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The Metamorphosis of a Powerplant — From Passenger Car to Pleasure Boat

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IT HAS BEEN SAID that the most difficult phase of engineering is not determining the best possible functional design, but rather selecting the best possible compromise. The design, development, and production of pleasure boat marine engines of today is a perfect example of that statement.

Although this paper shows an example of one solution to this problem its primary intent is a discussion of the engineering factors which must be considered in the engineering and application of current marine engines.

PROBLEMS INVOLVED

The principal marine engine customer is an original equipment boat builder. He has a good technical and marketing knowledge of the product. He looks at the engine in relation to what it can do for his total product.

The boat builder starts out with a given horsepower requirement. He then wants to know:

1. Cost - How much does it cost? The boat and engine businesses are both very competitive. Both the engineer and the boat builder frequently wish to put more quality into the powerplant, but if a practical level is not maintained, the boat builder may find that in paying for this quality his boat is no longer competitive in price. Cost is the big compromise in all engineering and, if not actually stated, it is implied in all of this discussion. We must keep in mind that in order to have a product which is competitive, the major components must be either standard automotive parts or be capable of being produced on high-volume automotive tooling. Engines have been built specifically for marine use but their cost was so high that sales volume dwindled to almost nothing.

2. Size - How much space is required for the powerplant? The "V" and inline marine engines to date require the boat builder to design around them by means of "dog houses" and raised decks. Although not desirable, this practice has become accepted as a necessary evil.

3. Weight - Boat weight affects boat performance. The boat builder of today finds himself caught in a performance race. This is one of the major factors that builders of small-size boats consider in determining whether to build just outboard boats or go into the inboard market. Unfortunately weight, cost, and reliability are tied closely together.

4. Reliability - Will this engine satisfy the boat owner? At the customer level, reliability is generally assumed.

The factors of cost, weight, size, and reliability are so interwoven that it is impossible to discuss one without involving the others.

The difference in service between the marine engine and its automotive counterpart can be most dramatically illustrated by Fig. 1 which shows the required horsepower versus speed curves for a typical automobile and a 19 ft pleasure boat. The small hump in the boat requirement curve represents the area where the boat goes on plane. The boat requires about the same power to get on plane as the car requires to travel most legal highway speeds, and it re-

ABSTRACT

This paper is a discussion of the problems involved in the engineering and application of modem high-speed marine engines. A sample solution to these problems is offered in a step-by-step coverage of an engine developed by Chrysler, from its conception to application. Such factors as cost, weight, size, and reliability are discussed.

quires as much power to run 30 mph as the automobile requires at almost 100 mph. The significance of this is that the boat owner, not realizing these differences, feels that by running his 36 mph boat at 30 mph he is actually taking it easy on his marine engine. This same owner would probably not expect good service from his passenger car if he "abused" it by long periods of operation at 100 mph.

Valve Life - The valve gear is the first component that suffers from prolonged high-level specific output. Chrysler uses stellite faced valves and exhaust valve rotators in order to get good valve life.

There is another factor influencing valve life -- nonleaded marine gasoline. It is claimed that "marine white gasoline" does not contain the tars and other compounds which form gum in the fuel system. This is fine and we like this --but this has nothing to do with the color or the lead content of the fuel. The nonleaded fuels may result in clean combustion chambers, but this is not necessarily good. When an exhaust valve runs very hot and no lead or other compounds are present to form a thin coating on its face, it may weld itself to the valve seat in small areas. The next time the valve lifts, it pulls out a small portion of the valve seat. The valve rotates to reduce valve burning. The rotating valve with the seat particles welded to its face acts as a grinding tool and grinds the valve into the seat at a fairly rapid rate. The engine usually runs well as long as the lash is adjusted properly but the time comes when there is no valve adjustment left and the valve begins to leak and burn.

Fig. 2 illustrates the results of valve seat wear using nonleaded fuel. The extreme exhaust valve seat wear can readily been seen. Even when sodium cooled valves are used as in Fig. 3, this still occurs.

We need a fuel with low content of gum and tar forming compounds. IF the marine white gasolines meet the octane number requirements of the modern marine engine without lead additives, why not add just enough lead to the gasoline to "contaminate" the valves? Three to five percent of the lead normally found in automotive gasoline would probably be enough to coat the valves, yet would have little effect on combustion-chamber deposits.

The weekly and winter layup of pleasure boat operation reveals problems not normally found in daily automotive operation. We have already discussed the gum and tar deposits that result from fuel oxidation. In addition to fuel having a longer time to oxidize in the tank (often all winter), copper is present to catalyze the oxidation process. The mild steel fuel lines used in automobiles are generally considered unacceptable in boats because of exterior corrosion; therefore, copper lines are used which accelerate the oxidation process and the formation of gum and tar deposits. Fortunately, the practice of using copper fuel tanks has been generally abandoned for tumplate, monel, fiberglass, or galvanized steel fuel tanks.

The long layup periods also make hydraulic valve tappets unacceptable. We would like to have the low main-

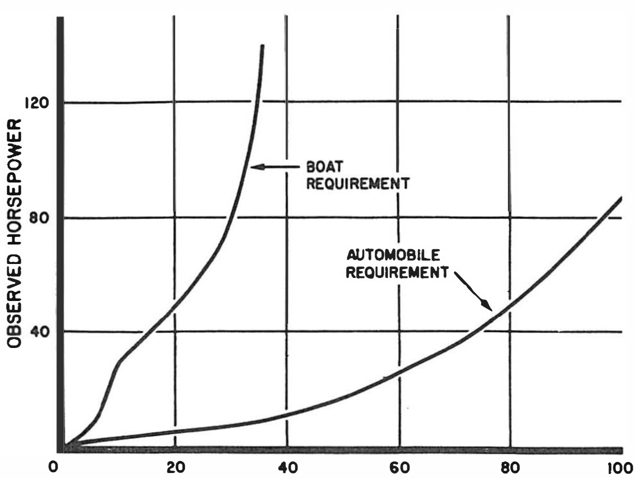

Fig. 1 - Boat and automobile power requirements

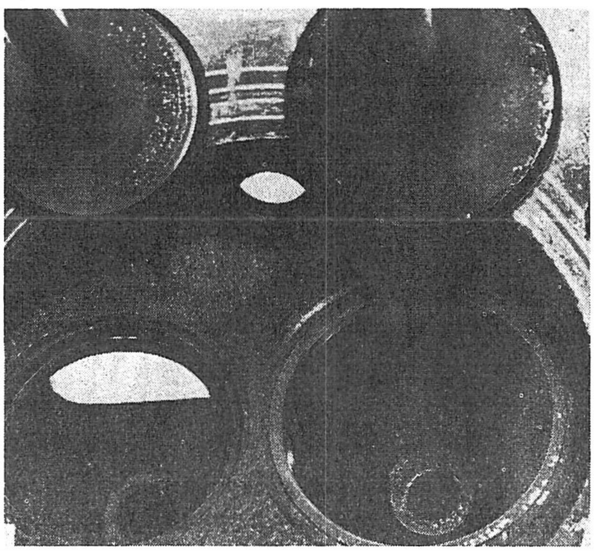
Fig. 2 - Nonleaded fuel valve wear

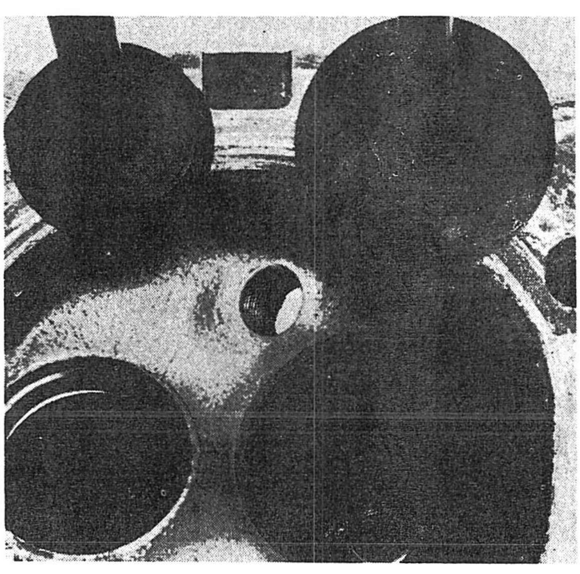
Fig. 3 - Nonleaded fuel sodium cooled valve wear

tenance qualities of the hydraulic tappet; however, the tappet materials and lubricants now available are not able to suppress corrosion in the tappet during periodic layups, and, as a result, the tappets corrode beyond use. Perhaps advancements in the lubrication field will someday reduce this problem to the point where we will be able to use hydraulic tappets for marine engines.

Oil Problem - The oil problem itself is unique. In boat operation, the engine may be warmed up for only a few minutes and then run near wide open throttle for an hour or two on the way to the fishing grounds. We then troll at idle for a long period and then off again at high power and speed to home or another fishing spot. Another owner may start out in slips or up channels, which call for extended idle operation before he takes off at high speed. The point is that extremes of operation are encountered, that is, both lighter-than-passenger-car operation and heavier-than-truck and industrial operation. This would seem to be the perfect application for multiviscosity engine oils. However, you might just as well use a single viscosity lubricant because some of the viscosity index improvers break down in a short time under high-speed, heavy-load operation.

The lack of cool air passing over the engine and pan does not help this situation. They are not always necessary but, in extremely heavy-duty application, heat exchangers for oil cooling are available to boat builders who desire such an accessory.

When discussing oil, it is interesting to note another problem that faces the boat owner. Marine oil pans are almost on the bottom of the boat and cannot be drained in the normal manner. Oil is generally removed by inserting a small tube down the dipstick tube and pumping out the oil through this tube. Although other oil pan openings are often furnished, they are seldom used because of the lack of accessibility.

Extremes in Engine Operation - When we talk of the extremes of engine operation, it is interesting to consider the plight of the spark plug engineer. All we ask of him is a plug cold enough to give satisfactory operation under conditions similar to an automotive dragster, and hot enough for conditions similar to those encountered by the cruising taxicab.

At Chrysler we have not been able to successfully use carbon core ignition cables in our marine engines. They lack the physical strength required. After considerable testing, we have had to retain solid core cables to avoid service problems. The marine engine does not have the low-temperature starting problems of the passenger car, but the bilge almost always contains water. It is not unusual to have the engine dripping with moisture and salt deposits which create voltage leaks and strain the ignition system, especially when trying to start.

Marine fuel filters are similar to the automotive type. They should be used in conjunction with gas tank or inline filters. Although good practice requires it, boat builders do not always install a coarse filter similar to that used in the automotive gas tank ahead of the fine engine filter. Because of its application, the marine engine may consume as much fuel in a weekend of operation as the passenger car does in 3000 miles on the road. In addition, we may have to contend with gum and tar. Adding to the filter problem is the fact that drain plugs are not used in marine fuel tanks because of the safety hazard and most methods of cleaning out the fuel tank are ineffective if, in fact, this is even attempted. Any dirt which may enter the tank remains there with the only exit through the filter. Also, a certain amount of sea water and condensation always manages to find its way into the fuel tanks. For this reason, a fuel filter is required which should also be a water-separator. Because the water may be salt water the filter should be corrosion resistant, and because copper is a catalyst that promotes fuel oxidation, we would prefer that the fuel-filter, water-separator not be made of copper.

The compression ratio of marine engines must be lowered in order to operate on fuel of the same octane quality used in equivalent automotive engines. This is because of the high specific loading of marine engines. Most marine engines are built to run on U. S. regular gasoline. In many countries, this is equivalent to their premium fuel and, in others, such quality fuel is not available at all and other engine modifications must be made.

Safety Factors - Safety requirements are a large portion of the marine engineer's problem. Because a boat hull is (usually) a large watertight container and gasoline fumes are heavier than air, all components must be sparkproof, and exhaust manifolds or other high-temperature components must be water jacketed. Alternators, starters, and other electrical components must be sealed to prevent electrical sparks. (Incidentally, alternators have been a boon to the marine industry because an engine may run a great deal of its life below the charging speed of the generator.)

All fuel lines are metal because rubber hoses have been considered unacceptable from a safety and durability standpoint.

In case of backfire, carburetors must be covered with a flame arresting device. This particular subject has been the object of a great deal of SAE activity in attempting to establish a standard test for flame arrestor acceptability. There are several methods of testing now employed which do not simulate all engine backfire conditions.

Cooling System - The cooling system uses sea water as a coolant. The marine engine usually pumps less water with a greater temperature rise through the engine than its automotive counterpart. Also, the exhaust manifolds are included in the system, which doubles the cooling load. The marine water pump must be self-priming and abrasive resistant so as to pick up water with varying amounts of sand each time the boat is put into the water. The water circuit most commonly employed is the bypass system where the water is recirculated until the temperature increases, then some water is released overboard into the exhaust system and cool makeup water is taken on.

By dumping water into the exhaust system it is possible to cool the exhaust gases down far enough to use a high-quality hose to duct the exhaust gas out through the boat transom. If insufficient water is added, steam comes out of the exhaust system and rolls up over the transom. The water also reduces exhaust noise to some extent. In larger boats, the engines may be set so deep in the hull that the exhaust manifolds are below the water line. Risers must be added to the exhaust manifold outlet to form a trap so that water will not flood the engine. The system must also protect against the pulsating effect of the high overlap camshafts drawing exhaust water into the exhaust manifolds. Also, the exhaust manifolds must have enough heat on them to boil off the water which collects in the exhaust passages of the manifold under idle conditions from condensation of the products of combustion. If the exhaust manifold runs too hot, the salt from the sea water will collect in the cooling jacket passages of the exhaust manifolds. Engines operating in fresh water usually circulate the cooling water at a higher temperature.

The fact that boat builders have several types of installations requiring exhaust systems to come at various heights and in almost all directions creates a large problem in itself.

Engine Mounts - The engine mount problem is also complex. The type of mounts or mount location required is dependent upon the individual boat, the construction of the engine bed, the angle of the engine installation, and so on. For years the distance between the engine stringers on which the engine is mounted has been 22-1/2 in., but this standardization is not always held. Loads over 10 g have been measured in pleasure boats, requiring mounts to be much stronger than those used in passenger cars. In addition to this load, the thrust of the propeller is transmitted to the hull through the engine mounts. The fact that the engine is mounted in a flexible hull (and the engine is a rigid body) greatly increases the potential stress level of the engine mounts. It would be desirable to mount the engines more flexibly to relieve the mount stresses but, in the conventional inboard installation, the engine is aligned with the propeller shaft and acts as a part of the shaft. If the engine moves relative to the hull, it must deflect the shaft to do so. Although the engine has often been blamed for the cause of boat vibration, in the case of inline 6 and V-8 engines which are inherently balanced, studies have shown that engine vibration is insignificant compared to the propeller and shaft vibrations.

Corrosion - Corrosion protection is one of the major differences between automotive and marine engines. Corrosion is a problem since many marine engines operate in a salt water atmosphere and use the salt water for a coolant. Oil pans set in corrosive bilge water must be made of stainless steel or cast iron. On the smaller engines where weight may be a factor, a cast aluminum pan is used. An inclined installation angle is used to match the propeller shaft angle in inboard installations. This may vary from 0-20 deg in the static position; the attitude of the boat when operating may increase the angle even a few more degrees. This requires a special sump oil pan and oil pump pickup. Wedges are used between the carburetor and intake manifold to level the carburetor so that it will function properly.

For corrosion protection, plain steel core plugs in the head and cylinder block must be replaced with brass plugs and valve springs must be plated. Since yellow brass automotive thermostats, while quite reliable in passenger cars, last only a short period of time in salt water, phosphor bronze, stainless steel, or naval bronze component thermostats are used for marine applications. Brass or rubber water lines and fittings are used. Stainless steel hose clamps and gaskets, and a heavy coat of paint on everything are other necessary steps.

Weight Reduction - Aluminum castings are used wherever possible to reduce weight. A major disagreement in the industry involves the use of water jacketed aluminum exhaust manifolds. Considerable weight can be saved by using aluminum instead of iron. One manufacturer used aluminum for a period until they encountered a serious problem of corroding through the wall between the water jacket and exhaust passage. It was concluded that the acidic combustion products accumulated in the exhaust manifold under idling conditions and ate through the jacket wall during shutdown periods. This manufacturer has now gone back to cast iron. Another manufacturer still uses aluminum manifolds, apparently feeling there is a market for lighter weight and shorter life. Chrysler would like to have lighter engines and may someday go to lightweight exhaust manifold castings. But believing reliability to be more important, we are looking for new material developments before doing so.

Rotation - The boat propeller exerts a sideways force on the water which depends upon the direction of rotation. For this reason, boat builders who use twin-engine installations desire counterrotating propellers to neutralize these forces. This is accomplished by using counterrotating engines. In addition to having mechanical valve gear, we also need valve gear for both engine rotations. Starters and alternators must not only be sealed but both rotations must be available. Distributor drives and crankshaft oil slingers must be engineered separately for both rotations.

Engine Power - Because of the load characteristics of the propeller, it is difficult to load the marine engine at low speed. If the marine engine is mated with the correct propeller, which at high speed acts as the engine governor, it will deliver power in the same general range in almost all applications for any given engine speed. This fairly well-defined band of engine operation allows the spark advance curve to be more closely tailored for maximum economy without danger of preignition than the passenger car engine with its many speeds and loads.

AN EXAMPLE SOLUTION

After studying pleasure boats in the 18-30 ft class, it was felt that the conventional powerplant used too much of the cockpit area. Fig. 4 is a scale drawing of an 18-19 ft runabout. The dotted lines represent the "dog house" which covers the normal inboard engine. The cover in the middle of the boat is for the normal shaft drive, and the one in the center of the rear is for the normal inboard-outboard drive. The front seat is divided in the middle (or on the side as shown) for entry. Boats are built for people, yet the engine cover in the middle of this boat takes up about 1/5 of the usable cockpit area. The cover in the rear, although it does not use as much area, splits the full rear seat into two small seats. With the front seat divided, there is no full-length seat in this pleasure boat for sun bathing, carrying passengers, and other activities where full-width seats are desirable. A full-width seat can be provided in this case by putting the seat ahead of the engine, but this uses even more of the available space than the version with the engine cover in the middle of the living space. The obvious solution in the past has been, if you want more room -- get a larger boat. But boaters do not always want to trail or buy a larger boat; a larger boat may not fit in the garage.

We felt that the Chrysler 225 cu in. engine had sufficient power for this class of boat. If laid on its side (Fig. 5) it would have a low enough profile to fit under the small boat seat, or it would allow the small cruiser builder to offer a flush deck cruiser without "dog houses" in the middle of the deck. Therefore, a new marine engine project was launched.

In order to keep costs competitive, it was necessary to use the automotive engine assembly with a minimum of modification. As a starting point, the block casting was laid on its side. The distance from the lowest point on the block at the water pump housing to the base of the oil filter on top is about 16.6 in. These lines were drawn as the parameters within which the design would be accomplished. New pistons were used to reduce the compression ratio to 8.2:1 so that it would accept a wide range of fuel quality. A dry sump oil system was originally contemplated but it was found that a wet sump pan with adequate capacity could be designed by using the full length and depth of the block without appreciably widening the package. Cast aluminum was used for minimum weight.

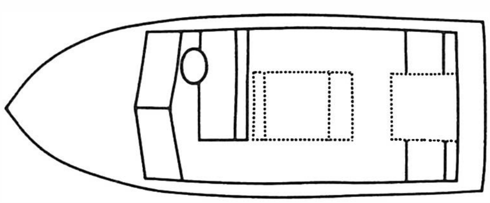

Fig. 4 - Boat engine layout schematic

The water jacketed exhaust manifold was the next major problem. This is made of cast iron for good exhaust gas corrosion resistance. Since the manifold is an all-new part, care was taken to add intake ports to the casting so that the basic passenger car intake manifold could be used with modification. The modification consisted of machining the carburetor pad to accept the two-barrel marine carburetor and machining the intake manifold hot spot to accept a new design water manifold to apply water heat instead of exhaust gas heat to the intake manifold. The loss of exhaust gas heat meant that the intake manifold hot spot type of automotive choke could not be used. This required a stove type choke with heat being transferred in an insulated tube from the exhaust manifold to the carburetor, similar to some automotive designs. The water manifold under the intake manifold hot spot was cast iron to give corrosion compatibility with the passenger car cast iron intake manifold. The manifold fasteners and all other external fasteners from approximately the crankshaft centerline down are stainless steel to resist corrosion.

An oil drain was added to the lower side of the rocker cover and routed back to the oil pan. Brass core plugs replaced the plain steel core plugs in the cylinder head and block. In addition, plated valve springs, stellite faced valves, and exhaust valve rotators replaced the automotive valve gear.

<u>Dynamometer Program</u> - The initial dynamometer devel-

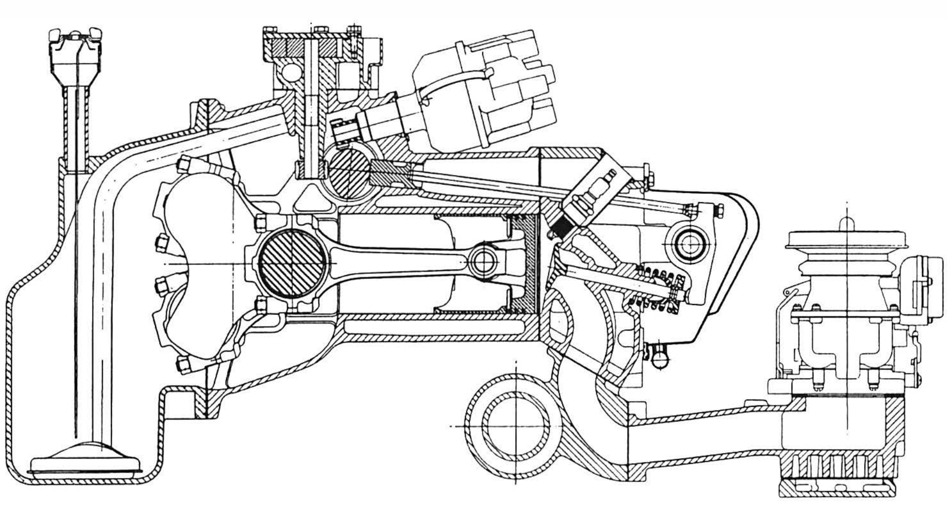

Fig. 5 - Chrysler Spacesaver engine cross-section

opment program indicated difficulties involving lubrication of both ends of the push rod at idle. At speeds above 2000 rpm, enough oil was being splashed and fogged to give more than adequate lubrication. Note in Fig. 5 that the push rod runs uphill to the tappet. Fig. 6 is a detail of this area.

First let us consider the rocker arm. In the Slant Six version of this engine, the oil holes were drilled so that the oil came out the top and valve end of the rocker arm. The manufacturing process on this part is such that the stamped components, when assembled, leave a natural oil passage around the bore of the rocker arm. The holes used for the vertical version were stamped shut and a new hole drilled into the natural oil passage just under the push rod adjusting screw ball. This shook enough oil on the ball to lubricate this end of the push rod. The oil then runs down the rocker arm to the end of the valve stem which, incidentally, was satisfactory before this modification.

The tappet portion of the push rod lubrication problem, although simple in solution, took much longer to solve. Many schemes involving machined tappet bores and intricately machined tappets were tried and, although they solved the problem, were expensive from the standpoint of special tooling and machining. The ultimate solution which worked as well as any of the elaborate systems tried, was to drill a hole in the side of the tappet just above the push rod socket. As the tappet rotates and moves back and forth, the edges of the hole pick up oil from the tappet bore surface and allow it to drip on the push rod end.

The second significant development as a result of the dynamometer program was the establishment of steam or air bleeds in the cooling system. A bleed was found necessary at each end of the block. In one end an existing drain boss was used; at the other end a locating pad for manufacturing operations was found suitable for the copper line bleeds which routed the steam or air into the exhaust system. Although other bleeds were anticipated in the design stages, they were not needed because the water flow did a good job of purging the system of air and steam.

Another element of the design was a large (to facilitate oil removal) combination dipstick and oil fill tube adapted from some existing Chrysler industrial engine tooling. The oil pan also has a plug in either end for the customer that has access to this piece of equipment.

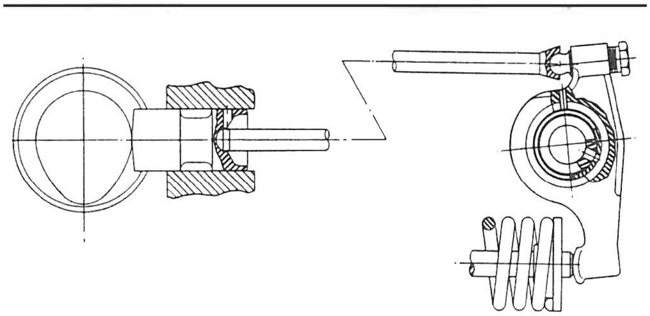

Fig. 6 - Detail of push rod area

The exhaust manifold, being on the bottom of the engine, would allow the engine to fill with sea water if a trap were not provided. A water jacketed exhaust manifold riser (as shown on the engine in Fig. 7) was designed to carry the exhaust gas up over a dam near the highest point of the engine, then down again to the crankshaft centerline level. At this point, water is introduced into the exhaust system. The exhaust is ducted out of the boat through a high-grade steam type rubber hose. The exhaust can be removed from either end of the engine.

The initial design had both the rocker cover drain and oil pickup near the rear of the engine. During boat tests, we found that this was not satisfactory in a V-drive installation. During fast accelerations where the boat angle was extreme when getting on plane and the acceleration forces were maximum, the oil would rush to the rear (normally the front or timing chain end of the engine) and uncover the oil pickup. Subsequent redesign offers a special oil pickup and rocker cover drain for this type of installation. The rocker cover drain caused oil accumulation, resulting in unacceptable oil consumption when operating at high angles for long periods.

Spark plugs, distributor, oil filler, oil filter, fuel pump, fuel filter, coil, and all other periodically serviced items are located on the top of the engine with generally better accessibility than in a car or boat. A new aluminum flywheel housing also locates the sealed starter at the top of the engine for maximum serviceability and protection from bilge water.

A bronze positive displacement marine water pump and a sealed brush alternator are belt driven on the front of the engine. A pair of rubber adjustable isolation marine engine mounts are also located on the front of the engine. In the case of the marine reverse gear type of installation, the rear mounts are mounted on the reverse gear.

The engine, in conjunction with the new Chrysler Drive 90 outdrive unit, has a unique mounting system and although not specifically mated to only this Chrysler engine, it would be of interest to discuss the basic functions of this inboard-outboard drive unit at this time.

The engine has long been blamed for the vibration and noise in power boats. However, the 4-cycle, inline 6, and

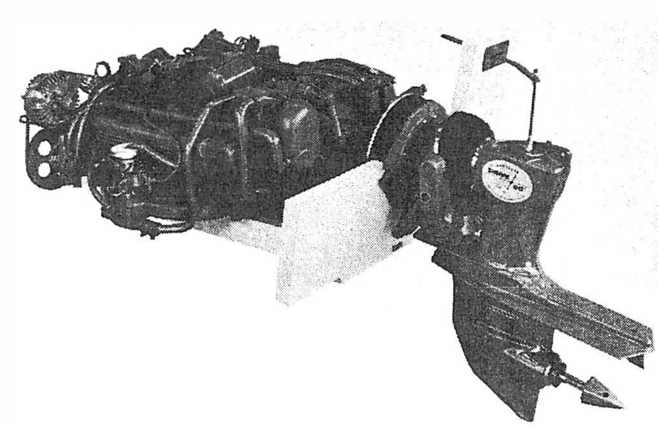

Fig. 7 - Chrysler Spacesaver with outdrive unit

V-8 engines are dynamically balanced, resulting in very little vibration. With the engine balanced, the majority of vibration must come from the propeller. Even though a propeller is dynamically balanced, there is a dynamic unloading and loading each time the blade passes by a strut or skeg. On the outboard or outdrive, each propeller blade passes by a strut twice in each revolution. Using a two-blade propeller results in each blade passing by a strut at the same time, which doubles the intensity of the dynamic loading and unloading and its resultant vibration. This effect can be reduced many times by using a three-blade propeller where only one blade passes either the strut or skeg at any one time. In high-speed applications, the two-blade propellers are more efficient and are used in spite of increased vibration.

The engine propeller and drive train are not directly responsible for the noise in a boat but do provide the exciting force; these vibration forces are transmitted to the boat hull which converts them into sound. Therefore, to minimize noise, vibration must be minimized and the vibration remaining must be isolated as far as possible so that it is not transmitted to the boat hull

By the use of a fully balanced engine and three-bladed propeller, the vibration is reduced to as low a level as is economically practical. In order to isolate the remaining vibration and prevent its transmission to the boat hull, the Chrysler Drive 90 power units are completely suspended in rubber. Rubber engine mounts are placed in the front and a rubber "donut" transom mounting is located in the rear. Nowhere does the unit fasten directly to the hull.

Until the advent of this outdrive unit, all outdrives on the market retained the undesirable shifting characteristics of the outboard motor. You could not shift at any speed above idle without a great "clunk" of the dog clutch and possible damage to the shifting mechanism or gears. This led to the use of single-lever controls in all outdrives to insure shifting at idle speed only. It was not possible to shift at higher speeds for precise maneuvering or to prevent occasional stalling of a cold engine.

The shifting of the Drive 90 is similar to the shifting of an automobile manual transmission. When the shift lever is in neutral, the selector gear in the outdrive unit is in neutral and the hydraulic mechanism (taking over the job of the foot on the clutch pedal) has disengaged the automotive type dry plate clutch. As the shift lever is moved toward forward or reverse, the first movement engages the selector gear. Further movement of the shift lever stops the hydraulic pressure to the clutch at the valve and this pressure bleeds down at a predetermined rate to give a smooth engagement of the clutch without any noise or abnormal strain on the driveline components. It is now possible to use individual shift and throttle controls.

The hydraulic pump used in the above application is a modified version of the regular automotive power steering pump.

RESULTS OF DEVELOPMENT PROGRAM

We have seen from this discussion that practically every automotive component has been redesigned, modified, or completely redone to be successfully used in marine applications. Now that we have completed the project, how well have we met the original goal?

Fig. 8 shows this engine in a 17 ft boat. Fig. 9 illustrates the space consumed by the Spacesaver engine as compared to a 100 hp outboard motor. When using an outboard, the seat must move far enough forward so that it does not interfere with the engine hood when the outboard is tilted up for trailering, or as the result of hitting an underwater object when running. The Spacesaver takes up less room in a boat than does the 100 hp outboard motor and consumes considerably less fuel while at the same time delivering considerably more power.

Fig. 10 is an illustration of the engine in a 22 ft day

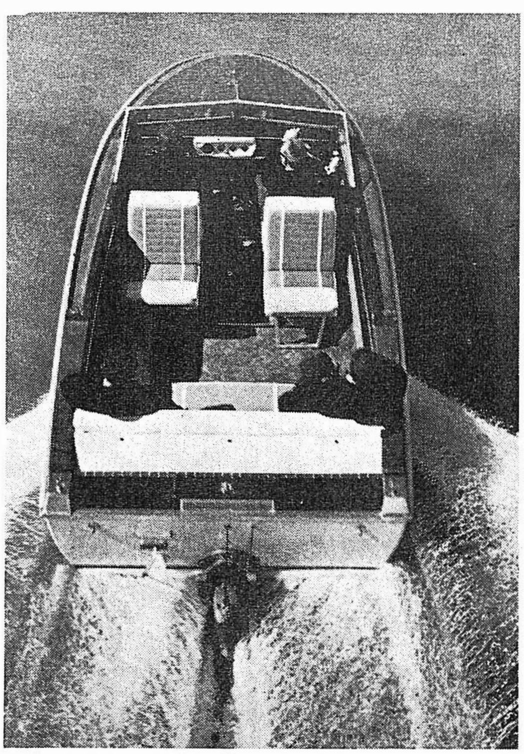

Fig. 8 - Chrysler Spacesaver installed in 17 ft boat

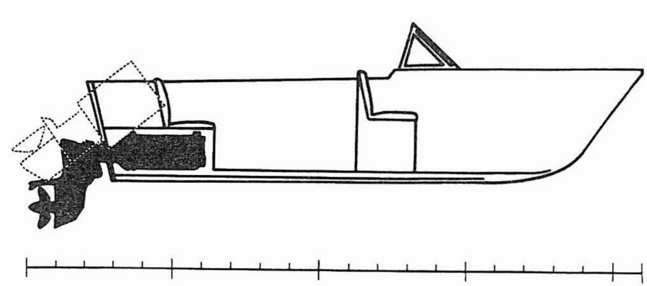

Fig. 9 - Spacesaver and outboard comparison

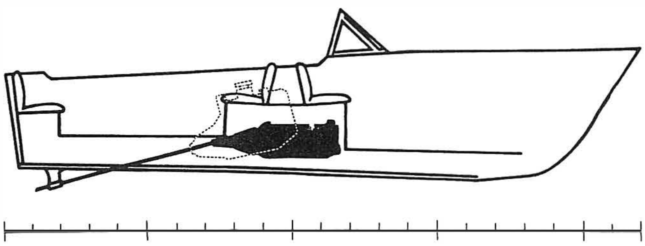

Fig. 10 - Spacesaver and V-8 comparison

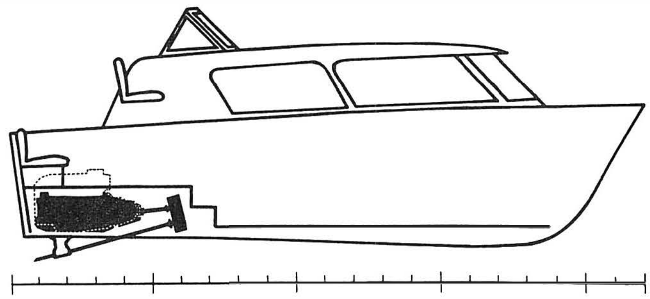

Fig. 11 - Spacesaver and low silhouette V-8 comparison

cruiser. The dotted line represents a V-8 engine of slightly more power. A 6-cylinder engine of the same power would be longer and taller than the V-8. By using front and back facing seats with the access split at one side, we have managed to hide the complete engine, allowing all of the cockpit area to be used for people.

Fig. 11 shows the engine in a 22 ft flush deck sedan cruiser. The dotted line represents a low silhouette V-8 marine engine. I know of no 22 ft cruiser of this type to date because the flush deck over the conventional marine engine raises the whole boat structure so high that the boat becomes unstable and unattractive.

Although we would like to see the weight reduced further, we feel at this time we have engineered a package of acceptable weight, giving thousands of service free hours of use at a very competitive price.