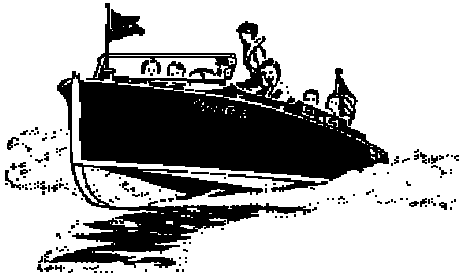

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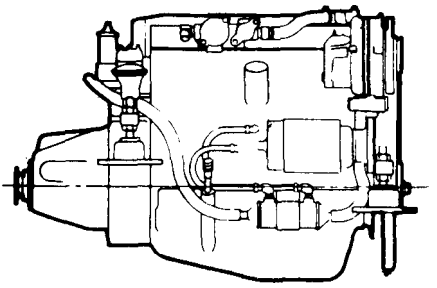
Maintenance Manual

GRAY MARINE®

4 & 6 CYLINDER GASOLINE ENGINES



Form No. 665

MAINTENANCE MANUAL

GRAYMARINE GASOLINE ENGINES

FOUR AND SIX CYLINDER MODELS

Specifications for Current and Non-Current Models

Table of Contents

INTRODUCTION

This pocket-sired hand book is supplied as a service to Gray owners. It is one evidence of our determination to make Gray service the most complete and useful in the industry. It covers both current models and older models.

The scope of this manual is necessarily limited by its size but includes gasoline marine engine operating instructions, trouble shooting guide and directions for making simple adjustments to engine and accessories: such operations as can be done on the engine in the boat.

Note that the section on "Installation" covers only such details as affect the care of the engine.

The intent of the booklet is one of usefulness, and not to encourage tinkering. In the interest of good service, safety and long engine life the manufacturer recommends that major repairs can always best be done by experienced marine service stations with a reputation for competent workmanship and a proper acceptance of the responsibility.

Gray Marine **Engine** Division will **be** glad to recommend the nearest competent marine shop if your boat IS not located near an authorized dealer. Also, remember that carburetors and electric accessories are made by companies with widespread service facilities; consult the classified telephone directory.

Important-When requesting information or when ordering parts—Be sure to state Gray Engine Model and Serial Number.

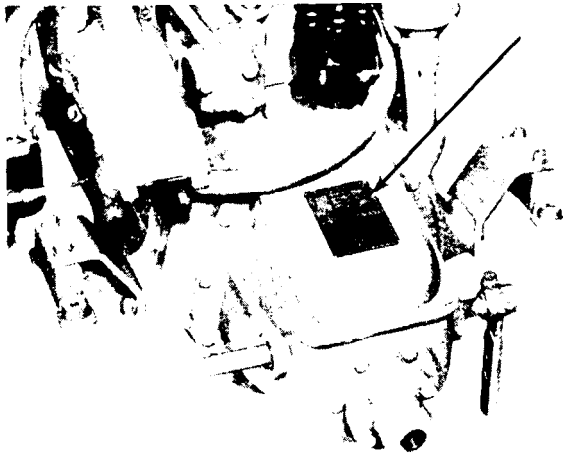


Fig. 1—Engine Model Number and Serial Number are Found on Name Plate Usually Attached to Cover of Clutch Housing, or on Top of Manifold.

MAINTENANCE INSTRUCTIONS

DAILY

- **Ventilate engine compartment thoroughly before starting engine.**
- **Check pump flow by observing water and steam at exhaust outlet, each time engine is started. Do this at once.**
- **Check lubricating oil level in crankcase (engine not running), and when necessary refill to high level mark on depth stick, using S.A.E. 30 oil.**
- **At the same time, check oil level in hydraulic reverse gear. (This applies only to engines so equipped, when reverse gear has a separate oil supply.) Note: if oil needs to be added, look for a leak, because reverse gear normally consumes no oil.**
- **Give grease cups on water pump one-half turn. Use water-proof grease. Do not over grease.**

EVERY 50 HOURS OF OPERATION

- **Inspect sea water strainer.**
- **Check water level in battery. Proper fluid gravity is 1.275.**
- **Put 3 to 5 drops of engine oil (S.A.E. 30) in the oiler on the outside of distributor body; or give grease cup one-half turn. depending on model.**
- **Remove oil from crankcase, using Gray sump pump, and refill with fresh oil, S.A.E. 30, to high mark on oil depth gauge. Note: Before removing old oil. run the engine until it is thoroughly warm.**
- **Put 3 or 4 drops of engine oil (S.A.E. 30) in oiler on generator, and two drops in oiler on cranking motor. (Some models have sealed bearings, so will have no oilers.)**

ONCE A MONTH

- **Inspect and clean Thermogard element. See page 27**
- **Clean sediment bowl on fuel pump.**
- **Check adjustment of clutch and reverse gear. See pages 43 to 52 for directions.**
- **Inspect flame arrester to make sure the air passages are clean and free from oil or lint. If dirty, remove and wash in mineral spirits.**

EVERY 150 HOURS

- **Replace cartridge in lubricating oil filter, if engine is so equipped.**
- **Apply one drop only of light engine oil (S.A.E. 10) to the breaker arm hinge pin in distributor.**
- **Givegrease cup on tachometer drive one** turn. **(Applies only to right angle type mounted on cylinder head.)**
- **Remove the distributor rotor and apply 3 to 5 drops of light engine oil (S.A.E. 10) to the felt in the top of the breaker cam and to the governor weight pivots.**

TWICE A SEASON
"TUNE UP"

- **Clean the engine thoroughly.**
- **Check distributor setting. See page 39.**
- **Check carburetor adjustment. See page 18.**
- **Check engine coupling for misalignment. Tighten lag bolts holding engine to bed.**
- **Check valve tappet adjustment. For correct clearance, see pages S-3, S-4, S-13 and S-15. in center section.**
- **Chock grease in drive** gear **housing of double gear type water pumps. Add bearing grease (EQ-2095) if required.**
- **Remove the distributor head and smear a bit of grease the size of a match head on the lobes of the breaker cam.**
- **Clean and adjust breaker points on distributor. Points should contact evenly, and gap must not exceed .020" or condenser can be burned out. See page 37.**
- **Check spark plugs and set gap, using a round** *wire* **feeler gauge. Clean fouled plugs and search for cause of fouling. Replace crocked** *or* **doubtful plugs. Use plugs of correct heat** range.

KEEP A SERVICE LOG

- **Inspect all wiring for loose connections or** ▪□□■ **insulation. Clean** battery **terminals with soda solution and coat lightly with Vaseline or grease after connection is made.**

EVERY 1000 HOURS
OR ONCE A SEASON

- Change oil in hydraulic reverse gear if engine is so equipped. Use Automatic Transmission Oil Type "A", Suffix "A", (SAE 30 engine oil may be used only in an emergency.) IMPORTANT: after running engine briefly in both forward and reverse, stop engine and recheck transmission oil level. See page 52.
- **Grind and adjust valves.**
- **Check valve stems** ⁄□□ **carbon.**
- **Give engine a thorough going-over.**
- **Clean Oil Cooler.**
- **Clean commutator on generator, using No. 00 sandpaper. Do not use emery cloth.**
- **If compression is weak, look for imperfectly seating valves or rings stuck in groove* on** piston.

EVERY 2500 HOURS

- **Time for a major overhaul.**
- **Install new piston rings. Check piston clearance.**
- **Check bearings. When oil pressure drops below 20 pounds, this is an indication of worn bearings.**

KEEP ENGINE CLEAN

INSTRUCTIONS ON STARTING ENGINE FIRST TIME

BEFORE STARTING THE ENGINE

After the engine has been properly installed ond all controls properly connected. the following instructions are to be carried out before starting a new engine:

1. **Check Fuel Supply:** Be sure the tank is clean, then fill with a good grade of gasoline. Refer to page S-2 in center section for fuel recommendation. Some models require premium ethyl.

2. **Check Lubricating Oil in Crankcase:** Engine is shipped dry from factory with oil drained from the crankcane. Do not fail to check oil level. Fill to the high level notch on oil depth gauge, using a good grade of oil, S.A.E. viscosity No. 30. Lift oil depth gauge during filling to permit escape of air. Note: If engine is equipped with hydraulic reverse gear, check oil depth stick on transmission for separate oil supply, using Automatic Transmission Oil, Type "A", Suffix "A".

3. **Check Lag Bolts** holding engine to bed: must be tight.

   IMPORTANT: If the boat came off a train or truck, or if it has been out of the water for considerable time, check the shaft alignment. (Instructions on page 16.)

4. **Inspect the Engine** for loose nuts or screws. Transportation frequently loosens fastenings on a new engine, on account of gasket shrinkage. After engine has had a preliminary run, take up on cylinder head nuts. See p. 56

5. **Check Storage Battery:** Make sure that storage battery is filled, with water level at least 3/8" above the plates, and fully charged. Proper fluid gravity is 1.275. Low battery will result in slow cranking speed and weak spark.

6. **Check All Electrical Connections** including battery cables. Make sure they are tight, and all connections soldered. (Use rosin flux in soldering.)

7. **Check Water Circulation System:** Open the gate valve on the cooling water intake line. This valve should be located in the bottom of the boat. Caution: if water pump is rubber impeller type, it must be primed at first start of the season.

6. **Check All Controls** to make sure they are working freely with sufficient travel so that they do not strike against woodwork. This refers to choke, throttle and reverse controls.

9. **Safety Precautions:** Check engine compartment and bilge for gasoline fumes. If boat is equipped with ventilating fan, run it for 5 minutes before starting; otherwise open hatch or engine box and let dead air out.

10. **Turn on the Gasoline:** The shut-off cock is properly located near the fuel tank.

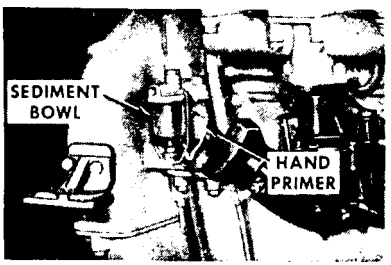


Fig. 2—Fuel Pump Primer

11 **Fill Carburetor:** Use hand primer on fuel pump (Fig. 2 to fill sediment bowl and carburetor. (Note: on some small engines fuel pump does not have hand primer.

12. **Put Clutch in Neutral.**

HOW TO START THE ENGINE

1. **Set the Throttle** above idling position, about 1/4 open.

2. **Pull Out the Choke:** Keep your hand on it for quick adjustment as soon as the engine starts. A marine engine, particularly if it has two carburetors. needs plenty of choke to start.

3. **Turn on Ignition Switch.**

4. **Press Starter Button.**

CAUTION: Do not operate cranking motor longer than 30 seconds. A longer period than **30 seconds** may damage the **solenoid switch** and cranking motor. If ● agiae does not **start,** refer to detailed instructions **on** Page 65.

NOTE: Engines which have been in transit and storage for a period of weeks may start hard the first time. In such case, remove spark plugs and clean the electrodes. While the plugs are out, put a tablespoonful (no more) of light oil, SAE 10. in each cylinder to provide an initial oil seal between piston rings and cylinder walls.

Memo on Flooding: If you flood the engine by too much choking, the correct way to dry it out is to open the throttle wide. Put the choke in the running or non-choking position. Then with ignition on, crank the engine a half dozen times. This draws nothing but air through the carburetor, as the idling jet is out of action at full throttle, and the engine does not revolve fast enough for the main jet to go into action.

OPERATING INSTRUCTIONS

1. To Drive the Boat Forward push operating lever forward until it snaps into a locked position.

2. To **Reverse,** pull lever back as far as it will go. Reduce speed before shifting.

CAUTION: The engine must not be operated unless the cooling water is circulating. See instructions below.

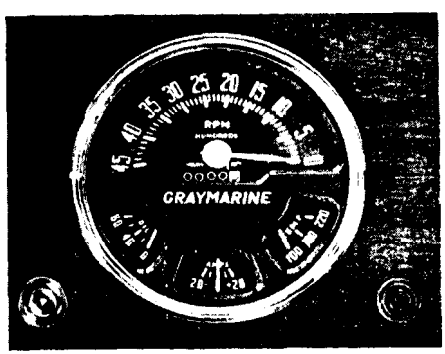


Fig. 3— Gray *Deluxe Instrument* Panel 77800 *(12v)* or 75650 *(6v)* with *Tachometer,* Operating Hours Register, Oil Temperature Gauge, and Ammeter *(panel* calibrated *at* 1796 *rpm)*

AFTER THE ENGINE STARTS

Check Oil Pressure Gauge: Normal oil pressure at operating speeds is 30-40 pounds. An oil pressure of less than 20 pounds calls for investigation (5 to 15 pounds is satisfactory at idle). NOTE: Gauge may show no pressure for a minute or two while the filter is filling with oil.

2. **Check Sea Water Pump.** Circulation should begin within a half minute after engine is started. On Thermogard-equipped models. only a small amount of water sufficient to cool the tailpipe will be expelled, the rest of the water being recirculated until engine warms up.

Neoprene **Impellers** are lubricated by the flow of water. Consequently, never operate a dry pump. Always prime pump if it has become dry after draining or extended idleness.

On bronze gear **pumps** (used on smaller four-cylinder engines) the prime of pump is assisted by sufficient grease sealing the impellers. If pump does not operate immediately, turn grease cup down ½ turn.

NOTE: Pictures of these units shown on Pages 24, 25.

CAUTION : (Applies only to bronze gear pump) :

If **boat is run** in muddy **waters,** the water pump should be **removed** and all old grease in impeller housing thoroughly **cleaned** out at **frequent** intervals. Silt which entered the pump will mix with the **grease and** act **as** a grinding compound. **This can cause** exceptionally rapid wear **on** metal parts.

3. The first time the engine is started, run it at idle for 5 minutes, no longer, then stop engine and recheck oil level in crankcase, and in reverse gear housing when applicable. (Do not check oil level while engine is running.) Oil level may be found low due to the fact that considerable oil is required to fill the oil passages: or it may be found high if depth gauge was not removed for venting air during the initial filling. Bring oil level to high mark on depth gauge.

4. Warm-up **Instructions:** (To be followed every time you start a cold engine.) As **soon** as possible put the clutch lever in forward position and run at fast idle for 10 to 15 minutes. in order to bring the oil up to proper temperature for full throttle work. An indication of warm oil is that the oil pressure will drop off about 5 pounds from what it was when engine was cold.

IMPORTANT: Do not under any circumstances race the engine with clutch disengaged.

FULL THROTTLE OPERATION

1. Recheck the Oil **Pressure as** soon **as** you try out the boat at full speed. If indicating needle on the oil pressure gauge fluctuates wildly, this will indicate either a leak in the oil line, or that the angle of the engine is such that oil pick-up screen is not completely submerged. The remedy for this is to stop engine and add more oil. See Fig. 10, page 21. for an understanding of the relationship between pick-up screen and oil level.

2. **Reduce Engine** Speed When Reversing: Gear should not be reversed at full engine speed except in extreme emergency.

3. Although all Graymarine engines ara thoroughly tested at the factory, good judgment is expected on the warm-up and operation during the early life of the engine. It takes from fifteen to twenty hours run-in to break in an engine for peak performance. On high speed models, oil consumption will be more until the piston rings fit themselves perfectly inside cylinder walls, after a few hours of fast operation.

ADJUSTMENTS ON A NEW ENGINE

1. Propeller Shaft Alignment: If the boat is new. be sure to check the alignment within a few days, after the hull has soaked up some water, because the hull is liable to change its shape slightly, especially when loaded, resulting in binding on the shaft.

2. Carburetors: Careful adjustment is made in the test room. Never re-adjust carburetor unless engine is warm and under full load. Make sure that control extensions permit full travel of throttle and choke levers.

3. Clutch Adjustment: After the first few hours of operation examine the adjustment of manual gear. Clutch lever should stay in either position without being held. It should snap into the forward position and shouldstay in reverse without forcing. (NOTE : This does not apply to some four-cylinder models which have wedge mechanism for reverse position, and must be held in reverse.) For instructions on clutch adjustment, see pages 45 to 52.

Warning: Never operate engine with loose and slipping clutch, because this condition will generate heat by friction, warping and galling the clutch plates, causing permanent damage. Clutch trouble is nearly always due to negligence.

4. After first 10 hours of operation, have the valve tappets readjusted to specified clearance (see center section) by a competent marine service station. This is your responsibility.

5. Valve Sticking: Sometime5 valve5 on new engine5 or those which have been in storage tend to stick. See page 59 for remedy.

FUEL

The Gray Marine Motor Company approve5 the use of high grade gasolines as marketed by reputable refiners. Good, fresh gasoline of the correct octane for the particular model engine should be used; the correct grade for each model

is shown in the data section for current models (page S-2) on tinted paper at center of book. Good gasolines are processed against gum forming tendencies even when subjected to long time storage. Some gasolines form gum deposits rather quickly; these deposits appear as a jelly-like coating within the copper fuel tanks; they are also observed as a whitish precipitate in the fuel lines, also in carburetor float bowls and jets, which deposits impair or restrict fuel flow. This gum-forming tendency with attendant deposit can also contribute to impaired operation of engine intake valves. Where the boat is to be out of commission for 30 days or more. drain the fuel tanks, fuel lines, fuel pump and the carburetor as a precaution against possible gum forming deposits within these parts. Use good gasoline supplied by a reputable fuel marketer, a gasolino of the required octane value am prescribed for your Graymarine engine.

On brand new steel tanks, the first fill of gasoline will often carry off rust-inhibitor coatings, flux and other matter which will be detrimental to the carburetor. Therefore, we suggest the addition of a solvent such as Siloo, Casite, or equivalent, in new tanks.

MOTORBOAT FUELING INSTRUCTIONS

(Issued by the United States Court Guard)

1. Fuel tanks should be properly installed and vented.
2. Fueling should be completed before dark except in
3. Whenever boat is moored at service tation for fueling:
   (a) Do not smoke, strike matches, or throw switchem.
   (b) Stop all engines, motors, fans, and devices liable to produce sparks.
   (c) Put out all lights and galley fires.
4. Before starting to fuel:
   (a) See that boat is moored securely.
   (b) Close all ports. windows, doors and hatohr.
   (c) Ascertain definitely how much additional fuel the tanks will hold.
5. During fueling :
   (a) Keep nozzle of hose or can in contact with fill opening to guard againmt ponible static spark.
   (b) See that no fuel spills got into hull or bilges.
6. After fueling is completed :
   (a) Close fill openingm.
   (b) Wipe up all spilled fuel.
   (c) Open all ports, windows, doors and hatches.
   (d) Permit boat to ventilate for at least 5 minutes.
   (e) See that there is no odor of gasoline in the ngtne room or below decks before tartfng machinery or lighting fire.
   (f) Be prepared to cast off moorings as soon as engine tartm.

ENGINE INSTALLATION

Proper installation is a condition of the Gray Warranty. This brief section is included to give emphasis to some essential details, because a high percentage of service troubles are caused by faulty installation.

1. **Moving the Engine:** The engine is fitted with either one or two lifting rings designed to carry the full weight of the engine, therefore auxiliary slings are not required or desired. Never try to put a sling around the engine, as this will not hold the engine safely, and may damage accessories.

2. Engine **Bed:** This should always be of sufficiently heavy section to insure rigidity, and well secured to the hull. Maximum operating angle of the engine at full speed, as mounted on this bed should not exceed 16 degrees from water level, because at a higher angle the lubricating oil pick-up screen may not be fully submerged (see Fig. 10, page 21). Remember that the angle may increase if the boat is loaded deeply at the stern and the bow is light and high.

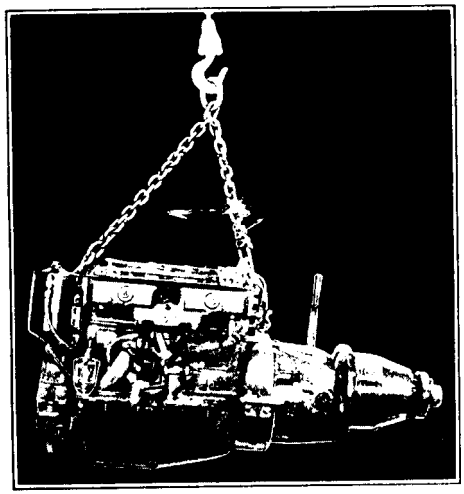


Fig. 4—Use Lifting Rings to Prevent Damage to Engine (Four-162 illustrated)

3. **Exhaust** Piping: This must never be reduced in size at any point smaller than the flange size supplied on exhaust manifold. It may be increased in size. Use standard pipe and fittings only, or tubing of equal or larger inside diameter than the corresponding iron pipe sire. Do not use "street ells" for connections (see Fig. 5). No bends should be more than 45°, and all exhaust exits must be above water line. For most installations, all of the discharged cooling water can be carried by the tailpipe., Water MUST enter exhaust pipe at a point lower than exhaust manifold, preferably 6 to 8 inches from flange, so that there will be no danger of any water getting back through the exhaust valves, regardless of boat's pitch. Water stream should enter exhaust flow diagonally; not at right angle. We recommend the use of a Graymarine water-cooled elbow at this point, available in sizes to fit all engine models. (See diagram next page).

4. **Water Piping:** Use standard pipe and fittings only, eliminating all "street ells" which impose a restriction on the flow (refer to Fig. 5). Connect sections with hose over pipe and hose clamps for vibration joints. IMPORTANT: Intake piping to water pump should never be smaller than the I.P.S. of intake fitting on pump. We recommend using nest pipe size larger than intake of pump for free flow. Avoid sharp bends.

5. **Water Intake Scoop:** Through-hull fitting should always be one size larger than the pump intake sire. Locate the scoop so that the intake pipe to pump will be as short and straight as possible. Bends reduce flow and add to load on pump.

6. **Sea Cock:** A gate valve in water intake pipe is desirable but not essential. It must be of free tlow type and of sufficient size to prevent any restriction to flow.

7. **Check Valve in Water Intake Line:** When this is an item of the installation use valve one size larger than intake pipe size, reducing to intake pipe size with bushings, to provide adequate flow area.

8. Water **Recirculation Line:** All current models of engines up to and including those with piston displacement of 226 cu. in. use a dual unit Thermogard temperature control system with choke-type thermostat at the outlet to overflow line, and a pressure valve at the outlet for the recirculation line, piping for which is shown in Fig. 4h. Larger engines use a single unit Thermogard valve, shown in Fig. 17, to be piped as shown in Fig. 5. In both types note that the T-fitting for recirculation line MUST be located below the load-water-line of boat. It is important that no restrictions of any kind exist in the recirculation line or the overflow line. Neither must be smaller than pump intake size.

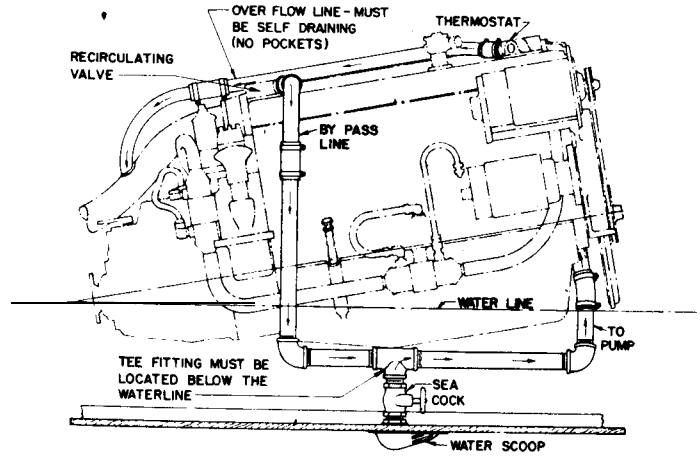


Fig. 4A—Piping Diagram for Engines with Dual Unit Thermogard. Pipe size for all external lines must never be smaller than the pump intake size

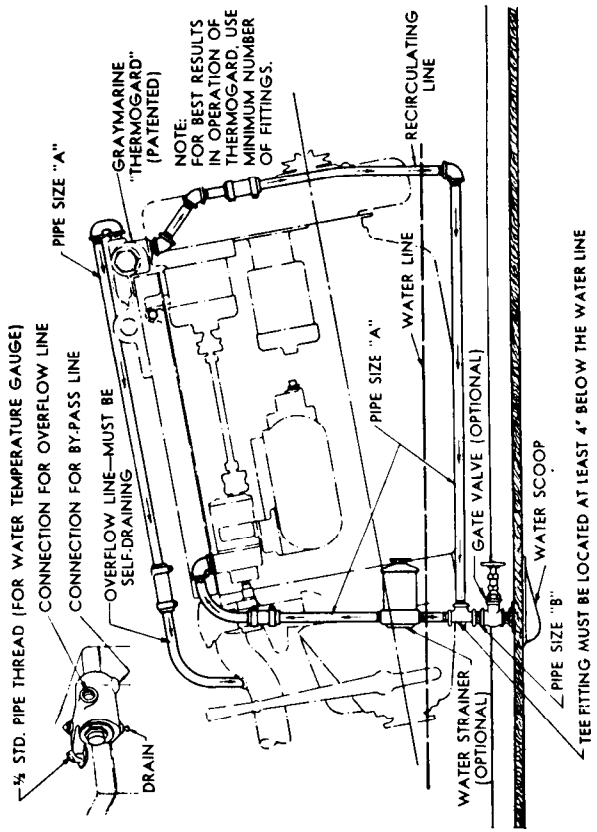


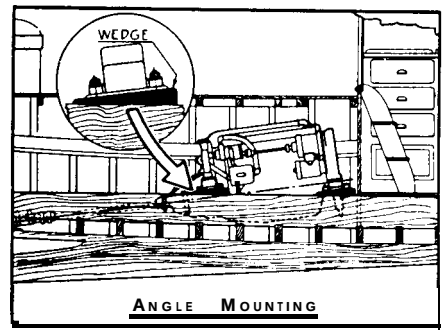
Fig. 5—Piping Diagram with "Thermogard". Pipe Size "A"-not smaller than pump ***intake*** size. ***Pipe Size "B"-one size*** larger ***than pump size.***

9. Fresh Water Cooling **System:** For engines with this equipment, we insist upon use of a heat exchanger unit approved for adequate size and proper design. Units supplied by Gray Marine Motor Company will give perfect service because they are engineered to fit the engine. CAUTION: Remove ⅛" pipe plug vent, in pump-to-manifold pipe, when filling the system with coolant. See pages 23-30.

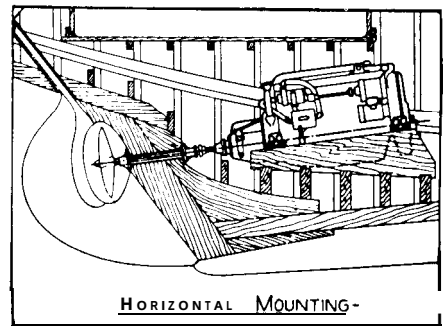
10. **Fuel Tubing:** Size must not be smaller than the size indicated by the tube nut on fuel pump fitting supplied with engine. A flexible section of sufficient size is desirable between the fuel line and fuel pump, or a loop in the tubing may be provided to prevent breakage due to vibration and strains.

Note: On twin engine installations, if you do not have two gas tanks, be sure to run a separate line from the tank to each engine-not through a header line.

11. **Oil Pressure Tube** to oil pressure gauge on instrument panel is connected to a brass fitting on carburetor side of cylinder block. Use ⅛" tubing, anchored with tape to prevent chafing, and with a loop in the tubing at engine end to prevent metal fatigue from normal engine movement. On rubber mounted engines, use flexible tubing or a flexible section at engine end.



—for installation on level engine girders, as in a typical cruiser or runabout Rubber mounts shown here, with aligning wedges.



-for installation on ***sloping engine*** beds, as shown ***here*** using solid mounts ***and*** aligning ***shims*** in ***a*** typical auxiliary. Similar ***conditions in many cruisers.***

Fig. ***6—Engine*** Mounts

12. **Thermo Switch** (supplied with Instrument Panels #75650, #77800. To install this, remove pipe plug from ½" I.P.S. threaded hole at front end of cylinder head. Insert thermo-switch element, and connect with single wire to instrument panel. See Wiring Diagram, page S-6.

13. **Tachometer Cable** (supplied only with instrument panel). Connect from instrument panel to fitting on side of reverse gear housing on most models. Note: on some models this connection is located in center of cylinder head.

14. **Electrical Connections:** Follow wiring diagram to conform to type of generator on engine (pgs. S-6-S-1 1) and use wire sizes no smaller than those 'indicated. Solder all connections. Locate battery as close to engine as possible, with short cable, not smaller than No. 0. For ground connections, see page S-5.

15. **Voltage Regulator** (supplied for engines with constant-voltage generator.) This should conform to ground polarity (see page S-5). After wiring is completed, repolarize the generator (instructions are on page S-8). NEVER polarize an alternator.

16. **Propeller Size:** Final selection of propeller should be size which will permit the engine to turn close to its maximum rated rpm. Tables of suggested propeller sizes are on pages 74-75.

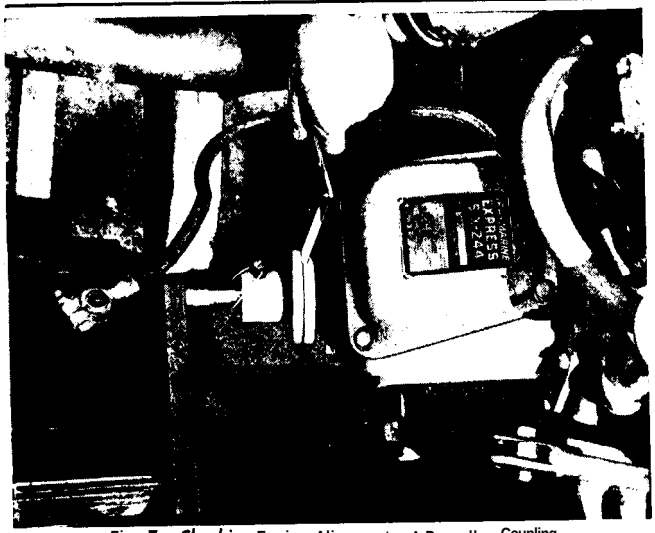


Fig. 7—Checking Engine Alignment at Propeller Coupling

17. Engine Alignment: Remove all the bolts from the coupling flanges, then rotate the shaft 360 degrees, or one complete turn, inspecting for gap with a feeler gauge. For satisfactory alignment the faces of the coupling halves should be exactly parallel, so that a .003" gauge cannot be inserted at any point (Fig. 7). After the first trial run of boat, recheck alignment as above.

18. **Installation Angle-Vee Drive, etc.:** If engine is to be used with Vee Drive gear, or otherwise installed in a horizontal position, special oil depth gauge and external oil line to clutch bearing are required. Refer to Vee Drive, page 55.

FUEL SYSTEM

Description: Fuel system properly includes fuel tank, fuel lines, fuel strainer, fuel pump, carburetor and flame arrester, choke and throttle controls, and intake manifold. Fuel stored in fuel tank flows through fuel strainer into fuel pump. Pump forces fuel, as required, into carburetor. There it is atomized and mixed with air drawn through intake manifold and valves into combustion chamber by vacuum caused by downward stroke of pistons.

Fuel Strainer: We recommend installation of an edge-type or ceramic fuel strainer between the shut-off valve and the engine.

Puel Pump: This is of the diaphragm type and is mechanically operated from an eccentric on camshaft. On most models pump is also equipped with a special hand-operated lever, which is useful in filling the carburetor when first starting up the engine, or after the tank has run out of fuel, or after the carburetor bowl has been emptied for any reason.

Note: If no stroke can be obtained on hand lever, crank engine over one revolution to change the relative position of operating arm to cam. Diaphragm is composed of several layers of specially treated cloth, which is impervious to gasoline.

Service—Fuel Pump: If pump fails to function properly, make sure that suction valve and pressure valve (N and 0 in Fig. 8) are seating properly. Each valve assembly is a self-contained

unit made up of a valve cage, a small fiber valve and a light coil spring. Valve assemblies are held in place by a retainer plug permitting easy removal. Note that on some models the retainer plug on the pressure valve is different from the one on suction valve, having an expansion chamber. In reassembling, use care to install the plug with ● xpantion dome in its correct place, over pressure valve, otherwise pump will not operate properly at high rpeed. Particular attention should be paid to the fuel pump valves if fuel pump does not function properly after the engine has been out of operation for any extended period. Remove retainer cap, taking care not to lore the rmall spring, and probe the fiber disc to make sure it is clean and loose so that it can move freely off the seat. A sticking pump valve, caused by gum deposit from dale gasoline, is nometimes found when engine har been out of service. When thin condition is found, it is necessary to clean and polish the valve discs thoroughly, valve chambers and valve seats. Valves mud be flat; a warped valve should be replaced. Use a new gasket under cap if necessary.

Another possible cause of pump trouble is a broken or punctured diaphragm. Only a slight movement of the diaphragm is required

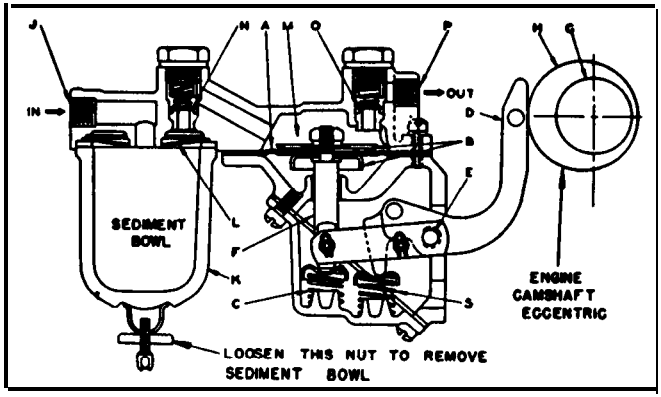


Fig. 8—Typical Fuel Pump Assembly

By revolving shaft (G) the eccentric (H) will lift rocker arm (D) which is pivoted at (E) and which pulls the pull rod (F) together with diaphragm (A) held between metal discs (B) downward against spring pressure (C) thus creating a vacuum in pump chamber (M).

Fuel from the *tank* will enter at (J) into sediment *bowl (K) and through* strainer (L) and suction valve (N) into pump chamber (M). On the return stroke, spring pressure (C) pushes diaphragm (A) upward, forcing fuel from chamber (M) through pressure valve (0) and opening (P) into the *carburetor.*

When tk carburetor bowl is filled the float in the float chamber will shut off tk inlet needle valve, thus creating a pressure in pump chamber (M). This pressure will hold diaphragm (A) downward against tk spring pressure (C) where *it will remain inoperative until the carburetor requires further fuel and tk needle valve opens.*

Spring (S) is merely for the purpose of keeping rocker arm (D) in constant *contact* with eccentric (H) to eliminate noise.

to handle the fuel supply to carburetor, and due to the extreme flexibility of the material, the diaphragm seldom fails from any cause other than age and drying. To replace diaphragm, first file-mark cover position on body, then remove screws from top cover, and remove diaphragm nut and retainer disc: diaphragm may then be lifted out. Replace with a new one and reassemble.

IMPORTANT: When reassembling, depress operating lever and hold while tightening screws. A leaky diaphragm permits gasoline to be drawn into the crankcase through the rocker arm opening, and will dilute the lubricating oil.

Sediment Bowl: Fuel pump, except on smaller four-cylinder engines, has a surge chamber, making it a simple matter to detect the presence of sediment in fuel pump. Bowl and screen should be checked and cleaned periodically. When engine falters-runs irregularly-stops when there is ample fuel in the tank, the first thing to look for is dirt in the sediment bowl.

In replacing the sediment bowl, make sure the cork gasket is in good condition and properly seated. If gasket is dry, a little film of grease on it will help to maintain the seal. Pump will not function if it is leaking air at any point. Don't use pliers on retainer nut or you may break the bowl.

CARBURETOR: The first rule on carburetors is: LET IT ALONE. Every carburetor is tested by the manufacturer, then given final adjustment under load at the Gray test room. Unless the boat is being operated in an altitude above 2000 feet, no readjustment should be necessary. The greatest enemy is dirt, and a good deal of carburetor trouble can be eliminated by installing a good fuel filter between the gasoline tank and the engine, and of course servicing the filter periodically. The metal screen on the fuel pump bowl is not fine enough to filter out all of the foreign matter

Main Jet Adjwtment: This adjustment can occasionally get upset, from vibration, tinkering, or the necessity of removing the needle valve to free a small particle of foreign matter. The packing gland nut should be loosened enough to permit turning the adjusting screw with thumb and forefinger. NEVER USE PLIERS. First, turn in the Main Jet Adjustment (2 in Fig. 9) as far as it will **go without forcing;** then turn out the number of turns recommended in the "Adjustment Data" on pp. S-3, S-4, S- 13 and S- 15. Final main jet adjustment must be made at full throttle under load after engine has been thoroughly warmed up. Turn in adjustment screw until engine loses speed. Then open adjustment to point where tachometer fails to advance, plus an extra quarter turn to keep from having too lean a mixture. Retighten packing gland nut to prevent adjustment from vibrating loose. Always check distributor timing after altering carburetor adjustment.

Idling Adjustment: The Throttle Stop Screw (5 in Fig. 9) prevents the throttle plate from being closed to the point where the engine might stall under load. Follow recommendations in "Adjustment Data" section for minimum idling speed according to engine model. The approximate setting of the Idling Needle Valve (3 in Fig. 9) is also given under "Adjustment Data," pp. S-3, S-4.

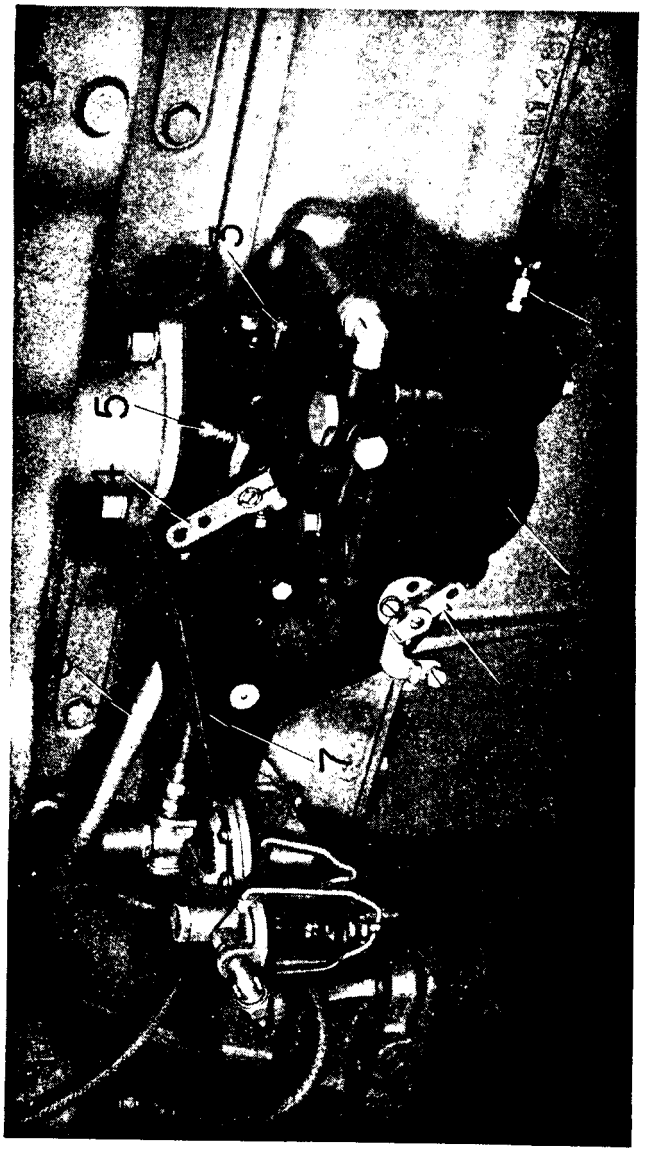


Fig. 9—Points of Adjustment on an Updraft Carburetor

1. Carburetor Body
2. Main Jet Adjustment
3. Idling Needle Valve
4. Throttle Lever
5. Throttle stop screw
6. Choke Lever
7. Flame Arrestor
8. Valve Chamber Breather Tube

S-l 1, and S-13. Make final setting with engine under load at minimum idling speed, Turn idling needle valve gradually in or out until the engine runs steadily and as fast as closed throttle position will permit.

Choke: The remote linkage from operator's station must allow a full closing of the choke lever (6 in Fig, 9). Because a marine manifold will condense a high percentage of gasoline out of the vapor on a cold start, the choke valve is used much more on a marine engine than on an automobile engine.

Dual Carburetors: Improper linkage is the most frequent cause of trouble on multiple carburetor installations. Throttle and choke levers must work in unison. When a two-carburetor engine is difficult to start, it usually means that the choke butterfly valves are not parallel. Priming with gasoline is a source of danger and is never necessary provided **both** chokes can be completely closed.

Flame Arrester: The flame arrester is mounted on the air intake horn of carburetor, which is held in place by a set screw. It consists of a grid of closely set brass louvers which permit air to pass freely through into the carburetor, but any flame passing in the opposite direction is instantaneously quenched, It thus performs two functions: (1) strainer for air supply to carburetor, (2) backfire trap. Never attempt to start engine without flame arrester in place.

It is important that the flame arrester should be kept clean because obstructions in the carburetor air inlet will decrease power and increase fuel consumption. At least once a month, the flame arrester should be inspected to make sure the air passages are clean and free from oil or lint. If dirty, remove and wash in kerosene. Blow out with compressed air if available.

Causes of back-firing include too lean a fuel adjustment on carburetor, obstruction in fuel line, dirt in intake screen on fuel pump, or spark set too late. "Popping back" through the carburetor usually indicates insufficient fuel from some cause, and the condition should be corrected at once, not only because of the fire hazard, but because weak mixtures tend to run very hot exhaust temperatures which will burn and pit the valves.

The valve chamber breather tube (8 in Fig. 9) should terminate ½" to ¾" from the flame arrester; if gap is too close, the carburetor will suck oil out of crankcase.

LUBRICATING SYSTEM

General Description: Lubrication of the entire engine except. ing the accessories mounted on outside of cylinder block is maintained by a positively driven gear pump located in crankcase, as shown in Fig. 10. The intake screen, which is at all times submerged in oil, picks up oil in volume proportionate to the speed of the engine, and the pump forces it through a cooler and delivers it under pressure to on oil gallery line within the cylinder block, whence it is distributed to crankshaft, camshaft, connecting

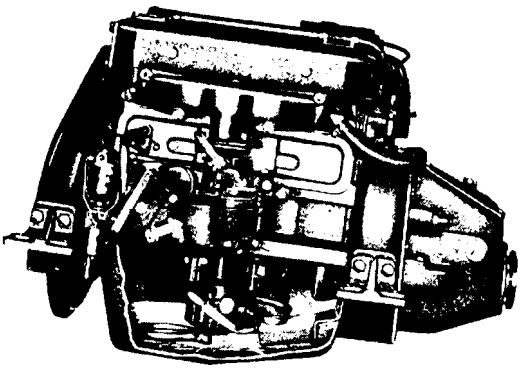


Fig. 10—Oil Level Must be Kept Above Pick-up Screen (Four-75, Illustrated)

rods, clutch and reverse gear, reduction gear, etc. all the internal parts of the engine.

Service: In general, the pressure lubricating system requires no attention other than maintaining the oil level at all times up to the full mark on oil depth gauge, using a good grade of S.A.E. 30 oil, and changing the oil every 50 hours of operation as specified under "Maintenance" The manual type reverse gear unit is on the engine's pressure system and requires no special attention. For lubrication of hydraulic clutch, see page 54. The accessories are separately lubricated and should be given periodic attention as specified in the schedule on pages 3 to 5.

OIL CHANGE

The importance of a periodic oil change must be appreciated by every boat operator if he expects to get satisfactory performance from his engine. We recommend SO hours of running between oil changes under average conditions. Remember that a marine engine is working against a constant load 100% of the time (compared to an automobile engine, which is substantially assisted by momentum) and often runs hour after hour at top speed. This means that oxidation and acid formation occur more rapidly in a marine engine. Engine should be warmed thoroughly before oil is changed. NOTE: Sump pump hose fits over, not into, oil dip stick tube (see Fig. 11).

When using the sump pump to remove old oil from the engine, it is advisable, when engine is on an angle, to remove clutch housing cover and pump oil from bottom of housing also.

Oil **Filter:** Supplied as standard equipment on some models, available on all. This requires attention periodically, and the cartridge should be changed every 150 hours of operation. Remember that when the filtering element is filled with accumulated sediment it no longer functions as a filter, as the oil thereafter by-passes it

Fig. 11—Use of Sump Pump

An Oil Filter is Not a Substitute for an Oil Change. h filter can remove impurities but it cannot add to the oil those factors which normal usage takes out. By eliminating grit and other harmful foreign matter, an oil filter prolongs the life of bearings, journals and other moving parts, but it does not have any effect on normal oxidization.

Always buy a marine-type oil mode by anv of the reputable refineries, and follow the viscosity recommendation on the clutch housing cover. An oil of lower viscosity may be substituted in cold weather to make starting easier.

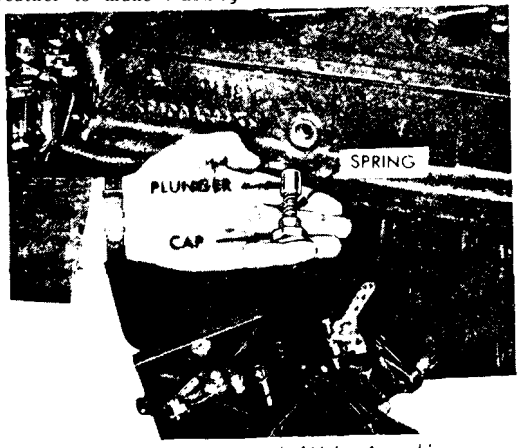


Fig. 12—Oil Pressure Relief Valve Assembly

Use of Special Brand Oils: W hen using detergent oil, follow the refiner's directions carefully See page 59 "Valve Sticking." Never mix special brands and never put detergent oil into an engine with an accumulation of carbon or sludge

Oil Pressure: A spring-loaded by-pass valve (Fig. 12) controls the pressure at high speeds and when the oil is heavy and sluggish during cold weather starting. Normal oil pressure at operating speeds is 30-40 lbs An oil pressure of less than 20 lbs. usually indicates worn bearings. (5 to 15 lbs. is satisfactory at idle.)

To increase oil pressure remove large hex-head cap to relief valve chamber (Fig. 12), located on the side of the cylinder block, and increase the tension on the spring by placing a washer behind it: this will increase the oil pressure. At the same time, clean the spring and plunger thoroughly, because the plunger may stick in the bore if it does not have a polished surface.

Function of the oil circulation system is not only to lubricate but also to cool the bearing surfaces.

Excess sludge is an indication of engine running too cold or of a water leak. If there is an accumulation of sludge, the engine should be removed from the boat and the oil pan thoroughly cleaned. Sludge will plug the oil pick-up screen, causing possible failure of pressure lubrication system. Never use a brush when cleaning the screen as it will cause some of the grit and other damaging material to be forced into the lubricating system.

COOLING SYSTEM

Running without water can damage an engine as quickly as running without oil. Operation of the sea water pump rhould always be checked first thing after starting the engine. Observe temperature gauge (or overheat flasher) in instrument panel. If excess heat is noted after starting, shut off engine immediately, and investigate flow through pump.

Note: There is no cause for alarm if water temperature gauge indicates high temperature immediately after turning off an engine. This is caused merely by the residual heat from the engine after water circulation is stopped.

Graymarine engines have direct sea-water cooling as standard equipment. Gray factory-installed indirect fresh-water cooling is available on almost all models.

Direct Type: This consists of a positive displacement type pump, oil cooler (on most models), water jackets for each cylinder, cylinder head and manifold, plus intermediate fittings and connections. The smaller fours may be equipped with a thermostat, extra. Many larger engine models have the "Thermogard" automatic heat regulator as standard equipment; available extra on others. Inlet and outlet lines are supplied by the boat builder according to installation specifications. We recommend the installation of a gate valve at intake. When boat is to be operated in water containing sand, silt, seaweed, etc., installation of a sea water strainer will prolong the life of the pump and keep oil cooler and water jackets clean. A sea water strainer is desirable for engines equipped, with "Thermogarcf". Water-cooled exhaust elbow, designed, manufactured and patented by Graymarine, is now available for all models.

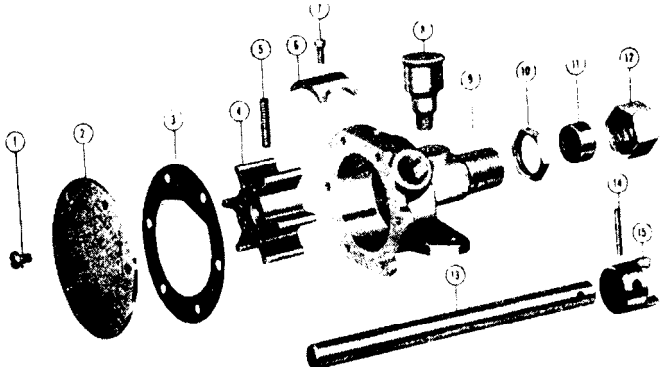


Fig. 13—Water Pump-standard Single Neoprene Impeller Type

WATER PIPE SIZES

Intake: The water intake scoop, the through-hull fitting and the pipe to water pump should all be one **size larger** than pump intake size (Fig. 5, page 14). Note: on some models this is taken care of by a pipe-to-hose elbow at pump inlet. If hose is used from scoop to pump, it should be non-collapsible type.

Outlet: Water outlet pipe to exhaust pipe (or Gray Water-Cooled Exhaust Elbow) should be the **same size** as water pump intake, no smaller.

Do not use street elbows or other restrictive fittings in cooling system. Remember that a single restricted connection or street elbow will cause as much damage as if the entire pipe installation were undersize.

SEA **WATER PUMP-Standard Single Neoprene Impeller Types:** Shown in Figs, 13, 15. Self-priming, single neoprene rubber impeller, with concentric location of shaft and impeller Flexible impeller rotates against inclined cam plate pumping water under pressure to outlet

Slotted holes in the pump mounting bracket permit accurate alignment of pump to generator to minimize bearing wear and to insure quiet operation; realign pump if tension on generator belt is changed.

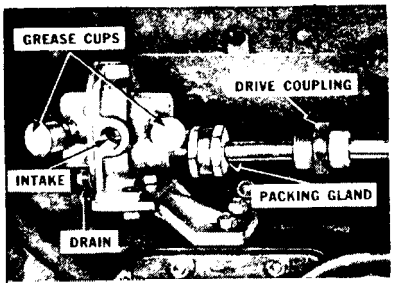


Fig. 14—Water Pump-Bronze Gear Type (not current)

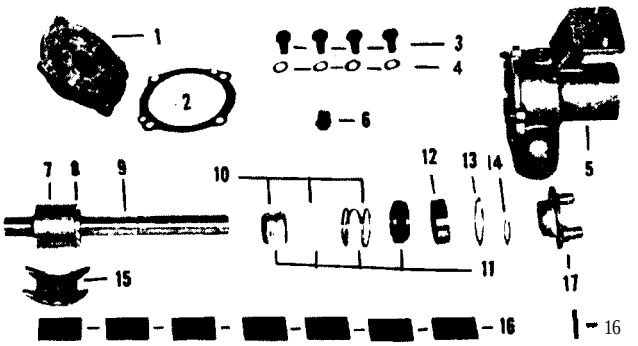


Fig. 15—Water Pump—Standard Single Neoprene Impeller Type (Sherwood)

CAUTION: Drain plugs are sealed with sealing compound at factory. If removed, use a box or socket wrench; then replace seal tight. An air leak at this point may seriously affect pump's performance.

Pumps are equipped either with mechanical seal or packing gland. On the latter a slight water leak may develop at drive shaft as normal wear occurs. Take up on packing gland nut just enough to stop the leak--too tight gland adjustment causes excess wear.

Lubrication: When impeller bearings are lubricated by grease cups, they should be filled with waterproof grease, and given a half turn daily.

SEA **WATER PUMP-Bronze Gear Type:** (not current) Shown in Fig. 14. Slotted holes in the pump mounting bracket permit accurate alignment of pump to generator to minimize bearing wear and to insure quiet pperation; realign pump if tension on generator belt is changed. Flexible couplings permit pump to run freely regardless of minor misalignment with generator, which is unimportant. If pump does not pick up its prime on starting, give grease cup an extra turn and do this at once. Do not use excess grease as it will combine with dirt particles to form harmful abrasive compound; and grease carried into the water line may clog oil cooler.

Lubrication: Fill grease cups with good waterproof grease only, A half-turn once a week is sufficient on a new pump, but this should be done more frequently as wear occurs.

Pump Replacement: Whenever the water pump is in worn condition from abrasion, and persistently fails to pick up its prime, it should be replaced to prevent damage to the engine from over-heating. Although bronze gear type of water Pump is no longer used on current engines. replacement pumps ore available from Service Parts Dept. and Graymarine distributors carry them in stock.

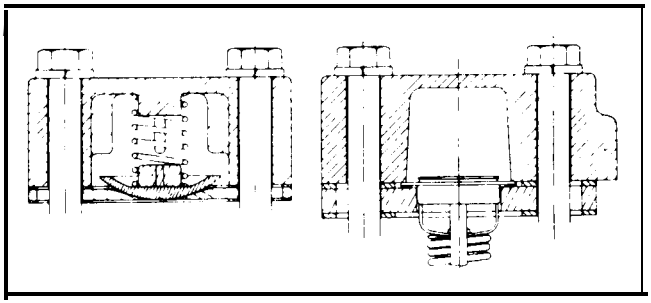


Fig. 16—Pressure Valve (left) and Thermostat (right) as used on Dual Unit Thermogard Temperature Control System

OIL COOLER: The engine oil cooler receives the full flow of water from the sea water pump. It performs the dual function of protecting the bearings by cooling the oil, and it also preheats cold sea water before it enters the cylinder block. On current models a tubular type is standard. On some models a plate type unit was used. A separate oil cooler is also supplied on Warner hydraulic transmission.

Service: Oil cooler should be checked periodically for pressure leaks, and the internal passages should be kept clean and free from obstructions.

On small four-cylinder models not equipped with an oil cooler or temperature control system, water is circulated from the sea water pump to the exhaust manifold jacket, where it acquires heat, and from there it is piped to the rear end of the cylinder block. From the block it rises by convection and pressure through passages at the gasket surface into the cylinder head. The outlet overboard is taken from the high end of the cylinder head.

"THERMOGARD" TEMPERATURE CONTROL: This is a thermostatically controlled recirculating system introduced by Gray in 1946 and now standard equipment on 6-cylinder engines, also available on all of the 4-cylinder models. Engines up to and including those with piston displacement of 226 cu. in. now use a dual unit system with choke-type thermostat at the overflow line, and a pressure valve at the recirculation line, shown in Fig. 16. Larger engines use a single unit Thermogard valve, shown in Fig. 17. Piping diagrams are shown on pages 13 and 14.

Service-Dual Unit Thermogard: If the engine runs too hot, first check the water pump and drive belt, then next remove the housing of the pressure valve, to which the recirculation line is connected, to inspect condition of pressure valve and its nylon seat. Look for dirt or some foreign object which may have jammed it. If engine runs too cold, remove the thermostat housing, located at front end of cylinder head, to check thermostat valve and its nylon seat, Clean thoroughly, Thermostat may be tested by putting it in hot water. If movement of its piston cannot be observed visually, replace it.

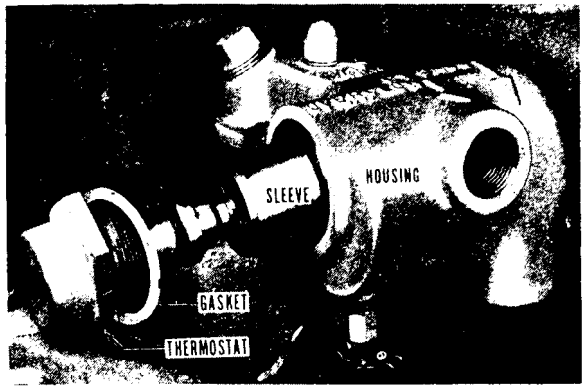


Fig. *17—Single Thermogard,* Showing *Element* Removed from Housing

Service-Single Unit Thermogard: Satisfactory operation of this unit depends on two things-connecting water lines installed precisely in accordance with directions in Fig. 5, pg. 14, and freedom from dirt. If the plunger of thermostat assembly sticks, the engine will probably run too hot. Therefore, inspect this plunger periodically by unscrewing the large hex nut, which permits removal of the element, as shown in Fig. 17. This should be done weekly in sandy water, monthly in salt water, and once a season in fresh water. Remove all dirt deposits from housing, and clean plunger with fine emery paper if required.

IMPORTANT: When replacing unit in housing, hex nut must be tightened snugly, because a loose nut will increase temperature.

Adjustment to Meet Special Operating Conditions: The controlled temperature in the engine's water jackets can be readily reduced or increased simply by making an adjustment on the thermostat sleeve. The sleeve is secured to the thermodat by a lock nut, With the thermostat facing you loosen the lock nut-turning the sleeve counter-clockwise has the effect of decreasing the engine's temperature. On the other hand if it is desired to increase the engine's temperature, turn the sleeve clockwise. Very small movement is required. A change of ,020" in endwise movement is sufficient.

Water Jacketing and Core Plugs: The main water-jacketed areas of the engine include the cylinder block, head, exhaust manifold, and on some models intake manifold. In these cored castings holes must be provided for the foundry to remove the cores, after which these holes are bored and sealed with core plugs. The core plugs are of various sizes, made of stainless steel, and either dish-shaped (so-called Welch plugs) or cup-shaped. They are a drive fit in the bore through the casting wall.

SERVICE-CORE PLUGS: These should be inspected at overhaul time for signs of leaking or corrosion. This is especially important in salt water operation.

To remove a loose core plug, bend it inward at the center with a piercing punch and hammer. This will bend the lip away from the bore and the plug can then be pried out. This operation is easily done but care should be taken not to crack the casting wall. If the plug appears likely to push through into the water jacket, it may be drilled and removed with a puller.

To install new plug, first clean the bore thorouyhly, apply sealing compound, and drive the plug in place using a driver of brass or hard wood. In ordering new core plugs always specify engine serial number, to make sure of getting correct size and type.

Draining Water Jackets: In cold weather, when operating in fresh water, cylinder block should be drained when engine is out of service to prevent freezing. Gray engines have drain plugs on cylinder block, on oil cooler, on water pump, on Thermogard. Prodding the drain holes with a piece of wire will make sure they are fully open and not clogged with sediment. Note also that some engines with hydraulic reverse gear have water-jacketed housing on the reverse gear, In freezing weather it is important to remove drain plug at bottom of housing to prevent fracture of the housing.

FRESH WATER COOLING SYSTEM: Graymarine has in the past supplied many 4 and 6 cylinder engines with factory-installed fresh water cooling system, using centrifugal pump as illustrated in Fig. 19, but this is not being listed for current models for the reason that satisfactory equipment is available from manufacturers specializing in fresh water cooling kits. These are sold and installed by most Graymarine dealers.

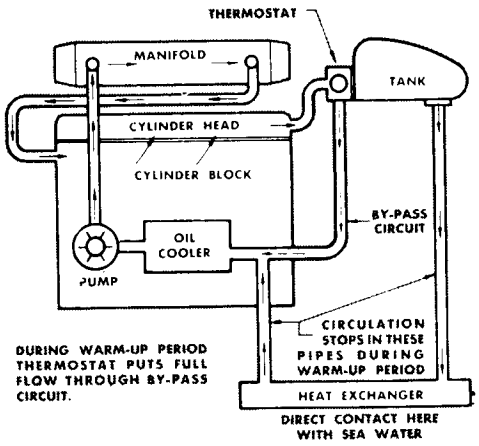


Fig. 18—Diagram of Indirect Cooling System

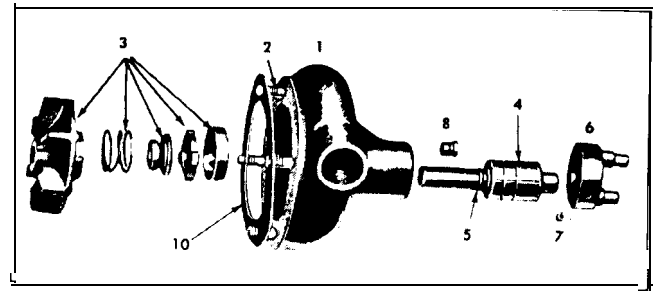


Fig. 19—Centrifugal Pump, Used with Indirect Cooling System

1. Pump Housing
2. Stud
3. Impeller Assembly
4. Shaft and Bearing
5. Snap Ring
6. Drive Coupling
7. Coupling Lock Screw
8. Drain Plug
10. Gasket

Heat Exchanger:

The heat exchanger may be either outboard type (Keel Kooler) or inboard type. and the latter may be either plate type or tubular type. A zinc electrode is usually provided in the heat exchanger to prevent electrolysis. This should be inspected periodically. and replaced when it becomes deteriorated. Whenever fresh water cooling system is used. a small auxiliary pump must be provided to cool the engine's exhaust line.

Any ethylene-glycol base anti-freeze solution can be used satisfactorily in a closed type cooling system for marine service. Do not use alcohol for the anti-freeze solution, because this can be vaporized. constituting a hazard in confined spaces.

Warning: We caution against the use of "home-made" fresh water cooling systems because the water pump on a standard engine has inadequate capacity for this type of service. and an incorrect installation can void the engine warranty. Reputable manufacturers of such equipment furnish water pump and heat exchanger of adequate capacity. and with proper installation instructions.

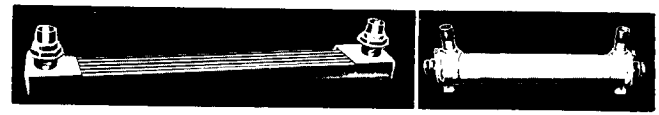


Fig. 20—Outboard type (left) and Inboard type Heat Exchangers

ELECTRICAL SYSTEM

Description: Older models used 6-volt electrical system with third-brush type 13-ampere generator. or 20-ampere constant-voltage generator. All Graymarine gasoline engines in current production have 12-volt electrical equipment as standard. Nearly all current models are equipped with 40-ampere marine-type alternator, as shown in Fig. 23.

Because of the wide variety of available electrical equipment, it is important to use the correct wiring diagram, and these are identified under the heading of "Data on Generators and Regulators" on page S-5 of the center section of this book. Some circuits have positive ground, some must have negative ground, and there are some which may use either positive or negative ground

The recommended spark plugs will be found listed on pages S-3, S-4, S-13 and S-l 5 of center section.

In the maintenance of the electrical system, the most important single factor is to keep all connections tight and clean. Loose or corroded connections will cause run-down batteries, weak spark and hard starting. Regular inspection of all electrical connections is the best safeguard against failures in the electrical system.

Battery Maintenance: Battery should be inspected and checked at least once a month, or every SO hours of running. Keep the battery terminals clean and tight, and well smeared with vaseline or light grease to prevent corrosion. Vaseline should be put on outside of battery posts after cables are connected, as vaseline is a non-conductor.

Add pure water (preferably distilled) to each cell until water level is approximately 3/8" above plates. If impossible to obtain distilled water, use rain water. Do not overfill cells, and be sure the vents are kept open in filler caps. These are for the escape of gas from the electrochemical action.

ALTERNATOR

This is now standard generator on all current models. It has sealed bearings and requires no lubrication attention. Wiring diagram is on page S-l 1 at center of book. Ground is negative.

Note: If center terminal of the regulator is not used in the installation, be sure the center terminal is tightened down, because if this vibrates loose, the clip may touch the regulator cover and cause a short.

Caution: In case of a run-down battery, always use extreme care in starting an engine equipped with alternator. by use of jumper leads from a dockside battery. I! the wrong polarity is applied, the rectifier cells in the alternator will instantly burn out.

GENERATOR

On all older models of Graymarine 4 and 6-cylinder engines, and on some current models, the generator is direct-coupled to the sea water pump as illustrated in Fig. 21. In another accessory arrangement, as used on other current models, the generator and water pump are independently driven, as shown in Fig. 22.

Wiring diagrams with the various types of Gray instrument panels will be found in the center section of this book. Identification of generators and regulators used on Graymarine engines will be found on page S-5 of center section Directions for repolarizing of generator will be found on page S-8.

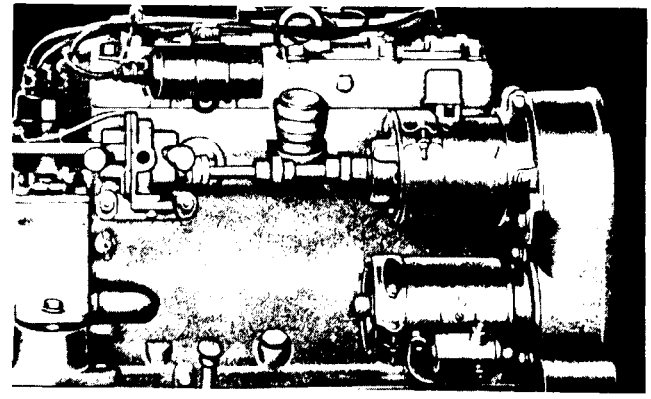


Fig. 21—Generator Direct-Coupled to Water Pump

Adjustment for generator belt tension is provided by the cradle-type mounting.

CAUTION: Excessive tension will cause rapid belt wear. At correct tension the driving belt may be depressed a distance equal to the thickness of the belt, with thumb pressed against center of its widest span.

Generator Maintenance: A periodic inspection should be made of the charging circuit: make it a rule to do this every time engine lubricating oil is changed. Keep all connections clean and tight. If the commutator is dirty or discolored it can be cleaned by holding a strip of 00 sandpaper against it while

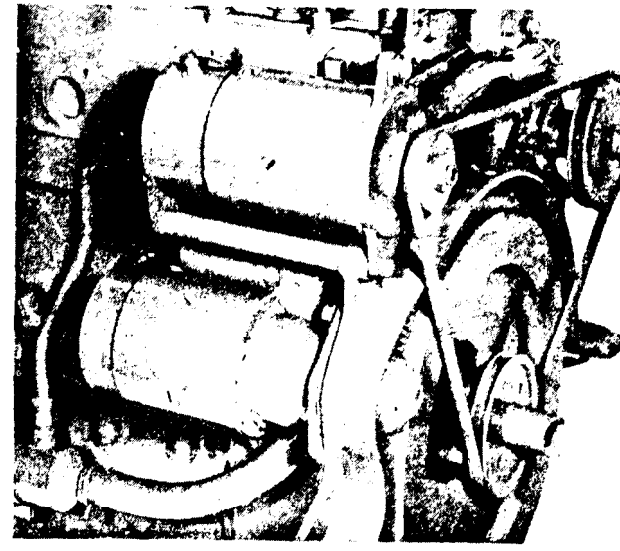


Fig. 22—Generator and Water Pump Independently Driven

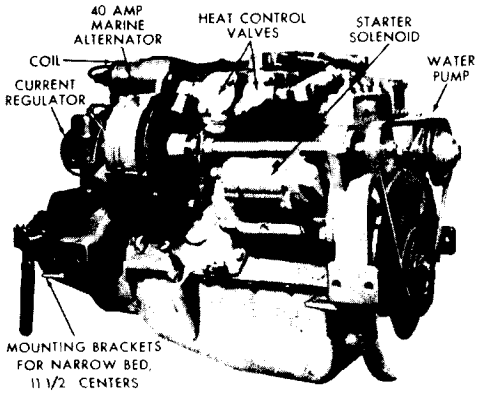


Fig. 23—Typical Arrangement with Alternator

turning the commutator slowly. DO NOT USE EMERY CLOTH. In time, the commutator will wear from use and may require resurfacing. If commutator is rough or worn the generator should be removed from the engine and the commutator turned down on a lathe. Remove only a thin cut, sufficient to true up and remove roughness and high mica. After turning the commutator, the mica should be undercut to a depth of 1/32".

The brushes will wear out from use and must be renewed when they get too short. Replace worn brushes, using only specified brushes for renewals, and make sure the brushes can slide freely in their holders to prevent sticking.

When replacing brushes it is necessary to reseat them so that they will have 100% surface contacting on the commutator. The brushes may be sanded to secure this fit by drawing a strip of 00 sandpaper (never use emery paper) between the commutator and brush, with sanded surface facing the brush holder, as illustrated in Fig. 23. Do not sand too much as this merely shortens brush life. After sanding, blow generator out with compressed air, to remove the sand and carbon dust. The generator should then be run under load long enough to secure a perfect brush fit. Do not test for output until the brushes are seated.

Output of generators equipped with third brush may be changed as follows: Moving the brush in direction of armature rotation will increase charging rate and moving in opposite direction will decrease the charging rate. Most generators have no fuse.

Check pigtail lead connections at the brushes to see that they are tight. The pigtail wires must not touch any metal except the brush holders to which they are attached.

Unsteady or Low Output may be caused by a slipping belt, by inadequate tension on the brush springs, or by the brushes sticking in the holders.

Cut-in speed too high may be caused by poor fitting brushes or inadequate wiring.

CURRENT-VOLTAGE REGULATOR

Description: Most models equipped with a constant voltage generator have the regulator already mounted on engine. If not mounted, the regulator should be mounted close to the engine inside the motor box, or as near the engine as possible or on the engine. This unit contains (1) a circuit breaker, (2) a current regulator, and (3) a voltage regulator.

The function of the circuit breaker is to open the circuit between the generator and battery when the generator falls below generating speed. The regulators are magnetic switches which operate on a principle similar to the circuit breaker, and their function is to prevent the generator's output from exceeding a safe maximum; also to reduce the output in accord with the requirements of the connected electrical load and the condition of charge of the battery.

It is important that the regulator must conform to ground polarity. If the wrong regulator is used, the life of the regulator will be brief, and it will eventually be burned out. Aside from this the unit is seldom a source of trouble. In case it becomes faulty, do not attempt to adjust it, but have this done by an electrical service station, or replace it.

CRANKING MOTOR (STARTER)

Description: Two different types of cranking motor are used. One type has the well known Bendix drive, with drive pinion on a spiral threaded sleeve When the armature revolves, the threaded sleeve turns within the pinion, moving pinion outward, causing it to mesh with the teeth of ring gear on flywheel, thus cranking the engine. This is Illustrated in Fig. 24.

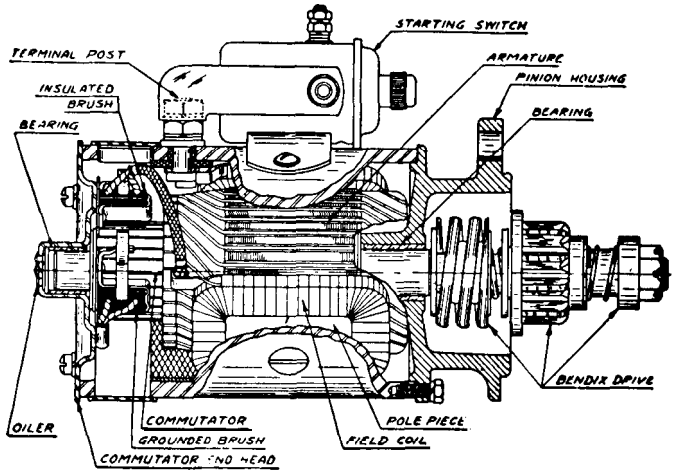


Fig. 24—Typical Cranking Motor with Bendix Drive

The second type of cranking motor, as illustrated in Fig. 25, has an over-running type of clutch. The clutch is spring-loaded, and linked to the solenoid piston, in such a manner that the movement of the solenoid piston first meshes the pinion with ring gear on flywheel, then further travel of the solenoid phton closer the heavy-current switch to start the cranking motor.

Operation of Cranking Motor: If the engine fails to start after normal cranking, locate the trouble and make correcttons. Continued cranking for a longer period than 30 seconds will develop excess heat in the cranking motor and there is danger of damaging it.

Starter Maintenance: The cranking motor cover band should be removed once or twice a season for inspection of the commutator and brush connections. If the commutator is rough, tt should be cleaned with No. 00 randpaper. Never use emery cloth to clean the commutator. A glazed or blue commutator does not indicate a condition requiring service, as this is a normal and satisfactory condition.

If the commutator is in bad condition, out of round, or if the mica extends above the copper, turn down in a lathe, then undercut the mica 1/32".

At inspection time, the brushes should be examined and replaced if unduly worn. Instructions for reseating the brushes are name as covered in Generator section.

All connections should be clean and tight and the brush tension maintained at 42 to 53 ounces. Do not permit dust and dirt to accumulate inside the motor. Keep outside of motor clean.

CAUTION: Never put oil on the commutator or brushes.

At inspection or overhaul time, or once a season, cranking motor should be removed from engine, and the drive mechanism should be washed in solvent to remove dirt and gum, then lubricated sparingly with light engine oil. Do not use heavy oil or grease.

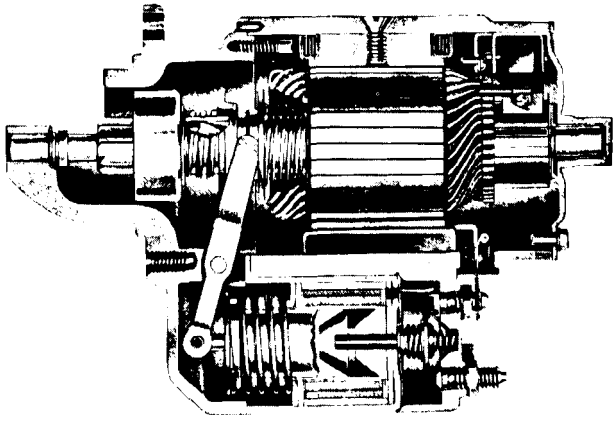


Fig. 25—Cranking Motor with Over-Running Clutch Drive

THE IGNITION SYSTEM

Description: The power in a gasoline engine is derived from the expansion caused by burning a gas-and-air mixture in the engine cylinders. In terms of fractional seconds, this is more like a continuous burning than an explosion.

In order to ignite this gas, an electric spark is made to jump across a small gap on the tip of the spark plugs, inside the cylinders. The spark must occur in each cylinder at exactly the proper time in relation to position of the pistons and crankshaft, and the sparks in the cylinders must follow each other in the proper sequence.

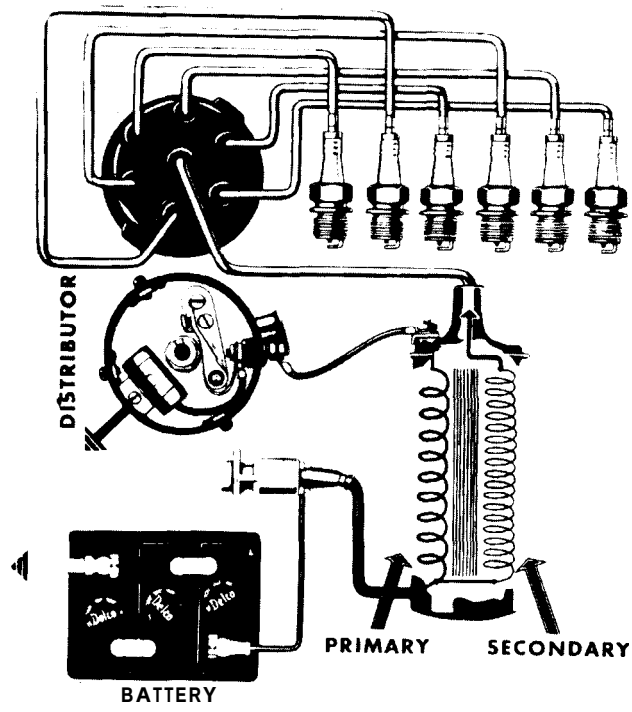


Fig. 26—Ignition Circuits, 6-Cylinder Engine

To accomplish this, the following parts are used: the battery which supplies the electrical energy; the ignition coil which transforms the battery current to a high tension current which will jump the gap in the spark plug under compression conditions; the mechanical breaker which opens and closes the primary circuit at the proper time; the distributor which delivers the spark

to the proper cylinders; the spark plug which provides the gap in the engine cylinder; the wiring which connects the various units; and the ignition switch for disconnecting the battery when it is desired to stop the engine.

Operation: There are two distinct circuits in the ignition system, namely, primary and secondary. Keeping these circuits in mind gives a better understanding of the operation of the system.

The PRIMARY low-tension circuit includes the battery, distributor contact points and circuit-breaker mechanism, primary winding of ignition coil, and condenser.

The SECONDARY high-tension circuit includes secondary winding of coil, distributor rotor and cap, high-tension wiring, and spark plugs.

Briefly, these ignition circuits function as follows: After ignition rwitch is turned on, the primary circuit is completed and broken by distributor breaker points, causing a build-up and collapse of a magnetic field in the ignition coil. When distributor points open, the current has a tendency to continue to flow and forms an arc across the points. The condenser, which is shunted across the distributor points, reduces this arc because it has capacity to store up electrical energy (condenser mounted outside distributor on some models).

A fraction of a second after the breaker points open, the counter-pressure in the condenser overcomes the surge pressure on the line and the condenser discharges back through the primary winding of the coil in the opposite direction to the magnetizing current. This action in the primary circuit causes a very rapid movement of the lines of force across the large number of turns in the secondary winding of coil, which induces a current of very high voltage and this flows from the secondary winding to the high-tension terminal at end of coil, then to the distributor, across the distributor rotor to contact in distributor cap, and thence over the high-tension wire to spark plug.

Distributor: From a study of the preceding paragraphs it will be seen that the distributor is a switching device, consisting of a set of breaker points operated by a fiber cam to make and break the primary circuit; while the rotor makes and breaks the secondary circuit in exact unison with the action of the breaker points. Spark control is entirely automatic, being operated by centrifugal weights pivoted on a plate whioh is an integral part of the shaft and connected to the breaker cam. This mechanism advances the timing automatically as the engine speed increases

DISTRIBUTOR MAINTENANCE:

1. **Check Distributor Cap** for cracks, carbon runners or corroded terminals. If any of these conditions are found, the cap should be replaced. If there is evidence of burning, the cap can be cleaned with carbon tetrachloride. Do not file.

   Keep cap free of moisture.

2. **Inspect Rotor** for cracks or burning. Replace if cracked or badly worn.

3. **Check Breaker Arm Hinge:** Make sure the breaker arm moves freely on its hinge, and apply a drop of light oil as covered under "Lubrication." Moisture or oil under certain conditions may cause swelling of the fiber bushing in breaker arm hinge, producing irregular running at high speeds. Remedy is to ream the bushing very slightly.

4. **Adjust Breaker Points.** If these are burned or pitted they should be replaced (but can be dressed down with a fine-cut ignition file in an emergency). Never use emery cloth to clean contact points. After filing, check the breoker point gap and reset to .020", using a feeler gauge as shown in Fig. 27. Breaker arm must be resting on high point of cam during this measurement.

   When replacing contacts be sure they are aligned and that they make contact near the center. Bend the stationary arm to secure proper alignment. Do not bend the breaker arm.

Fig. 27—Adjusting Breaker Points

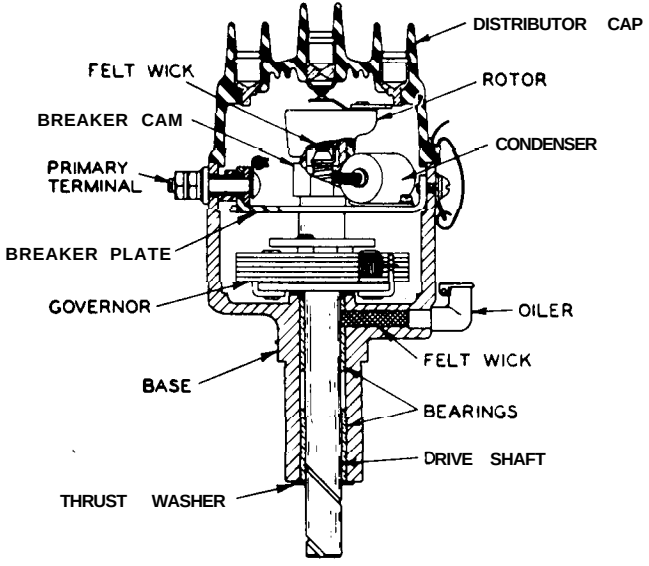


Fig. 28—Distributor

SPECIFICATIONS AND ADJUSTMENT DATA

FOUR AND SIX CYLINDER MODELS

GRAYMARINE GASOLINE ENGINES

CURRENT MODELS — GENERAL DATA

	FOURS	SIXES
Firing Order:		
Standard	1-3-4-2	1-5-3-6-2-4
Opp. Rotation	1-3-4-2	1-4-2-6-3-5

Graymarine Model	Sea Scout-91	Four-45	Four-112	Model 620	Four-162 Model 60	Four-75 Four-85	Fireball Four 90	Model 109	Model 116 Model 116	Model 120 Model 136	Model 166	Model 165 Model 175	Model 165 Model 206
Number of Cylinders	4	4	4	4	4	4	4	6	6	6	6	6	6
Bore and Stroke. in.	2⅛x3½	2⅛x3½	3⅛x3½	3¼x4⅜	3⅛x4⅜	3⅛x4⅜	3⅞x4¼	3⅝x4⅜	3⅝x4⅜	3⅞x4⅜	4x4⅜	4x4¹³⁄₁₆	4⅝x4⅞
Piston Displace. cu. in.	91	91	112	140	162	162	162	226	226	244	330	363	427
Maximum Horsepower At rpm	25 @ 2000	45 @ 3800	31 @ 2200	60 @ 3200	42 @ 1800 80 @ 3600	75 @ 3600 85 @ 4000	90 @ 4000	109@3400	118@3600 116@3600	120@3600 136@3600	150 @ 3400	165@3400 175@3400	185@3400 200@3400
Weight: Direct Drive Reduction Drive	398	396	405	625	565 620	650	640	775	675	825	1050 1250	1050 1250	1245 1380
Gen. Charge Rata Approx. 12 V. amp. (Fig. 21). Cut-in Speed	10 amps @ 1135 rpm 710 rpm	10 amps @ 1700 rpm 1065 rpm	10 amps @ 1135 pm 710 rpm	10 amps @ 1700 rpm 1065 rpm	10 amps @ 1350 rpm 900 rpm	10 amps @ 1700 rpm 1065 rpm	10 amps @ 1700 rpm 1065 rpm	10 amps @ 1350 rpm 900 rpm	10 amps @ 1700 rpm 1065 rpm	6 Volt 13 amps @ 2800 rpm 950 rpm	12 Volt 10 amps @ 1350 rpm 900 rpm	12 Volt 10 amps @ 1350 rpm 900 rpm	12 Volt 10 amps@ 1700 rpm 1065 rpm
Ge12 v. 12 amp. (Fig. 22). Cut-in Speed	—	—	—	—	12 amps @ 1350 750	12 amps @ 1350 750	12 amps @ 1350 756	12 amps @ 1350 756	12 amps @ 1350 756				
Approx. Oil Capacity, Qts.	4	4	4	7	7	7	7	9	9	10	13	13	13
Fuel	WRP	WRP	WRP	WRP	WRP	R P	P	R P	R P	R P	R P	P	R P
Lubricating Oil,	All Models—S.A.E. viscosity 30. Pressure at full throttle-40 pounds												

Code: W-White Gasoline, 66 octane min. R—Regular Ethyl Gasoline P—Premium Ethyl Gasoline

CURRENT MODELS — ADJUSTMENT DATA

	Sea Scout-91	Four-45	Four-112	Model 620	Four-162 Model 70	Four-75 Four-85	Fireball Four-90	Model 109 Model 116	Model 118	Model 120 Model 136	Model 150	Model 165 Model 175	Model 186 Model 200
Piston Clearance: ½" Feeler	.003	.003	.004	.004	.004	.004	.004	.003	.003	.004	.007	.003	.006
Pounds Pull	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10
Valve Tappet: Intake	.012	.012	.012	.014	.014	.014	.014	.017	.017	.020	.022	.022	.017
Exhaust	.012	.012	.012	.014	.014	.014	.014	.017	.017	.020	.022	.022	.022
Valve Seat Angle: Intake	30°	30°	30°	30°	30°	30°	30°	30°	30°	45°	30°	30°	30°
Exhaust	45°	45°	45°	44°	45°	45°	45°	44°	44°	45°	44°	44°	44°
Carburetor: Approx. Turns from Close:								109 116					
Main Jet	2½	2½	2½	2¼	2¼	2½	1¾	2 Fixd	2	2	2	2	2¼
Idling Valve	¾	1	¾	¾	¾	1¼	½	½ 1	½	½	1¼	1¼	1½
Throttle Stop set at rpm	500	606	500	500	500	500	600	500 500	500	500	500	500	600
Float Setting	1⅝	1³³⁄₆₄	1⅝	¹⁄₆₄	¹⁄₆₄	1³³⁄₆₄	1½	1³³⁄₆₄ —	1³³⁄₆₄	1³³⁄₆₄	2¼	2⁵⁄₁₆	2
Spark Plug Gap	.035	.025	.025	.025	.025	.025	.020	.025	.025	.020	.025	.025	.025
Spark Plug:	J-11J	J-11J	D-16	D-14	D-14	D-14	D-9J	D-14	D-14	D-14	D-14	D-14	†D-6
Breaker Point Gap	All Models .020												
Alignment	All Models—Maximum .002 between coupling freer												

†Model 166: D-14

CURRENT AND SPECIAL ADAPTATION MODELS

DATA AND ADJUSTMENT

Graymarine Model	80 4-80	4-80 SDE 4-80 SDW 4-m BTW 4-m BT 4-80 TD 4-75 TD	6111 122	6-111 SDE 6-111 SDW 6111 BTK 6-111 TD S-111 ET 109 ET 108 TD
Number of Cylinders..	4	4	6	0
Bore and Stroke, In.	3 1/16 x 43"	3 1/16 x 4 3/8	3 5/16 x 4 1/8	3 5/16 x 4%
Piston Displ. CU. In	162	182	220	226
Firing Order	I-M-2	1-3-4-2	1-5-3-6-2-4	& 1-5-3-6-2-4
Maximum H.P. . . . . . At R.P.M.	80 3600	80 3600	111 3600	111 3600
Weight	540	450	650	550
Gen. Charge Rate Approx. Ih. 10 • Ip. (Fig. 21) Cut-In Speed.	12 ampe @ 1100 rpm 735 rpm	12 • •□ @ 1100 rpm 735 rpm	12 ampe @ 1100 rpm 735 rpm	12 ampe @ 1100 rpm 735 rpm
Approx. Oil Capacity, Qts...	7	6	9	4
Fuel	RP	RP	RP	RP
Lubricating Oil—Viscosity	SAL 30	SAE 30	SAE 30	SAE 30
Piston Clearance, ½" Feeler Pounds Pull.	.004 5-10	.004 5-10	.003 5-10	.003 5-10
Valve Tappet Setting: Intake. Exhaust	.014 .014	.014 .014	.017 .017	.017 .017
Valve Seat Angle: Intake Exhaust	30° 45°	30° 45°	30° 44°	30° 44°
Carburetor: Approx. Turns from Close: Main Jet. Idle Screw.. Throttle Stop Set at rpm Float Setting.	2 ½ 500 7/64	2 ½ 600 7/64	2 3/8 600 7/64	2 3/8 600 7/64
Spark Plug.	D-14	D-14	D-14	D-14
Spark Plug Gap.	.025	.025	.025	.025
Breaker Point Gap..	.020	.020	.020	.020

& 109 TD and 6-111 TD Firing Order 1-4-2-6-3-5

DATA ON GENERATORS AND REGULATORS

Accessory Arrangement	Voltage and Output	Generator Type	Generator Make	Generator Code	Regulator Number	Ground Polarity	Wiring Diagram
Fig. 21	6-V 13-amp.	3rd Brush	Auto-Lite	GFA	—	Positive	B, E
Fig. 21	6-V 20-amp.	Regulated	Auto-Lite	GEG	VBO-4801J-1	Pos. or Neg.	C, F
Fig. 21	12-V 7-amp.	3rd Brush	Auto-Lite	GDB	—	Positive	B, E
Fig. 21	12-V 10-amp.	Regulated	Auto-Lite	GEH	VBO-4201K-1	Pos. or Neg.	A, (D), F
Fig. 21	12-V 10-amp.	Regulated	Auto-Lite	GJS	VBO-6201D-1	Pos. or Neg.	A, F
Fig. 21	6-V 13-amp.	3rd Brush	Delco-Remy	1102428-9	—	Positive	B, E
Fig. 21	12-V 7-amp.	3rd Brush	Delco-Remy	1102528-9	—	Positive	B, E
Fig. 22	12-V 14-amp.	Regulated	Delco-Remy	1102138-062	1119165 1119180	Neg. only Pos. only	A
Fig. 22	12-V 12-amp.	Regulated	Auto-Lite	GJO	VBO-6201G-1	Pos. or Neg.	A
Fig. 23	12-V 40-amp.	Regulated	Lrece-Neville	—	3629RA	Negative	G

NOTE: The regulators listed above are the latest specification, as supplied on current engines and on orders for replacements. In some cases, the type shown supersedes the one originally supplied with engine.

ELECTRICAL SYSTEM

NOTES

Ignition Coil: In installing a replacement coil note that the terminals are marked for positive and negative. The terminal which is connected to the distributor must have the same polarity as the battery ground, or the life of the ignition coil will be shortened.

Starter Push Button: There is an important difference in the solenoid circuit peak load on the two different types of cranking motors used on Graymarine engines. These are described and illustrated on pages 33 and 34.

The one with Bendix drive draws very small current in the starter solenoid circuit, as little **as 2 amperes, and for this reason the** push button may be connected in series with the ammeter **as** shown in wiring diagrams (B) and (C) on page S-S.

The other type, with over-running clutch type of drive, has to draw heavy current to engage the spring-loaded clutch linked to the solenoid, requiring about 20 amperes. For this reason, it is important to use a starter push button of ample capacity, with connecting wire of ample **size**, and to locate the starting push button in the circuit as shown in diagram (A) on page S-7. On this type, the push button should never be in series with **the** ammeter. Refer to the chart for recommended wire sizes.

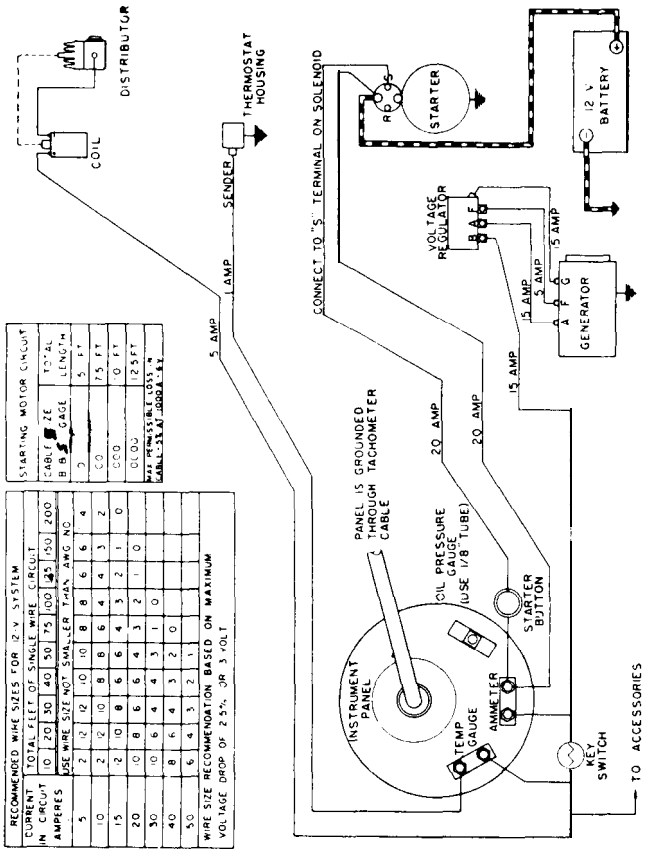
Repolarizing a Regulated-type Generator: After wiring has been completed on a new engine installation with constant-voltage generator, or any time generator has been repaired or tested, it must be repolarised to make sure that it has the correct polarity with respect to the battery. Failure **to repolartse the generator may result in burned relay contact points, a rundown battery and possible serious damage to the generator itself. The procedure is as follows:**

After all leads are reconnected, but before the engine is started, touch a jumper lead momentarily between the ARMATURE and BATTERY terminals of the regulator. This allows a momentary surge of current to flow through the generator, which correctly polarizes it.

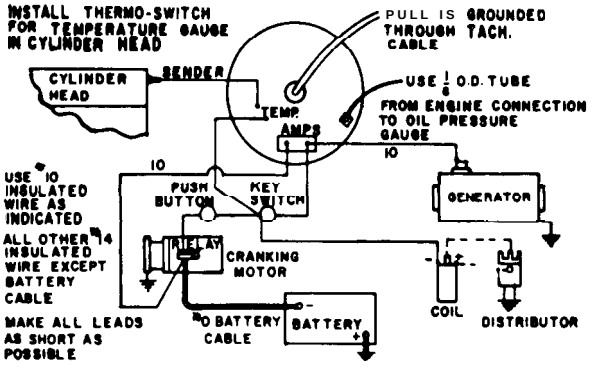
Caution: The instructions above do not apply for an alternator. which should never be polarized. as this will damage either the rectifier cells or the regulator. It should also be emphasized that operation of an alternator when it is connected to wrong polarity will immediately bum out its rectifier cells. Alternator wiring diagram is on page S-11 of this section.

CURRENT MODELS

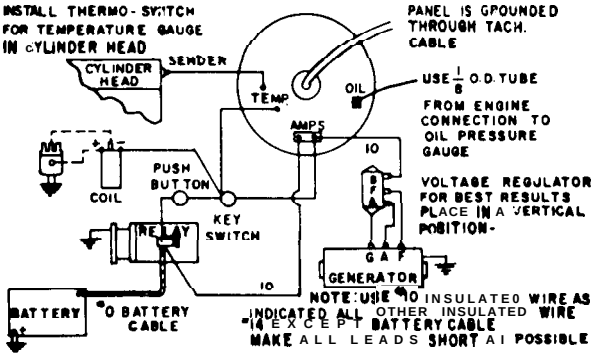
ENGINE INSTALLATION DATA



A **12-volt Wiring Diagram for current-model Engines, with Accessory Arrangement as shown in Fig. 22**

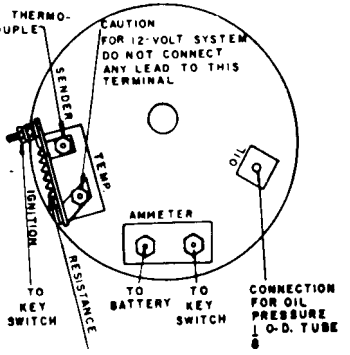


B **Wiring Diagram for Third Brush Type Generator with 6-volt Panel**



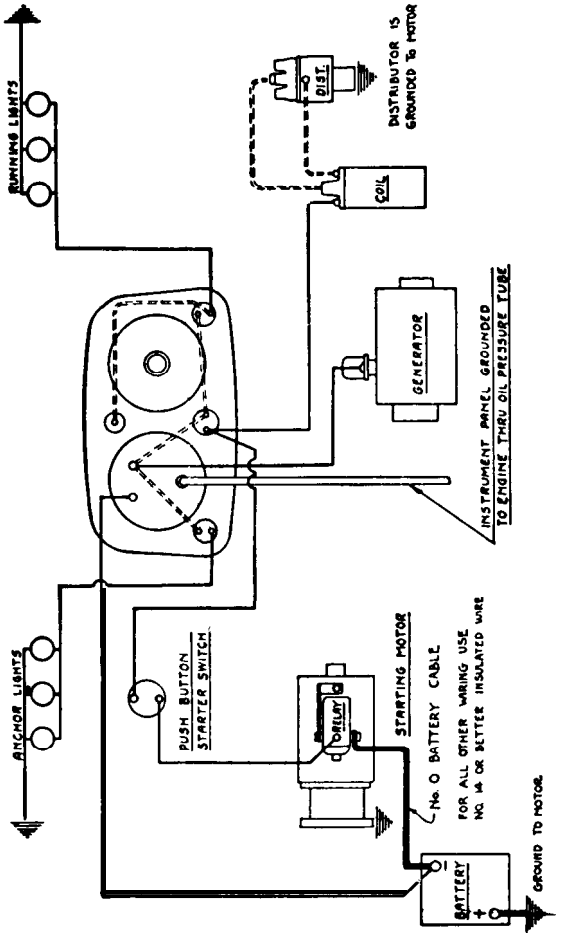
C **Wiring Diagram for Constant Voltage Generator with 6-volt Panel**

NOTE: 12-volt instrument panel #75699, as supplied with older engines, was a 6-volt panel converted for 12-V circuits by use of a resistor mounted between terminals for the electric sender to temperature gauge, which operates on 6-volts. This should be wired as shown in sketch at right. This panel now has been superseded by 12-volt panel #77800.



D **Connections for 12-volt Panel with Resistor**

1 3-AMPERE GENERATOR

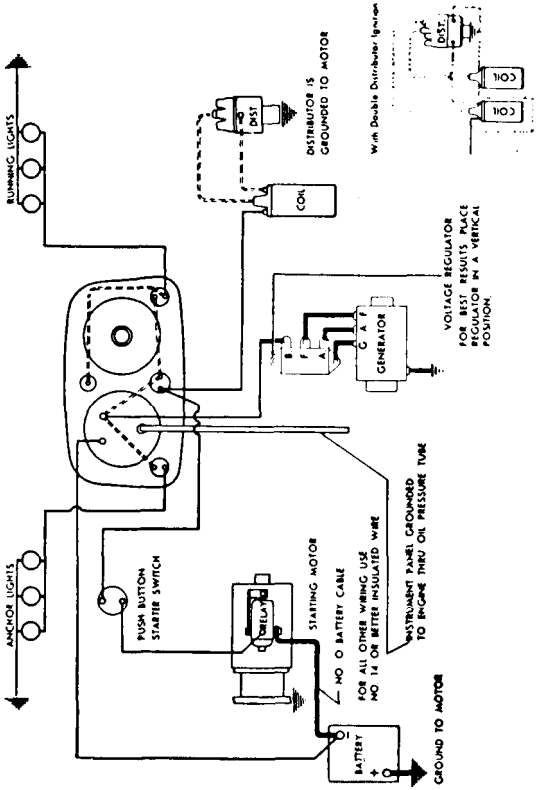


E WIRING DIAGRAM FOR THIRD BRUSH TYPE GENERATOR. AS USED ON OLDER ENGINES

WITH INSTRUMENT PANEL **EQ-52**

See page S-7 *for diagram with deluxe panels* 75650, 75699

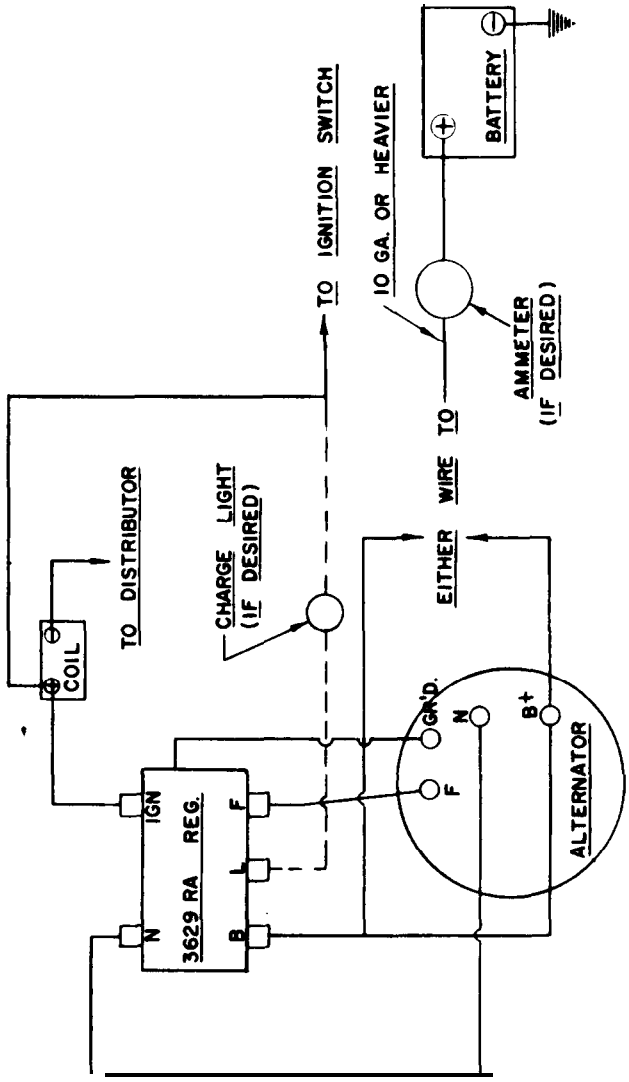
20-AMPERE GENERATOR



F WIRING **DIAGRAM** FOR CONSTANT VOLTAGE GENERATOR AS USED ON OLDER ENGINES

WITH INSTRUMENT PANEL **EQ-52**

See page S-7 for diagram with deluxe panels 75650, 75699



G ALTERNATOR WIRING DIAGRAM

1939 - 1958 MODELS-GENERAL DATA

MEDIUM AND HEAVY DUTY GASOLINE ENGINES

	FOURS	SIXES
Firing Order:		
Standard	1-3-4-2	1-5-3-6-2-4
Opp. Rotation	1-3-4-2	1-4-2-6-3-5

Graymarine Model	Light Four-69	Four-22	Four-140 Four-40	Four-162 Four-52	Six-186	Six-51	Six-71	Six-226 Six-77	Six-244 Six-91	Six-330 Six-121	Super Six-330	Super Six-363	Express Six-427	Super Six-427
Number of Cylinders	4	4		4	6	6	6	6	6	6	6	6	6	6
Bore and Stroke, In.	2½x3½	3 3/16x3½	3 3/16x4 3/8	3 7/16x4 3/8	3x4 3/8	3 1/4x4	3 1/4x4 3/8	3 5/16x4 3/8	3 7/16x4 3/8	4x4 3/8	4x4 5/8	4x4 13/16	4 5/16x4 7/8	4 5/16x4 7/8
Piston Displace., cu. in.	69	112	140	162	186	200	218	226	244	330	330	363	427	427
Weight:														
Direct Drive	370	410	510	540	650	650	665	710	825	1070	1050	1050	1250	1250
Reduction Drive	400	440	555	585	705	705	735	775	915	1190	1250	1250	1380	1380
Lugger:														
Max. H.P.	16 @	29	37	42	60	55	68	73	83	96	—	—	—	—
At r.p.m.	1800	2000	2000	1800	2400	2200	2400	2400	2400	2400	—	—	—	—
Express:														
Max. H.P.	—	45	55	63	73	71	84	93	102	124	150-3400	165-3400	150	180
At r.p.m.		3000	3000	3000	3000	3000	3000	3200	3200	3200	155-3400	175-3400	2800	3200
Gen. Charge Rate, Approx.	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	13 amps @	7 amps @	—	—
(3rd Brush Generator)	1800rpm	1800rpm	1800rpm	1800rpm	1800rpm	1800rpm	1800rpm	1800 rpm	1420 rpm	Lg.1800 Ex.2200	2200 rpm	1800 rpm	—	—
Cut-in Speed	525 rpm	525rpm	525rpm	525rpm	525rpm	525rpm	525rpm	525 rpm	450 rpm	Lg.525 Ex.675	675 rpm	900 rpm	—	—
Lugger:														
Gen. Charge Rate, Approx.	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	—	—	—	—
(20 Amp. Generator)	1175	1175	1175	1175	1175	1175	1175	1175	1175	1175	—	—	—	—
Cut-in Speed	700	700	700	700	700	700	700	700	700	700	—	—	—	—
Express:												12 Volt	12 Volt	12 Volt
Gen. Charge Rate, Approx.	—	—	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	20 amps @	10 amps @	10 amps @	10 amps @
(20 Amp. Generator)	—	—	1175	1175	1175	1175	1175	1175	1175	1450	1450	1120	1450	1450
Cut-in Speed	—	—	700	700	700	700	700	700	700	900	900	860	900	900
*Approx. Oil Capacity, Qts.	4	4	7	7	9	9	9	9	10	13	13	13	13	13
Lubricating Oil	All Models—S.A.E. viscosity 30. Pressure, full throttle—40 pounds.													
Fuel	All Models—80 octane (motor method) or better gasoline.													

* Fill to high mark on oil depth gauge after installation.

1939-1958 MODELS - ADJUSTMENT DATA

MEDIUM AND HEAVY DUTY GASOLINE ENGINES

	Light Four-69	Four-22	Four-140 Four-40	Four-162 Four-52	Six-186	Six-51	Six-71	Six-226 Six-77	Six-244 Six-91	Six-330 Six-121	Super Six-330	Super 3 Six	Express Six-427	Super Six-427
Piston Clearance:														
Lugger: ½" Feeler	.002	.002	.003	.0025	.003	.003	.003	.003	.004	.005	.007	—	—	—
Pounds Pull	5-10	10-15	5-10	8-12	5-10	5-10	5-10	5-10	5-10	5-10	5-10	—	—	—
Express:														
½" Feeler	—	.002	.003	.0025	.004	.004	.003	.003	.004	.007	.007	.003	.006	.007
Pounds Pull	—	10-15	5-10	8-12	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10
Valve Tappet:														
Intake	.012	.012	.014	.014	.014	.014	.017	.017	.020	.017	.020	.020	.017	.017
Exhaust	.012	.012	.014	.014	.014	.014	.017	.017	.020	.020	.022	.022	.022	.022
Valve Seat Angle:			30°											
Intake	30°	30°	45°	45°	30°	30°	30°	30°	45°	30°	30°	30°	30°	30°
Exhaust	45°					45°	44°	44°	45°	45°	44°	44°	44°	44°
Carburetor:														
Approx. Turns from Close:														
Main Jet	2½	2½	2	2¼	2½	2½	2½	2½	2½	2¼	2	2	2¼	2¼
Idling Valve	¾	¾	½	¾	¾	¾	¾	¾	¾	1¼	1¼	1¼	1¼	1¼
Throttle Stop set at r.p.m.														
Lugger	300	300	400	400	400	400	400	400	400	400	—	—	—	—
Express	—	—	500	500	500	500	500	500	500	500	500	500	500	500
Float Setting	1 5/32	1 5/32	3/64	3/64	1 39/64	1 39/64	1 39/64	1 39/64	1 39/64	2 5/16	2 5/16	2 5/16	2 5/16	2
Spark Plug Gap	.035	.025	.025	.025	.025	.025	.025	.025	.025	.025	.025	025	.025	.025
§Spark Plug: Lugger	A9/J11	BT8	BT4	BT8	BT8	BT8	BT4 5 Com	BT4. 5 Com.	BT4, 6 Com.	BT8, 8 Com.	—	—	—	—
§Spark Plug: Express	—	—		BT4	BT4	BT4	BT3 4Com	BT3, 4Com.	BT3, 4 Com.	BT4, 5 Com.	BT4, 5 Com.	BT4/6 Com.	5/6 Com.	BT5/6 Com.
Breaker Point Gap. All Models .020.														
Alignment	All Models Maximum .003 between coupling faces.													

§—Spark Plugs indicated are Auto-Lite and Champion, respectively.

1939 -1958 MODELS — GENERAL DATA

HIGHER SPEED ENGINES

	FOURS	SIXES
Firing Order:		
Standard	1-3-4-2	1-5-3-6-2-4
Opp. Rotation	1-3-4-2	1-4-2-6-3-5

	Fireball FOW-50	Phantom Four-62	Model 750	Phantom Four-86	Phantom Six-88	Phantom Six-90 Six-103	Model 100 Model 109 Model 110	Six-112	Phantom Six-104	Model 115 Phantom Six-125 Six-135	Fireball Six-140	Fireball Six-150	Fireball Six-160
Number of Cylinders	4	4	4	4	6	6	6	6	6	6	6	6	6
Bore and Stroke, in.	2⅞x3½	3⅛x4⅜	3 1/16x4⅜	3 1/16x4⅜	3x4⅜	3¼x4⅜	3⅛x4⅜	3⅛x4⅜	3⅛x4⅜	3 1/16x4⅜	3 1/16x4⅜	3 1/16x4⅜	3 1/16x4⅜
Piston Displ., cu. in.	91	140	162	162	186	218	228	226	226	244	244	2u	244
Weight, Iron: Direct Drive	390	525	500	465	625	625	680	875	840	**	800	730	785
Reduction Drive		570	545		680	565	775		700	900	—	820	
Maximum H.P. At rpm	50 4000	82 3600	75 3600	86 3600	88 3600	90 @ 3600 103 @ 3600	100 @ 3400 110 @ 3600	115 @ 3600	104 3600	115 @ 3400 125 @ 3600 135 @ 3600	140 4000	150 4000	4%
Gen. Charge Rate, Approx. (3rd Brush Generator) Cut-in Speed	13 amps @ 2800 rpm 950 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2300 rpm 850 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2800 rpm 950 rpm	13 amps @ 2300 rpm 850 rpm	13 amps @ 2300 rpm 850 rpm	13 amps @ 2300 rpm 850 rpm	13 amps @ 2300 rpm 850 rpm
*Approx. Oil Capacity, Qts.	4	7	7	7	9	9	9	9	9	10	10	10	10
Lubricating Oil	All Models—S.A.E. viscosity 30. Pressure at full throttle—40 pounds												
Fuel, Gasoline	80 octane (motor method) a better gasoline—91 octane for all Fireballs.												

*Fill to high mark on oil depth gauge after installation. **Model 115:825 and 915.

1939-1 958 MODELS-ADJUSTMENT DATA

HIGHER SPEED ENGINES

	Fireball Four-50	Phantom Four-62	Model 750	Phantom Four-86	Phantom SIX-88	Phantom SIX-90 SIX-103	Model 100 Model 109 Model 110	Six-112	Phantom SIX-104	Model 115 Phantom Six-125 Six-135	Fireball SIX-140	Fireball SIX-150	Fireball Six-160
Piston Clearance: ½" Feeler Pounds Pull	.003 5-10	.004 5-10	.003 5-10	.004 8-12	.004 7.9	.004 5-10	.003 5-10	.003 5-10	.004 7-9	.004 5-10	.008 5-10	Two .005 12-15	.008 5-10
Valve Tappet: Intake .012 Exhaust	.012	.014 .014	.014 .014	.014 .014	.014 .014	.014 .014	.017 .017	.017 .017	.014 .014	.020 .020	.020 .020	.020 .020	.020 .020
Valve Seat Angle: Intake Exhaust	30° 45°	30° 45°	30° 45°	30° 45°	30° 45°	30° 45°	30° 44°	30° 44°	30° 45°	45° 45°	45° 45°	45° 45°	45° 45°
Carburetor; Approx. Turns from Close: Main Jet	2	2¼	2½	1¾	2½	2	2	2	2	2	2¼ both	2¼ both	3 center 2¼ other 2
Idling Valve	1	1¼	1¼	½	1	½	½	½	½	½	½	½	½
Throttle Stop set at rpm	600	500	500	600	500	500	500	500	500	500	600	600	600
Float Setting	1 13/32	1 39/64	1 39/64			1 39/64	1 39/64	1 39/64	1 39/64	1 39/64	1 39/64	1 39/64	1½
Spark Plug Gap	.020	.025	.025	.025	.025	.025	.025	.025	.025	.020	.020	.020	.020
Spark Plug	A7-J8	BT4	BT4	BT4	BT4 5 Corn.	BT4 5 Corn.	BT4 5 Com.	BT4 5 Com.	BT4 5 Com.	BT3 4 Com.	BT4 R7	BT3 R7	BT4 R7
Breaker Point Gap	.015-.020	.020	.020	.025	.020	.025	.020	.020	.020	.020	.020	.015-.020	.015
Alignment	All Models—Maximum .002 between coupling faces.												

*Spark Plugs indicated are Auto-Lite and Champion, respectively.

Distributor Timing: If distributor has not been removed from the engine and is installed correctly with relation to the marks on timing gears, it is adjusted for final timing as follows:
Using a screwdriver, loosen up the clamp which holds the distributor body in position, then with engine running at full throttle and with clutch engaged (boat may be either moored to dock or moving) grasp the oiler on side of distributor and rotate the body a few degrees forward or back until the taahometer registers maximum revolutions. Ideal adjustment is to rotate the distributor body in the direction opposite to the rotation of the distributor rotor until the motor just starts to "ping." Then back off very slightly, and tighten down the set-screw holding the distributor body in position.

Engine Firing Order: If distributor must be removed for any reason, such as for installation of a new one, the timing to engine is based upon location of the firing position for No. 1 cylinder.

1. First remove No. 1 spark plug (the one nearest the flywheel). Put your thumb over spark plug hole and crank the engine slowly by hand, with ignition OFF, and test for compression stroke. When pressure is felt, continue until the keyway on crankshaft extension is in a vertical position facing UP. At this position, the timing marks on camshaft gear and crankshaft gear will be in exact register and the No. 1 piston will be on top dead center. The engine is assembled in this relationship, and it is impossible for this part of the mechanism to get out of time. (Note: the important timing operation is in replacing the distributor so that when the engine is set for firing on No. 1 cylinder, as above, the breaker points of distributor will just be separating at this instant. This is covered in following paragraphs.)

2. Remove primary and secondary wires from distributor to coil. Using a screwdriver, loosen the clamp holding the distributor in position. Distributor may then be lifted out vertically through the retainer clamp.

3. Insert the shaft of new distributor (cap removed) into the retainer, with primary terminal (see Fig. 28) facing aft. When the shoulder of distributor body seats against the retainer, the drive pinion will be meshing fully with the distributor drive gear. If the distributor will not install in this position because of interference with cylinder block, remove it and rotate the drive pinion a couple of teeth, then try again until shoulder seats firmly against the retainer.

4. When it is properly seated, rotate the distributor body counter clockwise until breaker points are just ready to open. Then tighten the clamp holding distributor body in position. Important: in this setting, be sure the breaker arm lift is on the correct side of the cam to correspond with cam rotation, which is clockwise on all Graymarine engines.

5. Install rotor on shaft above cam. The secondary terminal which the rotor will contact at this position, when cap is in place, will be the one to be connected to No. 1 spark plug. (Note: in assembly at Gray plant the secondary outlet farthest aft on the distributor cap is selected as the one for No. 1 cylinder, requiring the longest cable. To make sure that the cables will fit neatly, it is best to install the distributor so that the rotor is pointing toward primary terminal when the breaker arm is just contacting the cam, as outlined in paragraph 4.)

6. Having determined the secondary outlet for No. 1 cylinder as outlined in paragraphs 4 and 5, place cap on distributor and clamp to body with spring clips at sides. With the setting specified in paragraph 1, the engine is now timed for firing on No. 1 cylinder. Connect the cable from No. 1 spark plug to the secondary outlet which rotor is contacting.

7. Connect the other cables from spark plugs to distributor cap, following engine firing order in clockwise direction around distributor cap. Firing order on all 4-cylinder engines, regardless of propeller rotation, is l-3-4-2. Firing order on standard rotation g-cylinder engines is l-5-3-6-2-4, and on opposite rotation 6-cylinder engines it is l-42-6-3-5.

8. Connect primary and secondary wires to coil.

9. Engine is now in running order. Make final adjustment as outlined under "Distributor Timing", above.

Condenser: The condenser is made from long strips of metal foil separated by strips of oiled paper and wound in alternate layers into a tight roll. It is mounted with a clip inside or on side of the distributor. Correct condenser capacity protects the life of the breaker points by preventing excessive arcing.

Service on Condenser: If condenser is burned out or punctured, as indicated by feeble spark when high-tension wire from coil is held ¼" from cylinder head or by extensive pitting or welding of the breaker points in distributor, it must be replaced as it cannot be repaired successfully. Condenser may be checked for leakage and capacity on an approved condenser tester. A spare condenser is a good item to carry on board at all times.

Ignition Coil: The ignition coil consists of two sets of windings around an iron core. The primary winding, which has two terminals, has comparatively few turns of heavy wire, and secondary has many layers of fine wire. One end of secondary winding is grounded, and the other end is connected to "hot" terminal at end of coil.

Coil is mounted on cylinder head or block near the distributor. Note that the high-tension wire from distributor to the nearest spark plug is held away from coil case by a rubber grommet attached to next wire. This is to prevent possible scuffing and shorting.

Service-Ignition Coil: Due to its construction, ignition coil does not require any service other than to keep all connections and terminals clean and tight. Practically the only trouble in a coil is broken-down insulation, either in primary or secondary windings. In cases of coil failure, it is necessary to replace the complete coil

Spark Plugs: The engine is equipped with spark plugs which have been selected as having the correct heat range to fit its operating characteristics. Correct spark plugs for each model of Gray Marine engine are listed on pages S-3, S-4, 'S-13 and s-15.

Plugs are subjected to severe service under high pressure and extreme heat, and require the same degree of inspection and care as the other units of ignition system; in fact, spark plugs properly deserve more attention. Many other things can be mistakenly blamed for faulty operation of one defective spark plug.

An efficient spark plug is one which operates sufficiently hot to burn off carbon which deposits on the porcelain, and yet not enough to cause burned points, fused porcelain, and pre-ignition.

Service--Spark Plugs: At periodic intervals, when engine is being tuned-up, the spark plugs should be inspected for cracked porcelain, fouling, burned points and point gap.

A plug which is operating properly will have a light tan color on the porcelain nose.

Unusually severe operating conditions, such as long trips with heavy loads or at high engine speeds, may require a plug one step colder than specified. On the other hand, operation at low speed with prolonged periods of idling may require a plug one step hotter than specified. Be sure that the specified plug does not perform properly before deciding on a change.

Note that other causes of fouled plugs include a too-rich mixture, late timing, incorrect valve seating, compression leak, or oil-pumping due to cylinder and ring wear.

In installing spark plugs use new seat gaskets and use a spark plug wrench of correct size. Do not use an open end wrench as this is liable to crack the porcelain. Proper tightening of spark plugs is important because the only escape for heat is through the metal-to-metal contact, and looseness is a common cause of overheating. You can determine the correct degree of tightness by the feel of the gasket as it is compressing.

Setting Spark Plug Gap: If plug is clean and satisfactory for use, first check the gap using a spark plug gauge. If necessary to reset the gap, bend the side electrode only, making sure that you do not touch or strain the center electrode.

Accurate gap setting is Important, don't guess at it See Specifications Section S-3, s-4, S13, s-15

Locating Ignition Trouble: If you suspect ignition trouble when engine does not start (provided that battery is well charged and cranking motor is functioning), or if the engine is running Irregularly, the following routine is a good short method of locating the trouble:

1. Disconnect the high-tension wires to spark plugs, one cylinder at a time, and hold the end of wire about $\frac{3}{16}$" from the cylinder head, then trip the starter switch with ignition turned on, and observe if you get a good fat spark. Thrs may also be done by shorting across with a screwdriver, without disconnecting wire to the plug. Always check first for gasoline fumes; air out the engine compartment. This is an Important safety precaution.

   IA If spark is good, then the trouble is in the spark plug, which may be cracked or fouled. Remedy: install new plug or a clean one.

   1B. If spark is weak, or missing altogether, give attention next to the coil.

2. Pull out from distributor the wire leading from high tension terminal of coil to distributor, and hold end of wire $\frac{3}{16}$" from cylinder head, then test again for spark.

   2A. If you get a weak spark or no spark here, trouble is indicated in the coil or distributor. Examine the high tension wire, also the primary wire leading from distributor to coil.

   2B. If you do not get a satisfactory spark from coil after distributor has been checked, trouble is indicated in the coil.

3. Remove distributor cap and check the breaker points, which may be stuck or welded together. In an emergency these can be pried apart with a knife or screwdriver. If engine misses at high speed, gap is too wide; if engine misses at low speed, gap is too narrow.

   3A. If points are badly pitted or welded from arcing, weak spark or lack of any spark is likely to be caused by burned-out condenser.

   3B. Also check distributor cap and rotor for cracks, anu check the high-tension wires from distributor to spark plug. These wires must be dry as surface moisture will cause a short.

TRANSMISSION

Description: The transmission consists of a planetary type clutch and reverse gear unit contained in a one-piece housing bolted to the engine gear case. Clutch housing was accurately aligned with special jigs to assure quiet operation and to avoid undue wear on gears. A choice of two types of controls is offered—manual or hydraulic. Reduction gears of various reduction ratios are available on all models as original equipment. We do not advise a changeover from direct drive to reduction gear, or vice versa, in the field because of the high cost entailed. Reverse propeller speed is approximately 9/10 of forward speed.

Lubrication: In manual-type marine transmissions, the oil passages of the clutch, reverse gear and reduction gear are directly connected with the engine lubrication system, and therefore need no special attention. However, hydraulic clutches are separately lubricated: see instructions on page 54.

MANUAL TYPE REVERSE GEAR

General **Construction:** The assembly consists of a drum which serves both as gear case and clutch. Inside the drum at engine end are two or three (depending on clutch size) short pinions which mesh with the engine gear on crankshaft. These short pinions also mesh with two or three long pinions (see Fig. 32A) and the latter mesh with a central gear which is supported on ball bearings. This central gear is known as the propeller gear, and it carries the tail shaft to propeller coupling or reduction gear. Over the tail shaft, the drum carries a multiple disc clutch, comprising friction discs, one half of which are locked into slots in the drum, and the alternate discs are locked to the splines in tail shaft with a thick driver plate. This mechanism is engaged by a pressure plate and toggle mechanism with shifting collar and linkage to control shaft. Disc clutch is for forward drive, as explained below.

Outside of the drum is a brake band to grip the drum for operation in reverse, as explained below. The reverse band is faced with a moulded lining of asbestos material which is unaffected by oil and which has long wearing qualities. This lining is moulded in one or two pieces to match the contour of the drum, to provide perfect fitting and contact, and lining is riveted or bonded to the metal shell. Adjustment is provided at the toggle clamping mechanism on top.

Operation **in Forward Drive:** The forward drive is obtained by means of the multiple disc clutch. The locking or clamping of these discs is accomplished by pressure exerted by movement of the clutch fingers when the operating lever is thrown into the forward position. When the discs are compressed the whole reverse gear is locked together as a solid coupling, because since none of the inner gears or pinions can rotate in mesh, the drum revolves as a solid coupling (the gears remaining motionless in their relationship to each other). This transmits to the tail shaft the same rotation as the engine crankshaft.

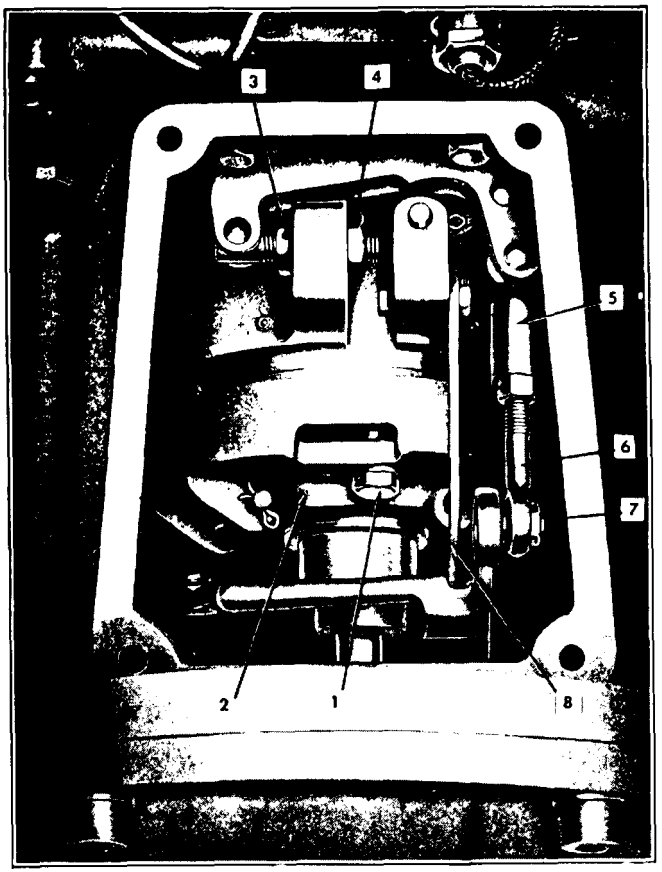


Fig. 30—Adjustments on Paragon Clutch (3XE)

1. Forward Adjustment Lockscrew
2. Finger Screw Collar
3. Reverse Adjustment Nut
4. Reverse Adjustment locknut
5. Reverse Linkage (Female)
6. Reverse Linkage (Male)
7. Reverse Link Screw
8. Brake Bond Brace

Operation in **Reverse:** When the operating lever is thrown into reverse position, the reverse band is clamped around the outside of the drum, which prevents the drum from turning, and at the same time the pressure is released from the multiple disc clutch so that the plates which are locked to the splines on tail shaft are free to turn between the plates locked to drum. Under these conditions, the pinions within the drum are free to rotate, **and** the gear train reverses the direction of rotation.

Operation **in Neutral:** In the neutral position, both the discs and brake band are free and the gears run idle.

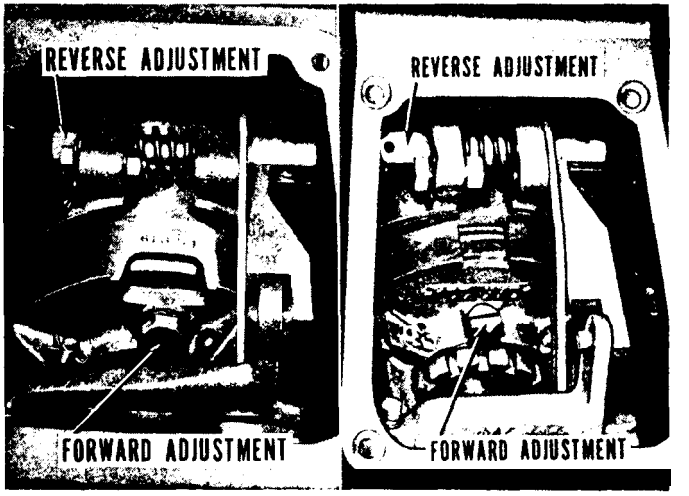


Fig. 31—Reverse Gear Adjustment—Paragon Clutch Models 1XE-90 (left) and OXKB (right)

PARAGON GEAR-Forward Drive Adjustment: The collar which carries the clutch fingers is attached to the drum by a threaded flange and held in adjustment position by a single locking screw. On some models the unthreaded end of this screw locks into one of a series of slots around the adjusting collar as shown in Fig. 31 (right). On other models as shown **in** Fig. 30 and 31 the adjusting screw is threaded into the face of the collar, its unthreaded end projecting into one of a series of holes around the outer edge of the pressure disc inside the drum. In both **cases** the function of the screw is to lock the position of the collar after adjustment is completed.

To adjust forward drive, remove cover plate, and back out the locking screw until the adjusting collar can be turned on the drum.

CAUTION: Be careful not to drop the locking screw or its lock washer into the reverse gear housing. Now: holding the **locking** screw with one hand, turn the finger collar about one inch, **feeling** with locking screw for next hole (or slot). Turn finger collar to the right to tighten clutch, and to the left to slacken off.

When lock screw is opposite the next locking position (hole or slot), try the clutch by engaging the operating lever. Repeat thb procedure until correct position is found. NOTE: On some models, a second tapped. hole in the finger collar provides a setting **midway** between any holes in the pressure disc, as shown **in** Fig. 30. When correct adjustment has been made, tighten down the locking screw and replace cover. Proper adjustment is secured when the clutch snaps in locking position with a positive engaging action, so that you can feel the toggle mechanism go into **place** firmly, but without forcing or jerking.

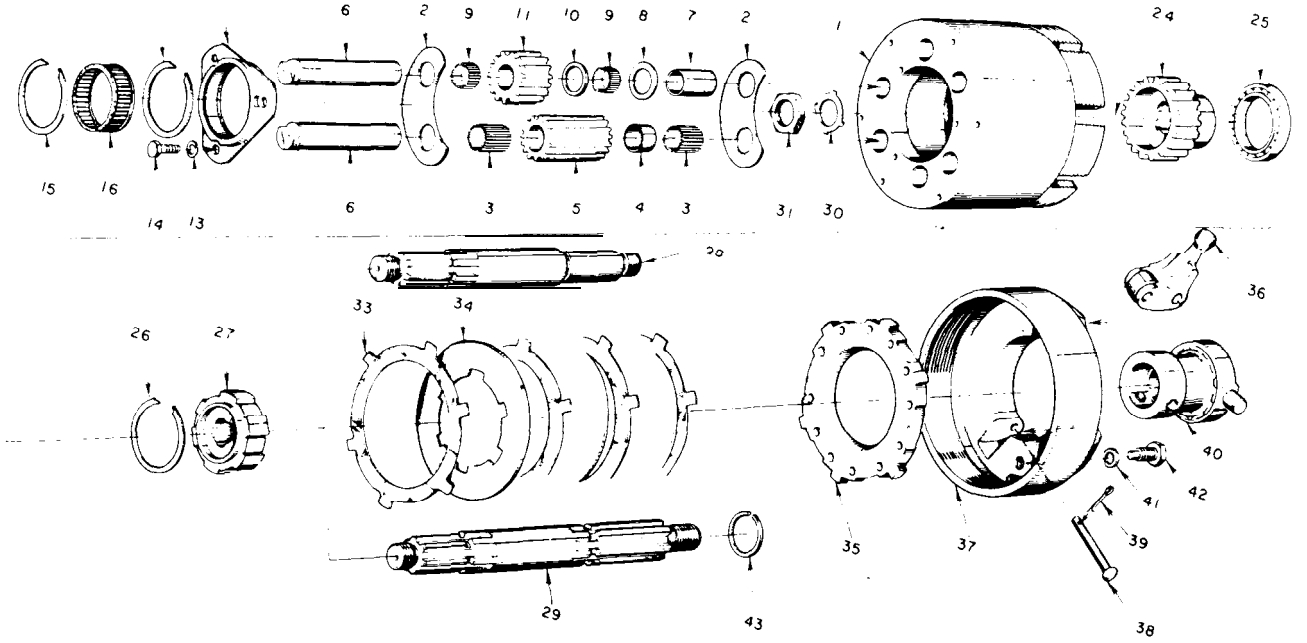


Fig. 32A—Exploded View of Gear Case and Parts of Typical Paragon Reverse Gear.

1. Gear Case
2. Thrust Pad
3. Pinion Bearing
4. Bearing Spacer
5. Long Pinion
6. Pinion Shaft
7. Pinion Spacer
8. Thrust Pad
9. Pinion Bearing
10. Bearing Spacer
11. Short Pinion
12. Bearing Race
13. Lockwasher
14. Bolt
15. Bearing Retainer
16. Case Bearing
24. Prop. Gear
25. Ball Bearing
26. Retain. Ring
27. Plate Carrier
28. Tailshaft—Direct
29. Tailshaft—Reduct.
30. Lockwasher
31. Locknut
33. Bronze Plate
34. Steel Plate
35. Pressure Plate
36. Finger
37. Screw Collar
38. Finger Pin
39. Cotter Pin
40. Oper. Sleeve
41. Lockwasher
42. Lockscrew
43. Shaft Ring
44. Adj. Bolt
45. Long Lever
46. Lever Pin
47. Cotter Pin
48. Link
49. Ball Joint
50. Adj. Nut
51. Reverse Band
52. Short Lever
53. Lever Pin
54. Cotter Pin
55. Screw
56. Band Brace
57. Lockwasher
58. Nut

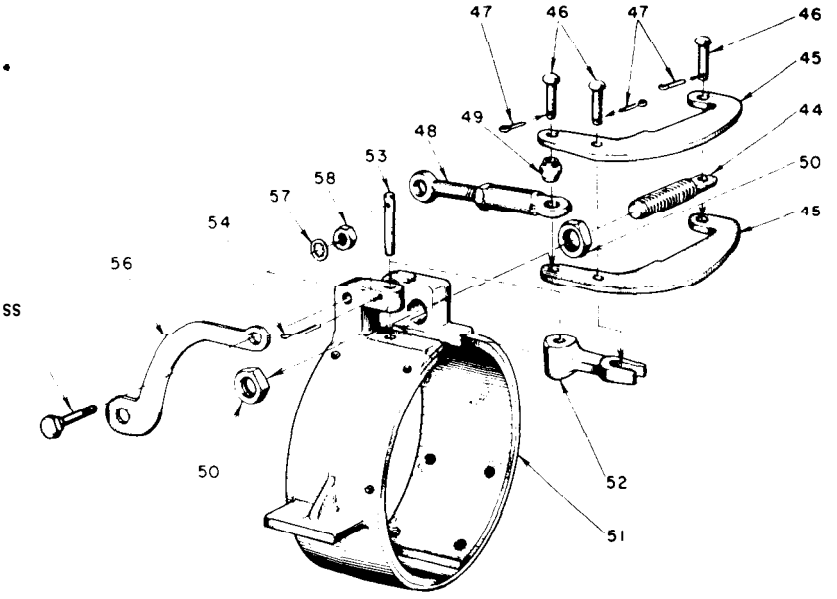
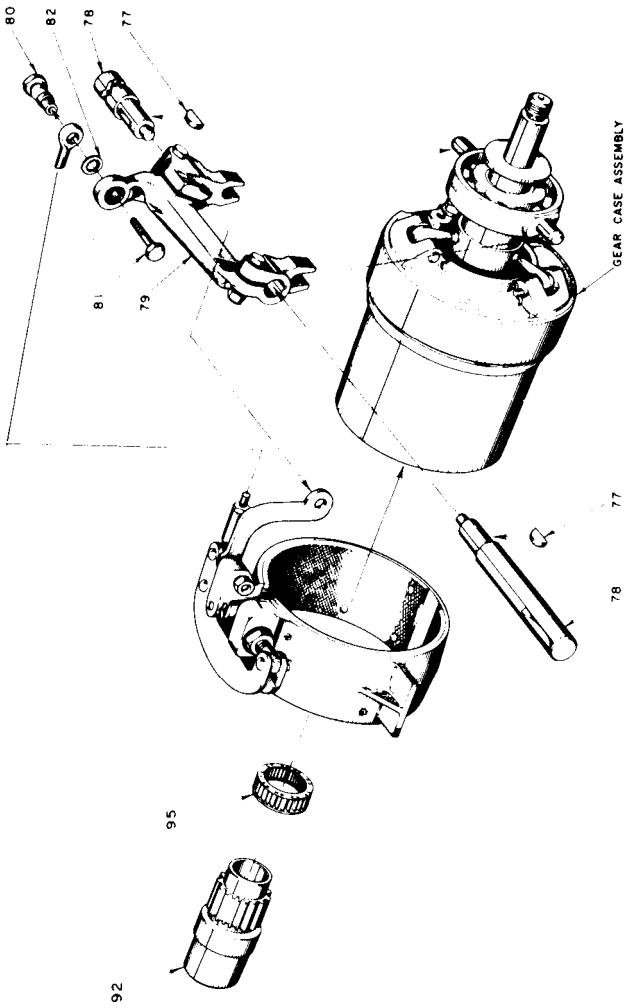


Fig. 32B—Exploded View of Reverse Brake Band and Toggle Operating Mechanism.



77. Woodruff Key
78. Cross Shaft
79. Yoke
80. Ball Joint
81. Screw
82. Lockwasher
92. Engine Gear
95. Pilot Bearing

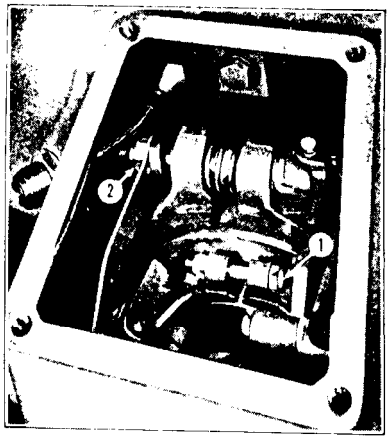


Fig. 33—*Capitol 1E* Reverse *Gear—Adjustments*
1. Forward Adjusting Drawbolt 2. Reverse Adjusting Nut

For proper adjustment this pressure should be 34 pounds for forward position, and 26 pounds for reverse position, on a 21-inch radius, which is the distance from center of cross shaft to center of handle. Total radius of throw from reverse to forward is approximately 35 degrees of arc.

Paragon Reverse Adjustment: Tightening action on the reverse band is controlled by an adjusting bolt attached to the left lug of the brake band clamp. To adjust, loosen locknut or remove lockwire, depending on model. Turn adjusting nut clockwise to tighten, counter-clockwise to loosen.

This adjustment should be tight enough so that the brake band grips the drum firmly and so that a decided snap is felt when the lever is thrown into the reverse position. When adjustment is correct, tighten the lock nut or replace lockwire.

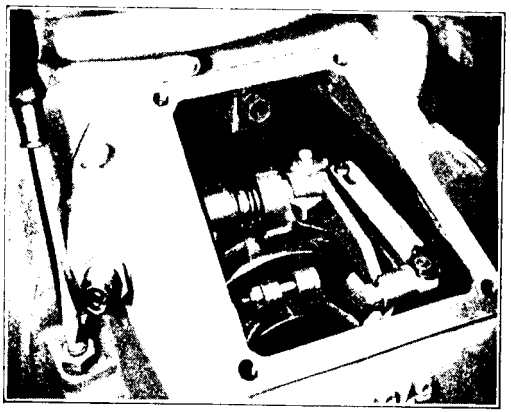


Fig. 34—*Anti-Backlash Adjustment—Capitol 1E Reverse* Gear

CAPITOL GEAR—Forward Drive Adjurtmcnt: On this clutch, the finger collar is secured in any degree of adjustment by means of a clamp and drawbolt on the outer face of the collar. To change adjustment, loosen drawbolt until finger collar can be turned by hand, clockwise to tighten or counter-clockwise to loosen. Adjustment should be corrected by a turn of one-hulf to one inch on the perimeter.

Capitol Reverse Adjustment: A heavy spring-loaded toggle controls the clamping action of brake band for reverse operation. Tension on the spring can be increased or decreased by means of an adjustment nut, mounted on the upper left side of the brake band. When properly adjusted, clutch will snap into reverse position and stay there without slipping.

Anti-Backlash Adjustment-Capitol Gear Only: On the side of the Capitol gear housing will be found an adjusting screw and locknut to prevent backlash of gears when in reverse operation. This is set at factory and normally requires no adjustment. However, if change is indicated, proceed as follows: Loosen adjusting screw; put operating lever in reverse position; turn adjusting screw until you feel it just contact the reverse band inside. **Do Not Tighten;** then set locknut.

Service Notes for All Manual-type Reverse Gears: If the engine shows a tendency to race or to increase suddenly in speed when under load, this is often an indication of a. slipping clutch. In such case, try taking up on the forward adjustment, a little at a time, until the clutch engages firmly. Unless this is done, the heat of friction caused by constant slipping of the plates will cause warping and scoring of the friction discs. Remember that compensation for normal clutch wear must be made by periodic readjustment of the clutch as necessary. If the clutch engages too easily, this may be an indication that it is in need of readjustment. It should engage with a firm, positive pressure.

In adjusting either the reverse band or the clutch for forward drive, always make sure that the operating lever snaps in to engagement in **the** proper manner, and do not make the mistake of setting the adjustment too tight. When forward adjustment is set up too far, the engaging action will not be completed, and the friction surfaces will slip, giving the impression that they are worn. When reverse band is set too tight, there is danger of breaking a lug from band. The feel of a correctly adjusted reverse gear is unmistakable, and is easily learned.

It is extremely important that the reverse gear be kept in correct adjustment at all times because an improperly adjusted clutch will slip, causing rapid wear, cutting, and possible warping of the friction discs. An over-tightened reverse band will drag, causing loss **of** power and damage to the drum surface.

It is sometimes necessary to disassemble a faulty reverse gear to discover the cause of the trouble. Look particularly for wear on the clutch engaging fingers and the friction discs. Also check the clutch discs for flatness, to make sure that none of them is warped. A warped, badly worn, or scored disc should be replaced by a new one, otherwise the clutch will not **operate** satisfactorily. "Propeller creep" is usually on indication **of** warped discs.

Reverse gear should alwoys **be** readjusted on a new engine **after** the first few hours of operation, and at periodic **intervals** thereafter, to take up the natural wear on clutch plates and **brake** band. Keeping the reverse gear in good adjustment will prevent roughening of the discs and drum; smooth surfaces always engage smoothly.

The reverse gear is subject to the same kind of wear from dirty oil or improper lubrication as ore the other parts of the engine Most frequent cause of reverse gear wear is improper adjustment, as outlined above. In checking the adjustment, make certain that the engine is in correct alignment with the propeller shaft. This is important because misalignment will throw on abnormal load on tail shaft and on reverse gear bearings.

The lining on reverse band is replaceable and is attached to its metal shell by soft brass rivets. However, the lining material has unusual wearing qualities and in normal service losts for the life of the engine. If replacement becomes necessary from any cause, it is simpler to replace the complete band.

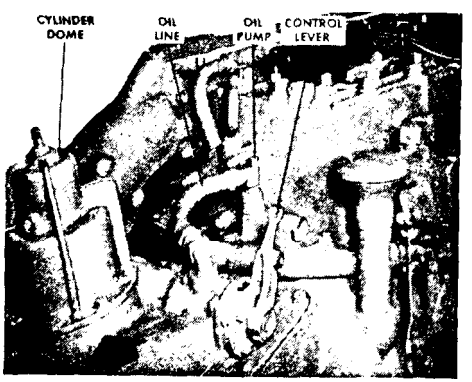
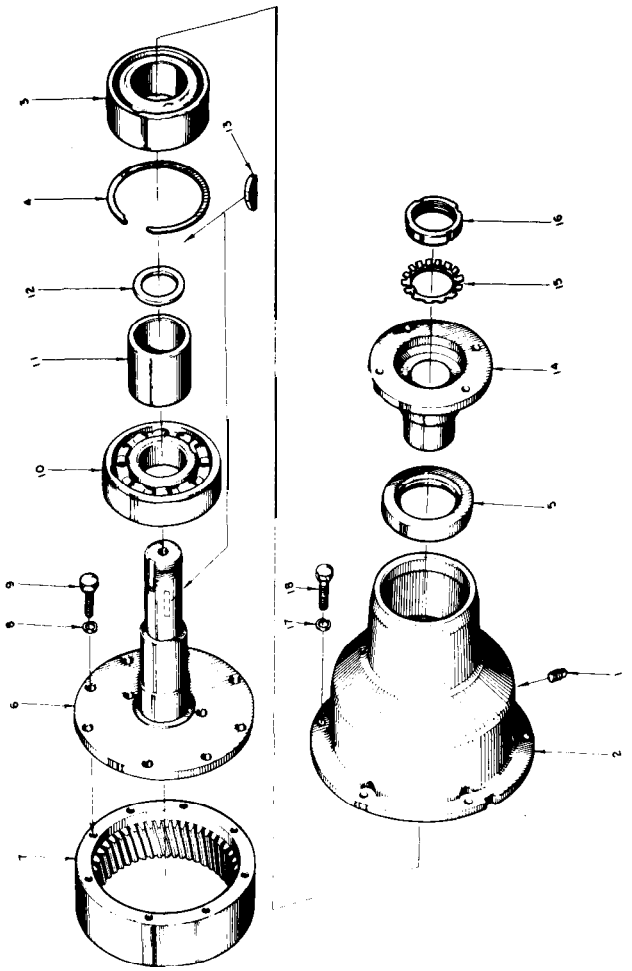


Fig. 36—Gray Hydraulic Attachment for Paragon *Reverse Gear*



1. Drain Plug
2. Reduction Gear Housing
3. Ball Bearing
4. Ball Bearing Retaining Ring
5. Oil Seal
6. Flanged Shaft
7. Ring Gear
8. Lockwasher
9. Bolt
10. Ball Bearing
11. Spacer
12. Seal Washer
13. Woodruff Key
14. Gear Half Coupling
15. Lockwasher
16. Locknut
17. Lockwasher
18. Bolt

Fig. 35—Exploded View of Typical Reduction Gear.

REDUCTION **GEAR:** The function of a reduction gear is to make possible the use of all of the power developed in the higher range of engine speed, at a shaft speed adapted to the requirements of a large propeller. There are no service adjustments on the reduction gear and, like the reverse gear, it is pressure lubricated from the engine.

Five reduction ratios are available 1.5: 1, 2: 1, 2.5: 1, 3: 1, and 3.5:1. The reduction gear can be attached to the clutch housing so that the propeller shaft C/L will be either above or below the crankshaft C/L, according to installation requirements.

Oil Seals: There are three oil seals in a direct drive clutch housing, one in the ball bearing retainer for the tail shaft and one on each side of housing for the yoke shafts. When a reduction gear is used, the rear end oil seal will be found in the reduction gear housing.

HYDRAULIC REVERSE GEAR: The hydraulic reverse gear used on Graymarine engines has a separate oil supply, and individual oil pump. (Gray did manufacture until recently a hydraulic attachment for Paragon manual reverse gears, as shown in Fig. 36-write for Instruction Manual Form GM-2056, including engine serial number. Replacement parts available.)

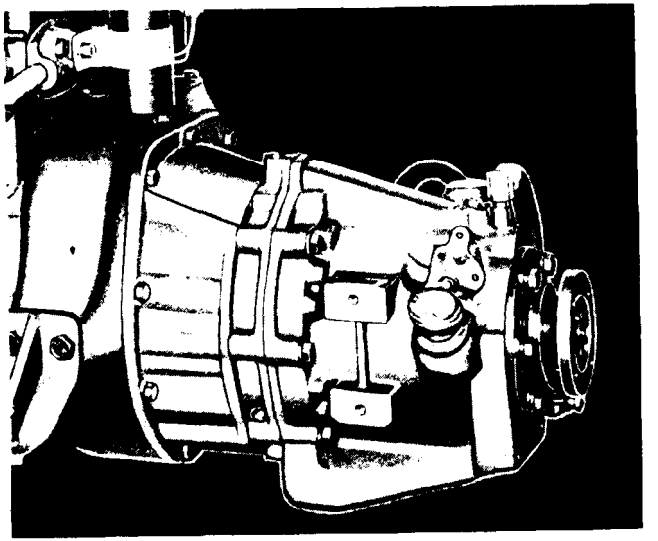


Fig. 37—Warner "Velvet Drive" Hydraulic Reverse Gear

No adjustments are required on this unit, because the oil pressure automatically compensates for normal wear, but it is important that control cable be installed so that there is exact register of the detent on each position of the shifting lever. There are three detents, one each for forward, neutral and reverse. If detent does not register, clutch will not fully engage, resulting in a rapid build-up of heat, warping the plates and damaging the clutch. Correct oil pressure is 115-125 psi.

For detailed description and service instructions on current hydraulic reverse gears, separate Service Manuals are available on both Paragon HB, HF and HJ Gears and on Warner Velvet Drive Hydraulic Gears. Manuals are available at $1.50 each. Specify model of gear and engine when ordering.

Essentially, the hydraulic unit parallels the construction of the manual type, except that the engagement of the forward and reverse mechanisms is accomplished by valving of oil under pressure. Power for the operation of the hydraulic transmission is provided by a pump mounted within the clutch housing. Control is transmitted by a small lever on top of housing, which is connected to quadrant at pilot station by means of flexible sheathed cable.

As original equipment, the hydraulic reverse gear is used interchangeably with the manual type, either on direct drive engines or on reduction gear models, however changeover is not feasible in the field. Control cable should be securely fastened and run without sharp bends. Control quadrant can be conventional or combined with speed control; secondary controls can be installed on a flying bridge or elsewhere.

Oporation: The principle of operation is similar to that for manual control. Due to the ease of handling, care should be taken not to operate too abruptly; a momentary stop should be made at the neutral position when reversing, to avoid undue wear on moving parts of the clutch. **Never** reverse engine at high speed.

Should the engine stall in forward or reverse and it is desired to restart the engine with the gear in neutral, simply place the shifting lever in neutral before starting the engine. The engine will then start in neutral without moving the boat in either direction.

Lubrication: All types of hydraulic reverse gear units in current production have an independent oil supply which is used both as the hydraulic medium and as lubricant for the clutch mechanism, also for the reduction gear when the latter is used. The oil is cooled by a circulation of cooling water which is piped from the regular engine cooling system (through jacketing in the gear case on Paragon, or through an external oil cooler on Warner gears).

Use Automatic Transmission Oil Type "A", Suffix "A". SAE 30 engine oil may be used only in an emergency.
Oil level must be maintained at the proper height according to the markings on the depth gauge of the gear, mounted on the starboard side.

Change transmission oil after the first fifty hours of running, and thereafter once a season (or every 150 hours). IMPORTANT: after running engine briefly in both forward and reverse, stop engine and recheck oil level.

Service: No adjustments are necessary, since the oil pressure automatically compensates for normal wear of the moving parts.

VEE DRIVE GEARS

Caution: In most Vee-Drive installations the engine is not installed at normal angle. Under such condition, a 1/8" oil jumper tube MUST be installed, either from the engine oil cooler or from the connection for oil pressure gauge, to supply oil to the end thrust bearing in the reverse gear. At normal angle, this is covered by oil, but at horizontal position it must have a pressure supply. Drill and tap the reverse gear housing at a location above the thrust bearing. Special dipstick may be required; available upon request. Consult your Graymarine dealer.

Alignment of Vee-Drive to propeller coupling is done in the same manner as conventional engine-to-propeller shaft alignment described on page 16. A flexible compensating joint between engine and Vee-Drive permits an offset up to 4".
Water jacket must be drained in cold weather.

PROPELLER COUPLING: This is a minor part, but an important one, and one frequently overlooked. Face of coupling should be true to within .003", and it must be in perfect alignment with engine coupling.

For instructions on alignmen!, see Installation Section, page 16.

POWER TAKE-OFF: The Twin Disc power take-off, which is available on Graymarine engines, usually for workboats, is lubricated independently from the engine. Directions for greasing this unit appear on the housing.

CYLINDER HEAD

Description: The cylinder head is of the conventional cast iron type, with water-jacketing completely surrounding every spark plug hole, and water circulation passages registering with corresponding openings in cylinder block. Head is tightly sealed to cylinder block by heat-treated studs, using a copper-faced gasket with inner layer of asbestos.

Service: To remove cylinder head, remove nuts from studs and remove electrical harness; disconnect water tubes. Just above the water pump there is a projecting lip on side of cylinder head: tap carefully against this, using brass rod or hammer to break cylinder head loose. Tap lightly around edges of head with a lead or rawhide hammer. Then touch the starter button. With the spark plugs left in place, the resulting compression will force the cylinder head upward along the studs.

CAUTION: Do not use a sharp chisel or screwdriver in prying cylinder head loose, or you will damage the gasket.

Examine the gasket surface of head for leaks or cracks. Clean

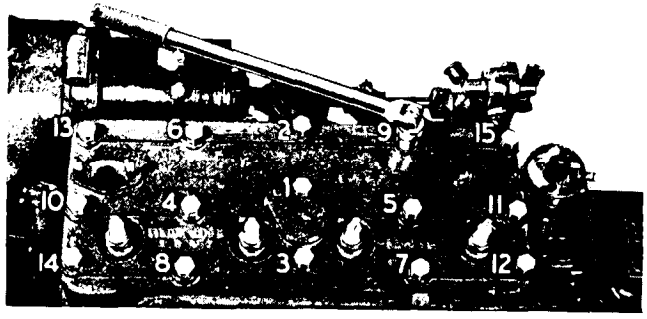


Fig. 38 — Tightening Cylinder Head. Work from Center Stud Nut Toward Sides and Ends, in Sequence as Illustrated. Four-Cylinder Engine Shown

carbon from combustion chamber, using a metal scraper, wire brush and mineral spirits, taking care to do a thorough job as carbon deposits increase the compression pressure, insulate against heat conductivity of the metal, and provide fragments of carbon which get incandescent and cause pre-ignition. Scrub gasket surface clean with cloth and mineral spirits.

In replacing the head, the gasket is dropped over the studs without the use of any shellac or grease. It is good practice to use a new gasket each time cylinder head is removed. If old gasket is re-used, soak it in water to expand asbestos. In tightening down the cylinder head, use a socket wrench as illustrated in Fig. 38, and work slowly and evenly from the center stud nut towards the sides and ends, in the sequence shown in Fig. 38. Tighten each nut moderately, then repeat the procedure. No one nut should ever be pulled down tight while the others are loose, as there is danger of cracking the cylinder head casting.

Torque Wrench: The use of a torque wrench on cylinder head stud nuts, and elsewhere, is recommended, as it permits even tension and allows sufficient pull without danger of damaging the studs. Lubricate threads to assure accuracy of torque.

Size-Diameter	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"
Cylinder Heads	.....	35-40	70-75	100-110	130-140	145-155
Main Bearing Caps and Connecting Rods	20-25	35-40	70-75	85-95	100-110	.....
Flywheels	20-25	35-40	70-75	85-95	100-110	145-155
Manifolds	15-20	25-30	50-55	80-90	100-110	130-140
Gear Covers, Water Pumps, Front and Rear End Oil Pans	15-20	25-30	50-55	80-90	.....	.....
Flywheel Housings	15-20	25-30	50-55	80-90	115-125	.....
Camshaft Nut	55-70	For All Models				

Spark Plugs: When replacing, always use a socket-type torque wrench, settings as follows:

14 mm size . . . 26- 30 lbs.
18 mm size 32-38

VALVES

The exhaust and intake valves in any internal combustion engine operate at high speed in extreme heat. With adequate cooling and lubrication they may operate two or more seasons without attention. Correct valve lash and clean accurate valve seating are important, because the contact at valve seat is the only escape route for heat from valve head. If it gets too hot, it will burn or warp. Valve failure may be caused by uneven wear at valve seat, carbon deposit on valve seat, warping due to running without water supply, or sticking stems caused by carbon, gum or rust. Valve failure is the chief cause of compression loss, evidenced by a falling off of power.

Valve Grinding: Complete directions for grinding valves and valve seats are published by the manufacturers of valve grinding tools. For a first class job, it is advisable to remove the engine from the boat before proceeding.

To Remove Valves: First remove cylinder head, carburetor and valve chamber cover. With the use of a good valve spring lifter, as shown in Fig. 39, remove retainer pins or keepers from foot of valve stems. The valve springs need not necessarily be removed from engine but should be lowered to the top of the tappet screw. It is advisable to pack a rag at base of valve to keep from dropping small parts into the base of engine.

All the valves should be removed and their heads and stems as well as the valve seats in block thoroughly cleaned of 0.11 carbon.

CAUTION: In removing valves be sure to lay them out so that each can be reassembled in same position from which it was taken. A small piece of 1 x 2 wood with 8 holes for a 4-cylinder engine and 12 holes for a g-cylinder engine drilled in it will help to keep valves in correct position. Next, clean out and oil the valve guides carefully.

Valve Springs: These can be removed after valves are out. Valve springs are made from a special analysis spring wire, and are protective-plated to prevent damage by rust or corrosion. They are accurately coiled, tempered and checked for tension. Use genuine Gray replacement springs: do not attempt to use a substitute spring just because it will fit. A substitute spring may fit, but may have the wrong tension for proper operation. The closer coiled end of spring is the upper end.

It is normal for a valve spring to break occasionally from metal fatigue, which is not surprising when you consider that every valve spring in an engine running at 2000 r.p.m. is flexed 60,000 times an hour. If valve breakage is persistent, look for the cause. Commonest cause of valve breakage is condensation, due to running the engine too cold.

Adjusting Valve Tappets: Three thin wrenches are required— 9/16", 3/4", 7/8". The adjusting screw clearance for both intake and exhaust valves on the engine should be exactly as stated in engine specifications, with the engine cold. The tappet screws

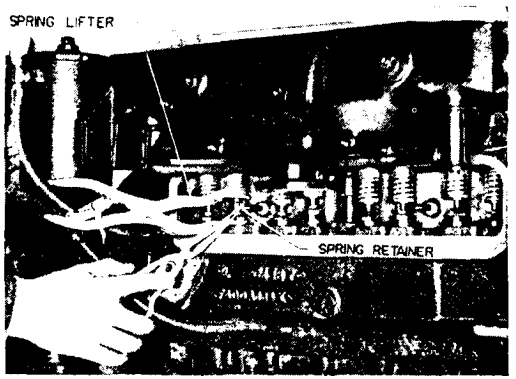


Fig. 39—Removing Valves

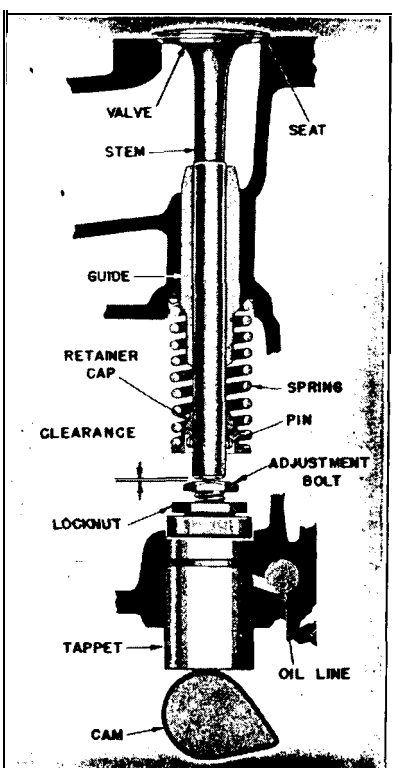


Fig. 40—Valve and Tappet Assembly

should not be set closer than stated, because less will not allow for normal expansion when the engine is warm, wtth the result that the valves will not reat, also the tappet faces and cam faces will &come badly scored and cut. This will further cause the head of the valve to become badly burned or warped, because the only escape for heat from the valve head is through a perfect seat, metal to metal, conducting the heat to the water-jacketing around the valve seat.

If the tappet face becomes scored there is nothing to do but replace it. If not too badly damaged, marks on the cams of the camshaft can be smoothed out by honing with an oil stone.

Adjusting valve tappets is an easy operation, but one requiring care. Use a feeler gauge and lock the tappet at its exact clearance as specified on pages S-3, S-4, S-11 and S-13, Specifications Section.

Adjust tappets only when piston is at top of compression stroke, with both valves closed.

Fig. 41—Adjusting Valve Tappets

Valve Sticking: This condition, which is no stranger to all types of automotive service, may be due to any one or more of a number of causes. They are mostly variables over which an engine manufacturer has no control. These include (1) running the engine too cold, (2) improper lubrication, (3) too close a fit between valve stem and quide, (4) gum or carbon formation on valve stems, (5) rust in the valve guides, (6) kick-back of overflow water from exhaust, or condensation condition.

When this condition may occur, do not jump to the conclusion that your trouble is something rare and unusual, or that your engine is defective; there is probably some other simple cause. Rust occurs more frequently in marine installations, and varnish-ltke gums develop under certain conditions in all types of service. For related reasons, valve sticking is especially prevalent with engines which have just been put into service, engines which are operated at slow speeds, or engines which are operated only intermittently.

A leading automobile manufacturer instructs all dealers to use a heavy-duty lubricating oil corresponding to U. S. Army Specification 2-104B, whenеru shipment is made by sea. This speci-

fication, for which over 700 brands of engine oil have qualified, is also used widely by fleet operators of trucks, because of its ability to reduce deposits. Heavy-duty lubricating oil is available at most filling stations. Use No. 10 or No. 20 S.A.E. heavy-duty oil on installations where frequent idling and low speed operations occur, or for "breaking in" o new engine.

CAUTION: Heavyduty oil has a detergent action which rapidly frees accumulated deposits. For this reason, when changeover is made to heavy-duty oil in an engine that has been previously operated with regular lubricating oil, we recommend at least one oil change after S-10 hours of operation when crankcase is first filled with heavy-duty oil, to clear system of excess sludge.

A corrective which is widely used in the automotive field is the use of a gum solvent in the fuel or a penetrating additive in the oil. Such additives are marketed widely by the leading oil companies, and include such products as Houghton's "Motor Fuel Concentrate," Shaler "Rislone," "Casite," "Siloo," "Wynn Oil," "Upperlube," and others. These additives are advantageous in counteracting special conditions because of their solvent and detergent effect.

The commonest cause of persistent trouble with sticking valves in marine service is water in the valve chamber, either from condensation caused by running too cold, or kick-back of overflow water cawed by an oscillation in the exhaust pipe. The latter may be eliminated by various methods, such as we of a water-jacketed exhaust pipe, or "venting." When sticking valves cause trouble a second time, suspect condensation first. Never ream the valve guides more than .0015", because excess clearance in the guides promotes accumulation of gum and coke.

TIMING

By timing in an engine is meant the synchronization of moving parts with the crankshaft and with each other. All moving parts are in time except the cranking motor, generator and water pump.

Timing is predetermined by the setting of gears and cams, so that for every degree of the crankshaft's revolution, the relative position of valves, pistons and distributor can be set. When an engine is not timed perfectly, it loses efficiency, and when the timing gears are not properly in mesh, the engine will not operate at all.

Under ordinary circumstances, the **operator need only be** concerned about one adjudment of timing, that on the dttibutor. setting of which is described on page 39. All other settings are fixed at the factory and cannot possibly get out of adjustment unless major repairs are undertaken.

In case of an overhaul, the following points of timing must be carefully checked:

1. Replacement at flywheel. Due to an offset stud, flywheel can only go on in one position; do not damage parts by attempting to force it in place incorrectly.

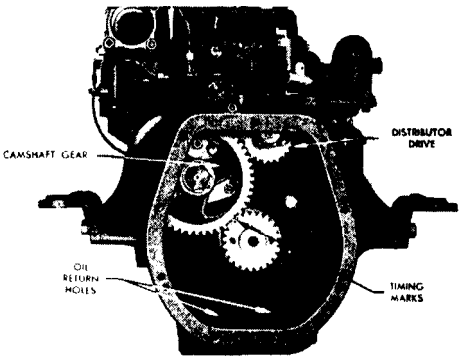


Fig. 42—Gear Train and Timing Marks

2. Replacement of crankshaft gear and/or camshaft gear. Together, these are referred to as the timing gears, since on their proper mesh is determined the whole timing system of the engine. On two adjoining teeth of the camshaft gear and on one tooth of the crankshaft gear will be seen punchmarks. These must be in mesh. They cannot possibly get "out of time" unless the crankshaft has been removed, at overhauling time.

3. If distributor has been removed for. any reason, instructions for replacement and timing are given under "Engine Firing Order," page 39.

4. Spark plug connections must be in accord with firing order, see pages S2-4 and S12-15, in Center Section.

LAYING-UP INSTRUCTIONS

For Care of Engine Preparatory to Storage

1. **First** Run the Engine, under load with clutch engaged, until it is completely warmed up. (Hot oil is thinner and will drain better; also it has the accumulated impurities held in suspension.) Then shut it off and remove crankcase oil, using the Gray sump pump. Reason for removing the old oil is that it may have an acid content, because most fuels have a trace of sulphur, and sulphur dioxide gas (SO_2) which is a product of combustion, plus water (H_2O), plus heat, forms sulphurous acid (H_2SO_3). Refill slightly over the "full" mark on oil depth gauge with fresh oil of viscosity S.A.E. 30..

2. **Then Start Up the Engine** Again to distribute clean oil through the engine, and while it is running at good speed, choke it off by pouring a cupful of regular No. 30 engine oil into the air intake on carburetor. Thid will have the effect of making the engine a trifle hard to start when it is again put into service, but not if you clean the spark plugs, and it will coat the combustion chamber as well as the carburetor jets with a protective film of oil. Turn off ignition switch.

3. **Close the fuel shut-off at tank,** and run the engine at idle until it stops. Purpose of this is to remove all gasoline from the fuel pump, because stale gasoline may deteriorate the fuel pump diaphragm. If the fuel tank can be readily drained (or syphoned off) without danger of spilling, this is good procedure.

4. Remove **spark lugs** and pour one to two ounces (no morel) of SAE 10 oil into each cylinder through the spark plug hole. Then before replacing the spark plugs, cover the cylinder head with a rag to prevent oil splashing, and crank the engine for at least ten revolutions to distribute this oil over the cylinder walls and piston rings. CAUTION: In this operation the spark plugs must be out, otherwise the oil may be compressed enough to break a piston or bend a connecting rod.

5. **Remove** battery, and have it stored with your marine service station or local battery dealer. To prevent sparks, always disconnect ground cable first.

6. **Next drain the engine thoroughly.** Most current models have 3 dram plugs, on cylinder block, on oil cooler and on exhaust manifold. Some models also have dram plug on water pump. Draining is best done after the boat is removed from the water During the draining, prod the drain holes with a piece of wire to make sure they are fully open and not clogged by rust or sediment. If there is any doubt about the thoroughness of the draining, break hose connections to be on the safe side. But if the boat is left in the water, be sure to close all drains after draining. Filling the cylinder block with rust preventative is no longer recommended. In salt water areas, flushing the block with fresh water is worth while.

7. **The sea water pump** requires special attention, especially if it is of the Neoprene impeller type because an impeller blade may become distorted or stuck to the pump housing during the lay-up period. The pump may or may not have a drain plug. On some models the pump can be drained only by removing the pump cover, in which case it is good procedure to remove the impellers for inside storage. On most engines the pump is secured by only two bolts, and it is easier to remove the entire pump assembly for inside storage.

8. **If engine is equipped** with Paragon hydraulic reverse gear, or vee drive gear, be sure to drain these units separately, because each has water-jacketed passages. Drain plugs are provided for this purpose. On engines equipped with Warner hydraulic transmission, drain transmission oil cooler.

9. **Care of Electrical Equipment:** Remove the coil and the high tension wires. These parts can best be kept clean and dry wrapped in waterproof paper. Cranking motor and generator may also be removed, but if they are left on the engine they should be cleaned and wrapped with rags. Spark plugs should be replaced in the cylinder head and tightened down firmly. These protect the threads and seal out dirt. Do not use corks in spark plug holes.

10. **Care of Battery:** Remove battery from boat and replenish water to bring level 3/8" above the plates. Fully charge the battery to 1.275 gravity, then store in a clean dry place and keep charged. Battery should be inspected once a month during storage period. Clean the cable terminals by dipping them in a solution of baking **soda,** then dry them and coat lightly with Vaseline or thin grease. Badly corroded terminals should be replaced.

11. **External Care of** Engine:

A. Cover all surfaces having a tendency to rust, by painting or spraying with a rust preventive. Use a rag, a paint brush or a spray gun, and pay particular attention to **rusty** spots. Remove the valve cover plate, and wipe or spray the valve springs, valve stems, and all **exposed** metal parts which are not painted.

B. Examine the paint on the outside of the engine, and repaint any damaged spots before rust appears. Gray Distributors can supply touch up paint in spray-type or open type cans, one pint size.

C. Always disconnect the propeller shaft from the engine at the coupling **before hauling boat** from **the water.** This is to prevent straining or bending the shaft. Now **is** a good time to check the propeller for bent blades.

D. Put a tarpaulin or waterproof canvas cover loosely over the engine to protect it from water drips and snow. Be sure the covering is not too tight, because good ventilation is desirable: this discourages rust and condensation.

12. **How About Overhauling?** If the engine has been in service for an extended period, its performance will be improved by a general overhaul. During storage period is the **time to** do it. Don't wait until the boat is needed in a hurry.

FITTING OUT AFTER STORAGE

1. Close all drams and examine hose connections.

2. **Fill** the fuel tank with the proper grade of clean gasoline, and open shut-off valve at tank. Most models have a hand primer on fuel pump-use this to fill fuel bowl.

3. Double check the gasoline line ond fittings for leaks.

4. If water pump has been removed from engine for storage, re-install it and check drive belt tension. If Neoprene impellers have **been** removed from pump housing, re-install them, and replace cover, using new gasket. Make sure that none of the Impeller blades are stuck to the pump housing, by turning the drive pulley by hand. At this time, insure the pump's initial prime **by** wetting the rubber impeller blades.

5. Check lubricating oil supply. If engine is equipped with an oil filter, the filtering element should **be** replaced at this time unless a new one was Installed at lay-up time. Make record in engine log

6. Put new grease in all grease cups, and a few drops of engine oil in the oil cups of generator and cranking motor, also on all control joints. Remove all old grease from grease cups before refilling.

7. Brighten up the terminal posts on the battery, using steel wool, and attach cables. After tightening down the clamps, smear lightly with vaseline or grease to exclude acid and air. Do not put vaseline on the battery posts **before** attaching the cables, as vaseline is a non-conductor.

8. Clean all contacts inside the distributor with fine sandpaper or an ignition file. If the points are pitted, replace them with a new set: these are inexpensive. Wipe inside of the distributor clean, and rub a very thin film of cup grease around the cam and terminals inside cap.

9. Inspect top of pistons by looking through the spark plug holes, using a flashlight, and make sure there is no excess oil standing on top of the pistons. Inspect spark plugs and check to make certain they are set for the correct gap. If they look doubtful, replace them with new plugs or have them sandblasted and tested. One faulty plug can cause no end of trouble.

10. If engine is equipped with an oil cooler, inspect this for any accumulation of dirt and debris On plate type oil cooler cover may be removed for inspection.

11. Now is a good time to recheck the stock of spares. It is good policy to carry on board an extra condenser, distributor rotor, distributor cap, coil, set of distributor points, set of spark plugs and filter element. These should be protected by wrapping in waterproof paper. For extended cruising, it is wise also to carry a spare water pump and spare propeller.

12. Tighten down all bolts, nuts, screws, paying particular attention to the cylinder head studs, the lag bolts holding engine to the bed, and electrical connections,

13. Reconnect the coupling **after** the boat is put in the water, and check the alignment. Tighten up on stuffing box as necessary.

14. CAUTION: Before starting the engine, remove the engine cover and let the engine compartment air out. Make sure the bilge is dry. Be certain there is no possible cause of fire— rags, gas or oil leaks, open tins of kerosene or gasoline, etc. onywhere around the **boat.**

15. Finally, with gasoline in the tank, oil in the pan, propeller tight on the shaft, stuffing box tight, engine running normally, water coming freely through the overflow, oil gauge and ammeter reading O.K., you will be ready for a trial run. It is important to check the reverse gear carefully at this time to make sure it is properly adjusted. A loose clutch will wear prematurely.

16. If you have questions, ask your dealer. Don't guess.

TROUBLE-SHOOTING GUIDE

Note: A good rule to follow in locating engine trouble is never to make more than one adjustment at a time. Stop and think how the engine operates, and figure out the probable cause of any irregular operation, locating the trouble by elimination. Remember that the cause usually is a simple one, rather than a mysterious and complicated one. The following outline will be helpful in locating ordinary engine troubles:

CRANKING MOTOR WILL NOT OPERATE

1. Discharged or low battery:
   Recommended test for battery is to check with a hydrometer or voltmeter.

   SAFETY CAUTION: Before working around the battery or ignition circuits, the engine compartment should first be thoroughly aired out, and a check made for gasoline fumes, before breaking any connections which might result in an exposed spark.

2. Loose or corroded battery terminals:
   Check cable connections at the terminal posts. Don't just look: break the connection, clean and reclamp.

3. Defective starter switch:
   First inspect the connections. Recommended test for a defective starter switch is to use a test lamp (a 6-volt lamp in socket with two loose terminals). Place one test lamp prod on the battery terminal of the switch and the other on the distributor terminal of the coil. The lamp should light with the switch ON.

4. Bendix pinion of cranking motor jammed:
   Reach under flywheel, and see if the starting pinion is free. If pinion is jammed against flywheel, it may be freed by loosening up the bolts which hold cranking motor to flywheel housing.

5. Defective cranking motor:
   Inspect commutator and brushes.

6. Engine itself may be frozen.
   Crank engine by band, to make sure it is free.

CRANKING MOTOR REVOLVES BUT ENGINE DOES NOT

1. Weak battery:

   Not sufficient power to turn engine at normal speed. When this condition exists the cranking motor will have a characteristic hum.

2. Acid-eaten cable:

   Insufficient current getting through. Give particular attention to ground connection on battery.

3. Broken Bendix drive, or gum on Bendix spiral:

   Remove the cranking motor and look for broken spring. If Bendix pinion does not move freely on spiral, wash pinion and spiral in mineral spirits and lubricate sparingly with light engine oil, S.A.E. 10.

4. Stripped gear on flywheel:

   This is extremely rare.

CRANKING MOTOR OPERATES BUT ENGINE WILL NOT START

(This also covers hard starting and slow starting. Possible causes will be covered under (A) Improper Carburetion, (B) Electrical Difficulties, (C) Poor Compression, (D) Wrong Timing.)

A. Improper Carburetion

1. Out of fuel: tank empty?

2. Is gasoline reaching fuel pump?

   See if sediment bowl on fuel pump is filled with gasoline. If it is not, and if there is fuel in tank, shut-off cock may be closed, or the line may be clogged. Try the hand primer. Disconnect line at fuel pump and blow through line. Look for dents in tubing, and air leaks in fuel pump gaskets or in fuel line connections. Make sure that vent to gasoline tank is open.

3. Is fuel reaching the carburetor?

   First remove sediment bowl from fuel pump and see if screen is clean. Then disconnect line from fuel pump to carburetor, and see if gasoline flows out freely. This line may be clogged with dirt.

4. Is fuel reaching the cylinders?

   Remove spark plugs and see if they are moist. It there is no trace of gasoline in the cylinders, carburetor may be out of adjustment, float level too low, or the jets may be clogged with dirt or gum.

5. Is choke closing properly?

   This is especially important on dual carburetor models, because if linkage permits one choke to remain partly open, both chokes will be out of action, causing hard starting

6. Engine flooded?

   If the spark plugs are wet, this indicates flooding, caused by using the choke too long. Refer to page 8 for instructions on deflooding the engine.

7. Vapor lock?

   This condition is caused by engine heat creating a gas pocket in the fuel line. Emergency remedy is to pour water on the fuel pump to cool it.

8. Air leaks at intake manifold.

9. Poor grade, old or stale fuel in combination with cold weather. In very cold weather, heating the oil and warming the plugs will help.

B. Electrical Difficulties

Possible troubles may be summarized as follows:

1. Primary Circuit
   - Corroded, dirty or loose connections
   - Weak, leaky or grounded condenser
   - Distributor points pitted or fused
   - Distributor points set to wrong gap, or loose
   - Breaker arm sticking
     - Spring weak or broken
     - Hinge bushing tight on pin

2. Secondary Circuit
   - Corroded, dirty or loose connections
     - Pay particular attention to high-tension wire from coil to distributor, and all wires in distributor cap
   - Wet wires
   - Moisture or carbon on spark plug porcelains
   - Cracked insulation, leaks and shorts
   - Cracked distributor cap
   - Carbon contact inside distributor cap broken or missing
   - Rotor contact spring broken
   - Ignition coil weak
   - Wrong type of spark plug
   - Improper gap on spark plugs
   - Fouled or cracked spark plugs
   - Distributor wired to wrong plugs

C. Poor Compression

A rough-and-ready check for compression is to remove a spark plug and place your thumb over the spark plug hole, then crank the engine. Accurate method is to use a compression gauge. Do not expect all cylinders to show the same compression pressure, but a decided difference will indicate improperly seating valves, worn rings, worn cylinder, or leaky gasket. After taking an initial reading, seal the piston with a teaspoonful of engine oil, poured through spark plug hole, and take a second reading; if pressure does not increase, this will indicate that improperly seating valves are at fault. Poor compression may be caused by any of the following:

1. Loose or warped cylinder head
2. Spark plugs loose in head
3. Damaged cylinder head gasket
4. Poorly seating valves

5. Broken or weak valve springs
6. Valves holding open due to insufficient tappet clearance
7. Valves sticking open due to warped stems or carbon and gum on stems or in stem guides
8. Badly worn, broken or stuck piston rings
9. Cylinder scored or worn excessively

D. Wrong Timing

Remove any spark plug, put your thumb over the spark plug hole and test for compression stroke, cranking the engine over by hand. Then probing with a stiff wire, set piston on top dead center of the compression stroke. At this position, the breaker points in distributor should be just starting to open, Firing order is 1-3-4-2 on 4-cylinder engines both rotations, 1-5-3-6-2-4 for 6-cylinder engines right hand rotation, and 1-4-2-6-3-5 for opposite rotation.

OVERHEATING

1. Worn water pump
2. Obstruction in oil cooler
3. Obstruction in water intake scoop
4. Scale or sand in water jackets
5. Collapse of intake water hose under load
6. Water by-pass valve off correct setting
7. Low oil level in crankcase
8. Thermogard stuck

LACK OF POWER

1. Faulty compression
2. Improper timing
3. Poor carburetion
4. Restriction in air supply to carburetor caused by dirt in flame arrester screen, or choke valve not completely opening.
5. Throttle control linked up so that throttle valve is not fully opening.
6. Dirt or water in sediment bowl of fuel pump
7. Dirt or water in fuel lines or carburetor jets
8. Air leak in fuel pump or fuel line
9. Air leak in manifold gasket
10. High engine temperature, caused by worn water pump or clogged water jackets
11. Vent of gasoline tank not open.
12. Pre-ignition, caused by carbon deposits, by wrong plugs, or warped valve head
13. Insufficient air getting into engine compartment
14. Engine and propeller shaft misalignment
15. Marine growth on boat bottom can greatly reduce engine rpm.

ROUGH, UNEVEN IDLING

1. Improper adjustment of idling screw on carburetor
   Float level too high or too low
   Idling jet air passage clogged
2. Air leaks in intake manifold or carburetor
   Loose manifold nuts
   Damaged gasket at manifold
   Warped manifold

3. Improper ignition
4. Weak ignition coil
5. Spark plug difficulties (gap too close)
6. Uneven compression
7. Water leak in cylinder head, block or manifold

MISSING AT HIGH SPEED

1. Spark plug troubles
2. Broken insulation on high-tension wires
3. Weak breaker-point spring
4. Fuel obstruction, indicated by back-firing
5. Weak valve springs
6. Improper tappet clearance

MISSING AT ALL SPEEDS

1. Blown head gasket between cylinders
2. Sticking valves, broken valve spring
3. Fouled spark plugs, broken insulation
4. Leaky high-tension wiring
5. Pitted or fused breaker points
6. Incorrect breaker-point gap
7. Improper valve tappet clearance
8. Punctured condenser
9. Gasket leak at intake manifold
10. Carburetor out of adjustment

CRANKSHAFT KNOCKS

(Do not confuse with normal reverse-gear back lash.)

These are usually detected as dull, heavy, metallic knocks which either increase in frequency as the speed and load on the engine is increased, or are more noticeable at idling speeds. The most common crankshaft knock is that caused by excessive clearance at one or more main bearings. This is most audible when engine is pulling hard, on acceleration, or when engine is cold. By alternately shorting out each spark plug, the approximate location of the loose bearing can usually be determined. Excessive crankshaft end play causes a sharper noise or rap which occurs at irregular intervals, In bad cases this can generally be detected by releasing and engaging the clutch. Causes of crankshaft knocks include the following:

1. Excessive bearing clearance
2. Excessive end play
3. Eccentric or out-of-round journals
4. Sprung crankshaft
5. Bearing misalignment
6. Insufficient oil supply
7. Low oil pressure
8. Badly diluted oil
9. Loose flywheel
10. Loose crankshaft gear

CONNECTING ROD NOISES

Connecting rod noises are usually a light pound or knock of much less intensity than main bearing knocks. The noise is usually evident with the engine idling and becomes louder when engine speed is slightly increased. Connecting rod noir can

best be located by shorting out one spark plug at a time. These noises should not be confused with piston or piston pin noises. Possible causes are as follows:

1. Excessive bearing clearance on crank pin
2. Insufficient oil supply
3. Low oil pressure
4. Badly diluted oil
5. Misaligned connecting rods
6. Out-of-round or tapered crank pin journal

PISTON NOISES

The most common piston noise is "slap," due to the piston rocking from side to aide in the cylinder. Piston slap usually causes a hollow, muffled bell-like sound, or a click. Slight piston noises that occur with a cold engine and disappear after the engine is warm, do not ordinarily warrant an overhauling. Piston slap is most audible when driving the engine at low speed under load. Do not confuse with reverse gear back lash, which is normal in a marine engine of this type, especially at speeds below 600 r.p.m. Piston ring noises generally cause a click, snap, or sharp rattle on acceleration.

Piston and ring noises can be located by putting a spoonful of heavy engine oil (S.A.E. 50) into the suspected cylinder through the spark plug hole. Crank the engine over by hand for several revolutions with the ignition off, until the oil has worked down past the piston rings. Replace the spark plug, start the engine, and determine if the noise still exists.

PISTON PIN NOISES

The most common piston pin noise is the result of excessive piston pin clearance. This is characterized by a sharp, metallic double knock, generally audible with the engine idling. Interference between upper end of the connecting rod and pin boss is difficult to diagnose and can be mistaken for a valve tappet noise. Possible causes:

1. Excessive piston pin clearance in piston boss
2. Excessive piston pin clearance in bushing
3. Bushing loose in connecting rod
4. Connecting rod end rubbing piston pin boss

VALVE AND TAPPET NOISES

Noisy valve action has a characteristic clicking noise occurring usually at regular intervals. The frequency of valve action noise is generally less than other engine noises, because the valves are operated by the camshaft running at one-half of crankshaft speed. If one or two of the valves or tappets are causing the noise, the clicking sound will be intermittent, but if the condition exists with a majority of the valves, the noise may be continuous

The common cause of valve action noise is that of excessive clearance between tappet and valve stem. Correct setting will be found in specifications. Instructions for valve tappet adjustment are covered in detail on page 57. Do not set for leas than specifications call for, since this is liable to cause burned valves.

Poarible causes of valve and tappet noises:

1. Excessive valve stem to tappet clearance

2. Threads stripped on adjusting screw
3. Weak valve springs
4. Excessive valve stem to guide clearance

SPARK KNOCK AND FUEL **KNOCK**

Included under this heading are Pre-ignition and Detonation. Pre-ignition is caused by an incandescent particle of carbon or metal in the combustion chamber, which fires the mixture prematurely, while the piston is still rising. Detonation is caused by fuel of wrong octane rating, which burns too rapidly, throwing a sudden and abnormally high pressure against the down-moving piston. The two have a similar sound, a metallic ringing knock which is often described as a "ping." This is usually heard when the engine is laboring, accelerating rapidly, or overheated. Causes:

1. Carbon deposits in combustion chamber
2. Ignition timed too early
3. Weak springs in automatic distributor advance
4. Incorrect spark plugs (too hot)
5. Carbon on spark plugs or burned porcelains
6. Sharp metallic edges in combustion chamber or on gasket edge
7. Cylinder head gasket projecting in combustion chamber
8. Hot valves resulting from:
   - Insufficient tappet clearance
   - Water lines too small
   - Use of wrong type of valve
   - Improper seating
   - Thin edge valves
   - Warped or cracked valve heads
9. Excessive engine temperature, caused by faulty water circulation
10. Low octane fuel
11. Old or stale fuel
12. Extremely lean carburetor mixture

BACK-LASH KNOCK

This can, under certain conditions, appear as a rattle or chucking noise in the reverse gear, and it may be easily confused with other types of engine knocks. It is caused by normal back lash between the teeth of the reversing gears, and it is heard only at low speeds, "washing out" when the engine is accelerated above 600 r.p.m. Normal back lash is not an indication of wear, and is harmless.

VIBRATION ORIGINATING AT ENGINE

The commonest sources of vibration originating in or on the engine, as distinguished from causes originating outside the engine (covered below) are as follows:

1. Misfiring
2. Misalignment of engine and propeller shaft
3. Bent or off-center coupling
4. Engine loose on bed
5. Engine support locea on cylinder block
6. Unbalanced or sprung crankshaft
7. Uneaual comoreaaion of cvlindera

COMMON VIBRATION OR NOISE ORIGINATING OUTSIDE THE ENGINE

Thumping sounds and vibration originating outside the engine often telegraph along the propeller shaft and **appear to originate** in the engine. These **may be caused by one or more of the** following:

1. Bent propeller
2. Sprung propeller shaft
3. Worn stuffing box

UNCOMMON ENGINE NOISES

The following possible causes of engine noise are more rare, but should be considered and checked in locating foreign sounds:

1. Flywheel loose on crankshaft
2. Crankshaft pulley loose on flywheel
3. Foreign object in exhaust passages
4. Loose exhaust pipe at manifold connection
5. Loose engine accessories, such as generator, water pump, etc.
6. Excessive timing gear back lash (sharp rap)

BACK-FIRING AT CARBURETOR

Engine back-firing through the carburetor when starting cold is many times unavoidable as it is the result of imperfect air. gasoline mixture, which will automatically correct itself after the engine reaches normal operating temperatures. The reason why of back-firing in this case is late burning of the mixture in the cylinder, due to improper ratio of fuel to air, igniting the incoming charge and causing an explosion in the intake manifold and carburetor. Thus lean mixtures and retarded spark are the commonest cause of back-firing. Continued back-firing after the engine is warm should be corrected by checking the following possible causes:

1. Excessively lean fuel mixture
2. Late ignition timing
3. Incorrect valve timing
4. Improperly seating valves, especially intake
5. Obstruction in fuel line
6. Dirt or water in sediment bowl
7. Intake manifold air leaks
8. Poor grade of fuel
9. **Secondary** wires crossed in distributor cap
10. Distributor governor sticking
11. **Badly worn or improper spark plugs**

ABNORMAL OIL CONSUMPTION

1. Worn rear end oil seal
2. Engine half of propeller coupling not contacting oil seal
3. Bad oil **seals** at clutch control shafts
4. Damaged or poorly fitting gaskets at base or ends of engine
5. Cracked oil pan
6. Leak inside oil **cooler** (oil will enter water lines)
7. Breather tube too close to carburetor **air intake**
8. **Worn piston rings**
9. Excessive valve stem clearance

NOTE: Marine engines normally consume more oil than automotive engines of like size.

LOW OIL PRESSURE

Complete absence of oil pressure is sure rign of a broken oil line, either inside or outside the engine. Normal oil pressure in a new engine in 30 to 40 pounds. A pressure of less than 20 lbs. calls for investigation. (5 to 15 lbs. is satisfactory at idle.)

Possible causes of low oil pressure:

1. **Incorrect grade of oil. (Correct viscosity is S.A.E. 30)**
2. **Badly diluted engine oil**
3. **Worn bearings**
4. **Oil relief valve not properly seating, or stuck**
   Look for dirt on seat of valve and put a washer behind spring to increase tension
5. **Clogged oil cooler**
6. **Air leak in oil pump suction line**
7. **Sludge on oil pick-up screen**
8. **Pick-up screen not submerged, due to insufficient oil or engine installed at too steep angle**
9. **Worn or damaged pump gears**
10. **Inaccurate oil pressure gauge**

HIGH OIL PRESSURE

Oil pressure should not exceed 40 lbs., except momentarily when the engine is started up cold. Abnormally high oil pressure is not desirable because it increases oil consumption. Possible causes of high oil pressure:

1. **Engine oil too heavy. (Use S.A.E. No. 30)**
2. **Relief valve not opening. (It may be stuck, or spring may be too stiff)**
3. **Obstruction in distributing line**
4. **Inaccurate oil pressure gauge**

FOULED SPARK PLUGS

1. **Worn piston ringe**
2. **Worn cylinders**
3. **Excess piston clearance**
4. **Rich mixture**
5. **Plugs too low in heat range**
   (For correct plug, see Specifications, Center Section.1
6. **Gap too narrow, causes missing at idle**

BURNED SPARK PLUGS

1. **Plugs too high in heat range**
   (For correct plug, see Specifications, Center Section.)
2. **Lean mixture**
3. **Late ignition timing**
4. **Engine overheated, due to worn water pump, obstructions, etc.**
5. **Low octane fuel**
6. **Badly leaking valves**
7. Cracked valve neat

AVERAGE PROPELLER SIZES

See Explanation on Next Page

These suggested sixes are for 3-blade propellers, to approximate maximum rated R.P.M. In each case, upper figures represent largest wheels for slower, heavier boats, while the progressively smaller sizes are for lighter, faster boats. Read instructions carefully.

Graymarine Model	Direct Drive	1.5:1 Ratio	2:1 Ratio	2.5:1 Ratio	3:1 Ratio	3.5:1 Ratio
*Light Pow-55 69 cu. in.	12x6 11x10		18x13 17x1s			
*Express Four-69 69 cu. in.	10x9 9x10		15x14 14x15			
Sea Scout-91 91 cu. in.	13x6 12x10		19x12 16x14			
Four-45 91 cu. in.	10x10 10x9					
*Fireball Four-50 91 cu. in.	10x10 10x9					
Four-1 12 112 cu. in.	14x9 13x10		20x12 19x14			
Model 520 140 cu. in.	12x10 11x12	16x10 15x12	17x15 16x16			
● Lqger Four-152 162 cu. in.	15x10 14x12	20x14 19x16	22x16 20x18	25x16 24x22	28x20 26x16	30x22 26x20
§ Model 70, Four-80 162 cu. in.	13x10 12x12	17x10 15x12	20x14 16x16	22x14 20x16	24x18 22x22	26x16 24x20
Four-85, Four-75 162 cu. in.	11x12 12x11					
Fireball Four-90 162 cu. in.	12x11 11x12					
*Lugger Six-226 226 cu. in.	15x10 14x11	18x12 17x14	23x14 22x16	26x17 24x19	28x19 26x23	30x20 28x24
*Express Six-226 226 cu. in.	14x10 13x11	16x12 15x14	20x14 19x16	23x16 22x18	26x18 24x20	28x20 26x24
Models 109 and *100 226 cu. in.	13x10 12x12	16x12 15x13	20x14 19x16	23x16 22x18	26x18 24x20	28x20 26x24
Models 116 and *110 226 cu. in.	13x11 12x13	16x12 15x14				
Model 118, *Six-112 226 cu. in.	13x11 12x13					
*Lugger Six-244 244 cu. in.	15x11 14x12	19x12 18x14	23x15 22x17	26x18 24x20	28x20 26x24	32x20 30x26
*Express Six-244 244 cu. in.	14x11 13x12	17x13 15x15	20x15 19x17	24x16 22x20	26x19 24x22	30x20 28x22
*Model 115 244 cu. in.	14x10 13x12	17x13 15x15	20x15 19x17	24x16 22x20	26x19 24x22	30x20 28x22
Model 120 244 cu. in.	13x14 13x13	17x14 16x15	20x16 19x18			
Model 136 244 cu. in.	13x14 13x13	17x14 16x15	20x16 19x18			
*Fireball Six-140 au cu. in.	12x14 13x12					
*Fireball sir-150 244 cu. in.	12x14 13x13					
*Lugger Six-330 330 cu. in.	†17x10 16x12	20x14 18x18	24x16 22x20	28x16 26x20	30x20 28x24	34x24 32x28
*Express Six-330 330 cu. in.	†15x10 14x12	18x13 17x15	21x16 20x18	24x18 22x22	28x18 26x22	31x20 29x22
Model 150 330 cu. in.	†15x10 14x12	18x13 17x15	21x16 20x18	24x18 22x22	28x18 26x22	31x20 29x22
*Super Six-330 330 cu. in.	†15x10 13x15	18x13 17x15	21x16 20x18	24x18 22x22	28x18 26x22	31x20 29x22
Model 165 363 cu. in	†15x11 13x16	18x14 17x16	21x17 20x18	24x19 22x22	28x20 26x22	
Model 175 363 cu. in.	†15x11 13x17	18x14 17x16	21x18 20x19	24x20 22x22	28x20 26x22	
Model 185 427 cu. in.	†15x12 14x14	19x14 18x16	22x18 20x20	25x20 24x22	28x22 26x26	
Model 200 427 cu. in.	†15x13 14x15	19x14 18x16	22x18 20x20	25x20 24x22	28x22 26x26	
*Express Six-427 427 cu. in.	†16x12 15x13	19x14 18x16	22x17 20x20	25x18 24x22	28x22 26x26	32x20 30x24

*Non-current models.

†*These engines for heavier boats usually show best results with reduction gears.*

§*Model 70 DIRECT DRIVE, use 13 x 8.*

Average PROPELLER SIZES

Based on performance reports of Graymarine gasoline engines, from operating data sent to us by Gray owners

The *tables* of *average* propeller *sizes* on *previous page* represent the accumulated *experience* of many *years*, as they include reference to *numerous* older *models*, *as well as current models* The flexibility of *engine sizes* built by *Graymarine*, plus the *available* reduction gear *ratios, makes it possible to fit* your boot for the best combination of speed ond *efficiency*

How to Use These Tables

For selection of the best propeller, there ore many variable factors, such as type and size of boat, beam, shape of stern, blade area of propeller, etc. The safest rule, where expert advice is not available, is to select a propeller which will permit the engine to come close to its maximum rated rpm.

These charts ore presented for reference only, and the sires shown ore selected to take best advantage of the power available, consistent with good economy, bared on our experience to tit the operating range as catalogued.

These wheels will of course not fit all boats, as diameter and pitch hove lo be varied according to the characteristics of the hull. The general rule when slip is excessive is to increase diameter and reduce pitch. For Auxiliary P-blade propellers, increase diameter by approximately 5%. Twin screw installations usually need a higher ratio of pitch to diameter, because one engine takes load off the other.

IMPORTANT: Note that these wheels ore selected lo give close to maximum rated R.P.M. The best combination of speed and economy often is a compromise between extreme sizer. If wheel size shown is not readily available, a change of on inch or so in diometer or pitch is admissible in most cores. Final perfection is always bored upon actual trials, ond cannot be absolutely predicted in advance.

Consult your Gray *Dealer* for *Specific* Advice