mode provides output rotation in the same direction as engine rotation. The transmission is normally supplied for a right hand engine (clockwise when viewed from the front). When a unit is supplied for a left hand (counterclockwise) engine a pump of counterclockwise rotation is normally required also. (See pages 9 and 18R for details.)

For marine application, a twin screw arrangement is possible provided the engines rotate in opposite direction, or if final drive is through vee drives, with one containing an idler for opposite rotation output.

1.3 ACCESSORIES

OIL COOLER
Various capacity coolers are available depending on engine horsepower and are purchased optionally. However an oil cooler must be used with a Capitol direct drive unit.

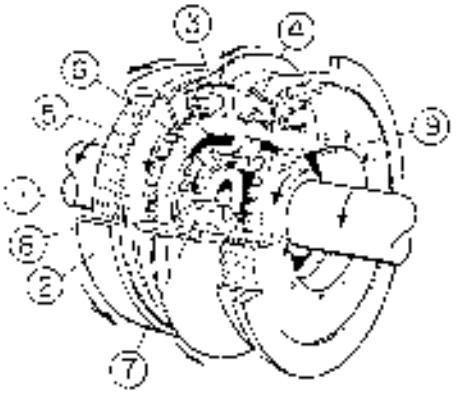
COUPLING KIT
A propshaft coupling kit, including mounting bolts, is available to meet most requirements.

SECTION 2. PRINCIPLES OF OPERATION

2.1 POWER FLOW

The drive flange, clutch driving drum and forward clutch driving discs always rotate at engine speed. When the forward clutch is activated the clutch pack rotates in engine direction. This causes the output shaft to rotate in engine direction also. A direct drive transmission, not having reduction gears, provides output rotation at engine speed.

When the reverse clutch is activated, the clutch pack is held stationary to the housing. Power is transferred through the bevel gears, reversing the rotation of the output shaft.



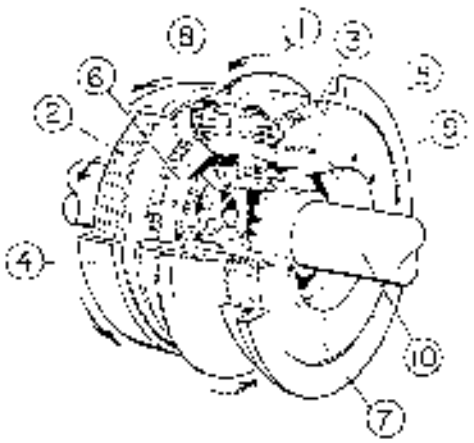
2.2 CLUTCH AND GEAR CARRIER

The clutch assembly is a multiple disc type clutch activated by a hydraulic mechanism. This mechanism is formed by a carrier for the bevel gears and by two cylinders bolted together which act as the clutch pistons. The movement of the cylinders is regulated by the selector valve which directs pressurized oil to the proper cylinder depending on the mode selected. The bevel gears inside the carrier transmit power flow to the pinion.

FORWARD MODE

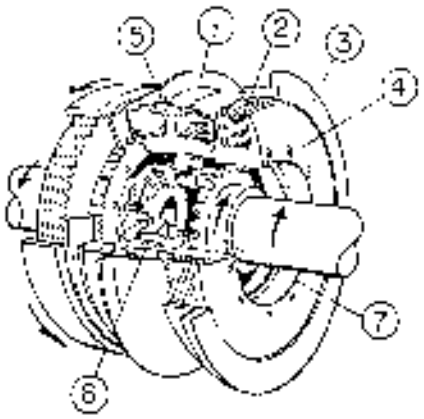
At all times, stub shaft (1), forward driving drum (2) and driving gear (5) are turning in engine rotation direction at engine speed.

Forward is achieved when selector valve is shifted to allow oil to pressurize forward half of cylinder (3). Cylinder then slides on bevel gear carrier (4) clamping clutch discs (6) together. Half of discs are splined to forward driving drum and half are splined to end flange (8). Because end flange is bolted to gear carrier and discs are now locked together, gear carrier with bevel gears (7) now rotates at engine speed along with driving gear. Rotating bevel gears cause driven gear (9) to turn with them and this causes rotation of output shaft in forward rotation.



NEUTRAL MODE

Both halves of clutch cylinder (1) are filled with pressurized oil. Cylinder cannot press against either forward (2) or reverse clutch discs (3). Discs splined to driving drum (4) and reverse drum (5) remain separate from discs splined to end flanges (6) & (7). Consequently no direct torque is applied to gear carrier (8) or driven gear and output shaft (9) & (10). Bevel gears may revolve on their own shafts and gear carrier orbits at half engine speed.



REVERSE MODE

Reverse is achieved when cylinder (1) is pressurized and slides against reverse clutch discs (2) clamping them together. Half of the discs are splined to the stationary reverse drum (3) and half are splined to end flange (4) bolted to gear carrier (5). Rotating gear carrier then stops. The bevel gears (8) now rotate on their shafts causing driven gear (7) to turn in anti-engine direction producing reverse output.

2.3 HYDRAULIC SYSTEM

Pressurized oil is provided by a gear type oil pump which is engine driven. From the pump oil flows through a cooler and filter before reaching the selector valve. Forward neutral and reverse are obtained by means of the selector valve which directs high pressure oil through internal passages to the clutch. Low pressure oil is channeled to cool bearings gears and clutch discs.

In neutral, the ports to both forward and reverse sides of the clutch cylinder are opened and the balanced pressure that results keeps the cylinder from activating either forward or reverse discs. Oil is distributed through the lubrication system.

When the selector valve is shifted to either forward or reverse mode, high pressure oil is allowed to flow only to one half of the clutch cylinder to engage the selected pack. Oil in the other half of the cylinder is exhausted to sump. Again low pressure oil is distributed through the lubrication system.

An oil dam completely separates the transmission lubrication system from the engine lubrication system.

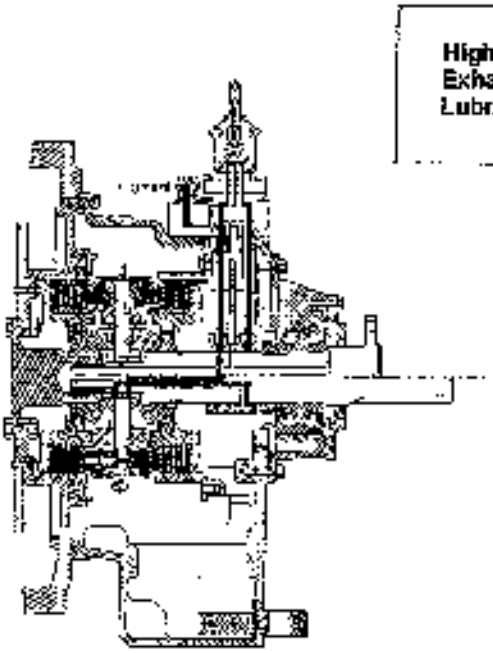


Fig. 4 **NEUTRAL**
Clutch Pressure Circuit (no exhaust)

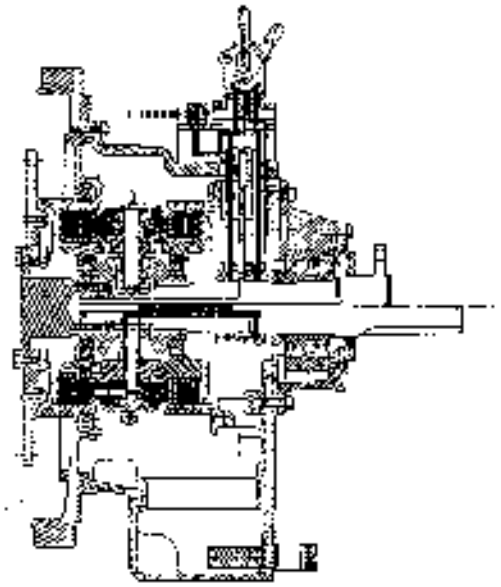


Fig. 5 **REVERSE**
Clutch Pressure and Exhaust Circuit

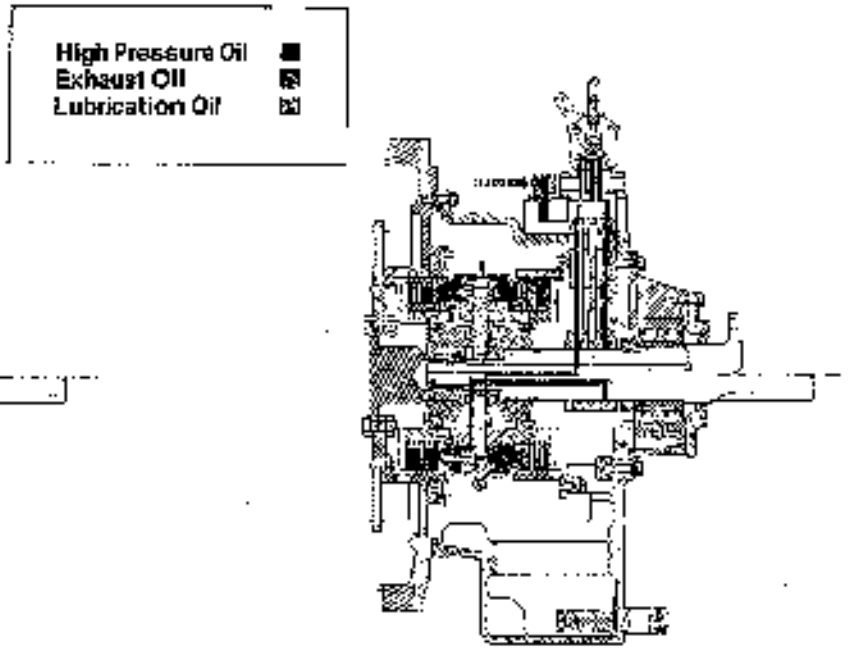


Fig. 6 **FORWARD**
Clutch Pressure and Exhaust Circuit

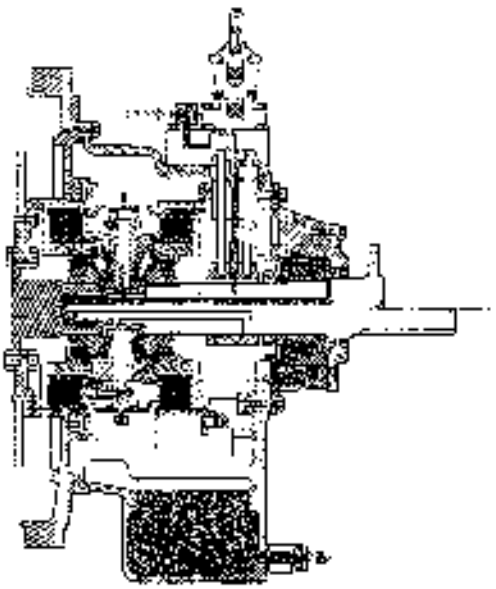


Fig. 7 **LUBRICATION**

SECTION 3. INSTALLATION AND OPERATION

3.1 UNCRATING AND HANDLING

Tapped holes have been provided for insertion of lifting hooks to aid in handling the unit. Average weight of HY 400 is 700 lbs., the HP 500 is 850 lbs.

Check parts for shortage and any damage that may have occurred (the parts information section may be used as reference). Report immediately any shortage or damage to your local distributor, transfer agent or Capitol Gears.

3.2 PRELIMINARY INSTALLATION

SPECIAL TOOLS REQUIRED

1. Chain Hoist or equivalent
2. Straight Edge
3. Feeler Gauge
4. Thousandths Dial Indicator

To insure proper alignment of driving members it is recommended that engine flywheel housing, flywheel, oil dam and stub shaft be dial indicated to insure trueness.

1. (Fig. 6A) Dial Indicate the bolt face of the engine flywheel housing flange. Rotate engine flywheel. Record reading. Face deviation must not exceed a total indicator reading of .007 inch.

2. (Fig. 6B) Mount indicator with stem riding on flywheel housing bore as shown. Rotate flywheel and record reading. The bore eccentricity must not exceed a total indicator reading of .007 inch.

3. (Fig. 6C) Mount indicator to flywheel housing so that stem is on inner face of flywheel. Record deviation of face runout. It must not exceed a total indicator reading of .007 inch.

4. (Fig. 6D) Set stem to ride on the pilot bore of the engine flywheel as shown. Record reading. Pilot bore eccentricity must not exceed a total indicator reading of .007 inch.

The sum total of all readings in steps 1 thru 4 must not exceed .007".

NOTE:
Keep all mating surfaces clean. Use cleaning solvent or diesel fuel.

5. Separate the clutch driving drum and flywheel drive flange assembly from the clutch assembly.

Remove clutch driving drum from the flywheel drive flange. Leave stub shaft attached.

6. Thoroughly clean the drive flange to flywheel mating surface and secure drive flange to flywheel.

7. Bolt on flywheel adaptor and stub shaft assembly to engine flywheel.

8. Secure oil dam on engine flywheel housing with 2 capscrews. "Top" mark goes up, or drain slots down.

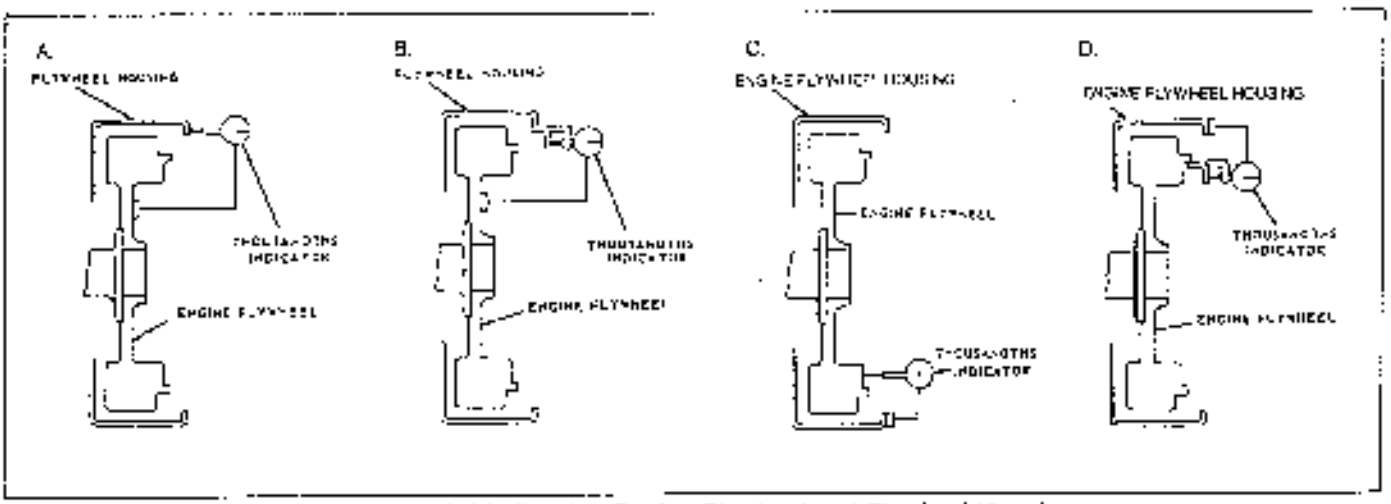


Figure 6. Dial Indicating Engine Flywheel and Flywheel Housing

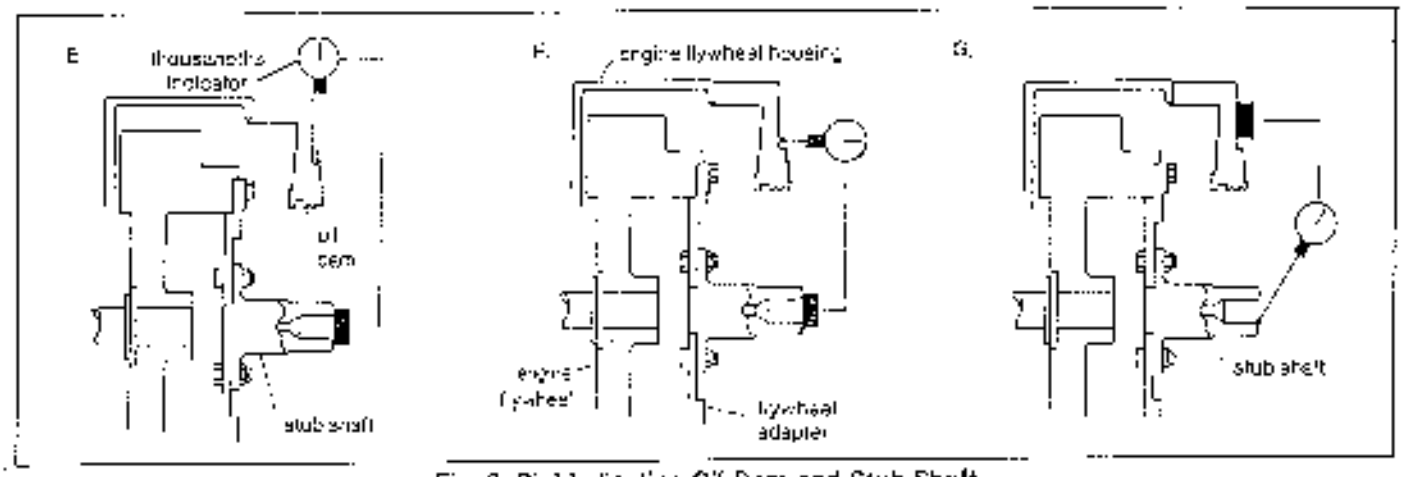


Fig. 9. Dial Indicating Oil Dam and Stub Shaft.

9. Dial indicate rear oil dam pilot O.D. as shown in figure 9E and dial indicate bolt face as shown in figure 9F. Record both readings. **Total indicator readings** must not exceed .007 inch.

10. Dial indicate stub shaft as shown in figure 9G. Record the reading. **Total indicator reading** must not exceed .007 inch.

The sum total of all readings in steps 9 and 10 must not exceed .007 inch.

11. If slinger shield is present on unit, remove slinger shield.

12. Install clutch driving drum on flywheel adapter sealing with #2 Permatex.

13. Check clearance between drive flange O.D. and oil dam I.D. with feeler gauge. Minimum clearance must not be less than .006". Secure with self-locking fasteners.

14. Reassemble slinger shield, if present, to oil dam, replace and tighten capscrews. Secure capscrews with lockwire.

15. Place sub-assembly consisting of clutch and gear carrier in position on splines of driving stub shaft. **Note:** The forward pack contains the greater number of discs and it goes toward the engine. Also the forward end flange is stamped "this side toward engine".

16. Remove the side inspection covers to facilitate installation.

3.3 INSTALLATION OF REVERSE GEAR

1. Using suitable hoist, lift reverse gear assembly into position behind engine. Ease unit forward over clutch assembly, taking care that clutch discs enter reverse clutch drum properly so that teeth are not damaged.

NOTE:
Use screwdriver through side inspection hole and move disc teeth to align with reverse drum.

2. Secure main housing to oil dam housing. Tighten capscrews to 42 pounds-foot torque (HY units) and 29 pounds-foot torque (HP units).

Check clutch end float:
a) Insert screwdriver through side inspection hole and pry clutch fore and aft.
End float should be 3/16" to 3/32".
b) Replace gasket and inspection covers.

3. Turn output shaft over for several revolutions making sure unit is free to turn.

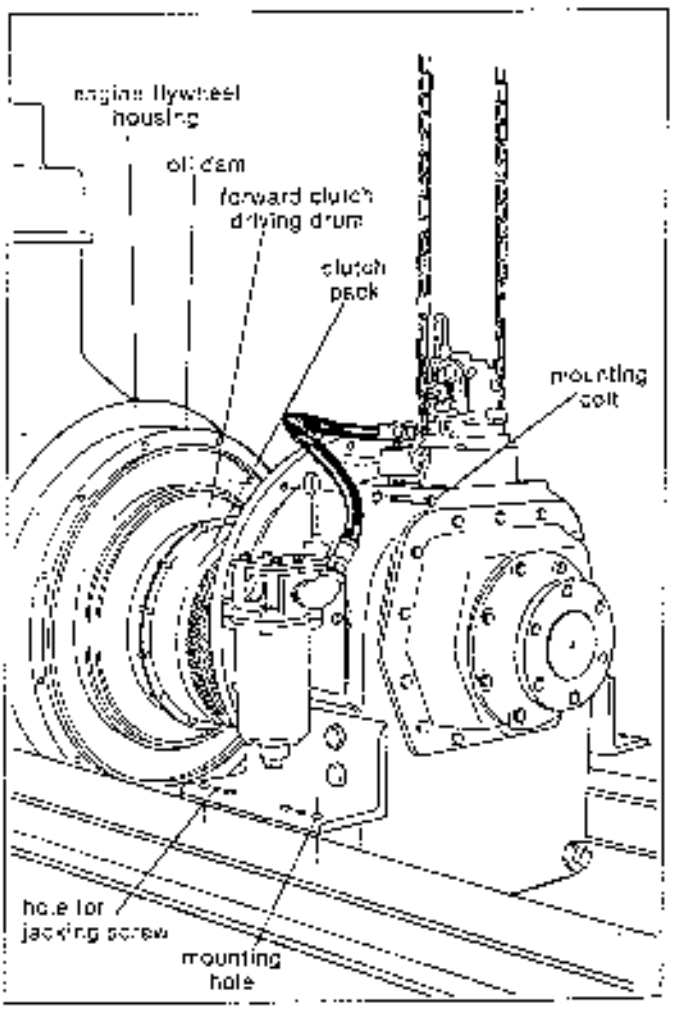


Fig. 10. Installing Reverse Gear

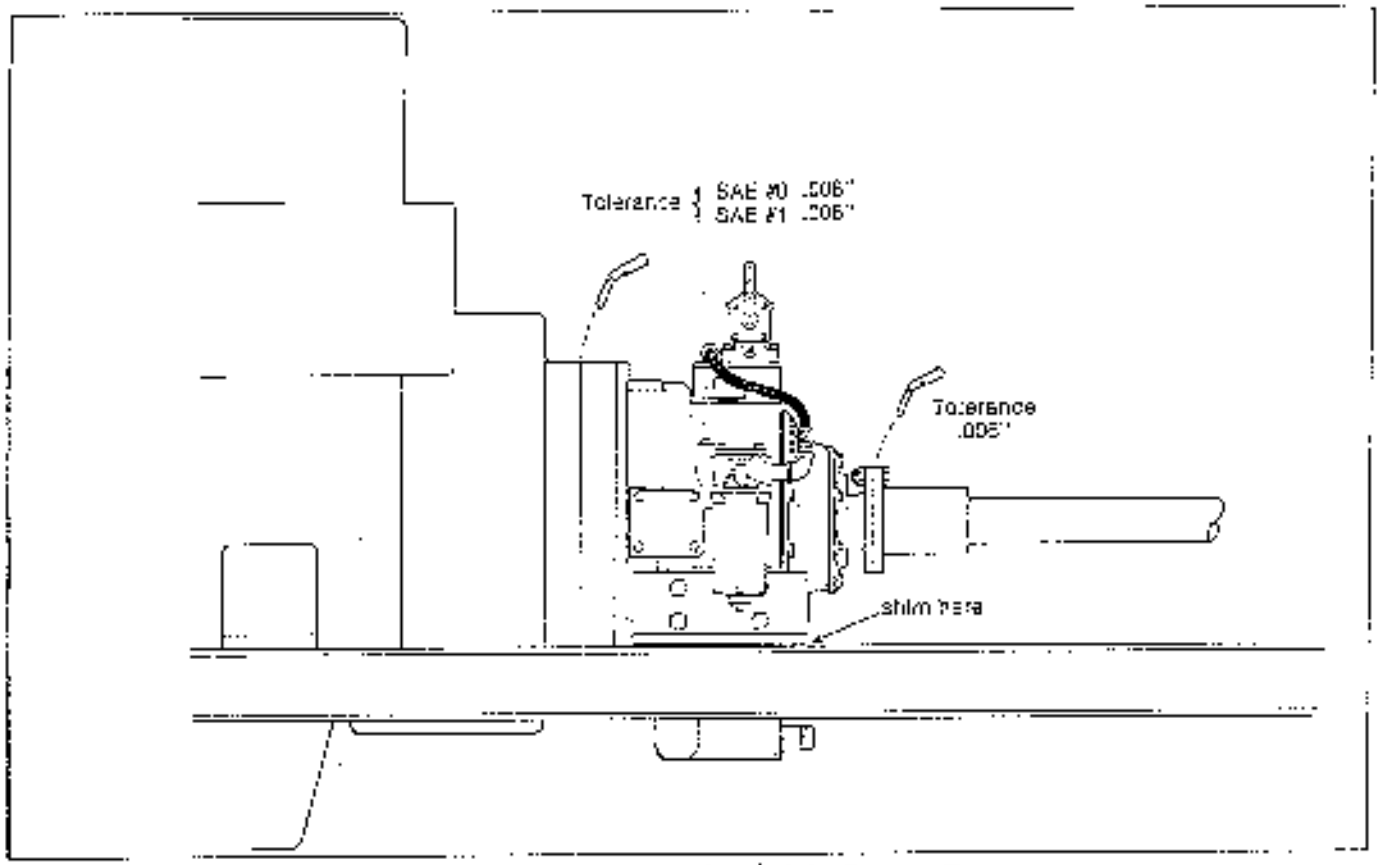


Fig. 11. Alignment of the Engine and the Reverse Gear

3.4 ALIGNMENT

In marine application, final alignment of output flange and propeller shaft coupling must be accomplished when the vessel is afloat and not in drydock, because most hulls will flex. This is positively necessary to meet warranty requirements.

Mounting pads on housing permit unit to be bolted to bed rails, power plant frame, keelsons, etc.

The distance of the first shaft bearing from the mating surface of the reverse gear output coupling is extremely important. To avoid undue force on the reverse gear bearings, the propeller shaft bearing should be located at least twelve and preferably twenty shaft diameters from the reverse gear output coupling.

NOTE:
The same alignment procedures should be followed even if a flexible coupling is used. The most accurate method is to use a non-flexible spacer of the same size. Flexible couplings are used only to dampen noise and vibration not to correct misalignment.

Now align shaft coupling to reverse gear coupling. Lay a straight edge across the edges at top and sides to line up couplings. Do not burr or mar mating surfaces. Insert feeler gauge between couplings and run it all around the flange. Clearance should not be more than .006" at any point. Shim engine and reverse gear as necessary.

Loosen gear housing to engine housing bolts and check with feeler gauge. Maximum variation for SAE #0 housing .003"; for SAE #1 housing .006".

Tighten four gear housing capscrews at 90° intervals. Secure engine and gear mounting feet. Loosen four gear housing bolts. Recheck housing and coupling parallelism. If within limits tighten housing and coupling bolts.

NOTE:
Under no condition is the engine to be supported by gear housing.

3.5 WATER PIPING

To assure proper cooling of Capitol's reverse gear units, connect the cooling system as indicated on one of the three diagrams shown. It is extremely important that the marine gear oil be cooled properly; the oil cooler must receive an ample supply of cold water.

The connections shown on the following diagrams are recommendations for optimum performance.

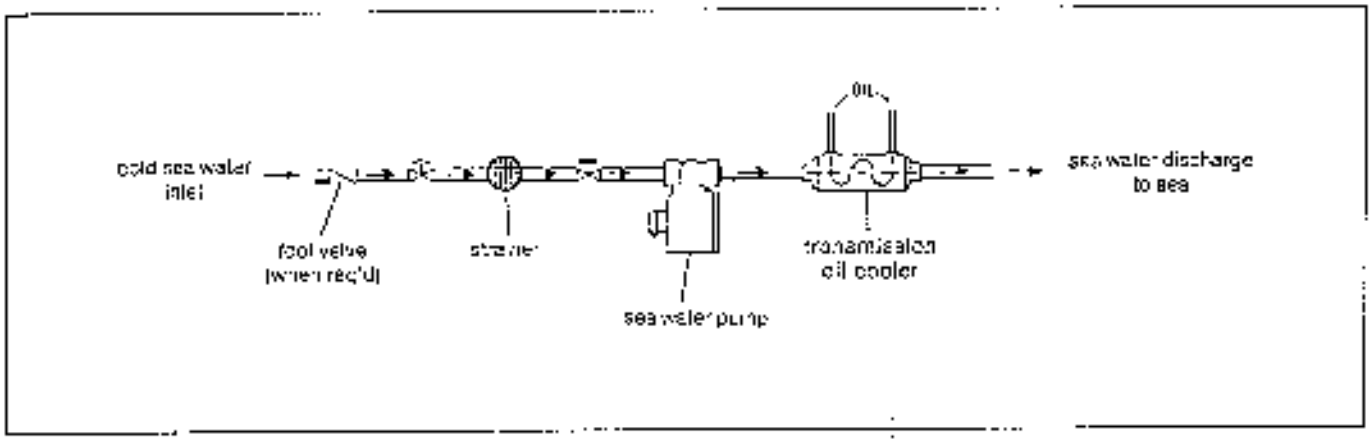


Fig. 12. Separate pump system

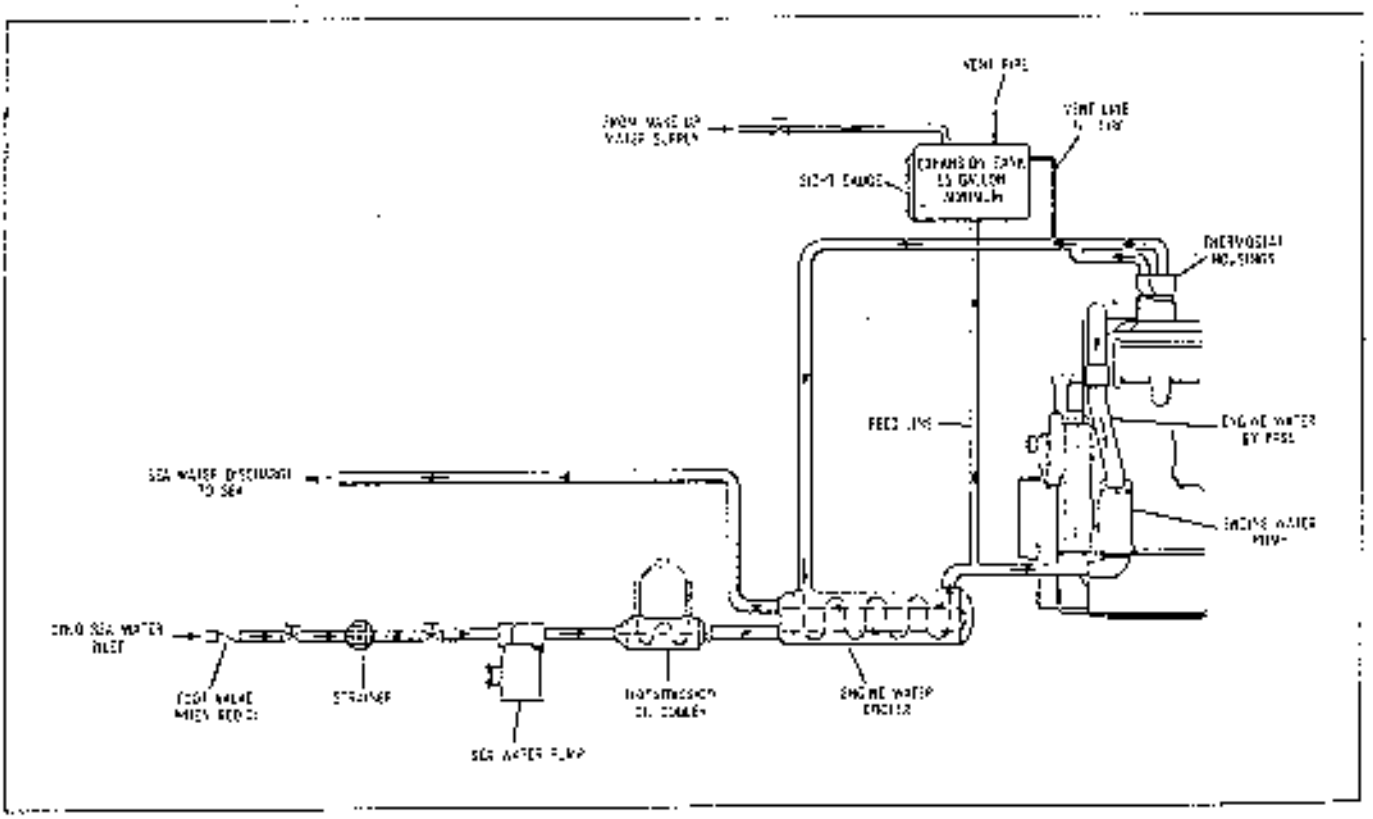


Fig. 13. Heat exchange system

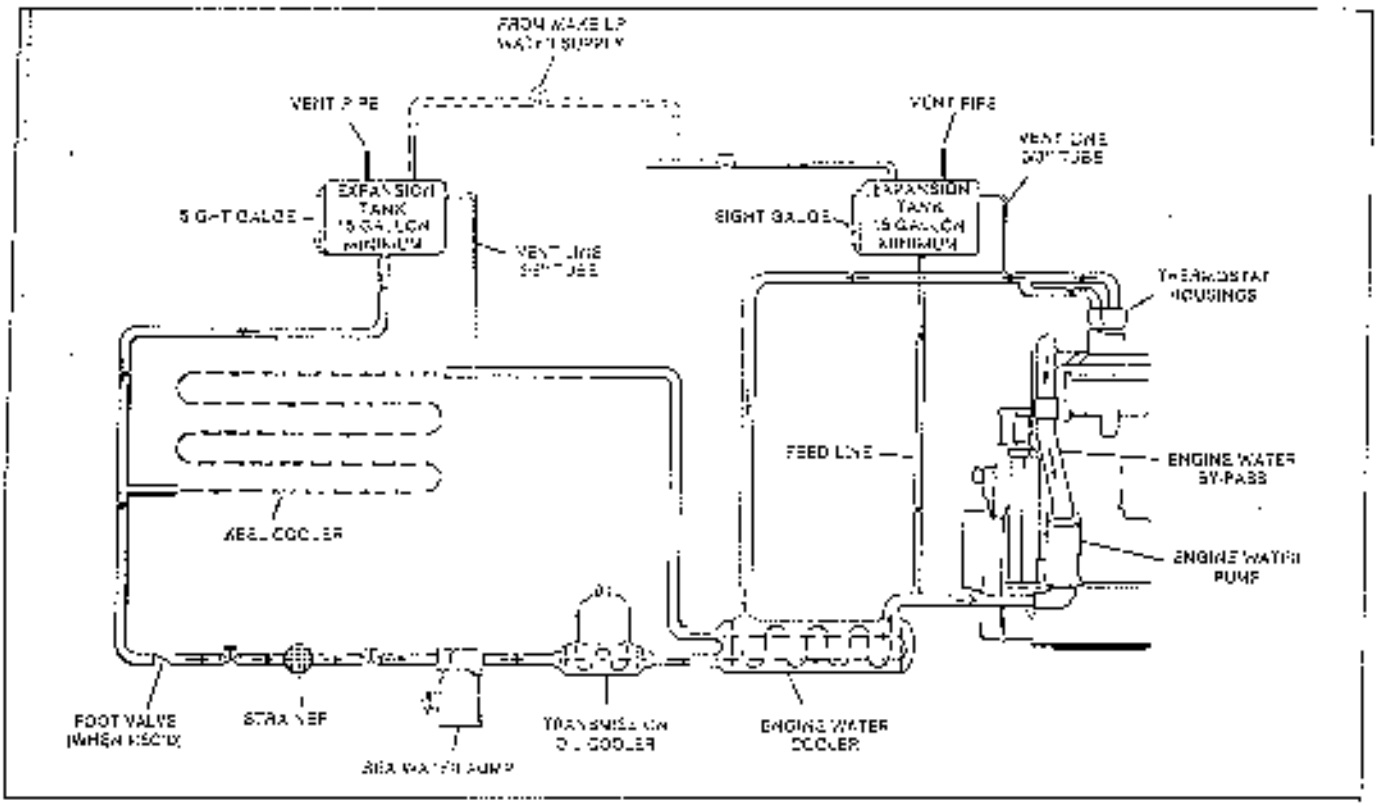


Fig. 14. Keel cooler system

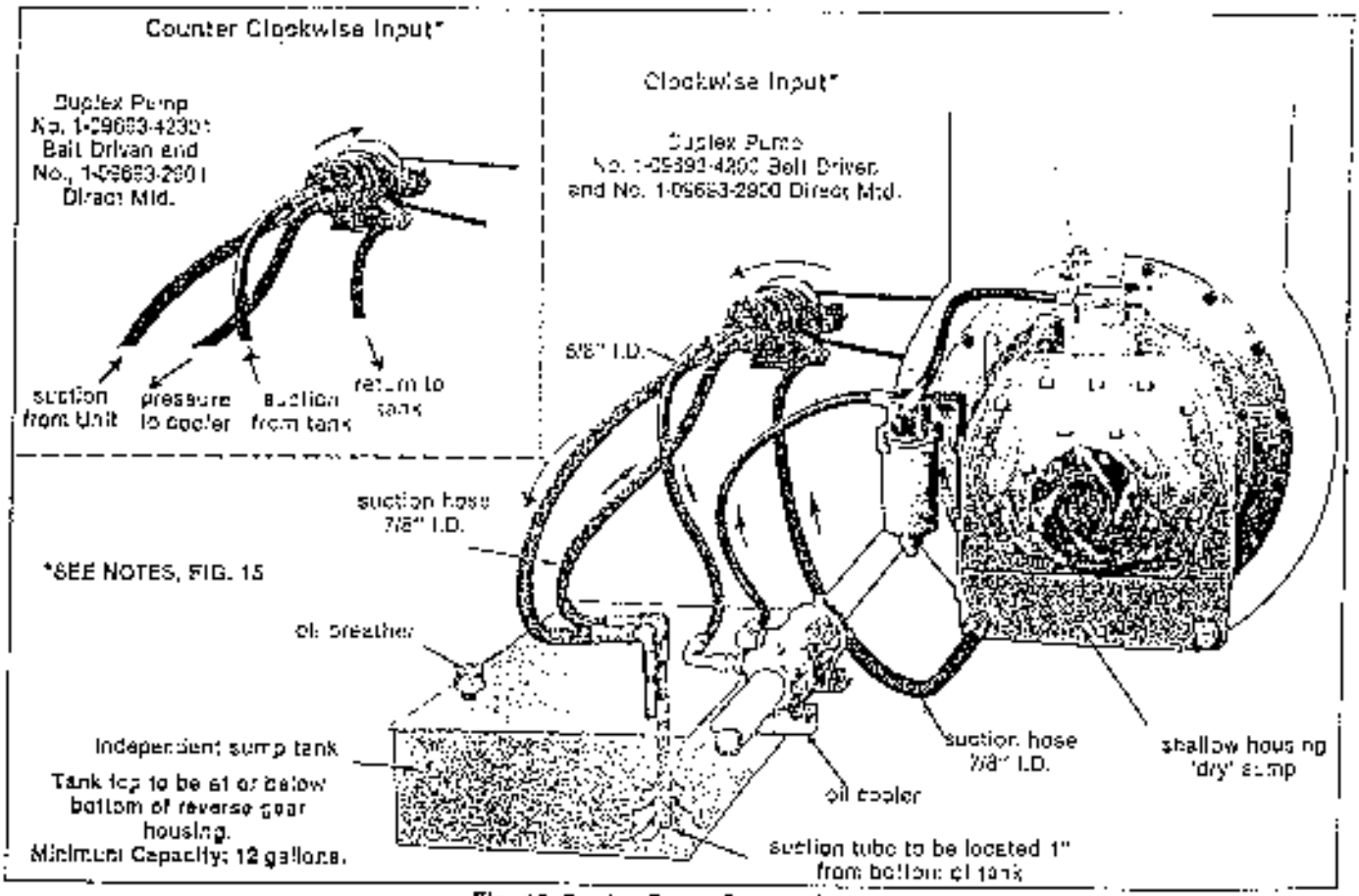


Fig. 16. Duplex Pump Connections

3.7 START-UP PROCEDURE

1. Remove reverse gear inspection cover and pour in recommended oil until level is up to full mark on dipstick (see lube chart). Replace inspection hole cover but do not secure.

2. Install pressure gauge of 300 pound capacity directly on top of gear or on bulkhead. Connect gauge to control valve with 1/4" steel tubing or hydraulic hose. (Note: Electric type oil pressure gauges are not recommended.)

Reverse gear is now ready for start up:

3. Engage starter for approximately 30 seconds. (DO NOT START ENGINE). This activates pressure pump which pre-lubricates reverse gear, preventing premature wear before load is applied.

4. Start engine and check oil connections for leaks.

5. Oil pressure is adjusted at factory for testing purposes only and it may be necessary to readjust pressure to the correct level (200-210 PSI). This should be done at normal operating speed and temperature.

NOTE:
Normally, unit pressure at idle start-up will be 180 PSI, but final adjustment must be made as noted above. See figure 17. below.

6. After unit has been operated a few minutes, stop engine, check oil level and add sufficient oil to bring level to full mark on dipstick. (See Lube chart for capacities, p. 11).

7. Shift several times to insure that all cylinders, hoses and cooler are full of oil.

8. Install selector valve cables and shift to insure valve lever goes into full detent in all 3 positions; forward, neutral and reverse.

NOTE:
We strongly recommend installing an interlock control system which prevents shifting at other than engine idle speed and greatly prolongs life of the gear.

9. Reverse gear is now ready for sea trials and final adjustment.

3.7 OPERATING PRACTICES

(CAUTION)

1. A Capitol reverse gear should not be shifted unless engine is at idle speed.

2. Reverse gear cannot be operated continuously in reverse mode for more than 30 minutes at 75% of available horsepower.

3. In marine application 'Windmilling' (freewheeling) is strictly prohibited as extensive internal damage may result. In the case of a twin screw application where only one engine may be used a great deal, shaft brakes should be installed. (As an alternative an auxiliary lube system may be installed).

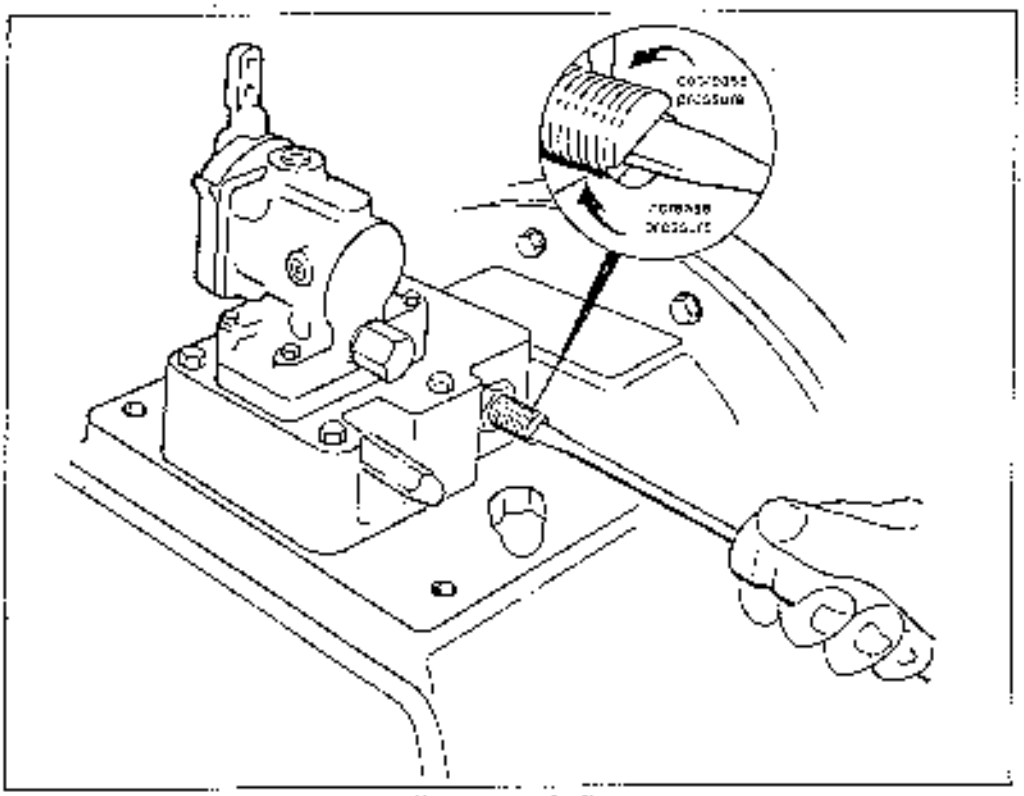


Fig. 17. Adjustment of oil pressure

CORRECT OIL PRESSURE: 200-210 P.S.I. at normal operating speed and temperature.

SECTION 4. PREVENTIVE MAINTENANCE

To insure a long service life of the Capitol direct drive gear and to prevent costly and unexpected failures it is very important that a regular maintenance schedule be established and followed.

4.1 LUBRICANTS

For all normal ambient operating conditions, 30°F. (-1°C) to 85°F (29°C), we recommend a good grade, anti-foaming, heavy duty, SAE 30 motor oil.

Where high ambient water temperatures are encountered, over 85°F (29°C), it may be necessary to use SAE 40 motor oil.

Where extremely cold ambient water temperatures are encountered, under 30°F (-1°C), it may be necessary to use SAE 20 motor oil.

Series 3 motor oils are not recommended as they may shorten clutch life.

CAUTION:
When using SAE 20 motor oil be very attentive to oil pressures. If proper pressure cannot be maintained (200-210 P.S.I.), it may be necessary to use SAE 30 and warm engine and gearbox thoroughly before engaging clutch. This condition would only be encountered at extremely low temperatures.

Oil Capacity

HY 400 and HP 500 (Deep Case Models) 18 quarts or more depending on hose length and cooler capacity.

Bring oil up to full mark on dipstick. Operate unit in forward and reverse for several minutes. This will fill cooler, clutch cylinders, pump hoses, etc. Stop engine and add required oil to return level to "Full" mark on dipstick.

Oil Pressure

Operating oil pressure should be 200-210 PSI at normal operating speed and maximum operating temperature.

Pressure Adjustment
see fig. 17, page 10.

Oil Temperature

Operating oil temperature range is 160°F. (71°C) at control valve, 160° to 180° (82°C) at sump.

4.2 ROUTINE MAINTENANCE

Oil Cooler Assembly

Check zinc pencils in oil cooler and change if badly eroded. Check zinc pencils at approximately every 400 hours of operation.

Check water tubes for obstructions at approximately every 2000 hours of operation and flush if necessary.

Oil Filter

The oil filter element should be replaced every 400 hours of operation or at the same time oil is changed.

Oil Breather

Remove oil breather every 400 hours of operation or at the same time oil is changed. Clean diesel fuel can be used for flushing.

Pressure Gauge

Periodically check pressure gauge by substituting a calibrated pressure gauge of known accuracy.

Visual Inspection

At frequent intervals check all oil lines, water hoses, and connections for leaks. Tighten all external bolts and connections and visually inspect external components for wear or damage.

Wear Analysis

At periodic intervals record pressure readings at idle speed. A gradual decline is normal. Readjust pressure relief valve to maintain proper operating pressures. See fig. 17, p. 10.

Inspection/Overhaul Interval

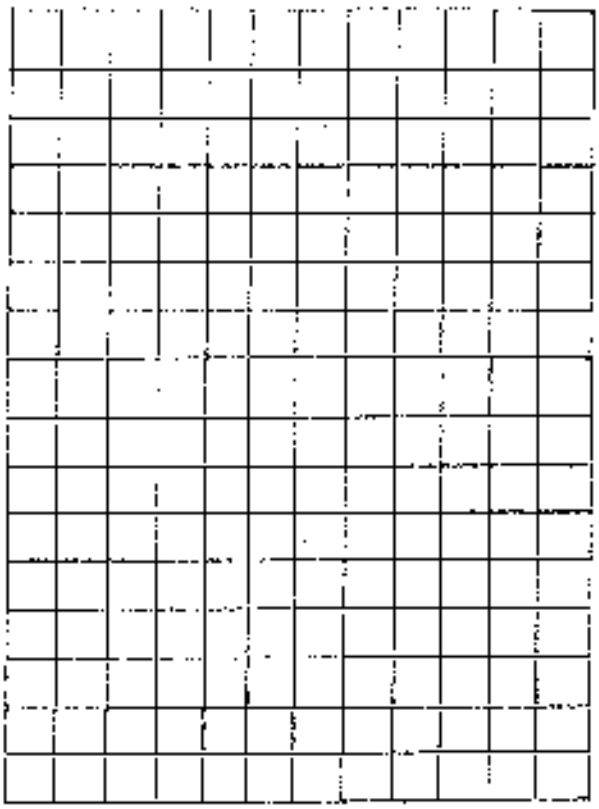
A complete inspection of the Capitol reverse gear should be made at least as often as the engine is overhauled. Parts such as commutator bushings, oil seals, quad rings, clutch discs, bearings, etc. showing any fatigue or wear should be replaced. It may be desirable to completely rebuild the reverse gear at this time (See section 6 and 7.)

Engineer _____

Reverse Gear Serial No. ___

Data Service Began _____

4.3 MAINTENANCE SCHEDULE AND CHECK SHEET

INTERVAL normal operation	MAINTENANCE DESCRIPTION	RECORD
DAILY	-Check oil level -Check oil pressure	
After first 100 hours	-Change oil and flush sump	
Every 400 hours	-Check zinc pencils -Change oil -Replace filter element -Remove and clean oil breather	
Every 2000 hours	-Check gear backlash -Check water tubes in cooler	
At engine overhaul	-Inspect clutch and all gearing and replace as necessary	
Frequently	-Check all oil lines and connections -Check all external components -Check all mounting bolts -Check alignment	

SECTION 5. TROUBLE SHOOTING

5.1 TROUBLE/REMEDY CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
A. Low oil pressure (At full operating speed and temperature).	1. Low oil level.	Inspect gaskets, seals, hoses and fittings for leakage.
	2. Clogged suction screen.	Remove suction screen and clean with a good grade solvent or diesel fuel.
	3. Clogged filter element.	Replace element.
	4. Dirt or sludge in transmission.	Remove drain plugs, flush gear with commercial solvent or diesel fuel. Start engine; at idle shift gear several times, full forward to full reverse for approx. 5-7 min. Shut down engine and drain gearbox thoroughly. Refill gear with proper oil and run for approximately 25 to 50 hours. Drain sump and refill with new oil. This will remove any residual solvent.
	5. Worn or incorrectly adjusted pump assembly.	Refer to oil pump section (Page 17) or fig. 17, p. 10.
	6. Oil too hot.	Check heat exchanger system for clogged oil cooler or hoses.
	7. Worn commutator bushings	See wear limits chart. (p. 22)
	8. Incorrect lubricant	See lube chart (p. 11).
	9. Scratched clutch cylinders or hard O'rings in clutch cylinders.	Replace as necessary. (p. 23)
B. High oil pressure (at full operating speed and temperature)	1. Incorrectly adjusted pump assembly.	1. Refer to fig. 17, p. 10.
	2. Inoperable relief plunger in base plate.	2. Refer to p. 20.
	3. Incorrect oil.	3. See lube chart (p. 11).
	4. Oil too cold.	4. Check heat exchanger system.
C. Overheating	1. Insufficient oil cooler capacity.	1. Install adequate oil cooler
	2. Insufficient flow of cooling water.	2. Increase water line sizes.
	3. Clutch slipping.	3. Refer to symptom A.
	4. Water temperature too high at cooler.	4. Decrease water temperature to cooler or relocate heat exchanger in cooling system.

D. Excessive noise in transmission.	1. Bearings worn or broken.	1. Inspect bearings for scored races, broken roller, flat spots, etc.
	2. Gears worn or broken.	2. Inspect gears and replace if necessary.
	3. Noise in forward only.	3. Reverse position may be mistakenly used for forward. Selector valve lever must point forward when boat is in forward motion.
	4. Noise in reverse only.	4. This is normal because more gears are in operation in reverse mode.
E. Noisy Pump	1. Dirt or sludge in oil.	1. Remove oil pump and hoses. Clean thoroughly and reinstall.
	2. Clogged hoses	2. Clean and replace as required.
	3. Pump cavitation	3. Inspect suction hoses for leaks. Oil level may be too low.
	4. Defective oil pump assembly.	4. Refer to oil pump section p. 16.
F. Clutch does not release	1. Improper oil in sump.	1. Refer to lube chart, p. 11.
	2. Clutch discs warped	2. Replace as necessary, see p. 26.
	3. Forward and reverse clutch cylinders dirty or distorted.	3. Clean or replace as necessary, see p. 25, 26.
	4. Rear commutator bushing is worn.	4. Replace as necessary. See wear limits, p. 22.
	5. Clutch discs fused due to slippage and overheating.	5. Replace as necessary, see p. 26.
G. Clutch slipping	1. Low oil pressure	1. See symptom A.
	2. Oil temperature too high	2. Temperature should be 160°F (71°C), at selector valve, 160°-180° at sump. Check heat exchanger system.
	3. Worn clutch discs	3. Replace as necessary, see p. 26.
	4. Improper oil	4. See lube chart, page 11.
H. Clutch burned out	1. Low oil pressure	1. See symptom A.
	2. Clutch is shifted at other than engine speed.	2. Install interlock shift controls.
	3. Transmission misaligned	3. Check alignment as described in installation section, p. 4.
	4. Excessive heat.	4. Check cooling system, see p. 7.

I. No neutral	1. Warped clutch discs	1. Replace as necessary, see p. 25.
	2. Scored clutch cylinders	2. Replace as necessary, see p. 25.
	3. Damaged seal rings	3. Replace all seal rings, see p. 25.
	4. Worn or damaged commutator bushings (forward or rear)	4. Refer to repair section, p. 23-25 or p. 29. See wear limits, p. 22.
	5. Worn selector valve	5. Replace if necessary. Note: Selector valve is the least likely source of trouble, p. 19.
J. Delay in clutch engagement	1. Cylinder timing screw out of adjustment	1. Remove dome nut and adjust screw (counter-clockwise) to speed up reaction. See p. 23.
K. Clutch engages too fast	1. Cylinder timing screw out of adjustment.	1. Remove dome nut and adjust screw in (clockwise) to delay reaction. See p. 23.