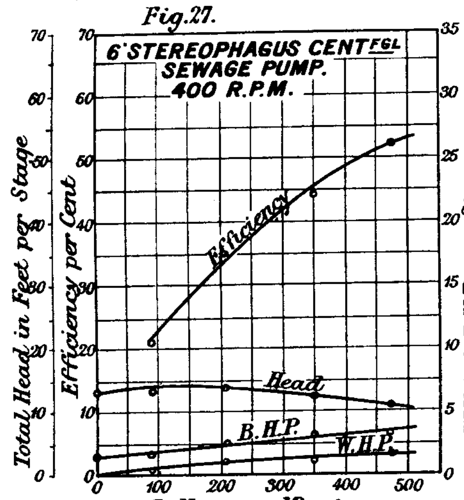
also with the necessary thrust-bearing. The main bearing is shown in Figs. 11 and 12, which illustrates what is practically the cover at the back of the pump. The bearing is grease-lubricated, under pressure. Unlike the ordinary centrifugal, the fluid forced through the pump does not leave the impeller at right angles to the spindle, but in a direction corresponding to the taper of the conical impeller. For this reason the whirlpool chamber (Figs. 13 to 21) is also set to this angle so as to minimise the resistance offered by the passage to the flow. Various sections of the whirlpool chamber, given in Figs. 16 to 21, show this, as do also Figs. 1 and 13.

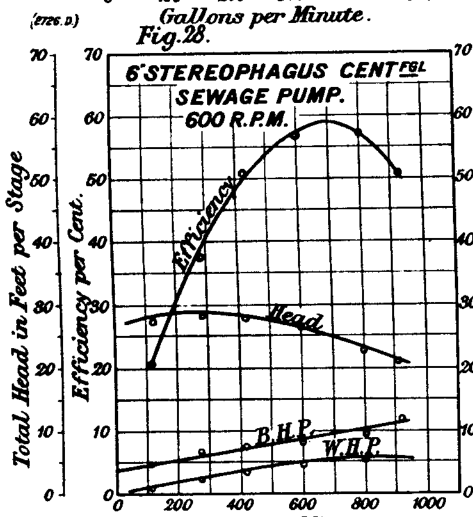
The impeller casing and inlet are shown in Figs. 22

Fig. 27.



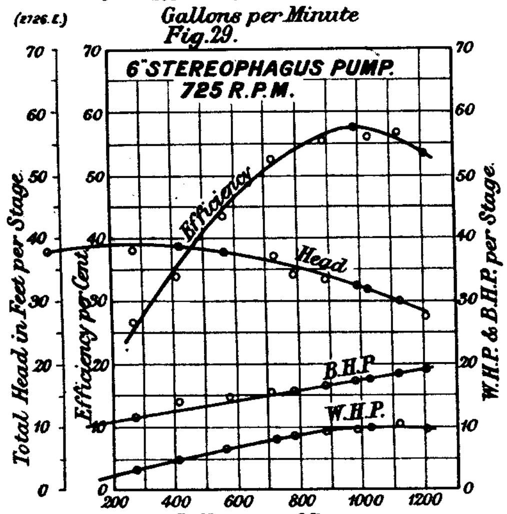
(2726.D)

Fig. 28.



(2726.E)

Fig. 29.



(2726.F)

and 23. This casting embodies several important features of the pump. In the first place, in Fig. 22, there is shown in the inlet passage, in dotted lines, a fin, which may also be seen in Fig. 1. This fin serves to guide the larger solid particles into a proper position on to the impeller blades. This casting is further provided with a knife-box, shown in section in Figs. 1 and 23, and made to receive the bevelled slanting blade and holder shown in Figs. 24 to 26, and in one of the half-tone illustrations. This blade is adjusted so as to be held only just clear of the revolving impeller blades. It can be forced in or out as it becomes worn, and may be locked in any desired position. By means of this blade the solids are cut into pieces of such a size as will pass through the pump. The arrangement of the knife-blade, &c., is rather different in the pump shown in Figs. 1 and 2 from that illustrated in the other figures.

In the cover illustrated in Figs. 22 and 23 there will, further, be seen to be a spiral groove facing the impeller. The object of this is that any substance which may become jammed between the impeller and the casing may slip into this groove and be cleared. The nose of the impeller is serrated in the pump shown in Figs. 1 and 2, but in that of which the impeller is illustrated in Figs. 9 and 10 it will be seen that alternate blades are cut down at the tip. The action of the pump is obvious from the above description. Solids are directed by the fin on to the impeller, the blades of which carry them round till they come in contact with the knife, which then slices bits off. The process is repeated, as in a turnip-cutter, until the whole is disposed of. The knife-blade is adjustable, as is also the impeller, which may be pushed forwards towards the impeller-cover as wear of the blades takes place, and the efficiency of the pump thus maintained. The wear of the knife and impeller blades is reported to be very small.

From a report of tests by Professor Capper, we gather that practically anything of the nature usually finding its way into drains will pass through pumps of this kind. It treats indifferently cotton-waste, wood-shavings, rags, ropes, pieces of wood, corks, brick, dead animals, pieces of sacking, clothing, &c. A report of the Pulsometer Engineering Company, Limited, at whose works these tests were carried out, states that an ash handle, a suit of overalls, and other solids passed through the pump, and that a ball of rope, waste, and rags so large as to completely plug the suction-pipe was also cleared and disposed of in a few seconds. A test was conducted using the same water, containing all sorts of rubbish, over and over again, until the liquid was churned into a mass, which very quickly completely blocked a screen of steel bars $1\frac{1}{2}$ in. apart. Yet the pump continued to deliver satisfactorily, and it is therefore evident that the usual substances found in unscreened sewage can be dealt with without difficulty, the above tests being of a very severe nature.

In Figs. 27, 28, and 29, we give diagrams showing the results of tests made at the Pulsometer Engineering Company's works on a belt-driven pump at different speeds. If allowance be made for the loss by the belt drive, and also for the fact that the point at which measurements were made on the discharge side of the pump was in the taper extension of the whirlpool chamber, where the velocities are comparatively high, instead of in the parallel length of discharge main, it is claimed that the efficiency would be fully 67 per cent.

There is a tendency for the impeller to work towards the front cover, so that provision is made more easily for the thrust than would be the case if the force were in the opposite direction. The adjustment of the impeller is also easily made by just slacking back the thrust collar.

Mr. Parsons has devised an automatic cut-in and cut-out arrangement, so that the pump when electrically driven may work without attention in small collecting stations in the sewerage system, and he has also devised a controller by which the speed of the motor is automatically varied by variations in the quantity of liquid to be pumped; by this means, in the case of a variable flow, both the pump and motor can be made to work at or near to their best efficiency, and a marked economy in energy can be effected when compared with the ordinary constant-speed pump working intermittently.

From the above it will be seen that the pump, although primarily designed for the pumping of sewage, is capable of application over a wide range of conditions, including all cases where a liquid has to be lifted containing solid or fibrous matter such as would tend to block any ordinary pump.

GAS-POWER FOR SHIP PROPULSION.*

By A. C. HOLZAPFEL, Associate.

DURING the last ten years, particularly after the introduction of independent gas plant for cheap power-gas, the feasibility of applying gas-power for ship propulsion has been in the minds of engineers and others. The difficulties, however, of carrying this into effect have been considerable, and relate partly to the vastly different conditions on board ship, and partly to the practical impossibility up to now of obtaining a reversible gas-engine.

Some seven years ago the late Mr. Emil Capitaine, of Frankfort, built a boat, suitable for fresh-water service only, fitted with gas-engines, and he read a paper on the adaptability of this method of ship propulsion before the German Institution of Naval Architects. Mr. Capitaine had obtained various patents in connection with gas-producers and gas-engines. This first vessel was a tug of small power, and the engine was not reversible; she therefore depended for reversing and manœuvring on a clutch gear. Mr. Capitaine's British patent rights were acquired conjointly by Messrs. Thornycroft, of Southampton, and Messrs. Beardmore, of Dalmuir; both these firms carried on experiments with Capitaine engines, and in particular Messrs. Beardmore built a gas-engine for sea-going purposes of 600 horse-power, which was placed on board H.M.S. Rattler. The engine was first tried on land, and the gas-plant at that time was intended to use bituminous coal; it was subsequently changed so as to use anthracite coal and coke, the Rattler also depending for reversing and manœuvring on a clutch gear. So far as I have been able to ascertain, the gas-engines and gas plant worked satisfactorily, but the clutch gear was unsatisfactory, and led to the abandonment of the experiment. Messrs. Thornycroft's experiments led to a similar result.

Mr. Capitaine founded in Germany a small company, and established works for building gas-engines and gas plant near Düsseldorf, where about a dozen engines of from 30 to 100 horse-power were built, and placed on vessels on the Rhine and other rivers. All these engines had several cylinders and were vertical; they were non-reversible and were fitted either with clutch gears or reversing propellers. One of the engines built by Mr. Capitaine's company was used for sea-going purposes; it was ordered by Mr. Walter F. Becker, of Turin, Italy, for a tug to run in the harbour of Genoa, Italy; it had three cylinders and was of 90 horse-power. After some apparently satisfactory trials, so many difficulties were encountered in connection with the working of this vessel that the experiment was abandoned and the vessel sold. A like fate happened to most of the other vessels which were supplied by the Capitaine Company of Düsseldorf, although it is possible that some may still be running. At any rate the departure was not a sufficient success to warrant a development towards larger powers. Engines of the type supplied by Mr. Capitaine would have been practically useless for large sea-going vessels, unless they had been fitted with some electric or other transmission arrangement, enabling reversing to take place, and lower speeds to be used, as clutch gears and reversing propellers with more than 300 brake horse-power are believed to be impracticable. Mr. Capitaine died about four years ago in Brussels, at a comparatively early age, a disappointed man.

Several canal boats with gas-engines of small power have been run on German and Dutch canals; these are also fitted with clutch gears or reversing propellers. Two or three small cargo boats of 60 to 70 tons have recently been built in America similarly fitted, but their work is chiefly in estuaries and rivers, so they cannot be called sea-going vessels.

I have still to mention the Carnegie, fitted with auxiliary gas-engines of 150 horse-power. She is the only sea-going gas-driven vessel which was built before 1911. The Carnegie is also fitted with a clutch gear; particulars of her performance are not in my possession.

About October last a sea-going vessel of 560 tons dead-weight capacity, called the Zeemeuw, started in Holland. This vessel has twin-screw engines of 150 horse-power each, and an anthracite coal-gas plant. The engines are reversible by compressed air. I understand she has made nine trips, chiefly between Rotterdam and Great Yarmouth, and the owners inform me that they are satisfied with the economic results.

They have come across some technical difficulties in connection with the producers and lubrication of the gas-engine, particularly in regard to the formation of slag on the fire-brick lining of the producers, and they are now fitting new producers, in which they hope to obviate its formation. It will be seen in the latter part of this paper that I have also experienced the same difficulties. The owners, Messrs. Vermeer and Van Den Arend, of Rotterdam, inform me that in other respects they have every confidence in the success of the new departure.

Being unable to obtain reversible engines, the prospect of introducing this motive power for large sea-going vessels some two years ago seemed to me comparatively remote, and the only means of reversing and manœuvring high powers and speeds at that time appeared to be by electric transmission. This system, while practicable, has, however, certain disadvantages, which are the following:—

(i) A loss of power in transmission of 20 per cent. to 25 per cent.

(ii) A very considerable additional weight to be carried in the form of dynamo and electric motor.

(iii) A large additional cost for dynamo and electric motor, and very expensive switching gear.

(iv) The danger connected with having a very large amount of electric power on board an iron or steel vessel.

In November, 1909, Professor Föttinger, at that time one of the engineers of the Vulcan Engineering and Shipbuilding Works at Stettin, read a paper before the German Institution of Naval Architects, describing his hydraulic transformer, which was brought out particularly for the purpose of using high-speed turbines in comparatively slow vessels; that is, for reducing the number of revolutions of a high-speed turbine to the required revolutions of ships, and also for reversing engines up to the largest powers.

Compared with an electric transformer this hydraulic transformer possesses many advantages. These were appreciated by the Holzapfel Marine Gas-Power Syndicate, who acquired the British rights of the transformer for gas-engines from the Vulcan Company and built an experimental sea-going vessel, the Holzapfel I., in order to test the adaptation and installation of gas-power on board a sea-going ship, and in particular to test the transformer with gas-engines. In deciding upon the size of the vessel the owners were guided by the following considerations:—

Firstly, a small vessel of 300 to 400 tons, such as the

* Paper read before the Institution of Naval Architects, March 28, 1912.

GAS-POWER FOR SHIP PROPULSION.

Fig. 1. GAS-DRIVEN SINGLE-SCREW SHIP "HOLZAPFEL I." DIMENSIONS 120' 0" X 22' 0" X 11' 6".

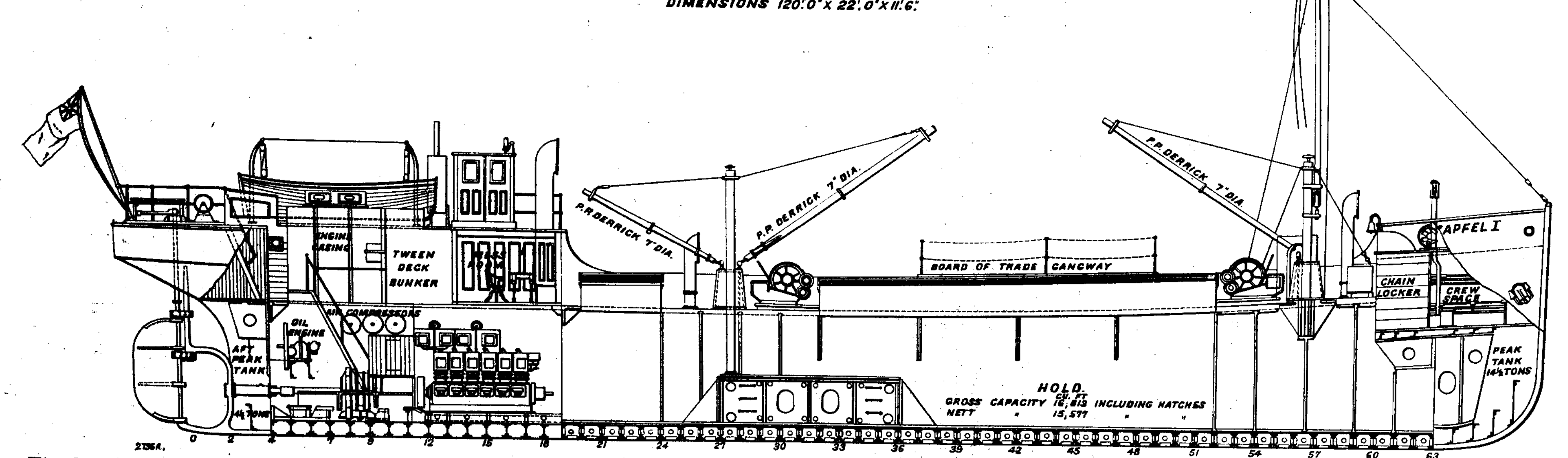
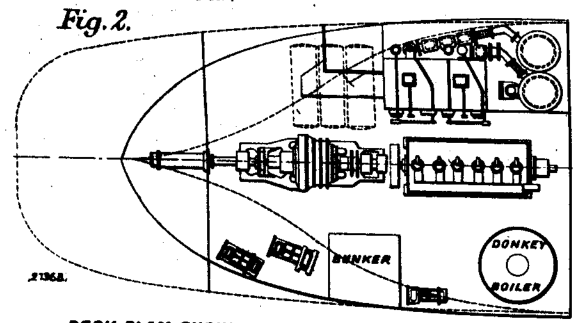


Fig. 2.



DECK PLAN SHOWING POSITION OF GENERATORS, ETC.

Fig. 3. HOLZAPFEL II. GENERAL ARRANGEMENT OF 800 B.H.P. PLANT IN 2 UNITS OF 400 B.H.P. EACH.

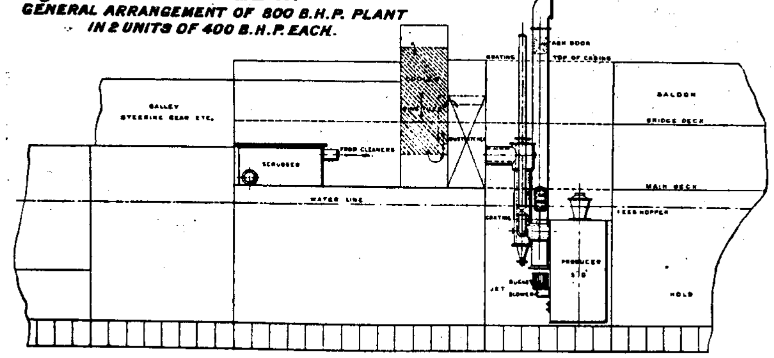


Fig. 4.

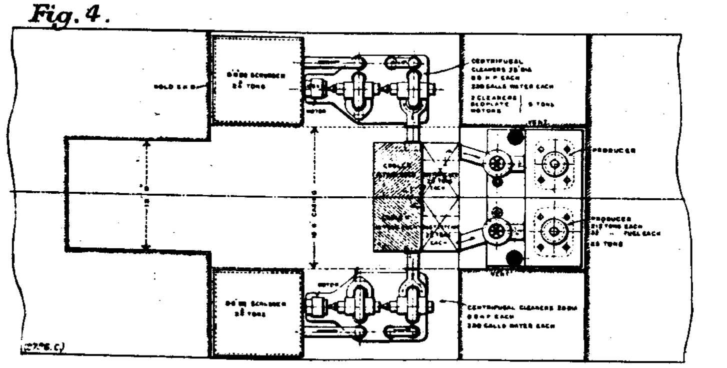
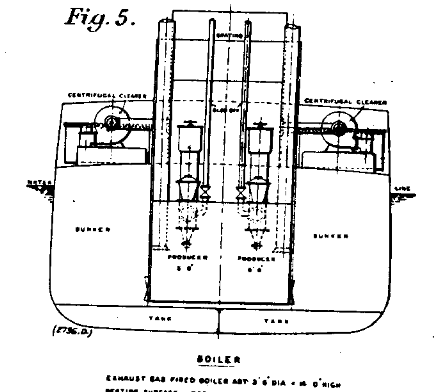


Fig. 5.



Holzapfel I., is used only for short voyages, and therefore comes into port every three or four days; as a consequence she is more suited for repairs and alterations than a vessel which has to make longer voyages.

Secondly, the initial cost of the experiment would be reduced to the lowest practicable figure for a vessel of commercial size.

Thirdly, the sea-going conditions in a small vessel are much more severe than in a large vessel, and as a result the gas plant and gas-power installation in a 300-ton vessel will show most readily all the defects which are likely to manifest themselves in a large vessel.

Fourthly, the Holzapfel I. is a vessel of a particular commercial type, the coaster, as far as size is concerned.

Fifthly, as far as the transformer is concerned, it is not suggested that vessels of the size of the Holzapfel I. need necessarily be fitted with an hydraulic transformer, as it is not impossible to have either a reversing propeller or a clutch gear in vessels of 180 horse-power (which is the power of the above ship); but it was considered that the installation as a whole was one which would be applicable to vessels of the largest size and power, and in this respect the installation is absolutely unique.

Sixthly, it was recognised that, in case of the general introduction of gas-engines for marine purposes, it will be necessary to use bituminous coal instead of anthracite, but the owners decided to leave the introduction of a gas plant for bituminous coal for a second experiment, believing that the task attempted in the Holzapfel I. was sufficient for a first experiment.

The vessel under notice has the following dimensions:—Length, 120 ft.; beam, 22 ft.; depth, 11 ft. 6 in. Her gross register is 291 tons, and her net register is 149 tons, and she carries 370 tons dead-weight on Lloyd's summer freeboard.

Reverting now to the machinery installed on board the vessel, we have to deal, in the first place, with the gas plant, which was built and supplied by the Power-Gas Corporation of Stockton-on-Tees. It consists of two producers, 3 ft. 6 in. square and 6 ft. 6 in. high, and of two scrubbers, 13 ft. high and 2 ft 6 in. in diameter. Exigencies of space on board so small a vessel forced the owners to agree to a somewhat cramped position for the gas plant, which, as will be seen from the illustrations above, is situated in the engine-room on the port side. The arrangement as it exists on board this vessel is probably the only one, so far as the producers are concerned, which could be adopted on a vessel of her size with engines aft.

These are placed on a platform 3 ft. 9 in. high, and they form part of a closed-in gas space, which is accessible by a gas-tight door from the engine-room, but is not supposed to be entered, except in case of urgent need, while the vessel is under power. The working of the producers, such as blowing-on, and the working of coal cocks is by levers from the engine-room. The only openings to the engine-room are the blowing-on cocks, which can be shut by a slide, and four air inlets, which are only open while the gas plant is under suction.

The producers are lined inside with fire-bricks: they were originally connected with the scrubbers by horizontal pipes entering the scrubbers at the base. The scrubbers were filled with coke to a depth of 6 ft.; sea-water from a tank on deck trickles down through this coke and serves to cool the gas and to free it from any dust which may enter from the producers. Above the coke is a space containing wood wool as a further means of cleaning the gas. The cooling water is discharged into a tank underneath the scrubbers, whence it is pumped overboard by a drum pump running by a belt from the main engine. Originally a centrifugal pump was fitted for this purpose, but it was found to be quite useless, and had to be changed for a drum pump. Steam vapour is supplied by eight flash boilers inside the producers, and fresh water has to be supplied for this purpose, and this is carried in the after-peak tank. In order to be able to use sea-water a new type of vaporiser has been designed, by which sea-water can freely be used, and this will be fitted to the exhaust in the early future.

I may here state that a sufficient supply of steam vapour—*i.e.*, 1 lb. of water evaporated for every pound of coal used—is essential, not only for the quality of the gas, but also to reduce the formation of slag in the producers.

The vertical gas-engine is by Messrs. E. S. Hindley and Sons, of Bourton, Dorset. It has six cylinders, 10⅞ in. in diameter and 10 in. stroke; it is designed to run at 450 revolutions per minute. It is a similar engine to the type now manufactured by several gas-engine builders for the purpose of working electric dynamos, and, in so far as it works on the hydraulic transformer, its task is practically identical with that of other vertical gas-engines on shore. The engine has forced lubrication and low tension magneto, and also Lodge ignition.

As regards the transformer, sufficient has already appeared in the technical press to obviate a general description of it. Roughly speaking, it consists of two centrifugal pumps driven by a main shaft attached to the gas-engine and two turbines, one for going ahead and one for going astern, mounted on a secondary shaft. Either of these centrifugal pumps delivers water into its turbine, according to the movement of a lever, which is fixed a little distance abaft the gas-engine. By a simple movement of this lever from forward to aft the revolutions of the propeller can be instantly changed from full speed ahead to full speed astern. While the lever stands in the middle there is no load on the engine, and the propeller remains stationary. The time required when going full speed ahead till the propeller moves in the reverse direction is about 4 seconds. Between the transformer and the gas-engine is fixed a small centrifugal pump driven by a bevel gear from the main shaft and absorbing about 3 horse-power. This pump is to pump back such water as may be lost by leakage in the transformer, and the water so lost is again replaced from the tank underneath the transformer into which it leaks.

This small pump runs on a ball-bearing, and, as originally fitted, the ball-bearing was either defective or of insufficient strength. As a result, while the vessel was on her voyage the ball-bearing was destroyed, and she had to put into Scarborough, where another ball-bearing of larger size was fitted. This has given entire satisfaction, and on examination in October last it proved to be in perfect condition. Altogether the transformer has since done its work in an entirely satisfactory manner. There is no appreciable heating of the water in the tank, and from this fact it can readily be concluded that the loss of power in the transformer is very small. Experiments on the test plate before delivery proved it to be from 11½ to 18 per cent., including the loss from the auxiliary pump. The transformer drives the propeller at about 120 revolutions per minute.

The vessel had her trials during the end of April last, and they unfortunately terminated in a collision with another vessel. After the repairs she proceeded on service, and has since carried the following cargoes:—

Tyne to London, 242 tons of coke.
London to Llanelly, 330 tons of scrap-iron.
Llanelly to London, 330 tons of lime.
London to Cork, 330 tons of hard-wood and cement.
Cork to Newhaven, 251 tons of oats.
Guernsey to London, 340 tons of granite.
London to Tyne, 340 tons of chalk.
Seaham to Morlaix, 331 tons of coal.
Guernsey to Weymouth, 331 tons of granite.

The consumption of anthracite coal during these runs varied between 25 and 35 cwt. per day of 24 hours, and was about one-half of that of steamers of similar power.

During this period several faults manifested themselves in connection with the machinery, and particularly with the gas plant; among them I should mention that the horizontal connecting-pipes between scrubbers and producers several times got filled with water, when the ship was by the stern, which shut off the gas from the engine and caused a sudden stoppage. As a consequence this pipe was altered so as to slant downwards from the producers to the scrubbers.

The coke in the scrubbers, moreover, was found to gradually pulverise, and it ultimately choked the outlet, so that the water rose, and even came into the producers, putting out the fires. Since that time earthenware tubes, of a design giving a maximum of surface, have been placed in the scrubbers as a substitute for the coke.

The firebrick lining of the producers was frequently covered with slag, and when this was removed the fire-bricks were injured. I have suggested that interlocking blocks of steatite would be a good substitute for firebrick, as I am of opinion that slag will not adhere to this, and an experiment for putting a partial steatite lining into one of the producers is now being made.

The two levers for opening the exhaust valves of the producers were originally on the port side of the engine. It happened several times that in cases of sudden stoppage of the engine, burning gas came from the producers into the engine-room, when it was difficult, on account of the gas flame, to get at the levers of the exhaust-valves. In order to avoid this, the shafts of the exhaust-valves have been brought right across the engine to the starboard side, and so arranged that both valves can be opened by one movement. I consider it essential that such or similar arrangements should be fitted to future gas-driven vessels.

The Lodge ignition, as originally fitted, and having wax as an insulating material, was found unsuitable on account of the high temperature prevailing in the engine-room, and a new design of ignition, specially adapted for the vessel, is now being fitted.

Another interruption in the working of the vessel was caused by the shifting and breakage of one of the oil-pressure pipes. This happened at a very inconvenient time, in very heavy weather, and caused some danger to the vessel. The oil-pressure pipes are now being placed into deep grooves, and very securely fixed into position so as to preclude the possibility of a similar accident.

In other respects the gas-engine has worked with fair regularity, but the power given with anthracite gas is probably nearer 160 than 180 horse-power, the power guaranteed by builders, which guarantee, however, was for gas of 140 B.T.U. The transformer has been in every way satisfactory.

It will be seen from the foregoing that the experience with this vessel has shown many essential points in regard to which the practice of gas-plant on shore will have to be altered for marine purposes. I am of opinion, however, that a great deal of valuable experience has been gained, and that, with the alterations now made, the vessel will be able to do her work in a regular and satisfactory manner.

Of course the Holzapfel I. is an experimental vessel, built in order to enable the owners to see which arrangements would be the most practicable for large sea-going vessels, and, although she has proved herself a successful vessel, capable of competing against steam-driven vessels of her size in the coasting trade on account of her very low consumption, the main purpose of the owners has been to evolve from the experience of this vessel a design for ships of large size to be driven by gas-engines. In this connection many important considerations have to be taken into account. First, in regard to the gas plant, it would be absolutely essential in a large vessel to use bituminous coal, as anthracite coal is not readily obtainable at many foreign coaling ports; moreover, the cost of anthracite is so considerably in excess of the cost of bituminous coal that economical considerations come into account here. Lastly, the gas derived from bituminous coal in British thermal units is of higher value than the gas derived from anthracite coal.

It will therefore be seen that with an engine of given size, fed with gas derived from bituminous coal, a larger power will be derived. So far as I am aware no gas plant driven with bituminous coal has hitherto been used at sea, but the illustrations on page 447 show arrangements for placing a bituminous gas plant of 800 horse-power on board ship. The producers stand in the bottom of the ship, in a separate compartment covered by gratings; the tops of the producers, which are each of 400 horse-power, are level with the main deck, the intention being to draw the coal out of a 'tween-deck bunker. An electric hoist could be fitted to lift coal from the lower bunker into the 'tween-deck bunker, so as to bring it on a level with the top of the producers. The coal in this case will be fed into the hoppers by hand, and the usual arrangement of ball seals to cover the four openings for stoking in each producer will be fitted. In order to make this absolutely gas-tight, hinged caps will be fitted over the balls, and screwed down when no stoking is being done. From the producers the gas passes into the coolers, or wet scrubbers; these are filled with earthenware rings, fitted tightly into position. These scrubbers will be about 15 ft. high and about 3 ft. 9 in. in diameter; the uppermost portion of each has a tank which will be fed with sea-water by a pump from the engine-room. The scrubbers are placed on the main deck and discharge the cooling water overboard on either side by gravitation. From the coolers or scrubbers the gas is drawn by centrifugal tar-extractors (driven electrically) formed as fans; these force the gas under pressure through the dry scrubber to the engine.

A very large number of centrifugal tar-extractors are at work in connection with gas plants using bituminous coal, and they do their work to absolute perfection, giving clean gas free from any tar. Attempts to dispose of the tar by other means or to gasify it have, however, been attended with many failures.

Coming now to the gas-engine, there are various considerations to be taken into account. Naturally, with an experimental form of engine, the twin-screw system offers additional security. It also has the advantage that engines of considerable power can be fitted in a vessel without piston cooling, thereby saving considerably in first cost and weight. At present, engines with cylinders up to 22 in. in diameter are being built without piston cooling; but this should be considered the outside limit. Some air cooling by a fan to the crank-chamber, and driving cold air through it, is contemplated, and this will no doubt assist to keep the working parts of an engine at a suitable temperature. Two types of vertical engines are being built, those with tandem cylinders and those with a single row of cylinders; the former having the advantage in saving space; the latter are, perhaps, more accessible for repairs. A tandem engine with six cranks can no doubt be built up to 1800 horse-power without water-cooling of pistons, and two such engines would be sufficient to drive a vessel of 15,000 tons displacement at 10 knots speed. The stroke of gas-engines is generally limited to a piston speed of about 800 ft. per minute, and engines such as have been considered suitable, and of the size not requiring water-cooling of pistons, will run at about 250 to 320 revolutions per minute.

In order to reduce the vibration to a minimum, engines of six or more cylinders are desirable. Mr. Milton's paper last year showed diagrams giving a distribution of pressure which speak eloquently in favour of six or more cylinders. The vibration of the engine as observed on the shaft leading to the transformer of the Holzapfel I. was not inconsiderable, so that at first the bearing between gas-engine and transformer showed signs of heating; forced lubrication was subsequently fitted to this bearing with satisfactory results, and this would no doubt be desirable with larger powers. A bearing of considerable size, moreover, will be needed in order to prevent undue vibration in the transformer.

As regards the Föttinger transformer, about 85 per cent. to 90 per cent. of the original brake horse-power of a prime mover of 800 brake horse-power can be transmitted to the propeller shaft if the revolutions are reduced from about 270 of the prime mover to 100 of the propeller. The weight of the transformer and water would be about 13 tons. The cost of such a transformer is only double that of a transformer of 150 horse-power; the greater the power the lower the cost per horse-power, and the higher the efficiency the greater also the saving in weight as compared with steam-engines and boilers.

While it cannot be said that the experiment of the Holzapfel I. has so far been a complete success, owing partly to several avoidable accidents, as, for instance, two collisions, which were in no way due to the machinery on board, and while it must be confessed that in consequence of these accidents an undeserved prejudice has probably been created in the minds of the public and of underwriters, making the economic insurance of future gas-driven vessels somewhat difficult until a continuance of regular and steady work has created a new confidence in the system, it must be admitted that the experiment has so far practically demonstrated the feasibility of using gas-engines at sea in conjunction with the hydraulic transformer. It has also shown the weak spots in gas plant as hitherto used on shore, and what is necessary to adapt it for sea-going purposes.

The fact of our almost unlimited coal supply, and the cheap price of this fuel in Great Britain as compared with liquid fuel, makes the introduction of marine gas-power particularly desirable in this country, not only from economic, but also from national considerations.

Compared to the triple and quadruple-expansion steam-engine of the present day, the gas-engine is still an imperfect piece of mechanism, and there is an almost unlimited scope for improvement and economy in a gas-plant, gas-engines, and gas-turbines.

So far the most perfect steam machinery has been evolved by the marine engineer, and I venture to hope that by this experiment the interest of marine engineers may have been aroused, and that the day is not far distant when their concentrated energy and intelligence will have so perfected marine gas plant and gas-engines, as to bring about their general introduction, with the resulting great saving of coal fuel—the most important national asset of this country.

I should mention that Mr. Max Holzapfel, of Newcastle-on-Tyne, shared with me the financial risk of this experiment, and that I was assisted in the design of the vessel and machinery by Messrs. H. A. B. Cole and T. W. Cherry, who also superintended the construction and installation of the machinery on board. Lastly, I have to thank the Vulcan Company, of Stettin, for their generous help and assistance at a time when difficulties gave us considerable trouble, and the Power-Gas Corporation, Limited, for their unfailing help in contending with the various difficulties which arose.

RESULTS OF TRIALS OF THE DIESEL-ENGINED SEA-GOING VESSEL "SELANDIA."*

By I. Knudsen.

On December 5, 1910, the East Asiatic Company, of Copenhagen, placed an order with Messrs. Burmeister and Wain for two vessels of the following dimensions:—Length between perpendiculars, 370 ft.; breadth, 53 ft.; and depth, moulded to upper deck, 30 ft. The two vessels are fitted with Diesel engines, having a total horse-power of 2500 indicated horse-power, divided between two propellers, and there are further two auxiliary motors, each of 250 indicated horse-power. The first of these vessels has been given the name Selandia, and her trial trips have recently taken place. A short description of the motors and a statement of the results obtained may therefore be of some interest.

The main engines are eight-cylinder Diesel motors, working on the four-stroke-cycle system; the number of revolutions at normal speed is 140 per minute. The starting in either direction takes place by means of compressed air. The cam-shaft from which the valves are moved is so arranged that it can be displaced lengthwise after all the rods, with the rollers connected to them, which lift the valves, have been removed from the shaft

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