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Construction of Ships.

A proposed method of minimising risks due to collision.

BY E. F. SPANNER (Member).

READ

Tuesday, November, 10, at 6.30 p.m.

CHAIRMAN: MR. R. S. KENNEDY (Vice-Chairman of Council).

THE subject of this paper is one that should make a strong appeal to all interested in ensuring the safe transit of passengers and cargo from port to port, across either sea or ocean. Several papers, dealing wholly or partly with "Sea Risks" have been written during the past ten years or so, and from these papers and from a study of the casualty returns issued by the Underwriters' Associations at frequent intervals, it is fairly obvious that the most serious risk to be encountered at sea is undoubtedly that due to collision. Every month there are roughly at least one hundred collision cases, the number of total losses varying from two to sometimes as many as ten ships in a month.

There can be no doubt, therefore, of the importance of any idea which has for its object the reduction of the risk that serious damage will result from a collision, and the elimination of "Total Loss" cases entirely.

Collision is the one sea risk in which at least two ships must of necessity be involved. This statement, of course, partakes of the obvious, but it is surprising how often the importance of this fact is overlooked. Collision may result from an error of judgment on the part of those in command of either one or the other of two ships. A vessel well found, well manned, and well officered may be run into, and possibly sunk, by another vessel, larger or smaller, under the control of a man who makes a mistake. Alternatively, but more rarely, it may be the vessel which is at fault which is run into and sunk. Again vessels may collide with one another, owing to a sudden blanket of fog, during a short snow squall, or under other conditions of poor visibility.

In any of these cases, it must be evident that the safety of no vessel is entirely within the control of her own officers.

Where a risk is one which involves more than the safety of the individual, it might be considered that there is sound ground for the view that the taking of reasonable precautionary measures should be made compulsory. This is a point which might be argued at great length, but there can be no gainsaying the fact that there are many directions, in which this principle has for a long time been rigidly followed.

Ashore, there are many examples covering great varieties of risk. For instance all vehicles must have head lights, tail lights and brakes—there are rules and regulations to be followed in designing buildings, which have as their sole raison d'etre the prevention of the spread of fire from one building to the next—the notification of certain diseases is compulsory, not that any benefit may result to the person already ill, often the reverse, but in order that the safety of others may not be jeopardised. One could quote plenty of other examples of such compulsory safety measures.

At sea, to refer to one or two instances, all vessels must carry the ordinary steaming lights, and at anchor other significant signals. The yellow flag must be flown under certain circumstances. These are compulsory rules.

Each rule imposes some slight obligation on those who have to obey it, but on the other hand there would be a general outcry were it proposed to abolish any one of them, or in any way to limit their application. It is hoped that discussion of the advantages of the proposals made in this paper will lead to sympathetic consideration of the idea that wide-spread benefit would result from their universal adoption.

The development of navigational science, and the perfection of means for enabling vessels to locate and communicate with one another, have done relatively little to eliminate risk of collision, while it cannot be denied that some of the most serious collisions have occurred in broad daylight. The increase in the average designed speed of ships, and the added need for the making of quick passages for economic and commercial reasons, are factors which will tend to maintain the status quo, so far as the probability of collision is concerned.

The results of the labours of the Bulkhead and Subdivision Committees provide evidence of the directions along which the greatest efforts have been made to prevent the loss of vessels at sea, due to the admission of water to one or more of the holds following damage to the ship's side. It is admitted that the Committees may have been influenced in their conclusions, by the fact that, at the time they were debating, there was great need to view the problem from the point of view of possible damage from mine or torpedo. That necessity does not now exist, and it is difficult to imagine any circumstance arising in the future, even in the event of another war, in which an enemy would resort to the use of either mine or torpedo against merchant ships. The view of the author is therefore that the extensive subdivision now required of certain types of passenger vessels, is necessitated wholly by reason of the possibility of the vessel being opened up underwater, as a result of a collision.

The severity of the damage which one vessel may cause to another into which she runs, is well known, and even with well subdivided ships of the highest class it is generally admitted that should such a vessel be rammed severely by another, she will only remain afloat under entirely favourable circumstances.

It is the recognition of the frailty of even the best vessels against this sudden and terrible risk, which has led the Board of Trade to insist on the provision of Life Saving Equipment involving additional expenditure, in the case of a vessel of fair size, of anything up to £10,000 or £20,000. There is no risk apart from collision which need necessitate the expenditure of these vast additional sums, for in these days of fast ships, and rapid and certain means of communication, it is only this one risk, which may result in the total disappearance of a large vessel in a quarter of an hour or a little more, which calls for the provision of means for rapidly and safely transferring all on board to small boats.

Briefly, the close subdivision of ships, if it is not to be entirely uneconomic, is not a great safeguard against total loss following underwater damage. Further, while the provision of life-saving appliances, at great cost, may save the lives of passengers and crew, such provision is almost entirely devoid of any commercial value, for it can save neither ship nor cargo.

It becomes obvious, therefore, that the real solution of the problem must lie, not in any attempt to prevent collisions—for experience points to the fact that the elements will inevitably fight against us on occasions, not in the endeavour to limit the inflow of water following a collision—for years of work on long and complicated calculations has convinced the most ardent theorist that it is impossible to design an unsinkable ship, which is at the same time to be a commercial proposition, but rather in the devising of some means whereby the blow of a collision may be softened, and the ramming ship prevented from rupturing the plating of the side of the vessel into which she has run.

If one body collides with another, the character of the damage or deformation caused in the case of each of the bodies, is greatly dependent on the shape and construction of the bodies, in the vicinity of the points of impact. Where it is desired that one of the bodies shall cut or pierce the other, arrangements are made to shape the former so that it will have a very small area of impact on the body against which its blow is directed. The reduction of the area of impact, greatly intensifies the severity of the local stress occurring in the material of what might be termed the passive body, with the result that the material of this body is ruptured. There is no need to labour this point as it is familiar to everyone, and a matter of hourly importance in any engineering workshop.

To prevent the bodies from cutting, the one into the other, it is first essential that the area of impact should be such that intense local stress is entirely obviated, i.e., the force of the blow must be spread sufficiently over the material that at no point will the breaking strength be exceeded.

Considering the practical application of this idea to ships, it becomes obvious that it is vitally necessary to ensure that all vessels are deprived of the sharp cutting edge associated with the ordinary type of construction, in which a bar stem is incorporated. There is no denying the fact that the normal form of stem bar is admirably designed to rip its way through the skin of another vessel, and the replacing of the stem bar by a well rounded plate is the first step towards preventing the "knifing" action so often resulting from a collision.

Incidentally, of course, the stem bar would not be forced through the side of the other vessel unless it were held up to its work, i.e., unless it were supported and stiffened by a substantial structure behind it. This longitudinal strength we find, in usual practice, is well provided for by the stiff longitudinal assembly of strakes of shell and deck plating.

The substitution of a well rounded plate for the stem bar, would not alone suffice to prevent eventual rupture of the side of the vessel struck, in any case in which the ramming vessel were moving at more than a very slow speed, for the force which would accumulate, and increase in local intensity at the bow, would eventually burst the rounded stem plate through the side of the rammed vessel, unless the area of impact were automatically increased to a degree at least equivalent to the total force being exerted by the ramming ship.

To carry the enquiry a stage further, no two vessels coming into collision will reach a state of relative rest until work has been absorbed in the structure of the vessels themselves, to an amount representing the difference in energy between the moving system, as it was before the collision, and as it is after relative movement has ceased, assuming, of course, that the engines are stopped.

Suggestions have been made as to methods by which buffers might be designed for attachment to the bows of ships, but they have invariably been of a character which would render them of little use in a full size job, and the task of mitigating the effects of a collision eventually involves the devising of some form of construction, for at any rate one of the vessels concerned, which will be capable of considerable distortion without serious risk to either of the colliding vessels.

This has been arrived at as follows:—

Having first removed the "cutting edge" by the adoption of the dished stem plate, the next step has been to replace the longitudinal arrangement of the shell and deck plating by an athwartship disposition of these essential members of the bow structure. This is a simple matter, and the form of construction thereby arrived at is indicated, in Figures Nos. 1 and 3.

It is obvious that with such an arrangement of plating as indicated, the result of the ramming of another vessel would be that the stem plate and successive strakes of plating would be

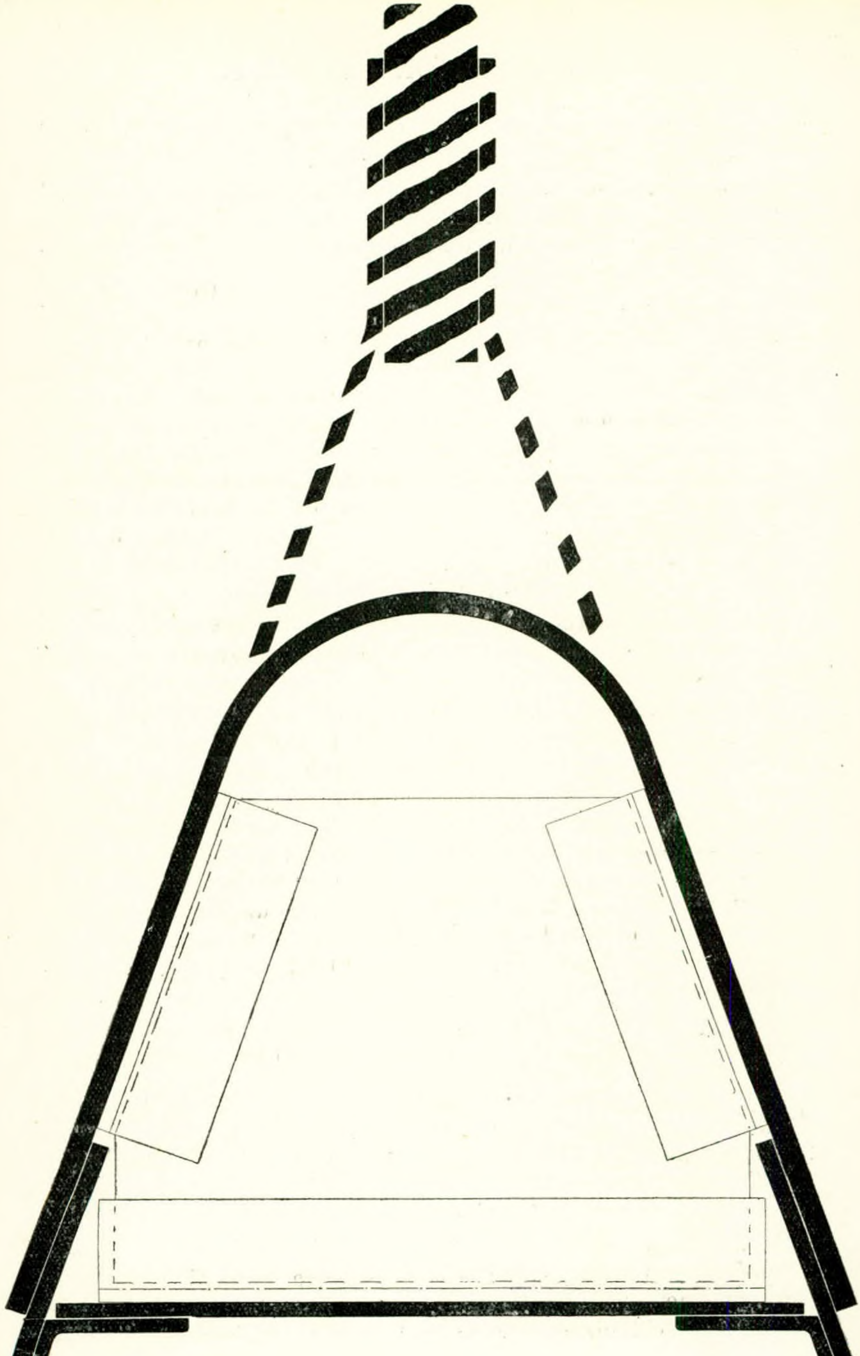


Fig. 1.

forced back until they took up positions somewhat as shown in Figure No. 2a. Figure 2b shows result of an ordinary vessel ramming another.

This presumes that the structure, against which the vessel runs, is sufficiently strong to cause the rivets securing the laps to fail, without itself being ruptured. From calculations and also from a careful study of ship side structures, it is considered certain that in no case would a ramming ship built along the lines of the author's proposals succeed in piercing a large hole in the side plating of another vessel, even though she might be much smaller. The side plating, stiffened as it would be by the decks, would hold substantially firm and unpierced, while the lap rivets in the bow plating of the ramming ship might be sheared, or forced out of their rivet holes.

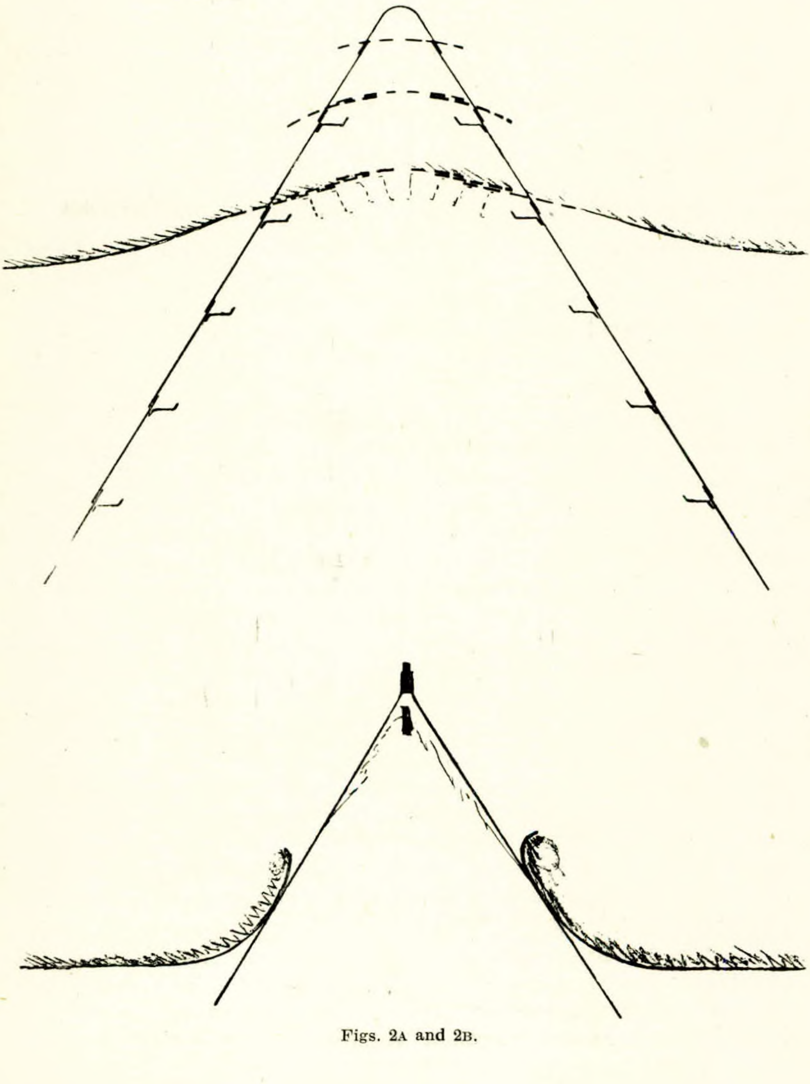
It is clear that once the rivets of the first lap had failed the stem plate would be squeezed to a more open bevel, so that a dent of large radius would be forced in the side of the rammed ship, dispersing the load, and reducing the risk of severe local intensity of stress becoming sufficient to cause actual rupture, to a minimum.

At the same time, work would require to be done in shearing the rivets and flattening out the stem plate, and the amount of work per foot set back of the bow would continually increase, owing to the increasing amount of internal stiffening which would require to be distorted, at successive frame stations abaft the stem plate. This would mean that the retarding force on the ramming ship would be applied in such a fashion that the shock of the collision would be minimised to the maximum extent possible, bearing in mind that the damage to the ramming ship must not extend back to the collision bulkhead.

The properly designed "soft end" would ensure that even were the ramming vessel to run into another vessel at a fair rate of speed, the work which would be absorbed in distorting and rupturing her bow, without the damage extending as far back as the collision bulkhead, would be sufficient to absorb by far the greater part of the energy which required to be dissipated, the bulging in of the side of the rammed ship, without rupture, accounting for the balance.

The ideas which have led to the devising of this form of construction have now been fully explained. The details of the manner in which these ideas can be applied to new vessels must be determined for each particular case, but it is clear from Figs. 3a, 3b, 3c and 3d, that there is no real difficulty to be anticipated in the practical application of the proposals.

Fig. 1 makes it plain that there is a decided saving of weight and cost in adopting the new form of construction, for the



Figs. 2A and 2B.

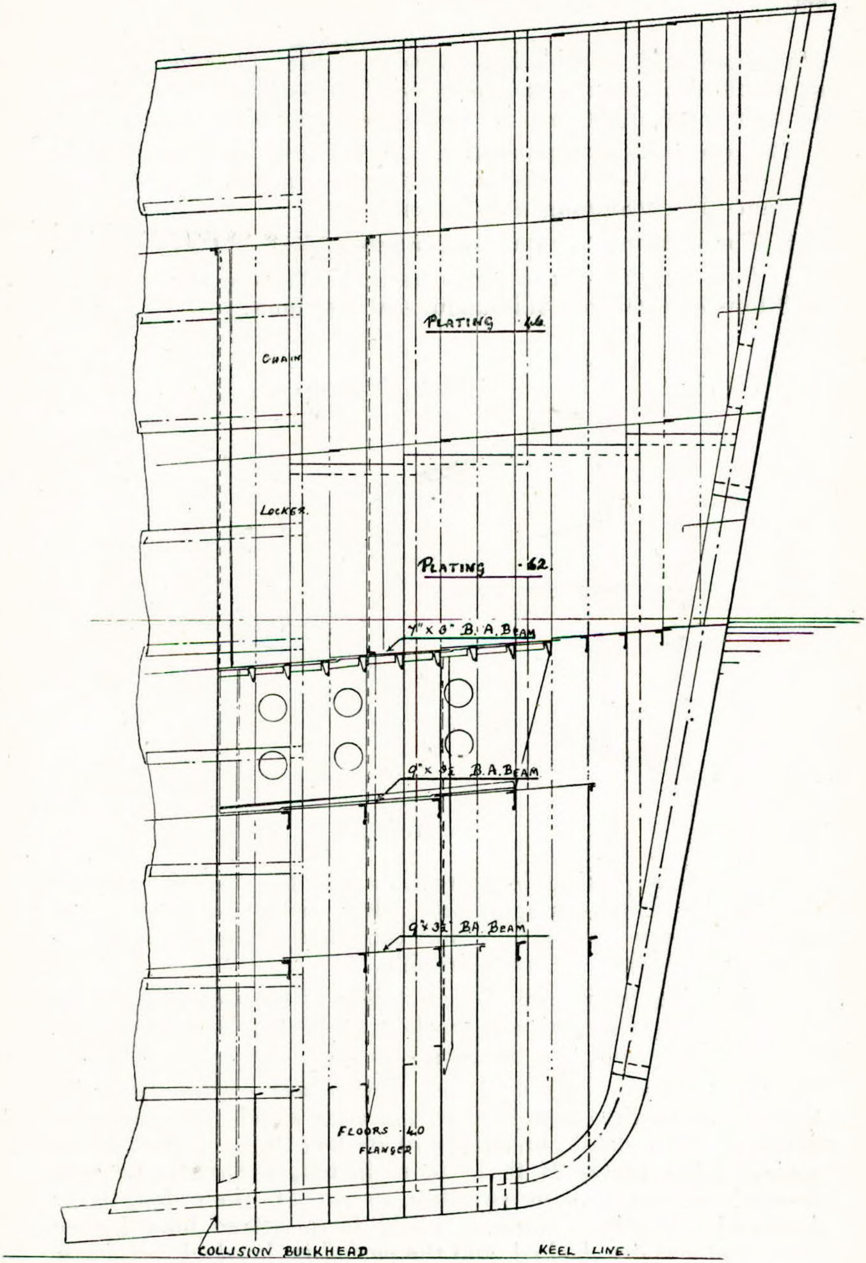

PLATING ·46
CHAIN
LOCKER.
PLATING ·62
7" x 6" B. A. BEAM
9" x 3½" B.A. BEAM
9" x 3½" BA. BEAM
FLOORS ·40
FLANGED
COLLISION BULKHEAD
KEEL LINE.

Fig. 3A.

heavy and useless stem bar—a relic of the old days of wood shipbuilding, when a considerable "half-siding" was necessary to house the side planking—is entirely unnecessary.

The vertical arrangement of the forward shell plating is advantageous for the following reasons, apart from its importance in cushioning a collision.

1. For working anchors and cables.

2. Less weight is involved—there should be a saving of up to 3 tons of steel in a ship about 400 feet long.

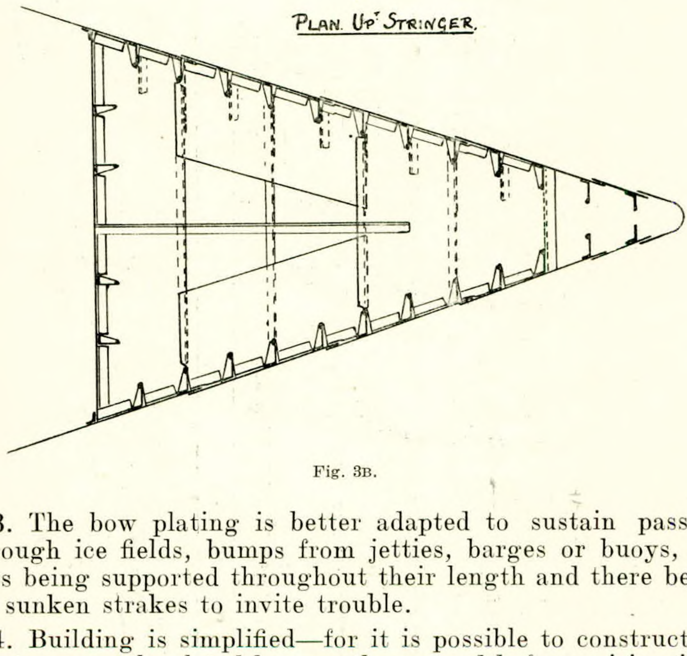


Fig. 3B.

3. The bow plating is better adapted to sustain passage through ice fields, bumps from jetties, barges or buoys, the laps being supported throughout their length and there being no sunken strakes to invite trouble.

4. Building is simplified—for it is possible to construct all the transversely plated bow on the ground before raising it as a completed whole into position.

5. Repairs are simplified and cheapened enormously—for there is no need to remove shell material which has only been damaged for a small percentage of its length, as is the case at present when plates 24 ft. or more in length have to be condemned because one or two feet or so of their length is damaged. Further, material could be prepared long before the vessel was dry docked, and the period in dry dock cut down

by two or three days at least. In some actual cases in which new stem bars were required, as much as a week or ten days might have been saved in dry dock, had the vessels been of the "soft end" type of construction.

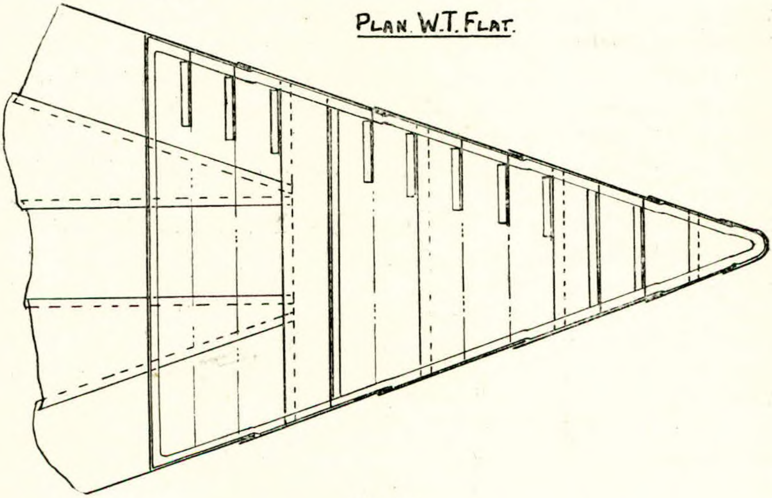


Fig. 3c.

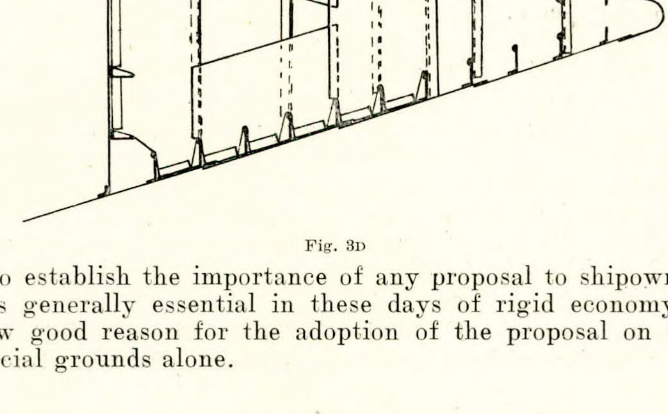


Fig. 3d

To establish the importance of any proposal to shipowners, it is generally essential in these days of rigid economy, to show good reason for the adoption of the proposal on commercial grounds alone.

This there is no difficulty in doing with the "soft end" type of construction, for the following very pertinent reasons.

In the first place the cost of building should be reduced. There is less steel weight, simpler riveting and caulking, and the possibility of eliminating some portion of the staging work usually required at the bow of a ship building.

Secondly, the character and arrangement of the structure is such that minor bow damages, strained laps, leaky stem rivets and so on, would be practically eliminated.

Thirdly, the making good of damage to the bow following a collision would be simplified and loss of earning time while repairs were being executed would be cut down to a minimum.

Fourthly, the chance of a vessel seriously damaging another vessel and causing her total loss would disappear. As a definite and immediate result there would undoubtedly be a reduction in insurance premiums, for the elimination of total loss cases would relieve the insurance market of considerable risk.

I have endeavoured in this paper to make as strong an appeal as I possibly can in favour of a proposal which has everything to recommend it on humanitarian grounds, on the grounds that it is a logical and practical advance in the science of ship construction, and also on purely commercial grounds.

There is a great deal to be gained by its universal adoption, and a permanent advance to be anticipated in the attainment of a greater degree of safety at sea.

Discussion on Mr. W. S. Patterson's Paper on "Metallic Corrosion," read 13th October, 1925.

Chairman: Mr. R. S. Kennedy (Vice-Chairman of Council.)

The Chairman: We have listened with great interest to this paper, and Mr. Patterson has, I think, endeavoured very successfully to make some abstruse points clear to us. As Mr. Patterson has to leave early to give another lecture, I will invite questions without further remarks from myself. Mr. Patterson will deal with these as far as possible as they arise, and he will reply to any points raised after his departure, in writing.

Mr. A. Jobling: The author has given us a very interesting paper dealing with the causes of corrosion, but unfortunately our education as marine engineers does not always include a knowledge of chemistry. It would interest us immensely to know how to apply this information practically, *i.e.*, in the prevention of corrosion in boilers, propellers, condensers and shell plates; also why the mechanical effect of circulators tends to prevent corrosion; why the present day condenser gives us more trouble than in the early days, and also why propellers corrode at the tips. These are the questions, the solution to which we are endeavouring to arrive.

Mr. Patterson: Mr. Jobling is desirous that I should give an applied treatise of my paper and explain the ways in which the theoretical aspect of the subject can cure the evils encountered in practice. Frankly I wish I could, but there are still practical problems awaiting solution, the underlying mechanism of which is not yet understood. Let us examine a few of Mr. Jobling's points however. "Boiler Corrosion" was the subject of a previous paper which I read before this Institute two years ago, and I would refer him to that paper and the discussion on it for assistance there. Propeller corrosion is probably to a considerable extent erosion caused by water hammer, whilst the difference in air concentration over the blade due to the churning action may account for electrolytic action, which produces the characteristic patchy corrosion. Condenser corrosion is a type of corrosion modified and controlled by very many influences. The composition of circulating water, the treatment of the condenser when out of use, and the development of local deposits during this period, the design of the condenser as regards variable water velocity and the actual composition of the metal of the tubes, with many other items must all have consideration in deciding the initiating factors in any case of condenser corrosion. If the chemist has not yet cured condenser corrosion he has at least found how multiple are the causes which produce it. The author's personal opinion is that the factors in condenser corrosion are so many that it will be exceedingly difficult ever to eliminate any chance of some of these coming into action. If a ship in home waters is fitted with tubes which resist corrosion and are designed and constructed of suitable metal for this purpose it by no means follows that a change in cooling water such as may occur in the estuary of a tropical river will not induce corrosion, and a similar line of argument applies to most of the factors.

Mr. J. MacDonald: Referring to the question of the corrosion of the tips of propeller blades, I suggest the reason for such is that the periphery of the propeller moves through a greater space than the centre in the same time, and is moreover exposed to the air and the surface of the water it may be revolving in, whereby it comes in contact with ash, bilge water animalculæ, and refuse of all kinds.

The same applies to main engine condensers, where ashes and other rubbish and bilge water containing all sorts of impurities from the engine room and stokehold find their way through the main injection.

I would suggest that bilge discharge pipes be above and abaft the injection valves, or on the opposite side of the ship, and that ashes from the stokehold be discharged overboard in such a way that there would be no possibility of the ashes entering the main injection valve, or coming in contact with the propeller.

In many parts in the East we find the harbour abounding in jelly fish, other small fishes and animalculæ of all kinds, and if a ship is lying for any length of time with this dead sea matter in the condenser tubes, it is apt to cause corrosion.

The means to obviate this is to flush the main condenser tubes when possible with fresh or sea water from the ship's ballast tanks.

With regard to the author's remark concerning the corrosion which occurs when metal is scratched—if you take a polished piece of iron or steel a foot wide, any thickness, and scratch it on the surface at right angles, one scratch lying North and South, and the other East and West, you will find the amount of subsequent corrosion or erosion differs.

Mr. W. McLaren: In some of the mysterious corrosive actions with which we have to deal it is difficult to say whether these are due to a natural temperature of the atmosphere or an artificial temperature. I know of one case of a vertical boiler which is examined every six months. I have never previously seen corrosion occurring between the water line at the working level and the steam space, but in this boiler I found this area of the plates to be a mass of corrosion. The plates were worn to a thin shell. On making enquiries I found that the boiler was in charge of a young, inexperienced man and before he went home at night it was his custom to blow it down and run it up with cold water, with the result that the boiler was simply peeling away in shells. I think there must be some connection between the temperature of the water supplied to the boiler and the corrosion. Of course, at sea there is a certain amount of protection in the salt scale.

As regards condenser corrosion, I have not had experience at sea for some time but we never used to be troubled with pitted condenser tubes; we merely had to contend with a softening of the cast iron doors. I once had the privilege of examining a case of the corrosion or, one might say, the softening of cast iron. This was in a jet condenser which had been 28 years in use, and we noticed that where the fall of the water into the condensing vessel occurred, the metal was flaking away. We wanted to re-tin the copper surfaces where the copper was connected to the cast iron, as the metal there was cut as if by a knife. In this instance the temperature was about 120°. We also had some deck fittings such as cast iron valves, in which corrosion occurred, and we tried to obviate it by using some old engine oil, rubbed on with a piece of waste. This proved successful and we had no trouble afterwards. There was also a case where we had a cast iron jacket with a copper lining containing steam and sometimes a considerable quantity of water remained, but not a vestige of corrosion occurred in that case. Possibly the purity of the metal is a factor in the process and that may explain why trouble occurs so frequently nowadays with mild steel plates. In my opinion if we kept the density of the feed water between three and eight degrees we did avoid the pitting. There is no doubt that the hardness of the water affects the problem. I am not yet convinced as to the effectiveness of the electrolytic process, and would like to have more information before I could accept the author's claims for it.

Mr. Patterson: With regard to the corrosion at the water line, I think that is probably a case of the accumulation of bubbles of dissolved gas. That is to say, the water line is the place where oxygen or CO_2 would tend to accumulate from the cool make up water. That probably accounts for the large amount of corrosion taking place there. The oxygen might attack the metal in combination with the CO_2, or differential aeration might be set up, or perhaps both of them. If it did, deep pitting would begin.

With regard to graphitic wasting of the ends of the condenser, I understand that it was the holder for the tube where this occurred; that is where one would expect trouble, because you have an electro-negative metal and on the other hand iron which contains a large amount of graphite. The conditions are such as would result in fairly continuous corrosion. I know of an instance of cast iron piping in contact with a gunmetal valve where the corrosion became so serious that the engineer had some cast iron pieces specially made and fitted and replaced them from time to time. That incident suggests other cases where a boiler fitter has carelessly left a gunmetal nut at the bottom of the boiler causing electrolytic corrosion.

Regarding the last case referred to, covering the cast iron with engine oil, I should say that that was a very excellent thing to do, because a film of salt solution would otherwise be formed over the cast iron, and cause rapid electrolytic corrosion. In cast iron you have carbon, graphite, and iron, just the conditions necessary to set up corrosion. If you cover the surface with any film which prevents the air or weather getting to the surface you would stop the corrosion.

Mr. R. H. MacKillican: The author refers in one part of the paper to the dissolving of the iron. Do you every find the iron in solution in the water? In the case of chloride of magnesium being present, you get decomposition of that chloride and chloride of iron is formed; that in turn is decomposed and ferrous oxide formed. I would like to know whether you ever get iron in the water under any conditions?

Mr. Patterson: The point raised by Mr. McKillican is whether or not the iron which initially dissolves remains in solution in the water and whether, say, in the case of boiler corrosion we ever find iron salts in the water drawn from the boiler.

Usually the iron salts react with other dissolved salts such as carbonates and rust is precipitated. Oxygen also precipitates the iron salts as rust by forming insoluble oxy salts. Hence we do not find iron in boiler water, it is precipitated as rust colouring the scale red. (See previous paper, October, 1923.)

Mr. J. MacDonald: I would like to make my last question clear regarding the need of a quick method of testing waters to prevent corrosion, particularly in boilers. We all know that ships have to go all over the world and that we have to supply extra feed water to the boilers. That may come from the fresh water tanks, but fresh water obtained in different parts of the world may vary in its properties and chemical characteristics, and as ships have to use sea water also, this again differs in various parts of the world. I want to make this point clear, that if there is a short method which enables engineers to test sea water and to know whether they are using water which is going to cause corrosion, it would be very useful to know of it.

A very large number of marine engineers already use litmus paper, and know that when litmus paper turns red it is said to possess an acid re-action, and on the other hand when litmus paper turns blue, it is known to have an alkaline re-action.

The CHAIRMAN: I am sure I am interpretating the wishes of the meeting in proposing a hearty vote of thanks to Mr. Patterson.

Mr. PATTERSON: I can only say that if what I have put before you to-night is of any assistance, I am more than repaid for preparing the paper.

The CHAIRMAN: Mr. Patterson hopes that the discussion will be continued; he will reply in writing to any further comments, as he has another appointment and will require to leave us.

Mr. A. JOBLING: It would be interesting to know whether the experience in the Royal Navy in regard to corrosion is similar to that in the Merchant Navy?

Engr. Rear-Admiral W. M. WHAYMAN: I think that is hardly a fair question, because in the Navy we use distilling plants which give pure water, consequently we do not experience the same conditions as in the Mercantile Marine. The general practice is to provide sufficient evaporating capacity for the feed water requirements and drinking water as well.

Mr. J. MACDONALD: Referring to distilled water which I have often used for boilers as well as supplying the crew and passengers, the same question applies regarding the engineer testing that water in order to determine whether it is going to cause corrosion or not. I know one case where distilled water has caused corrosion in a ship's boiler.

Every marine engineer knows that before proceeding to distil water for domestic purposes, all zinc plates should be removed from the boiler that is to be used for the purpose, and the boiler thoroughly cleaned and washed before filling.

I think the reason why corrosion was caused in this particular case was because the distilled water was aerated, and the pump which supplied this particular water to this boiler was also helping to aerate the water through the pet valves on the water cylinders.

Mr. J. C. Thompson: Regarding Mr. MacDonald's remarks about corrosion in condensers in the Service, in one case within my experience on a steam-driven submarine after one year's working, one-half of the condenser tubes had to be replaced. In the tube plate the corrosion occurred at the position where the tube plate joined the water box, centre division. I think the large amount of electrical gear on board in addition to the high speed of the circulating water tended to accelerate the corrosion. Such conditions we would never expect to experience in the Mercantile Marine.

Mr. W. M. Jennings: May I make a few suggestions for Mr. Patterson's consideration. He has put before us very ably the question or corrosion according to the chemical and physical laws as at present known. But another condition arises of great interest to marine engineers, that of corrosion due to micro-organisms and animal life in the sea. For example, I have a case in mind of a submarine pipe line off Trinidad, which leaked so badly after some six to nine months submersion, although protected in the best manner with bitumastic compound, that it had to be lifted above the water level. The leaks were found to be due to shell fish of the small barnacle type, which adhered to the pipe where the compound had pinholed, then died. After death this decayed matter bored a small hole through the pipe. The action appeared to be pure acid decomposition or corrosion of a purely chemical nature. The same type of action takes place on piles in sea water.

The Chairman: Experience during the war emphasised very much the last speaker's point. The shell plates of the German ships which were held up in warm waters during the war were very badly corroded, the pitted holes being $\frac{7}{8}$in. to 1in. in diameter and $\frac{1}{2}$in. in depth. There were hundreds of these holes in a plate and the cost of repairs was a large item.

Mr. W. M. Jennings: There is another point which occurs to me. When two copper plates are immersed in slightly acid water a difference of potential is created between the plates, and electrolytic action (or corrosion) takes place. Electro statically, if fluid velocities are changed over metal surfaces, a difference of potential will be created. This would appear to produce electrolytic corrosion action, but of this I am not quite certain. It, however, may account for corrosion in condensers, where the tendency is to increase the velocity through the tubes in present practice and therefore this question of corrosion becomes very important.

Mr. G. B. Plows : I would like to ask the author whether he can give any information regarding the curious action which strong alkaline mixtures have on steel plates.

There seems to be no question that wrought iron and mild steel are rendered very brittle by contact with such alkaline fluids, as, for instance, caustic soda.

I have seen steam jacketed vessels, which, after quite a short time become cracked in many places. These cracks, sometimes being parallel to one another and others at right angles, show a very crystalline fracture.

It is found that large vessels containing this alkali, heated by means of steam jackets, only last so many months and have to be replaced very soon.

This question is also of importance to boiler users as it is common practice with many to treat the feed water with soda so as to prevent the formation of sulphate scales, and the soda strength concentrates in the boiler.

It would, therefore, be of interest to know whether the author in his many experiments on boiler plates has ever come across such embrittlement which might have still more serious effects in a boiler than corrosion.

Mr. J. MacDonald : In one instance in my experience I had to change the whole of the tubes of a condenser due to corrosion. The last speaker but one referred to barnacles. I think the dead marine matter causes more trouble than the live matter, whether in condenser tubes, pump chambers, pipes or ships' hulls. If you examine the bottom of a ship in dock with both live and dead barnacles attached, you find more corrosion under the dead than under the live barnacles. Going into a port where you find all sorts of animalculæ, as for example in ports in the East, this occurs very noticeably. It was, of course, the composition of the first set of condenser tubes which caused them to deteriorate so quickly; the other which we put in gave no trouble as they were of a different composition.

Mr. F. Mayor : I shall be glad if Mr. Patterson could give some information regarding something which is familiar to many of our engineers, namely, the wasting and erosion of the points of rivets in the bottom of a vessel, where the plates have eroded and the rivets are found loose. It occurred to me that there must be something to account for the erosion attacking the rivet only and not the plate.

Mr. B. D. Smith (By correspondence): A point I would like to see raised in connection with Mr. Patterson's lecture is one which I believe is causing trouble at the present time to several users of softened water plant. These plants use the recognised method of soda ash and caustic soda at a temperature of about 160°F. Enough is used to result in an exact neutrality of the subsequent feed water—certainly no scale is found, and blowing down clears the boilers of all sediment. The boilers are clean but gun-metal fittings suffer bad corrosion: I have seen one cock which was corroded to a depth of 1/32in. in two months. To what cause can this be ascribed? It is not a solitary instance.

Is there danger of overstepping the amount of alkalines and of a slight alkalinity being worse than a higher degree?

Would the use of zinc be again resorted to? Or is it a case of the cure being worse than the disease?

As far as can be seen, steel is safe in this water, but most certainly these copper alloys are not, and the advice of Mr. Patterson on this point would probably be of general interest to all, and of great value to some.

I have seen no reference to this in Mr. Patterson's lecture in 1923, so am raising the point in this letter.

Mr. F. A. Beckett: Pure metals in engineering are ideal, but where can they be had for the commercial world? De-aeration of all feed water would be the acme of perfection. At the water level of many vertical boilers, the uptakes suffer through often being made to act as a superheater.

Many pittings on boiler shell bottoms is caused through lack of circulation in local places, particularly between stays, near the ends and under chambers.

Impure feed-water has caused corrosion more than impure metal, particularly difference in the feed specific gravity causes the lighter feed to travel further, and the consequence is that the furthest boiler from the feed pump suffers more by pitting.

A case lately of de-gassing the feed water has relieved what might have become a serious disaster, viz., upwards of about 18 cubic inches of free oxygen per gallon of feed water was found after several economiser tubes had failed; after being broken up, these tubes were found to be cleanly wasted internally by oxygen, not pitting corrosion now, I understand, since erecting a de-gassing plant, this difficulty has been overcome.

I am thankful to note about dry sulphur, that only when it is moist it corrodes; this has been my experience.

Peat acids in water gives one the thought of the modern farmer now using chemical manures on his land, and some of this by rain gets washed down streams to rivers, hence further impurities in our rivers for industrial works, etc.

Can Mr. Patterson say, why it is only on, or towards, the bottom end of vertical economiser tubes that they become corroded and wasted by " dew point " or other causes externally.

I do not understand why a tube being but half filled with moving water, can improve steam raising and upkeep; it seems to be that water-hammer would result. Allow me to compliment Mr. Patterson on his valuable paper and I think his summary of No. 1 to 7 includes all our troubles.

SUPPLEMENTARY REPLY FROM MR. PATTERSON.

MR. PATTERSON: Mr. McDonald has referred to a method of testing the corrosive qualities of feed and condenser water. I would refer him first to the Weir "Corrosion detector," an instrument which is designed to detect any corrosive tendency in the feed water. This test is empirical and shows only when the feed water is liable to cause corrosion without ascertaining the cause, and it therefore offers no real guidance to the engineer to correct the trouble. It does, however, appear to be a useful instrument to indicate when corrosion is likely to occur. I must be quite candid with Mr. McDonald; there is no short cut to a water examination, but quite useful information can be drawn from the following simple tests which I have outlined.

1. *Litmus or Phenolphthalein.*

These reagents indicate the alkalinity in water. Any sudden change over from acidity or alkalinity to the reverse condition should be treated with suspicion and its cause should be investigated.

2. *Silver Nitrate Solution.*

This reagent shows the presence of the salts known as chlorides, with which it gives a white turbidity. Generally speaking chlorides are not injurious in boiler feed water, but their presence in any quantity in condensate is, of course, a clear indication of leakage.

3. *Soap Solution.*

This reagent is suitable for testing the hardness of water. It can be obtained in form of a standard solution, of which 1 cc. corresponds to 1 grain per gallon of hardness. Occasional checks on the feed water hardness should enable an engineer to know when changes are occurring and give him an indication as to when too much lime or soda has been added.

Reference has been made to the use of condensate. The writer believes that this rendered slightly alkaline with sodium carbonate (soda ash) and de-ærated, is the ideal boiler feed.

Mr. Jennings will find a reference to one point he raises towards the end of the paper, when the variation in velocity of water in tubes is mentioned.

The influence of marine animal and vegetable organisms, either alive or dead, appears to be to induce corrosion. Some of these produces acidic matter, either whilst living or during decay, and this would undoubtedly induce corrosion. Generally speaking such corrosion will be caused by products obtained from the growths themselves. The use of anti-fouling paints, etc., will to some extent mitigate the evil.

Mr. Plows and Mr. Smith both raise the question of the induction of corrosion by excessively alkaline boiler feed. Mr. Plows, however, refers to the attack of steel plates whilst Mr. Smith is dealing with gun metal corrosion.

I think " season cracking " is a common phenomenon in steel plates exposed to strong alkaline solutions, it has been studied by metallurgists and is, I think, due to overheating for a prolonged period. Such treatment in contact with an excessively alkaline liquid such as Mr. Plows mentions would tend to produce inter-crystalline cracks and brittleness. I do not think under normal conditions, with such mild alkalinity as should be present in a boiler feed water, properly softened, that the trouble would arise to a great extent.

Mr. Smith's point is very interesting and the reverse of what one might expect from the conditions he described where one would anticipate the electro positive ferrous metal to be attacked whilst the copper alloy was protected.

Gun metal contains tin, a metal which is attacked by alkaline solutions and the possibility is that some attack of this type is occurring in the case cited. A change in the composition of the gunmetal would probably solve the trouble. I think no danger will result from a slight alkalinity in the water.

Where a very soft water is available as boiler feed it is customary to render it slightly alkaline. I have come across cases where the ferrous metal adjacent to gun metal fittings has been badly corroded, but the latter have been immune from attack. It should be remembered that the process of water softening by soda ash and lime consists in replacing all the metal salts other than sodium by sodium salts. Feed water is therefore rich in dissolved salts after such treatment and is an excellent electrolyte. The conditions for local electrolytic action between the phase constituents of a gun metal are therefore complete and the explanation of the phenomenon may lie here.

I am in complete agreement with Mr. Beckett and thank him for his contribution to the discussion. Although the influence of patent manures does not affect the marine engineer, the whole question of river pollution is of importance to station engineers and requires special precautions. The cause of the corrosion of the lower ends of economiser tubes is, I think, merely a matter of gravity, any liquid condensing on the tubes would tend to flow towards the lower end becoming richer in acid the longer it was exposed to the flue gas and thus concentrating the corrosion at the lower end of the tubes. The appearance of the deposit on such tubes frequently confirms this by its " streaky " formation.

I would like to thank all the members who have taken part in the discussion.

Notes.

The following is from " The Glasgow Herald " of November 10th:—

Corrosion of Metals.—Notwithstanding the large amount of work that has been done to ascertain the causes of metallic corrosion, there are still cases in everyday experience where the reasons for corrosive attack cannot be definitely ascertained. The problem is one common to all branches of engineering, and could some universal remedy be found, the possible savings would be enormous. To the general reader the most apparent examples are afforded by structures such as bridges, where the almost continuous presence of painters and cleaners suggests calculations on the cost of time and material that generally present startling results. The less spectacular, but equally destructive, corrosive effects in boilers and condensers are only fully appreciated by those in intimate contact with the working of such plant, but here again inspection and prevention methods make a large addition to upkeep cost. The modern demands for higher pressure in the boiler and higher vacuum in the condenser have increased not only the possibilities of but also the dangers arising from corrosive attack in these particular cases. Those who have studied the literature dealing with corrosion problems must have felt how unsatisfactory were many of the theories put forward to explain its action and how little they assisted in the planning of methods to prevent or lessen further attack. For this reason alone those interested are referred to a paper entitled "Metallic Corrosion" recently presented to the Institute of Marine Engineers by Mr. W. S. Patterson. The special feature of Mr. Patterson's paper is that not only is a comprehensive review of the usual electro-chemical theory given, but, in addition, attention is directed to recent work by Aston and Evans which seems to offer explanations of corrosive attacks that previously were difficult to understand. A preliminary review of some of the observed facts of corrosive action which require explanation may be useful. One of the most puzzling is the local and apparently capricious nature of corrosion. There is also the action of the layer of corrosion product which sometimes stops the corrosion process and at other times appears to accelerate the attack in the later stages. Equally difficult to explain is the phenomenon of pitting and the continued action that persists at the bottom of a corrosion pit. It is considered by Mr. Patterson that little satisfactory explanation can be given to the questions just raised by theories brought forward prior to 1916, and that it is to the developments resulting from later work that we must look for enlightenment.

Corrosion Theories.—In making a study of corrosion phenomena two different methods may be pursued. Thus, some particular case may be investigated with the definite object of effecting a solution without, of necessity, either detecting or comprehending its causes. On the other hand, causes may be investigated without an immediate endeavour to make a direct application to any particular problem, and the evidence thus obtained constantly reviewed until at last some understanding of the real mechanism of corrosion is secured. Generally speaking, researches following the first-named programme have been the most popular. This is only natural, since want of time and the pressing necessity for some immediate solution of the practical problem have prevented workers from devoting any great amount of time to general theory. It must also be stated that financial support is more readily obtained for a research which has for its aim some directly practical object than for a more fundamental investigation of which the commercial value is less obvious. Still, it must be acknowledged that a thorough investigation into the general mechanism of corrosion is the path along which new corrosion research should proceed. Once the primary principles which govern corrosion are understood, then more efficient means of preventing all types of corrosive attack will be devised. As a result of recent developments of corrosive research a modified electro-chemical theory has been brought forward to explain many important observations. By this theory, which was probably due to Davy, corrosion is considered to be due to the development of positive (anodic) and negative (cathodic) areas on the metal surface. A mass of metal on which such areas are established, if surrounded by an electrolyte, will cause the production of an electric current between the areas of different polarity. If, for example, the metal is iron, then ferrous ions will pass into solution at the anode, causing corrosion there, whilst hydrogen or its equivalent will be set free at the cathode, over which it may form a film. Such a system is known as a corrosion cell.

Corrosion Cells.—From the above statements it will be seen that the electro-chemical theory postulates the development of positive and negative areas. It is of interest, therefore, to examine some of the examples brought forward by Mr. Patterson to illustrate the manner in which some of these areas may be caused. It is fairly generally understood that definite impurities which are of different polarity to the surrounding metal will set up electrolytic action. Examples of such impurities are to be found in slag inclusions in wrought iron, graphite in cast iron, and certain forms of iron carbide in steel. Such impurities which are practically insoluble in the dominant metal and which tend to segregate, are likely to induce serious local corrosion and pitting. Impurities which dissolve completely, forming homogeneous solid solutions, are less likely to cause local pitting, but may produce corrosion, or what is called wasting, over a wide area. Differences of stress in the same piece of metal may also produce anode and cathode poles, and it has been shown that where a metal has been cold worked and then partly annealed an electric current may be produced where the cold worked or stressed part is the anode pole—that is, the part passing into solution or being corroded. Differences in physical structure in the same metal may also induce electrolytic action. Large coarse crystals, produced by burning or overheating, in contact with metal of a normal structure may give rise to a difference of potential with the consequent solution of metal at the anode. Where the metal has a distinct duplex structure, such as is to be found in certain brasses, there is a tendency to corrosion. The so-called dezincification of brass, so common in faulty condenser tubes, is probably partly due to this cause. It has also been found that the lodgment of foreign particles conveyed by water against a surface may have the effect of establishing areas of polarity and so initiating corrosion, while the effect of abrasion on a metal surface, otherwise chemically and physically uniform, may also be the production of local corrosion cells.

Differential Aeration.—Work by Aston, and more recently by Evans, has shown that areas of differing polarity can be produced by the unequal distribution of oxygen over a metal surface immersed in an electrolyte. Thus if, for any reason, one part of a metal surface is not so freely supplied with oxygen as another, then the part which is most aerated becomes electronegative and the part which is shielded becomes electro-positive. This results in electrolytic action where the part to which oxygen has least access becomes corroded. This fact is considered by the author of the paper to be of great importance, and the recognition of its influence as a factor of corrosion induction is stated to have revolutionised corrosion research in some directions. The discovery of this process of corrosion induction is stated to be due to Evans, and has been called by him "Differential Aeration." It appears to lead to a general statement that corrosion will take place on a metal surface at just those points where oxygen has the least degree of contact. As illustrations, cases are quoted of the corrosion which often occurs at the bottom of pits which have developed in plates or in cracks produced by bending at angles, etc. The shielded zones at the bottom of such pits and crevices become positive to the surrounding more freely oxygenated area and solution of the metal proceeds. The corrosion action is mainly confined to and concentrated on the small shielded anode, with the result that the rate of attack may be very high, with consequent perforation. The example quoted previously of the corrosion resulting from the lodgment of foreign particles appears only to be a special case of this differential aeration. Various observers have pointed out that local corrosion can be induced at any selected spot by placing there pieces of cotton wool, glass, coke, etc., and excessive corrosion is frequently observable in tanks where debris and deposits have covered the metal. Attention has also been drawn by Evans to the fact that steel winding ropes used in mines sometimes become internally corroded whilst the outer portion, which has been freely exposed to air, retains a bright, unchanged appearance.

The following from "The Times" of November 23rd, has been commented on in other papers and journals:—

NAVAL ENGINEERS. DEPRIVATION OF MILITARY RANK.—A Fleet Order of far-reaching significance was issued by the Admiralty on Saturday, which is likely to cause discussion, not only among the officers it actually affects, but in the engineering profession generally. It excludes naval engineer officers from the military branch, into which they were admitted as a result of the Selborne-Fisher scheme of common entry and training introduced in 1902. Under that scheme, executive and engineer officers were both trained at the naval colleges, and when later specialisation took place those who adopted engineering remained in the military branch, their status as (E) officers being analogous to that of (G), (T), or any other specialist officers. They remained on the same list and wore the same uniform. What was regarded as the coping stone upon this measure of reform was the absorption into the executive branch on January 1st, 1915, of the old scheme engineer officers, who were allowed to wear uniform exactly similar to that of officers of corresponding ranks of the former military branch, although retaining the distinctive colour between the lace on the sleeves.

Since the war very considerable changes in the training of engineer officers have been made, and, at the same time, the extent of engineering training for officers as a whole has been much reduced. Instead of waiting until they become lieutenants before electing to specialise, candidates for engineering have to do so before leaving Dartmouth College, while they are still cadets; while those who enter by the special entry system at a later age from the public schools have to declare before the entrance examination which class of cadetship they wish to obtain. The distinction between deck and engineer officers has thus been more clearly defined than was contemplated in the

1902 scheme, although up to the present time they have remained part of the military branch.

The chance of engineers rising to the command of a ship or fleet, however, has been withdrawn since 1918. It was found essential that the majority of officers forming the engineering corps should be " whole time " officers. In 1920, the First Lord stated that "there is a definite distinction, both as regards knowledge and capabilities, between those who are to be trained in the science of naval war and strategical and tactical methods of fighting, and those who are to deal with the upkeep and maintenance of engineering and mechanical appliances which are necessitated by the complex machinery and weapons of modern war. Each side requires a special study, and for this reason final separation of the branches is essential."

The sequel to the view then taken is the issue of the new order. Instead of the present division of officers into five branches—Military, Medical, Accountant, Instructor and Artisan—it has been decided that officers in future are to be divided into the following categories:—

Executive officers, Engineer officers, Medical officers, Dental officers, Accountant officers, Instructor officers, Chaplains, Shipwright officers, Ordnance officers, Electrical officers, Schoolmasters, Wardmasters, and Royal Marine officers.

The term " Executive officer " will include gunners, gunners (T), boatswains, signal boatswains, warrant telegraphists, warrant masters-at-arms and officers promoted therefrom, and the officers of the Permanent Cruiser Service. Similarly the term " Engineer officer " will include warrant engineers, warrant mechanicians and officers promoted therefrom, and the term " Accountant officer " will include warrant writers, warrant supply officers, warrant instructors in cookery, and officers promoted therefrom. All (E) officers will be included in the category of " Engineer officers."

The Fleet Order then proceeds to state that the eligibility to succeed to the command of a ship and to exercise military command will be limited to the executive officers defined above. Special arrangements have hitherto obtained whereby certain (E) officers have retained the eligibility to succeed to command. Lieutenants (E†), for example, might be permitted to drop engineering and to revert to deck duties on promotion to commander. These arrangements will now finally cease to exist. Lieutenant-Commanders (E) will be considered for promotion to Commander (E) in competition with engineer officers, and not in competition with executive officers. It is further provided that all officers qualifying or employed on engineering duties from midshipmen upwards will be shown in separate seniority lists in the Navy List, in the same section as the older engineer officers, in the following order:—

Engineer-commanders, commanders (E), lieutenant-commanders (E), engine lieutenant-commanders, lieutenants (E), engineer-lieutenants, sub-lieutenants (E), acting sub-lieutenants (E), mates (E), midshipmen (E).

A corresponding arrangement will also be followed in the retired list. (E) officers will also in future be shown under ships and establishments in the Navy List with other engineer officers in the order in which they take charge in their department.

In the matter of uniform, it has been decided that all (E) officers of the rank of midshipmen and upwards are in future to wear the purple distinction cloth worn by other engineer officers. A more distinctive shade of purple is to be used.

A letter pointing out the injustice of the proposed ruling has been published, signed by Lord Weir, Sir Chas. A. Parsons, Sir A. R. Ross, and Sir J. E. Thornycroft.

The following letter appeared in "The Times" of Nov. 23rd:—

Diving Dresses. Apparatus for Deep Water.—Sir,—The ordinary diving dress allows free movement of the diver and the use of his hands for skilled work. The usefulness of the German apparatus is restricted in that the diver is hampered in movement by the steel tank in which he is enclosed and cannot use his own hands, but only direct the use of clawlike tools which have to take the place of his hands. In the German apparatus the diver is at atmospheric pressure and the apparatus must be absolutely watertight, otherwise the water would enter and drown him.

The mechanical difficulty of making such a watertight apparatus can be overcome, and even a certain amount of movement made possible for the diver. Several forms of apparatus similar in principle to the German one have been put forward during the past 20 years, but none has been taken up in this country, because of the great disadvantages arising from restricting the movements of the diver. Observation chambers have, however, been designed which may be used, just as the German apparatus, for inspection previous to employment of divers. It is conceivable that a steel chamber might be constructed in which a man might be lowered even a mile deep. Perhaps this will be the next adventure for intrepid spirits after Everest has been climbed.

The danger of using the ordinary diving dress in deep water arises from two causes. Air has to be pumped into the dress corresponding to the pressure of water; every 33ft. of depth demanding an extra atmosphere or 15lb. per square inch of pressure. The diver in his helmet and watertight dress is surrounded by air which holds off the pressure of the water, and he breathes compressed air. As the pressure is equally distributed over his body his functions continue normal except in one respect—namely, his blood exposed in the lungs to compressed air dissolves this air in accordance with physical law and takes up about one volume per cent. of nitrogen for each extra atmosphere of pressure. On too rapid decompression of the diver, the excess of dissolved nitrogen may form bubbles and these, obstructing the circulation in one part or another, produce pains and paralysis. The excess of dissolved oxygen is not dangerous from the point of view of bubbling on decompression, but if sufficient in amount and prolonged enough in action during compression acts as a poison, producing convulsions and inflammation of the lungs. By use of efficient pumps and adequate ventilation and the method of gradual decompression by stages adopted by the Navy and given in the Davis Diving Manual, diving in the ordinary dress at 228ft., the depth at which the M1 is sunk, is quite practicable; in fact, divers of the United States Navy did successful work on the U.S. submarine F4 sunk in 275ft., from which depth the vessel was actually raised. The diver can go down safely to this depth in a few minutes, and the time spent in decompression, during ascent, with fixed stages for pausing, depends on the duration of his stay and the degree of saturation of his blood with excess of nitrogen. The duration of stay at greater depths is made such that he will not be poisoned by oxygen.

The plan was suggested by me of sending the diver down in a diving bell fitted with an inner compartment. He would leave the bell to do his work and, on entering the inner compartment after finishing, would close the door of this. The bell would be then quickly raised on deck and the compartment slowly decompressed in suitable stages.

If oxygen be introduced during the last stage of decompression it helps greatly to turn out the dissolved nitrogen from the blood quickly and safely, as I showed by drinking water and collecting samples of the renal secretion during decompression and measuring the volume of dissolved nitrogen in these.

To avoid oxygen poisoning, the amount of oxygen in the air delivered to the diver at great depths can be reduced so that the concentration is kept below the poisonous degree. The plan proposed was then to diminish the oxygen in the air breathed at the depths, and increase it as the diver came within 33ft. of the surface and paused at this stage during the ascent. By such means diving might be made possible at 300 and even 400 feet.

An improvement has been recently suggested and tried in the United States—namely, the use of helium to replace nitrogen. Helium is an inert gas and can be breathed just as well as nitrogen, and it has the advantage of being less soluble in the blood. A mixture of helium and oxygen, the latter reduced to the safe degree of concentration, is pumped to the diver at the depths; as he nears the surface, air is made to replace this mixture, and the dissolved helium is then rapidly and safely given off, the pressure when this is done being still such that bubbles cannot form in the blood. By this means the duration of decompression can be greatly shortened.

LEONARD HILL.

Osborne House, Loughton.

A diving suit was shown in the exhibition, and described to interested onlookers by the inventor, J. G. Perass, who stated that it was capable of sustaining the operator at a distance of fully 600ft. below the surface of the water, and without any detrimental action upon him.

The following is from "The Iron and Coal Trades Review," October 2nd:—

A HIGH-PRESSURE STEAM INSTALLATION.—In the new Weymouth station of the Edison Illuminating Company, Boston, U.S.A., has been installed a 1,200lb. steam plant, consisting of a boiler with primary superheater and reheater, stoker and combustion equipment, a turbo-generator, boiler, feed pumps and the necessary piping. The boiler and turbine are designed to operate at a maximum steam pressure of 1,200 lbs. per sq. in.

The boiler steam is superheated to 700° Fah., and then delivered to the turbine, which exhausts at 360 lbs. pressure into a reheater in the boiler, where its temperature is again raised to 700° Fah. The steam is then delivered to the other turbo-generating plant in the station, which operates at 350 lbs. per sq. in. The high-pressure boiler and turbine are operated together as a unit. The boiler is a modification of the conventional Babcock and Wilcox cross-drum type, the heating surface consisting of 2in. tubes 15ft. long, arranged in three passes. The drum is made from a seamless-steel forging, 32ft. long by 4ft. dia., forged on a mandrel in upper and lower banks with a primary superheater between. Above the upper bank of tubes is a secondary superheater or reheater. The location of this reheater is such that the gases pass through it between the first and second passes of the boiler. An adjustable baffle or damper permits by-passing all or part of the gases around the reheater. The induced draft and economiser are above the boiler, and are similar to the corresponding 350 lbs. equipment, but the economiser is built for 1,400 lbs. pressure. The power developed in the 1,200 lb. turbine unit is approximately 3,000 kw. The exhaust from this unit develops approximately 12,000 kw. in the 350 lbs. main units. The high-pressure boiler should, therefore, be credited with a total output of approximately 15,000 k.w.

The following is from the " Daily Telegraph " of 18th Nov., 1925 :—

King Awards the Albert Medal.—The King has conferred the decoration of the Albert Medal upon George Henry White, second engineer of the steamship *Paul Beau*, of Hong Kong. His Majesty, on the recommendation of the President of the Board of Trade, has awarded the bronze medal for gallantry in saving life at sea to So Hau, fireman of that vessel (announces last night's " London Gazette ").

On May 4th the *Paul Beau* was proceeding from Hong Kong to Canton when a tube blew out in the starboard boiler, projecting a stream of boiling water and steam 35ft. long into the after end of the boiler room and engine room, which are in one compartment, there being no dividing bulkhead. At the time of the accident two men, Hau Foong and So Hau, were on duty on the boilers, and two others on the engines. Hau Foong was immediately overcome and collapsed, and So Hau at once went to his assistance and, at the risk of his own life, managed to drag him clear of the scalding water before making his way on deck, when he collapsed also. Meanwhile the other two men sought refuge in the tunnel way.

Observing a thick cloud of steam rising from the engine and boiler rooms to the level of the promenade deck, George Henry White suspected what had happened, and, wrapping his face in wet towelling, he made his way through the steam along the top of the boilers and shut off the valves connecting the boilers to the engines and the valve connecting the two boilers. The three men in the engine and boiler rooms were reached as soon as the steam had cleared away, and were removed in a state of collapse to the upper deck. But for the gallantry of Mr. White they would in all probability have been suffocated by the escaping steam.

Mr. White ran a very grave risk, since he had to grope about in the scalding steam fog, blinded by the covering on his head, in his endeavour to shut the stop valves on the boilers, and he might have encountered the full force of the issuing steam, in which case the result would have been fatal. In spite of being badly scalded, he took charge, and having effected the necessary repairs, raised steam again, thus enabling the vessel to be brought safely to the wharf at Canton, where the injured men were removed to hospital.

Boiler Explosion Acts, 1882 and 1890. Report No. 2,740. —While the *Derbyshire* was berthed at Dartmouth on June 12th with steam on one boiler for auxiliary service, steam was ordered for one of the winches to hoist stores on board. The stop valve was opened to the pipe 4 3/32nds inch internal diam. leading to No. 3 winch at 9.45 a.m. No knocking was heard, and it therefore seemed that there was no water hammer action. At 10.45 the pipe burst, fortunately without injuring any one. The second engineer was at the time engaged on the fore deck and at once went to shut the stop valve. Investigation afterwards showed that the pipe had burst at a brazed patch, 3in. x 5in. previously fitted at an unrecorded date. In 1918 all the pipes had been tested under examination to 160 lbs., the steam pressure being 80 lbs. Investigation showed that the reducing valve was in good condition. The boiler pressure was set to 185 lbs., but at the time when the pipe burst the pressure was only 100 lbs. On examining the pipe it was seen that the fractured surfaces of the metal were of an extremely crystalline character, and there were also two large longitudinal cracks over which the patch had been brazed. The brazing metal covered the whole of the patch and was in a very rough state, which gave the appearance of excessive heat having been employed. The original cracks were of a serious nature, and it seemed surprising that the pipe did not fail before the patch was fitted. A new solid drawn copper pipe was fitted. The investigation was carried out and the report made by Messrs. S. A. Houghton and W. Dowson, Surveyors, Plymouth. The comment by Mr. Thos. Carlton, Engineer Surveyor-in-Chief, was that the pipe was of considerable age (28 years) and had developed defects at some previous time which had been inexpertly repaired; the material during the process of repair having been overheated. Evidently the part in question had been on the point of failure for some considerable time and the movement of the pipe due to heat expansion after steam was admitted into it, finally caused rupture.

The following is from the "Evening Post," Wellington, New Zealand, of September 14th :—

The very happy relations which have existed between the past president of the Institute of Marine and Power Engineers, Mr. A. Basire, and the members of the Institute, were evidenced on Saturday evening, when about 150 engineers and special guests assembled in the Institute social room to tender to Mr. Basire their thanks for his work in the interests of the engineering profession. Mr. Basire is one of the oldest members of the Institute, and had been an executive member for 25 years. He was elected vice-president in 1906, and this year retired from the presidency of the Institute, after five years in that position.

* * * * * *

On behalf of the members, the secretary (Mr. W. Sommerville) presented Mr. Basire with a gold watch suitably inscribed and with a silver cake stand for Mrs. Basire.

Mr. W. A. Cairns, vice-president of the Institute, also assured Mr. Basire of the goodwill and good wishes of every member; Mr. Basire's name would go down on the roll of the old stalwarts who had made the Institute the useful and successful organisation it had now become.

The health of Mr. and Mrs. Basire was drunk with musical honours.

In thanking the members, Mr. Basire expressed his warm appreciation of the support accorded him by the executive. Success, he said, had once been defined as consistent progress towards the goal aimed at, even though the goal itself might not be reached, and if the Institute had, during his term of office, made such headway, then he was well pleased and well rewarded. His aim had always been to uphold the dignity of the Institute, grown to-day into an influential body, though from quite a small beginning. In 1901 the total membership in New Zealand, in Auckland and Wellington, was 400, at the present time it was over 1,000. The Institute building was erected fifteen years ago, at a cost of £7,500, and the property would be free of all financial burden in a very few years. To-day the organisation was working very smoothly, and without a doubt engineers owed much to the body which had brought about great changes and improvements in their status and working conditions.

The toast of "The Institute of Marine and Power Engineers" was proposed by Sir John Luke, who congratulated the past president and members upon the great advances made by the organisation. The Hon. W. Earnshaw spoke in support of the toast, and the secretary responded.

The following is from the "Shipbuilding and Shipping Record, December 10th:—"While work appears to be prospering steadily on the *Navarina* treasure, another historical wreck has been discovered in the transport *Prince*, which went down in the great gale off Balaclava on November 13th, 1854. Local report is that she contains £5,000 in English gold, which was for paying the troops, and it is proposed to organise a salvage expedition to regain the treasure. It does not appear as though the bait is a very tempting one, for she is admitted to be deeply embedded in the mud under 40ft. of water, with big rocks, making the salvage work even more difficult. When she was built in 1852 for the General Screw Steamship Co., she was regarded as the last word in naval architecture, and was designed to run to Australia via the Cape. She was essentially a sailing ship with auxiliary steam, and on trial in fairly bad weather could only make about five knots, but was a fine roomy vessel, and in the beginning of the Crimean war was chartered to the French Government to carry 1,200 troops from Calais to Bomarsund. After making another voyage or two she went to

Balaclava with 800 British troops, and practically all the winter stores for the Army, but her people took no precaution in the face of a falling barometer, with the result that she was totally lost in the famous Balaclava gale with some 150 lives. It was this wreck that principally caused the terrible privations of the British Army in the Crimea during the winter of 1854/5, and was the subject of the bitterest comment at the time."

The Awards Committee have received the following essays, and it is hoped that others will follow:—

Student Graduate Section from "Coluba," "The Advantages and Disadvantages of Superheating." From "Pollux," "Auxiliary Machinery for Cargo and Passenger Ships."

Open Competition Section from "Entropy," "The Construction of a Three-throw Crankshaft."

It was anticipated that a paper on Transmission Gear would be read at one of our meetings, but circumstances did not admit it, and the following paper, read at a meeting of the Shipbuilders' Technical Society, Berlin, has been received to publish:—

The driving of Ships by Oil Engines with Hydraulic-mechanical Transmission Gear.

Paper read by Dr. Bauer, Hamburg.

The development of the technique of prime movers shows a strongly marked tendency, in order to effect a saving in material, for the earlier slow running engines to gradually give place to engines running at higher speeds of revolution. In other words, in every development of power producers, higher speeds of revolution are being adopted.

To give examples of this change, attention may be drawn to the fact that the first reciprocating engines for war ships were designed for about 50 revolutions per minute, whereas, the last built machinery of this type ran at about 150 r.p.m., and engines for torpedo boats, and torpedo boat destroyers, from 300 to 400 r.p.m., until finally, the reciprocating engine has been replaced for this class of vessel by the steam turbine, a prime mover with much higher speed of revolution. Even with the turbine drive for ships, we have witnessed, in recent years, the change from the relatively slow running direct-coupled turbine, to the high speed turbine working in conjunction with gearing. In connection with hydraulic work, a continual effort is being made, by the introduction of high speed water turbines, to increase the speed of revolution to the maximum possible under the circumstances.

Automobile practice furnishes still a further example, since in this direction the speed of revolution has been increased considerably during the last few years. In the same way, many further examples might be cited.

It is therefore natural to pause, and to ask whether in the propulsion of ships by internal combustion machinery, a similar development may be demanded. In other words, will the high speed engine be introduced, and in this case will it supersede the heavy slow running machine now standard.

Efforts which aim at introducing high speed internal combustion engines into ships, coupled to the propeller through gearing, have been partially realised, and experiments to this end have enhanced the possibility of this development. It is well known that the firm of Messrs. Blohm and Voss have installed in various ships, motor installations of this type. The Falk Company in America also, have interested themselves in a similar direction. Both these firms are seeking the solution of this problem through the agency of the interposition of an elastic coupling between the oil engine and the gear which it drives.

To-day I hope to interest you, and to make known the work undertaken and in progress with my firm, the Vulcan-Werke of Hamburg, which has in view further development of the propulsion of vessels by internal combustion engines of higher speed, coupled to transmission driving gear.

A considerable amount of information has already been published, concerning this system which uses hydro-mechanical transmission, called by the makers, the Vulcan gear, coupling the Diesel engine and the propeller.

As remarked, a number of articles on this system have appeared in periodicals, so that I shall not enter into a detailed description. Briefly, the system may be described as follows:— Two or more oil engines, running at a moderately high speed of revolution and not requiring reversing gear, drive through pinions, a gear wheel which is connected to the propeller shaft of the ship. The drive of the pinion engaging with the main gear wheel is not a fixed drive. Revolution in the ahead direction is given through a simple hydraulic coupling, and for the astern rotation through a hydraulic transformer, which reverses the direction of rotation imparted by the Diesel engine. The internal combustion engine therefore continues to run in the same direction, the propeller shaft being propelled ahead or astern, according to whether the ahead coupling or the astern transformer are filled with oil.

The hydraulic coupling, and also the hydraulic transformer for the astern running, are inventions of Professor Dr.-Ing. Föttinger, of Berlin, developed when he was associated with the Vulcan-Werke. The adaptation of this system for the propulsion of motor ships has been developed by the Vulcan-Werke within the last few years.

For the purpose of thoroughly testing this new type of drive, the Vulcan-Werke, at their own expense, built a motor ship of 2,000 tons capacity, called the *Vulcan*, in June, 1924. During the month of June, it was demonstrated to a large number of visitors in Germany and from the end of June until the present time she has given a regular and reliable performance in continuous service at sea.

The voyages made by this ship show that the distance covered from June, 1924, up to 31st October, 1924, is about 12,000 miles. In this period the ship has also completed 50 demonstration trial runs, and an enormous number of manœuvres have been carried out. The whole of the machinery installation has stood the test splendidly and never once failed. Moreover, it has never been necessary to stop the engines on account of any defects or to make any repairs, and the wear on the hydraulic and mechanical driving gear has been negligible.

In Drawing No. 3, for the first time the driving gear is illustrated in detail:—

At A. The primary shafts driven by the oil engines.

,, B. The hydraulic coupling for ahead running.

,, C. The transformers for astern running.

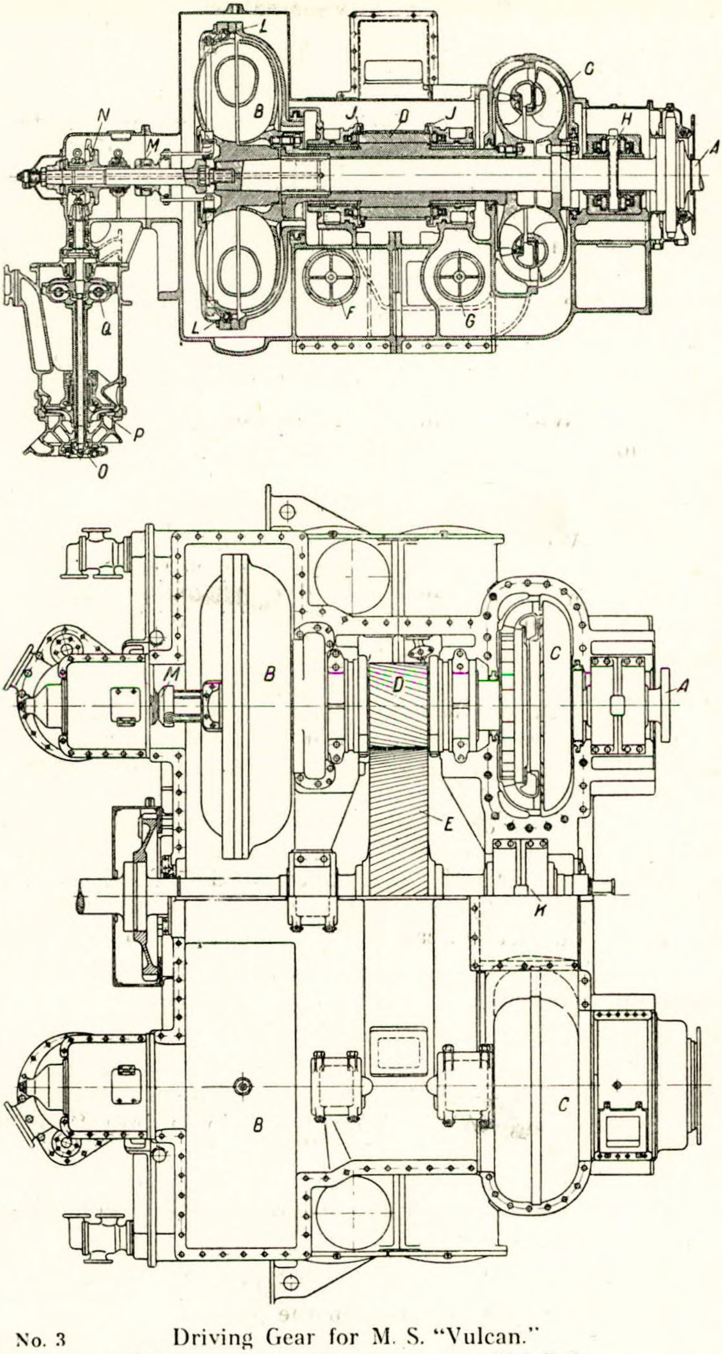
,, D. The pinion of the mechanical gearing.

,, E. The large gear wheel.

,, F. & G. The control valves for regulating ahead and astern running.

,, H. The thrust bearings on the primary shafts.

,, I. The thrust bearings on the pinions.



No. 3 Driving Gear for M. S. "Vulcan."

Output measured at propeller shaft . . . . 620 S. H. P.
Engines . . 300 r. p. m. Propeller shaft 85 r. p. m.

At K. The thrust bearing on the propeller shaft.
,, L. The outlet ring, which allows the oil to escape from the ahead coupling, when coming to a stop or when reversing the propeller shaft.
,, M. The controlling mechanism for the outlet ring.
,, N. The bevel gear for the pump drive.
,, O. The oil pump for make up oil coupled to the small bevel gearing.
,, P. The manœuvring pump.
,, Q. The hydraulic coupling controlling the manœuvring pump.

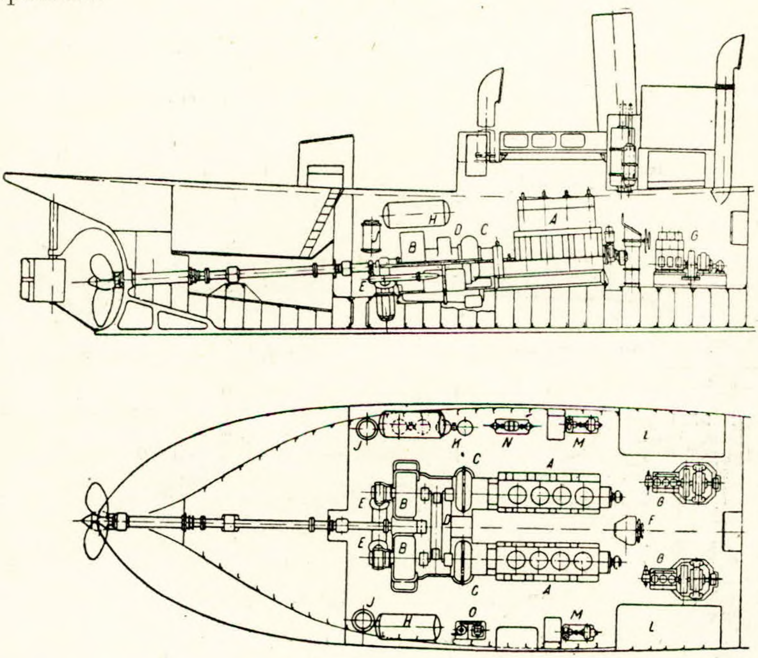
The mean results of several long distance runs from port to port are as follows:—

Revolutions per minute of the oil engines ...	307
Revolutions per minute of the propeller shaft	87,5
Reduction (total)	3,51
Slip in the ahead coupling	2,5%
Efficiency of the ahead coupling	97,5%
Output measured at the propeller shaft by means of torsion indicator	580 S.H.P.
Oil temperature in the gear casing	43°—47° C.
Largest output astern with the fuel lever in the position allowed for this purpose	470 S.H.P.
Starting torque ahead (maximum)	5600 mkg
Starting torque astern with the fuel lever in the position allowed for this purpose	4500 mkg

The excellent results achieved by this trial ship in good or bad weather, have led to the large number of orders, which we have received up to the present time, particulars of which installations will be found on the attached table.

Drawing No. 4 illustrates the machinery for a sea-going tug-boat built by Bremer Vulkan, which will be the first tug-boat fitted with this type of propelling machinery.

In this drawing, "A" indicates the main engines, " B " the ahead couplings, and " C " the transformers for astern running. Between the ahead couplings and the astern transformers are pinions driving the large gear wheel " D," just as in the case of the machinery for the motor ship *Vulcan*. Abaft the driving gear at " E " the drive of the make up and manœuvring oil pumps will be seen, and at " F," the manœuvring column which carries all the gear for manipulating the machinery. The Diesel dynamos are indicated at " G," starting air reservoirs " H," oil coolers " I," oil filters " K," fuel oil tanks " L," cooling water pumps " M," all of which auxiliaries are installed in duplicate. Reserve lubricating and fuel oil pumps are installed at " N," and " O " is an oil separator.



No. 4 **Sea-going Tug-boat of 490 S. H. P., built by Bremer Vulkan.**
Engines . . . 300 r. p. m. Propeller shaft . . . 100 r. p. m.

In Drawing 5 is illustrated the transmission gear provided for the installation indicated in the third column of the attached table. The following table explains the various items:—

" A." The primary shaft driven by the main Diesel engine.
" B." The hydraulic coupling for ahead running.
" C." The transformer for astern running.
" D." The pinions.
" E " & " F." The control valves for ahead and astern running.

"G." The thrust bearings on the primary shafts.

"H." The thrust bearings on the pinions.

"I." The oil outlet ring.

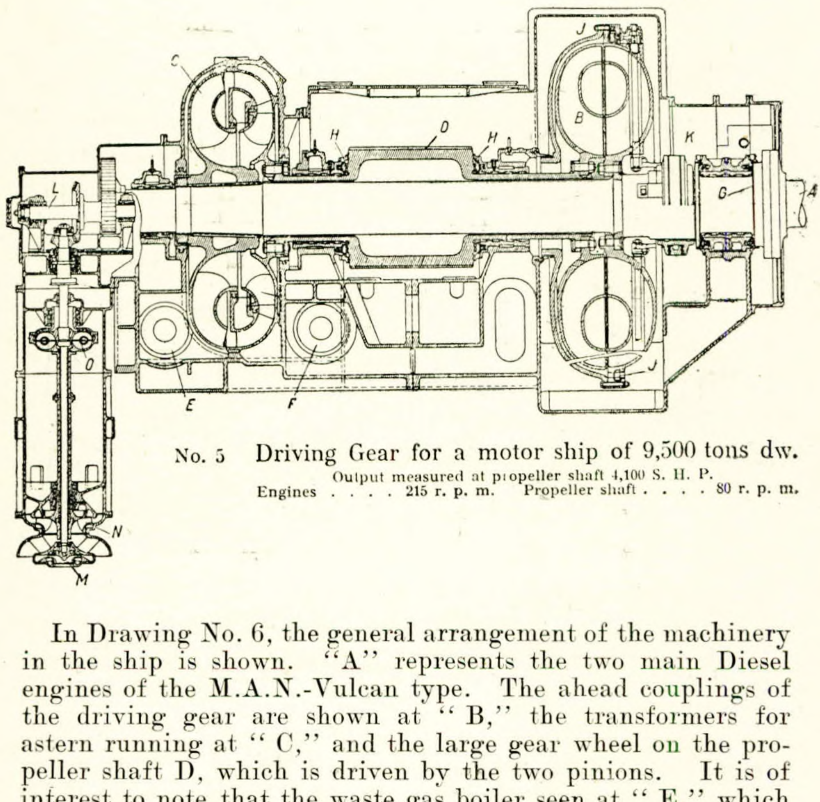
"K." The control mechanism for turning this ring.

"L." The drive for the manœuvring and make up oil pumps.

"M." Make up pump.

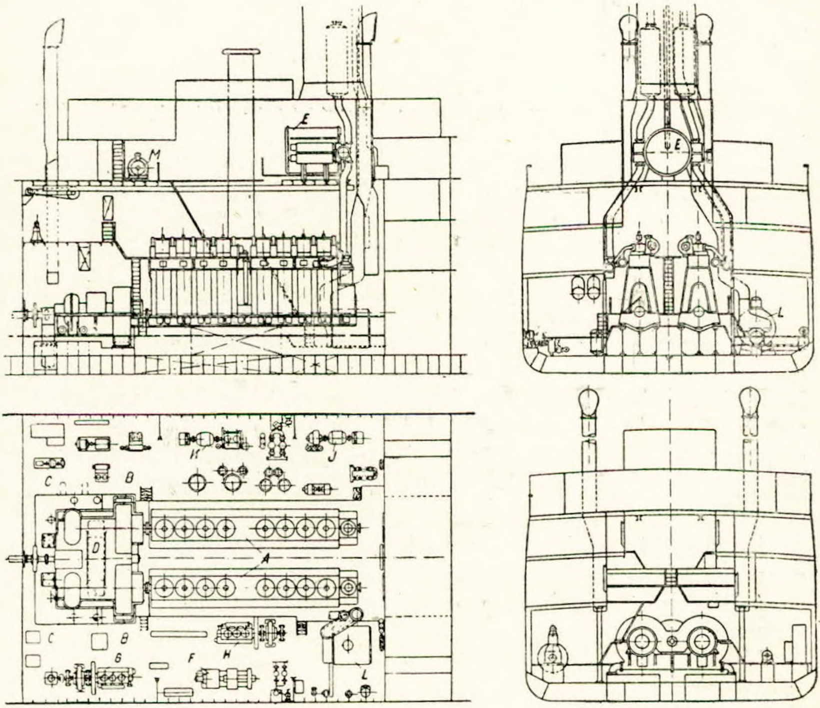
"N." The manœuvring pump required for emptying and filling the coupling during reversing.

"O." The hydraulic coupling controlling the manœuvring pump.



No. 5 Driving Gear for a motor ship of 9,500 tons dw.
Output measured at propeller shaft 4,100 S. H. P.
Engines . . . . 215 r. p. m. Propeller shaft . . . . 80 r. p. m.

In Drawing No. 6, the general arrangement of the machinery in the ship is shown. "A" represents the two main Diesel engines of the M.A.N.-Vulcan type. The ahead couplings of the driving gear are shown at "B," the transformers for astern running at "C," and the large gear wheel on the propeller shaft D, which is driven by the two pinions. It is of interest to note that the waste gas boiler seen at "E," which supplies about 1,600 kgs. (3,500 lbs.) of steam per hour at seven atmospheres (100 lbs. per sq. in.) pressure and 250° C., is sufficient to provide electric current for all the auxiliaries required when the ship is at sea. The electric current is developed in the turbo generator " F." The two Diesel dynamos " G " and " H " serve for port duty and as reserves. All the auxiliaries,including the deck winches, etc., are electrically driven. At " I " may be seen the electrically driven main cooling water



No. 6 Motor-Freighter of 9,500 tons dw. of the Deutsch-Australische Dampfschiffs-Gesellschaft.

Output measured at propeller shaft . . . 4,100 S. H. P.
Engines . . . . 215 r. p. m. Propeller shaft . . . . 80 r. p. m.

pump, and a twin lubricating oil pump; at " K " the ballast pump, and a twin lubricating oil pump; at " L " is the auxiliary boiler required for steam heating in harbour, which also can be used when necessary to supply steam for driving the turbo generator. " M " denotes the emergency generator set. The main propelling, reduction, and coupling gear is shown in column four of the attached table, is of the same design as described in the foregoing, although the auxiliary equipment is somewhat different.

The question of the efficiency of the hydraulic couplings and gear when running ahead, the influence of size, and number of revolutions on the efficiency, the details of the design of the blade for astern running, the complete elimination of torsional vibrations due to the introduction of the hydraulic medium, and lastly the control of the oil, necessary for removing it from the ahead to the astern elements or *vice versa*, for manœuvring the ship, have been the subject of the most careful and scientific researches lasting over a number of years. I regret that at the present time I have not been able fully to deal with these investigations in this paper, on account of other important matters, but it is hoped to deal fully with them on a later occasion.

So much for a description of the results which have been achieved up to date. Let us turn now to the investigation of the possibilities of this system for the propulsion of ships, by determining the advantages and replying to what may appear to be objections. Much has been published in the form of propaganda by my firm as to the advantages, and the following may briefly be said to be the leading points generally conceded.

(1) The interposition of a hydraulic medium gives an elastic coupling between the oil engine and the gear, and prevents inequalities in the turning moment of the oil engine from being transmitted to the driving gear. Consequently it is clear that—

(*a*) It is permissible to make the scantlings of the shafting abaft the gear wheel to exactly the same formula as applies to turbine machinery and therefore considerably lighter than is necessary with direct coupled Diesel engines, so effecting a considerable saving in weight.

(*b*) The main Diesel engines may be so constructed as regards critical speeds, that the number of specific oscillations of the primary shaft is much in excess of the driving speed, so that the main oil engines are never required to run through dangerous critical speeds. This obviates one of the most serious drawbacks to the successful continuous performance of such prime movers. Furthermore, if, during manœuvring or for any other reason, such as severe weather, etc., the speed of revolution of the main engines has to be reduced, there is no fear that a dangerous critical speed may be entered upon, as may be the case with direct coupled engines.

(2) The Vulcan System permits of the fitting of single screw ships, with two main engines, each of which may be coupled to the propeller shaft at will, giving the following advantages:—

(*a*) In the case of a mishap to one engine, it can, without stopping the propeller, be disconnected, brought to a standstill, re-adjusted, and whilst the rest of the main machinery continues to run, be again connected up.

(*b*) If it is desired to operate the ship for any appreciable distance at reduced speed, one engine can be disconnected, the other engine continuing to function on normal output, and therefore under the most economical conditions. When starting up such plant, the oil engines can first of all be run light, *i.e.*, with couplings empty and can then be connected singly or together to the propeller shaft as may be desired.

(*c*) Examination of either engine can be carried out without putting the ship out of commission.

(3) The reversing of the main engines with compressed air is eliminated:—

(*a*) In consequence, the necessity for providing large auxiliary compressors, and capacious air reservoirs is reduced to about one-fifth of that necessary for direct reversing engines. Reserve air reservoirs for compressed air, in the case of high pressure systems of 70—80 atmospheres (1,000 to 1,800 lbs. per sq. in.) having thick walls of 40 mm. (1 9/16ths inches) or thereabouts, are not required.

(*b*) The risk that the manœuvring capacity of the ship may suffer, due to the loss of compressed air, does not apply with the Vulcan System.

(*c*) The speed with which manœuvring can be effected is greater than in the case of direct coupled engines.

(*d*) The Vulcan System eliminates the necessity of admitting cold starting air into the heated main engine cylinders, which is one of the disadvantages of direct coupled engines, and which is becoming still more disadvantageous with the growing tendency at the present time, to instal double acting engines.

(4) The introduction of gearing permits of a lower speed of revolution of the propeller, with a consequent increase in effi-

ciency, which increase of efficiency generally, will more than counterbalance the loss of efficiency through the couplings and gearing.

Drawing 7 is a reproduction of a curve, giving the increase in efficiency with reduced speeds of revolution of the propeller. The example taken is an ordinary cargo ship of 6,300 tons. If driven by direct coupled oil engines at 100 r.p.m., and compared with a similar single screw equipment having a hydro-mechanical gear with the propeller running at 75 r.p.m., the voyage results with the latter system, would show an overall gain in efficiency of the propeller, of about 12%.

In addition to the foregoing advantages, which are generally conceded, there are many others, which are not yet acknowledged, and I would be indeed pleased, if through the publication of the following details, full discussion was stimulated: for instance:—

(5) By increasing the number of cylinders, the performance of the oil engine is improved in the following manner:—

(*a*) In engines with small or medium size cylinder, it is possible to work more nearly to completely interchangeable limits.

(*b*) All repairs are on smaller parts, and may consequently be more cheaply and quickly carried out.

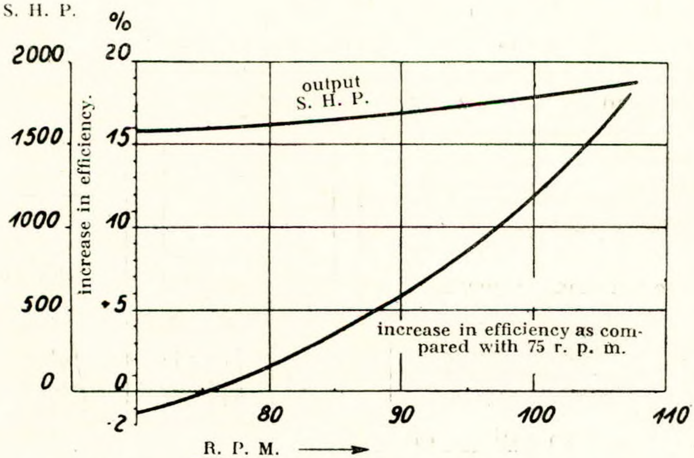
(*c*) Spare parts which have to be carried are lighter, and cheaper.

(*d*) The dismantling of single parts for examination and overhaul, is work which can be carried out with a small staff, and in a short time, light lifting tackle sufficing, and obviating the great amount of work entailed, in handling few parts of large size, and great mass, involved with direct coupled installation.

(*e*) The foregoing leads naturally to the advantages which small cylinder diameters offer, in the manufacture of such engines. Engines with a large number of small cylinders, are much more quickly produced, than engines with a few large cylinders, as the work is divided into a greater number of similar operations, each of which occupies a comparatively short time. In connection with the objection which may be lodged, that the large number of small parts increase the working expenses, I maintain, that the cost of transport of the large parts is reduced, that the risk of rejection is much smaller, and that the advantages of series manufacture are maintained; also, that mass production methods can more readily be brought to bear. Further, the patterns are certainly cheaper, and no more patterns are required, than in the case of the large engine with fewer cylinders.

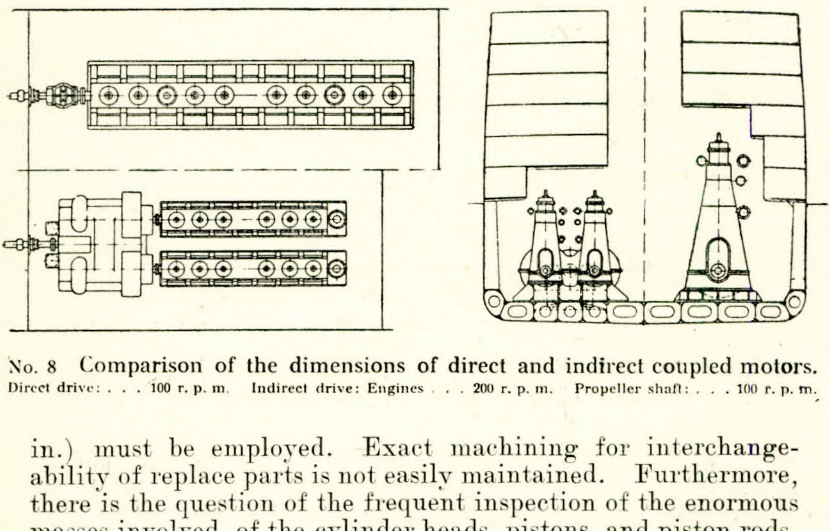
(*f*) Should one of the cylinders fail, due to any defects in material or supervision, the loss of power is not very serious.

At this point, I would like to revert a little. From many sides it is urged, in favour of the system, where the total power to be developed by the propelling machinery is obtained from



No. 7 Curve of efficiency for a single screw motor ship of 6,300 ts. dw. at $10^1/_2$ Kn.

a few cylinders, that by utilising the latest double acting engines, cargo ships of about 2—4,000 horse power, may be propelled by engines of not more than three cylinders. It is held in some quarters, that this system represents the ideal condition for the propulsion of ships, because it is familiar to the average sea-going, steamship engineer, and is as nearly as possible similar to the triple expansion steam engine. In travelling abroad, I have noticed that this is the type of propaganda usually carried out in favour of these large engines. The shipowner and the engine room personnel, when they have experience, would appreciate the difference between the internal combustion, and the steam prime mover. It must be remembered, that with the internal combustion engine, the pressure in the cylinders, is 30—40 atmospheres (450 to 600 lbs. per sq. in.) as against 12 in the steam engine (180 lbs. per sq. in.). The maximum load on each crank bearing, with a 2,500 horse-power engine, is increased from 33 to 98 tons. The highest temperature occurring in the cylinders, is not 300° centigrade but 1,500° centigrade. With such large internal combustion engines, severe stresses are imposed on the material, on account of the high pressures, and high temperatures, which are not present in the steam engine, and whereas with the steam engine, reversing is most conveniently carried out through the agency of the working medium, with internal combustion motors, a great storage of compressed air in enormous containers, at 70—80 atmospheres (1,000—1,180 lbs. per sq.

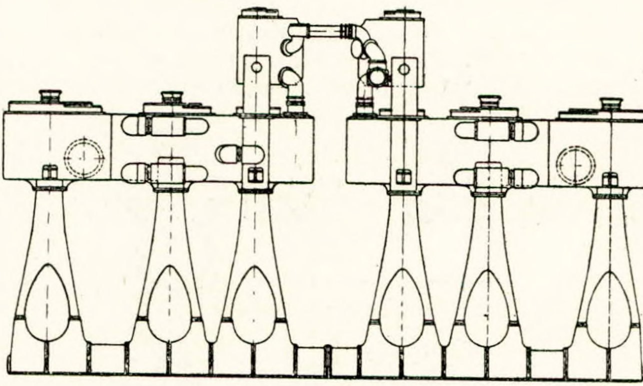


No. 8 **Comparison of the dimensions of direct and indirect coupled motors.**
Direct drive: . . . 100 r. p. m. Indirect drive: Engines . . . 200 r. p. m. Propeller shaft: . . . 100 r. p. m.

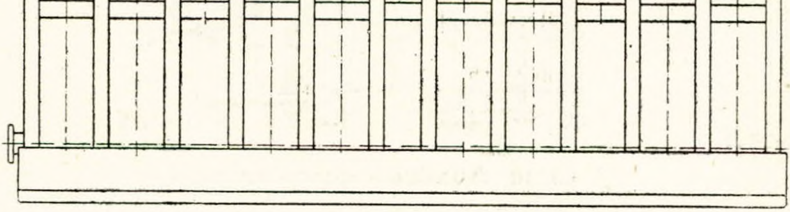
in.) must be employed. Exact machining for interchangeability of replace parts is not easily maintained. Furthermore, there is the question of the frequent inspection of the enormous masses involved, of the cylinder heads, pistons, and piston rods, in such large machines. Superficially, both systems can be said to be very similar, but in reality are found to be entirely different.

(*g*) With the direct coupled engines, all the difficulties which were formerly peculiar to the high speed reciprocating steam engines recur. For example, suppose that 12,000 brake horsepower has to be developed on a single shaft. In Drawing No. 8 is shown, a direct coupled, four-stroke cycle, double-acting engine, compared with our proposal, of machinery, operating through hydro-mechanical gear.

The dimensions of the direct-coupled motors for this output may be appreciated, by an inspection of the side elevation, of this 12,000 brake horse-power Diesel engine, in comparison with that of the largest reciprocating steam engine hitherto

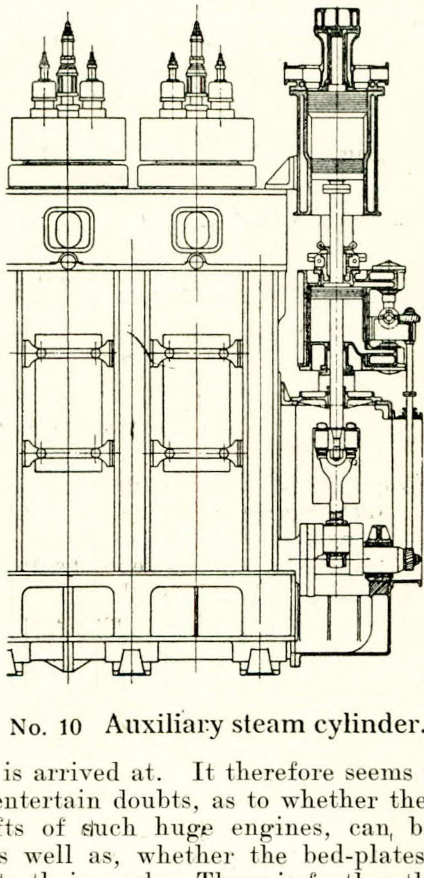


No. 9 a **Reciprocating steam engine.**
22,000 B. H. P. 180 r. p. m.



No. 9 b **Double acting four cycle oil engine**
12,000 S. H. P 100 r. p. m.

built, that for the *Kaiser Wilhelm II*, and *Kronprinzessin Cecilie*, of 22,000 horse-power, as shown in Drawing No. 9a. The height of the Diesel engine above the engine room floor will be about 13,5 metres (44ft.). The diameter of the crankshaft approximately 700 mm. (27,5 inches); the total weight of the crankshaft of such a motor about 200,000 kgs. (196 tons). The corresponding dimensions and weights with the engine of the *Kaiser Wilhelm II*, amount to 530/635 mm. (20,8/24,8 inches) and 109,000 kgs. (107 tons). Those who were intimately associated with the building and running of these old fast running reciprocating steam engines, will readily agree with me, that the limit of what can be expected from a recipro-



No. 10 Auxiliary steam cylinder.

cating engine is arrived at. It therefore seems to me entirely justifiable to entertain doubts, as to whether the alignment of the crankshafts of such huge engines, can be successfully maintained, as well as, whether the bed-plates and seatings will stand up to their work. There is further the difficulty in bedding the crankshaft bearings, so that they run cool and efficiently, without hammering, as the latter would cause considerable inconvenience to the passengers.

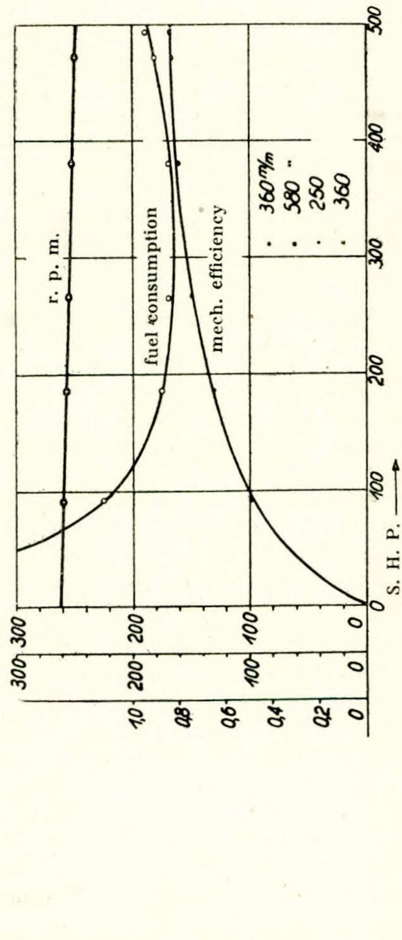
Such considerations raise the question, as to whether the engine seat can be made sufficiently strong, to guarantee a rigid foundation for perfect alignment. Scantlings of very ample dimensions will require to be adopted, in order that the necessary rigidity, is given to an engine of such great height; and finally, the running and maintenance of such machines, must cause the personnel considerable care, and entail much work, and will probably necessitate lengthy periods of laying up of the ship for overhaul, thus causing loss to the ship.

Furthermore, the drawings as given, indicate, that with such high engines, difficulties are encountered by the naval architect, in arranging for the accommodation of passengers. A considerable area of the three lower decks, has to be sacrificed over the entire length of the main engine, whilst with the proposed hydro-mechanical machinery, only the lowest deck has been curtailed, and that for a very short distance.

(*h*) The danger of heat stresses in the hottest part of the cylinder and cylinder head, is considerably less with small cylinders, than with large, and undoubtedly, difficulties of developing reliably with an internal combustion engine, are very considerably augmented, with increases of the diameter of the cylinder.

(*j*) It is equally true, that the stresses to be carried by the cylinder head studs or bolts, connecting the cylinder head with the engine framing, are very much reduced with small cylinders. With the increase in size of cylinder, the construction of Diesel engines, always becomes disproportionately more difficult, and the risks, which have to be taken by the constructors, are increased. It will not be seriously disputed, that cylinder diameters in excess of one metre, are at present impracticable.

(*k*) For the utilisation of the waste heat in the jackets, and exhaust, the non-reversing, relatively fast running prime mover, is particularly well adapted, because with the small dimensions of the working cylinders, the cooling spaces in the jacket, and in the cylinder head, are more easily designed and constructed for relatively high pressures. Warming up of non-reversing engines, is also much more readily accomplished, than with direct-coupled reversing motors. As already stated, in the case of the machinery installation, for the cargo motor ship for the German Australian Steamship Company, the steam generated by waste heat, is utilised in the turbo dynamo. Illustration No. 10 shows a proposal for utilising exhaust steam for driving the compressor. The steam cylinder is arranged below the compressor cylinder, in which manner, the power required by the compressor, is almost entirely derived from the



No. 11 Solid injection Diesel Engine made by the Motorenfabrik Deutz, A. G.

steam which is produced in the exhaust gas-boiler. Since the engine only runs in one direction, and is not reversible, the inclusion of the independent steam cylinder does not involve any complications whatsoever.

So much for the advantages of the Vulcan System as described. It may be permissible at this point, to make briefly, a few general observations on the economy, reliability, and maintenance, as well as on the lubricating oil consumption, of relatively high speed motors.

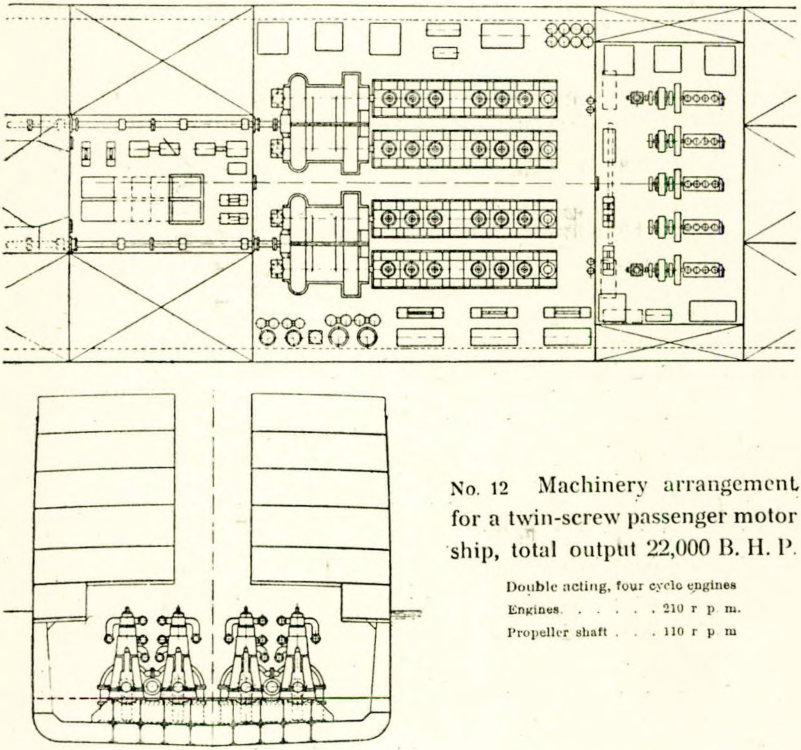
In regard to the first point, enquiries have been made in several places, regarding Diesel engines, which run at a speed of about 200 to 300 r.p.m., and which have been in operation for a considerable time. The answers have confirmed, that the operation of these engines, has given complete satisfaction. Inspection, and re-lining of the main and crank pin bearings, is only necessary after a number of years in operation. Enquiries from those who have experience of automobile engines running at 1,800 to 2,400 r.p.m., have confirmed, that in spite of bad roads, and long runs accomplished at high speed and continuous full performance, no complete overhaul of the engine has been required for years. There is also no reason whatsoever, why a relatively high speed, even a very high speed motor, provided the scantlings of the various parts are correct, should require any more overhauling, than a slow speed machine. The lining up and erection of a small engine, can more readily be carried out with the required accuracy; the absolute values of the powers to be transmitted are lower; the influence of heat stresses, is reduced more and more with the decrease in the dimensions, whilst efficient lubrication of a small surface is much more easily arranged, etc.

In regard to economy of high speed engines, I submit the following examples:—

(1) Experiments have been carried out by Professor Maier, on a solid injection Diesel engine, made by the Motorenfabrik Deutz A.-G., and the results have been kindly placed at my disposal by the makers. This engine is a four cylinder machine, single acting, with an output of 360 B.H.P., *i.e.*, 90 B.H.P. per cylinder, and a speed of revolution of about 250. The cylinder diameter is 360 mm. (14,17 in.) and the stroke 580 mm. (22,8 in.). In the curve, Fig. 11, are given the results of the experiments carried out by Professor Maier, from which, it will be seen that the fuel oil consumption per B.H.P.

per hour, has been reduced to the low figure of 167 grammes (0,37 lbs.). The piston speed of this engine is 4,84 metres per second (950 ft. per min.), and the mean effective pressure 5,45 kgs. per square centimetre (77,5 lbs. per sq. in.).

(2) At the British Empire Exhibition at Wembley, Messrs. Beardmore exhibited a high speed "Beardmore-Tosi" engine of the following dimensions:—2 cylinders with diameter of

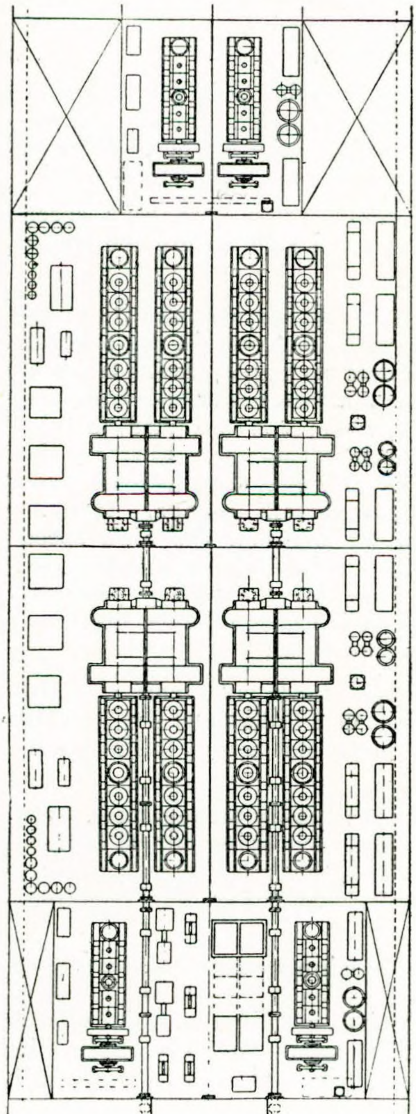


No. 12 Machinery arrangement for a twin-screw passenger motor ship, total output 22,000 B. H. P.

Double acting, four cycle engines
Engines . . . . . . 210 r p m.
Propeller shaft . . . . 110 r p m

345 mm. (13,58 in.), stroke 480 mm. (18,9 in.), giving 130 B.H.P. at 250 r.p.m. The piston speed is 4 metres per second (790ft. per min.), and the mean effective pressure 5,26 kg/cm² (75 lbs. per sq. in.). This engine is of the single acting trunk piston type. Careful trials with this machine, gave a fuel oil consumption of 186 grammes (0,41 lbs.) per B.H.P. per hour.

(3) Trials on a four-cylinder, direct-acting, four-stroke cycle engine, made by Messrs. Fraser and Chalmers, have been published. This engine developed 1,000 B.H.P. at 300 r.p.m. The

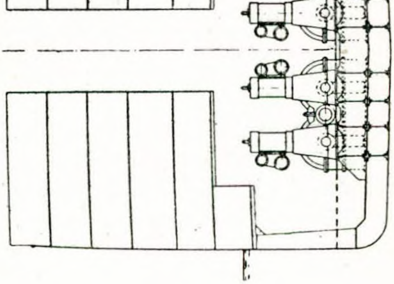


No. 13 Machinery arrangement for a fast passenger motor ship of 40,000 S. H. P.

Double acting two cycle engines.

Engines . . . . . 200 r. p. m.

Propeller shaft. . . 110 r. p. m.



cylinder diameter is 546 mm. (21,5 in.), and the stroke 558 mm. (22 in.), giving a piston speed of 5,58 metres per second (1,100ft. per min.), and a mean effective pressure of 5,8 kg/cm^2 (78,5 lbs. per sq. in.). This engine, when running at 1,150 B.H.P. came fully up to expectations, and gave a fuel oil consumption of 170 gr. (0,395 lb.) per B.H.P. per hour.

I have no doubt that it is still possible, to improve further the economy of the high speed Diesel engine. Indeed, in the natural course of development, the economy of the high speed Diesel engine, will gradually improve as the technique develops.

Finally, the lubricating oil consumption with high speed engines, should, by careful design, be kept within the limits of that of the slow speed types.

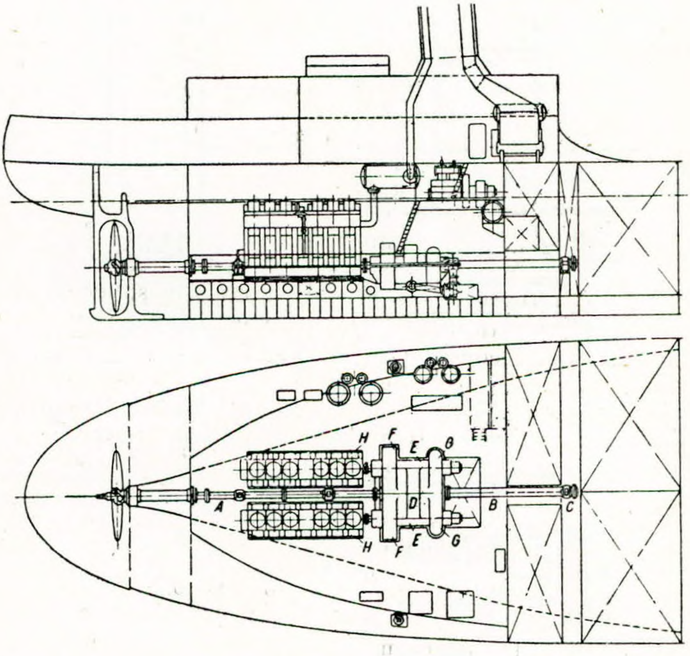
Of course, in dealing with marine engines, motors with crossheads, must not be compared with those which have trunk pistons. With trunk pistons, unless very great care is taken in the design, there is the risk, of oil being splashed from the crankcase on to the cylinder wall, where it is consumed, thereby increasing the consumption of lubricating oil. Further, the construction of the engine must be such, that the crankcase doors are absolutely oil tight, in order to prevent leakage. If these requirements are fully met, in my opinion, the high speed motor, should have a smaller lubricating oil consumption, on account of the smaller dimensions, for the purely practical reason, that with small engines, it is easier to trace leakages, and losses, and so maintain them oil tight.

I shall now describe a few proposals for machinery installations, remarking at the same time that I shall not put forward any designs, for which my firm would not accept full responsibility.

Illustration No. 12, shows the machinery arrangement for a combined cargo and passenger ship, developing 20,000 B.H.P. on two shafts. Each shaft is driven, through Vulcan couplings and gearing, by two, 5,000 shaft horse-power, double-acting, four-stroke cycle engines.

Illustration No. 13, shows the machinery for a fast passenger ship of 40,000 shaft horse-power. There are two shafts, each fitted with two Vulcan gears, which do not differ materially from the arrangement as shown in illustration 12. The engines in this case, are double-acting two-cycle engines, of 5,000 shaft horse-power each (M.A.N.-Vulcan type).

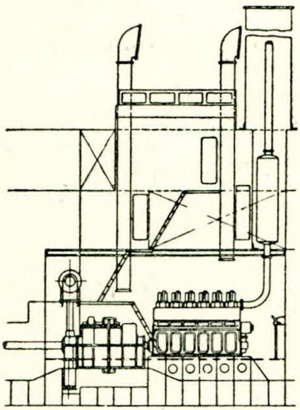
Illustration No. 14, shows the engine arrangements for a tanker. In this case two solid injection oil engines " H," running at 280 r.p.m. are utilised. The number of revolutions of the propeller shaft "A" is 80 per minute, and the total output 19,00 S.H.P. The power of the oil engines is transmitted in the usual way, by hydraulic couplings " F " and " G," to the

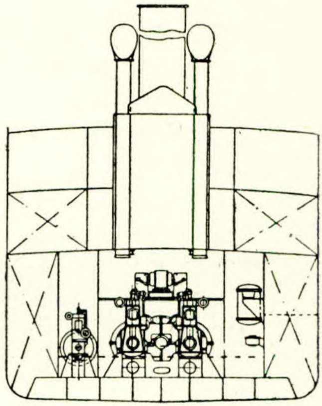


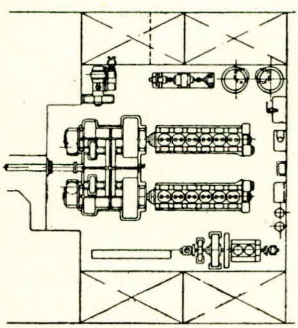
No. 14 Machinery arrangement for a tanker of 7,500 ts. dw.
Two solid injection oil engines.

Output measured at the propeller shaft . . . . 1,900 S. H. P.
Propeller shaft . . 80 r. p. m. Main engines . . 280 r. p. m.
Oil consumption of main engines . . 128 g./S. H. P./h.

pinions " E," and from these to the gear wheel " D." From the gear wheel " D," the power is not transmitted directly to the propeller shaft, but to a hollow shaft " B," which is carried to the forward end of the engine room, or better still through a short tunnel, to the cofferdam between the fuel oil bunker, and the cargo hold. The propeller shaft is carried through the centre of the main gear wheel shaft and the hollow shaft " C," to the *forward* end of which it is bolted. In this way, the propeller shaft is made much longer, and therefore more elastic, so that shocks from the propeller or propeller shaft do not reach the engines. This ensures smooth, steady running of the engines, tending to greater reliability and durability.







No. 15 Motor Freighter of 600 S. H. P.

Engines	450 r. p. m.
Propeller shaft	90 r. p. m.

A problem which may become acute in the near future, is that of the small motor ship. Shipowners who require vessels of about 1,200 to 2,400 tons, have not yet definitely decided upon changing from the steam engine to the Diesel motor, on account of the relatively high production costs of the latter; also, because of the greater space and weight, required by internal combustion machinery. A very practical method of obtaining the advantages of internal combustion machinery for such vessels is the use of high speed engines, with hydro-mechanical driving gear, as this type of ship frequently has to navigate in narrow waters, and on relatively short voyages, with much manœuvring. Such an installation is well suited for these conditions.

Illustration 15, shows the plan and section of the machinery installation of such a ship. The total power is of the order of 600 shaft horse-power, and is supplied by two Diesel engines, each running at 450 revolutions per minute. Revolutions of the propeller shaft are 90 per minute. The dimensions of the main engines are:—

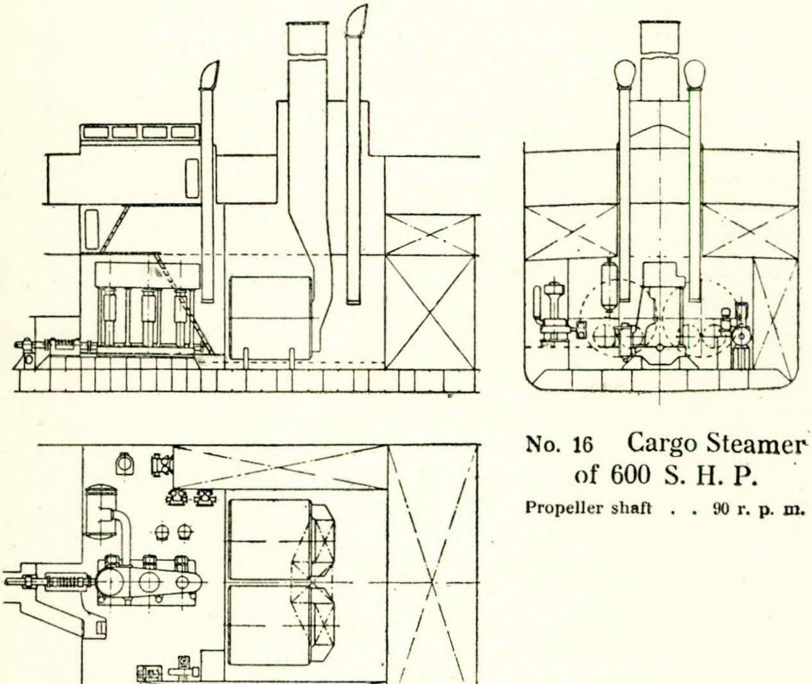
Number of Cylinders	6
Cylinder diameter	280 mm. (11in.)
Stroke	360 mm. (14,17in.)
Piston speed	5,4 m/sec. (1,060ft./min.)
Mean effective pressure ...	4,73 kg/cm^2 (68 lbs./sq. in.)

It will be seen, that the two last values (for piston speed and mean effective pressure) are quite within the limits, which are accepted as entirely reliable, in the case of auxiliary Diesel dynamo engines. The weight of such an installation complete, amounts to 116 tons, fitted on board and ready for sea, whereas the equivalent weight of a steam installation, as shown in Fig. 16 would be 183 tons. The area required for the Diesel engine is 58 sq. metres (624 sq. ft.), as against 101 sq. metres (1,087 sq. ft.) for the corresponding steam plant.

The hydro-mechanical gear shown in this plan, departs somewhat from the type previously described. In this case one hydraulic coupling is used for the ahead as well as for the astern running. Reversing is carried out by means of a simple gear wheel. Since a total power astern of 60% to 75% of the ahead power is quite sufficient, the coupling for astern running is made somewhat smaller than for ahead. This system represents, I might say, the absolute finality in regard to complete manœuvring capacity, since the ahead couplings have the characteristic of taking up a very large momentum with the greatest speed, as long as the fluid is supplied to them.

It is interesting to note from this diagram that the dynamo engine which supplies the current for the winches in harbour, is driven by a gear from the main motors, or from one of them, if so desired. In this way a costly auxiliary engine is eliminated. Uncoupling of the main engine and propeller shaft is not necessary, as in harbour, of course, the hydraulic-couplings are emptied.

With shallow draught boats the introduction of internal combustion machinery is facilitated by the hydro-mechanical driving gear.



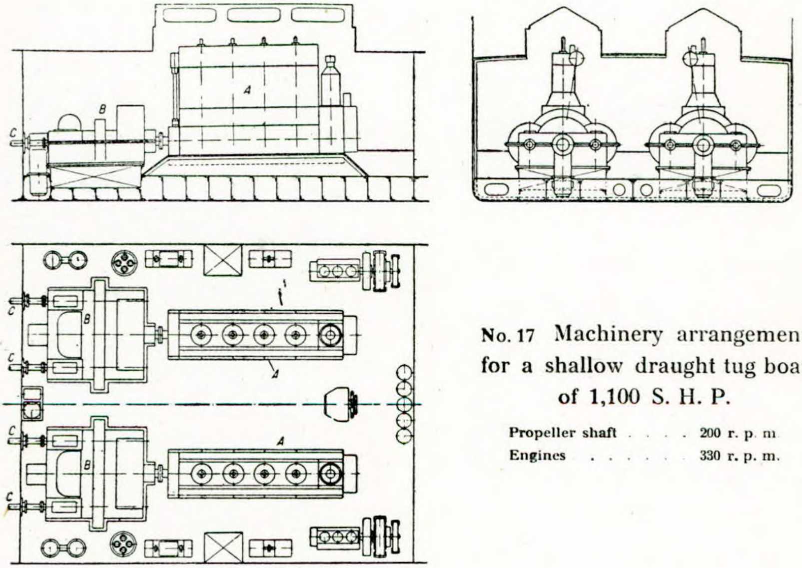
No. 16 Cargo Steamer of 600 S. H. P.

Propeller shaft . . 90 r. p. m.

Illustration No. 17 shows the machinery installation for a shallow draught tug boat of 1,100 B.H.P. divided between four shafts. The shafts must run at the relatively high speed of 200 r.p.m., because with the shallow draught, propellers of small diameter are necessary. The engines run at 330 r.p.m., and on account of the restricted deck height are single-acting four-cycle machines.

Each engine "A," drives two of the shafts "C," the power being transmitted to the shafts through the Vulcan Gear "B." The driving pinion is arranged in the centre, so as to engage with the gear wheel on both shafts. Reversing is carried out in the same manner as described in the previous case, *i.e.*, by means of a simple gear wheel.

The hydro-mechanical gear offers a simple solution to the problem of applying the internal combustion engine to paddle and stern wheel ships. The two main engines are placed athwartship, and each drives, by means of coupling rods, countershafts similarly placed, and on which are the primary parts for ahead



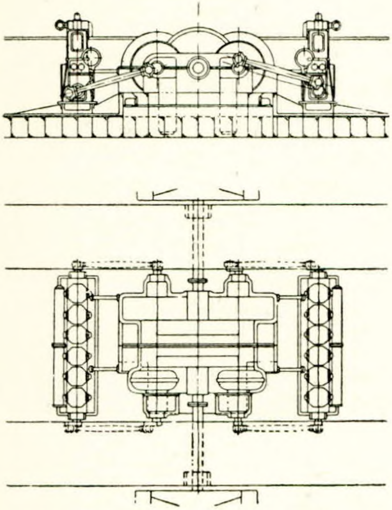
No. 17 Machinery arrangement for a shallow draught tug boat of 1,100 S. H. P.

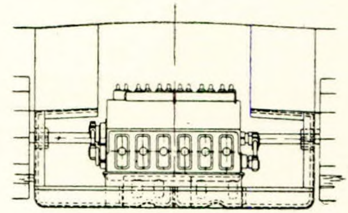
Propeller shaft	**200 r. p. m.**
Engines	**330 r. p. m.**

and astern running. Between the countershafts a hollow pinion is arranged, one end of which carries the secondary parts for ahead running, and the other end the secondary parts for astern running. The pinions drive the large gear wheel which is keyed to the driving shaft. Such an arrangement of machinery is represented in drawing No. 18, which will be understood without further explanation. The output at the driving shaft is about 700 H.P. at 40 r.p.m., the Diesel engines running at 280 r.p.m. If a greater output is desired, two engines can be arranged behind each other, and connected up with coupling rods in a similar manner.

I have taken the opportunity of acquainting you in the foregoing, with the merits and possibilities of development, which I claim for our new type of drive. To-day, when the high speed Diesel engine is in the earlier stages of development, there are still cases, where for one reason or another, direct driving engines are quite as suitable as engines driving through gearing, and I willingly grant, that very careful consideration must be given, as to which of the two types of drive is better adapted for each particular case.

However, as soon as the design and construction of high speed Diesel engines has reached the point where economy and reliability are as high as for example, in motor car engines, the





No. 18 Machinery arrangement for a paddle wheel ship.

Output at driving shaft . . . 700 S. H. P.
Driving shaft . . 40 r. p. m.
Engines . . . . 280 r. p. m.

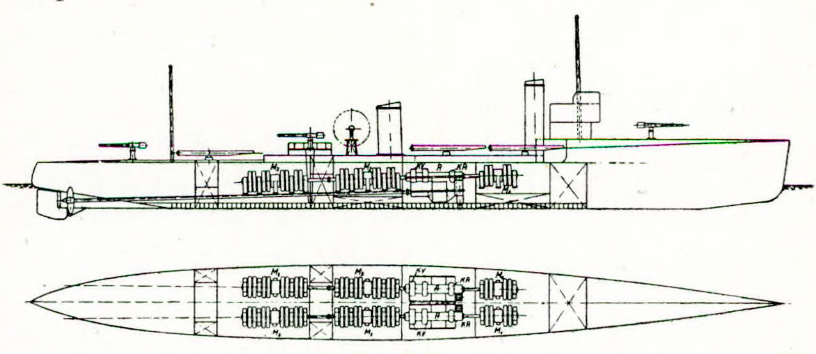
position will be changed. The geared drive will then become general, just as happened when the turbine displaced the reciprocating engine.

Gentlemen, from discussions which I have had with many friends of different countries, I know that our system of drive is regarded by the majority as decidedly capable of development, but there are also many who consider the introduction of the high speed oil engine as a Utopia, which is doomed to be wrecked by every possible technical difficulty. As opposed to this, I should like here to express the view, that if the marine engineering industry does not develop the high speed Diesel the aeroplane and airship industries will certainly do so. I think everyone present will agree that progress with aircraft is not stopped, but one of the first demands will be that the driving motors be suitable for using the cheaper and safer Diesel oil, instead of the present motors, using the more expensive and highly inflammable benzine. The price of Diesel oil to-day, is only about one-fifth the price of benzine, but even this will not be sufficient, and the builders of aeroplanes and airships will insist upon it that the high speed Diesel engine, once introduced, must be more economical, as reductions in weight to be carried is undoubtedly one of the most important questions in aircraft construction.

I am of opinion that the economical, reliable, high speed Diesel engine will come in any case; why, therefore, should the marine engineer not take it up in good time.

ADDITIONAL.

For the development of the internal combustion engine drive as applied to warships, the coupling already described is of importance.



No. 19 Torpedo boat of 1,200 ts. dw. and 23000B. H. P.

In the first place, it provides a simple solution to the problem of arranging a number of high speed units driving on to one shaft, because it obviates the use of complicated reversing mechanism, whilst the hydraulic medium absorbs torsional oscillations. In addition to this, each group of units can be cut out as required, so that only the units necessary for any given speed need be run, this is a great advantage in the case of warships as they must be able to run economically at various speeds. In drawing No. 19, is shown a scheme for applying this drive to a torpedo boat.

The motors consist of a series of cylinders arranged in star formation round the crank shaft.

List of orders up-to-date,
for Vulcan Transmission gear for ship propulsion.

Type of Ship	Freight ship of 2,000 tons dw	Sea-going Tug-Boat	Freight ship of 9,500 tons dw.	Freight ship of 11,300 tons dw	Freight ship of 6,300 tons dw.	Freight ship of 9,000 tons dw.	Freight ship of 9,000 tons dw.	Freight ship of 9,500 tons dw. (Duplicate)
Ordered by	Vulcan Werke Hamburg & Stettin A.-G.	Bremer Vulkan Bremen	Deutsch-Austral. Dampfschiffs-Ges.	Deutsche Dampfschiff-fahrts-Ges. "Hansa"	Conversion for an English firm	Hugo Stinnes-Linien, Hamburg	Hugo Stinnes-Linien, Hamburg	Deutsch-Austral Dampfschiffs-Ges.
Builder of Ship	Vulcan-Werke Hamburg & Stettin A.-G.	Bremer Vulkan Bremen	Vulcan-Werke Hamburg & Stettin A.-G	Vulcan-Werke Hamburg & Stettin A.-G.	Ship altered by Vulcan-Werke Hamburg	A.-G. Weser Bremen	Bremer Vulkan Bremen	Vulcan-Werke Hamburg & Stettin A.-G.
Number of Propeller Shafts	1	1	1	1	1	1	1	1
Number & type of Oil Engines	2 single acting, 6 cylinder, four cycle motors (MAN-Vulcan)	2 single acting, 4 cylinder, solid injection, Diesel motors	2 single acting, 8 cylinder, four cycle motors (MAN-Vulcan)	2 single acting, 8 cylinder, four cycle motors (MAN-Vulcan)	2 double acting, 3 cylinder, four cycle motors	2 single acting, 8 cylinder, four cycle motors	2 single acting, 8 cylinder, four cycle motors	2 single acting 8 cylinder, four cycle motors (MAN-Vulcan)
Builder of Engines	Vulcan-Werke Hamburg & Stettin A.-G.	Bremer Vulkan Bremen	Vulcan-Werke Hamburg & Stettin A.-G.	Vulcan-Werke Hamburg & Stettin A.-G	Vulcan-Werke Hamburg & Stettin A.-G.	A. G. Weser Bremen	Bremer Vulkan Bremen	Vulcan-Werke Hamburg & Stettin A. G.
R. P. M. of Oil Engines	300	300	215	210	240	245	245	215
R. P. M. of Propeller Shaft	85	100	80	78	90	80	80	80
Total output at the Propeller Shaft B. H. P.	620	490	4,100	3,800	1,600	3,050	3,050	4,100

Each shaft will be driven by two such series (marked M_1 and M_2).

Between the motor series M_1 and M_2, the transmission gear is arranged, and for each shaft only one pinion " R," is provided, on one end of which, the two ahead couplings " KV," are arranged (one each for M_1 and M_2), and on the other end the astern coupling " KR."

To suit the limitations of space, the pinion is arranged on top of the large gear wheel, and each pinion can be driven as desired, by either of the two motor series M_1 and M_2, so obtaining the most economical running at different speeds. The output of the combined motor groups amounts to 23,000 B.H.P., which would be sufficient to give a speed of 32,5 knots, to a torpedo boat of 1,200 tons displacement. The output per cylinder is about 100 H.P., the speed of the engines 1,000 r.p.m., and the propeller shaft 400 r.p.m. The weight of the engines and transmission gear together, would amount to 11,1 kgs. (24,4 lbs.) per B.H.P.; the total weight of the machinery installation including oil in the couplings, also shafting, propeller, auxiliary machinery, and piping, would be 22,6 kgs. (51 lbs.) per B.H.P.

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Election of Members.

List of those elected at Council meeting on 7th December, 1925:—

Members.

Claud Alexander, Faygate Wood, Sussex.
Henry Charles Bird, 9, Ashmead Road, St. John's, S.E.8.
Robert Frank Brown, 5, Queensgate Street, Hull.
James Buntin, Power Station, Municipality, Penang, S.S.
Thomas Clarkson, 4/5, Queen Anne's Chambers, Westminster, S.W.1.
James Daglish, junr., 8, Shottfield Avenue, East Sheen, London, S.W.14.
Samuel Terras Donald, 88, Dresden Road, London, N.19.
D. B. Elliott, 55, Everard Street, Barry Dock, Glam.
Eldred Charles Foster, 4, Bellevue Park, Cork, Ireland.

Walter Alexander Galt, 163, Fillebrook Road, Leytonstone, E.11.

George Gillanders, 18, Beech Hill Road, Eltham, S.E.

Ernest Stanley Greenhill, 52, Gordon Street, Hull.

Hugh McKay Stewart Herald, Second Avenue, Wilston, Brisbane, Queensland.

William Edward Hibbert, 14, Croftdown Road, Highgate, N.W.5.

Peter Martin, Lyle Shipping Co., Ltd., 124, St. Vincent Street, Glasgow.

John Ewan Prior, 22, Alnwick Road, Tyne Dock.

Douglas Rennie, *c/o* Union Castle Co., 3, Fenchurch Street, London, E.C.3.

George Herbert Roberts, 1, Gwladys Street, Walton, Liverpool.

William Harold Ryland, 58, Sandford Road, Bromley, Kent.

George MacLean Turnbull, 82, Fenchurch Street, E.C.3.

Edmund George Warne, 56, Kingsway, London, W.C.2.

Richard Maxwell Wright, 36, Victoria Avenue, Newtownards, Ireland.

Associate Members.

Francis Michael Harbord, "Lyndhurst," Birkenhead Road, Meols, Cheshire.

Walter Allan Harrington, 25, Harrington Square, London, N.W.

William Richard Isterling, 8, Balmoral Road, Elm Park, Liverpool.

Leslie Knopp, Messrs. Short Bros. (Rochester-Bedford), Ltd. Rochester, Kent.

Charles William Shields, 159, Caledon Road, East Ham, E.6.

Aubrey John Forsyth Trail, 21, Grosvenor Place, Jesmond, Newcastle-on-Tyne.

Ernest Thomas Walcroft, 98, Arodene Road, Brixton Hill, London, S.W.2.

Associates.

Douglas Grice, Malvern Villa, Christchurch, Newport, Mon.

George Thomas Lyne Lewis, 14, Moodkee Street, Rotherhithe, S.E.16.

Leonard Musto, 123, Bancroft Road, London, E.1.

Graduates.

Robert James Catto, 180, King Street, Aberdeen, Scotland.

William Joseph Wilson, 13, Lichfield Road, East Ham, E.6.

Transferred from Associate Member to Member.

John H. Skinner, "Glenmore," Westbourne Avenue, Hull.

Transferred from Graduate to Associate-Member.

William King, 126, Shield Street, Newcastle-on-Tyne.

Born in Newcastle-on-Tyne, 2nd February, 1874 and educated at St. Dominic's School there, Joseph S. Blackett served his apprenticeship at the works of Messrs. Wigham Richardson & Co's. Neptune Shipbuilding & Engineering Co., Walker-on-Tyne. He commenced his seagoing service at 21 years of age, joining the Atlantic Transport Line as junior. He passed for his Second-Class Certificate, then for his Chief's and held appointments as chief engineer in North Country Steamers. He joined the outside staff of Messrs. Smith's Dry Dock Co., North Shields, when 28 years of age and in February, 1905, was appointed ship and engineer surveyor to Lloyd's Registry at Middlesbro'; subsequently he was sent to Glasgow, and in 1906 he was transferred to New York.

After being on temporary duty at Quebec in 1913, he was transferred to San Francisco in 1914, where he became senior surveyor in March, 1918, and held this position up to the time of his death. He had an attack of pneumonia in the spring of 1925 and after recovery, he took a trip to Australia accompanied by his wife, returning to San Francisco, apparently quite cured. Shortly afterwards, unhappily, he caught a chill and pleurisy set in which carried him off after an illness of two or three days, the doctor stating that the end was caused by a clot of blood on the brain. He leaves a widow and two boys, 19 and 12 years of age respectively, to whom, also to his father, our sympathy is extended.

He was elected a member of the Institute in August 1909, and Vice-President in 1921.

JOSEPH S. BLACKETT, Vice-President.