SERVICE MANUAL
HP-9400 AND HP-10500
MARINE
TRANSMISSIONS

NOTE
THIS SERVICE MANUAL IS
GUARANTEED EFFECTIVE
FOR SERIAL NO.
ONLY.

CAUTION

DO NOT OPERATE IN REVERSE MODE TO MOVE VESSEL FORWARD
DO NOT OPERATE CONTINUOUSLY IN REVERSE MODE FOR MORE THAN 30 MINUTES AT 75% OF AVAILABLE HORSEPOWER.
DO NOT OPERATE UNIT OVER 180°F (82°C).
DO NOT OPERATE UNIT WITH HIGH OR LOW OIL PRESSURE
DO NOT 'WINDMILL' UNIT IN EVENT OF ENGINE FAILURE (PROP SHAFT SHOULD BE LOCKED TO PREVENT 'WINDMILLING').
DO NOT ATTEMPT FINAL ALIGNMENT OF OUTPUT FLANGE AND PROP SHAFT COUPLING WHEN VESSEL IS IN DRY DOCK.
DO NOT SHIFT TRANSMISSION UNLESS ENGINE IS AT IDLE SPEED.
DO NOT USE TRANSMISSION TO SUPPORT REAR OF ENGINE.

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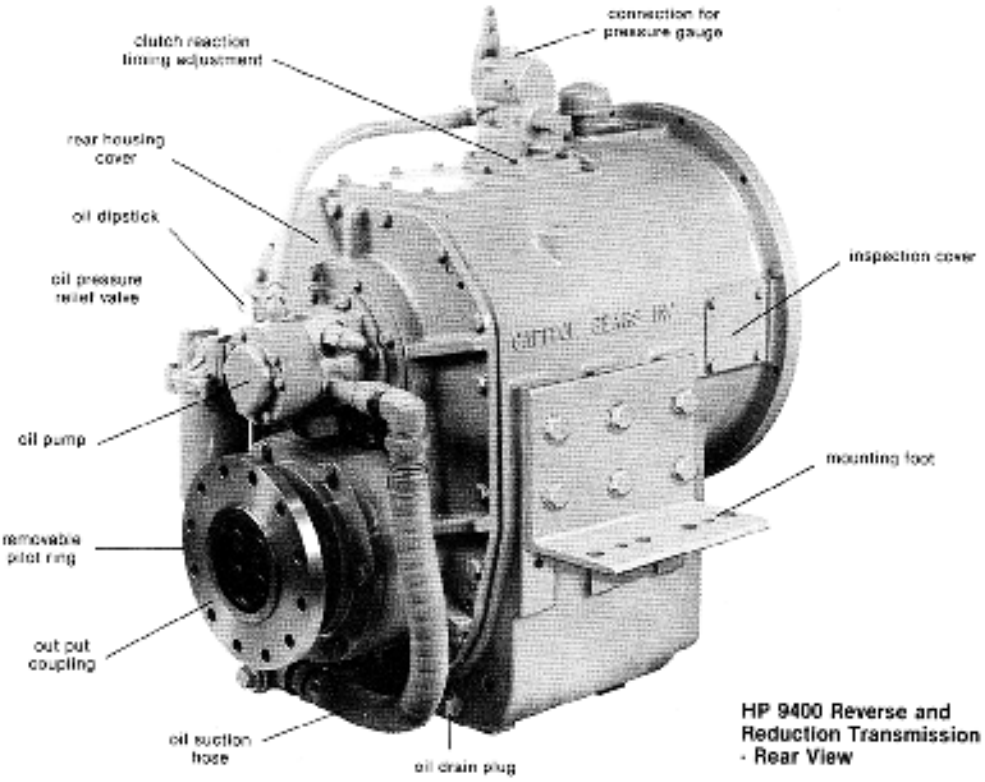
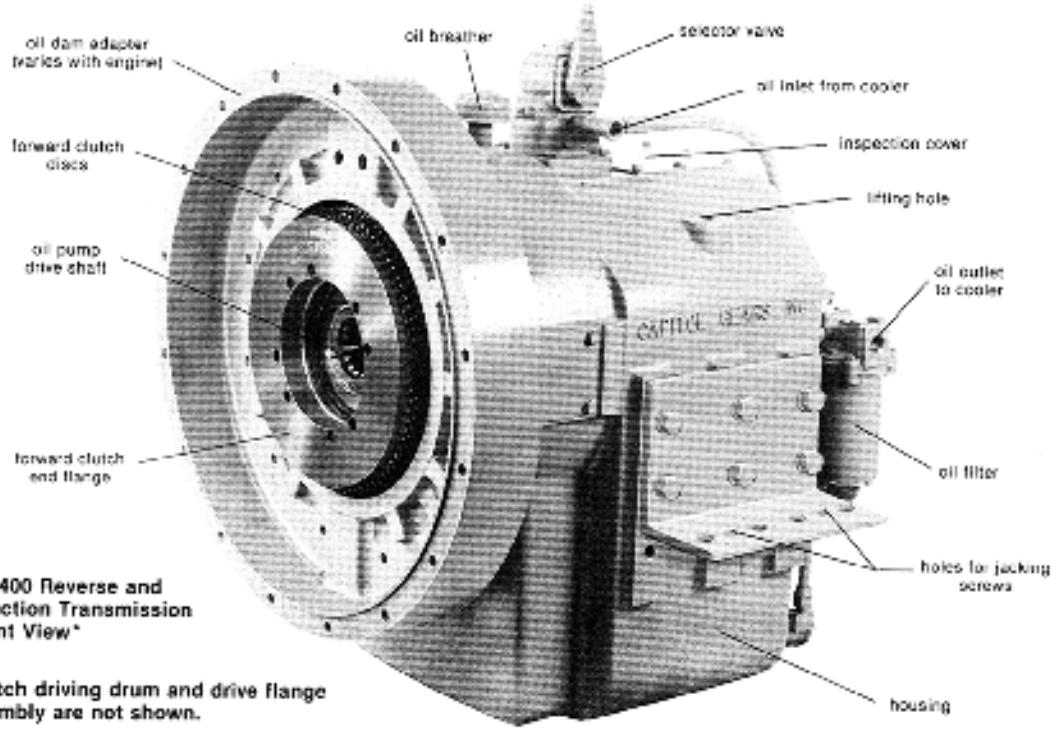
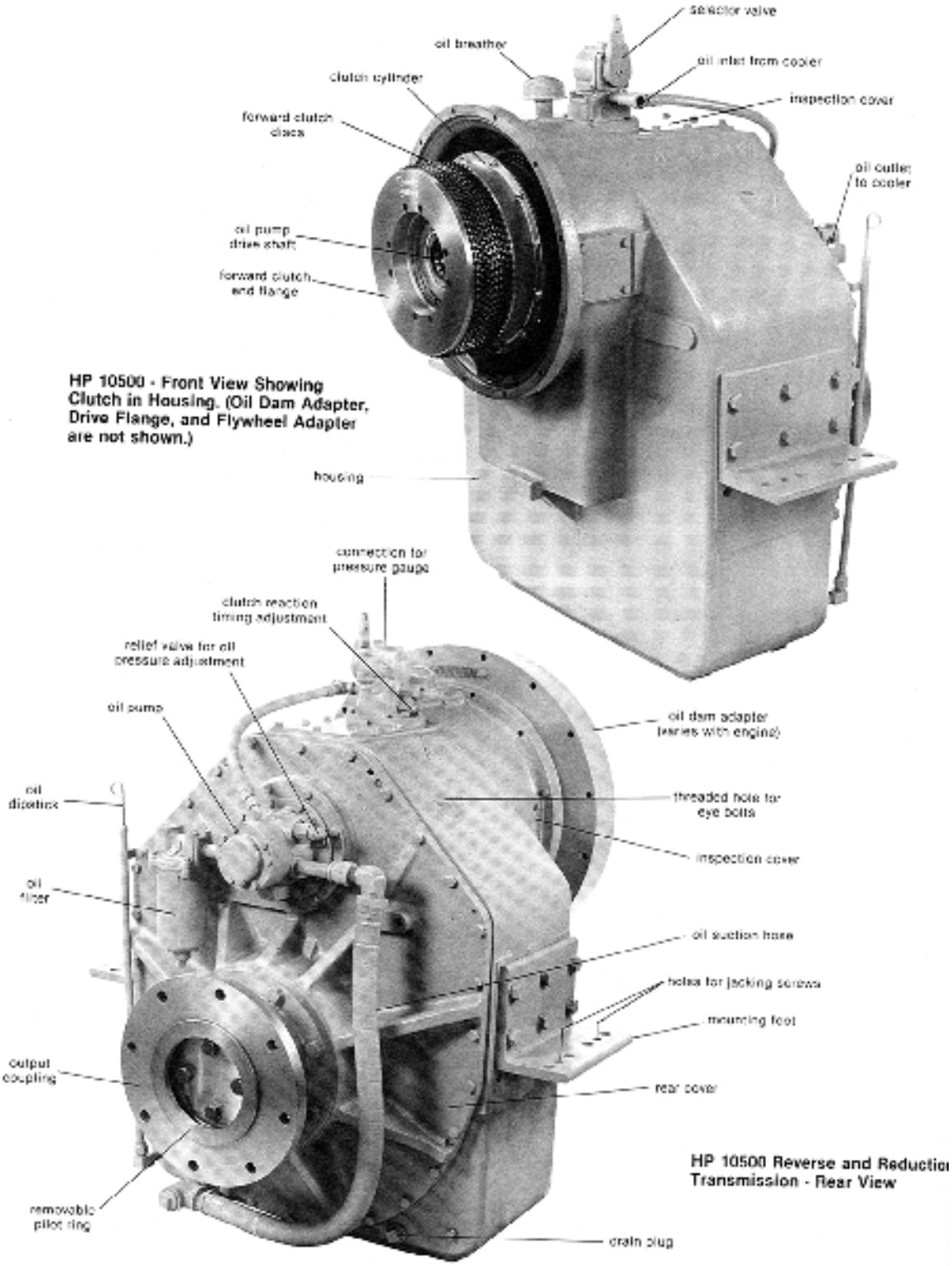


HP 9400 Reverse and Reduction Transmission - Rear View



HP 9400 Reverse and Reduction Transmission - Front View*

***Clutch driving drum and drive flange assembly are not shown.**



HP 10500 - Front View Showing Clutch in Housing. (Oil Dam Adapter, Drive Flange, and Flywheel Adapter are not shown.)

HP 10500 Reverse and Reductio Transmission - Rear View

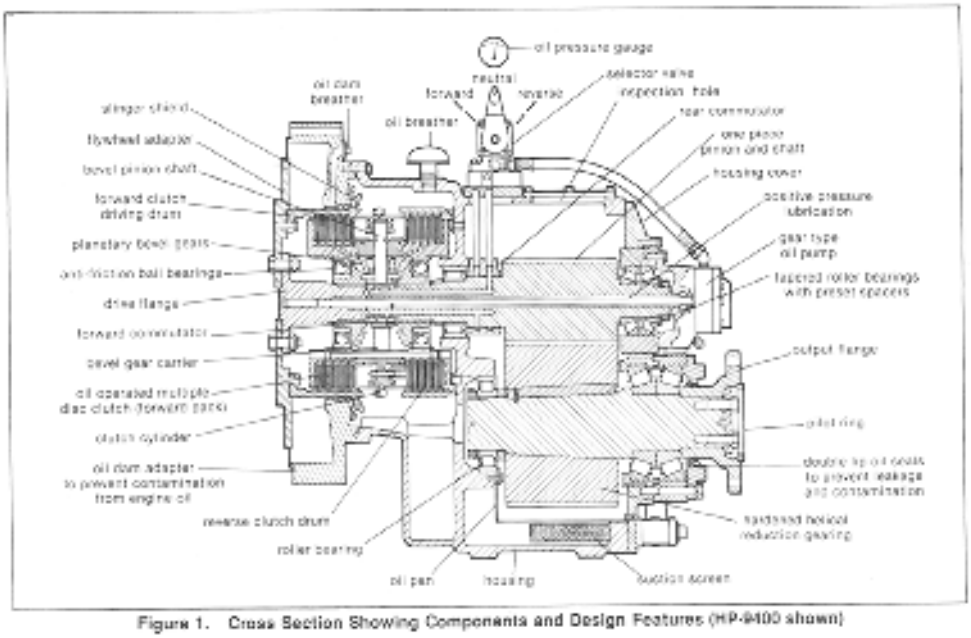


Figure 1. Cross Section Showing Components and Design Features (HP-9400 shown)

SECTION 1. INTRODUCTION

The purpose of this manual is to provide assistance to operation and maintenance personnel to reduce downtime and obtain consistent performance from the Capitol HP-9400 or HP-10500 Reverse and Reduction 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 Capitol marline transmission is operated hydraulically. The clutch is activated by high pressure oil and the gears, bearings and clutch discs and lubricated and cooled by low pressure oil.

The marine gear consists of six major groups of parts; adapter group, clutch pack oil pump, selector valve, pinion shaft and reduction gear. The adapter parts vary according to engine application and include a flywheel adapter, drive flange, an oil dam adapter to prevent engine contamination and a driving drum. 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 of bearings, gears and clutch. The selector valve is used to obtain forward neutral or reverse. The one-piece pinion and shaft drives the output gear directly or through an intermediary dear called an idler.

1.2 OPTIONAL EQUIPMENT

OIL COOLER
Various capacity oil coolers for salt or fresh water are available depending on engine size and are purchased optionally. However, oil cooler must be used with a Capitol marine transmission.

HOSE AND FIT TING PACKAGE
Kits that include the necessary hose and fittings are available for use with Capitol oil coolers.

PROP COUPLING KIT
A prop shaft coupling kit is available to meet most requirements.

POWER TAKE-OFF
A one way clutch may be furnished for power take-off reduction gears (HP PTO Series).

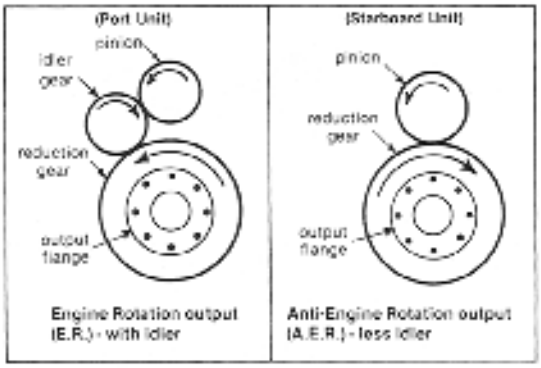
INDEPENDENT MOUNT
For installations where the transmission is not to be bolted directly to the engine, a keyed input shaft is available.

TORSIONAL COUPLING
A rubber element input coupling is available (HPI Series)

SECTION 2. PRINCIPLES OF OPERATION

2.1 OUTPUT OPERATION

The Capitol marine gear in forward mode provides output rotation in the opposite direction as engine rotation. The marine gear unit is normally supplied for a right hand engine (when viewed from the front). This produces a right hand rotation output of the prop shaft in forward (when viewed from the rear of the transmission). For twin screw installations, where two right hand engines are used, the port unit is furnished with an idler gear. The idler gear produces, in forward, an output rotation the same as engine rotation.* Thus the two propellers can be turning opposite each other in outboard direction (see diagram below). *Note: Engine rotation transmissions are installed on right hand engines only.



2.2 REDUCTION RATIO

The reduction ratio is the number of teeth in the reduction gear compared to the number of teeth in the pinion, for example, 144 teeth compared to 36, or 4 to 1. Output speed then is a product of engine r.p.m. X ¼ = 500 r.p.m. output speed. The HP-9400 features four reduction ratios available in anti-engine or engine rotation output. They are nominally 1:1, 1.5:1, 2:1 and 3:1. The HP 10500 is available in three ratios: nominally 4:1, 5:1 and 6:1 also in anti-engine rotation output.

2.3 POWER FLOW

The flywheel adapter, being directly fastened to the engine flywheel continually rotates the drive flange assembly, clutch driving drum and forward clutch discs at engine speed.

NEUTRAL

In neutral no direct torque is applied to clutch and pinion. Consequently reduction gear and output flange do not rotate.

FORWARD (see Figure 2.)

When forward is selected the entire clutch becomes locked with the driving drum and rotates at engine speed. The clutch drives the pinion in reduction gear and output flange in anti-engine direction at a speed determined by the reduction ratio.

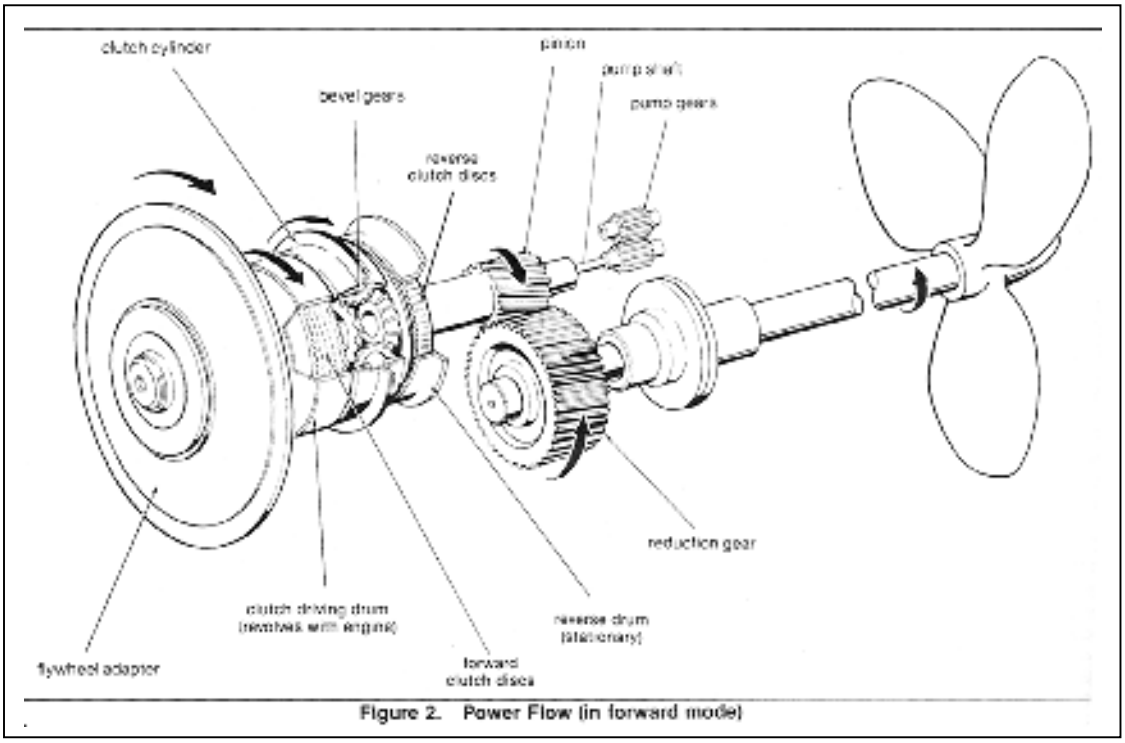
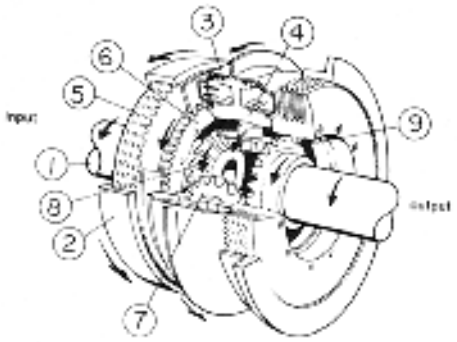


Figure 2. Power Flow (in forward mode)

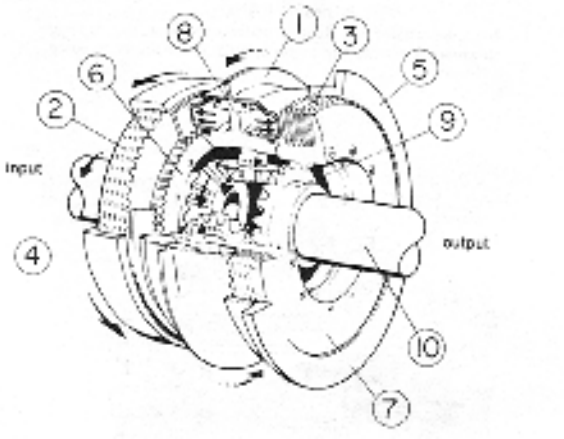


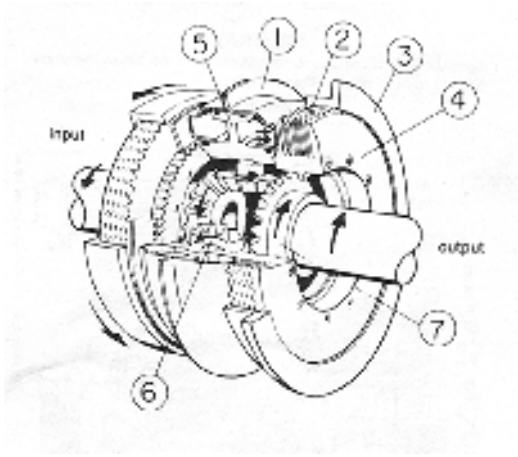
REVERSE
When reverse is chosen the clutch is held stationary to the housing. Engine power is transferred through the clutch bevel gears and the pinion is driven in anti-engine rotation at engine speed. This causes reduction gear and output flange to rotate in engine direction (reverse).

2.4 CLUTCH

The clutch assembly is a multiple disc type clutch activated by a hydraulic mechanism. This mechanism is formed by a carriers 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, clutch 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 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.

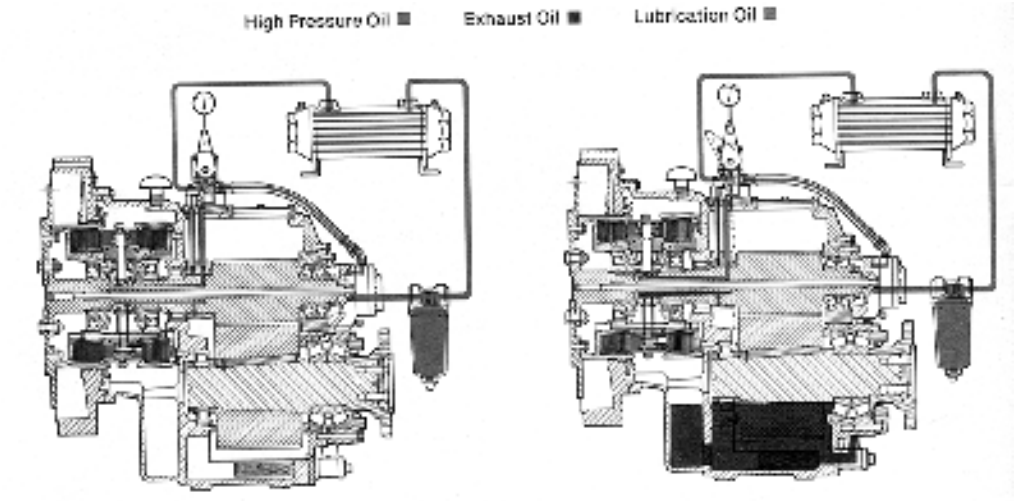
REVERSE MODE
Reverse is achieved when cylinder 1 is pressurized and slides against reverse clutch discs 2 clamping them together. Half of the discs are splined to the stationary reverse drum 3 and half are splined to end flange 4 bolted to gear carrier 5. Rotating gear carrier then stops. The bevel gears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

2.5 HYDRAULIC SYSTEM

Pressurized oil is provided by a gear type oil pump that is externally mounted and engine driven by means of a splined shaft. The pump includes a pressure relief valve to maintain the correct operating pressure relief valve to maintain the correct operating pressure. Oil is drawn from the sump through a suction hose and then sent under pressure to a filter and oil cooler and then to the sector valve. The selector valve is used to obtain forward, neutral or reverse by routing the high pressure oil through internal passages to the clutch. Low pressure oil is channeled to cool bearings, gears and clutch discs. An oil dam keeps the transmission oil within the transmission housing.

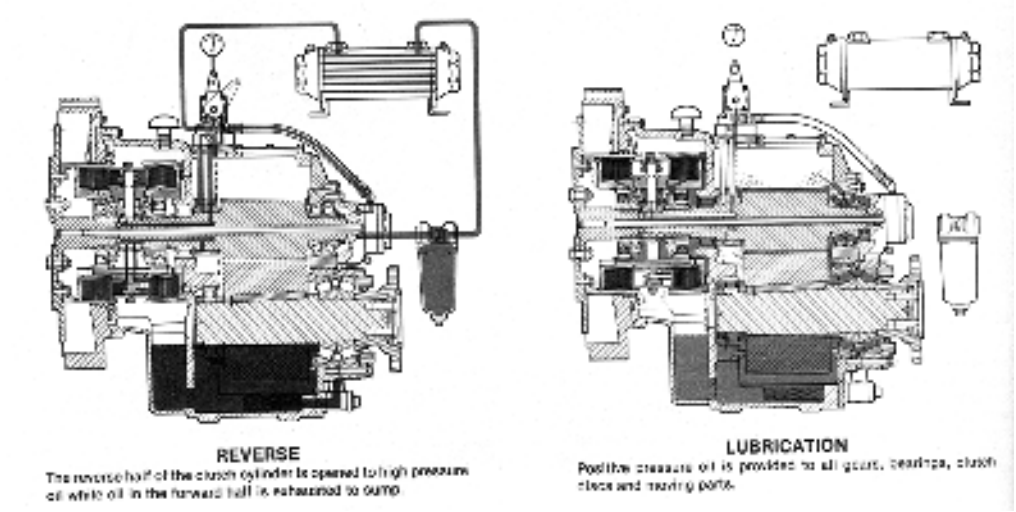
In neutral the ports to both the forward and reverse sides of the clutch cylinder are opened and the balanced pressure that results keeps the clutch cylinder centered between the forward and reverse clutch discs. Oil is distributed through the lubrication system.

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. In forward or reverse, oil is also distributed through the lubrication system.



NEUTRAL
Both the forward and reverse halves of the clutch cylinder are opened to high-pressure oil.

FORWARD
The forward half of the clutch cylinder is opened to high-pressure oil while the reverse half of the cylinder is exhausted to sump.



SECTION 3. INSTALLATION AND OPERATION

LUBRICATION
Positive pressure oil is provided to all gears, bearings, clutch discs and moving parts.

NOTE: IMPRPER INSTALLATION AND ALIGNMENT IS THE GREATEST CAUSE OF GEAR FAILURE. PLEASE FOLLOW INSTRUCTIONS CAREFULLY.

3.1 UNCRATING AND HANDLING

Tapped holes have been provided for insertion of eye bolts to aid in handling the unit. Average weight of HP-9400 is 1900 lbs.; HP-10500 is 3100 lbs. These weights vary with adaptation and clutch.

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

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, oil dam adapter, and stub shaft be dial indicated to insure trueness.

1. (Fig. 3A) 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. 3B) 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. 3C) Mount indicator to flywheel housing so that stem is on inner face of flywheel; record deviation of face run out. It must not exceed a total indicator reading of .007 inch

4. (Fig. 3D) 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.Remove the clutch assembly from the clutch driving drum and drive flange assembly (drive flange and flywheel adapter).

6.Remove clutch driving drum from flywheel adapter to engine flywheel mating surfaces and secure flywheel adapter (and drive flange attached to flywheel adapter).

7.Thoroughly clean flywheel adapter to engine flywheel mating surfaces and secure flywheel with cap screws and lock washers.

8.Locate oil dam adapter on engine flywheel housing with drain slots down. Secure oil dam tentatively with cap screws and lock washers.

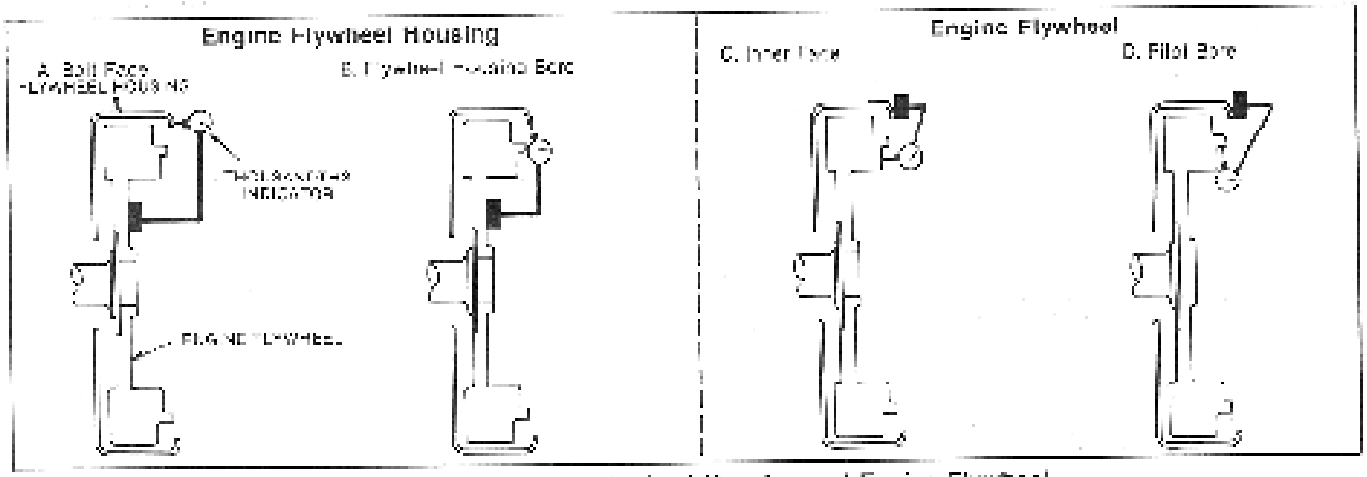


Figure 3. Dial Indicating Flywheel Housing and Engine Flywheel

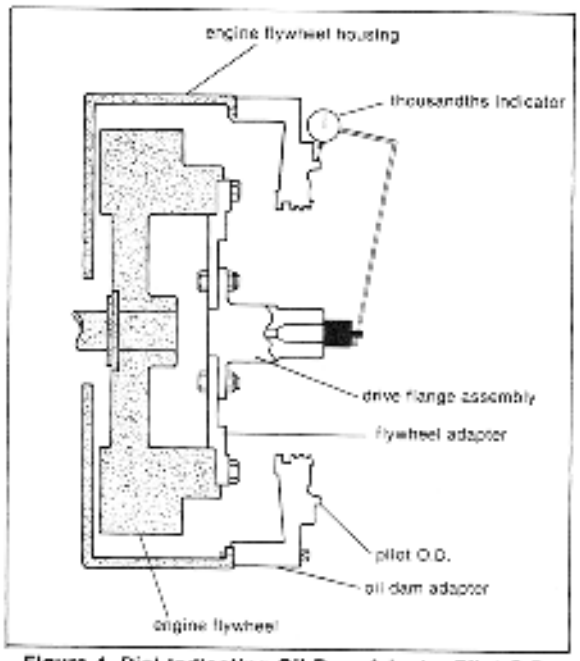


Figure 4. Dial Indicating Oil Dam Adapter Pilot O.D.

9.Dial indicate oil dam pilot O.D. as shown in figure 4. Record reading. **Total** indicator reading must not exceed .007 in.

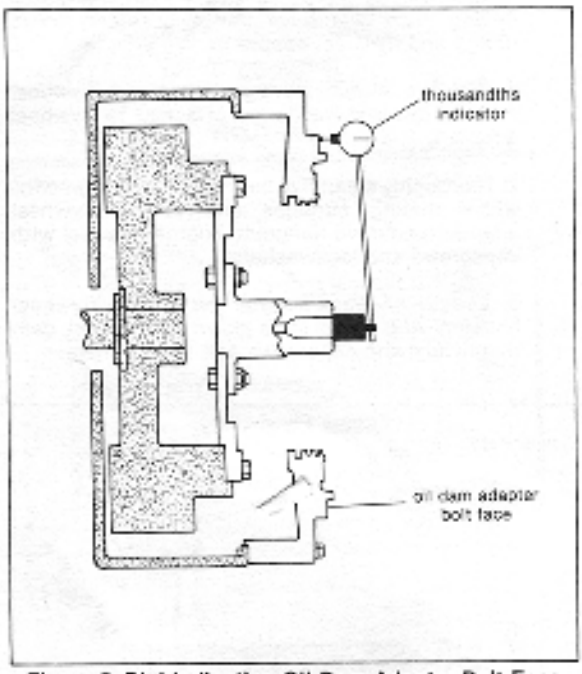


Figure 5. Dial Indicating Oil Dam Adapter Bolt Face

10. Dial indicates oil dam bolt face as shown in figure 5. Record reading. **Total** indicator reading must not exceed .007 in.

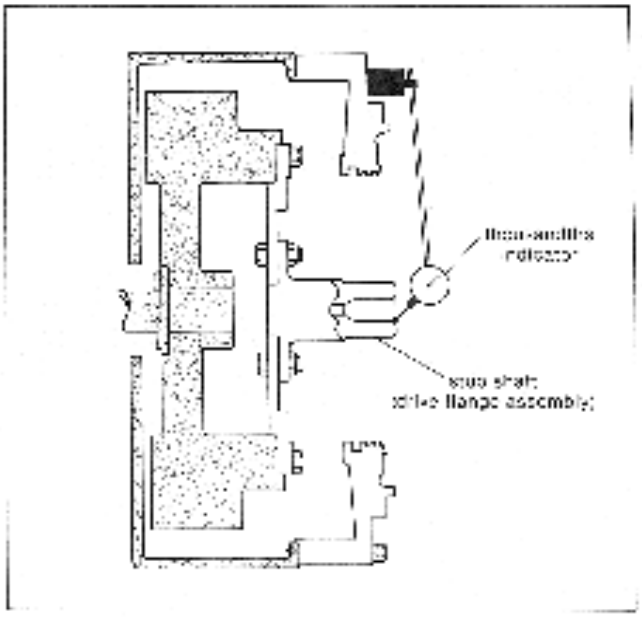


Figure 6. Dial Indicating Stub Shaft

11. Dial indicate stub shaft on chamfer as shown in figure 6. Record reading. Total indicator reading must not exceed .007 in.

The sum total of readings in step 4, 5 and 6 must not exceed .007 in.

12. Install clutch driving drum on flywheel adapter with hex head cap screws sealing with no.2 Permatex. Check clearance between clutch driving drum O.D. and oil dam adapter I.D. with feeler gauge. Minimum clearance must be at least .006 in. Tighten cap screws to 65 lbs.-ft. torque.

13.Reassemble slinger shield to oil dam adapter and tighten cap screws. Secure with locking wire.

14. Using an adequate hoist, install clutch on splines of drive flange shaft being careful that clutch disc teeth enter driving drum properly. **Be sure that the forward end flange marked "toward engine" is placed toward the engine flywheel.** The forward pack contains the greater number of clutch discs and must go toward the engine flywheel. Otherwise severe damage to clutch may result.

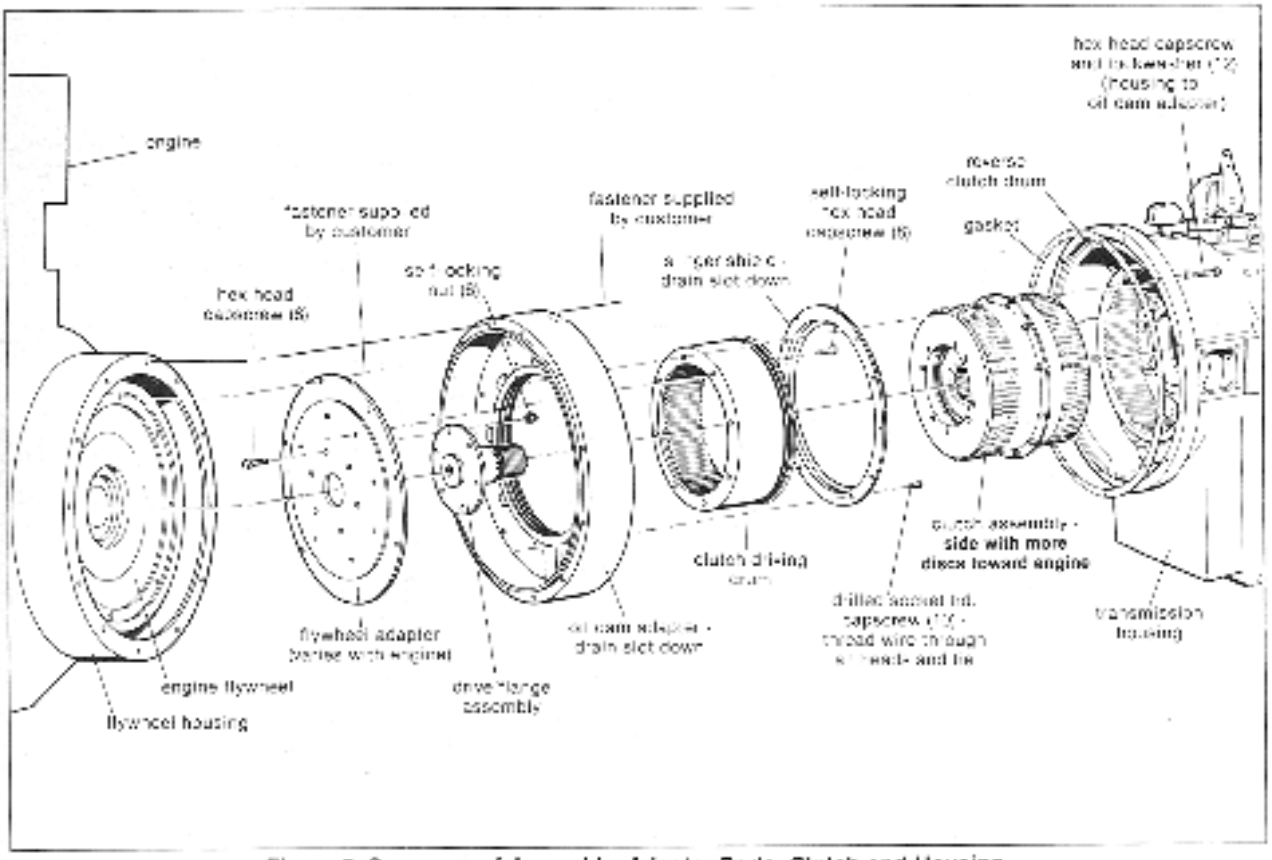


Figure 7. Sequence of Assembly: Adapter Parts, Clutch and Housing

9. Replace oil pump drive shaft, gasket and oil pump. Secure pump with capscrews and lockwashers and torque to 42 lbs. Ft.

3.3 INSTALLATION OF TRANSMISSION

1. Apply a small amount of grease to oil dam adapter and locate gasket.

2. Remove side inspection covers to facilitate installation.

3. Remove oil pump and oil pump shaft.

4. Using an adequate hoist and hoist guide (special tool no. 1-90021-0000) lift transmission into position behind engine. Ease unit forward over clutch assembly gently twisting transmission housing so that discs enter reverse drum properly without damaging teeth. A screwdriver may be used through the side inspection hole to align disc teeth with the reverse drum.

5. Secure transmission housing to oil dam adapter with cap screws and lock washers. Tighten to 28 foot pounds torque.

6. Check clutch end Float: Insert screwdriver through side inspection hole and pry clutch fore and aft. See fig. 20, page 22. End float should be 1/16" to 3/32".

7.Turn output coupling over for several revolutions making sure unit is free to turn.

8. Replace gaskets and inspection covers.

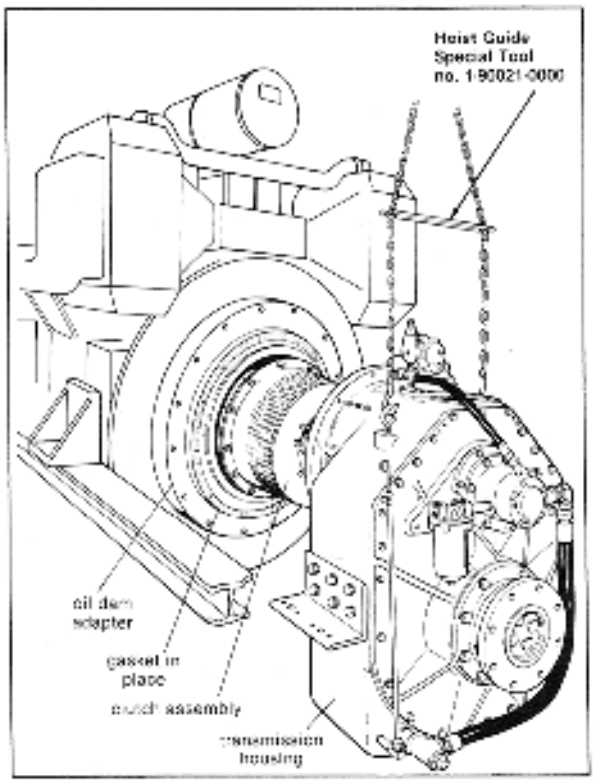


Figure 8. Locating Transmission Housing on Oil Dam Adapter

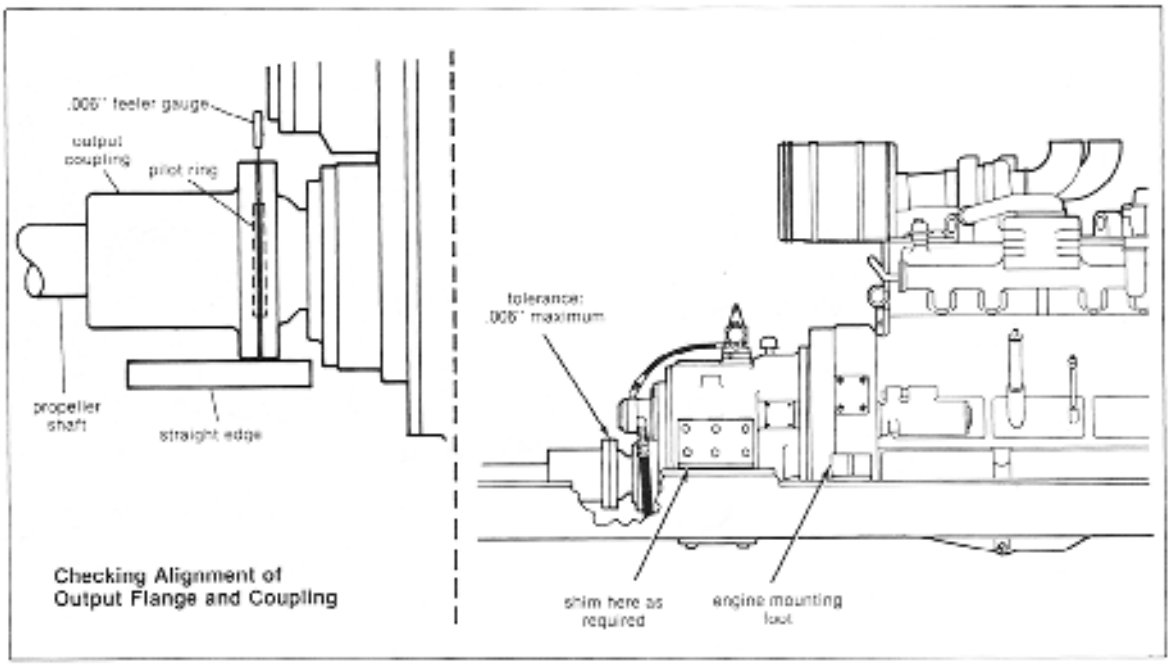


Figure 9. Alignment of Output Flange and Propeller Shaft Coupling

3.4 ALIGNMENT OF OUTPUT COUPLING

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

Mounting feet 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 first. Flexible couplings are used only to dampen-

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. Mounting feet have threaded holes for jacking screws.

Loosen gear housing to engine housing bolts and check with feeler gauge. Maximum variation for SAE #0 housing is.008”; for SAE #1 housing is .006”.

Tighten four gear housing cap screws at 90 deg. 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.

Be sure transmission is connected to oil cooler.

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

3.5 WATER PIPING

To assure proper cooling of Capital'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.

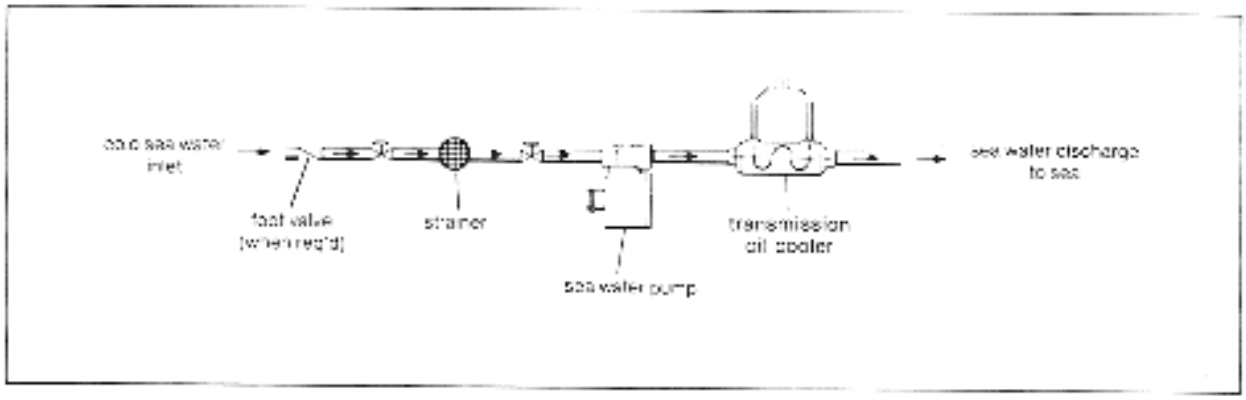


Figure 10. Separate pump system

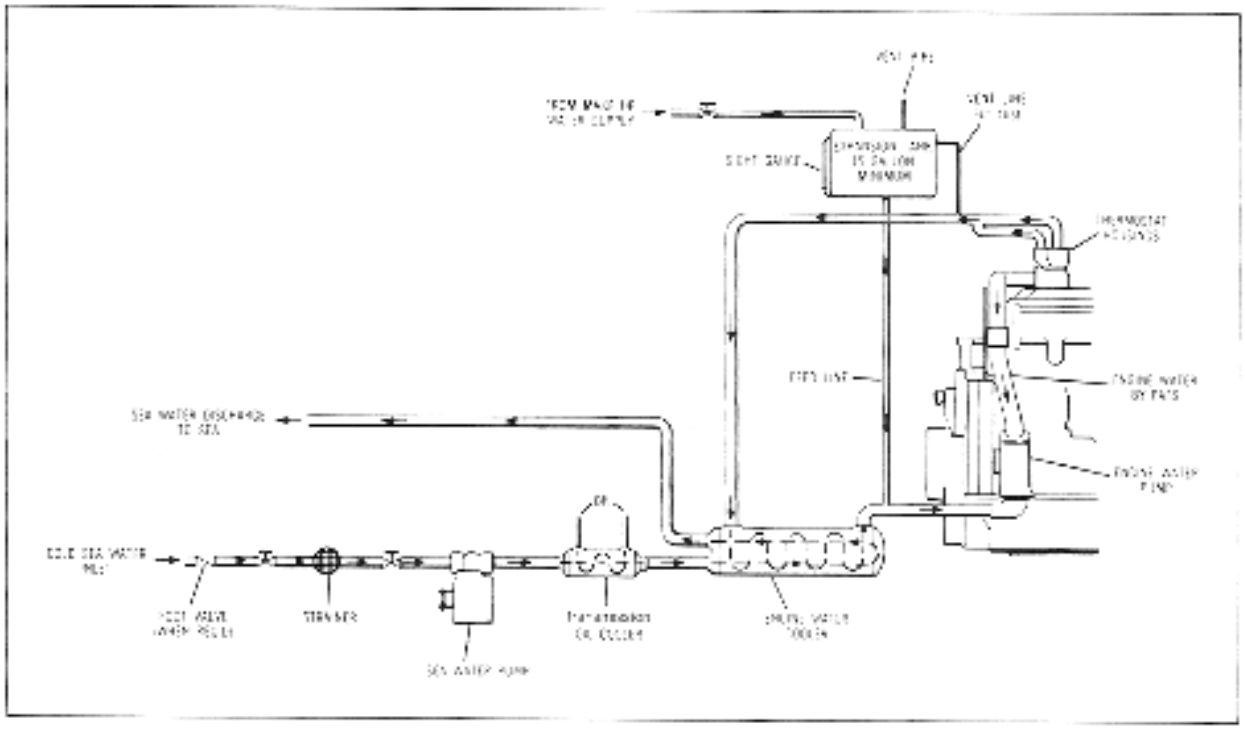


Figure 11. Heat exchange system

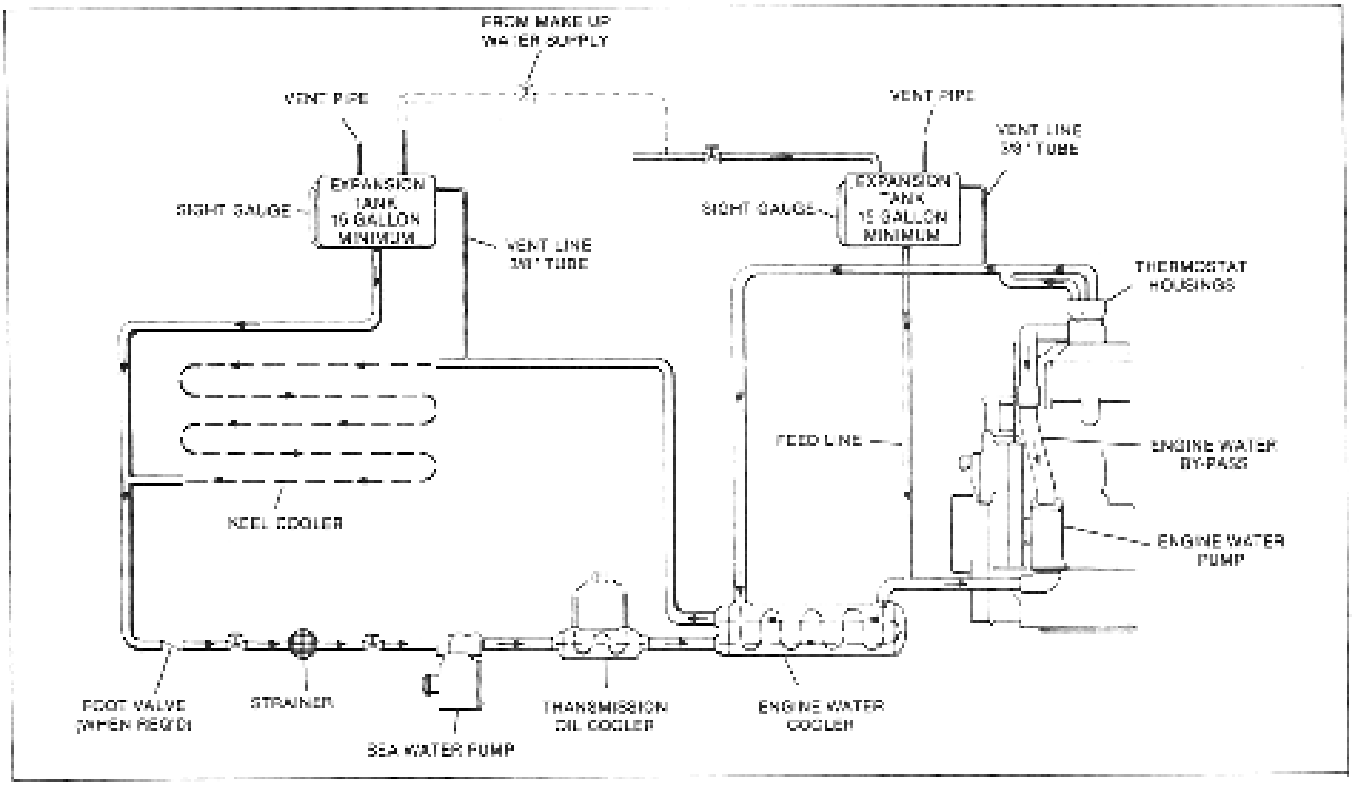
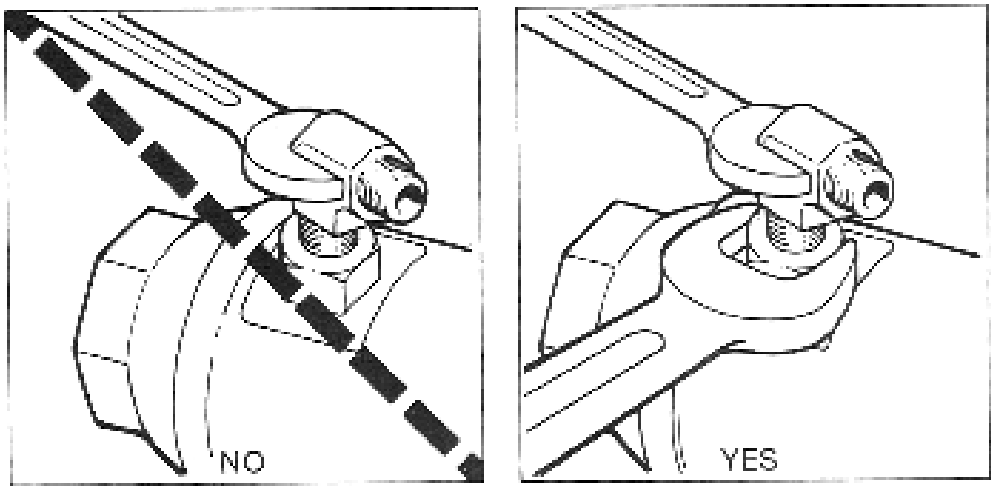


Figure 12. Keel cooler system



CAUTION: ALWAYS USE BACKUP WRENCH ON COOLER FITTINGS

3.6 START-UP PROCEDURE

1. Remove oil breather or top inspection cover and add recommended oil level is up to full mark on dipstick (see lube chart, p. 12). Replace 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 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, but DO NOT START ENGINE. This activates pressure pump which pre-lubricates reverse gear, preventing premature gear before, preventing premature wear before load is applied.

4.Start engine and check all connections for leaks.

5.Oil pressure is adjustable at factory for 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 temperatures (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). Secure oil breather or inspection cover.

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 recommended 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… 2500 RPM

3.7 OPERATING PRACTICES

CAUTION:

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

2. Reverse gear cannot be operated continuously in reverse mode for more that 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 installed. (As an alternative an auxiliary lube system may be installed).

4.Do not operate init with high or low oil pressure or if oil temperature exceeds 180 deg F.

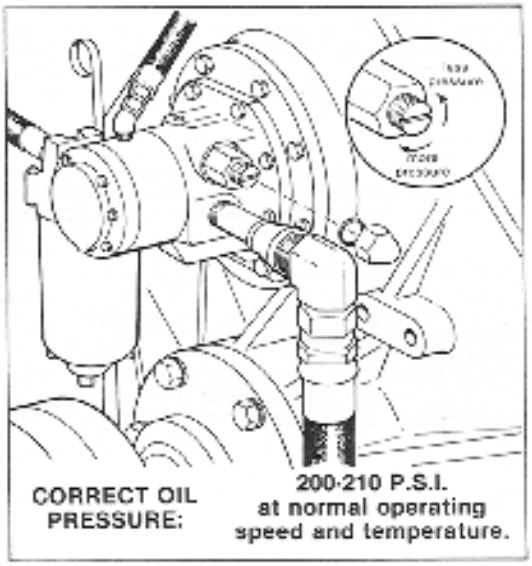


Fig. 13. Adjustment of Oil Pressure.
CAUTION: Relief Screw is Under Tension.

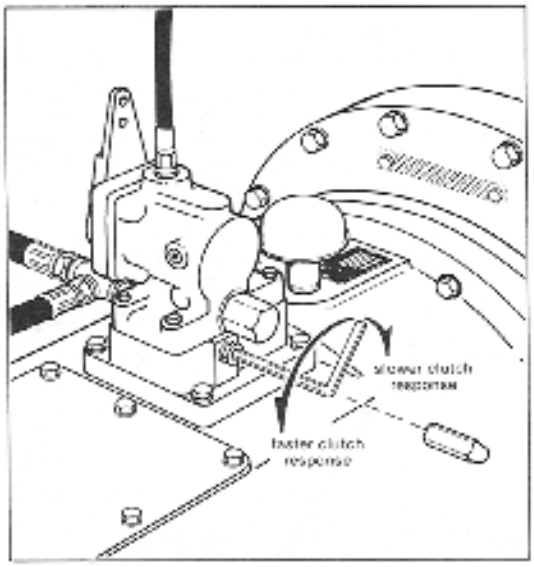


Fig. 14. Clutch Cylinder Timing Adjustment; used to regulate shifting time.

SECTION 4. PREVENTIVE MAINTENANCE

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

4.1 LUBRICANTS

Use oil meeting requirements of MIL-L-2104B or API SERVICE CLASS. SE/CC. Series 3 oils are not recommended because they may shorten clutch life.

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

Where high ambient temperatures are encountered, over 85 deg. F (29 deg. C), it may be necessary to use SAE 40 motor oil.
Where high ambient temperatures are encountered, under 30 deg. F (-1 deg. C), it may be necessary to use SAE 20 motor oil.

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 extremely low temperatures.

Oil Capacity (approximate, depending on cooler, hoses, etc.)
HP 9400: 10 gallons (38 liters)
HP 10500: 12.5 gallons (47.5 liters)

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 must be at least 200-210 PSI normal operating speed and maximum operating temperature.

Pressure Adjustment see fig. 13 p.11

Oil Temperature
Ideal operating oil temperature range is 140-160 deg. F (60-70 deg. C) at selector 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 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.

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 interval record pressure readings at idle speed. A gradual decline is normal. Readjust pressure relief valve to maintain proper operating pressures. See fig. 13, p. 11

Inspection /Overhaul Interval

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

4.3 MAINTENANCE SCHEDULE AND CHECK SHEET

Engineer_____
Reverse Gear serial no._____
Date service began_____

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 if contaminated - Remove and clean oil breather and suction tube - Replace filter element	
Every 2000 hours	- Check gear backlash (seep.34) - 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	

SECTION 5. TROUBLE SHOOTING

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
	2. Low oil level	2. Inspect gaskets, seals, hoses and fittings for leakage. Pressure test oil cooler- tubes may leak
	3. Clogged filter element	3. Replace filter element
	4. Clogged suction tube	4. Remove tube and clean with solvent. Blow dry
	5. Clogged parts in selector valve, baseplate or housing	5. Flush clean with solvent and blow dry
	6. Dirt or sludge in transmission	6. 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 3-5 mins max. Shut down engine and drain gearbox thoroughly. Refill gear with proper oil and run for 25 to 50 hours. Drain sump and refill with new oil. This will remove any residual solvent.
	7. Worn pump assembly	7. Refer to oil pump section or fig. 13.
	8. Incorrectly adjusted pressure relief valve	8. See fig. 13.
	9. Oil too hot	9. Check heat exchanger system for clogged oil cooler or hoses
	10. Worn commutator bushings	10. See wear limits chart
	11. Incorrect lubricant	11. See lube chart
	12. Scratched clutch cylinders or hard O-rings in clutch cylinders.	12. Replace as necessary
B. High oil pressure (at full operating speed and temperature)	1. Incorrectly adjusted pressure relief valve	1. Refer to fig.13
	2. Inoperable relief plunger in base plate	2. Refer to p.17
	3. Incorrect oil	3. See lube chart
	4. Cold oil	4. Check heat exchanger system
	5. Cold oil at start up	5. Transmission should be pre-heated see p.11

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
D. Overheating	1. Insufficient oil cooler capacity	1. Install adequate oil cooler
	2. Insufficient flow of cooling water	2. Increase water lines 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
E. 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.
	5. Improper alignment	5. Refer to section 5.
F. 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. Oil level may be too low
	4. Defective oil pump assembly	4. Refer to oil pump section
G. Clutch does not release	1. transmission is misaligned	1. Refer to installation section
	2. Improper oil in sump	2. Refer to lube chart
	3. Clutch discs warped	3. Replace as necessary
	4. Forward and reverse clutch cylinders dirty or distorted	4. Clean or replace as necessary
	5. Rear commutator bushing is worn	5. Replace as necessary. See replacement wear limits chart
	6. Incorrect linkage adjustment to selector valve assembly	6. Adjust linkage
	7. clutch discs fused due to slippage and overheating	7. Replace as necessary

H. Clutch slipping	1. Low oil pressure	1. See symptom A
	2. Transmission is misaligned	2. Refer to installation section
	3. Oil temperature too high	3. Temperature should be 140° to 160°F (60 to 71°C) at selector valve. Check heat exchanger system
	4. Worn clutch discs	4. Replace as necessary. See replacement wear limits chart
	5. Incorrect linkage adjustment to selector valve assembly	5. Adjust linkage
	6. Improper oil	6. See lube chart
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 control
	3. Transmission misaligned	3. check installation and alignment as described in installation section.
	4. Excessive heat	4. Check cooling system
J. No neutral	1. Transmission is misaligned	1. Refer to installation section
	2. Warped clutch discs	2. Replace as necessary
	3. Scored clutch cylinders	3. Replace as necessary
	4. Damaged clutch o-rings	4. Replace all 4 o-rings
	5. Worn or damaged commutator bushings (forward or rear)	5. Replace as necessary. See replacement wear limits chart
	6. Worn selector valve	6. Replace if necessary. Note: selector valve is the least likely source of trouble
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 fig. 14.
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. 14.

SECTION 6. REPAIR OF EXTERNAL SUBASSEMBLES

CAUTION
Avoid contact with rotating output coupling and always shut down engine when doing even minor inspection or repair. Avoid contact with metal surfaces as operating temperature may exceed 200 deg.

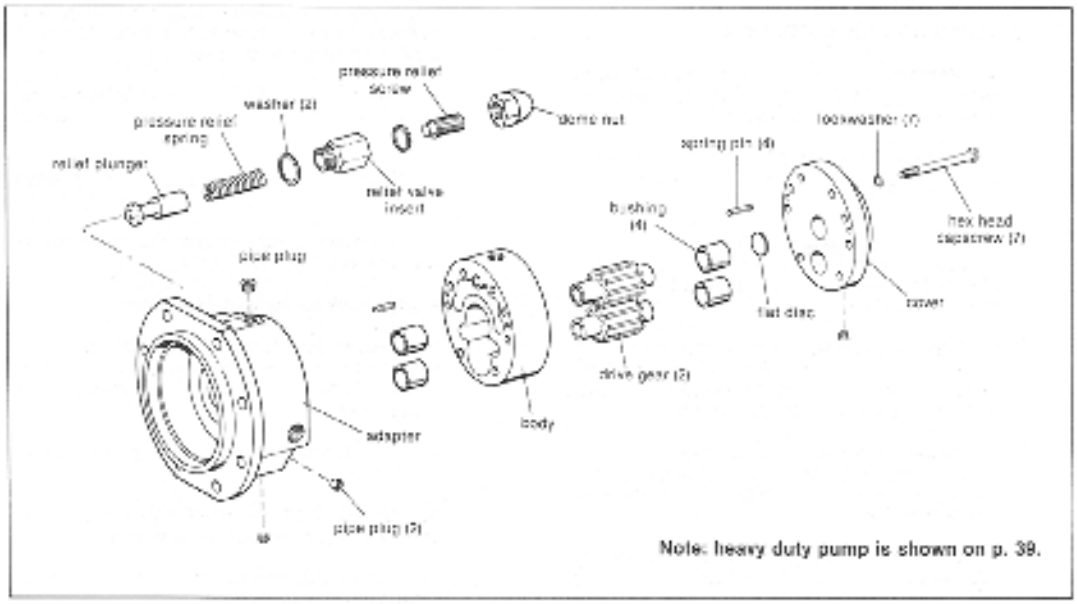


Fig. 15. Oil Pump Assembly (Pump no. 1-13041-1000 shown)

6.1 OIL PUMP

A. PRESSURE RELIEF ASSSEMBLY

1. With oil pump in place on marine gear remove dome nut, relief valve insert with screw, spring and accompanying washers. NOTE: UNSCREW INSERT CAREFULLY BECAUSE PRESSURE RELIEF SPRINGS IS UNDER TENSION

2. Check relief plunger to see if it is free moving. If not, inspect plunger for burrs, heat scores, or distortions. Burrs may be removed with fine crocus cloth, otherwise plunger should be replaced.

3. Clean all parts with a good grade cleaning solvent or diesel fuel. Blow dry with compressed air.

4.Generously lubricate relief plunger with oil or Vaseline. Insert plunger, cup end last. Check plunger for free movement.

5. Insert pressure relief spring into cup of plunger.

6. Screw pressure relief valve insert just enough to start threads.

7.Apply washer and install relief valve insert with pressure relief screw. Tighten insert, do not tighten relief screw.

8.Cap and lock pressure relief screw with dome nut and washer.

B. OIL PUMP DISASSEMBLY

1. Remove oil pump assembly and filter from main housing cover by removing cap screws and hoses.

2. Remove cap screws and lock washer securing pump cover, pump body and pump adapter.

3. Using a soft hammer, separate cover, body and adapter from spring pins, NOTE: FOR REASSEMBLY, PUNCH MARK ALONG SIDE OF COVER, BODY AND ADAPTER.

4. Remove pump gears resting in adapter.

5. Remove dome nut and relief valve insert. NOTE: PRESSURE RELIEF SPRING IS UNDER TENSION.

6.Unscrew and separate pressure relief screw from relief valve insert. Remove pressure relief spring and plunger.

C. CLEAN AND INSPECTION

1. Remove all permatex and clean all parts with good grade cleaning solvent or diesel fuel. Blow dry with compressed air.

2. Inspect gears and oil pump for damage or excess wear. See replacement wear limits chart.

3. Inspect cover and adapter for wear cause by gears. Note: If grooving does not exceed .030, both surfaces can be repaired by grinding smooth (.030" max cut).

4. Inspect bushings in cover for wear (see wear limits p. 23), out of round condition or burrs. If they are worn, damaged or loose, replace and ream to size (see p. 23).

5. Inspect bushings (2) in adapter for wear, out-of –round condition or burrs. If bushings are damaged, replace as necessary, and ream to size (see p. 23)

6. Check relief plunger for free movement in adapter bore. Replace if necessary.

7. Inspect all mating surfaces for smoothness.

8. Check to see that each oil passage is free from obstruction.

D. ASSEMBLY

1.Generously lubricate pump gears with lubriplate, Vaseline, or engine weight oil and position them in adapter. NOTE: BE SURE SPLINED ENDS (INSIDE DIAMETER OF PUMP GEARS) ARE TOWARD COVER.

2. To both mating surface of body, sparingly apply a very thin coat of 'SUPER 300' permatex or equivalent. Too much sealer can prevent pump from functioning.

3. Place body on adapter and cover on body following punch marks. Note: If new body is used make sure sharp inside corners are filled smooth.

4. Secure cover and body to adapter with cap screws and lock washers, -finger tight.

5. Drive spring pins (2) down through cover into body and adapter until they bottom in adapter. Drive 2 more spring pins into body until flush with top cover.

6. Insert pump shaft through adapter into pump gear and revolve shaft to check ease of operation.

7. Tighten all six cap screws to 16 foot-pounds torque.

8. Remove any excess permatex from seams with solvent.

9. Recheck for ease of operation.

10. Generously lubricate relief plunger with Vaseline or lubriplate and position cup end last in bore of adapter. Check to make sure plunger slides freely.

11. Insert pressure relief spring into cup of plunger.

12. Screw pressure relief spring into cup relief valve insert just enough to start threads.

13. Install washer and relief valve insert with pressure screw in place.

14. Tighten relief valve insert. Do not tighten relief screw.

15. Cap and lock pressure relief screw with dome nut and washer.

16. Recheck for ease or operation.

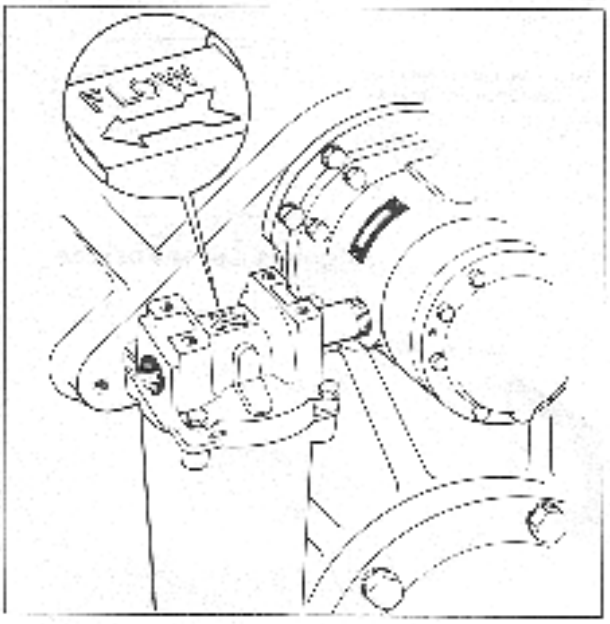


Fig. 16 CAUTION: Flow Arrow on Filter Must Point Away From Oil Pump.

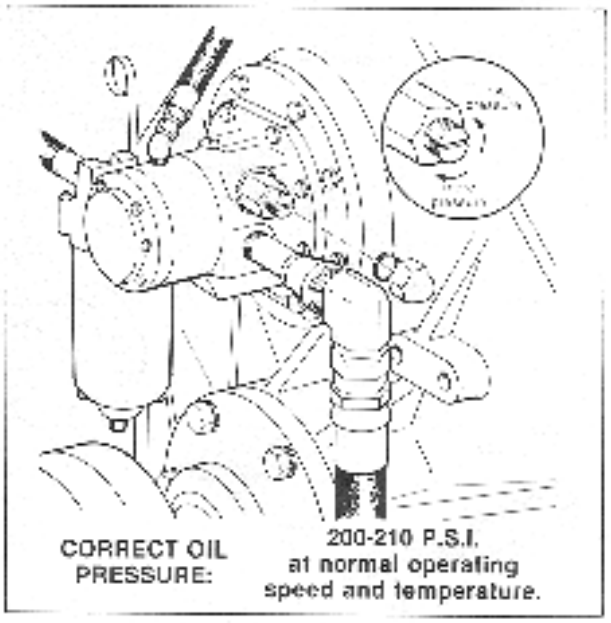


Fig. 17. Correct Operating Oil Pressure Should Be 200-210 P.S.I.

E. RE-INSTALLATION

NOTE: DO NOT use Teflon Tape. It may clog the pump.

1. Flush canister and install new filter element in filter.

2. Apply joint compound to threads and install pipe nipples, bushing and oil filter to oil pump. CAUTION: FLOW ARROW ON FILTER MUST POINT AWAY FROM PUMP. SEE FIG. 16.

3. Apply grease to bearing container and locate new oil pump gasket on container.

4. Install oil pump (and filter) on bearing container. Secure pump with cap screws and lock washers and torque to 42 lb. Ft.

5. Install suction hose to tee and oil pump.

6. On units with idler gear, connect hose from oil pump to idler shaft.

7. Be sure to re-adjust oil pressure to correct operating level when engine is started up. See Fig. 17.

F. PUMP ROTATION

The direction of pump rotation is the same as engine rotation. If engine rotation is changed the pluming to the pump must be changed. See cross section assembly drawing for details.

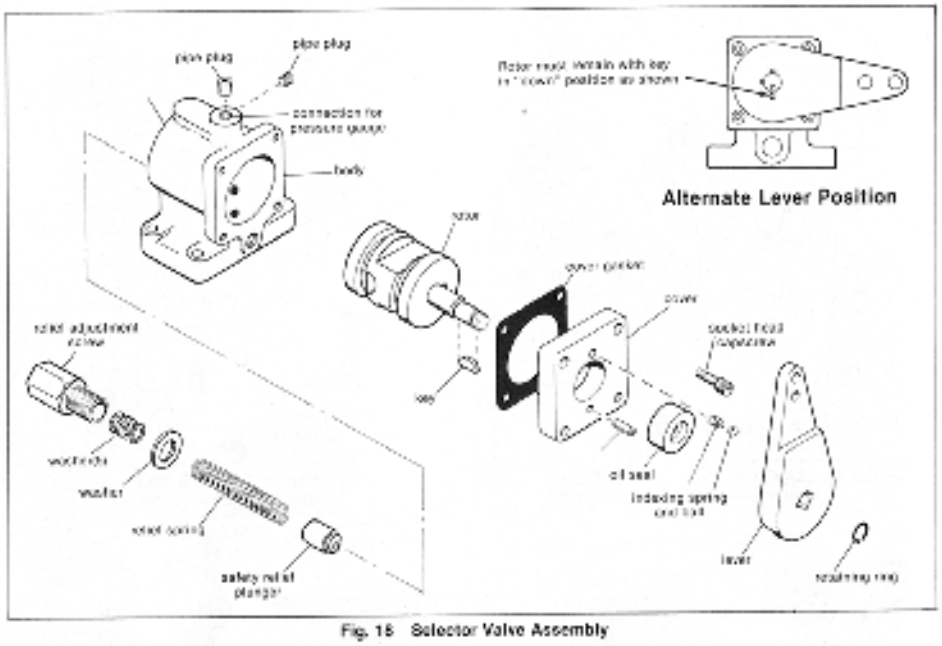


Fig. 15 Selector Valve Assembly

6.2 SELECTOR VALVE AND RELATED PARTS

A. REMOVAL

1. Disconnect hoses and control linkage from lever on selector valve.

2. Remove cap screws and lock washers and lift off selector valve and baseplate being very careful to keep gaskets in proper configuration for replacement. (They may be fixed in position with wire, etc.)

B .DISASSEMBLY

1. Remove retaining ring from rotor and note position of keyways on lever to rotor. (Matchmark if desired). Remove lever from rotor being careful not to lose indexing ball and spring.

2. Remove key from rotor shaft.

3. (Note position of cover). Remove cover, cover gasket, and rotor from block.

4. Remove safety relief adjustment screw, washer, spring and plunger. NOTE: SPRING IS UNDER TENSION.

C. CLEANING AND INSPECTION

1. Clean all parts thoroughly with oil and clean all ports. Blow dry with compressed air.

2. Inspect rotor and valve block for scoring Excessive scoring indicates replacement. Valves are not repairable.

3. Inspect oil seal in cover. If it is worn or shows evidence of leaking, replace it.

D. ASSEMBLY

NOTE: On all fittings use Permatex ‘Super 300’ sealant graphite paste, or equivalent. Caution: Do not use No. 1 Permatex or Teflon tape.

1. If necessary install new seal in cover. Press seal in until it bottoms in bore (rubber face out). Apply lubricant to seal.

2. Insert rotor shaft through oil seal in cover.

3. Set key in rotor shaft and install lever with indexing ball and spring. Make sure that keyway in rotor shaft remains toward bottom of cover.

4. Tap control lever into position with a soft hammer and secure with retaining ring.

5. Position new cover gasket on pilot face of cover.

6. Install rotor with cover into selector valve body. Secure cover with four cap screws. Tighten to 4 pounds-foot torque.

7. Install safety relief adjustment parts in rear of valve body.

8. Check for correct assembly by moving lever back and forth. Selector valve is now ready to be installed on main housing. See fig. 19.

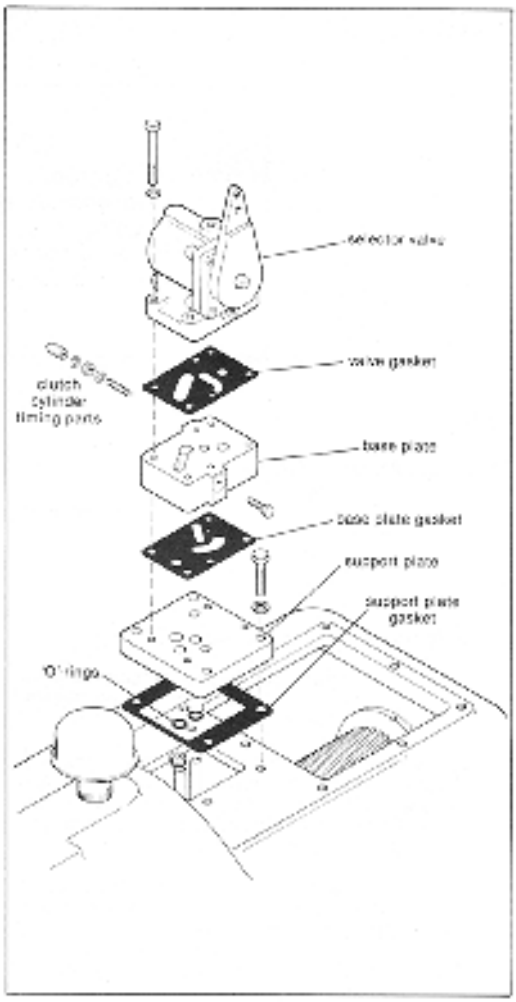


Fig. 19. Exploded View: Selector Valve and Related Parts.