further, to prevent the escape of cylinder gases into the engine room. Any leakage of gases goes into an annular chamber, which is connected to the scavenging pump suction, and is thus kept at a pressure below that of the atmosphere. The cylinder head is of cast steel, and has large cooling water spaces, with seven valve openings; one fuel, four scavenging, one starting air, and one safety. The piston of the Carels engine is in two pieces. The top piece is carried by a shoulder on the piston rod, and the bottom piece, or shroud, is carried at its bottom by another shoulder on the piston rod. Water cooling is adopted for the piston, and the water is circulated by the action of the plungers. The arrangement of the engine into two units of two cylinders each permits of a two piece crank shaft in interchangeable halves, of the vertical spiral drive for the valve gear being taken from the centre of the engine, and also of the scavenging pumps being driven from the two centre crossheads by links, as with the air pump of steam engines. The dimensions of the double acting scavenging air pumps are 27½ in. in diameter with a 23½ in. stroke, and give thus a ratio of free air compressed for scavenging to combustion air taken into the main cylinders of 1.65, which is higher

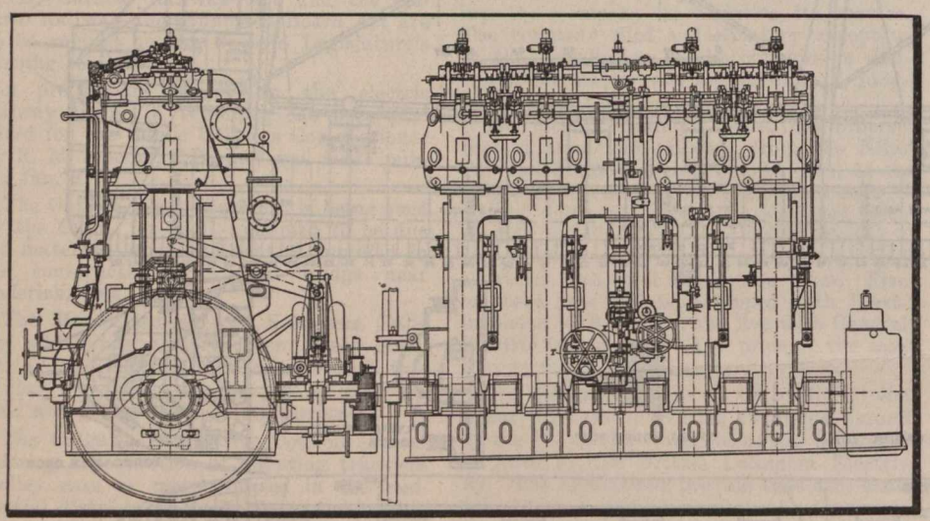

Diagram of Engines on Oil Engined Vessel Fordonian.

than the usual practice. The pressure of the scavenging air is 3 lb. per sq. in. There are four valves in the cylinder head for the inlet of the scavenging air to cope with the large volume of low pressure air used in the engine. The scavenging pumps are controlled by two piston valves worked by slipping eccentrics driven from the aft part of the two-piece interchangeable built up crank shaft, and the change of angular positon permitted by the slipping of the eccentric on the crank shaft automatically reverses the scavenging pump piston valves. The scavenging air is led by cast iron pipes from the valves to a built up 3-16 in. lap riveted steel plate reservoir running along the cylinder top and supplying the four scavenging valves on each cylinder. The exhaust is led down by bent cast iron pipes from the cylinder belt to the main exhaust pipe running along the engine to the cast iron silencer. These bends have internal water injection, and the silencer is also internally water cooled and is of the cascade design. The exhaust is led overboard under the counter. The funnel is for the exhaust gases from the donkey boiler. Separate leads are provided from the water cooling pumps worked off the links driving the scavenging pumps, and cocks are provided on all these leads to regulate independently the amount of cooling water supplied to each part. The temperature of this cooling water may be felt, as there are open discharges into funnels leading to the bilges. As regards lubrication, for the main bearings solidified oil is used, for the crank pin bearings the ordinary drip feed suffices, and the bearing pressures for the main and crank pin bearings are respectively about 300 and 650 lbs. per sq. in. For the lubrication of the cross head bearing, a small lubricating oil forcing pump is attached to each cross head, and worked by the swing of each connecting rod. This system of lubrication permits of an open crank case, and the bottom end bearings can always be easily felt by the engineer on watch. There are two guides for each. The piston is lubricated by four Mollerup lubricators, which force the oil between the piston and the cylinder; there are four inlets to the cylinder, and they are arranged to enter on the fore and aft and athwartship centre lines. There are seven valves and an indicator cock in the cylinder covers. These valves are operated in the usual way by cams and cam levers. The cam shaft is driven from the crank shaft by helical gearing through a vertical shaft, with cast iron helical wheels and pinions. For the reversing mechanism and its operation, there are two scavenging cams operating four scavenging valves, and these are reversed by turning the cam shaft through approximately 30 deg. by extending the driving vertical shaft by means of a compressed air servo-motor. The fuel pumps, of which there are four—one for each cylinder—are operated by eccentrics from the cam shaft. The control of the engine is by means of one wheel and two levers on the starting platform; one lever controls the compressed air engine, which gives the cam shaft its angular displacement by raising or lowering the vertical driving shaft, and also gives the manoeuvring shaft its fore and aft movement. The other lever controls the fuel. A wheel, operated by hand, gives the manoeuvring shaft its rotary motion. The cams upon the manoeuvring shaft act upon the suction valves of the fuel oil pump. Hand control is also provided by the handle on the column, which actuates a shaft running fore and aft on the engine, and so sets all the fuel pump suction valves. Although compressed air is used for actuating the vertical shaft, causing the angular rotation of the cam shaft and the rotation and displacement of the manoeuvring shaft, hand gear, in emergency, may be used. This vessel on her regular route trip from Montreal to Port Arthur must pass, each trip, through some 30 to 40 locks, and this demands manoeuvring qualities far above the average, and that the engines must be capable of being stopped, started and reversed in a very short time. Stopping from full speed ahead was on trial accomplished in two or three revolutions of the main engines, and reversals from full ahead to astern took six seconds. A trial of manoeuvring was then made, and reversals were carried out from the bridge to correspond with the actual conditions in service of this vessel; 63 reversals were accomplished in 42 minutes, with more than half of the high pressure compressed air still unused. The auxiliary steam driven compressor was, of course, in use for this trial. The system of having one fuel pump for each cylinder makes for easy regulation of the quantities of fuel oils supplied, and so permits of a very slow speed of revolution. On the trial trip 46 revolutions a minute was the minimum attained; but when the final tuning up has been accomplished, and all cylinders at all speeds are developing exactly the same power, a minimum speed of revolution of about 35 revolutions will no doubt be achieved. No governor is fitted, as rough weather is not normally encountered, and the heavy fly wheel, some 9 ft. in diameter and about 7 tons in weight, is relied upon. The compressed air for the injection of the fuel oil into the working cylinders, and also for the starting of the engine, is supplied by a reversible three stage compressor. The compressor is an integral part of the Diesel engine, and as such is driven from the main engine. The compressor is bolted on to the bed plate at the forward end, and is driven by a pin off the crank shaft. The stroke is 8 in. (7¾ in. net), allowing for the ¼ in. auxiliary ports; and the diameters are:—Two low pressure cylinders, 15 in.; one intermediate cylinder, 9½ in.; and one high pressure, 4¾ in. The volume of free air per minute dealt with by this compressor is 6,200 litres, and it was noted on trial that the air was supplied cool. This compressor has multitubular intercoolers. The cooling water and bilge pumps are driven off the scavenging air pump links in the same way that these pumps are driven off the links of the air pump with mercantile steam engines. The cooling water from the cylinders and cylinder covers is led to a trough placed high up in the engine room, at which trough all discharges are visible. From there the water goes overboard. The auxiliaries are steam driven from a cylindrical donkey boiler, situated aft on the awning deck in the fore part of the engine casing. The boiler uses exactly the same kind of fuel as the main engines. The auxiliaries are:—the dynamo, auxiliary compressor, ballast pump, oil fuel pumps, three winches, a windlass, and steering gear. The auxiliary steam driven compressor is of half the capacity of the main compressor, and runs normally at 300 revolutions a minute. Air storage for starting purposes is provided by four welded steel bottles, of 23⅝ ins. diameter by 8 ft. long, and that for trial fuel injection by one bottle, 1 ft. in diameter by 3 ft. long. The pressure of the fuel injection air and the starting air is 850 lb. per sq. in. The time taken by the auxiliary compressor to fill up the air storage provided is about one hour. The remainder of the auxiliaries are similar to steam practice. The weight of the main engine alone is about 100 tons, and if the auxiliaries are included, all ready for work, 150 tons is the weight of machinery aboard. There is fuel storage in two oil tanks placed on both sides of the oil fired donkey boiler, and two ready use tanks are placed aft of the engine room, and are provided