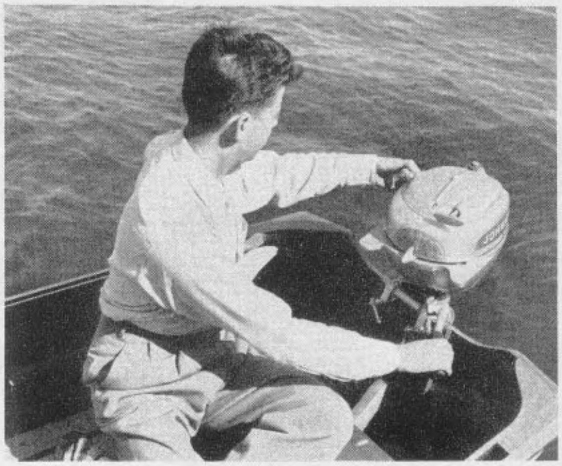
KNOW YOUR OUTBOARD MOTOR



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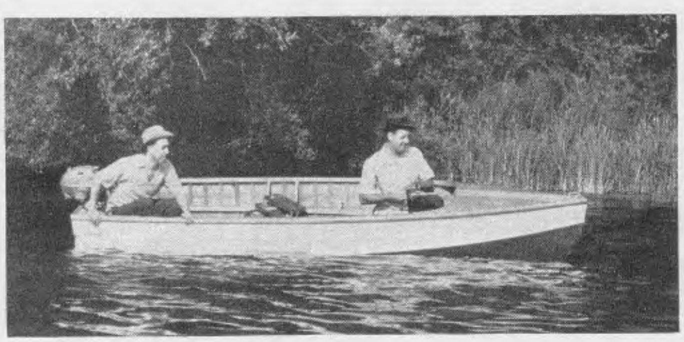
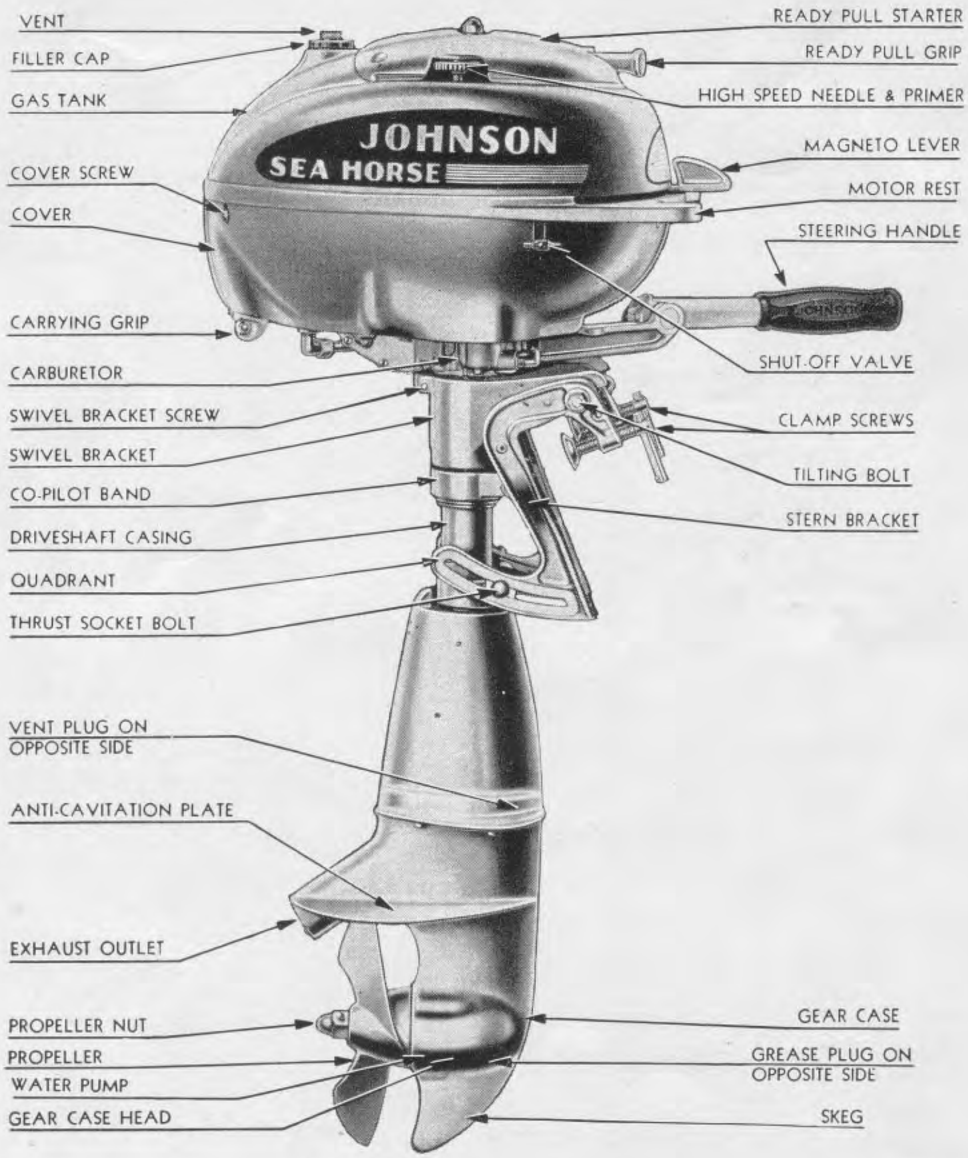
Foreword

Statistics show that more than eight million people in the United States buy fishing licenses every year. There are more millions who don't need them. While not all of these fishermen own and use outboard motors, a mighty lot of them do and profess almost as much genuine affection for their motors as for their favorite pastime and most satisfying recreation.

It is well for them to know "what makes the wheels go 'round" in such important and indispensable equipment for only in that way will they get full and complete returns. This book is neither an instruction book nor a service manual. It endeavors only to help the novice and old-timer alike to understand the fundamentals of outboard motor operation, care, and performance to the end that they may thus get even more enjoyment from them.

Knowing just a little more at just the right time about the operation of an outboard motor may spell the success of a long-planned vacation on the water. It is hoped that those who read these pages *will* know that little extra at a time when knowing will be gratifying.





Typical outboard motor, 5.0—N. O. A. Certified Brake Horsepower at 4,000 revolutions per minute, alternate firing twin with full pivot reverse, automatic re-wind starter and other features. This size and type is most extensively used for fishing, and particularly because of its slow trolling characteristics.

ORIGIN AND DEVELOPMENT OF OUTBOARD MOTORS

It was nearly thirty-five years ago that a young man rowed across a lake on a hot day to buy some ice cream for his girl and while he rowed back the ice cream melted—so the story goes. He designed an outboard motor and the first factory-built outboards were introduced by him about 1909. Just compare an automobile of that vintage with the sleek lined cars of today and get a fair idea of the progress that has also been made in outboard motors in the same time.

Outboard motors continued as heavy, crude, noisy and only semi-reliable until the early 1920's when there came into use that new wonder-metal aluminum. Weights decreased from 75 pounds or thereabouts to as low as 35 pounds for a smooth running twin motor of two horsepower. And that was when the outboard motor industry got its "second wind" and really started to go.

Back around 1922 even the largest motors were rated only about three or four horsepower. It was not until 1926 that larger motors came into the picture, motors that developed six or eight horsepower. But from there on the development progressed rapidly so that by 1929 four cylinder motors up to thirty horsepower and even larger were not uncommon.

Motors of thirty cubic inches piston displacement today develop above twenty horsepower. In those days they were not quite so powerful although ratings had not been standardized. In 1929, it was estimated at the time, the industry as a whole built and sold somewhere around fourteen thousand outboard motors of thirty cubic inches and larger. In no year since then has the large-motor volume been anywhere near that quantity. During the more severe depression years of 1932-33 it dropped to almost nothing. While small-motor production increased many fold from those years to 1940, large motor production and sale "came back" only part way — to an estimated half of what it was in 1929.

The greatest advancements in motor construction, resulting in a combination of light weight, low cost, dependability, carefree performance and operation features, took place from about 1937 to the present time. Where five horsepower had previously meant a price well above one hundred dollars and weight probably higher than forty-five pounds, then, and in later years, it came to a mere "handful" of only thirty-five pounds or less and a price as low as one hundred dollars.

This combination of better construction and performance with lower cost stimulated the use of outboard motors and the sale of new ones to well over twice what it had been in the former "boom" year of 1929.

That, in brief, is the history of this young, virile, industry. In size, no outboard motor producer can compare with an automobile plant, yet the engineering and production advancements of the industry have more than kept pace with its larger and older "big brother."

WHAT IS AN OUTBOARD MOTOR?

In the course of development of many mechanical products, a standardization of form has evolved. One sewing machine mechanism looks about like another on the outside—because over a period of years it has been found that is the best way to make a sewing machine. In general and fundamentally all automobiles made today are alike, with four wheels, a left-hand steering wheel, an engine in front, drive on the rear wheels. Yet, there have been three-wheel cars and cars with engines mounted under the front seat.

Outboard motors are built "that way" because it seems to be the best way. There have been outboard motors built with horizontal crankshafts but all of them now have vertical cranks. There have been motors with battery ignition yet nearly all of them today have magnetos. All outboards now have a powerhead or engine mounted at the top and carried above the transom (stern) of the boat by a clamp bracket attached to the transom; a shaft that extends downward into the water; and a gearcase enclosing right-angle bevel gears which drive the horizontal propeller shaft, to the outside end of which is the "pusher" type of propeller. An outboard motor is a boat propulsion power plant which is complete in itself with self contained engine, gasoline supply, ignition and starting apparatus. It is detachable from the boat (one of its most important features).

The engine or powerhead is an internal combustion engine; it burns its fuel in the working cylinder. Most outboard motor engines are of the two-stroke-cycle type (two cycle) differing in principle of operation from the common automobile, truck, tractor or inboard marine engine of the four-stroke-cycle type which has mechanically operated valves and but one power impulse for each four strokes (or two revolutions of the crankshaft) in any one cylinder.

Perhaps it would be well to take a look at this two-cycle principle, to see just how the engine operates, because most outboard motors are built that way and this has been found the type which in the long run gives the most dependable operation combined with low cost and long life.

On the first upward stroke of the piston, a partial vacuum or low pressure is created in the crankcase. As the piston progresses in its upward movement and nears the end of the stroke, intake port "A" is uncovered causing fuel vapor from the carburetor to flow into the crankcase—"B." The crankcase is now fully charged. (Three-port type.)

The piston on reaching the end of the stroke reverses its direction and begins a downward movement—covering or closing intake port "A." On its continued downward movement, the vapor charge in the crankcase is compressed until the piston nears the end of the stroke, when the by-pass port "C" is uncovered. This instantly releases the compressed crankcase charge, which flows thru the by-pass into cylinder "D"—being directed upward by the piston deflector provided for this purpose.

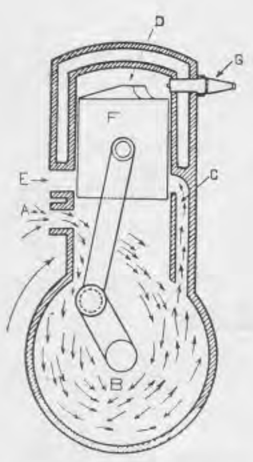
On the following upward stroke, the vapor now having been transferred to the cylinder is compressed and prepared for ignition. However, during this period a second charge has been drawn into the crankcase through intake port "A." There are now two charges—one compressed in cylinder "D" and the charge in the crankcase.

At the end of the compression stroke, a spark, created by the magneto, jumps the gap between the points of spark plug "G"—igniting the compressed fuel vapor in cylinder "D." The vapor in burning expands rapidly, forces piston "F" downward to deliver power required to turn the propeller. Power, however, is not delivered throughout the entire length of the stroke, some time is required to rid the cylinder of burned gases and to receive a fresh charge from the crankcase for the succeeding power impulse.

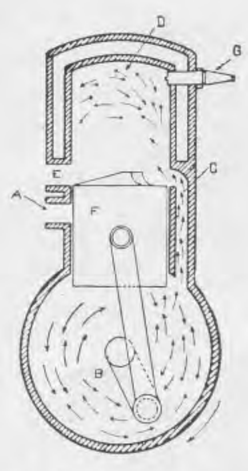
As the piston travels downward on its power stroke, the fresh charge previously drawn into the crankcase is being compressed.

Notice width of exhaust port "E" and by-pass port "C"—"E" is considerably wider than "C," therefore, piston "F" on nearing the end of its stroke uncovers the exhaust port somewhat earlier than it uncovers the by-pass port.

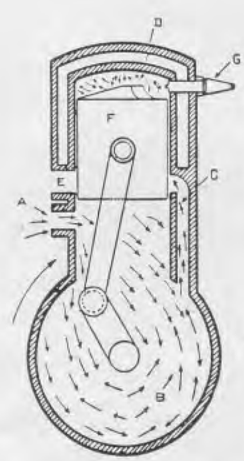
A comparatively high pressure exists within the cylinder at this time, consequently, at partial uncovering of exhaust port "E," the burned gases commence to flow out through the exhaust port. Further travel of the piston uncovers by-pass port "C." The compressed vapor charge now in the crankcase is instantly released, flowing through the by-pass port into the cylinder and directed upward by the deflector. The incoming fresh charge continues to force the burned gases out of the cylinder through the exhaust port and into the atmosphere to complete the cycle.



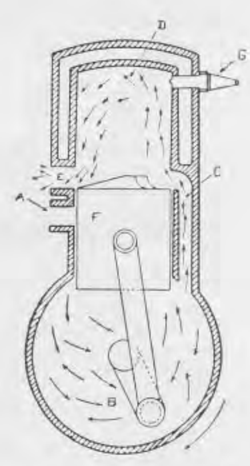
Intake of fuel and air to crankcase.



Fresh charge transferring from crankcase to cylinder.



Completion of compression, beginning of combustion in cylinder.



Exhaust from cylinder and transfer of new charge from crankcase to cylinder.

WHY ARE OUTBOARD MOTORS TWO CYCLE?

One may well ask why it is that outboard motors are two cycle while most other commonly used engines are four cycle. There are several reasons.

Since the two-cycle engine, in each cylinder, has one power impulse per revolution and since there is no camshaft, no valves with their operating parts, the two-cycle engine in small sizes may be built with considerably less weight per unit of power output. And light weight in an outboard motor is of prime importance for ease in carrying, attaching and operating. Compactness is also important.

For the same power output the two-cycle engine is lower in cost, too. It lends itself to low-cost manufacturing processes such as die-casting; it is simple in design and has few parts.

As a general rule two-cycle engines burn a little more gasoline, require a little more oil, than four-cycle engines. But outboard motors are small and at the most, even in larger sizes, require only a few cents worth of fuel per hour or per day so fuel economy is of little consequence. The four-cycle type of engine as used in automobiles, for example, must be economical and besides must operate at partial loads and at low-to-high speeds smoothly. Two-cycle engines have not been used in automobiles because it is more difficult to get such performance from a two-cycle engine of comparable size.

Great strides have been made in recent years in improving the flexibility of outboard motors. New methods of controlling fuel mixtures now permit consistent low operating speeds as well as high power output at high speeds. And ease of starting, one of the bugaboos in early years, has really ceased to be a problem in view of modern magnetos, improved carburetors, better mixture control, and new precision in the production of parts. It is probable that the two-cycle engine has made more progress in the outboard motor field than in any other except in very large Diesel power units where the principle is extensively used.

WHAT IS HORSEPOWER?

When one wants to measure the distance from here to there, a yard stick comes in handy. The result is expressed in inches, feet, yards and miles.

Power is just as tangible as distance. So engineers have a unit of measurement. "Horsepower" is the "foot" in the measurement of "the ability to do work." It isn't necessary for the average man to know what a horsepower is, technically, but here's the definition anyway: One horsepower is the ability to lift 33,000 pounds of weight one foot in one minute—usually stated as "33,000 foot-pounds per minute."

A ten horsepower outboard motor has ten times the ability to do the work above mentioned. Horsepower is actually measured on a dynamometer which gives just as definite a measurement as using a yardstick to measure feet and inches.

A good many years ago some manufacturers "guessed," and rather liberally too, at horsepower output with the result that in the heat of competition some became rather fantastic. Standardization was badly needed so the National Outboard Association agreed with certain manufacturers on the rules for "N. O. A. Certified Brake Horsepower." When the horsepower of an outboard motor is plainly stated by the manufacturer as "N. O. A. Certified Brake Horsepower," then that means that it is a true measurement made on approved equipment under the supervision of an impartial and qualified engineer under the supervision of N. O. A. Note that all such statements include the Revolutions per Minute at which the motor develops that stated power.

The speed and performance of a boat depends on the power which the outboard motor develops. And so horsepower (size) has become a general classification.

TYPES OF OUTBOARD MOTORS

Outboard motors are generally built in four different styles or types; single cylinder (in smaller sizes), twin cylinder opposed (up to 30 cubic inches piston displacement developing something over 20 horsepower), twin cylinder alternate firing (from the smallest up to around 16 horsepower), and four-cylinder (from as small as 5 horsepower up to the largest motors built).

Each type has its advantages some of which will be outlined here. But let it be said, first, that no one type is "best" under all conditions, in all sizes. Each has its place.

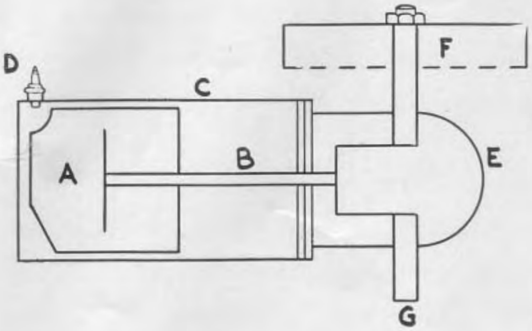
Single Cylinder Outboard Motors: Single cylinder motors are almost invariably built only in smaller sizes — from one-half horsepower up to around three horsepower. A "single" has fewer parts and is therefore, less costly to build. It is not usually lighter in weight per horsepower developed, however, partly because the lack of balance and the resultant vibration require strong parts to withstand the forces. Nevertheless, single cylinder motors in smaller sizes are excellent for small boats and slower speeds and are the preferred type for such pastimes as trolling in many localities. This was particularly true before the advent of the smaller, smoother, and still light weight twins that came into being within recent years.

Twin Cylinder Opposed Outboard Motors: The first light weight outboard motors back in the early 1920's when aluminum alloys first came into extensive use, were of this type. They were excellent motors as are those still being built in this type.

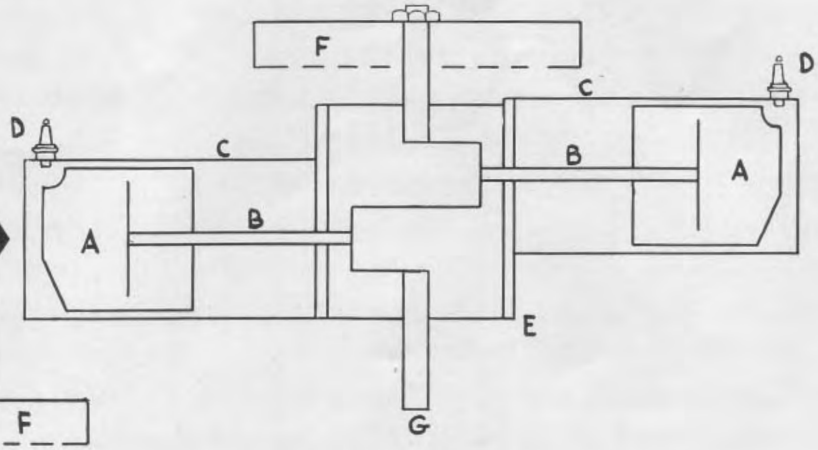
Both of the opposed cylinders, in this type, fire at the same time, driving the pistons toward each other. During approximately one-half revolution of the crankshaft both cylinders are on the power stroke, and compression of the fuel-and-air mixture is taking place in the common crankcase; during the next one-half revolution, the crankcase is under suction, taking in a new charge, and the pistons are compressing the previous charge in the cylinders.

The "torque vibration" of this type of motor is relatively high. This is the tendency for the whole motor to start revolving in a direction opposite to that of the flywheel and to then bounce back, whenever the impulses occur in the cylinders. It is particularly noticeable at slow operating speeds. The "fore-and-aft vibration," however, is not unreasonable because there is a tendency for the motion of one piston and the direction of one power impulse to oppose and offset the effect of the other. These opposing motions and forces are never actually in direct opposition, however, and there is, naturally, some vibration.

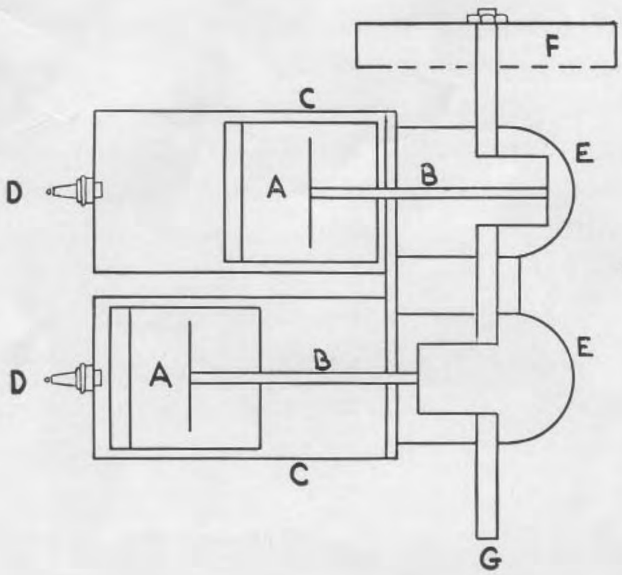
The flywheel must be large and heavy enough to carry the pistons in both cylinders at the same time through the compression



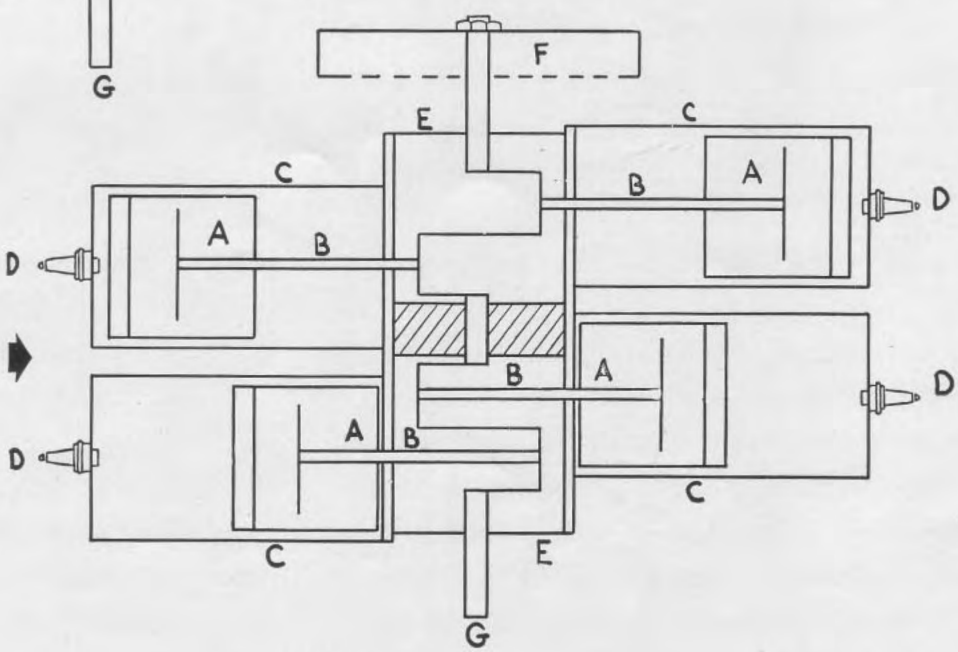
Single cylinder, two-cycle engine



Twin cylinder opposed, two-cycle engine



Twin cylinder alternate firing, two-cycle engine



Four cylinder, two-cycle engine

stroke; the pull on the starting cord must be sufficient to pull over compression in both cylinders at once; the carburetor and the muffler and exhaust passages must be large enough for the total piston-displacement volume of the motor; and the crankshaft, drive shaft, gears, and other working parts must have sufficient size and strength to stand up to the full combined impulse of both cylinders at the same instant, once per revolution.

An opposed twin motor running at 4,000 revolutions per minute produces 4,000 impulses on the crankshaft per minute, the same as a single cylinder motor.

The opposed type of construction is successfully used in motors as small as two or three horsepower and as large as twenty-two horsepower. The range of performance, therefore, is from the small fishing boat going perhaps seven or eight miles per hour up to the commodious runabouts which can top twenty-five miles per hour or the step-hydroplanes built for speeds that are even higher.

Twin Cylinder Alternate Firing Outboard Motors: In the alternate firing type of twin cylinder construction one cylinder is placed above the other, both on the same side of the crankshaft. Since the crankpins are opposite each other, in this type, one piston is moving toward the crankshaft while the other is moving from it. Each cylinder fires once each revolution, of course, but alternately. So, there are two impulses per revolution of the flywheel evenly spaced. Thus, as compared to an opposed twin of the same size, each impulse is half as big but there are twice as many. That makes for smoothness. The "torque vibration" is naturally less. It might be reasoned at first glance that the "fore-and-aft" vibration is more severe in this alternate firing type than in the opposed motor but it must be remembered that each impulse is half as large and that pistons and connecting rods are moving in opposite directions here as well as in the opposed motor. Actually, there is some vibration in all motors, but since in this type there are 8,000 impulses per minute in a motor running 4,000 revolutions per minute, the sensation is one of extreme smoothness.

In this type the flywheel needs only sufficient weight to carry one piston at a time past compression; the carburetor need be only large enough to admit the size of charge required by one cylinder; the muffler and exhaust passages can be smaller; and the shock-resisting strength of crankshaft, driveshaft, gears and other moving parts need be only enough to stand up to the one light impulse at a time. The cylinder block is more compact, lighter in weight. And there are some advantages in low cost production. The magneto, however, is somewhat more complicated, usually being built with two coils and two breakers. Even this may be an ultimate advantage, however, because should one coil or one breaker fail, the other will continue to operate one cylinder and make it possible to "get home" from some distant point.

Alternate firing twins are built from the smallest size (only four cubic inches piston displacement developing two-and-a-half horsepower) up to motors having real size and speed (twenty-two cubic inches piston displacement developing sixteen horsepower). While their introduction on the American market dates only from 1930, they have been highly developed over the intervening span of years and are becoming dominant in public preference because of their highly developed, wide range of performance.

Four Cylinder Outboard Motors: Formerly, back in the late 1920's, only large motors were built with four cylinders; more recently smaller motors of around five horsepower and larger have met with considerable success.

The four cylinder motor may be regarded as two twin-cylinder opposed motors mounted one on top of the other, or, just as reasonably, as two alternate firing twins mounted on opposite sides of a common pair of crankcases. The principal point to note, however, is that the two opposed cylinders on top fire simultaneously (at the same time) and likewise for the two lower ones. However, the firing of the two on top is alternate to the two on the bottom. So here is a combination of *both* opposed and of alternate firing types; a combination with some advantages and likewise some disadvantages.

A four cylinder motor running at 4,000 revolutions per minute has two impulses (not four) per revolution of the crankshaft; a total of 8,000 impulses per minute just the same as in an alternate firing twin.

There is considerable merit in the claim for four cylinder smoothness, as compared to twin motors of the same horsepower, in larger sizes, because the crankshaft and the reciprocating weights are in somewhat better rotational balance and, theoretically at least, the weight distribution in the powerhead may be better for the absorption of the "torque vibration." In actual practice, however, it is very questionable whether, from these causes alone, a motor operator would notice any improvement in smoothness over an alternate firing twin of the same power.

In very large motors the four cylinder type has a definite advantage for if any twin cylinder construction is carried into sizes much above thirty cubic inches piston displacement, then not only vibration factors but others enter the picture. There is a practical limit, for example, in cylinder size having to do with internal cooling, control of mixture burning and lubrication, particularly at the high speeds at which outboard motors must operate to get a favorable and practical power-to-weight ratio.

On the other hand, for a given size or power, it is obvious that four cylinder construction, with twice as many cylinder bores to machine and finish, with double the number of pistons, piston pins, piston rings and connecting rods, is more costly to build. Likewise, it is more difficult to evenly distribute the charge of gasoline and air to four cylinders than to two. And further, when cylinder and piston ring wear takes place after long use, there is a greater "leakage path" than in a twin. Usually, too, in a given size, a four cylinder motor is heavier than a twin.

CHOOSING A TYPE OF OUTBOARD MOTOR

As has been said, no one type is "best," at least not outstandingly so, for all conditions of operation. It may be hard to sift and judge the claims and counter-claims of manufacturers, dealers and salesmen. Yet, to a certain extent that is the only way to know what to choose. Bear in mind that as in most other mechanical fields, practically all outboard motors, of any type, are "good buys"—they give a reasonable value for the price. The fastidious and far-seeing buyer will, however, do several things: First, he will ride with and operate the motor (get a demonstration) to make sure that it satisfies his individual needs. Second, he will make sure that service (parts and expert workmanship) are available wherever he may go.

Third, he will buy from a reputable dealer. And fourth, he will question as many friends and acquaintances as convenient and average up their recommendations. If he will do those things, he won't go far wrong in choosing the type of *his* outboard motor.

OUTBOARD MOTOR ADAPTABILITY

Mostly, outboard motors are used for the sole purpose of "pushing a boat." But that is far from a complete answer. At least, it is interesting to know how very many and diversified are their uses.

Investigations made with a large number of outboard motor owners have disclosed that motors are used principally for "Fishing and Pleasure" or "Pleasure and Fishing." It is estimated from these studies that some 85% to 90% of all outboard motors in service are used sooner or later, little or much, for fishing. And that means sport fishing as distinguished from the commercial kind.

Many and increasing numbers of small boats are handsome, well-built, commodious pleasure boats that have numerous advantages over boats of similar passenger capacity with built-in (inboard) motors. In shallow, rock-strewn waters, for example, an inboard boat can seriously damage its propeller and driveshaft on contact, while an outboard motor will simply tilt up over the obstruction and then go merrily on its way—or, at the most, break a drive pin (put there for the purpose) which can be replaced in a few minutes. An outboard motor propelled boat may be beached—run right up on shore; the motor may be detached and carried away for safe housing or for repair; because of the efficiency of straight-line drive, fuel consumed by the outboard for the same amount of transportation is usually less; the outboard motor and boat, in smaller size, can be transported by car or trailer to almost any favorite water and there launched without difficulty; and the cost of the outboard motor and boat is usually far less than for the inboard boat.

The Conservation Departments of many states are completely motorized. Game Wardens and Patrol Officers find the outboard motor and small boat ideal. A large proportion of small sail boats usually carry an outboard for auxiliary power when navigating difficult waters, coming in to the mooring buoy, getting home when the wind dies.

Outboard motors are used extensively, too, for commercial purposes. Many fishing dories are outboard equipped because they can then get bigger catches quicker and make more money. Life boats on large ships are being equipped in ever increasing numbers. And on harbor works or waterside construction jobs, outboard motor equipped boats are found most adaptable and efficient for transporting men, tools, equipment and materials.

Many departments of the U. S. Government have found peacetime use for motors. The U. S. Engineers use them on harbor and river construction and maintenance. The Department of the Interior, the Agricultural Department, the Coast Guard, the Navy—all have needs for quick, adaptable water transportation and are using outboard motors constantly.

The American Red Cross has used large numbers of outboard motors for rescue work in time of floods. Explorers in all out-of-the-way corners of the world have found the small boat and outboard motor the only means of getting there and back. Admiral Byrd took them to Little America. Father Hubbard made a two thousand mile voyage in the Arctic Ocean north of Alaska with outboard motor propulsion only and has traversed many of that vast Territory's streams on exploratory trips.

While most outboard motors are used for sport and pleasure, they are likewise most efficient in commercial work where adaptability, portability, low-cost and dependability count most.

The wartime story of outboard motors will have to wait until all the important and sometimes startling facts are no longer of benefit to the enemy.

IMPORTANT TO KNOW YOUR MOTOR —AND WHY

The old adage "A little learning is a dangerous thing" applies to outboard motors importantly. Service Stations that repair motors and instruct owners report that owners may be divided into five classes.

1. The man who has no mechanical ability (though he may be an expert of the highest order, in his chosen profession) and doesn't care to learn even the simple fundamentals of motor operation. Too frequently, he is impatient with minor difficulties and makes much trouble for himself. He is the "repeater." The service station sometimes has to go over his motor after every trip.

2. The man who has practically no mechanical ability but thinks he has. He is the "tinkerer." Hand him an outboard motor in perfect adjustment and operating condition and after an hour he'll have it all out of adjustment. The best instruction for this type is "leave it alone."

3. The "expert." This class may have a high degree of knowledge and skill in certain kinds of machinery — even in automobile engines. They think they should be equally skilled in the operation and repair of outboard motors as well. You "can't tell them anything" because they already know all that's to be known — they think.

4. The non-mechanical sensible class of owner is the man who listens attentively to instruction, follows directions, doesn't tinker, and takes good care of his motor including a periodical check-up by a service station. He seldom has trouble. He gets the most for his time and money. The majority of owners are in this class.

5. The man who really knows outboard motors, how to operate them safely and efficiently, how to take care of them, how to diagnose any trouble that may arise, and how to make repairs when necessary — he is one that the service station never hears about unless it's when he buys a needed part. This man is an expert himself.

Few motor owners can, or should try to put themselves into class five. But certainly there would be far less criticism of outboards in general, much less trouble, many less headaches, if all would make an honest effort to get into class four. Fortunately, it isn't difficult.

HOW TO OPERATE AN OUTBOARD MOTOR

In the operation of any gasoline engine there are Three Fundamentals. Keep them in mind constantly. Know what they mean. Learn how to find out whether and how well these Three Fundamentals are fulfilled. Then you'll get the kind of satisfying performance your motor was built to give you.

The Three Fundamentals are these:

First, a proper mixture of gasoline vapor and air in the cylinder. This is the "food" that a motor "eats" to develop power. The carburetor is the device which mixes the gasoline and air in the right proportions.

Second, the compression of this mixture by the moving piston, first in the crankcase (your outboard motor is probably a two-cycle motor) and then in the cylinder. The mechanical condition of cylinder, piston, rings, has a great deal to do with good compression.

Third, a hot electric spark across the electrodes of the spark plug, at the right time. While a dirty or burned out spark plug or a leaky high tension lead from the magneto to the spark plug may interfere, the magneto is the principal part of the motor that is involved in this fundamental.

Given a proper mixture, good compression, a hot spark properly timed, and your motor will run and deliver power, barring minor mechanical difficulties.

This may be illustrated with a specific case. Through carelessness or otherwise, some water is present in the gasoline tank. The motor will not start. Why? The water feeds through the gasoline pipe from the tank toward the carburetor. It may not pass the screen. And it may prevent the gasoline from getting through. In that case the carburetor cannot fulfill Fundamental Number One; there is no "mixture of gasoline and air." If the water does get through to the carburetor, then it may pass through the jets and enter the air stream. But not enough gasoline gets through along with it to make a proper mixture. But if that water does go through to the cylinder and if it collects on the electrodes of the spark plug, then it short-circuits the spark at that point and Fundamental Number Three is not fulfilled.

You're going fishing. Your outboard motor is in the garage, your boat at the dock: The first thing is to see to the fuel supply. If the mixture (of gasoline and oil) already in the tank, left over from last time, is more than two weeks old, dump it out — into the tank of your automobile. Get fresh gasoline for the motor. (This is to prevent stoppage of small passages by "gasoline gum" which sometimes forms when the fuel is undisturbed for some time.)

In a clean container, mix the right amount of the right oil with the right gasoline. (Never attempt to mix in the motor tank.) The manufacturer's instructions are simple and explicit on the right oil mixture. Now you can fill the gasoline tank of the motor. Take along an extra can of mixed fuel; you might need it.

Set the motor on the back (stern or transom) of the boat. If the lower end hits bottom, move into deeper water or tilt the motor. Tighten the clamp screws. It is not usually necessary to use a wrench or pliers — just a good solid tightening up with your fingers should do the trick. More careful owners like to attach a short rope or chain to the motor and the boat so that should the clamp screws work loose or fail to hold, the motor will not be lost if it jumps off the transom.

Here's the usual starting procedure for the average four to six horsepower motor on a fishing boat:

Adjust the motor to a vertical position, not tilted back nor forward, as propulsion efficiency depends on the propeller thrust being horizontal.

Open the vent in the filler cap. If you don't, air cannot flow into the tank as the fuel flows out and pretty soon your motor will stop; no gas in the carburetor.

Open the gasoline shut-off valve or cock. This lets the fuel flow from the gasoline tank to the carburetor.

Set the "spark lever" or "timing lever" or "magneto spark control" or whatever its name may be on your motor, at the position marked "START." If set too far to the left (as you face the motor) the spark is too late (not properly timed) and probably the motor won't continue to run when you pull the starter cord. If it is too far to the right, the spark is too early and the motor may kick back and pull the starting cord out of your hand.

Wind the starter cord on the sheave on top of the flywheel. (If you have a motor with automatic re-wind, then your starter cord is already wound in place.)

Choke or prime the motor. If you have a choke, it is simply an obstruction of some sort in the air passage to the carburetor and it makes the carburetor deliver a much greater amount of gasoline for each cubic foot of air—it makes a "rich" mixture. Why? Because, just as in your automobile, when the engine is cold the gasoline does not all vaporize and consequently doesn't all "mix" with the air. To get enough to "mix," it is necessary to have more of it, otherwise, you won't have a combustible mixture to compress and ignite.

If your motor has a primer instead of a choke, it simply means that a small pump is provided to force more gasoline into the intake passages than will be normally picked up from the carburetor jets. It, also, provides a "rich" starting mixture.

Now, with your boat tied to the dock or pushed out and headed in the right direction (with plenty of water depth under the propeller), pull the starter cord. Don't "yank" it. Don't pull slowly. A sharp, quick pull of about twenty to twenty-four inches, depending on motor size and type, will do the job best. You are "spinning" the flywheel and crankshaft; you are forcing the pistons up on the compression stroke. If you have provided the Three Fundamentals, the motor will start and run.

The foregoing has presumed that the needle valve which adjusts the carburetor (some motors have two) was set in the right position and needed no change. Some operators like to open the needle valve slightly when starting a cold motor, adjusting it again after the motor is running.

As soon as the motor starts, advance the spark, if you want more speed, by moving the spark lever toward the right. And as soon as the motor has warmed up slightly, release the choke to prevent "flooding."

All the above is simple, isn't it? In the successful operation of your motor, you have performed those simple operations time and time again. When everything is in working order, "there's nothing to it." But just as soon as something happens to prevent any one of those very important Three Fundamentals from being fulfilled, then the motor doesn't run. So it may be well to look into some of those possibilities.

THE THREE FUNDAMENTALS OF OUTBOARD MOTOR OPERATION

Fundamental Number One has to do with "a correct mixture of fuel and air." That means carburetor, primarily, but also such things as quality of gasoline, quality and mixture of lubricating oil, freedom of fuel from water or dirt, clear screens and pipes from tank to carburetor, a vent to permit air to enter the tank as the fuel flows out.

So, if the motor doesn't start, start answering these questions in order:

1. Good grade of *fresh* gasoline?
2. Mixed in right ratio with good oil?
3. Vent on filler-cap open?
4. Gasoline shut-off valve open?
5. Fuel flowing clear to carburetor?
6. Screen and carburetor passages free from water and dirt?
7. Choke (or primer) providing rich starting mixture?
8. Needle valve on carburetor open the right amount?
9. Has motor been "flooded" by too much choking (or priming) or needle valve too far open?
10. Did you pull on the starter cord hard and fast enough to spin the flywheel so that the mixture was really sucked into the motor?

Suppose, on investigation, you decide that the motor is flooded, then what to do? In that case, close the gasoline shut-off valve so no more gasoline can flow to the carburetor. Release the choke. Close the needle valve. Now no more gasoline can be drawn into the motor. Now spin the motor a number of times with the starting cord. This should "pump out" the excess fuel and when this is down to the point where a good mixture is in the cylinders, the motor should run a few revolutions until all the supply is exhausted. In case of severe flooding it is sometimes adviseable to remove the spark plugs, in addition to all the above, to make sure that all excess fuel is blown out.

Details of correcting any of the other ten items above mentioned are omitted as the remedies are obvious. It should be said here, however, that usually the most difficult part of getting a "balky" motor to run is in diagnosing the trouble, finding out just what and where the trouble is. When that is known, fixing it or having it fixed is usually a rather simple matter.

Fundamental Number Two is "good compression of the mixture." Unless a motor is badly worn, or badly carboned so that the piston rings are stuck, or a gasket is blown out and leaking, or a spark plug has been removed, there is little likelihood of poor compression. At any rate, one with some experience can "feel" the resistance of the compression when pulling on the starting cord. If compression is lacking, it is usually a job for an expert repair man at a service station unless the operator is one of those Class Five owners who really knows motors inside and out.

Fundamental Number Three has to do with "a good hot spark, properly timed." The "timing" of the spark you need not worry about too much as that is fixed by the location of the flywheel (or rotor) keyed onto the shaft. Any great variation is obtained by moving the timing lever of the magneto to left or right. However, there is a form of "timing" inside the magneto — the relation of "magnetic break" to "electrical break" but this is of such a technical nature that it can be covered only in a complete service manual and adjusted only by one who has had special magneto training. However, many motor owners with a mechanical inclination can make one internal adjustment; the contact points of the breaker should be kept clean and adjusted to .020 or .025 inches (follow the manufacturer's specifications) using an accurate feeler gauge.

Probably the Fundamental most often blamed for difficult starting or improper running is the spark. Yet, with the possible exception of the spark plugs it is the most unlikely to cause trouble. Suppose difficulty in starting or running is experienced and Fundamentals One and Two are believed not to be at fault. Here are some points on the diagnosis of suspected ignition trouble.

First, remove the spark plugs. If they are carboned (all black on the white porcelain insulator inside) clean them thoroughly (if of the take-down type). If the porcelain is broken, chipped, or cracked, replace the plug with a new one. If a fleck of carbon or a drop of oil or water is across the gap between the electrodes (that would short-circuit the high tension spark) clean thoroughly. It is very important, too, that this gap be kept in proper adjustment, usually .020 to .025 inches. If closer than that specified by the manufacturer of the motor, adjust by spreading slightly with a small screw driver; if wider, adjust by slightly bending the ground electrode, the one which is anchored in the plug shell. Never bend the straight electrode that comes out of the inside of the porcelain; you may thus crack the insulator. If no feeler-gauge of the right thickness is available, use a U. S. Government one-cent post card which is approximately .010 inches thick, two thicknesses .020 inches.

It is usually not satisfactory to attach the high-tension wire to a plug, lay the shell on the motor, and then spin the motor to see the spark jump across the plug gap. When a spark gap is under compression as in an operating motor, the resistance across the gap is much higher than when out in the open air. A "dirty" plug may "spark" in the open but short-circuit when under compression.

Some times spark plugs are "burned." This is a condition of the porcelain insulator caused by extreme heat. A "burned" plug may look all right but still short-circuit the spark under compression. It is difficult to detect. Probably the best way is to replace with a new plug at least until it is determined that the old plug was not at fault. When the motor is running satisfactorily with the new plug, then put the old one in again and try it. If it works, the trouble was somewhere else and you can go ahead and use it; if it doesn't work, then replacement was the proper remedy.

Always and without exception carry at least one extra spark plug in the tool kit, two or more if convenient. Modern outboard motors, let it be honestly admitted, are "hard" on spark plugs because of the intense heat, the burning of lubricating oil mixed with the gasoline, the high speed and other factors. Unusual deterioration of spark plugs is not the rule but the life of a plug in an outboard is ordinarily not as long as in an automobile engine. Further, *always* use the make, type and model spark plug recommended by the manufacturer. Substitution of some other spark plug except in emergency is not good practice. Engineers have devoted much time to tests and development to select the one spark plug that gives the best results under most conditions. Stick to that one.

When the spark plug situation has been cleared up, by replacement, cleaning, adjustment, or other means, then it is time to look further if the motor still fails to start and run. (Being certain, of course, that Fundamentals One and Two are fulfilled.)

Remove the high tension cable or wire from the outer end of the spark plug. Hold its metal terminal (by taking hold of the insulation some distance back) about one-fourth inch from the metal of the spark plug shell or base (not the top terminal of the plug). Then spin the motor with the starting cord and note whether a spark jumps the one-fourth inch gap. If it does, then you know that a spark is being generated by the magneto and is reaching the spark plug. But if it does not, further search must be made. It may be that the high tension cable (wire or lead) is defective and that the spark is being "lost" or short-circuited somewhere along the line. In a dark room or at night, one may be able to see this occur but otherwise, it is difficult to locate. Replacement of an old, cracked, salt-encrusted, or frayed cable is the surest way of being certain of remedy.

About the only other investigation the average owner should attempt to make in case there is no spark (or a very weak one), is to make sure that the breaker contact points in the magneto are adjusted to the right distance when furthest open and are free from dirt, carbon, water, oil or any other foreign substance. This necessitates the removal of the flywheel in most cases, and that should not be attempted by the novice unless the motor is equipped with a "self puller" type of flywheel hold-on nut which, when loosened and backed off of the end of the crankshaft, "pulls" the flywheel from its taper seat on the crankshaft. Unless you have some mechanical experience and know just what you're doing, it is better not to attempt flywheel removal. Take the motor to a dealer service station.

A magneto which still does not spark after contact point cleaning and adjustment is beyond the usual ability of the owner to diagnose and correct and the motor should be taken to a service station for correction.

Now that the Three Fundamentals have been covered in some detail, it may be instructive to consider some other more or less common troubles briefly.

WATER IN THE MOTOR

Suppose that your motor has accidently fallen overboard, has been submerged. The first thing to do on recovery (if no service station is within easy reach) is to get the water out of it quickly, before rusting can start. Remove the spark plugs. Dump everything out of the gasoline tank and carburetor. Turn the flywheel slowly by hand while holding the motor vertical, horizontal and upside down. Usually this will "work" practically all water from the cylinders and crankcase. Clean the gasoline tank by putting a little fresh fuel in it and again dumping. See that the spark plugs, the high tension cables, the magneto wires running to the stop button, are all dry.

Then put fresh fuel mixture in the tank and start and run the motor. This will heat it up and evaporate all remaining traces of inside moisture. The best thing you can do for the motor is to get it running again as soon as possible.

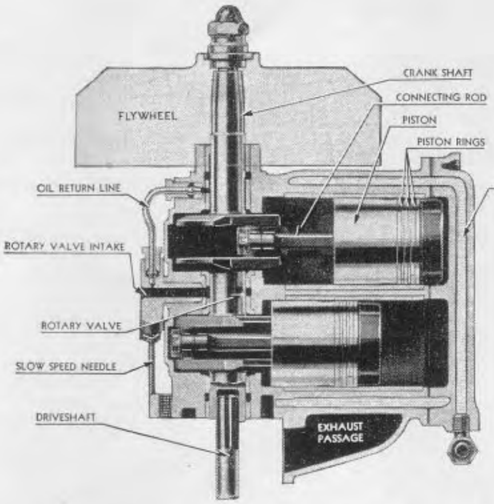
If the motor has gone overboard in salt water, it may not be that simple because salty water is a fair conductor of electricity and may short-circuit the magneto internally. Sometimes it is recommended that the magneto be removed from the motor and warmed or lightly "baked" in an oven to remove moisture. If you try this, don't let the oven get very hot—water will evaporate readily without reaching the boiling point. Also remember that when salt water is evaporated, salt remains and unless this is thoroughly cleaned off of all surfaces, it may cause short-circuits.

Usually when a magneto fails because of submersion, it is best to take the motor to a service station and have it thoroughly tested and repaired. In spite of great efforts on the part of manufacturers to make magneto coils entirely water proof, some coils will be completely ruined by submersion especially in salt water. This kind of an accident can result in the loss of the whole motor (in deep water or muddy bottom) or a sizeable repair bill.

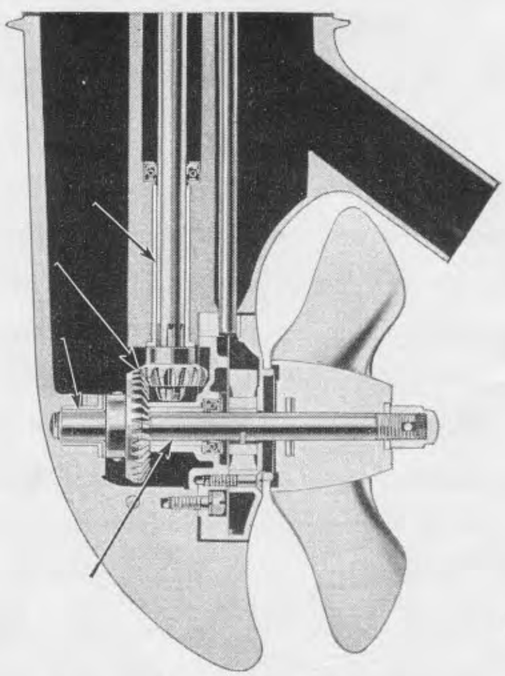
If a motor goes overboard or is otherwise submerged while running, severe damage may result from the trapping of water in the cylinder. The pistons hit the water solidly and the result may be bent or broken connecting rods or a badly sprung crankshaft. In this case, a service station repair job is the only answer.

A faulty gasket under a cylinder head, for example, may let water pass from the cooling system into the cylinder, and the motor is difficult or impossible to start—or runs poorly. It is interesting to note that in such case two Fundamentals may be violated. First, the water may short-circuit the spark at the plug gap so the mixture is not fired. Or, second, the water may "spoil" the mixture so that it will not fire even though the spark is good. The first is much more likely to be the case.

But water in the cylinder can cause a lot more trouble than that. It may be so little that the motor continues to run reasonably well but it affects the lubrication on the piston and cylinder walls and causes very rapid wear. This can be serious. And a very little water left standing inside the cylinder or crankcase of an unused motor may cause serious rusting.



Cross section of twin cylinder, alternate firing, two-cycle engine showing points lubricated by the oil which is mixed with the gasoline.



Cross section of typical outboard motor gearcase showing points lubricated by outboard motor gearcase.

Showing how gear grease should be inserted into gearcase--with vent open --to insure adequate filling.

LUBRICATION

Of almost equal importance to the Three Fundamentals is the matter of lubrication because this has an important bearing on friction, wear, motor life. Usually, there are only two places to lubricate in an outboard motor; oil mixed with the gasoline lubricates all parts of the powerhead; waterproof grease in the gearcase lubricates the gears, shafts and bearings in the lower unit.

Take the lower unit first. The best grease to use is that recommended and supplied by the manufacturer. It is best, too, to follow his instructions explicitly on how much grease to use, how to apply it, how often to replenish it. A good lower unit grease must not get too soft when warm (as when a motor lies on a dock in the hot sun) or it will leak out past the bearings; and one which will not get hard and stiff in very cold weather (as in early spring fishing in snow-fed streams) or it will fail to flow to the parts needing lubrication—or, more serious still, make the motor so "stiff" to turn that it cannot be started.

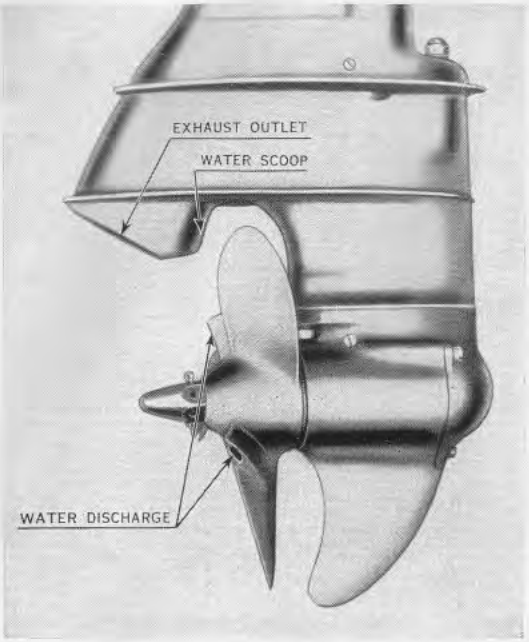
With most motors, under average operating conditions, but depending on design, construction, age and wear, it is well to at least inspect the gearcase after every ten to fifteen hours of operation and to put in more grease if needed. At the end of a season, the old grease and water should all be washed out with kerosene and replaced with new grease. Do not use a high-pressure grease gun unless it is recommended by the manufacturer. This may force grease up around the driveshaft where it is not wanted, or may make a plunger type water pump inoperative.

Good lower unit grease does not emulsify with water. It stays a good lubricant even though some water may seep into the gearcase as is almost inevitable.

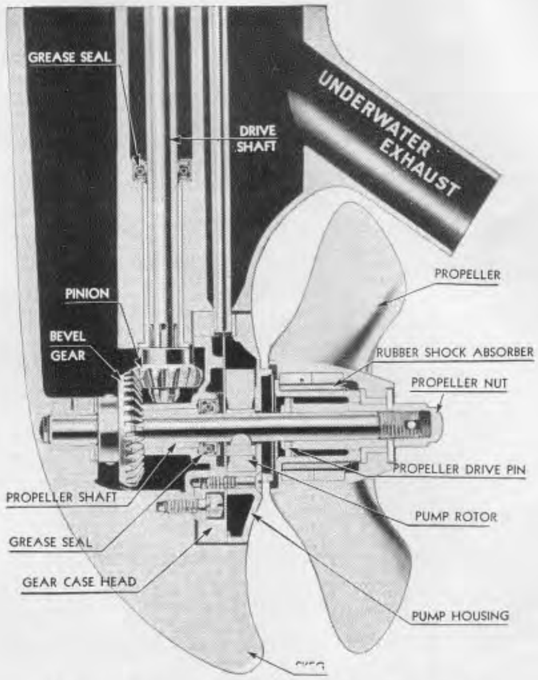
As for the powerhead, that, as stated, is lubricated by the oil which is mixed with the gasoline (in all two-cycle motors). This oil separates to some extent from the gasoline vapor inside the crankcase and bathes the crankshaft bearings, the connecting rods, the piston and cylinder walls. The excess oil burns in the combustion chamber or is blown out with the exhaust gases.

The first requirement is *Good Oil.* Use the kind recommended by the motor manufacturer or the motor dealer as both are genuinely interested in the good performance and long life of your motor. Second, of equal importance is the grade or weight of oil. When the manufacturer specifies an S.A.E. No. 40 oil, be sure to use it, nothing lighter or heavier unless, in an emergency where only lighter oil can be obtained in which case use a little more of it. And third, also important, is the amount of oil. Don't guess. Measure accurately and thoroughly mix the oil with the gasoline in a separate clean can (never in the motor tank).

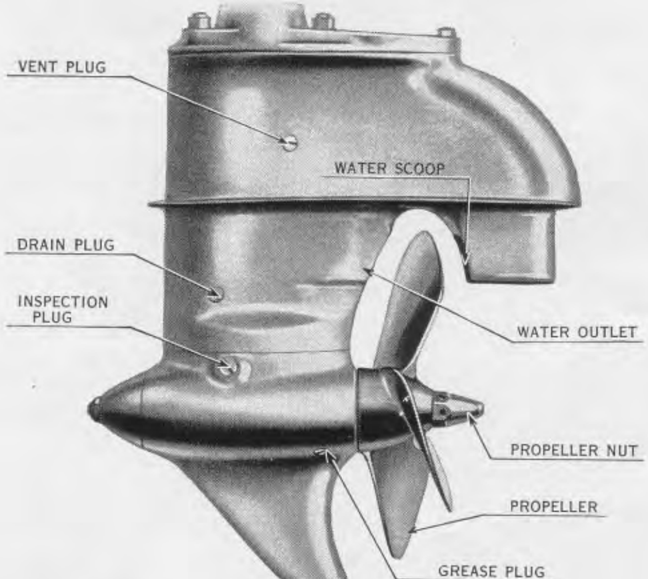
If these directions are followed fully and carefully, no lubrication troubles should develop. Too much oil or the wrong grade may result in fouled (carboned) spark plugs, stuck rings, loss of power, annoying blue smoke. Too little oil or the wrong grade may result in excessive wear, overheating of the motor, and short life.



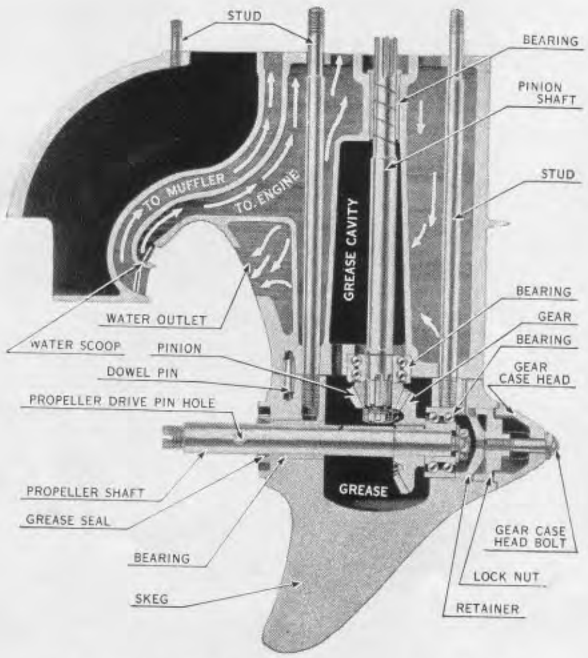
Cooling water circulation by means of pressure scoop and centrifugal action of hollow propeller blades.



Cross section of gearcase indicating position of rubber-rotor type of pressure water pump for cooling.



Gearcase with both pressure water scoop and vacuum outlet near propeller blades. This is called the pressure-vacuum type of cooling system.



Cross section of gearcase at left, showing cooling water passages.

COOLING

Cooling of the motor is important. While some air-cooled outboard motors have been built, by far the greater number are water-cooled (as is your automobile engine), so comments on cooling will be confined to the water-cooled type.

Gasoline engine cylinders are jacketed and cooling water is circulated through this jacket to keep the cylinder cool. If this were not done, the tremendous heat of combustion would raise the temperature so high that two serious things would occur. First, the metal would get "red hot" and ignite the incoming mixture of fuel and air before the right time, before the piston reached the right position to be pushed downward by the pressure created. This is pre-ignition. Second, the high temperatures would break down the oil—actually burn it—so that the hot metal of the piston would rub on the hot metal of the cylinder walls and rapid wear or actual tearing of the metal would result. This is scoring. And both pre-ignition and scoring do result if for any reason an outboard motor cooling system fails. Fortunately, it is not always that bad. In smaller size motors the friction caused by the first over-heating will usually stop the motor before serious trouble results.

Some kind of circulating means is employed to force the water from a submerged passage in the lower unit up to and through the cylinder jackets. This can be a plunger pump driven by an eccentric or cam on the lower driveshaft or the propeller shaft. Many thousands of this type are giving satisfactory service having the advantage that they force the water positively to where it should go, and likewise that such water, after it leaves the jackets may be "dumped" into the exhaust gases, cooling and quieting them. The greatest fault with the plunger type pump is abrasion of plunger and cylinder when used in muddy or sandy water. Another positive type of pump is the rubber-rotor design, a "wabbling" rubber disc in an enclosed annular space, submerged, which, without valves and without serious danger of abrasion in dirty water, forces the cooling water up to the cylinder jackets. This type has proven very satisfactory.

A centrifugal type of vane pump usually mounted on the vertical driveshaft about at the top of the gearcase is extensively used. This also has been very satisfactory in service since there are no valves to give trouble and little serious wear or abrasion in dirty water. This type has a tendency, however, to either under-cool at slow motor speed or to over-cool at high motor speeds. A slight amount of wear causing increase in certain clearances can have considerable effect on the efficiency of this type.

Still another successful type of water circulation utilizes no pump of any kind. In this, a scoop is interposed back of the revolving propeller. The propeller slip-stream forces water into the opening under considerable pressure. Likewise, another scoop is located in front of the propeller. Owing to the normal propeller action on the water there is a vacuum or suction created at this opening.

Thus water is forced up one pipe to the cylinder jackets and drawn back to the other scoop. It is aptly called the pressure-vacuum system. It's water pumping characteristics are somewhat like the centrifugal pump above mentioned and consequently it has not been extensively used on motors that are expected to run very slowly for trolling. Advantages of this type are that there are no extra moving or wearing parts, nothing except possible stoppage of the water pipes to cause trouble.

Still another circulating means utilizes the propeller blades also, being a modification of the pressure-vacuum system. In this, the return water pipe from the cylinder jackets is taken to a point inside the propeller hub from which passages lead outward through the propeller blades. These whirling passages act as a rather powerful centrifugal pump and thus add considerable suction on the returning water. This system, trouble-proof in the extreme, has given very satisfactory service, particularly on larger motors, and is effective at both high and low operating speeds.

Some motors spill the cooling water overboard from some point above water level where it can be seen, or throw a small portion from a small hole which is in plain sight. With those you can see whether the pump is working. Many, however, return the cooling water to the lower unit through closed pipes or in the under-water exhaust. With these you can know about failure of the cooling water supply only when the motor begins to get hot. Some degree of judgment is involved because most modern high-power motors, particularly those with aluminum cylinder blocks, are built to run at a high temperature all over.

Fortunately, cooling failure is a rather rare occurrence and even when it does happen, the motor will usually slow down and stop from pre-ignition or extra friction before much damage is done.

Cooling failure is most likely to result from (a) wear of pump (b) stoppage of water inlet openings in lower unit (c) stoppage in water pipe or jacket space (d) leakage in water pipe or suction side of system where a vacuum return is employed (e) very slow speed operation of the motor (f) cavitation of propeller near water intake. The remedies in each case are obvious but not always easy as some water pipes and passages are built inside where they may not be reached for cleaning without taking the whole motor down.

"BREAKING IN" A NEW MOTOR

"Breaking in" a new outboard motor is an operation similar to "breaking in" a new automobile. It means simply that a brand new motor should not be opened up to full power and speed until after it has had some running of a milder nature. Cylinder walls, piston ring surfaces, piston skirts, bearings and shafts are still microscopically rough. The "high spots" tend to cause a little extra friction. There may be a tendency to heat.

It is best, therefore, and makes for longer life, if the motor is "run in" at half throttle and half speed for from five to ten hours before it is given its maximum, full-horsepower job to do. Follow the manufacturer's instruction book on this — most recommend a little extra oil in the gasoline during the running in period. You cannot assume, however, that "if a little is good, a lot is better." Too much oil means smoke and extra carbon and carbon isn't good for outboard motors.

It is not as beneficial to run in a motor on a tank or barrel of water as on a boat. Without going into detail, it may be said that the flexibility of the boat transom as compared to the rigidity of the tank or barrel mounting has something to do with it. Also, the water in a barrel may get rather warm, or cavitation may cause trouble. There is always a lot of disturbance, turbulence in the water, in a closed tank. Sometimes a mixture of air and water is formed which may affect cooling water circulation and permit the motor to cavitate. The propeller does not have solid, quiet water to work against. It is better, if possible and convenient, to do your "breaking-in" on a boat.

When a motor is new or after a complete overhaul, it may be stiff, hard to turn, almost impossible to start and keep running. The same may occur in very cold weather especially if improper grease has been used in the gearcase. Here is a little trick sometimes employed. Take the propeller off. Submerge the lower unit as usual. Then start the motor. Extreme care is required; you dare not open the throttle and advance the spark because then the motor without the propeller load will "run away," speed up to such high speed that it may break up. (If the motor is one equipped with any sort of vacuum-pressure cooling system, such an operation is not possible as there is then no means of circulating the cooling water.) After the motor has been limbered up and warmed up, and the carburetor adjusted, then put the propeller back on and proceed as usual.

After an outboard motor has been used, it should be detached from the boat (at least over night) and put away in a dry garage or other building. It is best to have a rack available on which the motor may be hung in a vertical position as on a boat. If all the water has been drained from it after taking off the boat, it will do no harm to lay the motor down on the floor in a horizontal position, but if there is still water in it there is the possibility that this will drain back up the exhaust pipe, in through the exhaust ports and inside the cylinder where it can cause plenty of damage.

It should be noted here that a motor should never be tipped up so high when on the boat that the gearcase is above the powerhead nor should it be carried in that position. Otherwise, some water may get into the cylinders through the exhaust ports. This is *important*.

SALT WATER CARE

After use in salt water, a motor should be thoroughly flushed out by a few minutes operation in a barrel or tank of fresh water. If this is not done the salt water will not only start corrosion at critical points inside the motor but will also deposit a salt cake which may plug up the water pipes and water passages. The outside of the motor should then be wiped dry with a slightly oily rag before it is put away. Care of this kind will avoid trouble in operation and also give the motor longer life. While corrosion-resisting alloys and metals are extensively used in outboard motors and special protective chemicals and coatings employed to resist corrosion, nevertheless, some corrosive action is bound to take place sooner or later.

CAVITATION

This cavitation that has been previously mentioned sometimes occurs on a boat. It should be avoided. Cavitation is simply severe propeller "slippage" caused by a pocket or stream of air entering a whirlpool forward of the propeller and mixing with the water as the propeller passes through it. It acts very much like a slipping clutch in an automobile; the boat slows down (low propeller thrust); the motor speeds up, sometimes violently (low propeller load).

Anything that breaks the smooth, stream-line flow of water past the gearcase will tend to cause cavitation. It is more likely to occur with motors of larger size. The anti-cavitation plate found on most motors as a sort of horizontal shelf around the gearcase just above the propeller is to prevent the downward flow of air into the path of the propeller. A dead leaf or twig, a rag or piece of paper, any obstruction caught on the gearcase and capable of upsetting its true, smooth stream-line form may cause cavitation, particularly when making turns at speed.

A heavy keel on the boat forward of the propeller or a boat with a too high transom may cause it too, and necessitate removal or streamlining the back portion of the keel or cutting down the height of the transom.

The height of boat transoms have been rather well standardized because the distance from the stern bracket to the center of the propeller shaft on most outboard motors of similar horsepower is about the same on all makes. Usually, the manufacturer of the motor recommends a transom height of about fifteen inches for standard length motors. Since there are needs for motors with longer drive shafts, for use on sail boats as auxiliary power or on large commercial boats, many models are offered with a five or six inch longer length. Here the boat transom is, of course, that much higher.

DEALER SERVICE—AND WHY

Back in the "tremendous twenties" the largest selling automobile was the Model T Ford. It was a simple car and crude as we look at the modern glass enclosed carriages of recent years. But it was dependable. And almost anybody with a little mechanical ability could fix whatever went wrong. In fact, the old Model T did as much as anything to make the youngsters of America mechanically minded. The service station wasn't so necessary in those days before complication and close precision were introduced into motor cars for better, more carefree performance and longer mileage life.

The automobile of today is a different "animal." Special tools and special skill are almost necessary to diagnose and remedy many of the troubles that may develop. People have come more and more to depend on the service station to keep their cars in good running order—partly of necessity, partly of inclination.

The outboard motor situation is somewhat similar. Back in 1928, for example, a twin outboard with over nine cubic inches piston displacement developed two and a half or three horsepower at the most; today that size running at much higher speed will develop more than twice the power. Precision in workmanship and assembly must be far superior to do it. Then, too, new designs of somewhat more complicated or intricate nature have been introduced, not "just for fun" but to give these modern motors vastly superior performance.

Almost anybody who knew the real uses of a screwdriver and wrench and something about piston and bearing clearances could fix one of those old motors so that it would run tolerably well. That is not so true of the highly perfected motor of today.

And so, throughout the land, wherever outboard motors are owned and used, there are mechanically minded and trained merchants who have spent much time and money and have acquired a lot of experience in making outboard motors run right. Further than that, they have a complete knowledge of boating conditions and boating problems. And they have invested their earnings in stores, stocks of motors and repair parts and in equipment so that they can really serve those who patronize them.

It is fun to know all about your outboard motor yourself and enjoy a heap of satisfaction in being able to do your own work and reap the results. But likewise, there's a certain satisfaction in being able to wrap and bandage a cut finger or drive off a severe cold without calling on the doctor of medicine. There is no more justification in refusing to have a good outboard motor service station work on your motor than in neglecting to call a doctor when pneumonia or other serious disease strikes—except perhaps that one only affects pleasurable vacation hours while the other is a matter of life and death.

Service Station facilities are of course, available to any motor owner. But to make sure that such service is available it is not a bad rule to buy your motor from a dealer that does have a good shop and trained mechanics. He is more likely to take a close interest in your motor if he originally recommended it to you himself. You can bet on it, too, that a dealer with service is in a better position to expertly "fit you out" with just what you need. Usually, too, he's in better position to give you a fair trade on your old motor.

Another good rule is this: Regardless of how well your motor runs or how much you use it, take it back to the dealer periodically for a tune-up and check-over. He'll charge you for it; the time that any good expert gives you is worth money and the better he is, the more it is worth. But he'll earn every dime you pay him. And on the investment you'll get large dividends in carefree satisfaction.

Of course if it's merely a matter of adjusting the carburetor needle valve or changing spark plugs, every owner should take care of those simple things himself.

For those who live in a section where boating is necessarily discontinued during the winter months, most good service stations have a Winter Storage Plan. The extent and number of services rendered under this plan vary from one service station to another, but it usually includes, for a flat charge according to the size or model of motor, cleaning the motor when it is received, removal and replenishment of grease, adjustment and cleaning of spark plugs and dry, safe storage until the motor is needed in the spring. If, in checking the motor over, the service station finds some parts that need replacement or that a complete overhaul job is "the best medicine," he then quotes on the added material and work involved.

Each year more and more outboard motor owners are taking advantage of the Winter Storage Plan having learned that the little expense involved is more than repaid in the sense of security experienced and in the freedom from trouble which results. It prolongs motor life, of course, and promotes owner satisfaction.

Boating clubs have been formed in many places by groups having a common interest in boating. They sometimes have a clubhouse and extensive facilities for entertainment and boat storage but that is by no means necessary. Any group of outboard motor enthusiasts can get together in a boating club and in doing so will find that the value of the sport is greatly enhanced. Cruises, picnics, races—all sorts of worthwhile activities—may be engaged in to advantage.

In some sections, during the war emergency, outboard clubs have formed Civilian Defense Fleets and have made their members and their equipment available for defense work.

ABOUT HANDLING OUTBOARD MOTOR BOATS

There is no more pleasant pastime in season than boating. As a utility, making possible fishing and hunting, the boat is indispensable. Oars may be used to propel such boats but this method of propulsion is not only a hard physical burden but it is also too slow for this modern mechanized world. Boats are made for outboard motors and outboard motors are made for boats. In this discussion the two are inseparable.

Boating is not only pleasant, it is safe. It seems safe to say that there are far fewer accidents involving small-boat transportation than with automobiles, for example, on a passenger-mile or any other basis. Yet, as with any other mode of transportation, the human element is involved; judgment and common sense are necessary.

The very first of the "Rules of the Road" in boating is SAFETY FIRST. (You walk downstairs every day in your life and think nothing of it, but you still have to be reasonably careful.) Here's a good place to go back to the A. B. C's. of boating and discuss some of the DO's and DON'TS of it.

The first essential is a *good boat*. It should be strong and water tight; of a size capable of carrying whatever the load is to be; of a shape and design so that it will not tip over; of an over-all type which is adapted to the service and the kind of weather and water in which it will be operated.

There is no "best" boat for outboard motor use, just as there is no one motor truck that is "best" for all kinds of hauling. So, if you don't know from your own experience what boat will fit your needs best, rely on the experience and knowledge of an expert. You'll usually find that your outboard motor dealer knows what he's talking about on boats; let him guide you.

Second, know about the water and weather conditions where you are going to use the boat, not only what these are now, as you start out, but also what they might be before you get back. You must not take a twelve foot hydroplane out on water where only a good eighteen foot round bottom wave-rider is the minimum requirement for safety.

Third, know how to swim. It isn't very likely that swimming will be necessary but then it might mean saving your own or another life. But probably the best reason for knowing how to swim is that it will give you confidence. You'll be able to relax, to enjoy yourself, while boating. That doesn't mean that anyone should get over-confident to the point where he would be foolhardy or careless.

Fourth, equip the boat on every trip no matter how short or how protected, with the essential safety devices. There should be a buoyant life-jacket or cushion for each passenger; a pair of oars or at least one paddle; an extra can of fuel for the outboard motor; a small kit of tools—screwdriver, adjustable wrench, pliers; a couple of extra spark plugs; and a spare starter cord and several extra drive pins for the propeller.

Fifth, be sensible. Rocking the boat, making turns at too high speed, overloading, driving a motor-equipped boat close to or among bathers, venturing into water that is rough or may become so—none of those are sensible.

Aside from the safety factors, there's the matter of simply being "a gentleman." The use of outboard motors has been prohibited on too many bodies of water, particularly small lakes, because a few "wild" motor operators gave scant heed to the comfort of others. Enthusiasts have been known to arise in the early morning hours and speed up and down and around with the motor cut-out open or the muffler removed, waking sleeping neighbors, annoying the whole population — for their own pleasure. Some "cowboy" drivers delight in zooming close to a boat in which people are still-fishing or in swooping close to a party of bathers with a propeller which can slash quickly and very deep in a twinkling.

BOATING RULES

In many localities there are laws prohibiting the use of muffler cut-outs or removing the muffler from a motor. Manufacturers of motors are heartily in favor of quiet operation; they spend a great deal of time and money to make motors quiet because noise hurts the sport. It's too grand to be hurt unnecessarily.

It will always pay dividends in boating as in any other sport, pastime or activity, to remember "The Golden Rule." Besides, people who love the water are somehow just a bit more "sporting" in their relations with other members of the fraternity. How often it has been said that a bunch of fishermen or boaters are "good fellows." Well, when you're out in a boat, be a "good fellow" and do for others those things you'd like them to do for you under like circumstances. You can't go wrong.

By all means obey the laws. If a local ordinance says "no noise," then be quiet; if the state says "do not troll for fish from a motor equipped boat," then don't do it; if the Federal Government asks you (as it does) to always carry certain safety equipment in the boat when operating it on waters under Federal jurisdiction, then you'd better do it as the alternative isn't very pleasant.

The Federal Regulations now in effect, when the boat is operated on Federal Waters (which may mean almost any navigable lake or steam), cover all sorts and sizes of boats so it is a little difficult to cover the outboard motor boat requirements briefly. For full information, see your outboard motor dealer. If he doesn't have it, he can tell you where to get it. In general, Class A boats are up to, including, sixteen feet in length; Class One are sixteen to twenty-six feet. Outboard motor boats usually are not over eighteen feet. Approved type equipment as follows is required:

At night, a forward light showing red to port and green to starboard from direct ahead to two points abaft the beam; and a stern white light showing all around the horizon.

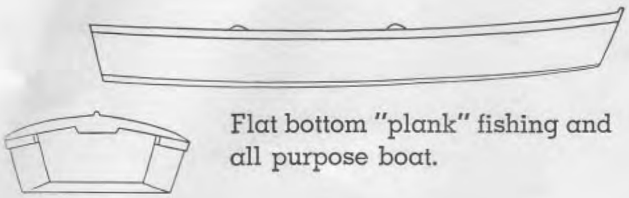
On boats over sixteen feet, a whistle audible at least one-half mile.

One life preserver or ring-buoy or buoyant cushion for each person on board.

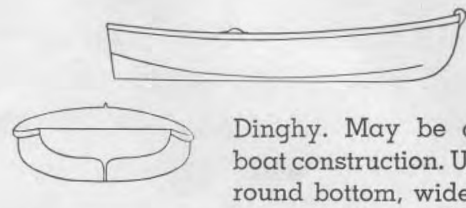
Reckless operation so as to endanger life, limb or property may be punished by fine up to two thousand dollars and up to one year in jail.

More recent Federal Laws provide for a Use Tax on boats of sixteen feet or more in length and for registration with the proper Federal authority.

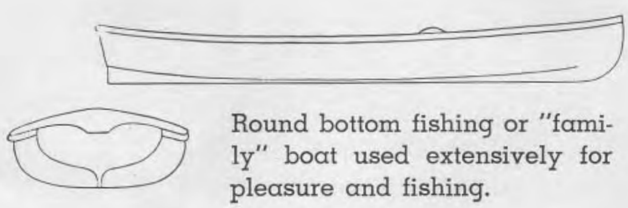
All the above rules are applicable to boats not used for commercial purposes and "not for hire." If a boat is to be used to carry passen-



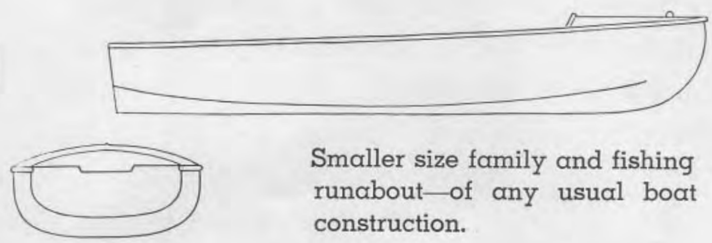
Flat bottom "plank" fishing and all purpose boat.



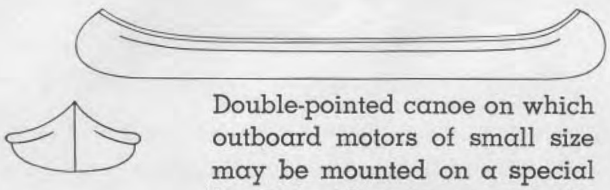
Dinghy. May be any type of boat construction. Usually short, round bottom, wide beam.



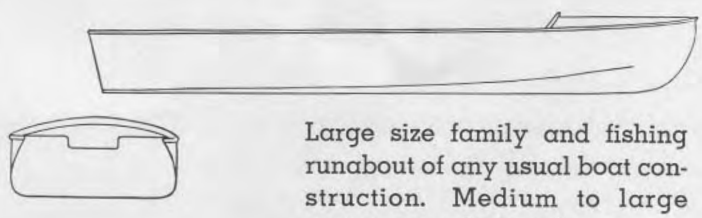
Round bottom fishing or "family" boat used extensively for pleasure and fishing.



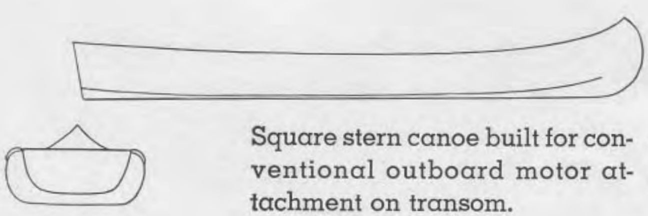
Smaller size family and fishing runabout—of any usual boat construction.



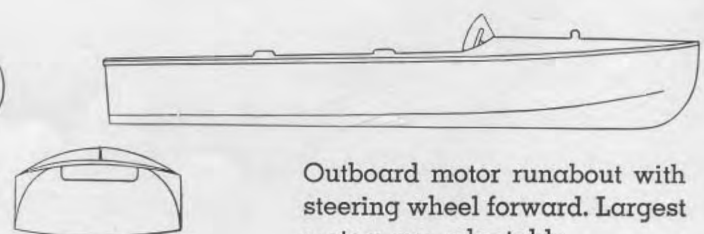
Double-pointed canoe on which outboard motors of small size may be mounted on a special bracket with motor on one side near stern.



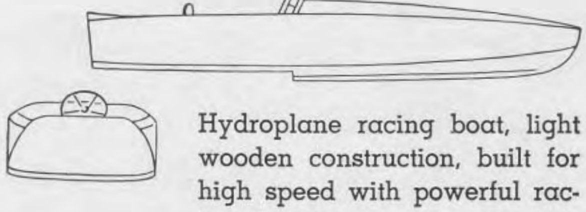
Large size family and fishing runabout of any usual boat construction. Medium to large motors may be used.



Square stern canoe built for conventional outboard motor attachment on transom.



Outboard motor runabout with steering wheel forward. Largest motors are adaptable.



Hydroplane racing boat, light wooden construction, built for high speed with powerful racing motors.

gers for hire, then more severe regulations apply and full information should be procured.

All boating laws and regulations whether municipal, state or federal are for the purpose of protection. Each owner and operator of a boat should be the one most interested in keeping boating safe and pleasant.

BOATS—TYPES AND SIZES

It would take a complete well illustrated book to comprehensively cover all the types and sizes of small boats alone, not mentioning larger craft, and another to even get started on an extensive coverage of the theory and science of design and construction. Here only the types most extensively used with outboard motor propulsion will be touched upon.

When the outboard motor first grew into wide use and to larger sizes, boat builders found it necessary to modify their small boat designs. A boat that is easy to row usually has a narrow stern with the greatest beam (width) amidship. That was quite satisfactory for small motors which "take the place of oars," but when the weight of a larger outboard motor is clamped to the transom there is too much weight, along with the operator steering the motor, for the narrow stern to support. The consequence is a boat badly out of trim—the bow goes way up in the air, the stern sinks. Not only the weight at the stern but also the "pumping" of the water from under the stern by the action of the propeller causes this result.

It was soon discovered, largely by trial and error that in a boat designed for outboard motor propulsion the widest and flattest part of the bottom should be at the stern so that the extra displacement, the extra buoyancy thus created, would support the weight and the propeller action. Such a boat isn't the best for easy rowing but then with modern motors, people don't plan to do much rowing except in case of an emergency.

The easy-to-row type of small boat is quite satisfactory for outboard motor use — if the motor is small, if there is weight (another person or some ballast) also at the bow, and many are in such use.

Small boats may be classified in several different ways. There are metal boats and wood boats. By far the larger number are made of wood. Metal boats have the advantage of not drying out (with consequent leaks and warpings) when stored. Usually they are heavier than wood boats; they sometimes pick up the vibration of an outboard motor to amplify the drumming sound; they do not snag easily on rocks or other obstructions but if they do they are somewhat difficult to patch; and they must be kept well painted to prevent eventual rust and corrosion. Seldom will one find a steel small boat in use in salt water.

Boats built of wood may be either planked —in several different ways—or made of plywood. Either type may be canvas covered. Either type may be flat bottom, V bottom or round bottom. In the case of high speed small runabouts and in racing boats, there may be one or more "steps" in the bottom in which event the boat is known as a "step hydroplane," usually very light in weight, rather short, and operable only on comparatively smooth water.

The common "home made" or small-shop fishing boat is usually made of as few planks as possible, with straight flaring sides and flat bottom. The cost is low and for ordinary small lake or stream fishing with motors of five horsepower or less they serve very well. Of course there are modifications of this type: mahogany planks or frames; special finishes, cedar or cypress or pine planks; batten or caulked seams—and so on.

Boats with V bottoms are very popular. These usually are built with wide planks screwed to sawed frames. The V is of course most pronounced at the bow, tapering off to a flat or nearly flat, wide bottom at the stern. They ride rough waters well when strongly made and securely fastened together as most factory-built boats are.

Boats with round bottoms are usually planked on steam-bent ribs except in the bow where they are decidedly V shaped in most designs. Planks may be narrow strips edge-nailed and riveted or screwed to the ribs or may be "lap-strake" (clinker built) with one plank lapping over the next like siding on a house. Each type of planking has its proponents—either may be made deep and with wide beam for heavy loads and rough water or on a more conservative mold for small smooth waters.

Canvas covered boats are most generally of the canoe type either with pointed stern as well as bow or with a wide flat stern and transom for outboard motor use. The planking is very thin clinch-tacked to steam-bent ribs. The canvas is stretched over the hull tightly and marine glue is used to cement it to the planking all over. A special "dope" is applied to the outside to shrink the canvas as well as to permeate it with water proofing material. The outside protective coat of paint and varnish is tough and strong.

Double pointed canoes may be successfully propelled with a small outboard motor, usually of not over two and a half horsepower, attached overboard at one side of the stern with a special canoe bracket. Owing to the small supporting area under the stern, this type of canoe, if carrying only one passenger, needs ballast in the bow.

Square stern canoes are built for motor propulsion and are in reality canvas covered, canoe-construction boats. There are runabouts and there are small car-top boats made this way for lightness. The cost is sometimes slightly higher but the annoyance of leaking caused by drying out on the beach or in storage is avoided. A snagged and torn canvas covered boat isn't hard to patch with canvas, glue and a hot iron for applying.

Many boats are built every year "at home" by amateurs, in the basement, barn or garage, from plans which may be obtained from boating and science magazines. If one has an aptitude for wood working and some good tools and a heap of patience, there is no reason why a good boat can't be made this way. There may be a saving in cost if time is not computed. There is always the pride of accomplishment. It must be pointed out, however, that the starting novice should not attempt a too difficult design. A round bottom boat, for example, with steam-bent ribs, requires a costly form over which it must be shaped. A steam box is required and numerous clamps as well as some special tools. A simple V type, on the other hand, is a matter of making up sawed, assembled forms to which the planking is attached and with a reasonable assortment of tools and having the right kind of well seasoned planking available, the skilled amateur should get along rather well.

Factory built knock-down boats are available to those who want to "build a boat" without starting from scratch. The more difficult woodwork has already been done so that accurate assembly and finishing (painting and trimming) are all that are required. This type might well be recommended for the first effort. Later the builder may wish to graduate to something more intricate and difficult.

Boat manufacturers have developed their designs and methods of construction through extended experimental work costing many dollars and much time. They are naturally reluctant to give detailed plans to others or even to sell them. In most cases it is not effective for an amateur to try to copy a factory boat by drawing up his own plans from a model. Nor should anyone who is inexperienced attempt to design any boat other than a very simple "tub" which is not required to have any great rowing facility or adaptability to a motor.

SELECTING A BOAT

In the selection of a boat, as in the selection of an outboard motor, it is in the long run best to rely on the knowledge and experience of others. Buy and use the type and size that others have found most satisfactory for the same purposes on the same water. The one place where all such information comes to a focus is your boat dealer who is also, very likely, your outboard motor dealer too. A good boat and motor dealer would rather not sell you an outfit at all than see you get one that he himself knows is not practical or is unsafe for your boating conditions. It is well to rely on him as well as on information you get from other boaters like yourself.

Probably the most frequently asked question is "How fast will it go?" That is similar to asking "How far is up?" Because there are a lot of factors entering into boat speed. One outboard motor manufacturer has this to say: "Boat speeds are governed by numerous variables such as: Boat design; boat weight and length; load and trim; actual motor power; wind and waves; currents and tides; skill of operation—and others."

There are, nevertheless, a few very "general" rules which can serve as a guide. The following table is only that, and no more, so please don't use it as a factual criterion.

Motor H. P.	Type of Boat	Length Boat Feet	Weight Boat Pounds	*Top Speed Range in M.P.H.
1½ to 2	Rowboat or Canoe	12-15	100-150	6-7
2½ to 3	Rowboat or Canoe	12-15	100-150	7-8
5 to 6	O.B. Boat Fish Boat	12-16	125-200	9-10
9 to 10	Runabout or O.B. Boat	14-16	200-300	10-18
16 to 18	Runabout or O.B. Boat	14-17	200-300	18-25
20 to 23	Runabout or Large O.B. Boat	15-18	300-500	22-30
30 to 35	Runabout	15-18	300-500	25-35

*M.P.H.—Miles per Hour.

It must be explained here that from the performance standpoint boats again divide into two classes: Displacement boats and boats that plane on top of the water. Usually, any type of boat for the regular use of motors up to around six horsepower are displacement boats when in operation; they ride in and through the water. If, however, that same boat has a wide flat stern and is equipped with a large motor, say sixteen horsepower, then, if the load isn't too heavy, it will become a hydroplane. Many of the boats built especially for large motors will plane with up to three or four people of average weight. Even a small boat of the fishing type and of light weight construction when operated with only five or six horsepower will plane at considerable speed.

Doubling the power on the stern of a purely displacement type boat will increase the speed only a little. But if a suitable boat can be pushed "over the hump"—from down *in* the water to up *on top* — by getting it up to speed, then at that point the speed may go up fifty to one hundred percent. All the racing records are made with very small, light weight hydroplanes with motors that have been designed and built specially for racing.

This matter of planing a boat presents a special outboard motor problem. A five horse power motor which is built to run at 4000 revolutions per minute may have a propeller of eight inch diameter and seven and a half inch pitch. On a suitable fishing boat running at around nine miles per hour the motor will run at about its rated speed. But if that same outfit with a light weight operator "goes over the hump" and starts planing, the boat may make a speed of fourteen miles per hour. That will permit the motor to turn well over its 4000 r.p.m. and may prove injurious to it. There is a solution. A propeller with more pitch, say nine inches, will help, but again there is a difficulty; it is possible that the motor won't be able to turn the new propeller fast enough, while the boat is getting up speed, to put the boat "over the hump." Then it never will get into planing position. Such a circumstance occurs, usually, only where the motor power is just enough, and little to spare, to get the boat up into planing position. But it is discussed here to explain that, contrary to widespread popular belief, a higher pitch propeller is put on a motor *to slow it down* and not to increase boat speed. The simple act of equipping a motor with a higher pitch wheel doesn't mean higher boat speed (although sometimes under certain conditions it does) but lower motor speed. And sometimes the application of a propeller of lower pitch, as on a heavy slow boat, will actually increase boat speed.

Most outboard motors steer, not by a rudder action, but by turning the direction of the propeller thrust. By far the majority of outboard motor boats are steered with the "steering handle" or tiller. This means that the operator sits in the stern of the boat close to the motor. And that has been found most practical except, perhaps, in large runabouts. In those steering wheel steering is preferable. The conventional boat steering wheel may be mounted within easy reach of the operator from his seated position near the motor. That position seems preferable because the operator must be near the motor to start it anyway. Nevertheless, the steering wheel is sometimes installed forward as in an inboard boat. Then if there is only one man in the boat, he must climb over any and all obstructions to get from the motor to the forward seat after the motor is started—not entirely safe nor completely comfortable. The forward position does, however, give better weight distribution and a somewhat better view ahead.

Cables, preferably bronze center, cotton covered and waxed "tiller cord," are attached around the drum on the steering wheel assembly, carried aft along each side of the boat through pulleys (or screw eyes in small boats) and then, from the two ends of the transom these should be brought through pulleys to the motor. Some manufacturers can supply for some models of motors a steering bar to which the cables may be attached. This is the best arrangement. In some cases the cables are fastened to the motor steering handle. The object, of course, is to have the motor turn through an angle of perhaps sixty degrees for steering when the steering wheel is turned. Since one cable may tighten and the other become loose when turning to one extreme or the other, a long coil spring can be used between the cable and the motor to constantly take up the slack but this is not always satisfactory.

Throttle opening (for changing speed) is usually accomplished by using a bowden wire control attached at one end to the throttle lever and taken forward along the side of the boat to a quadrant on or near the steering wheel. A pair of insulated wires, one attached to the "live" post on the magneto, the other to some metal part of the motor (for ground) can be taken forward along the side of the boat to the steering wheel position and there attached to a switch. When the switch is closed (in contact) it will "ground" the magneto current and stop the motor. The switch may be a push button of any good substantial type with positive contact. It should clearly show whether it is "on" or "off," however, because if it is making contact the motor cannot be started. The push button type is best.

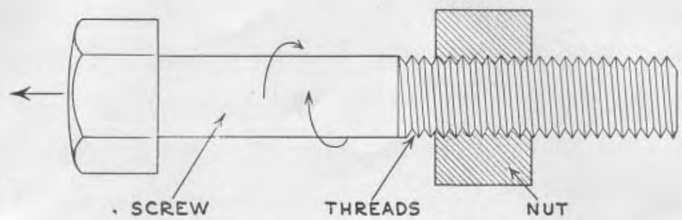
TROLLING

Many outboard motors used for fishing are run at slowest possible speed for trolling. (Some States prohibit trolling with a motor-propelled boat.) In more recent years great advancements have been made in outboard motor design and construction to get slow, consistent trolling speeds. Where previously only smaller motors could be so used successfully, now motors to five horsepower or more are so perfected that very slow operation is attained. Manufacturers found it more difficult to develop a slow motor that would also run fast than to build motors for speed alone.

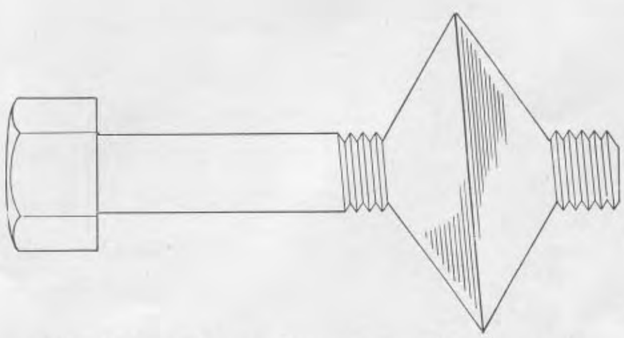
Slow speeds are obtained by a variety of methods and a combination of features. For example, it is not enough just to have a carburetor and good fuel distribution that permit of slow motor speed, if the magneto doesn't continue to deliver hot ignition at those low speeds.

Probably the most successful design for slow speed is the dual carburetion and duel intake system. Here there is in effect one small carburetor for slow speed, another and larger one for full power. By properly designing the size of the small slow-speed carburetor, and providing special intake passages of the right size, and using rotary or other valve arrangements which are specially timed for slow speed, consistent, steady operation is obtained. However, all this avails nothing if not accompanied by precision manufacture of all moving parts. A motor that runs slow for trolling must be in first class mechanical condition. And the adjustments of fuel controlling needle valves must be just right.

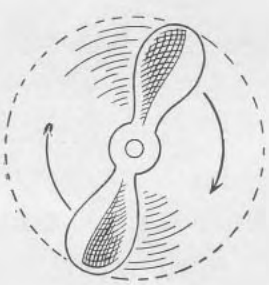
There are several ways to get trolling boat speeds even though the motor is too large or incapable of slow enough operation. Trolling plates as accessories have been made available by manufacturers for some models. These are simply "brakes" — a vertical plate attached just above the propeller and extending down back of it or a disc attached to the propeller shaft to blank off part of the effective area of the propeller blades. Some automatic types have been made which, under spring tension, present a broad area to the water but which straighten out to a nearly horizontal position with little drag when the motor is speeded up. The simpler types — attached plates of one kind or another—are something of a nuisance as they must be removed when it is desired to speed up. Under some conditions, with some kinds of motors and trolling attachments, speeding up the motor without removing the plates will permit too high motor speed. And anyway, the boat won't make much progress.



Bolt with threads, and nut. Hold the nut, turn the bolt as indicated, and the bolt will move toward the left.

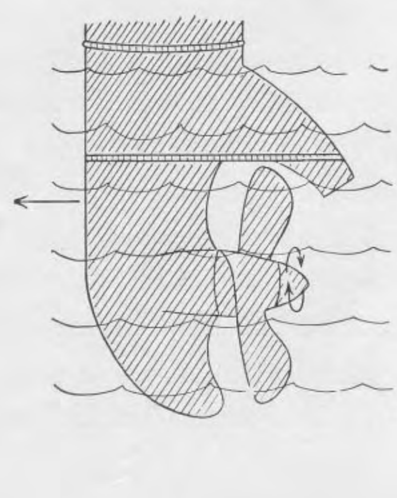


The bolt with one thread greatly enlarged.



The one enlarged thread about three-fourths cut away, leaves two blades or segments which develop into a two-blade propeller.

Mount these two segments on a shaft and turn it: The water in which it turns is the stationary nut; The screw (propeller) then moves forward.



Another method for getting slow boat speed but one which fishermen don't like very well, is to tie a steel bucket on a rope and tow it behind the boat. This provides so much resistance that the boat is considerably slowed down. Another method sometimes employed is to use two motors; one larger one for "going places" at top speed and a small one for trolling on arrival at the fishing spot. This is of course costly and cumbersome.

The best way to get satisfactory trolling speed is to get a motor that is capable of running slowly. Then keep it in the pink of running condition and be very sure that the operator knows exactly how (and why) to adjust it for best performance.

A good, slow and sweet running trolling motor on a small, easy-to-push boat with a light load is bound to make more miles per hour at slowest turning speed than the same motor on a big, heavy, heavily loaded boat which is harder to push through the water. In trolling, the larger boat is the better, but when it comes to going home the smaller boat will outrun it. It must be remembered, also, that "slow trolling" for one fisherman in one body of water may not be satisfactorily slow for another fisherman out after other game. "Trolling speed" will vary from the slowest possible crawl up to around five or six miles per hour. A "good trolling motor" of around five horsepower when in first class condition and properly operated on a not-too-light fishing boat can get down to one and a half miles per hour consistently and sometimes slower.

While it is true that two-cycle engines operate best without back pressure restrictions on the exhaust, the use of a cutout to relieve exhaust pressure when running slowly is not recommended. Well designed underwater exhaust systems do not impose very great back pressure even at slowest speeds and very little improvement in motor performance will result from the use of a cutout. Besides, too many "forget" to close the cutout when operating at high speed and thus create a noise nuisance which annoys others and in many localities violates the law. It isn't good for the sports of fishing and boating.

OUTBOARD MOTOR PROPELLERS

Everyone knows what a propeller is and what it does even though many have had little occasion or opportunity to study its action in detail. Perhaps it will help considerably in getting the most from your outboard motor to discuss the fundamentals and explain some of the factors that enter into propeller design and operation.

Principally, there are four major factors involved in the design of a propeller for a particular job. The designer starts with two known values—the power available to turn the propeller and the probable speed the vessel on which it is to be used will make under that power. Then he works out the best combination of (1) Propeller turning speed, (2) Diameter, (3) Blade area (and whether to be distributed in two or three blades), and (4) Pitch.

As a general rule, a large heavy slow speed boat will need a large diameter, slow speed, large area and low pitch wheel. Conversely, a small hydroplane type, light and for high speed, will have a high speed, small diameter, small area, high pitch wheel.

Theoretically, for highest efficiency and performance, every boat and every different load for that boat, should have a propeller with one, two or all four of the factors varied to suit conditions. This, obviously, is impossible. So, every propeller design is something of a compromise. On an outboard motor of five horse power, for example, the propeller might be ten inches in diameter or eight inches; the designer will probably select the eight inch size to keep weight and bulk down. He could go to six inches in diameter but experience has indicated that he would then sacrifice too much in efficiency.

A propeller is a screw. The "nut" on this screw is the water. When the screw is turned, it screws itself out of the nut and advances. The amount it advances in one turn (with a solid nut) is the pitch. Since water is not solid, there is some "slippage"—the water flows one direction, the propeller goes the other. With a certain amount of power available, it is necessary that the propeller blades "push" on a large enough column of water (back of the propeller) to get a good, solid, "toe-hold"—that influences diameter and blade area.

The pitch is such that when the engine turns the propeller at its rated speed (absorbing all its power at that speed), the forward motion of the "screw" in the "nut" will be just a little more than the probable speed of which the boat is ordinarily capable with that much power.

The outboard motor designer can't know what boat his motor is going to be used on, nor what load it will carry. So, from experience, he selects the combination of speed (propeller R.P.M.), diameter, blade area and pitch which will fit the *average* boat condition. On a very light, fast boat he may have a little too little pitch; on a heavy, slow boat he may have too much pitch and not enough blade area. But outboard motors, particularly in smaller sizes, up to around ten horsepower, are adaptable. So, on one boat the motor may be able to turn 4100 revolutions per minute; on the other only 3700 revolutions per minute. It makes little difference because the power that the motor is able to deliver doesn't vary too much from 3700 to 4100 R.P.M. And the effect on the boat speed is practically unmeasurable.

As has been explained, the pitch of an outboard motor propeller should not be changed to improve boat speed but only to make sure that when the motor throttle is wide open it cannot run faster than its rated speed. That is why a higher pitch wheel is used on lighter, faster boats. It is not the *cause* of the higher boat speed (although the right propeller, boat and motor combination helps get maximum performance) but only the restriction on the engine to keep it turning at the speed where it operates best.

Under most conditions, therefore, the propeller that is furnished on the motor by the manufacturer is the best—on smaller motors. Fantastic claims for gains in miles per hour for this propeller or that are sometimes heard (and believed). And sometimes the gain is accomplished. But usually it is only by letting the motor run at above its rated speed. On large motors, which are used on a wide variety of boats, the propeller should be changed from the standard if the boat or operating conditions are unusual — but the same conditions govern — the propeller should have that diameter, blade area and pitch which will keep the motor within its rated speed limits.

Is a three-blade propeller better than a two-blade? Or vice versa? There is no definite answer. A good two-blade propeller is ever so much better than an incorrectly designed or fitted three-blade. Or the other way around.

Three blades may be used to get more blade area within a given diameter, particularly on a slow speed wheel, or for other reasons such as to better operate a pressure-vacuum cooling system. Most designers consider a two-blade more efficient in small size and for higher boat speeds. A two-blade lends itself better to weedless design. Most "work boat" propellers have more than two blades.

Is a brass or bronze propeller better than an aluminum propeller? Again it all depends on the service, the application. Bronze is used for strength and for its non-corrosive properties in salt water. Modern aluminum alloys are strong too, and with proper protective treatment are surprisingly free from salt water action. A bronze propeller used in proximity to an aluminum gearcase will set up some electrolytic action which in itself may cause the very corrosion one seeks to avoid.

OUTBOARD MOTOR FEATURES— AND WHAT THEY DO FOR YOU

It has been said and sometimes demonstrated that automobiles are sold on the convenience of an extra ash-tray or the beauty of an instrument panel. It is probable that some outboard motors have been sold on the strength of some incidental gadget. Each make of motor, and frequently each individual model, usually has some special features of design which are brought to the fore for selling purposes. Some serve a real purpose while others are "talking points."

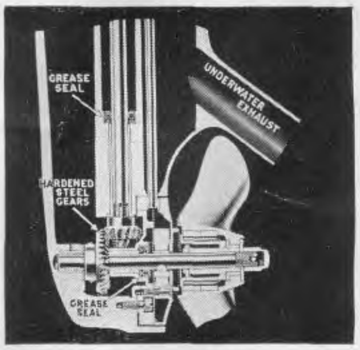
By far the most important "feature" of any outboard motor is *dependability*. How is it attained? That is a long story because there are many factors involved. In general, it must first be designed and then built into the motor by the manufacturer. He must design for strength and durability and long life. If the choice lies between ordinary brass and high grade, costly bronze for an important bearing, then he will select the bronze and the result is a bearing that you, the owner, can depend on. If the choice lies between simply boring out this bearing or finishing it on a diamond boring machine, he will choose the latter because it makes a better bearing. And again you can depend on it for more years.

Thus throughout the whole motor, when there is a choice between two methods, as there always is, the manufacturer of a dependable motor will choose the better way.

Dependability means that when you want to start the motor, it starts; when you go to a distant fishing spot, it takes you there and back again; when you come to a long, hard pull upstream, the motor never falters but comes through. The satisfaction you get over weeks, months and years, particularly years, depends on a multitude of little things well done in the first place.

There is one sure way to choose a dependable motor; that's to take the word of experienced friends, friendly and capable dealers, reputable manufacturers. You must rely considerably on reputation.

One of the most widely used features, especially on motors used for fishing, is *slow speed for trolling*. This has already been discussed in some detail. The attainment of satisfactory slow speed operation is the result of a combination of several things including design of magneto, carburetor, intake system, control devices, and, finally, extreme precision in manufacturing. It might be said that you can count on it that a motor that will troll slowly and consistently has been well designed and well built.

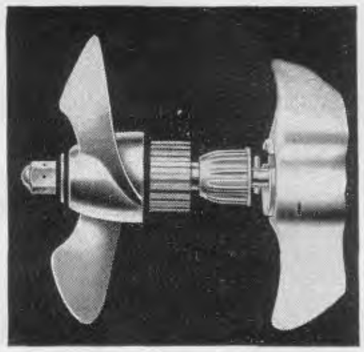


Grease Seals

...keep the grease in the gear case, keep the water out. Hardened steel gears and shafts and bearings always well lubricated; only occasional replenishment of grease needed. All openings to gear case now sealed. Also note exhaust.

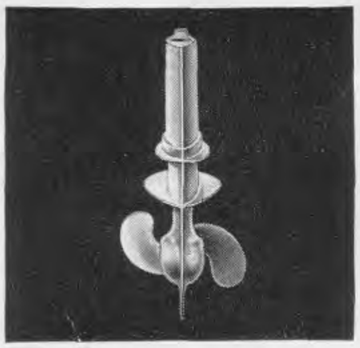
Reverse

...as a part of full Pivot 360° Steering, provides for complete maneuverability forward, sidewise, around, and backward. Just turn the motor around, it then locks automatically. A most *important* feature.



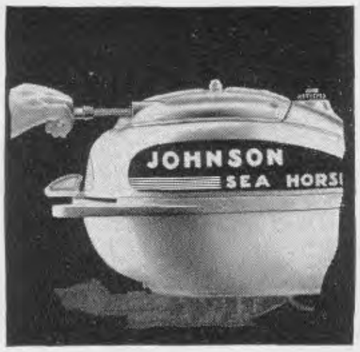
Rubber-Flow Shock Absorber

...prevents shearing of drive pin when propeller hits obstructions; built into propeller hub; permits carefree operation in shallow water, among obstructions; simple construction, no adjustments required.



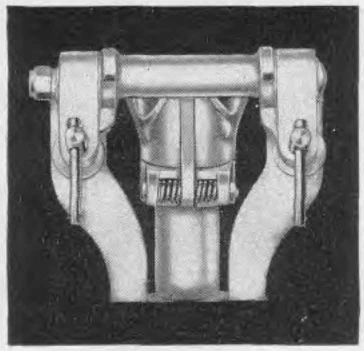
Streamline Gear Case

...is made of special aluminum alloy Alrok treated for corrosion protection; large grease capacity; large, hard bronze bearings; contour for least resistance. Propeller weedless type.



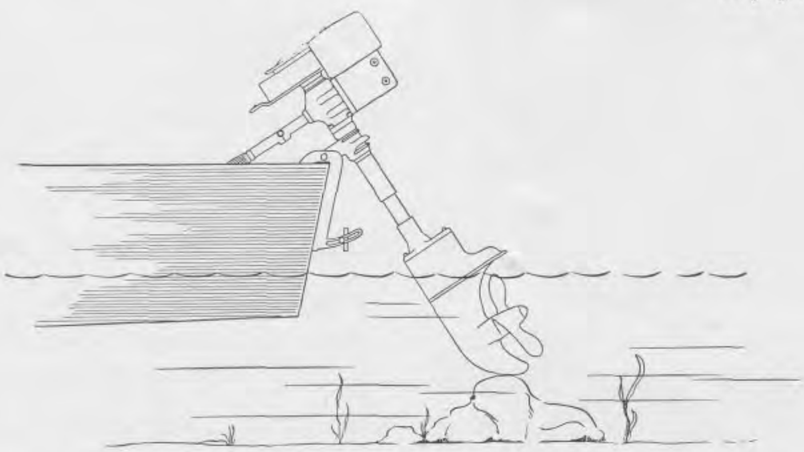
Ready-Pull Starter

...rewinds the permanent starting cord quickly, automatically and eliminates the separate starting cord. Always ready. Completely enclosed. No moving parts after motor is started.



Co-Pilot

...is fully automatic and adjustable to varying needs. It "takes hold of the motor when you let go," holding the motor from turning and driving you off course. Fix your tackle, light your pipe, relax at full power or trolling speed.



Free and automatic tilt over obstructions and for beaching boat.

Reverse is another of the more important features. Years ago there were motors with "feathering" propellers which provided for both forward and backward propulsion, but these were not altogether satisfactory and are not now manufactured. An intricate propeller construction hitting on rocks and "dead heads" didn't prove reliable.

Full Pivot Reverse is the accepted type. The motor is so built that it can be turned through a full 360° circle. Turning the front of the motor to the back, 180° turn, reverses the direction of the propeller thrust and the boat moves backward. Since the back end of the boat is square, it is obvious that the motor should be throttled to partial speed when reversed as otherwise the water will pile up and spill over the transom into the boat.

Reverse is a major convenience. With the motor throttled one can maneuver a boat into the dock—and away again. Or when an obstruction shows up dead ahead, reverse will stop the boat quickly to avoid the encounter. The boat may be beached and pulled off again if there is sufficient water depth at the stern. If a fishline is snagged or if the hook is taken by a "big one," the boat may be stopped quickly and backed up to a better salvage position. While the need for and use of a reverse may be infrequent, it is nevertheless a valuable feature of performance. It is not generally applied to larger motors because in the hands of an inexperienced or careless operator boat tipping (when in the 90° position) or an undue strain on the boat transom might cause trouble.

One of the greatest, most important motor developments was the combination of *streamline contour* of the *lower unit* (gearcase) with the anticavitation plate. Without it, larger, more powerful motors would hardly be possible or practical and smaller motors would be heavier, less efficient. Streamline design of the powerhead enclosure not only provides a more pleasing appearance but protects the spark plugs, carburetor, magneto and other important parts.

The device which holds a motor in position when not guided by the operator yet permits steering without undue drag is one of those delightfully simple devices that does a big job. Referred to as a *co-pilot,* it flexibly grips the motor shaft from turning in spite of the torque vibration which tends to turn the motor from its set course. It is not an "automatic steering device;" it will not keep a boat on its course in spite of wind or wave direction, but it does relieve the operator from constant attention. One may head for his destination across the lake and then with only an occasional readjustment of the motor position or direction, busy himself with whatever task or chore needs attention. The co-pilot "takes hold of the motor when you let go," to quote one manufacturer's literature.

Underwater exhaust, almost universally employed now on all motors to silence the exhaust and carry away exhaust gases and smoke under water, was not only a boon to the occupants of the boat but equally so for those on shore. When effectively designed, the underwater exhaust system reduces power to no appreciable extent at full speed although it does make necessary more care in the design and construction of the motor to get the best slow speed operation. Underwater exhaust deserves a large portion of the credit for new feminine interest in outboard motoring and has increased the pleasure of the sport for all concerned.

Another feature developed in more recent years which has gone a long way toward popularizing the wider use of motors, is the *automatic re-wind starter.* Previous to its development and appearance on the market, motors were (and many still are) started by winding a starting cord around a sheave on the flywheel and pulling it off to spin the motor. This is effective and simple but it is inconvenient. Starter cords get lost or fall overboard; they get wet and dirty; the snap of the rope end sometimes catches an unwary forward occupant of the boat with considerable force and resultant damage.

The re-wind starter uses a cord, in fact, it operates on the same principle. But the cord, usually a bronze-center cable with cotton exterior, is wound on a drum and the drum contains a long flat spring which rewinds the cord when the pull has been relaxed. Suitable clutching or ratchet means is employed to engage the flywheel when the cord is pulled and to release from it when the pull is relaxed or when the motor starts. It is much more convenient, quicker, safer. A growing large percentage of motor models on which the re-wind starter is offered are now being factory equipped. This convenience feature shares with underwater exhaust the credit for greatly extending feminine interest in outboard motoring.

One of the inescapable faults of inboard power plants is the inaccessibility of the propeller down under the boat. If the propeller hits an obstruction, propeller damage is likely to result and it isn't easy to reach for repair. There are two features in outboard motors that eliminate most of such trouble. One is the *automatic tilt* which is built into all outboard motors. The motor tilts over obstructions when encountered; it can be manually tilted to remove weeds or trash or to clear known obstructions or to clear the bottom when beaching the boat. The other feature is the *shock-absorber drive* which usually is in the form of a slipping clutch interposed between the powerhead and the propeller. In normal operation of the motor it doesn't slip but if there is a shock caused by the propeller hitting something, it does slip. It prevents propeller damage and avoids the shearing of the propeller drive pin (shear pin). Many boaters have reported whole season operation without having to replace a drive pin. But some who do not have the shock-absorber drive have found themselves in trouble during the time taken to tilt the motor, remove the propeller and replace the drive pin.

In some designs the shock-absorber drive mechanism is incorporated in the drive shaft, in some it is worked into the gear design inside the gearcase, but usually it will be found as a cone friction device or a rubber-flow arrangement inside the propeller hub. To prevent drive pin breakage is by no means its sole purpose for it prevents shocks to the propeller shaft, gears, driveshaft and crankshaft of the motor and thus avoids breakage.

Easy starting is an essential feature of every outboard motor and everybody who makes or sells motors claims he has it, which is largely true. The large and unfortunate fact is that "easy starting" is applied only to the motor; it is influenced no less, perhaps more, by the person who is doing the starting.

If the Three Fundamentals of gasoline engine operation have been fully studied and are understood, then it isn't difficult to see that any outboard motor will start *if* the Three Fundamentals have been fulfilled. The motor itself can't think and it can't move; it is just a "hunk of metal." It is the *operator* who must make the adjustment, do the right things, keep the motor in working order. That done—starting is easy.

But it will have to be admitted that some motors when not in the pink of condition are hard to adjust. Everything must be *just right* before the Three Fundamental conditions are fulfilled. The motor is "hard to start" only because it is hard to adjust. It might have been built that way if it's an old model; it might be "delicate" and "temperamental"; and it could be that the operator just doesn't know what he is doing.

It was difficult to adjust and keep in condition some of the old models; motors were sometimes designed for utmost speed with other characteristics sacrificed. As a consequence, outboard motors did have a hard time for a while, now happily about over, living down a reputation for hard starting. But there is no excuse for it today. Modern outboard motors that are kept in proper condition and are properly operated are no chore at all. Usually a quick flip on the starter cord and away they go. Improvements in magnetos (spark), carburetors (mixture of fuel and air) and in close precision machining of working parts (compression) have made this so. If any operator experiences difficulty in starting these days he should look to the Three Fundamentals, the condition of his motor, and himself.

Smoothness is another of those intangible features which everybody claims and all have in a degree. This was discussed under motor types so about all that need be said here is this: smoothness is something greatly to be desired in an outboard motor. Whether a particular motor has that lack of vibration which will satisfy a purchaser can best be determined by a demonstration. It need not be true that a four-cylinder motor is smoother than a twin of the same size; and some small single cylinder motors have less annoying vibration than some twins of larger and more power. The general opinion seems to be that in large motors of more than twenty horsepower, the four-cylinder is smoother; in medium sizes of say eight to eighteen horsepower it is pretty much of a toss-up between a four and an alternate firing twin; while in smaller motors of from two to six horsepower the alternate firing twin is better than the opposed twin; and the real small twins of any type are smoother than the singles.

Simplicity of operation leads to avoidance of trouble through incorrect adjustment and to better operation by a novice. The interconnection of spark advance and throttle is one of the methods used to attain simplicity. Here, the proper relation between spark advance and throttle opening is automatically maintained. The inexperienced operator doesn't have a chance to run with retarded spark and wide open throttle or vice versa. The results are better. A high speed needle valve for gasoline adjustment is connected to the primer so that one more control gadget is eliminated. And on some motors the low speed needle valve adjustment is purposely made somewhat inaccessible to prevent unwarranted "tinkering" with it.

There are almost innumerable features; each builder has his pets and talking points. Most are worth looking at and trying out. It should be remembered, however, that "clothes do not make the man" and "features," as such, do not make a motor. A good, sound, modern, fundamental motor design is ever so much more important. And the verbal "letter of recommendation" that the majority of owners are willing to give a motor speaks highly for it. After all, the proof of the motor is in the running. It might well be said, too, that a good, honest, conscientious dealer with a lot of knowledge and a service shop, can be very helpful when you are giving consideration to a motor purchase.

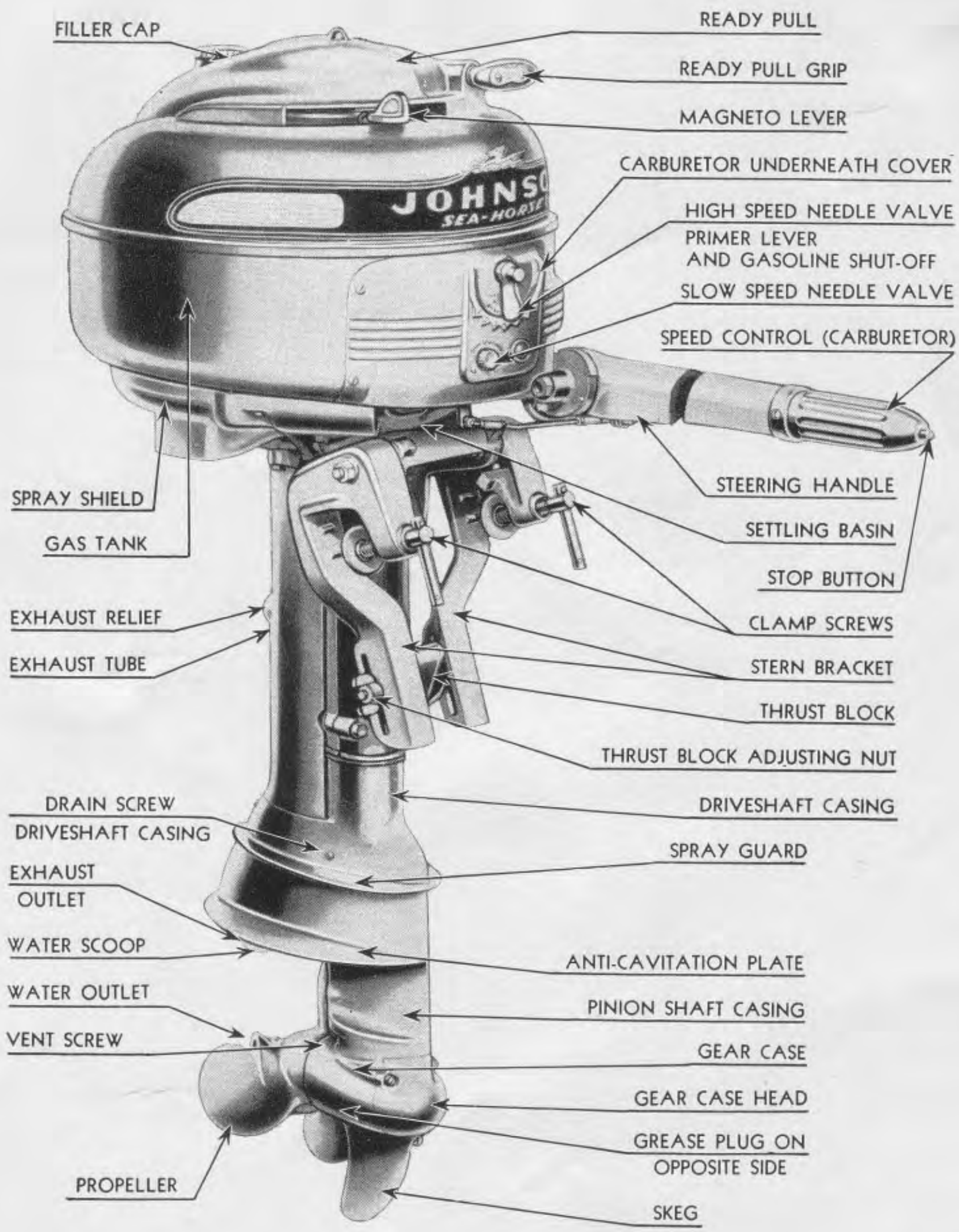
GENERAL CONCLUSIONS

In closing, the question arises whether all of the foregoing has been sufficiently specific. Perhaps not. But then, a learned physician writing on a disease probably couldn't be of much help to some individual patient: the patient should follow the general instructions and get the more specific information from his local doctor.

The outboard motor owner who will follow the general information herein will be able to improve his water motoring enjoyment, but when he is in need of specific help, he should call on the service station and get an expert to tell him what to do—or have done.

Outboard motoring is a grand sport. If that has been said before, it will bear repeating again and again. But it is regrettable that too many are not getting *all* the satisfaction and enjoyment that it affords. Just a little more interest, a small amount of study, some care and attention to details in motor and boat operation will pay them big dividends.

THE END



Powerful outboard motor developing 16.0—N.O.A. Certified Brake Horse Power at 4,000 revolutions per minute yet weighing only slightly more than five pounds per horse power, accomplished by extensive use of light, strong aluminum alloys.

INDEX

NOTES

MY MOTOR:

Make..

Model..

Serial No..

Horsepower..

Spark Plug Type..

Oil to Use..

Date Purchased..

From (dealer)..

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Remarks:..

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