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Reply to Discussion on the Internal Combustion Engine for Marine Use.

By Mr. W. R. CUMMINS (Member).

Mr. Cummins: My task in replying to the adjourned discussions on the paper read at the Japan-British Exhibition in June last, is a comparatively easy one, as the concensus of opinion seems to be that the internal combustion engine in some form, will, in the future, and perhaps the near future, displace the steam engine on board ship. As has been pointed out, gas and oil engines are in use to a certain extent on trawlers and other fishing boats, while a large number of barges and canal boats have been fitted with the same class of engine. The next step will probably be the adoption of the new power for the ordinary tramp steamer, and I notice in this connection that a vessel fitted with internal combustion engines under the supervision of the British Corporation Registry has completed successful trials on the Tyne, and will shortly start on her maiden voyage. Some name must now be found for this new type of vessel. Obviously they cannot be called "steamers." They might be called "gassers."

I note that in Mr. Timpson's experience of oil engines he has found that, for small powers, the two-stroke engines are giving more economical results than the four-stroke. He, however, agrees with Mr. Durtnall's contention that for large powers the four-stroke is more economical than the two-stroke. Among the largest gas engines manufactured in this country are those produced by Messrs. W. Beardmore & Co., who use the Oechelhauser system, which is a two-stroke engine, with separate pumps dealing with the gas and air, and giving an impulse every revolution.

A very high economy is obtained with these engines, viz., 1 lb. of bituminous fuel of 13,500 B.T.U. calorific value per B.H.P. hour. This is with a gas-producer efficiency of 72 per cent. I do not know of any four-stroke engines using bituminous fuel which can better this performance.

The reason why this economy can be obtained is that special means are taken to positively scavenge the power cylinder, and the separate gas and air pumps supply a definite unvarying volume of mixture. The scavenging air is admitted before the gas, and forms a buffer between the latter and the hot exhaust gases. By this method no gas can be lost through the exhaust ports.

Mr. Timpson says that a pump is not necessary for the two-stroke engine. A pump or its equivalent is necessary to charge the power cylinder during the time the crank is passing over its bottom centre. In many cases the bottom of the power cylinder is used as a pump, and the crank chamber as a receiver. This type is illustrated very clearly in Mr. Durtnall's paper. This is a radically bad system, as the incoming mixture is in contact with the hot exhaust gases, and there is bound to be some loss of gas through the exhaust ports, in spite of the deflector on the piston, which naturally gets red hot and makes a very undesirable igniter. The only merit of the engine is its cheapness and its valvelessness. I wish to again emphasize the fact that if a two-stroke engine for marine use be designed on such lines as, for instance, the well known Oechelhauser system I have just referred to, then its thermal economy must be equal to or superior to, the four-stroke engine. Cheap but inefficient designs will not be accepted by marine engineers; a little extra complication can be afforded to secure efficiency, seeing that many of the complications of the steam engine will be dispensed with, such as the boiler, the condenser, the air pump and the feed pump.

With regard to the use of compressed air for working the deck machinery, I notice that Mr. Timpson has seen air driven winches and capstans on board fishing boats.

They were uneconomical, no doubt, on account of the air being used after it had lost all its heat of compression. Where air is so used and it is attempted to use it expansively, trouble arises through the freezing of the contained moisture, the ice formed interfering with the action of the valves. For use in winches, however, only a small rate of expansion is required, and the efficiency of the process can be increased considerably by utilizing the waste heat of the exhaust gases to reheat the air after compression.

The two-stage compressor would have an inter-cooler, and perhaps water injection to keep down the temperature of compression to as near the isothermal as practicable, thus diminishing the work of compression. After compression the air would pass through a heater before going on to the winches, or to the starting valves for the main engines.

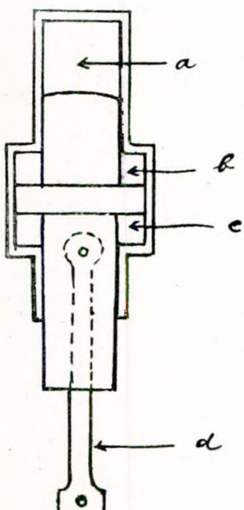
A similar system of heating the air by petrol is now used for the compressed air engines driving torpedoes, with a marked increase of efficiency.

With reference to Mr. Shackleton's remarks, the long exhaust pipe referred to in the paper is still used by Messrs. Crossley Bros. It is a cheap method of scavenging. Other makers, for instance, the Premier Gas Engine Co., and Messrs. Beardmore with their Oechelhauser engine, use an air pump. It is true, as Mr. Shackleton says, that builders of gas and oil engines for land use have paid little or no attention to cushioning. It has been pointed out *ad nauseam* that land engine practice must be modified to suit marine conditions, and one of the first modifications to be made must be the abolition of the enormous fly-wheel used on gas engines for land use. This means that every effort must be made to improve the crank shaft torque. The adoption of the two-stroke engine is a big stride in the right direction, and the system of cushioning the down strokes is an additional help towards the same object. We do not want to go back to the Holt engine of many years ago, with its single crank and large fly-wheel.

By cushioning the down stroke, the cylinder is made partly double acting; approximately, one-quarter of the power of the down explosion stroke is bottled up in the air forming the cushion, and this power is given back on the up stroke. In addition to this, the cushioning cylinder is utilized for driving the engine with compressed air when starting and reversing. This keeps the starting air and its valves, etc., separate from the power cylinder and the pump, so that these latter can take up their functions as soon as the compressed air sets the engine away.

The only addition to the usual number of parts of a two-stroke engine, which consists essentially of a power cylinder and a pump, is an end closing the bottom of the pump cylinder.

The sketch herewith gives a rough idea of the system proposed.



(a) Power cylinder: (b) Mixture pump; (c) Cushioning and scavenging end of cylinder, also used for compressed air for starting and reversing; (d) Connecting rod.

Engineers have not developed the cushioning system for land gas engines, because in the usual four-stroke engine a large amount of fly-wheel power is necessary in any case, and cast iron in the form of a fly-wheel is very cheap. After what I have said above about the Oechelhauser engine, I cannot agree with Mr. Shackleton's assertion that the two-stroke engine is bound to lose a portion of the new charge by the scavenging arrangements. If a portion of the charge were lost, the engine could not give such economical results as it undoubtedly does.

With regard to the comparative weight of the two-stroke and four-stroke engine, if the two-stroke has the same compression pressure, and same strength of mixture and runs at the same speed as the four-stroke, it is self-evident that the weight of the two-stroke must be about one-half that of the four-stroke. I do not quite understand Mr. Shackleton's suggestion as to the middle propeller and turbine. Does he propose to generate steam from the exhaust gases of the wing gas engines and use this steam in a reversing turbine? This is what I gather from his remarks in the discussion of October 17. If so, it is not clear how steam can be raised or generated, unless the gas engines are kept going, and as they presumably run in one direction only, it is difficult to see how manœuvring can be effected, unless the boiler is also hand fired. But in any case the proportion of power available from the exhaust of the gas engines is not sufficient for full speed astern purposes. I can sympathize with Mr. Robertson's and Mr. Newall's feelings in regard to the reliability of the gas engine. I have seen a good many gas engines on land that I would not care to be shipmates with, but on the other hand, I have seen steam engines on land to which the same remark would apply.

A great deal of this feeling of distrust will disappear when a thorough knowledge of the working of the gas engine is diffused, and the design is in the hands of marine engineers.

With regard to Mr. Newall's fears about the odours given off by crude oil and paraffin, there are hundreds of steamers using crude oil to generate steam in their boilers, and a large number of H.M. warships are now fitted with means for using oil fuel, which is stored in the double bottom. Proper precautions are, of course, taken to avoid risks of explosion, and there is no more danger from this than there is in coal bunker explosions.

As regards the products of combustion, they will be discharged up a funnel same as in a steamer, the only difference being that only half the amount of products will have to be dealt with, as the amount of fuel burnt will be practically one-half the amount of coal used. I say "used" intentionally, as a good deal of the coal put in the furnace goes up the funnel.

You can hold a sheet of note paper over the exhaust pipe of a well designed gas engine, and it will not be soiled, but you could not write a billet-doux on a sheet of note-paper which had been held over the funnel of a coal-fired boiler.

As regards the comparative weights of steam and gas engine plants, I cannot just yet give any definite figures, but the saving on weight and space occupied in the case of oil fuel is very great, somewhere about one-half, and the whole of the space now occupied by the boilers and coal bunkers of a steamer can become cargo space, as the oil will be carried in the double bottom.

Another point Mr. Newall raises is that of the heat of the cylinders. Perhaps he is not aware that the whole of the surface exposed to the heat of combustion is water-jacketed, the temperature of the outlet water from the jacket being about 150° F. This is the temperature of the surfaces radiating heat into the engine room. In the case of steam of 200 lb. pressure the temperature is over 380° F.

In a steam engine, of the total heat generated 25 per cent. goes up the funnel, 75 per cent. travels through the pipes, valves and cylinders up to the condenser, about 12 per cent. being turned into work, and the remaining 63 per cent. goes overboard with the circulating water.

Ordinary ventilation will be quite sufficient. Mr. Newall is, no doubt, aware that gas engines are used in submarines when running on the surface, and their engine rooms are not ideal as regards ventilation. When on the subject of unpleasant temperatures, that of the stokehold of a steamer in the Red Sea, in the hot season, may be instanced. As regards Mr. Newall's query as to the limit of power of gas engines, the following are the powers obtained from a single-cylinder in some examples of land work—

Oechelhauser: 1,500 B.H.P. at 95 revs.; cylinder 42 in. dia., 51 in. stroke (two-cycle).

Snow Steam Pump Co.: 1,350 B.H.P.; cylinder 52 in. dia., 60 in. stroke (four-cycle).

Richardson's Westgarth: 400 B.H.P., 100 revs.; cylinder $39\frac{1}{2}$ in., dia. $43\frac{1}{2}$ in. stroke (four-stroke).

Koerting: 400 B.H.P., 107 revs.; cylinder $21\frac{1}{2}$ in. dia., $39\frac{1}{2}$ in. stroke (two-stroke).

Crossley: 350 B.H.P., 105 revs.; cylinder 38 in. dia., 39 in. stroke (four-stroke).