Rudder "ON" Series

On Marine Motors and Motor Launches

Herbert W. Trowbridge
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Boston

ON

MARINE MOTORS

AND

MOTOR LAUNCHES

A HANDY BOOK FOR YACHTSMEN

BY

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PREFACE

THE gasoline engine for marine propulsion is fast becoming one of the most extensive factors in power craft of small sizes. That it is not taking hold faster is because it is not understood as well as it should be both by the builder and the engine runner. While there are quite a number of very good engines, there are, unfortunately, a great many more of which it may be said that, while the makers' intentions were good, the results have not fulfilled his intentions. The steam engine has so long been a factor in our life that it has ceased to be looked upon with awe, and any one with the least pretensions to a knowledge of engineering understands the general principles of operation of the older motor. While the gas engine is simple and, in fact, much less complicated than the steam engine in so far as its mechanism is concerned, it is but imperfectly understood even by many who have had close dealings with it for years. Owing to the fact that a gasoline engine is self-contained and produces the propulsive force from the fuel as it is needed, the derangement of any function is very likely to throw the entire motor out of working order. A knowledge of the principles of operation involved, as well as the troubles that are likely to arise and where to look for the cause, is essential to the runner. Quite frequently the remedy is one that can be applied immediately, and no inconvenience will result from the derangement. Should, however, the engine runner not know what the matter is and the remedy to apply, he might as well have no engine. It was to help the engine runner that the present series of articles now appearing in book form were written. The author trusts that the hints contained in this small book will accomplish the object he has had in view in their preparation, i. e., to smooth over many of the rough places in the operation of a marine gasoline engine.

CHAPTER I.

PRINCIPLES OF OPERATION.

WHEN selecting a gasoline engine for driving a boat there are a number of considerations to be dealt with, but all of them, great and small, subservient to the primary consideration of reliability of operation at all times and under the most trying conditions. It is a very peculiar thing about the gasoline engine that it is expected to be in good working order at all times and that it must never break down. If it does, the owner or operator, as the case may be, will decry the gasoline engine, its builders and all who have anything to do with it, in language that is probably not of the mildest kind. If a steam engine breaks down, there may be some strong words used with reference to the maker, but as a rule nothing is said against the steam engine as a prime mover, for the simple reason that we are accustomed to its vagaries and take them as a matter of course.

While much more is usually expected of the gasoline engine than of the steam engine, the previous assertion is none the less true that reliability of operation is the primary consideration and by all means the most important. Economy of fuel, which is a matter of first importance with all prime movers on land, becomes a secondary requirement as far as the marine gasoline engine is concerned, and more especially when these engines are to be used for small powers and go as a rule under the care of the unskilled. It is a very mistaken notion that anyone, even a child, can operate a gasoline engine. True, a child will get on very well after being taught, and until something happens. Then comes the necessity for a man with reasoning powers that are well developed and with a clear head. All kinds of things may happen to a vessel, if its motive power gives out. What these are it is scarcely necessary to explain to the reader. A great many things may happen to a gasoline engine in indifferent hands, and the greater portion of this article will be devoted to the things that may happen and what to do in case accidents occur.

Before taking up the matters of selection and care of a gasoline engine, it will be necessary to explain briefly the principles of operation of the two types available for marine purposes. These types are the four-cycle engine, in which there is but one impulse at full power for each two revolutions of the crankshaft, and the two-cycle engine, in which an impulse occurs at each revolution of the crankshaft. Of the two, the four-cycle engine is that most in use for stationary purposes, but in marine practice the two-cycle engine is driving the other very hard. Although not generally considered as economical of fuel as the four-cycle engine, it can be built much lighter for the same power, and the great frequency of the impulses makes it much steadier in operation. This can perhaps be realized better when it is remembered that a single cylinder steam engine receives an impulse at every stroke of the piston, or two impulses at every revolution of the crankshaft, while the four-cycle gasoline engine receives but one impulse to two revolutions, or one impulse to four in the steam engine. The steam engine also receives two impulses during the same time that the two-cycle engine receives one. It is supposed, of course, that both the steam engine and the gasoline engine are running at the same speed. Suppose again that the mean pressure within the cylinders of each class of motor (steam and gasoline) are the same, then the power of the steam engine for the same cylinder diameter, and the same stroke and running at the same speed would be twice that of the two-cycle engine and four times that of the four-cycle engine.

The principles of operation of the four-cycle engine may be best understood by reference to Fig. 1. In this figure there are shown four operations of the engine, one operation taking place during one stroke of the piston. At A is shown the first operation in which the piston P is on the downward stroke, and the inlet valve is open, allowing an explosive mixture of gasoline and air to be drawn into the cylinder as indicated by the arrows. Just as the piston reaches the bottom of the suction stroke the valve is closed, and upon the following upward stroke, shown at B, the mixture, called the charge, is compressed into a space at the end of the cylinder which is not entered by the piston and the volume of which is about one-third of the volume displaced by the piston during its stroke. Thus the charge is compressed into a volume equal to one-quarter of what it was originally, or to something in the neighborhood of seventy-five or eighty pounds to the square inch. Just before the piston reaches the top of the compression stroke, the charge is ignited by means of a spark passing between the two points of the igniter I. This causes a sudden rise of pressure in

Fig. 1

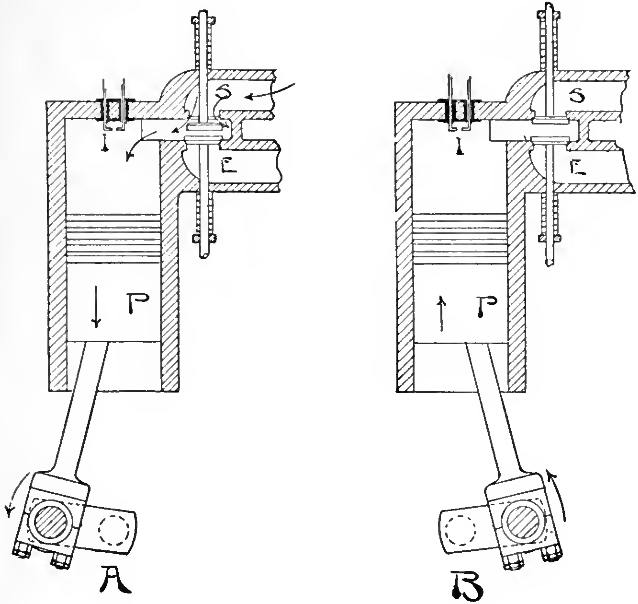
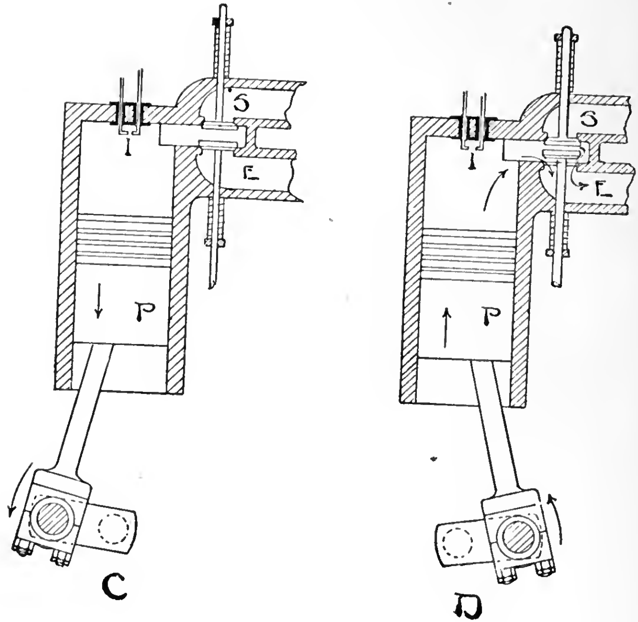


Fig. 1



the cylinder, which will, if the spark occurs at the proper time, reach a maximum value just at the end of the stroke. The piston then descends as shown at C, and the products of combustion expand until, when the piston has reached a point about 10 per cent. of the stroke from the bottom of the stroke, the exhaust valve E is opened and the burnt gases escape through the exhaust pipe to the atmosphere, being driven out by the return of the piston during the next stroke of the piston as shown at D. This completes the cycle or series of operations, which consists of the four operations shown, and hence the name four-cycle, which, to be strictly correct, should be called four-part cycle. In the four-cycle engine, the exhaust valve E is invariably opened by the mechanism of the engine, which is in nearly all cases a cam on a shaft called the cam—or lay-shaft, and which makes one revolution to two of the crankshaft. Many devices have been introduced in order to avoid the necessity of using reducing gears for operating the exhaust valve, but the majority of builders use either a pair of spur gears, a pair of bevel gears, or a pair of skew or helical gears. The first and third of these are the ones in most general use. The suction valve S is operated either by a cam in the same manner as the exhaust valve or by means of a vacuum formed within the engine cylinder upon the down stroke of the piston.

The operation of the two-cycle engine may be explained by means of the diagrams in Fig. 2. In the two-cycle engine the same general principles are involved as in the four-cycle engine, the only difference being that the suction and the exhaust strokes are cut out in a very ingenious manner. In the two-cycle engine of the type that is employed so extensively in small marine engines, the crank and the connecting rod are enclosed in an air-tight case called the crank-case, so that the piston is alternately producing suction and compression in the crank-case. At A in the figure the piston P has started upon its upward stroke, and may be supposed to contain a charge of gasoline vapor and air. The charge is compressed and ignited near the top of the stroke as in the four-cycle engine. At the same time the suction caused by the upward stroke of the piston is drawing a fresh charge into the crank-chamber through the valve S. On the following downward stroke of the piston the burnt gases are expanded and the fresh charge in the crank-chamber is compressed. Just before the piston reaches

Fig. 2

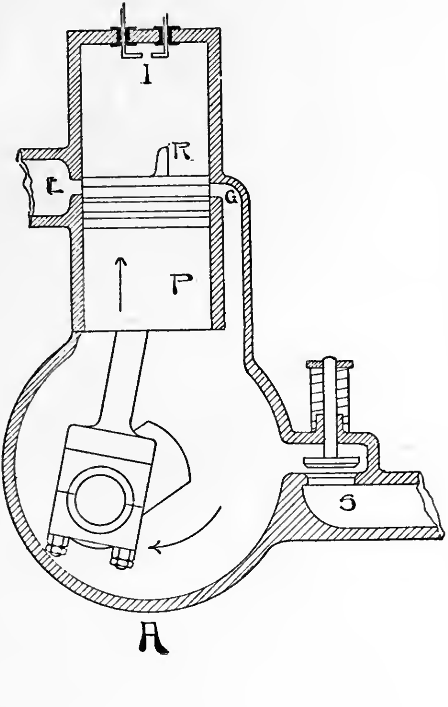
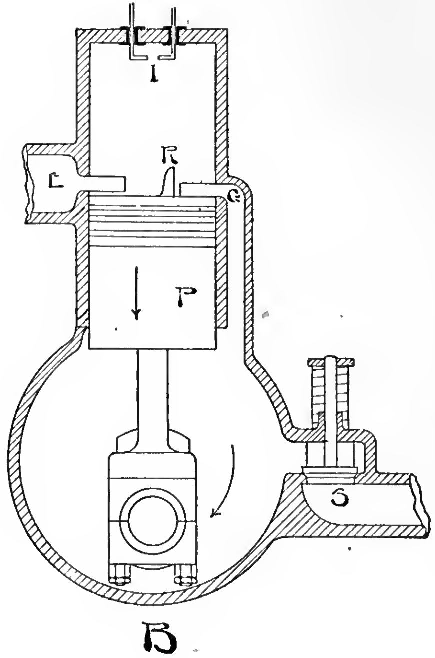


FIG. 2



the bottom of its stroke, it passes the exhaust port E, and the products of combustion escape through the exhaust pipe to the atmosphere. Immediately after the exhaust port is opened, the piston passes the inlet port G and the fresh charge which has already been raised to a pressure of from five to six pounds in the crank-case rushes into the cylinder and is deflected by the plate R to the top, as indicated by the arrows, and drives out the major portion of the previous charge. The cycle is then repeated as in the case with the four-cycle engine. It may be seen that the complete series of operations is finished in two strokes of the piston, or in one revolution of the crank-shaft. The name two-cycle is derived in the same manner as that of the four-cycle engine, and similarly it is in reality a two-part cycle.

The two-cycle engine is growing rapidly in favor both with the yachtsman and the manufacturer. The valve S in Fig. 2 is operated by the suction of the piston and the only mechanism employed is a reciprocating rod operated by an eccentric to drive the water pump and the igniter. Much trouble is experienced at times with the two-cycle engine from ignition taking place in the crank-chamber, and is due to several causes, which will be explained later. It often happens that, in a poorly proportioned engine, a portion of the fresh charge will escape through the exhaust with the products of combustion. One of the greatest of troubles with this type of engine is, however, that it is usually the first one to be built by an amateur, and he generally makes the engine so out of proportion that it will not operate successfully under very favorable conditions. The author has frequently run across cases of this kind, and he has one in mind where an unfortunate designer far away in Manitoba sent the author a photograph of his engine with a mournful appeal to tell him why it would not run. Unfortunately the photograph had nothing about it to indicate the proportions of the engine, and it was of course impossible to suggest a remedy without writing the inquirer a long dissertation on design.

In addition to the features of the engine shown by the diagrams there is usually a hollow chamber surrounding the cylinder through which water is caused to circulate by means of a pump, in order to prevent overheating of the cylinder and the piston, although in some small gasoline engines the cooling is effected by means of radiating ribs of metal, which project from the outside of the piston. This device works very well with engines having cylinders of three and one-half inches diameter and below, if there is abundant access of air. But the fact that water is always present in plenty when the engine is employed for marine purposes makes this arrangement appear somewhat unnecessary. A gasoline engine will often stop from overheating of the cylinder, and a plentiful supply of water is at all times a certain preventive of this trouble.

CHAPTER II.

METHOD OF FUEL SUPPLY.

THERE are three distinct methods of supplying gasoline to the engine, the principal object of each being to furnish gasoline in such a manner that it will be in a finely divided state and well mixed with the air at the time ignition takes place. The first method in use is that of passing the air either over or through the body of the fuel in order that it may take up a portion, charging the air with gasoline vapor. This is called the carbureter system, and the device by which it is accomplished is called a carbureter. Only a portion of the air that passes into the engine cylinder is allowed to pass through the carbureter, as the carbureted air is usually too heavily charged with gasoline to be explosive. One of the most successful marine gasoline engines in use employs a carbureter, but the system has the objection that it will take up only the lighter portions of the fuel, leaving a heavy residue in the bottom of the carbureter that is useless for the purposes of the engine. Warming the gasoline by passing a portion of either the exhaust or the hot jacket water through a pipe which in turn passes through the liquid fuel in the carbureter will usually overcome this difficulty to a great extent.

The vaporizer system is one in which the air passes by a small opening leading to a reservoir containing a limited quantity of gasoline and drawing the fuel with it much in the same manner as in the familiar perfume atomizer, or a valve is opened by the action of the air passing into the engine, allowing a small quantity of the fuel to flow into the path of the entering air. In fact a vaporizer may be defined as any device so arranged that the air, in passing by an opening, carries with it the requisite amount of fuel.

Jets are devised by which gasoline is forced into the path of the air by means of a small gasoline pump, no dependence being placed upon the action of the air current. Of the three methods it is the author's experience that the last gives the most trouble in the hands of the unskilled operator. I have seen several makes of gasoline engines which operated both regularly and smoothly with a jet feed, but as soon as the inexperienced operator takes them in hand and changes the adjustment, as he invariably will, the trouble commences. Vaporizers and carbureters both have their individual troubles. Carbureters will quite frequently "freeze up" in winter, i. e., the gasoline will get so cold that it will not evaporate. The effect is heightened by the very nature of the process. The action of the evaporation carries off heat from the liquid and rapidly lowers the temperature of the fuel, which soon becomes too cold for effective working except when the lost heat units are supplied from an outside source, either from the air in summer, or from hot jacket-water or exhaust gases in winter. Vaporizers are inclined to cause trouble from the fact that the openings are so small as to easily become clogged by any foreign matter that may find its way into the gasoline. For this reason, the writer advises that all gasoline should be poured into the tank through a strainer. If a fine wire strainer is not obtainable, a piece of muslin will answer the purpose very well. Keeping gasoline in old paint or varnish cans is especially pernicious in its effects, as the gasoline will dissolve any residuum in the cans and is quite inclined to deposit it in the small passages of the vaporizer. For the same reason the tank should be thoroughly cleaned at frequent intervals, and precaution taken to prevent foreign matter from entering. The outlet pipe which carries the fuel to the engine should not be taken from the bottom of the tank, but its opening should be at least one-half inch above the bottom.

CHAPTER III.

OPERATION.

TROUBLES with gasoline engines are, quite frequently, the outcome of the operator's carelessness in reading or understanding the instructions sent out by the builder. A gasoline engine will not run on pure gasoline or vapor nor with igniter so set that it ignites the charge halfway down the expansion stroke. These remarks may appear unnecessary to the experienced operator, yet it is a fact that I was once called upon to examine an engine in which both these things were done. To the reader who has had no experience in the operating of gasoline engines, I would say, always read the instruction book carefully and follow the instructions to the letter. Bear in mind that the builder is quite certain to know more about the engine than you do yourself. Because you are a good steam engineer is no reason that you should be able to operate a gasoline engine successfully from the start. It is quite likely to increase your confusion.

When starting a gasoline engine, it is a good plan to have in mind a certain routine of the necessary operations and to follow this routine every time in order that nothing may be omitted. First fill the charging cup, which will be found attached to the cylinder of nearly all gasoline engines. The amount of gasoline to use for this purpose will usually be noted in the instruction book sent with the engine. Allow the contents of the cup to flow into the cylinder, and then close the valve between the cup and the engine. It is well to note at this point that more gasoline is required for this purpose when the cylinder is cold than when it is warm, and the proper quantity for each case may be determined best by experiment. The gasoline should be given a short time to evaporate, and, in the meantime, other things may be attended to. All valves between the engine and the gasoline tank should now be opened and the oil cups filled. It is a good plan to fill the oil cups every time you start upon a trip, no matter if they are nearly full already. Carefully examine the ignition device to see that it is in good working order. This may be done, with an electric igniter, by touching the two ends of the wires together and seeing if a good "fat" spark results. Then press the movable electrode against the stationary one and determine if there is a circuit by holding one wire in place and wiping the other on its binding post. If a flash results, there is no obstruction to the circuit. If it is suspected that the ignition mechanism is not working properly, the above operations should be repeated when the engine has been turned over until the igniter is just about to snap and again after the "snapping" has taken place. If there is a charge of gasoline in the cylinder, be careful to keep one of the wires away from its binding post when the igniter is in operation. No flash should occur after the igniter has "snapped."

To start the engine, the relief cock should be opened, and, if there is a device for delaying the action of the igniter, the lever for that purpose should be moved to the position for starting the engine. The gasoline valve should then be opened, but only about one-half the distance it should be when the engine is running at full speed, or else the charge will be too rich. Turn the engine over by means of the starting crank until one or more explosions take place, and the engine will go of itself. As the engine gets up to speed, open the gasoline valve cautiously, and, should the engine show signs of slowing down, lessen the opening of the gasoline valve until it starts off again. When the engine is well under way, look to the water circulation and so adjust the water valves that after the engine has been running for about fifteen minutes the exit water will be about as hot as can be borne comfortably by the hand. If for any reason the water circulation has been neglected and the engine runs hot, the water should be turned on with great caution, as too sudden cooling of the cylinder may cause it to contract so rapidly as to bind the piston.

Numerous difficulties are frequently encountered by the inexperienced gasoline engine operator. If the engine runs too hot from defective circulation within the water jacket it may shut down altogether. Should the ignition battery be weak, the engine will start very well, but it will soon begin missing explosions, and the misfires will gradually increase until it fails entirely to ignite. Explosions in the crank-chamber of a two-cycle engine are the result of either too weak a mixture or of leaks in the crank-chamber, which lessen the compression. Premature ignitions, those that take place too soon and cause a severe shock in the cylinder, are the *bete noir* of the gas engineer. Aside from an improperly adjusted igniter, they can usually be traced to some projection within the compression space which reaches a temperature so high as to act in the same manner as a hot tube and ignite the charge before the proper point in the stroke. Disconnect one of the igniter wires or open the switch, if there be one, and should the engine continue to run with the current cut off, there is a hot point in the compression space. Projections upon the end of the piston or at any point within the cylinder are inclined to gather carbon, which may form in the shape of a cone or a thin flake and become highly heated after the engine has been running a short time. Even the igniter points have been known to act in this manner. Compression raises the temperature of the charge, and if the compression is too high it may of itself cause the ignition of the mixture. If the trouble can be traced to no other cause, it is a good plan to reduce the compression, or, in case the air is heated before it enters the cylinder, to reduce the temperature of the entering air by leading a portion of it around the heater.

Much trouble in the operation of both gas and gasoline engines is due to the use of a cylinder oil that is not adapted to the purpose. Too heavy an oil will carbonize in the cylinder and deposit carbon to the detriment of the operation of the engine. This is especially true of oils in which a portion of the mixture is of direct animal origin. There is an oil which has been placed upon the market and advertised as made expressly for gas engines which has caused untold trouble to the users. This oil will give good satisfaction as long as the engine is run with a comparatively hot cylinder, and will probably cause but little trouble when used on marine engines. It has proven inadequate to the task when employed in enclosed crank-chambers, as it is apt to cake and thus to lose its lubricating properties. My advice to the gas engine runner is to invariably use the oil recommended by the maker of his engine, or else to look out for trouble. If at any time it is found that the piston rings are rusted fast in the grooves it is a sign that an improper oil has been employed. An unusual deposit of carbon in the cylinder or in the exhaust passages is also an indication of an imperfect oil, and this result may be traced to oils of too great specific gravity or to those which have a proportion of animal oils.

Explosions in the exhaust passages may generally be traced to misfires, and they sometimes occur from a leaky exhaust valve, the direct cause of the trouble being, of course, the presence of an explosive mixture in the passages. At the first sign of a leaky valve, especially when it is the exhaust valve, there should be no delay in regrinding it to its seat. Neglect of this matter will result in a rapid increase of the leak, until the valve soon becomes useless and has to be replaced. Exhaust valve stems should be lubricated with kerosene only, as the use of the heavier oils will cause a deposit that will result in the valve sticking. All packing for gasoline valve stems and similar joints should be lubricated with soap. Every portion of the gasoline attachments should be cleaned at frequent intervals, a good cleansing compound being a strong suds made with warm water. After cleaning, the parts should be rinsed in gasoline.

A part of the gasoline engine that is apt to be neglected is the water jacket. It should be cleaned occasionally and all solid matter removed. The easiest way to do this is, perhaps, with a stream of water from the nozzle of a hose. If no hose is at hand, or if the deposit is too hard, it should be dug out with a hook similar to a poker, or to one of the little hoes used for cleaning stoves.

If trouble is experienced in starting a gasoline engine in cold weather, it may be heated by filling the water jacket with boiling water. A hot brick or a hot stone may also be laid on the vaporizer or the carbureter. Failure to start in any weather may be due to any one of many different causes. The current may not pass through the igniter, as the igniter may be corroded or be put out of order in other ways. The mixture may be too rich in fuel, or too weak. The gasoline may have been forgotten and the valves not turned on. The gasoline supply pipe or the valves may be clogged up. The igniter may not be set properly.

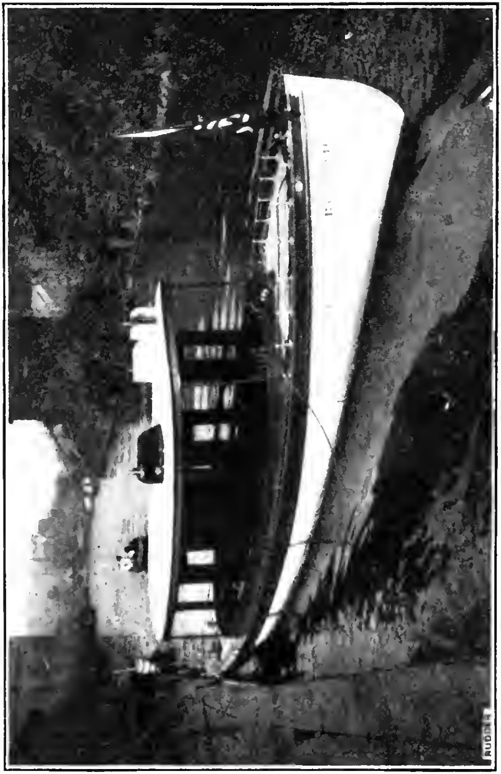
Pounding may result from premature explosions, from an excessively rich mixture, or from a loose bearing. Swinging the fly-wheel back and forth through a short arc will show a loose bearing, and premature ignition will usually be indicated by the violence of the knock. If it is found that the pounding ceases upon cutting off the igniter and that the bearings are in good adjustment, the pounding is probably due to an excessively rich mixture. Explosions in the crank chamber of a two-cycle engine are also productive of pounding. An engine having an imperfect vaporizer will also give similar results, but the jar will vary in strength, and upon some cycles be absent altogether. It is well to avoid a vaporizer that is not controlled automatically, and which supplies the fuel in proportion to the amount of air taken into the cylinder irrespective of hand regulation. This is one of the objections to the jet, and it will occur with devices in which the gasoline feed is opened wide at every stroke of the engine, and the amount of gasoline taken into the cylinder is not dependent upon the amount of air that enters.

There are other features about a gas engine that may cause trouble. A leaky valve may be caused by the spring being a weak one, so that it does not seat properly. A weak spark may be due to a short circuit or a leak in the spark coil. It is well to always keep the spark coil in as dry a place as possible, and if necessary to place it in a water-tight box. The engine may lose in power from a leak in the cylinder or past the piston, so that it does not hold its compression. Leaky pistons are usually indicated by smoke issuing from the open end of the cylinder. The state of the mixture may be quite readily determined while the engine is running by the color of the flame which appears at the priming cup if it is open at the time of an explosion. The most perfect combustion is indicated by a flame of a deep purple color, while a mixture that is too rich in fuel is indicated by a flame that is tinged with orange or yellow, and a mixture poor in fuel is shown by the flame being a pale blue. This is also a very good way to determine the manner in which the vaporizer is working. If the vaporizer is giving mixtures of the same proportion at every stroke of the engine, the color of the flame will be the same at each explosion; but should the vaporizer be working unevenly, the flame shows it at once by changing color from time to time. This is a simple way to determine if the engine is pounding because of too rich a mixture. Misfires may sometimes occur because the igniter is so situated that it is in a pocket which is filled with the burnt products of combustion left from a previous charge and which have not time to escape. About as good a place for the igniter as can be found is in the direct path of the entering charge, as it is then subject to the cooling effect of the air and is always located in fresh mixture.

There is but one engine in the market that is fitted to reverse at full speed, all others being designed to run in one direction only, and in order that the direction of motion may be changed from ahead to astern it is necessary to supply some device for this purpose which is independent of the engine. To supply the demand for such a device there has been designed the reversible propeller. In this propeller the blades are arranged to rotate about a line drawn through the root of the blade through the tip, and through an angle of ninety degrees. The blade is thus changed from a left hand to a right-hand screw, or from a right-hand to a left-hand screw, as the case may be. Again, there is the solid propeller of the type so familiar to the steam engineer, and this is so arranged that its shaft may be reversed independently of the engine. This is accomplished in a number of different ways, with the aid of various combinations of friction clutches and gears too numerous to mention. Either system has advantages peculiar to itself, as well as advantages which are not found in the other. The reversible propeller takes up less room on board the boat, but the principal parts of the operating mechanism are on the outside and hard to reach when there is a necessity for their adjustment and repair. Again the reversible propeller is a hard thing to throw weeds off of for the reason that the direction of rotation is never reversed. The mechanism of the reversing clutch is on the inside of the boat and takes up considerable room, but it has the advantage of being easy to get at in case of trouble, and also the direction of the propeller shaft may be reversed in order to clear it of weeds. It is the general custom among gasoline engine builders to supply reversible wheels with small craft and on engines of six or eight horse-power and less, and reversible clutches on engines of larger sizes. It is a very poor plan to depend upon stopping the engine and starting it again in the opposite direction, as the ability to reverse quickly is practically a necessary feature, particularly when the boat is to be used in a crowded water way.

It is a good plan when selecting a gasoline engine for a boat to see another of the same make you propose buying at work in another boat. Find out if possible from the owner if he has had much trouble with it, and if he has had a great deal of trouble look around a little more before you purchase. Don't buy anything just because it will run, as you may get a poor engine, of which there are unfortunately quite a number on the market. If you wish to make a long cruise and need an economical engine, purchase a four-cycle. Get a two or three cylinder if you can afford to pay the difference in price. And if you can do so conveniently, and without too great an outlay, have an expert from the factory teach you how to run the engine.

A gasoline engine is an ideal power for pleasure craft, especially when the operator desires to be his own engineer. You can enter the boat wearing a spotless white duck suit, run the engine all day, and leave the boat at night with the suit as clean as when you went aboard in the morning. There is no smoke, soot, or heat, and no hard work. There is no delay in getting started, as the engine is always as ready to run as a steam engine with full pressure up in the boiler at all times. There is no waste of fuel when standing idle, and in contrast to the electric launch, you are dependent only on your supply of gasoline, which can be replenished anywhere at a trifling cost.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CHAPTER IV.

ABOUT GASOLINE.

GASOLINE, also called naphtha, is a by-product in the manufacture of kerosene oil from crude petroleum. The term naphtha, while not altogether erroneous, is somewhat misleading, as, strictly speaking, it is a term synonymous with petroleum.

Gasoline is the name usually applied to a by-product in the manufacture of kerosene which has a specific gravity midway between that of the heavier kerosene and the lighter benzine. It is classified by the petroleum trade as A naphtha, B naphtha, and C naphtha, C naphtha being the lightest of the three.

Petroleum, and of course all of its derivatives, belong to that large family of chemical compounds known as hydrocarbons. The name is derived from the two elements, hydrogen and carbon, of which all hydrocarbons consist. These two constituents form chemical unions in different proportions and at ordinary temperatures they exist in the forms of gases, liquids and solids, ranging from the constituents of the familiar illuminating gases, through the ethers, benzine, gasoline, kerosene, light and heavy machinery oils, vaseline, paraffine wax, tar and coke.

Each variation in the proportion of the two elements forms a different substance from its fellows, and quite frequently hydrocarbons are found on which the proportions of the constituents are precisely the same, but in properties of which they are entirly different.

The origin of petroleum has been attributed to various sources, but the latest investigations point to an undoubtable animal origin. During prehistoric times, large numbers of animals, principally the inhabitants of the sea, were buried by convulsions of the earth. The fleshy portions of the dead animals not being exposed to the air, underwent a transformation into petroleum, while the bones and the shells were transformed into stone. The name "coal oil" is therefore a misnomer, for although hydrocarbons similar to the petroleum derivatives have been artificially produced from coal, there is no evidence to support a theory of vegetable origin for petroleum.

So much for science. The origin and properties of petroleum are most interesting to the student, but to the operator of a gasoline launch a knowledge of the proper-

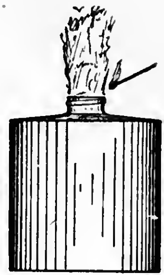


FIG. 1

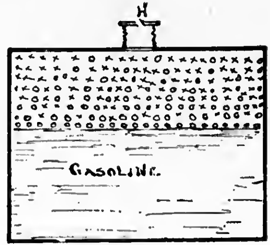


FIG 2

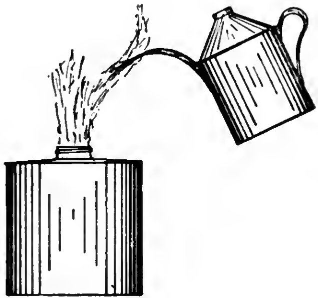


Fig 3

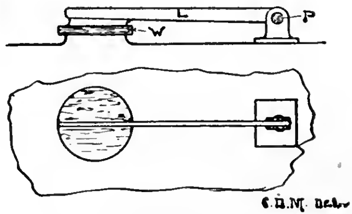


Fig 4

ties of gasoline are of the greatest importance. I dare say that nine out of ten people would take to their heels if it were proposed to pour a stream of gasoline into a fire from an ordinary oil can in their presence. The same persons would undoubtedly run if a lighted match were thrown into an open can of gasoline. Yet either may be done with impunity, for the expected explosion would not occur.

For instance, the top may be removed from the can, Fig. 1, and a lighted match held near the opening, and unless the can has been quite recently filled no explosion will occur. The gasoline vapor will burn at the opening in a manner similar to gas issuing from the gas pipe. The reason no explosion follows this seemingly foolish action of holding a match to the opening is that there is not sufficient air mixed in the gasoline at the top of the can to form an explosive mixture.

Gasoline evaporates quite rapidly at ordinary temperatures, and shortly after the can has been filled the vapor has driven practically all air from the top of the can. Gasoline cans will explode after they have been filled for some time, but only under the following circumstances:

A gasoline can which has no vent and is exposed to a temperature considerably higher than that at which the gasoline will evaporate, will explode from a rise of pressure due to the transformation of the liquid into vapor. Contrary to the popular opinion, an explosion of this nature is not necessarily followed by a conflagration. In fact the writer can call to mind a case in which a can of benzine exploded in a building and the benzine did not catch fire, because neither the liquid nor the vapor was exposed to a flame.

The state of affairs in a gasoline can or reservoir shortly after being filled is illustrated in Fig. 2. In the figure gasoline vapor is represented by circles and air by crosses. The relative proportions of air and gasoline vapor in any portion of the reservoir is indicated by the relative number of crosses and circles. The figure shows that near the surface of the liquid there is nothing but vapor, while near the top of the reservoir the proportions of air to vapor is about 4 to 1. The time which would elapse before the condition of affairs shown in the figure would exist depends upon several conditions.

These conditions are, the specific gravity of the gasoline, the proportion of the surface exposed to the volume by the space above the liquid and the temperature of the surrounding atmosphere. But within a very short time after filling the tank such a condition exists, as shown in Fig. 2, and gradually the air is entirely displaced by gasoline vapor. Gasoline vapor alone, and even when mixed with air in the proportion of four or five volumes of air to one of vapor is not explosive. The slow evaporation of the heavier hydrocarbon kerosene permits an explosive mixture to remain above the liquid in a kerosene reservor much longer than in the case ot gasoline. In fact there is much less danger of a reservoir of gasoline exploding from the application of a flame at an opening than if the reservoir contained kerosene. This is strictly true notwithstanding the popular opinion to the contrary.

It is the well-known volatile property of gasoline which is the foundation of the popular belief in its dangerous properties, that is in reality the basis of its safety under the circumstances already discussed. In fact, the more volatile a product of petroleum the less is the danger of an explosion coming from the application of a flame to the opening of a reservoir which contains it.

Apropos of the present discussion may be mentioned another popular fallacy, one which has afforded much amusement to those who know better. It is generally supposed that if a flame be applied to the open neck of a balloon, a violent explosion will follow. Balloons have caught fire, but no explosion has ever followed such an occurrence, because there was not sufficient air mixed with gas to cause an explosion. If the balloon should contain an explosive mixture of gas and air its buoyancy would be destroyed. Balloons have exploded, but no fire has followed. A balloon explosion is caused by tying up the neck of a gas bag and ascending to a high altitude. The gas expands owing to the reduced pressure of the surrounding atmosphere and the internal pressure becomes so great as to rend the fabric.

Returning to the subject of gasoline, take the reservoir shown in Fig. 1, and light the vapor at the opening. From an ordinary spout oil can filled with gasoline a stream of the liquid may be poured into the opening in the reservoir directly through the flame into the reservoir, as shown in Fig. 3, and without an explosion occurring. The flame will mount the stream, but will not enter the can. Stop pouring and a tiny flame will remain at the end of the spout. This may be extinguished with a light tap of the finger, and the flame at the reservoir opening may be put out by a light tap of the palm of the hand.

To avoid an explosion from expansion due to overheating, every gasoline reservoir should have a vent, as shown in Fig. 2 at H, or be provided with a safety valve. A simple form of such a valve is illustrated in Fig. 4. This valve consists of a leather washer W—do not use rubber—which is attached to an arm L pivoted at P. The valve may be weighted if desired, provided the reservoir is strong enough to stand some pressure. Instead of a lever a spring may be used, which is held under compression, but the lever arrangement is undoubtedly better, for the reason that a sudden overheating or a possible explosion, due to a mixture of air with the gasoline vapor on top of the reservoir, will blow the valve so far off its seat as to leave the reservoir open and give a free exit for the rush of gas.

For the reason that a gasoline tank is liable to explode from overheating it is best to place the tank under ground, or at least in the shade of a properly constructed shed. When the gasoline tank is placed upon a boat a corresponding precaution should be taken and a space should be left between the deck upon the top of the tank and means afforded for free ventilation of such a space. The vent in the tank should communicate to the outside of the vessel, and suitable precaution should be taken to prevent the escape of the vapor into the space about the tank.

Owing to the explosive properties of a mixture of gasoline vapor and air when confined, every precaution should be taken to prevent either the liquid gasoline or its vapor from escaping into any enclosed portion of the boat. Leaks from any portion of the gasoline supply system should be effectualy stopped as soon as discovered. A partial stoppage of the leak is as bad as none, and it by no means avoids the presence of danger. A forcible example of the danger of a leak into the enclosed portions of the vessel is a lamentable accident which occurred to a gasoline launch on Long Island Sound.

The danger that arises from leaks in the gasoline supply pipe may to a great extent be avoided by using an extra pipe surrounding that through which the gasoline flows to the engine. This is a wise precaution at all times and one that is taken by a great many gasoline launch builders. If every portion of a gasoline launch into which the vapor might escape were to be thoroughly ventilated, a large percentage of the danger would be eliminated.

The writer remembers a disastrous explosion which occurred on one of the small lakes in Northwestern New York some six years ago. In this case the engine, although it used gasoline as a fuel, was not a gas engine. A leak in the gasoline supply system permitted the liquid to flow into the engine room which was enclosed, and the vapor that accumulated formed an explosive mixture with the air in the cabin. This mixture took fire from a torch and exploded, tearing the upper works of the boat to pieces, injuring the owner and crippling the engineer for life.

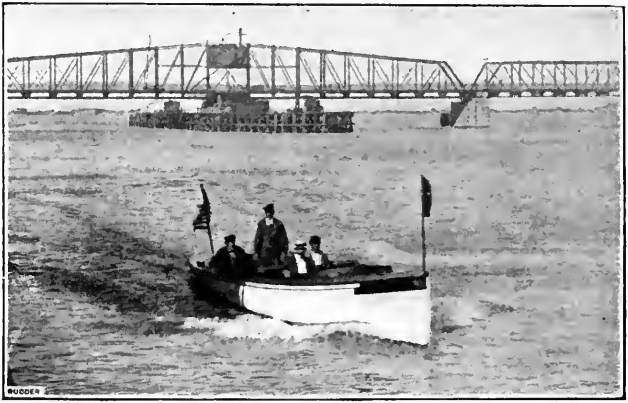
In the face of the facts already stated, it would seem advisable to always put a gasoline engine in an open part of the boat. But if precautions are taken never to enter the engine room with a light after it has been unoccupied for some time, especially if it has been kept closed, and to keep the engine room thoroughly ventilated at all times, there will be very little danger of an explosion of this nature. Cleanliness in the engine room and the avoidance of leaks by proper care, such as an experienced engineer would ordinarily take, would avoid much of the trouble from this source.

As in a gasoline launch the greatest danger is from leaks and the only way in which an explosion could occur would be from a leak into an enclosed portion of the boat or from the explosion of the gasoline tank shortly after it has been partially filled, there is not so very much to look after in order to avoid danger. An explosion seldom if ever occurs from the latter cause; thus it will be seen that leaks are the principle thing to look after. In an engine which uses electric ignition there is no danger of an explosion even should a leak occur, unless someone lights a match in the boat or a naked flame is present. Therefore, should a leak occur, those in the boat should not light matches, although there is no danger of igniting gasoline or its vapor from an ember like that of a burning cigar.

It will thus be seen that with proper precaution the dangers of an explosion or its disastrous consequences in a gasoline launch are not so great as one might suppose. No one should run a boat having a gasoline engine without a thorough knowledge of the fuel. The chief danger lies in handling gasoline carelessly. It is entirely wrong for anyone to blame an explosion on the engine itself or upon its makers, as many are ofttimes inclined to do. When a steam boiler explodes the blame is generally laid at the door of the operator, where it almost invariably belongs. No one would think of making a wholesale condemnation of the steam engine because of a boiler explosion, or an accident which happened to any part of the machinery. No more should the gas engine as a power be condemned because of an occasional accident. It is the same with any branch of machinery, and no branch is entirely free from the danger of an accident.

If by any chance the quantity of gasoline should take fire, water should never be used to put it out unless it can be employed in such a manner as to wash the gasoline overboard, or at least to a place where it would burn itself out without doing great damage. Should water be used, the burning oil will float on top, and spread rapidly, carrying the flame with it. It is likely in this manner to do more damage than it would if left to burn out in place where the fire originated. To choke the flame, some porous non-combustible substance should be spread over the burning oil. If the body of gasoline is not deep, sand or earth will answer the purpose very well and will be more effectual if damp. But if the body of the fluid is deep and a large quantity of earth and sand cannot be quickly spread upon the oil, the sand will sink to the bottom and the oil is quite likely to continue burning on top of the sand. For this reason ordinary flour is a much better extinguisher, as it will float on top of the oil and effectually choke the flame. Should gasoline catch fire in a room which may be tightly closed, the best extinguisher and the one that will act most quickly is aqua ammonia. A bottle of this liquid thrown into a room in which there is a fire, and with force enough to break it, will soon extinguish any fire. This is because the fumes of ammonia will rapidly spread, and atmosphere will soon be so filled with it that it will no longer support combustion.

If a bottle of ammonia is hung by a string containing a fusible link in a room where gasoline is stored, the arrangement will make a very effective fire extinguisher. The string should pass over a pulley in the ceiling of the room, and the link should be placed in a position where fire is most likely to occur. The link may be made out of ordinary fuse wire, such as is usually employed by electricians and which may be obtained of any electrical supply store. Several fusible links may be placed at different points in the string. Then a fire starting near a link would melt it and let the bottle of ammonia drop on the floor and break, permitting the ammonia to escape into the room. The writer has never tried this fire extinguisher, but suggests it as something that is sure to prove effectual. He believes that two quarts of strong ammonia will be sufficient for a room containing 1,000 cubic feet of space. Employing ammonia as a fire extinguisher is an idea that is not original with the writer. It has already prove itself effectual in extinguishing fires in warehouses containing cottonseed, an exceedingly inflammable substance.


RUDDER

CHAPTER V.

CHOOSING AN ENGINE.

THOSE who are thinking of purchasing or building a gasoline pleasure boat for the next season's outing, would do well to make their selections at an early date. Those who put the matter off until after New Year's day are likely to find the factories overcrowded with orders, and they may not be able to secure their boat until the summer season is far advanced. This is especially true when the boat is built to order and to suit the individual taste or needs of the purchaser. No one is more at sea than the average layman who goes about the selection of a gasoline engine, and it is the object of this article to aid this class of individuals.

When about to select an engine, decide first upon the horse power that will be required. If you are not particular about speed, the following rough rule will give a resultant horse power that is suited to average conditions, and for craft between 20 and 50 feet l. o. a.: subtract 9 from one-half the l. o. a. and the result will be the delivered horse power of the gasoline engine required. Stated as a formula:

Let H=the horse power required.
Let L=l. o. a.

$$\text{Then } H=\frac{L}{2}-9.$$

For Example: Suppose it is desired to find the horse power suited to a 35-ft. boat. L=35, then H=35/2—9=17½—9=8½, say a 9 or 10-horse-power engine. Remember, that this rule is a rough one only. If a definite speed is desired, the problem is too complex for any one but a marine engineer, and it had best be left to the builder of the boat, or its designer, if such a person be employed.

Having decided upon the size of the engine, the next thing to do is to select the style of engine. Two-cycle engines are best for small craft where the question of fuel economy is not an important one. They are of simpler construction than the four-cycle engine, and for this reason there are fewer parts to take care of. If well designed and carefully made, a two-cycle engine is fully as good as the four-cycle engine; but strange to say, it is not every engine maker who understands the requirements of a two-cycle engine. They do as a rule use a little more gasoline per horse power than the four-cycle engine, but they are as reliable under intelligent management as the four-cycle as is shown by the fact that one of the longest journeys ever made by a gasoline yacht was with one driven by a two-cycle engine.

Concerning the proportion of weight to power, the two-cycle engine has a slight advantage, but the difference between the average weight of two-cycle engines and the average weight of four-cycle engines of the same horse power is not so great as might be supposed. Concerning the choice between the two styles of engines, when both are equally well designed and constructed, the whole matter narrows itself down to one of fuel consumption, and even then the advantage possessed by the four-cycle engines is not as a general rule so very great, although personally the author would prefer a two-cycle engine for small powers and a four-cycle engine for large powers, say of over fifteen or twenty horse power.

In the matter of duplication of cylinders, the author would say that, leaving the matter of first cost out of consideration, he believes the multiple-cylinder engine has many advantages over an engine with a single cylinder. Among these are steadier running, greater ease of starting, and less weight for the same power. Although a multiple-cylinder engine makes more parts to take care of, in case one cylinder gets out of order, it is quite possible to run to port with the remaining cylinder or cylinders. Gasoline engines of from four to six horse power and up can usually be obtained in multiple cylinders, and quite frequently with three or four cylinders. It seems to be the general opinion of experienced gas-engine men that, so far as easy running and steadiness of propulsion are concerned, a three-cylinder engine is all that may be desired, and that the four-cylinder engine has its only advantage in the fact that it is not so tall as a three-cylinder engine of the same power, a condition which lowers the center of gravity.

Having decided upon the size and upon the number of cylinders required, the next thing in order is to choose the particular make of engine which will best suit your requirements. In the first place, be strictly on your guard against that smoothly-talking individual, the gas-engine salesman, whose business is to sell engines regardless of their good qualities. The agent himself is, as a rule, in nowise to blame for selling an engine of poor quality, as that is his business. In fact the poorer the article and the less its reputation the better is the salesman who manages to dispose of it. This phase of the question is a more troublesome feature in the gasoline engine business than in any other. And it is so, because manufacturers of this class of machinery seldom, if ever, give a written guarantee to cover anything further than the material of which the engine is built. They will very seldom guarantee the operation of the engine for even a limited time. This state of affairs is the outcome of the story once scattered broadcast by the gasoline-engine builders that their engines would practically run themselves. It is now the prevailing idea that such is the case, and the man who has never run a gasoline engine thoroughly believes that all he has to do is to give the crank one turn, and that the engine will run without any attention whatever until stopped.

Gasoline-engine builders have learned better, and now they send out with their engines more or less carefully compiled instruction books. Dissipating such a well-rooted idea, however, as that the engine will run itself, is like breaking up a bad habit. It almost needs a surgical operation. Still another cause of the unwillingness to give a guarantee of satisfactory running is the tendency of the gasoline runner to entirely ignore instructions, and the preconceived notion that he knows more about running the gasoline engine than the man who built it. The inexperienced man seems to be determined to throw every adjustment on the engine out of order, and in fact he keeps fiddling away until the engine will not run at all. Then he sends post haste for a man from the factory to come and straighten the matter out, and generally wishes the builder to pay the man's expenses.

The first step for the prospective buyer to take is naturally to write to every maker of gas engines who advertises in his favorite paper, and secure their catalogues and price lists. He will find of course that each one builds the best engine on earth, if his story is to be believed; but it is a sad truth that there are many very poor gasoline engines offered for sale to the unsuspecting public. You will probably find several catalogues which contain an engine very nearly the size which you have selected for your new launch. If the circulars you received contain testimonials from persons who live in your vicinity, make it a point to call on them, and have a private chat about their gas engines. If you do not find their testimonials, it is quite possible that the manufacturers from whom you receive the catalogue can give you references to owners of their make of engine who live within easy reach.

Having selected one or more of these individuals, prepare yourself beforehand with a stock of questions to ask him about the performance of his engine, and place more reliance upon the words of a man who has his engine for a considerable period than upon the statements of one who has had his engine only a few weeks.

Before asking the questions get the man's confidence, find out how much the engine has been run, and secure a narrative of all his experiences with the engine when he was running it himself. Then begin your questions. Find out, if possible, the longest as well as the shortest time it has taken him to get the engine started, and how long it has run continuously at any time without stopping. Learn, if possible, if the engine is addicted to thumping or pounding in any part of the mechanism, and whether such a condition is of frequent occurrence, or only occasional Ask him how long his ignition apparatus will last, and how frequently the battery has to be renewed. Find out if he has ever had any breakdowns, and their nature and extent.

If possible, get him to take you out in his boat, and watch the running of the engine yourself. Note if there is much work about starting the engine, and try to find the length of time it takes to get the boat under way. Note if there are any complicated attachments or a great number of attachments on the engine. Simplicity is of the first consideration, and much lessens the bill for repairs in a season's running. If the engine is in a filthy condition, or if it is running with its parts badly out of adjustment when it is apparent that proper adjustments could readily be made, it is a point in favor of the engine. Any engine that will run fairly well when badly handled has considerable to recommend it. Should the engine be clean and all the adjustments properly made, and yet run in a manner that is noisy and jerky, it is a very poor engine.

A badly balanced engine will transmit a great deal of vibration to the boat at all speeds. Almost any engine will set up vibration of the boat at one particular speed, but not at others. This is because the rate of vibration of the boat itself is in time with the speed of the engine just at that moment. If you find that the engine transmits very little vibration to the boat, it may be presumed that it is well balanced.

Another way to tell whether an engine is in good balance is to see if it will run for quite a little time after the fuel and the igniter current have both been turned off. Of two engines, that are of the same size, and equally well lubricated, and which have practically the same friction load, the engine will run the longer after power is shut off that is in better balance. Resting the hand upon the cylinder head when the engine is running without power, you should be unable to detect a jar at each revolution, for if a knock is perceptible when the engine is running idle it is a certain sign that it is out of balance.

If the engine is counterbalanced in the fly wheel instead of on the crank webs or crank disks it gives a wrenching action to the shaft, and the balancing is imperfect. A well-balanced engine should have the counterweight as nearly opposite the crank pin as it is possible to put them. In a two-cylinder engine with the crank pin at 180°, or in a three-cylinder engine with the cranks at 120°, a balancing effect is obtained which is much better than that produced by a counter-weight. It is the custom with some makers to put the crank pins on the same side of the shaft for a two-cylinder engine, for the reason that the impulses are thus better distributed throughout the two revolutions of the engine. It is generally conceded that a better balance is obtained with the cranks at 180° and in a vertical two-cylinder engine of the four-cycle type with an enclosed crank case. the latter arrangement avoids the pumping action that occurs when the cranks are on the same side of the shaft, and there is, therefore, no necessity of a hermetically sealed crank case.

Should the counter-weight be in the fly wheel, see if there is much of a wavering motion when the engine is running, or, in other words, see if the fly wheel is out of true sideways. Should such be the case, it shows that the crank shaft is too weak for an engine of this kind.

Note if the bearings give much trouble from overheating, and be particular to ask your mentor his experience in this matter. Find out if he considers it necessary to keep his eye on the engine at all times, or whether he feels secure in giving the engine only an occasional glance to see if matters are all right.

If you can see the inside of an engine of the kind you wish to purchase, after it has been running for some little time, it will assist you in judging of the pains taken in its manufacture. One of the most important things in a gas engine is to have a piston that is perfectly gas tight, for any leak past the piston causes a loss of power, and in a two-cycle engine it will produce explosions in the crank chamber. If it is feasible to do so, remove the cylinder head of the engine, and turn the fly wheel over until the piston is at the lower dead center. If there is much oil on the side of the cylinder wipe it clean with a piece of waste, and see if there has been an even wear on the entire inner circumference of the cylinder wall. If the wear has been uneven, some parts of the cylinder may be brighter than others, but if the engine has been running for some time, and the wear is even, there will be a polish of the same degree of brightness all over the inner surface of the cylinder.

There are two ways of cutting the packing rings for the piston. One is to make a straight slot in the ring, dividing it at an angle of about 45° to the side of the ring. This form of slot answers very well, until the rings and the cylinder begin to wear, when it opens up, and leaves a path for leakage of the gases. The other method of cutting the packing ring is to make a slot halfway through the ring at right angles to the side and a similar slot, not very far from the first one, from the other side. These two slots are usually from half an inch to an inch apart, and are joined by another slot parallel to the side of the ring. If carefully made, there will be no leak through this kind of a cut in the ring, no matter how much wear should occur. It is scarcely necessary to say that the latter arrangement is the one to be preferred.

While a cylinder head is off, note the location of the igniter, and also its construction. The points of an electric igniter should be short and thick rather than long and slender, and they should be placed as nearly as possible in the path of the incoming charge in order to keep them cool, and to prevent premature explosion. Note also if there are any springs or bearings in the igniter which would be surrounded by the heat of combustion, as, should this be the case, the igniter will surely give trouble. Projections of any sort in any part of the combustion space are detrimental to the working of the engine, and if they are not so placed as to be kept cool either by the water jacket or by the impact of the incoming charge, they are certain to cause annoyance. Projections of any sort on the end of the piston in the shape of boltheads, nuts, igniter strikers, or anything of that sort which would be likely to become heated to a high temperature or to collect soot, are productive of premature explosions, and should cause a prospective purchaser to buy an engine of another make. This does not include the deflecting plate or tube of a two-cycle engine, as this is generally quite thick, and it is, in any case, exposed to the cooling effect of the incoming charge.

The collection of soot, either from the fuel itself or from the lubricating oil, is apt to occur upon any projection or sharp corner in the combustion space, where it deposits in the form of flakes or cones. These flakes or cones get red hot very soon after the engine has been started, and are apt to ignite the charge before the proper time, thus causing a thumping in the engine.

In a two-cycle engine, it is quite important that the crank case should be gas tight. If it is not, much fuel will be wasted by being driven through the leaks and a dangerous explosive mixture may collect in the engine room. Such a condition is easily determined by watching the joint of the crank case and the ends of the crank-shaft bearing while the engine is running, and it will be shown by the exudation of oil through the leaks.

A marine engine, particularly when it is to go in the hands of the novice, should preferably have good brass or bronze bearings, rather than Babbit metal, as an over-heated bearing is quite likely to cause the Babbit metal to melt and throw the engine out of commission. The throttle valve for controlling admission of the charge into the cylinder should be of the type that will permit of its being opened or closed by a small movement of a lever. The writer knows of an engine which had a globe valve throttle, and which required about four turns of the valve to shut off the charge when the engine was running at full speed. Anybody who has run an engine to any extent can readily see that such an arrangement is nothing more than a nuisance.

Turning again to the igniter mechanism, choose an engine which has a mechanism of the kind which can be adjusted without removing the cylinder head. Do not buy an engine which has a long igniter rod tripped by a toothed cam, as such an arrangement is uncertain in its action and very noisy. The trips should be as near to the reciprocating part of the igniter as it is possible to place it. Avoid any engine which employs flat springs, as they are inclined to cause trouble, and break without the slightest warning.

For a marine gasoline engine, the vaporizer is usually to be preferred to a carbureter, and as these two instruments are very often confused, and their meaning is not clearly understood by everyone, an explanation is necessary.

A carbureter is an instrument by means of which a portion of the air which passes to the engine is unriched with vapor by passing this air either over or through a considerable body of the liquid.

A vaporizer is a device which is employed to transform a small quantity of the gasoline to a finely divided spray, which usually turns at once into a vapor. It differs from the carbureter, in that it transforms the fuel into vapor only as it is needed and vaporizes only the exact quantity required for a single charge, while the carbureter always contains a quantity of vapor from which a supply is drawn to the cylinder.

Carbureters are wasteful of fuel, in that they only vaporize only its lighter constituents, leaving a useless residue which has to be thrown away. They are also very sensitive to changes of temperature, and in extremely cold weather it is necessary to heat them or the air that passes through them, in order that they may work properly. A properly designed vaporizer, on the contrary, is subject to none of these troubles, and on a marine engine they prove themselves much more convenient and easier to handle.

If you can induce a friend who has had a great deal of experience with gas engines to make your selection for you, or if you will hire a reliable expert who is not prejudiced in favor of any particular engine, it will probably save you much trouble in selecting an engine, and you will feel quite certain that your outing will be a season of pleasure rather than a chapter of troubles. A little knowledge of the subject on your part will not, however, come amiss, and you will be able to know whether your agent is working for your benefit or for that of the builder. If, however, you can find an engine that has run several seasons, and has given its owner little or no trouble, its a pretty good sign that the purchase of such an engine will be a good investment.

CHAPTER VI.

IGNITERS.

THERE is nothing that will put a gas engine out of commission so soon as a disordered ignition device. In fact, the igniter may be said literally to furnish the spark of life for the engine. It takes but a few successive missfires to stop an engine, and even missfires, occurring at frequent intervals, will reduce the power of the engine. While the plan of following strictly the printed instructions which usually accompany the engine is a very good one, and while if they are followed intelligently a great deal of trouble will be avoided, yet at times an emergency will arise which the printed instructions do not cover. It is in these emergencies that a knowledge of the fundamental principles of electricity is a prime requisite. For the reason that the electric igniter is employed upon at least ninety per cent. of the marine gas engines in use at the present time, it is the purpose of the author to give in this article a brief description not only of the electric igniter itself, but also of the electric principles involved, in order that the reader may be prepared for any emergency.

In order to make this discussion intelligible to those who know nothing whatever of electricity, the author will start at the foot of the ladder and explain the meaning of the terms involved. He trusts that those of his readers who are better informed will pardon this elementary portion of the discussion.

A source of the electrical energy produces a difference of pressure, and when there is a complete circuit from one terminal of the source to the other, consisting of electric conductors, this difference of pressure causes a current to flow. The most familiar sources of electrical energy are the dynamo and the chemical source known as the electric cell, commonly but erroneously called a "battery." A battery is a combination of cells grouped together in such a way that the combined strength of the entire group may be concentrated in one circuit. In order that an electric current may flow there must be a continuous, unbroken path of conducting material from one terminal of the source of energy to the other, and through the source of energy to the other terminal.

In order that this phase of the subject may be better

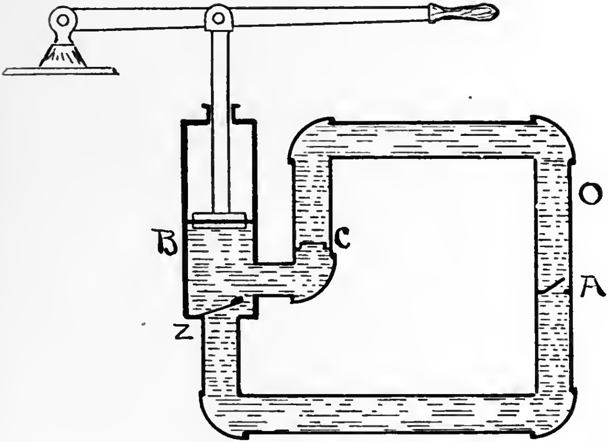


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FIG 1

understood it will be explained by what is generally known as the "waterworks analogy." Consider the pump, *B*, Fig. 1, as corresponding to the source of electrical energy, or battery, *B*, in Fig. 2. So long as the pump is in operation and there are no obstructions in the pipe, *c o z*, a current of water will flow from *c* to *z*. In the same way, if the battery, *B*, is in good order, and there is no obstruction to the circuit, *c o z*, Fig. 2, a current will flow from *c*, through the conductor, to *z*.

It is easy for the reader to understand that an obstruction in the pipe, *c o z*, Fig. 1, or in the pump, *B*, will produce a resistance to the flow of water, and the pressure at the pump would be increased by the obstruction. An obstruction in the pump itself will have the same effect as one in the pipe, for it is obvious that the water must not only flow through the pipe, but also through the pump from *z* to *c*. The same thing is true about the electric circuit in Fig. 2. An obstruction of any kind in the wire or in the source of energy, either one, would reduce the flow of current or necessitate an increase of pressure at *B*, in order to retain the same flow of current in the circuit. In an electric circuit this obstruction may consist either of a reduction in the size of the

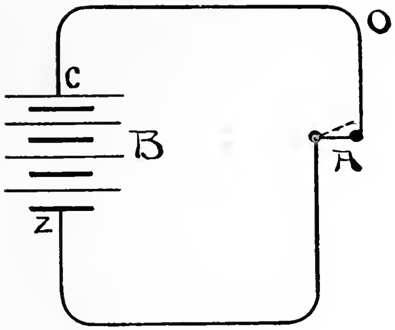

FIG 2

wire or other material used as a path for the circuit, or in the introduction of material through which it is more difficult for the current to flow. Thus in the waterworks system a pipe with a rough interior will form a path of higher resistance to the flow of the current of water than a pipe having a smooth interior. Again, a pipe of small diameter will offer greater resistance to the flow of water than one of larger diameter. This reduction in the size of the pipe is analogous to a reduction in the size of the wire in Fig. 2, and the rough pipe and the smooth one are analogous to wires of high and low resistance respectively.

An increase in resistance to the flow of water causes a generation of heat at the point where the resistance is located. This is, however, not perceptible in the water conductor, owing to the cooling effect of the liquid. In an electric conductor the heat generated by resistance is quite frequently manifest to the casual observer. This generation of heat causes a loss of energy directly in proportion to the amount of heat given off, and wherever it occurs it makes a corresponding reduction in the amount of energy in the circuit which is available for other purposes than heat.

Suppose a valve to be placed at *A*, in Fig. 1, If this valve be closed slowly, the effect upon the valve of the current of water will not be perceptible, but, if the valve be shut quickly, the inertia of the moving column of water will be so great that if a valve be not a strong one it may be broken open, for the tendency of the water is to continue on its path. Likewise a sudden obstruction in the circuit, Fig. 2, as for instance, parting the wire at *A*, producing an air gap which has a high resistance to the passage of an electric current, has a similar effect. The tendency of the current is to continue flowing. Its inertia will have a tendency to break down the obstruction and to continue flowing towards *z*. It is impossible to break the circuit quickly enough to prevent a momentary continuation of the current through the short air gap produced at the first parting of the circuit. The passage of the current through this obstruction produces heat, owing to the high resistance of the gap, and a spark results. If a portion of the circuit, *c o z*, consists of a coil of wire surrounding an iron core, the inertia at the moment of breaking is heightened to a considerable degree, and the spark is larger in consequence. Such a coil is that used with the ordinary make-and-break igniter, and is known as a "spark coil." It will now be seen that any obstacle in electric circuit reduces the amount of current flow, and that the circuit must be a complete one, not only outside the source of energy, but within it. It has been shown that resistance causes heat and loss of energy, and that sudden parting of the circuit produces a spark, which is intensified by the use of an instrument like a spark-coil.

Obstructions to current flow may be produced in many ways, and the reader must remember that in order to get the greatest efficiency out of this apparatus he must have the fewest possible number of obstructions in the circuit. It necessitates a certain amount of current and pressure to produce a spark at the gap of sufficient intensity to ignite the charge of gas and air in a gas engine. Any obstruction in the circuit in the form of resistance, no matter of what nature, reduces the amount of current flow. For this reason the greatest of pains should be taken to use wire of ample size, to employ the least possible number of connections, and to have all of these as good as they can be made. Every reasonable precaution should be taken against loose connections, and they should at all times be kept bright and clean, for the reason that the outsides of the metals are poor conductors.

Both in order to make the resistance of the circuit low and to decrease the liability to breakage, it is advisable to use No. 14 copper wire for all connections; weather-proof insulation or covering for the wire of the very best quality should be employed, in order to avoid leakages of current.

In order to obtain a spark across a gap in a circuit in which the pressure is not a very great one it is necessary to first close the circuit and then to open it, so as to produce an air gap. That is to say, there must be first an unobstructed path for the current, and then an air gap must be introduced in this path in order to get a spark. When there is a spark coil in the circuit the circuit must be closed for a time, depending upon the coil itself, in order to get the largest possible spark, for the following reasons: In an electro-magnet the magnet does not reach its full power at the instant the circuit is closed. The magnetic strength is built up gradually, and although this building up takes place in a very small fraction of a second, this time element must be considered in the operation of an electric ignition device. A change in the strength of a magnet around which is wound an electric conductor will cause a current to flow in the wire if the

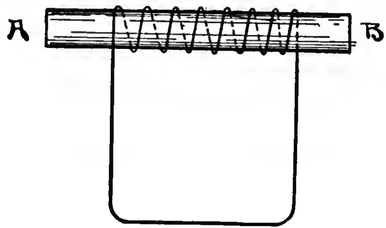

FIG 3

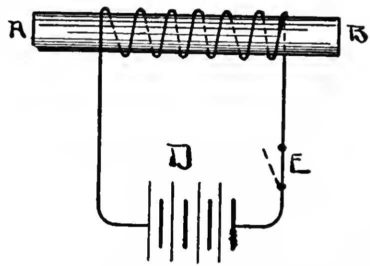

FIG 4

ends are joined, making a complete circuit, of which the coil is a part. The pressure generated by this change in the magnetic strength depends both upon the magnitude of the change and the rapidity with which it is made.

Suppose a magnet, *A B*, Fig. 3, to be surrounded by a coil of wire as indicated, and that by some means the strength of the magnet is suddenly altered from its full strength to nothing, a current of short duration will be induced in the wire in one direction. If the strength of the magnet is made to rise suddenly from zero to the same strength as before the magnetism was taken away a current will be made to flow in the wire equal in amount to that when the strength was reduced, and the direction of flow will be opposite to that produced when the strength of the magnet was taken away.

Suppose that *A B* is simply a bundle of soft iron wires, and that a current is made to flow through the wire from an external source as the battery, *D*, Fig. 4. The current flowing in the wire induces magnetism in the core, *A B*. If after the magnetism has risen to its full strength the circuit be broken at *E*, the magnetism in *A B* makes a sudden drop to zero, and this change tends to produce a flow of current in the coil, and greatly increases the inertia effect over that manifested when there is no coil in the circuit.

Since the strength of the induced current depends upon the magnitude of the change, it is evident that the magnet must be allowed to reach its full strength before breaking the circuit, in order to get the maximum inertia effect. As the pressure produced by the coil depends also upon the rapidity of the change, it may be seen that it is necessary to have a quick break at *E* in order to get as large a spark as possible. The shorter the core, *A B,* the quicker will the magnetism reach its full strength, and the shorter will be the time necessary for the circuit to be closed in order to get the magnetism built up. It is for this reason on high-speed engines, where the sparks occur at frequent intervals, that a short spark coil is necessary. This interval between sparks is so small that, if a long core is used, the circuit cannot be closed long enough for the magnetic strength to reach its maximum. Hence the effect of the spark coil is reduced, weakening the spark. This is a matter which has been recognized by engine-builders, and spark coils are now to be seen only six inches in length, where several years ago ten or twelve-inch spark coils were used.

There is another feature of electrical induction—as this effect of a magnet upon an electric conductor is called—which it may be as well to point out to the reader in connection with the above discussion. In the first place, a coil of wire without a core has a similar reaction upon itself when there is a change in the current strength, although this reaction is not so great as when a core is present. A coil of this kind, or, in fact, any coil wound in a helix, as the winding shown in Fig. 3 and 4 is called, is known as an inductive resistance. Any inductive resistance is a greater obstruction to a current of varying strength than when the pressure on the line is constant, or when the conductor is comparatively straight. This obstruction to the current flow is also called inductive resistance, but in this case it means an effect upon the circuit, and not a portion of the circuit itself.

If two inductive resistances are placed in the same circuit, and their time element does not happen to be the same, one will, to a greater or less extent, annul the action of the other. For this reason it will not do to place two spark coils in the same circuit, as the strength of the spark is generally reduced by such an arrangement. If it is found necessary to reduce the amount of

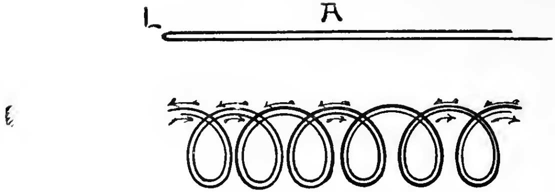

FIG 5 C.D.M. DEL.

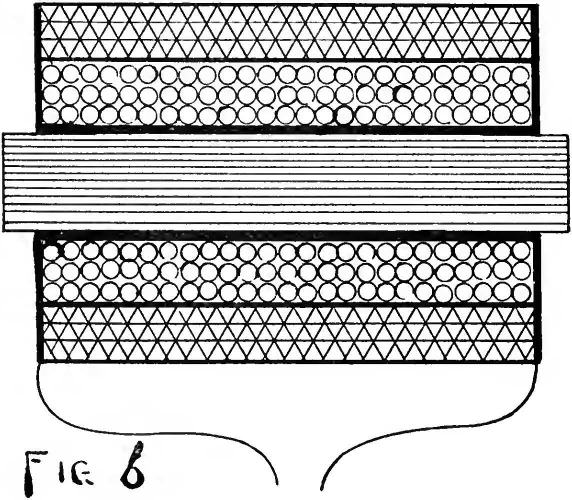

FIG 6

current flowing through the circuit in order to save burning the igniter point, what is known as a non-inductive resistance should be used. A non-inductive resistance is usually made of two coils of wire, in which the current flows in opposite directions in either coil. This kind of a coil can be most readily produced by the method shown in Fig. 5. Take the amount of wire necessary to make the coil and double it, as shown at *A*, then begin winding the wire around a core, say a wooden spool, beginning at the loop *L*. The winding opened out will then appear as shown in the lower portion of the figure, and the current in contiguous wires will be flowing in opposite directions, as indicated by the arrows, and the current in one wire will annul the inductive effect of that in the other.

If in Fig. 4 a great many turns of fine wire were to be wound on the outside of the coil through which the current from the battery, *D*, is allowed to flow, every fluctuation in the strength of the magnet, *A B*, produced by a variation in the strength of the current in the battery circuit will induce a current of a much larger pressure in the coil of one wire. If, in order to get a practically continuous current in the coil of fine wire, the battery circuit be rapidly opened and closed, the apparatus becomes what is known as a Ruhmkorff coil, which is illustrated in cross section in Fig. 6. The circuit of coarse wire is what is known as the primary circuit, and the coil of wire through which the battery current flows is called the primary winding. The fine wire coil which is usually wound upon the outside of the coarse wire is known as the secondary winding, and this becomes the source of energy for secondary circuit. If there are a suffiient number of turns in the secondary, as compared with those in the primary winding, the current in the secondary winding will be at such a high pressure that it will arc or jump across a small air gap without the circuit being closed beforehand. This secondary spark is what is called a "jump-spark," and this form of coil is now generally known in gas engine parlance as a "jump-spark coil." It has become very popular because of the simplicity of the timing mechanism and because it lends itself more readily than the primary or make-and-break spark to the requirements of engines running at high rotative speeds. Its popularity has manifested itself since the advent of the automobile, and is used quite extensively on motorcycle engines.

In Fig. 7 is illustrated the principles of operation of the

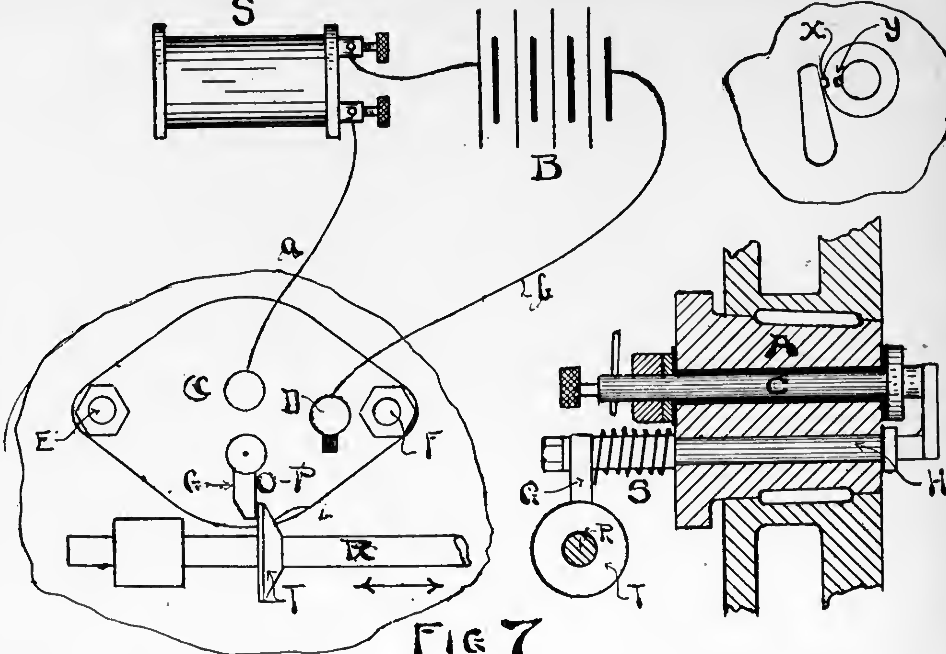

FIG 7

mechanism used for the make-and-break igniter. As explained before, the idea is to get a closed circuit for the proper length of time, and then to break the circuit with a quick movement. In the figure, *B* represents the source of energy, *S* the spark coil, *a* and *b* wires from the spark coil and the battery respectively. The wire, *a*, is connected to the insulated electrode, *c*, and *b* to a binding post, *d*, attached to the framework of the engine, Attaching a wire in this manner is called "grounding" it upon the engine.

Those parts of the igniter which are intimately connected with the production of the spark are usually inserted in a taper plug, as shown at *a*, and this plug is placed in an opening in the engine cylinder wall, as indicated in the figure. The plug is made gas-tight by making it a perfect fit in the opening in the wall. It is held in place by two or more studs, as shown at *E* and *F*. The electrode, *c*, is separated from the metal in the plug by a non-conducting material, mica being the material most generally used for this purpose. The movable electrode, *H*, does not require insulation, for the reason that its side of the circuit is grounded on the engine. It is by means of this movable electrode that the circiut is opened and closed.

About the outer end of *H* is a spring *S*, one end of which is connected to *H* and the other to the movable arm, *G*. The rod, *r*, carrying the collar, *t*, is reciprocated by an eccentric on the engine, and, on moving to the left, *T* strikes *G*; but the swing of the eccentric on the return stroke causes the collar *T* to pass *G* without touching it. When collar, *t*, strikes *G* it first brings the points *x* and *y* in contact, and further movement of *G* winds the spring. The tension of the spring forces *x* hard against *y*, insuring good contact. A still further movement of *G* causes it to slip off the collar, *t*, when it flies back against the pin, *p*, opening the circuit with a jerk, and making a spark between *x* and *y*. While the mechanism shown is not employed with every electric igniter, the same principles are involved in practically all of those employed upon marine engines.

In the care of an igniter of the make-and-break variety, the following precautions should be observed: The spark coil should be kept dry at all times. It is a good idea to keep the coil on a shelf near the top of the cabin, or, if the boat is an open one, to put it near the top of the locker, and to enclose it in a perfectly water-tight box. A source of electrical energy, giving at least four volts, should be employed, and the generator or battery should be capable of giving ample current. Electric cells of the sal-ammoniac type, such as ordinarily used for electric bells, and known as open circuit cells, are not suitable for the purpose. Cells that will keep up a steady current and not run down when connected in a circuit of low resistance are the best for this purpose. Of the primary cells, the caustic soda type is the best. As the pressure given by these cells is low, being less than one volt for each cell, four or five cells should be used for the battery.

When a source of electric current for charging them is located at a convenient point a storage battery of two cells, having a normal discharge rate of three or four amperes, would be found a very good source of energy. There is no mussing with chemicals when they are to be re-charged, and the expense of re-charging is only a matter of a few cents. The first cost is also but little if any more than that of a caustic soda battery. It is a good plan to test the igniter always before starting on a trip, to see if the spark is made at the proper time of the stroke. This should be when the engine is compressing, and the proper distance of the ignition point from the end of the stroke should be determined from the makers of the engine, and care should be taken to keep the igniter set for this sparking point.

When the ignition takes place before the end of the stroke, it is said to have lead. The higher the speed of the engine and the longer its stroke the greater will be the distance of the piston from the end of its stroke at the time when the ignition takes place; *i.e.*, the greater will be the lead. It is a good plan to make a mark on the fly-wheel rim that cannot be obliterated, and also to make a similar mark somewhere on the engine. Then have these marks placed in such a position that when they are opposite one another the piston will be at the proper distance from the end of its stroke for ignition to take place. After these marks are once properly located, they will be found very convenient to use when setting the igniter. Presuming that the marks have been made, it is now necessary only to make sure that the arm, *G*, Fig. 7, slips off the collar, *T*, just as these marks coincide. It is advisable to occasionally test the spring, *S*, by swinging the arm, *G*, with the finger in order to determine if it has a sufficient degree of stiffness. The plug, *A*, should be removed once

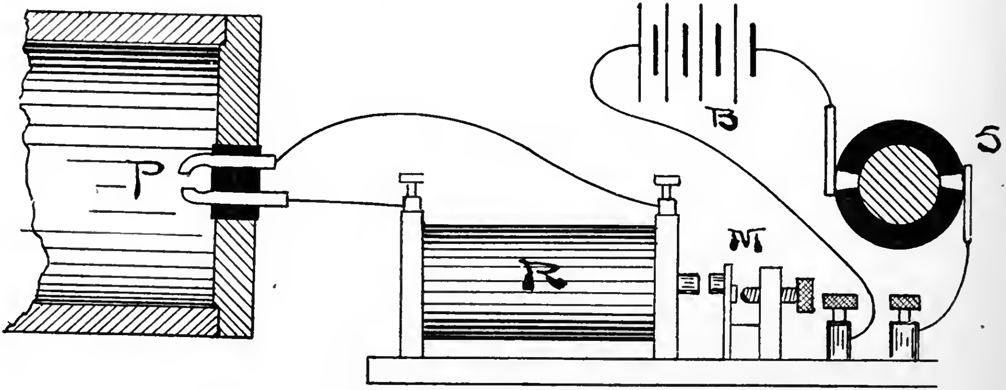

FIG 8

in a while to see if points *x* and *y* are not worn out, and also to clean of soot those portions of the igniter which project into the cylinder.

Jump-spark ignition is but very little used on marine engines at the present time, and only the diagram of connections will be shown here. The system of wiring for a jump-spark igniter is shown in Fig. 8. The switch, S, upon the valve shaft of the engine closes the circuit of the battery, *B*, through the primary winding of the induction coil, *R*. The current is compelled to pass through a magnetic vibrator, *M*, which rapidly opens and closes the circuit during the time that the switch, *S*, is closed. This pulsating current induces a pressure in the secondary winding, as explained in connection with Fig. 6, and the high pressure of the secondary causes a spark to jump between the terminals of the plug at *P*, inside of the gas engine cylinder. There are two methods of connecting the secondary circuit. In one of these both sides of the circuit are insulated, as shown in the figure. In the other, only one of the secondary terminals is insulated, and the other is grounded on the engine.

CHAPTER VII.

WEIGHT IN GAS ENGINES.

THE author has frequently been asked the question, "Why are gas engines so heavy?" The purpose of the present chapter is not only to answer this question, but to point out ways and means to the future designer for obtaining the lighest practical engine within keeping with strength and efficiency. The author might as well mention that the observations here made in regard to reducing weight to the lowest point consistent with strength are many of them the outcome of observations made while in the service of Mr. Hiram S. Maxim in England on his experiments in flying machines. While to the non-scientific the mention of flying machines may be productive of smiles, to the engineer of to-day it means but a fascinating problem all the more attractive because of the apparently unsurmountable difficulties.

In return to earth, or rather to the gas engine, it may be said that the principal reason for the great weight of gas engines as compared with steam engines is due in the main to the fact that the impulses in the steam engine cylinder occur at more frequent intervals during the same number of revolutions than in the gas engine. As compared to the four-cycle gas engine the steam engine gives four impulses to one of the gas engine. In the two-cycle engine the ratio is two to one. The engine must be designed to withstand a greater pressure for the same horse-power, and again the maximum pressure in the gas engine is considerably greater than in the steam engine operating under the same average pressure, and the ratio of strength must be made greater than four to one or two to one, as the case may be. A further allowance of strength for the shock produced at the moment of explosion must be made, although this is not so great as some designers have been led to think.

In spite of this increased weight the fact that the gas engine is its own pressure generator, doing away with all devices analogous to the steam boiler, makes it more than the equal of the steam engine when comparing the weights necessary for the same power. Notwithstanding the advantage in weight possessed by the gas engine in its present form, there is still much room for improvement, as has already been shown to a certain extent in engines designed for driving automobiles.

In the present competition between the owners of craft driven by gasoline engines comes the demand for speed, and hand in hand with this demand goes another, *i. e.*, the call for engines possessing the greatest amount of power with the smallest amount of weight. Mr. Maxim's rule, which was so successfully followed in the design of his flying machine, and which was indelibly impressed upon the author, is as follows:

"Take off every superfluous ounce in all parts of the device." Cut down the weight at every point, not only by reducing the part to the smallest section compatible with strength, but use the material which is the strongest, weight for weight.

If it is desired to design an engine for a racing yacht the designer should keep the following points in mind at all times: An engine will give double the horse-power at double the speed, provided the same average pressure in the cylinder is obtained in each case. With precisely the same amount of weight in the engine, the power is doubled. Actually, however, the increase in speed of the engine permits of a reduction of the weight of the flywheel, which comprises a considerable fraction of the total weight. Doubling the speed of the engine permits of the use of a flywheel one-fourth the weight required at the slower speed. Thus a three-horse-power engine running at 350 revolutions per minute would require for a single cylinder engine of the four-cycle type a flywheel weighing about two hundred pounds. Double the speed of the engine, making it run at 700 revolutions per minute, and it becomes a six-horse-power, while the necessary flywheel will weigh but fifty pounds.

Taking up the first catalogue I can lay my hands on, I find the weight of a three-horse-power engine given as 570 pounds, or 190 pounds per horse power. Following out the suggestions in the last paragraph, the engine becomes a six-horse-power, weighing 420 pounds, or 70 pounds to the horse power. Such a radical change would make almost any designer hesitate, and he would probably be horrified at the mere suggestion. The author would hardly care to make such a change himself without careful experimenting before placing the engine in a boat. He has, however, given what might be considered an exaggerated example in order to make the point the more apparent.

Still another means of reducing the ratio of weight to horse power is to increase the number of cylinders working on one crank shaft. It is practicable to run engines with multiple cylinders at higher speeds, for two reasons. In the first place, the cylinders are smaller, and this in itself permits the use of higher speeds. Again, the more perfect balancing that may be obtained in a multiple-cylinder engine permits a higher speed to be used than for a single-cylinder engine with the same size cylinder as used for those in the multiple engine. Here again comes an opportunity for a reduction in the weight of the flywheel The greater frequency of the impulses reduces the amount of inertia that is necessary to store in the flywheel.

Taking the solution of a sample case, suppose the single-cylinder engine considered previously was coupled on the same crank shaft with another engine of the same size. The engine, if running at the same speed (350 r. p. m.), would now develop six horse power. As the engine now has two impulses where the single-cylinder engine had one, the flywheel is required to store energy for a period only one-half as long as for the single-cylinder engine. Therefore, instead of a 200-pound flywheel, one weighing 100 pounds would be sufficient The engine is, however, a six-horse-power, and if it were a single-cylinder six-horse-power engine running at 350 revolutions per minute it would require a 400-pound flywheel. Thus it will be seen that by either doubling the speed of the engine or doubling the number of cylinders the weight of the flywheel required is materially reduced. The reduction in total weight of the engine is, however, considerably greater when the speed is doubled than when the number of cylinders is doubled. Turning again to the catalogue, I find the weight of a two-cylinder six-horse-power engine running at practically the same speed as the three-horse-power to be 900 pounds. A single-cylinder engine of the same power would weigh approximately twice what the three-horse-power weighs, or 1,140 pounds, and the gain by multiplying cylinders is, therefore, 240 pounds.

The gain in multiplying cylinders is not all in the fly-wheel. Much of it is in the framework of the engine, and in such parts as may be utilized for both cylinders without increasing their size. The crank-shaft, for instance, need not be larger in diameter for a two-cylinder six-horse-power engine than for a single-cylinder three-horse-power.

Both the crank-shaft and the connecting rod of an engine may be decreased in weight by making them tubular, and the use of steel in the place of wrought iron will allow of a smaller cross section being employed. Cast-steel for the frame of the engine, instead of cast iron, will permit of reducing the weight materially, and it will answer as well as, if not better than, cast iron. Cast iron should be used for both the cylinders and the piston of the engine unless a particularly close-grained steel casting can be obtained. Cast steel has been tried for this purpose, but as far as the author is aware it has invariably fallen short of the requirements. This has been presumably because an inferior grade of casting was employed in those instances which came under the author's observation. Another objection to steel is that it is more liable than cast iron to be scored by the hot gases As an example of what may be done in the reduction of weight in cylinder walls, the author would state that the cylinder walls of Mr. Maxim's flying-machine engines were only three-sixty-fourths of an inch thick. The diameters of these cylinders were five and eight inches respectively for the high and the low-pressure sides. The material was gun-lock steel, the cylinders being bored and turned from a solid ingot. The engines were operated with a steam pressure of from 300 to 350 pounds per square inch.

The weight of the cylinder could be reduced by the use of steel, making the walls correspondingly thinner and also by using a thin brass tube for the outer wall of the jacket. This is usually cast with the cylinder, but it is quite practical to make the jacket wall of a thin sheet of brass or wrought iron, as the water pressure on a marine engine is at no time very great. The wall of the cylinder head jacket could also be made in the same manner.

The reader is warned against the use of aluminum in any part of the engine where strength is desired. In order to obtain an equal amount of strength, a weight of the metal equal to that of a piece of steel that would answer the same purpose must be employed. For such parts as are not exposed to heat, or liable to be under pressure at any time, an aluminum casting would be found a convenience, perhaps.

In the design of an engine that would not justify the extra cost of steel castings, much unnecessary weight may be saved by the use of brackets in locations where there is great strain to resist, instead of making a heavy casting and omitting the brackets. These will add to the cost of the patterns, but there the expense ceases, and should there be a number of engines to be built from the same design, the extra cost for the pattern would soon be overbalanced by the saving in iron. Much iron could also be saved by an intelligent design of the engine base. In small engines particularly, making a set of lugs on the side of the crankcase or frame would save much of the iron that is so often seen put into a heavy foot at the extreme limit of the frame. Long brackets on the sides of the cylinder must be made heavy in proportion to their length, and are best avoided wherever it is practicable to do so.

Many engines on the market to-day—most of them being the product of amateur designers—are loaded down with several auxiliary shafts, appurtenances of various kinds, and quite often with a multitude of piping that is quite uncalled for. The author has in mind a design of this kind which was sent to him for criticism and suggestions. The engine was a two-cycle, but from one point of view the engine was almost hidden with pipes. On another engine which he made a trip down into New Jersey to see was supplied with two camshafts, one on each side of the engine. Needless to say, the engine never appeared on the market. And now that I think of it, this engine was supplied with two mufflers as well, one for each cylinder. Another case of unnecessary weight was that of a two-cycle engine with an auxiliary cylinder for pumping air. This cylinder was supplied with a separate piston, driven by a second connecting rod. Strangest of all, the two last engines were designed for automobiles. Both lie in the scrap heap to-day. In fact, the author could describe many more such engines, a number of them being among the old iron.

Returning to the flywheel, it may be pointed out that the energy-storing power of a marine flywheel is much less, weight for weight, than the wheels used on stationary engines. This is because it is necessary to put the center of the crankshaft as low in the boat as is practicable, and increasing the diameter lessens the weight in proportion to the square of the diameter. It is unusual, however, to find a marine flywheel larger in diameter than three times the stroke of the engine. Quite often they are less than this. Widening out the rim in a direction parallel to the axis of the crankshaft will help matters a little, but there is a limit to this. The designer, when considering the reduction in flywheel weights permissible with increase of speed, should consider the engine as occasionally running at a reduced speed, and make some allowance on that score. If the boat is to be used almost entirely for a racer the limit may be given to the weight. But if it is also to be run at a reduced speed much of the time, he should design the flywheel to suit the average conditions.

Recent developments in gas enginery have again brought forward the double-acting gas engine taking in impulse at either side of the piston, as does the steam engine. This has been accomplished with promises of good results by making the piston rod hollow and forcing a stream of water through it. With a double-acting four-cycle engine an impulse is obtained once in each revolution. This is also accomplished in the two-cycle engine, which, while single acting, receives an impulse at each revolution. For some unaccountable reason these engines do not as a rule give more than fifty per cent. greater power than a four-cycle engine of the same dimensions, running at the same speed. They are usually lighter, however, than the four-cycle engine of the same power, and their simplicity makes them find favor among a great many gas-engine users. If well designed, they will give good service, and are practically as reliable as a four-cycle. A poorly-designed or poorly-constructed two-cycle engine is much more likely to be cranky than a four-cycle that has been poorly built or designed.

Another opportunity for decreasing the ratio of the weight to the power obtained is to increase the compression before ignition. There is a limit to the compression that may be used in a gasoline engine without giving trouble. Gasoline ignites at a lower temperature than many of the fixed gases, and about 85 to 90 pounds is the practical limit. Ordinarily, gasoline engines are designed to compress to pressures of from 45 to 60 pounds. Increasing the compression from 45 to 85 pounds means a gain in power of nearly 40 per cent , and by increasing the compression from 60 pounds to 85 pounds the power of the engine is augmented over 20 per cent. Increase in compression necessitates more careful attention on the part of the designer to details, in order to avoid premature ignition. Many of them do not know how to design an engine which will not ignite prematurely at these high compressions, and they keep to the low compressions. The use of high compressions means not only an increase of power for an engine of a certain size, but it means an increase in the efficiency of the engine and a reduction of the fuel consumption per horse power.

The purchaser of gasoline engines for marine uses may wonder in what respect the foregoing discussion concerns him. The author trusts he will find it of value in the selection of an engine to suit his purpose. It will be especially valuable if he desires to buy an engine for racing purposes. Again, the amount of cast-iron in an engine has some effect on its price. The discussion will show many of the requisites for reducing weight, and will, the writer trusts, enable the buyer to know where to look for unnecessary metal.

The designer, especially if he be experienced in gas engines, would do well to bear in mind the points brought out when designing gas engines. Don't be afraid to speed the engine up to a point a little above what other engines have run at. In order to do so with some show of success it is necessary to be careful about the port openings, and to make them ample for the higher speed. While it may not always be desirable to build a racing engine, there is ample room for reduction in weight on many of the marine engines in use to day, a large number of them weighing ten to twenty per cent. more than is really necessary.

RUDDER NAUTOTYPES

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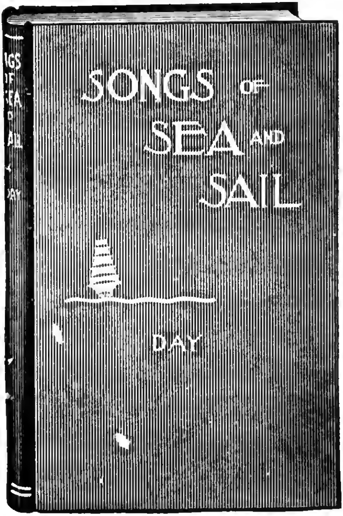

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