Diesel Marine Engines*

A Resume of Recent Performances

By Herr Th. Saeuberlich of Osterholz-Scharmbeck

Since the days of the old low-pressure steam engines there has been no time when marine propulsion attracted more attention than to-day. In the place of the highly developed steam engine, the efficiency of which it appears impossible further to increase, the Diesel engine is now making its way for marine purposes. It is at the present moment the most perfect oil engine. According to recent experiments, the heat efficiency amounts to from 33 to 35 per cent, against 23 per cent with gas engines and 13 per cent with the best superheated steam engines. This arises from the direct burning of the fuel in the cylinder, by which means perfect combustion is attained.

In its manufacture the Diesel engine is known to demand great care in the choice of materials for most of its parts. But in view of the present-day knowledge with regard to metals, and the ease with which every sort of high-class and suitable material specially adapted for its purpose can be obtained, and above all, in consequence of the vast strides made in machine tool manufacture, there is no particular difficulty in turning out Diesel engines.

The large Diesel motor is very similar in its construction to the steam engine, and its development will, like that of the large gas engine, follow the example set in steam engine construction.

The prejudice against Diesel motors which still exists in shipbuilding circles has to a great extent broken down, and recently it has become clear that various shipyards are in the position to build Diesel engines, free from faults and reliable in working, even with their present equipment.

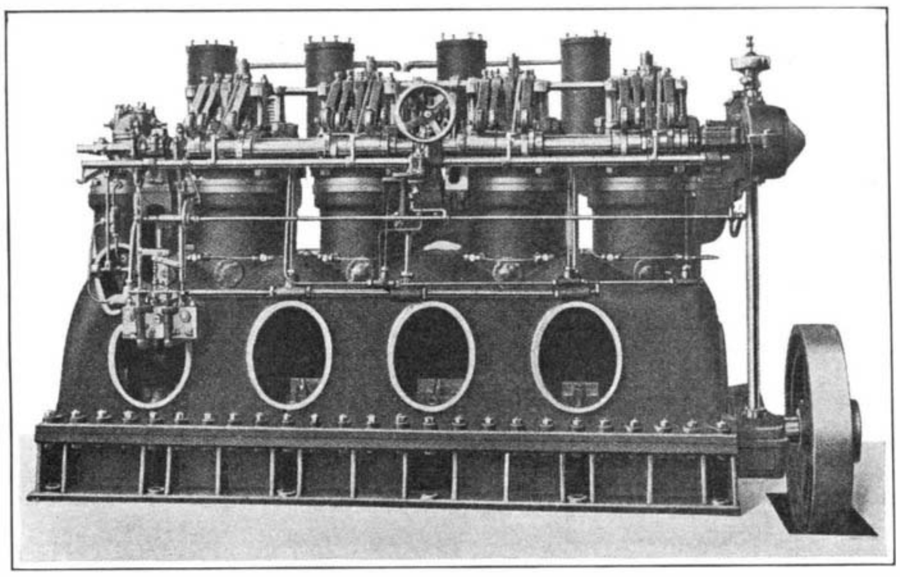

Fig. 1.—200 HORSE-POWER REVERSING DIESEL ENGINE OF THE "FRERICHS"

Hitherto the Diesel engine has been made almost exclusively single acting. As a rule the four-stroke cycle method has been used, but recently the two-stroke cycle has come into prominence. The efforts to utilize the Diesel engine for quite large undertakings, and finally for the propulsion of large vessels, have given an impulse to the employment of double-acting engines both on the four-stroke and two-stroke cycles. Indeed, such progress has already been made that ultimate complete success cannot be doubted, and leading shipowners, having recognized the great value of internal combustion engines, are already one by one approaching the shipbuilders with their orders.

The constructor is now confronted with the task of giving to the Diesel engine the reliability in working and capacity for maneuvering which distinguish the marine steam engine, and further, in consequence of the continual decrease in boiler plant, to find gear simple enough in handling and maintenance to suit the rough requirements of a ship's auxiliariese.

The advantages of the Diesel engine for marine purposes as compared with the steam engine differ according to the type of ship and the size of the equipment, but in general the following are among the most notable: The gain in useful space by the reduction of boiler plant and small size of the fuel

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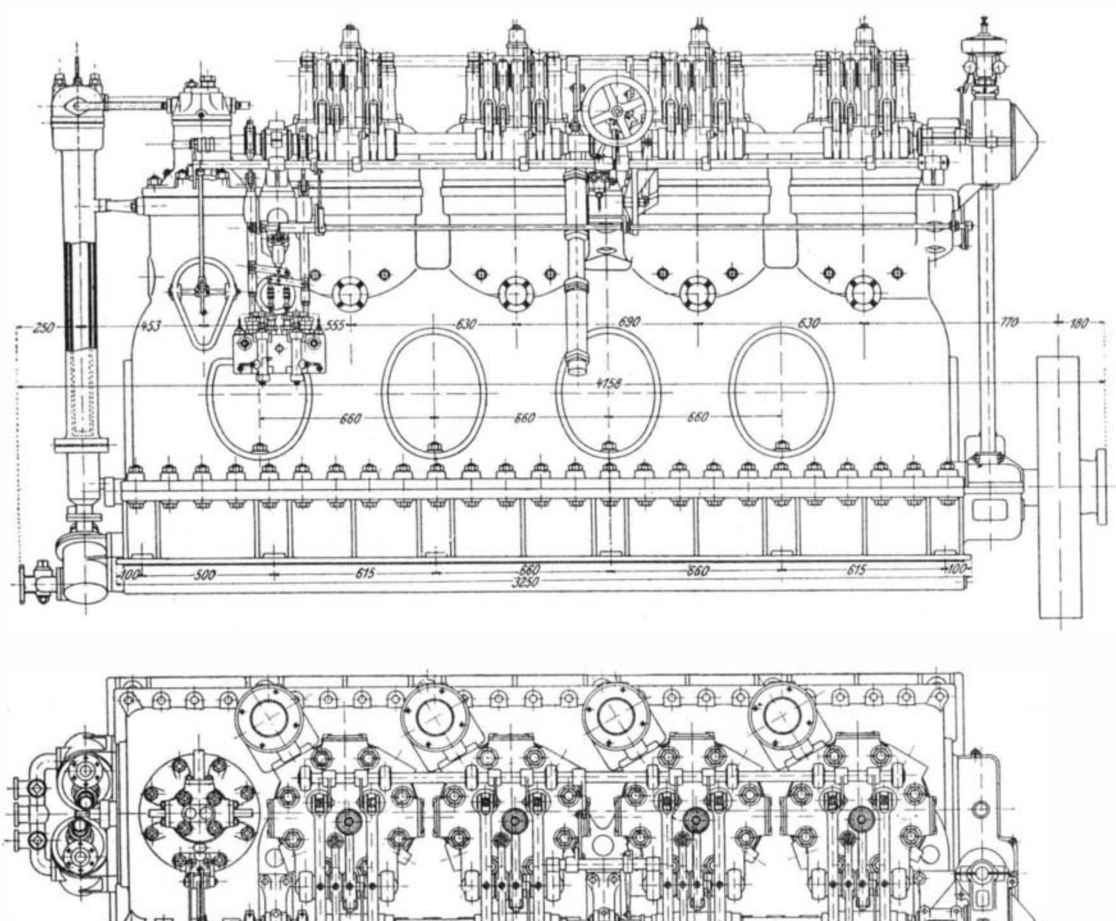

Fig. 2.—ENGINES OF THE "FRERICHS"

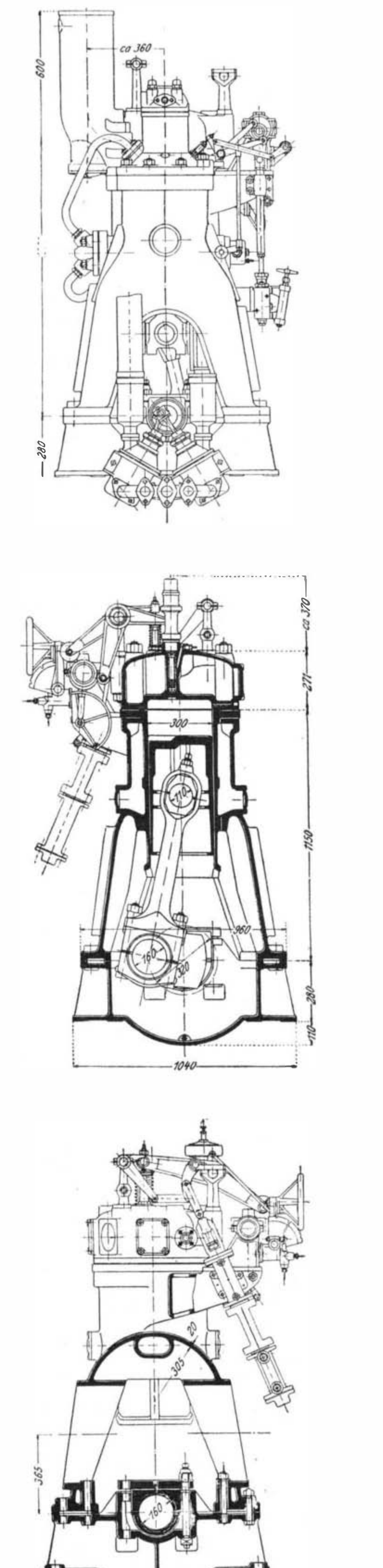

Fig. 3.—END ELEVATION AND SECTIONS

holders; increased capacity due to the small weight of the engine plant and the fuel; utmost utilization of the otherwise limited useful space taken for fuel bunkers; gain in time, and economy of wages, due to quicker and easier bunkering, and also to decrease in coal trimming; quicker starting of the engine; reduced and easier management; personal and space economy by reduction of the number of the stokers; reduced cost of fuel; cooler engine rooms, resulting in the increased mechanical capacity of the personnel, especially in hot climates; the possibility of carrying more fuel, and therefore enlarged field of action.

But the introduction of Diesel marine engines also involves the solution of recent economic and constructional problems, of which the chief are the following: (1) The lack of suitable fuel in many harbors; (2) the lack of steam for actuating the auxiliary engines on deck and in the engine room, as well as for heating.

The engines here dealt with are the first marine Diesel engines built according to special design and put into service by a shipyard on the North Sea—J. Frerichs & Co., in Osterholz-Scharmbeck and Einswarden—and they form another link in the unceasing progressive development of the marine Diesel engine. They are (1) the direct reversing four-cylinder Diesel engine of a maximum effective 200 horse-power, with 360 revolutions per minute, fitted to the service boat "Frerichs," built by the above-named firm; (2) the 90 effective horse-power two-cylinder marine Diesel engine and reversing gear for driving the herring lugger "Ewersand," which is employed by the Brake Herring Fishing Company in Brake.

The Service Boat "Frerichs."—This service boat is a single-screw vessel built according to the rules of the German Lloyd for small coasting traders, and has been in use since the spring of 1910. She serves for the special purpose of communication between the shipyard in Einswarden and the opposite bank of the Weser, but especially for towing. For this purpose she is equipped with a strong towing gear. The towing power amounts to about 2,000 kilogrammes measured on the rope. The fuel employed is the so-called gas-oil, 1,000 kilogrammes of which are provided in two tanks under the cabin; double this quantity could, however, have been conveniently carried. These 1,000 kilogrammes permit of a voyage of 240 sea-miles at 9.5 knots, a distance which corresponds to about the voyage from Bremerhaven to Hamburg and back.

The vessel in external appearance is like a steam tug, since she has a funnel for carrying off the gases. With a length of 18 meters, she has a very spacious engine room. On deck, near the pilot house and other deck erections, is a large cabin affording room for twenty people. The existence of this roomy accommodation is due to the omission of boiler and coal-bunker space. The motor, Fig. 1, is a reversing four-cylinder four-cycle engine, direct coupled to the propeller shaft; at 360 revolutions it develops 200 effective horse-power, measured on the fly wheel, and gives the ship a maximum speed of about 10 knots. Its weight is about 10,000 kilogrammes.

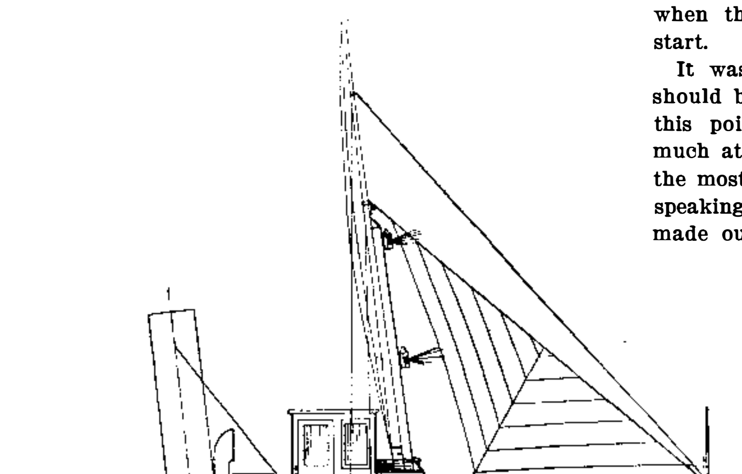
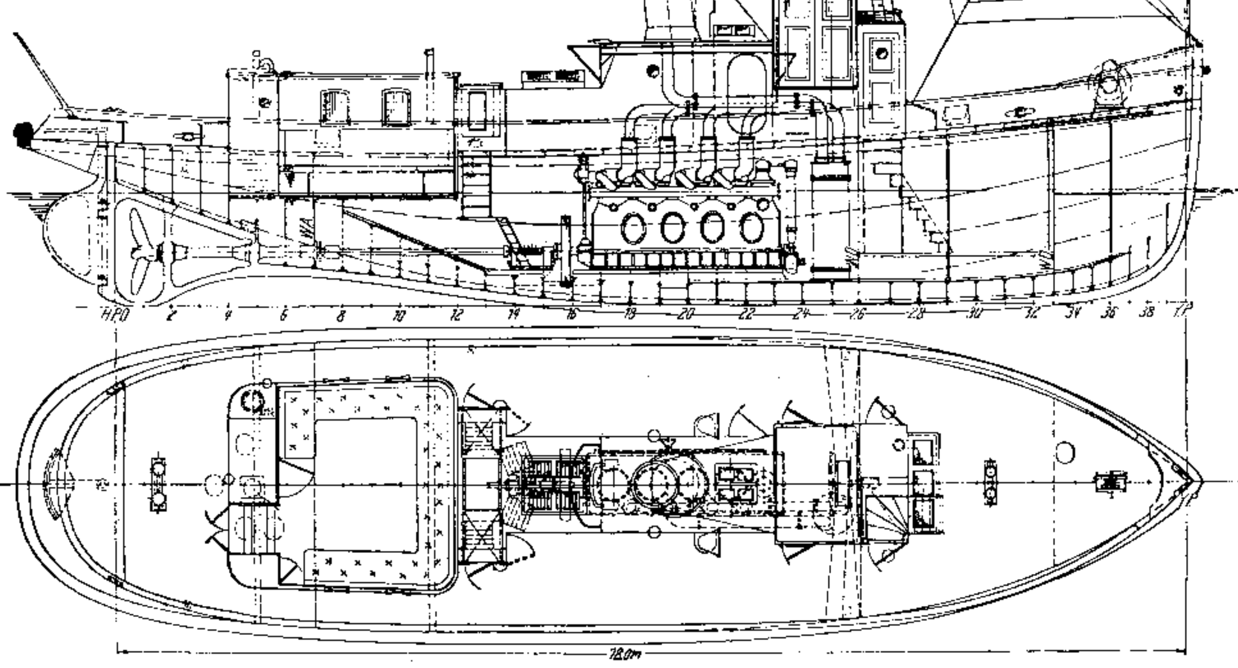
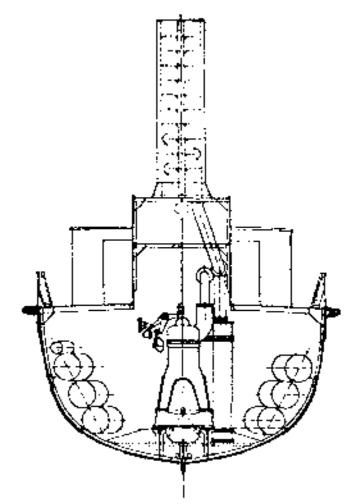

FIG. 4.—THE SERVICE BOAT "FRERICHS"

The reversing gear is actuated by compressed air, abundance of which is available, which moves the horizontal cam shaft endwise, thus bringing a second set of cams into action. Starting can be made quickly and safely, and can even be effected in one second. By a special arrangement of the compressor, perfect certainty is guaranteed with regard to the starting of the engine in either direction, even in the event of the motor stopping on the dead center. The valve gear of the motor is the simplest imaginable. All the necessary movements and arrangements are combined in a single mechanism. For the entire manipulation, including the regulation of the motor for high or slow speed, all that is required is a single lever, which for convenience is designed as a hand wheel.

The cooling water pumps and Lenz pumps are driven by the engine crank shaft by an overhung crank, and are—see Fig. 3—fixed to the common base plate.

The hot exhaust gases are cooled with water on their discharge from the cylinder in a double-walled chamber. After their union in a collecting pipe they are conducted into a large condenser which acts the part of a silencer. From there the exhaust pipe leads into the funnel, where the exhaust gases pass into the air.

The Lenz pump provides cooling water for the exhaust. The compressed air which is required for maneuvering is generated by the motor itself by means of a two-stage compressor which constitutes, as it were, the fifth cylinder of the motor. It is received in six large receivers—Fig. 4—which are placed along the side of the engine room and made fast to the ship's side, where they take up little room. Further, a smaller air receiver is also arranged on the port side. From it the air for the injection of the fuel into the cylinder and for reversing is taken. The six large receivers serve only for starting. The air used for starting is during the voyage gradually restored again from the small supply tank. In the construction of the motor the utmost simplicity was sought, and it was especially demanded that the number of the cylinders and the movable parts should be limited as far as possible.

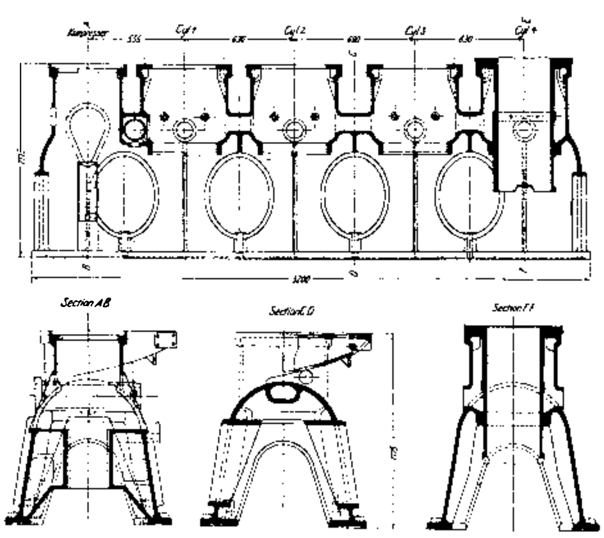

FIG. 5.—CAST IRON STANDARDS

To start a four-cycle motor in any position at least six cylinders are required if the usual method is adopted. It was, however, desired to limit the number to four cylinders, and a way was found by making use of the compressor direct coupled to the motor. This compressor is of special design and is provided with a gear which makes it possible to use it as a motive cylinder driven by the air from the receivers when the engine cylinders are not in a position to start.

It was further required that the cost of the plant should be reduced to the lowest possible amount. To this point of view the constructor cannot pay too much attention, since the cost of Diesel engines until the most recent times has always been, comparatively speaking, very high. The base plate of the motor is made out of cast iron and in one piece. It is closed underneath, and the separate crank pits are connected below by channels, so that the lubricating oil can flow to one end. The main bearings—Fig. 3—are recognizable as, on the whole, similar to the usual type in ship construction; the lower brass is rounded and therefore easy to remove; the upper, on the contrary, is squared. A plate of Siemens-Martin steel takes the place of the bearing cap.

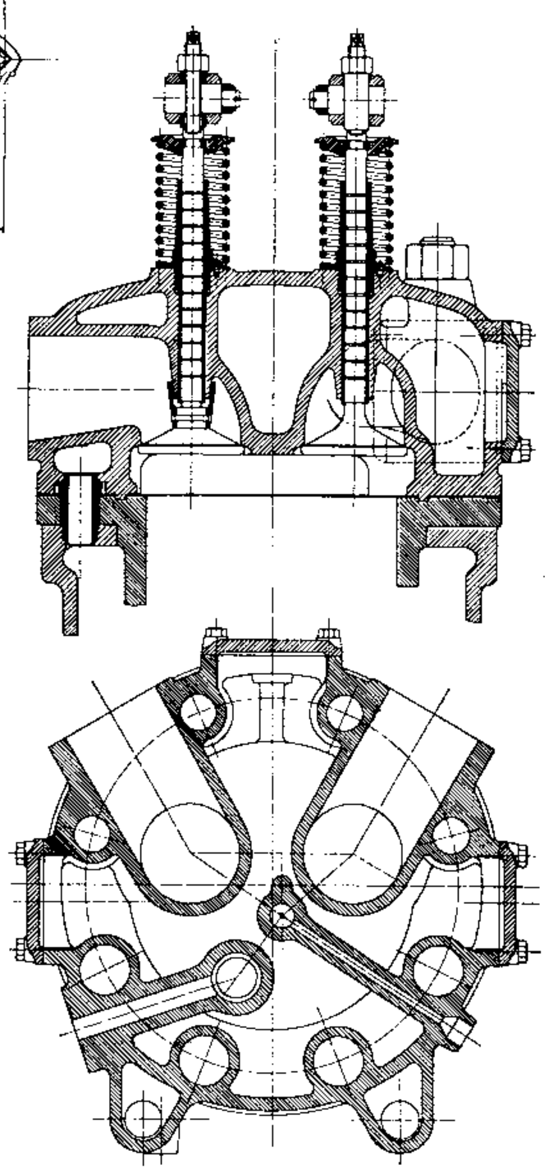

FIG. 6.—CYLINDER COVER

The general form of the standards will be gathered from Fig. 5. It will be seen that great care has been taken to avoid sharp corners and sudden changes of form. The whole piece is a single iron casting. The lower part is semi-cylindrical above, and the ends of it are domed. The two walls are splayed outward to the base, and pierced by large elliptical openings. The cylinder liners fit the casting as shown, and the water jacket is kept tight by a calked leaden ring. All the jackets are in communication with each other by the passages shown in the drawing. Round cleaning holes are provided in each jacket. Between the compressor and the adjacent cylinder a square box is formed in the casting, which constitutes an intercooler for the compressor. The brackets, which support the valve shaft, are also cast on. The thickness of the casting is throughout about 20 millimeters.

The cylinder cover is the largest and heaviest casting in the engine, and on it are collected all the principal valves—the suction valve, the exhaust valve, the starting valve, and the fuel valve. All these parts have to be got into a constricted area little bigger than the piston diameter, and yet to avoid unequal thicknesses of metal reasonable spaces must be left between the separate parts. This arrangement is also necessary to insure equal cooling, and to avoid stresses being set up by unequal heating. Furthermore, an exceedingly sound casting is absolutely essential, particularly at the joints and valve faces, and at those surfaces subjected to the high internal pressure in the cylinder or connected with the high-pressure air supply.

To carry out all these requirements, however, presented little difficulty. As may be seen from the engraving, Fig. 6, the suction and exhaust bends are separated from the two tubes or passages which take the starting and fuel valves. The exhaust bend is entirely surrounded by water, and is of such a shape as to give an easy flow to the gases. The exhaust and admission valve seat direct on the cover, for in no other way was it possible to bring them so close together. It may be objected to this arrangement that dismantling is far more difficult than when separate valve cages are employed, as it involves the removal of the whole cylinder cover, but in an engine of this size no trouble in this direction has been experienced. The only real objection is that the part of the valve spindle exposed to the hot gases may wear more rapidly than the remainder which is water cooled, but to reduce this objection the lower part of the spindle is protected by a cone from the direct impact of the hot gases. In the case of larger valves the employment of a liner is, of course, recommended. In order to make the cooling as effective as possible, the walls are made only 12 millimeters thick.

From the foundryman's point of view the casting of the cover presents now no difficulty, but before the best mixture was found a considerable number were tried. In the tests the fact that only the closest and densest blends should be employed was disregarded, and it was proved that the best results were obtained with the iron in ordinary use for steam engine cylinders. All that is required is to use special care during casting and to keep the liquid iron after the mold is full in constant motion by means of a pump, to make sure that the mold is completely filled and the iron homogeneous.

(To be continued.)

The Two-point System Ignition

Merits of the Scheme Outlined

A TALK on ignition and ignition methods given by Roger B. Whitman of the Bosch Magneto Company not long since before the Long Island Automobile Club developed the merits claimed for the two-point system. Mr. Whitman dealt with the details of ignition and its method. His paper is given almost in its entirety below:

The state of perfection of the present day internal combustion engine has not been reached without deep study and investigation, in the course of which it has been realized that ignition has vastly more to do with efficiency than was at first believed.

The early conception of ignition was the production of a spark some time toward the end of the compression stroke, and if this spark was successful in igniting the mixture that was all that was desired. The character of the spark, the accuracy of its production, or the exactness of its timing were points that were disregarded by the designer, because he did not understand that these had any bearing on the power output or on the fuel consumption of the engine.

The modern designer takes an entirely different view of the subject, however, and it may be of interest to outline the problem as it is now understood.

To appreciate the fine points of ignition as they are understood to-day the engine must be considered in its true light as a heat engine pure and simple.

The mixture that is drawn into the cylinder during the inlet stroke represents a certain heat value, and the efficiency of the engine depends upon the manner in which this heat is applied to the expansion of the gases. Any condition by which some of this heat is lost or by which it is not applied directly to the forcing of the piston outward on the power stroke will reduce engine efficiency.

The first step in the securing of efficiency will be to study the points at which losses of heat may occur and to adopt means by which these losses may be prevented.

The charge of mixture represents a certain heat value and has a certain maximum pressure. To exert the greatest possible proportion of this pressure against the piston each particle of mixture should be made to give up its heat at the instant when the piston is at the end of the compression stroke and ready to move outward on the power stroke.

To gain this result it would be necessary to ignite each particle of the mixture at the same instant, and thus to have ignition and combustion occur at top dead center. The mixture would thus be compressed into a minimum space before ignition, and the rise in pressure due to combustion would then be most abrupt, the piston being driven outward with maximum force.

No existing ignition system will permit the ignition of all of the particles of mixture at the same instant. The system in use therefore permits ignition of the mixture at one or two points from which the flame is expected to communicate itself to the remaining mixture particles.

In a perfect mixture each particle of gasoline vapor will be surrounded by the particles of air necessary for combustion, and to ignite the mixture it will be necessary to raise the temperature of these particles to the point at which the chemical change known as combustion will occur.

Under usual motor conditions the heat developed by the electric spark is depended upon to raise the temperature of certain of these particles to the point at which they will ignite, and the flame thus started is communicated to the particles of the mixture immediately surrounding it, this being propagated throughout the entire charge.

To our senses the spread of the flame from the point of ignition is instantaneous, but in comparison with the speed at which a gasoline engines operates the time required is very considerable and must be taken into consideration. Thus there enters into our calculations the period of time that must elapse between the instant at which ignition occurs and the instant at which the entire charge will be inflamed.

We desire to apply to the piston the greatest pressure possible, and obviously the greatest possible pressure will be produced at the instant when combustion is complete. At this instant, therefore, the piston should be at the top of its stroke. We must not overlook the fact, however, that some pressure is produced at the instant when ignition occurs and that this pressure will be constantly increasing as combustion spreads. If combustion is to be complete when the piston is at its top point it is clear that ignition must occur while the piston is still moving upward on the compression stroke. For the last portion of its stroke the pison will therefore be subjected to this pressure, which is rising to maximum, and by which the piston will tend to be driven backward, at the same time the momentum of the flywheel is urging the piston upward. Some of the power of the engine will thus be required to force the piston upward, and in this is found one of the most serious of the losses in engine efficiency. If the engine is going at a sufficient speed the momentum of the flywheel will force the piston against the pressure in the combustion space to top center, but the result of the conflicting pressures will be shown in abnormal wear of the wrist pin, crank pin, and main bearings.

You have all had experience with a back fire when cranking an engine and know that it is the production of maximum pressure in the combustion space before the piston reaches the top of its stroke, the result being that the engine starts to run backward. This same condition in a lesser degree exist in a running engine under the normal condition of ignition occurring before top center.

The charge of mixture represents a certain heat value and can be made to exert a certain definite pressure upon the piston. To get the best possible results all of this pressure should be exerted against the piston when the latter is at the top of its stroke. If some of the pressure is exerted before the top center is reached less pressure will, of course, remain to act on the piston during the power stroke. This entails a double loss, for not only is the rotation of the crank shaft somewhat retarded, but the maximum pressure developed at top center is reduced. The effect is shown in an increase in the consumption of fuel and in a reduction of the power output.

Another loss that results from ignition earlier in the stroke is due to the absorption of heat by the cylinder walls; the surfaces being of metal are natural conductors of heat, and of course the longer the period during which the flame is in contact with these surfaces the greater will be the heat absorbed and wasted in this manner.

The obvious way to reduce loss of power from these causes is to produce ignition as late in the stroke as possible, but in this we are limited by the necessity for having combustion complete at top center.

The remedy will therefore be to hasten ignition as much as possible, or in other words to reduce the time necessary for the propagation of the flame throughout the mixture.

One of the most important factors in this is the location of the spark plug, which should be so placed that the distances through which the flame must be spread are as short as possible. If, for instance, the plug is located in the inlet valve cap the distance through which the flame must spread will be practically maximum, and the operation will require more time than would be necessary if the spark plug were located in the cylinder head. Furthermore, the plug should be located that its points are actually plunged in the mixture and not set in a cavity or pocket. Engines are occasionally seen with valve caps that are solid and possibly an inch thick. If a standard plug is screwed into such a cap the spark points will be found some distance up the hole, the spark will ignite the mixture which is in the hole and some little time will be required for the flame to spread down to the hole and to be communicated to the mixture.

Such a construction will require considerably more advance of the spark than would be necessary if the spark points were in direct contact with the charge.

The size of the ignition spark is also a factor that determines the time required for combustion. The ideal ignition spark should be a mass of flame with as large a surface as possible, for this will result in the ignition of a large number of mixture particles. It should be understood that the spark must come into actual contact with the mixture particles in order to ignite them, and if the spark is thin it will be quite possible for it to pass through a throttled mixture without actually coming into contact with any of the particles. With a spark that is in the nature of a flame this cannot take place. A large spark not only insures ignition, but makes combustion more rapid, for combustion will certainly be more rapid if, for instance, a hundred mixture particles are ignited by the spark instead of but one.

Following along this line brings us to the proposition that it might be better to ignite the mixture at two widely separated points instead of at but one, on the theory that this will reduce the time necessary for the propagation of the flame.

If a spark plug is placed in the inlet and a second one in the exhaust valve, and sparks are caused to occur at these plugs at the same instant, the time required for the spread of the flame throughout the whole charge will be much less than would be necessary were the flame to originate at one side and be required to spread across the entire width of the combustion space.

This has been theoretically admitted for a long time, but the difficulty in its practical application lay in the securing of apparatus that would permit the production of two sparks at absolutely the same instant.

Ignition apparatus of this character has now been perfected, however, with results that are satisfactory from every point of view. It may be said at the beginning that it is essential to locate the spark plugs properly. If the two are set side by side in the inlet valve cap, for instance, there will be no gain through the use of two spark ignition over one spark. To secure proper results from this system it is necessary to separate the plugs and to locate them so that the flame will have an approximately equal distance to spread in all directions from each.

A series of comparative tests was recently made on