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VOLUME XXXIII.

Lecture.

"EXPERIENCES IN RUSSIA" (with Lantern Views).

BY MR. W. T. BRAWLEY (Member).

Tuesday, February 1, 1921.

The CHAIRMAN (Jas. Adamson): Our meeting to-night happens on an auspicious date—the 32nd birthday of the Institute. On February 1st, 1889, we started in the Langthorne Rooms, Stratford, where we rented a reading room. It is pleasing to witness the realization of hopes founded upon a good ideal; and at our dinner on January 28th many expressions of goodwill were uttered, and congratulations given, as we assembled in the reception hall. These were accentuated by several of the speakers on the toast list, who referred to the usefulness and development of the Institute. With these few remarks to open the meeting and resisting the temptation to expand on reminiscences, we give a cordial welcome to our lady visitors and friends.

I will now call upon Mr. Brawley to relate his experiences and show the views which are mostly re-productions from photographs of his own making, added to by others he procured for the occasion, to increase our interest and knowledge of the vast Russian territory.

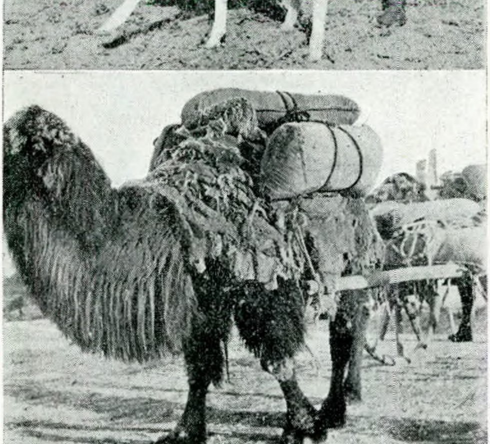
On opening the subject, Mr. Brawley said it was hard for anyone who had not visited Russia to express an opinion on the subject of what was taking place there, even with all the data furnished by the press. Since the advent of the class which seized the reins of power by driving out, or tyrannically murdering those whose views of life differed from their own, and compelling liberty to hide, much nonsense has been printed and many contradictory reports circulated regarding Russian affairs, so that it was small wonder that the British public had passed through various stages of feeling, ranging from impressions of horror at outrages and murders, to mystification at the advocacy of a section endeavouring to excuse the tyrannic abuses. Although he had spent some years in Russia, on two different occasions, he did not propose to express any authorative view of the situation, but simply to relate his experiences which might interest his fellow members and friends.

He then showed a map illustrating the immense area of Russia as compared with the rest of Europe. Leaving London in February, 1913, to take up an appointment in a mining district on the Kerghis steppes, and travelling via Berlin and Moscow to Djonsalie, a station on the Orenburg-Tashkent Railway, he found on arriving at the railway terminus that the remainder of the journey would require to be made by camel sledge, and the weather was such that it was doubtful when he would be able to start on a trip which would take about three weeks to accomplish. A Kerghi at length agreed to act as driver, and it was wonderful how he found his way across the snow without any visible landmarks. The conveyance was a canvas covered sleigh drawn by two camels, followed by three pack camels with provisions for the trip; the average speed was one and a half to two miles per hour. There were rest houses erected by the mining company at intervals by the way. The food obtainable was not palatable nor the rest houses very comfortable, but after eighteen hours travelling over the snow the respite was appreciated even with these drawbacks. The mining camp was reached in twelve days, and a week's rest was none too short to recover from the effects of the journey.

The travellers had found in the course of their travels in 1913, that the Russian railway system was very good, comfortable and cheap, and at stages on the way, hot water was provided for the convenience of passengers. This experience was in vivid contrast to what they suffered a few years later.

The mining Company's property consisted of copper and coal mines, 80 miles apart, with smelting works. The copper mine had historical associations, as the earliest working period, reckoned by experts dated back 500 years. The camp was well provided and the wants of life properly attended to, while the

Camel and Baby a few hours old.



Camel loaded.

staff collaborated to make the social as well as the business side, pleasant to all. The houses were built of brick and stone $2\frac{1}{2}$ ft. thick, comfortably furnished. Springtime was noted as glorious, imparting a feeling of lightness, with the banishment of the heavy winter garb. In a week after the snow melting the verdure and flowers showed, while six weeks later the sun withered them by its glare. As the conditions of life and the surroundings were pleasant, Mrs. Brawley arrived in the summer and found many compensations to make up for separation from old friends in England.

Camel and Sleigh.

Camel and Car.

The news of the outbreak of war was a surprise, and the Cossacks left at once for their settlement base, 400 miles to the north. The order for mobilisation was promptly obeyed by the men, to the detriment of the working of the mine. Later, some of them were officially returned to carry on and prevent stoppage of the works. In July, 1916, Mr. Brawley was given leave and started with Mrs. Brawley for Petrograd, hoping to reach home; but conditions did not admit of this, and a visit to the Crimea was suggested. On arrival at Sinferopol, the way

Mr. and Mrs. Brawley on skates.

Kerghis Native Hut.

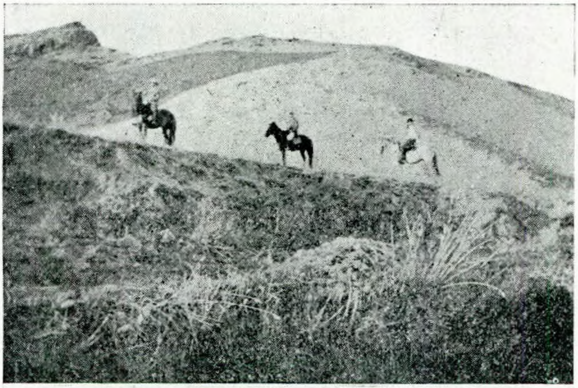
to Sevastopol was barred, so a visit was paid to Yalta, a pleasant town on the coast, which was overflowing with visitors, mostly Jewesses and Poles. Accommodation was hard to get and prices high, with little comfort. After six weeks sojourn, Moscow was made for, en route to Djousalie, where a pleasant week was spent and then the journey was continued to their home near the mine.

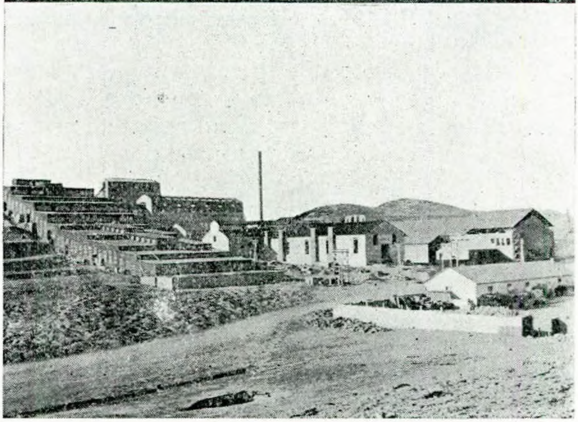
Native Hut Erecting.

Water Carriers.

Extensions were carried out in connection with the smelting works, and quite a town was rising on the barren steppe. The difficulty of transport was great, wood and other material had to be taken 300 miles from the railway by camels. The abdication of the Tzar was followed by scenes of turmoil. An instance was related by an old schoolmaster, who had been in the habit of hiring the same drosky from his house to the school, and on the morning after the abdication, the driver instead of keeping to the course drove zig-zag, and in reply to a question as to his sobriety, said that he was sober, but he was now free to do as he liked. The prevailing idea at first go off seemed to be freedom from all control, and probably they found out their mistake later.

The Steppes on the Hillside near the Camp.





Office Buildings near the Works.

The Russian political agitators among the workmen, called meetings and did their best to upset the control of the officials in the mines and works; but the Khergiz remained faithful and held the extremists in check. Some of these secured official positions near the district and tried to make trouble; but when some of the Cossacks returned, they had to desist.

The difficulties of the situation increased, food and money became scarce. In the spring of 1918 orders were received to close up and protect the property as far as possible, in spite of obstacles interposed by some of the extremists. A transport of 400 camels was obtained, to remove the workmen and their families, the terms being added to exhorbitantly when the helplessness of the case became apparent. The Russian members of the staff then began to fear for their lives, and it was arranged for them to get away; the Khergiz being left to finish up. A party of Bolsheviks came upon the scene with demands for motor car and what they fancied, and which were refused. The next step was to get the wives and children away, and this was managed by motor car to Atbazar where they were housed by Cossacks in June, 1918. The car returned for the husbands, who rejoined them at Atbazar, and remained for two weeks, hoping to make a course for England. A five days journey by horses brought the party to Petropavlosk. The villages in this district are about twenty miles apart, the fields are unfenced and the peasants live in the villages, going thence to and from their fields. The town was policed by Czechs, but unfortunately not until it had been pillaged by Bolsheviks; the view entertained was that had the Czechs been well backed up, the situation would have been saved.

It being considered impossible to get home, Mr. Brawley was requested to return to the mine to take charge. After severe work, he arrived to find a Bolshevik had installed himself in one of the furnished houses, excusing himself as being their protector. But after events exposed this fallacy. The months that followed were full of anxiety, as efforts were made to terrorise the men with threats of killing. In May, 1919, the first letter from England since August, 1917, arrived via Siberia, through the courtesy of the British mission, and in July the General Manager of the Company and a British officer arrived in a motor car. Mr. Brawley was relieved from duty in August, 1919, and left with his wife by hired camels, they were on the road for eight days, travelling about sixteen miles a day. On reaching Atbazar, rumours were rife, but no authentic information could be obtained, and a start was made by horses for Petropavlosk with all speed. Meeting refugees by the way it was evident that events were happening and the driver declined at last to go any further, intending to go south and save his stock from being stolen. The peasant farmers had the same fears and were inclined to crop only as much as they required for their own use.

Fortunately a Tartar driving a party arrived on the scene, and as he was returning to the town he was ready to take passengers at £50—in place of 4s., the former usual rate of payment. Arriving at midnight, they found Petropavlosk almost deserted by civilians, and soldiers much in evidence; all were nearly starving. The British Railway Mission on being interviewed said that the prospects of getting away were slender—all the British had gone except themselves. Ultimately a third class mission coach was secured as far as Omsk, after waiting in it two days at the station before starting. The sights around the station were heartbreaking, men, women and children seeking for refuge. The normal journey to Omsk took from eight to nine hours, but it was the sixth day before the bridge over the river was reached, and on the wrong side. The crowd waiting to cross the ferry was in a long line and the method adopted was ' first come first served.' To cross by the bridge involved risk from the traffic and side to side manœuvring. However, the risk was taken and the passage occupied a day. A seven miles journey brought Mr. and Mrs. Brawley to the Company's Agency where they were made welcome, but the only available accommodation was on a bare floor. A train left for Vladivostock once a week, special permits being required for travellers, and with this the General Manager of the Company and staff had left a month previously. The permits obtained, our member and his wife left Omsk. Two days after, they passed a derailed refugee train which had been bombed by the Bolsheviks and resulted in a scene of havoc, the sight of the killed and wounded being distressful, while the living had to seek refuge from the intense cold of Siberia, in the woods and burrow underground, the Red Cross Society did its best to relieve all the sufferers in their extremities. On arrival in Vladivostock after a nine days journey, the British Consul arranged for a passage in a troopship via Canada; meanwhile accommodation for six weeks was obtained in a compartment at the barracks with floor space boarded off, and soldiers' rations. A warm reception was given on arrival at Vancouver and the Canadian ports of call, and at Montreal they left to pay a visit to friends in America, returning to England in the "Imperator" after an absence of seven years.

In concluding, the lecturer said he had a warm regard for Russia and those he had been associated with there. From his observation and personal experience he considered that Bolshevism was the direct antithesis of all civilisation, it was a blight on every form of industry. He further quoted the warning words of Mr. Urquhart, Chairman of the Russian-Asiatic Consolidated Co., one of the greatest authorities on Russia: " when the basic principles of civilisation are recognised by the Russian Government: Sanctity of contract, the right of private property, freedom of speech, thought and person: then the economic reconstruction of Russia will be possible; until then the position is almost hopeless."

The Bolshevik doctrine seemed to be, "what's yours is mine and what's mine is my own."

A hearty vote of thanks was accorded to Mr. Brawley for his lecture, and the large number of views he had obtained to illustrate it; and to Mr. McLaren for operating the lantern.

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Installation of Marine Oil Engines.

By Mr. WALTER POLLOCK (Member).

READ

Tuesday, February 8, at 6.40 p.m.

CHAIRMAN: MR. G. J. WELLS (Member).

THE installation of marine oil engines does not usually receive the attention that its importance deserves, no doubt because the conditions are entirely different from those in ordinary marine steam engine practice. As an illustration, many of the most successful oil engines on the market have caused disappointment and have given trouble from time to time because of weak and unsatisfactory engine bearers, while the arrangement of oil fuel tanks is often a source of trouble. When owners and superintendents hear of these and other troubles, they are naturally prejudiced against the adoption of internal combustion engines as the main propulsive power of their vessels, although the oil engines themselves are in no way responsible.

The advantages of oil engines over steam machinery will be dealt with in another paper; it is however a mistake to think that there are no disadvantages, and that any engine room designed for a steam plant can be used for oil engines.

The first consideration, in the case of cargo vessels, is the position of the oil engines; although it is usual to fit them as far aft as the space required for the removal of the tail shaft will permit, designers should bear in mind that for any given power, oil engine machinery is much lighter than steam machinery so that the trim of the vessel is affected much more according to whether the ship is light or loaded. The reduction in the weight of the engines, etc., will in fact often necessitate additional water ballast tanks to give the vessel the same light immersion as a steamer and the same seagoing qualities.

In arranging the machinery space, it should be borne in mind that large Diesel engines call for a considerable number of auxiliaries, and it is necessary to provide ample space so that they can be disposed in accessible positions in the engine room. As most of these auxiliaries are driven by oil engines, they must be placed in such a position as to have sufficient head room to permit the pistons and the connecting rods being drawn.

The above remarks also apply to main engines as regards accessibility, and it is very important that there should be plenty of head room above the engines and strong lifting gear, so that the covers, pistons, piston rods and connecting rods can be taken out for examination quickly, as it will be found that these parts of the engine are usually inspected much more frequently than in the case of steam machinery.

The line of the tail shaft is an important question, and this can be kept lower than with a steam plant of the same power, as the propellers are generally smaller in diameter except in the case of some of the highest powered Diesel engined ships. The smaller diameter is due to the fact that at the present time the revolutions of oil engines are higher than those of steam machinery. In the case of engines, say 250 h.p., the revolutions of oil engines are double those of the steam engine, but for modern large Diesel engines, they are approximately the same as, or only slightly higher than, those of steam engines of similar power.

Again for any given hull and given power of machinery, the oil engines will weigh less than steam machinery and consequently the displacement when light will be less than that of the hull with steam machinery and the draft aft will also be less, so that the propeller shaft should be kept well down to ensure immersion of propeller.

The lower line of shafting, and the advantage of keeping the propeller as low down as the stern frame will allow, will have the tendency of pushing the engines further forward, owing to the fineness of the lines in the after run of the ship. To avoid setting the engines too far forward, in some cases the shaft line is sloped downwards from the forward end, which inclines the engine aft even when loaded, and much more so when light.

This should be avoided as much as possible, because of the trouble with the circulation water, and the natural wear and tear of the after-end of all working parts if the angle is excessive. The best practice, where possible, is to keep the line of shafting parallel with the bottom line of the ship.

When the machinery is fitted amidships, these difficulties do not usually occur, but in the case of twin screw ships, the longitudinal position of the shaft line calls for consideration.

To enable twin-screw machinery to be handled with the least number of men, and to obtain a compact engine room, the engines should be placed as close together as the space necessary for handling them will allow. On the other hand, the propellers should work in water as solid as possible, and to ensure this they must be placed well away from the deadwood. This means that the shaft lines will not be parallel to the centre line of the ship, but this is of no moment, and on many occasions great advantage will be obtained by spreading the shaft lines further apart aft than they are amidships.

For tropical vessels special consideration should be given to the arrangement of the engine room, especially where surface ignition oil engines are fitted, so that the heat from the bulbs will have free escape aft and not interfere with the engineers or drivers or even with the men on deck. Usually the engine room is open above the main deck and a light upper or sun deck is fitted over the machinery space. In the case of passenger vessels, the space between the two decks or between the coaming and the deck above is filled in with netting.

The design and construction of the engine bearers is of the utmost importance, because oil engines are almost universally single-acting, and the fact that their starting is not so smooth as that of a steam engine must be recognised. It is not necessary to have an expensive construction, but it is essential that the bearers should have greater strength than would be required for steam machinery of similar power.

A short time ago a certain vessel was bought and fitted with two sets of engines of a well-known make, and after the first voyage a large number of renewals were required. It was found that the bearers were designed and constructed of many small pieces of plate and angle so arranged that the natural working of the engine caused "concertina action" and resulted in the engines moving about in a most alarming manner. The engines consequently had to be lifted out and a large sum had to be spent on the bearers to make them good.

The majority of Diesel engines have rigid bedplates, and the engines themselves form a more or less rigid structure.

Many of the surface ignition engines have very shallow bedplates due to the requirements of the closed-in crank cases, and the necessity of getting to the bottom ends without dismantling the engines. These difficulties in the design, frequently cause the cast iron bedplates to be more or less flexible, which adds enormously to the cost of installation and lining up, and is the cause of much trouble to the bearings should the bearers show the slightest sign of weakness. It will therefore be seen that great attention must be paid to this point.

In the case of engines in steel ships and having strong bearers, the packing strips should be of hard wood with cast iron chocks fitted in way of the holding down bolts, as is usual in the best steam engine practice.

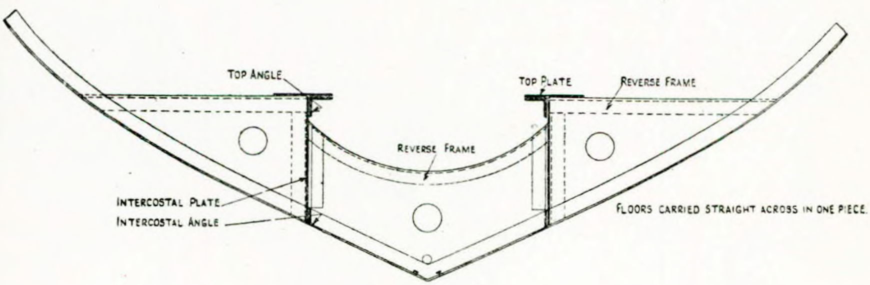

Fig. 1.

Bearers and Floors.—The author advocates the floors of steel vessels being carried up from the bottom of the ship to the top bearer plate and right across the ship all in one piece, the longitudinals being intercostal with the exception of the thick top plates and the longitudinal angle connecting the top plates to the intercostals. Fig. 1 shows the suggested design, and the recommended scantlings are given in Table 1.

TABLE I.

B.H.P.	25	50	100	200	300	500	750	1,000	1,500	2,000
No. of Cyls.	2	2	2	4	4	4	4	4	6	6
Frames ...	1½ x 1½ x ·18	2½ x 2½ x ·25	3½ x 2½ x ·35	4 x 2½ x ·35	5 x 2½ x ·35	6 x 3 x ·40	6 x 3 x ·40	7 x 3 x ·44 bulb angle	7½ x 3 x ·46 bulb angle	8 x 3½ x ·48 bulb angle
Spacing ...	16	18	20	21	22	23	23	23½	23½	24
Reverse Frames ...	2 x 2 x ·25	2½ x 2½ x ·25	3 x 2½ x ·30	3½ x 3½ x ·40	4 x 4 x ·40	4 x 4 x ·50	5 x 4 x ·50	4 x 3 x ·50 double	4½ x 3 x ·50 double	5 x 3 x ·50 double
Floors—Thickness..	·25	·25	·28	·34	·40	·45	·46	·47	·48	·50
Top Plates, each... ...	6 x ·375	10 x ·40	12 x ·50	12 x ·75	15 x ·75	16 x ·85	17 x ·875	18 x ·90	19 x ·95	20 x 1·0
Top Angles	3 x 3 x ·35	3½ x 3 x ·35	3½ x 3½ x ·35	4½ x 3½ x ·40	4½ x 4½ x ·40	5 x 4 x ·50	5 x 5 x ·50	5 x 5 x ·50	5 x 5 x ·60	6 x 6 x ·75
Intercostal Pit	·18	·25	·30	·35	·40	·45	·475	·50	·52	·55
Intercostal Angles ...	1½ x 1½ x ·18	2¼ x 2¼ x ·25	2½ x 2½ x ·25	3 x 3 x ·34	3½ x 3½ x ·40	4 x 4 x ·45	4 x 4 x ·45	5 x 4 x ·50	5 x 5 x ·50	5 x 5 x ·50

NOTE.—The above dimensions are in inches.

Engine Bearers for Steel Vessels.

The riveting requires careful attention, and the finest workmanship is necessary.

In existing vessels, the floors, reverse frames and keelsons should be removed in way of the engine space, particularly in way of the engine bearers, and entirely new bearers fitted as Fig. 1. There have been many failures and disappointments in fitting oil engines on existing vessels by trying to build up on the floors and reverse frames, instead of carrying out the recommendations suggested. Fig. 2 shows the arrangement of engine bearers for vessels built of wood, and Table II. gives suggested scantlings.

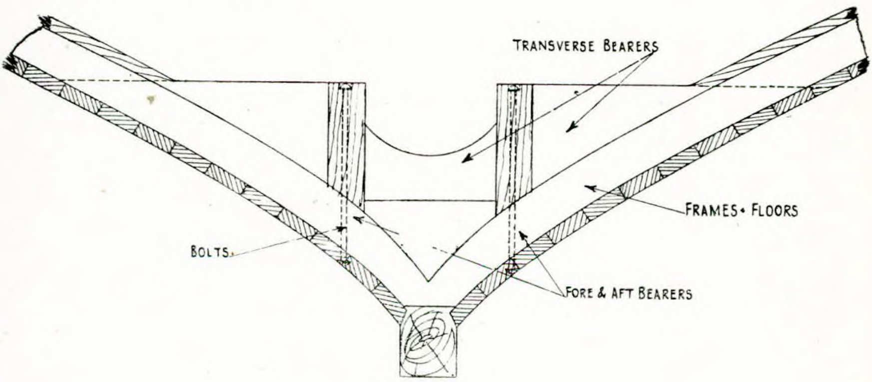

Fig. 2.

TABLE II.

B.H.P.	25	50	100	200	300	500	750	1,000	1,500	2,000
No. of Cyls.	2	2	2	4	4	4	4	4	6	6
Floors ...			6" x 6"	8" x 8"	9" x 9"	11" x 11"	13" x 13"	14" x 14"	15" x 15"	16" x 16"
Frames ...	2½" x 2½"	4" x 4"	5" x 5"	7" x 7"	8" x" 8	9" x 9"	11" x 11"	12" x 12"	14" x 14"	15" x 15"
Spacing ...	14"	16"	18"	20"	23"	26"	30"	32¼"	33½"	34½"
Fore & Aft Bearers Width ...	4½"	5"	8"	9½"	10½"	12"	13"	13½"	14"	14½"
Length of Bearers in ft. ...	13	17	25	40	50	60	65	70	75	80
Transverse Bearers Width ...	4"	4½"	6"	7½"	9"	10½"	11"	11½"	12"	12"
Bolts thro' Bearers Dia. ...	⅞"	1"	1¼"	1½"	1¾"	2"	2"	2"	2"	2"

Engine Bearers for Wooden Vessels.

The saving in space which can be effected by the use of oil engines instead of steam machinery of the same power, is so considerable that new conditions and calculations have to be considered for any given type of ship. In the case of Naval vessels, the advantage is very great, because the sub-division of the vessel into small compartments can be obtained with ease and without any loss of efficiency or economy in working.

For vessels that are designed to carry bulk cargoes, additional cubic capacity is easily obtained. In dealing with shallow draft vessels, which are usually of light scantlings, it is important to carry the longitudinal bearers as far fore and aft as possible, and where convenient, for a distance at least twice the length of the engine; in no case should the longitudinals stop abruptly at the end of the engine. A few web frames in way of the transverse bearers or floors, also prove of advantage if they are not in the way of the oil tanks.

Fuel Tanks.—In the case of large vessels, double bottom tanks can be used for fuel, but these should not be carried immediately under main engines if it can be avoided. With smaller vessels, cylindrical tanks are usually found the most satisfactory, as if well designed they are not so liable to leak when say half full and being strained in a sea-way. Rectangular tanks should be avoided for anything over 250 gallons.

Besides main fuel tanks which can be usually stowed at the sides of the engine room, it is usual to have a daily service tank, and this should be arranged and marked in such a way that the hourly consumption can be checked when required, and should have connections from all the main fuel tanks. This daily service tank should be fitted in such a position that the bottom of the tank is well above the fuel pumps, and that the fuel pipes may be arranged without any upward or sharp bends, so as to avoid the risk of an air lock.

All main fuel tanks should have filling pipes at least 3 ins. diameter, where possible, connected to the main deck. It is wise to have a large gauze funnel with a screwed end to connect it to the deck filling pipe, so that the fuel tanks can be filled rapidly from the shore pipe connection.

All fuel tanks should have overflow pipes to the deck with a goose neck end and arranged so that they are always open and thus relieve the pressure on the tanks should any expansion of the oil take place. Again, the tanks should be designed with large manhole doors in easily accessible positions to enable the tanks to be thoroughly cleaned out at least once every six months. Connections to the tanks should have thickening or boss plates, so as to ensure a good oil-tight connection. The drain cock at the bottom of each tank should if possible be fitted with a "sump," and be placed in an accessible position.

All tanks should be of heavy scantlings with plenty of sub-divisions to prevent rapid movement of the oil in bad weather, when only partly full. Electric welding makes the best job, especially for the rings for manholes and the seats for fittings, sump attachment, etc.

The service tanks should be so fitted that in the event of the oil pipes breaking away there is no chance of the oil pouring on to the engine or any of the auxiliaries, and causing risk of fire.

In cold climates, arrangements should be made for warming the oil in the fuel tanks. This can generally be arranged by attaching a heater to the daily service tank, and when the engine is under way the engine room will soon become sufficiently warm to reduce the viscosity of the fuel in the main tanks, and allow the daily service tank to be pumped up with ease. In any case, the pump from the main fuel tanks to the daily service tank should be of simple and efficient design, to give a good pressure on the discharge side, and it should be fitted as low down as possible, so that the oil will flow into it.

In small vessels a semi-rotary hand pump is usually sufficient, though in large vessels a power driven pump is desirable.

Pipe Lines should be so arranged that all joints are in an accessible position where any leakage can easily be seen. Care should also be taken that the valves are fitted where they are easily accessible.

All small fuel pipes should be of copper with ground coned joints. Copper fuel pipes should be re-annealed periodically—the greater the vibration to which they are subjected the shorter should the interval be.

Drip Trays should in every case be fitted under the main engines and all fuel tanks, and these should have a "sump" with a large drain cock on the lowest portion of it. These "sumps" and drain cocks like those in the fuel tanks should be fitted at the after end, as oil-engined vessels are usually down by the stern, especially when light. In any case, the drain cocks should be so arranged as to allow a can or bucket to be placed under them; if this is impossible a drain pipe should be connected up to serve the purpose.

Ventilation of Engine Room.—This item requires more care and consideration than in the case of steam machinery; even in the best regulated engine rooms with oil engine machinery a certain amount of oil will find its way into the bilges. It is therefore necessary to have a down-cast ventilator from the upper deck or casing carried right down below the engine room floor to the bilges, and as far forward as possible, the design of floor bearers being so arranged that the air will freely find its way right aft. An up-cast ventilator must also be fitted at the after end of the engine room. In any case, the position of the ventilators should be such that the incoming air will not be directed into the cylinders or engines. Ventilation of fuel tanks is discussed on another page.

Water Drip Tanks.—In vessels fitted with engines which require water cooling of the bulbs to prevent pre-ignition, it is necessary to provide sufficient storage for clean fresh water. These tanks should be separate from the drinking water tank, and placed in the engine room, as high above the cylinders as possible to ensure sufficient head of water.

On no account must salt water be used in these tanks or for "water drip." The consumption of water is generally about the same as that of fuel when running at normal speed.

Deck Machinery.—The deck machinery, such as the winches, windlass, capstan, etc., will, if driven by oil engines, call for the provision of a good supply of cooling water, which, if drawn direct from the sea, may lead to trouble in the case of large vessels, owing to the height of the pump above the sea. In the case of coasters which are frequently loaded and discharged when ashore in tidal harbours, this method becomes impossible, and the best arrangement is to fit cooling water tanks in a convenient place on deck, with the necessary water connections. If these tanks are fitted in an exposed place, the usual atmospheric conditions assist the cooling process; on the other hand the water may get frozen in winter. In every case, they should be so disposed that manhole doors for cleaning and cocks to drain the water off, can be fitted in an accessible position.

The pipes connecting the tanks to the deck auxiliaries should where possible, be of galvanised iron and should be clipped up to the bulwarks or hatch coamings as far as possible off the deck, great care being taken that the drain cocks can drain off the water in frosty weather.

Deck Control is sometimes required in small vessels. Fig. 3 illustrates a useful method that can be applied to almost any type of oil engine.

Steering Gears that require to be driven by machinery are troublesome things, especially for oil-engined vessels; so far a directly connected oil engine has not been adopted. The electric hydraulic system fitted at the rudder head is very efficient although somewhat expensive for small vessels.

Some designers have fitted a donkey boiler arranged to burn oil fuel, so that steam steering gear and steam winches, wind-

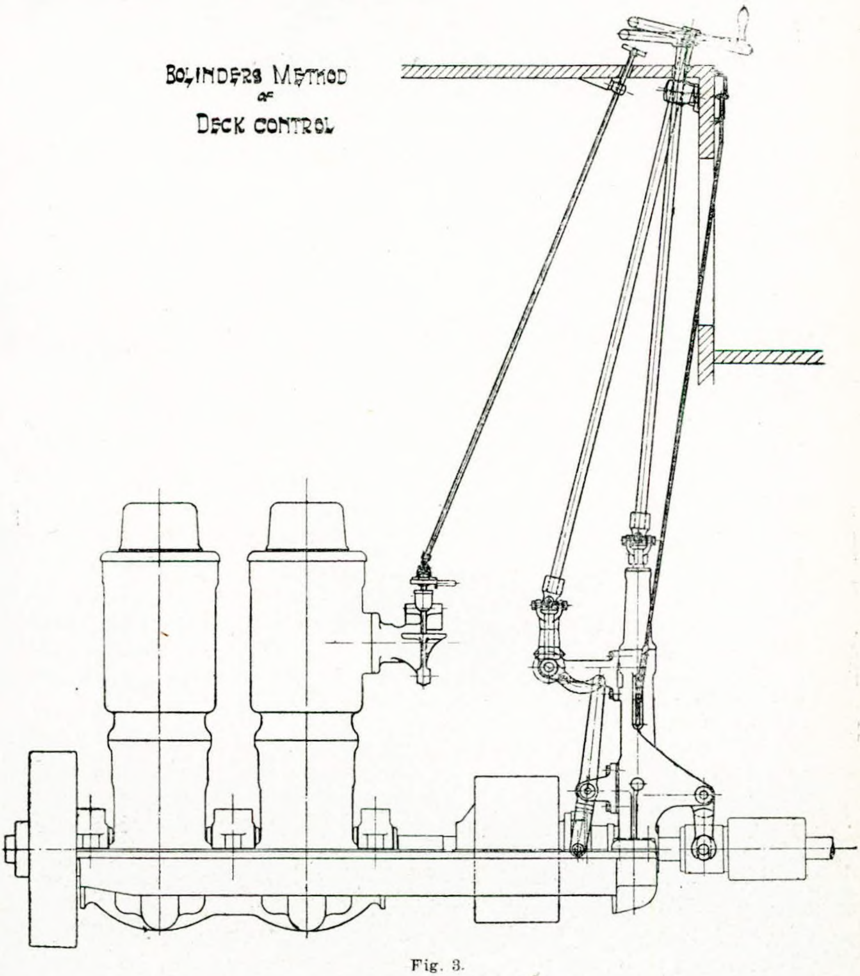

Fig. 3.

lass and capstan can be adopted, although the inefficiency of such a method is not fully recognised; however, should it be decided to have a donkey boiler, under no circumstances should it be in the main engine room, but it is absolutely necessary to fit it in an entirely separate compartment, without any direct connection to the engine room in any way; so as to avoid the smoke and soot which are inseparable from an oil fired furnace when steam is being raised or shut down.

Winches.—In this paper, the question of oil driven winches in small vessels up to only 200 or 300 tons will be dealt with. One or two winches, each with a separate oil engine will suffice, but in larger vessels with two hatches on one deck the most economical method is to instal an oil engine in a central house to drive at least four winches, see Fig. 4.

Windlass.—In small vessels of a few hundred tons, it will be most economical to drive the windlass by a messenger chain from the forward winch. In larger vessels, a windlass directly driven by an oil engine is more satisfactory. In this case, the oil engine, and if possible the windlass, should be fitted below the forecastle deck. In any case, the oil engine should not be fitted above the forecastle deck owing to the difficulty of starting in rough and dirty weather.

Capstans can be fitted aft and driven by a separate engine, as the after deck house provides accommodation for the engine or will at least form some shelter.

Air Bottles or reservoirs are necessary in every oil-engined ship, and it is extraordinary to find how many of them are fitted in totally inaccessible positions, although it does not matter whether they are fitted vertically or horizontally.

It is absolutely imperative that they should be of ample capacity and fitted so that all the valves and pressure gauges are 4 or 5 ft. from the platform from which they are operated. Fig. No. 5 indicates a satisfactory method of fitting these air bottles.

It will be noticed that any one bottle can be shut off and removed for cleaning or repair, without disturbing the remainder. For this purpose it may be necessary for each bottle to have separate clips. If the bottles are of very large diameter, an eye bolt should be fitted in a deck beam above, so that a small tackle can be used to handle them.

It is assumed that all air bottles over 7 ins. or 8 ins. in diameter will have removable tops or bottoms, or alternatively have cleaning doors, as it is almost impossible to inspect and to clean out a bottle built with only a pipe connection at the top and a drain cock at the bottom.

All air bottles must have a drain cock at their lowest part, and this should be used frequently to blow down any water and oil which may have accumulated, more particularly on those engines which charge the bottles with the products of combustion.

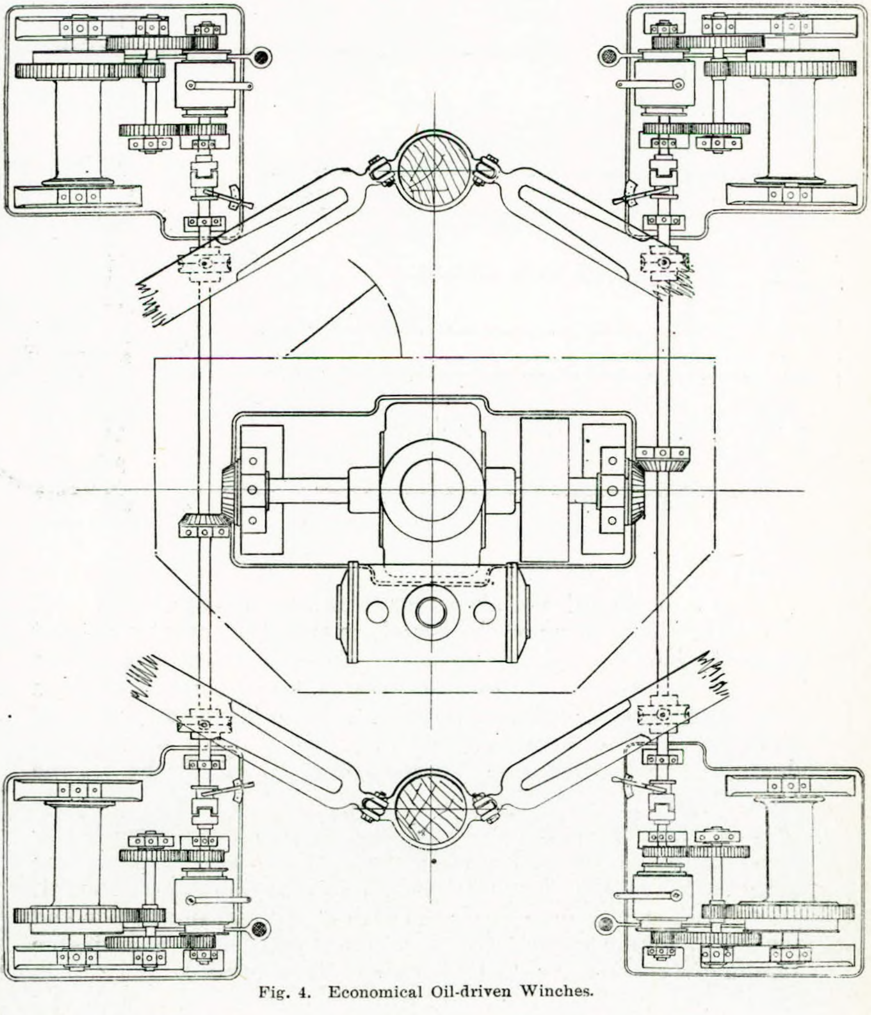

Fig. 4. Economical Oil-driven Winches.

In small vessels without air compressors, it is necessary to have an efficient means of pumping up the air bottles for starting; probably the best method is to have a hand plunger pump driven by a crank shaft fitted with a heavy flywheel.

Circulating Water.—The supply for internal combustion engines should be ample, more especially if it is likely that they will be worked in the Tropics.

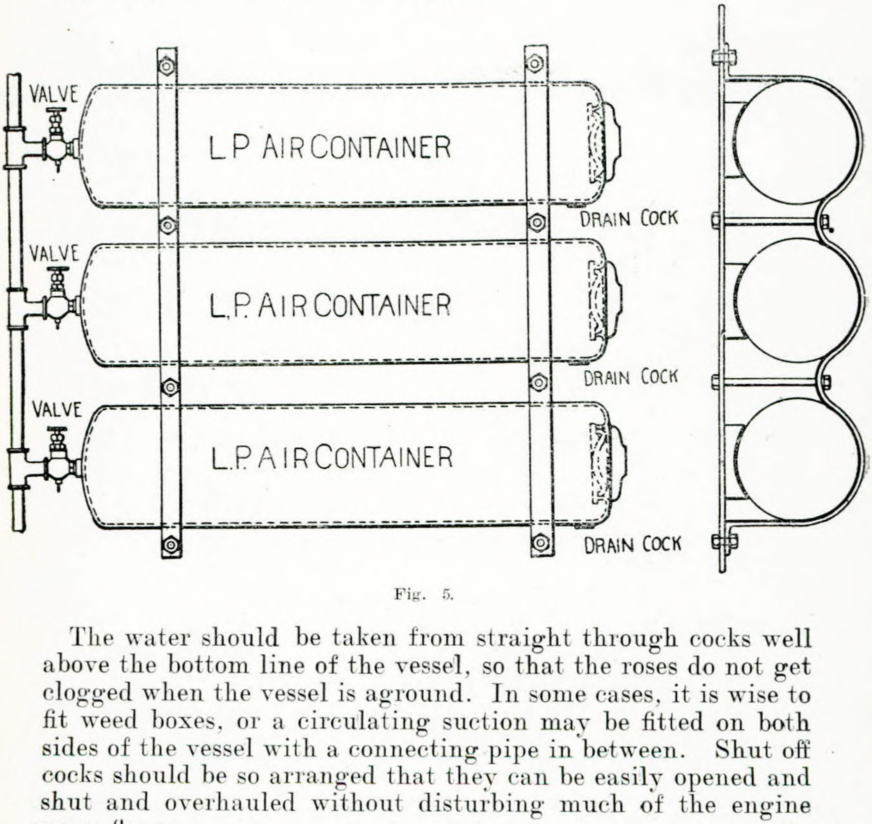

Fig. 5.

The water should be taken from straight through cocks well above the bottom line of the vessel, so that the roses do not get clogged when the vessel is aground. In some cases, it is wise to fit weed boxes, or a circulating suction may be fitted on both sides of the vessel with a connecting pipe in between. Shut off cocks should be so arranged that they can be easily opened and shut and overhauled without disturbing much of the engine room floor.

It is common in most oil engines to pump the circulating water through the cylinder jackets first, then through the cylinder heads, then into the silencer jacket and then overboard. Sometimes the water is also used to cool the air compressor and the main bearings, but this is a complicated and undesirable arrangement, and should be avoided where possible.

In some cases the designer has no option but in others he can arrange that each cylinder and its accompanying parts shall have a separate water circulating system supplied from the one pump. This is of special advantage for vessels working in tropical climates, as the circulation of water from one cylinder to another leads to too great a difference in temperature.

The overflow or discharge pipe on a ship's side should be fitted in such a position that it can easily be observed by the engineer from the deck. In smaller vessels, especially in Scandinavia, it is usual for the circulating water to be discharged into a funnel in the engine room, and thence overboard so as to be in constant view, though of course, this practice cannot be adopted for sea-going vessels.

Silencers.—A cast-iron water jacketed silencer is fitted on the engine, and as has been previously mentioned, there are many types of secondary silencers, the most usual being the vertical one formed of steel plates fitted in the upper portion of the engine room casing, or in the funnel, arranged with a manhole door for cleaning, and a "sump" with a drain cock and pipe to drain to a convenient position.

Some designs of silencers provide for perforated baffles or divisions, others for partial baffles or divisions, but all these should be avoided, and the perfectly plain silencer will be found the most effective and will cause the least resistance to the flow of the exhaust gases.

Exhaust Pipes even in the best regulated oil engines have to convey hot gases, the natural outlet for which is a funnel. All exhaust pipes should be attached to a silencer usually fixed to the engine. Where possible, the exhaust pipe should be carried vertically and into a secondary silencer, thence to a funnel.

Under no circumstances should the exhaust pipe be reduced in area, in fact it will be found good practice to make the internal diameter 10% greater than the outlet on the silencer.

Bends in steel exhaust pipes should have a radius of at least five times the diameter of the pipe. In the case of yachts and passenger vessels, light cast-iron exhaust pipes, water cooled for the whole length, are sometimes fitted.

Several installations, especially in small vessels and auxiliary sailing ships, have had horizontal exhaust pipes carried right out to the stern. This practice should be avoided where possible on account of the risk of sea-water getting into the exhaust pipe, and in due time forming a deposit, and the difficulty of cleaning the pipes, while the heat given off causes trouble if the pipes pass through the accommodation. Where a funnel is not required for the sake of appearance and to obtain a "steamer's turn" in loading and discharging in port, a simple exhaust pipe can be carried straight up from the first silencer through a secondary silencer, and discharge into the atmosphere above the casing. This is a specially convenient method in the case of twin-screw vessels. In the case of sailing vessels and yachts, a satisfactory method is to carry the exhaust pipe well up one of the masts, but it should be kept a few inches clear and large iron plates should be fitted in way of wooden decks, and bulkheads and air casing plates or outer pipes round the intermediate parts, to prevent risk of fire or radiation of heat,

The exhaust from oil driven deck auxiliaries cannot be dealt with in the same way as that from steam auxiliaries. Generally it will be found most advantageous to carry the exhaust pipe up the mast or casing 10 or 15 ft. above the deck. To prevent noise, these pipes should be of larger diameter than the exhaust outlet on the engine. They should also be secured firmly to the mast or casing. A drain cock of large diameter should be fitted at the bottom of the pipe or at the lowest point of the silencer, so as to draw off any water which might have accumulated owing to rain or bad weather.

Funnels are usually favoured especially in coasters and tugs, as the owners think they make the vessels look as if they were fitted with powerful machinery. The funnel can be used to accommodate the secondary silencer and also to act as a ventilator to the engine room or other parts of the ship.

Bilge Pumps are essential for all vessels that go to sea. The installation should provide for one driven from the main engine and also one as a stand-by, driven from one of the auxiliaries, the pipes and connections being arranged in the usual way.

The deck water service can be supplied by the bilge pump if a water connection to the ship's side is provided; the usual care should be adopted in fitting non-return valves in way of the bilge suction so that the bilges cannot be flooded from the sea-cock.

Overboard discharge pipes, if placed near the water line, generally have non-return valves fitted to prevent flooding in the event of fracture.

Engine Room Fittings.—A whistle is required on deck, as in steamers, and the air for this should be taken from the low pressure containers. If only high pressure containers are fitted a reducing valve should be used. The whistle should be of extra large size, and if possible should be adjustable, so that it can be used with any variations in the air pressure.

Fuel oil filters should be fitted between the daily service tank and the fuel pump, the fuel pipe being so arranged that air locks are impossible. The most economical type of filter is one of cast iron about 10 ins. in diameter with a loose cover for taking out and cleaning the filtering medium.

In a number of engines, a fuel priming cock is fitted on the side of the filter to pump the fuel oil and air through the pipes.

The engine room floor, benches and racks should all be of steel, wood being entirely dispensed with, except perhaps for the top of tne engine room seating.

Sand boxes and fire extinguishers are recommended for all types of oil engines, both being fitted near the engine room entrance, the fire extinguisher being on deck near the top of the engine room ladder.

Guards are necessary and advisable, especially in way of the fly-wheel and pump gear, but they should be so fitted that they are easily removable.

To make an efficient installation, it is very necessary that proper steps and platforms should be fitted to enable the engineers to get at the various parts, the tops of the cylinders, the pressure gauges, the air valves and connections, the cocks to the service tanks, the lubricating oil tanks, etc.

The tail shaft should, like all well designed jobs, work in oil or grease. and the gland at the after end should be so designed that it will not get damaged when a rope or chain gets round the propeller or the end of the tail shaft.

Dock Authorities.—As this paper deals principally with engines that use safe fuel oils, there is not much doubt about the installations of such vessels passing any Harbour Board or River Authority, but is is well to consult the Harbour Engineers of any particular port that the vessels have to work out of.

Classification.—There are not at present many rules concerning the installation of oil-engined vessels issued by the various Classification Societies and Board of Trade, although it is as well to get the latest rules from the Societies in the case of vessels being "classed," and the Board of Trade rules for vessels that are destined to have passenger certificates.

Cleanliness should be considered by the Naval Architect as well as the engineer. All ledges or shelves should be avoided where possible, so as to minimise the number of places where dust can rest. Where these horizontal surfaces are essential, they should be so arranged that any angle stiffeners both fore and aft and transversely that may be necessary, are fitted on the under side, so as to leave a smooth surface on top for cleaning purposes.

The engine room ladder should be fitted clear of the engine. If it is absolutely necessary that it should cross over any portion of the engine or shafting, the ladder should be plated underneath for its full length, to prevent the smallest amount of dust or dirt getting on to the engine. Proper mats either rubber or coir, should be fitted outside the entrance to each engine room, also inside on the grating platforms and again at the foot of the ladder.

Simple arrangements should be made to enable ventilators and skylights to be covered over or closed quickly when in the neighbourhood of any form of dust, such as when loading or discharging, or when near other vessels that may be coaling or dealing with dusty cargoes or when near a quay where the wind may be blowing the dust off the roads or quay.

Lubricating oil tanks, drums and the filling cans should all be arranged so that it is impossible for the slightest amount of dirt or grit to get in to the oil, and even if it does, then the method of filtration should be such that it is impossible for it to get to the oil boxes of the engine.

Engine rooms are not cleaned out as frequently as they should be in oil-engined vessels, and it is not uncommon to find the bilges in a very dirty state; in many cases these troubles arise through faulty installation. If engineers and drivers would appreciate the importance of having an absolutely clean engine room under every condition, they would have much less trouble in the long run and the oil engine would soon have a better reputation for good and efficient work. A number of installation plans or small vessels are laid on the table and details will be explained with pleasure.

Mr. Timpson: I have listened with pleasure to Mr. Pollock's comprehensive paper. He rightly points out the necessity of taking great care in the bearers fitted in the ship for holding down the engine seating which requires more special attention than an ordinary steam engine installation, and I expect want of this has caused trouble occasionally, especially when fitting oil engines into old vessels. We are not told much about installing oil engines into wooden vessels, probably as these are getting out of date; yet a deal of trouble has arisen when care was not taken to fit proper bearers for the sole plate, and I believe defects arose through fitting thwartship, instead of fore and aft bearers. Mr. Pollock has given us many points and a good idea of what should be done to ensure a good and well-working installation; and the latter part of his paper, in which he lays great stress on cleanliness and avoidance of dirt, can be taken to heart and fully regarded by all who are running oil engines, as there seems a deal of carelessness in respect to this, and it is one of the worst enemies the oil engine has, especially in small vessels.

Mr. MAYOR: The completeness of the paper robs us of the chance of much criticism. I should like more detailed information in regard to steering gears. I have to deal with a class of vessel, working on the Thames, in which the steering gear plays a very important part—almost as important as the propelling machinery. Everybody, I think, knows the duties of these smaller river vessels, and I think Mr. Pollock is a competent authority on that point. The duties of these engines are very heavy and exacting, and I should like to know how he proposes to deal with the steering gear, where it is in constant use. Without steam steering gear a lot of the work that is at present carried out would have to be left undone, and for that reason a good steering gear is an absolute necessity for this class of vessel. Reference is made to steering gear, but if Mr. Pollock would give more detailed information it would be of considerable value.

Mr. W. MCLAREN: These lectures on the marine oil engine are becoming interesting. Now we have come into the region of the ship-building. In regard to the first paragraph in the paper—I think engineers at the present day are quite confident of the oil engine giving good service, but there is a doubt about the reversal of the oil engine on the part of marine steam engineers. Oil engines have been brought to great perfection, but there is a feeling that they are not so flexible as steam engines; with further experience of the oil engine we shall get more confidence in them as we go along.

Then comparing the weights of the oil engine with the steam engine (less boiler plant), what is the average weight per horse-power of the oil engine? I mean the weight of metal in the construction of the engine. In an engine room constructed for an oil engine, I apprehend there would be plenty of head clearance, as there is no necessity for midship bunkers. Some of the old conditions were bad and I hope that in the present day arrangements the engineer or driver is not confined to berth in a cabin where fresh air and the light of the day enter not. In a well-designed engine room we should have ample clearance for drawing any piston or overhauling machinery, and that reminds me to ask: Are the pistons drawn with piston rods or are they pistons with trunks? I understand, in gas engine practice, the trunks are drawn from the underside, or crank-side of the cylinder. What is about the average piston speed of these engines, up to 250 horsepower? They have about double the revolutions of the steam engine. What is the behaviour of the oil-engine driven ship when "light," and more especially when these engines are aft, as near to the stern as it is possible to get them? I take it they cannot be placed any nearer to the stern-post than a steam engine. I agree as to the scantlings for holding the bed-plates down as shown, but I think a little might be saved in the transverse girdering, angles and plates, to avoid too many enclosed spaces, so that everything might have a wash.

We cannot get away from gases being thrown off from the oil used, and there is always the danger of a naked light, as bilges are not ventilated to the preventative degree. With regard to the oil tanks I always thought the cylindrical tank was the cheapest to make, and the safest. But I do not see any provision for cleaning it out, except a large manhole door. Unless you have a method of washing out before re-filling with oil, risk of dirt becomes greater. I do not know whether this oil leaves any scum about the plate. These are little points well worth taking the advantage of asking questions about, seeing the author of the paper is present to give us an opinion on them. Then we come to the auxiliaries, and I am afraid I cannot say much more beyond what has been elaborated upon here. Certainly, in our Transactions the paper will form a record with others that one can appeal to in quiet moments, when one comes to study up the pros and cons of oil-engined ships. Then there is the deck gear. We have at the present day, and have had for some time, good submersible motors for deck gear. Instead of spreading oil engines all over the ship so that we have, as some people tell us, an engineer's shop in every hole and corner, why cannot we have something of a stable engine? I do not think the cost would be so heavy. Then let this engine drive a generator in the engine room, and motor it in from that to any auxiliary you may have. There would be no question of cooling water, no question of Baltic terrors, of getting frozen up and split pipes.

Mr. Mayor spoke about steering gear. To have that electrically driven and controlled would, I think, be an advantage to the oil-engined ship. I will now close by thanking Mr. Pollock again for his paper, which is one for young and old, indeed for all who want to go to sea with an oil-engined ship.

Mr. J. B. Harvey: The author in his paper seems to lay great stress on the necessity of having the donkey boiler in a separate compartment of the ship, away from the engine altogether. The reason he gives is on account perhaps of a little dust getting on to the machinery. But surely, with this class of engine it is not absolutely necessary that no dust at all should settle on them. I have been aboard several ships on which the donkey boilers are in the engine rooms. These were oil-fuel boilers, and no trouble had arisen. It seems to me that if the internal combustion engine has to be guarded against every little bit of dust that may blow into a ventilator when working cargo, it is hardly right and in my opinion these engines should be made so that the dust should not interfere with the working of it. I should like to know if the author has any other reason why the donkey boiler should be placed in a separate compartment.

The Chairman: The remarks made by Mr. Pollock on the question of silencers interests me, for he tells us that baffles should be avoided, and apparently he would take baffles out, whether wire gauze or plates perforated with holes. I agree with him, and I recall my experience with a car engine of 50 horsepower. When trouble arose I suspected the silencer, so when the car came in, the silencer was opened out, and all the plates were removed. Later the owner was taken for a ride and he made no suggestion that there was more noise and as the car pulled very well he was pleased. I tried another silencer. Instead of a long tube three or four feet in length, I arranged a series of short tubes, and they acted as a series of short expansion chambers, and it was much quieter. The ideal silencer is an apparatus in which the volume of the exhaust gases is continuously being increased so that the pressure falls continuously down to that of the atmosphere. The trouble of noise arises when the engine exhausts directly into the atmosphere. Then gases issue at high pressure, striking the air suddenly and so gives rise to the noise. If the gases from the exhaust valve pass into a chamber with sufficient volume to act as an elastic buffer, and so take up the kinetic energy of the exhaust gases, the expansion down to the atmospheric pressure can take place without any great noise. Mr. Pollock spoke of the engineers' ladder, and I quite expected some of our members would have some caustic remarks to make on this feature of an engine room. When you have to go down a bulkhead by means of a nice little ladder placed so snugly against the bulkhead, with $\frac{3}{8}$ in. round bars for the treads, that there is only just sufficient room for the ends of your toes, and have to hang on in half a gale, you are apt to say rude things about designers of ladders. Personally, I am inclined to the view that an engineer cannot design a ladder. He can only curse them. There is another point raised about dust. Now the good old steam engine will go right on to the last kick. We can get her going with slack in the bearings and other defects; but she will keep turning round. But the oil engine does not act anything like that. It just stops, and that leads men like Mr. Pollock to take and advise the greatest precautions. In the case of a motor car, you will sit down and examine the carburetter, and having done that you are conscious of having done nothing beyond making your fingers greasy. But she starts up, and runs merrily. You stop again, and look once more for a piece of dust in the carburetter, and the vibration of opening out will usually jar out the elusive speck of dust. I feel with Mr. Pollock that every precaution should be taken for the avoidance of such troubles as that. At sea you are not troubled with carburetters, but because one trouble is removed it often follows that there are four of five others—if not more—equally troublesome to contend with. Another point was the question of propellers. Mr. Pollock speaks of an inclined shafting, and his advice is not to have it. He says: "The best practice, where possible, is to keep the line of shafting parallel with the bottom line of the ship." I am not possibly quite up to date with regard to the latest experience in the use of inclined shafts, but I remember, in the case of a certain Heroshoff vessel which was brought over here some time since, that the shaft came out below the rudder and went two or three feet astern; so that the propeller was really in solid water. That arrangement could only be used in a vessel which was always going to run in deep water. If she were near the land she would touch the ground with her propeller first, and crumple it up. Mr. Pollock advises that, with twin-screws they might open out towards the stern. It seems to me that in doing so we are running the risk of the propellers standing out and becoming a nuisance when lying alongside a quay or wharf. Perhaps he has some qualifications to this, because that is a point that cannot have escaped his attention. That the propellers should work in solid water is an undoubted fact, because nothing would spoil their efficiency so much as to work in troubled water. Otherwise cavitation would not hurt the propeller. The paper contains quite a number of practical features that mark it out as one that is written by a man who has first hand knowledge of his subject. I wish I could persuade more of you to speak, particularly those who are handling this type of engine. Can I persuade anyone to add a word before Mr. Pollock replies generally to the discussion.

Mr. F. M. Timpson: The question of compressed air starting has been referred to, and the loss of air, also to the lot of labour in getting back the pressure. I can sympathise with this view from similar experience. I recently saw an old Bell-crank type compressor installed in a new vessel for emergency compressor service, when one would look for an improved type of a rotary design of which I believe there are several makes available. Some forms of rotary air compressors I have seen will pump up air pressure quickly and in one instance the fitting of a rotary compressor with connecting hose on a river-side wharf was a great saving of time in helping out cases where engine starting air had been used up. Another point in the paper was in connection with water drip. One had hoped that water drip was disappearing, but it seems to be in as much use as ever with the general run of hot-bulb engines. I agree with Mr. Pollock when he says not to use salt water; and one has to be careful not to use water with solids in it. I have heard of cases where cylinders were badly worn from gritty deposits left in them by the water drip. It may be an advantage to use distilled water or rain water.

Mr. W. Pollock: In the first place I thank you for the cordial reception given to the paper, and also for the valuable contributions that have come in the discussion. A number of the points in the paper may be considered as elemental. It is rather strange, especially in small ships, to find small but important things over looked. Mr. Mayor raised a question in regard to steering gears. In so doing he has raised a question in regard to one of the most difficult problems we have to deal with. I take it from what he said, that he was referring to tugs. It is a very difficult proposition, that of steering properly, and at the present moment we only have hand gear for oil-engined boats of moderate size. But I do not doubt we shall ultimately use some form of hydraulic or electric steering gear for the vessels he has in view. Up to, say 800 horsepower, I do not think a direct-coupled oil engine is a practical proposition at the present time, because of the work, and intermittent load. That subject, I may mention, is dealt with in the next paper I am reading, on Auxiliary Machinery. Other than the hydraulic or electric steering gear, one might have air, using the air compressor to supply a reservoir. I think it is quite possible, where the engine is not exposed, to obtain a steering gear worked entirely by air. The efficiency, I believe, is very much greater, if not exposed, than is generally believed. A friend of mine has this proposition before him, and is experimenting. If he obtains efficiency he hopes it will also apply to winches, capstans, and other fittings. Mr. Low referred to auxiliary compressors. I do not know quite what size he had in his mind. Mr. Timpson also referred to the same subject. Of course, with very small engines you only have a more or less glorified motor car pump. Then we have various compressors worked by hand; but as I have mentioned in the paper the best method is to have a hand plunger pump driven by a crank handle fitted with a heavy fly-wheel. Then you come to the next stage which Mr. Low suggested, and that is that you should have a power-driven pump. There are a number of power-driven air compressors, which I shall mention in detail in my next paper. You can deal with it by having it driven off the main engine direct, or, as I have done on many occasions, through a clutch. You can drive them by belt off a small fly-wheel, or you can have an entirely separate engine. One of the difficulties we have to deal with in installations of, say 150 h.p., is the cost of a separate air compressor driven by a separate engine. You can get a fairly satisfactory arrangement by using a petrol or paraffin engine, but it is not desirable. To get a heavy type of engine driving the air compressor becomes too expensive for the ordinary installation. I have found from experience that the main oil engine is already quite expensive enough. A very good method is to have the air compressor driven by a separate engine, and have a coupling on each side, so that an air compressor can be driven from one end and an electric light plant and/or bilge pump from the other end, so that you have a combination auxiliary set. Many alternatives could be adopted with one small engine. Mr. W. McLaren raised several interesting points. I did not quite follow all of them, because I was not sure what size of engine or what size of machinery he had in view. With regard to weight per horsepower, that is a very varying quantity. In the case of the Diesel engine it depends whether it is a 2 or a 4-cycle engine; and in my view the weignt of the engine is of very small consequence when you have to take into consideration the enormous weight of auxiliaries. But I have a number of figures and I will look these up and forward them. Taking the ordinary small type of engine, say of 350 horsepower, of the hot-bulb or surface ignition type, you will find it will weigh about 25 tons, or 14 horsepower per ton. That is the engine complete up to the end of the shaft; and the engine requires little or no auxiliaries. With regard to the removal of trunk pistons, there are very few, except fairly large Diesel engines, that can be removed at the lower end, and if you can remove the trunk pistons in that way there is greater risk in handling and consequent damage than lifting overhead.

I think it is generally found more economical to take them through the top. With regard to piston speed—this, of course, varies with different engines; good practice is for an engine of 350 b.h.p. to have a piston speed of 675 ft. per minute. Mr. McLaren also raised a question in regard to deck gear and motors, mentioning the engineroom auxiliary in the form of an electric set. These questions are being dealt with in a paper already written to be read next month. I am dealing with the same subject in several aspects, and I shall look forward to having Mr. McLaren's criticism when the paper is read. Mr. Harvey raised a point in regard to having a separate engine room for the donkey boiler. In a Diesel engine job it is not so necessary to separate the donkey boiler from the engineroom, but there are very few—I do not know of one—Diesel engine installations from 2,000 to 5,000 horsepower, that has not a small auxiliary engine, usually of the surface ignition type. That small engine is a sufficient reason for doing away with the practice of having the donkey boiler in the engine room. It is a very nice proposal to suggest that the engines should be made so that they will not be troubled by a small amount of dust, but if Mr. Harvey will carefully examine any of the well-known makes he will find the degree of accuracy of workmanship is astonishing. It is because of that accuracy that the least possible amount of dirt will cause trouble. It is really a simple matter, to put the donkey boiler in some other position, and the object of it all is to get an installation that will give as little trouble as possible. In a record of 120 cases of trouble in surface ignition engines up to 300 or 400 horsepower, it is no exaggeration to say that 30 per cent. are due to dirt and dust, either in the engine room or in the lubricating oil. In many cases of boats working in river service I think it would be more correct to put the percentage at 60 per cent. The Chairman raised the question of the silencer with short pipes. There are many forms of silencer. One I remember with five or six fairly large tubes, but the difficulty we found was to clean them. It meant taking off the whole of the end of the silencer and the exhaust pipes and individual cleaning. If you have a silencer of the ordinary open drum type you can, with the smallest amount of heat in the engine room, bring the oil deposits down to the bottom of the silencer, and if it is arranged with a sump, as suggested in the paper, it is not very difficult to draw it off. It is quite a simple matter to take off the manhole door and put your arm in and clean the deposit of soot and oil out. One great difficulty is not only the back pressure of the exhaust, but a far greater difficulty is to keep the silencer clean. In one case I know of a silencer which had a series of holes $\frac{1}{2}$ in. to $\frac{5}{8}$ in. diameter. Measuring these holes up we found we had a total area of at least 60 or 70 per cent. in excess of the area of the exhaust pipe. But that did not prevent the top of the silencer being blown out, as the accumulation of deposit and oil due to bad combustion, etc., was so great that there was practically no clear area through these holes. We had all these division plates removed and the silencer put back, and although there was slightly more noise it was assumed the engine was working better and there was no further trouble with the silencer. With regard to ladders—it only shows that even small matters are of importance, especially if you try and run down a ladder quickly. If you avoid the old round bars, also the cast-iron steps, and adopt three ordinary square bars arranged diamond-fashion on edge, I do not think you will have any trouble of the sort to which the Chairman has referred. With regard to the Heroshoff inclined shaft—I remember the case that the Chairman has mentioned, and do not think the efficiency had much to do with the inclination of the shaft. It was due to the more thorough immersion of the propeller. That, of course, is a very nice proposition, and is quite satisfactory in yachts and demonstration boats such as Heroshoff built, but quite impracticable in commercial boats, because the propeller cannot be used below the heel of the stern frame. In regard to twin-screw shafting, if you keep the propellers apart to get the additional efficiency by more solid water you may expose the propellers to possible damage. But before you can arrange these shaft lines you must design the ship, and when you have arranged your shaft lines to get efficiency from the propellers you should arrange your stern and counter adequately to protect them. Mr. Timpson afterwards raised the question of water drip, and the use of distilled water. He hopes, I hope, and we all hope, that water drip will soon be eliminated. Most manufacturers are working to that end, and some have obtained greater success than others; and some claim greater success than they have attained. There is no doubt that in a few years water drip will be entirely dispensed with, and any engine working with water drip will be quite out of the market. Thank you again for your very kind attention to this paper.

Mr. Inson: I have pleasure in proposing a vote of thanks to Mr. Pollock for his interesting paper, and also for the way he has dealt with the questions put to him.

Mr. W. McLaren: I have pleasure in seconding the vote of thanks, adding my appreciation of his coming here again, and for his courtesy in answering our questions. They may be trivial, but we are only being educated up to this new phase of power which has been brought into sea life; and we find we are brought hard up against a fresh-water and salt-water question. We thought we had had enough of that question when we had to produce a good supply of fresh water for the boilers. I do not know whether they will ever compound the internal combustion engine. We now have triple, quadruple, and, I believe, five cylinder sets of steam engines, and I do not know what the internal combustion engine will be like in the future, but we hope it will have a fair and straight way.

Mr. Pollock: Many thanks for your cordial vote. Mr. McLaren has referred to the possibility of compounding and trippling the internal combustion engine. Personally I do not think I would like to take it on at present. But I will commend it for consideration.

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Marine Engine Curiosities of Practice and Experience.

BY MR. A. E. SEATON (Member),

READ AT

THE EFFICIENCY EXHIBITION, OLYMPIA,

ON

Tuesday, February 15, 1921, *at* 7 *p.m.*

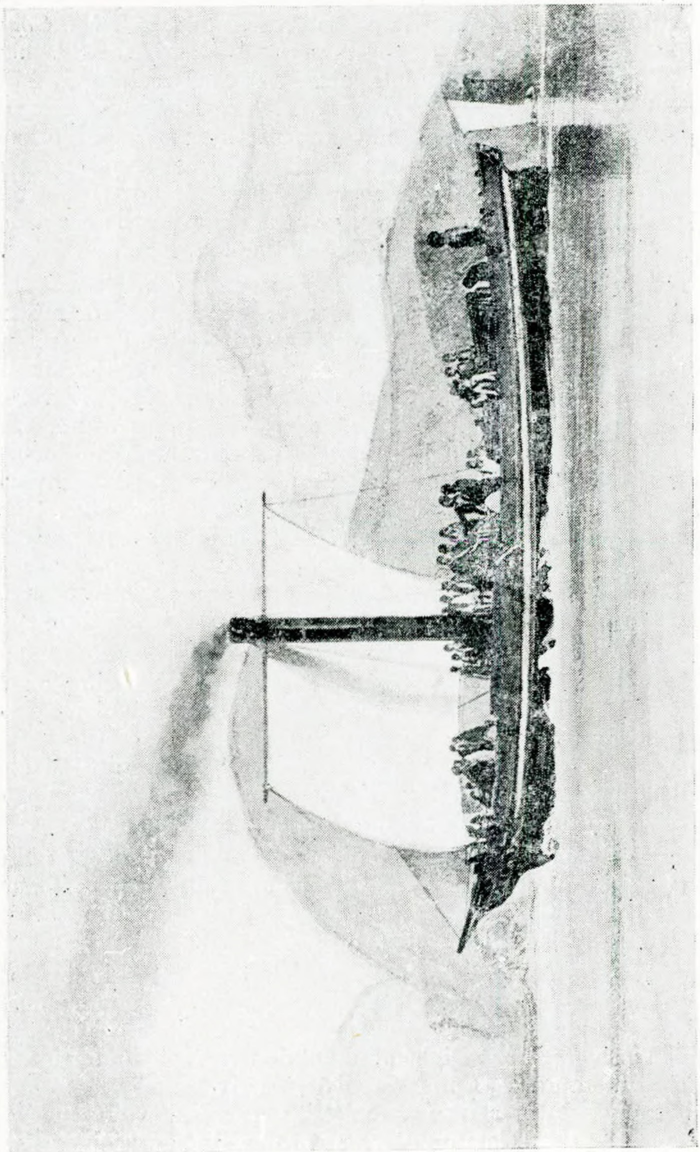
CHAIRMAN: MR. B. P. FIELDEN (Member).

IT was suggested that the members would like me to give them some interesting matters pertaining to the early history of Marine Engineering, especially those relating to personal experiences with engines and boilers. From my early acquaintance with many of the engine room veterans I have made a collection of such as are both interesting and instructive. I have also studied Marine Engineering History as gathered from the magazines, books and other early records, and, moreover, gained no small amount of knowledge by perusing the Patent Extracts as published by the Patent Office in years gone by.

To-day I purpose to give a selection which I believe you will find interesting, and I hope in some respects edifying, as exposing to you some of the foundations on which is built up the knowledge we possess, and as inviting you to respect the forerunners in our profession who battled successfully with the few and inferior weapons through the contests in which they were engaged, and have thereby made things comparatively easy for you to carry on now.

In 1812 the first steamship to be used in this country for trade purposes was the *Comet*, quite a small ship, but the forerunner of the very many beautiful and large steamers by which the passenger traffic has been and is carried on still in the Clyde Estuary.

In 1816 we find steamships being built in the Humber District, viz., at Gainsborough and Thorne, the engines for which came from Staffordshire and Derbyshire. In passing, it is also worth remembering that in 1822 the Butterley Iron Works fitted into the *Yorkshireman*, built at Thorne, near Goole, a set of engines which ran at a fairly high rate of revolution and geared down to the paddle shaft by pinion and spur wheel. Such an arrangement is quite possible to-day as a means for driving paddle steamers by Turbines, or even by high revolution reciprocators—steam or oil.



THE "COMET" ON THE CLYDE.

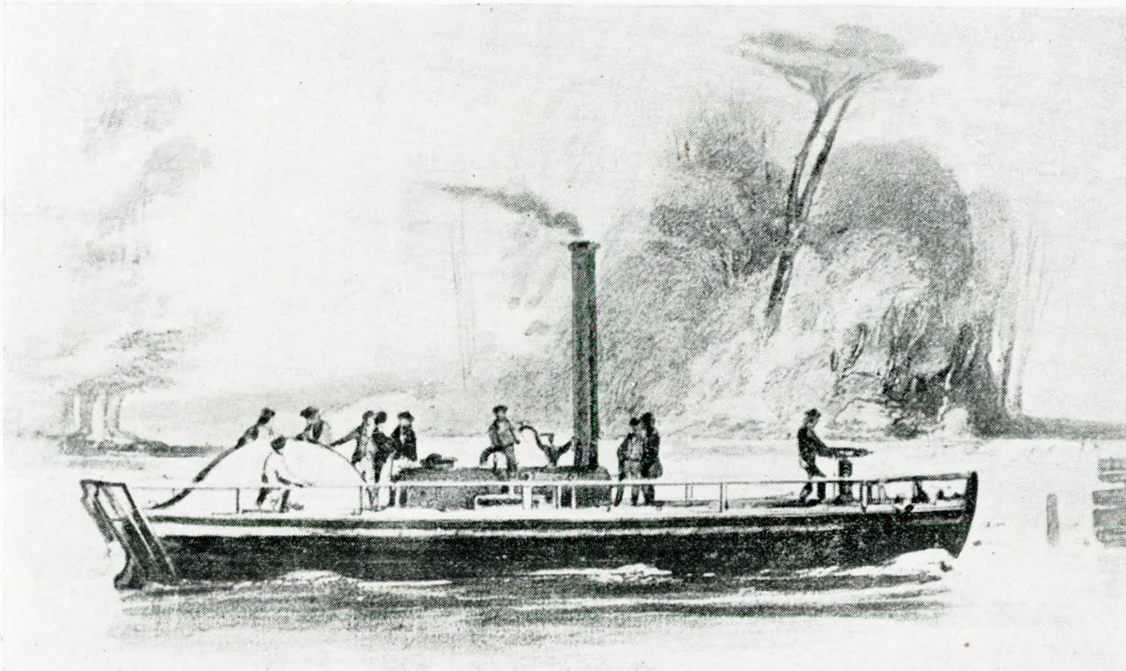
In 1820 the Admiralty acquired their first steamer—a small tug, and in 1822 had built another tug, also named the *Comet*. Paddle tugs had been employed many years before at Chatham, and probably at Deptford and Portsmouth for docking and also transporting warships in the harbour. They were worked by horse-power (the I.H.P. is not known) by means of gins or whims. Whether the drivers were transformed into engineers on the introduction of steam, as we have seen in these days coachmen made into chauffeurs, or if an engine room artificer to give expert assistance was or was not added, I do not know.

1820 seems to have been noted for some other beginnings besides Admiralty Tugs and Johnny Walker's spirit for internal combustion. Perhaps the most important event after all was the exhibition of a working model of an Internal Combustion Engine by the Rev. W. Cecil to the Cambridge University Philosophical Society, and the reading by him of a most able and interesting paper on this method of obtaining motion and power. Petrol was then unknown and the only spirit available for the purpose was turpentine. Mr. Cecil, however, began with compressed hydrogen, so that his was really a gas engine; nevertheless, it may be taken that he was the originator of the reciprocating internal combustion engine, and curiously enough he was a Parson of a noble family. The use of turpentine spirit on such engines soon followed.

A few years later we find steam motor cars running on the highways, not only for joy riding, but for commercial purposes. Again, strange to say the inventor and producer of the best of these was not an engineer, but a Doctor of Medicine—Goldsworthy Gurney. He was a Cornishman, as was also Hornblower, the first inventor of the Compound Steam Engine.

Gurney patented and made Water Tube Boilers for these purposes, which he worked at a pressure of 120 lbs. per square inch, and were the prototype of those now used on shipboard for high speeds with such success.

In 1829 there sailed from Woolwich the first ship to go to the Arctic Regions fitted with the means for propulsion by steam. I say this advisably, for one can hardly consider a ship to be classified as a *steamer* which could not do five knots under favourable circumstances. I am enabled to give you some very singular and interesting experiences as related in the logs and reports of her Commander, Sir John Ross, which indicate what happened on board some ships in those days; now, although



THE "CHARLOTTE DUNDAS" ON THE FORTH AND CLYDE CANAL.

I cannot say that these are fair samples, I can conclude that the happenings were not such as to be singular or even uncommon, for had they been so, neither the engineers nor the other officers would have gone on in that ship after what was experienced in the first few days of the voyage.

We know what the commander thought from what he has left on record; but what the engineer thought we don't know, and I fear if we could gather what he had said you could not print it in the transactions. Perhaps, however, he may have been like the carter that President Lincoln told the story of to illustrate his axiom, that when you could not do justice to a theme properly, it was better to refrain altogether. When this carter found that coming up the hill his load of coke had all dribbled out as a consequence of the tail board slipping off, while he walked ahead of the horse, said to those waiting to hear him explode with a flowery eloquence for which he was famous, "No gentlemen, I am not equal to this occasion," and remained silent.

This little ship was of 150 tons burden only, and had been in the Liverpool and Isle of Man Service previous to her purchase for Arctic work. She was raised some five feet, had her planking doubled, and otherwise was strengthened for resisting ice pressure, etc. She was fitted with machinery by Messrs. Braithwaite and Ericsson (two very capable and eminent engineers), the engines being very special ones. The paddle wheels were designed so as to be raised out of the water in one minute when in the ice or when the ship was to go sailing, and to be lowered down when steam propulsion was required. The boilers had no funnel, but had furnaces and tubes. They were fitted with a big and small bellows worked by the main engines, so that this was probably the first attempt at raising steam by a forced draught. Fuel was taken on board equal to 1,000 days' consumption for all purposes. The engine room staff consisted of a chief and a second engineer and three stokers.

The ship sailed from the Thames on the 23rd May, 1829, 91 years ago, and Capt. Ross begins to enter his log at Gravesend, where, he states in his report, "the makers of our execrable machinery left us." It took them 12 hours with steam and sail to reach Margate, by which they had discovered her speed to be $3\frac{1}{2}$ to $4\frac{1}{2}$ miles per hour. Sir John writes, "The defects of the machinery began to weigh seriously on my mind," and he likewise adds, "the boilers leaked so much that the additional forcing pump which worked by hand was kept constantly going, while the fresh water necessary to compensate that loss could not be spared." It is apparent by this that they had some sort of reserve feed tanks in those early days.

Then he adds, " it was impossible for the men to remain for any length of time in the place, as the temperature there was 95°. They did not murmur, however, but one of them fainted, and they were all exhausted."

Sir John ends by " Nevertheless, we had no resource but to persist, and while rounding the Foreland a breeze sprung up which induced us to heave the paddles out of the water, etc."—the true old bulldog hold-fast type which would have pleased some steamship owners of these times. I fancy if I had been there I should have funked and gone back to Gravesend, or even to Sheerness, especially as Sir John relates that as the breeze freshened and a swell arose, the ship leaked so badly as to require the use of two pumps. As he had only nine seamen, they must have had a rough time; but in their case there was no 95°, and, consequently, I suppose no fainting on their part.

By May 27th they had reached the Lands End, and in the meanwhile the engineer had found one of the guide wheels of the starboard piston rod " so much worn as to require a piece to be brazed to it," and what was worse, " the connecting keys of the main shaft were found to be loose," and they had no spare keys, for the absence of which he blames Ericsson and Braithwaite. Roller guides did not seem to be a success; although I saw them on Maudslay's shop engine, which had the date 1827 on it. Brunel was the inventor of them.

On the 29th they found they had LOST three miles in beating to windward; as the engine was reported fit, they, therefore, downed wheels and steamed head to wind. Unfortunately on the 30th, those wretched keys worked loose again, and at about 4 a.m. the principal one broke. On examination it was found to be a bad bit of steel (untested by Board of Trade, of course), and they had no steel on board large enough to make a new one. They had some iron, however, and made one of it; but it soon gave way too. Three new ones of iron stood for a bit, but gave way on June 1st. These stoppages had given the captain time to look into matters and reflect somewhat, whereby he came to the conclusion that " independently of these defects, the performance of the engine was most unsatisfactory. Even with a pressure of 45 lbs. per square inch, we could never obtain more than 15 strokes in the minute," which meant only a peripheral speed of wheel of 5 miles. On June 1st, " the boilers also continued to leak, though we had put dung and potatoes in them by Mr. Ericsson's direction," but Sir John had devised means whereby the hand feed pumps were operated from the lower deck.

Then he began to make more discoveries which remind me of what the chief engineer of the *Pharos* discovered some 40 years ago, and confided to me as the reason why they never could have a decent vacuum in the surface condenser of that ship. He told me it was arrived at the knowledge, as the result of prayer, he being a good old Highlander from the Hebrides. He informed me he had measured the feed pumps and found that one was by itself quite sufficiently large to take all the condensate and feed the boilers. He, therefore, concluded that the other pump must be doing something else, and that, of course, was " pumping out the vacuum." He recommended his superior, the consulting engineer, that the pumps should be fitted so that only one at a time could operate, and apparently convinced him, for he got an extra order for carrying this improvement out. I may hardly add that the vacuum was no better for the change.

Well, Captain Ross says, " Finding further that the condensing apparatus was defective, inasmuch as the air pump always drew a quantity of water, and the feeding pump was insufficient to supply the boiler, we disconnected the whole apparatus, except the latter, which we proceeded to supply by a cock; and having led the steam from the eduction pipe by tubes and hose to the upper deck, we put the engine in motion, and thus by means of a pressure of 47 lbs. on the inch obtained a velocity of sixteen strokes in the minute, being one more than when the condensing apparatus was in action."

This also recalls to my mind a book I read a review of some time ago in the *Nautical* Magazine for, I think, 1838. It must have been a sort of an early Manual of Marine Engineering. I judge this from the fact that the reviewer says that by its use the commanding officer on the bridge can be independent of the engineer in the engine room.

Well, Captain Ross was evidently bossing the chief engineer, with the not unusual result, for he says, " It was thus shown that power had been wasted, partly in this part of the contrivance, and partly through the vacuum pump; but whatever our correction was it could avail us nothing at sea from the great loss of water to which it gave rise."

However, the gallant captain was nothing daunted, and soon looked round for fresh engineering conquests, and says, " In addition to these unproductive connections, we next tried the effect of disengaging the great bellows: Yet, though we saved considerable power in this manner, we found that it did not last, and that the small one was incapable of maintaining the requisite heat, and were wearing so badly as to threaten to become useless." " Everything in fact was imperfect, since even the cylinders were too small to perform the duties required of them." I should add that he does admit that the design had some good features; among them he admits that the "omission of the funnel had saved much weight, and that the consumption of fuel was less than with the original engines."

They reached Douglas, Isle of Man, on June 4th. Leaving there on June 7th, a new experiment was tried, viz., using only the lee paddle wheel. This was apparently a success, for the rate of revolution was 18, as against the original 15, and they could beat to windward as well as any of the vessels near them, and beat some of those that had previously beaten them. But ill fortune dogged their steps, for after doing 30 miles during the night, " at 10 a.m. William Hardy, the principal stoker, came up from the engine room on deck, unassisted and alone, and though without complaint or exclamation presented his left arm shattered and nearly severed above the elbow." His foot had slipped when feeling round, and he fell with his arm caught between the guide wheels—was it I wonder the one with the bit brazed on?—and the frame. He was very badly injured, and as Captain Ross says, " it demanded amputation and no time ought to be lost in performing this operation." Unfortunately for poor Hardy the surgeon had not joined the ship, so was not on board; his instruments, however, were, but unfortunately again, the amputation saw could not be found. Captain Ross, however, was equal to the situation and managed to render sufficient surgical and medical aid to him, so that when they did reach land, the surgeon was able to make a good job of it.

On June 8th, when apparently all was going well, there was a " loud crash in the engine room; the teeth on the fly wheel of the bellows had given way, and a report came that the boilers had burst." This latter, however, was not quite an accurate statement, but it was found that "some of the joints of the boilers had given way, that water was pouring out of the furnace door, so that in ten minutes the fire was extinguished." They reached Port Logan on the Mull of Galloway under sail, where there was a sort of mutiny among the men. You will, of course, not be surprised at the "downing of tools" under the foregoing circumstance, but when I tell you it was the sailor men and the deck hands who struck, you may be, and will be more so—when you learn it had nothing to do at all with the machinery, but was only a question of the sharing the proceeds of the voyage if they returned with a full ship, that is of whale blubber, etc. Captain Ross, however, expresses his belief that really they feared being detained beyond the summer, and there might not be provisions on board for a winter sojourn. As, however, they were in the end away four years, perhaps they had some reason for funking. He took this opportunity of getting rid of the donkey boiler, and the engine for cutting the ice, as he considered they had enough machinery to worry them without those things.

After considerable trouble with the men in the consort ship which was to sail with them, but apparently with no trouble with engine room and stokehold crew, the *Victory* sailed on June 14th, and under sail; experienced rather bad weather until June 30th, when it became fine, so much so that the gallant captain could turn his attention once more to the machinery, for he logs on that day that "the boilers seemed to continue tight, and the pump was in considerable progress; the bellows being also finished; so that we had the prospect of being able to use our steam."

It is evident and strange that they had not taken advantage of being so near Greenock to get some Scotch intellect to bear on this fractious machinery. Perhaps Sir John Ross was a Scotchman of the sort that did not properly value a prophet in his own country; or perhaps, wonderful to relate, he had more faith in his own chief; but of that, more anon. I am coming to that eminent engineer soon. On July 5th they arrived off Cape Farewell, where the temperature of the air was 41°, and of the sea 43° at midnight. On July 10th when steam was wanted, it was found that the gear for the feed pump was not so complete as had been thought, so he could not have the engines; it was also found that there was still a leak in one of the boilers.

It was July 17th before the engines were again started, when, with the lee wheel down they got the seventeen revolutions which helped them much in getting to windward. After three hours work, however, one of the boilers started to leak, so that it had to be put out of action, and with only one they could not keep the lee wheel running. On examination it was found that the "largest and the larboard pipe which are placed within the boiler had been pressed flat, and the outer edges rent, thus accounting for the escape of water." "We immediately set to work to replace the large and to repair the small pipe, but found this to be both tedious and difficult. The screw holes in the flanges did not correspond to each other (no sort of standardisation in days)." However, they did what they could by plugging the holes, etc. "Thus did we labour till midnight," "and in the end to give it up and fit two new pipes, which occupied the whole of July 17th." On the 18th steam was got up and the engines started, but after running on the lee wheel for half-an-hour the main key on the shaft gave way, and the weary captain writes, "There seemed no end to the vexations produced by this accursed machinery." I should like to be able to tell you what the engineer said—I expect it was appropriate—but I cannot. However, they started on repairs and had more bad luck, for in lifting the shaft the tackle block gave way and came down by the run, but no harm was done, and after some more appropriate language "we fitted a new tackle and then got the wheel out of the water." By July 29th the engine had had a new key fitted, and the leaks on the boilers had taken up so that the engines were once more usable, and therefore on the 21st they were started and were of some service until one of the boilers gave out again, and with one only they did about a mile an hour.

I was struck with the philosophy of Sir John, for he records then, "In compensation we had the continued advantage of enduring these endless trials of our patience; and whatever reward may be allotted to the exertions of this virtue we had assuredly a fair claim to them." They might nowadays have had a fair claim to "M.B.E." On July 22nd they managed to get 10 revolutions only, and no effort of the engineers could get the lee wheel beyond 16 revolutions.

After a prolonged stay at a Danish Settlement the voyage was continued under sail, but on July 29th we find recorded, "being little wind we attempted to take advantage of the engine; and in some manner or other it continued to work all night." On August 1st, however, we find that the engine was again made ready. To no purpose, however, as "one of the boilers appeared to leak once more." On the 3rd the engine was kept at work till it had to be stopped to repair the feed pump. This was done, and on the 4th the engine was re-started, when "the starboard boiler began to leak again," and with the port only 10 revolutions with one wheel was possible, producing a speed of $1\frac{1}{4}$ miles per hour. Later on, however, with the two boilers they got $1\frac{1}{2}$ miles, and the engines continued to run without a stop for 14 hours. One of the stokers was nearly suffocated by inhaling some sulphurous gas at the furnace mouth. No doubt he, poor man, regretted the absence of a funnel.

On the 6th it is recorded that the engine had run for 24 hours and "conducted itself so far beyond all its former doings." The speed, however, was only about one mile per hour, and soon after it was stopped, as the feed pump had gone wrong once more. On August 7th steam was again got up, but could not be raised over 30 lbs., so the engine did only 10 revolutions and the ship $1\frac{1}{4}$ miles per hour. On the 8th the engine ran all day at 11 revolutions, and the ship did $1\frac{1}{2}$ miles per hour. On the 9th the report is "the engine kept in action till 3 o'clock, though by considerable exertions of the men at the bellows." On August 24th they had recourse to the engines, but the report is that "it acted very ill." On August 25th "all the power it could exert was very feeble": apparently the draught was so sluggish that the boiler tubes kept getting "choked with coke dust." For many weeks they ceased to use the engines and did much navigation, intricate and often dangerous, under sail only, most of which could have been done much better under steam could they have relied on the machinery. By October 1st, Captain Ross had come to the conclusion that the machinery was only an encumbrance occupying much space and adding seriously to the weight to be carried, he therefore determined to take it to pieces and land it at the first convenient spot. This was found, and on October 16th they commenced to unload the boilers. On the 20th "the last of the engine was hoisted out, and there was not one of us who did not hail this with pleasure." They did not, however, chuck it overboard, but carefully stored it on Fury Beach, where it is I suppose still standing awaiting the visit of a learned explorer who had never heard of the *Victory*. He will doubtless examine the ruins and see in them evidence of an early unrecorded civilisation which had steam engines quite different from any of those known to have been in use in Europe. Such was the fate of the product of two engineers of the highest eminence and repute as skilful designers and manufacturers, to be rejected after only four months of sea service and ignominiously cast on a lonely beach.

Now for the personal equation. You will naturally want to know what the Chief and Second Engineers were like who could be parties to all these machinery calmities and to take part in the final execution. Well, Captain Ross has carefully painted and left a record of their portraits, which I am able to present to you as examples of what the seagoing engineer in those early days was like. I presume they were, if anything, above the average, or they would hardly have been recommended by the engine builders, nor accepted by so experienced a captain as Sir John Ross undoubtedly was for such responsible posts. This is what he writes of them, and it may be noticed in passing that both engineers were Scotchmen.

Alexander Brunton, Chief Engineer, was born at Temple in Midlothian, is 5 ft. 4 ins. high, blue eyes and brown hair, sallow complexion, having much the appearance of a half worn tradesman. He served his apprenticeship to Mr. Stephenson, the engineer, at Edinburgh, with whom he continued some time afterwards as a workman; he set up in business for himself at Leith as a scale beam and edge tool maker, but failed, and entered into several steam vessels as engineer. Having served five years he came to London; and after working at printing machine making for some time, he got into Messrs. Maudslay's Manufactory where he was five years; from thence he went to Messrs. Braithwaite's and joined the *Victory* in 1829. Having been one of those employed in constructing the engine, I considered him a great acquisition, especially as he had strong recommendations from his masters; he had had work certainly until the 21st August, as he had almost daily to repair one part or another of the engine; but it was then given up, and his place was a sinecure. He is an excellent, but a very slow workman. He made tin utensils for the officers and men at Fury Beach, each of which, at his high rate of wages cost £1.

Allan MacInnes, Second Engineer, was born in 1798 at the Isle of Mull. He is 5 ft. 7 ins. high, stout made, swarthy complexion, and marked with small-pox. He was the son of a farmer, but served his apprenticeship first to a baker, then to an engineer at Gloucester. He had been five years in steam vessels before be volunteered for the *Victory*. His situation would also have been a sinecure after the engines were given up, but he was wanted in his calling as a baker, and was found very useful while at Fury Beach, where he made excellent bread. On his return home, after seeing his friends, he applied to me, and I gave him a recommendation to Maudslay and Field.

Now I don't give this history as being typical of the ordinary life on shipboard in the engine department of those early days, nor can I suppose that all the machinery of that day was so liable to breakdown; but I do know that then and for many years after boiler troubles were experienced common enough. It was not till after the Board of Trade were empowered to deal with such matters that the boilers were constructed, fitted, and rendered safe and efficient; and although we have been and still are apt to kick against some of the rules and regulations when they seem to hurt us like an ill-fitting shoe, and we are sometimes disposed to treat lightly or almost with contempt what to some appears to be grandmotherly conduct, yet we must all admit that since 1875 boilers have been more satisfactorily designed, more carefully built, better supplied with mountings and fittings, and taken more care of than was usually the case before. Having known personally all the Engineers-in-Chief's of the Board of Trade, I can cheerfully testify to their ability and zeal, but above all to their good intentions in the interest of the officers and crew, as well as in that of the passengers. Moreover, really and truly, but not always so evident, they have acted for the real advantage of the owners themselves—and not forgetting the underwriters. I can say this sincerely, in spite of the many controversies I have had with them all; for while I have not always seen eye to eye with the Surveyors, I have had no better intentions than they had, and we generally differed rather in methods than in the ends desired.

It will perhaps have been noticed that the working pressure of the *Victory's* boilers was no less than 47 lbs., which must have been in 1829 a very unusually high one. There were in those days no Board of Trade or Lloyd's rules for design, and what water testing there was then and what those particular boilers were tested to we don't know. But judging by the continuous troubles and leakages, which even dung and potatoes did not remedy, we may conclude that their design and construction would not have been approved by the B.M.E.D. & C. Committee you no doubt have heard of recently. The fact is, that then and for a long time after, the boilers were much more troublesome than the engines, and this was no doubt the principal reason why on shipboard generally the working pressure remained low.

I could give you many instances of boiler troubles which indicate defective design, construction and improper treatment, but I cannot remember an instance of really bad or unsuitable materials of which copper was in common use.

In 1831 there was a very serious loss of life by the wreck of a steamship. This disaster had followed a considerable number of other minor ones, many of which were due to boiler troubles. Public feeling was aroused to such an extent that a Committee was appointed to enquire into the causes of losses of, and accidents with, steamships. Later on, evidence was taken from time to time by the Commissioners who reported in 1839, some of which I propose to give you in condensed form as follows:—

P.S. *Earl Grey*. An explosion of the boiler took place in 1835, by which 10 men were killed and several more injured. The boiler was rectangular in form, had no stays; had lever-loaded safety valves, which had not blown off during the 15 minutes she stood at the landing pier, but when the engines started the boiler exploded.

P.S. *James Gallacher*, in 1838, had a rectangular boiler with lever-loaded safety valves; the fireman, a boy of 17, took it on himself to increase the load by changing the weights. The explosion took place with the steam blowing off and the ship alongside the pier.

The report states that in North British ports very few inaccessible safety valves were to be found. "All the valves in the Clyde River steamers are exposed, and very few have steam gauges." It also states that many seagoing steamers of North Britain had exposed lever valves.

The following curious case was given by an experienced commander:—

"A steamer on her passage from Ireland to Scotland was perceived by her commander during the night and in smooth sea to be going with much greater than her ordinary velocity through the water. The engineer was not at his post. The captain enquired of the fireman how it was the engines were going so fast. The man said, 'He could not tell for he had very little steam, and had been firing hard nevertheless.' The captain began to look about him, and, approaching the chimney where the exposed valves were fixed, he perceived a passenger fast asleep with the greater part of his body resting on the flat cheese-shaped weights of the valve. This man had contrived with some luggage to make his bed there for warmth. On arousing and turning him off, the valve rose and the steam escaped with a roar which denoted its having attained a very elevated pressure."

P.S. *Union*. Primary cause said to be carelessness in allowing the flues to be bare of water. No glass water gauge, only test cocks. Engine men often have the water very low at starting to save labour of pumping up by hand. J. Scott Russell recommended a donkey pump.

P.S. *Victoria*. A large steamer built at Hull in 1836 and fitted with engine and boilers by Napiers, of Glasgow. These boilers were cylindrical and had furnaces 48 inches diameter of iron $\frac{5}{16}$ inch thick. They were each in a water drum surmounted with a steam drum. She had no donkey feed pump, only the usual hand-worked one. It is said in the evidence that the circulation of water and steam was so uncertain that the engineers could never be sure of the amount of water in each. (To-day with most of the water-tube boilers, it is practically impossible to know how much water is really in them when steaming at full speed.) Anyway, the furnaces of the *Victoria* gave way on two occasions, when it was assumed that there was really a shortage of water due to heavy blowing of the safety valves on a sudden and unexpected stoppage. Strange to say that it was at their bottom they gave way and not at the top where they might have been red hot. At the time, the conclusion come to was that the pressure due to the head of water at bottom was greater than that at the top of them. By the one explosion five men were killed; by the other nine, and in each case others injured.

The fact is, in my opinion that many, if not the most of these explosions, were due to reaction shock on the parts which were under really too high a load when starting the engine or on lifting of the safety valves; a case of dynamic rather than static force.

S.S. *Archimedes*. Boiler exploded in 1839. Mr. Field in his evidence states that it was the ordinary low pressure kind as used in river steamers, box type; insufficiently tied together by stays. "Top of the boiler had been lifted by the pressure of the steam, the crown of it had been distorted, and by that means the safety valve had been stopped from acting, the spindle being jammed: saw no steam gauges, so actual pressure on valve was not known. Had examined and calculated the load on valves and found one had 5·33 lbs. and the other 6·25, which was higher than he would have loaded them. Thought if it had been sufficiently stayed 5·25 lbs. would have been sufficient load.

He said he would not have worked a steam vessel from London to Portsmouth without a steam gauge: and I don't suppose any of you would do so even now with a Board of Trade Certificated Boiler.

The first ship reported with boiler exploded was P.S. *Norwich*, 1817; it was cylindrical, of cast iron; 9 killed, many injured.

In 1834, another cylindrical, viz., P.S. *Herald*; no lives lost; high pressure.

In 1836, another cylindrical, viz., P.S. *Freedom*; 1 killed.

In 1838, another cylindrical, viz., P.S. *Victoria*; 14 killed, many injured.

In 1838, another cylindrical, viz., P.S. *Vivid*; 2 killed; boiler worn out.

In 1839, another cylindrical, viz., P.S. *Morning Star*; 2 killed; boiler worn out.

Out of 23 explosions reported 7 occurred with cylindrical boilers, and of the 23, 19 happened when stopping or starting the engines.

Captain Bain, R.N., reported to the Commissioners that "There is a very general deficiency both in river and sea-going steamers, particularly in North Britain, of glass water gauges and steam pressure gauges; instruments absolutely essential to the safety of boilers and used in all well appointed vessels. That the boilers of many vessels are without these simple instruments, and the engineers and firemen when doubtful of the accuracy of the test cocks try to ascertain the height of the water by hitting the boiler with a stick or hammer, etc."

Mr. Shaw stated that "the boilers of the *Fingal* in 1835 were "so weak that they had to be shored between the deck and their tops, which latter otherwise expanded and contracted like a pair of bellows."

Long after this a curious thing happened on the S.S. *Otto*, of the Wilson Line. Her engines were simple expansive condensing, working with steam at 20 lbs. pressure supplied from two box boilers placed side by side only a few inches apart. They were of the same design, but right and left-handed with semi-dry uptakes. Crossing the Bay, the boiler or boilers gave out somewhere in the narrow dividing space. The weather was fine, so the Chief Engineer (Mr. John Jamieson, probably well-known to some of you) obtained some cabin mattresses and rammed them in tightly between the boilers. The load on the safety valves was reduced to a pound or so over atmospheric. The engines would run well at that pressure, so that in this way and by the help of the sails, with which in those days she was rigged, just as a sailing ship, they got to Gibraltar. Mr. Jamieson assured the captain he could take the ship on to Malta in this way, and recommended him to do so, as at the dockyard there the repairs could be effected, which could not be done then at Gibraltar. This passage was made in fairly good time, and some hours after arrival, when the boilers had been blown down and cooled, and the bedding removed, Mr. Jamieson went into one boiler and sent his leading stoker into the other to search out the damage. He assured me he was never more startled in his life than when he heard a voice from the other boiler, "Mr. Jamieson, Sorr, I can see your candle." Sure enough both boilers had given out at the corresponding place near the uptake sides.

The first screw ship in the Navy was the *Rattler* (1843). The safety valves of her boilers were loaded to 5 lbs. only. By the old Board of Trade Rules the hydraulic test would have been 10 lbs., thus giving a margin of 5 lbs. Her second set of boilers had a working pressure of 10 lbs., so that their test would have been 20 lbs. or a margin of 10. That is it was double that of the first set. It should, however, be remembered that the actual *absolute* working pressure in the first was 20 lbs., and in the second 25 lbs., so that the load on the engines was increased by only 25 per cent., whereas that on the boiler shell, stays, and furnaces, etc., was increased by 100 per cent.

The second ship of that name—the *Rattler*, of 1862, had boilers whose safety valves were loaded to 20 lbs., so that the working pressure absolute was 35 lbs., or 75 per cent. above that of the original, whereas the increased load on the boiler was as much as 200 per cent. over the first, and even 100 per cent.

over the second set. You will see then that while the increased load on the engines in those days was not very great, that on the boilers was seriously greater.

In 1854 H.M.S. *Malacca* and several other warships were fitted with cylindrical boilers of considerable size, the safety valves of which were loaded to 60 lbs. pressure. The engines were non-condensing and exhausted up a waste steam pipe besides the funnel. They were made by Maudslay, Sons and Field, and by John Penn and Son. Most of them had cylinders 30 inches diameter, and 30 inches stroke, and developed about 600 I.H.P. at 100 revs. per minute. The cough of the exhaust pipe was loud and pronounced, and it was no doubt from this that non-condensing engines were called HIGH PRESSURE, and are even now known as such. Some of these large boilers had each as many as five furnaces in two rows, two furnaces in the lower, and three in the upper. At the close of the Crimean War these ships were all relegated to harbour service, so that the engines were then seldom used. About the same time a number of gunboats were built with these high pressure engines supplied with steam at 60 lbs. pressure from two cylindrical boilers having the furnace and tubes in line with a combustion chamber interposed. They were quite good little boilers, and had they been fed with fresh water, would no doubt have given complete satisfaction and lasted longer.

Before the invention and introduction of the Bourdon gauge, both boiler pressure and condenser vacuum were indicated by means of the Mercury column in metal or glass tubes. Included in the engine room stores of all ships in those days was a bottle of Mercury. I remember that years after the Mercury gauges were gone and forgotten, the bottle of Mercury was not omitted from the supplies shipped at the dockyards. It always came back and with the remains of the glasses of water gauges and the debris of other damages, wear and tear of fittings, etc., delivered to the dockyard storehouses. It would appear from some of the evidence that it was not uncommon for a merchant steamer to have no mercury gauge in working condition, dependence being altogether on the safety valve for indication of pressure.

The Committee, already alluded to as taking evidence, consisted of Captain Pringle, R.E., and Josiah Parkes, C.E., who reported on the Causes and Means of Prevention of Steamboat Accidents in 1839 and recommended:—That a Board be appointed in connection with, and under the President of the Board of Trade, whose business it shall be to register and classify all vessels navigated by steam. . . . . The Register to record detailed specifications of hull and machinery—periodical surveys to be made upon them—and particulars of all disasters and accidents which happen to, or may be occasioned by steam vessels. It then goes on further to recommend the appointment of Local Surveyors to inspect, etc. The Board to grant or withhold licenses on their reports. The Board to make annual reports to Parliament. The Board to frame and issue general instructions for the guidance of Surveyors. To publish an Abstract of the law to be hung in a conspicuous part of the ship. If owners object to carry out things ordered by the Surveyors they shall call in experts to survey and report. First survey of boilers, engines and machinery to be made while they are being placed in the vessel, and they are to be surveyed every six months afterwards. The License is to express whether for cargo only; for towing vessels; for conveying passengers; or for all three purposes. Also whether for river or sea service. The Surveyors to ascertain if safety valves are sufficient to pass all the steam which the boilers can generate. The maximum pressure load to be fixed by the maker of the engines or boilers. Safety valves to have levers, spindles, etc., not exposed so as to be overloaded. Penalty for adding. All steamers to have glass water gauges, and mercurial pressure gauges if they are to have Passenger Certificate. Consider fusible plugs no substitute for proper care. If Surveyor hears of a boiler being deteriorated and unfit, he shall be empowered to examine, and if faulty, to suspend passenger license. Many other recommendations chiefly relating to the hull and equipment.

It is interesting also to read further the following Extract from the Report:—" There is one additional measure strongly advocated, but we feel great doubts of its practicability, viz., the compelling of engineers employed on board steam vessels to undergo a preparatory examination, and to find surety for their good behaviour. There is no existing Board at the different ports competent to determine the fitness of this class of men for their occupations, and we think it would be difficult for any local Surveyor to decide individual qualifications."

These are brief Abstracts of the Report on which as a basis so much has been built up. Seeing how really good and reasonable it was, we are to-day at a loss to understand why it was so long in bearing fruit. It was in 1854, or fifteen years after, that we get the celebrated Merchant Shipping Act as the first great measure. It was many years after this that the boiler question was tackled by the Board of Trade, and it was so late as 1873 or 1874 that an attempt was made to require that boilers should be designed and made to accord with Rules issued by the Department for guidance of its Surveyors.

In 1917 a Committee was appointed to consider and unify all the rules then in use for guidance of the Surveyors of all the several Authorities; and last year, or 80 years after the above report, we have such unified Rules in force. On that Committee we had, amongst others, Representatives of the Institute of Marine Engineers, and as Chairman of it, I thank you for having selected such able men. They not only represented you and your own interests, but were most helpful in every way, but especially so as users of, and responsible for, the safety and efficiency of the marine boiler. From their experience they could give us most valuable practical evidence, as well as advice, both of which, I am pleased to assure you, proved to be always very helpful to us.

In conclusion, I would impress on you always to study carefully the failures you experience in engineering, as from them you may learn much. From successes you are never very certain what you have discovered, for you cannot always tell how far away you have been from the danger zone.

The French Government in 1839 had the following Rules in force:—

High Pressure Boilers (over 7 lbs. pressure) to be tested by hydraulic pressure three times the working pressure. Rectangular Boilers exempt from proof when working pressure did not exceed 7 lbs. per square inch. All Cylinders and Cylinder Jackets of steam engines to be proved to three times the working pressure. Marine Machinery to undergo inspection every three months. The engine man to be a skilful mechanic and possessed of sufficient knowledge to maintain the machinery in good repair. Rules to be formulated and hung in the engine room for the guidance of the engineer. Every boiler to have a water float and index, two glass water gauges, three gauge cocks, and an open-ended mercurial steam gauge. Also recommend a pipe with whistle to warn when water is too low. Two Safety Valves to each boiler. High pressure to have lever load. Low Pressure direct weights. Two fusible plugs. Rules for the management of fires and for the conduct of the engineer and captain reciprocally when the engine has to stop, etc. Passengers had the right to inscribe their remarks in the Log Book.

The following copy of letter from Mr. P. Ewart, of Woolwich Dockyard, to Mr. Dinnen at Chatham, who was, later on, Chief Inspector of Machinery at the Admiralty, and eventually killed by being run over at Charing Cross, shows the sort of precautions taken at the date of the Committee's Report to ensure a successful trial trip:—

Woolwich Yard, 5th August, 1839.

Mr. Dinnen,

Dear Sir,

Please to request Mr. Cragg to provide proper stokers for trying the *Hecla*, and I request you will see that, before any water is put into her boilers, the insides of the boilers be carefully painted over with black lead and tallow, and also that two sacks of oatmeal be scattered uniformly down the water spaces before the water is put in. I may not reach Chatham before two o'clock on Wednesday.

Your Obedient Servant, P. Ewart.

This was written 81 years ago, when there was always the fear of the formation of a hard deposit of sulphate of lime, most difficult to remove. Probably the boilers of the *Victory* would have remained freer from leaks if they had omitted the dung and potatoes.

A hearty vote of thanks was accorded to Mr. Seaton for the interesting sketches he had given—reminiscent of the past, paving the way for the present and the future.

The Effective Propulsion of Craft for use on Shallow and Obstructed Waterways.

BY MAJOR J. H. W. GILL, C.B.E.,

READ AT

THE EFFICIENCY EXHIBITION, OLYMPIA,

On Tuesday, February 22, 1921, *at* 7.0 *p.m.*

CHAIRMAN: MR. G. J. WELLS (Member).

EFFICIENCY is very rightly a watchword of the present time, but, owing to the incompleteness of many of the definitions which have been formulated to explain the term, it does not always imply effectiveness. If the definition of efficiency be so framed as to convey the idea that efficiency is the attainment of the most favourable results in exchange for the energy expended, *under the necessary conditions of working*, then it becomes synonymous with effectiveness, or the economical accomplishment of the particular end in view. Many devices which are correctly claimed to be efficient, prove relatively ineffective under any conditions of operation other than those which may be described as ideal, and the user is frequently disappointed with the practical and financial results obtained therefrom.

In common with other applications of science to industry, the effective design of marine propulsion appliances is subject to many compromises between sheer mechanical efficiency and overall utility; while, owing to the present incompleteness of our knowledge, empirical rules must be largely made use of, pending the amplification of theory in accordance with the accumulated results of accurate observation.

The immersed type of marine screw propeller, in spite of certain imperfections, is, deservedly, the means now almost universally adopted for the propulsion of open water craft of practically all classes; the reason being that it proves effective over a wider range of conditions than any other existing appliance for the same purpose. It also can be, and, as the result of investigations and experiments conducted by the author, recently has been so modified as to increase its field of usefulness. There are, however, very many cases, both in this country and overseas, where extremely shallow water, weed growths, and other impediments to navigation render the marine screw propeller an "ineffective" device for the propulsion of any type of craft. Under such circumstances some other solution of the propulsion problem must be sought.

The alternative practical devices for the mechanical self propulsion of vessels are, at the present time, exhausted by the enumeration of:—

Semi-Immersed Screw Propellers. Aerial Screw Propellers. Side Paddle Wheels. Stern Wheels. Hydraulic Propulsion.

Semi-Immersed Screw Propellers have frequently been advocated, and to some extent successfully employed on small vessels of the "skimmer" type. Their use, however, necessitates the adoption of awkward hull forms, involves the acceptance of relatively bad manœuvring and sterngoing powers and is prone to cause vibration.

Aerial Propellers have been fitted to several small vessels of shallow draft but they labour under the disadvantage of operating in a light and compressible fluid to propel a body floating in a denser fluid. They do not conduce to good manœuvring, are liable to damage from overhanging branches in river work, involve a high superstructure, and are noisy in operation.

Side Paddle Wheels are only effective under practically the same conditions as those in which a screw propeller of the immersed type could be employed. They involve the disadvantage of increased overall width of vessel, with augmented weight and bulk of plant, while they are very liable to be damaged by floating obstructions, or by grounding. Their use, however, confers great manœuvring facilities, which gives them one advantage over the screw propeller under certain conditions of operation, and for this reason they are frequently employed on ferry service.

Stern Wheels have hitherto been almost invariably adopted for vessels designed to operate on extremely shallow draft, whether in clear waters or in those infested by weeds, and, in spite of many defects, they have given useful but frequently not really "effective" service. The Stern Wheel constitutes an overhung weight at the after end of the vessel and renders a good design of hull difficult to attain. It interferes seriously with manœuvring powers and renders steering difficult. It is also very liable to be damaged by grounding, or by floating obstructions, and is accepted by those who have the handling of such installations as, at best, a fairly satisfactory compromise.

The *Immersed Screw Propeller*, *Semi-Immersed Screw Propeller*, *Aerial Screw Propeller*, *Side Paddle Wheel*, and the *Stern Wheel*, possess one feature in common, in that they are all devices which are mounted externally on the hull of the vessel. This characteristic remains, even though the screw propeller be mounted in a tunnel, the aerial propeller be surrounded by a guard, or the paddle wheel be carried in a casing; hence, they are all liable to be fouled or damaged by external obstructions, while propelling the vessel to which they are attached, and cannot be so protected as to render them practically immune from fouling of any kind, except at such expense to their mechanical efficiency as to render them generally ineffective.

Hydraulic Propulsion is the remaining alternative for the very large number of cases where navigation cannot be effectively carried on by the use of one or other of the devices previously dealt with. In principle it consists of a pump of the continuous discharge type, mounted within the vessel, receiving water preferably from the direction in which the vessel is to be propelled and discharging it in the opposite direction. It is the only mechanical device for the self propulsion of a water-borne body, which finds a direct parallel in Nature; it normally has no working parts external to the hull of the vessel, and it can be so designed as to be practically immune from trouble caused by weeds, floating matter, or grounding. Owing to structural restrictions which limit the quantity of water dealt with, the mechanical efficiency of the hydraulic propulsion system is normally less than that attainable with a good screw propeller or paddle wheel, but for use in very shallow, weed-grown, and otherwise obstructed waterways, it can be designed to give more effective practical results than any of the other known devices for mechanical propulsion.

Under the name of Jet Propulsion this method has been known and experimented with for upwards of 250 years, and it has probably suffered more from the too-sanguine claims of its non-technical supporters than from the frequently ill-considered criticisms of its opponents. During the fifty years which elapsed between 1835 and 1885, vessels of from two tons to nearly 1,200 tons displacement, were equipped and tried with various forms of hydraulic propulsion, but they were invariably pitted against paddle or screw propelled vessels of practically the same power and displacement *under open water conditions of trial*.

EFFECTIVE PROPULSION OF CRAFT FOR USE ON SHALLOW WATERWAYS.

On account of the limitations previously touched on in this paper, the result was lower average speed in the case of the hydraulically propelled boats and the system consequently fell into disrepute. It appears that Mr. J. F. Green was the first person to recognise the advantages of this type of propulsion as a "special purpose" installation, for he introduced it as a means of propelling lifeboats, and a number of these craft which were so equipped by Messrs. Thornycroft between 1887 and 1897, are still in successful operation.

During the ten years previous to the outbreak of the war, the author closely investigated the system as a means of mechanical propulsion for the shallow draft vessels used in Eastern waters, and formulated a design to overcome the trouble caused by weeds and floating matter, under such conditions of service. During the war the matter remained in abeyance, except in that two special service trawlers were equipped with hydraulic propulsion installations during 1918-1919, and gave good results on trial and in subsequent running.

At the beginning of 1920, however, the question of hydraulic propulsion for shallow draft vessels in weed-grown and difficult waters was seriously taken up, and the results since obtained in actual working are entirely satisfactory. It has been proved that by means of a specially designed hydraulic propulsion installation a boat can be successfully driven and manœuvred under her own power, through waters so shallow, weed-grown, and obstructed by snags as to be impassable to craft propelled by alternative devices, while in open water the same boat develops a reasonable speed and exhibits extraordinary manœuvring powers.

Before undertaking a detailed description of the most recent developments of hydraulic propulsion, for the particular classes of navigation to which it is essentially suited, it will be well to review the fundamental principles which underlie the operation of all practical methods of marine self propulsion.

Whether the propelling device be a screw propeller, float wheel, or pump, the principle on which it operates is that of imparting Kinetic energy (or energy of motion) to a stream or streams of water, the reaction due to the mass of water thus projected sternward through the water in which the vessel floats, overcoming the resistance to forward motion and propelling the ship ahead. Even in the case of the aerial propeller the principle is the same, though the fluid acted upon is air and not water. Furthermore, it is a matter of indifference with regard to the dynamic effect whether the stream of accelerated water from the propelling apparatus be discharged below or above the waterline, for, as previously stated, it is the *reaction effect* which is utilised to propel the vessel. It becomes apparent on consideration that the energy remaining in the discharge stream moving astern from the propelling apparatus with a velocity relative to the water in which the vessel floats is wasted, as far as propulsive effect is concerned, as soon as it has left the propelling device; also that the amount of this waste energy is proportional to the weight of the mass of water discharged, multiplied by the square of its absolute velocity.

Now, screw propellers or float wheels, having large effective areas acting on the water, can normally deal with larger quantities at lower discharge velocities than can a pump of reasonable size, employed to propel the vessel by taking in and discharging a stream of water. Thus it becomes apparent that in order to secure a reaction from a propelling pump of reasonable dimensions, equal to that developed by either of the other two devices, the velocity of the discharge must be higher, in order that the necessary mass of fluid can be dealt with per unit of time. This naturally implies a larger waste of energy in the discharge, or slip stream, and it becomes evident why the mechanical efficiency of the hydraulic propulsion system is normally below that of a screw propeller or float wheel, used under suitable conditions.

Theory obviously indicates that the propelling pump employed in a hydraulic propulsion installation should deal with a very large volume of water at a low velocity of discharge, in order to approximate to the ideal of performance, and this also involves dealing with the water under a very low head value. Here, however, practical considerations and the results of trials with various installations modify the theoretical treatment, for the reason that the actual pump efficiency under conditions of very low head becomes so small as to negative the increase in jet efficiency, due to a large discharge volume with a low discharge velocity. In practice there is a point of balance between pump efficiency and jet efficiency, for every installation, and it is only by carefully determining this condition of working and proportioning the discharge area thereto, that the best results can be obtained. In many cases the discharge orifice may with advantage have an area equal to half that of the inlet to the pump, while in certain cases the best results have been obtained by making the discharge considerably less than half the inlet area. The mathematical treatment of the problem of marine propulsion is dealt with in the appendix, but it may here be stated that an overall mechanical efficiency representing two-thirds that of a good screw or paddle-wheel installation is not difficult of attainment in modern hydraulic propulsion sets. This representing slightly more than three-fourths the speed of vessel obtainable with the same power input and approximately the same weight of plant.

This diminution in speed for the same power input must be compensated by more than corresponding advantages in other directions, and there is no question of these having been attained in the type of hydraulic propulsion installation specially designed for propelling, steering and manœuvring craft of very shallow draft in weed-grown and difficult waters.

The special installation normally involves a cylindrical well, which is built into the hull of the vessel, as near to the after or to the forward end thereof as consistent with the necessary flatness of hull section and the development of the necessary steering couple. A considerable latitude in the choice of the position of the well is usually available in the flat-bottomed hulls necessary for shallow draft work. The well opens through the bottom of the vessel, but does not project beyond the skin. It is preferably carried up to a level above the waterline, so that the pump may be installed or removed while the vessel is afloat, and this well is usually constructed of metal sheet or plate flanged at the top and bottom. The pump itself consists of a casing of drum shape, having such diameter as to rotate freely within the well, and the bottom of the casing is normally flush with the outside of the hull. The intake to the pump is formed in the bottom of this casing and curves upwardly from a forward facing direction, to the eye of the pump, which is at some little distance above the bottom of the drum.

The pump, which is of a specially designed centrifugal type, has an impeller which is mounted on a vertical spindle, its intake being situated at the eye of the inlet passage. This impeller discharges into a passage or passages which form the collecting chamber of the pump and the discharge stream is led downward through the lower end of the pump casing or drum, in such a manner as to issue in a direction opposite to that of the curved intake passage, through openings situated on each side of this passage or through a single opening behind it. The depth of the drum or pump casing is normally about half that of the well, and its top is closed by a cover having a neck or upward extension, which surrounds and carries the impeller spindle. This pump casing is supported by a fixed bridge or cover piece extending across the top of the well and is mounted on bearings in this bridge in such a manner as to be freely rotatable.

The rotation is controlled by means of a steering wheel mounted on the bridge and carrying gearing which couples it to the upper end of the rotatable pump casing. The impeller spindle is driven by means of transmission gearing which connects it with a horizontal shaft carried in bearings on the bridge piece, and in its turn driven by the prime mover or engine.

An alternative arrangement is to mount the prime mover, or transmission motor, on the bridge piece itself and to drive the pump spindle direct, but the horizontal shaft and transmission gearing usually constitutes a more suitable arrangement. The transmission gearing may consist of a bevel or worm type of gear alone, or may include the addition of a balance gear which takes up the torque of the drive as between tne pump casing and the impeller spindle, in order to eliminate a tendency of the internal friction to cause rotation of the pump casing.

The pump casing is preferably centred in the well by rollers or by rubbing pieces, to take the horizontal thrust of the reaction off the bearing by which the pump is suspended and to transmit it directly to the walls of the well; while it is advisable to provide some type of packing ring which prevents the circulation of water between the outside of the pump casing and the inside of the well.

It will thus be seen that the means by which the vessel is propelled consists of a centrifugal pump mounted in a cylindrical casing, and carried within a well in such a manner that it can be rotated at will by means of steering gear, either while working or when stationary.

Consideration will show that by bodily rotating the propelling pump the reaction effect of the discharge stream can be caused to operate in any desired direction. Thus, the full propelling power of the pump can be employed to manœuvre or steer the vessel on any course. The fact that the pump can be rotated confers another advantage, for, by fixing a grating on to the outside of the inlet orifice and providing a shallow metal keel secured to the boat and at a small clearance from the face of this grating, any weeds or other obstructions which gather at the intake are automatically sheared off between the grating and scraper keel, with every movement of rotation given to the pump.

Practical trials of this propelling installation have shown that boats so fitted can be stopped within their own length from full speed, by rotating the pump through 180°, can be turned round in their own length, or rotated about a point somewhat forward of amidships, and can be steered either ahead or astern at any speed, with extraordinary rapidity and precision. Trials have been carried out in which a boat fitted with this device was repeatedly beached on mud banks at full speed, both ahead and astern, and was readily refloated on rotating the pump through 180°. Such a boat has also been driven on to and over weed banks of such thickness that the hull could only with difficulty be forced through them and, though the intake grating naturally became choked when left in one position, a movement of rotation given to the pump readily cleared it. The same boat has also been driven under her own power through over 200 miles of inland and coastal waterways, long stretches of which had been abandoned for navigational purposes, and, in spite of difficulties which were declared unsurmountable, a good passage was made.

Practical tests of this nature, which have been carried out during a period of many months, have proved beyond any possibility of question that there is a large and useful field for the practical application of hydraulic propulsion in cases where other systems, each efficient under its own suitable conditions, have proved to be ineffective.

No one system of mechanical propulsion for marine craft is suitable to every condition of service, and it is irrational to decline to employ any system which is particularly applicable to certain given practical conditions of working. A distinct field of useful and effective application for the hydraulic system is found in those cases where shallow, tortuous and weed-grown waterways are to be used by commercial vessels of low and moderate speeds, though there are other cases in which the unusual manœuvring powers conferred by specially designed hydraulic propulsion installations render them desirable for use even in unobstructed waterways.

Where the great manœuvring powers conferred by the rotatable type of installation are not desired, a fixed pattern of hydraulic propulsion set, which is not different in principle, may be employed. This type of propulsion installation provides for going ahead and astern only and is that which has been made use of, in various forms, in earlier applications of the system. It enables a vessel to be propelled either ahead or astern in very shallow water and can be provided with an arrangement for continuously removing weeds from the intake.

The most practical device for obtaining the stern-going effect in an installation of this type, is to fit a movable deflecting bucket in line with the discharge orifice, this bucket being retracted within the hull when going ahead and interposed in the discharge stream when it is desired to reverse the direction of flow, for the purpose of going astern. The discharge in this case being, of course, below the waterline and preferably in line with, and some little distance abaft, the intake.

Various types of hydraulic propulsion installation, employing pumps of other than the true centrifugal pattern have been proposed and tried, but experience has shown that the balance of advantages gained remains entirely with the true centrifugal pump and that different conditions can be more successfully designed for when adhering to this type. To secure the best effects the pump must obviously be designed to work under the special conditions governing its use in hydraulic propulsion and, though its characteristics may be entirely different from those found in commercial pumps of the low lift pattern, yet the principles of design remain practically the same. A statement of these principles may be referred to in an appendix to this paper, for the information regarding principles of propulsion and design is probably more accessible when grouped in the form of appendices rather than when embodied in a paper which is necessarily general and descriptive.

In conclusion, attention is again drawn to the fact that nett mechanical efficiency does not necessarily imply gross overall effectiveness, unless the conditions of working are suitable, and that hydraulic propulsion furnishes an instance in which a class of installation which has frequently been criticised on the score of relative inefficiency, can be made to give results which are the most effective obtainable under certain limiting conditions of working.

APPENDIX A.

The general fundamental principles which govern the operation of all normal types of marine propulsion appliances, may be stated in the following form :—

Let. "a" denote in sq. ft. the total initial cross sectional area of the stream or streams of water projected astern by the screw, paddle or pump.

Let. "v" denote in ft. per sec. the mean initial velocity, relative to the vessel, of the stream or streams of total cross sectional area = "a".

Let. "w" denote in lbs. the weight of each cu. ft. of sea water (say 64 lbs.).

Let. "g" denote in ft. per sec. the acceleration due to gravity (say 32 f.p.s.).

Let. "m" denote in lbs the *mass* per cu. ft .of sea water $= \frac{w}{g} = \frac{64}{32.}$

$= 2$ lbs. mass per cu. ft.

Let. V denote in ft. per sec. the velocity of the vessel, relative to the water in which it floats.

Let. S denote (v—V) in ft. per sec., this being the "true slip" or mean initial discharge velocity of the projected stream or streams of water, relative to the water in which the vessel floats.

Then the *Thrust* or *Reaction* which balances the *Resistance* of the vessel, moving at a speed of "V" ft. per sec. $= \frac{w}{g}$ av (v—V) = mav (v—V) = 2 av S lbs.

In this expression "2" represents the lbs. *mass*, or effective weight of one cubic foot of sea water and "a × v" represents the number of cubic feet discharged per second by the propelling apparatus, while "S" represents the velocity in feet per sec. *relatively to the water in which the vessel floats*, with which the total mass of water dealt with, is projected astern.

If the vessel were working against a dead pull, as in trying to tow off a stranded ship, then "V" would have a zero value, while "S" would be equal to "v", and the expression would become, *Thrust* or *Reaction* (when V = O) $= \frac{w}{g}$ av (v) $= mav^2 = 2\ av^2$.

If the vessel were employed in towing, and was under way, then " V " would again have a value; though it might be small in relation to " v ", *i.e.*, the " true slip " " S " would have a high value in the expression " 2 av S ", though not equal to " v ".

The most important consideration in connection with the design of a hydraulic propulsion installation, is the velocity (v) to be given to the discharge stream or jet, relative to the designed speed (V) of the vessel, for this velocity governs the quantity ($a \times v$) of the discharge required to develop the necessary reaction; it therefore defines the area (a) to be given to the discharge orifice, while the dimensions of the whole plant are really dependent on the same factor. In this connection it must be recognised that the energy remaining in the discharge stream, moving astern with a velocity of ($v - V$) = " S " feet per second, *relative to the water in which the vessel floats*, whether this surrounding water be still or in motion, is wasted as soon as the propelling apparatus has ceased to act directly on the water discharged, and that the amount of this energy is proportional to the mass of the water discharged, multiplied by the square of its absolute velocity.

It is a logical conclusion that in order to secure high efficiency of propulsion, " S " or ($v - V$) should be kept to a low value by adopting a minimum velocity (v), and a large quantity of water ($a \times v$) dealt with by the propelling apparatus. This, however, implies the use of propelling plant of excessive bulk and weight, and to bring the design within the range of practical engineering construction the value adopted for the discharge velocity (v) is usually about twice that of the desired speed (V) of the vessel, thus involving a discharge orifice having an area equal to half that of the inlet.

Under such conditions the discharge stream is projected sternward *through the surrounding water* just as fast as the vessel proceeds ahead, relatively to this water, and as the theoretical efficiency, as a propeller, of the discharge stream or jet *alone* is given by the expression $\frac{2V}{v+V}$, (when the forward motion of the ship is taken advantage of), the efficiency figure is represented by $\frac{2V}{3V} = \frac{2}{3}$, or 66 per cent. If the forward motion of the ship be not taken advantage of to feed the propelling pump, then the theoretical efficiency is represented by $\frac{2\ V\ (v\text{-}V)}{v^2}$ $= \frac{2\ V^2}{4\ V^2} = \frac{1}{2}$ or 50 per cent.

The "jet efficiency" of a hydraulic propulsion installation may, in practice, not fall far short of 60 per cent., which is the equivalent of the normal propulsive efficiency of a good screw propeller. Pump efficiencies in the region of 60 per cent. may also be obtained and the losses in the prime mover may be taken as equal in the case of either screw or hydraulic propulsion.

A fair statement of the component and overall efficiencies for like craft of small and medium sizes, fitted alternatively with either well designed screw, or hydraulic propulsion installations, can thus be taken as follows:—

Screw Installation.		*Hydraulic Installation.*	
Total Power	100	Total Power	100
(Efficiency) Prime Mover	·9	(Efficiency) Prime Mover	·9
	90		90
,, Shaft & Thrust	·9	,, Pump ...	·6
	81		54
,, Propeller ...	·6	,, Jet ...	·6
,, Overall ...	48·6	,, Overall ...	32·4

and $\frac{32 \cdot 4}{48 \cdot 6} = \frac{2}{3} = 66$ per cent.

Thus, a well designed hydraulic propulsion set working under suitable conditions may be expected to develop an efficiency of 2/3rds or 66 per cent., that of a good modern screw propulsion set, working under equally suitable conditions. As the speeds attained may be taken, without any considerable error, to vary in the ratio of the square roots of the power inputs, which in turn are proportional to the efficiencies of the installations, the relative speed values can be estimated at $\frac{\sqrt{2}}{\sqrt{3}}$ = say ·8, giving the speed of the hydraulically propelled boat as equal to 4/5ths that of the screw propelled boat of equal power.

Under very favourable conditions some increase in the pump efficiency may be obtained, but it is not likely that an overall efficiency exceeding 40 per cent. can be anticipated from a hydraulic propulsion installation of reasonable bulk and weight, though, as previously indicated, this somewhat low relative value can be more than counterbalanced by definite advantages gained for certain conditions of working.

APPENDIX B.

The considerations which govern the design of centrifugal pumps have an intimate bearing on the application of hydraulic propulsion, and, though it is by no means uncommon to obtain efficiencies in the region of 80% for centrifugal pumps handling comparatively large volumes of water, at lifts of say 20 to 40 ft., it is extremely difficult to secure good efficiency when the static head has a zero value, and the total head is made up by frictional losses and the velocity head only. In such cases the internal losses bear a large proportion to the useful external head and it is for this reason that, in practice, an improved overall efficiency is frequently obtained by restricting the discharge outlet, with consequent reduction in jet efficiency, but more than compensating increase in pump efficiency, owing to a reduced proportion of internal flow losses.

In designing the pump a necessary precaution is to so proportion the areas of the internal passages that the water dealt with is not subjected to any sudden acceleration or deceleration of flow, and to insure that the area of the discharge orifice is such that, with the determined velocity of flow therefrom, the reaction developed shall balance the resistance of the vessel at the desired speed, also that the incoming water is picked up at a velocity as nearly that of the ship as can be reasonably arranged for.

The total head which has to be generated by the pump to produce the required flow, must be calculated by determining the sum, of the loss of head due to bends in the pumping system, the loss of head due to internal friction, and the head due to the velocity of flow. The velocity head will have a value lying between $\frac{(v-V)^2}{2g}$ and $\frac{v^2}{2g}$ while the losses due to bends and friction can be ascertained by reference to hydraulic tables.

In order to deliver the determined quantity against the total head, found as above, the speed of revolution of the pump impeller must be such that a resultant velocity of not less than $\sqrt{2gh}$ (say $8\sqrt{h}$) is produced in the water discharged from its periphery, "h" being the *total head* determined as above.

The diameter of the eye, or inlet to the impeller, must necessarily correspond to that part of the inlet passage which leads up to it, and the outside diameter of the impeller can be made from 1·25 to 1·75 times the diameter of the eye, depending on the revolution speed adopted and the angle which the tips of the impeller vanes make with tangents to its periphery. The flatter this angle, for a given diameter of impeller, the higher is the revolution speed required to produce the determined resultant velocity of discharge, the angle being determined in conjunction with the revolution speed and impeller diameter, by drawing a parallelogram of velocities as set forth in standard works on pump design.

The inlet angle of the vanes should be such that, taken in conjunction with the determined speed of revolution and speed of flow, the incoming water can be picked up without shock. The number of vanes adopted must be sufficient to prevent undue slip, and depends to a considerable extent on the vane angles, but in ordinary practice it may be taken that a 12 inch impeller requires six vanes, 24 inch eight vanes, 36 inch ten vanes, and 48 inch twelve vanes.

The impeller may be of the open-ended or of the shrouded type, though the former pattern tends to clear itself more effectively from weeds and floating matter.

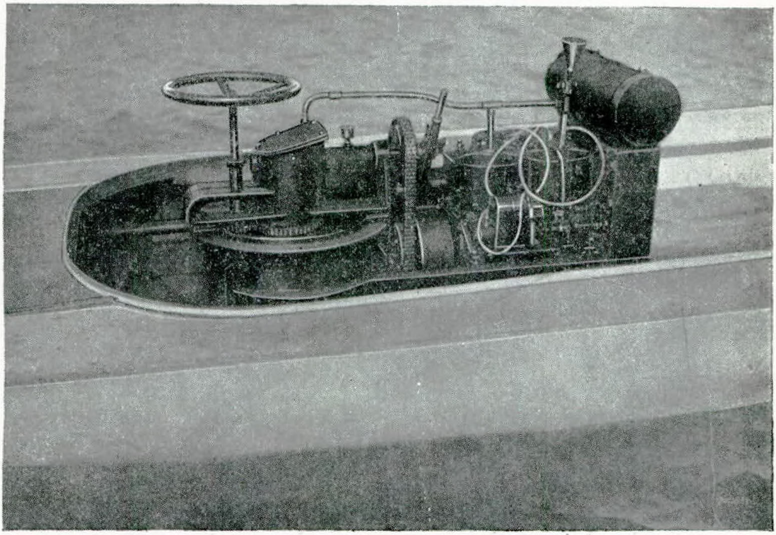
All internal surfaces of the pump should be well finished, and running clearances must be kept down to a minimum value, for only by attention to such details and by the avoidance of internal eddies and shock losses, can good efficiency be obtained.

Mr. John R. Ruthven: I have much pleasure in proposing a hearty vote of thanks to the author of this most interesting paper.

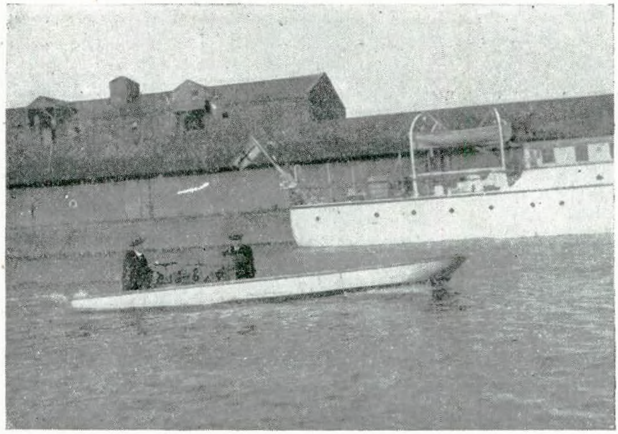
I have for long been a firm advocate of jet propulsion as the best for ships under all conditions; for speed, for quick stopping and for great pumping power for discharging water from a leak. Major Gill has produced a very ingenious design for a special purpose, and deserves great credit for the success he has attained.

I would give him the advice given by John Scott Russell, the builder of the *Great Eastern*, to my father many years ago, after a paper had been read on the hydraulic propeller: "Go on, feel your way, puzzle your brains, get as many clever men to work as you can, and go on with your hydraulic propeller, and I promise you in the end that you will certainly succeed."

———o———



Hydraulic Propelling, Steering and Manœuvring Unit installed in Scow of 20ft. x 6ft. x 6ins, draft.



20ft. x 6ft. Scow Propelled, Steered and Manœuvred by rotatable Hydraulic set.

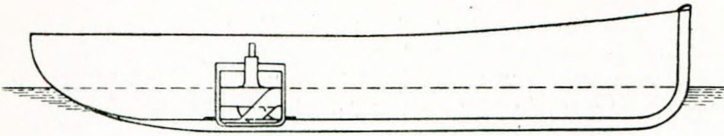


FIG. 1.

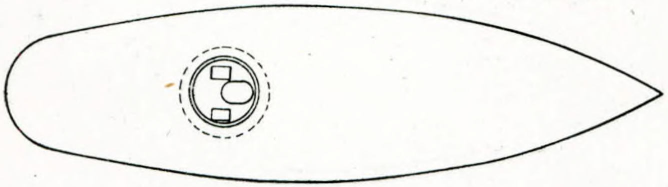


FIG. 2.

DISPOSITION OF UNIT IN BOAT.

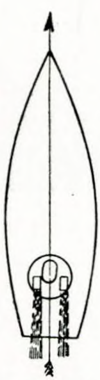


FIG. 3.

HELM AMIDSHIPS.

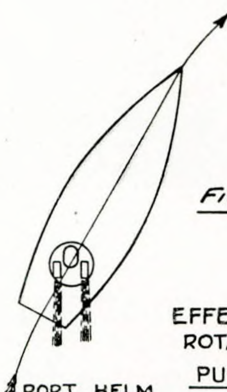


FIG. 4.

PORT HELM

EFFECTS OF ROTATION OF PUMP BODY.

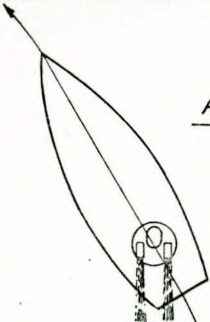


FIG. 5.

STARBOARD HELM.

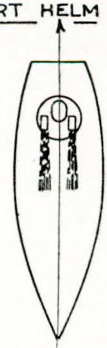


FIG. 6

HELM AMIDSHIPS GOING ASTERN.

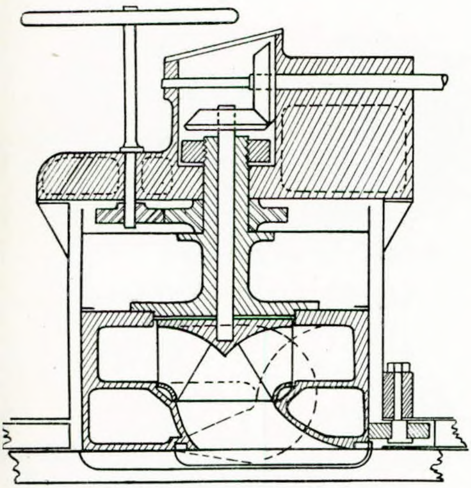


Fig. 7.

LONGITUDINAL SECTION OF UNIT.

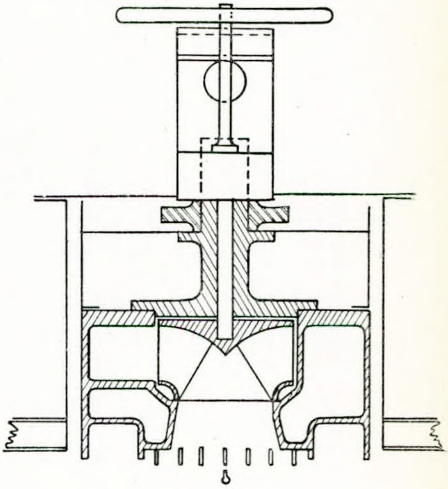


Fig. 8.

TRANSVERSE SECTION OF UNIT.

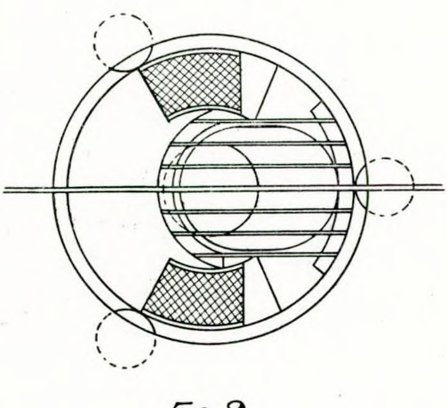
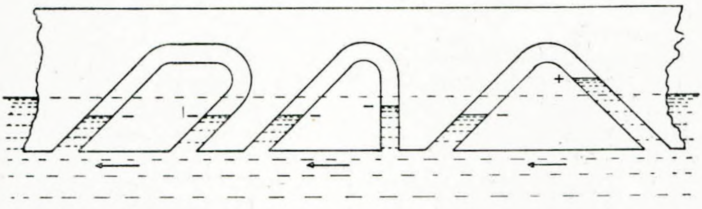


Fig. 9.

PLAN OF UNIT FROM BELOW.

EFFECTIVE PROPULSION OF CRAFT FOR USE ON SHALLOW WATERWAYS.



DIAGRAMMATIC LONGITUDINAL SECTION OF PART OF A VESSEL WITH THREE SYPHON SHAPED PIPES OPEN ENDED TO THE WATER BELOW THE HULL; THE WATER HAVING A FLOW SHOWN BY ⟵ RELATIVE TO THE VESSEL.

The head produced or work done by the flow of the external water is negative (−) or positive (+) in its effect in accordance with the signs marked against the water levels in the pipe branches.
The right hand type is adopted for hydraulic propulsion pumps, to avoid waste work.

FIG. 10

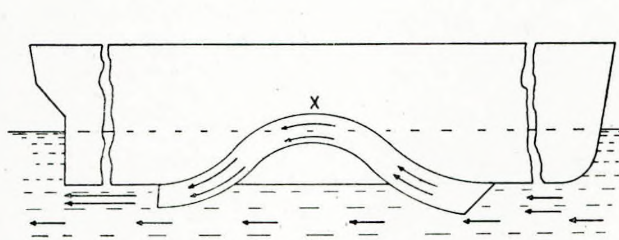


FIG 11

DIAGRAMMATIC REPRESENTATION OF ACCELERATED FLOW THROUGH A CONTRACTING SYPHON PIPE SYSTEM SUCH AS EMPLOYED IN THE APPLICATION OF HYDRAULIC PROPULSION TO VESSELS.

Arrows indicate the direction and relative velocities of flow of water, the increasing velocity in the pipe being produced by a pump at X.

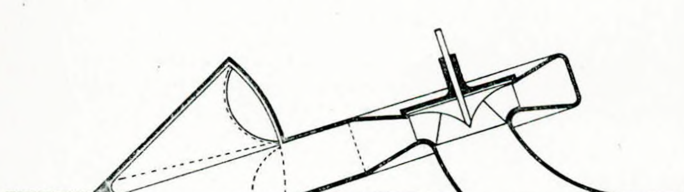


FIG. 12

DIAGRAM SHOWING ARRANGEMENT OF INCLINED TYPE HYDRAULIC PROPELLING PUMP OF FIXED PATTERN WITH NO PROJECTING PASSAGES.

Reversing is effected by sector shaped pivoted scoop fitting.
Intake inclines forward and discharge inclines aft.

Obituary.

JAMES KEITH (Member of Council, Inst. Mar. Engrs.).

We regret to record the death of Jas. Keith, of The Jas. Keith and Blackman Ventilating Co., on February 23rd, of pneumonia.

Born at Arbroath in 1849, he was the eldest son of ex-Provost George Keith. On completing his educational curriculum at Arbroath High School, he entered his father's works as an apprentice, and after finishing his term he had the opportunity of enlarging his engineering experience in Canada and the United States.

On returning home, he started business for himself and devoted his attention to ventilating, heating, and hydraulic appliances, manufacturing several patents of his own invention. One of his inventions in the early portion of his business career was an apparatus for the economical manufacture of gas from mineral oil. He designed the up-to-date sectional hot-water boiler for heating buildings.

In 1900 he amalgamated with the Blackman Ventilating Co., and became managing director of the combined Company. He was well-known in engineering circles, and his personality was appreciated by many old friends.

Mr. Keith read several papers on the subject of fans, draught and ventilation, on which he was a great enthusiast. He was elected a member of Council of the Institute of Marine Engineers in 1920.

To his widow and family we extend our deep sympathy. The funeral took place at Hampstead Cemetery on February 26th.

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Review of Books Presented to the Library.

Mr. H. M. Rounthwaite has kindly presented 16 vols. of "Engineering," dated 1881 to 1888.

—o—

Election of Members.

Members elected at the Meeting of the Council held on 7th March, 1921:—

Members.

Matthew B. Beatty, 168, All Soul's Avenue, Harlesden, N.W.10.

James Bell, 2, Keble Road, Bootle, Liverpool.

James Dugdale, 1, Mayor Road, Canton, Cardiff.

Geo. Aitchison Fitzpatrick, P.O. Cable Depot, Trinity Street, Woolwich, S.E.

George Gadd, 38, Birchfield Street, Poplar, E.14.

John Bartle Hastings, Grosvenor," Woodwick, Pem., S. Wales.

Frederick Jas. Hodson, 2, Bay View, Newhaven, Sussex.

George Isaacs, 18, Phoebeth Street, Brockley, S.E.4.

Claude Alfred Johnson, 3, Earl Road, Penarth, near Cardiff.
Herbert Geo. Jones, 3, Ramsden Road, Balham, S.W.
Frank Slatter Jordan, "Ravenbourne," Perry Vale, Forest Hill, S.E.
George Wm. Kitching, 1, Lime Street Square, E.C.3.
John Simeon Clayton Marshall, 25, Park Road, Ilford, E.
Douglas Allan Niven, "Roselea," St. Andrews, Fifeshire.
Edward Gray Norris, 15, Seething Lane, E.C.3.
Samuel Owen, Egremont, Terrace Road, Swansea.
Charles Philip Peters, Port Stanley, Falkland Islands, S.A.
John McDonald Scott (Engr. Lt.-Commdr., R.N.), 139, Hamlet Gardens, Ravenscourt Park, W.6.
Albert Edgar Sharp, 52, Eltham Road, Lee Green, S.E.12.
Arthur Conrad White, "Dagmar," Pear Tree Avenue, Southampton.

Associate-Members.

Walter Austin Cotton, 18, South Crescent, Lewisham, S.E.13.
Henry Howard Hosking, "Rock Villa," Rock, Wadebridge, Cornwall.
Harry Ian McIver, 44, Chapel Street, Liverpool.
Richard Surtees Pringle, 6, Botany Cottages, Purfleet, Essex.
Eric Prince, c/o G.P.O. Cable Depot, Trinity Street, Woolwich, S.E.
Alfred Eaton Wrigley, 40, Brazennose Street, Manchester.

Graduates.

Thomas Wm. Bailey, 50, South Bank Road, Edge Lane, Liverpool.
Edw. Cecil John Kennedy, "Croxford," 52, Arthurdon Road, Brockley, S.E.4.
William Edw. Mallett, 46, Orchard Hill, Lewisham, S.E.13.
John Ambrose Matthews, 210, Hither Green Lane, Lewisham, S.E.13.
Ian Ross, 31, Cromwell Road, Aberdeen.
William Spencer Hudson, Bicester House, York Street, Rugby.

Tranfer from Graduates to Members.

J. E. Hawthorn, "Toledo," 30, Blakehall Crescent, Wanstead, E.11.
David Langharne Thornton, 11, Cross Banks, Shipley, Yorks.

From Associate-Member to Member.

Robt. Keith Craig, The Model Farm, Wolvesnewton, Chepstow.
Fredk. W. Pilton, 85, Galbraith Street, Cubitt Town, E.14.

From Graduates to Associates.

Frank H. Hawthorn, "Toledo," 30, Blakehall Crescent, Wanstead.

George A. Hawthorn, "Toledo," 30, Blakehall Crescent, Wanstead.

SPECIAL NOTICE.

An Extraordinary General Meeting of members will be held on Thursday, May 12th, at 6 p.m., in the Lecture Hall, when a Resolution will be submitted in accordance with the regulations to increase our membership to 3,000.

A meeting will be held on Thursday, May 26th at 6 p.m., to confirm the Resolution.