SERVICE MANUAL
5HD 200
Direct drive reverse
Transmission

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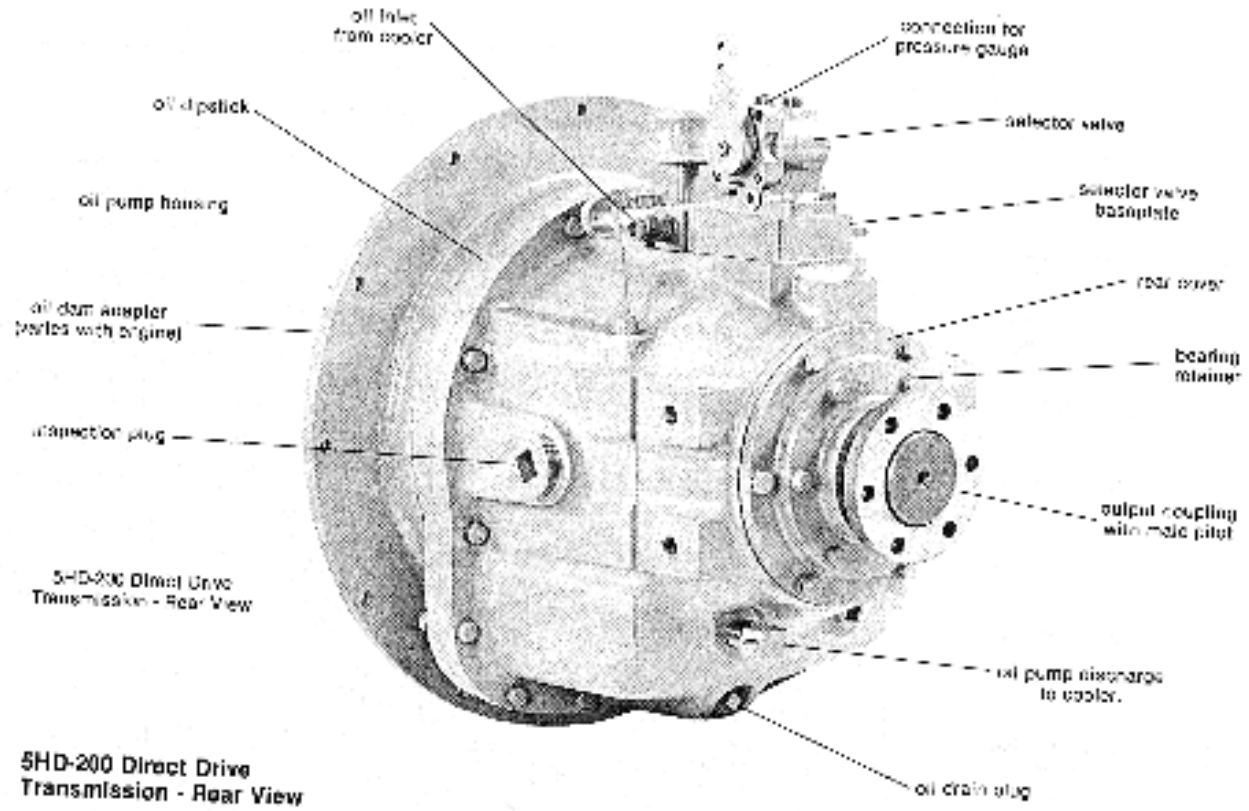
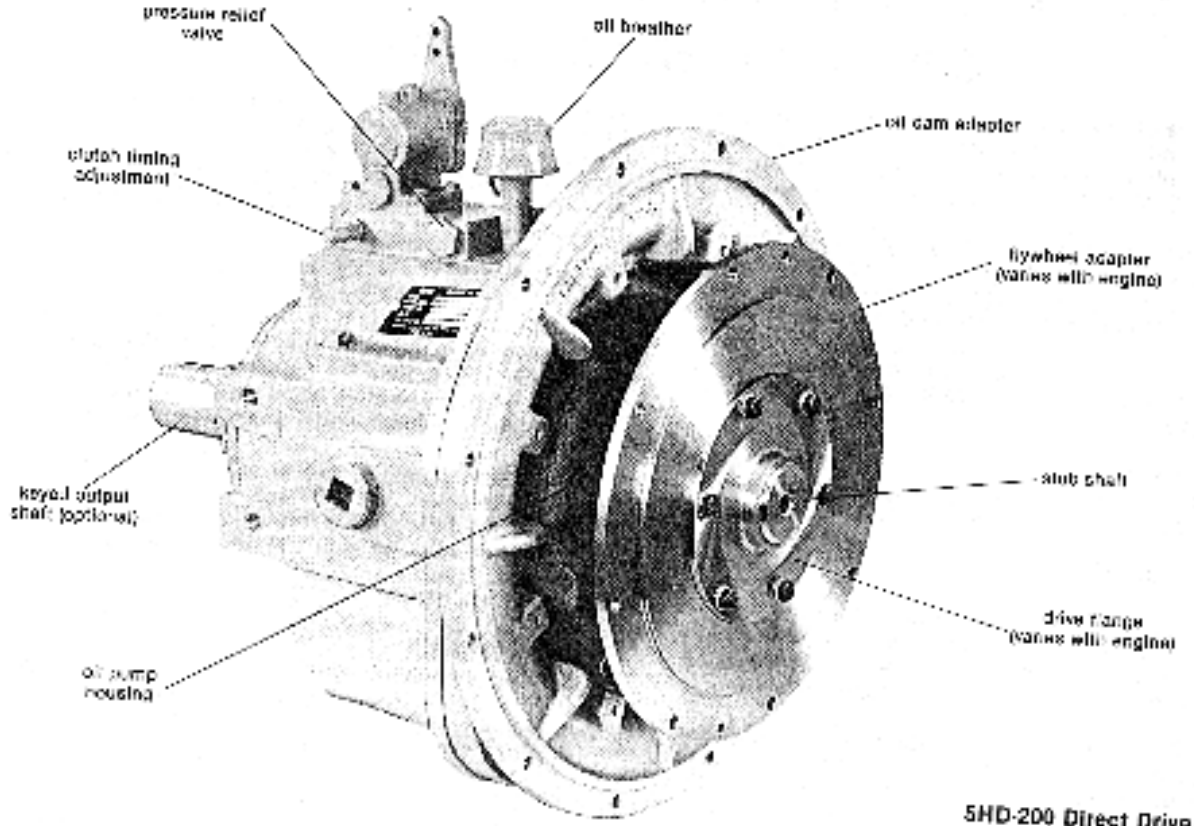


5HD-200 Direct Drive Transmission - Rear View



5HD-200 Direct Drive Transmission - Front View

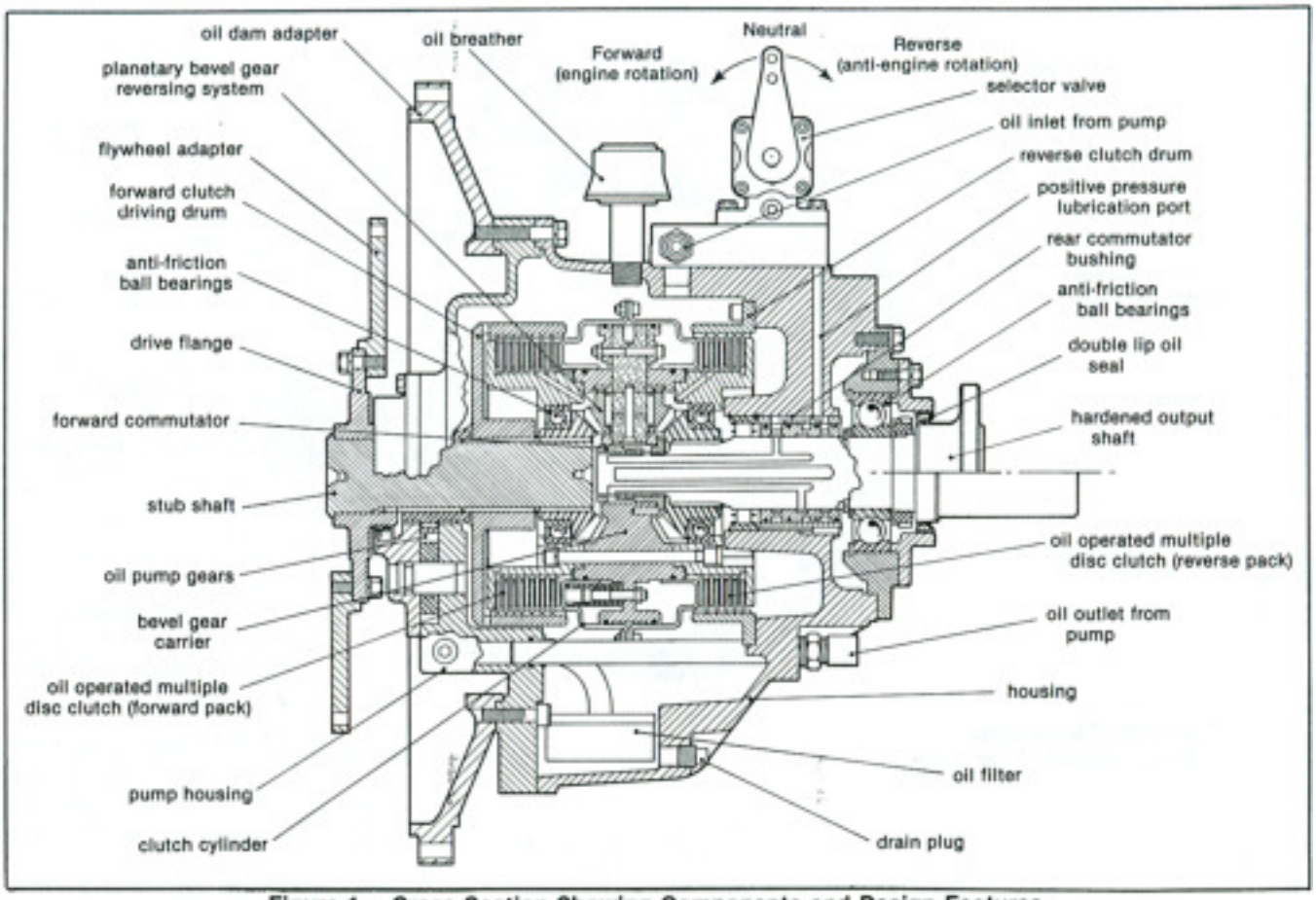


Figure 1. Cross Section Showing Components and Design Features

SECTION 1. INTRODUCTION

The purpose of this manual is to provide assistance to operations and maintenance personnel to reduce downtime and obtain consistent performance from the Capitol 5HD-200 Direct Drive Reverse Transmission.

This service manual contains thorough installation and operation procedures, steps for proper maintenance and repair, a trouble shooting guide for assessing difficulties promptly, an illustrated parts information section, and engineering drawings for fabricating special tools. It should be made readily available to all those responsible for the operation or servicing of the reverse gear.

Performance characteristics and other details may be obtained from the engineering department of Capitol Gears, inc., St. Paul, Minnesota, U.S.A.

1.1 DESCRIPTION

The 5HD 200 direct drive reverse transmission is operated hydraulically; the clutch is activated by high-pressure oil and the gears, bearings and clutch discs are lubricated and cooled by low-pressure oil.

The direct drive transmission is direct engine mounted by means of a flywheel adapter and an oil dam adapter and includes 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 and provides a barrier against contamination from engine oil. The selector valve is used to obtain forward, neutral or reverse, and the one-piece output shaft may be keyed or flanged depending on application.

1.2 OUTPUT ROTATION

The Capitol reverse gear in forward mode provides output rotation in the same direction as engine rotation. The transmission may be supplied for a right hand engine (Clockwise rotation when viewed from the front) or a left hand engine
(Counter clockwise rotation.)

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 oil cooler must be used with a capitol drive unit.

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

SECTION 2. PRINCIPLES OF OPERATION

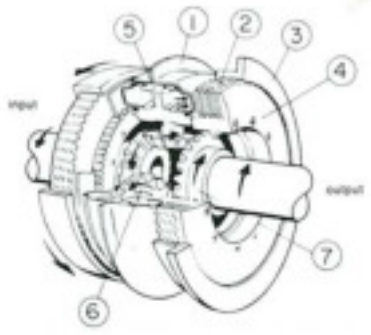
2.1 POWER FLOW

The flywheel adapter, which is directly fastened to the engine flywheel, rotates the drive flange, stub shaft, forward driving drum and forward clutch discs always at engine speed. When the forward clutch is activated the whole 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

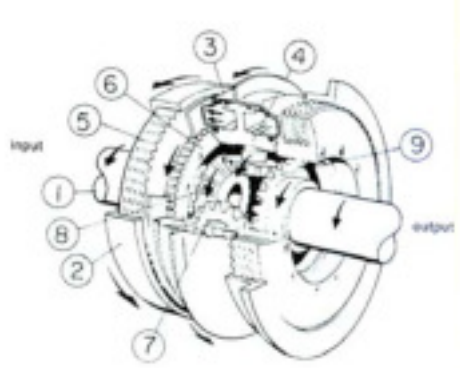
2.2 CLUTCH

The clutch assembly is a multiple disc type clutch activated by a hydraulic mechanism. This mechanism is formed by a carrier to 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.



REVERSE MODE

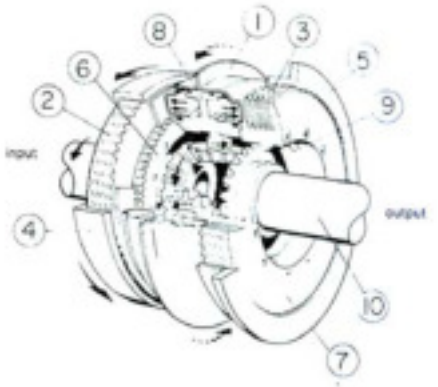
Reverse is achieved when cylinder (1) is pressurized and slides against reverse clutch discs (2) clamping them together. Half of the discs are splined to the stationary reverse drum (3) and half are splined to end flange (4) bolted to gear carrier (5). Rotating gear carrier then stops. The bevel gears (6) now rotate on their shafts causing driven gear (7) to turn in anti-engine direction producing reverse output.



FORWARD MODE

At all times, stub shaft (1), forward driving drum (2) and driving gear (8) 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 (5) together. Half of discs are splined to forward driving drum and half are splined to end flange (6). 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.

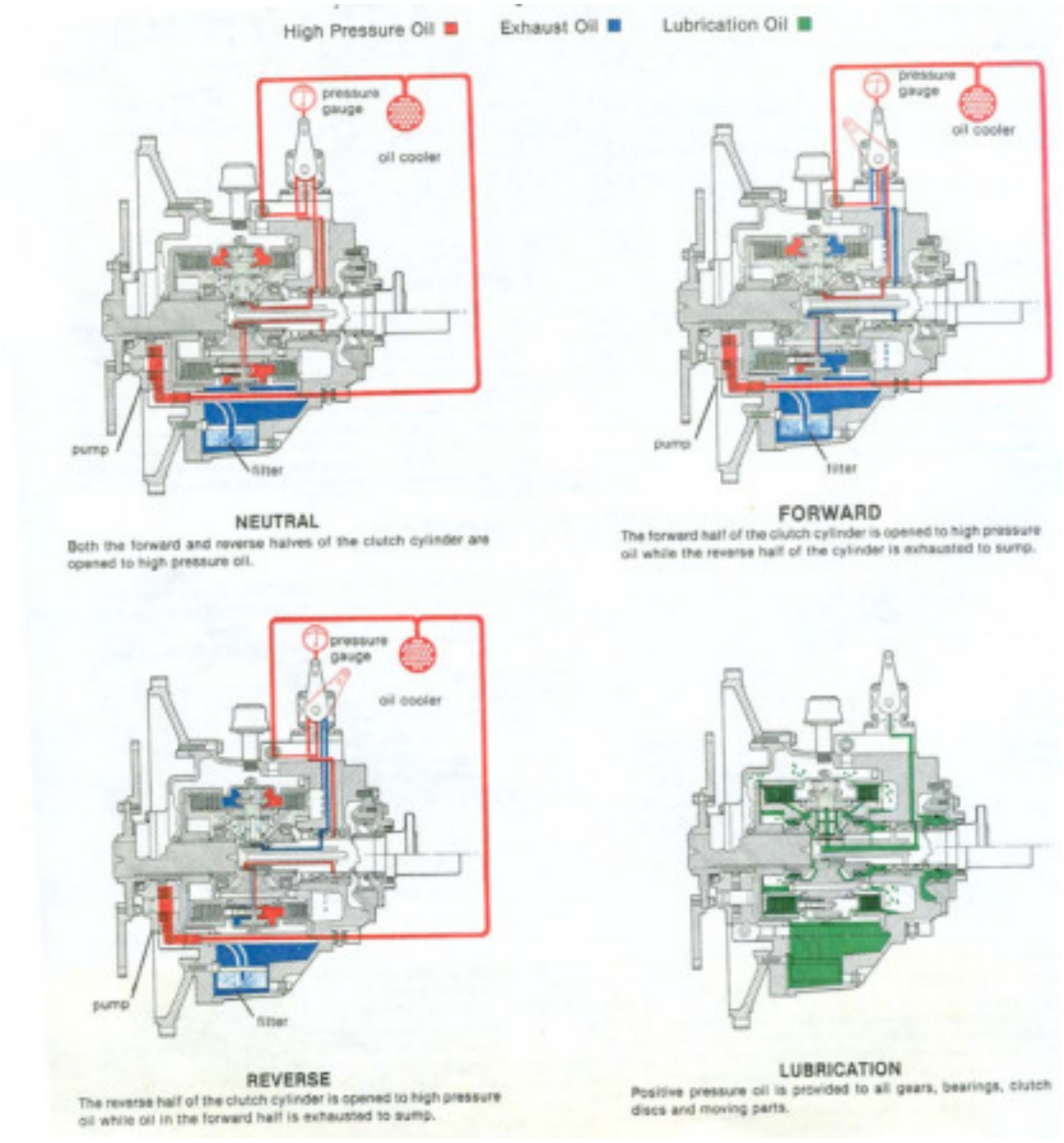
2.3 HYDRAULIC SYSTEM

Pressurized oil is provided by an internal gear type oil pump which is engine driven. From the pump oil flows through a filter and cooler 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.

The pump housing completely separates the transmission lubrication system from the engine lubrication system.



SECTION 3. INSTALLATION AND OPERATION

3.1 PRELIMINARY INSPECTION

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 INSTALLATION PREPARATION

An installation plan drawing has been provided in the rear of this manual.

Average weight of the 5HD 200 is 170 lbs dry.

SPECIAL TOOLS REQUIRED

1. Chain hoist or equivalent
2. Lifting eye (Special tool No. 1-90020-0000)
3. Straight edge
4. Feeler Gauge
5. 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.2A) 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.2B) Mount indicator with stern 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.

Record reading. Pilot bore eccentricity must not exceed a total indicator reading of .007 inch.

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

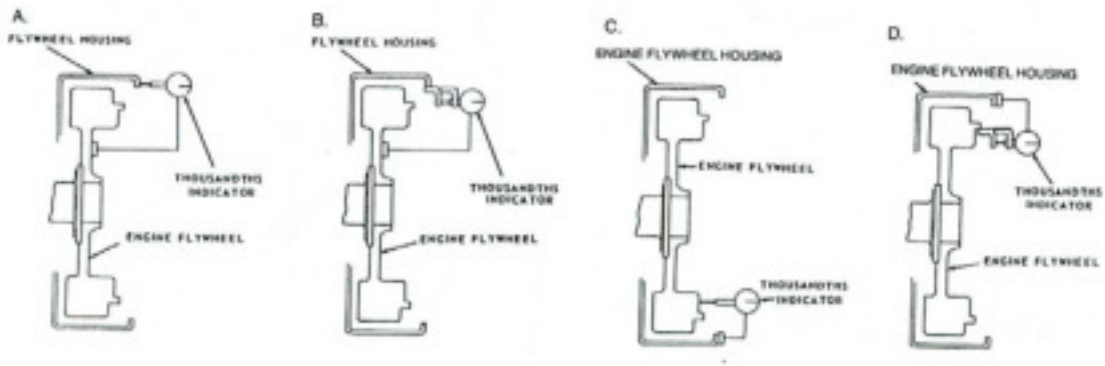
NOTE:
Keep all mating surfaces clean. Use cleaning solvent or diesel fuel.

1.Remove bolts from flange of reverse gear housing and remove oil dam and pump housing.

2. Separate the forward clutch-driving drum from the stub shaft. Allow drive flange assembly (Stub shaft, drive flange and flywheel adapter) to remain together.

3. Remove all burrs and thoroughly clean the engine flywheel and flywheel adapter mating surfaces; Secure drive flange assembly to engine flywheel.

4. Secure oil dam to engine flywheel housing with capscrews and lockwashers.



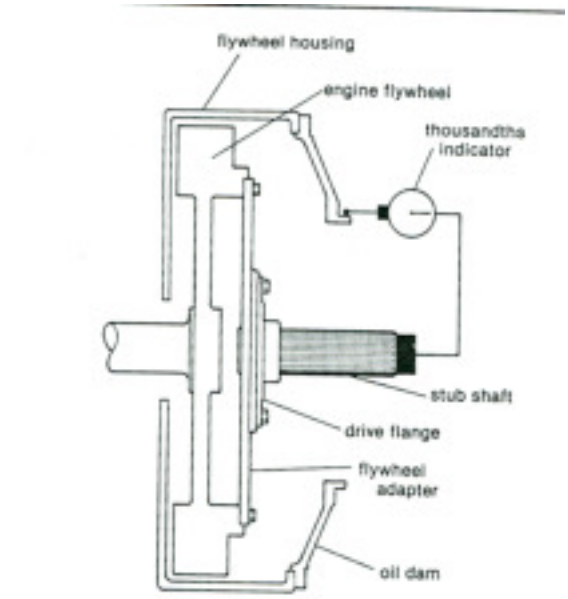


Figure 3. Dial Indicating Oil Dam Pilot O.D.

5. Dial indicate oil dam pilot O.D as shown in figure 3. Record reading. Total indicator reading must not exceed .007 inch.

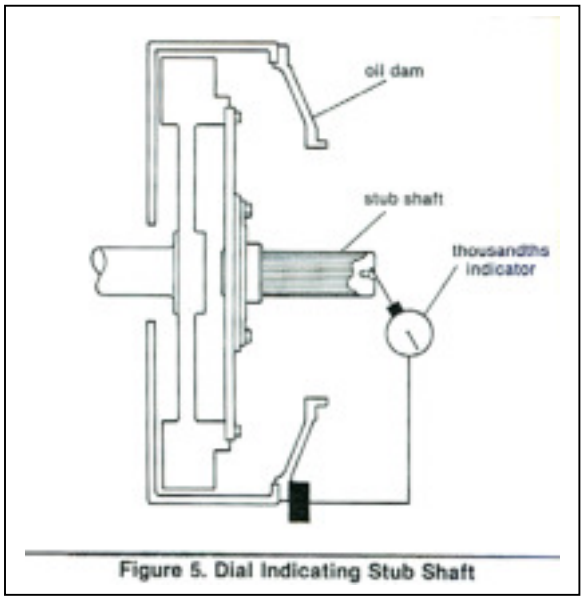


Figure 5. Dial Indicating Stub Shaft

7. Dial indicate stub shaft as shown in figure 5. Record reading. Total indicator reading must not exceed .007 inch.

The sum total of readings in steps 5,6 and 7 must not exceed .007 inch.

8. Install oil pump housing onto stub shaft being careful not to damage oil seal. Secure pump housing to oil dam with 2 socket head capscrews (at bottom of housing). Refer to figure 7.

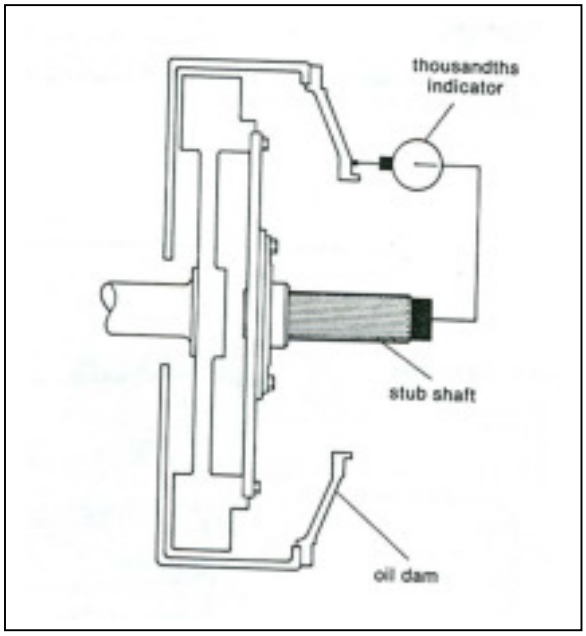


Figure 6. Securing Forward Clutch Driving Drum with Snap Ring.

9. Secure forward clutch driving drum on stub shaft. Make certain that dogs on pump drive gear enter slots in driving drum. Install snap ring in groove on stub shaft and make sure ring seats in groove (see figure 6).

10. Place clutch assembly on splines of stub shaft. Be sure flange marked “FORWARD” is toward engine flywheel. Note: The forward pack contains the greater number of clutch discs and it must go toward the engine flywheel. Otherwise severe damage may result

11. Install oil filter in pump. Filter must go in central hole directly below the bore. See figure 7.

12. Locate gasket on pump housing, using a small amount of grease to hold it in place. Remove oil breather from top of reverse gear housing.

3.3 INSTALLATION OF REVERSE GEAR

1. Using a suitable hoist and sling (or lifting eye, special tool no. 1-90020-0000) lift reverse gear in position behind engine (see fig.7). Ease unit forward over clutch assembly gently twisting reverse gear so that discs enter reverse drum properly without damaging teeth (Note: avoid damage to oil filter assembly).

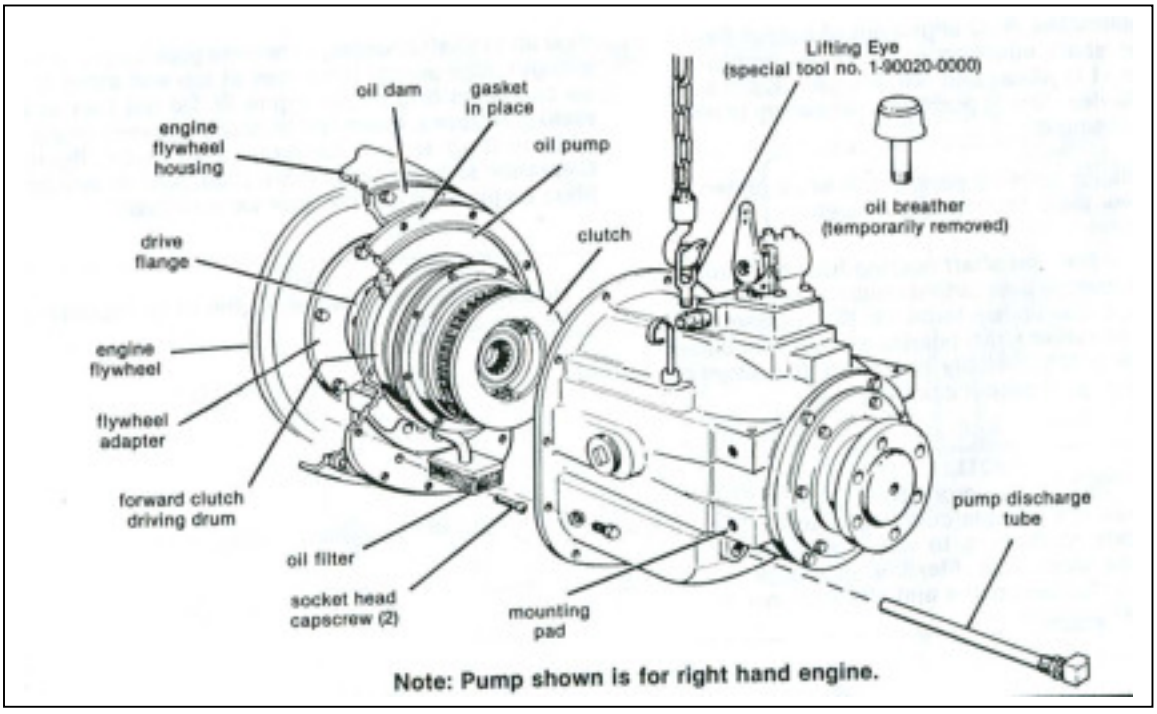
2. Secure transmission housing to oil pump housing and oil dam with capscrews and lockwashers. Tighten to 28 pounds- foot torque.

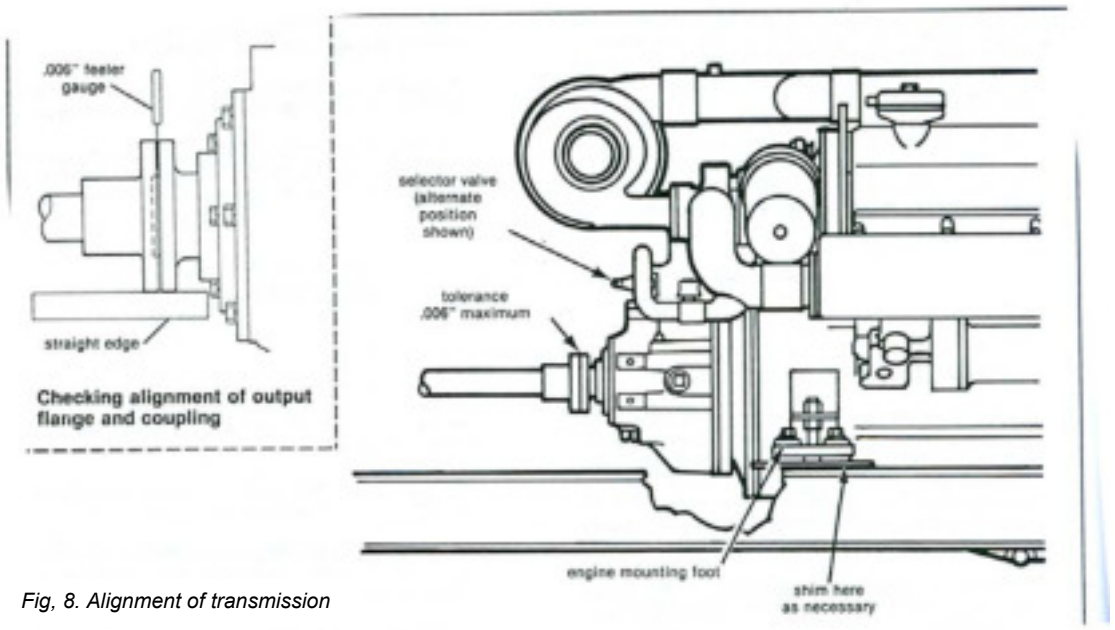
3. Check clutch end float. Insert screwdriver through oil breather hole or side inspection Hole and pry clutch fore and aft. End float should be 1/16 to 3/32”.

4. Turn output shaft over for several revolutions to check for free movement of transmission.

5. Remove plastic plug in bottom rear of housing and install pump discharge tube through gear housing into hole in pump housing (see fig. 7)

6. Connect hoses from discharge tube to oil cooler and from cooler to selector valve base plate (see installation drawing at rear of book and water piping instructions on page 8)





Fig, 8. Alignment of transmission

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 fame, 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 alignment shaft coupling to reverse gear coupling. Lay a straight edge across the edges at top and sides to line up couplings (See insert, figure 8). Do not burr or mar mating surfaces. Insert feeler gauge between couplings and run it all around the flange (See insert, figure 8). Clearance should not be more than .006” at any point. Shim engine and reverse gear as necessary.

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.

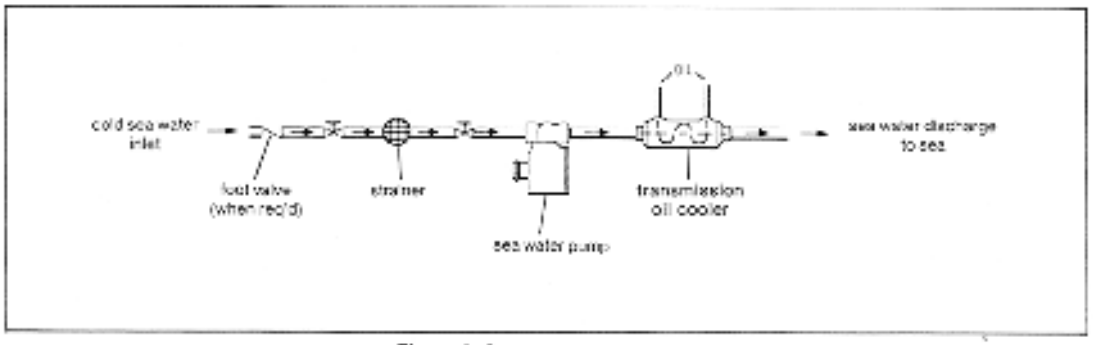


Figure 9. Separate pump system

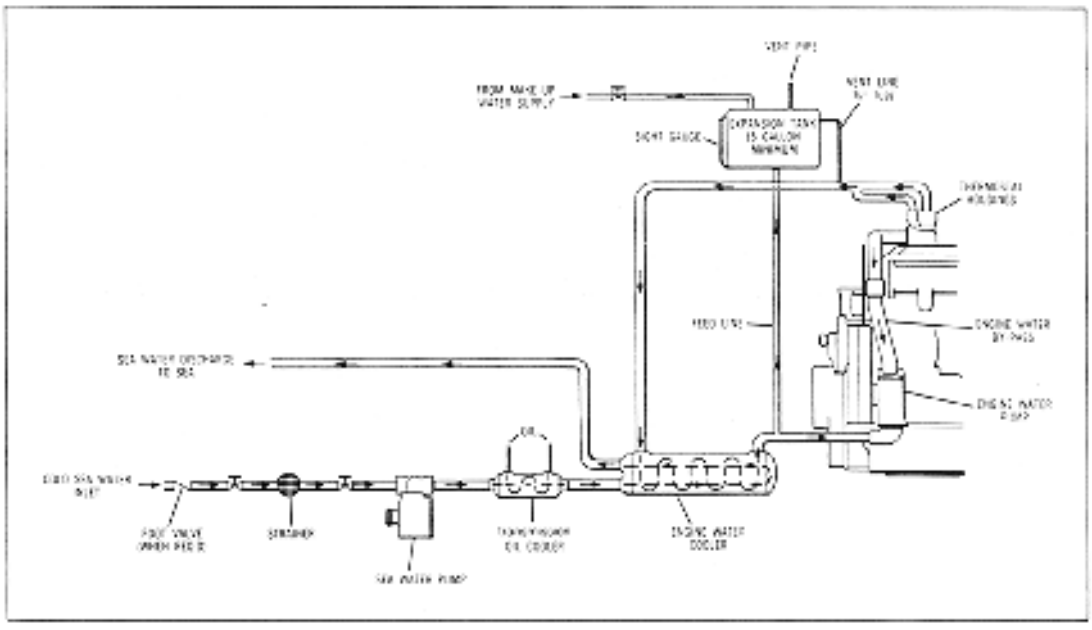


Figure 10. Heat exchange system

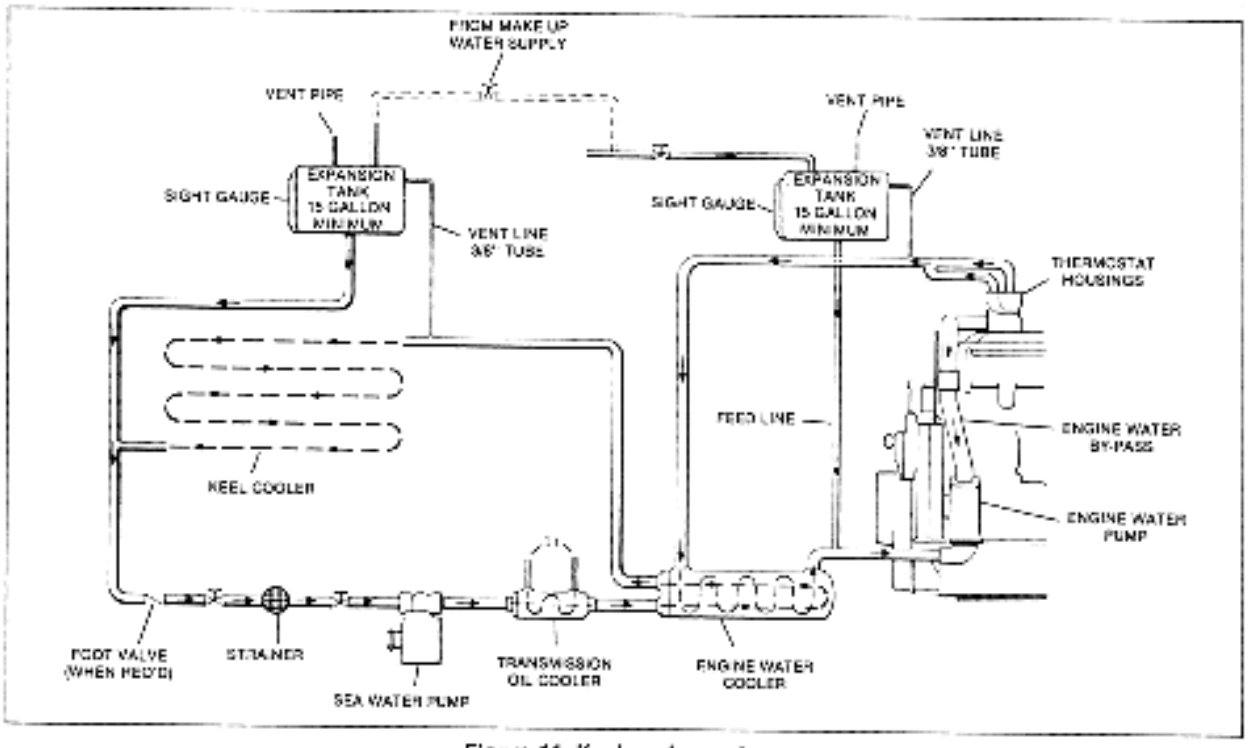
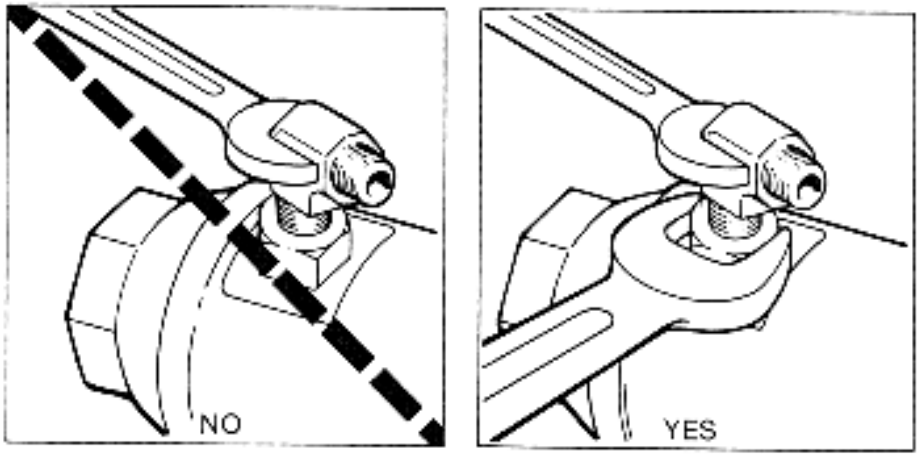


Figure 11. Keel cooler system



CAUTION: ALWAYS USE BACKUP WRENCH ON COOLER FITTINGS

3.7 START UP PROCEDURE

1.Remove oil breather or inspection plug and add recommended oil unit level is up to full mark on dipstick (See lube chart, p.14). Replace but do not secure.

2.Install pressure gauge of 300-pound capacity directly on top of gear or bulkhead. Connect gauge to control valve with ¼" 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 all connections for leaks.

5.Oil pressure is adjusted at factory or testing purposes only and it may be necessary to readjust pressure to the correct level (200-210 PSI). This should be set for normal operating speed and temperature (See fig.12 below).

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

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). Replace oil breather or inspection plug.

7. Shift several times in 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.

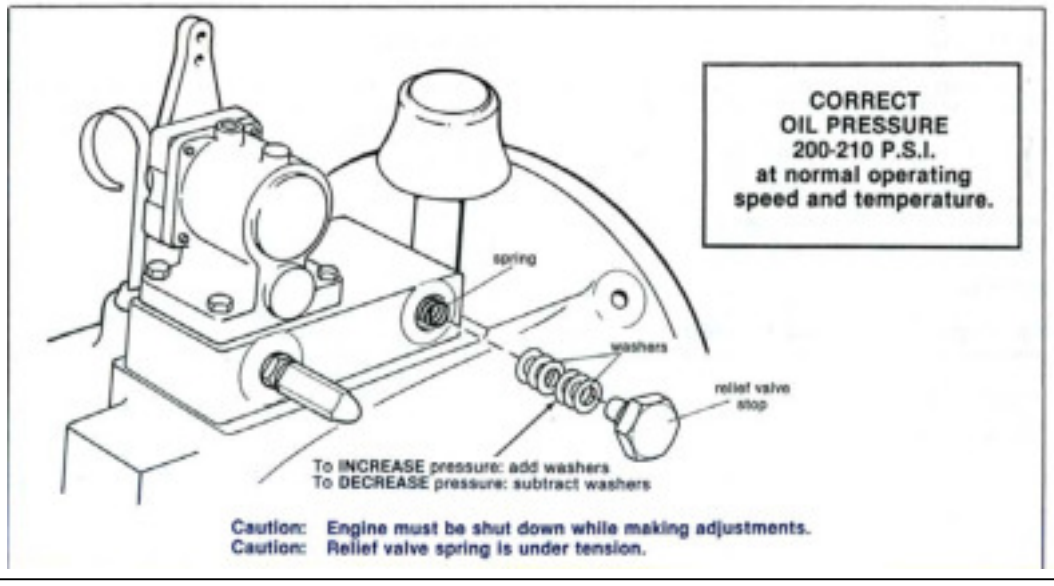
9. Reverse gear is now ready for sea trials and final adjustment.

MAXIMUM INPUT SPEED… 3000 RPM

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).



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, 30ºF, (-1ºC) to 85F (29ºC), we recommend a good grade, anti-foaming, heavy duty, SAE motor oil.

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

Where extremely cold ambient water temperatures are encountered, under 30ºF (-1ºC), it may be necessary to use SAE 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
Oil capacity is 3.5 to 4 quarts. Total capacity may be more depending on hose length and cooler size.

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.12, page 13.

OIL TEMPERATURE
Operating oil temperature range is 100º-150º F (38º-66ºC) at control valve. Unit will tolerate higher temperatures but clutch life may be shortened considerably.

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 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.12 p.13.

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.)

4.3 MAINTENANCE SCHEDULE AND CHECK SHEET

Engineer_____
Reverse Gear Serial No._____
Date Service Began_____

INTERVAL Normal operation	MAINTENANCE DESCRIPITION	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 -Remove and clean oil breather	
Every 2000 hours	-Check water tubes in cooler	
At engine overhaul	-Inspect clutch and all gearing and replace as necessary -Inspect and/or overhaul entire transmission.	
Frequently	-Check all oil lines and connections -Check all external components -Check all mounting bolts -Check alignment	

SYMPTOM	PROBABLE CAUSE	REMEDY
A. Low oil pressure (at full operating speed and temperature.)	1. Faulty pressure gauge	1. Check gauge against one of known accuracy.
	1. Low oil level	1. Inspect gaskets, seals, hoses and fittings for leakage.
	2. Partially clogged oil filter	2. Remove oil filter and clean with a good grade solvent or diesel fuel.
	3. Damaged or clogged pump discharge tube	3. Remove tube and clean with solvent. Blow dry.
	4. Clogged parts in selector valve, base plate or housing.	4. Flush clean with solvent and blow dry.
	5. Dirt or sludge in transmission	5. Remove drain plug, flush gear with commercial solvent or diesel fuel. Start engine; at idle shift gear several times, full forward to full reverse for 3-5 minutes maximum. Shut down engine and drain gearbox thoroughly. Refill gear with proper oil and run for 25-50 hours. Drain sump and refill with new oil. This will remove any residual solvent.
	6. Worn pump assembly	6. Refer to oil pump section (p.22) or fig.12 p.122
	7. Incorrectly adjusted pressure relief valve	7. See fig.12 p.13.
	8. Oil too hot	8. Check heat exchanger system for clogged oil cooler or hoses.
	9. Worn commutator bushing	9. See wear limits chart (p.23). For replacement see pg.26 and 30.
	10. Incorrect lubricant	10. See lube chart (p.14)
	11. Scratch clutch cylinders or hard O-ring in clutch cylinders	11. Replace as necessary (p.26, 27)
B. High oil pressure* (At full operating speed and temperature)	1. Incorrectly adjusted pressure relief valve	1. Refer to fig. 12, p.13.
	2. Inoperable relief plunger in base plate	2. Refer to p.20
** Note: High oil pressure may also be caused by cold oil. Unit should be pre-heated, see section 3.6*	3. Incorrect oil	3. See lube chart (p.14)
C. No oil pressure	1. Faulty pressure gauge	1. Check pressure with gauge of known accuracy.
	2. Broken hose	2. Replace hose, inspect all hoses.
	3. No oil in transmission	3. Fill with proper oil. See pages 13-14.

D. Overheating	1.Insufficient oil cooler capacity 2. Insufficient flow of cooling water 3. Clutch slipping 4. Water temperature too high at cooler	1.Install adequate oil cooler 2. Increase water line sizes. 3. Refer to symptom A. 4. Decrease water temperature to cooler or relocate heat exchanger in cooling system.
E. Excessive noise in transmission	1. Bearings worn or broken. 2. Gears worn or broken 3. Noise in forward only 4. Noise in reverse only 5. Improper alignment	1. Inspect bearings for scored races, broken roller, flat spots, etc. 2. Inspect gears and replace if necessary 3. Reverse position may be mistakenly used for forward. Selector valve lever must point forward when boat is in forward motion. 4. This is normal because more gears are in operation in reverse mode. 5. Refer to sect. 3.4, page 10
F. Noisy Pump	1. Dirt or sludge in oil 2. Clogged hoses 3. Pump cavitation 4. Defective oil pump assembly	1. Remove oil pump and hoses. Clean thoroughly and reinstall. 2. Clean and replace as required 3. Oil filter may be clogged. Oil level may be too low 4. Refer to oil pump sect. p.22
G. Clutch does not release	1. Improper oil in sump 2. Clutch discs warped 3. Forward and reverse clutch cylinders dirty or distorted. 4. Rear commutator bushing is worn 5.Incorrect linkage adjustment to selector valve assembly 6. Clutch discs fused due to slippage and overheating	1. Refer to lube chart, p.14. 2. Replace as necessary 3. Clean or replace as necessary 4. Replace as necessary. See p.23, 29, 30 5. Adjust linkage 6. Replace as necessary

H. Clutch slipping	1. Low oil pressure	1. See symptom A
	2. Oil temperature too high	2. Temperature should be 150ºF to 160ºF (71ºC). Check heat exchanger system
	3. Worn clutch discs	3. Replace as necessary, see p.29.
	4. Incorrect linkage adjustment to selector valve assembly	4. Adjust linkage
	5. Improper oil	5. See lube chart, pg.14.
I. 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.10
	4. Excessive heat	4. Check cooling system see p.11 ,12
J. No Neutral	1. Warped clutch discs	1. Replace as necessary
	2. Scored clutch cylinders	2. Replace as necessary
	3. Damaged quad rings	3. Replace all 4 quad rings
	4. Worn or damaged commutator bushings (forward or rear).	4. Replace as necessary
	5.Worn selector valve	5. Replace if necessary. Note: Selector valve is the least likely source of trouble. See p.19
K. Clutch engages too slow	1. Cylinder timing screw out of adjustment	1. Remove dome nut and adjust screw (Counter-clockwise) to speed up reaction. See figure 24
L. Clutch engages too fast	1. Cylinder timing screw out of adjustment	1. Remove dome nut and adjust screw in (clockwise) to delay reaction. See fig. 24