Removal/Inspection/Installation

The governor components are contained in the timing gearcase (Figure 42, typical). Refer to Figure 47 or Figure 48 for an exploded view of the governor mechanism.

1. Remove the timing gearcase as described in Chapter Five or Six.

NOTE
Do not distort or damage the governor spring.

2. Carefully disconnect the governor spring (15, Figure 47 or Figure 48).

3. Check the governor shaft assembly for damage or looseness. Excessive play can cause improper governor operation. The shaft rides in bearings and should rotate smoothly without binding. The pinned levers should be tight on the shaft.

NOTE
Tapered pins secure the levers to the shaft. Remove a pin by driving against the small end of the pin.
GOVERNOR ASSEMBLY
(2GM, 2GM20, 3GM, 3GM30, 3HM AND 3HM35 MODELS)

1. Nut
2. Washer
3. Speed control lever
4. Bracket
5. Stop lever
6. Taper pin
7. Lock screw
8. O-ring
9. Timing gearcase
10. O-ring
11. Snap ring
12. Speed control shaft
13. Spring post
14. Secondary governor spring
15. Main governor spring
16. Snap ring
17. Washer
18. Control lever
19. Spring post
20. Governor lever
21. Taper pin
22. Roll pin
23. Shaft
24. Start spring
25. Needle bearing
26. Roll pin
27. Shaft support
28. Lockwasher
29. Bolt
30. Taper pin
31. Governor fork
32. Thrust collar
33. Thrust bearing
34. Governor sleeve
35. Pin
36. Flyweight
37. Governor flyweight assembly.
38. Roll pin
39. Stop cam
40. Washer
41. Lockwasher
42. Nut
43. Spring
4. If disassembly of the governor shaft assembly is required, remove the retaining bolts (29, Figure 47 or Figure 48) and remove the shaft assembly. To disassemble the components, detach the snap ring (16), then drive out the tapered pins that retain the levers. Replace the worn parts.

5. Remove the idle adjuster bracket and side cover (4, Figure 47 or Figure 48).

6. Check the speed control lever and shaft (12, Figure 47 or Figure 48) for excessive play between the shaft and the timing gearcase and between the lever and the shaft.
   a. If the shaft is loose in the timing gearcase, remove the nut (1, Figure 47 or Figure 48), then remove the speed control lever (3). Remove the shaft (12) and determine if the shaft, the timing gearcase or both are worn. Replace or repair the worn part.
   b. If the lever is loose on the shaft, remove the nut (1, Figure 47 or Figure 48), then remove the speed control lever (3). Determine if the lever, the shaft or both are worn. Replace any worn parts.

7A. On 1GM and 1GM10 models—Check the stop shaft (5, Figure 47) for excessive play between the shaft and the timing gearcase. If excessive play is evident, remove the nut (42), then withdraw the shaft. Determine if the shaft, the timing gearcase or both are worn. Replace or repair any worn parts.

7B. On 2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 models—Check the stop shaft (5, Figure 48) for excessive play between the shaft and the timing gearcase. If excessive play is evident, drive out the taper pin (6) by driving against the small end of the pin. Remove the locking screw (7). Remove the nut (42), then remove the shaft. Determine if the shaft, the timing gearcase or both are worn. Replace or repair any worn parts.

8. Inspect the governor springs for damage and distortion. Measure the length of the main and secondary governor springs as shown in Figure 49. Replace either spring if its free length dimension is not as specified in Table 2. If either spring is questionable, take it to a Yanmar dealership for testing.

9. Remove and inspect the thrust collar (32, Figure 47 or Figure 48). Replace the thrust collar if damaged or if the thickness is less than 2.9 mm (0.114 in.).

10. Remove the thrust bearing (33, Figure 47 or Figure 48). Replace the bearing if damaged.

11. Remove the governor sleeve (34, Figure 47 or Figure 48). Inspect the governor sleeve and crankshaft for damage. Refer to the specifications in Table 3.

12. Check the operation of the flyweight assembly (37, Figure 47 or Figure 48). The flyweights should move smoothly without excessive looseness. The contact surface in the flyweight groove should not be excessively worn. The flyweight assembly must be replaced as a complete assembly. Remove the crankshaft nut as described in Chapter Five or Six to remove the flyweight assembly.

13. Reassemble the governor assembly by reversing the disassembly procedure while noting the following:
   a. Do not distort the governor springs during installation.
   b. Install the governor springs so the long hook end engages the speed control lever (12, Figure 47 or Figure 48).
   c. Install the secondary governor spring (14, Figure 47 or Figure 48) so the lower end of the spring fits in the loop on the main governor spring.
   d. Note that the pins securing the levers on the shafts are tapered. The lever should fit tightly on the shaft when the pin is installed. If not, replace the worn part.
   e. Check the movement of all the parts after assembly. Motion should be smooth without binding.

14. Reinstall the timing gearcase as described in Chapter Five for single cylinder engines or Chapter Six for multi-cylinder engines.
### Table 1 TIGHTENING TORQUES

<table>
<thead>
<tr>
<th>Fastener</th>
<th>N·m</th>
<th>ft.-lb.</th>
<th>in.-lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injector fuel nut</td>
<td>20</td>
<td>15</td>
<td>–</td>
</tr>
<tr>
<td>Injection pump retaining nuts</td>
<td>25</td>
<td>18</td>
<td>–</td>
</tr>
</tbody>
</table>

### Table 2 GOVERNOR SPRING FREE LENGTH

<table>
<thead>
<tr>
<th></th>
<th>1GM, 1GM10</th>
<th>2GM, 2GM20</th>
<th>3GM, 3GM30, 3HM, 3HM35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main governor spring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>76 mm</td>
<td>78 mm</td>
<td>78 mm</td>
</tr>
<tr>
<td></td>
<td>(2.99 in.)</td>
<td>(3.07 in.)</td>
<td>(3.07 in.)</td>
</tr>
<tr>
<td>L2</td>
<td>18 mm</td>
<td>20 mm</td>
<td>20 mm</td>
</tr>
<tr>
<td></td>
<td>(0.71 in.)</td>
<td>(0.79 in.)</td>
<td>(0.79 in.)</td>
</tr>
<tr>
<td>Secondary governor spring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>26 mm</td>
<td>23 mm</td>
<td>23 mm</td>
</tr>
<tr>
<td></td>
<td>(1.02 in.)</td>
<td>(0.90 in.)</td>
<td>(0.90 in.)</td>
</tr>
<tr>
<td>L2</td>
<td>5 mm</td>
<td>10 mm</td>
<td>10 mm</td>
</tr>
<tr>
<td></td>
<td>(0.20 in.)</td>
<td>(0.39 in.)</td>
<td>(0.39 in.)</td>
</tr>
</tbody>
</table>

### Table 3 GOVERNOR SLEEVE AND CRANKSHAFT SPECIFICATIONS

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Governor sleeve inside diameter</td>
<td>25.053-25.063 mm (0.9863-0.9875 in.)</td>
<td></td>
</tr>
<tr>
<td>Governor sleeve length—wear limit</td>
<td>14.8 mm (0.583 in.)</td>
<td></td>
</tr>
<tr>
<td>Crankshaft diameter</td>
<td>24.972-24.993 mm (0.9831-0.9840 in.)</td>
<td></td>
</tr>
<tr>
<td>Governor sleeve clearance on crankshaft</td>
<td>0.060-0.111 mm (0.0024-0.0044 in.)</td>
<td></td>
</tr>
<tr>
<td>Maximum allowable clearance</td>
<td>0.20 mm (0.008 in.)</td>
<td></td>
</tr>
</tbody>
</table>
Chapter Eight

Cooling System

This chapter covers service procedures for the thermostat, engine water pump, seawater pumps, drive belts and connecting hoses in both standard and closed cooling systems.

Cooling system flushing procedures are provided in Chapter Three. Drain and refill procedures are described in Chapter Four.

Table 1 and Table 2 are located at the end of this chapter.

NOTE
Except where specified, F and D series engines are included when a basic model number is specified. For example, if model 3GM is called out in a procedure, the procedure also applies to 3GMD and 3GMF.

COOLING SYSTEMS

Seawater (Standard) Cooling System

All engines are equipped with a seawater cooling system. The water in which the boat is being operated is used as a coolant to absorb engine heat. Water from outside the boat passes through the water intake to the impeller-type seawater pump located on the engine (Figure 1, typical). The seawater pump sends the water to the engine for circulation through the engine block, head and manifold.

A thermostat controls water circulation to provide quick engine warm-up and maintain a constant operating temperature.

Refer to typical cooling system diagrams in Figure 2, Figure 3 and Figure 4.
SEAWATER COOLING SYSTEM
(1GM AND 1GM10)

Mixing elbow
Rubber hose
To outside of boat
Cylinder head
Cooling water temperature switch
Cylinder block
Anticorrosion zinc
Thermostat
Drain plug
Thermostat cover
Cooling water pump
Seacock (except 1GM10C)
SEAWATER COOLING SYSTEM
(2GM AND 2GM20)

- U-type mixing elbow
- Rubber hose
- Mixing elbow
- Anticorrosion zinc
- Drain plug
- Thermostat housing
- Thermostat switch
- Thermostat
- Cooling water pump
- Seacock (except 2GM20C)
SEAWATER COOLING SYSTEM
(3GM AND 3GM30 MODELS)

3HM AND 3HM35

Exhaust manifold

Thermostat housing

Mixing elbow

To outside boat

Anticorrosion zinc

Anticorrosion zinc

Drain cock

Cylinder head

U-type mixing elbow

Drain plug

Joint

Rubber hose

Thermostat cover

Thermostat switch

Thermostat

Thermostat housing

Cooling water temperature switch

Thermostat

Seacock (except 3GM30C and 3HM35C)

Cooling water pump

Elbow
Freshwater (Closed) Cooling System

Two- and three-cylinder engines with a model number ending in F are equipped with seawater and freshwater (closed) cooling systems.

The closed cooling system is divided into two separate subsystems: one uses seawater and the other uses a coolant mixture of distilled water and ethylene glycol antifreeze. The subsystem containing the coolant is referred to as the freshwater system. Refer to the typical freshwater cooling system diagram in Figure 5. Typical components are shown in Figure 6.

Various configurations of the closed cooling system are used, but all function essentially the same. The seawater system operation is similar to the standard cooling system previously described, except as follows:

a. Coolant in the closed cooling system cools the engine block, cylinder head and exhaust manifold.

b. A belt-driven seawater pump (Figure 1), located at the front of the engine, delivers seawater to the heat exchanger, instead of passing seawater directly into the engine.

After passing through the seawater pump, the seawater travels through a series of parallel copper tubes in the heat exchanger, where it absorbs engine heat before returning to the exhaust elbow for discharge from the boat. Figure 7 shows a typical heat exchanger.

The freshwater system pump circulates the coolant mixture inside the engine to absorb engine heat. This
CLOSED COOLING SYSTEM (TYPICAL)

- Pressure fill pipe
- Overflow pipe
- Heat exchanger
- Mixing elbow
- To outside of boat
- Remote tank
- Cylinder head
- Drain plug
- By-pass flow
- Thermostat
- Seawater pump
- Freshwater pump
- Seacock (option)
- Cylinder block
- Drain plug
- U-type mixing elbow
- Joint
- Rubber hose
- Elbow
Coolant travels to the heat exchanger, where the heat absorbed from engine operation passes through the parallel copper tubes to the water in the seawater system.

Engine cooling is thus accomplished without seawater entering the engine. This eliminates the corrosion, deposit buildup and debris accumulation that occurs in a standard cooling system, resulting in longer engine life—especially if the boat is used in saltwater.

Like an automotive cooling system, the freshwater section is pressurized at 13 psi. This raises the boiling point of the coolant to permit higher operating temperatures for increased engine efficiency.

A thermostat controls coolant circulation. When the thermostat closes, it prevents coolant from entering the heat exchanger, rerouting it back to the engine circulating pump. Once the thermostat opens, it closes off the passage to the circulating pump and sends the coolant through the heat exchanger before returning it to the engine pump. This provides quick engine warm-up and maintains a constant operating temperature.

**THERMOSTAT**

The thermostat blocks coolant flow to the exhaust manifold (standard cooling) or heat exchanger (closed cooling) when the engine is cold. As the engine warms, the thermostat gradually opens, allowing coolant to circulate through the system.

**CAUTION**

*Do not operate the engine without a thermostat. This can lead to serious engine damage.*

Thermostats are rated according to their opening temperature. The opening temperature value is stamped on the thermostat. The thermostat should start to open at the temperature stamped on the thermostat and should be fully open at 250 °F (140 °C) above that temperature. Check the thermostat rating after removing the thermostat and compare it to the specifications in Table 2.
Removal/Installation

Seawater cooling systems

The thermostat on 1GM and 1GM10 engines is located in the cylinder head (Figure 2). The thermostat on two- and three-cylinder engines is located in the thermostat housing (Figure 3 and Figure 4). 3HM and 3HM35 engines are equipped with two thermostats (Figure 4).

1. Drain the seawater from the engine as described in Chapter Four.
2. Loosen the hose clamps and disconnect the hoses from the thermostat cover (Figure 8).
3. Remove the thermostat cover retaining bolts and washers. Remove the cover and the gasket. Discard the gasket.
4. Remove the thermostat (Figure 9). On 3HM and 3HM35 engines, remove both.
5. Test the thermostats as described in this chapter.
6. Clean the thermostats cover and housing or cylinder head mating surfaces of all gasket residue.
7. Install the thermostat in the housing or cylinder head with its thermostatic element facing the engine. The thermostat flange must fit into the housing recess.
8. Coat both sides of a new gasket with sealant and install the gasket onto the thermostat cover.
9. Install the cover. Note that the inlet and outlet nipples are stepped. Install the cover so the outermost nipple faces down, as shown in Figure 10. Tighten the bolts securely.
10. Reconnect the hoses to the thermostat cover and tighten the clamps securely.
11. Operate the engine and check for leaks. Operate the engine until it reaches normal operating temperature. Immediately shut down the engine if overheating occurs and correct the problem.

Freshwater cooling systems

1. Drain the coolant from the engine as described in Chapter Four.
2. Loosen the hose clamp (Figure 11) securing the coolant hose to the thermostat cover.
3. Remove the thermostat cover retaining bolts and washers (Figure 11). Remove the cover and the hose. Discard the gasket.
4. Remove the thermostat (Figure 12).
5. Test the thermostat as described in this chapter.
6. Clean the thermostat cover and housing mating surfaces of all gasket residue.
7. Install the thermostat in the housing with its thermostatic element facing the housing. The thermostat flange must fit into the housing recess.
8. Coat both sides of a new gasket with sealant and install the gasket onto the thermostat cover.
Testing (Out of Engine)

1. Pour some tap water (not distilled water or coolant) into a container that can be heated. Submerge the thermostat in the water and suspend a thermometer as shown in Figure 13.

   NOTE
   Suspend the thermostat with wire so it does not contact the pan.

2. Heat the water until the thermostat starts to open. Check the water temperature on the thermometer. It should be approximately the same as the temperature value stamped on the thermostat. If the thermostat has not started to open at this temperature, replace it.
3. Heat the water another 25°F (14°C) above the temperature value stamped on thermostat. The thermostat should now be fully open. If it is not, replace it.
4. Allow the water to cool to 10°F (6°C) under the thermostat’s rated opening temperature. If the thermostat valve is not fully closed at this temperature, replace it.
5. Remove the thermostat from the water and let it cool to room temperature. Make sure the valve seals tightly by holding the thermostat up to a light. If light is visible around the edge of the valve, replace the thermostat.

Testing (In Engine)

Thermostat operation can be tested without removing it from the engine or reservoir. This procedure requires the use of two thermomelt sticks (Figure 14) available from marine supply or automotive parts stores. A thermomelt stick looks like a carpenter’s pencil and is made of a chemically impregnated wax material that melts at a specific temperature.
This technique can be used to check thermostat opening by marking the thermostat housing with two thermomelt sticks: one with a temperature lower than the thermostat opening temperature, and one with a temperature higher than the full open position. When the coolant or water reaches the first temperature, the mark made by that stick will melt. The mark made by the second stick will not melt until the coolant or water increases to that temperature.

**WARNING**

*Do not remove the pressure fill cap from a freshwater (closed) cooling system while the engine is warm. Coolant may blow out of the heat exchanger and cause serious personal injury.*

Overheated Engine

1. Relieve the freshwater cooling system pressure by carefully removing the pressure fill cap from the heat exchanger. See Figure 15, typical.
2. Rub a 180° F (82° C) thermomelt stick on the thermostat cover.
3. Start the engine and run at a fast idle.
4. If no coolant flows into the heat exchanger by the time the mark starts to melt, either the thermostat is stuck closed or the water pump is failing. Remove the thermostat and test it as described in this chapter. If the results are satisfactory, replace the water pump.

Slow Engine Warm-Up

1. Relieve the freshwater cooling system pressure by carefully removing the pressure fill cap from the heat exchanger. See Figure 15, typical.
2. Rub the 160° F (71° C) thermomelt stick on the thermostat cover.
3. Start the engine and run at a fast idle.
4. If coolant or water flows into the heat exchanger before the mark starts to melt, the thermostat is stuck open and should be replaced.

**HOSE REPLACEMENT**

Replace any hoses that are cracked, brittle, or very soft and spongy. If a hose is in doubtful condition, replace it to be on the safe side. Hoses in some installations are extremely difficult to change; attention to hose condition can prevent a failure while off-shore.

Hose manufacturers generally rate cooling system hose life at two years. How long the hoses will last depends a great deal on how much the boat is used and how well the system is maintained; however, it is a good idea to change all hoses every two years. Always replace a cooling system hose with the same type as removed. Pleated rubber hoses do not have the same strength as reinforced molded hoses. Check the hose clamp condition and install new marine-grade clamps with a new hose, if necessary.

- Partially drain the cooling system when replacing upper hoses. Completely drain it when replacing lower hoses.
  1. Loosen the clamp at each end of the hose to be removed. Grasp the hose and twist it off the fitting with a pulling motion.
  2. If the hose is corroded to the fitting and will not twist free, remove the clamp and insert a small screwdriver or pick tool between the hose and the fitting. Work the tool around the fitting, then remove the hose.
  3. Clean any rust or corrosion from the fitting with a wire brush.
  4. Wipe the inside diameter of the new hose with liquid detergent and install the hose ends on the fittings with a twisting motion.
  5. Position the new clamps at least 1/4 in. (6.4 mm) from the end of the hose. Make sure to position the clamp screw for easy access with a screwdriver or nut driver. Tighten each clamp snugly.
6. Refill the cooling system. Start the engine and check for leaks. Recheck the clamps for tightness after operating the engine for a few hours.

**DRIVE BELTS**

Inspect all drive belts at regular intervals to make sure they are in good condition and are properly tensioned. Replace worn, frayed, cracked or glazed belts immediately. The components to which they direct power are essential to the safe and reliable operation of the boat. If correct adjustment is maintained on each belt, all will usually give the same service life. For this reason, and because of the cost involved in replacing an inner belt (requiring the removal of the outer belt), it is a good idea to replace all belts as a set. The added expense is small compared to the cost of replacing the belts individually and eliminates the possibility of a breakdown on the water, which could cost far more in time and money.

Drive belts should be properly tensioned at all times. If loose, the belts will not permit the driven components to operate at maximum efficiency. The belts will also wear rapidly because of the increased friction caused by slippage. Belts that are too tight will be overstressed and prone to premature failure. An excessively tight belt will also overstress the bearings, resulting in premature failure.

Only install heavy-duty belts. Do not install light-duty belts, such as those designed for automobile use.

Refer to Figure 16 for drive belt routing diagrams.

**Belt Adjustment**

Refer to Chapter Three for belt adjustment procedures.

**Belt Replacement**

*Alternator drive belt replacement*

Replace the alternator drive belt as follows:

1. Loosen the alternator bracket and pivot bolts (Figure 17, typical).
2. Move the alternator toward the engine and slip the belt off the crankshaft and alternator pulleys, and if equipped with freshwater cooling, the circulating water pump pulley.
3. Install a new belt over the pulleys.
4. Move the alternator away from the engine and adjust the belt tension as described in Chapter Three.
Seawater pump drive belt replacement (except 1GM and 1GM10 engines)

Replace the seawater drive belt as follows:
1. Loosen the alternator bracket and pivot bolts (Figure 17, typical).
2. Move the alternator toward the engine and slip the belt off the crankshaft and alternator pulleys, and if equipped with freshwater cooling, the circulating water pump pulley.
3. Loosen the seawater pump bracket and pivot bolts (Figure 18, typical).
4. Move the seawater pump toward the engine and slip the belt off the crankshaft and pump pulleys.
5. Install a new belt over the pulleys.
6. Move the seawater pump away from the engine and adjust the belt tension as described in Chapter Three.
7. Install the alternator drive belt onto the crankshaft and alternator pulleys, and if equipped with freshwater cooling, the circulating water pump pulley.
8. Move the alternator away from the engine and adjust the belt tension as described in Chapter Three.

SEAWATER PUMP

All engines covered in this manual use a seawater pump (Figure 19, typical). The seawater pump on 1GM and 1GM10 engines is driven by the end of the oil pump driveshaft. All other engines use a belt-driven seawater pump. A rubber impeller inside the pump moves water through the pump. The pump draws water into the intake port as the impeller vanes flex outward, and it pumps water out of the discharge port as the impeller vanes flex inward, as shown in Figure 20.

The impeller only operates in a counterclockwise rotation (viewed from cover side of pump) and remains in a flexed (compressed) position at all times. Over time, this causes the impeller to take a set in one direction. Turning an impeller over and attempting to turn it against its natural set will cause premature impeller failure and engine damage from overheating.

Replace the impeller every time the water pump is disassembled. The impeller must only be reused if there is no other option. If the impeller must be reused, reinstall the impeller in its original position.

Overheating and extensive engine damage can result from a faulty water pump. Therefore, it is highly recommended that the water pump impeller, seals and gaskets be inspected after every 1,500 hours of operation as a preventive maintenance measure. Individual operating conditions may dictate that the pump will require service more often.
Seawater Pump Precautions

The seawater pump suffers from many misconceptions about its ability to withstand operation without water being supplied to it. All impellers are made of some variation of rubber. The water pump housing is made of metal. If a piece of rubber is rubbed across a piece of metal, there is severe friction and considerable heat buildup. However, if the metal is flooded with water while the rubber is moved across it, the friction would be greatly reduced and the heat buildup non-existent.

Basically, the water pump works the same way. The water passing through the pump lubricates and cools the impeller and pump housing. Without the water, the pump will overheat and the impeller will begin to melt almost instantaneously. Of course, this can be secondary to the potential damage to the engine from overheating.

Once the impeller sustains any damage, its pumping ability is greatly diminished because the impeller can no longer seal adequately. The impeller must seal on its edges, as well as the blade tips.

If the engine was run without an adequate supply of water to the pump, disassemble the pump and replace the impeller and any other damaged parts.

Water Pump Operating Mistakes

Do not run an engine immediately after pulling a boat out of water. This is an extremely risky operation, but here is why some people often seem to get away with it. If an engine has just been pulled out of the water, there is residual water in the cooling system and engine that drains back down to the water pump. This water will lubricate the water pump for a short period of time (perhaps a couple of minutes), but the pump will be damaged as soon as the heat from operation evaporates all water in the system. Do not operate the pump without an adequate water supply.

Do not start an engine with the boat out of the water, but without a water supply, to make sure the motor will run when the boat is launched. This is an unacceptable and very dangerous procedure. If an engine has been sitting for any length of time, the water pump is completely dry and the impeller will sustain immediate damage if the engine is operated without an adequate water supply. Water must be supplied to the pump through the boat's water intake or supplied under pressure from a flushing device.

CAUTION
Supply the pump with an adequate water supply anytime the engine is running.

Do not crank the engine for an extended period, such as during troubleshooting. This is detrimental to a water pump that is completely dry. Consider attaching a flushing device before initially cranking an engine with a dry water pump. This will ensure the pump is wet and will not be damaged. It will not be necessary to keep the water supply flowing during all cranking periods; it is just important to keep the pump wet during extended cranking.

Removal/Installation

1. If the boat is in water, make sure the seacock is closed.
2. Drain the seawater from the engine as described in Chapter Four.
3. Loosen the hose clamps, then detach the water hoses from the seawater pump.
4. Remove the pump retaining screws (Figure 21) and remove the pump. Remove and discard the gasket, if so
equipped. Some engines are equipped with an O-ring that seals between the pump and engine.
5. Reverse the removal steps to install the pump. Refer to Table 1 for the tightening torque of the pump retaining screws.

**2GM, 2GM20, 3GM and 3GM30**

1. If the boat is in water, make sure the seacock is closed.
2. Drain the seawater from the engine as described in Chapter Four.
3. Loosen the hose clamps, then detach the water hoses from the seawater pump.
4. Loosen the seawater pump bracket and pivot bolts (A, Figure 22).
5. Move the seawater pump toward the engine and slip the drive belt off the pump pulley.
6. Remove the pump mounting bolts (B, Figure 22), then separate the pump from the mounting bracket.
7. Reverse the removal steps to install the pump. Refer to Table 1 for the tightening torque of the pump mounting bolts. Adjust the belt tension as described in Chapter Three.

**3HM and 3HM35**

1. If the boat is in water, make sure the seacock is closed.
2. Drain the seawater from the engine as described in Chapter Four.
3. Loosen the hose clamps, then detach the water hoses from the seawater pump.
4. Loosen the seawater pump bracket and pivot bolts.
5. Move the seawater pump toward the engine and slip the drive belt off the pump pulley.
6. Unscrew the pulley retaining nut (B, Figure 23), then remove the pulley for access to the pump mounting bolts.
7. Remove the mounting bolts (C, Figure 23), then separate the pump from the mounting bracket.
8. Reverse the removal steps to install the pump. Refer to Table 1 for the tightening torque of the pump mounting bolts. Adjust the belt tension as described in Chapter Three.

**Disassembly/Reassembly**

**1GM and 1GM10**

1. Remove the three screws securing the pump cover to the body (1, Figure 24).
2. Remove the cover (2, Figure 24) and gasket (3). Discard the gasket.
3. Extract the impeller (4, Figure 24) from the pump body.
4. Rotate the pump shaft to check the bearings for roughness, excessive wear or other damage. Do not remove the shaft assembly unless replacement is necessary.
5. Unscrew the cam retaining screw (6, Figure 24), then remove the cam (5).
6. Remove the snap ring (15, Figure 24) at the rear of the pump body.
7. Lightly tap the impeller shaft toward the rear of the pump to remove the impeller shaft and bearing assembly.

**NOTE**
When removing bearings, note the snap ring located between the bearings.

8. Press the bearings (11 and 14, Figure 24) from the pump shaft (12) using a universal press plate and arbor press. Force each bearing away from the locating snap ring (13, Figure 24).
9. Extract or push out the seals (9 and 10, Figure 24).

10. Clean all metal components with solvent, then dry them with compressed air.
11. Thoroughly clean all gasket material from all mating surfaces.
12. Inspect the pump shaft (12, Figure 24) for grooves in the seal contact area.
13. Inspect the impeller (4, Figure 24) for cracked blades or excessive wear at the tips of the blades. Replace the impeller if any defects are observed.
14. Inspect the pump body and cover for grooves or other damage. A damaged or excessively worn body or cover will reduce pump efficiency and may damage a new impeller.
15. Install the shaft seal (9, Figure 24) so the lip is toward the impeller side of the pump body.
16. Install the oil seal (10, Figure 24) so the lip is toward the bearing side of the pump body.
17. If removed, install the snap ring (13, Figure 24) into the groove in the impeller shaft.
18. Press the shaft bearings onto the pump shaft until they seat fully against the snap ring. Press only on the bearing inner races.
19. Install the shaft and bearing assembly into the body. Install the snap ring (15, Figure 24).
20. Install the cam (5, Figure 24) and the cam retaining screw (6).

   **NOTE**
   *Replace the pump impeller anytime it is removed from the pump. If the original impeller must be reused, make sure to install it in the same rotational direction as originally installed.*

21. Lightly lubricate the tips and sides of the impeller. Install the impeller into the pump body by rotating the impeller counterclockwise. Be certain all impeller blades bend in the same direction (Figure 25).
22. Install the cover and gasket.
23. Install the three screws securing the pump cover to the body.

**2GM, 2GM20, 3GM and 3GM30**

1. Remove the six screws securing the pump cover (19, Figure 26) to the body (12).
2. Remove the cover and gasket. Discard the gasket.
3. Extract the impeller (17, Figure 26) from the pump body.
4. Rotate the pump shaft to check the bearings for roughness, excessive wear or other damage. Do not remove the shaft assembly unless replacement is necessary.
5. Unscrew the pulley retaining nut, then remove the pulley (3, Figure 26) and spacer (4).
6. Remove the snap ring (5, Figure 26) at the rear of the pump body.
7. Lightly tap the impeller shaft (9, Figure 26) toward the front of the pump to remove the impeller shaft and bearing assembly.
8. Unscrew the cam retaining screw (13, Figure 26), then remove the cam (16).
9. Remove the seal ring (10, Figure 26) and bearing cover (8) from the shaft.
10. Press the bearings from the pump shaft using a universal press plate and arbor press. Force each bearing toward the threaded end of the shaft. Note the spacer (7, Figure 26) between the bearings.
11. Extract or push out the seal.
12. Clean all metal components in solvent, then dry them with compressed air.
13. Thoroughly clean all gasket material from all mating surfaces.
14. Inspect the pump shaft for grooves in the seal contact area.
15. Inspect the impeller for cracked blades or excessive wear at the tips of the blades. Replace the impeller if any defects are observed.

16. Inspect the pump body and cover for grooves or other damage. A damaged or excessively worn body or cover will reduce pump efficiency and may damage a new impeller.
17. Press the bearings onto the shaft with the spacer (7, Figure 26) between the bearings. Seat the bearings against the shoulder on the shaft. Press only on the bearing inner races.
18. Install the seal (11, Figure 26) into the pump body so the lip is toward the impeller side of the body.
19. Install the cam (16, Figure 26), then install the cam retaining screw (13).
20. Install the bearing cover (8, Figure 26) with the concave side toward the bearing.
21. Install the seal ring (10, Figure 26) onto the shaft.
22. Install the shaft assembly into the pump body.
23. Install the snap ring (5, Figure 26).
24. Install the spacer (4, Figure 26), pulley (3), washer (2) and nut (1), then tighten the nut.

   **NOTE**
   *Replace the pump impeller anytime it is removed from the pump. If the original impeller must be reused, make sure to install it in the same rotational direction as originally installed.*

25. Lightly lubricate the tips and sides of the impeller. Install the impeller into the pump body by rotating the impeller counterclockwise. Be certain all impeller blades bend in the same direction (Figure 27).
26. Install the cover (19, Figure 26) and gasket.
27. Install the six screws securing the pump cover to the body.

**3HM and 3HM35**

1. Remove the six screws (19, Figure 28) securing the pump cover (18) to the body (12).
2. Remove the cover (18, Figure 28) and gasket (17). Discard the gasket.
3. Extract the impeller (16, Figure 28) from the pump body and remove the drive key (8).
4. Rotate the pump shaft to check the bearings for roughness, excessive wear or other damage. Do not remove the shaft assembly unless replacement is necessary.
5. Remove the snap ring (4, Figure 28).
6. Lightly tap the impeller shaft (7, Figure 28) toward the front of the pump to remove the impeller shaft and bearing assembly.
7. Unscrew the cam retaining screw (14, Figure 28), then remove the cam (15).

NOTE
When removing bearings, note the snap ring located between the bearings.
8. Press the bearings from the pump shaft using a universal press plate and arbor press. Force each bearing away from the locating snap ring (6, Figure 28).
9. Extract or push out the seal (11, Figure 28).
10. Clean all metal components solvent, then dry them with compressed air.
11. Thoroughly clean all gasket material from all mating surfaces.
12. Inspect the pump shaft for grooves in the seal contact area.
13. Inspect the impeller for cracked blades or excessive wear at the tips of the blades. Replace the impeller if any defects are observed.
14. Inspect the pump body and cover for grooves or other damage. A damaged or excessively worn body or cover will reduce pump efficiency and may damage a new impeller.
15. Install the shaft seal (11, Figure 28) so the lip is toward the impeller side of the pump body.
16. If removed, install the snap ring (6, Figure 28) into the groove in the impeller shaft.
17. Press the shaft bearings onto the pump shaft until fully seated against the snap ring. Press only on the bearing inner races.
18. Install the bearing cover (9, Figure 28) with the concave side toward the bearing.
19. Install the washer (10, Figure 28) onto the shaft.
20. Install the shaft assembly into the pump body. Install the snap ring (4, Figure 28).
21. Install the slotted washers (2, Figure 28), pulley (3) and nut (1), then tighten the nut.
22. Install the impeller drive key (8, Figure 28) in the slot in the impeller shaft.

**NOTE**

Replace the pump impeller anytime it is removed from the pump. If the original impeller must be reused, be sure to install it in the same rotational direction as originally installed.

23. Lightly lubricate the tips and sides of the impeller. Install the impeller into the pump body by rotating the im-
peller counterclockwise. Be certain all impeller blades are facing the same direction (Figure 27).
24. Install the cover (18, Figure 28) and gasket.
25. Install the six screws securing the pump cover to the body.

FRESHWATER PUMP

The freshwater circulating pump may warn of impending failure by making noise. If the seal is defective, coolant or water may leak from behind the pump pulley. It is recommended that the pump be replaced as an assembly. Individual replacement parts are available.

Removal/Installation

1. Drain the freshwater cooling system. Refer to Chapter Four.

   NOTE
   If pump pulley removal is not necessary, proceed to Step 3.

2. Loosen, but do not remove, the pump pulley retaining bolts (A, Figure 29).
3. Loosen the alternator adjusting and pivot bolts (B, Figure 29). Swivel the alternator toward the engine and remove the drive belt from the pump pulley.
4. Unscrew the pump pulley screws and remove the pulley.
5. Unclamp and disconnect the hoses from the circulating pump and detach any hose brackets that interfere with access to the water pump bolts.

   NOTE
   Note the length of the pump retaining bolts during removal and, if necessary, mark them according to location.

6. Remove the pump retaining bolts (Figure 30). Remove the pump and gasket. Discard the gasket.
7. Clean all gasket residue from the pump and engine block mounting surfaces.
8. Installation is the reverse of removal. Tighten the water pump fasteners to the tightening torque specified in Table 1. Adjust drive belts as described in Chapter Three. Fill the freshwater section of closed cooling systems with coolant. See Chapter Three. Start the engine and check for leaks.

FRESHWATER COOLING SYSTEM MAINTENANCE

Pressure Testing

If the freshwater (closed) cooling system requires frequent topping off, it probably has a leak. Small leaks in a cooling system are not easy to locate; the hot coolant evaporates as fast as it leaks out, preventing the formation of tell-tale rusty or grayish-white stains.

A pressure test of the freshwater section will usually help to pinpoint the source of the leak. The procedure is very similar to that used in pressure testing automotive
cooling systems and requires the same type of pressure tester.

1. Remove the pressure fill cap from the heat exchanger. See Figure 31, typical.

2. Wash the cap with clean water to remove any debris or deposits from its sealing surfaces.

3. Check the gasket, if so equipped, and rubber seal on the cap for cuts, cracks, tears or deterioration. See Figure 32. Replace the cap if the seal is damaged. Make sure the locking tabs on the cap are not damaged or bent.

4. Dip the cap in water and attach it to a cooling system pressure tester, using the adapters supplied with the tester. See Figure 33.

5. Pump the pressure to 13 psi (90 kPa). If the cap fails to hold pressure for 30 seconds without dropping under 11 psi (76 kPa), replace it.

6. Inspect the filler neck seat and sealing surface (Figure 32) for nicks, dents, distortion or contamination. Wipe the sealing surface with a clean cloth to remove any rust or dirt. Make sure the locking cams are not bent or damaged.

7. Check coolant level. It should be within 1 in. (25.4 mm) of the filler neck. Top off if necessary.

8. Connect the cooling system pressure tester to the filler neck and pressurize the system to 15 psi (104 kPa). If pressure does not hold constant for at least two minutes, check all hoses, gaskets, drain plugs, drain valves and other potential leak points for leakage. Listen for a hissing or bubbling sound while the system is under pressure.

9. If no leaks are found, disconnect the seawater outlet hose from the heat exchanger (Figure 34). Repressurize the system to 15 psi (104 kPa) and note the outlet connection on the heat exchanger. If water flows from the connection, air bubbles are visible in the water or a bubbling or hissing noise is heard, there is probably a leak between the fresh and seawater sections within the heat exchanger.
10. If no signs of leakage can be found in Step 8 or Step 9, yet the coolant level continues to require frequent topping off, there is probably an internal leak. This could be caused by a blown head gasket, loose cylinder head, or a cracked or porous head or block.

Cleaning

Flush and clean the freshwater section every other season or periodically as needed. Use any high-quality automotive cooling system cleaning solution to remove scale, rust, mineral deposits or other contamination. Use the cleaning solution according to the manufacturer’s directions.

If extremely dirty or corroded, flush out the remaining deposits with a pressure flushing device. Refer to the cooling system flow diagram (Figure 35) and follow the manufacturer’s instructions regarding the connection of the pressure flushing device and procedure to be followed.

Cleaning the Seawater Section of the Heat Exchanger

Contaminants and minerals collect inside the copper tubes in the seawater section of the heat exchanger during engine operation. Such foreign material reduces the ability of the heat exchanger to operate efficiently and, if not removed periodically, will eventually lead to engine over-
FRESHWATER EXHAUST MANIFOLD/HEAT EXCHANGER

1. Pressure cap
2. Filler neck
3. Gasket
4. Overflow tube
5. Exhaust manifold/heat exchanger
6. Heat exchanger core
7. Cover
8. O-ring
9. Gasket
10. End cap
11. Elbow
12. O-ring
13. Stud
14. Washer
15. Nut
16. Drain valve
17. Plug
18. End cap
19. Fitting
20. Gasket
21. Gasket
22. Cover
23. Drain fitting
24. Drain valve
heating. It is recommended to remove and clean the heat exchanger whenever the coolant is changed. Refer to Figure 36.

1. Drain both sections of the cooling system. Refer to Chapter Four. Loosen the hose clamps and disconnect the seawater inlet and outlet hoses from the end caps (Figure 37).

2. Remove the end cap retaining bolts.

3. Remove the heat exchanger end caps. Remove and discard the gaskets.

4. Remove the heat exchanger (Figure 38).

   **NOTE**

   If the heat exchanger is plugged or contains heavy scale deposits, take it to a marine dealership or automotive radiator repair shop for proper cleaning to avoid potential damage to the unit.

5. Clean all gasket residue from the end caps and heat exchanger sealing surfaces.

6. Insert an appropriate-size wire brush into each passage in the heat exchanger. Work the brush back and forth with a vigorous motion, but work carefully to avoid damage to the soldered joints.

7. Remove the brush, hold the heat exchanger vertically and blow loosened particles out with compressed air.

8. Repeat Step 6 and Step 7 as necessary to remove as much of the accumulated deposits as possible.

9. Reinstall the heat exchanger by reversing the removal procedure. Position the heat exchanger so the index pins (Figure 39) in both ends fit in the holes in the end caps.

10. Fill the freshwater section with coolant. Refer to Chapter Three. Start the engine and check for leaks.

**SEAWATER COOLING SYSTEM MAINTENANCE**

The only maintenance required for the seawater cooling system is periodic flushing. Refer to Chapter Three.
### Table 1 TIGHTENING TORQUES

<table>
<thead>
<tr>
<th>Fastener</th>
<th>N·m</th>
<th>ft.-lb.</th>
<th>in.-lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seawater pump</td>
<td></td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>1GM, 1GM10</td>
<td>9</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>All other models</td>
<td>25</td>
<td>18</td>
<td>–</td>
</tr>
<tr>
<td>Freshwater pump</td>
<td>20-25</td>
<td>–</td>
<td>177-221</td>
</tr>
</tbody>
</table>

### Table 2 RECOMMENDED THERMOSTAT

<table>
<thead>
<tr>
<th>Model</th>
<th>Opening temperature</th>
<th>Full open temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>All engines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seawater system</td>
<td>108° F (42° C)</td>
<td>126° F (52° C)</td>
</tr>
<tr>
<td>Freshwater system</td>
<td>160° F (71° C)</td>
<td>185° F (85° C)</td>
</tr>
</tbody>
</table>
Chapter Nine

Electrical System

All engines covered in this manual are equipped with a 12-volt, negative-ground electrical system. Many electrical problems can be traced to a simple cause such as a blown fuse, a loose or corroded connection, a loose alternator drive belt or a frayed wire. While these are easily corrected problems that may not appear to be important, they can quickly lead to serious difficulty if allowed to go uncorrected.

Complete overhaul of electrical components, such as the alternator or starter motor, may not be practical or economical. In some cases, the necessary bushings, bearings or other worn parts are not available for individual replacement.

If tests indicate a unit with problems other than those discussed in this chapter, replace it with a new or rebuilt marine unit. Make certain, however, that the new or rebuilt part is an exact replacement for the defective one removed. Also be sure to isolate and correct the cause of the failure before installing a replacement. For example, an uncorrected short in an alternator circuit will most likely burn out a new alternator as quickly as it damaged the old one. If in doubt, always consult an expert.

This chapter provides service procedures for the battery, charging system, starting system and switches.

Wiring diagrams are included at the end of this book. Table 1 and Table 2 are located at the end of this chapter.

NOTE
Except where specified, F and D series engines are included when a basic model number is specified. For example, if model 3GM is called out in a procedure, the procedure also applies to 3GMD and 3GME.

BATTERY

Because batteries used in marine applications endure far more rigorous treatment and are often used differently than those used in an automotive charging system, they are constructed differently. However, battery advancements developed for automotive batteries have been applied to marine batteries. This has resulted in new battery designs that provide the boater with more choices. A battery may be selected that better accommodates the electrical requirements for the engine and the boat’s accessories than the typical older, wet-cell battery designs.

If buying a new battery, consult with a marine dealership that sells a full line of marine batteries. To obtain the best advice, provide the engine model and a list of electri-
cal devices that will be powered by the battery and how they will be used.

Automotive batteries should be used only in an emergency situation when a suitable marine battery is not available. If used, the automotive battery should be replaced with a suitable marine battery as soon as possible.

Refer to Table 1 for recommended battery capacity.

Safety Precautions

When working with batteries, use extreme care to avoid spilling or splashing the electrolyte. This solution contains sulfuric acid, which can ruin clothing and cause serious chemical burns. If any electrolyte is spilled or splashed on clothing or skin, immediately neutralize with a solution of baking soda and water, then flush the area with an abundance of clean water.

**WARNING**

Electrolyte splashed into the eyes is extremely dangerous. Always wear safety glasses while working with batteries. If electrolyte is splashed into the eyes, call a physician immediately, force the eyes open and flood with cool, clean water for approximately five minutes.

If electrolyte is spilled or splashed onto any surface, it should be immediately neutralized with baking soda and water solution and then rinsed with clean water. While batteries are being charged, highly explosive hydrogen gas forms in each cell. Some of this gas escapes through filler cap openings and may form an explosive atmosphere in and around the battery. This condition can exist for several hours. Sparks, an open flame or a lighted cigarette can ignite this gas, causing an internal battery explosion and possible serious personal injury.

Take the following precautions to prevent injury.

1. Do not smoke or permit any open flame near any battery being charged or that has been recently charged.
2. Do not disconnect live circuits at battery terminals, since a spark usually occurs when a live circuit is broken.
3. Take care when connecting or disconnecting any battery charger. Make sure its power switch is off before
making or breaking any connection. Poor connections are a common cause of electrical arcs that cause explosions.

**Care and Inspection**

The following battery maintenance information applies to unsealed, wet-cell batteries. Although some of the procedures also apply to other types of batteries, consult the battery manufacturer for specific recommendations.

1. Disconnect both battery cables (negative first, then positive) and remove the battery hold-down or retainer clamp. See **Figure 1** for a typical open installation and **Figure 2** for a typical enclosed installation.

**NOTE**

*Some batteries have a carry strap built in for use in Step 2. See Figure 3.*

2. Attach a battery carrier or carrier strap to the terminal posts and lift the battery from the battery tray. Remove the battery from the engine compartment.

3. Check the entire battery case for cracks or other damage.

4. If the battery has removable vent caps, cover the vent holes in each cap with small pieces of masking tape.

**NOTE**

*Keep cleaning solution out of the battery cells in Step 5, or the electrolyte will be seriously weakened.*

5. Scrub the top of the battery with a stiff bristle brush, using a baking soda and water solution (**Figure 4**). Rinse the battery case with clear water and wipe it dry with a clean cloth or paper towels. Remove the masking tape from the filler cap vent holes, if so equipped.

6. Inspect the battery tray or container in the engine compartment for corrosion. Remove and clean it, if necessary, with the baking soda and water solution. Rinse it with clear water and wipe it dry, then reinstall.

7. Clean the battery cable clamps with a stiff wire brush or one of the many tools made for this purpose (**Figure 5**). The same tool is used for cleaning the battery posts (**Figure 6**).

8. Reposition the battery on the battery tray or container and remove the carrier or strap. Install and tighten the hold-down device.

9. Reinstall the positive battery cable, then the negative battery cable.

**CAUTION**

*Be sure the battery cables are connected to their proper terminals. Reversing the polarity can damage the alternator.*
10. Tighten the battery cable connections to 9 ft.-lb. (12 N•m). Overtightening the connections can cause damage to the battery case. Coat the connections with petroleum jelly, or a light mineral grease. Aerosol anti-corrosion sprays can also be used.

_NOTE_
_Do not overfill the battery cells in Step 11. The electrolyte expands due to heat from charging and may overflow if the level is more than 1/4 in. (6 mm) above the battery plates._

11. Remove the filler caps and check the electrolyte level. The electrolyte should cover the battery plates by at least 3/16 in. (4.8 mm). See Figure 7. Top off with distilled water to the bottom of the fill ring in each cell, if necessary.

**Battery Testing**

Hydrometer testing is the best way to check battery condition. Use a hydrometer with numbered graduations from 1.100-1.300 rather than one with color-coded bands. To use the hydrometer, squeeze the rubber ball, insert the tip in a cell and release the ball (Figure 8).

_NOTE_
_Do not attempt to test a battery with a hydrometer immediately after adding water to the cells. Run the engine or charge the battery for 15-20 minutes prior to testing._

Draw enough electrolyte to float the weighted float inside the hydrometer. When using a temperature-compensated hydrometer, release the electrolyte and repeat this process several times to make sure the thermometer has adjusted to the electrolyte temperature before taking the reading.

Hold the hydrometer vertically and note the number aligned with the surface of the electrolyte (Figure 9). This is the specific gravity for the cell. Return the electrolyte to the cell from which it came.

The specific gravity of the electrolyte in each battery cell is an excellent indicator of that cell’s condition. A fully charged cell will read 1.260 or more at 80°F (27°C). If the cells test below 1.220, the battery must be recharged. Charging is also necessary if the specific gravity varies more than 50 points from cell to cell.

_NOTE_
_If a temperature-compensated hydrometer is not used, add 0.004 to the specific gravity reading for every 10°F above 80°F (27°C)._
warm up to room temperature before charging. The battery does not have to be removed from the boat before charging, but it is a recommended procedure since a charging battery gives off highly explosive hydrogen gas. In many boats, the area around the battery is not well ventilated and the gas may remain in the area for several hours after the charging procedure has been completed. Sparks or flames occurring near the battery can cause it to explode, spraying battery acid over a wide area.

Disconnect the negative battery cable first, then the positive battery cable. Make sure the electrolyte is full. Remove the vent caps and place a folded paper towel over the vent openings to absorb any electrolyte that may splatter as the battery charges.

Connect the charger to the battery; negative to negative, positive to positive. If the charger output is variable, select a 10-12 amp setting. Set the voltage selector to 12 volts and plug the charger in. Once the battery starts to accept a charge, reduce the charge rate to a level that will prevent excessive gassing.

The length of time required to recharge a battery depends upon its rating, state of charge and temperature. Generally speaking, the current input time should equal the battery amp-hour rating. For example, a 45 AH battery will require a 9-amp charging rate for five hours (9 × 5 = 45) or a 15-amp charging rate for three hours (15 × 3 = 45). Check charging progress with the hydrometer.

### Jump Starting

If the battery becomes discharged, it is possible to start and run the engine by jump starting it from another battery.

Before jump starting a battery when temperatures are 32° F (0° C) or lower, check the condition of the electrolyte. If it is not visible or if it appears to be frozen, do not attempt to jump start the battery, as the battery may explode or rupture.

**WARNING**

*Use extreme caution when connecting a booster battery to one that is discharged to avoid personal injury or damage to the system.*

1. Connect the jumper cables in the order and sequence shown in Figure 11.

**WARNING**

*An electrical arc may occur when the final connection is made. This could cause an explosion if it occurs near the battery. For this reason, the final connection should be made.*
to the alternator mounting bracket or another good engine ground and not the battery itself.

2. Check that all jumper cables are out of the way of moving parts on both engines.
3. Start the engine with the good battery and run at a moderate speed.
4. Start the engine with the discharged battery. Once it starts, run it at a moderate speed.

CAUTION
Racing the engine may damage the electrical system.

5. Remove the jumper cables in the exact reverse order shown in Figure 11. Begin at point 4, then disconnect at points 3, 2 and 1.

Battery Cables

Poor terminal connections will cause excessive resistance. Defective cable insulation can cause partial short circuits. Both conditions may result in an abnormal voltage drop in the starter motor cable. When this happens, the resulting hard-start condition will place further strain on the battery. Check cable condition and terminal connections periodically.

ELECTRICAL PROTECTION

Some electrical systems are equipped with a battery cutoff switch connected between the positive terminal of the battery and the starter solenoid. The switch provides a means to cut off all circuits from the battery in case of fire.
or other electrical emergencies. Using the cutoff switch also prevents any electrical drain on the battery.

All engines are equipped with a 30-amp fuse installed in the wiring harness between the ignition switch and starter motor. If a failure occurs in any part of the electrical system, always check the fuse first to see if it is blown. Usually, the trouble is a short circuit in the wiring. This may be caused by worn insulation or by a wire that has worked its way loose and shorted to ground.

Treat a blown fuse as more than a minor annoyance; it serves as a warning that something is wrong in the electrical system. Before replacing a fuse, determine what caused it to blow and correct the problem. Always carry several spare fuses of the proper amperage values onboard. Never replace a fuse with one of higher amperage rating than that specified for use. Failure to follow these basic rules could result in heat or fire damage to major parts or even the loss of the entire vessel.

**CHARGING SYSTEM**

The charging system consists of the battery, alternator, voltage regulator, ignition switch, charge lamp and connecting wiring. All engines are equipped with a Hitachi alternator. Refer to Figure 12 for a typical charging system.

**Preliminary Testing**

The first indication of charging system trouble is usually a slow engine cranking speed or running lights that dim as engine speed decreases. This will often occur long before the ammeter or voltmeter indicates that there is a
potential problem. When charging system trouble is first suspected, perform the following:
1. Check the alternator drive belt for correct tension (Chapter Three).
2. Check the battery to make sure it is in satisfactory condition and fully charged and that all connections are clean and secure.
3. Check all connections at the alternator to make sure they are clean and secure.
4. If the charging system is not performing as it should after each of the above points has been carefully checked and any unsatisfactory conditions corrected, refer to Chapter Two and perform the Charging System Tests.

Alternator Removal/Installation

This section provides alternator replacement procedures. Complete alternator overhaul is not practical for the home mechanic. In some cases, replacement parts are unavailable.

This procedure is generalized to cover all applications. Access to the alternator is quite limited in some engine compartments and care should be taken to avoid personal injury.

1. Disconnect the negative battery cable.
2. Disconnect all wiring harnesses and leads at the rear of the alternator. See Figure 13, typical.

**NOTE**

*When loosening the retaining nut on an alternator terminal, hold the terminal with a wrench to prevent the terminal from rotating.*

3. Loosen the alternator adjusting and pivot bolts (Figure 14, typical).

4. Swivel the alternator toward the engine and remove the drive belt from the alternator pulley.
5. Support the alternator with one hand and remove the adjusting and pivot bolts, noting the position of any washers or spacers used. Remove the alternator.
6. Installation is the reverse of removal. Tighten fasteners securely and adjust drive belt tension (Chapter Three) before reconnecting wiring harnesses and leads to the rear of the alternator.

**NOTE**

*Make sure the rubber boots at the end of the wires fit snugly over the terminals on the alternator; otherwise, the wire ends and terminals may corrode.*

STARTING SYSTEM

The starting system consists of the battery, starter motor, starter solenoid, starter switch, key switch, fuse and connecting wiring. See Figure 12, typical.

Yanmar marine engines are equipped with a Hitachi starter motor. The starter solenoid is enclosed in the drive housing to protect it from exposure to dirt and adverse weather conditions.

Starter service requires experience and special tools. Refer to Chapter Two for troubleshooting procedures. The procedures described below consist of removal, installation and brush replacement. Any repairs inside the unit itself (other than brush replacement) should be performed by a dealer or certified electrical shop. Installation of a professionally rebuilt marine-type unit is generally less expensive and more practical.

Starter Removal/Installation

1. Disconnect the negative battery cable.
2. Disconnect the solenoid terminal wires. See Figure 15.
3. Remove the starter motor mounting bolts. Pull the starter motor away from the flywheel and remove it from the engine.
4. Installation is the reverse of removal. Tighten mounting bolts to torque specified in Table 2.

**Solenoid Removal/Installation**

To remove the solenoid it is necessary to partially disassemble the starter. Note that the starter used on series 1GM, 1GM10, 2GM, 2GM20, 3GM and 3GM30 engines are equipped with an antitorque spring that stabilizes the actuating yoke.

1. Remove the starter as previously described.
2. Disconnect the solenoid terminal wires (Figure 15).
3. Remove the screws securing the solenoid to the starter. The solenoid will be loose but still attached to the actuating yoke in the starter. It is necessary to partially disassemble the starter to remove the solenoid and yoke.
4. Remove the two throughbolts (29, Figure 16 or 33, Figure 17).

**NOTE**

*Do not allow the armature to move forward because the commutator may slide out of the brushes, which will require disassembly of the rear of the starter to reinstall the brushes.*

5. Carefully separate the drive end cover (3, Figure 16) from the frame (15 or 22) so the armature shaft withdraws from the drive end housing, but stays in position in the frame.

6. Remove the solenoid with the actuating yoke (6, Figure 16 or 7, Figure 17) and spring, if so equipped.
7. Remove the yoke and spring, if so equipped, from the solenoid.
8A. To install the solenoid on models equipped with an antitorque spring, reverse the disassembly procedure while noting the following:
   a. Position the antitorque spring on the solenoid plunger so the spring ends fit in the holes in the solenoid (Figure 18).
   b. Position the yoke in the solenoid plunger so the notch on the yoke fits against the closed end of the anti-torque spring as shown in Figure 18.
   c. Make sure the open end of the yoke properly engages the ears on the overrunning clutch body (Figure 19).
8B. To install the solenoid on models not equipped with an antitorque spring, reverse the disassembly procedure while noting the following:
   a. Make sure that the pads on the open end of the yoke properly fit between the flanges on the overrunning clutch body.

**Brush Replacement**

1GM, 1GM10, 2GM, 2GM20, 3GM and 3GM30 models

Brush replacement requires partial disassembly of the starter.
1. Disconnect the positive lead from the solenoid.
2. Remove the cover (26, Figure 16) on the end cap.
3. Detach the E-ring (25, Figure 16) and remove the washers from the armature shaft.
4. Remove the brush holder retaining screws (30, Figure 16).
5. Remove the two throughbolts (29, Figure 16).
6. Remove the two throughbolts (29, Figure 16).
7. Separate the end cover (21, Figure 16) from the starter.
8. Note the position of the brushes in the brush holder. Use a suitable tool to pull back and hold the brush retaining clip, then remove the brush. See Figure 20, typical. Repeat this step to remove the remaining brushes.
9. Remove the brush holder from the armature shaft.
10. Use an ohmmeter or self-powered test lamp to check for continuity between the insulated brush holder and the base of the brush holder assembly. See Figure 21. If there is continuity, replace the brush holder.
11. Inspect brush and brush spring condition. Measure brush length. Replace all brushes if any are oil-soaked or worn to 12 mm (0.47 in.) or less in length. Replace any broken or distorted brush springs.
STARTER MOTOR
(EXCEPT 3HM AND 3HM35 MODELS)

1. Bolt
2. Lockwasher
3. Drive end housing
4. Bushing
5. Dust cover
6. Yoke
7. Spring
8. Shims
9. Solenoid
10. Retaining ring
11. Retainer
12. Drive
13. Center plate
14. Armature
15. Frame assembly
16. Positive lead
17. Brush (pos.)
18. Brush (neg.)
19. Brush spring
20. Brush plate
21. Commutator end cover
22. Bushing
23. Washer
24. Washer
25. E-clip
26. Cover
27. Lockwasher
28. Screw
29. Throughbolt
30. Screw
31. Lockwasher
STARTER MOTOR
(3HM AND 3HM35 MODELS)

1. Bolt
2. Lockwasher
3. Drive end housing
4. Bushing
5. Clip
6. Dust cover
7. Yoke
8. Actuator
9. Washers
10. Shims
11. Solenoid
12. Pin
13. Stopper washer
14. Criclip
15. Retainer
16. Drive
17. Bushing
18. Center plate
19. Armature
20. Washer
21. Washer
22. Frame assembly
23. Positive lead
24. Positive brush
25. Brush plate
26. Negative brush
27. Brush spring
28. Bushing
29. Commutator end cap
30. Lockwasher
31. Screw
32. Lockwasher
33. Throughbolt
11. To replace ground (negative) brushes, remove the brush lead attaching screws from the starter frame. Remove the brushes and install new ones.
12. To replace field coil brushes, cut the insulated brush leads as close as possible to the field coils. Attach new brush leads and solder the connections together with rosin core solder and a 300-watt soldering iron.

NOTE
Always replace brushes in complete sets.

13. Install the brush end holder.
14. Pull back and hold the brush retaining clip with a wire hook, then install the brush. Repeat this step to install the remaining brushes. Make sure the brush springs rest in the small cutout on top of each brush.
15. Reassembly is the reverse of Steps 1-6.

3HM and 3HM35 models

Brush replacement requires partial disassembly of the starter.
1. Disconnect the positive lead (23) from the solenoid.
2. Remove the brush holder retaining screws (31, Figure 17).
3. Remove the two throughbolts (33, Figure 17).
4. Separate the end cap (29) from the starter.
5. Note the position of the brushes in the brush holder. Use a suitable tool to pull back and hold the brush retaining clip, then remove the brush. See Figure 20, typical. Repeat this step to remove the remaining brushes.
6. Remove the brush holder from the armature shaft.
7. Use an ohmmeter or self-powered test lamp to check for continuity between the insulated brush holder and the base of the brush holder assembly. See Figure 21. If there is continuity, replace the brush holder.

8. Inspect brush and brush spring condition. Measure brush length. Replace all brushes if any are oil-soaked or worn to 14 mm (0.55 in.) or less in length. Replace any broken or distorted brush springs.
9. To replace ground (negative) brushes, remove the brush lead attaching screws from the starter frame. Remove the brushes and install new ones.
10. To replace field coil (positive) brushes, cut the insulated brush leads as close as possible to the field coils. Attach new brush leads and solder the connections together with rosin core solder and a 300-watt soldering iron.

NOTE
Always replace brushes in complete sets.

11. Install the brush end holder.
12. Pull back and hold the brush retaining clip with a wire hook, then install the brush. Repeat this step to install the remaining brushes. Make sure the brush springs rest in the small cutout on top of each brush.
13. Reassembly is the reverse of Steps 1-4.
SWITCHES

The instrument panel is equipped with two switches: a key switch and a start switch. A lighting switch is also used on instrument panels equipped with a tachometer. Most engines are also equipped with a battery cutoff switch. Refer to the following sections to check the operation of these switches. Also refer to the wiring diagrams at the back of this manual.

Key Switch

The key switch is mounted on the instrument panel. When the key is in the ON position, the switch directs current to the circuits it controls.

Perform voltage or resistance checks to determine if the switch is operating properly.

Start Switch

The start switch mounted on the instrument panel is a push-button switch that closes the starter motor circuit when the button is depressed.

Perform voltage or resistance checks to determine if the switch is operating properly.

Battery Cutoff Switch

The battery cutoff switch is connected between the positive terminal of the battery and the starter solenoid. The switch provides a means to cut off all circuits from the battery in case of fire or other electrical emergencies. Using the cutoff switch also prevents any electrical drain on the battery.

To test the switch, check for voltage at the starter solenoid terminal, or disconnect the positive battery cable and check the switch using an ohmmeter.

SENDERS

The engine is equipped with senders that trigger warning lights and the alarm buzzer if engine oil pressure or water temperature reaches a dangerous level. The senders are essentially switches that complete an electrical circuit.

Oil Pressure Sender

Refer to the oil pressure circuit in Figure 22. The sender is closed at zero oil pressure, which allows current to light the warning lamp and sound the alarm buzzer when the key switch is on. When oil pressure rises above 9.8-29.4 kPa (1.4-4.3 psi), the sender opens, the warning lamp goes out and the alarm buzzer quits.

The oil pressure sender on 1GM and 1GM10 is located on the oil filter adapter as shown in Figure 23. The oil
pressure sender on 2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 engines is located below the oil filter as shown in Figure 24.

To check the oil pressure sender, proceed as follows:

**CAUTION**

*Before checking the oil pressure sender, make sure the engine is filled with oil.

1. Disconnect the wire at the sender terminal.
2. Connect an ohmmeter between the sender terminal and the hex on the base of the sender.
3. With the engine off, the meter should show continuity.
4. Start the engine. As the oil pressure builds above 9.8 kPa (1.4 psi), the meter should switch from continuity to no continuity. If it does not, replace the sender unit.

**Coolant Temperature Sender**

Refer to the coolant temperature circuit in Figure 25. The sender is open at ambient temperature, which prevents current from lighting the warning lamp and activating the alarm buzzer. When coolant rises above the specification, the sender closes, the warning lamp and the alarm buzzer come on.

On 1GM and 1GM10 engines, the coolant temperature sensor is located on the cylinder head (Figure 26). The coolant temperature sensor on two or three cylinder engines is located on the front or side of the thermostat housing (Figure 27, typical).

Two different senders may be used depending on the type of cooling system. Engines equipped with seawater cooling are equipped with a sender that is color-coded white and has a closed temperature of 148-154° F (63-67° C).

C. Engines equipped with freshwater cooling are equipped with a sender that is color-coded green and has a closed temperature of 193-202° F (89-95° C).

To check the coolant sender, proceed as follows:

1. Remove the switch from the engine.
2. Connect a digital ohmmeter to the switch.
3. Immerse the sending unit and a cooking thermometer in a container of oil.
4. Heat the container over a flameless heat source and note the ohmmeter reading. The switch should close as follows:
   a. seawater switch (white)—148-154° F (63-67° C).
   b. freshwater switch (green)—193-202° F (89-95° C).
5. Remove the container from the heat and let it cool. The switch should reopen as follows:
   a. seawater switch (white)—136° F (58° C).
   b. freshwater switch (green)—190° F (88° C).
6. Replace the switch if it does not function as specified at each temperature range.
3. To determine if a bulb is defective, substitute a good bulb. All warning lamps use the same type of bulb.

**Charging System Warning Lamp**

The warning lamp for the charging circuit should illuminate when the key switch is ON and the engine is not running, or when there is a malfunction in the charging circuit.
1. To check the circuit for the charging system warning lamp, detach the lead from the L terminal on the alternator.
2. With the key switch ON, ground the detached lead. The charge system warning lamp should come on.
3. To determine if the charging system bulb is defective, substitute a good bulb. All warning lamps use the same type of bulb.
4. If a good bulb does not light, check the charging system as described in Chapter Two.

**ALARM BUZZER**

The alarm buzzer provides an audible warning in addition to the coolant and oil pressure warning lamps. Two types of alarm buzzers are used: a buzzer with two leads and a buzzer with multiple leads. Note the terminal locations in **Figure 28** for the buzzer equipped with multiple leads.
1. Check the alarm buzzer while it is installed.
   a. Detach the lead from the coolant temperature or oil pressure sender.
   b. With the key switch ON, ground the sender lead. The alarm buzzer should come on.
2. Check the alarm buzzer with all leads disconnected from the buzzer or with the buzzer removed from the instrument panel.
   a. On the buzzer with multiple terminals, note the terminal locations in **Figure 28**.
   b. Connect a 12-volt battery to the terminals as follows: Connect a positive battery lead to positive buzzer terminal. Connect the negative battery lead to each of the remaining buzzer terminals. The buzzer should sound; if it does not, replace the buzzer.

**TACHOMETER**

Some engines may be equipped with a tachometer. A sensor located on the clutch housing (**Figure 29**) provides an electrical signal that drives the tachometer. The electromagnetic sensor counts the teeth on the flywheel ring.
gear as it rotates. The sensor sends the resulting electrical signal to the tachometer, which converts it into indicator needle movement.

**NOTE**
While the sensors for all engines are interchangeable, the tachometers are not. Due to the difference in number of ring gear teeth, the tachometer used on 3HM and 3HM35 engines is not interchangeable with other engines.

Before troubleshooting the tachometer, check for faulty connections, then recheck tachometer operation. If the problem remains, refer to the following sections.

**Tachometer Sender**
To check the tachometer sender, proceed as follows:
1. Disconnect the leads from the sender (Figure 29).
2. With the engine stopped, use an ohmmeter to check the resistance between the sender terminals. Resistance should be 1500-1700 ohms.
3. Run the engine. Measure the alternating current voltage between the sender terminals. The voltage reading should be at least one volt.
4. If the sender fails either test, replace the sender.

**Tachometer Gauge**
To check the tachometer gauge unit, proceed as follows:
1. Disconnect the red/black and black wire leads from the tachometer. With the key switch ON, measure the voltage between the two wires. There should be 10-16 volts (battery voltage). If not, determine the cause.
2. Disconnect the orange and blue/red wire leads from the tachometer. Run the engine. Measure the alternating current voltage between the orange and blue/red wire leads. The voltage reading should be at least one volt.
3. If the voltage reading in Step 2 is less than one volt, check the wires and connections and check the sender as described in the preceding section.
4. If the voltage readings in Steps 1 and 2 are satisfactory, replace the tachometer.

<table>
<thead>
<tr>
<th>Model</th>
<th>Voltage</th>
<th>Battery capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GM, 1GM10</td>
<td>12 V</td>
<td>70 amp-hours</td>
</tr>
<tr>
<td>2GM, 2GM20</td>
<td>12 V</td>
<td>70 amp-hours</td>
</tr>
<tr>
<td>3GM, 3GM30, 3HM</td>
<td>12 V</td>
<td>70 amp-hours</td>
</tr>
<tr>
<td>3HM35</td>
<td>12 V</td>
<td>100 amp-hours</td>
</tr>
</tbody>
</table>

**Table 1 BATTERY CAPACITY (MINIMUM)**

**Table 2 ALTERNATOR AND STARTER MOTOR TIGHTENING TORQUES**

<table>
<thead>
<tr>
<th>Model</th>
<th>Alternator mounting bolt</th>
<th>Starter motor mounting bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GM, 1GM10, 2GM, 2GM20, 3GM, 3GM30</td>
<td>22-27 N(\text{m}) (16-20 ft.-lb.)</td>
<td>45-50 N(\text{m}) (33-37 ft.-lb.)</td>
</tr>
<tr>
<td>3HM, 3HM35</td>
<td>22-27 N(\text{m}) (16-20 ft.-lb.)</td>
<td>75-80 N(\text{m}) (55-59 ft.-lb.)</td>
</tr>
</tbody>
</table>
Chapter Ten

Transmission—KM Series

This chapter covers the Kanzaki KM2A, KM2C, KM2P, KM3A, and KM3P marine transmissions that are attached to Yanmar 1GM, 1GM10, 2GM, 2GM20, 3GM20D and 3GM30 engines. Refer to Table 1 for a cross-reference of engine and transmission models. The identification plate located on the transmission case (Figure 1, typical) specifies the transmission model.

The KM2 and KM3 series transmissions are inline transmissions that provide forward and reverse direction. All gears are constant mesh. A cone-type clutch engages internally tapered gears to transmit power to the output shaft. Oil contained in the transmission case lubricates the internal transmission components.

Basic design is the same for all the transmissions with the exception of the shifting mechanism. Transmissions with a P suffix are equipped with a shifting device that engages detent notches in the shifter housing. All other models use spring-loaded pins and a spring-loaded actuator that engage detents and ramps on the shift shaft.

Refer to Chapter Three for maintenance information.
Tables 1-7 are located at the end of this chapter.

OPERATION

The input shaft on the transmission engages the drive disc attached to the engine flywheel. Because this is a constant-mesh transmission, engine power is transmitted to all gears. Power flows to the output shaft when the cone clutch engages either the forward gear or the reverse gear. In Figure 2, the cone clutch is shown engaged with the forward gear. Because power flows from the input shaft gear through the reverse idler gear to the reverse gear, the reverse gear rotates in the opposite direction of the forward gear. When the cone clutch engages the reverse gear, the output shaft rotates in reverse.

On Model KM2A, KM2C, and KM3A transmissions, moving the shift lever (Figure 3) rotates the shift shaft. When the shift shaft rotates, the shifter slides the cone clutch into engagement with the forward or reverse gear, or into neutral. When the shifter reaches the proper position, the upper spring-loaded detent pin sits on a ramp that
CONE CLUTCH

Input shaft
Forward gear
Drive cone
Reverse idler gear
Reverse gear
Coupling flange

SHIFTER (KM2A, KM2C AND KM3A MODELS)

1. Connector
2. Circlip
3. Spring retainer
4. Spring
5. Circlip
6. Holder
7. Cotter pin
8. Washer
9. Stud
10. Shift lever
11. Bolt
12. Seal
13. Setscrew
14. Spring
15. Detent pin
16. Body
17. Gasket
18. Plug
19. O-ring
20. Bearing
21. Shift shaft
22. Shifter
forces the shifter to push the clutch cone into the gear. The springs in the shift actuator hold the shifter in position.

The shifter mechanism on Model KM2P and KM3P transmissions includes a spring-loaded shifter (Figure 4). Movement of the shift lever forces the shifter to move the cone clutch against the forward or reverse gear. Detent notches in the shift housing hold the shifter pin in position.

REMOVAL/INSTALLATION

The following procedure addresses units that are accessible. In some cases, it may be necessary to remove the engine and transmission as a unit before removing the transmission from the engine. If engine removal is necessary, refer to Chapter Five for single-cylinder models and Chapter Six for multi-models.

1. If not previously disconnected, disconnect the remote control cable from the transmission shift lever.
2. If not previously disconnected, disconnect the drive coupling from the transmission drive flange.
3. Remove the bolts that secure the transmission to the engine bellhousing.
4. Remove the transmission from the engine.
5. Reinstall the transmission by reversing the removal procedure. Make sure to align the splines on the transmission input shaft and the drive disc during installation. Tighten the transmission retaining bolts to the torque specified in Table 2.
OVERHAUL

Disassembly

1. Remove the drain plug (A, Figure 5) and drain the transmission oil.
2. The output flange retaining nut is staked (Figure 6). Use a chisel to cut away the staked portion so the nut will rotate.

   NOTE
   The output flange retaining nut has left-hand threads.

3. Use a tool or other device to hold the output flange so it cannot rotate.
4. Unscrew the output flange retaining nut by rotating the nut clockwise (left-hand threads).
5. Remove the oil dipstick (Figure 7).
6. Remove the shifter retaining bolts (B, Figure 5) and remove the shifter assembly.
7. Remove the transmission flange retaining bolts.

NOTE
In Step 8, position the transmission so the transmission input shaft is up when removing the transmission flange so the transmission shafts will not fall out.

8. Tap on the transmission flange (A, Figure 8) using a soft-faced hammer to dislodge the flange. If tapping will not dislodge the flange, install jackscrews (B) into the
b. Carefully drive out the intermediate shaft while removing the intermediate and input shaft assemblies from the transmission case.

11. Using a large screwdriver, pry out the oil seal in the transmission case. Be careful not to damage the case or the adjacent bearing race.

12. Using a large screwdriver, pry out the oil seal in the transmission mounting flange. Be careful not to damage the case or the adjacent bearing race.

13. If inspection indicates additional disassembly is necessary, refer to the following sections.

**Inspection**

**Input shaft**

1. Check the gear teeth for excessive wear, corrosion and mechanical damage. Check the teeth for galling, chips, cracks, missing pieces, distortion or discoloration from overheating. Replace the input shaft if the gears are damaged.

2. Inspect the input shaft bearings (Figure 11) and seal surfaces for excessive wear, grooves, metal transfer and discoloration from overheating. Use a press to remove damaged bearings and to install new bearings.

**NOTE**

*Shims behind the outer bearing race in the mounting flange determine bearing preload for the input shaft bearings. Save the shims and reinstall them if reusing the original parts.*

3. Inspect the input shaft bearing outer races in the transmission case (A, Figure 12) and mounting flange (A, Figure 13). If either race is damaged or excessively worn, remove it using a suitable puller.
Intermediate shaft

1. Remove and discard the O-ring (Figure 14) at the end of the shaft.
2. Remove the thrust washer, gear and roller bearings.
3. Inspect the bearings, shaft and reverse idler gear inside diameter for excessive wear, grooves, metal transfer and discoloration from overheating. If necessary, replace the shaft, gear and bearings.
4. Check the idler gear teeth for excessive wear, corrosion or rust and mechanical damage. Check the teeth for galling, chips, cracks, missing pieces, distortion or discoloration from overheating. If necessary, replace the gear.
5. Reassemble the intermediate shaft. Install a new O-ring on the shaft.

Output shaft

Refer to Figure 15.

1. Using a suitable puller (Figure 16), remove the bearing, spacer and reverse gear from the output shaft.
2. The retaining nut at the end of the shaft is staked. Use a chisel to cut away the staked portion so the nut will rotate. To hold the output shaft, position the coupling flange in a vise, then set the output shaft into the splines in the flange as shown in Figure 17.

NOTE
The retaining nut has left-hand threads.

3. Unscrew the retaining nut by rotating the nut clockwise (left-hand threads).
4. Using a suitable puller, pull the bearing, spacer and forward gear off the output shaft.
5. Remove the pin from the shaft.

NOTE
Mark the clutch cone in Step 6 according to forward or reverse end so it can be reinstalled in its original position.

6. While holding the clutch cone, tap the end of the shaft with a soft-faced hammer to remove the inner roller bearing race, spacer and cone clutch. A suitable puller or press may also be used. Remove the remaining inner bearing race and spacer.
7. Check the forward and reverse gear teeth for excessive wear, corrosion and mechanical damage. Check the teeth for galling, chips, cracks, missing pieces, distortion or discoloration from overheating. If necessary, replace the gears.

8. Inspect the forward and reverse gear inside diameters for excessive wear, grooves, metal transfer and discoloration from overheating. If necessary, replace the gears.
9. Install the cone clutch on the output shaft and check movement of the clutch on the output shaft. If the clutch does not move smoothly, inspect the splines on the clutch and shaft for burrs, scoring, galling or other signs of damage. If dressing will not correct the damaged splines, replace the clutch and/or shaft.
10. Inspect the tapered surface of the forward and reverse gears for galling, scoring or other damage that will prevent smooth cone clutch engagement. If necessary, replace the gears.
11. Install the cone clutch into the forward and reverse gears. Measure clutch depth as shown in Figure 18. Compare the measurement with the specification in Table 3. Replace the part, in necessary.
12. Measure the width of the shifter groove in the cone clutch (Figure 19) and compare with the specification in Table 4.
13. Inspect the roller bearings and inner bearing races for excessive wear, grooves, metal transfer and discoloration from overheating. If necessary, replace the bearings and inner races.
14. Measure the wear surface of the thrust washers. If wear exceeds 0.20 mm (0.008 in.) on the thin thrust washer, replace the washer. If wear exceeds 0.05 mm (0.002 in.) on the thick thrust washer, replace the washer.
15. On KM2P and KM3P transmissions—Measure the width of the spring cups and compare them with the specifications in Table 5.
16. On KM2P and KM3P transmissions—Measure the width of the spring cup retainers and compare them with the specifications in Table 5. If any surface wear on the retainer exceeds 0.10 mm (0.004 in.), replace the retainer.
17. Assemble the output shaft by reversing the disassembly procedure while noting the following:
OUTPUT SHAFT

1. Shims
2. Nut (LH)
3. Washer
4. Roller bearing
5. Thrust washer
6. Retainer (KM2P and KM3P)
7. Spring cup (KM2P and KM3P)
8. Forward gear
9. Needle bearing
10. Inner bearing race
11. Thrust washer
12. Pin
13. Output shaft
14. Clutch cone
15. Reverse gear
h. Tighten the nut (left-hand threads) to the torque specified in Table 2.
i. Make sure the gears rotate freely.
j. Stake the nut to lock the nut in place.

**Shifter (KM2A, KM2C and KM3A models)**

Refer to Figure 20.

1. If not previously removed, detach the cotter pin and remove the actuator from the shift lever.
2. Remove the shifter.

**NOTE**

*Make alignment marks on the shift lever and shift shaft so the shift lever can be reinstalled in its original position.*

3. Loosen the clamp bolt and remove the shift lever.

**NOTE**

*The setscrew and plug contain the springs and may fly out.*

4. Remove the setscrew and plug, then remove the springs and detent pins.
5. Remove the shifter shaft.
6. Remove and discard the O-ring.
7. Use a screwdriver or suitable tool to pry out the seal. Be careful not to damage the bearing.
8. Inspect the bearing. If it is faulty, replace it as follows:
   a. Heat the shifter body to 212° F (100° C), then drive out the bearing.
   b. Install the new bearing with the stamped end out. Push in the bearing until it bottoms.
9. Inspect the shift shaft. Check the detent portion of the shaft for cracks or excessive wear that will allow poor clutch engagement. The ramps should be smooth and the neutral detent hole should be unworn (Figure 21).
10. Inspect the detent pins. Replace the pins if they are damaged or excessively worn.
11. Inspect the springs for deformation or other damage. Specified spring free length is 34 mm (1.34 in.).
12. Inspect the shifter for damage and excessive wear. Measure the shifter width and shaft diameter. Replace the shifter if the measurements exceed the specifications in Table 6.
13. Check the internal movement of the actuator. The actuator should slide without binding. To check spring tension, attach a spring scale to the threaded end of the actuator and measure the spring tension when the actuator rod is pulled 5 mm (0.20 in.) from the end of the tube (Figure 22). If the spring tension is not as specified in Table 6, replace the spring.

---

**Figure 21**

If reinstalling the original clutch cone, install it in its original position—forward end toward the forward gear.

b. Install the pin before installing the inner roller bearing race.

c. Use a suitable tool or sleeve to drive the inner roller bearing race onto the shaft. Do not use excessive force. Drive the race onto the shaft until it bottoms.

d. Use a suitable tool or sleeve to drive the tapered roller bearing onto the shaft. Do not use excessive force. Drive the bearing onto the shaft until it bottoms.

e. On KM2P and KM3P transmissions—Install the spring cups so the cupped side is toward the gear.

f. Install each thick thrust washer so the stepped side is toward the tapered roller bearing.

g. Install the washer so the pin in the output shaft fits in the groove in the washer.
14. Reassemble the shifter by reversing the disassembly procedure. Note the following during reassembly:
   a. Apply sealant to the detent setscrew threads.
   b. Install the shift lever on the shift shaft while aligning the marks made during disassembly.
   c. If no alignment marks are available when installing the shift lever, rotate the shift shaft so the shifter bore is down as shown in Figure 23. The shift shaft should engage the neutral detent. Install the shift lever at a 45° angle as shown in Figure 23.
   d. Install the shift lever on the shift shaft so the side clearance between the lever and body is approximately 0.5 mm (0.020 in.).

**Shifter (KM2P and KM3P models)**

Refer to Figure 24.
1. If not previously removed, remove the control cable connector from the shift lever.
2. Remove the shifter and spring.
3. Remove the stop bolt and shims.
4. Loosen the clamp bolt and remove the shift lever.
5. Remove the shifter shaft.
6. Remove and discard the O-ring.
7. Use a screwdriver or suitable tool to pry out the seal. Be careful not to damage the bearing.
8. Inspect the shift shaft. Check the detent pin for damage and excessive wear. If necessary, replace the detent pin. Measure the shifter shaft bore in the shift shaft and compare with the specifications in Table 7.
9. Inspect the body for galling, scoring or other damage to the bore. Inspect the detents for damage and excessive wear that will cause poor clutch engagement (Figure 25).
10. Inspect the spring for deformation or other damage. Specified spring free length is 22.6 mm (0.89 in.). Minimum spring length is 19.8 mm (0.78 in.).
11. Inspect the stop bolt. Replace it if it is excessively worn.
12. Inspect the shifter. Measure the large diameter of the shifter shaft and compare it with the specifications in Table 7.
13. Reassemble the shifter by reversing the disassembly procedure, but do not install the stop bolt until final installation of the shifter assembly on the transmission.
14. Reassemble the shifter by reversing the disassembly procedure. Note the following during reassembly:
   a. Do not install the stop bolt until final installation of the shifter assembly on the transmission.
   b. Rotate the shift shaft so the detent pin engages the neutral detent (Figure 25). On the KM2P transmission, install the shift lever so the side with the triangle mark (A, Figure 26) is out. On the KM3P transmission, install the shift lever so the side with the triangle mark is toward the shifter body. With the shift shaft in neutral, position the shift lever at a 45° angle as shown in Figure 26 and tighten the clamp bolt.

**REASSEMBLY**

**NOTE**

On KM2P and KM3P transmissions, refer to the *Bearing Adjustment* section prior to reassembly if the following components have been replaced: input shaft, input shaft bearings, output shaft, thrust washers and output shaft bearings.

1. If removed, install the outer bearing races into the transmission case and mounting flange.
2. Apply sealer to the outside diameter of the oil seals and install them into the transmission case and mounting flange with the open side to the inside.
3. Install the input shaft into the transmission case.
4. Install the intermediate shaft assembly into the transmission case. Install a new O-ring on the intermediate shaft. Use a soft-faced hammer to tap the shaft into the case.
5. While holding the input shaft out of the way, insert the output shaft assembly into the transmission case. Move the gears into mesh on the intermediate shaft, input shaft and output shaft while installing the output shaft.
6. If the following components have been replaced, refer to the *Bearing Adjustment* section: input shaft, input shaft bearings, output shaft, thrust washers and output shaft bearings.
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**SHIFTER (KM2P AND KM3P MODELS)**

1. Shoulder bolt
2. Connector
3. Shift lever
4. Washer
5. Nut
6. Stop bolt
7. Shims
8. Bolt
9. Seal
10. Bolt
11. Shift body
12. O-ring
13. Shift shaft
14. Detent pin
15. Pin
16. Spring
17. Shifter

25  

**SHIFTER DETENTS (KM2P AND KM3P MODELS)**

- Reverse
- Neutral
- Forward

26  

![Diagram showing the direction of movement: Reverse (A) and Forward (B) with an angle of 45 degrees.](image-url)
bearings. After adjusting the bearings, continue to reassemble the transmission as described in the following steps. If the preceding components have not been replaced, bearing adjustment is not necessary and the original shims may be reused. Proceed to the following step.

7. Position the transmission on a vise with soft jaws so the input shaft is held by the vise jaws.
8. Apply sealer to the mounting flange and install it onto the transmission case.
9. Tighten the mounting flange retaining bolts to the torque in Table 2.
10. Install the output flange on the output shaft.
11. Install the O-ring on the output shaft.

**NOTE**
The output flange retaining nut has left-hand threads.

12. Install the output flange retaining nut by rotating the nut counterclockwise (left-hand threads). Tighten the nut to the torque specified in Table 2.
13. Stake the nut to lock the nut in place.
14A. On KM2A, KM2C and KM3A transmissions—Install the shifter assembly on the transmission using the following procedure:

**NOTE**
Note that the bolt holes in the shifter mounting flange are sufficiently large to allow movement of the flange around the bolts.

a. Install the shifter assembly on the transmission and tighten the retaining bolts.
b. Measure the amount of shift lever travel from neutral to forward and from neutral to reverse (Figure 27). The measurement should be equal from neutral to either forward or reverse.
c. Loosen the shifter retaining bolts and slide the shifter assembly fore or aft as needed to obtain equal shift lever movement.
14B. On KM2P and KM3P—Install the shifter assembly on the transmission using the following procedure.
a. Position the shifter so its curvature is as shown in Figure 28.
b. Install the shifter assembly on the transmission and tighten the retaining bolts.
c. Move the shift lever 10-15° from the neutral position to either forward or reverse position.
d. Measure the depth of the end of the shifter shaft from the end of the shift shaft as shown in Figure 28. Measure the length of the stop bolt (Figure 29).
e. Subtract the length of the stop bolt from the shifter shaft depth.
f. Install shims on the stop bolt that equal the result of substep e.
g. Apply sealer to the stop bolt threads, but not to the threads at the end of the bolt (approximately 0.20 in.). Install the stop bolt into the shifter.

**BEARING ADJUSTMENT**

Perform the following procedure if the following components have been replaced: input shaft, input shaft bearings, output shaft, thrust washers and output shaft bearings. This procedure determines the thickness of shims that must be installed so the tapered roller bearings properly contact the bearing outer races.

**KM2A, KM2C and KM3A**

1. Install the input shaft, intermediate shaft and output shafts as described in the Reassembly section.
2. Position the transmission case so the open end is up and no pressure is being applied to the splined end of the output shaft.
3. Install the outer bearing races on the input and output shaft tapered bearings.
4. Measure the distance (A, Figure 30) in millimeters from the mounting flange mating surface on the case to the top of each bearing race. Record the measurements.
5. Measure the distance (B, Figure 31) from the mounting flange mating surface to the bottom of the bearing race bore for both the input and output shaft bearings.
6. Subtract the A measurement from the B measurement for each shaft.
7. From the result obtained in Step 6, subtract 0.0-0.05 mm. This result equals the thickness of the shim(s) that must be installed in the bearing bores in the mounting flange.
8. Install the shim(s) in the bearing bores in the mounting flange, then press the bearing outer races into the mounting flange on top of the shims. Make sure the races are bottomed.

**KM2P and KM3P**

**Input shaft**

*NOTE*

The following procedure for adjusting the input shaft bearings is similar to the procedure for the KM2A, KM2C KM3A transmissions, but only use the callouts in Figure 30 and Figure 31 that pertain to the input shaft.
1. Install the input shaft assembly in the transmission case.
2. Position the transmission case so the open end is up.
3. Install the outer bearing race on the input shaft tapered bearing.
4. Measure the distance (A, Figure 30) in millimeters from the mounting flange mating surface on the case to the top of the bearing race. Record the measurement.
5. Measure the distance (B, Figure 31) from the mounting flange mating surface to the bottom of the bearing race bore for the input shaft bearing.
6. Subtract the A measurement from the B measurement.
7. From the result obtained in Step 6, subtract 0.0-0.05 mm. This result equals the thickness of the shim(s) that must be installed in the bearing bore in the mounting flange.
8. Install the shim(s) in the bearing bore in the mounting flange, then press the bearing outer race into the mounting flange on top of the shims. Be sure the race is bottomed.

**Output Shaft**

In the following procedure to adjust bearing preload, the neutral position of the clutch cone must be established for proper transmission operation. The desired clutch cone groove centerline on Model KM2P is 48.3 mm from the mating surface of the transmission case. On Model KM3P the desired clutch groove centerline is 47.3 mm from the mating surface of the transmission case.

**NOTE**

*To perform the following bearing adjustment procedure, the output shaft must be out of the case and the outer bearing races must be on the bearings and not installed in the case or mounting flange.*

1. Measure and record the distance (A, Figure 32) from the mounting flange mating surface to the bottom of the bearing race bore for the output shaft bearing.
2. Measure and record the distance (B, Figure 33) from the mounting surface of the case to the bottom of the bearing race bore for the output shaft bearing.
3. Measure and record the distance (C, Figure 34) from the faces of the output shaft bearing races.

**NOTE**

*In Steps 4 and 5, force the gears toward the cone clutch.*

4. Measure and record the distance (D, Figure 34) between the faces of the forward and reverse gears.

5. Measure and record the distance (E, Figure 34) from the face of the reverse gear and the face of the rear bearing race.

6A. On KM2P transmissions—To determine rear shim thickness (Figure 35), proceed as follows:

   a. Subtract 48.3 mm from measurement (B, Figure 33).
   b. Divide measurement (D, Figure 34) by 2.
   c. Subtract substep b from substep a.
   d. Subtract measurement (E, Figure 34) from substep c.
   e. Subtract 0.0-0.05 mm from substep d. The result is the required rear shim thickness.

6B. On KM3P transmissions—To determine rear shim thickness (Figure 35), proceed as follows:
a. Subtract 47.3 mm from measurement (B, Figure 33).
b. Divide measurement (D, Figure 34) by 2.
c. Subtract step b from step a.
d. Subtract measurement (E, Figure 34) from step c.
e. Subtract 0.0-0.05 mm from step d. The result is the required rear shim thickness.
7. To determine front shim thickness (Figure 35), proceed as follows:
a. Add measurement (A, Figure 32) to measurement (B, Figure 33).
b. Subtract measurement (C, Figure 34) from step a.
c. Subtract the rear shim thickness (determined in Step 6A) from step b.
d. Subtract 0.0-0.05 mm from step c. The result is the required front shim thickness.
8. Install the shim(s) in the bearing bores in the mounting flange and case, then press the bearing outer races on top of the shims. Make sure the races are bottomed.

**DRIVE DISC**

The drive disc attached to the engine flywheel transmits power from the engine flywheel to the transmission input shaft. Bolts secure the disc to the flywheel while the transmission input shaft engages the splined hub on the drive disc. The drive disc incorporates springs that dampen driveline shocks between the engine and transmission.

**Removal/Installation**

1. Remove the engine from the boat.
2. Remove the transmission.
3. Remove the drive disc (Figure 36, typical).
4. Install the drive disc by reversing the removal procedure. Install the drive disc so the side marked FLYWHEEL SIDE (Figure 37) is toward the flywheel. Tighten the drive disc retaining bolts to the torque specified in Table 2.

**Inspection**

Replace the drive disc if any of the following conditions exist:
1. Broken spring.
2. Worn or damaged splines in hub.
3. Damaged disc.
4. Damaged pins.
### Table 1 ENGINE/TRANSMISSION MODELS

<table>
<thead>
<tr>
<th>Model</th>
<th>Transmission</th>
<th>Transmission ratio (forward gear)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GM</td>
<td>KM2A</td>
<td>2.21, 2.62 or 3.22</td>
</tr>
<tr>
<td>1GM10</td>
<td>KM2C or KM2P</td>
<td>2.21, 2.62 or 3.22</td>
</tr>
<tr>
<td>2GM</td>
<td>KM2A</td>
<td>2.21, 2.62 or 3.22</td>
</tr>
<tr>
<td>2GMF</td>
<td>KM2A</td>
<td>2.21, 2.62 or 3.22</td>
</tr>
<tr>
<td>2GM20</td>
<td>KM2C or KM2P</td>
<td>2.21, 2.62 or 3.22</td>
</tr>
<tr>
<td>2GM20F</td>
<td>KM2C or KM2P</td>
<td>2.21, 2.62 or 3.22</td>
</tr>
<tr>
<td>3GM</td>
<td>KBW10D</td>
<td>2.14, 2.63 or 2.83</td>
</tr>
<tr>
<td>3GMF</td>
<td>KBW10D</td>
<td>2.14, 2.63 or 2.83</td>
</tr>
<tr>
<td>3GMD</td>
<td>KM3A</td>
<td>2.36, 2.61 or 3.20</td>
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<tr>
<td>3GM30</td>
<td>KM3A or KM3P</td>
<td>2.36, 2.61 or 3.20</td>
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<tr>
<td>3GM30F</td>
<td>KM3A or KM3P</td>
<td>2.36, 2.61 or 3.20</td>
</tr>
<tr>
<td>3HM</td>
<td>KBW10E</td>
<td>2.14 or 2.83</td>
</tr>
<tr>
<td>3HMF</td>
<td>KBW10E</td>
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</tr>
<tr>
<td>3HM35</td>
<td>KBW10E</td>
<td>2.14 or 2.83</td>
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### Table 2 TIGHTENING TORQUES

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<th>Fastener</th>
<th>N·m</th>
<th>ft.-lb.</th>
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<tbody>
<tr>
<td>Transmission mounting flange</td>
<td>20-25</td>
<td>15-18</td>
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<tr>
<td>Output shaft nut</td>
<td>85-115</td>
<td>63-85</td>
</tr>
<tr>
<td>Output flange nut</td>
<td>85-115</td>
<td>63-85</td>
</tr>
<tr>
<td>Drive disc</td>
<td>25</td>
<td>18</td>
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</table>

### Table 3 CLUTCH DEPTH

<table>
<thead>
<tr>
<th>Normal depth</th>
<th>Wear limit</th>
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<tbody>
<tr>
<td>KM2A, KM2C</td>
<td>24.1 mm</td>
</tr>
<tr>
<td>(0.961-0.972 in.)</td>
<td>(0.949 in.)</td>
</tr>
<tr>
<td>KM2P</td>
<td>2.8 mm</td>
</tr>
<tr>
<td>(1.150-1.173 in.)</td>
<td>(1.106 in.)</td>
</tr>
<tr>
<td>KM3A</td>
<td>29.6 mm</td>
</tr>
<tr>
<td>(1.177-1.189 in.)</td>
<td>(1.165 in.)</td>
</tr>
<tr>
<td>KM3P</td>
<td>32.4 mm</td>
</tr>
<tr>
<td>(1.287-1.311 in.)</td>
<td>(1.276 in.)</td>
</tr>
</tbody>
</table>

### Table 4 CLUTCH GROOVE WIDTH

<table>
<thead>
<tr>
<th>Standard width</th>
<th>Wear limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>KM2A, KM2C and KM3A</td>
<td>8.3 mm</td>
</tr>
<tr>
<td>(0.315-0.319 in.)</td>
<td>(0.327 in.)</td>
</tr>
</tbody>
</table>

### Table 5 OUTPUT SHAFT

<table>
<thead>
<tr>
<th>Standard width</th>
<th>Wear limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust washer</td>
<td>0.20 mm</td>
</tr>
<tr>
<td>Thin washer</td>
<td>(0.008 in.)</td>
</tr>
<tr>
<td>Thick washer</td>
<td>0.05 mm</td>
</tr>
<tr>
<td></td>
<td>(0.002 in.)</td>
</tr>
</tbody>
</table>

(continued)
### Table 5 OUTPUT SHAFT (continued)

<table>
<thead>
<tr>
<th>Component</th>
<th>Standard</th>
<th>Wear limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring cup (KM2P, KM3P)</td>
<td>2.6-3.1 mm</td>
<td>2.6 mm</td>
</tr>
<tr>
<td></td>
<td>(0.100-0.122 in.)</td>
<td>(0.102 in.)</td>
</tr>
<tr>
<td>Spring cup retainer (KM2P, KM3P)</td>
<td>2.92-3.08 mm</td>
<td>2.8 mm</td>
</tr>
<tr>
<td></td>
<td>(0.115-0.121 in.)</td>
<td>(0.110 in.)</td>
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### Table 6 SHIFTER (KM2A, KM2C AND KM3A)

<table>
<thead>
<tr>
<th>Component</th>
<th>Standard</th>
<th>Wear limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shifter width</td>
<td>7.80-7.85 mm</td>
<td>7.7 mm</td>
</tr>
<tr>
<td></td>
<td>(0.3071-0.3091 in.)</td>
<td>(0.303 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>7.7 mm</td>
<td></td>
</tr>
<tr>
<td>Shifter shaft diameter</td>
<td>9.986-9.996 mm</td>
<td>9.95 mm</td>
</tr>
<tr>
<td></td>
<td>(0.3931-0.3935 in.)</td>
<td>(0.392 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>9.95 mm</td>
<td></td>
</tr>
<tr>
<td>Detent spring free length</td>
<td>34 mm</td>
<td></td>
</tr>
<tr>
<td>Actuator spring tension</td>
<td>2.8 kg</td>
<td>2.5 kg</td>
</tr>
<tr>
<td>Standard</td>
<td>(6.2 lb.)</td>
<td>(5.5 lb.)</td>
</tr>
<tr>
<td>Min.</td>
<td></td>
<td></td>
</tr>
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</table>

### Table 7 SHIFTER (KM2P AND KM3P)

<table>
<thead>
<tr>
<th>Component</th>
<th>Standard</th>
<th>Wear limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shifter spring free length</td>
<td>22.6 mm</td>
<td>19.8 mm</td>
</tr>
<tr>
<td></td>
<td>(0.89 in.)</td>
<td>(0.78 in.)</td>
</tr>
<tr>
<td>Min.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shifter shaft diameter</td>
<td>11.966-11.984 mm</td>
<td>11.95 mm</td>
</tr>
<tr>
<td>Standard</td>
<td>(0.4711-0.4718 in.)</td>
<td>(0.470 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>11.95 mm</td>
<td></td>
</tr>
<tr>
<td>Shift shaft bore</td>
<td>12.0-12.018 mm</td>
<td>12.05 mm</td>
</tr>
<tr>
<td>Standard</td>
<td>(0.4724-0.4731 in.)</td>
<td>(0.474 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
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</tr>
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</table>
Chapter Eleven

Transmission—KBW Series

This chapter covers the Kanzaki Hurth KBW10D and KBW10E marine transmissions that are attached to Yanmar 3GM, 3HM and 3HM35 engines. Refer to Table 1 for a cross-reference of engine and transmission models. The identification plate (Figure 1) located on the transmission case specifies the transmission model.

The KBW10 series transmissions covered in this chapter are inline transmissions that provide forward and reverse direction. All gears are constant mesh. A plate-type clutch engages the gears to transmit power to the output shaft. Oil contained in the transmission case lubricates the internal transmission components.

Refer to Chapter Three for maintenance information. Tables 1-3 are located at the end of this chapter.

OPERATION

The input shaft on the transmission engages the drive disc attached to the engine flywheel. Because this is a constant-mesh transmission, engine power is transmitted to all gears. Power flows to the output shaft when the clutch engages either the forward gear or the reverse gear. The clutch contacts a clutch pack of several discs adjacent to the forward and reverse gears. In Figure 2, the clutch is shown engaged with the forward gear. Because power flows from the input shaft gear through the reverse idler gear to the reverse gear, the reverse gear rotates in the opposite direction of the forward gear. When the clutch engages the reverse gear, the output shaft rotates in reverse.

Moving the shift lever rotates the shift shaft. When the shift shaft rotates, the shifter fork slides the shift ring into engagement with the forward or reverse gear clutch. The drive hub on the output shaft transfers power from the selected clutch to the output shaft.
REMOVAL/INSTALLATION

The following procedure addresses units that are accessible. In some cases, it may be necessary to remove the engine and transmission as a unit before removing the transmission from the engine. Refer to Chapter Six if engine removal is necessary.

1. If not previously disconnected, disconnect the remote control cable from the transmission shift lever.
2. If not previously disconnected, disconnect the drive coupling from the transmission drive flange.
3. Remove the bolts that secure the transmission to the engine bellhousing.
4. Remove the transmission from the engine.
5. Reinstall the transmission by reversing the removal procedure. Make sure to align the splines on the transmission input shaft and the drive disc during installation. Tighten the transmission retaining bolts to the torque specified in Table 2.

OVERHAUL

Refer to Figure 3.

NOTE
Overhaul of the KBW transmission requires special tools, which can be obtained from Yanmar or fabricated. If the special tools are not available, have a Yanmar dealership overhaul the transmission.

Disassembly

1. Remove the drain plug and drain the transmission oil.
2. Position the transmission in a vise with soft jaws so the input shaft is held by the vise jaws.
3. The output flange retaining nut is staked. Use a chisel to cut away the staked portion so the nut will rotate.
4. Install a tool that will prevent rotation of the output flange.
5. Unscrew the output flange retaining nut.
6. Remove the oil dipstick.
7. Make match marks on the shifter cover and the transmission case so the shifter can be installed in its original position.
8. Remove the shifter retaining bolts and remove the shifter assembly.
9. Remove the transmission from the vise.
10. Using an 8 mm Allen wrench, remove the shift bar retaining plug (68, Figure 3) in the rear of the case.
11. Install a 10 mm bolt into the end of the shift bar, then pull the shift bar (58, Figure 3) out of the case while also removing the shift fork (57).
12. Remove the transmission mounting flange retaining bolts.

NOTE
In Step 13, position the transmission so the transmission input shaft is up when removing the mounting flange so the transmission shafts will not fall out.

13. Tap on the mounting flange using a soft-faced hammer to dislodge the flange. Position the transmission with the input shaft up, then remove the flange from the transmission case.
14. Remove the output shaft assembly from the transmission case and set aside for disassembly.
15. Remove the intermediate shaft assembly from the transmission case and set aside for disassembly.
16. Remove the input shaft assembly from the transmission case and set aside for disassembly.
17. Using a large screwdriver, pry out the oil seal in the transmission case. Be careful not to damage the case or the adjacent bearing race.
18. Using a large screwdriver, pry out the oil seal in the transmission mounting flange. Be careful not to damage the case or the adjacent bearing race.
19. If inspection indicates additional disassembly is necessary, refer to the following sections.
TRANSMISSION

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>Mounting flange</td>
</tr>
<tr>
<td>2.</td>
<td>Shim</td>
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<tr>
<td>3.</td>
<td>Output shaft</td>
</tr>
<tr>
<td>4.</td>
<td>Key</td>
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<tr>
<td>5.</td>
<td>Bearing</td>
</tr>
<tr>
<td>6.</td>
<td>Thrust washer</td>
</tr>
<tr>
<td>7.</td>
<td>Bearing inner race</td>
</tr>
<tr>
<td>8.</td>
<td>Bearing</td>
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<td>9.</td>
<td>Spacer</td>
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<td>10.</td>
<td>Forward gear</td>
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<td>Belleville springs</td>
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<td>12.</td>
<td>Retainer</td>
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<td>13.</td>
<td>Snap ring</td>
</tr>
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<td>14.</td>
<td>Friction plates</td>
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<td>Steel plates</td>
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<td>Shims</td>
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<td>Pressure plate</td>
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<td>18.</td>
<td>Balls (3)</td>
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<td>19.</td>
<td>Spring</td>
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<tr>
<td>20.</td>
<td>Detent pins</td>
</tr>
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<td>21.</td>
<td>Alignment pin</td>
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<td>Driving plate</td>
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<td>Pressure plate</td>
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<td>Return spring</td>
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<td>25.</td>
<td>Shift ring</td>
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<tr>
<td>26.</td>
<td>Shims</td>
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<tr>
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<td>Spacer</td>
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<td>Inner bearing race</td>
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<td>Bearing</td>
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<td>Friction plates</td>
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<td>31.</td>
<td>Steel plates</td>
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<td>32.</td>
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<tr>
<td>33.</td>
<td>Retainer</td>
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<td>Belleville washers</td>
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<td>Reverse gear</td>
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<td>37.</td>
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<td>38.</td>
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<td>Input shaft</td>
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<td>42.</td>
<td>Bearing</td>
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<td>43.</td>
<td>Intermediate shaft</td>
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<td>44.</td>
<td>Roller bearings</td>
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<td>Idle gear</td>
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<td>O-ring</td>
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<td>Shift lever</td>
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<td>49.</td>
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<td>Shifter cover</td>
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<td>Gasket</td>
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<td>Shift shaft</td>
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<td>Snap ring</td>
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<td>54.</td>
<td>Springs</td>
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<td>Detent pin</td>
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<td>56.</td>
<td>Bearings</td>
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<td>58.</td>
<td>Shift bar</td>
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<td>59.</td>
<td>Oil dipstick</td>
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<td>60.</td>
<td>Gasket</td>
</tr>
<tr>
<td>61.</td>
<td>Case</td>
</tr>
<tr>
<td>62.</td>
<td>O-ring</td>
</tr>
<tr>
<td>63.</td>
<td>Seal</td>
</tr>
<tr>
<td>64.</td>
<td>Flange</td>
</tr>
<tr>
<td>65.</td>
<td>Nut</td>
</tr>
<tr>
<td>66.</td>
<td>Gasket</td>
</tr>
<tr>
<td>67.</td>
<td>Drain plug</td>
</tr>
<tr>
<td>68.</td>
<td>Plug</td>
</tr>
<tr>
<td>69.</td>
<td>Dowel pin</td>
</tr>
</tbody>
</table>
**Input shaft**

1. Check the gear teeth for excessive wear, corrosion or rust and mechanical damage. Check the teeth for galling, chips, cracks, missing pieces, distortion or discoloration from overheating. Replace the input shaft if the gears are damaged.
2. Inspect the input shaft bearings and seal surfaces for excessive wear, grooves, metal transfer and discoloration from overheating. Use a press to remove damaged bearings and to install new bearings.

**NOTE**

*Shims (39, Figure 3) behind the outer bearing race in the mounting flange determine bearing preload for the input shaft bearings. Save the shims and reinstall them if reusing the original parts.*

3. Inspect the input shaft bearing outer races in the transmission case and mounting flange. If either race is damaged or excessively worn, remove it using a suitable puller.

**Intermediate shaft**

1. Remove and discard the O-ring (46, Figure 3) at the end of the shaft.
2. Remove the thrust washer (47, Figure 3), idle gear (45) and roller bearings (44).
3. Inspect the bearings, shaft and reverse idler gear inside diameter for excessive wear, grooves, metal transfer and discoloration from overheating. If necessary, replace the shaft, gear and bearings.
4. Check the idler gear teeth for excessive wear, corrosion or rust and mechanical damage. Check the teeth for galling, chips, cracks, missing pieces, distortion or discoloration from overheating. If necessary, replace the gear.
5. Reassemble the intermediate shaft. Install a new O-ring on the shaft. Check that the idler rotates freely on the shaft.

**Output shaft**

**NOTE**

*Exercise care when using the puller in Step 1. Make sure the threads on the output shaft are not damaged.*

1. Using a suitable puller, remove the output shaft from the forward and reverse gear assemblies as shown in Figure 4. Do not mix the forward gear parts and reverse gear parts.

2. Remove the spacer (9, Figure 3) and the bearing inner race (7) from the output shaft.
3. Hold the threaded end of the output shaft so the threads are protected.
4. Place the outer race onto the front bearing inner race. Using a suitable bearing driver, gently drive the inner bearing race away from the shaft collar approximately 10 mm.
5. Place a pulling support plate (such as Yanmar special tool 17099-09030) between the collar of the output shaft and bearing.
6. Use Yanmar special tool 17095-09070, or a suitable equivalent tool, to press the bearing off the shaft, as shown in Figure 5.
7. Remove the clutch friction plates (14, Figure 3) and steel plates (15) from the forward gear (10).
8. Use Yanmar special tool 17095-09070, or an equivalent tool, to compress the Belleville springs (11, Figure 3) and remove the snap ring from the forward gear, as shown in Figure 6.
2. Inspect the output shaft bearings and seal surfaces for excessive wear, grooving, metal transfer and discoloration from overheating.
3. Inspect the key and output shaft keyway for damage.

**NOTE**
Shims behind the outer bearing race in the mounting flange determine bearing preload for the output shaft bearings. Save the shims and reinstall them if reusing the original parts.

4. Inspect the input shaft bearing outer races in the transmission case and mounting flange. If either race is damaged or excessively worn, remove it using a suitable puller.
5. Measure steel plate warpage as shown in Figure 7 and compare the result with the specification in Table 3.
6. Measure the width of the steel plates tangs and compare the result with the specification in Table 3.
7. Measure the width of the grooves in the pressure plates and compare the result with the specification in Table 3. The clearance between the tangs and the grooves should be 0.6 mm (0.024 in).
8. Measure the width of the friction plates and compare with the specification in Table 3. Both sides of friction plates have a 0.35 mm (0.014 in) copper sintered layer. Replace the friction plates when the copper layer is worn more than 0.2 mm (0.008 in.) on one side.
9. Measure four friction plates. The sum of wear of four friction plates (forward or reverse) must not exceed 0.8 mm (0.031 in.). If wear exceeds 0.8 mm (0.031 in.), replace all friction plates (forward or reverse).
10. Assemble each set of steel and friction plates. Compress the plates to remove steel plate warp. Measure the assembled plates. The assembled thickness must exceed 10.0 mm (0.394 in.).
11. Measure the backlash between the teeth on the friction plates and the gear splines. The backlash must not exceed 0.9 mm (0.035 in.).
12. Lay the shift ring and pressure plate assembly flat and remove the pressure plate return springs (24, Figure 3). Lift off the top pressure plate (17) and remove the steel balls (18).
13. Lift the shift ring (25, Figure 3) and driving plate (22) off the bottom pressure plate and remove the three remaining balls.
14. Slip the shift ring (25, Figure 3) off the driving plate (22).

**Inspection**
1. Check the gear teeth for excessive wear, corrosion or rust and mechanical damage. Check the teeth for galling, chips, cracks, missing pieces, distortion or discoloration from overheating. Check the splines for excessive wear or damage. Replace the gears if damaged.
2. Refer to Steps 7 and 8 and disassemble the clutch components on the reverse gear.
3. Lay the shift ring and pressure plate assembly flat.
4. Remove the pressure plate return springs (24, Figure 3), then lift off the top pressure plate (17) and remove the steel balls (18).
5. Lift the shift ring (25, Figure 3) and driving plate (22) off the bottom pressure plate and remove the three remaining balls.
6. Slip the shift ring (25, Figure 3) off the driving plate (22).
7. Remove the alignment pins (21, Figure 3) and detent pins (20) with springs (19) from the driving plate (22).
16. Measure the return spring end gap (Figure 8) and compare the result with the specification in Table 3.
17. Check the driving plate ball grooves (Figure 9), detent pin bores, detent pins (A) and keyway (B) for any noticeable wear.
18. Measure the driving plate hub outer diameter (C, Figure 9) and compare it with the specification in Table 3.
19. Measure detent pin spring (D, Figure 9) free length and compare it with the specification in Table 3.
20. Measure the plate spring retainer thickness (A, Figure 10) and compare the result with the specification in Table 3. Measure the plate spring inside diameter (B) and compare with the specification in Table 3. Measure the plate spring shoulder diameter (C) and compare the result with the specification in Table 3.
21. Measure the free width of the Belleville springs and compare it with the specification in Table 3.
22. Inspect the shift ring pressure grooves (A, Figure 11) and pin contact grooves (B) for any signs of excessive wear. Measure the width of the circumferential groove (C) and compare the result with the specification in Table 3.

Reassembly

1. Install the Belleville springs on the forward gear so the concave sides face each other as shown in Figure 12. Position the retainer (12, Figure 3) over the Belleville springs and slide the snap ring onto the spline of the forward gear. Using Yanmar special tool 177095-09070, or a suitable equivalent tool, compress the forward gear assembly in a vise and engage the snap ring in the groove around the forward gear splines.
2. Refer to Step 1 and assemble the reverse gear, Belleville springs, retainer and snap ring.
3. To determine the correct thickness of shims (16 and 26, Figure 3), install the inner bearing race and spacer in their respective gears. Measure the depth (A, Figure 13) of the bearing race from the end of the gear as shown in Figure 13. Install shims equal to the depth.
4. Alternately install four friction plates (14, Figure 3) and three steel plates (15) on the forward gear (10) splines starting with a friction plate.
5. Refer to Step 4 and assemble the reverse gear, steel plates and friction plates.
6. Using a suitable bearing driver, install the output shaft front bearing onto the shaft. Be sure the bearing inner race contacts the collar on the end of the output shaft.
7. Install the thrust washer on the output shaft with the sintered copper surface facing away from the bearing.

8. Using a suitable bearing driver, install the needle bearing inner race on the output shaft. Be sure the race bottoms against the thrust washer.

9. Install the needle bearing, spacer and shim on the output shaft.

10. Install the forward gear assembly on the output shaft and align the steel plate tangs.

11. Fit the key (4, Figure 3) into the slot on the output shaft so the fillet side of the key faces the threaded end of the output shaft.

12. Install the pressure plate, with the ball slots facing up, so the steel plate tangs fit into the three slots in the pressure plate. Make sure the pawls of all three steel plates engage the pressure plate.

13. Install three steel balls into the slots on the pressure plate. Install the drive plate onto the output shaft so the side of the drive plate with concentric groove is facing the forward gear assembly. Make sure all three steel balls remain in place and the grooves of the pressure plate and the drive plate match when the drive plate is installed.

14. Insert both locating pins into the drive plate so they engage the torque limiter slots of the pressure plate.

15. Install the shim, spacer and inner needle bearing race on the output shaft using a suitable bearing driver.

16. Insert the detent pins and springs into the drive plate. Install the shift ring over the drive plate so the three legs with grooves are facing the forward gear and the detent pins in the drive plate properly engage the pin slots of the inside diameter of the shift ring.

17. Install three steel balls in the slots of the drive plate and place the pressure plate over the drive plate. Make sure the steel balls remain in position and the slots of both plates match.

18. Install the pressure plate return springs between the shift ring and the drive plate. Attach the spring ends to the small holes inside the pressure plates as shown in Figure 14.

19. Install the reverse gear assembly so the tangs of all three steel plates properly engage the slots in the pressure plate.

20. Install the needle bearing and thrust washer with the copper sintered side of the washer facing the reverse gear.

21. Using a suitable bearing driver install the rear output shaft inner race onto the output shaft. Make sure the race bottoms against the thrust washer.

22. Check for smooth rotation of both the forward and reverse gears. Check for correct operation of the shift ring.

**Shifter**

Refer to Figure 3.

**NOTE**

Make alignment marks on the shift lever and shift shaft so the shift lever can be reinstalled in its original position.

1. Loosen the clamp bolt and remove the shift lever.

2. Remove the shift cam.
3. Push in the detent pin, remove the snap ring and remove the pin and springs.
4. Use a screwdriver or suitable tool to pry out the seal.
5. Inspect the shift ring. Check the detent notch for excessive wear that will allow poor clutch engagement.
6. Inspect the detent pin. Replace the pin if it is damaged or excessively worn.
7. The shift ring contact surface of the shift fork is plated with molybdenum. Renew the shift fork if the plating is peeled or the shift fork base metal is exposed.
8. Reassemble the shifter by reversing the disassembly procedure. Install the shift lever so the triangle mark on the lever is out.

Reassembly

1. If removed, install the outer bearing races into the transmission case and mounting flange.
2. Apply sealer to the periphery of the oil seals and install them into the transmission case and mounting flange with the open side to the inside.
3. Install the input shaft into the transmission case.
4. Install the intermediate shaft assembly into the transmission case. Position the thrust washer so the beveled corner is toward the input shaft. Install a new O-ring on the intermediate shaft. Use a soft-faced hammer to tap the shaft into the case.
5. While holding the input shaft out of the way, insert the output shaft assembly into the transmission case. Move the gears into mesh on the intermediate shaft, input shaft and output shaft while installing the output shaft.
6. If the following components have been replaced, refer to the Bearing Adjustment section: input shaft, input shaft bearings, output shaft, drive plate, spacer, thrust washers and output shaft bearings. After adjusting the bearings, continue to reassemble the transmission as described in the following steps. If the preceding components have not been replaced, bearing adjustment is not necessary and the orginal shims may be reused. Proceed to the following step.
7. Install the input shaft oil seal.
8. Coat the case mating surface with RTV sealer.
9. Install the mounting flange and tighten bolts evenly.
10. Place the shift ring in neutral position and install the shift fork through the side opening.
11. Insert the shift bar through the hole in the rear of the case while installing the shift fork onto the shift bar.
12. Install the shift bar plug. Make sure the threaded end of the shift bar is installed toward the rear of the case.
13. Install the shifter assembly. Align the marks made during disassembly and tighten the retaining bolts securely. Loosen the shift lever clamp bolt and position the lever so it points up at a 45° angle toward the rear of the transmission. Retighten the clamp bolt.
14. Check the operation of the transmission. A click should be audible when the gears are properly engaged. If the gears do not engage, loosen the shifter retaining bolts and reposition the shifter. If improper engagement continues, remove the shifter and check for improper assembly of the shifting components.
15. Install the O-ring on the output shaft.
16. If not previously installed, install the oil seal into the case.
17. Install the coupling flange onto the output shaft. Tighten the retaining nut to the torque specified in Table 2.
18. Install the drain plug and oil dipstick.
19. Fill the transmission with the recommended transmission fluid. Refer to Chapter Three.

BEARING ADJUSTMENT

Perform the following procedure if the following components have been replaced: input shaft, input shaft bearings, output shaft, drive plate, spacer, thrust washers and output shaft bearings. This procedure determines the thickness of shims that must be installed so the tapered roller bearings properly contact the bearing outer races.
1. Install the input shaft, intermediate shaft and output shafts as described in the Reassembly section.
2. Position the transmission case so the open end is up and no pressure is being applied to the splined end of the output shaft.
3. Install the outer bearing races on the input and output shaft tapered bearings.
4. Measure the distance (A, Figure 15) in millimeters from the mounting flange mating surface on the case to the top of each bearing race. Record the measurements.
5. Measure the distance (B, Figure 16) from the mounting flange mating surface to the bottom of the bearing race bore for both the input and output shaft bearings.
6. Subtract the A measurement from the B measurement for each shaft.
7A. Input shaft—From the result obtained in Step 6, subtract 0.0-0.05 mm. This result equals the thickness of the shim(s) that must be installed in the bearing bore in the mounting flange.
7B. Output shaft—From the result obtained in Step 6, subtract 0.0-0.1 mm. This result equals the thickness of the shim(s) that must be installed in the bearing bore in the mounting flange.
8. Install the shim(s) in the bearing bore in the mounting flange, then press the bearing outer race into the mounting flange on top of the shims. Be sure the race is bottomed.

**DRIVE DISC**

The drive disc attached to the engine flywheel transmits power from the engine flywheel to the transmission input shaft. Bolts secure the disc to the flywheel while the transmission input shaft engages the splined hub on the drive disc. The drive disc incorporates springs that dampen driveline shocks between the engine and transmission.

**Removal/Installation**

1. Remove the engine from the boat.
2. Remove the transmission.
3. Remove the drive disc (Figure 17, typical).
4. Install the drive disc by reversing the removal procedure. Install the drive disc so the side marked FLYWHEEL SIDE (Figure 18) is toward the flywheel. Tighten drive disc retaining bolts to the torque specified in Table 2.

**Inspection**

Replace the drive disc if any of the following conditions exist:
1. Broken spring.
2. Worn or damaged splines in hub.
3. Damaged disc.
4. Damaged pins.
### Table 1 ENGINE/TRANSMISSION MODELS

<table>
<thead>
<tr>
<th>Model</th>
<th>Transmission</th>
<th>Transmission ratio (forward gear)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GM</td>
<td>KBW10D</td>
<td>2.14, 2.63 or 2.83</td>
</tr>
<tr>
<td>3HM</td>
<td>KBW10E</td>
<td>2.14 or 2.83</td>
</tr>
<tr>
<td>3HM35</td>
<td>KBW10E</td>
<td>2.14 or 2.83</td>
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### Table 2 TIGHTENING TORQUES

<table>
<thead>
<tr>
<th>Fastener</th>
<th>N·m</th>
<th>ft.-lb.</th>
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<tbody>
<tr>
<td>Transmission mounting flange</td>
<td>20-25</td>
<td>15-18</td>
</tr>
<tr>
<td>Output shaft nut</td>
<td>85-115</td>
<td>63-85</td>
</tr>
<tr>
<td>Output flange nut</td>
<td>85-115</td>
<td>63-85</td>
</tr>
<tr>
<td>Drive disc</td>
<td>25</td>
<td>18</td>
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</tbody>
</table>

### Table 3 CLUTCH SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel plate warpage</td>
<td>1.4-1.7 mm (0.055-0.067 in.)</td>
</tr>
<tr>
<td>Steel plate tang width</td>
<td>11.8-12.0 mm (0.464-0.472 in.)</td>
</tr>
<tr>
<td>Pressure plate groove width</td>
<td>12.0-12.1 mm (0.472-0.478 in.)</td>
</tr>
<tr>
<td>Friction plate thickness</td>
<td>1.70-1.75 mm (0.067-0.069 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>1.5 mm (0.059 in.)</td>
</tr>
<tr>
<td>Pressure plate thickness</td>
<td>6.4-6.6 mm (0.252-0.260 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>6.3 mm (0.248 in.)</td>
</tr>
<tr>
<td>Return spring end gap</td>
<td>16.5-17.5 mm (0.650-0.690 in.)</td>
</tr>
<tr>
<td>Driving plate hub outer diameter-min.</td>
<td>58.8 mm (2.315 in.)</td>
</tr>
<tr>
<td>Detent pin spring free length</td>
<td>32.00-32.85 mm (1.260-1.283 in.)</td>
</tr>
<tr>
<td>Plate spring retainer thickness</td>
<td>2.72-2.80 mm (0.107-1.110 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>2.60 mm (0.102 in.)</td>
</tr>
<tr>
<td>Plate spring retainer inner diameter</td>
<td>65.9-66.0 mm (2.594-2.598 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>65.7 mm (2.587 in.)</td>
</tr>
<tr>
<td>Plate spring retainer shoulder diameter</td>
<td>57.56-57.606 mm (2.266-2.268 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>57.8 mm (2.276 in.)</td>
</tr>
<tr>
<td>Belleville spring width</td>
<td>6.15-6.35 mm (0.242-0.250 in.)</td>
</tr>
<tr>
<td>Min. width</td>
<td>6.0 mm (0.236 in.)</td>
</tr>
<tr>
<td>Shift ring circumferential groove width</td>
<td>6.0-6.1 mm (0.236-0.240 in.)</td>
</tr>
<tr>
<td>Wear limit</td>
<td>6.3 mm (0.248 in.)</td>
</tr>
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<td>battery</td>
<td>multicylinder</td>
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<td>engine tune-up</td>
<td>single-cylinder</td>
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EARLY MODELS WITH LARGE INSTRUMENT PANEL

Wiring Diagram:

- Push button switch
- Key switch
- Light switch
- 30 A fuse
- Starter switch (option)
- Battery switch (option)
- Battery
- Extension cable 3m (standard)
  - The total length extension must be less than 6m.
- Alternator
- Coolant temp. switch
- Oil pressure switch
- Tachometer sender
- Rubber seal switch (for Sail-drive)
- Charge lamp
- Coolant temp. warning lamp
- Oil pressure warning lamp
- Rubber seal lamp (Sail-drive)
- Tachometer
- Buzzer

Diagram Key:

- Connectors
- Ground
- Frame ground
- Connection
- No connection

Color Code:
- B Black
- W White
- R Red
- L Blue
- O Orange
- W/B White/Black
- W/R White/Red
- W/L White/Blue
- R/B Red/Black
- L/B Blue/Black
- L/R Blue/Red
- Y/W Yellow/White
LATE MODELS WITH SMALL INSTRUMENT PANEL
(NO TACHOMETER)

Diagram Key
- Connectors
- Ground
- Frame ground
- Connection
- No connection

Color Code
B Black
W White
R Red
L Blue
O Orange
W/B White/Black
W/R White/Red
W/L White/Blue
R/B Red/Black
L/B Blue/Black
L/R Blue/Red
Y/W Yellow/White

Extension cable 3m (standard)
The total length extension must be less than 6m.

Alternator
Coolant temp. pressure switch
Oil
Spare connector
Spare connector

Battery switch
Battery switch

Start motor

Push button switch
Key switch

Charge lamp
Coolant temp. warning lamp
Oil pressure warning lamp
Buzzer

30 A fuse