

NEW TYPES OF GAS ENGINES FOR MARINE WORK.

BY COMMANDER A. B. WILLITS, U. S. N.

The four-cycle principle is the most perfect one in theory and practice. Here the explosion of a charge performs its expansion and works completely to the end of the first stroke. It is then exhausted and expelled by the return of the piston through the entire second stroke, while the third stroke draws in fresh mixture, which is compressed on the fourth stroke ready to be exploded at the beginning of the next. Here there is certainty of obtaining a full charge of the mixture in the proportions delivered through the carbureter, and both the increased reliability of action of this type and the decreased fuel consumption per horse-power are positive and marked. It is the type used in nearly all of the automobile engines built, and, in the marine-motor field, is the type along which high powers are being designed.

The Bureau of Steam Engineering has taken keen interest in the current advances in this class of motive machinery, and has had its representatives witness the tests of the latest types with a view to the opening for such installations in torpedo boats when the fuel question is less uncertain. Already there are fourteen gasoline and gas motors installed in naval small craft and eight others waiting completion of hulls. Besides these, motors for light-powered boats for torpedo craft have been designed and are being built under the Bureau's directions at the Norfolk yard. The question of replacing the machinery of some of the torpedo boats by explosive-mixture motors is still under advisement, and nothing is being lost through lack of keeping in touch with the latest developments. The naval installations thus far are as follows:

	H. P.
"Adder," submarine.....	Otto 4-cycle, 160
"Grampus," submarine.....	Otto 4-cycle, 160
"Moccasin," submarine.....	Otto 4-cycle, 160
"Pike," submarine.....	Otto 4-cycle, 160
"Porpoise," submarine.....	Otto 4-cycle, 160
"Shark," submarine.....	Otto 4-cycle, 160
Sixty-foot Indian Head ferryboat.....	"Standard" 4-cycle, 300
Yard ferryboat, Portsmouth, N. H.....	"Standard" 4-cycle, 300
"Sylph's" tug.....	"Standard" 4-cycle, 25
"Sylph's" tender.....	"Standard" 4-cycle, 12
"Maine's" 28-foot whaleboat.....	Jager 4-cycle, 10
Special 20-foot whaleboat, Norfolk.....	Godschalk 2-cycle, 10
Special 20-foot tender, Norfolk.....	"Standard" 4-cycle, 12
"Vesuvius" 28-foot launch.....	Jager 4-cycle, 10
Total.....	1,639

Those awaiting completion of hulls are:

	H. P.
Submarine "Nine" (Fore River).....	Craig 4-cycle, 250
Submarine "Ten" (Fore River).....	Craig 4-cycle, 250
Submarine "Eleven" (Fore River).....	Craig 4-cycle, 250
Submarine "Twelve" (Fore River).....	Craig 4-cycle, 250
Seventy-five-foot ferryboat, Training Station, S. F., U. I.	Works 4-cycle..... 250
Water barge, Mare Island, Union Gas Co., 4-cycle.....	200
Water barge, Portsmouth, N. H., (2) Globe, 100 each, 4-cycle.....	200
Total.....	1,570

It is seen by the above that 300 I.H.P. is the largest size motor thus far purchased by the government, and this installation in the 60-foot launch built for service between Indian Head and Washington stood a most satisfactory trial and gave excellent performance. This is a single-acting, six-cylinder, "Standard" gasoline motor. It is of light construction, and its peculiarity is that it is started as well as reversed by means of compressed air and a single movement of a cam-shaft lever, exactly as if handling an ordinary reversing link motion. Compressed air to 250 pounds per square inch is primarily pumped up into two air tanks running along the side of the engine room, by means of a small auxiliary, 1-horse-power gasoline engine driving an air pump for the purpose, this engine being also intended to drive a bilge pump and small dynamo for lighting and charging storage battery. Only the three after cylinders are connected to compressed air, and when

the reverse lever is thrown to the first notch away from center, either forward or back, the cam shaft is shifted along to such a position as will bring cams to operate the compressed-air valves on these three cylinders, and to lift the exhaust valves on same once every revolution, instead of every other revolution. The three forward cylinders operate always on gasoline, the cam shaft shifting governing the rotative direction of the engine only. The three after cylin-

ders are now operated by opening the compressed-air throttle valve, and the instant the engine starts and makes two or three revolutions, the lever is pushed on to the next notch, which cuts out the compressed-air valves, and adjusts the cams to trip the valves in a regular, four-cycle sequence. Practically, the handling of this motor is very simple, there never being a minute's hesitation in the action of the engine or the result on the boat, as the motor jumps to full speed

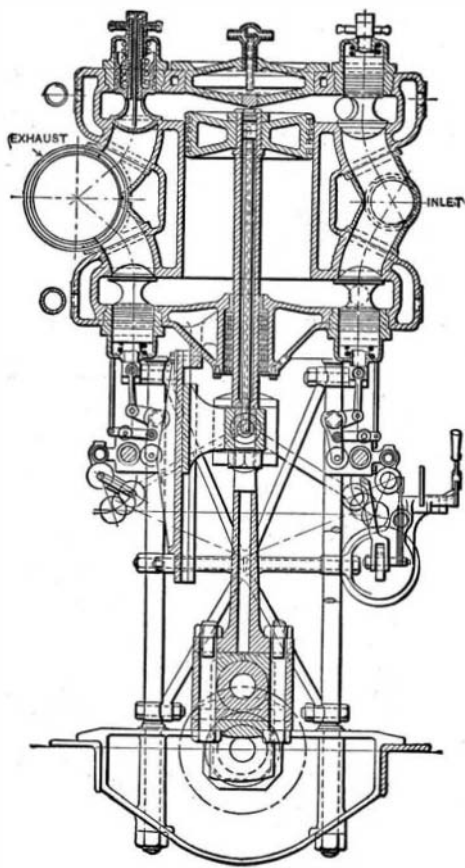


Fig. 1.—Vertical Cross-Section of Double-Acting Four-Cycle Gasoline Engine.

almost instantly. While running, an air pump or compressor, attached to the main-engine shaft, keeps the air supply up in the tank, but can be shut off at will. There is no difficulty in keeping up pressure for weeks at a time in the tank, and in reversing there is usually but a drop of about five pounds in the pressure.

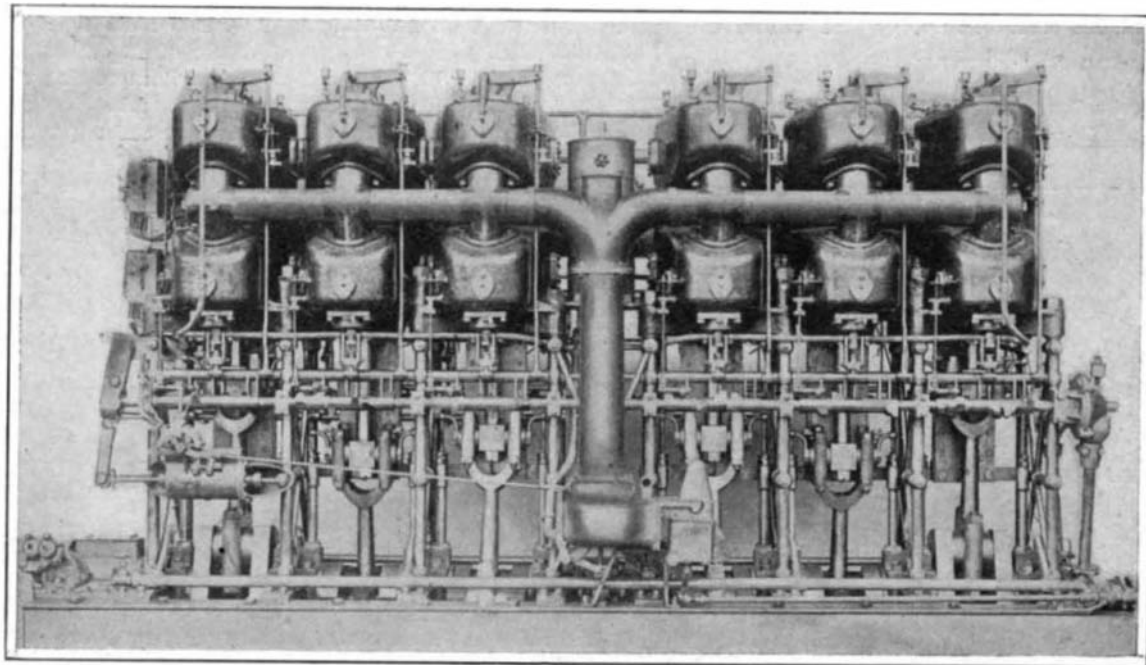
There will be no future for the single-acting motor for large powers in marine work. The manifest advantages in the matter of weight and arrangement for variations in cruising powers, as well as in greater effectiveness in distribution in the double-acting type, will make it unquestionably the only one to be considered in the development of this class of machinery for sea-going craft. The difficulties at first experienced in arranging for the proper cooling of pistons and rods, and in devising efficient packing for the rod stuffing boxes, have been overcome, and, as before

motor for the Indian Head boat, except that a regular reversing controlling cylinder is used with compressed air instead of steam, bringing the reversing under perfect control. Means can also be provided by which, with one motion of a lever, all the lower exhaust valves can be lock opened and all the lower inlet valves can be lock closed instantly, thus changing the engine at once to a single-acting six-cylinder motor, or, in other words, cutting down to half power with one movement and without any substantial decrease in economy. Furthermore, the two units of three cylinders each can be unclutched so that the after three cylinders can be operated alone single acting, which actually reduces the power to one quarter of the original. Taking these points into consideration, together with the fact of being able (with a liquid primary fuel) to get under way at a moment's notice under full power and maintain absolute regularity of speed as long as the fuel lasts, there seems to be little more to be desired toward securing an ideal marine motor, and, even should producer gas be used, the same control of the variations of the power is maintained, although the ability to instantly start from cold port conditions is not secured, there being, of course, some delay in getting the fire properly under way in the retort.

Many of the details of the construction of this 500-horse-power double-acting motor are shown in the photograph and are extremely interesting to the naval engineer. In Fig. 2 the inlet side is shown, the carbureter (overflow type) being in the middle and placed low down, and directly controlled by the throttle-valve lever at the reversing cylinder on the left. The inlet valves for compressed air are on the back, and not shown, but are merely applied in this type to the lower ends of the three after cylinders, so that the three upper ends of these cylinders and the entire three forward cylinders are constantly "on" gasoline, either in the go-ahead or backing position of the cam shafts; and, as the sparking continues in all cylinders during the action of reversal, the very moment the compressed air starts the engine in reverse the other cylinders immediately take up action with gasoline, and the engine is running on explosive fuel immediately, so that the action of the compressed air is not practically more than the shifting into reverse motion and starting the engine in the desired direction. The moment this results the reverse lever is shifted to the full-throw notch, which restores the lower ends of the after cylinders to gasoline. This reversal is practically instantaneous. All the cam shafts are positively driven by gearing from the main shaft, and, consequently, the adjustments of the cams are exact, and the tripping of the valves in this arrangement is accomplished almost noiselessly.

The lubrication of this motor is also a very interesting feature. Forced feed with sight-feed adjustment is accomplished through plunger boxes shown on the after end of the motor, the upper box being for delivery to the center of each cylinder, and the lower box for delivery to the middle of the piston-rod stuffing boxes, the plunger pumps for each of the small pipes being worked by a lever with a small connecting rod to a pin on the end of the exhaust-cam shaft, which

gives sufficient rotary motion for the desired lift, the lift being also further regulated by a slot in the plunger lever, to which the connecting rod is attached. The lubrication for the crossheads and crank pins is accomplished by a small plunger pump worked by a gear at the forward end of the exhaust-cam shaft, similar to the gasoline pump shown at the forward end of the inlet-valve cam shaft in the photograph, the oil being kept in a constant flow from the crank pit into which it falls, up through a strainer box between the two sets of three cylinders (and just seen in the photograph), back of the middle branching of the inlet pipe, and fed by gravity from this tank to the journals; a surplus of oil being constantly circulated by this method and kept



A 6-Cylinder, Double-Acting, Standard Marine Gasoline Engine of 500 Horse-Power.

The cylinders of this engine are of 12 1/4-inch bore and stroke. A 1000 H. P. engine with 16x16-inch cylinders is under construction.

A NEW TYPE OF GAS ENGINE FOR MARINE WORK.

noted, examples of double-acting gasoline motors of 500 horse-power are already in satisfactory operation afloat.

It will be seen from Fig. 1 that the valves are positively operated, water-cooled, and balanced. The pistons are cooled by water circulating through the cross-head, up a tube in the piston rod, providing a return circuit around this tube. The reversing of the engine is similar to that described for the 300-horse-power

constantly strained without waste. The journals are of ample dimensions and give no trouble whatever from heating with this system of lubrication.

Another important feature in this installation is that connected with the circulating water. As the boat is designed to run in salt water, there has been a connection made by an ordinary keel condenser between a small fresh-water tank inboard and the circulating-water pump, this latter pump being a slow-moving one

of ample dimensions worked by direct gearing on the main shaft. It is found by this means that ample cooling water can be maintained from a very moderate original supply of fresh water, and the objectionable features of having salt-water circulation are entirely obviated. Unquestionably this will be an important factor in all salt-water installations of this kind, and will greatly add to the endurance and protection of the outfit. Where the circumstances make a keel condenser in any degree objectionable, a regular tube condenser (more properly a cooler) can be adopted with circulating pump for it, and secure ample provision for the work.

In the boat inspected containing this motor, an independent installation of a small 4-horse-power "Standard" motor was made for the purpose of driving a dynamo for lighting the vessel and charging storage battery, a bilge pump for constant use, an air compressor for pumping up the compressed-air tanks whenever necessary, and a small magneto for sparking. This auxiliary is not necessary to use except when particularly desired, as, when the main engines are in operation, the air supply is kept up in the tanks by attached pumps, and it is easy, of course, to attach bilge pumps to the main shaft, so as to permit disuse of the auxiliary engine, except at night.—Journal of the American Society of Naval Engineers.

A HIGH-SPEED MOTOR BOAT THAT CAN BE BUILT AT HOME.

The illustrations shown herewith depict the Brooks Boat Company's "No. 13," as viewed from the front, rear, and side when traveling at high speed through the water. When the fact is considered that this boat was claimed to be going 28 miles an hour when the photographs were taken, one can readily see that the model of hull used is a good one, and one that throws but little spray when compared, for instance, with the "Standard," shown at the bottom of page 168. Fitted with a 60-horse-power, six-cylinder Sterling engine, "No. 13" is claimed to have made a measured mile in 2 minutes 8 seconds last summer, which would be at the rate of 28.12 miles an hour. As the photographs show, this boat looks every inch a racer, and appears from the shape of the hull to be capable of attaining the speed claimed. It is 39 feet 7 inches in length by 5 feet beam, with a depth of hull at the bow, amidship, and at the stern of 31, 29, and 19½ inches, respectively. The draft depends upon the size of propeller used, as the hull is made flat at the stern, so that it glides nearly on the surface of the water.

The builder of the above-described speed boat is one of the oldest boat-building concerns in this country. This company not only builds boats, but also makes a specialty of furnishing frames complete, with all the necessary material for putting them together and with patterns for cutting the planking. When supplied with all this material and instructions, which can be had at relatively small cost, the amateur can build himself a boat during leisure hours, knowing that when it is completed, his craft will not be an experiment either with regard to appearance or speed.

Besides the racer shown, the Brooks Company builds, or supplies frames for, several smaller speed craft, among which are a 30-foot racing boat claimed to make 16¼ miles an hour with an engine of 10 horse-power, and a 22-foot speed launch, claiming also 8½ miles an hour with a 2-horse-power motor, and which should therefore make as high as 12 miles an hour with 6 to 8 horse-power. Still another interesting model is a stern-paddlewheel boat, which can be built in varying sizes from 25 to 40 feet in length. This boat can be built as an open or closed launch or as a boat for freighting purposes on shallow lakes or streams. Equipped with a 7 to 12 horse-power motor, it will attain a speed of from 6 to 9 miles an hour.

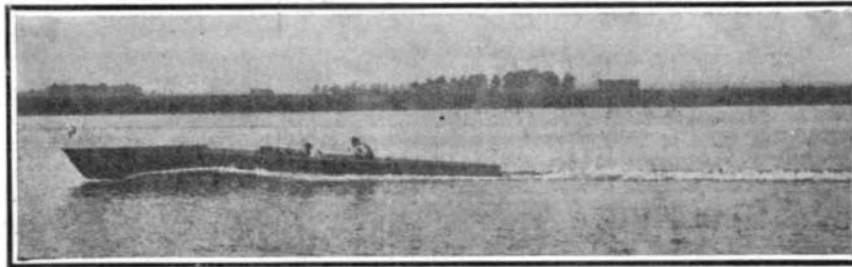
Cupro-nickel, says the Brass World, is used for two purposes: In the manufacture of bullet jackets and in the production of five-cent pieces.



Bow View, Showing Wave Formation.



Stern View, Showing Wake.



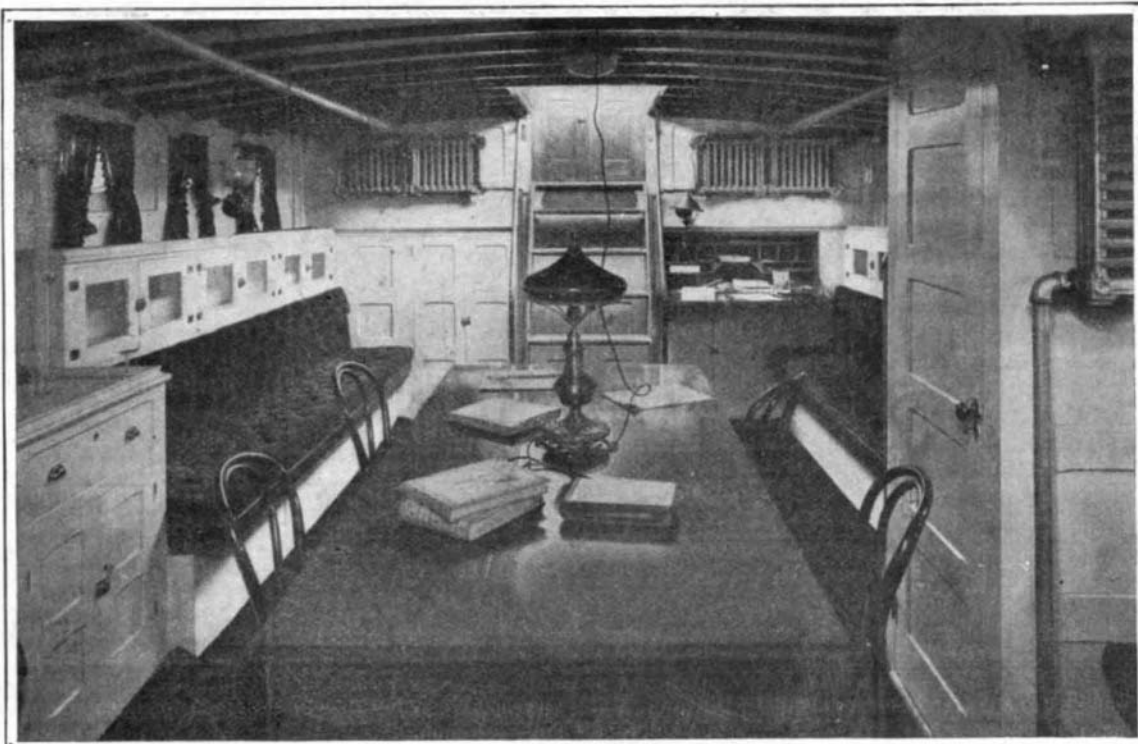
The Brooks "No. 13" Making 28 Miles an Hour.
A RACING MOTOR BOAT FOR AMATEUR BUILDERS.

Bullet jackets consist of 80 per cent of copper and 20 per cent of nickel. The five-cent pieces made by the United States government are composed of 75 per cent of copper and 25 per cent of nickel.

INFLUENCE OF THE AUTOMOBILE ON LAUNCH DEVELOPMENT.

(Concluded from page 167.)

tools—have been utilized in the production of engines of phenomenal lightness, up to 300 horse-power or high-



Cabin of the U. S. Coast Defense Inspection Boat "Norka," Which is Noteworthy for Its Roominess and Comfortableness.

A TYPICAL MOTOR-BOAT INTERIOR.

er, and especially designed for launch installation. At the same time every improvement in the automobile world in the line of carbureters, ignition devices, lubricators, etc., has been transferred to the marine engine.

In this country, under somewhat different conditions of manufacture, the builder has had on the one hand his old, heavy, slowly-turning engine, and, on the other, the French automobile and auto-marine engines, of wonderful refinement and lightness. The result is seen in several magnificent machines in the larger sizes, purely of the marine type, with the skeleton framework of the steam torpedo-boat engine, light and powerful to an extent not dreamed of five years ago, with all the latest advances in gas-engine practice and electrical science making them as reliable and practically as flexible and tractable as the steam engine. Every development of automobile engineering in the line of better materials, finer tools, and improved methods has gone to further the perfection of the marine engine.

But the full measure of advance is not to be gaged solely by such costly machines as the double-acting, six-cylinder engine of 500 horse-power, started and reversed by compressed air. The improvement begins with the smallest and cheapest of the two-cycle engines, where better materials, improved design, standard tools of greater accuracy, and more scientific carbureters and ignition devices, have raised the standard and decreased the relative cost. Throughout the whole range of heavy engines, still in demand for much of the yacht work and in fishing and working vessels, there has been a general improvement along the same lines. Next to these stands a new class of launch engines of varying sizes from 20 to 80 horse-power, mostly of high speed as compared with the old type, but far lighter, more compact, practically as strong and durable, and superior alike in reliability and economy.

With the improvement of the engine and the multiplication of types and sizes has come a reconstruction of the entire power pleasure fleet on new lines. Limited no longer to a few sizes of engine of a single type, the yachtsman and his designer have been free to plan a great variety of new craft. For day use there are launches of comparatively high speed of from 20 to 80 feet; for ordinary pleasure running there are comfortable and convenient craft of good speed, easily handled by one person and safe in any ordinary weather. Where cruising is the main object, the reduction in size and weight of engine has brought about a corresponding change in the refinement of the hull, which is no longer a homely box from which a speed of but six or seven miles per hour is expected, but is as handsome and graceful as a sailing yacht, with double the accommodation on the same length, and with a speed of at least a dozen miles. Still another new type is the rough-water cruiser, from 30 feet upward, including the 40-footers that raced around Cape Cod in 1905 and 1906 and the 40 to 60-footers that will race to Bermuda this year. While for this special work the old type of heavy engine still takes precedence of all others, the development of this most useful and interesting class may be traced back directly to the auto-boat racing of two and three years ago—a reaction and a protest it is true, against the extreme racing type, but nevertheless owing its origin to it.

CANOVETTI'S AIR-RESISTANCE EXPERIMENTS.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

In view of the great activity which we find at present in the line of aeroplanes and airships of different forms, the study of the resistance which the air offers to moving bodies becomes one of considerable importance. This question is also of interest in the design of high-speed trains or automobiles and in another field, in the design of projectiles for artillery. Newton was the first who formulated a series of laws for air resistance, supposing that it is produced directly by the inertia of the molecule of air as acted upon by the moving body. But this hypothesis is far from being in accord with what happens in reality, and the laws which result from it