With regard to steam jackets, there can be no doubt that a certain degree of economy attends their use, especially when the steam has not been superheated before reaching the engines, as the extra amount of heat contained in the steam around the cylinders tends to retard the cooling of the steam inside the cylinders during expansion and exhaustion.

By this theory of the steam jacket it will be seen that its object is almost the same as that of the superheater, namely, by imparting a greater amount of heat to the steam than that due to its actual pressure, to make up for any loss it may undergo from radiation of heat, either external or internal.

In many steamers where steam jackets are fitted they are not used at all while the engines are running. But although the benefit derived from them may be small when superheaters are fitted, still all marine engines of large size should be jacketted round the cylinders, for the purpose of warming them up previous to starting. By letting steam into the jackets before starting, the whole metal of the cylinders is warmed up gradually and equally, so that there is no danger when starting the engines of cracking the cylinders by unequal expansion.

Cylinders have sometimes been cracked by carelessness in this respect, the throttle valve having been opened while the engines were cold, thus causing an unequal strain on the metal by suddenly raising one part to a high temperature before the heat had time to penetrate the whole mass.

* * * * *

Comparatively few of our steamers are fitted with dampers to their funnels, by means of which the generation of steam may be checked when entering or leaving port.

Most coasting steamers are continually in and out of port.

Those engaged in carrying mails have often to run to a given point off a port, drop anchor while mails, passengers, &c., are exchanged, and then proceed on their voyage. As these vessels have usually all they can do to maintain their contract time, not a minute can afford to be wasted, and it is desirable to maintain full speed as nearly as possible to the point of stoppage, and to be able to start at full speed again as soon as the order is given.

When no damper is fitted it becomes necessary on stopping the engines to open all the furnace and tube doors, which practice is very detrimental, as it allows the cold air to come suddenly in contact with the heated internal surfaces of the boilers; but when a damper is fitted the fires may often be efficiently checked without opening the tube doors, the fires are therefore in better order for getting away again, and a saving in time is effected.

In a river, too, or when approaching or leaving a wharf, where the engines are often slowed suddenly, it is very convenient to be able to regulate the fires from the engine room by means of the damper, instead of the usual practice of continually opening and shutting the furnace doors.

. . . . .

Most engineers after having filled their boilers with fresh water are very careful to keep it fresh by blowing off as little as possible at the safety valves. In coasting steamers, which blow their boilers down once a fortnight, or once a month, the water may with care be kept comparatively fresh at the end of that period. Although the scale thus formed is very thin, yet it is much harder than it would be had the boiler been worked at a greater degree of saltness. This hard scale is very difficult of removal, so that when the vessel is laid up more expense is often incurred in scaling the boilers than would be the case had they been worked at a greater density. Indeed the deposit formed by water of from 8 to 10 ounces gives little trouble to remove, and generally falls away itself in flakes from the furnace crowns. The scale-forming properties of fresh water appear to vary greatly in different districts, and care should therefore be taken to note the quality of the scale forming on the plates before working the boilers too fresh. It is a remarkable fact that the thickness of scale which may be allowed, say upon a furnace crown, must be decreased with high pressures. That is to say, that a certain thickness of scale with a working pressure of 60 lbs. might be quite capable of conducting the heat to the water, but if the same thickness of scale existed with a boiler working at 160 lbs. it would be sufficient to bring down the furnace crowns by allowing the plates to become overheated. This is the reason why triple expansion engines whose boilers always carry a high pressure, usually take their supplementary feed from a fresh water tank instead of from the sea, as is commonly done.

. . . .

Where vessels of ·light draught were required, and narrow rivers were to be navigated, twin screws have been fitted, it being thought that they would then draw less water, and possess greater facilties for rounding sharp bends. But it is found in practice that twin screw vessels as a rule draw as much water as those fitted with single screws; and although they are undoubtedly more readily handled in a river, the advantage is trifling when compared with the increase in their working expenses.

When steamers are fitted with twin screws worked by two independent sets of engines, the first cost is considerably increased.

More coal is burned in proportion to the power developed; and the number of working parts being doubled, the amount of oil and stores used is greater.

The engines are also more liable to accident; require more attention; and additional work is necessary to keep them in repair.

Also, the brackets and outer bearings for carrying the propeller shafts offer obstructsons which greatly increase the resistance to the vessel's progress through the water.

The propellers themselves being small in diameter, cannot be so well proportioned, as would be the case were one screw of large diameter used. In single screw vessels also, the sides of the engine-room may be utilized for bunkers, or for other purposes, thus economising space, but with twin screw vessels this cannot be done, as the full width of the ship is necessary to accommodate the engines. Vessels fitted in this way are therefore seldom a success, so far as economy is concerned.

It is an argument frequently urged in favour of twin screw vessels, that they are not likely to become totally disabled; as if one engine broke down, the other one would still be able to keep the vessel going. Even admitting this to be the case, the advantage is practically of little importance, especially in a coasting trade, but, inasmuch as there are two sets of engines instead of one, the risk of a break down is doubled.

Twin screw ships have also a bad habit of carrying away their propeller blades, as being placed so near the sides of the vessel, they are very liable to be broken against wharves or other impediments. In this respect they compare unfavourably with the single screw, which from its protected situation is not at all liable to be broken.

* * * *

Of the various designs of compound marine engines, the most common is that in which the cylinders being inverted, the condenser is situated behind them, and the air, circulating, feed, and bilge pumps placed at the back of the condenser, worked by levers extending over the top of the condenser, and attached to the pumps at one end, and to the engine crossheads at the other, by means of the usual links and brasses.

Perhaps a better arrangement is that adopted in the A.S.N. Co.'s steamer, "Tenterden," engined by the North Marine Engineering Company, of Sunderland.

In this vessel all the pumps are worked directly from the crossheads by means of a single straight bar on each engine, and to the ends of which the pump rods are attached, without any intermediate links whatever. The condenser is placed horizontally below the sole plate, and is so arranged as to be quite as accessible and easily overhauled as when placed in the ordinary way. The engine-room above is therefore kept perfectly free of condenser, pumps, links, and levers; and is consequently very easily kept clean.

By working the pumps from the crossheads in this way twenty pairs of brasses, with their links and pins are done away with. The work necessary to keep them in repair is therefore done away with; much less oil is used to run the engines; they are lighter, and cost less for repairs. Their first cost is also lessened, as there are not so many working parts.

The arrangement altogether is a very neat one. The engines work very quietly, give no trouble, are not liable to accident, and prove most economical.

* * * *

One of the chief difficulties in connection with the new triple expansion engines appears to be that of obtaining a good and suitable valve motion. In these engines the piston valves are usually placed at the sides of the cylinders, for if arranged between the cylinders in the usual way, the length of the engines overall would become excesssive.

Owing to this position of the valves, the ordinary link motion is not so well adapted for working them; and many efforts have been made to supersede this expensive and somewhat complicated valve gear.

The triple expansion engines of the White Star Liner "Australasian," are fitted with a valve motion which is a modification of "Gooch's fixed link," the valves receiving their motion partly from the connecting rods, and partly from the pump levers.

In locomotives, Joy's valve gear is now much used instead of the link motion, and appears to work very well.

This gear consists of rods worked from the engine crossheads, attached to a block which slides upon a reversing link placed in front of the engines.

The principal advantage of Joy's valve gear over the link motion for marine engines is, that by its use the crank shaft is left perfectly free of eccentrics and straps, so that the main bearings may be increased in length.

In other respects it is not so well adapted for inverted marine engines as for locomotives.

This arises from the fact that in a locomotive the reversing link is held vertically, so that there is no weight upon it beyond that due to the friction of the valve. But in a marine engine as the link must be placed in a horizontal or at least diagonal position, the whole weight of valve, valve spindle, and valve connnecting rod comes upon it.

The weight of these parts in a large marine engine is considerable, and added to the friction of the valve itself is sufficient to cause excessive wear at this part.

The triple expansion engines of the steamers "Coorangamite" and "Burrumbeet," of Huddart Parker and Co.'s line, are fitted with Joy's valve gear. As applied to these vessels the gear possesses as many working parts as an ordinary link motion, and gives some trouble to keep in order. The link blocks especially wear away very quickly from the excessive friction caused by the weight upon them.

On the last visit of the "Aberdeen" to this port, the writer took an opportunity to visit her and ascertain a few particulars as to the working of her machinery. She is a vessel of 362′ in length, with a beam of 44′ 4″, and a gross register of 3616 tons.

Her triple expansion engines are by Robert Napier and Sons, built in 1882, the cylinders being 30, 45, and 70 inches in diameter, respectively; the stroke 54″; and the working pressure 120 lb.

Under these conditions the engines indicate at sea 1900 horse power. The consumption per day of Welsh coal is 37 tons, and of colonial southern coal, 41 tons. These figures, which are well within the mark, give a result of 1·8 lbs. per I.H.P. per hour for the Welsh coal, and of 2 lbs. per I.H.P. per hour for the colonial coal; thus showing a decided improvement on the results obtained from average compound engines, which under the same conditions burn from 2 to 2½ lbs. per I.H.P. per hour. This vessel is fitted with piston valves placed behind the cylinders, and worked by the usual link motion.

* * * * *

Considerable expense is often caused in steamers by the necessity which exists for lifting the crank-shaft from time to time, for the purpose of lining up the bottom brasses. This is caused by the shaft wearing down either at one end or the other from the strain not being equally distributed fore and aft on the main bearings; and also from the brasses themselves wearing quickly away owing to deficiency of bearing surface. This unequal strain is sometimes the result of a heavy wheel for the turning gear being keyed on the shaft, either at forrard or after end, and by its weight adding considerably to the strain upon the adjacent bearing. Whenever a wheel of this kind is fitted, either the bearing next it should be increased in length, or else the wheel itself be made so that it can be disconnected from the shaft when the engines are in motion, which might be easily done.

The main bearings at either side of the cranks should also be placed as close up to them as possible, so as to allow no room for leverage to be exerted by the cranks in bending the shaft. A crank shaft has very little strength to resist a bending strain, on account of the gaps made in it by forming the cranks, and it is therefore important that the strain should be taken close up to the crank cheeks.

The shaft should also be in line, so that all the main bearing brasses may embrace it as closely as possible.

By this means, less play being allowed in the bearings, the shaft has a better chance of withstanding any sudden or undue strain which may be brought upon it. In most marine engines the main bearings are deficient in surface and wear down very quickly, the result being that in a short time the whole engine is thrown out of line. There is no doubt that when a crank shaft is properly in line, with the brasses fitted in such a way as to take up the strain during the whole stroke without shake, that the shaft is not so likely to break as it is when working out of line. When out of truth, the brasses must be left slack so that the shaft is constantly being sprung backwards and forwards at every stroke of the engine.

A good illustration of the advantages of bearing surface and truth of construction is afforded by a set of triple expansion engines built for the s.s. Enfield, by the Central Marine Engineering Company, West Hartlepool, and for the account of which we are indebted to the *Engineer*.

The cylinders of these engines are 21, 35, and 57 inches diam., respectively, and 39 inches stroke, with a working boiler pressure of 160 lbs. per square inch. The main bearings have much more surface than usual, the two inner ones being two and a half diameters in length, and extending from crank-cheek to crank-cheek. These bearings are so arranged that the bottom brasses may be removed for lining up or renewing without lifting the shaft. The centres of the cylinders are all the same distance apart, so that the crank shaft of any engine will fit any other. The shaft itself is a built one, the pieces being shrunk together, and the crank pins are forged from hollow ingots of steel.

In order to ensure truth in the construction of these engines, the builders first constructed a level erecting table on the floor of the shop, and the sole plate of the engines having been planed underneath, it was bolted to the table and was not again disturbed until the engines were completely finished. The main bearings were bored out and faced down the sides by a steel cotter-bar 27 feet long and 8½ inches diameter.

The engines, after being completed, were moved by steam before being removed from the table, the steam being taken from the shop boilers, and the injection water from the dock alongside. This plan of finishing the engines and steaming them upon a table in the shop has proved so successful that the firm intend increasing the length of their table to 150 feet, so that several sets of engines may be erected upon it at the same time.

The cylinders in these engines are cast separately and joined together by faced joints, which, however, are not steam joints. The valves are all piston valves arranged behind the cylinders and placed as closely as possible to them, so as to lessen the lengths of the steam ports. The cylinders and valve chambers are all fitted with hard cast iron liners fitted steam tight, the liners in the cylinders forming steam jackets completely round them. The valve spindles, valve rods, and reversing rods, are all of forged steel, and all the valve gear brasses are of phosphor bronze. The stern bush is of brass lined with "lignum vitæ" strips, the length of the bearing part being 54 inches. The Enfield, herself, is 275 feet long by 37 feet 2 inches beam, and 20 feet 6 inches mean draught. When the trial runs were made she had on board over 2800 tons of coal, the ship's total displacement being 4340 tons.

Six runs were made over the measured mile, the mean speed obtained being 10·6 knots per hour. The midship area immersed was 685 square feet, and the speed co-efficient by this becomes

$$\frac{X \times V^3}{I.HP.} = 943 = \text{co-efficient.}$$

The mean horse power indicated was 866, and the truth and balance of the engines were such that they could be run in dock as slowly as eight revolutions per minute without stopping. The vessel was built by W. Gray and Co., of West Hartlepool, and is owned by Pynam Brothers, of London

*   *   *   *   *

In the foregoing description of the Enfield it is to be regretted that no particulars are to hand of the boilers, or of the quantity of coal consumed in developing the given power, for the amount of fuel expended in producing the power forms the true test of the economy of a vessel's machinery.

Generally speaking then, the most important point towards economy and efficiency of working is to have the boilers made of ample size, also the condenser, and the air and circulating pumps. The formulæ given in books for the proportions of these parts are sometimes misleading, and in designing a steamer and estimating her probable speed, these proportions should be considered with relation to the climate in which the vessel will be engaged, the temperature of the injection water with which the condenser will be supplied, and the quality of the fuel to be obtained, a fair allowance being made for fouling of the vessel's bottom, accumulation of scale on the boiler plates, and fouling of the condenser tubes.

A better result is also obtained where simplicity of design is observed in the engines, and where the stroke of piston and length of connecting rods bear a good proportion to the diameters of the cylinders. A good result is seldom obtained from short dumpy engines.

It is also desirable to leave plenty of room in the boilers, between the furnace, combustion chambers, and tubes, so that they may be quickly and easily cleaned and repaired.

Everything which tends to economy and reduction of labour in a vessel is not only a saving in itself but is a direct source of gain, inasmuch as the very best class of men may easily be obtained to work the vessel. Every steamer also should be well supplied with gear and the necessary tools to effect repairs in the event of accident.

The causes which act most quickly in decreasing a steamer's speed are fouling at the bottom, and deposit of scale on the heating surfaces of the boilers. Although much thought has been given to these important subjects, no preventives appear yet to have been brought forward which possess sufficient merit to ensure their general adoption.

* * * * *

In conclusion, it may be observed that, no matter how much pains are taken to ensure a well constructed and reliable set of engines and boilers, and a well found vessel in all respects, very much depends upon the management of them by those placed in charge.

A want of cleanliness and discipline in a ship usually lead to more expense than years of fair wear and tear.

The writer is acquainted with one vessel in which the bilges were kept in such a disgusting state that a gallon of disinfecting fluid was obtained by the chief engineer with the stores every month and poured in the bilges to keep down the stench from them. It is needless to add that the management of the engine-room in this vessel, and the state of the machinery generally, were in a correspondingly disgraceful condition.

Next to the boilers the bilges and pump strums perhaps deserve attention, for when these are neglected the bilge pumps soon become choked by the dirt washed up by the rolling of the ship in bad weather. Dirty bilges also cover the bright work of the engines with rust, and destroy the paint, thereby causing trouble and expense.

* * * * *

In closing this paper attention is drawn to the fact that the quality and efficiency of a crew depend mainly upon the character and competency of those above them. Few men suffer more personal discomfort than those who follow the sea; and no class of men, especially in a climate like that of our northern coast, earn their living harder than do firemen. The writer takes this opportunity of doing justice to our colonial firemen by stating that even under these adverse conditions a crew of them may be obtained in a vessel, which for intelligence, sobriety, and faithful performance of downright hard work, will compare favourably with any other class of men in any similar station of life.

It will be found good policy to give attention to those details, which may lighten the labours and promote the comfort of the crew, such for instance as the supply of a bath for the use of firemen coming off watch. These matters, which are often overlooked, have a direct influence on the economy of a steamer. By obtaining a superior class of men in the ship a higher degree of discipline may be maintained, more work is done, the vessel is kept in the best order, and repair lists are reduced to a minimum, so that credit is done to the owner.