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Lecture on Lighthouses.

BY MR. G. J. WELLS (Vice-Chairman of Council).

Tuesday, December 7, 1920.

THE interest attaching to this subject was enhanced by the excellent lantern views shown embracing the historical as well as the technical side, and tending to give a clear conception of the important part played in the navigation of coast lines by lighthouses.

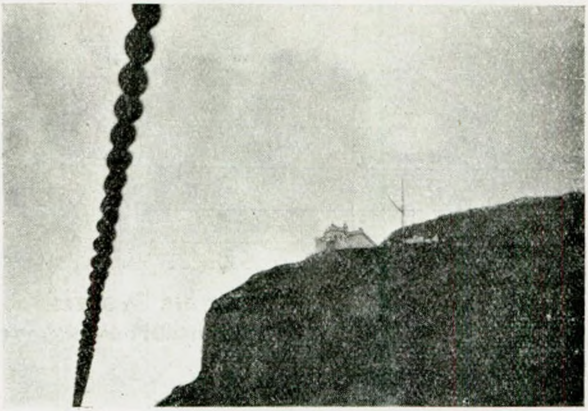
Passengers during a voyage sometimes manifest curiosity concerning the methods employed by the Captain in the determination of the ship's position and the course to be set in order to reach port; but probably all are more keenly interested in the buoys, beacons, and lights that mark the coast-line, shoals, etc., which indicate the safe route in or out of harbour.

Dealing only with the question of lights the lecturer showed by means of some 40 to 50 lantern slides the gradual development of the modern lighthouse from the earliest beacons employed by the ancients. In these early attempts the light was due to a fire maintained at the top of an eminence during the hours of darkness, and may be regarded as simply a beacon light. This would have the defects due to varying lightness on account of the need for adding fresh fuel and of varying quality at intervals; also irregularities due to the varying conditions of the elements acting on the fire, each of these causes adding its quota to the uncertainty of its visability on stormy nights where its value would be at a maximum to the sailor.

On outlying rocks the brightness of such a light could not be maintained even in fine weather, and to mark this class of danger spot a different form of light tower was found to be absolutely necessary. To illustrate the evolution of the modern tower, slides illustrating the successive towers at the Eddystone rock were placed on view. These slides showed how the early workers were forced to realise the immense strains imposed upon a tower by the impact of heavy seas during storms and tempest leading on to the final solution of the difficulty by the monolithic type of construction, due to Smeaton. The causes leading up to the building of a new Eddystone tower, which

Cromer, Norfolk, Headland Type, Catoptric Light.

was designed by Douglas, were discussed and illustrated. The difficulties encountered in the building of a lighthouse were illustrated by reference to the methods adopted in the building of a tower accessible to the shore, such as the Beachy Head light; and the building of the Eddystone tower showed the course adopted when dealing with a tower at sea. A series of photographs illustrated heavy seas, one exhibiting the damage done to the pier at Tynemouth when huge masses of masonry were broken, turned over and moved considerable distances; these bore eloquent testimony to the character of the strains which lighthouses are called upon to withstand during their construction as well as after completion.



Great Orme's Head Lighthouse.

Passing on from the building of the lighthouse, the next consideration requiring serious attention was the character and nature of the illuminant employed. It was interesting to notice that the slide showing the light used in Smeaton's tower was a candelabra supporting a few candles. Smeaton actually employed a clock to call the time for "snuffing" the candles, and this clock has been preserved. Oil lamps, gas and electric lights have each in their turn been employed. Several slides showed how the intensity of the light varied in every direction around the illuminant, so that when it is remembered that only the horizontal rays can possibly reach the horizon, it was made evident that there was inevitably a great loss of light energy from any tower. To meet this trouble, reflectors and lenses were introduced, and succeeding slides showed how the many rays could be caught and bent into the horizontal plane, thus increasing the power of the light, without incurring the use of more powerful illuminants.

Having traced the necessity for and the value of lens systems in the economy of lighthouses, the next development was a scheme for the ready identification of adjacent lights, based upon the principle of the Morse alphabet, *i.e.*. short and long flashes of light arranged so that the identity of a light could not remain in doubt. To obtain these distinctive characteristics the system of lenses employed had to be modified, and to make this quite clear, diagrams of the light at the Eddystone were shown and explained; also a model was shown in action

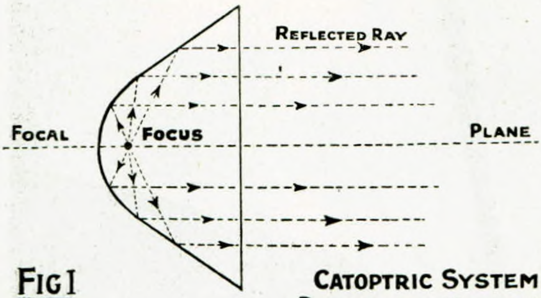


FIG I

CATOPTRIC SYSTEM
PARABOLOID MIRROR (PLATED).

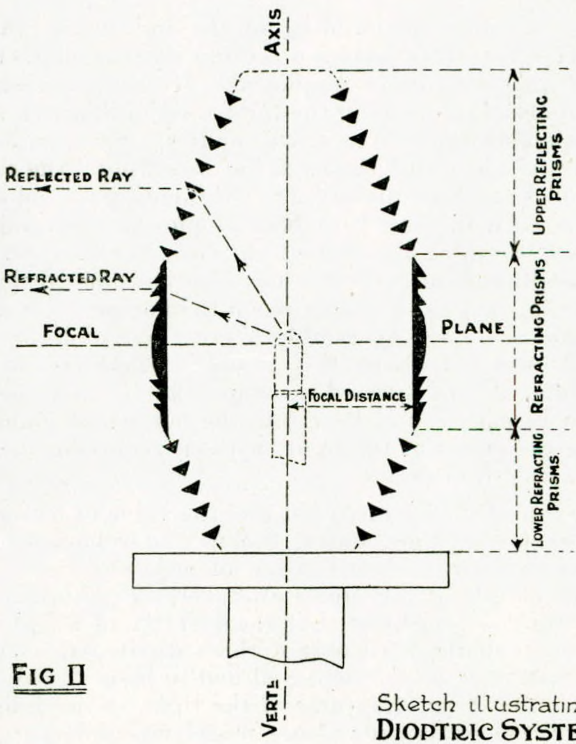


FIG II

Sketch illustrating
DIOPTRIC SYSTEM

illustrating the scheme visibly. Succeeding slides showed several very massive lens frames, and the methods of mounting, so that they are capable of rotation at uniform speed continuously during the hours of darkness, by the clock. The roller bearings employed, and latterly, the mercury flotation scheme, to reduce the frictional resistances to a minimum, were illustrated and explained. The methods of ventilation so that the lamp chamber may be kept clear of the products of combustion were shown.

The interior arrangements of a tower designed for the continuous accommodation of the light-keepers were shown by a series of photographs, and finally a few photographs of lighthouses and out-buildings were shown, so that the syrens used for fog signalling were, together with the air-compressing plant, readily seen. A slide showing an *unattended* light; also one of the damage done to the Scarborough light by the Germans during the late war, were included. The lecturer concluded by thanking Mr. MacLaren for manipulating the lantern, and to his nephew for functioning as the light-keeper of the model tower.

A cordial vote of thanks was accorded Mr. Wells. We are indebted to the *Marine Engineer and Naval Architect* for the loan of the blocks to illustrate the lighthouses and the lenses.

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The Lubrication of Diesel and Semi-Diesel Engines.

BY MR. EDMUND G. WARNE.

READ

Tuesday, December 14, 1920, *at* 6.40 *p.m.*

CHAIRMAN: MR. F. M. TIMPSON (Member of Council).

As a preface, before I start this lecture I should like to refer to one point, which is that I feel it is quite impossible for me to deal with the whole subject of the lubrication of Diesel and semi-Diesel engines in the course of a lecture. Oiling depends on the engineer. There are no two systems of lubrication alike on any two makes of engine, and I think it is all to do with the way the engineer in charge sets about matters as to whether the machinery is going to run rightly. From a practical standpoint it means nothing more or less than investigating the

[illegible] pressure-fed oil supply introduced, and closing in the lower part of the machinery to an extent which would prevent splashing of oil, while at the same time draining off the surplus to a working tank in the circuit, as is usual with most present-day Diesel machinery.

In the foregoing remarks I have given some indication of the broad lines on which current practice is instituted, and at the same time endeavoured to hint at future designs, but it will be recognised that a great deal depends on circumstances. Cost of construction, while not everything, is a very serious item, and one which is not likely to hasten the advent of the forced-lubrication two-stroke semi-Diesel engine. At the present market prices of machinery, uncertain developments, strikes, rumours of strikes and other disturbing factors affecting trade in general, we may fully expect to have to deal for a long time to come with the semi-Diesel engine as we find it now, and not as we would wish to have it. In the meantime builders, we imagine, are not entirely unaware of the possibility of improvement, and we must rest content to concern ourselves at this juncture with lubrication systems as applied to modern, and perhaps somewhat restricted, developments.

A good many practical suggestions have been made of late concerning the general running of semi-Diesel machinery, and it seems to me to be fair to assume that such definite propositions as have been advanced are sufficiently disinterested to warrant investigation. On points of general running, most engineers are agreed that modern plant of this type is of an excellent character. There seems to be little difference of opinion as to lubrication: it is not difficult to detect condemnation of a good many features of modern practice, but at the same time the suggestions for improvement do not always come along at the same rate. I think that engineers and drivers of semi-Diesel machinery should not hesitate to propose any improvements in existing practice that may appear beneficial to users generally.

As far as the average type of marine Diesel engine is concerned, the lubrication system settled down to a basic principle of arrangement in the early days of its career, and in most cases the system employed follows forced-lubrication steam practice to a great extent. It appears to be fairly well established that the most workable scheme comprises a main pressure supply from which is tapped a series of connections leading to each main bearing. Around the circumference is turned a groove in the metal coinciding with the point of entry of the oil. At any position on a coincident line around the circumference of the shaft a hole is drilled to the centre, meeting the central hollow portion of the shaft itself. The crank web is drilled (and, of course, suitably plugged afterwards) while communication is established between the hollow crank pin and the interior of the main shaft. The same process is followed out in the case of the crank-pin and crankhead bearing. From the latter the oil has to be conveyed to the gudgeon, and in order to effect this the connecting rod may be drilled through its length (if not originally hollowed) or alternatively an external pipe may be fitted.

Thus a state of pressure exists from main bearings to gudgeons, while if the engine is of the crosshead type the oil is conveyed through to the guide surface, thence draining down to the crankpit. This pressure is chiefly dependent on three items. First of these is the pressure in the main supply from the pump. Next in order of importance is the degree of adjustment of bearings, whilst a third factor present in the course of ordinary running is the temperature of oil in the system. From a practical standpoint I am leaving out considerations of quality, viscosity, etc., of the oil used and assuming that a reasonably suitable lubricant is employed.

On the question of pressure it seems to be a kind of unwritten law that 10 lbs. per sq. in. on the gauge is—if not precisely a red line of demarcation—at least a happy medium, and I do not know that this more or less accepted standard needs or deserves any adverse comment. It has stood the test of time and is therefore a figure to be treated with due reverence, but at the same time I believe that on account of the nature of its origin, i.e., in connection with high-speed steam-driven dynamo or similar practice, it may become customary to lower the figure slightly, regarding 10 lbs. as a maximum. As a reason, I would point to the tendency to lower the rate of revolutions of marine Diesel plant, while at the same time bearing in mind that an excess of pressure is not to be aimed at. The considerations are mainly with reference to the maintenance of a film of oil between journals and bearings under load.

Reversal of pressure, to some extent a deciding factor in lubricating problems, has a bearing on the matter, and some doubt has been cast on the high-powered two-stroke Diesel as regards capability of standing up to its work. It is rather early yet to express an opinion, and in any case mere prophecy is of little value, but I believe indications go to prove that, contrary to some previous expectations, a high bearing oil pressure is not necessarily demanded, provided that the bearings are properly constructed; possibly, more than one firm constructing two-stroke marine Diesel plant up to maximum present-day powers has already proved that abnormal oil pressures are entirely unnecessary. The design of bearings is a much more scientific performance than was imagined to be the case some years ago, not only with regard to dimensions, but also with respect to the admission and retention of the oil film.

A good many marine engineers are by this time acquainted with the Michell thrust block, and I know of no better instance of efficient design. It was established by Prof. Reynolds that the two surfaces of a journal and bearing must incline towards each other in the direction of motion, so that the oil film could take up a tapered formation, and this principle is followed out by the Michell thrust and ordinary journal bearings. Time does not permit of an investigation into the special considerations involved, but I mention this particular construction because it shows what can be done by careful design (and, incidentally, without forced lubrication). I must leave this interesting subject here, but at the same time I should recommend every marine engineer to take an opportunity of investigating the design, because it carries with it one or two useful lessons in lubrication, quite apart from the particular form of construction employed.

Returning to the subject of the usual type of bearing and its treatment; provided the surface has not been disfigured with a wonderful network of unnecessary oil grooves, it will stand up to its work in a satisfactory manner, given enough oil. The advent of forced lubrication assisted, in a large measure, to prove that a bearing, of which the oilways when placed end to end would reach from the earth to the moon—more or less—is not the last word in efficiency. On the contrary, with a pressure supply on the lines indicated no oil grooves are required, beyond those necessary to convey the lubricant from bearing to bearing, and at the same time the clearances can be, and should be reduced to a minimum. One or two moderately slack brasses will have the effect of lowering the oil pressure to an appreciable degree as soon as the circulation has proceeded for a short time and the temperature has risen a few degrees, whereas an engine in which the bearings are up to the safe working limit, in the first place, will keep a satisfactory pressure for months on end.

As far as the pumps themselves are concerned, the design is of small moment. The general practice appears to be that engine-driven plunger pumps are fitted to smaller plant, whilst the high-powered modern marine Diesel engine takes its oil supply under pressure from ordinary gear-wheel pumps, usually in duplicate, or, in some twin-screw vessels, triplicate. They are mostly electrically driven and work excellently. Plunger pumps may of course be driven from any convenient portion of shafting, having due regard to speed and capacity of the pump. One system is perhaps worthy of comment, in which the pump is directly-driven from an eccentric on the main shaft, whilst the plunger is bored up its length and discharges firstly to the eccentric strap, thence through a hole in the sheave to the main shaft, bearings, crankheads and gudgeons—not a single pipe being fitted to the system. However, this arrangement is, no doubt, somewhat uncommon.

That the working temperature of the oil has a decided bearing on the efficiency of the engine has been realised for some considerable time, and there are definite indications that considerable importance was attached to this feature by German engineers in their development of the submarine Diesel engine, during the war. As far as our own activities in research work are concerned, a good deal of private and Government experimentation has been carried out from time to time. Some recent tests at the National Physical Laboratory in connection with a worm gear testing machine show that with a pure mineral oil an efficiency of 95·6 per cent. was obtained, whilst at 52 degrees Centigrade the efficiency fell off slightly, dropping to 93·5 per cent. at 75 degrees Centigrade. Between 50 degrees and 62 degrees Centigrade violent oscillation of the gear rendered readings difficult to obtain, and it is interesting to note that the critical temperature remained the same when the load was doubled.

This critical temperature is about 71 degrees centigrade for cylinder oil, and a characteristic of all mineral oils appears to be that the efficiency drop occurs suddenly at a particular heat. Sperm oil shows a gradual decrease in efficiency as the temperature rises, while castor oil, as might perhaps be expected, gives the best results, rape oils being next in order of efficiency. The value of adding graphite to oil has also been the subject of investigation, and it appears that while animal and vegetable oils show but faint signs of improvement, with mineral oils the addition of graphite has, in some instances, a beneficial effect. In the case of a hot bearing graphite has often proved useful, but its employment must be attended with care, and very moderate quantities only should be employed on account of the risk of choking oilways. As regards cylinders, I have not heard of any experiments with Diesel and semi-Diesel plant, but it seems not improbable that graphite might usefully be employed in small amounts. Concerning petrol and paraffin machinery its use has been attended with excellent results, as it is unaffected by heat, and not only lubricates the piston rings but assists towards filling up minute blow-holes, scores, etc., and thereby increasing the compression in a badly worn engine.

In the ordinary way, cylinder liners of both Diesel and semi-Diesel plant are generally lubricated through an encircling ring of piping provided with branches which communicate with holes in the cylinder. These branches, of course, run through the jacketing space; the oils used are of various qualities, but with a new engine a low viscosity oil is most suitable on account of the comparatively small clearances, while as these increase a more viscous oil may be employed. A comparatively high flash-point is desirable, in order to avoid the risk of explosion in the crankcase should the gas blow past the pistons and rings; but of course this qualification does not arise in the case of large engines fitted with crossheads, guides, and isolated cylinders.

Air compressors demand care in the selection of oil, as the corrosion of intercooler coils has been traced to organic acids formed by oxidation of the lubricant. Generally speaking, a mineral oil of low specific gravity and high flash-point is considered suitable for the purpose. Testing for flash-point and viscosity is rather out of the scope of the practical engineer on board, but I may perhaps mention that as far as viscosity is concerned it is possible to test this by an instrument of simple construction and approaching the accuracy of laboratory devices. However, as the viscometer I have in mind is somewhat expensive, and, moreover, testing of this description is out of the real province of the driver, further reference need not be made to it here.

Lubricating oil pipes and fittings are fruitful sources of trouble unless fixed with care. Throughout the engine no system of piping better exemplifies the proverb concerning a stitch in time, and when fitting up after inspection or repair it should be a hard and fast rule to blow through all pipes, union connections, etc., or, alternatively, pass a wire down, in order to ensure that there is complete freedom from foreign matter.

When dismantling, if the pipes are to remain off the engine for any length of time, it is a paying proposition to bind up the male screwed ends with twine. Nothing is more annoying than to find a damaged thread, especially if the nut has to be screwed up in an awkward position, and in fact many a thread has been stripped through a burred edge giving the nut a false start. If short union connections are fitted on main or other bearings they should be tightened well home—preferably making a metal-to-metal joint; if this is not done, as soon as the union is slacked for dismantling in all probability the nipple will twist off unless observed in time.

The practice of soft-soldering lubricating pipe connections is one to be avoided, excepting in an emergency. Brazing is the most suitable method and assists in prolonging the life of the connection. Vibration will quickly find the weak point of a pipe, and if the joint is out of sight serious trouble is bound to develop should the pipe part.

Centrifugal lubricators and their connecting pipes for crank-head bearings demand special attention if the risk of running the metal is to be avoided. Unless spigoted in such a manner that incorrect fitting is practically impossible, the banjo should be tested circumferentially and laterally by fixing a wire on the adjacent bearing or other convenient position and turning the engine a complete revolution with the turning gear, if there is any doubt about the fitting being perfectly central. In any case, after the banjo is in place and the lubricating pipe is in its correct position, the engine should be turned and the arrangement checked. At least one type of engine is designed with a lubricating system of a different nature, *i.e.*, the crank pin receives its oil supply via the gudgeon, through a hollow connecting rod, thus avoiding the use of a banjo lubricator.

Oil pipes to centrifugal lubricators may be made of steel, with advantage, and a more or less general use of steel piping is often advocated. The disadvantages are obvious, and include less flexibility and greater liability to rust.

Probably the most common form of lubricating the gudgeon in a semi-Diesel engine is through a pressure fed pipe leading through the liner and coinciding with a hole in the pin itself. The majority of designs do not provide for adjustability of the gudgeon brasses, so that wear can only be remedied by fitting a new bush; in any case, this wear can be minimised by paying due attention to the oiling, and as a matter of fact a gudgeon will readily seize up if the engineer allows the oil feed to fail.

The oil pumps supplying the various bearings are usually efficient in working, but nevertheless pay for attention. The discharge is generally variable, and adjustment may be effected by altering the length of the plunger-stroke. In practically every case this may be performed while the engine is running, and the number of drips per minute checked through a sight-feed. There are many different makes of pump, but I do not think that the majority present any difficulties to the least experienced driver, provided he gives them a careful preliminary survey. A great point is cleanliness in the well of the pump, and oil should be strained before filling; moreover, a strainer should be conveniently fixed on the filling orifice, or across the top of the box if the whole cover is removable. A periodical clean out is advisable, but on no account should the box be wiped out with waste. Swilling out with paraffin is a good plan, after which the box should be left to drain.

Operating mechanisms for pumps are often provided with adjustable ratchet-feeds from the shaft, and many cases of failure have been traced through carelessness in watching the drive, which, if the teeth or pawls become worn, may cease. Generally the pawl wears, and it may be mentioned that an engineer who recently had to deal with eleven cases of crankhead failure found that seven instances were due to this cause. The average semi-Diesel engine is not prone to breakdown, but it has been stated in more than one quarter that ninety per cent. of failures are due to lack of attention and failure of the oil-drip. The engineer who allows himself to become lax in the matter of attention to lubricators gets himself a bad name, but what is considerably worse, he may also get the engine a bad name, and I am afraid that it is only too true when it is stated that the more careless the engineer in regard to lubrication the more thorough is his abuse of the engine when a breakdown occurs.

It is recommended that ratchet wheels of lubricators be painted, say, with a line of bright red across. They can thus be more readily observed, and stoppage is likely to be noticed almost immediately.

Water and bilge pump eccentric straps often come in for more than their share of neglect, especially when grease lubricators are fitted. A grease lubricator has a comfortable look about it; one hopes it contains grease, but the lubricating pro-

This is a very simple thing to do, and would save a lot of trouble, and I should have preferred the writer to have emphasised this point more fully, because all the care in the world, on the part of the best possible engineer, is so much loved labour lost if the oil in use is not up to the standard, and the poor engineers would get all the blame. With forced lubrication I cannot say that it is quite perfect yet.

I had one instance during a critical time in the late war when an auxiliary engine stopped dead and couldn't be started. After taking the doors off it was found that the metal had run out of the bottom end. This was the effect, but the cause was very difficult to find out, the press-gauge showed 10lbs. up to time of stoppage, the crankshaft had to be taken out, and the white metal drilled out in the oil holes. I may say the oil was of good quality and well filtered, and was running all right in another closed engine beside it. The only conclusion that I came to was that some piece of white metal had come off and blocked up the oil-hole. Mr. Warne speaks of thermometers, etc.; I am in favour of these but it would be difficult to fit one to the bottom end of a connecting rod in an enclosed engine, it would not give the engineer on watch any notice, simply because he couldn't see it.

This particular engine I have just mentioned had the oil pump in the corner of the crank case (the most awkward corner to be correct) and to overhaul it was a very difficult job. I should like to suggest that oil pumps in this class of engine should be fitted outside and worked with some kind of gearing so that the speed of the pump could be increased in the hot weather and reduced in the cold weather. The suction pipe could always be felt by the engineer on watch, and this would be an indication of how the bearings were working. Thermometers could be fitted here as required.

The discharge side of the pump could be fitted to lead to the different bearings, and a sight feed could be fitted showing the amount of oil going to each bearing, with taps to regulate the flow of oil as required.

There are a few more points I should like to mention, but as Mr. Warne has other work before him elsewhere, I thank him very much for giving us the benefit of his experiences this evening.

The Chairman: In regard to water drip from which we get water interfering with the lubrication in the oil engine:—The trouble is common in steam, but in an oil engine it might be useful to mention where we should look for water interfering with the lubrication.

Mr. Warne: It is chiefly in connection with outside bearings, and I am speaking more particularly of the small shafts, as well as the main shafts, to which no pressure supply is made, and ordinary worsted feed boxes are fitted; possibly there is a drip from the circulation system, then you get the water at the bottom of the boxes, and do not know it is there. I have known cases where this has gone on for some time. The bearings have been in a bad state, yet the boxes always showed a good quantity of oil.

Mr. A. H. Mather: I think we can understand that in the working of the engine there should be no water in the ordinary way with enclosed engines. But if you take the case of a small engine-room when the vessel is at sea and jumping about, you will get water into the bilge and that will find a way into the oil. I do not know any precaution you can take that will prevent water having access to the oil under varied sea conditions.

Mr. Warne: I think it is a good system to go round with a syringe and dip the syringe to the bottom of the boxes, thus using it as a pump to test them.

There are many things I should like to have expounded in order to have made the subject more complete. On the question of forced feed lubrication I must say that I had most decidedly advocated forced feed lubrication for Diesel engines, but my point was that one could not apply it to the semi-Diesel engines. As regards the pure Diesel engine, I do not think there is anything better. My experience in connection with the operation of Diesel engines is that having a respectable forced feed lubrication system your time may readily be occupied with other things. Once you have got rid of the idea of hot bearings then you can consider the points of operation of the engine which should be attended to. The man who is always rushing round with an oil feeder and a bucket of water cannot pay so much attention to the general running of the plant. In regard to the elimination of oil grooves; with a forced lubrication system oil grooves are unnecessary. I think that has been very conclusively proved. The oil gets out of the bearings fast enough without any oil grooves to help, and it will find its way into the bearings in a most satisfactory manner. I have seen gudgeon pins knocked into white metal bushes with a 14 lbs. sledge hammer and the engine has run perfectly without any oil grooves at all. That has led me to believe that oil grooves are rather a mistake. On the question of working temperature, I do not think I can add anything to the remarks made. It is a matter of great importance, and why I mentioned that the use of castor oil might be expected to give good results was because it usually does give good results—in an engine, I mean. If you can get castor oil to use with a hot bearing, and you use that oil instead of the ordinary mineral oil, you stand a chance of cooling the bearing down very much more quickly. In taking my leave of you to-night I feel I cannot go away without thanking you for the attention you have paid me and the discussion which has followed the reading. I am quite sure the remarks made in the discussion are more valuable than the lecture. I shall have great pleasure in adding something, and at the same time I shall bear your remarks in mind for future reference.

On the motion of Mr. Buchanan, seconded by Mr. Dibb, a cordial vote of thanks was accorded Mr. Warne for his lecture.

The CHAIRMAN: Mr. Walter Pollock, who takes great interest in this series of lectures, has sent a few remarks, and he regrets he has not been able to attend personally.

WALTER POLLOCK (Member), stated that he was very much interested in Mr. Warne's Paper, and felt sure it would be a valuable contribution towards the proposed series of papers for the instruction of oil engine engineers.

Mr. Warne made slight reference to straining the oil before filling the oil boxes, but we would like to have heard much more of this extremely important subject. Obtaining the very best quality of lubricating oil will not itself avoid trouble; it should be passed through a filter and refiltered at least two or three times before getting to the part lubricated. Most lubricating boxes and receptacles have gauze wire over the divisions, which are very inefficient, and in most cases will allow fine grit to pass. Again, one will often see the can containing the oil for filling up boxes, etc., standing on a bench or seat entirely open to the atmosphere and sometimes close to the dirt and dust from the engine room ladder. If these were prohibited in an engine room and only cabinets with tops so arranged that they could not be left open, were used, many of the lubricating troubles would be avoided.

The filling cans should have a fine filter medium fitted in the spout, so arranged that it is easily removable for cleaning purposes. The filling cans themselves should be left upside down under cover of the cabinets.

No doubt the many readers of Mr. Warne's paper would be pleased to hear more on the quantity of oil to be used in different parts of a well-designed engine. Perhaps Mr. Warne will take say six different kinds of engines and five or six different parts to form such a table. One of the greatest difficulties a Marine Engineer or driver has in working an oil engine at sea is to know how much or how little oil should be used in the various parts.

Mr. Warne has told us of the disadvantage of over-lubrication, and we all know the disadvantage of under-lubrication. No doubt other contributors to the discussion will give us of their practical experience, especially with regard to the lubricating oil that should be used, and whether single service oil should be used for top and bottom ends or whether a type of cylinder oil for the former, and engine oil for the latter has been found more satisfactory.

Mr. Warne: Mr. Pollock has emphasized the necessity for straining oil, and has indicated that he would like to have heard more on the subject. To bring the whole, or perhaps even part of the many questions affecting the subject of oil engine lubrication within the scope of a lecture means, I am afraid, but brief reference to many interesting points, and I have found it necessary to limit myself in many ways, in order to deal as generally as possible with what appear to me to be the more salient features in connection with the subject.

Regarding the suggestion that a table might be drawn up, taking six different kinds of engines and various parts of the mechanism, giving the quantity of oil to be used at each point, I do not think this would be quite practicable. No two engines use the same amount of oil (at least, that is my own experience), and any attempt to tabulate quantities is likely to have bad results in some quarters. One cannot safely tie down a driver too closely to a fine measure of oil consumption. It annoys the driver, never has paid, and never will pay. On the whole, I think such a table as Mr. Pollock suggests (if I am interpreting him correctly) would serve little practical purpose. Needless to say, I am looking on the question quite from the point of view of running the engine under ordinary sea-going conditions.

A type of cylinder oil for top ends would no doubt prove more satisfactory than engine oil in the long run, but I do not know of any prolonged tests showing that this is the case. I take it that Mr. Pollock refers to the gudgeon bearings of a trunk piston engine, and not to the top ends of a crosshead type of Diesel or semi-Diesel plant.

Mr. A. H. MATHER: In a great many cases, with the smaller type of semi-Diesel engine, you have frequently to place them in charge of a man who is more or less semi-qualified. He has not got a full qualification for the work, but we have to trust him. In this way a great many of the troubles which have occurred, particularly with the semi-Diesel engine, have not been due to the engine itself. I was interested to note the remarks in regard to generous lubrication where the author refers to the engine actually running away on the lubricating oil taken up from the crank chamber. I knew of a case of this kind, and I mentioned it to one or two people who might have been expected to have had experience of it, and they laughed at the idea. They said "That's a traveller's tale." But it happened, as a matter of fact, on a trial of a submarine engine on the test bed in the works where it was being built. The engine had to be stopped for some purpose, but the thing would not stop with the fuel shut off. It was running entirely on lubricating oil. In that particular case, when the operating costs came to be worked out, the lubricating cost was heavier than the fuel cost, taking into consideration the quantity of each and the relative cost per gallon. On the subject of cylinder lubrication of these semi-Diesel engines, and of Diesel engines generally, the author refers to the method of supplying oil to the cylinder liners. It seems to me that the usual method of supplying oil to a chamber or passage round the cylinder and taking it away at more than one point round the circumference is not a good method of securing effective lubrication of the cylinder. The pistons, of course, are a good fit to the cylinder, but almost in every case it will be found that the piston lies more toward one side of the cylinder than the other, particularly where there is no crosshead, that is, where the gudgeon pin is in the piston. The oil supply escapes at the freest point and that is the point that requires least lubrication. The point where the piston is rubbing close to the cylinder wall is where it requires oil most. I would prefer to put a separate feed separately controlled to each of the points round the cylinder and reduce one and increase the other as required. I think that would be a much more satisfactory way of lubricating a cylinder. When the oil is supplied to the cylinder by the general system, oil is in the chamber or passage round the cylinder all the time. I think a much better plan would be to inject the oil at a certain time. I would put it in when the piston is at the bottom of its stroke, and the oil would then be carried up the cylinder walls by the piston on its return stroke. This is done by a good many makers now, and in every case it has resulted in much better working, and in a marked reduction of the quantity of oil used. Mr. Warne has referred to the use of graphite in conjunction with lubricating oil. Personally I do not like the idea of adding graphite to the oil. I would prefer to keep to a clean clear oil without any material in it which could possibly help to increase the cylinder deposits, which are sufficiently troublesome as they are.

On page 296 Mr. Warne says, in regard to graphite: "As regards petrol and paraffin machinery, its use has been attended with excellent results, as it is unaffected by heat, and not only lubricates the piston rings, but assists towards filling-up minute blow-holes, scores, etc." That statement contains in itself the condemnation of graphite as a cylinder lubricant, as if it will fill up blowholes, etc., it will also fill-up the spaces behind the piston rings. I should prefer to use a lubricant that would not tend to increase the deposits. Separation of the graphite from the oil will always tend to occur even when the special type of graphite, known as "deflocculated" is used. This is a manufactured substance which will remain better in suspension in oil than natural graphite, but there is no means of keeping natural graphite in suspension in oil, and as soon as any water or moisture gets into the mixture the graphite separates at once.

Mr. E. A. Evans: I feel deeply indebted to your Institute for the privilege of being here to listen to the interesting and instructive paper which has been read by Mr. Warne. To me it has been a source of great pleasure and enlightenment.

As a chemist I regret Mr. Warne's decision from a practical standpoint to leave out considerations of quality, viscosity, etc. I should imagine that quality and viscosity are of paramount importance whatever engines the engineer may design, or whatever system of lubrication he may adopt. It seems to me that he is very largely dependent upon the quality of the oil. Either he must obtain the correct quality of oil to suit his design of engine or else design his engine to suit the oil. Since the engineer is primarily concerned with the design of the engine he prefers to select the oil which will give the best results subsequently. Therefore, from a practical consideration, perhaps a few more moments might have been spent on this particular phase of the question.

Reference has been made both by Mr. Warne and several speakers to the continued running of an engine, after closing down, on lubricating oil. In my own experience I have found it quite an easy matter to keep an internal combustion engine running on lubricating oil after the fuel was shut off, but only with a certain type of lubricating oil, generally an oil more or less unsuitable, although a moderately good oil may possess the same propensity if it has suffered decomposition in an enclosed engine. Once again quality arrests our attention. At high working temperatures and pressures oil is liable to crack and give rise to substances which are sometimes highly explosive. This point was referred to rather fully in a paper which I have read before the Diesel Engine Users' Association in 1917.

I am a little lost to know whether or not Mr. Warne recommends forced feed lubrication. Perhaps he will be good enough to express his views on this point a little more fully. Nor do I quite understand whether he suggests that oil grooves should be entirely eliminated. Surely the use of oil grooves involves the principle of oil-bath lubrication, efficiency of which is well-known and well-established.

Then as to working temperature: that is undoubtedly far more important than is suggested in the paper. One has to realise that the viscosity of any oil diminishes with rise of temperature, consequently if the working temperature be left uncared for it might steadily rise and the oil decrease in viscosity until the critical point is reached when either the piston seizes or the bearings go. The rise in temperature after a certain point is reached becomes very rapid, possibly too rapid to be dealt with before trouble is encountered. If wide variations of working temperature are permitted it is essential that a special oil to meet the conditions shall be used otherwise unnecessary fluid friction is introduced which should be eliminated. How far the experiments carried out at the National Physical Laboratory on the lubrication of worm gears assist in solving the problems of Diesel engine lubrication remain to be illustrated. The sudden drop of efficiency, quoted in the National Physical Laboratory's reports, occurs at a temperature which is coincident with that at which a sudden drop in viscosity occurs. This may be a coincidence, or it may be a clue to the explanation, I cannot tell without a closer analysis of the reports, and perhaps more experimental work. Why castor oil might be expected to give the best results is not quite as apparent to me as it is to Mr. Warne. I have had a considerable amount of experience of castor oil, both alone and in conjunction with mineral oil, and the more research which I do the more complex does the subject appear.

The use of graphite has its limitations, although it has some advantages in special cases. In a general way I do not advocate its use, but there are cases where graphite has proved its value. Its particular advantage appears to be at the moment of starting so that directly the starting has been effected its sphere of usefulness diminishes. With the particular subject we have before us to-night I do not think that anybody would seriously advocate the use of graphite.

Reference is made to the use of low viscosity oil for new engines. As the term "low viscosity" is a comparative expression rather than an absolute, a little qualification is necessary. The modest reference to the selection of oil for the air compressors might well have been amplified by reference to the explosions which have occurred with the loss of life through the use of unsuitable lubricants.

I presume that the viscometer of simple design is the cup and ball variety, if it is I can say that my experience with it is not altogether a happy one; in fact I am unable to obtain even moderately consistent results, perhaps my instrument was not in perfect order.

Then, as to the use of waste for wiping out crank chambers. Periodically there is an epidemic of complaints of the oil containing fibrous matter from engineers, but on investigation the microscope soon reveals the exact nature of the fibre, and it is usually easily traceable to the wipers which have been used.

The subject of filtering the used oil has been raised, and I cannot do better than refer you to a general discussion on the recovery of lubricating oil, about two months ago, by the Diesel Engine Users' Association, in which I was invited to take part.

I should suggest that why the Germans used thermometers in such profusion was because they realised that they were getting a very hot time and these thermometers would show them how hot things were getting for them.

Mr. W. J. Dibb, R.D., R.N.R.: Viscosity to my view is a most important thing in regard to the oil for the engine, and a test for viscosity some engineers seem to fight shy of, but by practice it becomes quite a simple matter. I have used Redman's viscometer many times to check the viscosity of an oil, and from my own experience I should have approved of the author of the paper enlarging upon the use of the instrument and advocating all engineers to become skilled in its use for checking the viscosity of the oil supplied. The subject can be enlarged upon so much that much time might be occupied in discussing it. The viscosity of an oil varies according to the temperature, and this is not always recognised; I would commend the study of it to all, also the testing of the oil. Referring to the stoppage of the engine mentioned, the oil we were using was very good oil, specially suited for the job. We used to draw the oil off. There was a steam coil to heat it, and we filtered it, yet the engine stopped. We overhauled it at Liverpool, and after the examination all we could conclude was that something must have got off the bearing and into a vital spot to stop the running. One thing I noticed, when using this particular oil was that the far away bearing got the least oil. For proper lubrication you must have all bearings getting their proper amount of oil, and there must be some means of seeing that the oil goes where it ought to go. The oil must go through its proper channel, and each bearing must have its proper quantity and this is sometimes a difficult thing to bring about.

Mr. Evans: The last speaker has suggested that all engineers should have the viscometer and flash-point apparatus. It is a comparatively easy test to those who are regularly engaged on the work, but even qualified chemists send out varying results from time to time with the ordinary viscometer. When you have these viscosities it is very handy.

The Chairman: That, I think, was what the speaker was aiming at—that there is room for more scientific investigation by Marine Engineers than at present. We could get a lot of information if the necessary instruments were supplied.

I am not sure whether there are any other members who wish to add to the discussion. It is a subject upon which a lot can be said, and perhaps there are some who have attended with the purpose of speaking but have not had an opportunity of giving their remarks, and these may be of great value to the paper. If there is anyone who wishes to speak on the paper it is open to him to do so now. Any contributions sent in afterwards can be replied to by Mr. Warne and included in the Transactions.

Notes on the Management of Marine Diesel Engine Installations.

BY MR. HOMER McCRIRRICK (Member).

READ

Tuesday, December 21, 1920, *at* 6.30 *p.m.*

CHAIRMAN: MR. W. E. McCONNELL (Member of Council).

The CHAIRMAN: In the absence of the author, Mr. Homer McCrirrick, the paper will be read by the Hon. Secretary.

The Diesel Engine which has now established its position as a reliable and very efficient power unit suitable for ship propulsion does not seem to be getting the publicity from a practical point of view among Marine Engineers that it should.

The construction of large vessels which are to be propelled with Diesel Engines is increasing at a steady rate. Up till a few years ago developments with this type of engine were confined to land practice, and so the Marine Engineer is placed at rather a disadvantage as he had very little opportunity of gaining experience in this line during his marine training. At present most of the engineers for the new motor vessels will be men whose past experience has all been with steam plant, they will be seeking out what practical information can be got as to how the Diesel Engine behaves, what troubles they are likely to encounter on long voyages, and the best means of remedying same before a serious breakdown occurs.

As the wading through books and technical journals is rather a heavy task when one has not too much time at his disposal, and as very little has been published regarding the practical side of Diesel work, a few notes from a Marine Engineer's point of view may be the means of opening up other sources of practical information. Many valuable papers have come before the Institute on the internal combustion engine, and much serviceable data can be got from a close study of same, but the present call seems to be from the more practical side. These notes which have been collected during the past few years both ashore and afloat are penned with the hope that they will initiate a discussion among the members and be the means of bringing the practical side of the heavy marine internal combustion engine to the fore among Marine Engineers in general.

The most successful and reliable type of Diesel Engines at present afloat are working on the four-stroke cycle. For long continuous running when the power units per cylinder are over 100 b.h.p., the use of blast air for injecting the fuel into the cylinder is well worth the extra cost of power and extra space required for fitting compressors for this purpose. The little extra labour necessary for the upkeep of these compressors repays itself in the much longer time exhaust valves, fuel valves and pistons can remain in operation without being dismantled for overhauling. This saving of labour can be put down to a more complete burning of the fuel taking place in the cylinder, also I think it can be said that the extra number of heat units obtained from the fuel for useful work in the engine when blast air is used will compensate for the power required to drive the air compressor.

In two-stroke engines which exhaust through ports that are uncovered before the bottom dead centre, trouble seems to have been experienced with the water jacket and liner joint near these ports, also the cracking of the liners caused by the unequal expansion and rather awkward construction in way of the ports. Against this we have no exhaust valve troubles, but an exhaust valve is much easier renewed than the water jacket and liner joint. Pistons in the two-stroke engines seem to have given more trouble than the pistons in four-stroke engines owing to overheating and cracking, as they have twice the amount of heat to dispose of in a given time. Piston trouble seems to be now receiving marked attention from the metallurgical side, and this, combined with the various reliable piston cooling systems now in operation, should help matters greatly, also with careful attention by the ship's engineers to the fuel pump adjustments, cylinder lubrication and the piston cooling water temperatures, the Diesel piston should not require any more overhauling than the high pressure steam engine piston.

When a piston becomes badly cracked the cylinder gases will pass through to the water side and displace the cooling water from the piston, this can be detected by only hot gases passing from the piston cooling return pipes, and it is advisable to shut the fuel and blast air off from that cylinder and have the piston removed at the first opportunity.

Cylinder Heads or Covers.—In the four-stroke engines, cylinder heads or covers are rather intricate castings owing to the number of valves which have to be accommodated in them, namely-fuel, air starting, exhaust and inlet. Many points have to be considered in the design of the cover, its large depth to allow of sufficient area for the air inlet and exhaust gases passing to and from the cylinder. The circulating water must have a clear passage over as much bottom area as possible. Provision has to be made for a passage through the water space to carry the starting air to the starting valve which will be at a pressure of 20 to 25 atmospheres. The air passage which has to carry this high pressure will most likely be eliminated in the future, and the air starting valve designed to take air from a pipe coupled up to it on the outside of the cover.

The under-side of the cover when the engine is working will have to withstand a pressure of 40 atmospheres when the average temperature during the power stroke is about 2,200° Far., so any bad distribution of metal is liable to cause distortion, and cracks will probably result. Care should be taken that no large quantity of sand or mud is allowed to find a way into the covers and deposit on the bottom. Hand doors are provided for the examination of the inner surfaces, and should be opened occasionally, and any deposit removed. Deposits are also likely to be found at the bottom of the liner water jackets, this is not so serious provided it does not choke up the water passage. In small engines of less than 100 b.h.p. per cylinder it will be found advisable after three or four years operation to have the cylinder liners drawn, in most cases the small ports round the top of the water jacket will have become partly choked and will therefore be liable to cause over-heating to the covers through insufficient circulation.

Many cracked cylinder covers are at present doing duty on engines running with full load; if much manœuvring has to be done these covers become a source of danger, and whenever a stop is called for any length of time it is always advisable to shut down the circulating water pressure from the engine and so minimise the risk of water finding its way into the cylinder in case the covers have time to cool down and perhaps the cracks open. These cracks usually extend from the fuel valve across to the inlet and exhaust valves, round this area is where the water passages are greatly contracted and a most likely place for mud to deposit.

The joint between the cover and liner is usually a ground face to face joint with a little oil and graphite painted on the surface. When these joints show signs of leakage it is advisable to have them seen to at once, as the passage of hot gasses between the two surfaces will soon burn the spigot. Grinding rings are sometimes supplied for facing up these joints or else copper joint rings can be inserted between the faces. Cases have been known where the burning has become so deep that a piece of copper had to be dovetailed and pinned into the spigot before a tight joint could be obtained.

Fuel Injection Valves.—One of the characteristic parts of a Diesel Engine is the fuel valve, the whole success of burning the fuel properly lies in the design and adjustment of this valve. With regular overhauls and the use of a good packing material, very little trouble will be experienced, the gland packing box which has usually a depth of four spindle diameters seems to answer its purpose well when packed with good lamp cotton plaited to size and well soaked in oil and graphite. There are one or two kinds of semi-metallic packing on the market, which also answer their purpose well, but what must be, guarded against if possible, is wear taking place on the spindle where it passes through the packing, this wear, which is often found to start in the form of pitting, may be caused by some chemical in the oil. After it has been going on for some time slight scores or grooves form along the rod in way of the packing, this I think can be put down to a fine grit finding its way into the packing from the oil, and though the spindles are case hardened, it seems to have effect on them. It is always advisable when overhauling fuel valves to try and smooth over any roughness on the spindles with a very fine emery stone.

The most destructive trouble with the fuel valve is a small leak starting on the valve face, this may be caused by a particle of hard grit adhering to the face and allowing burning to take place thereon. A fuel valve with a slight leak caused by the valve face being pitted or burned, or the spindle partially seizing in the gland, can very often be detected by a slight blow back of air through the inlet valve muffler during the time the inlet valve is open.

If a leak attains any size, dangerously high pressures will be formed in the cylinder causing the escape valves to lift. Pre-ignitions are liable to occur with a leaky valve and they can be detected by a dull heavy knock. A fuel valve leakage caused either by a burned valve face or a seizure of the valve spindle, is quite capable of bringing the engine to a stop through loss of blast air.

Seizure of valve spindles mostly occur when starting up a cold engine or when manœuvring after a long run. Sometimes this sticking of a valve spindle can be overcome if sufficient blast air can be obtained for the short time of manœuvring the engines, but it is not recommended that this be done unless in cases of urgent necessity, as there is always the risk of dangerous explosions occurring in a cylinder with a leaky valve.

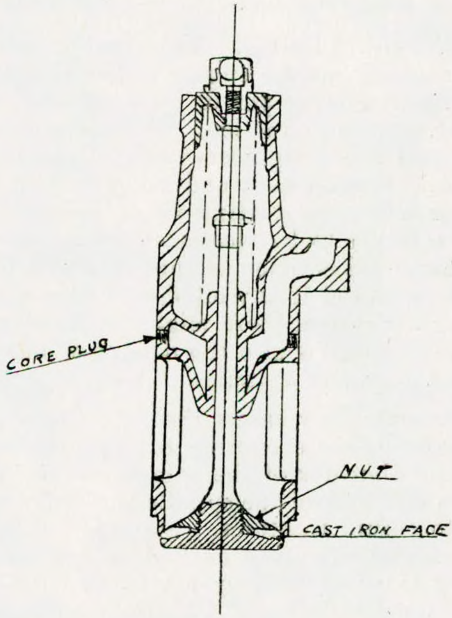
The pulverising and spraying of the fuel is effected by means of a number of drilled or slotted washers and a special grooved cone piece. Generally speaking, these do not receive very much attention apart from cleaning when the valve is opened up for overhauling. At the present time most motor ships are on regular runs, and so able to obtain the most suitable fuel oil, these conditions are not going to continue for ever with the increasing number of motor ships. More practical information is therefore wanted for the adjusting of pulverisers which will enable the engineers to judge different grades of fuel oil and so meet any valve trouble before it becomes serious.

Another rather important item in the fuel valve is the small non-return valve fitted in the valve casting to prevent blast air finding its way down to the fuel pump. These valves do not require very much attention apart from an occasional grind on to their seats with very fine powder, care must be taken when the small valve cage is replaced in the fuel valve casting that the copper ring joint is well bedded all round. As a further precaution against blast air passing the non-return valve and finding its way to the fuel pump another valve of the same type is inserted in the fuel pipe line. When only one non-return valve was fitted to each fuel valve, a leakage of air past same, caused by either the valve sticking open or a piece of grit adhering to its face, would be liable to cause a stoppage of the engine if the air passes in sufficient quantity to displace the oil from the pump.

Exhaust Valves.—Valve faces in exhaust valves are manufactured from a special mixture of cast iron suitable to withstand gases at a tempearture of 700° Far. passing over them. Valve spindles are made of steel and means are provided in large valves to renew the cast iron faces on them by unscrewing a nut and bedding on a new C.I. face.

In exhaust valve cages the spindle guide is usually water-cooled as shown in Fig. 1. After these valve cages have been in use for some time corrosion has started at the core plugs and allowed water to find its way into the exhaust piping. If the engine has been standing for any length of time with this leakage going on, a considerable amount of water may find its way into a cylinder through an open exhaust valve. The

FIG. Nº 7



trouble is then to find where the water has come from, as in large engines there is always the possibility of a leakage starting in the water-cooled exhaust box, or cylinder covers may be cracked and leaking.

Broken levers have been caused by springs being fitted into valves and not having sufficient compression clearance; whenever a new spring is fitted or an old one packed up with washers always make sure that the valve has the required travel.

Inlet Valves.—These valves are practically of the same construction as exhaust valves, except for the omission of the removable C.I. valve face and the water-cooled spindle guide. Air strainers or silencers are fitted on the inlet induction pipes, these must be frequently cleaned to allow of a sufficient supply of air reaching the cylinder during the time the inlet valve is open and so permit the complete combustion of the fuel. If this condition is not fulfilled a vacuum is likely to be created in the cylinder and the slight back pressure of the exhaust gases will tend to jump the exhaust valves off their seats and allow burnt gases to pass back into the cylinder, this will result in bad combustion, loss of power and a smoky exhaust.

Air Starting Valves.—These valves are only in operation when starting up the engine either ahead or astern; immediately the engine is put on fuel the starting valves are automatically cut out of action. When engines are slow in picking up on fuel some engineers are inclined to interfere with this automatic arrangement and allow fuel to be injected into the cylinder when the starting valves are also in operation. This practice is not to be recommended as when the burning of a fuel charge takes place the pressure will be above the starting air pressure, and if any oil should have found its way into the starting air system there might be the danger of an explosion in same. There is also the danger of burnt gases carbonising the starting valve spindles.

The starting air enters the valve by a passage through the cover, the pressure tending to open the valve is balanced by the large diameter of the spindle above the opening; in large engines this part of the spindle is fitted with small ramsbottom rings to ensure tightness. Starting valves should receive the same careful attention as fuel valves, as in all likelihood a starting valve sticking open a little will prevent a start of the engine until it is freed. A slight leakage past the face of a starting valve while under way can sometimes be overcome by a restart of the engine with air, or by turning the valve round to a different position on its seat. If this will not stop the leakage it is advisable to change the valve at once as the small hole or groove will only enlarge with the passing of the burning gases. As the valves are common to the one air pipe, these gases, if allowed to pass, will only tend to carbonise up the starting valve spindles. The cage for holding the starting valve in the cover has usually a metal to metal face joint at the bottom, and provision is made for a thin soft joint at the top. The space between these two joints is where the air is led to the valve; care should be taken that both joints are properly bedded, as a leakage at the bottom would admit air to the cylinder when not required, or the cylinder gases will pass back to the air starting system when the engine is under way. A badly made joint at the top would cause a loss of starting air, or with the engine working on load, any fuel oil leaking from the fuel valve spindle gland may find its way into the starting air system and might be the cause of an explosion the next time the starting valves came into operation.

Valve Timing.—In engines working on the four-stroke cycle the following table gives approximately the timing of valves in cylinder with the I.H.P. in each ranging between 100 and 400 and with a piston speed of 700 to 800 feet per minute:—

Fuel Valve opens 6° before T.D.C. and closes 34° after T.D.C.

Starting Valve opens 10° after T.D.C. and closes 140° after Top Dead Centre.

Exhaust Valve opens 40° before B.D.C. and closes 10° after T.D.C.

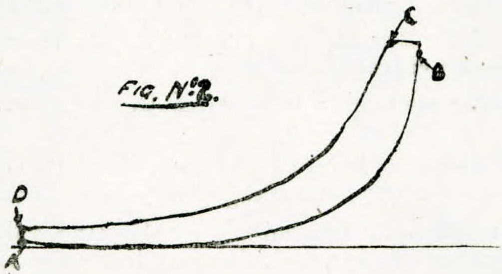
Inlet Valve opens 20° before T.D.C. and closes 15° after B.D.C.

The same settings are arranged for ahead and astern.

Great care should be taken when adjusting valve lever or push rod clearance on cams. After any large overhaul, or once a year, the fuel valve settings should be tried for correctness. In small engines where the cam shaft is driven by bevel or skew gearing from the crank shaft, and every part of the vertical shaft, coupling, and gearing is enclosed, any slackness of keys is apt to remain unnoticed. If a key has been an easy fit sideways when the engine left the works, it is bound to work itself further slack in a year or so, with the result that the cam shaft setting will be retarded. A key slackness of a little over 1/16th inch that came before the writer's notice, was found to alter the valve timing by 6°, when this engine first showed signs of sluggish starting it was put down to change of temperature conditions in the engine room. After this passed over and there was no change in the starting up of the engine the trouble was looked for in the valves, fuel pump and cylinder compression clearances; as these were all found in order, a further search had to be made which resulted in a slack key being found in the muff coupling of the vertical shaft, which drove the cam shaft.

Indicator diagrams play a most important part in tuning up the Diesel Engine, they provide the quickest means of ascertaining what adjustment may be required to obtain the best combustion of the fuel and also seeing that the load is distriputed equally in each cylinder.

Fig. 2 is the approximate form of a theoretical diagram. Compression starts from A when the air will be at a temperature of about 120° Far., it then continues until point B when the temperature will reach 970° Far. and the pressure will be about 500 lbs. per square inch. The injection of fuel oil now starts and is injected between B and C; combustion should proceed at a rate which will permit the increase of volume, due to the motion of the piston, to be so balanced by the increase of temperature, due to the combustion of the fuel, that the pres-



sure will remain constant until the whole of the fuel has been injected when the temperature at C will be about 2200° Far., burning of the fuel still continues, it is stated, until the piston has travelled about one-fifth of the stroke, when expansion will then continue until the exhaust valves open at D and the gases will be released at a temperature of about 750° Far. To come as near this ideal condition as possible in practice, all valves in the cover must be kept in good condition, rings must be free in piston, and the compression clearance should be adjusted regularly, as the wear on top and bottom ends is taken up.

When the engine has been running for a little and is properly warmed up, compression cards should be taken from each cylinder with the fuel and blast air shut off, everything being in order they will indicate a pressure of 500 lbs. per square inch. We now come to the combustion of the fuel, which should be sprayed into the cylinder in particles of such a size as will expose sufficient surface to allow of combustion taking place within the proper time, and also not of a very violent nature. If combustion takes place too quickly, the blast pressure should be reduced, as the greater the excess of blast pressure above that of compression, the more quickly will the quantity of oil measured out per impulse of the fuel pump into the valve casing be blown into the cylinder. If the fuel oil is of such a highly inflammable nature that a reduction of the blast pressure will not regulate the period of combustion sufficiently, then it may be advisable to alter the sprayer plates in the fuel valve and so prevent the fuel oil from being broken up too finely. On the other hand, care must be exercised when any adjustment is made of the sprayer plates, that the combustion of the fuel will not be delayed to such an extent that burning will take place during the later part of the expansion stroke.

The effects of after-burning have the same effect as incomplete combustion and cause excessive cylinder temperatures, which tend to burn the film of lubricating oil from the cylinder walls. This shortage of lubrication will cause increased wear on the cylinder walls, danger of piston seizure and piston rings sticking. In large engines with open cylinder ends, shortage of cylinder lubrication can usually be detected by a slight grunting noise from the affected piston. If caught in time, the supply of oil from the lubricator can be increased for half-an-hour or so, but if the piston has become much overheated and sparks are passing down from same it is advisable to cut off the fuel oil from that cylinder, slow down the engine, and attempt to spray cylinder oil up inside the liner with a syringe.

The combustion part of the cycle takes place when the piston is moving slowest, with the usual type of indicator gear supplied, the record of pressure change in the cylinder at this time is put into very small space. Should further investigation be required as to what is taking place during combustion, it can be obtained with a draw card, this can be taken by disconnecting the indicator cord and at the instant that fuel starts to be injected into the cylinder, the indicator pencil should be held to the card and the drum quickly moved round by hand.

In figure No. 3 a full power diagram is shown, the line above the top of the diagram is the usual type of draw cord obtained when combustion is proceeding in the required way. At point A the injection of fuel is starting, a slight rise of pressure is indicated here and continues for a time until the fuel valve closes and the burning of fuel ceases and expansion starts.

Figure No. 4 is a card from a cylinder having rather early ignition of fuel, the height of the card has increased and the burning of the fuel appears to take place quicker. This can usually be overcome by increasing the clearance between the push rod and the fuel cam a little, should a slight adjustment of the clearance not be sufficient then the position of the fuel cam piece will have to be put back a few degrees.

FIG. No. 3

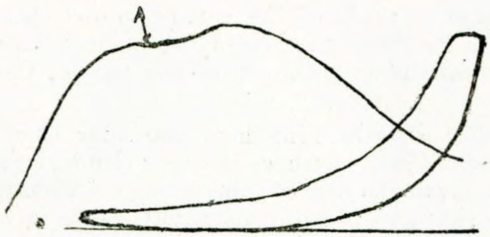
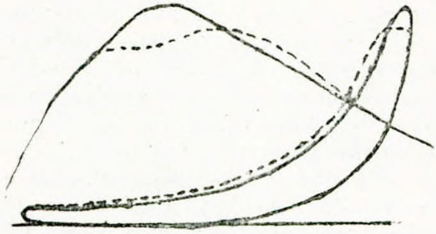


Figure No. 5 is a card from a cylinder having very early ignition, if the valve setting is correct this may be caused by a leaky valve or else the spindle is seizing to such an extent that

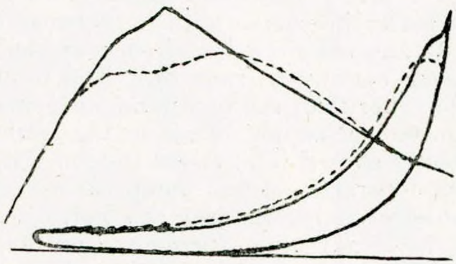
FIG. No. 4.



the force of the spring cannot close the valve. A valve in this state will not continue to operate long, if it is not convenient to stop the engine and change the valve, it is advisable to shut the fuel and blast air off, as dangerous compression pressures may be generated in the cylinder.

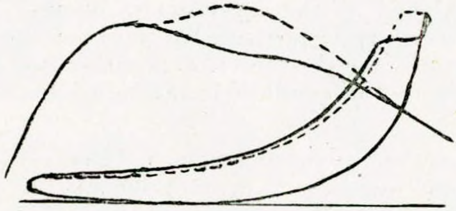
Figure No. 6 is a card from a cylinder having very late ignition. In cold weather, cylinders with the ignition taking place so late will be difficult to start firing when getting under way or manœuvring, and the combustion of the fuel will not be perfect, resulting in a smoky exhaust. A card of this type may also be obtained from a cylinder using heavy oil which has not been pulverised sufficiently, and also through using too low a blast pressure if the engine is on load.

Fig No 5.



There is also the possibility that sufficient air is not finding its way into the cylinder to allow of proper combustion. If there is any doubt about this, a card taken with a weak spring in the indicator will indicate by the distance of the exhaust or inlet above or below the atmospheric line whether there is too great a resistance for the gases to leave the cylinder freely, or the air to enter freely.

Fig. No 6.



At light loads there will be more than the required quantity of air in the cylinder, and with the extra air coming in as blast along with such a small quantity of oil, the ignition is bound to be retarded owing to the cooling effect of the large proportion of blast air over the fuel.

Particular attention should be given to the fuel pump adjustments, once these are set and a card taken from each cylinder showing the required mean pressure, which is generally about 6·5 Kg./C.M2 or 95 lbs./sq. inch, the fuel pumps should not be individually interfered with to increase the quantity of oil supplied to any one cylinder which may show a falling off in power during continuous running. The trouble will in all probability be other than the fuel pump adjustments, and may be such as inefficient supply of air to the cylinder caused by either a partially choked inlet or exhaust, or a little grit interfering with the operation of fuel pump valves. The first cause may be removed when overhauling at a port of call, the second may remove itself any time during the ordinary running of the engine. If the amount of fuel delivered per stroke of a fuel pump has been increased over the ordinary settings of the other fuel pumps, and the loss of power has been removed from the cylinder by causes as stated above, this cylinder will now start to develop much more than the required power and a cracked piston may result before the increase of power is noticed.

Air Compressors.—Air compressors are of the two stage trunk piston type in small engines and the three stage type in large engines. In the past, most of the trouble with compressors was due to valves breaking; a large amount of attention has been given lately to the design of these valves and also the quality of material used in their construction. Valve trouble has now been reduced to a minimum, and compressors can run for months without any overhaul, provided the lubrication of them is carefully watched by the engineers in charge. Excessive lubrication seems to be responsible for most compressor worries at the present time, the surplus oil gets carbonised and adheres to the valves, with the result that through time they become choked up.

The air strainers or silencers on the L.P. stage must be kept free from dirt and oil, so as to prevent the slits in them becoming closed up and not allowing sufficient air to pass into the compressor. If the passage of air is any way restricted a vacuum will be formed during the suction stroke and in a two-stage compressor of the trunk piston type there will be a tendency for vapour and oil to pass from the crank case to the top of the compressor piston. Scraper rings are fitted in the lower end of the piston to prevent this, but unless these rings are kept a good fit the lubricating oil seems to find its way past them, and will eventually deposit at the valves, or in the air passages, and become a source of danger.

The safety valves on the water side of the intercoolers should receive periodical attention to prevent their sticking fast, in case a leaky tube or coil tends to raise the pressure inside the water casing to a dangerous height.

The air passages which are part of the compressor casing containing the suction and discharge valves at each stage, are also fitted with safety valves, which should receive occasional attention, as there is a danger of explosions taking place in these passages, through excessive lubrication and the heat of compression in the air.

A small air leakage from a compressor coil or intercooler may be detected when the engine is running, by the pumping action of the circulating water when it leaves the ship's side. Or by leaving the cooling water circulating round the compressor or intercoolers, when the engine is stopped any leakage will show up by a continual drip of water from the drain on the air side of the coolers.

A quantity of lubricating oil seems to find its way into the L.P. and I.P. coolers with the compressed air, and adheres to the tubes, reducing their cooling effect, these tubes are so arranged that they can be bodily withdrawn from the cooler casing for cleaning purposes, and under ordinary running conditions it will be advisable to clean the tubes about every two years.

The greatest wear in compressor cylinders takes place at the top end of the H.P. stage, and after three or four years running it will be found advisable to have them bored out parallel and a new top fitted to the piston.

Lubrication.—The general practice now with large engines is to supply oil under pressure to all the main bearing surfaces, small bearings, such as cam shaft and levers, are oiled by hand.

The crank cases are entirely closed except for small breathing holes situated near the top. In the large 3,000 I.H.P. installations, about 20 tons of lubricating oil is carried in a small part of the cellular double bottom, this oil which is circulated round the engine bearings falls to the bottom of the crank case and is then drained to the double bottom tank, where it has the benefit of the cooling surface of the ship's skin.

The lower ends of the cylinders in large engines are usually separated from the crank case by a distance piece, fitted with a tray through which the piston rod passes. This space between the lower end of the cylinder and the top of crank case is open to the engine room, and means are provided to drain away all the surplus oil which gathers here, this waste oil should on no account be collected and used for lubricating purposes, being mainly composed of oil that has had its substance burned away, and containing particles of carbon and ash that have been carried down from the piston top, it will thus act as a fine grinding paste on any bearing surfaces that it comes in contact with.

Careful attention should be given to all connections and joints in the water-cooled guides and piston cooling gear, so as to avoid any large mixing of water with the lubricating oil. After any large overhaul of moving parts, any waste, wood, or other refuse should be carefully removed from every corner of the crank case, or they will only become a source of trouble when the engine gets under way. In cold weather lubricating oil that has had a large percentage of salt water mixed with it, will tend to thicken up, and trouble will most likely be experienced with the pumps and also in getting the oil to flow freely back to the D.B. tanks. This may cause serious delays and a lot of unnecessary work and worry on the part of the engineers, so the importance of keeping the lubricating oil free from all foreign matter cannot be too strongly impressed on all the engine room staff.

The consumption of lubricating oil with 3,000 I.H.P. installations under full running conditions, will average about 1/14th of a ton per day of 24 hours, any loss can be put down to evaporation and small leakages. To keep the oil in as good condition as possible, I think it is advisable once a year to allow it to settle for four or five days and permit any foreign substance or water to fall to the bottom of the tank. The suction pipe should then be raised about eight inches above the bottom of the tank, and the oil pumped back into the crank case, the tank can then be throughly cleared out and fresh oil added to make up the deficit.

Engine and compressor pistons are lubricated by small force feed oilers, which are filled up every watch by the attendant;

in view of the importance of compressors being supplied with the correct oil, it will be found expedient in large motor ships to paint compressor oil tanks, oil cans and lubricants, a distinct colour, and so avoid any errors in oiling when perhaps the vessel has started on a voyage, with a new engine room crew.

Lubrication troubles have been caused in auxiliary engines by the oil adhering to the walls of the oil passages in the crank shaft and eventually closing them up. When any serious oil thickening has been encountered, a little time spent blowing steam or compressed air through the crank shaft oil passages, may save many hours work at some future time, and also the cost of replacing overheated bearings.

With care and good judgment on the part of the ship's engineers in the adjustments of the motors, a well kept storeroom and properly indented spare part list, there is no reason why the Diesel Engine cannot be made as reliable as steam plant. Repair bills on the old ships seem to be on the high side at present, but with the increasing improvements in design and choosing of suitable material for the various parts which show deterioration, the bills will be greatly reduced in the future.

The CHAIRMAN: Well, gentlemen, I think you will agree, after hearing this paper, that the first impression we receive is that the Diesel engine is not quite so simple as it looks, and I am bound to say that if the writer of this paper is recording the difficulties which he enumerates as having occurred in his own experience, he has had a lively time. Even two or three of these small difficulties would mean to the uninitiated hours of delay, trouble and difficulty in finding out things. But a great deal of food for thought and discussion has been provided. It is only my part to allude to one or two salient points. I want to know, first of all, the differences in the expressions of opinion by Mr. McCrirrick and the author of the paper published in our last edition of the journal. The last edition contained a paper on solid injection by Mr. McTaminey. Mr. McCrirrick deals more with the air blast system. Perhaps some of you here have personal experience on this subject. I think that valuable as this paper is it would have been much more so if the author could have increased the number of drawings. It becomes difficult at times to follow the wording. That means you have to read the paper more carefully. There is no mention made in this paper of the opposed piston type, now receiving a good deal of consideration. Perhaps some information in regard to that kind of engine would be of very great use in expanding the discussion and giving this paper fuller value; also on the relative values of the four-cycle and two-cycle types. Mr. McCrirrick seems to think the four-cycle is the more reliable. There are some authorities of considerable standing who think differently. They think, at least, that whatever the defects of the two-stroke type may be at the moment, the two-stroke will ultimately become the predominant type at sea. I hope, therefore, those of you who have any observations to make on the subject will let us have the benefit of them.

Mr. W. McLaren: I must congratulate the author on putting his experience in such a detailed manner. Whatever his likes and dislikes, as between the old steam engines, the four-stroke gas engine or the two-stroke one, they have certainly not been put on that reliable and flexible reversible control that the steam engine gives. I do not want to pour cold water on it. I would like to learn more about the internal combustion engine of large powers. I have seen the first Diesel engine that ever came into London. It was about 17 years ago, and I was recommended to have a look at it, being told that it was going to give such great results in cheapness of fuel and upkeep. Some ten years later I was introduced to another Diesel set. Well, I had come ashore then, but I felt at sea when I was alongside that fellow. There was a bed 12 ft. by 7 ft., and about 7 ft. deep of solid concrete, with a well or trench clear all round of the main basement pit. She was like a rocking horse. It was all in movement knocking and pounding. We have heard the old ballast pump when on deck. Well, that was a small sample of the noise to recommend the like of these machines to one. However, it was really ignorance of their internal working, and from what you could see of the levers and so forth, it was certainly not very enlightening. I am glad to hear they are getting so much further forward and can be run in one direction a continuous length of time. I think that is the salvation of the gas or oil engine at the present time. A later experience came about three years ago, when we got an oil engine about 7 h.p.; I could not get it to go, and when we examined it right through we found that the fuel arrangements where it is like a needle point of microscopic size, wanted cleaning. The makers sent us needles of different gauges, and we got it put together again—we had had all the parts laid on the floor like a clock. We started it up with the fly-wheel, puffing and blowing at the job. When it started it ran reverse and we let it run so for about ten minutes. Then we tried again, and a feint was made to go forward, but it reversed again. On the third trial it went well in the forward direction. We called in the makers, and they said we had reversed the microscopic piece of plate. Well, one cannot say that that was all that was wrong, and I want to know why it was that engine went reverse. It seemed to be drawing air in from the exhaust and discharging through the suction end. That was my experience.

Mr. Plow: In the case of the plain Diesel engine I think a great deal can be done to assist the main running by due regard to the oil filters. In a Diesel engine of 300 or 400 h.p., carbonised oil may be dropping into the crankcase, and often the filter is placed in the bottom, not readily come-at-able and it is not convenient always to stop. To quote one instance, we found it much more convenient to put a by-pass into the suction line and have a filter similar to a bilge mud-box, which was of great assistance to us in cleaning out this carbonised oil. Another point in regard to the large type of Diesel engine was that we always made it a practice when over-hauling in port to clean out the crankcase thoroughly, put on the oil pressure from the main and examine every bearing to see the oil was going to each. As a good deal of pressure is often lost by a bad fitting liner these ought to be watched. We checked the oil system before starting up, including the oil boxes, both for the lubricating and pressure oils. Each trip we had probably different men; this caused trouble in training the attendant to watch and note where the different oils should go. In order to lessen the risk of mistakes in the oil supply system the various oil boxes should be plainly marked. We found great help from having a guard fixed to the doors along the cross crankcase, as it prevented a lot of the carbonised matter dropping down, and after the engine had been running for some weeks we found the guard covered with carbonised oil. The course of the oil can be checked at the sight feed, but often you are not sure that it is getting ample.

The Chairman: Mr. Plow has given us a very practical and valuable addition to the discussion. I hope we shall not fall into the error of saying nothing, because we have not had experience of the Diesel engine. This type of engine will clearly be developed out of the minds of men with years of sea experience behind them. Mr. McLaren is apparently not inclined to enthuse about the internal combustion engine. There is no doubt that the Diesel engine has a great deal to improve upon before it is thoroughly established. But it has proved so efficient that now its position is unassailable. We know, as practical engineers, that the mechanical difficulties and the details of design have yet to receive much attention before they approach the degree of perfection arrived at by the steam engine. The reason is that the work hitherto has been developed on divergent lines.

We have a small number of large firms who have developed this engine on lines of their own, so much so that amongst some of the first class people we find very strong divergences of construction. The mechanical perfection which we have evolved in the steam engine took a long time to achieve. It is practically perfect to-day. Whoever builds a quadruple expansion reciprocating engine to-day you will find it is pretty well the same from whichever works it comes. The same process will have to be carried through with the Diesel engine. It has to be standardised. Ultimately what is best in each firm's design will be embodied—stolen, if you like—in a design which will eliminate the more difficult and intricate features, and at length we shall have a type of engine which will be as simple as it can possibly be made, and which, at the same time, will preserve all the advantages which have hitherto been evolved by the best brains given to the subject. I suggest to you that it would be a very poor compliment to Mr. McCrirrick if we had to say that no discussion followed on his paper. I think that Diesel engine designers and those in charge of Diesel engines will learn a great deal from those who have had a long experience of the steam engine. The steam engine which appears so familiar and so obvious to us, took a long, long time to perfect. I notice that a writer very recently has stated that the differences in mechanical design which exist between the Diesel type and the reciprocating steam engine will in process of time disappear. In other words, the Diesel engine will tend to be more and more modelled on the lines of the steam reciprocating engine. Take the question as to whether the engine should be of the enclosed or open type. Can any of you suggest any reason why the makers of Diesel engines should continue to adopt the enclosed type of crankcase? You know it is the practice—almost universally, but not quite. An expression of opinion on that subject will help. Similarly, on the question as to whether the opposed piston type, on the two-stroke cycle or the four-stroke type, with fixed cylinder head, has most in its favour. I just throw out these suggestions in the hope that they will be taken up, and that something valuable will result from the discussion which ensues.

Mr. C. N. Hunter: The author states in one paragraph: "The safety valves on the water side of the intercooler should receive periodical attention to prevent them sticking fast, in case a leaky tube or coil tends to raise the pressure inside the water casing to a dangerous height."

I quite agree with him there, but let us proceed further. The intercooler castings are tested to about 100 lbs. per sq. in. The coils inside contain air varying from 300 to 1,000 lbs. sq. in. Two accidents with intercooler coils came under my notice when at sea on a Diesel engined vessel. The intercoolers were fitted with the usual safety valve. The valve was adjusted to 25 lbs. per sq. in., and it was about the same area as the circulating water discharge pipe. One intercooler contained a coil at 300 lbs. pressure, the other a coil at 900 lbs. pressure. In each instance when the coils burst the intercooler casting burst also, despite the safety valve. I have heard of similar accidents, and it appears to me that something more positive than a safety valve is required on the intercooler. I would suggest that a disc, similar to those found on the CO_2 machine, be fitted about 4 or 5 inches diameter, so that in the event of a coil bursting the disc would blow out, save the casting, and probably avoid fatalities.

With regard to starting valves, anyone interfering with the automatic arrangement and allowing fuel to enter the cylinders with the starting air is courting disaster. an explosion would probably occur and wreck the whole engine. Mr. Plows has mentioned an incident which did happen when fuel accidentally found its way into the starting air system.

With reference to the paragraph on cards: It is not always convenient to take compression cards, in the method mentioned, off the "mains" after starting up; further, there is not always time to spare for this purpose. My practice was to obtain a set of draw or hand cards at first opportunity, and from these could always assure myself whether the cylinders had proper compression or not, and then adjust accordingly.

The author states that the average temperature during the power stroke is 2,200°F. I should be glad if he would state at what mean effective pressure the engine referred to worked at, as it appears to me a very high average temperature.

The CHAIRMAN: This is shown as a card indicating a wrong condition in the engine. If everything is working all right you get your ordinary compression right from the ordinary card, and if you do not get your compression right it is an indication that there is something wrong with the engine. The remarks on the subject of the safety valve are really weighty remarks; two instances have been quoted of accidents that might have been fatal, and in one case did result in injury. It is difficult to say how far the present practice in regard to evaporators applies. It is precisely that state of affairs that we are trying to guard against in the case of evaporators to-day. We have a diaphragm with an orifice and the area of the orifice is calculated to be well within the danger mark. The fitting of a disc would be a matter of some nicety, that is to say, a disc of sufficiently large an area so attached that there would be no fear of it blowing off at normal pressures, whilst yet it would be certain to blow off when called upon to handle a very much larger pressure. Perhaps Mr. Hunter would suggest the best way in which that disc could be attached. I think this is very important, and I think it will be one of the most useful contributions to the discussion. I will ask him to give his opinion as to how that disc can best be attached to be firm whilst only dealing with waterpressures, but be sure to operate if called upon in the case of explosion or fracture.

MR. HUNTER: In reply to the Chairman the disc could be fitted in the form of a blank flange, with a compensating ring on its outer edge for stiffening to allow for jointing purposes, the diameter of the disc to be about 5 ins. I think that would be quite effective for the compressors on board any of our large motor ships of the present day. The disc could be made of some thin metal; copper would serve.

The circulating water pressure is usually about 20 lbs., seldom more. The disc could be designed and constructed to operate at 22 lbs. so that in event of the cooler casing attaining that pressure the disc would blow out.

When a coil bursts the air impinges on a solid mass of water, something must give way, and it is usually the casting. That is why I recommend a disc which would be weaker than the casting, and could be easily replaced at small expense.

Mr. F. O. Beckett: In my experience, which I may make more clear on the blackboard, we had 300 lbs. on the square inch and the liability of explosion. The relief valve could lift up at the arranged pressure. The disc put in here was of lead, 4 ins. diameter and 5/16 in. thick. There were 4 or 5 vessels connected with this SO_2 arrangement. This was the master valve in the whole lot to prevent explosion.

In the event of a defect or a big pressure, this disc would simply break and save the whole system all round so that no damage would be caused in that direction. The idea is that this disc rips open, and you can easily replace it. That is the style that the valve can be made so as to be quite safe. Mr. Hunter has referred to an explosion. I have not previously met anyone who has had an explosion experience, and it is a point I have gone into once or twice—the possibility of an explosion with the 2 and 3-stage air compressors. Can you tell me: Have there been any gases formed on the walls of the cylinders of the air receivers? Is it from the lubricating oils, or is it a question of simply allowing the air to condense down and create this air liquid? There is drainage of course. When you close down you get a drainage. Does it carry any hydro-carbons and these turn into a gas to attack the steel of which the shells are made? We have a lot of pitting, and this wasting by pitting is a source of danger to the engineers in charge, whatever the plant may be, whether on board ship or ashore. The question is, "What is the cause of this deterioration going on?" It goes on right from the first starting out. We have much of this to look forward to. There is one point where the author speaks of lubricating oil for 3,000 I.H.P. plant, and he wants $1\frac{1}{2}$ cwt. a day. I think that is a fearful lot of oil—more than Mr. McLaren would, I think, allow. The author speaks of the spraying of fuel oil. Can we compare that with the trouble in a steam plant when an engineer has to burn Welsh and then Indian coal? You know what he does, pulls a couple of fire bars out. The area of this spraying: Have they some standard of comparison in regard to combustion?

Mr. C. N. Hunter: In reply to Mr. Beckett, the air and carbonised oil, etc., carried with it, travels at high speed through the coil, and it has a scouring effect in the coil. On one occasion I opened out a burst coil for examination, and found that the inside was oval, the inner half retained its original thickness, whereas the outer half had worn quite thin.

Mr. H. D. ADAM: With reference to the insurance of Diesel engines, it is usual to have the air compressor copper coils weighed when first put in, a record of this weight being kept. The coils are weighed again from time to time during overhauls. When the weight is reduced about ten per cent. the coil is rejected as being of no further use and a new coil is fitted. The acid in the oil deteriorates the coil, as well as the abrasive dust in the atmosphere. The oil used in the main cylinder is very often not good for compressors due to cracking and formation of acid at high temperatures.

With reference to preventing fracture of air-cooler water jackets, instead of the copper suggested, vulcanised rubber discs have been fitted and they have worked efficiently.

I do not know how you would like it at sea, but for land work it is all right. The author refers to cracked cylinders and cracked pistons and the shutting off of fuel and blast air, but you are very likely to get water into the compression space if you do this. The piston comes up to within about five-eighths inch of the head of the cover, so if you get water into the compression space you will get a damaged connecting rod and very likely wreck the whole engine. Some submarine engines were damaged in this way. Our practice was always to turn the engine to get rid of the water before starting up by means of small compression cocks or indicator cocks placed on a level with the top of piston when on top centre. Most station engineers now turn their engines before starting up to get rid of the water.

In regard to this question of the fuel supply through the Diesel valve, I do not think you pay sufficient attention to the fact that this valve is only open for about one-sixteenth of the stroke, and it is highly important that this period should be absolutely the same for each cylinder, and if the clearance between the Diesel valve and the cam varies the slightest amount, the cylinders will be unequally loaded. I refer to the case where you have got a distributor instead of a separate pump per cylinder. When each cylinder has a separate fuel pump great care has to be taken to insure that all pumps are delivering the same amount of oil as each other, in proportion to the load on the engine.

It is impossible to take compression diagrams with fuel and air supply on. I do not think you could possibly tell what compression you have unless you shut off the fuel and air, because you might have a false compression due to a leaky Diesel valve.

In regard to shutting off cylinders, is it advisable to shut off too many cylinders? You are liable to get a strain on the crankshaft due to too few cylinders doing the work. A lot of trouble in land stations is due to strained crankshafts owing to uneven turning moments and excessive pressures. Great care must be taken to keep the crankshaft dead true in its bearings, as constant flexure due to uneven support causes crystallisation and ends in a broken shaft.

The CHAIRMAN: The last speaker has given us a very useful addition to the discussion in regard to obtaining the compression temperature without cutting off the fuel. I take it the speaker will agree that that method would only be operative when the ignition was normal. In Fig. 5 in the paper we notice that there is an altogether artificial height on the card which is due to preignition. I take it that in that case a card of that description would be no indication of the actual compression in the engine itself.

Mr. H. ROLFE PARFITT: In one part of his paper the author refers to the fact of many engines running with cracked cylinder covers, by which I take it that although known to be cracked they are not renewed. This appears to me very strange, as the author previously informs us that the pressure in the cylinder at times reaches 40 atmospheres.

The CHAIRMAN: You will understand this cylinder cover is hollow. There is a top and bottom, with a considerable depth between. If the under surface is cracked the flange and upper portion, which take the thrust, are intact. The action, I think Mr. Hunter has explained, is really due to a peculiar type of erosion. It is not corrosion. It is erosion of these pipes due to the passage of hot air at a high pressure, and at a high velocity, and it is a fact that some very serious accidents have occurred in these intercoolers. These pipes, which convey the air, work in a chamber surrounded by water, and these pipes have exploded in a way that in the beginning was quite inexplicable. It was only the adoption of the ingenious idea of weighing these pipes that has enabled those in charge of these plants now to satisfy themselves as to the degree to which wastage has gone. That point I wanted to emphasise, in case it might not be apparent to those who heard of it for the first time precisely what was meant.

I am sure we have all heard some useful additions from the experience of those who have spoken on this subject, and I am sure everyone of us understands quite clearly that we cannot afford to stand-off from this subject. It is easy to understand the willingness of people to speak on a topic with which they are indifferently acquainted. But it is going to be everyone's business. The scarcity of oil is a rather serious setback for this type of engine at the present time. That scarcity of oil will probably be overcome in one way or another. I put it to you to think about, that if we cannot find our oil we will grow it in the fields. It is perfectly feasible and without a doubt we can expect ultimately that large tracts of the earth's surface, which now bear no crops could be adapted to the growth of root crops specially raised and developed for the purpose of bearing a large alcohol yield. That is one of the lines upon which internal combustion engine fuel will probably develop. We have all heard Lord Pirrie's warning, and we know that the oil problem at the moment is a difficulty; but it is not permanent. But it is everybody's business to study this question, and its practically unlimited possibilities. I now ask you to accord a hearty vote of thanks to the author for his thoughtful and useful paper as I am sure a practical paper like this appeals to all Marine Engineers, and I have great pleasure in proposing a vote of thanks to him.

Mr. E. Shackleton: I have much pleasure in seconding the vote of thanks to the author of the paper. Nearly 20 years ago I was present at the test of the second Diesel engine that came into this country. (The engine was, so far as I remember, a single cylinder one of about 30 B.H.P., made at Augsburg Works, which concern was later merged in the well-known Maschinenfabrik Augsburg Nurnberg A.G., the original constructors of the Diesel engine). At that time none of us were so far in advance of the times to anticipate the important position the engine would attain in the marine world. The Diesel engine has come to stay, and the modern Marine Engineer will no doubt be brought in contact with it sooner or later, so without question it is well worth considerable study. There have been difficulties, there are still some to be surmounted, but as occurred in the development of the large gas engine, experience has enabled defects to be remedied and extreme reliability in working to be possible. Combustion in the Diesel engine is a most important feature, and whilst the general laws are known in this connection, there is an immense field in actual working practice of which little is known. As progress is made it will become possible to build larger units, but whether the type will be two or four-cycle, or double acting, or of the opposed piston class is not at the moment easy to forecast. In my own opinion when the cylinder diameters commence to exceed 45 ins. to 50 ins., then a critical stage will have been reached and considerable research will be necessary in many directions. At the present time our cylinders are roughly in the neighbourhood of 30 ins. as a limit. I am very much interested in the old question of air compressors and some difficulties in operation, such as rusting in the intercoolers, purgepots, errosion, etc. It was recently advocated that certain internal iron or metal exposed parts be treated with a hard drying graphite compound which arrested rusting. Whilst, however, mineral acids have been responsible for corrosion and errosion. it must not be assumed that the lubricating oil is in all cases the root cause of the trouble, as frequently the corroding agent may be traced to condensed moisture and high temperature compressed air, which form the base of the corrosive element. Close attention therefore to the draining of water from the compressor system at regular intervals is of first importance. To minimise the danger of explosions in the intercoolers, due to high temperature and excess lubricating oil. it should be clearly understood that under no circumstances should the LP compressor be allowed to have air intake restricted, as any wiredrawing at this point causes a vacuum which the oil may reach, and on this happening pulverisation occurs and the mingled compressed air and oil vapour, in its passage further in the compressor system, reaches a temperature stage when conditions are favourable to an explosion. It is desirable, therefore, where the compressors deliver a volume in excess of the blast, bottle or receiver requirements, either to leave the drains slightly open on the compressors or arrange that air unrequired is blown off at the relief valves provided.

A point of much importance in Diesel engine operation is to observe closely unequal temperatures at the various points of the water cooling system. as recorded by the temperature gauges, as after a voyage or so on reference to the daily log a reliable mean will have been recorded, and any wide variations whether from the water-cooled exhaust valves or from the pistons, from the main barrel of the jacket, or from the breech end, will need to be closely scrutinised so that the reason for any departure from uniform working temperatures may be ascertained.

I congratulate the author of the paper, which is of a most practical character, and hope we shall have many papers from him on similar subjects.

Mr. J. Hawthorn : Mr. Macfarlane Gray once said that breakdowns at sea were providential ways of educating Marine Engineers. I think that when any Marine Engineers have had experience of trouble with any new ideas and they bring them forward in discussion, such experiences are to the benefit of us all. We are all to a certain extent educated by hearing of the experiences of others, and I fully endorse the words that have been spoken by the Chairman in respect of the value of a paper such as we have heard to-night. Many of us may study the thermodynamics of the Diesel engine, but to those who have had no actual handling of the engine and no actual experience in the construction of the engine, it is of undoubted value to get a paper of this description into the Transactions. We should take away this paper to-night and study it. If I may say so, from the hammer and chisel point of view, we want the actual experience of those who have had the handling of these engines, and we want to be in touch with them to educate our younger men. This paper is undoubtedly a source of education to many of our youngsters. I am very pleased to support the vote of thanks to the author of the paper. It is some time now since I was here, and in looking back over the 32 years of the Institute's existance it is brought forcibly to my notice the improvement we have had in the papers read before us and it indicates the growing interest that Marine Engineers are taking in their profession.

It is not quite enough to go in for a profession merely for our living, just for the money it brings us in. Everybody should endeavour to know as much as possible of that which provides his daily bread. We cannot know too much in this world, so I would commend this paper to the careful study of all present. I have very great pleasure in supporting the vote of thanks.

The Hon. Secretary : Having read the paper on behalf of Mr. McCrirrick, who is at Singapore, I shall have pleasure in conveying to him the vote of thanks so cordially voted to him.

Mr. Hall : Before parting I should like to take the opportunity of proposing a very hearty vote of thanks to the Chairman for the able manner in which he has conducted the meeting; the very lucid remarks that he has interposed between the various speakers have considerably added to the value of the discussion. I feel sure he has the subject very much at heart, and has endeavoured to elucidate the remarks of the speakers and encourage others.

Mr. J. THOM: I have much pleasure in seconding the vote of thanks.

The CHAIRMAN: Mr. Hawthorn, in supporting this vote of thanks, has uttered some words of wisdom. Some here are still quite young, but you have before you the sterling example of the accomplishment which waits upon honest application. The splendid building we occupy to-night is the direct outcome of the enthusiasm and fervour of a small band of pioneers who took up this work so long ago. The first sign of nobility in any man is his recognition of his debt, and we inherit the fruits of the labours, and self-denial of those pioneers. Make no mistake, their's was a very self-denying labour in the building up of this Institute, and we who inherit and enjoy the fruits of those labours, inherit with those fruits and that enjoyment the responsibility of passing it on improved to those who come after us. And those things are not done lightly nor easily. The accomplishment means steady application and a little self-denial, but with it all there is that abundant reward of having deserved well of one's own generation. Each man's contribution is infinitesimal, but the whole is magnificient, and I think everyone of us should be inspired by the reminder that Mr. Hawthorn has given us of the humble beginnings of this splendid Institute that we have round us to-night. And we all ought to be firm in the intention of not only carrying on this work, but of building it up and increasing its power and scope and using worthily the magnificient instrument that is placed in our hands. You know that the lecture we have heard to-night forms one of an important series. The next lecture is to be on January 4th, at 6.30, on "Internal Combustion Engine Gearing," by Mr. Walter Pollock. a member of the Institute and an influential and authoritative member. I hope you will all be present, and that you will do what you can in the meantime to stimulate the interest of those who have not been to this lecture, in the series of which to-night's paper forms a part.

Mr. W. McLAREN: I would suggest that at the next oil fuel engine, or internal combustion engine lecture Mr. Shackleton be invited to come and give us his experiences. He dealt with the subject at our meetings at the Romford Road premises, and since then he has gathered information and experience which he might give us the advantage of for our series of papers on the internal combustion engine.

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Review of Books Presented to Library.

CENTENARY VOLUME (*C. Griffin & Co.*).—This famous publishing house has now completed a century of work which has made its name a household word. All students of science and technology have made acquaintance with the text books which Messrs. Griffin have made their speciality, and the Centenary Volume now presented to our Library is a record in outline of the progress of scientific literature as developed by this progressive firm, of which they have just reason to be proud.

WIRELESS TELEGRAPHY (*Bennett, C. A.*).—This subject has many students outside those who have made it their chosen calling, and Wireless Telegraphy is destined to play an even larger part in our lives in the future. For those who, as amateurs, are interested in this marvellous branch of science, this volume will be found a useful introduction.

STEAM AND OIL, B.O.T. ORALS AND MARINE ENGINEERING KNOWLEDGE (*MacGill*).—This volume is a much enlarged successor to the "Elementary Questions and Answers" of Tod and MacGibbon, which was the favourite primer of young marine engineers twenty years ago. It cannot be too often stated that books of this Question and Answer type, which are frankly described as preparations for Board of Trade Examinations, cannot take the place of a thorough study of elementary physics, *e.g.*, Mechanics, Fluid and Solid; Steam and Heat, Thermodynamics, Hydraulics; Magnetism and Electricity, the Properties of Metals, Natural Science, and above all, Mathematics. The book under review is a valuable auxiliary to the text books, on the above subjects, and contains the necessary information on the practical applications of the principles which should have been previously mastered. It is not difficult for the experienced Examiner to detect the "Question and Answer" trained student, but all too frequently a few questions on Natural Phenomena, *e.g.*, the properties of the atmosphere, reveal the fact that if it is not in the "Question and Answer" book the student has never heard of it. With this warning proviso, the book is recommended to all young marine engineers, who will find it, as his father probably found its predecessor, a very useful compendium of practical information.

THE SLIDE RULE. *C. N. Pickworth.*—The student has in this handy little volume an ideal manual on this important subject. A little attention and study given to this clearly written work will enable even a beginner to use the slide rule with confidence for calculations which he perhaps never realised were within the scope of a slide rule. The work is strongly recommended to all engineers not already fully familiar with the subject.

Notes.

SOLID INJECTION DIESEL ENGINE.

Mr. C. McTAMENEY: I regret I was unable to read my paper on Solid Fuel Injection at the Institute on Tuesday, October 26th. With regard to the remarks by the Chairman as to the cost of upkeep and the time required for repairs in port, the *Trefoil* from the time she left the builders till she went for a refit, 18 months had expired, during all that time we were under one hour's notice to be ready for sea. I must say it was astonishing how these engines ran so long without having any repairs done—the only part of the engine we had adrift was one of the exhaust valves spindles, which had stuck; as for any other parts nothing had been touched, not even a bearing of any sort, in fact the main engines could have carried on another twelve months without a refit. Credit is thus due to the engine builders for their workmanship.

With reference to Mr. Beckett's letter of the 16th December asking whether there was any corrosion in the air receivers due to gas or acid getting into those cylinders, I really could not tell you. All I noticed was that slight pitting took place through water being left, and that by careful attention to draining it off this action ceased. Whether there was acid or not we all know that there is a tendency for pitting to take place where water lies in a partly filled boiler, and that in these receivers, as water is carried over with the air we have to pay particular attention that they are carefully drained and watched.

Extract from "Marine Engineering Knowledge"
(*W. C. MacGibbon*).

"The following piece of poetry on the Burning of Fuel Oil should be committed to memory by every Junior Engineer :—"

BURNING FUEL OIL.

Set the burners open wide,
Do not touch the valves at side;
Keep the pressure on the pump,
And up the bally steam will jump,
If the smoke is black and thick,
Open up the fans a bit;
If the smoke is thick and white,
To slow the fans will be quite right;
For when sufficient air is given,
No smoke ascendeth up to heaven.
If the jets refuse to squirt,
Assume the cause is due to dirt.
Should the flame be short and white,
You have combustion clear and bright;
But should the flame be yellow and long,
Combustion is entirely wrong.
A wise man to his heater sees,
And keeps it 200 degrees;
To have it more is not quite wise,
Because the oil may carbonise;
A little lower has been found
To give as good results all round.
If the filters are kept clean,
No rise in pressure will be seen;
But should the pump kick up a ruction,
There's likely air within the suction.
The pressure governs the supply,
So do not keep it very high.
If these instructions you will follow,
You'll beat the other fellow hollow.

Election of Members.

Members elected at the Meeting of the Council held on 6th December, 1920 :—

Members.

Wilfrid Bayliss, 73, Sedgeley Road West, Tipton, Staffs.
James Alwyn Brough, 138, Huxley Road, Leyton, E.10.
Herbert Henry Brown, Government Surveyor of Ships' Office, Penang.
Roy Cable, 7, Lathom Road, East Ham, E.
James Cormack, 15, Rastall Avenue, S.W.2.
Andrew Cunningham, 72, Buckingham Road, Liverpool.
Wilfrid Henry Drew, Cia Luz y Fuerza, Colon y Brown, Bahia Blanca.
Robert Forshaw, 23, Sycamore Road, Waterloo, Liverpool.
George Gair, 38, Blythswood Road, Goodmayes, Essex.
Harry Godfree, 164, Hampton Road, Twickenham, Middlesex.
Benjamin Hooley, 71, Orchard Road, Southsea, Hants.
George Albert Janes, H.M.S. "Malaya," c/o G.P.O., London.
Jeffery Lee Johnson, 28, Northbrook Road, Ilford, E.
Walter Kimber, 82, Grangehill Road, Eltham, S.E.9.
Claud Charles Lapsley, 17, Sandways Road, Wallasey, Cheshire.
Edmund Rees Mack, 146, Abingdon Road, Middlesbrough.
James Martin Maid, 38, Byne Road, Sydenham.
John James Scanes, Pingmore Lodge, Teddington Park Road, Teddington.
George Speck, 30, Avenue Reine Elisabeth, Cappellen, Antwerp.
John Fraser Smail, 96, Cavendish Road, Clapham, S.W.12.
Frank Stinson, Point House, Rothesay.
Frederick Charles Sykes, Annesley Lodge, Annesley Park, Rathmines, Co. Dublin.
James Ezra Sykes, Enniscorthy Asylum, Co. Wexford.
John Herbert Thom, "Craigengower," Hillhead Road, Cardonald, Glasgow.

Companion.

John Menzies, 280, Burdett Road, E.14.

Associate-Member.

Reginald J. Conway, "Whitehall," Lowlands Road, Harrow.

Associates.

Seth Eaton Chatterton, 30, Lorne Road, Forest Gate, E.7.
Cecil Cooke Hambling, 7, Milton Road, Birkenhead.
Alexander Stokes, 49, Valentine Road, Ilford, E.

Graduates.

Clifford Henry Bailey, 74, Grange Park Road, Leyton, E.10.
Archibald John Watson Loudon, 33, Coleridge Avenue, West Hartlepool.
Thomas Durant Shilston, East View, Stockton Road, West Hartlepool.

Student-Graduate.

Robert Burns Miller, "Elmbank," Park Terrace, Dunston-on-Tyne.

Transfer from Associate-Member to Member.

Cyril H. Kelly, 37, Locksley Street, Limehouse, E.