THE NON-MAGNETIC GAS ENGINE OF THE "CARNEGIE"

BY JAMES CRAIG, JR.

[The construction of the non-magnetic vessel, "Carnegie", for the Carnegie Institution of Washington, to be engaged in ocean magnetic surveys, presented various interesting mechanical problems. Especially so when it was decided to equip the vessel—primarily a sailing one—with sufficient auxiliary power to drive her, in calm weather, at a speed of about six knots.

Of the various types of motors available—steam, gasoline, gas producer—investigations made by the architect of the vessel, Mr. Henry J. Gielow, of New York City, first with regard to the initial cost from a non-magnetic standpoint; secondly, as to cost of maintainance, and thirdly, with reference to the possibility of obtaining practically everywhere the fuel to be used, resulted in the selection of the third type.

The initial cost of the desired non-magnetic propulsion plant was heaviest for the steam engine, next for the gas producer, and cheapest of all was the non-magnetic gasoline engine. As to the cost of maintainance, however, it was found that the gas producer plant would be the most economical, with the added advantage over the gasoline motor of using a less dangerous and a more generally available fuel. With the plant provided on the "Carnegie", it is estimated that a cruise of 2,000 nautical miles at a speed of six knots, with a coal consumption of but twenty-five tons, can be made.

The following description is largely extracted from Mr. Craig's interesting article in "Motor Boating", New York, June, 1909. It ought to be stated that the makers of the gas engine (Craig Engine Shops, West 34th street, New York City), as well as of the gas producer (Marine Producer Gas Power Company of New York City), took a personal interest and pride in their respective tasks far beyond what might be expected from a *purely* commercial standpoint.—L. A. B.].

The motor selected was a four-cylinder Craig engine of 200 H. P., of the open-base pattern as regularly built, but with the following two special requirements: First, that the fuel should be producer gas instead of gasoline; second, that it should be non-magnetic, not over 500 lbs. weight of iron or steel being allowed in a total weight of 10,000 lbs. These two requirements resulted in the motor being practically re-designed and also required special construction of even the smallest part.

The use of producer gas, which of course was made necessary by the impossibility of obtaining gasoline or kerosene in all the parts of the Earth, where the work of the vessel will extend, necessitated three radical alterations in design and construction of the motor on account of the fact that producer gas contains fewer heat units than gasoline vapor, is slower to ignite and slower

to inflame. Accordingly, we found it necessary to make an increase of about 50 per cent in the area of the intake ports and valves, to provide a compression of about 150 lbs. instead of about 70 or 80, and to provide not only a larger quantity of electric current, but also more care in its control.

The requirement that bronze or copper should be used for practically every portion did not demand extensive changes in the design of the motor, but necessitated the special construction of every part down to the smallest screw and bolt. In fact the smallest parts, such as bolts and nuts, caused an amount of trouble entirely out of proportion to their size and importance. In building an ordinary motor, the screws, bolts and nuts are invariably of standard size, whether in steel or iron, and can be bought at any well-equipped hardware store. In the case of the *Carnegie* motor, however, these were out of the question, and it was not possible even to use ordinary brass screws and bolts, for the reason that these are always made from scrap metal containing a considerable percentage of iron. For this reason every piece of metal in the motor was especially cast from new pure metal, with a testing piece attached, which was submitted, in every case, to the representative of the Institution at Brooklyn, Mr. W. J. Peters, for making the required tests as to non-magnetic effects.

The bolts and nuts were machined from hexagonal brass rods, turned to the required size and threaded upon a lathe. The nuts were cut from similar rods and bored and tapped to the required size and thread.

As the strength of manganese bronze is practically the same as that of ordinary forty carbon steel forgings, we did not find it necessary to increase the size of most of the parts, but an increase was made in a few parts which were required to sustain a heavy load such as the stanchions of the base, the connecting rods and the crank shaft, which were made about 15 per cent heavier than usual. As brass shrinks about 10 per cent more than iron when cast, it was necessary to make special patterns for all castings, in order to allow for this difference in shrinkage, which of course involved a large amount of labor. The brass castings also proved much more difficult to machine than is the case with iron. For example, we had to bore the cylinders four or five times, as the hard metal wore the edge from the tools so rapidly that the first two borings were tapered and not straight.

FIG. 1. Plan of engine and of gas producer.

FIG. 2. Elevation of engine and of gas producer.

In its general features, the *Carnegie* motor resembles the regular Craig four-cylinder air-starting model. The cylinders are eleven inches bore and twelve inches stroke, giving a rating of 200 H. P., and are cast of gunmetal. Both the cylinders and heads are cast separately. There are two inlet and two exhaust valves for each cylinder, which are placed in the heads. In addition there is an exhaust port in the lower portion of the cylinder which carries off 80 per cent of the exhaust. This is controlled by a back cam shaft and valves so arranged that this exhaust port is wide open when the piston reaches the end of the down exhaust stroke, and as the piston ascends the regular exhaust valves in the head are opened.

The pistons are of cast iron, the cams are of steel, and the exhaust and inlet valves are of nickel steel, these being the only iron or steel parts of the motor. All the heated surfaces of the cylinder, including the walls, heads and the exhaust pipes, are waterjacketed, making the operating conditions practically the same as with an ordinary motor.

The crank shaft is of manganese brass, hammer forged, and is four and one-fourth inches in diameter at the journals and crank pins. The crank pins are bored hollow to facilitate oiling, and both the journal and the crank pins babbitted. The shaft weighed 1,600 lbs. in the rough forging, but was reduced to less than 750 lbs. when finished. The fly wheel is of brass, with the rim bored hollow and filled with lead. The shaft is of Tobin bronze, and the propeller is five feet in diameter, with two reversing blades.

The motor has a self-starting device operated by compressed air. There are a series of revolving discs upon the inlet valve faces, and these discs are provided with ports arranged to admit and to cut off the supply of compressed air to the cylinders in their proper sequence. The air for this purpose is compressed by a pump operated by the motor and stored in tanks. The motor is not reversible, but is fitted with a reversing clutch. The engine will run at 350 to 400 revolutions per minute.

The gas producer was built by the Marine Producer Gas Power Company, of New York City, and is also practically non-magnetic, as there are only about sixteen hundred pounds of very feebly magnetic metal (non-magnetic manganese steel) out of a total weight of 10,500 lbs. The manganese steel comprise only those portions of the producer which are exposed to intense heat, yet, on account of their use, can not be made of bronze, such as the

cleaning door of the fuel chamber and its frame, the grate, the poker and other cleaning tools and the gas offtake in the top of the producer. All the other parts are made of either copper or bronze, except that fire brick, of course, is to be used to line the fuel chamber.

The gas is generated in a copper producer installed just forward of the motor. From the generator it passes directly into a scrubber, or cleaning tank, also of copper, which is placed to one side and above the motor, and is suspended from the deck beams by copper straps. This is supplied with water for the cleaning and cooling the gas by a pump attached to the engine shaft. The gas enters the scrubber at the forward end and leaves it at the after end, and passes directly into the cylinders of the motor. When the motor is stopped, any gas generated will pass through a special valve from the producer through a vent pipe to a short stack above the engine room, which will also carry away the exhaust from the motor.

The gas producer has a capacity of 1,600 lbs. of anthracite pea coal per hour, producing a gas containing 80 per cent of the heat units contained in the coal. Provision is made for carrying twenty-five tons of coal, which will give the boat a cruising radius of about 2,000 miles and speed of six knots.

THE LAUNCHING OF THE "CARNEGIE", JUNE 12, 1909

BY MRS. L. A. BAUER

The morning of the eventful June 12th dawned fair, though later a slight cloudiness overspread the sky, proving a grateful shield from the fierce rays of the Sun.

The buildings near the entrance of the ship yard of the Tebo Yacht Basin Company (the builders of the "Carnegie") at the foot of 23d street, Brooklyn, N. Y., and the vessels in the harbor were gayly decorated in honor of the occasion. It was estimated that from 3,000 to 4,000 people had gathered to witness the launching.

The vessel itself was gayly trimmed with the flags of all nations, indicating that its mission, when completed, was to be of benefit to the whole world, and flying high above them was the newly chosen flag of the Carnegie Institution of Washington, a red pennant bearing as an emblem a white globe with the parallels and meridians in black.

At about 3 o'clock the official party ascended the platform built around the bow of the vessel. Miss Louise Dorothea Bauer, who had been chosen by the Trustees of the Carnegie Institution of Washington to perform the christening ceremony, was then shown the bottle to be used, encased in non-magnetic wire netting and tied with streamers