shaft and move it along the propeller shaft with the base pressed firmly against the keel until the shaft is approximately in the center of the bearing hole. Screw the strut to the keel at this point but do not tighten down. Using small wooden wedges, center the propeller shaft in the shaft hole. Make final adjustment of the strut and tighten its hold-down screws and angle adjusting nuts securely.

3. INSTALLING ENGINE STRINGERS AND BEDS

Engine stringers should now be installed (See Fig.6). These longitudinal members should run at least two-thirds the length of the hull, and to them the engine bed will be fastened. In most modern hulls, these members will be included in the hull plans and usually will be placed to take an engine with $22\frac{1}{2}$" mounting centers. If these stringers

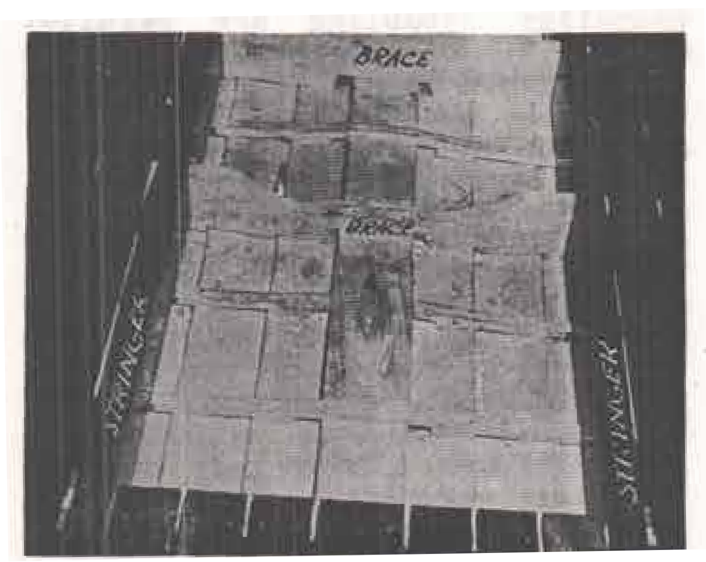


Fig.6 Photo of Engine Stringers

are not in place, they should be constructed of 8" by 2" oak or maple and should run from the transom to at least three feet forward of the engine location. The distance between them should be the distance between mounting centers of the engine plus one thickness of the material to be used for engine beds. They should rest firmly on the hull ribs and be cross-braced at intervals by notching into 2" by 8" members running at right angles to them. The braces and stringers

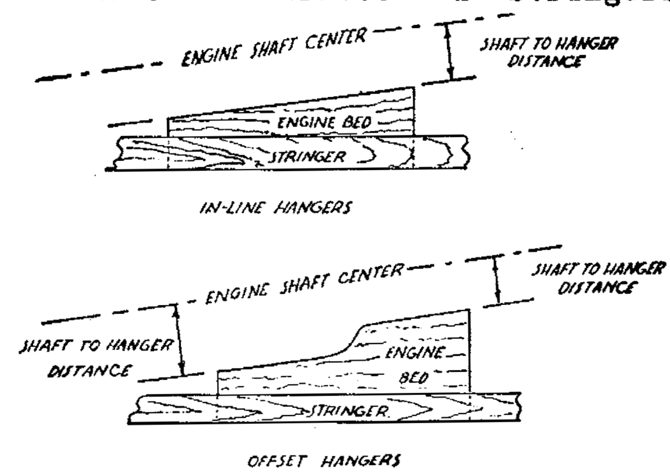


Fig.7 Engine Bed Construction

should be drift-bolted together. These cross-braces should conform to the shape of the hull and those that will be under the engine must be cut to fit the contour of the underside of the engine.

The next step is the construction of the engine bed. (See Fig. 7). These are pieces of 2" hardwood 8" to 10" longer than the length of the engine. The width of the material needed will depend on the angle at which the engine is to be mounted, the depth of the engine below the shaft line, and the type of engine hanger - that is, whether the hangers are parallel to the shaft line or offset in height. The height of these engine beds is easily determined by removing the propeller shaft and stretching a string through the strut, shaft hole and stuffing box and fastening it to a piece of stock tacked temporarily in place somewhat forward of the engine location.

A piece of engine bed material is then placed on edge alongside the string in the position where the engine is to be mounted. It is then a simple matter to measure down from the string, which represents the center of the shaft, to the position of the hangers using the figures given on the engine scale drawing. If the mounting lugs are parallel to the centerline of the shaft, the top of the engine beds are then simply cut at the same angle as the string and below it the distance of the mounting lugs. If the forward and rear mounting lugs are offset, the top of the engine bed is cut in steps at the angle of the string with the distance from the string to the top of each equaling the distance from the centerline of the engine to the mounting lugs.

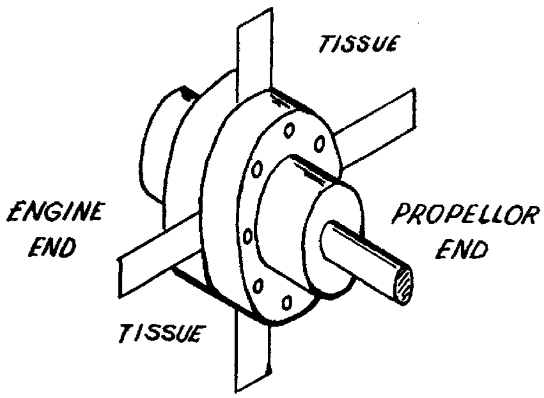
After the pattern of the engine bed is completed, replace the propeller shaft and fasten the propeller coupling in place on the shaft. The engine must now be lifted into the boat and temporarily blocked in place with the propeller coupling in as close alignment to the coupling half on the propeller shaft as possible. If the engine is a small one, this can be done by fastening a pole securely to the lifting eye on the engine and with two men on each end of the pole bodily lifting the engine in place. If the engine is large or help is not available, an "A" frame with a block and tackle can be used. Or the job can be done by a truck equipped with a winch. In any case, extreme care must be taken that all hitches used are secure and all tackle of sufficient strength to hold the load. A broken rope or slipped knot at this point could result in a very leaky boat and a very discouraged boatman.

With the engine securely blocked in place, slide the engine beds in place under the engine and on the inside of the stringers. When in place, fasten them temporarily with "C" clamps. Four 1/2" holes are then bored equally spaced along the length of the engine bed, through the stringers and bed. One-half inch carriage bolts are then inserted in the holes and securely tightened. Use washers under all nuts. The position of the engine hold-down bolts is now marked on the top surface of the engine beds. In some cases, it will be possible to drill these holes without disturbing the engine; in others, the engine must be removed. Drill these holes using a drill 1/8 inch smaller than the lag screws to be used for fastening the engine in place. Three-eighths-inch lag screws which will project three inches into the engine beds will be sufficient. Insert the engine hold-down bolts with washers under the heads and screw them to within three or four turns of being tight.

4. ALIGNING THE ENGINE

The blocking can now be removed from the engine and the engine lined up with the propeller shaft. The engine will be in alignment when the faces of the two halves of the propeller coupling are parallel within .003 of an inch or less. A feeler gauge is used, checking all around the two faces and shims added under the engine hangers until the two faces are in alignment. If no feeler gauge is available, four narrow strips of paper can be placed between the two faces at four points around the circle. Any variation of alignment can then be felt by the looseness of any one of the strips. Each time a shim is added or removed, tighten all hold-down bolts and recheck alignment. Extra care at this time will pay off in terms of future performance.

Do not attempt to bring the two faces of the coupling together by springing the propeller shaft. When the engine is in perfect alignment, bolt the two halves of the coupling together and remove the wedges from around the propeller shaft. With the engine in neutral, the propeller shaft should turn easily. If not, check for tightness in the stuffing box or slight misalignment in strut location or angle.



With engine installed and properly aligned, it must now be supplied with fuel, water, and electrical power, and provisions made for exhaust. How these elements are to be installed will depend to some extent on the model of engine being used, location of the gas tank, location of the instrument panel and personal preference as to side or stern exhaust. In any case these things should be installed in a workmanlike manner and certain good practices adhered to.

5. EXHAUST PIPING

Exhaust piping should be at least as large as the opening on the exhaust manifold. Either copper tubing or galvanized pipe may be used. If

Fig. 8 Photo of Exhaust Piping

elbows are necessary in the line, they should never exceed 45 degrees. A short piece of steam hose (See Fig. 8) placed in the exhaust line close to the engine will help quiet the exhaust and prevent fracture of exhaust line due to vibration of the engine. It is common practice to direct cooling water from the engine into the exhaust line. In so doing, two purposes are served: the hot exhaust line is cooled below the danger point and the water quiets the exhaust. In this type of installation, two precautions must be observed. First, the water must enter the exhaust no less than 5" below the bottom of the manifold opening and some provision must be made to direct the flow of water away from the manifold. These provisions are necessary to prevent cooling water from backing up into

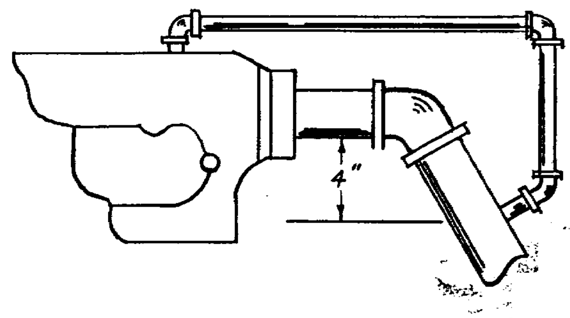


Fig. 9 Method of Cooling Water Discharge

the exhaust manifold and perhaps warping the hot exhaust valves.

There are several types of water-cooled elbows on the market which will serve both of the above purposes and are worth their cost in labor of fabricating a substitute. However, a substitute can be made by welding a steel elbow into the exhaust line at least 4" below the exhaust manifold in such a way that the water will be directed away from the manifold. (See Fig. 9)

6. COOLING WATER SYSTEM

Water piping can best be done with standard copper tubing. Again, a short piece of flexible hose should be used between the intake piping and the engine. The water intake scoop should be located as close to the water intake on the engine as installation permits. Some engines are equipped with reversing and re-

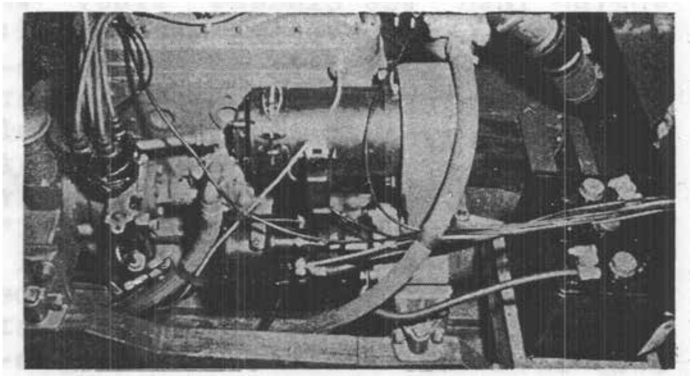


Fig.10 Suggested Battery Installation

duction gears that are also water cooled, in which case the manufacturer recommends that the cooling water enter at this point and be piped from there to the engine.

Installation of the water scoop is a simple process. A 3" square by 3/4" thick block is fastened to the inside of the bottom of the hull with four wood screws and set in bedding compound. A hole is then drilled through the block and hull the same diameter as the outside dimension of the water scoop pipe. The scoop pipe is then inserted in the hole from the bottom of the hull and fastened in place. A sealing compound is placed around the pipe on the inside and the locknut tightened.

7. THERMOSTAT AND BY-PASS VALVE

Most often engines are installed with water piping that simply draws water to the pump directly from the sea, circulates it through the engine and discharges it all overboard. In this type of system, engine temperature is determined by the temperature of the incoming water, pump capacity and the degree

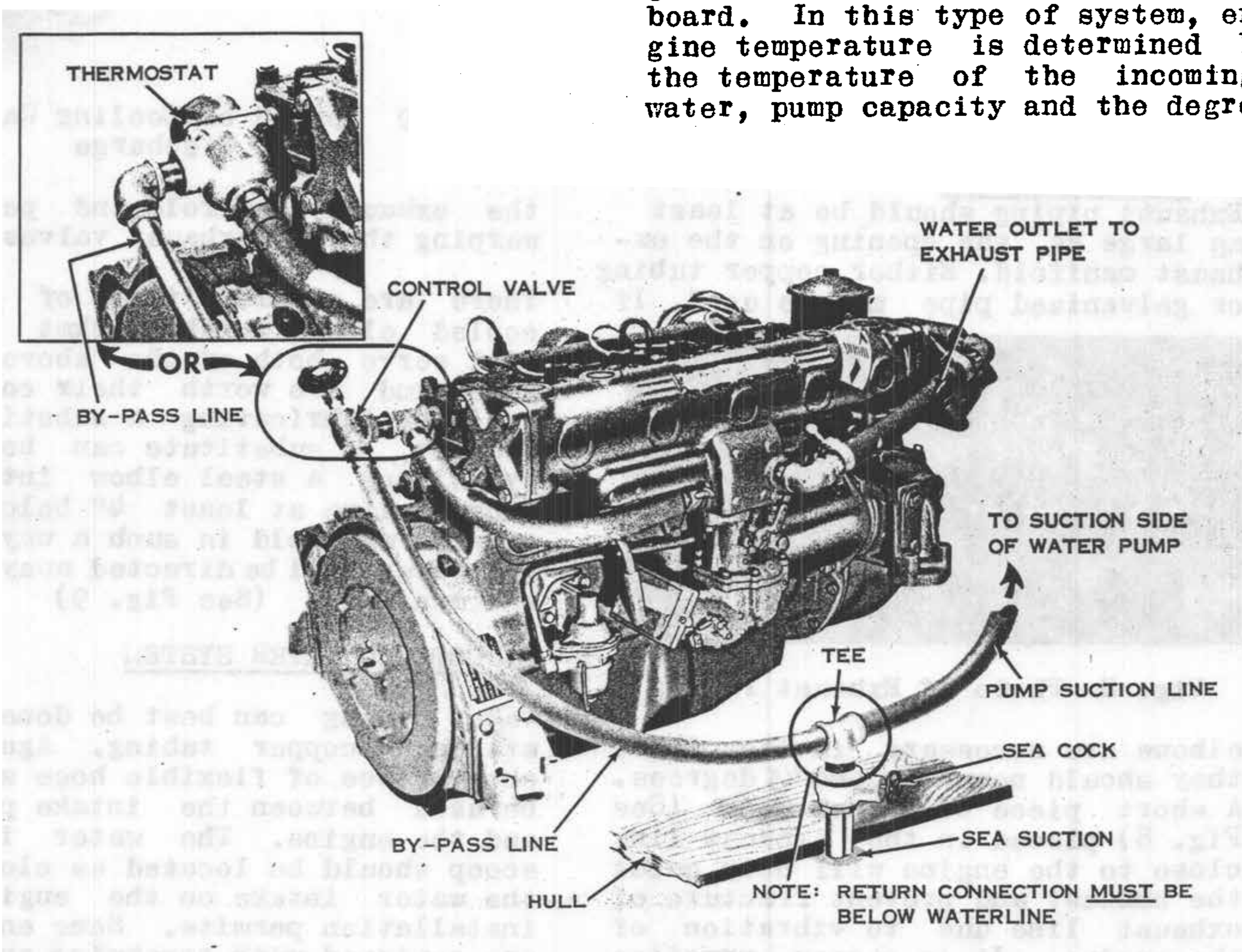


Fig. 11 Methods of Engine Temperature Control

of restriction to flow offered by the piping. It is quite common to find engine operating temperatures as low as 90° F. in these installations. We do not recommend this type system because the usually low operating temperature is conducive to valve sticking, sludge formation in the crankcase, dilution of crankcase oil with cylinder wall condensation and shortened valve spring life. We recommend a nominal operation temperature of 150°F. obtained through the use of a by-pass system as shown in the piping diagrams of Fig. 11. Do not attempt to control temperature by restricting the flow of water either into the pump or overboard.

In the by-pass system a quantity of warm water leaving the engine is diverted back into the pump suction line to be recirculated through the engine. By varying the amount of warm water fed back to the pump the engine temperature can be controlled. Control of water passing through the by-pass line is accomplished with either a hand control valve or a thermostat installed as shown in the piping diagrams. Opening the valve will divert a larger amount of warm water back into the engine and raise its operating temperature. If a thermostat is used it will automatically divert nearly all of the warm water leaving the engine back to the pump for recirculation when the engine is cold. When engine temperature nears 150° F. the thermostat will react to decrease the amount of recirculated water and will divert only enough to maintain engine temperature at about 150° F.

Generally, the thermostat will give faster warm up and closer temperature control over the engine speed range than will the hand control valve. The hand control valve should be adjusted to give adequate temperature at the usual running speed of the engine. It should not be necessary to continually re-adjust the valve.

On installations using the hand control valve, water should be noted issuing from the exhaust pipe soon after the engine is started. A lack of water indicates the pump has not primed and the engine should be stopped until the source of trouble is found.

On installations using a thermostat, only a trickle of water and sometimes only steam will issue from the exhaust until the engine reaches operating temperature at which time the thermostat will open to discharge more water overboard. The thermostat is designed to allow a small quantity of water to pass it and keep the exhaust pipe cool until the engine reaches operating temperature. When starting a cold engine always keep a close watch on the temperature gauge until it steadies to a constant value.

8. FUEL SYSTEM

A marine type gasoline tank should be used in all installations, constructed with internal baffle plates and a filler pipe which goes nearly to the bottom of the tank. Should a fire occur during the filling of such a tank only that vapor trapped in the filling tube will burn and this can be snuffed out by placing something over the neck of the tube. The gasoline outlet from the tank also enters at the top of the tank and passes down through the tank to just a short distance off the bottom. This pipe should be slightly larger in size than that required by the fuel pump on the engine.

The tank will also have a vent and overflow tube coming off the top of the tank of at least half-inch copper tube size. This tube should be run as directly as possible to a suitable through-hull fitting, located in most cases just below the sheer line of the hull. Overflow gasoline and tank vapors will thereby be discharged harmlessly over the side. Connection from the tank to the engine should be made with copper tubing of a size recommended by the engine manufacturer. A short section of flexible line should be placed in the line at the point of attachment to the fuel pump to prevent leaks occurring due to fatigue of the metal tubing.

9. ELECTRICAL SYSTEM

The importance of adequate and safe wiring aboard a boat cannot be overemphasized. All connections must be clean, tight, and free from oil. Where solder connections are necessary, the connection should be made mechanically secure before soldering. Use only rosin flux when soldering to prevent corrosion. All wiring should be kept as short as possible to minimize voltage drop in the circuits.

A battery box should be built as close to the engine as possible, securely fastened to the boat and of a size to prevent shifting of the battery. Any cover on the box should be readily removable for periodic checking of water level in the battery (See Fig. 10).

All wiring should be run in such a fashion as to prevent mechanical injury. Wires for all circuits should be of a large enough size to minimize voltage drop in the circuit and of sufficient current carrying capacity to prevent overheating. (See Table 3)

10. FINISHING THE JOB

The instrument panel may be installed at any convenient location at the control station. Oil pressure and water temperature gauges should be connected in accordance with the instructions that come with the unit.

Gear shifting can be accomplished by using the shifting lever supplied with most engines or one of several types of controls available. These controls may be operated from a remote lever, either mechanically through a system of rods or hydraulically through piping.

With the engine installed, the propeller is then fastened to the shaft, care being taken to maintain proper clearances from the bottom of the boat and the rudder.

After the engine is installed and all connections completed, the engine should be enclosed in an engine box. In designing this box, keep in mind the possibility that it may be necessary to make adjustments or repairs in the future. A box with removable top and sides is desirable.

It must also be kept in mind that an internal combustion engine uses roughly 14 parts of air to one part of gasoline when operating. Therefore, sufficient ventilation must be provided to allow it to operate at full efficiency. This will vary with the size of the engine; the higher the horsepower the greater must be the ventilating area. Five square inches of ventilating area is sufficient for engines up to 25 H.P. and 15 square inches for engines up to 150 H.P.

After completion of the installation and with the boat in the water, the alignment of the engine to the propeller shaft should be checked once more. The engine may then be started and all connections checked for signs of leaks. Oil pressure and water temperature gauges should be closely watched for signs of improper operation. After making sure that everything is operating properly, the boat should be taken on a short run at slow speed. Final checking and adjusting is done on this trip and the boat is now ready for operation.